U.S. DEPARTMENT OF ENERGY | Office of Science

Convective and Orographically Induced Precipitation Study Field Campaign Report

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ARM

Convective and Orographically-induced Precipitation Study

COPS Field Report 2.1

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An observation program within the Priority Program
"Quantitative Precipitation Forecast (PQP)"
funded by the German Research Foundation

and

a World Weather Research Program
Research and Development Project

in coordination with
the World Weather Research Program
Forecast Demonstration Project
MAP D-PHASE,

the Operation of the
US Atmospheric Radiation Measurement Program
Mobile Facility,

and the
TRACKS Project of the Helmholtz Society

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with contributions of the COPS PIs

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1 The Priority Program “Quantitative Precipitation Forecast”

1.1 Objectives and Set up of the Priority Program

Significant deficiencies of QPF, which are existing for many years, led to the initiation of the Priority Program (PP) 1167 “Quantitative Precipitation Forecast PQP” by the German Research Foundation (DFG) in 2003 (PQP stands for Praecipitationis Quantitativae Praedictio). This research program addresses the challenges identified by many user groups with respect to QPF. The program gathers atmospheric scientists at German and Swiss universities as well as research institutes to combine their knowledge for improving QPF. In close cooperation with the German Meteorological Service (DWD), its operational forecast systems are used and refined as a basic backbone for model development, testing, and validation. The structure of PQP is depicted in Fig. 1.1.

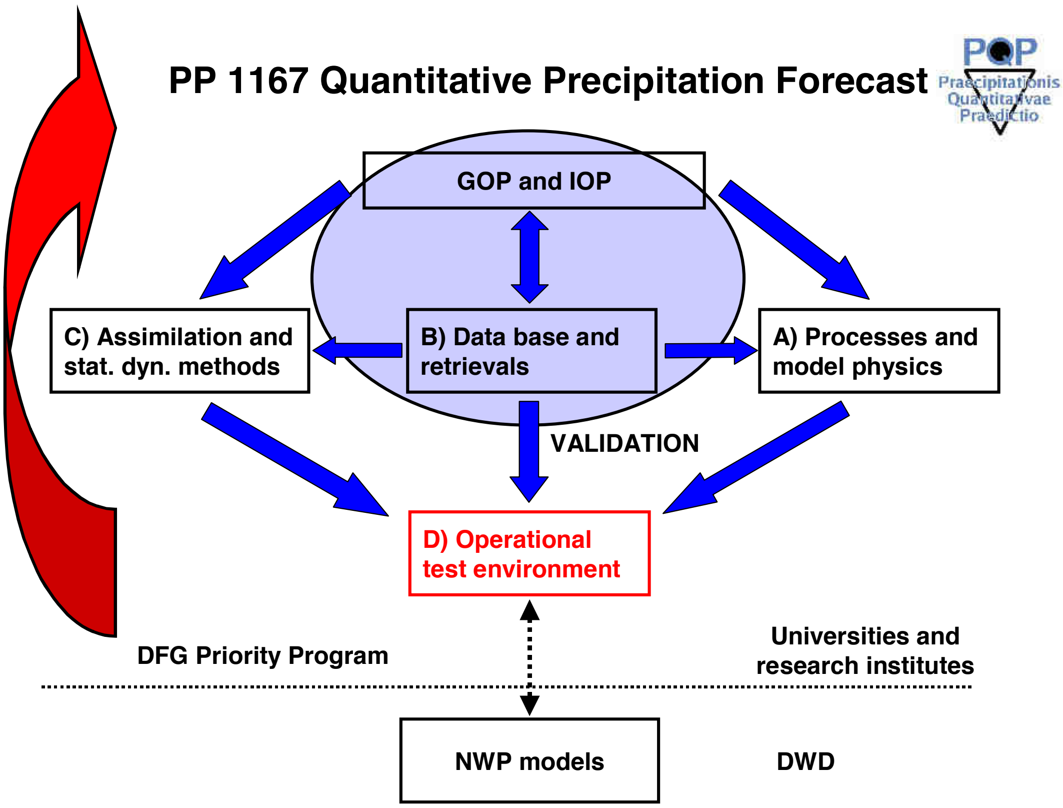


Fig. 1.1 Structure of Priority Program 1167 Quantitative Precipitation Forecast – Praecipitationis Quantitativae Praedictio (PQP). GOP: General Observations Period, IOP: Intensive Observations Period = COPS.

The priority program focuses on reaching the following scientific objectives:

I. Identification of processes responsible for deficiencies in QPF.

II. Determination and use of the potentials of existing and new data as well as new process descriptions to improve QPF.

III. Determination of the predictability of weather forecast models by combined statistical and dynamical analyses with respect to QPF.

Presently, the main deficiencies of QPF are due to a combination of errors in the initial fields, suboptimal methods for the assimilation of observations, inadequate modeling of components of the water cycle, and fundamental problems in the interpretation of deterministic models.

The schedule of PQP is presented in Fig. 1.2. The program has been accepted in May 2003 and was started in April 2004. The duration will be 6 years. The program is divided in three 2-year funding periods. More details are found on the PQP webpage (www.meteo.uni-bonn.de/projekte/SPPMeteo/).

	April 2004-2005	April 2005-2006	April 2006-2007	April 2007-2008	April 2008-2009	April 2009-2010
Year	1	2	3	4	5	6
	Period 1		Period 2		Period 3	
GOP				One year		
IOP	Phase 1: Preparation			Phase 2: Performance: Summer 2007	Phase 3: Data analysis	

Fig. 1.2 Funding and timing of PQP. Exp: Experiment. GOP: General Observations Period, IOP: Intensive Observations Period (= COPS).

More than 20 research projects have been funded by the DFG after review processes, which took place in winter 2003/2004 and 2005/2006. These projects are related to surface-atmosphere exchange, convection, aerosol and cloud microphysics, data assimilation, remote sensing, numerics, and verification. More details are presented on the PQP web page. Strong collaboration between PQP PIs is fostered by the performance of joint workshops. International collaboration is strongly supported. The field campaign, which is subject of this proposal, is an example.

Separately, funding has been requested for experiments, which shall be performed within the scope of the PQP. These experiments are imbedded in the center of the PQP program so that these activities can be coordinated with all PQP research projects. Furthermore, this permits to perform IOP-related projects and the corresponding data analysis within the duration of the PQP.

1.2 Experiments Within the Scope of PP 1167

The urgently required improvement of knowledge on the relevant processes as a basis of model optimization with respect to the currently blatant uncertainty of QPF can only be achieved when data are made available, which meet a far higher standard than the measurement values that are routinely recorded for weather forecast and climate investigation. It is therefore indispensable to extend the database by field experiments, where advanced sensors allow for the observation of decisive atmospheric variables. These include the atmospheric dynamics, the water vapor field, as well as aerosol, cloud, and precipitation variables.

The experimental set up takes into account the huge temporal and spatial distribution of precipitation making the analysis of its statistics very difficult. The entire experiment shall comprise a large-area observation phase of one year **(General Observations Period, GOP)**, and a dedicated experiment regarding the precipitation process over several months **(Intensive Observations Period, IOP = COPS)**, providing high-resolution, four-dimensional measurements of atmospheric variables. The performance of the COPS field campaign is the subject of this Field Report (FR).

During the GOP, all available observations routinely performed are gathered (e.g., rain gauges, three-dimensional radar observations, satellite observations) in an area covering the major part of Europe. Research institutes shall be supported for operating their "standard" instruments. Available instruments shall be redistributed within the GOP area to obtain information on the atmospheric state at certain sites as complete as possible. Strong cooperation with European Observatories (Cabauw, Chilbolton, Lindenberg, Palisieau) is ongoing. Additionally, at least one special long-term observation site shall be operated within the COPS area at a critical location, which has been identified in the experiment preparation phase. The Atmospheric Radiation Measurement Program (ARM) Mobile Facility (AMF, see www.arm.gov/sites/amf/blackforest/) is already operating since April 1, 2007, for this purpose. This integration of operationally not employed data will result in the presently achievable optimum of information on the state of the atmosphere being supplied to a regional forecast system. Further information about the preparation and performance of the GOP is found at gop.meteo.uni-koeln.de.

COPS stands for Convective and Orographically-induced Precipitation Study, which was performed in summer 2007 in southwestern Germany and eastern France for 3 months. Precipitation processes were observed in 4D by means of a synergy of a new generation of research remote sensing systems operated on ground, aircrafts, and satellites. The whole life cycle of convective precipitation from the initiation of convection, to the formation and development of clouds, to the formation and development and decay of precipitation was observed in detail. Detailed information about COPS with background information and many links is found at www.uni-hohenheim/cops.

COPS data shall not only give rise to a far improved data set for assimilation and validation of models, but also to an improved in-depth process understanding. Evaluation of the data sets obtained under PQP will lead to a better representation of relevant processes in models and, hence, to improved QPF.

2 Coordination with international activities

2.1 Overview

The ambitious goals of COPS can only be reached by strong international collaboration. It has to be considered that convection initiation and development of clouds and precipitation in low-mountain regions is controlled by land-surface processes, orography, and the mesoscale and synoptic scale settings, simultaneously. The relative importance of these forcing mechanisms shall be evaluated, separated, and quantified. This requires observations of the large-scale environment and small-scale observations in the COPS domain. Fig. 2.1 presents an overview of the international collaboration initiated in connection with COPS.

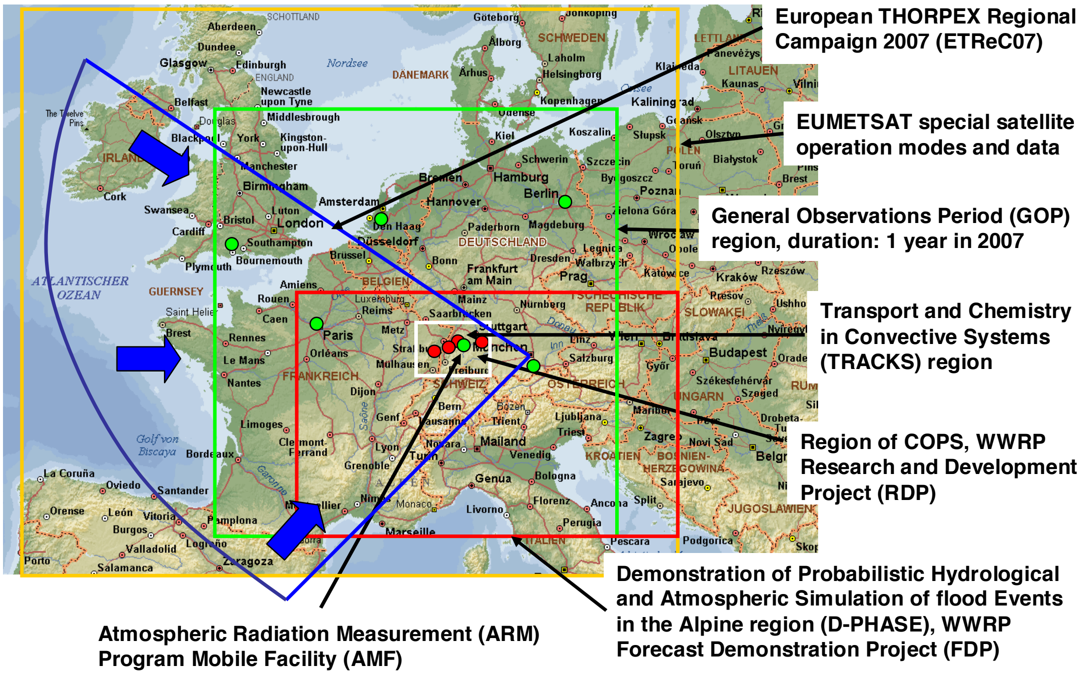


Fig. 2.1 International collaboration within COPS during summer 2007.

The observations coordinated with COPS include the following activities:

A strong collaboration between THORPEX (www.wmo.int/thorpex/), a Global Atmospheric Research Program, of the World Weather Research Program (WWRP) of the WMO and the PQP community. COPS and the GOP have been combined with the first summertime *European THORPEX Regional Campaign* (ETReC07). This allows for improving the representation of the large-scale conditions in the COPS area using targeting techniques in combination with denser or additional observations. The impact of targeting can be validated and the interaction of large-scale and small-scale processes can be studied in detail in the COPS region.

The project *Transport and Chemical Conversion in Convective Systems* (TRACKS) of German Helmholtz Centers (www.fzk.imk.uni-karlsruhe.de/english/seite_417.php) providing additional airborne observing systems. This project is aiming at the observation of the chemical conversion and the transport of pollutants by convective systems.

The collection of routine observations in the *GOP* region (gop.meteo.uni-koeln.de) during the full year of 2007. This will enable us to relate COPS observations to a larger context and to compare these with results from other regions.

Strong collaboration with climate researchers and experts on radiative transfer by the deployment of the *US Atmospheric Radiation Measurement* (ARM, see www.arm.gov) *Mobile Facility* (AMF, www.arm.gov/sites/amf.stm) for 9 months in the COPS region. This unique combination of instruments alone, which operation is funded by the ARM program, provides for a previously unachieved data set concerning initiation of convection as well as cloud and precipitation microphysical properties in a low-mountain region.

Strong support by *EUMETSAT* by providing special satellite observations and products. These include special observation modes such as Meteosat Second Generation (MSG) Reduced Scans and data of new satellite remote sensing systems such as the METOP platform.

The intense interaction with modeling efforts includes the following activities:

Application of the newest generation of operational, high-resolution deterministic and ensemble prediction mesoscale models optimized for application in complex terrain. This is ensured by the collaboration with the WWRP Forecast Demonstration Project (FDP) *Demonstration of Probabilistic Hydrological and Atmospheric Simulation of flood Events in the Alpine region* (D-PHASE) community (www.map.meteoswiss.ch/d-phase).

Real-time data assimilation of research institutes and weather forecast centers using COPS observations such as additional radiosonde launches from the AMF and from other sites as well as Global Positioning System slant path and zenith path delays.

Archiving of a D-PHASE, GOP, and COPS data at one institution, the *World Data Center for Climate* (WDCC, see www.mad.zmaw.de/projects-at-md/cops-campaign/ and http://cops.wdc-climate.de/), at the Max Planck Institute for Meteorology in Hamburg, Germany.

2.2 World Weather Research Program Research and Development Projects

The importance of QPF in complex terrain was recognized by the Science Steering Committee (SSC) of the WWRP. Therefore, on October 3, 2005, a proposal was submitted for review at the 8th Session of the WWRP SSC in Kunming, China, from October 26-30, 2005, in order to endorse COPS as WWRP Research and Development Project (RDP). The COPS WWRP RDP Proposal can be found on the COPS web site www.uni-hohenheim/cops.

The criteria for WWRP RDPs are found on www.wmo.int/web/arep/wwrp/wwrp_homepage.shtml. Development Projects within the WWRP are expected to arise from two main sources – those developed by the WWRP, and those which are endorsed by the WWRP as being of particular merit to weather prediction research and development. At the WWRP SSC Meeting in Kunming, the importance of COPS for QPF research was highly appreciated. The successful collaboration with other international partners was another aspect, which led to the recommendation of endorsing COPS as Research and Development Project (RDP) of

WWRP. At the CAS Meeting in Cape Town, South Africa, from February 16-24, 2006, this recommendation was accepted and COPS was formally endorsed as WWRP RDP.

2.3 Atmospheric Radiation Measurement Program

A unique support of COPS is provided by the US Atmospheric Radiation Measurement (ARM) Program. From **April 1 – December 31, 2007**, the ARM Mobile Facility (AMF) is operated in the Murg valley in the Northern Black Forest (see section 5.3.4).

The operation of the AMF is the result of an international proposal with the title *"Initiation of convection and the microphysical properties of clouds in orographic terrain: AMF + COPS"*, which has been submitted to ARM on July 15, 2005. This proposal highlighted the scientific win-win situation provided by the operation of the AMF during COPS. The COPS+AMF proposal can be downloaded from the COPS web site.

On the one hand, for the first time, the AMF produces a unique data for COPS research in complex terrain. On the other hand, special German instrumentation is operated at the AMF site to improve furthermore the sensor synergy. This includes soil moisture measurements in three depths, humidity and temperature measurements in the atmosphere with GPS, two additional microwave radiometers (MWRs) for retrievals using the integrated profiling technique and for measurements of low liquid water path in clouds with high accuracy. A micro rain radar (MRR) is deployed for measurements of rain drop size distribution. Furthermore, during the COPS campaign, a multiwavelength lidar and a Doppler lidar were operated.

Using this set up, key science topics of the ARM program can be addressed. Within the COPS+AMF proposal, the following questions are addressed:

- What are the processes responsible for the formation and evolution of convective clouds in orographic terrain?
- What are the microphysical properties of orographically induced clouds and how do these depend on dynamics, thermodynamics, and aerosol microphysics?
- How can convective clouds in orographic terrain be represented in atmospheric models based on AMF, COPS, and GOP data?

To answer these science questions, the observations (ground-based, air- and satellite borne) have been strongly linked with the D-PHASE atmospheric models ranging from detailed cloud microphysical models over state-of-the art mesoscale models used in short-range weather prediction to General Circulation models (GCM). Using this set of tools it is possible to investigate how representative are the observations of an atmospheric column by the AMF for a model grid box (from about 2 to 200 km) in orographic terrain.

After extensive logistic preparation and excellent support by the local government and the rectorate of Hohenheim University (UHOH), the AMF went into operation on April 1, 2007. UHOH scientiss played a major role in the logistical preparation of the site. All instruments are operating successfully and the data including quality control are routinely stored in the AFM data archive (www.archive.arm.gov).

2.4 The WWRP FDP MAP D-PHASE

D-PHASE can be considered as the fourth phase, the *Demonstration Phase*, of the Mesoscale Alpine Programme (MAP). The corresponding proposal on a WWRP FDP D-PHASE has been submitted to the WWRP SSC Meeting in Kunming simultaneously with the COPS RDP proposal. Like the COPS project, the MAP D-PHASE FDP was endorsed at the CAS Meeting in Cape Town from February 16-24, 2006.

WWRP FDPs are aiming at methods of demonstrating improved prediction capacity and indicate the extent to which a number of qualifying attributes are present. Particularly, forecasts of weather of international applicability shall be addressed, which emphasis on high impact weather. FDPs form an essential part of the WWRP programs and are intended to confirm, by objective measures, the '*enhanced prediction capabilities* gained through improved understanding and/or the utilization of enabling technologies'.

This is clearly fulfilled by D-PHASE. During this FDP, for the first time, the next generation of convection permitting models have been operated for a period of 6 months. New data assimilation and ensemble prediction techniques have been applied. A new data set called TIGGE+ has been defined, which will be stored at the WDCC and will allow in-depth evaluations of model physics.

Another specialty of D-PHASE is the strong interaction with end users. To this end, an end-to-end forecasting system has been designed and operated continuously during the D-PHASE Operations Period (DOP) from **June 1 – November 30, 2007.**

The D-PHASE End-to-End Forecasting System is presented in Fig. 2.2. From -5 – day 0, a unique combination of atmospheric global and regional deterministic and ensemble models was applied to determine alerts in critical catchment areas. These alerts are shown on the D-PHASE Visualization Platform (VP). Starting from day -2, hydrological forecasts were performed in the catchment areas and their results were transferred to the end users. Also in the COPS region, a catchment area has been defined by the Hochwasservorhersagezentrale in the federal state Baden-Württemberg.

Whereas in D-PHASE atmospheric models were used for calculating alerts and as input for hydrological models, their data were applied within COPS for mission planning and model evaluation. An overview of the models operated during D-PHASE and the involved institutions can be found on the D-PHASE web site www.map.meteoswiss.ch/d-phase.

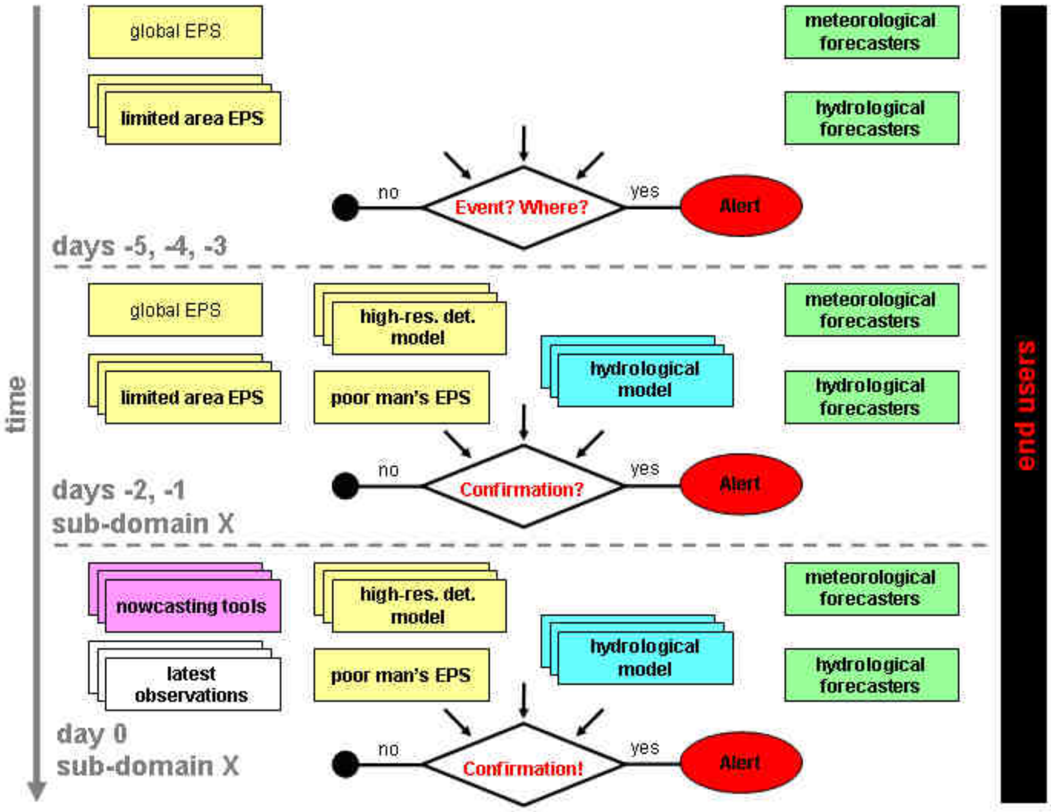


Fig. 2.2 The D-PHASE End-to-End Forecasting System.

2.5 TRACKS

From July 16 – July 31, 2007, the field campaign TRACKS (*Transport and chemical conversion in convective systems*) was performed in close relation to COPS. Whereas COPS is concentrating on meteorological aspects of convective systems, TRACKS focuses on the transport of atmospheric trace gases and on chemical reactions under convective conditions. COPS and TRACKS were arranged in close cooperation, the logistics of both campaigns were intensively coordinated.

The measurement area of TRACKS was not totally identical with the experimental area of COPS. The TRACKS region covered a large part of the valley of the upper Rhine between Mannheim/Ludwigshafen and Strasbourg. Parts of the Black Forest and Alsace were included in dependence of the intended experimental mission. Further information of the TRACKS missions can be found in sections 7.1 and 7.6 as well as Fig. 7.1 and Fig. 7.3.

TRACKS comprises three types of mission.

<u>Mission 1:</u> Lagrange Experiment (city plume, see Fig. 7.5 and Fig. 7.6)

Mission 1 considered the city plume of the Mannheim/Ludwigshafen area and its transport southerly through the Rhine valley. The measurements were performed in Lagrangian approach by using the Zeppelin NT, which ideally moved downwind inside one airmass. Therefore it is possible to study chemical reactions in dependence of the atmospheric preconditions, namely the available concentration of trace gases and the meteorological conditions.

Appropriate weather conditions with incoming flow from the northeast were required for this mission. With southwesterly winds a smaller-scale study was performed between Mannheim/Ludwigshafen and Darmstadt.

Mission 2: Vertical profiles of trace gases above areas with differing vegetation

The ground cover may influence the atmospheric conditions in the micro- and mesoscale significantly. This is also valid for the distribution of air pollutants. Therefore vertical profiles of different trace gases were measured and compared above different ground vegetation at specific locations.

Mission 3: Convective transport of trace gases

Mission 3 investigates the effectiveness of vertical transport. In the case of strong upwinds, the trace gases even reach the stratosphere and effectuate an extended spacious transport.

The determination of mass balances of trace gases and humidity in Cumulonimbus clouds helps to understand the transport processes and to give new input to models (see

Fig. 2.3).

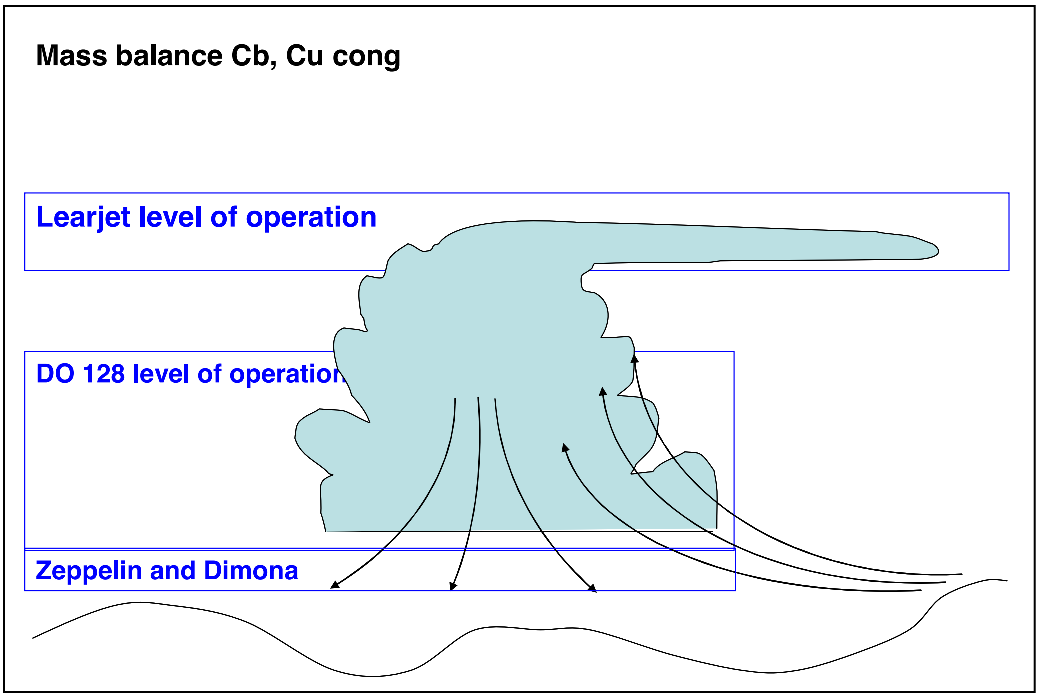


Fig. 2.3 Determination of the mass balance inside a convective system.

In order to realize the three missions of TRACKS, several measurement platforms were applied. Together with COPS or in addition to COPS, TRACKS used the following measurement platforms:

Ground--based platforms

The ground-based measurements were mainly be covered by COPS. In addition, TRACKS accessed existent instrument networks of LUBW, LUWG and the cities of Mannheim und Ludwigshafen. Mobile measurement vehicles of BASF and the above mentioned agencies completed the ground-based platforms.

Airborne platforms

Airborne measurements were performed by several aircraft which partly (BAE 146, Do 128, Dimona, UL Enduro) were also involved in certain COPS missions. Additionally, the Zeppelin NT was employed by Forschungszentrum Jülich (lead organization) and FZK in order to perform Lagrangian investigations. A Learjet operated under responsibility of the Max Planck Institute for Chemistry in Mainz contributed solely to TRACKS. An overview of all airborne platforms is given in Table 5.16.

Further information about TRACKS can be found in the TRACKS operation plan and by the link http://www.imk.uni-karlsruhe.de/417.php.

2.6 The future role of COPS research within international research programs

COPS is focusing on one of the most challenging but also on the most important topics in atmospheric sciences, QPF. Tools for advancing QPF shall be developed which can also be applied in other critical regions of the globe.

Within COPS, a large community has come together benefiting from previous collaboration and experience within field campaigns as well as QPF projects in atmospheric sciences. In this regard, COPS can be considered as a part of series of international QPF experiments, starting with MAP in 1999 in high mountains, continuing with IHOP_2002 in flat terrain but with large heterogeneities in dynamics and humidity, and CSIP in 2005 in marine environment.

Another way to illustrate the extensive collaboration and coordination within COPS is depicted in Fig. 2.4. As mentioned above, COPS is imbedded in the 3-phase, 6-year QPF program PQP of the DFG. COPS took place in the second phase, which permits funding of COPS-dedicated projects in the third phase of PQP. Except the WWRP RDP MEDEX, which field phase will be performed between 2008-2010, COPS is coordinated with the operation of the AMF, ETReC07, and the performance of the GOP. Strong modeling activities are ongoing within D-PHASE.

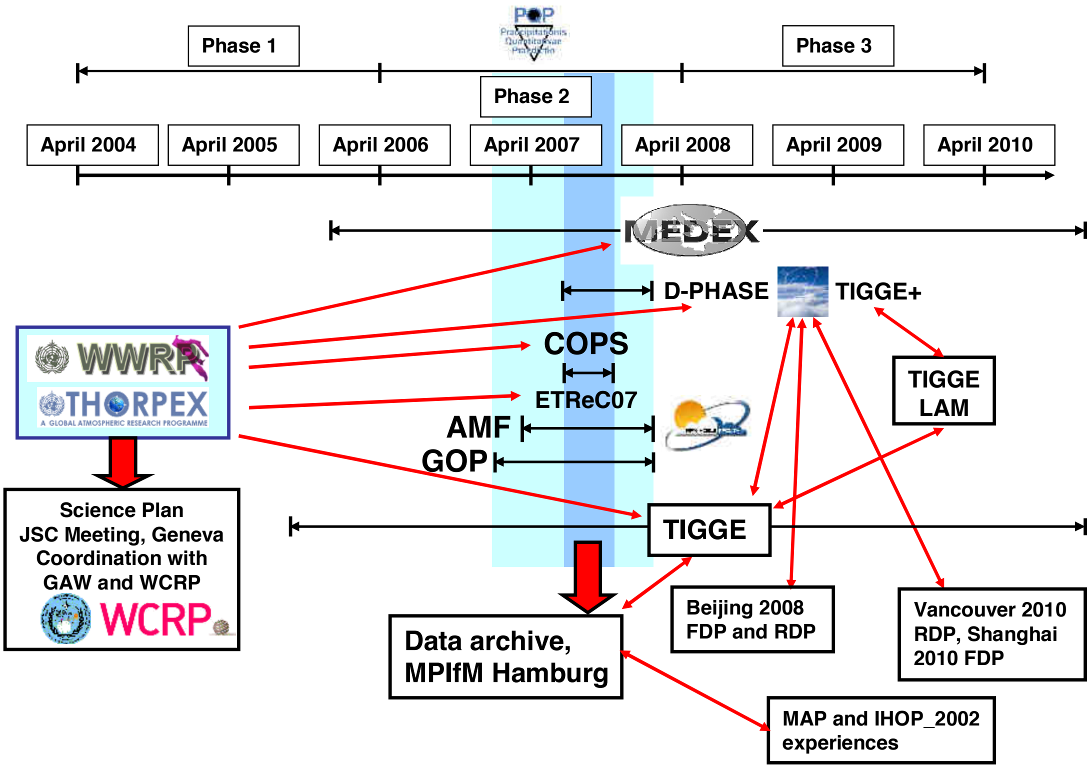


Fig. 2.4 *International collaboration within COPS during summer 2007.*

The COPS, GOP, and D-PHASE data will be archived at the WDCC of the group on Models & Data at the Max Planck Institute for Meteorology (MPI) in Hamburg, Germany (see http://cops.wdc-climate.de/). It is expected that the D-PHASE data set and experience will be very valuable for the TIGGE-LAM project of THORPEX. D-PHASE experience will also be very valuable for the preparation and performance of the upcoming FDPs and RDPs in Beiing 2008.

The scientific results will be evaluated within WWRP research programs and the German PQP program. It is envisioned that COPS research will continue for several years after the performance of the campaign. It shall contribute to the topics of the WWRP Strategic Plan 2008-2015, which is currently under development. Furthermore, improvement of model physics within COPS shall also contribute to climate research and research in atmospheric chemistry. This so-called “seamless approach to weather, climate, and atmospheric chemistry” is one of the most important overarching research activities of WMO within the next decade.

3 COPS Science Goals and Hypotheses

3.1 Scientific Organization of COPS

The scientific work of COPS is organized by the COPS International Science Steering Committee (ISSC) under the auspices of the WWRP. The members of the COPS ISSC are listed in Appendix II. Four Scientific Working Groups (WGs) have been founded according to process chain leading to the initiation and development of precipitation. The chairs and the members of these WGs have been endorsed by WWRP as well and are found in Appendix II as well. The scientific structure of COPS is depicted in Fig. 3.1.

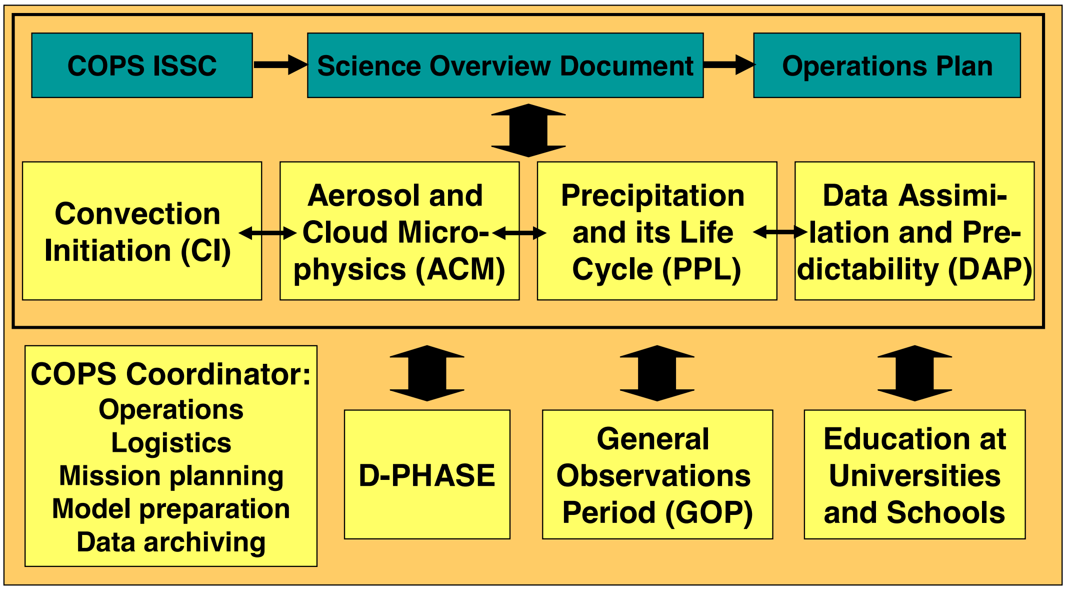


Fig. 3.1 Scientific structure, logistics, and coordination of COPS.

Responsible for the logistical preparation of COPS was Andreas Behrendt, the COPS Coordinator at the COPS Project Office at the University of Hohenheim. Fig. 3.1 shows that not only the coordination with other research programs but also the education of students at schools and universities was taken into account during the performance of COPS.

3.2 COPS Region and Overarching Science Goal

It is the overarching objective of COPS to identify the physical and chemical processes responsible for the deficiencies in QPF over low-mountain regions with the target to improve their model representation. The campaign will be performed from **June 1 to August 31, 2007** where significant thunderstorm activity can be expected in the COPS region (see SOD, chapter 4, and Fig. 3.2). Correspondingly, the overarching goal of COPS is to

Advance the quality of forecasts of orographically-induced convective precipitation by 4D observations and modeling of its life cycle.

The determination and use of the potentials of existing and new data sets and of better process descriptions are central issues to improve QPF in this context. In extensive discussions with the COPS ISSC and the PIs of the other PQP projects the following fundamental hypotheses have been developed:

- **Upper tropospheric features play a significant but not decisive role for convective-scale QPF in moderate orographic terrain.**
- **Accurate modeling of the orographic controls of convection is essential and only possible with advanced mesoscale models having a resolution of the order of a few kilometers.**
- **Location and timing of the initiation of convection depends critically on the structure of the humidity field in the planetary boundary layer.**
- **Continental and maritime aerosol type clouds develop differently over mountainous terrain leading to different intensities and distributions of precipitation.**
- **Novel instrumentation during COPS can be designed so that parameterizations of sub-grid scale processes in complex terrain can be improved.**
- **Real-time data assimilation of key prognostic variables such as water vapor and dynamics is routinely possible and leads to a significant better short-range QPF.**

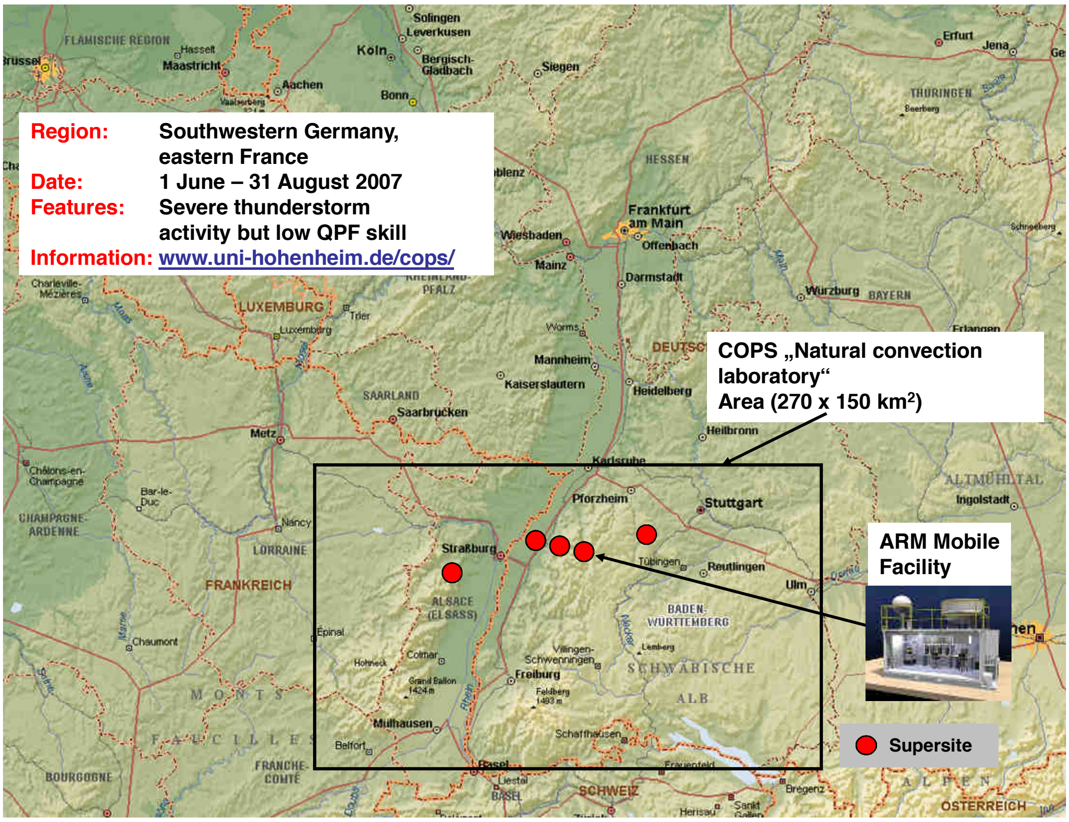


Fig. 3.2 The COPS domain in southwestern Germany/eastern France. Due to severe thunderstorm activity in summer it is called the COPS convection laboratory. The location of the AMF is also indicated.

This shall be achieved by combining:

1) A synergy of unique in-situ and remote sensing instruments,
2) Advanced high-resolution models optimized for operation in complex terrain,
3) Data assimilation and ensemble prediction systems.

This combination of tools required a sophisticated scientific preparation and a careful coordination between the efforts of the institutions involved.

3.3 Science Goals of COPS Working Groups

In the following, the key science questions of each Working Group (WG) of COPS are summarized. The scientific derivation and the importance of these questions have been pointed out in the Science Overview Document (SOD) (see chapter 6).

Answering these science questions will be performed in two steps. First of all, key instrumentation was identified, operation modes for each instrument were determined, and the data have to be carefully collected, specified, and archived. Secondly, data exploitation will be performed within international collaboration and the German QPF project PQP in its third phase (see Fig. 1.2).

3.3.1 WG Initiation of Convection (CI)

The **WG Convection Initiation (CI)** is focusing on high-resolution, 4D observations and modeling of convection in orographic terrain. Dynamical and thermodynamic theories shall be developed to understand the complex flow and the related moisture variability in order to understand the timing and location of the initiation of convection. For this purpose, a unique combination of instruments have been applied to study the pre-convective environment in 3D including the upper tropospheric forcing and secondary forcing due to orography.

The CI component of COPS is dedicated to answer the following questions (see also SOD, section 6.1):

- **What is most relevant for the heterogeneity of the boundary layer fields of key prognostic variables (differences in soil moisture, surface parameters, vegetation, orography, etc.)?**
- **How are small-scale inhomogeneities of atmospheric humidity, temperature, and wind in complex terrain related to CI?**
- **How is the diurnal cycle of CI related to processes at the surface and in the boundary layer and why is the diurnal cycle of convection not represented adequately in the models?**
- **To which extent do gravity waves and mountain waves initiate or inhibit convection?**
- **What is the relative importance of the large-scale flow versus local orographic and surface driven processes in determining the location, timing and intensity of convection in regions of moderate orography?**
- **Do aerosol particles influence CI?**

The latter question shall be answered in collaboration with WG ACM. Answering of these questions requires simultaneous measurements of surface properties including soil moisture and vegetation as well as the 4D structure of the diurnal cycle of the boundary layer, particularly in regions where CI is expected. Therefore, networks of surface stations, various ground-based remote sensing systems at the supersites, preferable with scanning capability, and radiosoundings were operated.

3.3.2 WG Aerosol and Cloud Microphysics (ACM)

The **WG Aerosol and Cloud Microphysics (ACM)** is exploring the relationship between aerosol properties and cloud microphysics in a low-mountain region. For instance, they will study whether sub-cloud aerosol variability affect convective precipitation. The relation between cloud turbulence and condensation, coalescence, aggregation and thus precipitation is also addressed. Furthermore, the correlation between measurable aerosol properties and ice formation will be determined.

Building on the 4D thermodynamic fields provided within the WG CI, the WG ACM aims at providing answers to the specific questions (see also SOD, section 6.2):

- **What is the role of aerosol particles in changing cloud microphysical properties and the initialization of convection?**
- **Does sub-cloud aerosol variability affect convective precipitation?**
- **Does cloud turbulence promote condensation, coalescence and aggregation and thus precipitation?**

Conditions with different aerosol characteristics are expected, which were observed within ACM before onset of convection. Once convection started, ground-based remote sensors analyze the evolution of clouds. With the COPS network of measuring stations the temporal and spatial development of clouds originated from a known aerosol environment can be followed. Moreover, with lidars and airborne measurements the aerosol conditions in the inflow region (cloud base) as well as in the environment influencing clouds by lateral entrainment are investigated. A further important contribution to COPS is provided by different types of radars yielding distributions of reflectivity, particle shapes, mean velocity, and in-cloud turbulence.

While being of extreme importance for mid-latitude precipitation processes, the issue of ice formation is at the same time one of the most difficult ones to address within COPS. Reasons for the formidable challenges connected with this issue comprise the complexity of potential processes, e.g., the rarity of suspected related aerosol components, and the lack of sensitive and specific measuring techniques. Therefore, the ice-related science questions covered by COPS are more exploratory in nature than other issues addressed by ACM:

- **Is there a correlation between measurable aerosol properties (e.g., depolarization) and ice formation?**
- **What statistical information about ice formation in COPS can we derive from present satellite sensors?**

To answer the science questions, the WG ACM operated instrumentation, which comprises ground-based aerosol measurements upwind of the potential initialization of convection; ground-based vertical profiling of aerosol characteristics and aerosol fluxes; aerosol, cloud, and precipitation microphysical properties through active and passive remote sensing; airborne mesoscale aerosol mapping, and airborne in-situ aerosol, cloud and precipitation microphysical and dynamical measurements.

3.3.3 WG Precipitation Processes and its Life Cycle (PPL)

The **WG Precipitation Processes and its Life Cycle (PPL)** is investigating the role of orography for the development and organization of convective cells. A critical point is also the distribution of the condensed water into the different hydrometeor categories (cloud water and ice, graupel, snow, rain water) where large differences between mesoscale models have been noted. To study the development of graupel, hail and the drop size distribution of precipitation, a combination of polarimetric radars, satellite observations, micro rain radars, and disdrometers are used as well as observations from supersites to study the onset of full precipitation from drizzle conditions.

Most observations of deep convection have been performed in relatively flat terrain before COPS. The question as to which degree orography can influence the evolution of convective cells shall therefore be investigated within COPS. It has been observed before COPS that orography can trigger the development of cells; however, it is unknown whether convection is suppressed in the subsiding flow in the lee of hills. It is assumed that the life cycle of single cells can be modulated by orography, but it is unclear whether orography like Vosges Mountains or Black Forest can have a significant influence on the formation and propagation of multi- or super-cells or even mesoscale convective organizations. How significant is this influence if the cells have already been formed before they interact with orography? Especially windward/lee effects so far are poorly represented in NWP systems (see SOD, section 1.3).

Another fairly open question is the role of embedded convection triggered by orography. Formerly stable stratified precipitating clouds may be destabilized by the forced uplift through mountains, which leads to stronger precipitation than expected from the stratiform precipitation.

The goal of the working group precipitation processes and life cycle is to investigate the following scientific questions (see also SOD, section 6.3):

- **What is the role of orography for the development of convective cell? To what extent does this affect organized convection?**
- **Does orography affect the hydrometeor distribution, development of graupel and hail, and the precipitation rain drop size distribution (RDSD)? Is this different for orographically induced and non-orographically affected convective precipitation?**
- **How does RDSD change during the cloud life cycle?**
- **What triggers the transfer of drizzle (virga) into full precipitation?**
- **What is the reason for the windward/lee problem and can it be solved by high-resolution mesoscale modeling without convection parameterization?**
- **The purpose of the measurements was also to confirm or falsify the following hypothesis:**

- **The life cycle of single cells is affected by orography but not the one of larger systems.**

The observational basis of PPL consists of ground-based instrumentation such as radars and disdrometers. The life cycle of precipitation can be studied by scanning weather radars. Operational radars provide volume measurements of reflectivity and Doppler velocity with a spatial resolution of about 1 km^3 and a temporal resolution of 5–15 minutes. The COPS region was covered by 8 operational Doppler radars (DWD: Neuheilenbach, Feldberg, Frankfurt, Türkheim; FZK: Karlsruhe; MeteoSwiss: Albis; MeteoFrance: Nancy, Montancy). This dense network provided a complete coverage of the COPS region with maximum ranges from the radars of about 100 km (see SOD, section 10).

Since the Doppler radar coverage is limited close to the surface in mountainous regions, additional mobile Doppler radars (DOWs from CSWR, Boulder, USA) were operated to get better multiple Doppler coverage close to "hot-spots" of convection or in the inflow region of the larger Black Forest valleys.

In order to retrieve microphysical parameters like hydrometeor type or the size distribution of raindrops, it was necessary to use polarimetric weather radars. Only the operational radar at Montancy was polarized by 2007 so that additional radars were necessary to cover the COPS region, especially the Rhine valley between the Vosges Mountains and the Black Forest. We operated the DLR C-band polarimetric Doppler radar (Poldirad) (see section 5.3.6) for this purpose.

To investigate the life cycle of precipitating clouds and their rain drop size distributions (RDSDs) relative to orography and the state on the lee side, a transect across the Black Forest with rain gauges, disdrometers, and vertical pointing Doppler radars (e.g., the micro rain radar, MRR) along a radial direction from a polarimetric radar was set up. This transect covered the lee side, and provided an optimum strategy for observing the modification of the RDSD by orographic effects. Since the retrieval of MRR drop size distributions assumes no vertical air velocity, it is necessary to develop procedures in synergy with other radar measurements to overcome this limitation and to be able to retrieve the RDSD even in the presence of orographic or convective induced vertical wind flow.

3.3.4 WG Data Assimilation and Predictability (DAP)

The **WG Data Assimilation and Predictability (DAP)** is studying the impact of current and new observations for improving QPF. Data assimilation is the key to separate errors due to initial fields and parameterization, as the model can be forced to reduce forecast uncertainties due to initial fields by means of assimilation of the whole COPS and GOP data set. Therefore, data assimilation is an essential tool for process studies. Furthermore, using a variety of mesoscale models in combination with ensemble forecasting, studies on the predictability of convective precipitation shall be performed.

The COPS/GOP data set provides a unique opportunity to evaluate and improve all aspects of Numerical Weather Prediction (NWP) systems. The overarching goal is to quantify and extend the limits of predictability of convection through high-resolution ensemble forecasting and advanced data assimilation. The key scientific questions of WG DAP are:

- **What are the relative roles of upper and mid-tropospheric forcing versus local orographic and surface flux influences on the predictability of convective precipitation in a region of moderate orography?**
- **What is the impact of the assimilation of high resolution remote sensing data on short-range forecasts of convective precipitation, and what data assimilation methods are best suited for this task?**
- **What is the impact of model errors on forecast accuracy, in comparison to error in initial fields, and can a synergetic use of observations lead to a characterization and reduction of model error?**

To achieve this, the following program was initiated:

(Preparation for COPS) High-resolution simulations and ensemble forecasts are being applied to typical weather event in the COPS region to identify an observing strategy that lead to maximum impact in numerical simulations.

(During COPS) As described below, preliminary studies using COPS data were carried out in near real time to provide feedback to the operations center.

(Phase 3 of SPP) Following the experimental period, there will be systematic analysis using a wide array of models, data assimilation systems, ensemble strategies and verification techniques, applied to selected case studies and longer measurement periods. International partners will be involved through the ETReC 2007 and D-PHASE projects.

During the COPS campaign itself, new real-time mesoscale model forecast products for use in the daily COPS briefings were provided. These included realtime assimilation of GPS signals for water vapour, and best-member selection of mesoscale ensemble forecasts.

3.3.5 General Observations Period (GOP)

The main goal of the General Observations Period (GOP) is to gather a comprehensive data set suitable for testing hypotheses and new modeling techniques developed within PQP. The GOP encompasses COPS both in time and space to provide information of all kinds of precipitation types and to relate the COPS results to a broader perspective (longer time series and larger spatial domain). The duration of one year will open up the possibility to statistically approach model problems and better pin down specific model weaknesses: Some problems e.g. initial and boundary conditions might cancel out when longer time series are considered. The GOP will therefore provide a basis for reaching the PQP goal: **Determination and use of the potentials of existing and new data as well as process descriptions to improve QPF.**

To achieve this goal the GOP will

- gather as many data about the atmospheric state as possible within an area covering Germany and it neighboring states. The Alpine states (e.g. Austria and Switzerland) are of special interest to include the complex orography and to connect with D-PHASE,
- optimize the exploitation of existing instrumentation by gathering routine measurements normally not available to the scientific community,
- focus on continuous/coordinated observations using existing instrumentations which are suitable for statistical evaluation,

- focus on measurements, which are available in near real-time to enable a timely use within the PQP,
- perform a rigorous quality control, cross-checking, and error estimation of the data,
- tailor the observations to model output (e.g., LM, D-PHASE forecasts),
- enable an easy access to data, quicklooks, and first order analysis to PQP.

3.3.6 Education

3.3.6.1 COPS Summer School

For university students wishing to participate in COPS, a summer school, the COPS Outdoor Institute of Meteorology took place from July 23th – August 3rd 2007. This event gave national and international well known scientists the opportunity to present lectures on their work in general and their activities during COPS in special to students ("COPS Outdoor Institute of Meteorology"). This summer school backs up the respective student activities with regard to the student measurement campaigns within COPS.

The schedule of the "COPS Outdoor Institute of Meteorology" is available at http://www.meteo.uni-bonn.de/projekte/SPPMeteo/spp1167.html. Nearly 30 PIs arranged specific lectures on (a) modern measurement techniques, (b) dynamics of convection, (c) data assimilation, (d) predictability and orography in mesoscale meteorology, (e) microphysics in models and observations to cover the scientific hypotheses of COPS and of PQP. More than 80 students from university institutes from Germany and nearby European countries participated in the summer school.

The students were an integral part of the COPS measurements activities either with individual measurement groups coordinated by the COPS soil moisture group or by visiting the Supersites, the Operation Center, and several measurement projects accompanied by detailed and thorough guidance and practical training or measurements.

For the lecturing scientists involved in the measuring process it was temporarily impossible to leave their measurement site. Thus, it was difficult to fit them into a fixed time schedule. Therefore, we divided the graduate learning program in two groups. One group covers a fixed time schedule, where scientists gave lectures at the residence of the students (YH Forbach-Herrenwies). The other group was provided with a rough schedule only. We decided in short-term who and where (e.g., at one of the Supersites) lectures were given, which mainly depends on the weather situation. Altogether, two or three lectures a day were typically given in the morning and late afternoon.

3.3.6.2 MiA activities in summer 2007

“Meteorology in Action” (MiA) is an accompanying educational program to the SPP 1167, in which educational participation of learners were organized and coordinated.

One educational principle of the MiA-Program is the hands-on character of learners’ actions. We know that the relevance of a topic is more obvious to learners when this topic is embedded in a holistic context where learners are motivated to work in a problem-oriented way. A positive and interesting learning environment gives orientation and freedom at the same time, in which experiences can be structured. This seems to be important for learners in order to develop scientific concepts. In this context, COPS was a great possibility to let children in grades 3 and 4 experience and participate in scientific work. That way Scientific Literacy will be promoted from an early age.

For that reason, so-called learning-stations for Elementary Science Education in the field of Atmospheric Science/Meteorology were didactically structured and prepared by members of the MiA-Program at the Hornisgrinde supersite. There was certain period during COPS when learning groups from interested schools in Baden-Württemberg could not only visit and watch the scientists work, but were also didactically accompanied by students in teacher-education to explore and experiment at their learning-stations.

The project regarding educational affairs established a transfer of knowledge and education to schools regarding the vocational training of participating teachers and of students in teacher education as well as the educational research on learners' perceptions and learning pathways.

4 Measurement Strategy

4.1 Validation Efforts

Thorough control of the data quality is the fundamental basis of the success of any measurement. This is especially true for large campaigns in atmospheric science where the latest generation of state-of-the-art instruments and novel measurement techniques are employed in the field. In addition to internal quality control and standard calibration, the measurement data of the same quantity must also be compared with each other in order to ensure a consistent data set. Consequently, part of the operation time of the instrumentation were allocated repeatedly during COPS for intercomparisons.

It is obvious that intercomparisons have to be as close in space and time as possible to minimize the effects of atmospheric variability. Thus stacked formation flights of the aircrafts carrying remote sensing instrumentation were performed. These intercomparison flights need not be at the cost of employing the same instruments for the other meteorological aims of the campaign, e.g., they could be made on the ways to and from the central region of interest. In addition to such stacked formation flights also frequent overpasses over the ground-based supersites were organized when the flight patterns are planned. Frequent overpasses are necessary to identify potential instrumental biases with good accuracy, as the data of the remote sensing instruments are averaged in space and time and different air masses are sampled during these airborne/ground-based intercomparisons.

4.2 Phases for observing the chain of key processes

4.2.1 Analysis of typical weather conditions for COPS mission design

The general climatology of weather processes in the COPS region leading to significant precipitation has been studied in the SOD (section 4.3). It was found that three large-scales conditions are typical:

1. Forced/frontal with embedded convection along a surface front in a region of large-scale lifting,

2. Forced/non-frontal with large-scale lifting, but no surface front, so convection breaking out over a wider area (this case will be analyzed below),

3. Air mass convection (non-forced/non-frontal).

The design of the field campaign was matched to these conditions.

It is reasonable to divide the observation of the life cycle of precipitation in four generic phases while considering the temporal/spatial scales of the relevant processes. Altogether, this leads to a priorization of suitable observing systems, suggestions of their operation, and reasonable designs of the observing networks.

4.2.2 Phase 1: Pre-convection, definition of target regions

Phase 1 is defined by the presence of a pre-convective situation. The analysis performed in the SOD (section 4.3) showed that the location of and timing of CI depends in this case on the position and structure of upper-tropospheric synoptic or mesoscale troughs. Therefore, within the ETReC07, targeting was performed for improving large-scale forecasts a few days ahead before CI is taking place. For this purpose, target regions were determined by ECMWF, UK Met Office, and Meteo France. Targeting can be performed by more extensive use of satellite and aircraft data in the critical region or by data thinning in the other regions. For this purpose, the DLR Falcon aircrafts were operated, as this platform carried a water vapor and wind lidar as well as dropsondes.

These measurements were performed in the context of the **COPS large-scale target region.** It extended up 1000 km upstream and up to 48 hours before the expected convective event. Upper tropospheric forcing is often associated with potential vorticity streamers or mesoscale troughs that can be seen as dry regions in Meteosat water vapor imagery. The intensity of the dynamically forced ascent, and thus the rate of destabilization for moist convection are determined by the strength of the potential vorticity gradient and its rate of movement, and can thus be inferred from the horizontal (geostrophic) wind field, with measurements of the humidity structure testing the link to the routinely available water vapor imagery. If the lifted air mass is potentially instable, convection can develop very rapidly over a wide area, several hundreds of kilometers in extent. The location and timing of individual convective features are strongly influenced by local orographic features and forcing by surface fluxes of heat and moisture.

The **COPS mesoscale target region** covered about 200 km x 300 km of the central observational region (see Fig. 3.2). Observations in this region were essential for better characterization of the inflow in the COPS region. Mesoscale target regions were detected either by calculating backward trajectories and analysis of mesoscale ensemble forecasts within D-PHASE. Furthermore, in this region middle to upper tropospheric instabilities were continuously observed. This could be performed with ground-based remote sensing systems, radiosoundings, as well as aircraft and satellite observations. Aircraft flight patterns were designed accordingly.

For mesoscale targeting, operational large-scale networks using GPS and radar as well as additional ground-based observation systems in the critical regions were operated. During Phase 1, measurement of key variables such as dynamics, humidity, and temperature in the pre-convective environment were essential.

Observations on this scale are also important for the other critical weather conditions such as embedded convection within convergence lines and frontal zones. Prior to the passage of a trough, direct thermal circulation systems develop, sharpening convergence lines and frontal zones. Enhanced instability gives reason for the formation of embedded convection, forming thunderstorms and squall lines with increased risk of severe weather.

It is clear that in the meantime boundary layer processes and aerosol microphysical properties had to be characterized in great detail in 4D in the COPS domain. Therefore, **COPS small-scale target regions** of 20 km x 20 km had been defined. In these regions, differential heating of the Earth's surface and in moisture uptake by the lowest layers is taking place modified by orographic effects in the low mountain region. Therefore, characterization of land surface inhomogeneities with flux and soil moisture networks is critical. The WGs CI and ACM worked closely together, as their measurements of aerosol properties and the thermodynamic environment had to be performed simultaneously in 4D at the locations where CI was expected. Therefore, lidars and radars provided the backbone for these kinds of observations, as only these systems are able to perform rapid scans and range-resolved measurements with high resolution and accuracy.

Consequently, it was reasonable to combine different kinds of remote sensing systems in so-called **Supersites** in order to take advantages of sensor synergy (see SOD, section 7.4).

4.2.3 Phase 2: Convection Initiation

During **Phase 2**, CI and cloud formation is expected within a few hours. Development of convection may take place in flat terrain and over low mountain ranges. Secondary circulation systems developing during daytime in the larger valley systems are responsible for triggering of convection and subsequent precipitation. For instance, convergence of air masses takes place due to small-scale circulations around and in the valleys of the Black Forest. It is obvious that the pre-convective thermodynamic environment has to be observed close to ridges. Furthermore, it is important to study the dynamics around and in the valleys.

Consequently, during Phase 2, the measurements concentrated on the **COPS small-scale target regions.** The operation modes of scanning lidar systems and radiometers were adapted for 4D observations of atmospheric key variables and aerosols in the expected region of convection. Scanning microwave radar measurements were added for extending the range of 4D observations into clouds and for investigation aerosol-cloud interaction. WG PPL got ready for the observation of precipitation.

Simultaneously, targeting on the **mesoscale target region** was continued in order to characterize the advection of air masses in the COPS domain as best as possible.

4.2.4 Phase 3: Development of Convection and Onset of Precipitation

During **Phase 3**, CI is continuing and precipitation is forming. Now, the COPS measurements were extended by cloud and precipitation measurements focusing of the **small-scale target region.** Suitable remote sensing systems had to be well coordinated to capture the event as accurate as possible. The thermodynamic environment of clouds, aerosol distributions, as well as cloud and precipitation microphysical properties were measured simultaneously in 4D. Consequently, a strong cooperation between the WGs CI, ACM, and PPL as well as with the GOP PIs was very important.

As soon as the convective system left the coverage of the remote sensing systems at the supersites, observations were continued in the **mesoscale target regions**. Clear-air and cloud measurements were used to study the organization of convection, and precipitation radars were added. Tracking of the convective system was started with ground-based mobile instrumentation such as Doppler-on-Wheels (DOWs), aircrafts, radar systems with large range, as well as satellite observations.

4.2.5 Phase 4: Maintenance and Decay of Precipitating System

This phase is defined by the evolution of the convective system, which should also be observed as continuous and detailed as possible. In some cases, it was necessary to extend the measurements again to the **large-scale target region**.

The choice of operation modes of the synergy of ground-based and airborne systems was prepared by extensive analyses of model forecasts in the COPS Operations Center (see chapters 8 and 9). A very flexible ground-based and aircraft mission planning was essential. In some cases, convective systems with long lifetime evolved in direction of the eastern part of Germany and even in the Alpine region so that GOP and satellite data in the lee side of the COPS region became an important part of this tracking exercise.

4.2.6 Proposed coordination of sensors and of sensor synergy

Fig. 4.1 summarizes the finding of the previous sections. On the large-scale, targeting observations with aircrafts was collected in advance of the time when initiation of convection in the COPS domain will be expected. These measurements have been complemented with satellite observations, and operational ground-based networks.

In the COPS mesoscale domain and in its surrounding, a densification of existing networks was required complemented with intensified radiosoundings and a synergy of advanced remote sensing observations. The synergy of sensors was concentrated on Supersites so that 4D small-scale observations of the chain of processes could be observed taking advantage of the multiwavelength information content of each instrument.

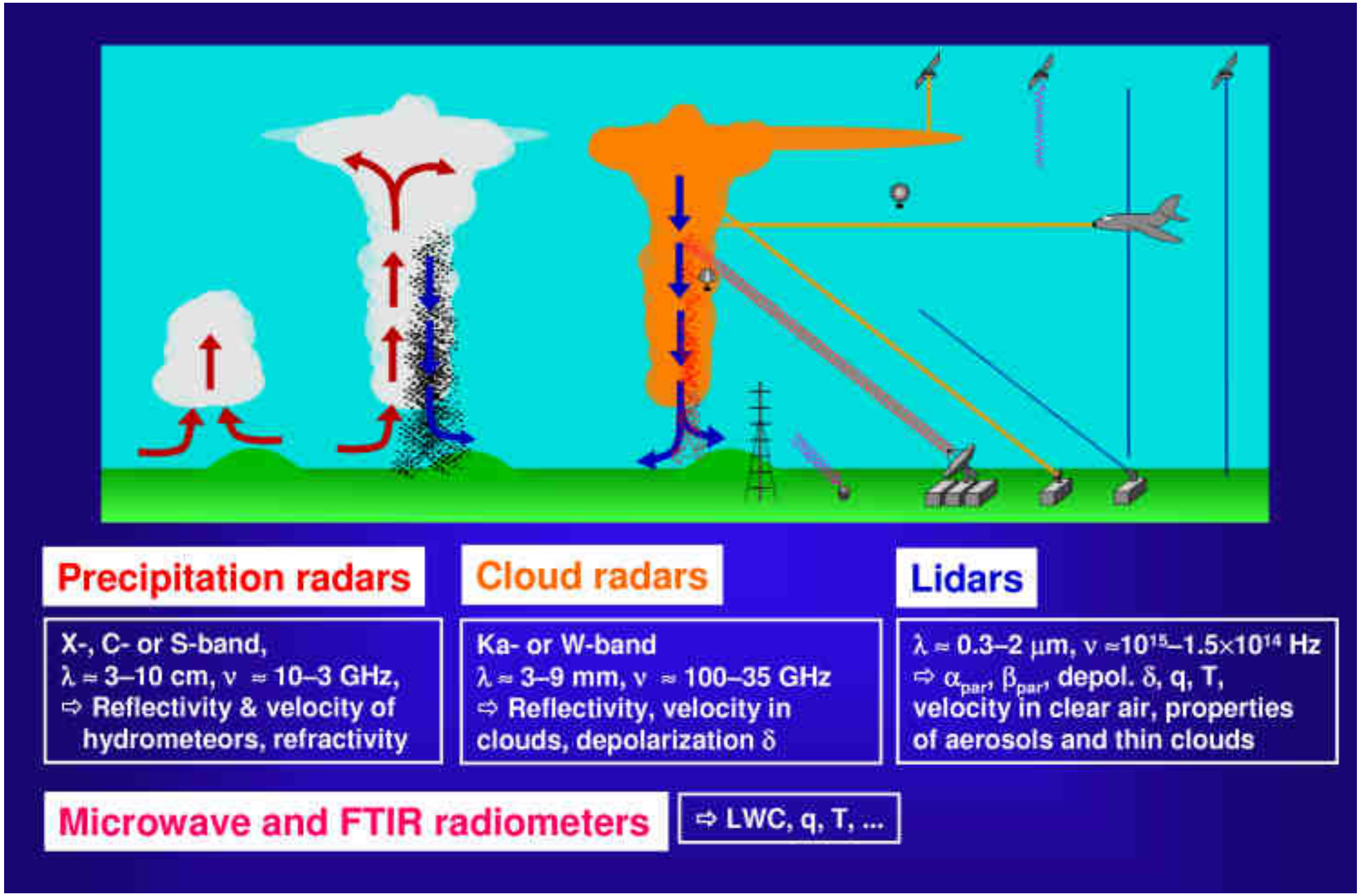


Fig. 4.1 *Sensor synergy for COPS for observing the life cycle of convective precipitation. A station with this equipment of sensors is called a Supersite and consists of a synergy of in-situ sensors as well as passive and active remote sensing systems such as radiometers, precipitation radars, cloud radars, and different types of lidars. Instrumentation was operated and coordinated on ground-based, airborne and space-borne platforms. This way, convective processes can be studied in high spatial and temporal resolution and in both clear air and within clouds. Detailed instrumentation and location of COPS Supersites is presented in Fig. 5.22 and Table 5.7.*

5 COPS Instrumentation

5.1 Overview

The operation of the COPS instrumentation is adapted to the key science questions by means of the strategy depicted in Fig. 5.1. An excellent overview about the participating institutions and instruments is provided by the COPS web site www.uni-hohenheim.de/cops and the COPS Operations Center web site www.cops2007.de under facility status.

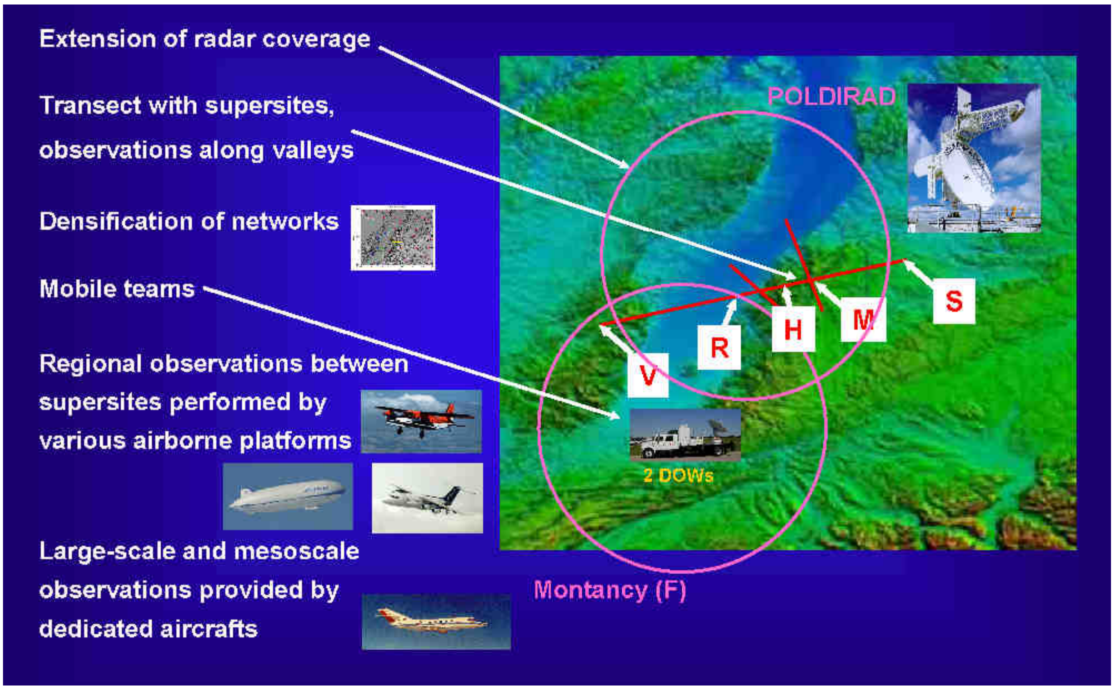


Fig. 5.1 COPS observing strategy.

During COPS, observations are available with such a high quality that key processes involved in the whole chain of events leading to precipitation can be studied. The existing radar network was extended by research radars such as the IMK C-band radar in Karlsruhe. Furthermore, the C-band Poldirad of DLR Oberpfaffenhofen was moved for the first time and located close to Strasbourg. Existing networks such as mesonets and Global Positioning System (GPS) were densified. Research networks were set up, e.g., measuring surface fluxes and energy balance in key regions. The mobile teams included teams launching drop up sondes at selected sites and two US Doppler-on-Wheels (DOWs).

A special component of COPS was the deployment of sensor synergy at Supersites in small-scale target regions. In order to observe convergence above the ridges and to study windward/lee effects, these are oriented along a transect through the COPS region. These Supersites are called Supersite V (Vosges low mountain region), R (Rhine valley), H (Hornisgrinde mountain site), M (Murg valley), and S (Dornstetten close to Stuttgart).

In order to link ground-based observations in small-scale target regions and to close gaps between these observations, various aircrafts were operated. For large-scale observations in target regions and for mapping the inflow and outflow of atmospheric variables around the COPS regions, two Falcon aircrafts were operated. Several aircraft were dedicated to boundary layer observations. The UK BAE146, the SAFIRE ATR 42, and the Partenavia were available for in-situ measurements of aerosol-cloud-precipitation microphysics (see also section 5.5)

We distinguish between four types of data:

Operational data: These data include ground-based stations, which already existed in and around the COPS domain, e.g., surface precipitation networks, as well as operational radar and satellite data. These data were collected within the GOP and D-PHASE. A challenge was the combination of data sets from different Meteorological Services in order to get European coverage with same data quality control.

Data provided by densification of networks and by research networks: If these instruments were operated during COPS only, the will be collected by COPS PIs, otherwise they will be handled by the GOP PIs. The corresponding instruments were running continuously during the GOP and/or COPS and do not required special notification prior or during COPS missions.

Special ground-based sensors: These sensors were operated in synergy at the Supersites or by the mobile teams. Their data were provided during COPS according to the respective mission plans. Also research radar data and the data of the mobile teams fall in this category.

Aircraft data: These data were collected within COPS missions. Aircraft operation required extensive planning and coordination efforts in collaboration with Air Traffic Control (ATC).

5.2 Timing

Time base: All instruments used UTC as time base. Clocks were synchronized using NTP with the server of the Physikalisch Technische Bundesanstalt (ptbtime1.ptb.de / 192.53.103.108), using radio controlled clocks or the GPS time signal. At the Hornisgrinde Supersite, a local NTP server was installed.

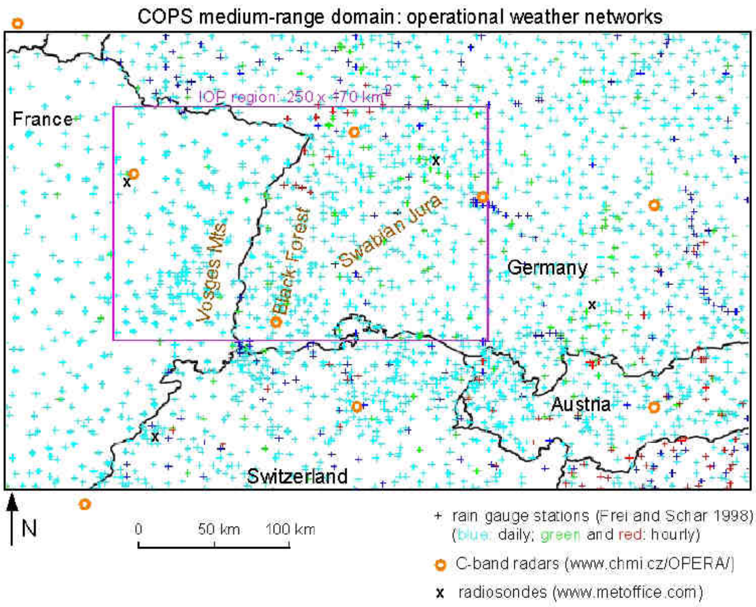
Time resolution: Data were stored with the highest reasonable time resolution. In case of averaging, parts of multiples of 15 minutes are preferred to synchronize with weather service and satellite products. Further details are specified in the Data Implementation Plan (DIP).

For precise timing, the difference between true UTC and GPS-time must be considered, which is currently 14 s ahead. At 12:00:00 h UTC most GPS systems (if no option UTC-correction activated) show 12:00:14 h. Consequently, for all data sets it will be specified whether GPS-time or true UTC is used. Difference like this cannot be neglected if precise synergetic scans between different instruments or eddy correlation measurements are performed.

5.3 Ground-based operational networks

Central Europe, which contains the COPS region, is characterized by several independent networks measuring meteorological data and in particular precipitation. The available different data sets and the density of stations are presented in Fig. 5.2 and Fig. 5.3. In the COPS domain (Fig. 5.3), networks of the German federal states Baden-Württemberg, Hessen, and Rheinland-Pfalz are measuring precipitation with a time resolution of up to 10 minutes.

The 50 SYNOP stations of the German Weather Service (DWD) provide hourly values of the standard SYNOP-dataset, while the 34 DWD-MIRIAM stations measure precipitation and other meteorological data automatically in 10-minute intervals. At the approx. 500 DWD-RR24 stations, precipitation measurements are available every 24 hours. Radiosoundings are made by DWD in Stuttgart on four times a day at 00, 06, 12, and 18 UTC. There are several aerological stations performing radiosonde launches around the COPS region at Munich, Payerne (Switzerland), Nancy (France) and others.



Network	Quantity	Frequency
DWD surface stations	50	hourly
DWD raingauges	34	10-min
European rainguages	700	daily
Radiosondes	5	6-hourly
Lightning detection network	Dense array	Continuous
C-Band radars	4	Continuous

Fig. 5.2 Operational weather networks in the COPS medium-range domain.

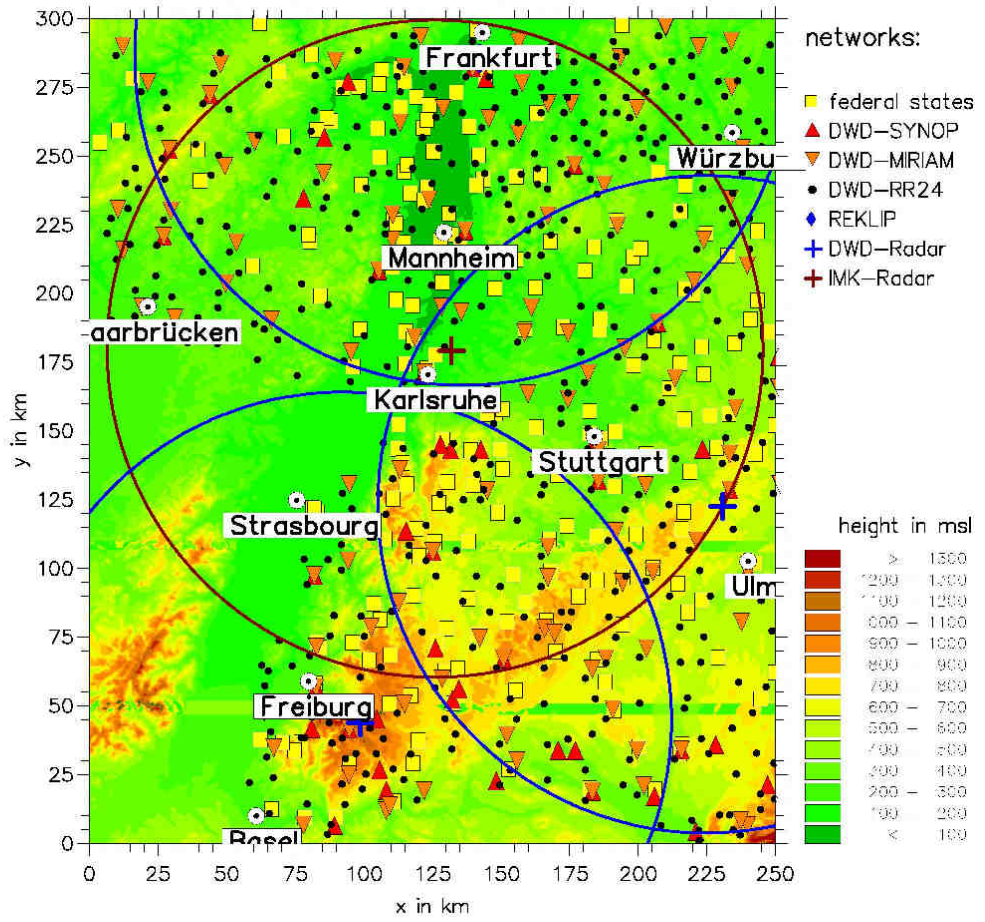


Fig. 5.3 *Networks for precipitation measurements operated by DWD and environmental protection agencies. The radius of view (120 km) of the IMK precipitation radar located at the Forschungszentrum Karlsruhe (red circle) and the radii of DWD radars at Frankfurt (north), Türkheim (east), and Feldberg (south) are also shown). The networks in the French part of the IOP region, operated by Meteo France and others will be included.*

In the COPS region, several radars are operated by DWD, FZ Karlsruhe, Meteo France and Meteo Swiss (see Fig. 5.4). The ranges of the radar systems are approx. 120 km. The three radars of the DWD-radar network located at Frankfurt, the summit of the Feldberg (1483 m) in the southern Black Forest and at Türkheim near Ulm (blue circles). Furthermore, the IMK research radar, which is located at the Forschungszentrum Karlsruhe approx. 12 km north of Karlsruhe (red circle), is operated routinely and its data are transferred in real time to the COPS Operations Center. All radars are C-band and Dopplerized. Of great importance are data from French radars to have a good representation of the upstream inflow. Two French radar systems are also overlapping with the COPS domain. These are located in Nancy and Montancy. Of particular interest is Montancy radar because it was by 2007.

The first dual-pol variables of the Montancy radar were collected at the end of April. The dual-pol variables look consistent but an intensive evaluation of their quality has still to be performed. COPS will be a unique opportunity for this effort. The radar is exactly of the same kind (and manufacturer : GEMATRONIK/SELEX) as the Trappes (Paris) radar, which was thoroughly assessed over several months. Its overall quality has been considered excellent. As Meteo France is aware of the value of the Montancy radar with respect of the COPS experiment, they made sure that the data (PPIs of Zh, Zdr, RhoHV, PHIDP and of course Doppler velocities) are archived for post analyses.

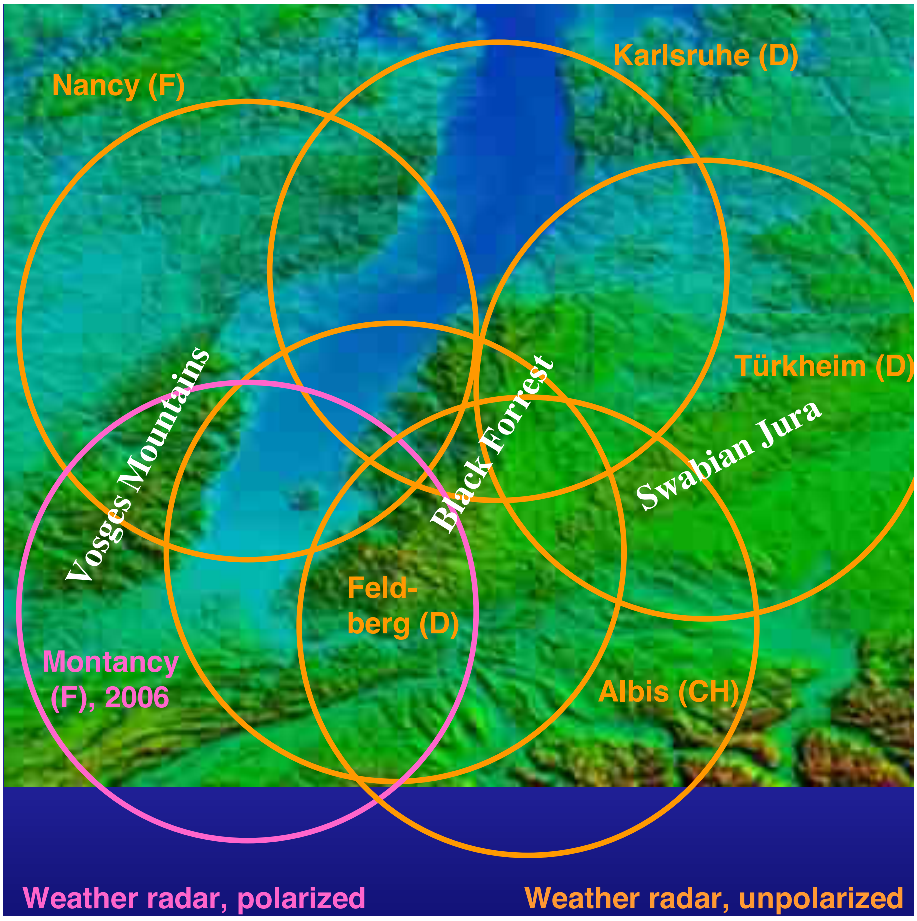


Fig. 5.4 *Network of operational weather radars covering the COPS region in 2007. Of these radars, only the Meteo France radar in Montancy will be polarized in 2007. It should be noted, however, that the coverage of the operational-radar network is affected close to the ground by orographic shielding.*

In addition, Fig. 5.5 presents an estimation of the overlap, which can be used for dual Doppler measurements. Shielding of the radar beams by orography leads to a considerable reduced coverage from to the surface up to a few kilometers above ground. The flow and dynamics of cells developing in larger valleys (Murg, near the city of Rastatt; Kinzig near the city of Lahr) can only be monitored if there are radars within the valleys. It was therefore highly beneficial to increase the areal coverage and to avoid shielding by orography by the installation of additional Doppler radars in the COPS region. Therefore, the US DOWs were operated in several key regions where low level convergence leading to CI was expected (see section 5.6.2).

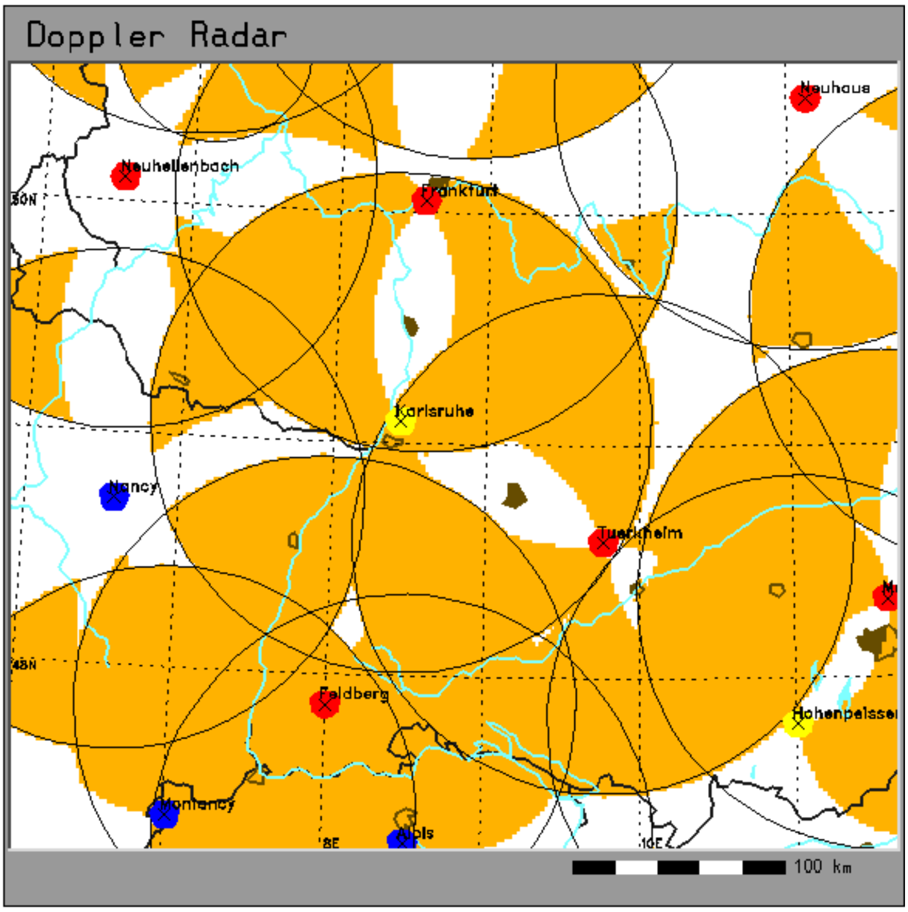


Fig. 5.5 *Operational C-band Doppler weather radars in the COPS region. Circles indicate the 125 km range. The radar at Montancy is polarized. The shaded areas indicate areas where dual-Doppler wind field retrieval are possible. Shielding by orography is not considered here, but reduces the area with of dual-Doppler coverage considerably at lower altitudes.*

Two operational lightning detection networks covering Central Europe are available. One system (BLIDS) is operated by Siemens AG and another system by the University of Munich together with Nowcast GmbH (LINET). Both systems provided data for the COPS region.

A key data set for COPS research is the Global Positioning System (GPS) network. Fig. 5.6 presents the standard distribution of stations operated by GeoforschungsZentrum (GFZ) Potsdam, Germany: Also slant path data were available in real-time during COPS so that these could be used for real-time data assimilation.

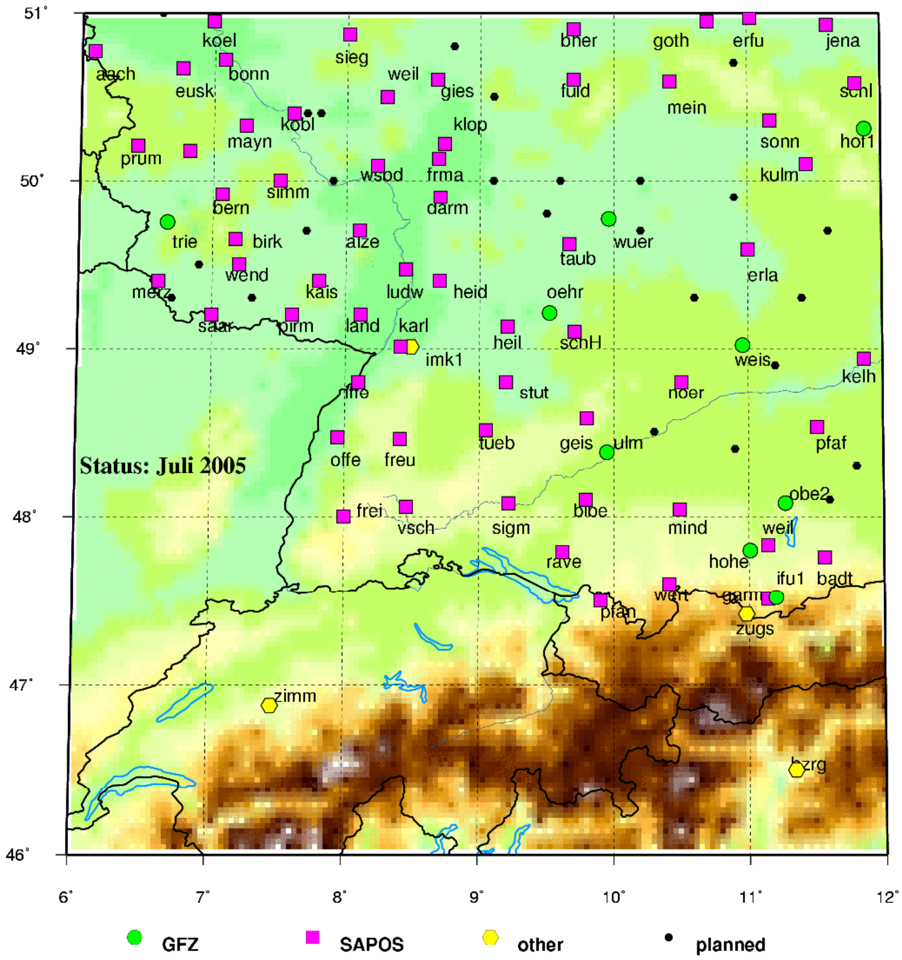


Fig. 5.6 *Location of standard GPS observations within the COPS area and its surroundings. Five additional stations were installed as part of the GOP in the COPS region.*

5.4 Ground-based research networks

During COPS, extensive activities have been performed for densification of existing networks and for the set up of special research networks. These included the following networks:

- Soil moisture
- Mesonet
- Densification of rain gauges
- Energy balance and turbulence
- Densification of GPS stations
- Sodars
- Radiosoundings
- Lightning

Data storage is coordinated using time stamps in UTC, synchronized by radio clock. The start / end time stamp have been defined by the COPS network community. The data will be submitted and stored with the highest available resolution (device-depending) on the COPS data archive.

5.4.1 Soil moisture network

5.4.1.1 PI and contact information:

The responsible PI for the soil moisture network is Christian Hauck of Karlsruhe Research Center (FZK), Karlsruhe, Germany. Phone: +49 (0) 7247 824225. Email: Christian.Hauck@imk.fzk.de. Further contributions are provided by French scientists.

5.4.1.2 Set up and distribution:

This network has the following features:

Measurements at all Supersites were performed.

Soil moisture measurements were generally performed at 5cm, 20cm, (50cm if resources) depth.

A Supersite S, soil moisture measurements were performed at 10 cm, 20cm, 30cm, and 50cm depth.

Soil temperature measurement were performed at 5cm, (10cm if resources), 20cm, (50cm if resources) depth

Heat flux plate was added at 10cm depth. A software to calculate ground heat flux is available from University of Bayreuth (UBT).

Regular gravimetric measurements were provided (if possible weekly).

One time determination of organic content was added.

There will be not additional data files for soil moisture data rather they will be included to our station data, e.g., energy balance data. It will be mentioned in Meta-data where soil data are found.

The majority of the network was installed with FDR-probes of the type SISOMOP (Simplified Soil Moisture Probes), which were newly developed within the Soil Moisture Group, University of Karlsruhe. Additional soil moisture stations were provided by

University of Bayreuth: 4 stations in Kinzig valley (TDR probes, IMKO)

University of Freiburg: 2 stations (Hartheim/Tuttlingen: TDR CS615 Campbell)

Meteo France: Supersite V (Thetaprobe ML2X, Delta T)

University of Bonn: Supersite S (Easy AG)

Fig. 5.7 and

Table 5.1 present the distribution and location of the soil moisture sensors.

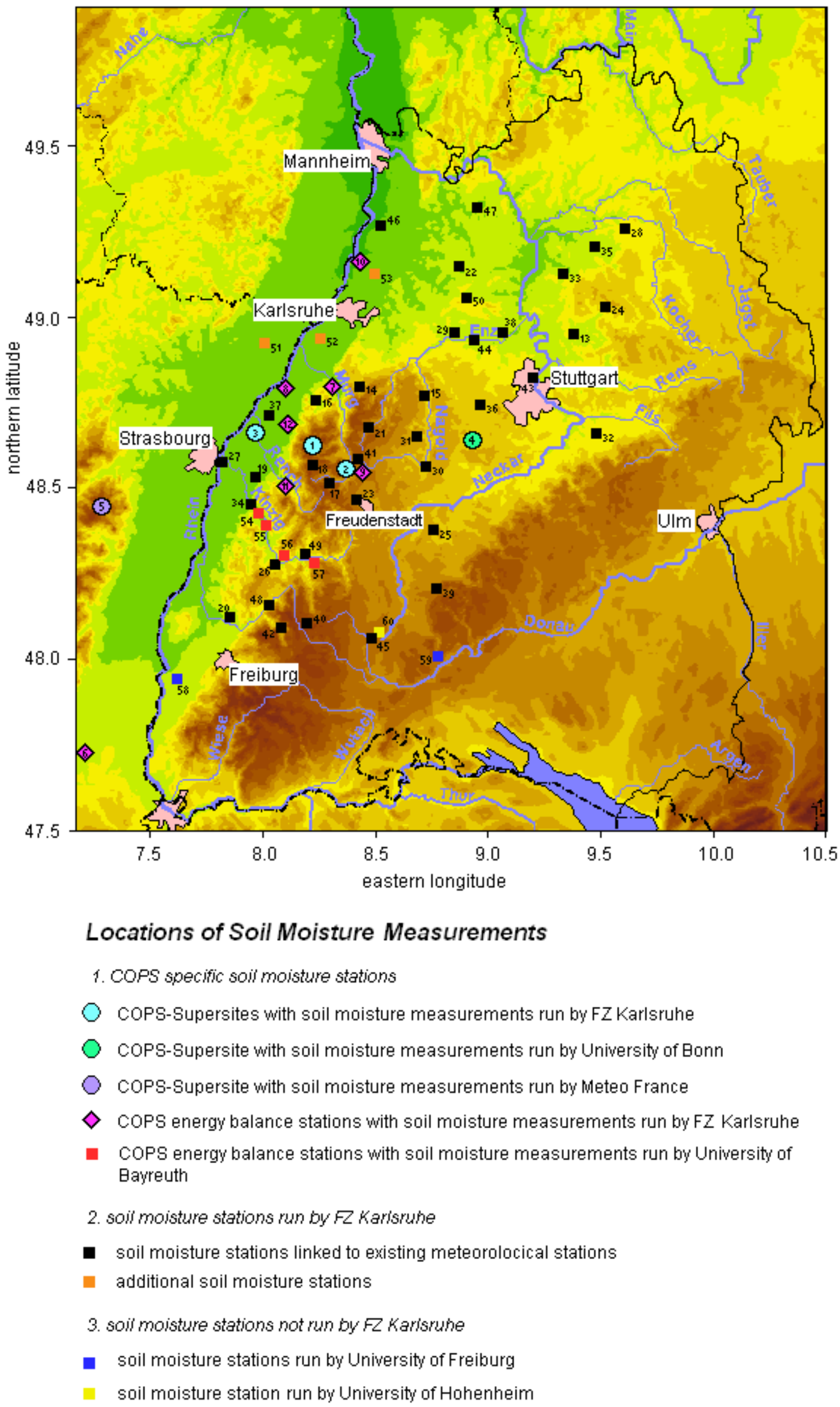


Fig. 5.7 Distribution of soil moisture sensors.

Table 5.1 Distribution of soil moisture network

sequential number	location	Coordinates [°] eastern longitude	northern latitude	altitute [m]	probe type	responsible
1	Supersite H - Hornisgrinde	8,20	48,60	1177	SISOMOP	N. Kalthoff, FZ Karlsruhe
2	Supersite M - AMF-site, Heselbach/ Murg Valley	8,41	48,55	ca. 500	SISOMOP	C. Hauck, FZ Karlsruhe
3	Supersite R - Achern/ Rhine Valley	8,07	48,64	ca. 140	SISOMOP	C. Hauck, FZ Karlsruhe
4	Superstite S - Airport Deckenpfronn	8,81	48,64	575	Easy AG	University of Bonn
5	Supersite V - Vosges Mountain	7,55	48,44	154	Thetaprobe ML2x	G. Pigeon, Meteo France
6	Burnhaupt le Bas - Alsace	7,15	47,71	300	SISOMOP	N. Kalthoff, FZ Karlsruhe
7	Gaggenau Bad Rotenfels - Murg Valley	8,29	48,82	127	SISOMOP	N. Kalthoff, FZ Karlsruhe
8	Hügelsheim - Baden Airpark	8,07	48,77	120	SISOMOP	N. Kalthoff, FZ Karlsruhe
9	Igelsberg - waste deposit	8,43	48,52	771	SISOMOP	N. Kalthoff, FZ Karlsruhe
10	Linkenheim - Rhine Valley	8,39	49,13	98	SISOMOP	N. Kalthoff, FZ Karlsruhe
11	Oberkirch - Rench Valley	8,09	48,51	215	SISOMOP	N. Kalthoff, FZ Karlsruhe
12	Sasbach	8,09	48,65	155	SISOMOP	N. Kalthoff, FZ Karlsruhe
13	Backnang	9,40	48,93	233	SISOMOP	C. Hauck, FZ Karlsruhe
14	Bad Herrenalb	8,44	48,80	351	SISOMOP	C. Hauck, FZ Karlsruhe
15	Bad Liebenzell	8,72	48,77	352	SISOMOP	C. Hauck, FZ Karlsruhe
16	Baden-Baden Geroldsau	8,25	48,73	240	SISOMOP	C. Hauck, FZ Karlsruhe
17	Baiersbronn-Mitteltal	8,32	48,51	596	SISOMOP	C. Hauck, FZ Karlsruhe
18	Baiersbronn-Ruhestein	8,22	48,56	916	SISOMOP	C. Hauck, FZ Karlsruhe
19	Durbach-Ebersweier	8,00	48,50	196	SISOMOP	C. Hauck, FZ Karlsruhe
20	Emmendingen-Mundingen	7,84	48,14	201	SISOMOP	C. Hauck, FZ Karlsruhe
21	Enzklösterle	8,47	48,67	600	SISOMOP	C. Hauck, FZ Karlsruhe
22	Eppingen-Elsenz	8,85	49,17	220	SISOMOP	C. Hauck, FZ Karlsruhe
23	Freudenstadt	8,41	48,45	797	SISOMOP	C. Hauck, FZ Karlsruhe
24	Großerlach-Mannenweiler	9,60	49,02	523	SISOMOP	C. Hauck, FZ Karlsruhe
25	Haigerloch-Weildorf	8,77	48,37	524	SISOMOP	C. Hauck, FZ Karlsruhe
26	Haslach im Kinzigtal	8,09	48,28	220	SISOMOP	C. Hauck, FZ Karlsruhe
27	Kehl Hafen	7,82	48,57	137	SISOMOP	C. Hauck, FZ Karlsruhe
28	Kupferzell-Rechbach	9,67	49,24	354	SISOMOP	C. Hauck, FZ Karlsruhe
29	Mühlacker	8,87	48,97	244	SISOMOP	C. Hauck, FZ Karlsruhe
30	Nagold	8,72	48,62	380	SISOMOP	C. Hauck, FZ Karlsruhe
31	Neubulach-Oberhaugstett	8,68	48,65	570	SISOMOP	C. Hauck, FZ Karlsruhe
32	Notzingen	9,46	48,67	325	SISOMOP	C. Hauck, FZ Karlsruhe
33	Obersulm-Willsbach	9,35	49,13	230	SISOMOP	C. Hauck, FZ Karlsruhe
34	Ohlsbach	7,99	48,43	176	SISOMOP	C. Hauck, FZ Karlsruhe
35	Öhringen	9,52	49,21	276	SISOMOP	C. Hauck, FZ Karlsruhe
36	Renningen-Ihinger Hof	8,93	48,74	478	SISOMOP	C. Hauck, FZ Karlsruhe
37	Rheinau-Memprechtshofen	8,00	48,67	131	SISOMOP	C. Hauck, FZ Karlsruhe
38	Sachsenheim	9,07	48,96	250	SISOMOP	C. Hauck, FZ Karlsruhe
39	Schömberg-Stausee	8,76	48,12	650	SISOMOP	C. Hauck, FZ Karlsruhe
40	Schönwald	8,19	48,10	1031	SISOMOP	C. Hauck, FZ Karlsruhe
41	Seewald-Besenfeld	8,42	48,59	804	SISOMOP	C. Hauck, FZ Karlsruhe
42	Simonswald-Obersimonswald	8,09	48,08	419	SISOMOP	C. Hauck, FZ Karlsruhe
43	Stuttgart (Schnarrenberg)	9,20	48,83	311	SISOMOP	C. Hauck, FZ Karlsruhe
44	Vaihingen/Enz	8,95	48,92	200	SISOMOP	C. Hauck, FZ Karlsruhe
45	Villingen-Schwenningen	8,46	48,05	720	SISOMOP	C. Hauck, FZ Karlsruhe
46	Waghäusel-Kirrlach	8,54	49,25	105	SISOMOP	C. Hauck, FZ Karlsruhe
47	Waibstadt	8,90	49,30	178	SISOMOP	C. Hauck, FZ Karlsruhe
48	Winden	8,01	48,14	303	SISOMOP	C. Hauck, FZ Karlsruhe
49	Wolfach	8,24	48,30	291	SISOMOP	C. Hauck, FZ Karlsruhe
50	Zaberfeld-Emetsklinge	8,91	49,05	249	SISOMOP	C. Hauck, FZ Karlsruhe
51	Buhl	8,00	48,91	133	SISOMOP	C. Hauck, FZ Karlsruhe
52	Durmersheim	8,28	48,92	117	SISOMOP	C. Hauck, FZ Karlsruhe
53	Messwiese FZK	8,42	49,09	117	SISOMOP	C. Hauck, FZ Karlsruhe
54	Fußbach 1	8,02	48,37	178	TDR (IMKO)	T. Foken, Univ. of Bayreuth
55	Fußbach 2	8,02	48,37	180	TDR (IMKO)	T. Foken, Univ. of Bayreuth
56	Fischerbach	8,13	48,28	225	TDR (IMKO)	T. Foken, Univ. of Bayreuth
57	Hagenbuch	8,20	48,28	245	TDR (IMKO)	T. Foken, Univ. of Bayreuth
58	Hartheim	7,60	47,93	201	TDR CS615 Campbell	University of Freiburg
59	Tuttlingen	8,75	47,98	645	TDR CS615 Campbell	University of Freiburg
60	Schwenningen	8,55	48,67	706	TDR	J. Ingwersen, Univ. Hohenheim

Data availability:

The data will be converted to NetCDF. It is planned to make them available to the COPS-community two to three month after the campaign via the DA or at the end of 2007 at least.

5.4.2 Mesonet

5.4.2.1 PI and contact information:

PI of this activity is Manfred Dorninger of the University of Vienna:

Email: manfred.dorninger@univie.ac.at

Tel. (in the field): 0177 6500625

Tel. (office in Vienna): 0043-1-4277-53731

5.4.2.2 Set up and distribution:

During COPS, a huge network of weather stations was distributed. The site criteria were based on a compromise between coverage and density. Furthermore, it wasfocused on measurements along critical valley, which cause important slope flows for convection initiation, and measurements along west-east transects for studying the windward/lee effect.

The following network of surface weather stations (networks) were deployed during COPS:

- University of Vienna (U.VIENNA) mesonet.
- All energy balance stations were also measuring relevant variables of met. stations (section 5.4.4).
- GFZ operated at each GPS-site a met. station (Vaisala PTU 200: pressure, humidity and temperature, section 5.4.5).
- Most of the sodar stations were equipped with met. stations (section 5.4.6).
- University of Munich (UM) was installing further 6 AWS in the field.
- University of Leeds (UL) and the University of Innsbruck (UI) were installing a mesonet of about 20 stations in the Murg and the Enz valley as well as along transects in the region of Black Forest Supersites.
- Some lidars and radiometers were equipped with an AWS.
- The mobile teams (section 5.6.1) operated 4 mobile AWS in the northern Black Forest during the IOPs at the sites of the mobile radiosonde stations during 10 CEST to 22 CEST.
- Three met. stations were operated by the University of Hohenheim: Ihinger Hof, Hohenheim weather and climate station, and at the Hohenheim soil moisture measurement site in Schwenningen.

<u>University of Vienna mesonet:</u>

96 AWS (HOBO) were arranged in a raster scheme as depicted in Fig. 5-8. The spacing of the stations is approximately1 km. Further four sonic anemometers, together with a temperature sensor and a raingauge were deployed in the Teinach-Valley in addition to 4 AWS at the plateaus. Finally two high quality AWS (MAWS) were operated at the supersite S and at Lerchenberg and 10 high quality precipitation systems complemented the mesonet. The AWS were equipped with a wind speed and direction sensor at 3m height, temperature and humidity sensor at 2m and pressure sensor in the data logger box at 1.5m above ground (see Fig. 5-9). The rain gauge was installed on a wooden pole at 1m height in a distance of 2-3 meters. Measurement interval was one minute to cover the evolution of e.g. Bows of the AWS and two minutes for the rain gauges. The stations were time synchronized in UTC. The stations were visited regularly in a two to three week interval for data download and maintenance.

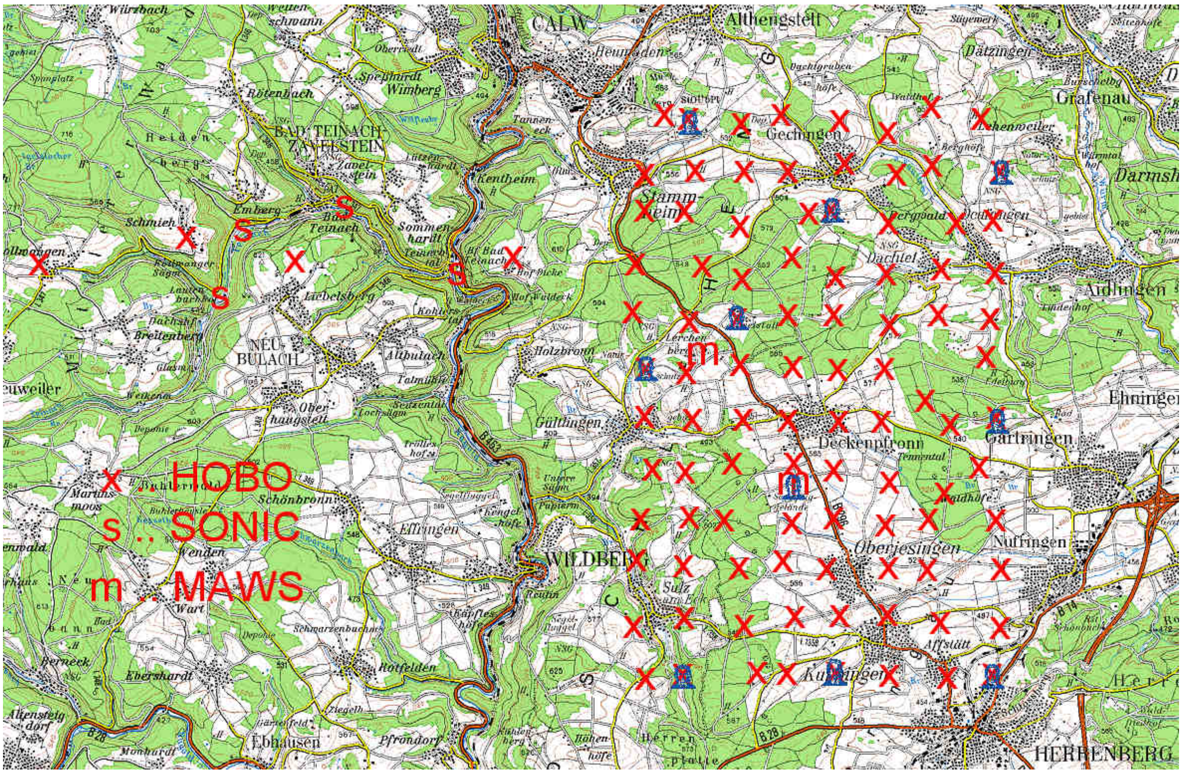


Fig. 5.8 Exact location of the mesonet stations. The symbol indicates the location of the high quality precipitation stations operated by University of Frankfurt..

Fig. 5.9 Example view of the used AWS and raingauge for the mesonet (Hobo type).

FZK, University of Munich, University of Leeds , and University of Innsbruck mesonet:

Fig. 5.10 presents the distribution of the mesonet of FZK, UM, UL, and UI. FZK and UM stations started operation at the beginning of June. The UK and UI stations went in operation at the end of June.

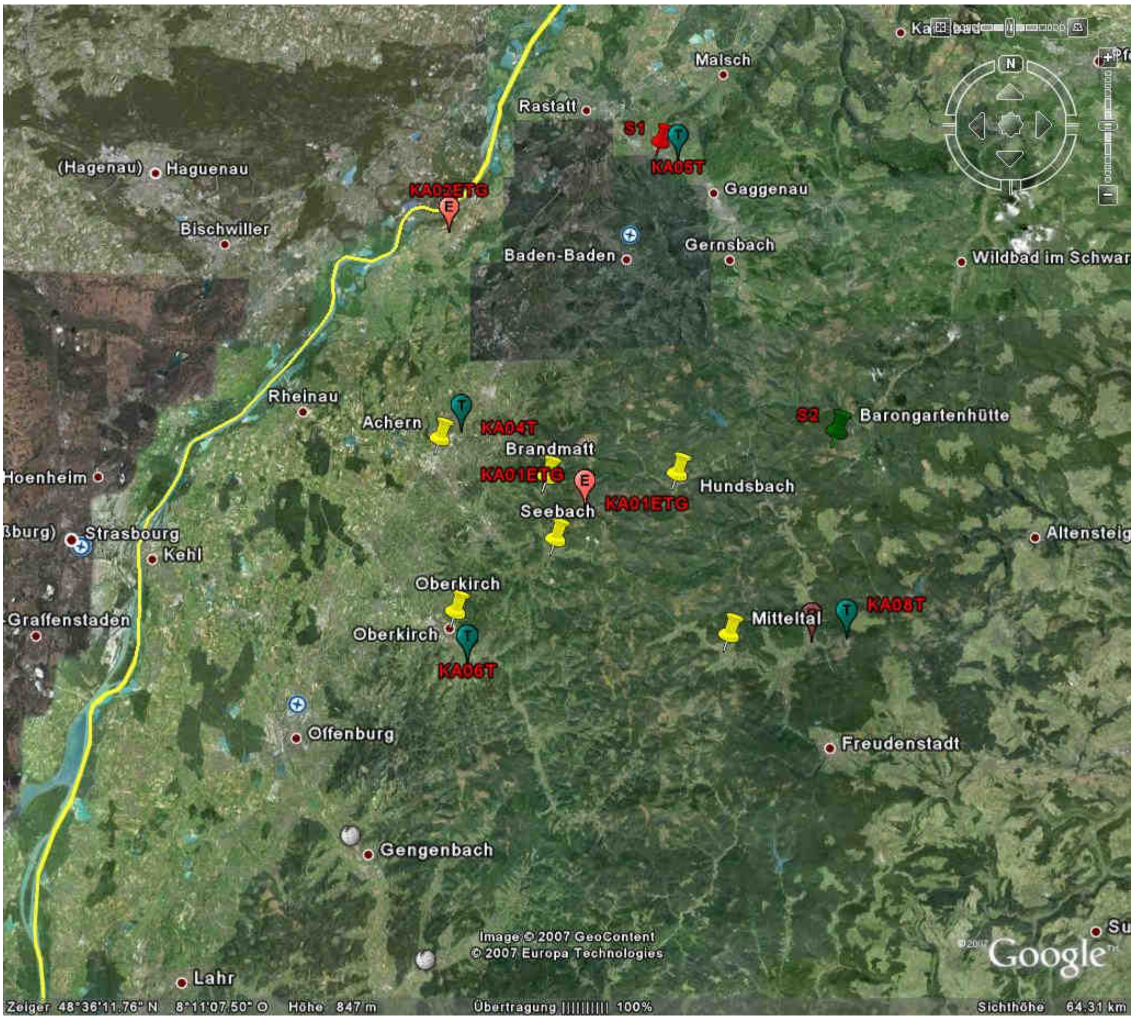


Fig. 5.10 Distribution of FZK and UM mesonet. The ackronyms are explained in the text. Yellow: UM mesonet, red: FZK mesonet, green

The location and the FZK and UK sites were as follows:

KA01ETG Hornisgrinde "E2": 48°36'14.03“ N, 8°12'4.56“ E, 1177 m asl

KA02ETG Baden-Airpark, Hügelsheim "E1": 48°46'40.51" N, 8° 4'25.20" E, 120 m asl

KA03ETG Flugplatz Linkenheim "E3" (not on the map): 49° 8'33.72" N, 8°23'54.77" E, 96 m asl

KA04T Sasbach "T1": 48°39’06“ N, 8° 5'19.49" E, 155 m asl

KA05T Klärwerk Gaggenau Bad-Rotenfels "T3, S3": 48°49'31.65" N, 8°17'27.21" E, 127 m asl

KA06T Oberkirch, Renchtal "T5, S4": 48°30'47.92" N, 8° 5'52.75" E, 215 m asl

KA07T Burnhaupt le Bas, Burgundische Pforte, Frankreich "R1, T2" (not on the map): 47°42'32.40“ N, 7° 9'16.20“ E, 300 m asl

KA08T Igelsberg Mülldeponie "T3, S1": 48°31'40.85" N, 8°25'50.35" E, 771 m asl

Munich AWS (in yellow):

Achern/Rheingraben: 48°38'15.44" N, 8° 3'53.66" N

Oberkirch/Renchtal: 48°32’02’’ N, 8°04’52’’ E

Brandmatt/Schwarzwaldwesthang: 48°36’43’’ N, 8° 09’41’’ E

Seebach/Achertal: 48°34'35.18" N, 8°10'14.08" E

Hundsbach/Schwarzwaldostseite: 48°36'55.56" N, 8°16'46.55" E

Mitteltal/Schwarzwaldostseite: 48°31’13’’ N, 8°19’23’’ E

There are additional stations from the Bayreuth group in the Kinzig valley (between Offenburg and Gengenbach)

Sodar and AWS: Barongartenhütte, Enztal (S2): 48°38'26.72" N, 8°25'25.06" E, 870 m asl

Sodar: Super Site R (Achern)

AWS: Super Site H (Hornisgrinde, KA01ETG)

5.4.2.3 Data availability:

The data will be converted to NetCDF and it is planned to make them available to the COPS-community two to three month after the campaign via the DA or at the end of 2007 at least.

5.4.3 Densification of precipitation network

5.4.3.1 PI and contact information:

The responsible PIs are Martin Hagen of DLR Oberpfaffenhofen and Gerhard Peters of Hamburg University.

5.4.3.2 Set up and distribution:

This work is performed in coordination with the GOP and the set up of other precipitation sensors such as C-band and micro rain radars. Additional surface precipitation measurement sensors will be provided by the University of Frankfurt. An updated figure of all additional stations will be included soon.

5.4.3.3 Data availability:

The data will be available at the end of March 2008 latest. The data format will be NetCDF.

5.4.4 Energy balance and turbulence stations

5.4.4.1 PIs and contact information:

This work is led by

Thomas Foken

University of Bayreuth (UBT)

Email: Thomas.foken@uni-bayreuth.de

Phone: +49 (0)921 552293 or +49 (0)179 2176391

and Norbert Kalthoff of FZK (norbert.kalthoff@imk.fzk.de,). Key information about the activities of this group is found at its web site www.bayceer.uni-bayreuth.de/COPS/.

5.4.4.2 Set up and distribution:

The energy balance stations were situated at places with a fetch of 100-200 m in the main wind direction. After the final installation a detailed analysis of internal boundary layers and footprints will be performed.

Fig. 5.11 shows the resulting distribution of energy balance and turbulence stations. A station indicated with E was measuring the complete energy balance at the surface. A T-station measures shear stress and sensible heat flux whereas a station indicated by a G measured soil heat flux. For instance, as a station with E and T determined G, too, its became the index ETG. Further details are found in the surface group experimental plan available from www.bayceer.uni-bayreuth.de/COPS/. Furthermore, small aperture scintillometers were deployed at BT01ETGS and UV01EG.

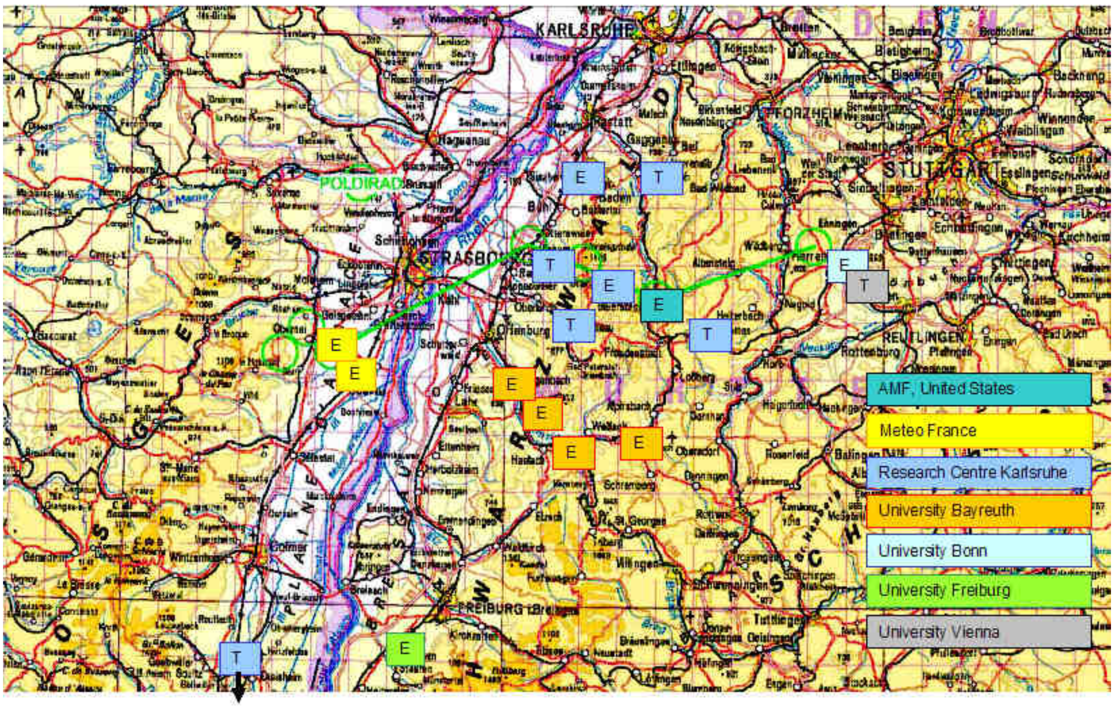


Fig. 5.11 Distribution of energy balance (E) and turbulence (T) stations.

Table 5.2 COPS Enbergy Balance network, E: energy balance, T: turbulence (momentum flux and sensible heat flux, G: Soil heat flux, S: Sodar; for details see http://www.bayceer.uni-bayreuth.de/COPS/

code	site	coordinates		height	manager
BN01ETG	Deckenpfronn (meadow) supersite S	48°38’ 22.18	08°49’11.79”	575m	University Bonn Dirk Schüttemeyer (schuettemeyer@googlemail.com)
BT01ETG S	Fußbach 1	48°22’ 08.45“	08°01’20.75“	178 m	Unive rsity Bayreuth Thomas Foken (thomas.foken@uni-bayreuth.de)
BT02T	Fußbach 2	48°22’ 01.37“	08°01’15.23“	180 m	
BT03ETG	Fischerbach	48°16’ 57.86“	08°07’55.87“	225 m	
BT04ETG	Hagenbuch	48°16’ 54.80“	08°12’14.99“	245 m	
FR01ETG	Hartheim (*Pinus sylvestris* L)	07.6°E	47.93°N	201 m	University Freiburg Jutta Holst (jutta.holst@meteo.uni-freiburg.de)
KA01ETG	Hornisgrinde (meadow)	08°12'4.56“	48°36'14.03“	1177 m	University and Research Centre Karlsruhe Norbert Kalthoff (norbert.kalthoff@imk.fzk.de)
KA02ETG	Baden Airpark	08°4'25.20"	48°46'40.51"	120 m	
KA03T	Sasbach (meadow) next to supersite R	08°05’21“	48°39’06“	155 m	
KA04T	Gaggenau	08°17'27.21"	48°49'31.65"	127 m	
KA05T	Oberkirch	08°5'52.75"	48°30'47.92"	215 m	
KA06T	Burnhaupt le Bas (meadow)	07°9'16.20“	47°42'32.40“	300 m	
KA07	Igelsberg	8°25'50.35"	48°31'40.85"	771 m	
MF01ETG S	Meistratzheim (meadow)	48.443°	7.545°		Meteo France Gregoire Pigeon (gregoire.pigeon@meteo.fr)
MF02ETG	Bishenberg (meadow)	48.483°	7.473°		
UV01EG	Deckenpfronn (meadow) supersite S	48°38’ 22.18	08°49’11.79”	575m	University Vienna Manfred Dorninger (manfred.dorninger@univie.ac.at)
US01ETG	Murg Valley meadow Supersite M	48.545°	8.405°	500 m	Los Alamos National Laboratory David R. Cook (drcook@anl.gov)

5.4.4.3 Data availability:

This group provided quick looks of fluxes during the experiment.

The retrieval software is called TK2 and will be checked by other participating groups (Freiburg / Vienna groups) in order to coordinate the input formats. The archived data will be based on planar fits for the whole period. The data format will be NetCDF format plus additional Metadata file. Details are coordinated between WDCC in Hamburg and Thomas Foken, which file conversion tool to use (Zurich / Wageningen).

5.4.5 Densification of GPS stations

5.4.5.1 PIs and contact information:

Resonsible for the set up and operation of the GPS networks in connection with COPS are Cédric Champollion of Service d'Aéronomie (IPSL, Paris, France, champoll@aero.jussieu.fr) and Galina Dick of GFZ (dick@gfz-potsdam.de)

5.4.5.2 Set up and distribution:

The GPS network has been set up first to obtain the regional distribution of water vapor for the entire COPS domain with a resolution of 50 km *50 km. Secondly, a densification of the Vosges, Rhine valley, and Black Forest has been performed to provide a quasi continuous observation of the water vapor around and between the supersites (see Fig. 5.12 and Table 5.4). Special attention has been given to have GPS stations both in the crests and in bottom valley of the Vosges and Black Forest Mountains. Pressure and temperature surface measurements will not be available at all GPS stations.

GFZ provided GPS raw measurements of the German real time network (SAPOS) of stations in the COPS region (7-9° longitude; 48-50° latitude) during June 1 – August 31, 2007 and IWV results for the entire network, operationally analyzed at GFZ. In addition 5 temporary GPS stations were installed (see Fig. 5.13 and Table 5.3). Key criteria for the selection of additional GPS receivers were: infrastructure to provide real time data, sensor synergy with the 4 German Supersites (GFZ0-3). The location of the station GFZ4 was selected in coordination with Prof. Foken (Uni Bayreuth) to guarantee real time data transfer. For all 5 additional stations GFZ also installed meteorological sensors to provide high precision (class A) pressure, temperature and humidity information.

5.4.5.3 Data availability:

GPS tomography will be applied to retrieve 3D water-vapor field with a horizontal resolution of 0.5°*0.5° for the entire COPS domain and 0.1*0.2 between the 4 supersites. The 3D water vapor products from the tomography will be available for the 3 months (June to August) with a temporal resolution of 15 or 30 minutes.

The Service d'Aéronomie (IPSL, Paris) will provide post-processed zenithal and slant delay for assimilation purposes as well as IWV and GPS tomography for convection cases studies and IASI satellites products validation. Post-processing has been chosen to provide quality controlled GPS products with high accuracy.

GFZ will process all GPS raw data available within COPS for generating a consistent set of IWV data in real time, if supplementary meteorological data are provided.

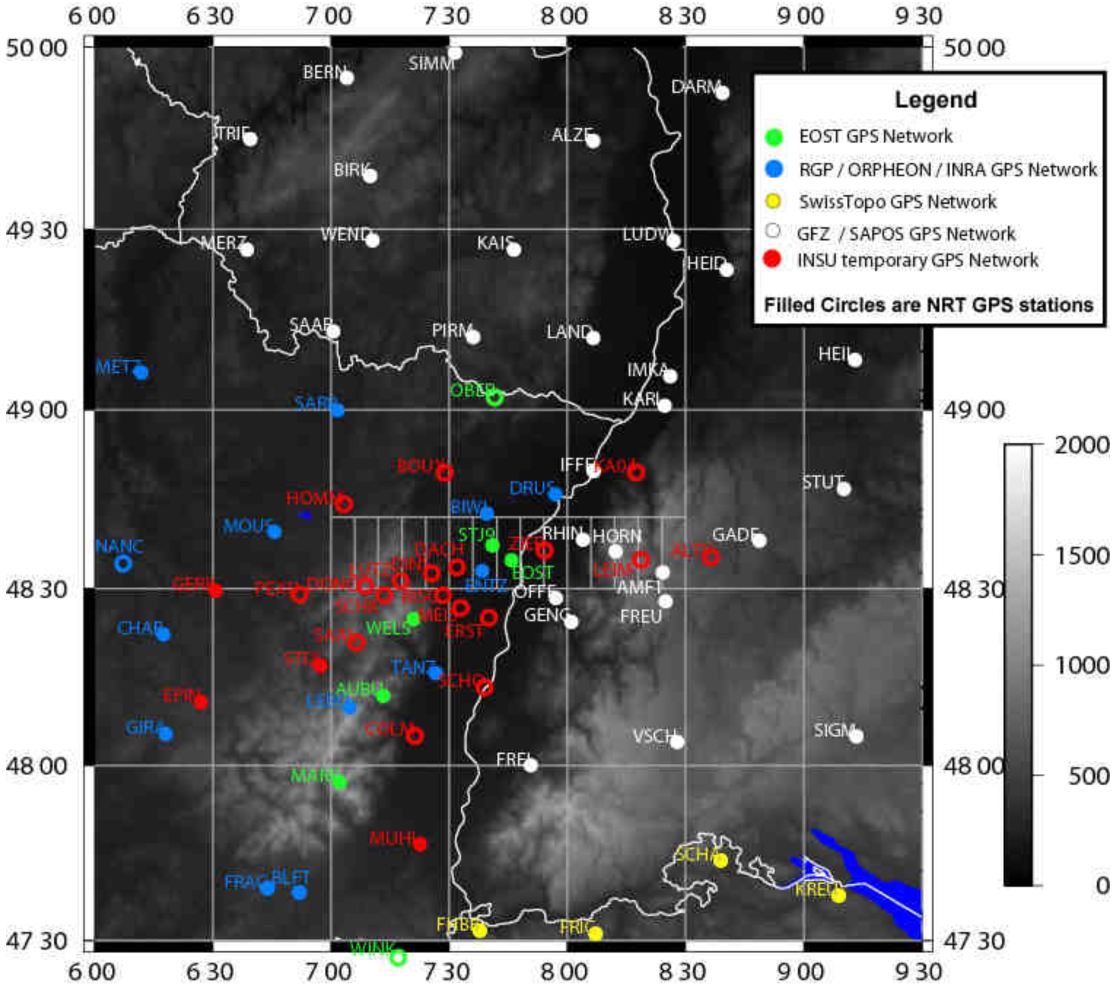


Fig. 5.12 Location of standard GPS observations within the COPS area and its surroundings by Network owner and Near real Time (NRT) capabilities (see legend). The grey color bars indicate the orography in meters. The grey grid (with the small subgrid along the supersites) will be the horizontal grid for the GPS tomography.

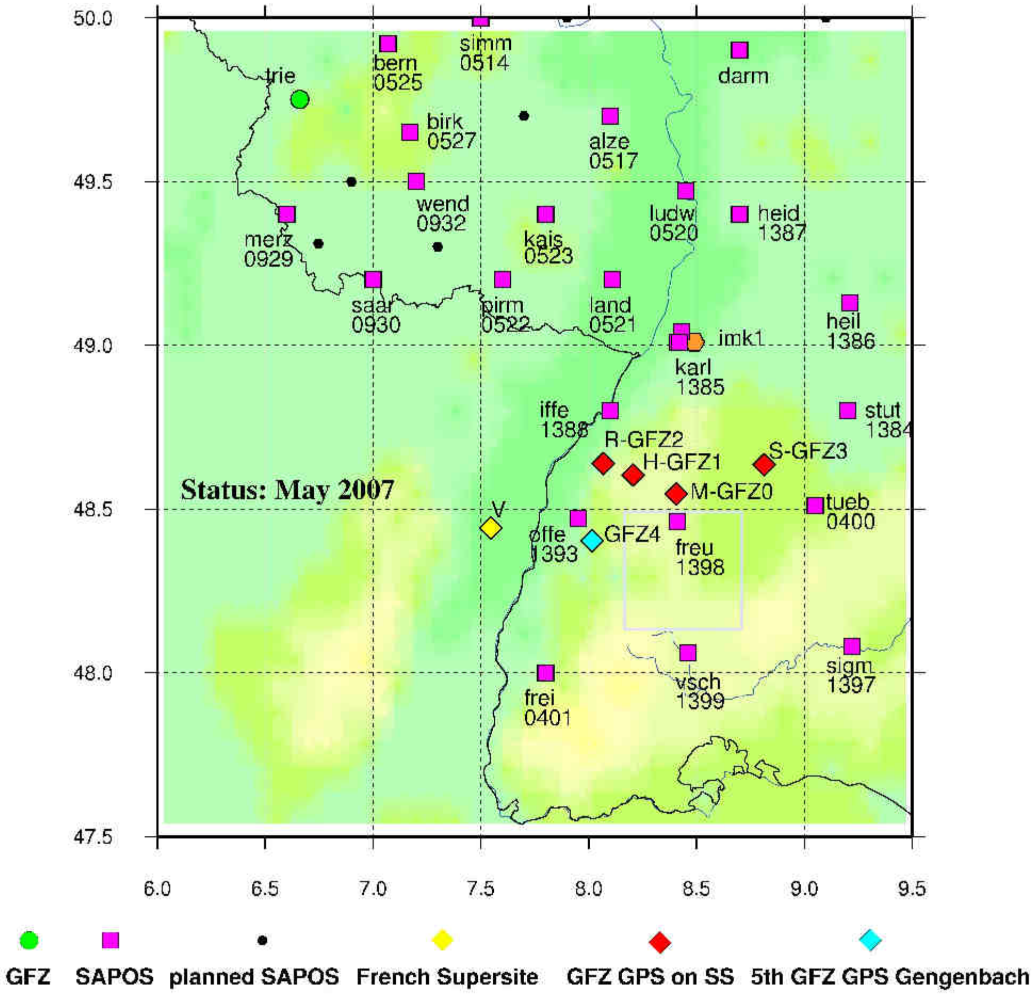


Fig. 5.13 Location of standard GPS observations within the COPS area and the additional stations provided by GFZ.

Table 5.3 Additional GPS stations for the COPS project, installed by GFZ.

Name	*Location*	*Installation status*
GFZ0	*Supersite M*	*20.03.2007*
GFZ1	*Supersite H*	*01.06.2007*
GFZ2	*Supersite R*	*01.06.2007*
GFZ3	*Supersite S*	*01.06.2007*
GFZ4	*Gengenbach*	*01.06.2007*

Fig. 5.14 Photograph of gfz0.

Fig. 5.15 Photograph of gfz1.

Fig. 5.16 Photograph of gfz2.


Fig. 5.17 Photograph of gfz3.


Fig. 5.18 Photograph of gfz4.

Table 5.4 List of GPS stations relevant for COPS.

#French stations INSU								
SAAL	48.3480831	7.10866	561.788	20.00	1013.00	0.2	11.0	A
HOMM	48.7373494	7.05509	270.873	20.00	1013.00	0.2	11.0	A
BOUX	48.8247706	7.48169	231.111	20.00	1013.00	0.2	11.0	A
SCHO	48.2220973	7.64870	168.721	20.00	1013.00	0.2	11.0	A
KA04	48.8253308	8.29091	135.620	20.00	1013.00	0.2	11.0	A
PEXO	48.4835386	6.86740	322.052	20.00	1013.00	0.2	11.0	A
SCHK	48.4816515	7.22456	381.491	20.00	1013.00	0.2	11.0	A
LUTZ	48.5214653	7.29330	279.134	20.00	1013.00	0.2	11.0	A
DINS	48.5424446	7.42689	195.180	20.00	1013.00	0.2	11.0	A
DONO	48.5073100	7.14551	728.200	20.00	1013.00	0.2	11.0	A
DACH	48.5603090	7.53257	163.954	20.00	1013.00	0.2	11.0	A
LEIM	48.5811419	8.31114	658.234	20.00	1013.00	0.2	11.0	A
ZIER	48.6076179	7.90369	135.074	20.00	1013.00	0.2	11.0	A
COLM	48.0838218	7.35449	190.631	20.00	1013.00	0.2	11.0	A
ERST	48.4177948	7.66760	151.421	20.00	1013.00	0.2	11.0	A
ALTE	48.5892991	8.60676	505.929	20.00	1013.00	0.2	11.0	A
#French supersites								
BISC	48.4818501	7.47405	258.225	20.00	1013.00	0.2	11.0	A
MEIS	48.4454579	7.54811	153.397	20.00	1013.00	0.2	11.0	A
#French NetRS NRT								
EPIN	48.1802604	6.44901	354.232	20.00	1013.00	0.2	11.0	A
GERB	48.4949820	6.51109	271.364	20.00	1013.00	0.2	11.0	A
MUHL	47.7759015	7.37655	232.399	20.00	1013.00	0.2	11.0	A
STDI	48.2820237	6.95450	352.704	20.00	1013.00	0.2	11.0	A
#German supersites								
RHIN	48.638	8.066	140.000	20.00	1013.00	0.2	11.0	A
HORN	48.604	8.204	1150.00	20.00	1013.00	0.2	11.0	A
AMF1	48.545	8.405	500.000	20.00	1013.00	0.2	11.0	A
GADE	48.635	8.813	600.000	20.00	1013.00	0.2	11.0	A
#Stations of Orpheon								
MOUS	48.66	6.76	262.000	20.00	1013.00	0.2	11.0	A
LEBO	48.1651882	7.07908	912.307	20.00	1013.00	0.2	11.0	A
BIWI	48.7102169	7.65888	176.238	20.00	1013.00	0.2	11.0	A
GIRA	48.09	6.30	858.000	20.00	1013.00	0.2	11.0	A
FRAC	47.65	6.73	536.000	20.00	1013.00	0.2	11.0	A
#Stations IPGS (Strasbourg)								

AUBU	48.1975002	7.22131	824.082	20.00	1013.00	0.2	11.0	A
STJ9	48.6215285	7.68373	159.804	20.00	1013.00	0.2	11.0	A
EOST	48.5799006	7.76351	139.714	20.00	1013.00	0.2	11.0	A
WINK	47.4834584	7.26460	540.300	20.00	1013.00	0.2	11.0	A
MARK	47.9536604	7.03797	1067.80	20.00	1013.00	0.2	11.0	A
OBER	49.0354196	7.69383	283.430	20.00	1013.00	0.2	11.0	A
WELS	48.4147781	7.34983	693.932	20.00	1013.00	0.2	11.0	A
#Stations TERIA								
BLFT	47.6382093	6.86495	372.338	20.00	1013.00	0.2	11.0	A
TANZ	48.2615933	7.44429	170.274	20.00	1013.00	0.2	11.0	A
SARR	48.9985	7.0275	250.000	20.00	1013.00	0.2	11.0	A
CHAR	48.3715	6.2907	320.000	20.00	1013.00	0.2	11.0	A
DRUS	48.7647	7.9494	170.000	20.00	1013.00	0.2	11.0	A
SMSP	49.1306572	4.54318	141.068	20.00	1013.00	0.2	11.0	A
#Stations AGNES (Swiss)								
FHBB	47.53	7.63	377.731	20.00	1013.00	0.2	11.0	A
FRIC	47.52	8.12	725.769	20.00	1013.00	0.2	11.0	A
SCHA	47.73	8.65	638.206	20.00	1013.00	0.2	11.0	A
KREU	47.63	9.15	529.981	20.00	1013.00	0.2	11.0	A
#stations IGN RGP								
ENTZ	48.5494	7.6399	204.289	20.00	1013.00	0.2	11.0	A
METZ	49.1036	6.1979	269.483	20.00	1013.00	0.2	11.0	A
BSCN	47.2449228	6.02190	246.591	20.00	1013.00	0.2	11.0	A
SMSP	49.1306572	4.54318	141.068	20.00	1013.00	0.2	11.0	A
#Station INRA								
NANC	48.57	6.12	280.000	20.00	1013.00	0.2	11.0	A
#GFZ and SAPOS German Stations								
GENG	48.4067022	8.01610	200.675	20.00	1013.00	0.2	11.0	A
DARM	49.8749751	8.6568401	223.929	20.00	1013.00	0.2	11.0	A
FREI	48.0010340	7.8454811	357.214	20.00	1013.00	0.2	11.0	A
KARL	49.0112454	8.4112592	182.894	20.00	1013.00	0.2	11.0	A
IMKA	49.0940583	8.4364217	183.045	20.00	1013.00	0.2	11.0	A
TRIE	49.7483090	6.6585869	328.808	20.00	1013.00	0.2	11.0	A
LAND	49.1998248	8.1094477	208.044	20.00	1013.00	0.2	11.0	A
LUDW	49.4687053	8.4506017	158.321	20.00	1013.00	0.2	11.0	A
ALZE	49.7432203	8.1091492	252.787	20.00	1013.00	0.2	11.0	A
SIMM	49.9844993	7.5249722	419.421	20.00	1013.00	0.2	11.0	A
KAIS	49.4441331	7.7740102	307.445	20.00	1013.00	0.2	11.0	A
PIRM	49.2021169	7.6024578	448.352	20.00	1013.00	0.2	11.0	A
BERN	49.9160795	7.0665335	184.303	20.00	1013.00	0.2	11.0	A

BIRK	49.6475197	7.1657797	441.615	20.00	1013.00	0.2	11.0	A
MERZ	49.4434399	6.6440116	244.232	20.00	1013.00	0.2	11.0	A
SAAR	49.2176947	7.0086338	284.283	20.00	1013.00	0.2	11.0	A
WEND	49.4700489	7.1757088	350.289	20.00	1013.00	0.2	11.0	A
VSCH	48.0669047	8.4647922	792.891	20.00	1013.00	0.2	11.0	A
SIGM	48.0835902	9.2239130	645.285	20.00	1013.00	0.2	11.0	A
FREU	48.4644829	8.4157865	784.419	20.00	1013.00	0.2	11.0	A
OFFE	48.4730491	7.9509944	233.490	20.00	1013.00	0.2	11.0	A
STUT	48.7794781	9.1709240	341.022	20.00	1013.00	0.2	11.0	A
HEIL	49.1384923	9.2183223	234.797	20.00	1013.00	0.2	11.0	A
IFFE	48.8300984	8.1125877	185.437	20.00	1013.00	0.2	11.0	A
HEID	49.3889040	8.6753013	168.832	20.00	1013.00	0.2	11.0	A

5.4.6 Sodars

5.4.6.1 PI and contact information:

The sodars were also handled by the energy balance group and managed by their web site www.bayceer.uni-bayreuth.de/COPS/.

5.4.6.2 Set up and distribution:

Sodars with RASS are capable to determine wind and virtual temperature profiles in the surface layer/lower boundary layer. They are very useful to study the stability in the surface layer and to relate this to the surface fluxes. Therefore, their set up was also coordinated by the energy balance and turbulence group. They were located at

Fußbach, Kinzig valley, at energy balance station: Metek RASS operated by the University of Bayreuth (BT)

Oberkirch, Rench valley, at AWS of University of Munich and FZK turbulence station: Scintec operated by the University of Freiburg

Gernsbach/Rotenfels, Murg valley, at turbulence station: Metek RASS operated by FZK and University of Leeds

Igelsberg, Black Forest lee side, at FZK turbulence station: Scintec operated by FZK

Enzklösterle, Black Forest lee side, at University of Leeds (UL) AWS: Scintec operated by UL

Supersite Achern: Scintec operated by UL

French Supersite: Remtech

Their distribution is presented in Fig. 5.19. Most of the sodars were operated continuously during the campaign. Otherwise they were operated in low mode during night and high mode during convection.

5.4.6.3 Data availability:

Common time stamps will be realized and the data format (NetCDF) will be developed in collaboration with WDCC.

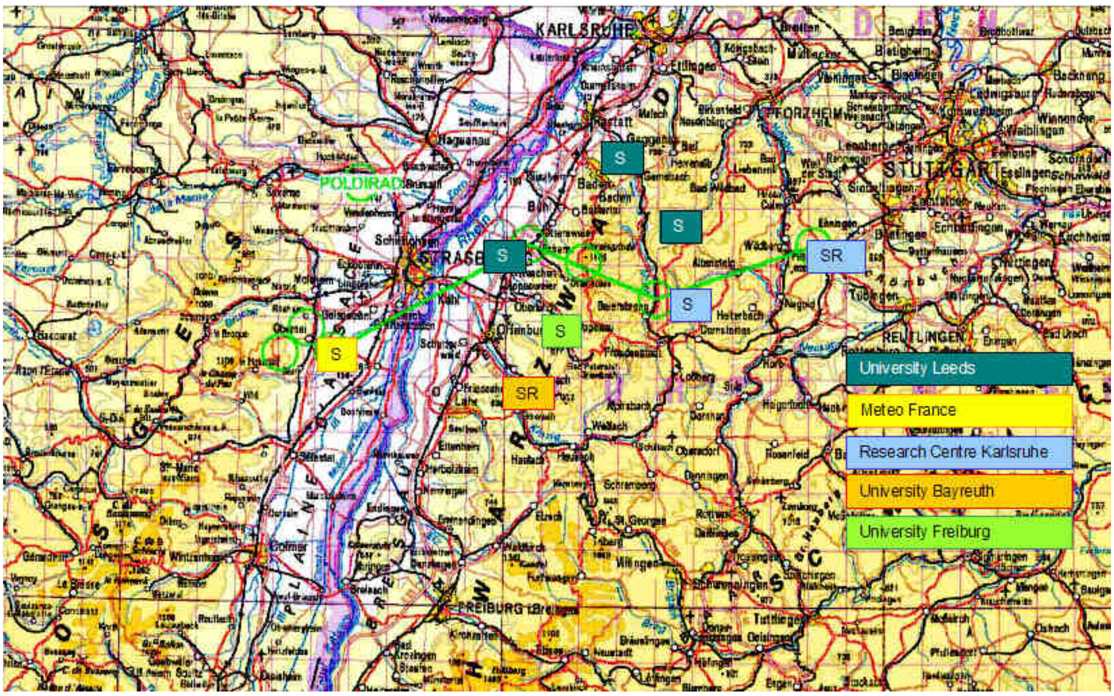


Fig. 5.19 Distribution of sodar stations in the COPS area.

5.4.7 Radiosoundings, Tethered Balloons, and AMDAR data

5.4.7.1 PIs and contact information:

The radiosonde stations were handled by the Supersite managers in collaboration with

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Tel: 07251 42953 (home)

Email: norbert.kalthoff@imk.fzk.de

5.4.7.2 Set up and distribution:

Substantial efforts have been put in the set up and operation of radiosonde stations. The goal was to achieve an equipment of all Supersites and to perform regular launches. However, boundary conditions were limited funding and operation times of our partners as well as safety restrictions by Air Traffic Control (ATC). Fig. 5.20 presents an overview of the distribution of the COPS radiosonde stations. Table 5.5 presents an overview of all radiosonde stations.

The AMF at Supersite M (see section 5.3.4) provided a particular dense set of radiosonde launches. During the full operation time of the AMF all six hours a radiosonde launch was performed. Its data are available via the GTS since May 18, 2007.

DWD, MeteoSwiss, Meteo France, and KNMI agreed to support COPS and ETReC 2007 not only by carrying out but also by funding of additional EUCOS radiosoundings. MeteoSwiss upgraded its 06 and 18 UTC radiosonde ascents at Payerne from simple PILOT to full TEMP measurements on 40 days during the 3 COPS months. MeteoSwiss allows additional 80 radiosondes in total. This includes soundings for ETReC at 6 days.

DWD carried out additional 06 and 18 UTC soundings at Meiningen, Stuttgart, and Munich on 40 days on demand. Furthermore, DWD supported ETReC 2007 with soundings from several more sites (in the requested area: 35°N/10°W to 55°N/10°E), allowing a total number of 300 additional soundings for both experiments together.

Meteo France conducted additional radiosonde soundings at Nancy at 06 and 18 UTC during July. This was performed on each day without required request. In addition, Meteo France carried out 150 radiosonde ascents in total in the experiment area itself (at Supersite V).

KNMI confirmed to support ETReC 2007 by extra soundings at De Bilt on 6 days on demand. Concerning this activity, the COPS OC in Baden Airpark was responsible for announcing an ETReC 2007 IOP.

Most of these radiosonde data were automatically ingested in GTS for real-time data assimilation.

Furthermore, EUCOS decided to buy sub 3-hourly AMDAR data (aircraft measurements) from Air France and Lufthansa at the following airports:

Air France: PARIS(CDG), CLERMONT FERRAND, GENEVA, LYON/SATOLAS, STRASBOURG, TORINO

Lufthansa : GENEVA, LYON/SATOLAS, MILAN/LINATE, ZURICH

Routinely the national Met. Services, participating in EUMETNET/EUCOS, are purchasing AMDAR data from European airports with 3 hour intervals. In addition, DWD (also routinely) buys hourly data from German airports, thus no German airport is included in the above-mentioned list. There is a potential to increase AMDAR data coverage at the mentioned airports and in total (i.e. from all these airports together) we are expecting up to 50 additional vertical profiles per day. These additional AMDAR measurements were activated during the entire COPS campaign.

EUCOS activated additional (i.e. sub 3-hourly, if possible hourly) AMDAR data from almost 60 airports in the area of interest (35°N, 10°W – 55°N, 10°E) at the requested 6 ETReC 2007 days during July. For this activity a notification 2-3 days in advance was necessary.

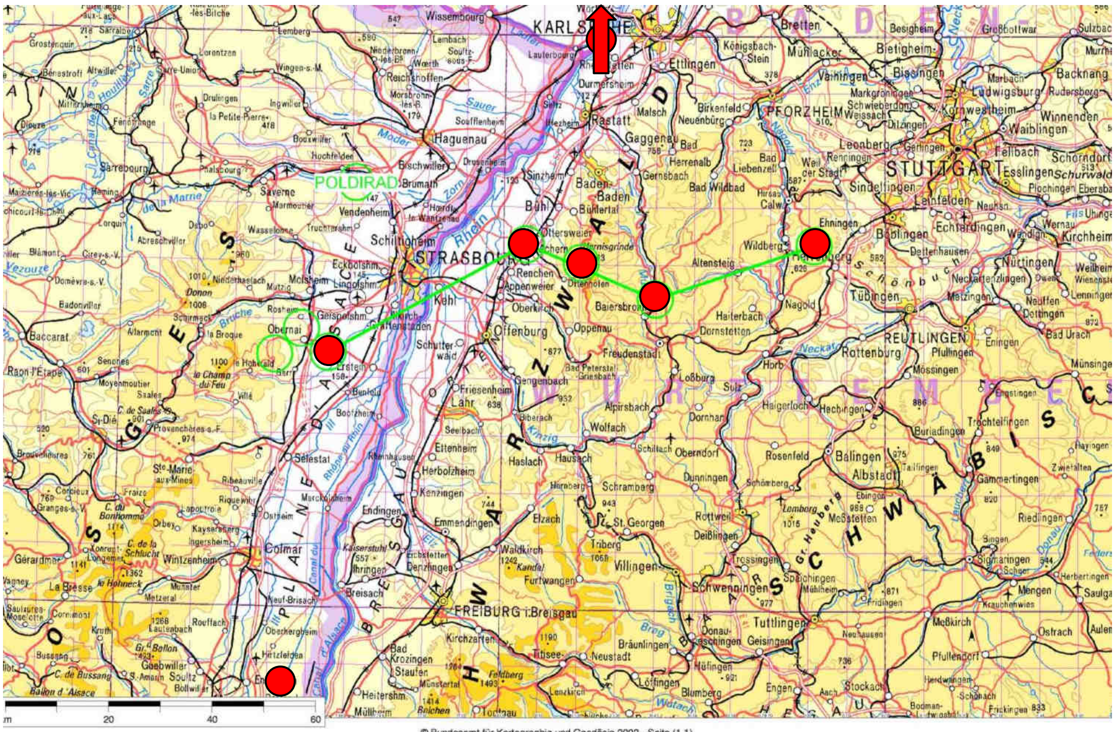

Fig. 5.20 Distribution of radiosonde stations in the COPS area.

Table 5.5 Overview of radiosondes applied during COPS.

Location Parameter	FZK Karlsruhe	Burnhaupt le Bas	Supersite V Meistratz -heim	Supersite R Achern	Supersite H Hornisgrinde	Supersite M Heselbach	Supersite S Decken-pfronn	DROP UP sondes in north-ern Black Forest
Country	D	F	F	D	D	D	D	D
Koordinates	8.431 E 49.097 N	7.167 E 47.720 N	7.545 E 48.443 N	8.066 E 48.638 N	8.204 E 48.604 N	8.405 E 48.545 N	8.813 E 48.635 N	Region with corners at Karlsruhe-Mühlacker-Rottweil-Kenzingen
Sonde, Type	Graw	Graw	Vaisala	Vaisala	Vaisala	Vaisala	MeteoLabor	ETEWE
Sonde, mass	150 g	150 g	< 500 g	< 500 g	< 500 g	< 500 g	1570–1870g (sonde + balloon + parachute), diameter of balloon1-3 m Balloon color: red	~ 1400 g (Sonde + balloon + para-chute), diameter of balloon: 1-3 m Color of balloon: red
Type of op-eration	Ascent and descent	Ascent and descent	Ascent and descent	Ascent and descent	Ascent and descent	Ascent and descent	Ascent and descent	Launch speed: 3-4 ms[1] Fall speed 7-10 ms[1]
Maximum	> 15 km	> 15 km	> 15 km	> 15 km	> 15 km	> 15 km	> 15 km	12 km, separation from

height								balloon; descent to ground using parachute Flight time (ascent and descent: ca. 75 min)
Operation days June – August	10-20	10-20	10-15	10-15	10-15	90	10-15	10-15 (concentrated between 11.06.-31.07.)
Number of launches per day	6-8	6-8	6	6+1	6+1	4 daily	6	Max. 5 launches from 5 mobile stations: 25 per day. Launches simultaneous at all 5 stations between 2 – 4 h
Total number of launches	60 - 120	60 - 120	60 - 90	60 - 90	60 - 90	360	60	max. 250
Launch times	Sunrise to sunset					23:30,05:30 11:30,17:30 UTC	Sunrise to sunset	10-22 Uhr local

Furthermore, at two locations it was planned to operate tethered balloon, which are depicted in Table 5.6. For operation of the tethered balloons, ATC was involved and notified.

Table 5.6 Overview of tethered balloons during COPS.

Location Parameter	Hartheim	Supersite S Deckenpfronn
Country	D	D
Coordinates	7.601 E 47.934 N	8.813 E 48.635 N
Type	Basic ADAS Tether Sonde System (Typ TS-3B1), AIR Inc.	Vaisala, 4 sensors
Maximum height	700 m above ground, 900 m asl	2 km above ground, 2.6 km asl
Duration of operation	24 – 48 h	24 – 48 h
Modus of operation	1 – 2 launches per h	Fixed
Days of operation Juni – August	10 - 20	10 - 20

5.4.8 Lightning

5.4.8.1 PI and contact information:

PI of this activity was Hartmut Höller (email: hartmut.hoeller@dlr.de, phone +49 (0) 8153/28-1536).

5.4.8.2 Set up and distribution:

The LINET lightning detection network was operated in a co-operation by DLR and LMU: a deployable version of 6 stations was provided by DLR and an already existing permanently installed network was made available by LMU. The DLR stations enhanced resolution and thus provided especially an improved vertical resolution of the data. An optimum deployment of these stations during the summer 07 was around a polarimetric radar site (radius 100 km around Poldirad). Fig. 5.21 presents the distribution of operational and additional LINET stations in the COPS region.

Fig. 5.21 LINET stations in the COPS region. Green existing operational LINET stations, yellow additional sensors operated by DLR.

5.4.8.3 Data availability:

Data were included in the operational network and provided in real time.

5.5 Supersites and Poldirad site

5.5.1 Introduction

The equipment of Supersites with sensor synergy was one of the key topics during the COPS workshops. Furthermore, site selection was considered very important. It was decided to orient the Supersites as best as possible along a west-east transect through the northern part of the Black Forest. Fig. 5.22 shows the result of the planning process. COPS scientists were successful to set up of six sites equipped with a synergy of state-of-the-art instrumentation. The site of Poldirad was selected so that this radar could perform RHI scans over several Supersite in order to support their remote sensing measurements with, e.g., estimates of the distribution of hydrometeors in precipitation.

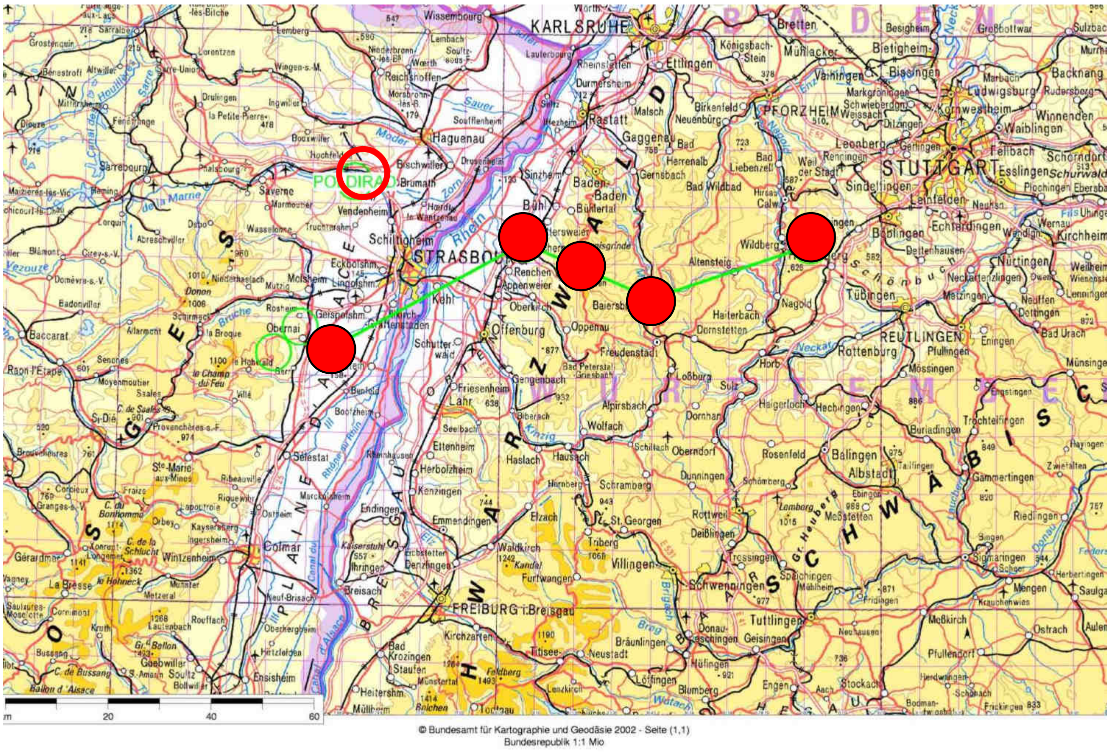

Fig. 5.22 Location of COPS Supersites and POLDIRAD.

Each Supersite was managed by a PI who was responsible for logistics, communications, and operations. Furthermore, this manager reported the status of Supersite instrumentation to the COPS OC. The manager also suggested joint operation modes of the instrumentation during the four phases of observations in order to optimize the synergetic use of the observations. Table 5.1 summarizes the responsible PIs and the locations of Supersites and Poldirad site.

Table 5.7 Managers and locations of COPS Supersites and Poldirad site.

Site	Site manager	Location
Supersite S (for Stuttgart), Airport Deckenpfronn	Manfred Dorninger, University of Vienna Siegfried Vogt FZK	8.813 °E, 48.635 °N, ca. 600 m ASL
Supersite M (Murg valley), AMF site, Heselbach	Kim Nitschke, LANL	8.405 °E, 48.545 °N, ca. 500 m ASL
Supersite H (Hornisgrinde)	Andreas Wieser, Ulrich Corsmeier, FZK	8.204 °E, 48.604 °N, ca. 1150 m ASL
Supersite R (Rhine valley), Achern	Paolo Di Girolamo, UNIBAS, Potenza, Italy	8.066 °E, 48.638 °N, ca. 140 m ASL
Supersite V (Vosges mountains)	Joel van Baelen, LMP, Clermont-Ferrand Cyrille Flamant, CNRS, Paris	Valley: Meistratzheim, 7.545 °E, 48.443 °N Mountain: a) Mont Ste Odile Monastery, 7.405 °E 48.438 °N b) Bishenberg, 7.473 °E 48.483 °N
POLDIRAD, Waltenheim sur Zorn	Martin Hagen, DLR Oberpfaffenhofen	7.610 °E, 48.739 °N, ca. 250 m ASL

Fig. 5.23 summarizes the impressive combination of instrumentation at all Supersites. We managed to combine at all Supersites instruments for clear air, cloud, and precipitation measurements according to the mission of COPS.

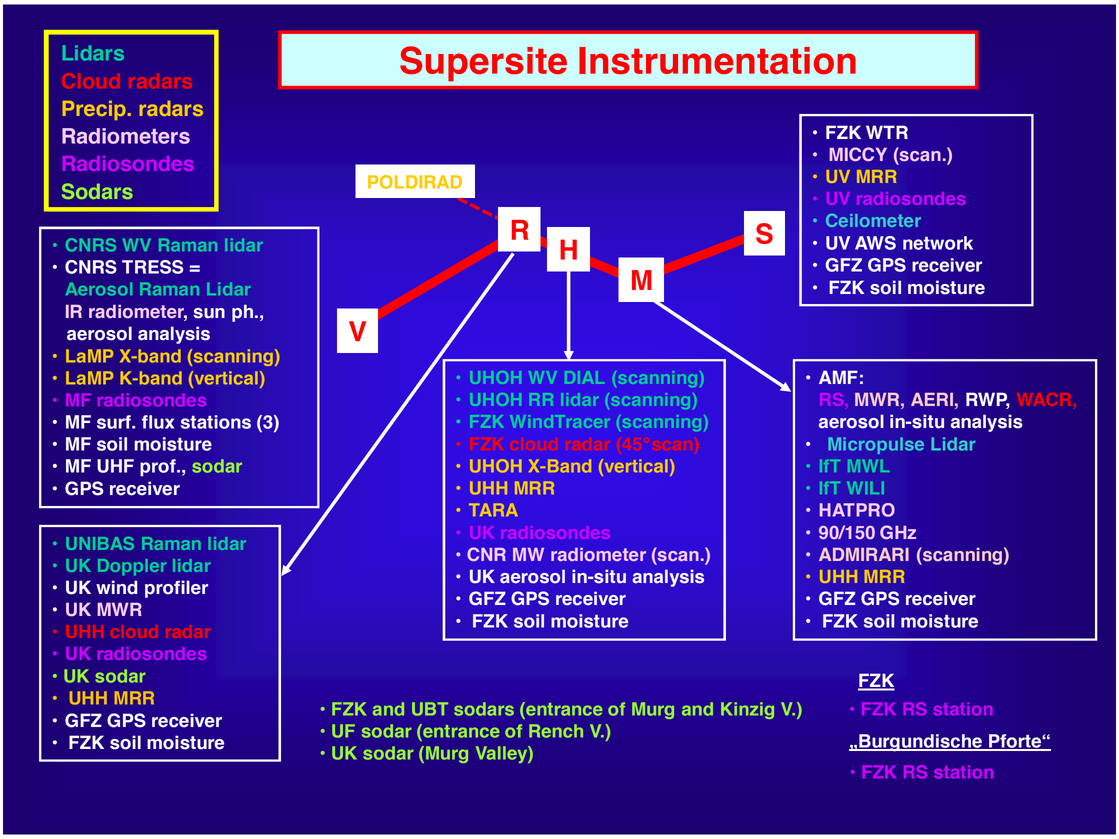

Fig. 5.23. Distribution of instrumentation at Supersites.

5.5.2 Supersite Vosges (V)

5.5.2.1 Managers, communication, and access

Managers for this Supersite were

Cyrille Flamant

Institut Pierre-Simon Laplace

Service d'Aéronomie, CNRS-UPMC

Email: cyrille.flamant@aero.jussieu.fr

Phone: +33 1 44 274872 /+33 620491561

and

Joel van Baelen

Laboratoire de Météorologie Physique (http://wwwobs.univ-bpclermont.fr/atmos)

Email: j.vanbaelen@opgc.univ-bpclermont.fr

Phone: +33 473405426

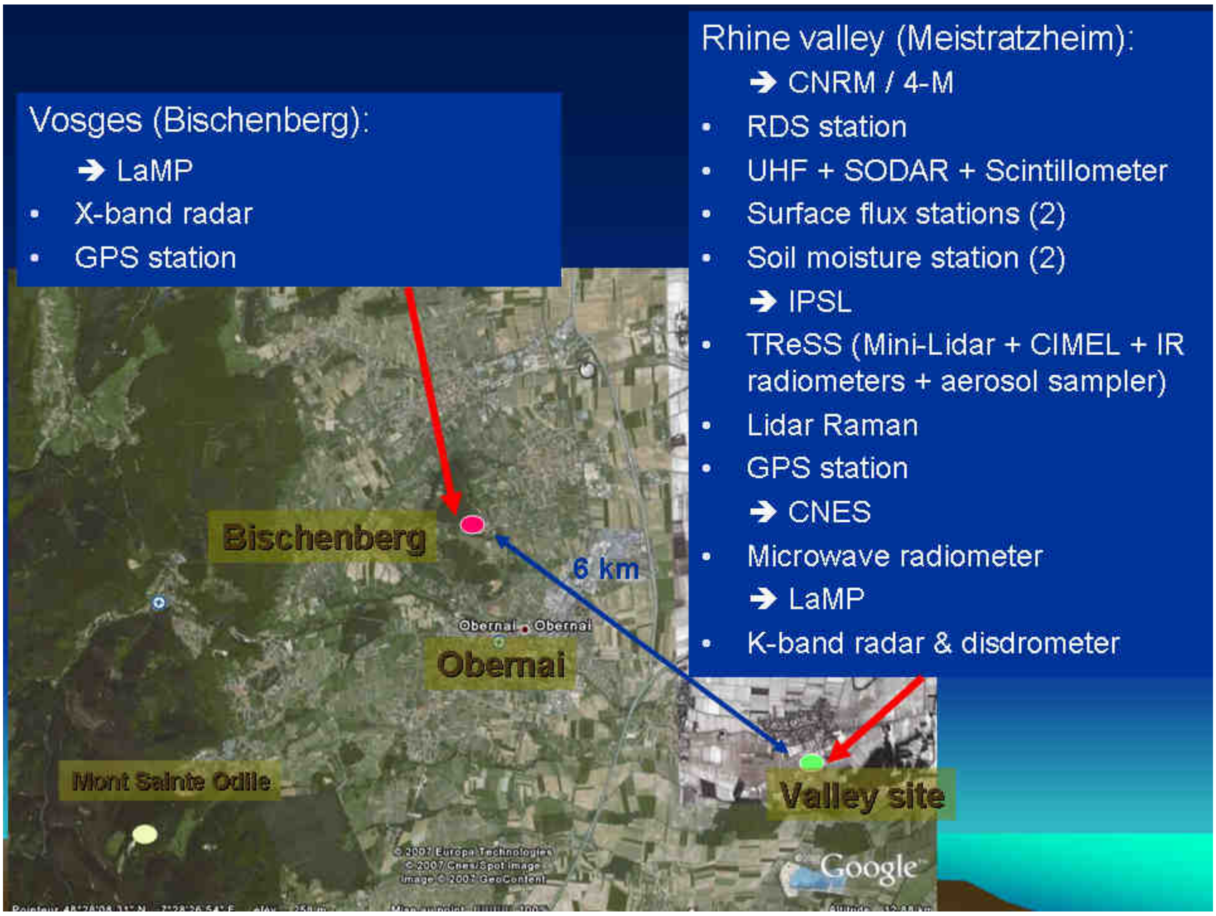

Fig. 5.24 Aerial overview of Supersite V.

The Supersite was composed of 2 sites (see Fig. 5.24): the "Valley site" in the Rhine Valley, near the town of Obernai in the town of Meistratzheim (7.545 °E, 48.443 °N) and the "Mountain site" on top the Bischenberg hill (7.473 °E 48.483 °N). The instrumentation deployed on this supersite was operational from 1 to 31 July 2007. The supersite instrumentation was installed from 25 to 30 June.

Most of the instrumentation of the "Valley supersite" was located just outside of Meistratzheim. A "Valley site" coordinator was available on site to interact with the COPS Operational Center, mostly by phone, as no internet access was available.

Table 5.8 Coordination at supersite V during the summer detachment.

Coordinator	E-mail	Cell phone	Period
J. Cuesta	cuesta@lmd.polytechnique.fr	33-6-21552955	25 June – 8 July
G. Pigeon	gregoire.pigeon@meteo.fr	33-6-98053336	9 July – 19 July
P. Bosser	Pierre.Bosser@ign.fr	33-6-77096804	20 July – 26 July
D. Edouart	edouart@lmd.polytechnique.fr	33-6-63600390	27 July – 06 August

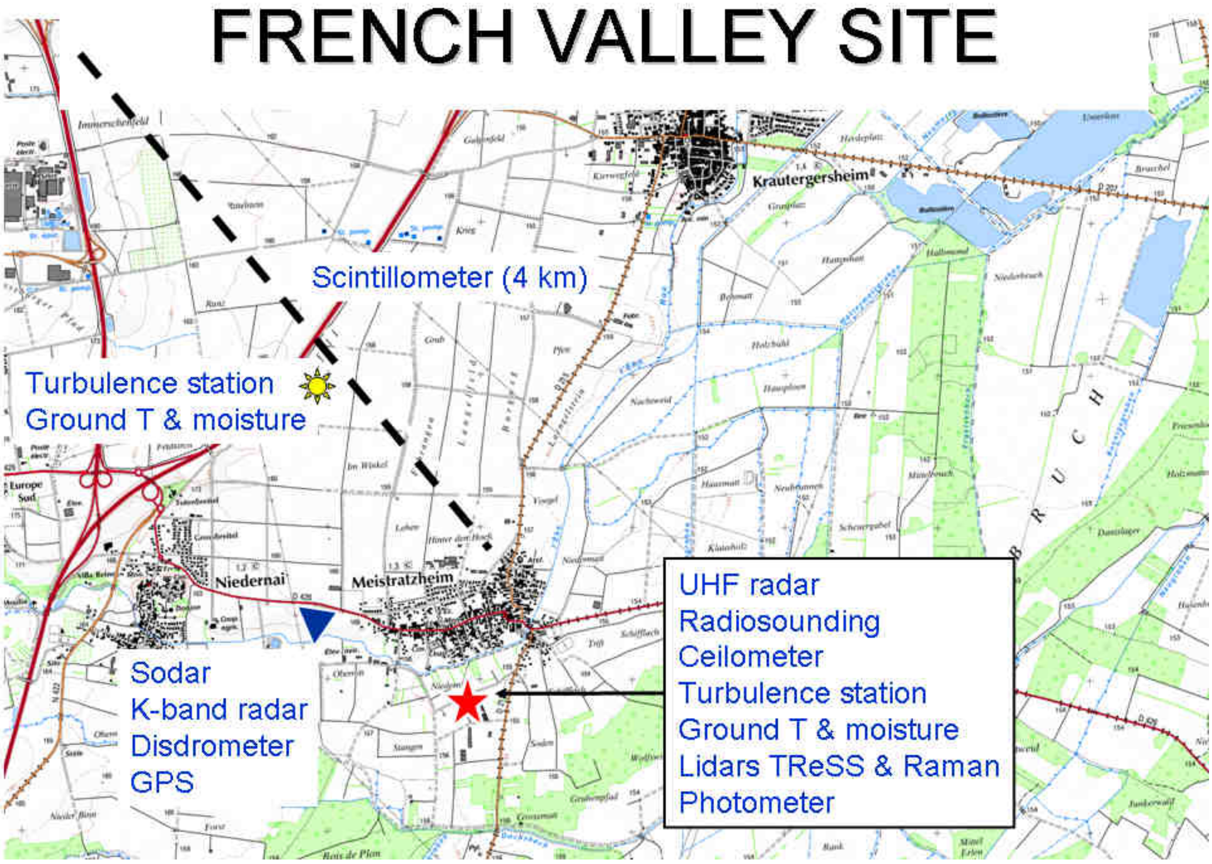

Fig. 5.25 Layout of the instrumentation at the "Valley supersite" around the town of Meistratzheim.

5.5.2.2 Instruments

Table 5.16 summarizes the instrumentation of Supersite V and their operation modes. The layout of the instrumentation at the "Valley supersite" around the town of Meistratzheim is shown in Fig. 5.25.

Table 5-8 Supersite V instrumentation.

Instrument	Measurement period	Steering mode	Operation time	Misc.
IGN/IPSL Raman lidar	IOP	Vertical & slant path	July 1 – July 31	➔ Operating at 355 nm ➔ Day & nighttime measurements ➔ Slant path measurements at night
LaMP X-band radar	continuous	Scanning	June 15 – July 31	➔ High spatial and temporal resolution (60 m et 30 sec.) ➔ Max. range ~20 km ➔ Adjustable fixed elevation 1 or 2°
LaMP K-band	continuous	Vertical	June 15 –	➔ Radar reflectivity pro-

			July 31	files up to 3 km with 100 m height resolution ➔ DSD spectra calculation ➔ Drop fall velocity estimation
IPSL TReSS Aerosol Lidar, IR radiometer	IOP	Vertical	July 1 – July 31	Backscatter Mini-Lidar - 532 nm // - 532 nm ⊥ - 607 nm (Raman channel) - 1064 nm IR Radiometer (9.5-11.5 μm)
IPSL TReSS Aerosol sampler	IOP	At the surface	July 1 – July 31	Filters ➔ 1 filter prior to and after convective events ➔ 1 filter/day otherwise
IPSL TReSS sun photometer	continuous	Vertical	July 1 – July 31	8 channels: 340, 380, 440, 500, 670, 870, 936, 1020 nm
IPSL TReSS Optical particle counter	continuous	At the surface	July 1 – July 31	15 classes in the range 0.15 µm < r < 10 µm
MF UHF prof., sodar	continuous	Vertical	July 1 – July 31	At the water treatment facility located between Niedernai and Meistratzheim (see Fig. 5-Y)
MF radiosounding station	IOP	Vertical	July 1 – July 31	100 sondes ➔ 6 RDS / day during IOPs (0600-2100 UTC) for 11 IOPs (**total 66 RDS**) ➔ 1 RDS / night on 3 nights (**total 3 RDS**) for Raman lidar calibration purpose ➔ 2 RDS / night during 5 nights (**total 10 RDS**) for Raman lidar satellite tracking – SIWV) ➔ 1 RDS at 1200 UTC on non-IOP days (**total 20 RDS**)
GPS receiver (2)	continuous	Slant path	June 1 – August 31	➔ 1 GPS at Bischenberg ➔ 1 GPS together with MF sodar at the water treatment facility
MF soil moisture (2)	continuous	-	July 1 – July 31	➔ one of the soil moisture station will be located along the scintillometer path, halfway between the emitter and the receiver (see

				Fig. 5-Y).
MF surf. Flux stations (2)	continuous	-	July 1 – July 31	➔ one of the flux station will be located along the scintillometer path, halfway between the emitter and the receiver (see Fig. 5.25).
MF scintillo-meter	continuous	-	July 1 – July 1	➔ 4-km path north of Meistratzheim (see Fig. 5.25)
CNES micro-wave radiome-ter	continuous	-	July 1 – July 1	➔ together with MF sodar and LaMP K-band radar at the water treatment facility

Note that 2 GPS receiving stations were installed for a period of 3 month as part of the **GPS network**. The flux stations and soil moisture stations were also integrated in the framework of the **energy balance and turbulence stations network and soil moisture network.**

5.5.2.3 Operation

IGN/IPSL Raman lidar, IPSL TReSS backscatter lidar, and MF radiosondes were operated in an IOP mode. The TReSS backscatter lidar was operated in a zenith pointing mode. Whenever possible, active remote sensing instruments acquired data from dusk to dawn. Lidar was not operated during rainy events.

The IGN/IPSL Raman lidar was operated in both zenith pointing and sideways pointing (aiming at satellites from the GPS constellation) at night. Daytime measurements were made in a zenith pointing mode (before 1200 and after 1600 UTC). Synergies with F20/LEANDRE 2 overpasses of the site were used. Synergies with coincident instruments at the supersite V (sunphotometer, microwave radiometer, GPS and TReSS backscatter lidar) were a priority.

Water vapor mixing ratio measurements acquired on this site (surface stations, radiosondes, Raman lidar) will be assimilated in the GPS tomography derived time evolving 3D water vapor field.

The X band precipitation radar scanning domain was entirely included within the line of sight of POLDIRAD at 100 m elevation. Scanning was continuous at a fixed elevation angle and rotation rate is 24 RPM. The resolution is 60 meters in range, 1 or 2° in azimuth, 30 or 60 seconds in time. Strong instrumental synergies are expected between the X-band radar in the "Mountain site" and the K-band radar and the microwave radiometer located at the "Valley site", and distant of about 6 km, with the K-band radar beam intersecting the X band scan. There are many synergies envisioned with the collocated instruments at the V super site, as well as with POLDIRAD and some airborne measurements.

Fig. 5.26 Photo of LaMP X-band radar.

5.5.3 Supersite Rhine valley (R)

5.5.3.1 Managers, communication, and access

Manager for this Supersite was

Paolo Di Girolamo

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Supersite R was located at the water treatment facility in Achern. Fig. 5.27 shows an aerial view of this site.

The area is fenced, electricity with sufficient power and internet were available. There was good access to this site. The ground is stable (partly paved). The distance to Supersite H is about 10 km. Supersite R is close to a line extending to Supersites M and V and to POLDIRAD site.

5.5.3.2 Instruments

Table 5.9 presents the instrumentation available at Supersite R and Fig. 5.28 its distribution.

The University of Salford Doppler lidar and MW Radiometer, the University of Manchester Radio Wind Profiler was shipped on June 11 and installed on June 11-12. University of Basilicata Raman lidar (BASIL) was installed on May 23-25. University of Hamburg rain was installed on May 17-18 and operated since then. The University of Hamburg cloud radar was installed on May 30. The ARM radiometer was installed on May 23-24 and operated since. The University of Munich Weather Station was installed on May 23 and the IMK soil moisture station on June 4. The University of Leeds Radiosonde system was shipped on May 30 and was installed shortly afterwards.

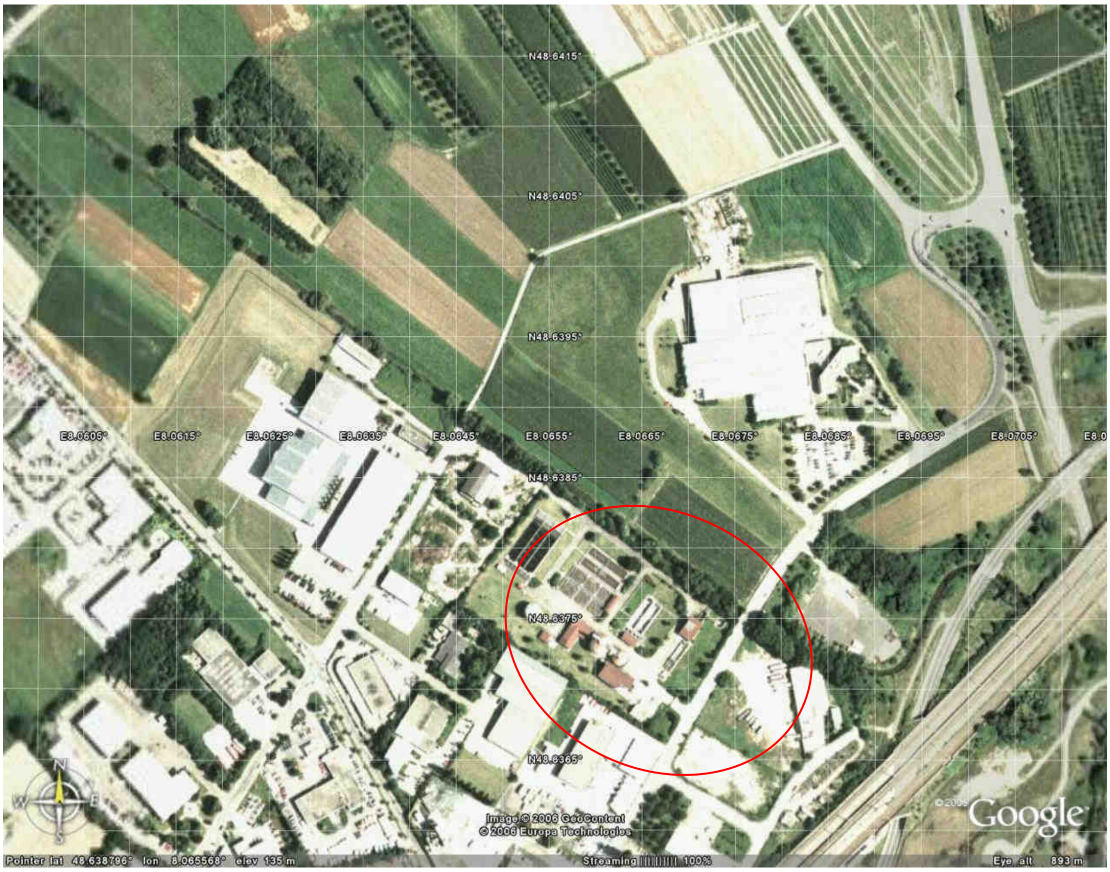

Fig. 5.27 Aerial view of Supersite R.

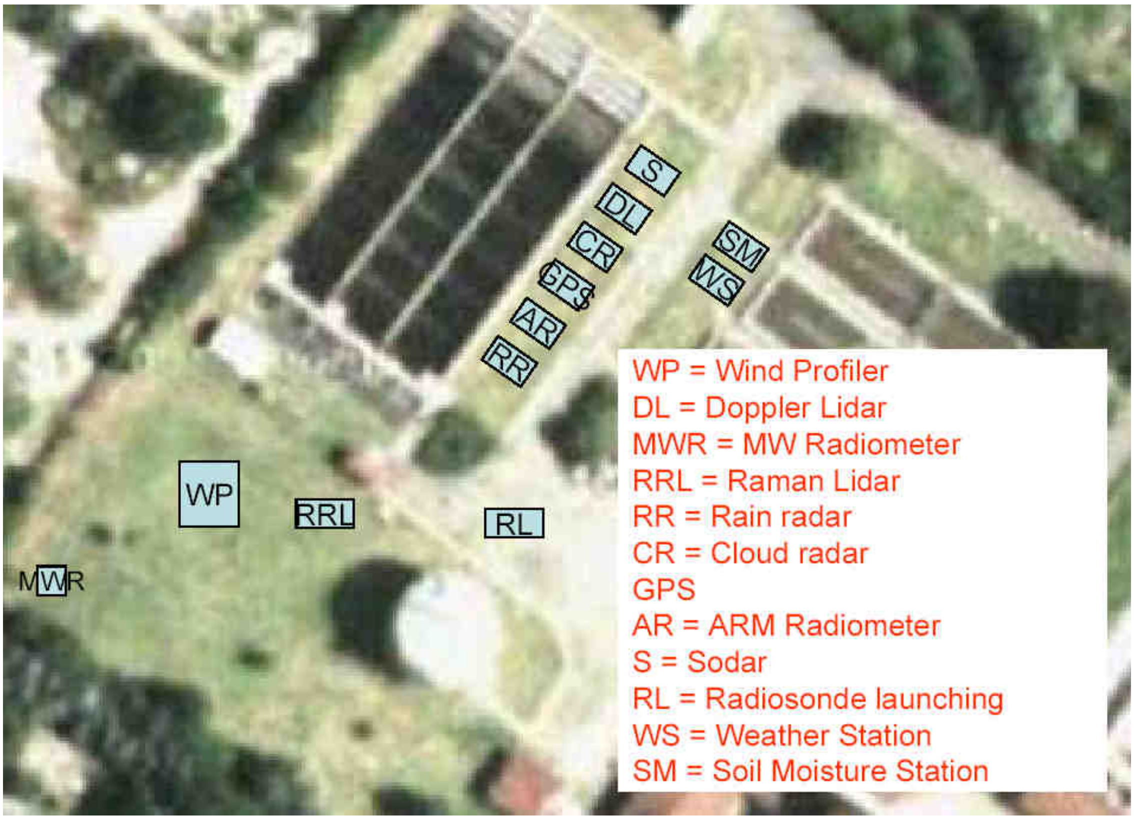

Fig. 5.28 Spatial distribution of Supersite R instrumentation

Table 5.9 Supersite R instrumentation.

Instrument	Measurement period	Steering mode	Operation time
UNIBAS Raman lidar (BASIL)	IOP	Vertical	June 1 – August 31
University of Salford Doppler lidar	continuous	Scanning	June 15 – August 31
University of Manchester wind profiler	continuous	Vertical	June 15 – August 31
University of Salford MWR	continuous	Vertical	June 15 – August 31
UHH cloud radar	continuous	Vertical	June 1 – August 31
UHH micro rain radar	continuous	Vertical	June 1 – December 31
GFZ GPS receiver	continuous	Slant path	June 1 – December 31
University of	continuous	Vertical	

Leeds sodar			
University of Leeds radiosondes	Two launches per day + intensive launches during IOPs	Vertical	June 15 – August 31
University of Munich weather station	continuous		
ARM radiometer	continuous		
FZK soil moisture	continuous	-	June 1 – December 31
Turbulence station not available but operated closeby in Sasbach	-		June 1 – December 31

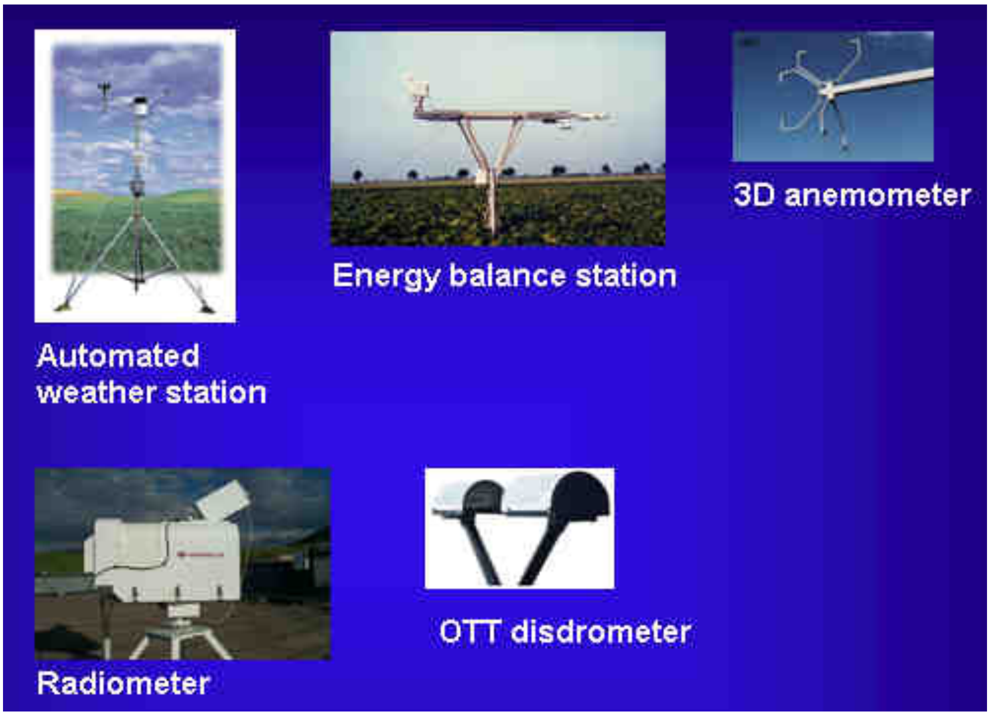

Fig. 5.29 In-situ and passive instruments at Supersite R.

Fig. 5.30 Active instruments at Supersite R.

5.5.3.3 Operation

As most of the systems were operated continuously and in vertically steering mode, no sophisticated coordinated scans had to be considered. The UNIBAS Raman lidar was operated during IOPS. The scanning mode of the UK Doppler lidar was coordinated with the FZK Doppler lidar on Supersite H (see section 11.5.3).

5.5.4 Supersite Hornisgrinde (H)

5.5.4.1 Managers, communication, and access

Managers for this Supersite were Andreas Wieser and Ulrich Corsmeier.

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Ulrich Corsmeier (ulrich.corsmeier@imk.fzk.de)

Phone at Supersite: +49 (0) 7022 479 344

Email: cops.supersites@googlemail.com

IP Supersite via: Hornisgrinde.dynsys.info

Fig. 5.31, Fig. 5.32, and Fig. 5.33 give an overview of the properties of this Supersite.

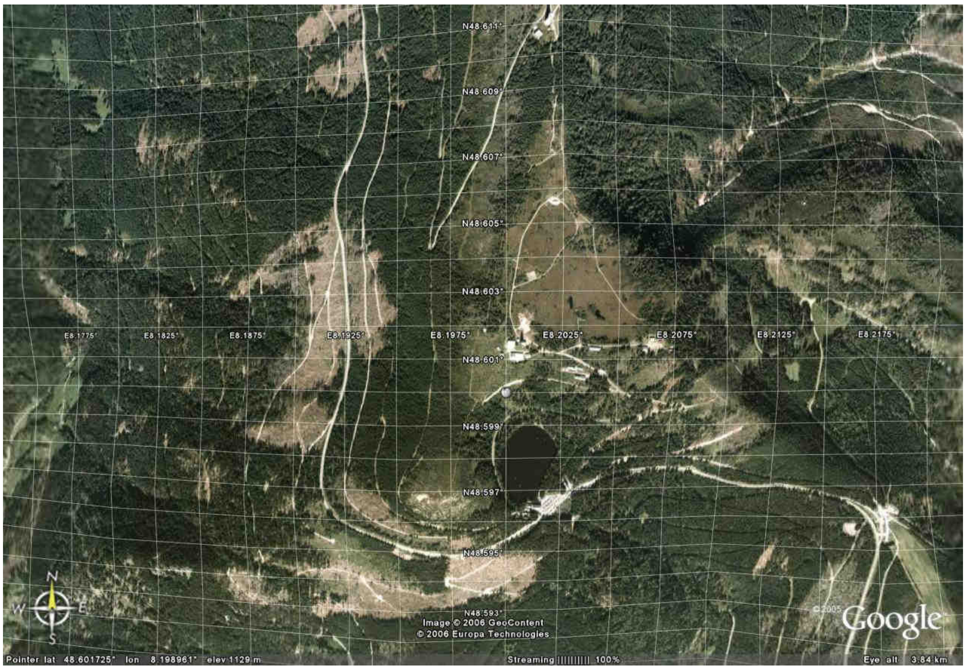

Fig. 5.31 Aerial overview of Supersite H.

Fig. 5.32 Zoom-in aerial overview of Supersite H.

Fig. 5.33 Aerial overview of Supersite H with helipad.

5.5.4.2 Instruments

Table 5.10 summarizes the instrumentation at Supersite H. This Supersite was very well equipped with a synergy of scanning instrumentation. It was a particular challenge to make optimum use of this synergy. Hornisgrinde area is a natural protection area so that special care had to be taken in the set up and operation of the instruments.

Table 5.10 Supersite H instrumentation.

Instrument	Measurement period	Steering mode	Operation time
FZK WindTracer Doppler Lidar	continuous	Scanning	June 1 – August 31
UHOH water-vapor DIAL	IOP	Scanning	June 15 – August 31
UHOH rotational Raman lidar	IOP	Scanning	June 1 – August 31
FZK cloud radar	continuous	Scanning	June 1 – August 31 (but defect August 4 – 24)
TU Delft TARA radar	IOP	Scanning	June 1 – August 31

CNR MWR	IOP	Scanning	June 1 – August 31
UHOH X-band radar	IOP	Vertical	June 1 – August 31
UHH micro rain radar	continuous	Vertical	June 1 – December 31
UK Radiosonde station	IOP	Vertical	June 15 – August 31
GFZ GPS re-ceiver	continuous	Slant path	June 1 – December 31
FZK cloud cam-era	continuous	-	June 1 – August 31
UK aerosol analysis	continuous	-	June 15 – August 31
FZK soil mois-ture	continuous	-	June 1 – December 31
FZK energy balance station	continuous		June 1 – August 31
ARM radiation sensors	continuous		June 1 – December 31

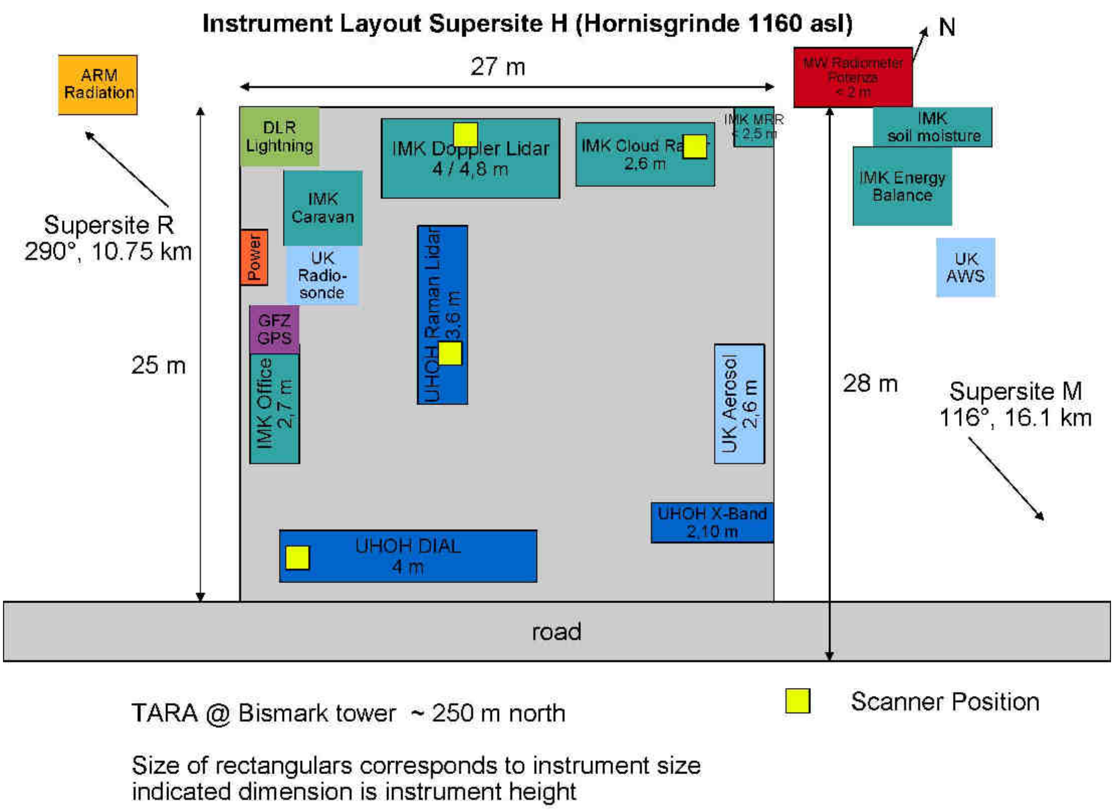

Fig. 5.34 Instrument layout at Supersite H.

Most of the instruments were deployed on the helipad which is 8 m below the Hornisgrinde peak with open view to the Rhine Valley. Minimum possible elevation for full 360 degree PPI scan was approx. 4-5 degrees. Space on the helipad was very limited (27x25 m) – locations of the instruments had to be well coordinated. There was no fence around the instruments, but the site is closed for motor vehicle traffic which gave protection against vandalism. The site is accessible for standard sized lorries. An office container was installed at the site. Electrical power was available from April 11th. Internet connection with 2 MBit SDSL was installed 1st week of May by Deutsche Telekom. Local WLAN was established during May.

At least on fix IP Address for the site was available. Instruments could be contacted from outside by port forwarding. Ports were assigned in a first come first serve order by the Supersite responsibilities. A VoIP phone was available in the office container. A coordinated scan strategy hads been developed by IPM and IMK in coordination with the involved PIs. Scan strategy was coordinated with flight plan and instruments at other Supersites as well (see section 11.5.3).

5.5.4.3 Operation

Hornisgrinde Supersite was ready for instrument deployment since May 9th. The site was operated from June 1 to August 31, 2007

Useful synergies are the combination of Doppler, temperature, and water-vapor DIAL together with the cloud and precipitation radar. Vertical steering of Doppler lidar with temperature and water-vapor DIAL can permit the determination of sensible and latent heat flux profiles using the eddy correlation method. In the region of clouds, attempts can be made for deriving condensation rates.

According to the 5th Workshop, scan strategies for 2 situations during IOPs (no or very low wind speed expected / significant wind velocity) have been suggested. Announcing an IOP, the operations center informed about the expected wind situation. During IOPs expected as calm or with very low wind speed instruments vertically steering operation was proposed. During IOPs with significant wind velocity, a scan pattern suitable for calculating a wind profile every 15 or 30 minutes was applied. Scanning instruments at other sites applied a coordinated scan pattern during these IOPs as well.

5.5.5 Supersite Murg valley (M)

5.5.5.1 Managers, communication, and access

Manager for this Supersite was

Kim Nitschke

Operations Manager

Tropical Western Pacific / ARM Mobile Facility Management Office

Los Alamos National Laboratory

Phone +1 505 667 1186

Fax: +1 505 667 9122

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Phone at AMF site: + 49 7442 120 – 718 or - 719

Site access has to be requested via www.db.arm.gov/SAR2/

The status of the AMF can be found in www.arm.gov/sites/amf/blackforest/

The AMF data can be accessed via www.archive.arm.gov

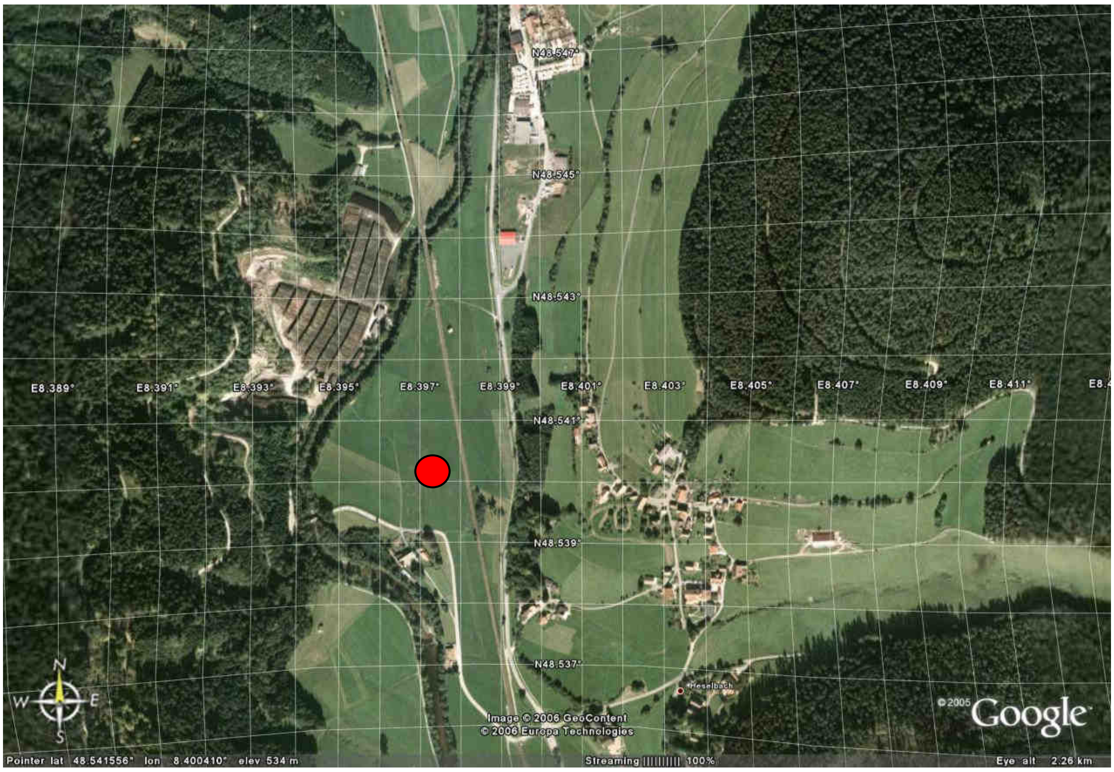

Fig. 5.35 Aerial view of Supersite M.

5.5.5.2 Instruments

The layout of the instrumentation is presented in *Fig. 5.36*. The AMF instrumentation is presented in Table 5.11. The equipment consisted of a radiation station, an eddy covariance station, and a meteorological tower. Tropospheric profiling was performed by a combination of passive and active remote sensing systems. These included a wind profiler, an AERI, a micropulse lidar, and a 94-GHz cloud radar. Furthermore, a comprehensive set of aerosol microphysics was available. A particular unique feature are regular radiosonde launches all six hours during the full duration of the AMF operation with Vaisala RS92 radiosondes.

The unique AMF instrumentation was further supported by soil moisture measurements of FZK, two advanced radiometers (HATPRO and 90/150 GHz), a GPS receiver from GFZ, the University of Hamburg MRR, as well as the multi-wavelength lidar and the Doppler lidar WiLi from IfT (see Table 5.12).

The operation time of all instruments except the IfT lidars exceeds the duration of the COPS field phase and will last until 31 December 2007 (see below).

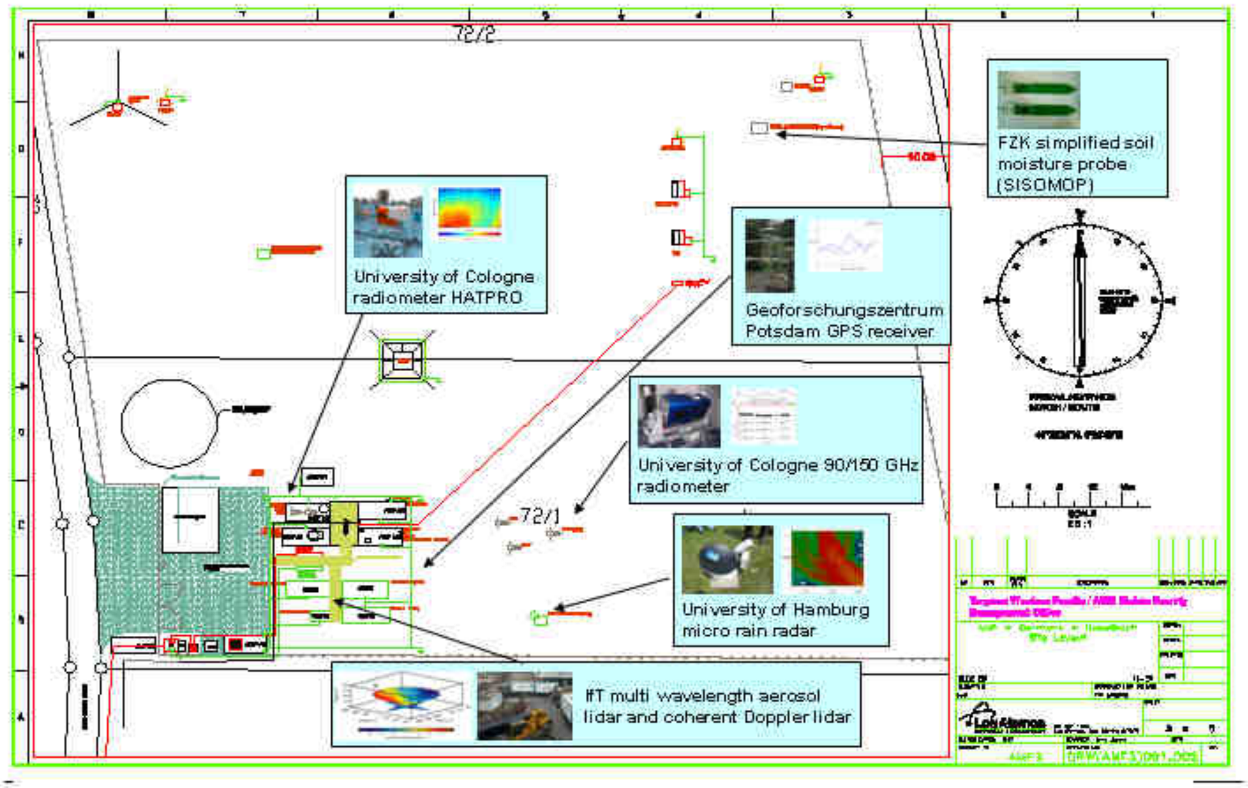

Fig. 5.36 Instrument layout at Supersite M.

Table 5.11 AMF instrumentation at Supersite M. The instrumentation was operated continuously from April 1 – December 31, 2007. All remote sensing instruments were operated in vertically steering mode.

AMF Core instrument acronym	Instrument
SKY Rads	Radiometer
SKY IRT	IR Therm
GRD Rads	Radiometer
GRD IRT	IR Therm
MFRSR	Radiometer
SMET WD	Anemometer
SMET T/RH	Temp/humid
SMET BAR	Barometer
SMETORG(815)	Rain gage
PWD	Present Weather Detector
TSI	Camera
ECOR	Eddy Correlation
BBSS Digi/Ant	Up air sonde
CEIL	Lidar
MPL	Lidar
MWR	Radiometer
MWRP	Radiometer
NFOV	Radiometer
AERI	Interferometer
WACR (94GHz)	Radar
CIMEL	Photometer
RWP (1290MHz)	Radar Wind Profiler
CIMEL	Sun Photometer
AOS Core Instruments	Aerosols
TSI neph x 2 Dry	TSI 3563 Nephelometer at low RH
TSI neph + humidograph	Nephelometer + humidograph system for scanning RH
RR PSAP	Radiance Research 3 wavelength Particle soot absorption photo-

	meter
CPC CPC=CNC	TSI 3010 Condensation nuclei counter
CCNC	DMT Cloud condensation nuclei counter

Table 5.12 German instrumentation at Supersite M.

Instrument	Measurement period	Steering mode	Operation time
IfT Doppler lidar	IOP	Scanning	June 1 – August 31
IfT multi-wavelength lidar	IOP	Scanning	June 1 – August 31
UC HATPRO	continuous	Scanning	April 20 – December 31
UC 90/150 GHz MWR	continuous	Scanning	May 2 – September 31
UHH micro rain radar	continuous	Vertical	May 1 – December 31
GFZ GPS receiver	continuous	-	April 1 - December 31
FZK soil moisture	continuous	-	May 1 – December 31

5.5.5.3 Operation

The operation of the AMF was started on April 1, 2007 and will continue until December 31, 2007. During this time, the entire AMF instrumentation will operate continuously. All six hours, radiosonde launches are performed.

The German soil moisture, GPS, HATPRO, and MRR instruments will also be operated until December 31. The IfT systems will be operated during COPS. The German radiometers and the IfT lidars have all scanning capability.

All German instruments are operated continuously except the IfT multi-wavelength lidar (MWL) and the Doppler lidar (WiLi). During IOPS, the MWL will steer vertically whereas WiLi will perform all 30 min three PPI scans with 3 elevations. Otherwise, WiLi will point vertically.

5.5.6 Supersite Stuttgart (S)

5.5.6.1 Managers, communication, and access

Manager for this Supersite were Manfred Dorninger and Siegfried Vogt.

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Phone (office in Vienna): 0043-1-4277-53731

Siegfried.vogt@imk.fyk.de

Phone (in the field): 0160 90546646

Phone (office): +49 7247 82 4231

Address of the University of Vienna group (office and flat of University of Vienna):

Lammgasse 4

75392 Deckenpfronn

Supersite S was located on the lee side of the Black Forest. Observations at this site w very important to study the spatial variability of cloud and precipitation microphysics. The site was close to the glider airport Deckenpfronn in flat terrain. Fig. 5.37 presents an aerial view on Supersite S.

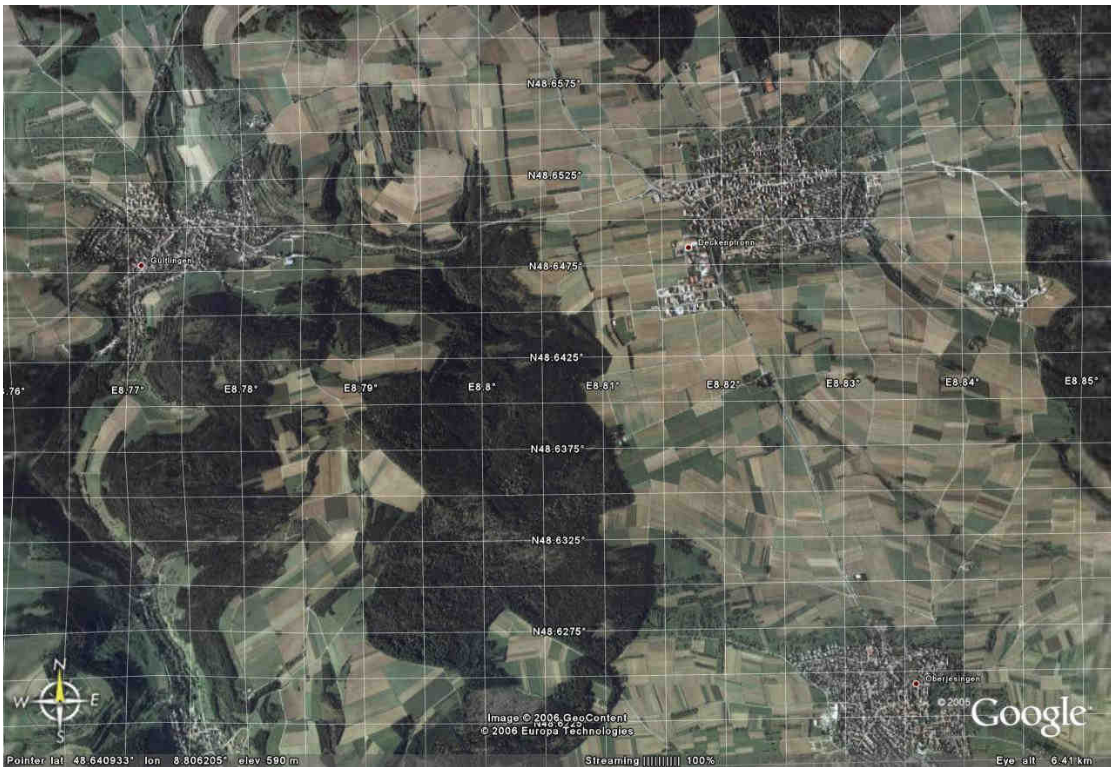

Fig. 5.37 Aerial view of Supersite S.

Fig. 5.38 Photographical view of Supersite S (courtesy of Reinhold Steinacker)

5.5.6.2 Instruments

The following instrumentation was deployed:

Table 5.13 Instrumentation of Supersite S.

Instrument	Measurement period	Steering mode	Operation time	Misc.
FZK Wind-temperature radar	continuous	Vertical	June 1 – August 31	
U.VIENNA micro rain radar	continuous	Vertical	June 1 – August 31	
U.VIENNA radiosondes	IOP	Vertical	June 1 – August 31	Restrictions due to ATC
GFZ GPS receiver	continuous	-	June 1 – August 31	
U.VIENNA AWS network	continuous	-	June 1 – August 31	
FZK soil moisture	continuous	-	June 1 – August 31	
U.VIENNA energy balance station	continuous	-	June 1 – August 31	
U.VIENNA disdrometer	Continuous	-	June 1 – August 31	
UBonn MICCY	Continuous	Scanning	June 20 - August 31	
UBonn energy balance station	Continuous	-	June 1 – August 31	
UBonn Large Aperture Scintilometer	Continuous	-	June 1 – August 31	
DWD (operated by UBonn) Ceilometer	Continuous	Verical	June 20 - August 31	

5.5.6.3 Operation

Most of the systems were operated in a continuous mode except the tethersonde and radiosonde system from the University of Vienna, which were restricted to the IOPs. Due to ATC restrictions and limited amount of radiosondes only a subset of the upcoming IOPs could be covered.

Synchronous measurements of WTR, POLDIRAD, MRR and Disdrometer resulted in a comprehensive picture of rain and cloud droplet distribution in the area. Radiosonde launches together with the tethersonde profiles and concurrent overflight(s) of the FALCON-DLR will complement this picture by exploring the water vapor distribution.

The two energy balance stations of the U.Vienna and UBonn have a completely different instrumental set-up. The results will be used for comparison and evaluation. Both systems were included in the energy balance network (see section 5.4.4).

The vertical velocity measured by the WTR will be used to correct the MMR measurements.

5.5.7 Poldirad site (P)

5.5.7.1 Managers, communication, and access

The manager of this site was

Martin Hagen

Institut für Physik der Atmosphäre

DLR Oberpfaffenhofen

Email: martin.hagen@dlr.de

Phone: +49 (0) 8153/28-2531)

Location: F-67670 Waltenheim-sur-Zorn, 48° 44’ 23.1“ N 7° 36’ 37.2“ E (see Fig. 5.39).

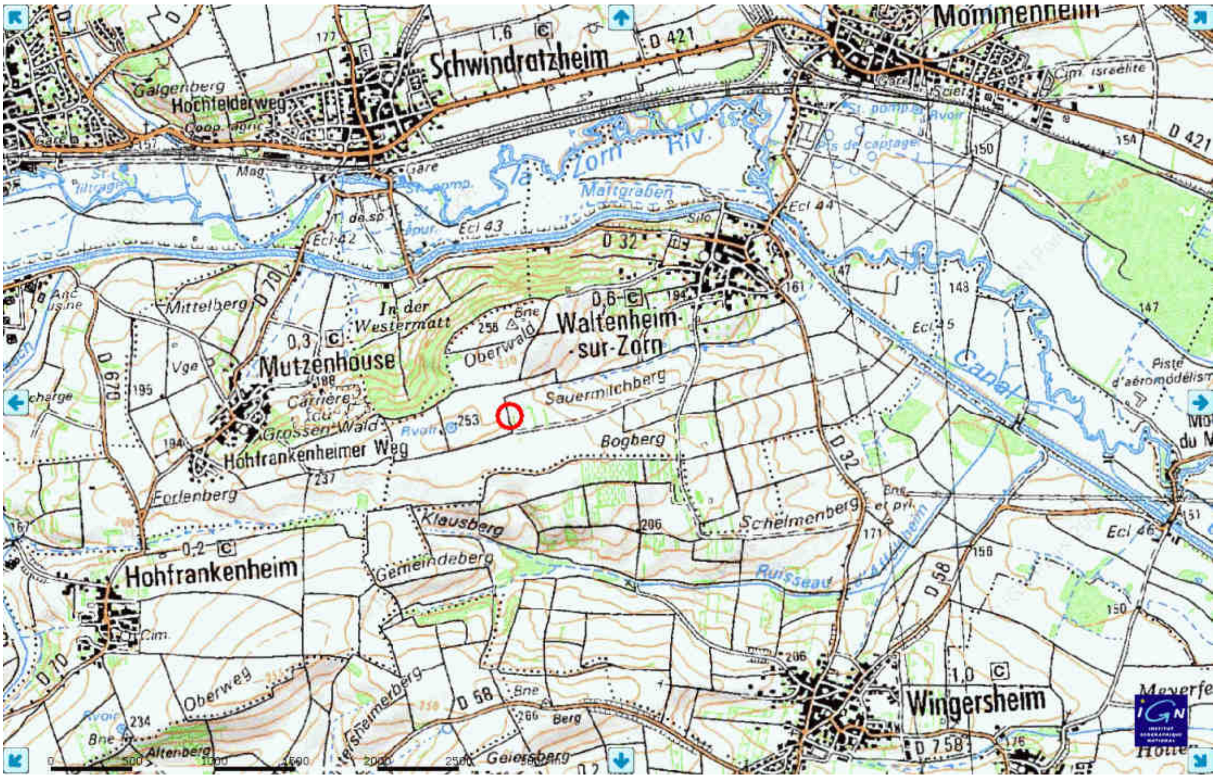

Fig. 5.39 Location of POLDIRAD at Waltenheim-sur-Zorn.

5.5.7.2 Instrument

POLDIRAD is a polarization diversity Doppler weather radar operating at C-band. Fig. 5.40 presents the set up of POLDIRAD and

Table 5.14 its specifications. Its capability to perform polarimetric measurements makes it very valuable for understanding of precipitation microphysics. It was operated in synergy of airborne instrumentation, the instrumentation at other Supersites, as well as with mobile DOW X-band radars.

Fig. 5.40 Set up of Poldirad at measurement site.

Table 5.14 Specifications of Poldirad

Technical Characteristics	
Frequency	5.503 GHz
Wavelength	5.45 cm
Transmit Power	250 kW
Pulse Rep. Freq.	400 - 1200 Hz
Pulse Width	1.0, 2.0 μs
Beam width	1.0 °
Max. Range	300 km
Scan speed	2 rpm max
Products	Reflectivity, Doppler velocity, Diff. reflectivity, Depolarization ratio, Different. phase, Correlation coefficient

5.5.7.3 Operation

From the Poldirad site, excellent overlap was achieved nearly along a line of Supersites R, H, and M. This permitted many synergetic observations. For instance, retrievals of precipitation microphysics using Poldirad and MRR will be possible over all these Supersites. Fig. 5.41 presents the corresponding overlap between Supersites and Poldirad measurements. Fig. 5.42 and Fig. 5.43 present the possible coverage of dual Doppler measurements at two heights.

Poldirad was operated from June 4th to August 31st. Poldirad requires manual operation and at least two persons had to be present at the radar site. Therefore, a continuous operation was not possible. Operation times depended on the weather situation. A daily operation from 6 to 16 UTC was typically possible. Depending on weather forecast or selected COPS missions, Poldirad was operated during additional times.

Even though Poldirad offers flexible and adaptive scanning patterns, experience from past field campaigns shows that for the homogeneity of the data a more strict scanning strategy is more appropriate and will facilitate data evaluation. A scan repetition rate of 10 minutes was therefore used. Graphics showing the reflectivity field of the volume scan and of the RHI as well as the VAD wind profile were transferred in real-time to the OC.

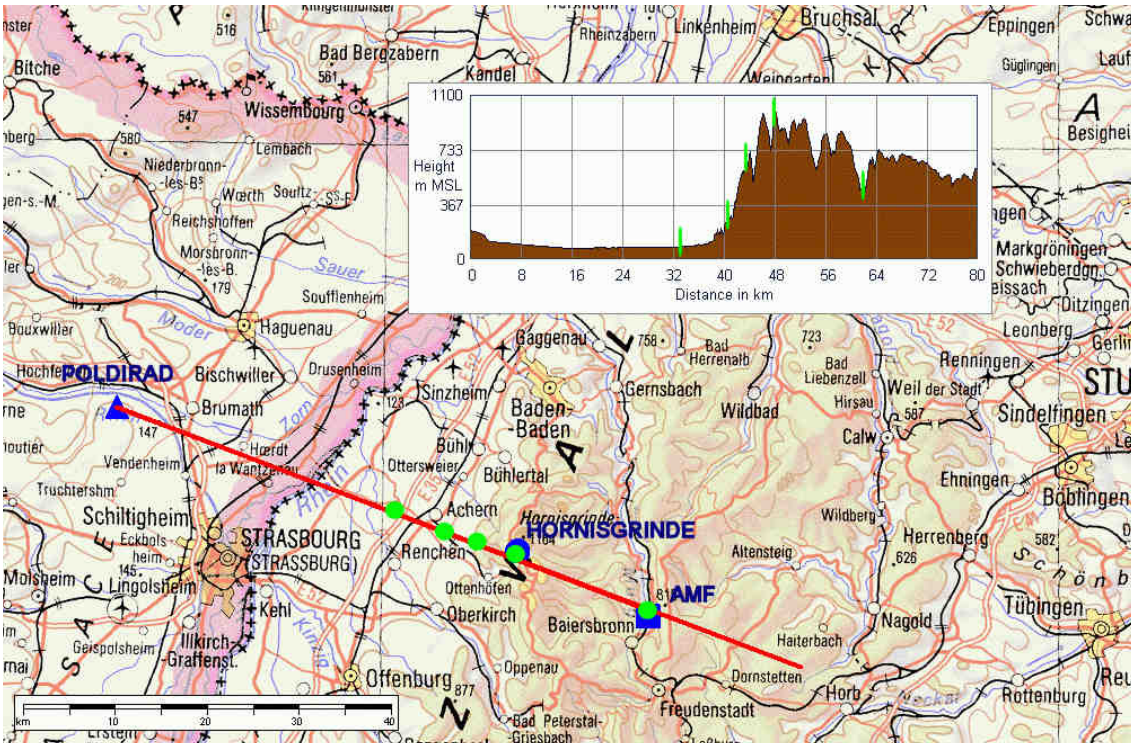

Fig. 5.41 Overlap between MRRs at Supersites and POLDIRAD.

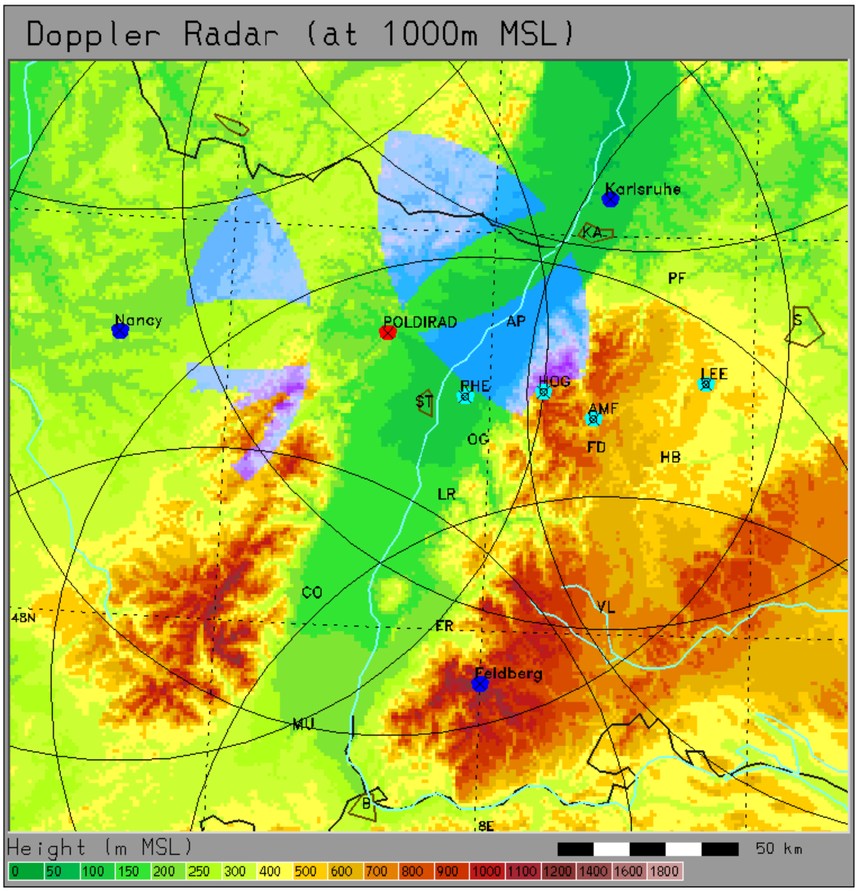

Fig. 5.42 . Dual Doppler overlap (indicated in blue) between POLDIRAD, weather radars, and IMK radar at 1000 m MSL.

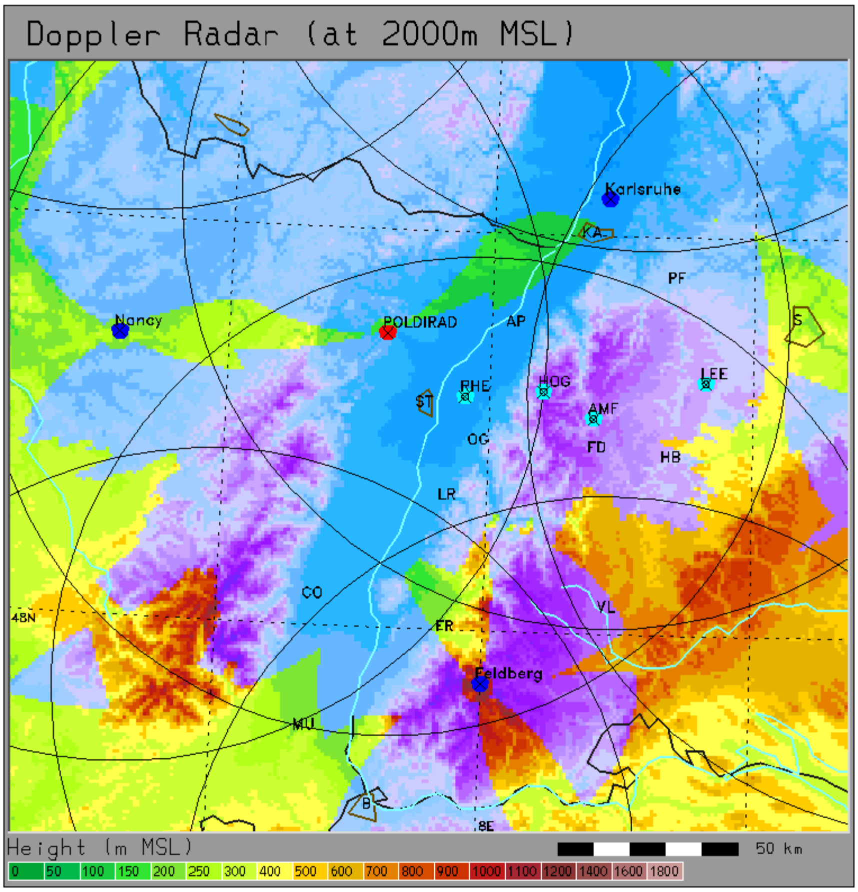

Fig. 5.43 Same as Fig. 5.42 but for 2000 m.

5.6 Mobile Teams

5.6.1 Drop up sonde teams

PI and team leader for the operation of the 5 drop-up-sonde teams are

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E-Mail: holger.mahlke@imk.fzk.de

The Institute for Meteorology and Climate Research was contributing with 5 mobile drop-up-sonde teams (3 persons per team), which were launching upgraded radiosondes in the northern Black Forest under and close to the location of developing convective systems in regions permitted by German Air Traffic Control (ATS; Deutsche Flugsicherung, DFS). Strong coordination with aircraft operation in these regions was very important. Table 5.15 summarizes the pre-selected possible launching locations and Fig. 5.44 and Fig. 5.45 present their positions on road maps. The coordinator of these teams was Ulrich Corsmeier. The team leader in the field was Holger Mahlke.

The 5 teams performed drop-up launches in the northern Black Forest where initiation of convection was expected. The weight of the sondes is about 1400 g, the weight of the whole system is 1800 g. Maximum launch height is 12000 m above sea level. At this height, the sondes are separated from the balloon and they are gliding with a parachute to the ground. Shortly before landing, a GSM signal is sent so that the team can locate the position of the sonde on ground by the precision of about 20 meters. Afterwards, the sondes are recovered by the team and the measured data are saved.

There were five operating teams with five to six sondes each. Depending on the weather situation, in the morning of every IOP each team was positioned at one of the 73 possible stations (see map). These stations were normally fixed for the day of the IOP. Only in case of a significant change of the meteorological situation the teams could relocate their positions and move to another pre-selected site. At four of the five stations a 4 m high meteorological tower was additionally installed, to measure the basic meteorological parameters and precipitation during the day. The teams could launch their sondes in a time-lag of 30 minutes. The operation times ranged between 10 and 22 LT. The number and the frequency of operation days was strongly dependent on the success of the teams in recovering preparing the launched sondes. From IOP to IOP there were also less than 5 teams active and less than 5 sondes launched by each team.

Table 5.15. Selection of locations for drop-up sonde launches. Launching at the stations 33-36 was not possible without special permission on IOP – basis from DFS.

Station	Road	Lat. (N)	Lon. (E)	Name	Distance
				Sinzheim - Offenburg	
1	B 3	48°45'21"	08°09'55"	Sportplatz Sinzheim	0 km
2	B 3	48°42'24"	08°08'35"	Landwirtsch. Weg vor Bühl	6 km
3	B 3	48°40'21"	08°07'08"	Parkplatz Firma Hogg	5 km
4	B 3	48°37'42"	08°03'36"	Parkplatz Lidl Achern	8 km
5	B 3	48°35'00"	08°00'20"	Parkplatz Getränke Kloos	7 km
6	B 3	48°32'33"	07°58'41"	Parkpl. Minimal Appenweier	5 km
7	B 3	48°29'09"	07°56'58"	Firma ETG vor Offenburg	7 km
				Kniebis - Baden-Baden	
8	B 28	48°28'27"	08°17'42"	Parkplatz Skilift Kniebis	0 km
9	B 500	48°29'13"	08°16'25"	Parkplatz "Zimmerholz"	3 km
10	B 500	48°31'19"	08°13'09"	Parkplatz "Schurkopf"	6 km
11	B 500	48°33'41"	08°13'22"	Parkplatz Skilift Ruhestein	6 km
12	B 500	48°35'44"	08°13'04"	Parkplatz Skilift Seibelseckle	5 km
13	B 500	48°37'45"	08°12'27"	Parkplatz Skilift Untersmatt	7 km
14	B 500	48°39'49"	08°14'19"	Parkplatz Kurhaus Sand	6 km
15	B 500	48°43'20"	08°14'32"	Bushaltestelle Malschbach	10 km
				Freudenstadt - Gernsbach	
16	B 462	48°29'35"	08°22'39"	Aldi Parkplatz Friedrichstal	0 km
17	B 462	48°32'37"	08°23'58"	Parkplatz Karl-Transporte	7 km
18	B 462	48°37'14"	08°21'23"	Murgschleuse	11 km
19	B 462	48°41'31"	08°21'33"	Parkplatz "Montana Forbach"	11 km
20	B 462	48°44'45"	08°20'52"	Bahnhof Oberstrot	7 km

				Freudenstadt - Calmbach	
21	B 294	48°28'01"	08°26'17"	Freudenstadt N. "Brand-weg"	0 km
22	B 294	48°31'04"	08°25'46"	Gerodete Waldlichtung	8 km
23	B 294	48°35'06"	08°25'12"	Wiese	7 km
24	B 294	48°37'32"	08°27'59"	Waldlichtung	8 km
25	B 294	48°39'54"	08°32'52"	Campingplatz Rehmühle	9 km
26	B 294	48°42'09"	08°33'47"	Forellenpark Kleinenztal	5 km
27	B 294	48°45'31"	08°35'06"	Grillplatz (Schaukel)	7 km
				Gernsbach - Bad Wildbad - Calw- Nagold - Altensteig - FDS	
28	L 76 B	48°44'15"	08°21'54"	Rastplatz nach Weisenbach	0 km
29	L 76 B	48°43'31"	08°25'19"	"SOS" Richtung Wildbad	8,7 km
30	L 351	48°41'42"	08°30'39	Wiese	9,6 km
31	L 351	48°45'47"	08°33'15"	Parkplatz Ritz Spedition	9,7 km
32	B 296	48°44'27"	08°38'51"	Sportplatz links	9,5 km
33	B 296	48°43'46"	08°43'56"	Sportplatz nach Hirsau	8,4 km
34	B 463	48°41'33"	08°43'55"	Wiese nach Kentheim links	6,1 km
35	B 463	48°39'41"	08°43'36"	Parkplatz rechts	5,1 km
36	B 463	48°37'46"	08°44'28"	Nach Wildberg links	7,6 km
37	B 463	48°33'30"	08°43'28"	Digel Fabrik / Aldi	9,2 km
38	B 28	48°34'40"	08°41'19"	Parkplatz Ensseln Büroei-nrichtung	7,3 km
39	B 28	48°35'49"	08°37'35"	1a Autoservice	6,6 km
40	B 28	48°33'56	08°35'04"	Wiese Richtung Spielberg	7,5 km
41	B 28	48°31'19"	08°32'30"	Rechts Richtung Waldsägmühle	6,5 km
42	B 28	48°28'34"	08°28'47"	Rechts Wiese Clubhaus	7,7 km
				Offenburg - Gegenbach - Wolfach - Alpirsbach - FDS - Oberkirch - Appen-	

				weier	
43	B 33	48°26'35"	07°57'17"	Rechts an B33 (Erdbeer-feld)	0 km
44	B 33	48°21'06"	08°01'03"	Parkplatz rechts an B 33	12,9 km
45	B 33	48°18'30"	08°03'23"	Ausfahrt Steinach, Parkpl. unter B33	6,6 km
46	B 294	48°16'44"	08°07'12"	Parkplatz nach Haslach	7,1 km
47	B 294	48°17'05"	08°11'33"	An Umspannwerk rechts	6,4 km
48	B 294	48°17'28"	08°16'01"	Wiese Notrufparkplatz	7,7 km
49	B 294	48°17'29"	08°21'06"	Schiltach Normaparkplatz	8,0 km
50	B 294	48°19'02"	08°23'17"	Nach Schenkenzell rechts	5,0 km
51	B 294	48°22'12"	08°24'42"	Wiese Bushaltestelle Unte-rehlen	7,3 km
52	B 294	48°24'50"	08°27'02"	Parkplatz in Loßburg	7,6 km
53	B 28	48°27'10"	08°23'22"	Links B 28 Waldwiese	10,8 km
54	B 28	48°27'27"	08°15'25"	Wanderparkplatz "Ren-chtalblick"	13,2 km
55	B 28	48°26'55"	08°13'46"	Bahnhof Bad Griesbach	4,9 km
56	B 28	48°25'47"	08°11'14"	Parkplatz nach Bahnvia-dukt	5,1 km
57	B 28	48°28'03"	08°09'46"	Parkpl. Gasthof Finken in Oppenau	5,4 km
58	B 28	48°31'08"	08°07'01"	Parkplatz Bahnhof Lauten-bach	7,3 km
59	B 28	48°32'06"	08°03'18"	Oberkirch Zentr. Wiese	5,7 km
60	B 28	48°31'57"	07°57'21"	Parkplatz vor A 5 rechts	9,0 km
				Alpirsbach - Horb - Wal-dachtal	
61	L 415	48°20'47"	08°25'31"	Nach Alpirsbach rechts runter	0 km
62	L 410	48°20'51"	08°29'30"	Vor Busenweiler rechts	6,2 km
63	L 410	48°21'46"	08°31'47"	Im Wald rechts ab (Teer-weg)	5,2 km
64	K 5508	48°22'20"	08°34'47"	Kurz vor Ortsausgang Hopfau rechts	5,2 km
65	K 5508	48°23'21"	08°37'54"	Nach Glatt rechts in Feld-weg	4,9 km
66	B 14	48°25'49"	08°39'42"	In Ihlingen rechts in Ne-	7,0 km

				ckartalweg	
67	L 370	48°27'07"	08°40'02"	Kleiner Feldweg links	8,5 km
68	L 370	48°27'01"	08°35'17"	Beim Schild "Bittelbronn 1km"	6,4 km
69	B 28 a	48°28'22"	08°30'30"	Rechts in Gresbacherstr.	7,0 km
				Horb - Nagold	
70	B 14	48°27'03"	08°42'09"	Nach Horb Parkplatz "Rauschbart"	0 km
71	B 463	48°28'42"	08°43'16"	Kurz vor Kreuzung zur K 4718	4,2 km
72	B 463	48°30'08"	08°42'38"	Nach Hochdorf bei SOS-Säule links	4,2 km
73	B 463	48°31'37"	08°43'20"	Kurz nach Friedhof links in Feldweg	4,2 km

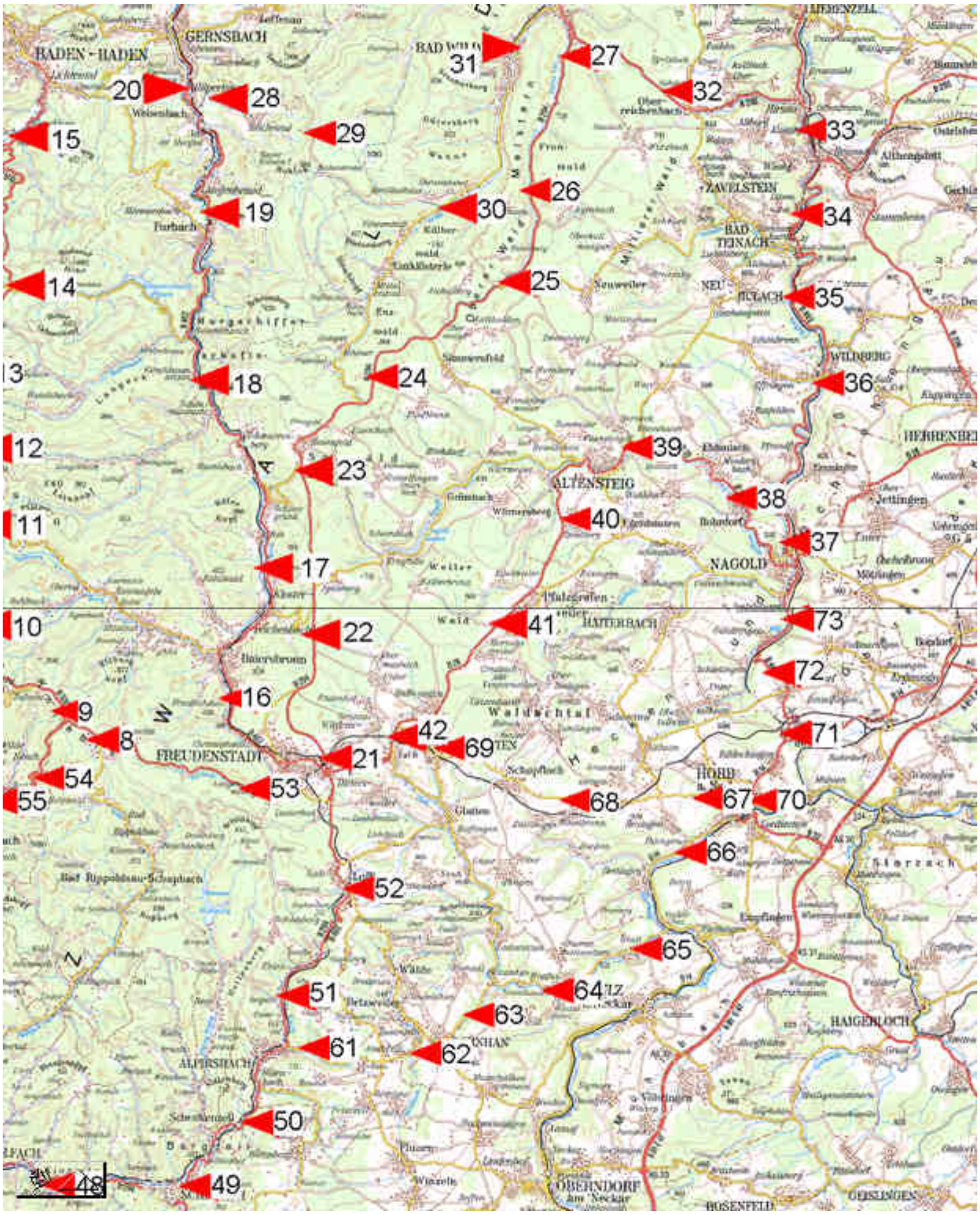

Fig. 5.44 Overview of pre-selected stations: eastern part of the northern Black Forest .

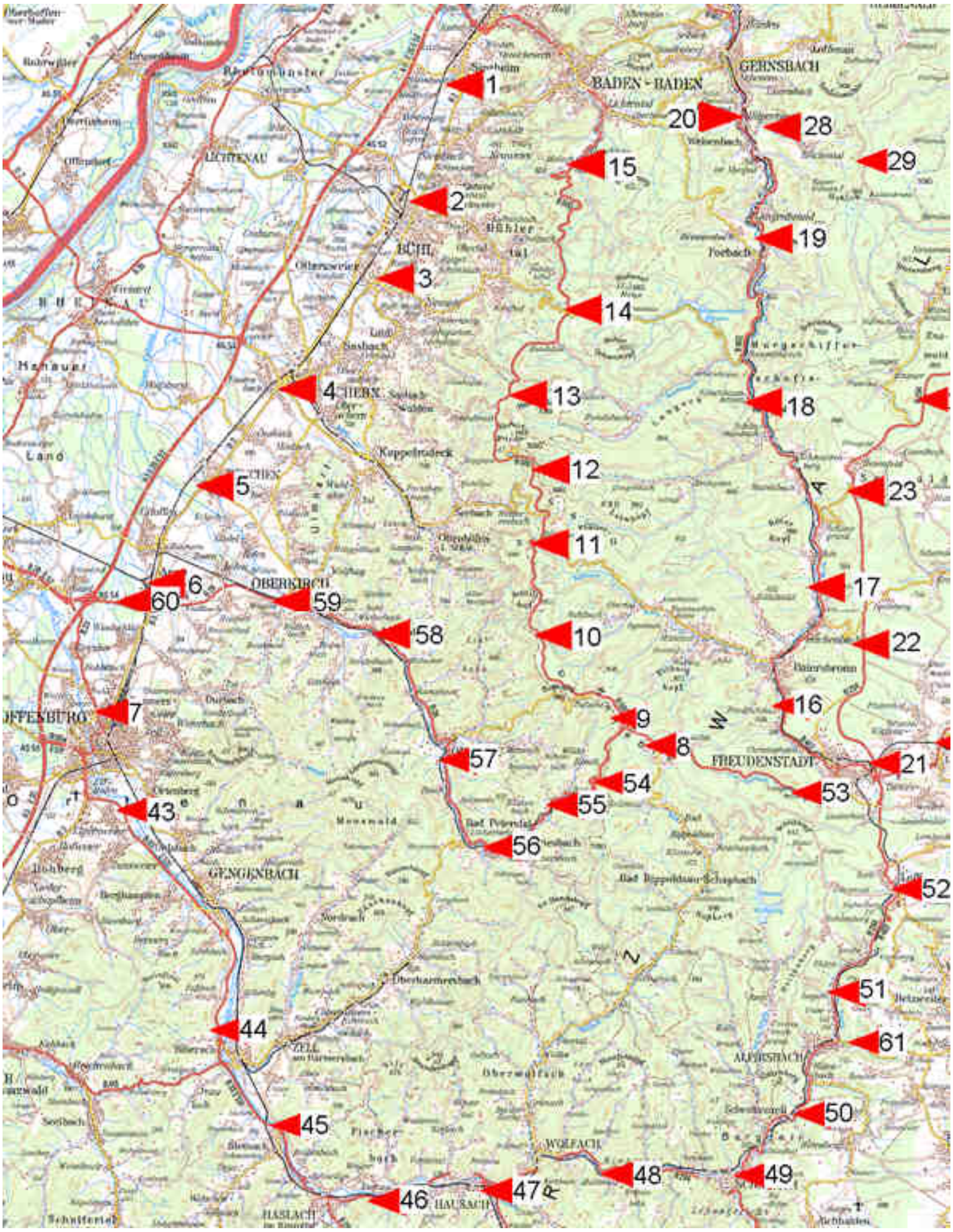

Fig. 5.45 Overview of pre-selected stations: western part of the northern Black Forest.

5.6.2 Doppler-on-Wheels

PIs for the operation of the Doppler-on-Wheels are

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The DOWs are X-band mobile Doppler radars. Radial velocity, reflectivity and spectral width data are the primary radar products. The DOWs can detect air motions in clear air out to ranges of about 50 km in the summer. The DOWs can collect data within one minute of arrival at a site, although typical setup times are 5-10 minutes.

Monitoring winds, water-vapor, and cumulus cloud development prior to precipitation growth over the ridge lines is required as part of the basic studies into storm initiation. Retrieved wind fields using two DOWs, along with Poldirad (see Fig. 5.46), shall foster better understanding of convection initiation and precipitation processes. In particular, the high-resolution DOWs are the only means for obtaining the 3-D wind flow at low levels near the mountains, on the opposite side of the mountains, and in the mountain gaps.

A site survey for DOW operations was already performed in December 2006 and repeated in May 2007. We focused on the windward and lee sides of the Hornisgrinde and Feldberg peaks. The extensive trees and complicated topography made the identification of ideal radar sites with clear horizons toward the peaks challenging. However, 15-20 very good sites for both single and dual-Doppler operations were found.

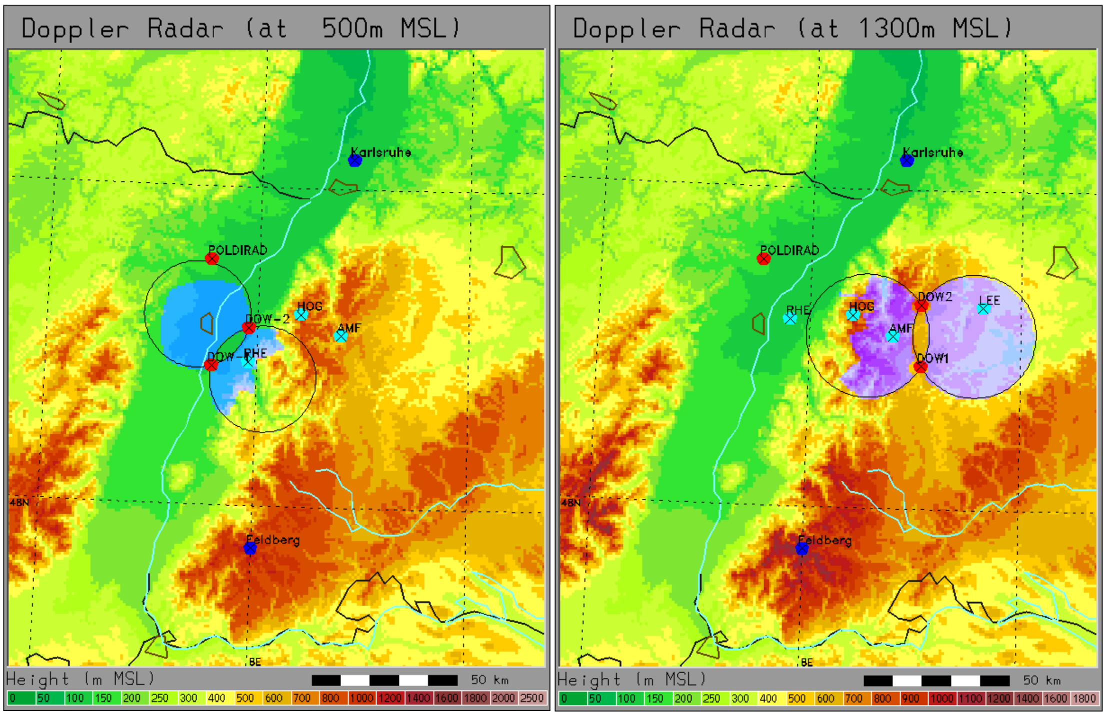

Fig. 5.46 Color-contoured topographic map of the locations for two DOWs and Poldirad. Circles indicate 30 deg between-beam-angle dual-Doppler lobes for the DOWS (a) at sites near Poldirad and (b) at sites in the lee of the Black Forest. Blue (low terrain) and purple (high terrain) colors within the circles indicate the regions of retrievable dual-Doppler data at (a) 0.5 km MSL and (b) 1.3 km MSL and above. ARM Mobile Facility (AMF) site is shown as a blue dot. Likely Supersite location (HOG) is shown as a blue dot. Figures courtesy of Martin Hagen (DLR).

For some of the experiments, the DOWs have been closely coordinated with Poldirad so that high resolution 4-D wind observations could be obtained over many of the instrumentation sites in the northern Black Forest region. Additionally the DOWs had alternative sites in the southern Black Forest to obtain critical clear-air dual-Doppler measurements in the Feldberg area when convection was forecasted in this region. For other missions, the DOWs were located close to the mountains or within valleys in order to provide high-resolution low-level winds in that area. Furthermore, the DOWs could be located on the leeward side of the Black Forest so that dual-Doppler winds were available on both sides to assess the influence of the terrain on convection initiation and/or ongoing convection.

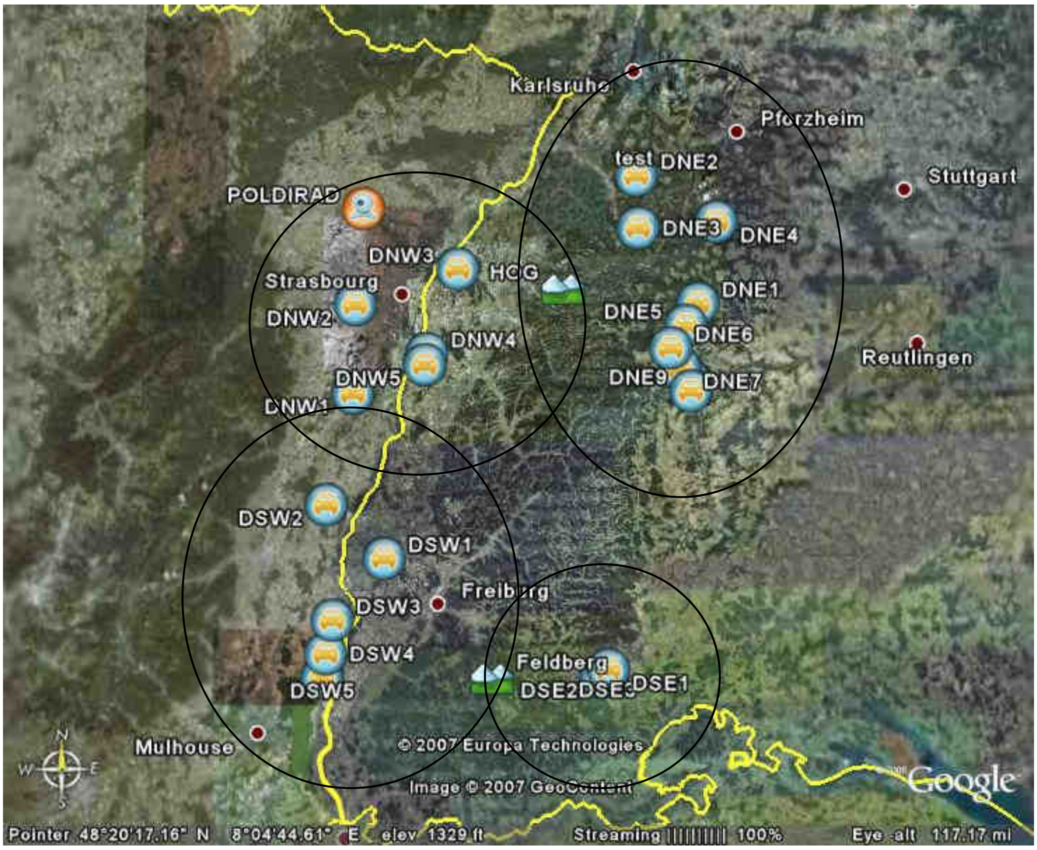

Fig. 5.47 *Potential DOW sites (marked with D**# labels) as determined by a site survey in December 2006. The sites were partially chosen to obtain upwind and downwind measurements on Hornisgrinde (HOG) and Feldberg peaks. Approximate DOW coverages extending ~30 km from the four groups of potential sites are shown.*

Fig. 5.47 shows potential DOW deployment locations. These locations were chosen based upon minimal blockage, optimum viewing of likely convection initiation locations, dual-Doppler scanning potential and coordination with other instrumentation. Measurements at these locations provided unique support for reaching the COPS science goals with respect to the detection and understanding of convection initiation. As far as possible, DOW measurements werte obtained in regions where other instrumentation was fielded to increase the potential for integration of datasets.

5.7 Aircraft

5.7.1 Overview

Responsible for the flight coordination were

Ulrich Corsmeier (FZK. Ulrich.corsmeier@imk.fzk.de) and Heinz Finkenzeller (DLR, Heinz.finkenzeller@dlr.de).

Fig. 5.48 presents an overview of the participating aircrafts. The unique combination of aircrafts with key measurement properties became possible due to the collaboration between COPS and TRACKS.

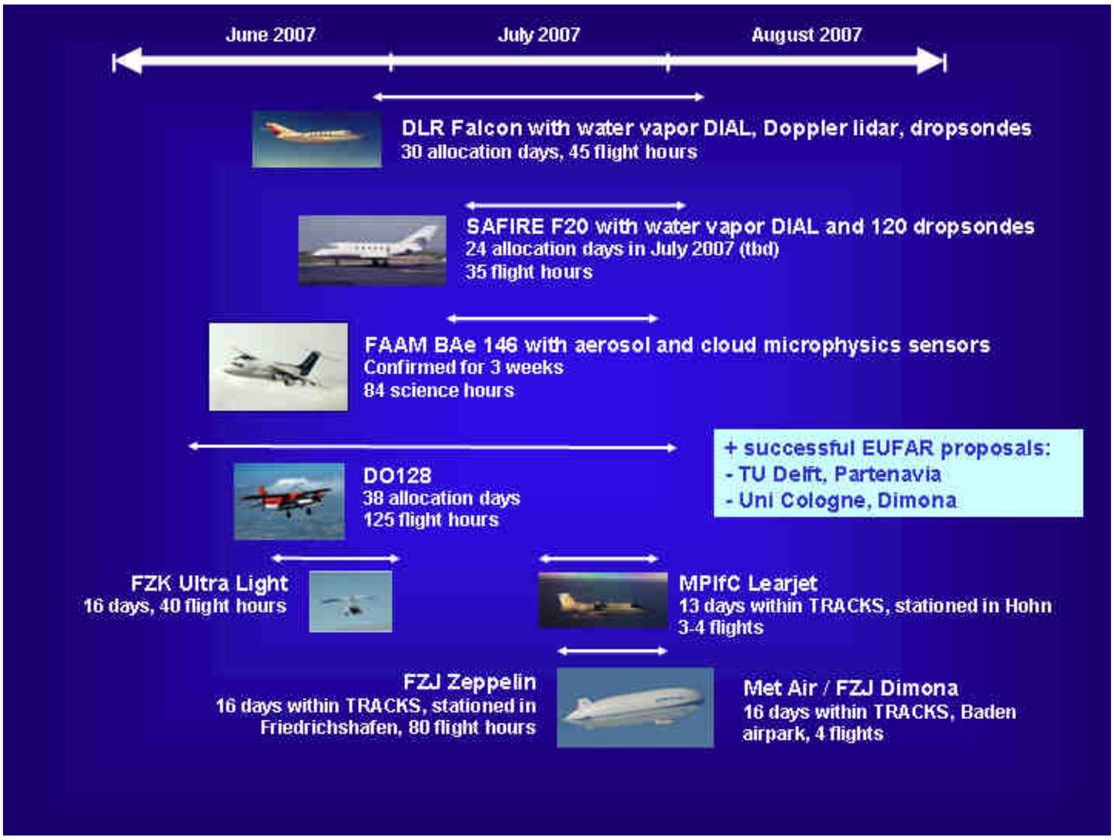

Fig. 5.48 Aircrafts participating in COPS and TRACKS and their availability periods.

Table 5.16 presents an overview of the participating aircrafts and their operation times. It demonstrates that the most active month with respect to aircraft operations was July 2007.

It can be distinguished between aircraft suitable for clear air measurements and aircrafts, which are capable to fly in clouds and precipitation. To the second category belong the BAE 146 and the Learjet. All other aircraft was dedicated to fly in pre-convective environment or around convective systems.

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Table 5.16 COPS and TRACKS aircraft overview with location of aircrafts and contacts.

Aircraft and location	PI	Range, km	Height, km	Operation times, flight days, flight hours	Endurance , h Speed , m/s	Key instruments except standard meteorology	Resolution and accuracy	Expected contributions to COPS WGs	Expected contributions to Phase 1-4	Contributions to other projects linked with COPS
DLR Falcon, Oberpfaffenhofen	Gerhard Ehret, Christoph Kiemle Gerhard.Ehret@dlr.de Christoph.Kiemle@dlr.de	2200-3000	4-12	28.06.-05.08. 30 days 45 h	4 150-200	WV DIAL Doppler lidar, 57 dropsondes	see instrument description	CI, ACM, DAP	1 – 3	ETReC07, D-PHASE
SAFIRE Falcon Baden Airpark	Cyrille Flamant Cyrille.Flamant@aero.jussieu.fr Paolo Di Girolamo (via EUFAR) digirolamo@unibas.it	2250	5-6 Level 150	10.07. - 02.08. 24 days 35 h	3:45 h 165-175	WV DIAL 80 dropsondes	See instrument description	CI, ACM, DAP	1 - 3	D-PHASE, EUFAR
DO-128 Baden Airpark	Ulrich Corsmeier Ulrich.Corsmeier@imk.fzk.de	800	Up to 7	11.06.-31.07. 35 days 125 h	3.5 65	Tracer, radiation, fluxes	see instr. description	CI, ACM	1 – 3	TRACKS
BAe 146 Baden Airpark	Alan Blyth, Stephen Mobbs, Phil Brown blyth@env.leeds.ac.uk	tbd	Up to 8	9.07 – 27.07. 84 h	5 100	Extensive aerosol and cloud micro-physics	see instr. description	CI, ACM, PPL	1 - 3	TRACKS
Learjet 35A Hohn	Horst Fischer, Mark Lawrence hofi@mpch-mainz.mpg.de lawrence@mpch-mainz.mpg.de	~1600	Up to 13 (level 400)	16.07.-28.07. 3-4 flights	3 ½ (4 h prep. time) tbd	Photochemistry	see instr. description	CI, ACM	1 – 4	TRACKS

Zeppelin NT Baden Airpark	Frank Holland, Andreas Hofzumahaus F.Holland@fz-juelich.de a.hofzumahaus@fz-juelich.de	550	0.02 – 1.0	16.07.-31.07. 80 h	10 0-25	Photochemistry	see instr. description	CI, ACM	1 - 2	TRACKS
UltraLight Schmidtler Enduro Baden Airpark	Rainer Steinbrecher, Wolfgang Junkermann Rainer.Steinbrecher@imk.fzk.de Wolfgang.Junkermann@imk.fzk.de	500	0.02 - 4.5	15.06.-30.06. 8 days 4-5 h/day VFR condition	6 25	Radiation, Aerosol microphysics, turbulence, fluxes	10 %	CI, ACM	1 – 2	TRACKS
METAIR DIMO Baden Airpark	Bruno Neininger, Heiner Geiß bruno.neininger@metair.ch h.geiss@fz-juelich.de Jan Schween (via EUFAR) Jan.Schween@uni-koeln.de	800 km	< 4	16.07.-31.07. 4 days	4 – 5, 40	Photochemistry Tracer, Wind & Turbulence + standard meteorology	see www.metair.ch/ SYSTEMS.htm Or EUFAR pages	CI, ACM	1 – 2	TRACKS, EUFAR
SAFIRE ATR-42, Baden Airpark (per EUFAR)	Yann Dufournet (via EUFAR) y.dufournet@irctr.tudelft.nl	At 4000m: 3000	0.1 – 7.5	20.07.-29.07. 10 days, 10 h	6 h (max) 70 - 134	Two PMS-2DC probes FSSP 100 Gerber PMV100	See www.safire.de - instrumentation	ACM, PPL		EUFAR
ENVISCOPE PARTENAVIA, Baden Airpark, (per EUFAR)	Christine Brandau (via EUFAR) c.brandau@irctr.tudelft.nl	1000	Up to FL120	02.07.-31.07. 3-4 days, 7 - 8	4 – 5 60	Aerosol and cloud microphysics	See www.enviscope.de	ACM, PPL		EUFAR

5.7.2 DLR Falcon with novel water vapor and wind lidars

5.7.2.1 Communication

PI of this aircraft is Gerhard Ehret (Gerhard.ehret@dlr.de, +49 (0)8153 28-2509). Base of aircraft operations was Oberpfaffenhofen. This is mainly because the in-situ instrumentation and the lidar payload required extensive equipment and personnel for calibration and maintenance. The ferry flights to/from the COPS region were used for ascent/descent which minimized the loss of operation range. 132.225 MHz was the reserved frequency for direct communication with the pilots during flight. In addition, an IRIDIUM mobile phone (881621464884) was on board.

5.7.2.2 Aircraft properties

The particular strength of the Falcon aircraft is its high flexibility and the possibility to quickly sample a representative area in heterogeneous situations over complex orography extending up to synoptic scales. The latter allows capturing the humidity advection from across a larger area into the region of interest. The meteorological research aircraft Falcon 20 (D-CMET) operated by the German Aerospace Center (DLR) is a well established research platform for more than 20 years. It provides two large optical windows (diameter 40 cm) in the fuselage at the bottom which can be used as transmitting and receiving ports for both lidar systems. The Falcon has a maximum endurance of 5 h carrying a payload of 1100 kg and a maximum operating altitude of 42000 ft (12.8 km). Due to the modifications (windows for LIDAR measurements nadir and zenith viewing) and the excellent range/height performance, the DLR Falcon is a unique airborne European platform suitable for the proposed experiment (see Table 5.16).

5.7.2.3 Instrumentation

During COPS, a novel combination of wind and water vapor lidars was operated. From the combination of both water-vapor DIAL and Doppler wind lidars on the Falcon, aircraft measurements of humidity variability and its transport throughout the troposphere and of latent heat flux profiles in the boundary layer can be obtained. For the DIAL water vapor profiles from 0.5 to 12 km altitude with 10 % accuracy the horizontal resolution is between 1 and 5 km, and the vertical resolution between 300 and 500 m, with the new four wavelength DIAL system. In the boundary layer the DIAL resolution for 5 % accuracy is comparable to the wind lidar resolution. Using a trade-off between resolution and accuracy an optimum choice can be made with respect to the scientific goals when processing the data.

The airborne DLR Doppler wind lidar system measures wind profiles beneath the aircraft using the velocity-azimuth display technique. The instrument performs a conical scan around the vertical axis at 20° off nadir. Alternatively the scanner can be switched off for precise wind measurements in one direction with higher spatial resolution, e.g. for vertical wind speed in the boundary layer.

The scanning wind lidar yields profiles between 0.5 and 12 km altitude with an accuracy of 1 m/s at a horizontal resolution of 5 to 10 km, depending on the measurements' boundary conditions. Vertical wind speed in the boundary layer is measured with an accuracy of 0.1 m/s at a horizontal resolution of 1 s or 150 m. The vertical resolution of the measurements is 100 m.

The DLR Falcon carried a device to release dropsondes. A total of 57 dropsondes was available for the COPS missions. The sondes were dropped by a lidar operator or an on-board mission scientist, if there were no more than 5 sondes per flight. If there were more, 1 additional person on-board was required. See http://www.vaisala.com/ for further information.

The DLR Falcon in-situ instrumentation measures position, pressure, wind, temperature and humidity, using GPS positions, a nose boom for wind, a chilled mirror for dewpoint and a Lyman-alpha humidity sensor. Calibration is performed on ground with special equipment. More details are found under http://www.dlr.de/fb/.

5.7.3 Safire F20

5.7.3.1 Communication

PI of this aircraft is Cyrille Flamant (cyrille.flamant@aero.jussieu.fr, +33 (0)1-4427-4872). Base of aircraft operations was airport Karlsruhe Baden-Baden (EDSB). No mobile phone wason board. All logistical matters associated with the SAFIRE F20 detachment were handled by the COPS SAFIRE coordinator, Eric Mathieu (eric.mathieu@safire.fr). The aircraft was in hangar D 416, the laboratory for crew and scientists is in building E 207 of Baden Airpark.

5.7.3.2 Aircraft properties

The SAFIRE F20 was operated between 10 July and 2 August 2007. The Falcon 20 is available for research experiment since the beginning of 2006. It is an original Dassault Falcon 20 GF specially modified to scientific use. It is registered as F-GBTM. During COPS it was operated from a fairy low flight altitude (FL 140-160, ~5 km) for a duration of about 4 h (see Table 5.16 for other specifications). It may embark a scientific payload (normal operation) of 1200 kg, which for COPS consisted of the DIAL LEANDRE 2, an AVAPS dropsonding system and in situ measurements. Apart from the pilots, the crew on-board consisted of two persons dedicated to the operation of LEANDRE 2 (including the LEANDRE 2 PI), and a SAFIRE expert (also operating dropsondes).

5.7.3.3 Instrumentation

During COPS, the water-vapor DIAL jointly developed by IPSL with the technical support of INSU and the financial support of CNES was operated onboard the SAFIRE F20. The water-vapor DIAL LEANDRE 2 contributed to the airborne measurements of humidity variability and transport throughout the lower troposphere in a 170 km x 250 km box comprising the Vosges and the Black Forest. Water vapor profiles are retrieved from 0.5 to 5-6 km altitude with 10 % accuracy. The horizontal resolution is between 1 and 5 km, and the vertical resolution between 300 and 500 m.

Trade-off between resolution and accuracy an optimum choice can be made with respect to the scientific goals when processing the data.

The SAFIRE F20 carried a device to release dropsondes. A total of 80 dropsondes was available for the COPS missions. The sondes are dropped by a dedicated operator. However, during COPS dropping was not allowed in France, and was limited to restricted areas in Germany. The complete list of instruments is given in Table 5-16.

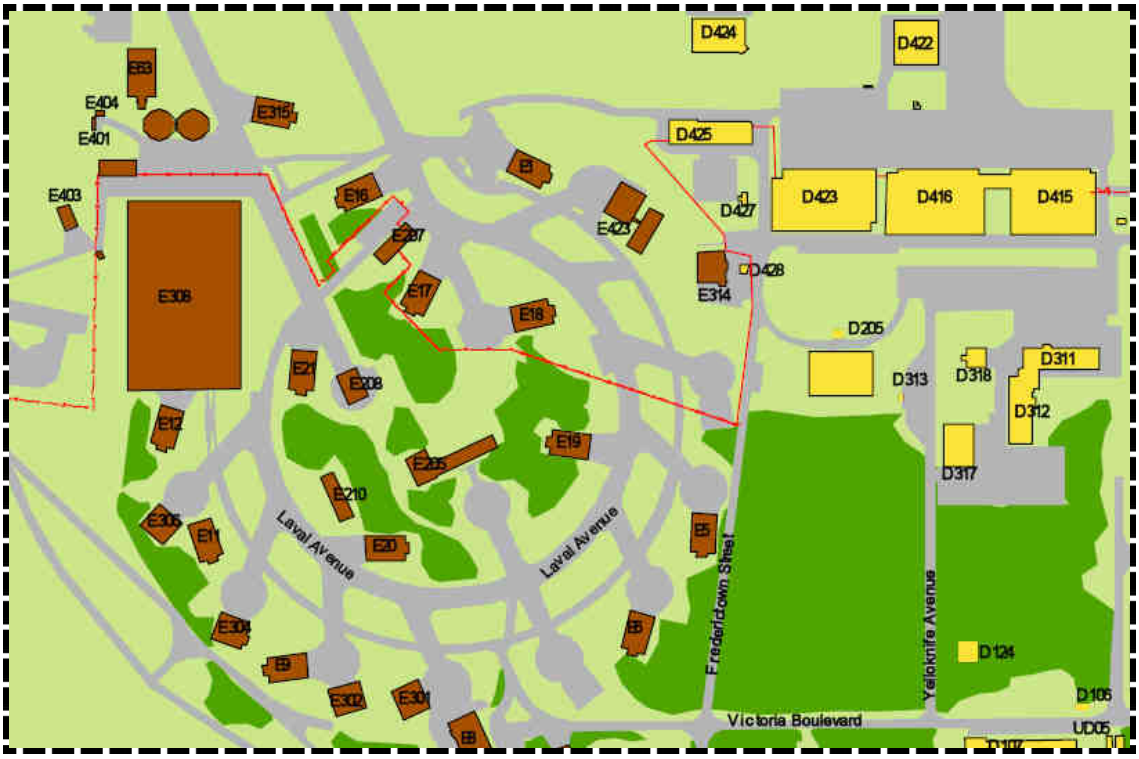

Fig. 5.49 Location of Safire F20 at Baden Airpark

Table 5.17 Measurements on-board the SAFIRE F20

General Eastern dew point sensor 1011B	Dew point	SAFIRE
INS, GPS	Position, winds, u,v,w	SAFIRE
Rosemount	Temperature T	SAFIRE
Aerodata humidity sensor	Relative Humidity	SAFIRE
AVAPS dropsondes	Vertical profiles of dynamical variables	SAFIRE
Pygreometers and Pyranometers (Up/down)	Upwelling/Downwelling, Vis/IR Broadband radiation	SAFIRE
Multichannel thermal infrared radiometer (CLIMAT)	Brightness temperature	SAFIRE
Differential absorption lidar LEANDRE 2	2D water vapor field (below the a/c)	IPSL

5.7.4 DO 128 research aircraft

5.7.4.1 Communication

PI of this aircraft is Ulrich Corsmeier.

Ulrich Corsmeier

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Tel: 0179 8062365 (mobile)

E-Mail: ulrich.corsmeier@imk.fzk.de

Contact PI and aircraft crew via

COPS OP: +49-(0)7229-66-2550 or +49-(0)7229-66-2551

132.225 MHz is the reserved frequency for direct communication with the pilots during flight. In addition, an IRIDIUM mobile phone (+881631814308) was on board. The DO 128 aircraft was located at airport Karlsruhe Baden-Baden (EDSB) in hangar D 416, the laboratory for crew and scientists was in building E 207 (GAT-building, rooms 4 and 5) .

5.7.4.2 Aircraft properties

The Dornier 128 aircraft, D-IBUF, participated in COPS within the timeframe from June, 11th to July, 31st ; in total 125 flight hours (100 h on the COPS project and 25 h on the TRACKS project). The research aircraft DO 128 was operated by the Institute of Flight Guidance and Control of the University of Braunschweig in cooperation with IMK scientists from the University of Karlsruhe and the Forschungszentrum Karlsruhe. The aircraft is an excellent platform for making measurements of the thermodynamics, dynamics and chemical species in the boundary layer and the lower and middle troposphere up to a height of approx. 7 km. The DO 128 has a low operating speed of 65 ms^{-1}, it is powerful and flexible, and it is equipped with state-of-the-art instrumentation that is specially designed for boundary-layer studies. Additionally, the DO 128 aircraft is the platform for dropping upgraded radiosondes (see section 5.6.1) within the dropping areas A and B from FL 220. During one flight dropping of up to 30 sondes within 30 minutes is possible.

5.7.4.3 Instrumentation

Meteorological in-situ measurements were made of temperature, humidity, pressure, the 3-dimensional wind vector, and long- and short-wave radiation from the sky and from the surface. The aircraft is also equipped with a scanning (+/- 22.5 degrees) infrared thermometer for detecting the temperature of the Earth's surface. In addition, the forward-looking camera was useful for documenting the convection scenarios which are under investigation in COPS. Air chemical instrumentation for the measurement of O_3, CO, CO_2, NO, NO_2, PAN and some NMHC compounds was on board as well. Air quality in convective systems was measured during the COPS integrated project COPS-TRACKS. The full list of instruments on the DO 128 is given in the Table 5-17. The aircraft was based together with the other airborne facilities at the airport Karlsruhe Baden-Baden (EDSB).

Table 5.18 Scientific equipment of the research aircraft DO 128, D-IBUF

Parameter	Probe, Sensor, Equipment
Static, dynamic and differential pressure	Rosemount 5-Hole Probe
Static, dynamic and differential pressure	Rosemount 1221, 1201 Pressure Transducers
Position and speed	Novatel Differential GPS-Receiver
Height	Optech 501 Laser Altimeter
Pitch, bank, yaw, angular velocities, acceleration, INS-position, ground speed	Honeywell Lasernav
Radar height	Sperry Radar Altimeter
Surface temperature of the earth	KT19 sensor
Humidity of air (fast sensor)	Lyman-Alpha Sensor, 100 Hz sampling
Temperature of air	Rosemount PT 100 Sensor
Temperature of air	Open wire Rosem. PT 100 Sensor, 100 Hz sampling
Humidity of air	Aerodata-Humicap
Humidity of air	Meteolabor Dew Point Mirror TP 3
Wind (horizontal)	5-hole-probe; GPS; 100 Hz sampling
Wind (vertical)	5-hole-probe; 100 Hz sampling
Radiation	Kipp & Zonen Pyranometer CM 22
Radiation	Kipp & Zonen Pyrgeometer CG 4
O_3	Environment O_3 41M (UV-Absorption)
O_3	Fast ozone sensor (Chemiluminescence)
NO	NO_xTO_y with CrO3 (Luminol-

	Chemilum.)
NO_2	NO_xTO_y (Luminol-Chemilum.)
NO_y	NO_xTO_y Mo/CrO3 at heated intake (Luminol-Chemilum.)
PAN	NO_xTO_y (CrO3/heat) (Luminol-Chemilum.)
CO	AL 5001 (Resonance fluorescence)
CO_2	LI-COR 6252 (IR-Absorption)
Temperature, Humidity, pressure, wind	Dropsondes (up to 30 sondes)

5.7.5 FAAM BAe 146

5.7.5.1 Communication

The PIs of this aircraft are Alan Blyth (blyth@env.leeds.ac.uk), Stephen Mobbs (stephen@env.leeds.ac.uk) and Phil Brown.

5.7.5.2 Aircraft properties

The aircraft is described on www.faam.ac.uk). The FAAM BAe 146 is a collaboration between the UK Met Office and the Natural Environment Research Council (NERC). FAAM has been established as part of the National Centre for Atmospheric Science (NCAS) to provide an aircraft measurement platform for use by all the UK atmospheric research community on campaigns throughout the world. The BAE 146 aircraft is owned by BAE Systems and operated for them by Directflight. Applications include:

Radiative transfer studies in clear and cloudy air

Tropospheric chemistry measurements

Cloud physics and dynamics studies

Dynamics of mesoscale weather systems

Boundary layer and turbulence studies

Remote sensing: verification of ground based instruments

Satellite ground truth: radiometric measurements and winds

Satellite instrument test-bed

5.7.5.3 Instrumentation

The FAAM BAe 146 wasequipped with the aerosol mass spectrometer (AMS), CCN probe, VACC (volatility) and standard cloud microphysics instruments (PCASP, Fast FSSP, 2DC, 2DP, Cloud Particle Imager and Small Ice Detector) in order to study the growth of cloud droplets, the formation and growth of ice particles and precipitation particles in the context of the detailed dynamics of the orographic convective clouds, and the detrainment of aerosols from the cloud system.

Long legs were made within the boundary layer and in the free troposphere in order to measure the aerosols and, when possible, cloud base conditions. Multiple penetrations were then made in developing orographic convective clouds at increasing altitudes in order to stay close to the ascending cloud tops to measure the development of the particles. Specific penetrations were made when possible in developed clouds in and just above the Hallett-Mossop zone (-3 to -8 C) in order to test for ice splintering with the small ice probes. Particular instruments relevant to COPS are summarized in Table 5.19.

Table 5.19 BAe 146 instrumentation

Instrument	Measurement
FFSSP	Cloud droplets
2D-C	Large cloud particles (25-800μm)
2D-P	Precip (200-6400μm)
Cloud particle imager	Small cloud particles (10-5000μm)
Small ice detector (SID2)	Small spheres vs non-spheres (2μm min.)
PCASP	Aerosols (0.1-10μm)
Aerosol mass spectrometer	Size and composition of some aerosols
Filters	Size and composition of aerosols
VACC	Volatility of aerosols
CCN	Cloud condensation nuclei
Johnson-Williams	Cloud liquid water content
Nevzerov probe	Cloud and total water
Turbulence probe	3D winds
Rosemont temperature	In-cloud temperature (cold cloud)
Hygrometer	Water vapor

The complete list of FAAM instruments can be found at: http://www.faam.ac.uk/public/instrumentation.html. Only a subset is fit on the aircraft for a single project.

5.7.6 Learjet 35A

5.7.6.1 Communication

PIs of this aircraft are Horst Fischer and Mark Lawrence. Horst Fischer (hofi@mpch-mainz.mpg.de) was responsible for the daily flight planning out of the aircrafts home base Hohn in northern Germany, while Mark Lawrence (Lawrence@mpch-mainz.mpg.de) was responsible for the coordination between Hohn and the COPS operation center in Baden Airpark.

5.7.6.2 Aircraft properties

The aircraft used is a Lear-Jet 35A, that has a maximum ceiling of 13.7 km and a max. range of 2000 km. It was operated from Hohn Airport, approx. 50 km north of Hamburg. The plan will mainly probe the convective outflow at high altitudes.

5.7.6.3 Instrumentation

The instrumentation included in-situ instruments for the quantitative measurement of OH, HO_2 (via laser induced fluorescence), NO, NO_2, O_3 (via chemoluminescence), HCHO, CO, CH_4 (via quantum cascade laser absorption spectroscopy), H_2O_2, ROOH (via dual enzyme technique), partially oxidized volatile organic compounds (via proton transfer reaction mass spectrometry), and H_2O, as well as canister and cartouche samples for offline non methane hydrocarbon analysis. Additionally, J values for NO_2 were measured via filter radiometers.

5.7.7 Zeppelin NT

5.7.7.1 Communication

PIs of this aircraft are Frank Holland and Andreas Hofzumahaus.

Dr. Frank Holland

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FAX: +49-2461-61-8186

E-Mail: a.hofzumahaus@fz-juelich.de

5.7.7.2 Aircraft properties (as envisaged during field campaign)

payload (kg)	~ 1000
endurance (h)	max. 10
max. height (m)	1500
min. height (m)	20
max. speed (km/h)	75
min. speed (km/h)	0
asc. Rate (m/s)	6

5.7.7.3 Instrumentation

OH and HO_2 (LIF)

HONO (LOPAP)

HCHO (Hantzsch)

NO, NO_2 (Chemiluminescence)

O_3 (UV photometer)

VOC (canister sampling, Online GC)

Actinic flux (SR)

Trace gas profiles of NO_2, O_3 (MaxDOAS)

Aerosol data (CPC, SMPS)

CO (resonance fluorescence)

5.7.8 METAIR DIMO

5.7.8.1 Communication

PIs of this aircraft are Bruno Neininger (bruno.neininger@metair.ch), Heiner Geiß (h.geiss@fz-juelich.de), and Jan Schween (jschween@uni-koeln.de) via EUFAR Proposal NEWVAP.

METAIR-DIMO is a very small (2-3 persons), mobile team, with no permanent internet connection (only GPRS/UMTS via Notebook). The main contact is the mobile phone of BN (+41 79 340 77 33) for voice and SMS. During flights, also the onboard system can be contacted via SMS to +41 79 542 90 81 (pop-up on the operator screen).

5.7.8.2 Aircraft properties

METAIR-DIMO with call sign HB-2335 is a TMG (Touring Motor Glider) with up to five hours endurance at speeds between 150 and 180 km/h. The appearance is a slim silhouette with long wing span (16.5m) and underwing-pods (see pictures on www.metair.ch). We exclusively operate VFR during daytime. We can enter controlled air space (radio contact and transponder), but, we do not file in detailed flight plans like the larger aircraft need for IFR procedures (we operate very much comparable with UL Enduro of IFU-IMK).

The crew consists of the pilot and the scientific operator (side by side). Especially the Lagrangian flights asked for flexible in-flight decisions, which are well established.

The numerous parameters we are measuring are listed in www.metair.ch/SYSTEMS.htm. Within TRACKS, the focus is on photochemistry (including GC for VOC's) and transport, and within NEWVAP it is on "fluxing". For the first, our flight patterns are variable (mainly horizontal transects and vertical profiles in the Rhine Valley on altitudes mainly between 300 and 500 m above round, (occasionally up to 3000 m MSL), and for NEWVAP we operated in the Murg Valley.

The flights planned both for TRACKS and NEWVAP were regular VFR flights (except for low flying). Except for departure and landing, there was no need for coordination with other aircraft. Operation for NEWVAP was very local, with occasional profiles above the boundary layer (maximum 3000 m MSL or FL100) in the Murg and Rhine Valley. The main safety issue for the NEWVAP flights was emergency landing field near the station in the Murg Valley.

5.7.8.3 Instrumentation

See www.metair.ch/SYSTEMS.htm or the EUFAR pages (www.eufar.net , search for METAIR-DIMO). The focus was on the meteorological parameters including 3-d turbulent wind, fast temperature and accurate dew point, plus CO, NO_2, NOx, NOy, VOC's, O_3, CO_2, H_2O, and aerosol number concentrations for the atmospheric composition.

5.7.9 UltraLight D-MIFU

5.7.9.1 Communication

PI of this aircraft is Wolfgang Junkermann.

Forschungszentrum Karlsruhe, Institut für Meteorologie und Klimaforschung, IMK-IFU, Kreuzeckbahnstr. 19, 82467 Garmisch-Partenkirchen, Tel. 08821 183180, mobile 0171 8601214, Fax 08821 73573, email: wolfgang.junkermann@imk.fzk.de

The aircraft was based in Karlsruhe-Baden-Baden during the campaign from June 15 to June 29 and from July 18 to July 29

5.7.9.2 Aircraft properties

The ultralight aircraft is the smallest aircraft within the European Fleet for Airborne Research. It is an open aircraft with flexible wing and carries up to 80 kg scientific payload. With a cruise speed of ~ 50 kts and the very low noise level it is specifically suitable for planetary boundary layer studies also in low elevation. Due to its comparably high climbing speed of > 5 m/sec and the ceiling at 15000 ft vertical profiles in the lower troposphere reaching into the free troposphere can be easily performed. Within COPS/TRACKS the aircraft was used to characterize the three dimensional regional distributions of aerosols and radiation between the Rhine valley and the Murg valley and for turbulence and flux measurements within the valleys of the Northern Black Forest. The endurance of the aircraft is 6 hours, a typical research flight will be ~ 4 hours. The aircraft is usable under visual flying rules only and was restricted under convective precipitation conditions to morning flights without precipitation.

5.7.9.3 Instrumentation

The instrumentation for the COPS/TRACKS campaign covered radiation parameters like the actinic flux in the wavelength range of the photolysis rates JO1D and JNO2, global radiation balance and spectral albedo at four wavelengths, aerosol size and optical properties and micrometeorological instrumentation. For flux measurements a turbulence probe and a fast open path CO2/H2O sensor was available. Also included was a new thermographic camera system for measurements of the ground surface temperature.

Table 5.20 Scientific equipment of the ultralight research aircraft D-MIFU.

Parameter	Probe, Sensor, Equipment
Static, dynamic and differential pressure	5-Hole Probe
Static, dynamic and differential pressure	Pressure Transducers
Pitch, bank, yaw, angular velocities, acceleration, INS-position, ground speed	Oxford Technologies, RT3100 INS
Height above ground	Universal Laser Sensor, up to 600 m
Surface temperature of the earth	InfraTEC thermographic camera, 3 Hz
Humidity of air (fast sensor)	Data Design open path IR sensor
Temperature of air	Meteolab temperature sensor
Temperature of air	Open wire fast fast temperature sensor 50 Hz
Humidity of air	Meteolabor Dew Point Mirror TP 3
Wind (horizontal)	5-hole-probe; GPS

Wind (vertical)	5-hole-probe
Turbulence	As "wind", 100 Hz sampling, 10 Hz averaging
Actinic Radiation	Up and down actinic flux radiometers 300 and 380 nm
Radiation	LICOR Pyranometers
Spectral Albedo	2 SKYE 4 wavelangth radiometers, 400, 550, 660, 996 nm
O_3	PSI O_3 (UV-Absorption)
Aerosols number > 10 nm	TSI 3010, 1 Hz
Aerosols size 5 -350 nm	GRIMM 5403 spectrometer, 2 min
Aerosols Size 300 nm – 15 um	GRIMM 1108 spectrometer, 6 sec
Aerosols spectral absorption	MAGEE AE42 7 wavelength aethalometer, 2 min
Aerosols scattering	AVMIII Nephelometer
CO_2	Data Design Open Path CO2/H2O Probe, 20 Hz

Fig. 5.50 Sketch of the Ultralight D-MIFU aircraft

5.7.10 SAFIRE ATR-42

5.7.10.1 Communication

PI of this aircraft is Yann Dufournet via EUFAR-Proposal (OSMOC – Observation Strategy for Mixed-phase Orographic Clouds, www.eufar.net, go to research and experiment – Research projects)

5.7.10.2 Scientific aspect:

Yann Dufournet

IRCTR – TU Delft university

Mekelweg 4, 2628CD Delft (The Netherlands)

Tel: +31 (0) 152789526

Fax: +31 (0) 2781034

E-mail: y.dufournet@tudelft.nl

Technical aspect:

Eric Mathieu (Safire coordinator)

SAFIRE – Base aerienne 101

31998 - Toulouse armee

Tel: +33 (0) 534572303

Fax: +33 (0) 534572300

E.mail: eric.mathieu@safire.fr

The aircraft will be based in Baden-Baden airport from July 19th to July 29th.

5.7.10.3 Aircraft properties

Aircraft acronym: SAFIRE - ATR42

Operated by: SAFIRE

Aircraft category: Large Tropospheric Aircraft

Manufacturer and aircraft type: ATR42-320

The ATR42 represents the largest tropospheric aircraft of the French fleet. Its size makes it suitable for measurement campaigns requiring a lot of different in-situ measurements or manpower (8 seats available). All aircraft specifications can be directly found on Safire website www.safire.fr.

5.7.10.4 Instrumentation

The instrumentation of the aircraft can be found on the website: www.safire.fr. Besides the permanent instrumentation (indicated with the letter P on the Safire datasheet) some other instruments listed below were added to fully take into account the Eufar proposal specifications (see the OSMOC project on www.eufar.net):

Two PMS-2DC (oriented in two perpendicular positions)

PMS FSSP 100

Gerber PMV100

5.7.11 Enviscope Partenavia

5.7.11.1 Communication

PIs of this aircraft is Christine Brandau via EUFAR-Proposal (OMAC- **O**bservation **M**ethodologies of the First Indirect **A**erosol Effect in Water **C**louds, www.eufar.net, search for Research Projects, OMAC)

Christine Brandau

PhD Student

International Research Centre for Telecommunication and Radar (IRCTR)

Delft University of Technology

Mekelweg 4

2628 CD Delft

The Netherlands

Phone: +31 152787603

E-Mail: c.brandau@irctr.tudelft.nl

5.7.11.2 Aircraft properties

Aircraft acronym: *enviscope*-Partenavia
Operated by: *enviscope* GmbH (www.enviscope.de)

Aircraft category: Small Tropospheric Aircraft
Registration number: D-GERY
Manufacturer and aircraft type: Partenavia P68B

This aircraft is a small twin engine aircraft (length**:** 9.55 m; height: 3.40 m; wingspan**:** 12.00 m) with full IFR equipment and especially applicable for water cloud microphysical targets within all the special devices. Additionally low cruise speeds (min speed: 32 m/s, max speed**:** 96 m/s, usual speed during transit flights: 77 m/s) are advantageous in order to achieve a better spatial data resolution in close vicinity to the ground base stations. See www.enviscope.de, search for Airborne platform, Partenavia.

5.7.11.3 Instrumentation

The instrumentation of the aircraft covers water cloud microphysical targets (cloud liquid water content, cloud water droplet size, cloud water droplet concentration) as well as standard avionic and meteorological parameters (time, altitude, geo-position, pressure, temperature, humidity, relative/absolute humidity, dew point, water vapor, true air speed, relative wind, wind direction).

List of instruments

Particle volume Monitor – PVM-100

Nevzorov Hot-Wire LWC/TWC Probe

Cloud Imaging Probe – CIP

Forward Scattering Spectrometer Probe – FSSP-300

Condensation Particle Counter – CPC-3010

Dew Point Mirror TP3-ST

Temperature-Humidity Sensor Vaisala HMP-320

Pressure Transducers SETRA 239/270

GPS TRIMBLE Approach 2000

5.8 Satellite observations

During COPS, unique support was provided by EUMETSAT by performing dedicated reduced scans of the northern hemisphere. The update time of each scan was 5 min. The data were disseminated via EUMETSAT operations and were visualized via NinJo and another batch mode system at the COPS OC in real time. Table 5.21 summarizes the contributions of EUMETSAT.

Table 5.21 EUMETSAT contributions to COPS

Instrument	Measured Parameters/Type
Special satellite products	
MSG	Reduced scans
MSG	Global Instability Index (GII)
MSG	Cloud microphysical parameters
Metop: IASI, GRAS, MHS	Several; COPS data for validation

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison, in collaboration with Dr. John Mecikalski at the University of Alabama in Huntsville (UAH), was providing convective storm diagnostic and nowcasting products using MSG SEVIRI imagery over the COPS domain. The suite of all available products is listed below in Table 5-20. These products incorporate objective cumulus identification and high-density atmospheric motion information to identify newly-glaciated, rapidly-growing cumulus cloud features that were expected to evolve into deep convective storms up to 1 hour in the future. 3 km MSG SEVIRI Infrared imagery channels 1 through 11 are interpolated to the 1 km channel 12 High Resolution Visible (HRV) resolution to preserve the detailed cloud structures observed within the HRV channel. These products were interpolated to a constant .01 degree resolution grid and output in NetCDF format. NetCDF files are archived locally at CIMSS and will be made available to COPS researchers upon request. Quick-look images for selected products are available for viewing at:

http://cimss.ssec.wisc.edu/snaap/cops/quicklooks.php

An in-depth description of CIMSS/UAH motivation for this COPS MSG satellite research effort can be found at:

http://cimss.ssec.wisc.edu/snaap/projects/msg-seviri-convection-products-for-cops/

Table 5.22 CIMSS/UAH COPS Convection Nowcasting Product NetCDF Output Fields

1) 1km Pixel Latitude
2) 1 km Pixel Longitude
3) High-Resolution Visible Reflectance
4) 1.6 micron Reflectance
5) 3.9 micron Brightness Temperature
6) 10.8 micron Brightness Temperature
7) 6.2-10.8 micron Channel Difference
8) 8.5-10.8 micron Channel Difference
9) 12.1-10.8 micron Channel Difference
10) 13.4-10.8 micron Channel Difference
11) Convective Cloud Mask
12) Mesoscale Atmospheric Motion Vector U-Component
13) Mesoscale Atmospheric Motion Vector V-Component
14) Convective Initiation Nowcast Product

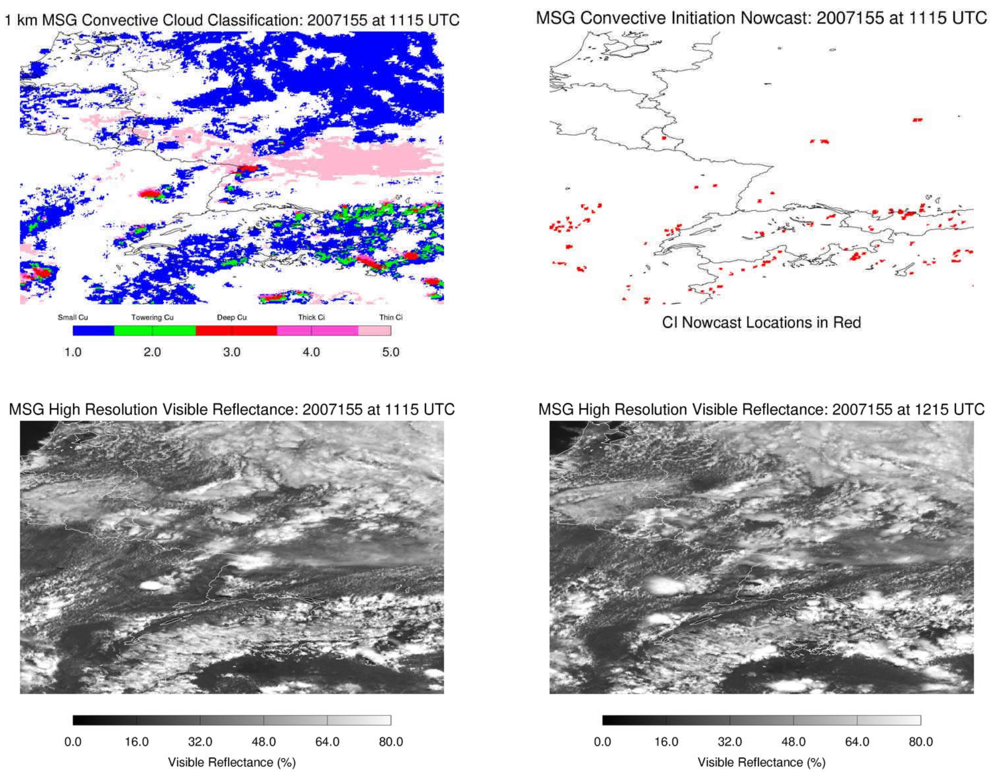


Fig. 5.51 *(upper-left) CIMSS/UAH convective cloud classification product covering the COPS domain at 1115 UTC on June 4th, 2007. (upper-right) Red pixels represent small and towering cumulus clouds likely to evolve into deep convective storms within the following hour. (lower-left) High-resolution visible imagery (HRV) at 1115 UTC when the convective initiation nowcast was made. (lower-right) HRV imagery at 1215 UTC, showing that many nowcast pixels evolved into deep convection.*

5.9 Real-time data assimilation

Real-time assimilation activities were an important aspect during COPS for mainly two reasons. First, numerical forecasts were an important part for the mission planning in the Operation Center. Here, the results of several numerical weather prediction models were analyzed operationally, and provided an overview over the meteorological situation during the following days. Therefore, they built the basis for the daily mission planning. Furthermore, the assimilation of data collected during COPS in real-time enables impact studies of the corresponding observing system on the daily forecasts over an extended period of several months.

5.9.1 Operational real-time assimilation of the national weather centers

COPS is coordinated with the WWRP Forecast Demonstration Project D-PHASE. During its operational phase, covering the entire COPS period, the national weather centers of Germany, Switzerland, France, and Italy performed operational high-resolution real-time assimilation in an area encompassing the COPS region. This was complemented by global forecasts performed at DWD, ECMWF, and NCEP. Parts of the forecast products were provided to the operation center and form the basis for the daily mission planning meeting. However, the assimilation systems of the weather centers have strong requirements to the used data. Therefore, in all operational real-time assimilation systems, only already operationally available observations have been used, so that most data collected during COPS was not fed into the assimilation systems.

The following table summarizes the high-resolution real-time assimilation activities of the national weather centers.

	Model	Resolution, Number of levels	Assimilation method	Forecast initial times [UTC]
DWD	COSMO-EU	7 km,	Nudging	00, 12, 18
	COSMO-DE	2 km, 50 levels	Nudging+latent heat nudging	00, 03, 06, 09, 12, 15, 16, 21
Switzerland	COSMOCH7	7 km,	Nudging	00, 12
	COSMOCH2	2 km, 60 levels	Nudging+latent heat nudging	00, 03, 09, 12, 18
France	ALADIN	9.5 km, 46 levels	3DVAR	00, 06, 12, 18
	AROME	2.5 km, 41 levels	3DVAR-FGAT	00

5.9.2 Real-time assimilation of additional COPS data

Here, mainly two actions were performed during COPS. At DWD additional radiosondes from COPS were assimilated into the COSMO-DE model (e.g. the sondes launched at the ARM Mobile Facility (AMF)).

At the University of Hohenheim, the mesoscale community model MM5 and its 4DVAR system was used for real-time assimilation and forecasts using GPS slant path delay data provided by the Geoforschungszentrum Potsdam (GFZ) and GPS ZTD data provided by the MetOffice.

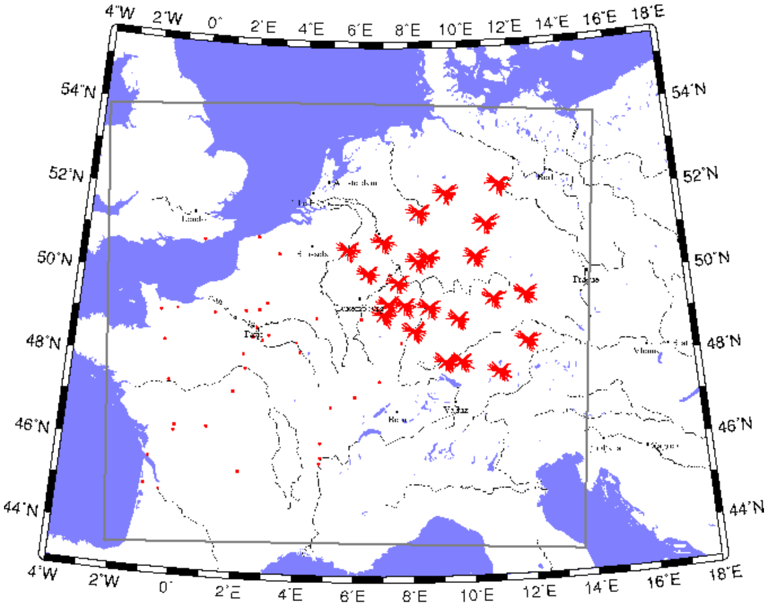


Fig. 5.52 Schematic comparison of the information content between GPS ZTD (over France) and GPS slant path (over Germany) measurements. The grey box shows the region of our outermost model domain in which the assimilation of GPS data is done.

GPS provides an accurate, all weather observation of the integrated water vapor along the line of sight from a GPS satellite and a receiving station at the surface. Fig. 5.52 shows the stations used for the assimilation in the outermost model domain (grey box). New in the approach is that not only the zenith total delay (ZTD) is used for the operational assimilation. Here, also the slant wet delay is used, providing humidity information from regions surrounding the receiving ground station to the assimilation system. During the 3-hour assimilation window, around 900-1200 slants and profiles remain after quality control and data thinning.

The necessary forward operator to assimilate the data was developed and tested for the use during COPS. The projection from the model to the observational space is done using the following equation.

$$H = \int_{rec}^{mtop} \left(c_1 \frac{P}{T} + c_2 \frac{PQ}{(c_3 + Q)T^2} \right) ds + H_0$$

It integrates the water vapour in the grid boxes along the ray path between the ground-based receiving station and the model top. P, T, and Q are the grid box values of temperature, pressure and water vapour mixing ratio. H_0 is the delay caused by the part of the atmosphere above the model domain which can be accurately estimated with the Saastamoinen model.

MM5 was used in two different configurations. This is necessary, since the 4DVAR system requires an adjoint version of the model including the used parameterizations. Since they are only available for the simple parameterizations, the 4DVAR was done using a simplified physics, while the free forecasts afterwards use the best possible physical packages available. Furthermore, due to the enormous computational demands, the assimilation with 4DVAR was only done in the coarse 18 km domain. For the free forecasts, 3 domains with 18-6-2 km horizontal resolution were used in a 2-way interactive nesting mode. In the innermost 2 km domain, the convection parameterization was switched off. During the whole COPS and D-PHASE period two forecasts were performed each day. One initialized only by the ECMWF operational forecast at 00Z. The other one was in addition initialized by the 4DVAR of GPS data.

As an example, Fig. 5.53 shows the impact of the assimilation of GPS slant path data on the specific humidity field at 850 hPa for two different time steps from the forecast initialized at 00Z, 27th of June 2007. On Fig. 5.54 the impact on the temperature field is shown for the same two time steps. On both Figures it is clearly seen, that the assimilation of GPS data has a large-scale impact on the corresponding fields.

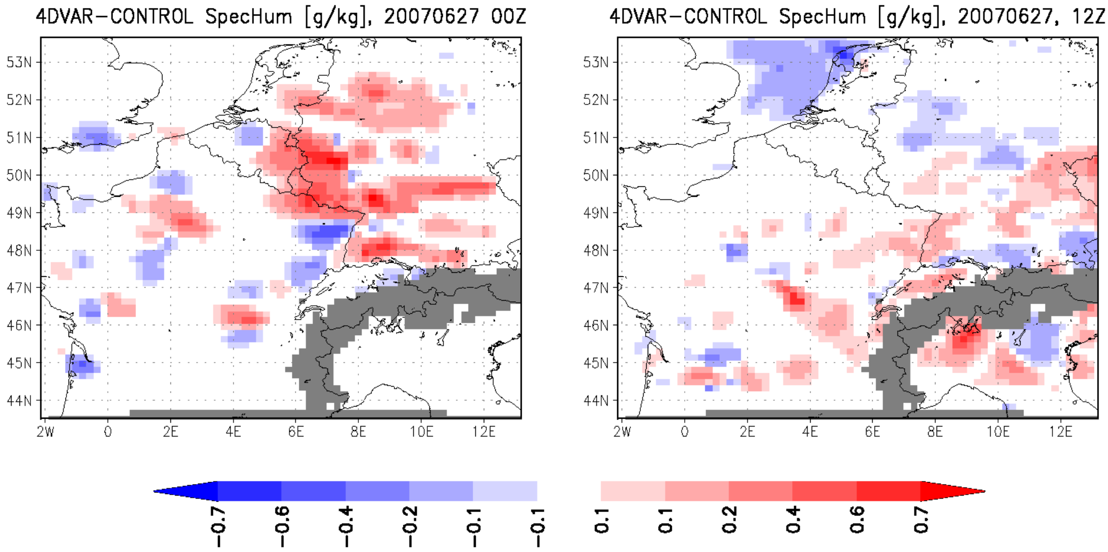


Fig. 5.53 Difference 4DVAR-CONTROL of the specific humidity [g/kg] at 850 hPa for the initial time 20070627 00Z (left) and 12 hours later (right).

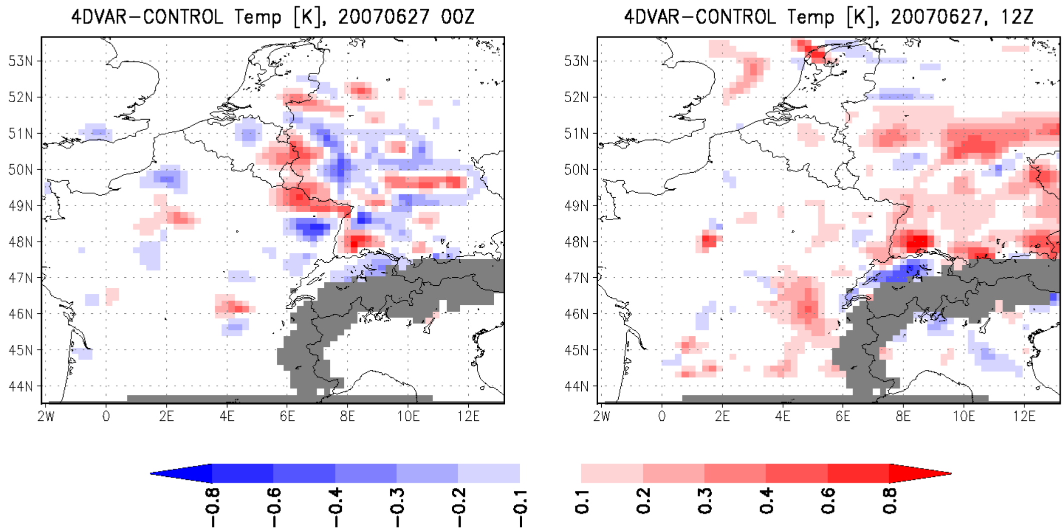


Fig. 5.54 Same as Fig. 5.53 but for the temperature field.

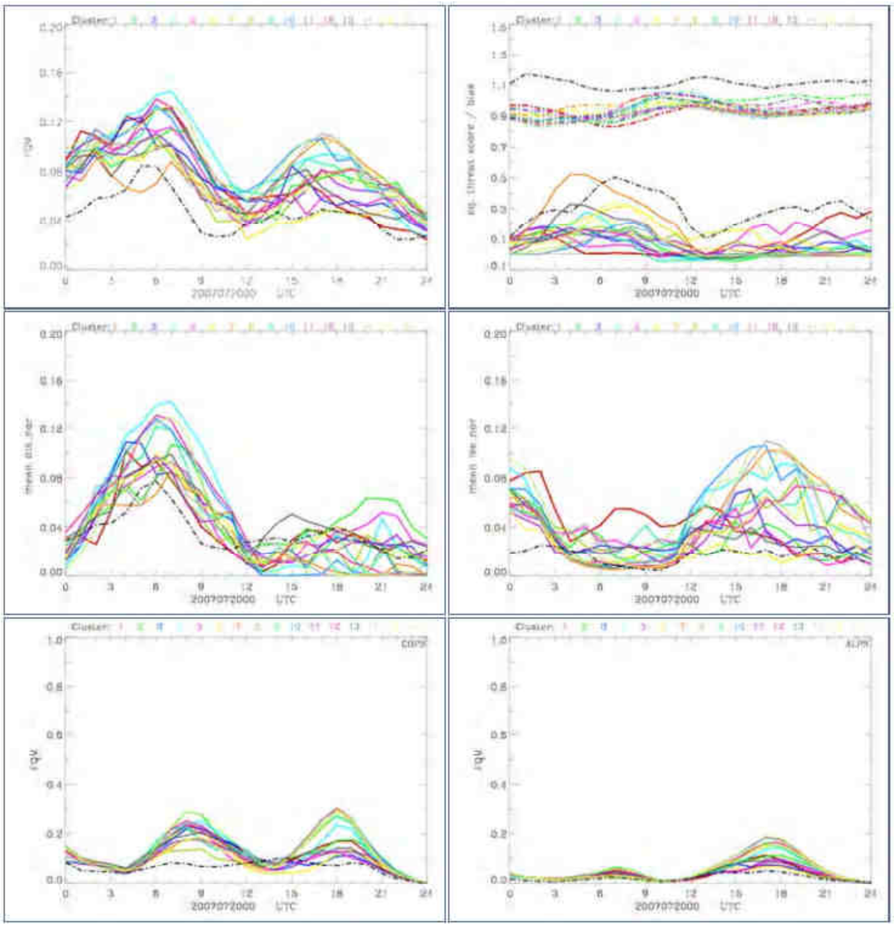
5.9.3 Operational evaluation of COSMO-LEPS forecasts

An evaluation of the operational COSMO-LEPS limited-area ensemble forecasts using the Forecast Quality Measure of Keil and Craig (Keil, C., and G. C. Craig, 2007: A displacement-based error measure applied in a regional ensemble forecasting system. *Mon. Wea. Rev.*, 135, 3248-3259.) was provided during the campaign on the DLR COPS website. An example is shown in the figure below.

COSMO-LEPS displacement-based FQM for 2007072000

Monitoring of COSMO-LEPS forecast quality employing the displacement-based Forecast Quality Measure FQM (Keil and Craig, MWR 2007) applied on hourly Meteosat-9 IR-imagery.

The 16 different ensemble members (started 12 UTC the previous day) are color-coded, the short-term deterministic COSMO-EU forecast (started at 00 UTC) in black.
Order of figures: FQM over full domain (1780x1780km2) (top left) , conventional scores bias and equitable threat score (top right), normalized displacement (middle left), normalized squared error (middle right), FQM over COPS region (bottom left), and FQM over D-Phase domain (bottom right).



Order of figures: FQM over full domain (1780x1780km2) (top left) , conventional scores bias and equitable threat score (top right), normalized displacement (middle left), normalized squared error (middle right), FQM over COPS region (bottom left), and FQM over D-Phase domain (bottom right).

Fig. 5.55 Example of COSMO-LEPS displacement-based Forecast Quality Measure (FQM).

6 Field schedule and duration in coordination with international programs

Within COPS, many activities had to be coordinated. This includes sharing COPS and GOP instrumentation, operation of the AMF and German instrumentation at Supersite M, coordination of mobile teams, and aircraft operation. Furthermore, COPS activities have to be performed in coordination with D-PHASE and ETReC07.

The basic information on the operation of ground-based instrumentation is summarized in Fig. 6.1.

Fig. 6.1 demonstrates that the most active period was July. This is confirmed by Table 6.1 where all aircraft operation times are summarized. Particularly, operation of all observing systems during July required an excellent preparation and coordination.

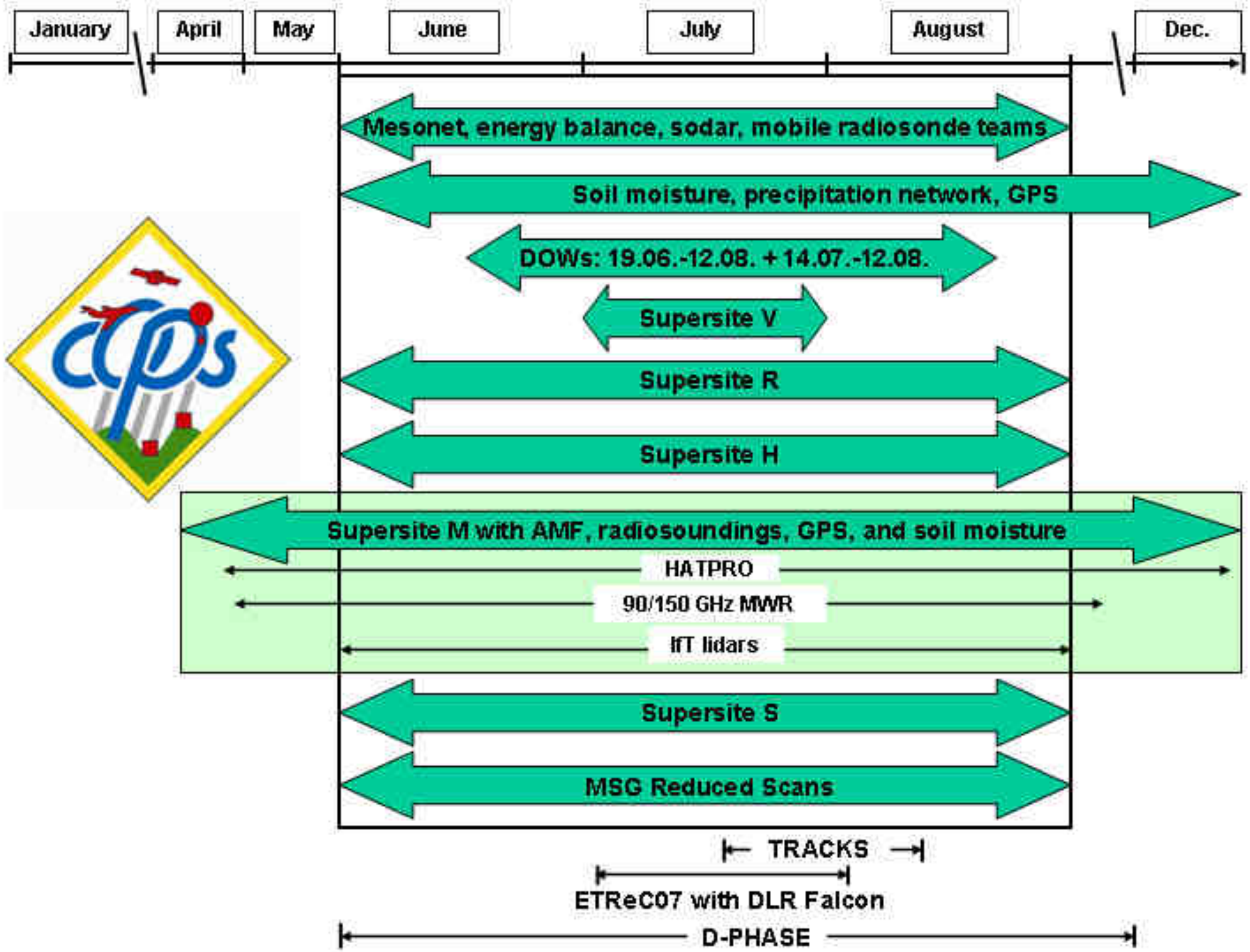


Fig. 6.1 *Operation times of ground-based and satellite instrumentation dedicated to COPS. The duration of TRACKS, D-PHASE, and ETReC07 is also shown.*

Table 6.1 Availability of aircrafts during COPS

		Juni 2007																														
N° Plat	Platform	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
2	G-Falcon																															
5	DO 128																															
8	Enduro																															

		Juli 2007																														
N° Plat	Platform	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	Learjet																															
2	G-Falcon																															
3	F-Falcon																															
4	BAE-146										2		d	o	w	n	d	a	y	s		w	i	t	h	i	n					
5	DO 128																															
6	Dimona																															
7	Zeppelin																															
8	Enduro																															
9	Partenavia			5		F	L	I	G	H	T	S		I	N		T	O	T	A	L											
10	ATR42																															

		August 2007																														
N° Plat	Platform	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2	G-Falcon																															
3	F-Falcon																															
9	Partenavia																															

7 Missions and their coordination

7.1 Introduction

In the COPS domain, mainly three types of conditions were expected leading to significant amounts of precipitation: forced/frontal convection, forced/non-frontal convection, and air mass convection (see SOD, section 4.3). These situations in combination with the four observation phases introduced in section 4.2 led to the development of two missions called

- Forced Convection, which includes both force/frontal and forced/non-frontal situations, and
- High Pressure Convection

Furthermore, in connection with ETReC07 a mission

- Targeted Observations,

in connection with TRACKS a mission

- City Plume,

in connection with EUFAR proposals, a scenario

- Stratus –Cloud Physics

as well as a scenario

- NEWVAP

have been developed.

The region where COPS aircraft have been operated was modified with regard to the properties of aircrafts and to the requests of ATC. Fig. 7.1, Fig. 7.2, and Fig. 7.3present the selection of the aircraft domains.

An overview of the aircraft planning and coordination is found in the flight planning playbook, which summarizes detailed plans of all mission scenarios for easy reference.

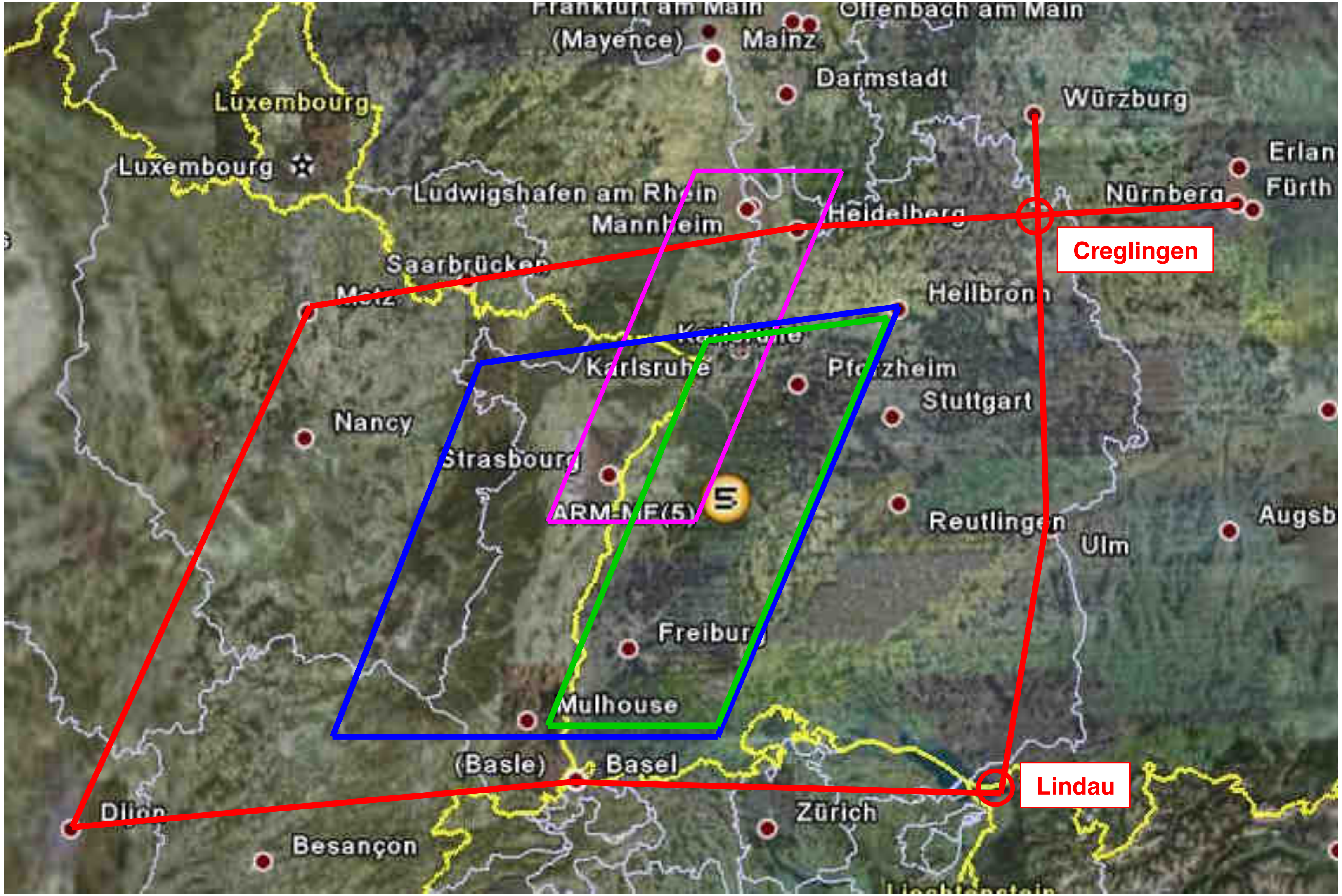


Fig. 7.1 *Area under Investigation: COPS area with aircraft domains for missions 1, 2, 4, and 5. Sub areas blue and green are dedicated for missions 1, 2, and 5. TRACKS areas (mission 4) are green and pink.*

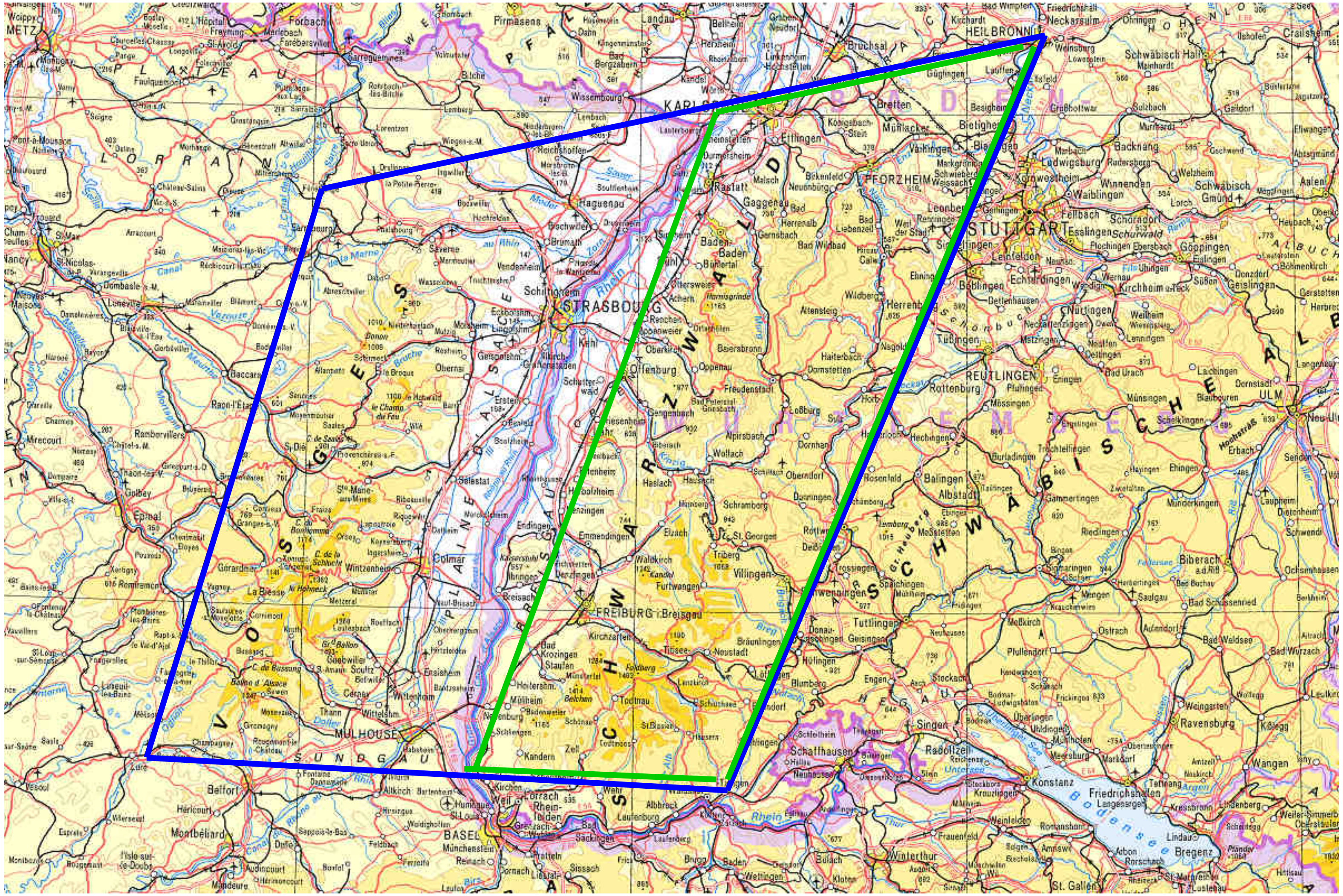


Fig. 7.2 COPS sub areas for missions 1, 2,and 5.

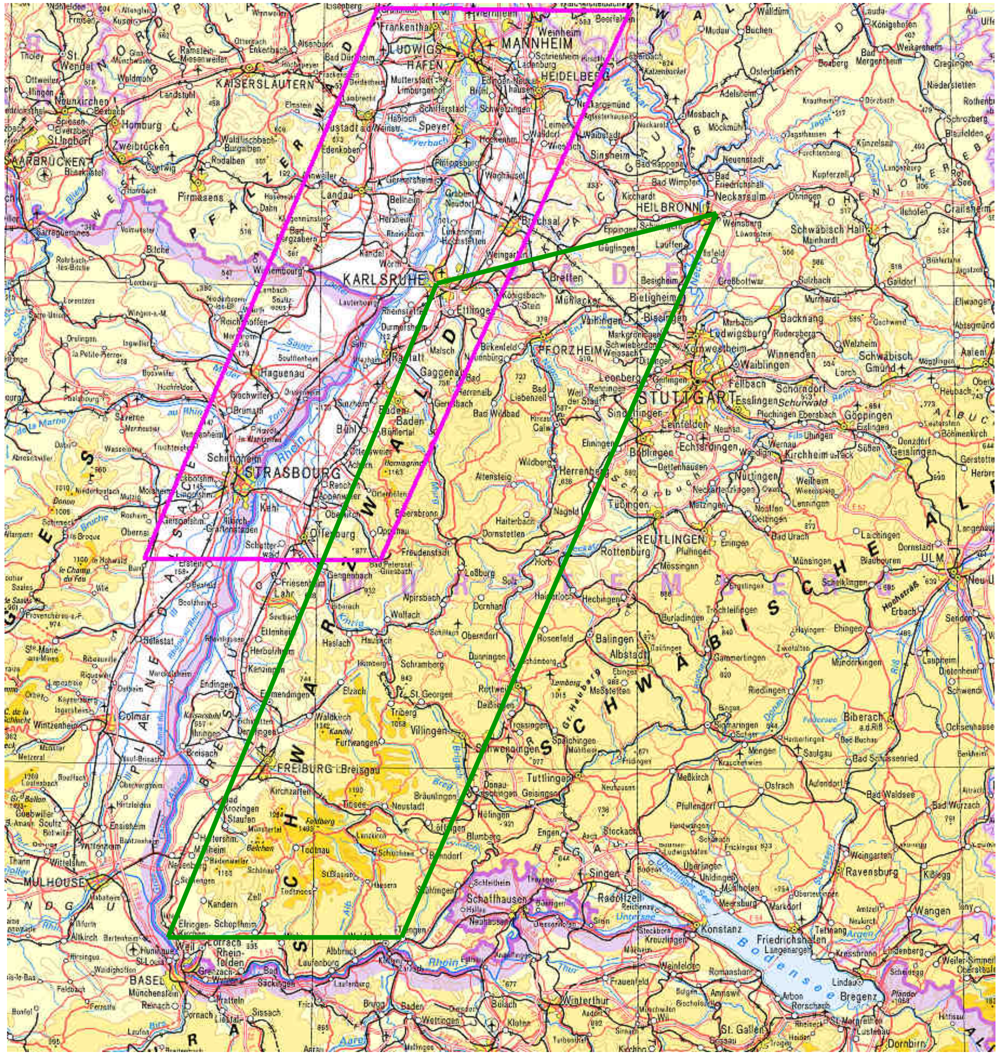


Fig. 7.3 TRACKS areas (mission 4). The "City plume" region is pink and the "Convective Transport" region is indicated in green.

Table 7.1 Domains for COPS mission scenarios

Area	NW (N)	NE	SE (S)	SW
RED	6.1622 E, 49.1143 N Metz (8.6842 E, 49.4140 N Heidelberg)	10.0327 E, 49.4772 N Creglingen	9.6721 E, 47.5532 N Lindau (7.5795 E, 47.5553 N Basel)	Dijon
BLUE	7.0206 E, 48.8433 N Fenetrange	9.2248 E, 49.1523 N Heilbronn	8.2709 E, 47.6383 N Tiengen	6.4996 E, 47.6847 N Lure
GREEN	8.2273 E, 49.0005 N Karlsruhe	9.2248 E, 49.1523 N Heilbronn	8.2709 E, 47.6383 N Tiengen	7.5092 E, 47.6624 N Efringen-Kirchen
PINK	8.1769 E, 49.5700 N Grünstadt	8.9476 E, 49.5678 N Beerfelden	8.1667 E, 48.4329 N Bad Peterstal	7.4662 E, 48.4162 N Barr

In all cases, it was expected that an atmospheric condition occurs in close to the proposed ideal mission. During more complicated conditions, the COPS OC had to decide how to combine components of different missions.

Based on the categorization of the sensors in section 5, for mission planning we can categorize the data sources in operational data (1), research networks (2), special ground-based sensors (3), and aircraft (4).

Operational data were collected routinely so that they did not need to be considered for mission planning and performance. The same held for the research networks except extra radiosoundings and operation of tethered balloons. Furthermore, the major part of the sensors in (3) as well as all aircraft (4) had to be included in COPS mission planning and performance.

7.2 Coordination with ground-based instrumentation

For mission performance, the activities of the following activities had to be organized and coordinated:

- COPS and EUCOS radiosondes
- Tethered balloon sondes
- Mobile drop up sondes
- DOWs

Supersite operation: Particular emphasis had to be put on the coordination of scanning systems at the supersites.

It was reasonable to coordinate these teams according to the COPS observation phase 1-4. The length of operation depended on the instrument. For instance, lidar operation should be started as early as possible in pre-convective environment. Most of these systems had to be shut down during heavy precipitation. Cloud and precipitation radars were taking over here and continued to study the evolution of clouds and precipitation.

It was important that vertical steering or scan modi were maintained as long as possible in order to get long and consistent data sets. In all cases, the COPS OC requested notification about the proposed scan modi so that coordination with other sites and aircraft was ensured.

7.2.1 COPS and EUCOS radiosondes

If the COPS missions 1 or 2 were announced, all radiosonde teams, except the launches at Supersite M, performed radiosonde launches during IOPs. Launch schedules were typically all 3 h. Particularly important were observations during Phase 1-3.

EUCOS radiosoundings were initiated during mission 3, an ETReC07 IOP.

7.2.2 Tethered balloons

Tethered balloons were only operated during Phase 1 of an IOP, if the wind was calm. ATC had to be notified and permission of operation by ATC had to be confirmed. Measurements started as early as possible to capture the evolution of the ABL during the course of the day.

7.2.3 Supersite V

The major part of this instrumentation was operated in vertically steering mode during an IOP. The only scanning instrument was the LAMP X-band radar. This system performed mainly RHI scans in direction of Poldirad and other Supersites in order to take advantage of multi-wavelength retrievals of precipitation microphysics.

7.2.4 Supersite R

Here, one scanning system was installed, namely a coherent Doppler lidar. Due to the relative high signal-to-noise (SNR), Doppler lidars can perform scans with high speed in the near-range. Whereas all other instruments were steering vertically, it was recommended that the Doppler lidar was performing alternating PPI and RHI scans in coordination with the Hornisgrinde Doppler lidar. The RHI scans were mainly performed in direction of Poldirad and the Supersites.

7.2.5 Supersite H

The most challenging site with respect to scanning system coordination was Supersite H. It was very reasonable to design a RHI scan strategy in a plane, which covers Poldirad and Supersites R, H, and M. This sychronized scan was executed by the UHOH DIAL and temperature lidars, the FZK cloud radar, TU Delft TARA, and ADMIRA-RI. For the Doppler lidar a combination of VAD scans for wind profile measurements alternating with an RHI scans was recommended. Each operation of the instruments continued as long as possible without interruption of the operation modus. The scan operation can be considered to track certain features in the atmosphere simultaneously such as developing clouds.

The performed scanning scenarios are described in section 11.5.2.

7.2.6 Supersite M

Here scanning operations could be performed with the MWR HATPRO and the 90/150-GHz profiler. These activities were coordinated with the IfT lidar PIs. The multi-wavelength lidar of IfT can only scan in one plane. It was suggested to perform all scans in the same plane and then to switch to other configurations if necessary.

7.2.7 Supersite S

The scanning probabilities of MICCY are restricted to a fixed plane from low elevation angles to the zenith and back again. The beam has been directed in southwesterly direction upstream of expected tracks of convective systems. Coordination with other instruments at the supersite was not necessary since MICCY was operated in a continuous mode.

7.2.8 Poldirad

A scan repetition rate of 10 minutes was used. Scans were a volume scans consisting of a series of PPIs at elevations between 0.5 and 25° with a range to 120 km. Number of elevations was dependent on the weather situation. Data from the volume were also used to provide the vertical wind profile through the VAD technique. Further a RHI scan was performed towards the direction of 109.5° passing across the supersites R, H, and M (see Fig. 5.41). This scan was performed at the end of the 10 minutes cycle. An additional RHI towards the Karlsruhe C-band radar (56.9°) was performed for comparison purposes at selected times. A sector volume scan covering only certain regions of interest can speed up the scanning cycle or would allow for a higher vertical resolution, however it easily can happen that the development of new cells outside of the sector are overseen.

7.2.9 Drop-up Sonde Teams

In case of an announcement of an IOP, the number of available drop-up sondes was checked. This implied the number of teams which were distributed in the area. The teams entered the drop-up area in the evening before an IOP starts. During the morning briefing at the OPC the launching sites for the teams were discussed and fixed in cooperation between drop-up PI, science director and forecaster. The selection of sites (1 to 5 from 73) depended on the location where convection was expected to develop during this IOP. The teams were typically on site at 10 local and started with the installation of the mobile meteorological tower. From now on the sky was observed in the area by the drop-up team, by other COPS teams and by the PI, the science director, and forecaster in the OC. When convection (deep convection) started, different scenarios were possible, depending on the speed of convective development and depending on the availability of the DO 128 aircraft for dropping sondes. Changing of sites during an IOP by one or more drop-up teams was not foreseen in the standard operating procedure, however, was possible in specific situations. The individual dropping scenarios were:

A: First release of drop-up sondes from the surface, then dropping from DO 128.

B: First dropping from DO 128, then release of drop-up sondes from the surface.

C: First partly release of drop-up sondes from the surface, then dropping from DO 128, than again release of drop-up sondes from the surface.

D: Only launching of drop-up sondes from the surface.

E: Only release of drop sondes from the DO 128.

The selection of scenarios was done by the drop-up PI in close coordination with ATC.

As long as the DO 128 droped sondes in areas A and B, these areas were closed for all other aircraft including other COPS aircraft in all FLs below the DO 128.

7.3 Forced Convection

Areas and Layers of Operation of Airborne Platforms
Mission Scenario "Forced Convection"

Aircraft No.	Aircraft	Area	Flight level (Flight layer)	IFR/VFR Operation
1	Learjet	GREEN	~ FL 400	IFR
2	G-Falcon (D-CMET)	BLUE	FL 250/400	IFR
3	F-Falcon	BLUE	FL 150	IFR
4	BAE 146	BLUE	< FL 100 FL 100/300	VFR IFR
5	DO-128 (D-IBUF)	BLUE	< FL 100 FL 245	VFR IFR
6	Dimona	GREEN	< FL 100	VFR
7	Zeppelin NT	GREEN	< FL 100	VFR
8	UL Enduro	GREEN	< FL 100	VFR

Mission Scenario **"Forced Convection"**

*: VFR

Blue Sky --- > Shallow Convection -- > Deep Convection-- > Dis. Convection
forced, non frontal/frontal

07—08--09---10---11---12---13---14---15---16---17---18---19---20---21---22 local

Learjet ----------BOX pattern, tropopause -------BOX pattern, outflow anvil----------------------
----------FL 330/400, low appr. EDSB ---- FL 330/400, low appr. EDSB ---------------------

G-Falcon -----------------MAP pattern (2 MAPs) ------→Box pattern CuCong, Cb ------------------
-----------------FL 250/400, Drops ---------→FL 250/400, Drops -----------------------

F-Falcon -----------------MAP pattern (1 MAP) -------→BOX pattern CuCong, Cb------------------
-----------------FL 150, Drops--------------→FL150, Drops ---------------------------

(*)BAE 146----------------------------LONG-LEGS----→BOX pattern-------------------------------
----------------------------VFR < FL 100---→FL 100/270 ---------------------------------

(*)DO 128------PreCon pattern---SupDe pattern (3x)------BOX pattern (DeDe)-----------------------
-----low PBL (VFR)-----low, mid PBL, BL-Inv ---up to FL 245 (IFR) -----------------------

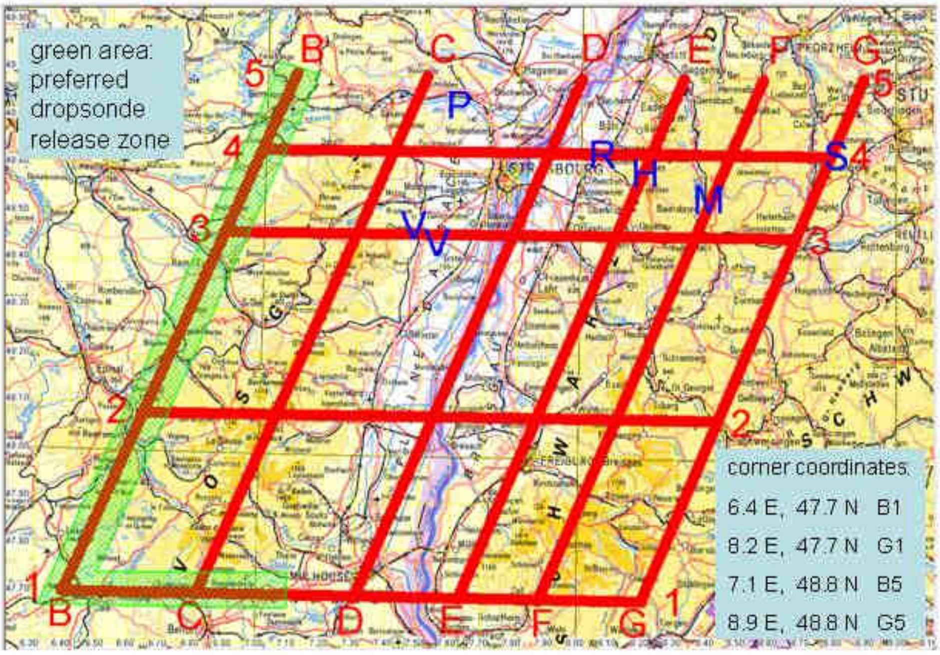
*Zeppelin--Valley pattern (Rhine-Kinzig-Murg-Nagold)----------Valley pattern (R-K-M-N)--→CuCong---
--lowest level, VFR---------------------------------lowest level, VFR--------→on request-

*Dimona-----------------MAP (2 MAPs) or Valley------------MAP (2 MAPs) or Valley---------------
-----------------lowest level PBL (VFR)-------------lowest level PBL (VFR)---------------

*Enduro-----------------Triangle or Cross-Sec., profiles ----Triangle or Cross-Sec., profiles ---------
-----------------low PBL, FL100 (VFR)--------------low PBL, FL100 (VFR)----------------

Scenario: Forced Convection
Platform 2: G-Falcon, D-CMET
Mission: MAP

Supersites V, R, H, M, S, P



7.4 High Pressure Convection

Areas and Layers of Operation of Airborne Platforms

Mission Scenario “High Pressure Convection”

Aircraft No.	Aircraft	Area	Flight level (Flight layer)	IFR/VFR Operation
1	Learjet	No participation in "High Pressure Convection"		
2	G - Falcon (D-CMET)	RED	FL 100/130 or 170	IFR
3	F - Falcon	RED	FL 150	IFR
4	BAE 146	RED	< FL 100 FL 100/300	VFR IFR
5	DO-128 (D-IBUF)	BLUE	< FL 100 FL 245	VFR IFR
6	Dimona	GREEN	< FL 100	VFR
7	Zeppelin NT	GREEN	< FL 100	VFR
8	UL Enduro	GREEN	< FL 100	VFR

Mission Scenario B “High Pressure Convection”   *: VFR

Blue Sky --- > Shallow Convection -- > Deep Convection-- > Dis. Convection

non frontal / non forced

07—08--09---10---11---12---13---14---15---16---17---18---19---20---21---22 local

Learjet ---

G-Falcon ---

F-Falcon ---

(*)BAE 146----------------------LONG-LEGS---------→BOX pattern------------------------------------
--------------------VFR < FL 100--------→FL 100/270 -----------------------------------

(*)DO 128----------SS-QC--------------CHAFF R/SVs/HL--------SS QC-----------------------------------
----------VFR < FL 100--------PBL, very low----------VFR < FL 100------------------------------

Alternative

(*)DO 128----------SS-MET--------------CHAFF R/SVs/HL-------SS MET-----------------------------------
----------VFR < FL 100--------PBL, very low----------VFR < FL 100------------------------------

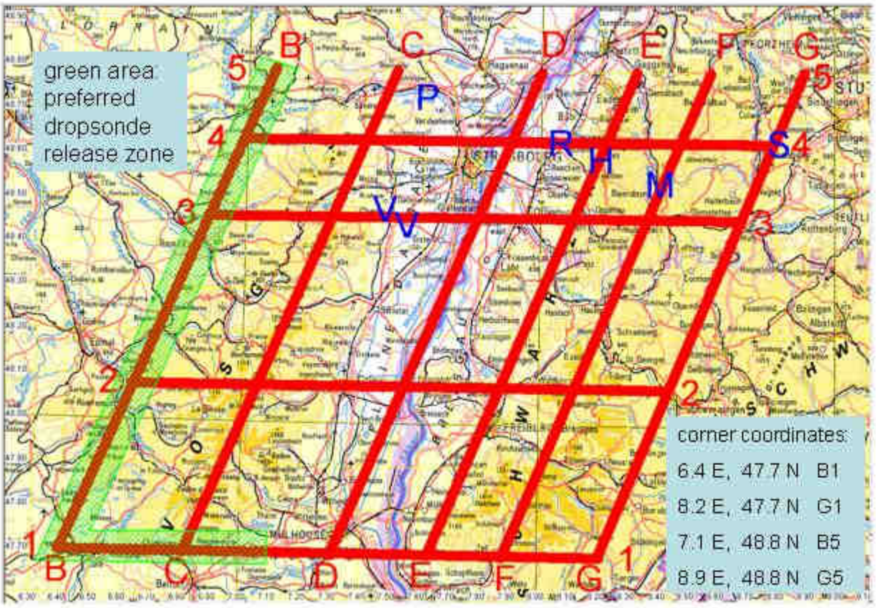
*Zeppelin--Valley pattern (Rhine-Kinzig-Murg-Nagold)----------Valley pattern (R-K-M-N)--→CuCong---
---lowest level, VFR------------------------------------lowest level, VFR---------→on request-

*Dimona---------------------MAP (2 MAPs) or Valley-----------MAP (2 MAPs) or Valley-----------------
---------------------lowest level PBL (VFR)-------------lowest level PBL (VFR)-----------------

*Enduro-------------Triangle/Cross-Section/Slope---------------Triangle/Cross-Section/Slope-----------
--------------low PBL, FL100 (VFR)----------------------low PBL, FL100 (VFR)-------------------

Scenario: Forced Convection
Platform 3: F-Falcon, F-GBTM
Mission: MAP

Supersites V, R, H, M, S, P

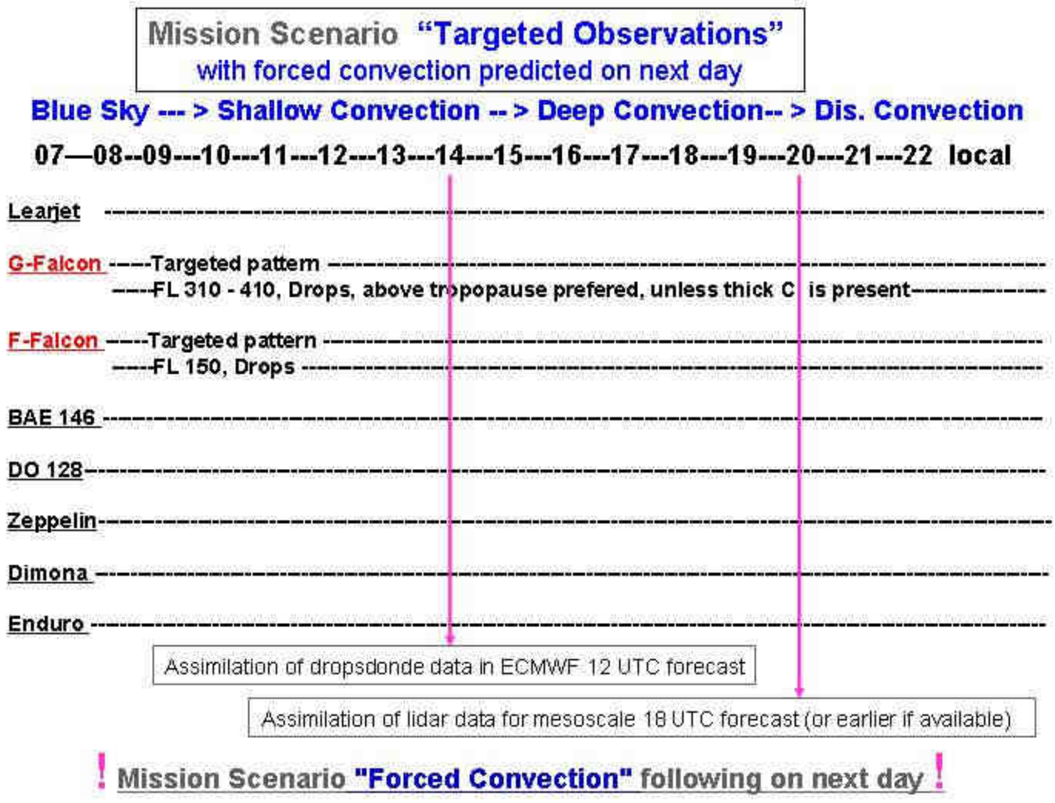


7.5 Targeted Observations

Areas and Layers of Operation of Airborne Platforms

Mission Scenario "Targeted Observations"

Aircraft No.	Aircraft	Area	Flight level (Flight layer)	IFR/VFR Operation
1	Learjet	No participation in "Targeted Observations"		
2	G - Falcon (D-CMET)	> RED	FL ???	IFR
3	F - Falcon	> RED	FL 150	IFR
4	BAE 146	No participation in "Targeted Observations"		
5	DO-128 (D-IBUF)	No participation in "Targeted Observations"		
6	Dimona	No participation in "Targeted Observations"		
7	Zeppelin NT	No participation in "Targeted Observations"		
8	UL Enduro	No participation in "Targeted Observations"		



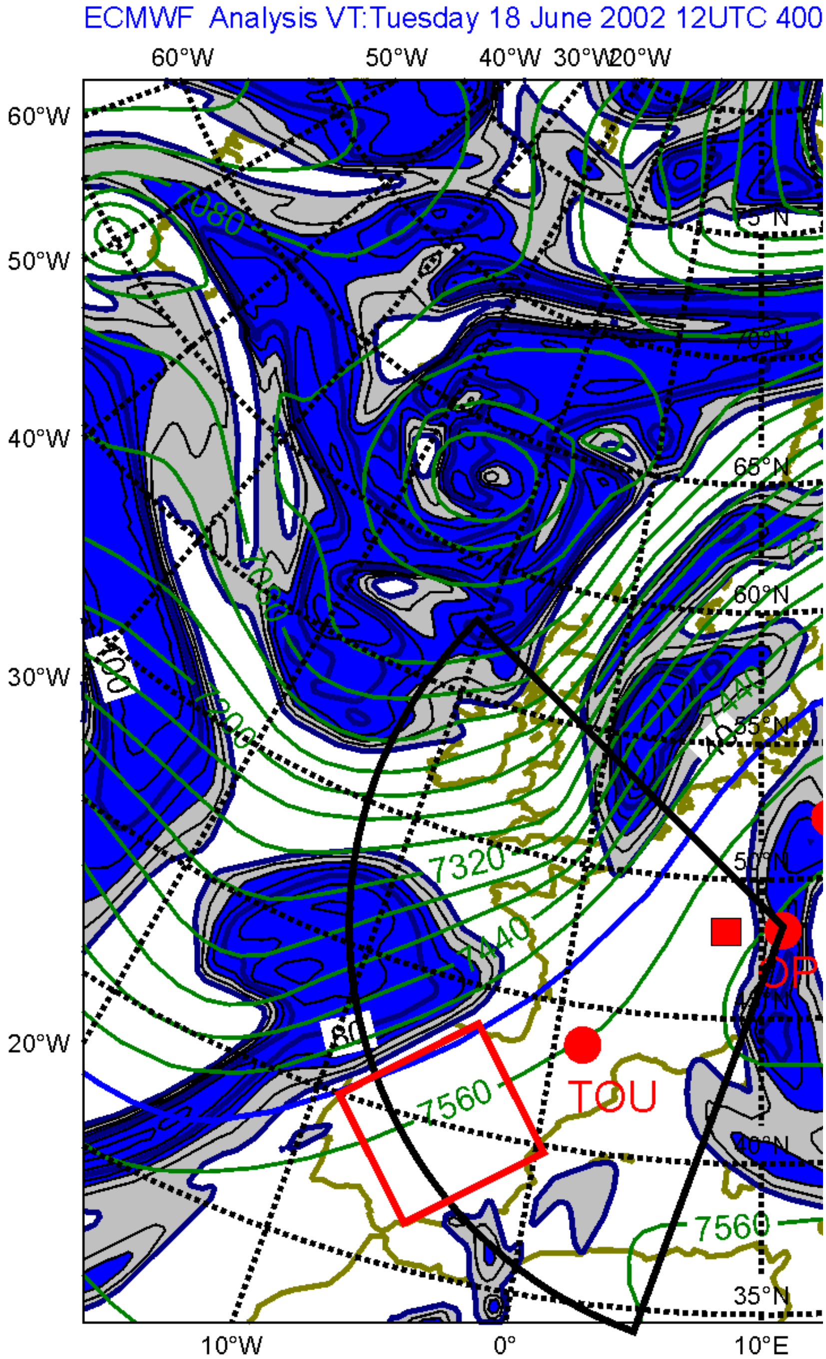


Fig. 7.4 *ECMWF analysis for June 18, 2002, 12 UTC, 30 h before a heavy precipitation event occurred in the Black Forest region. Shown are contours of geopotential height and specific humidity (color coded) in 400 hPa, overlaid with a DLR Falcon flight route for mapping the stratospheric intrusion.*

The black sector in Fig. 7.4 shows the possible range of operations of the DLR Falcon for targeting measurements in sensitive upstream regions with a radius of 1800 km. The red box is the target region, within which the on board wind and water vapor lidars could observe the 3D wind and humidity field beneath the aircraft from 12 km flight altitude with high spatial resolution. The lidar profiles were complemented by dropsondes wherever possible.

7.6 City Plume

Areas and Layers of Operation of Airborne Platforms

Mission Scenario "City Plume - Lagrange"

Aircraft No.	Aircraft	Area	Flight level (Flight layer)	IFR/VFR Operation
1	Learjet	No participation in "City Plume - Lagrange"		
2	G - Falcon (D-CMET)	No participation in "City Plume - Lagrange"		
3	F - Falcon	No participation in "City Plume - Lagrange"		
4	BAE 146	No participation in "City Plume - Lagrange "		
5	DO-128 (D-IBUF)	pink	< FL 100	VFR
6	Dimona	pink	< FL 100	VFR
7	Zeppelin NT	Pink	< FL 100	VFR
8	UL Enduro	No participation in "City Plume - Lagrange "		

Mission Scenario B "City Plume - Lagrange"

*: VFR

-----Blue Sky --------> Shallow Convection --------- >Dis. Convection-----------------

07—08--09---10---11---12---13---14---15---16---17---18---19---20---21---22 local

Learjet ---

G-Falcon ---

F-Falcon ---

(*)BAE 146---

(*)DO 128------Lee Cross Sections (6)------ Lee Cross Sections (6)-----------------------------------
------FL 1000 ft, 3000 ft agl--------FL 1000 ft, 3000 ft agl-------------------------------------

*Zeppelin-----------Lee Zick-Zack pattern—(long time) ---
-----------FL 1000 ft agl, up to 7 hours duration--

*Dimona------------Lee Cross Sections (3)---
-----------FL 1000 ft, 2000 ft agl---

*Enduro---

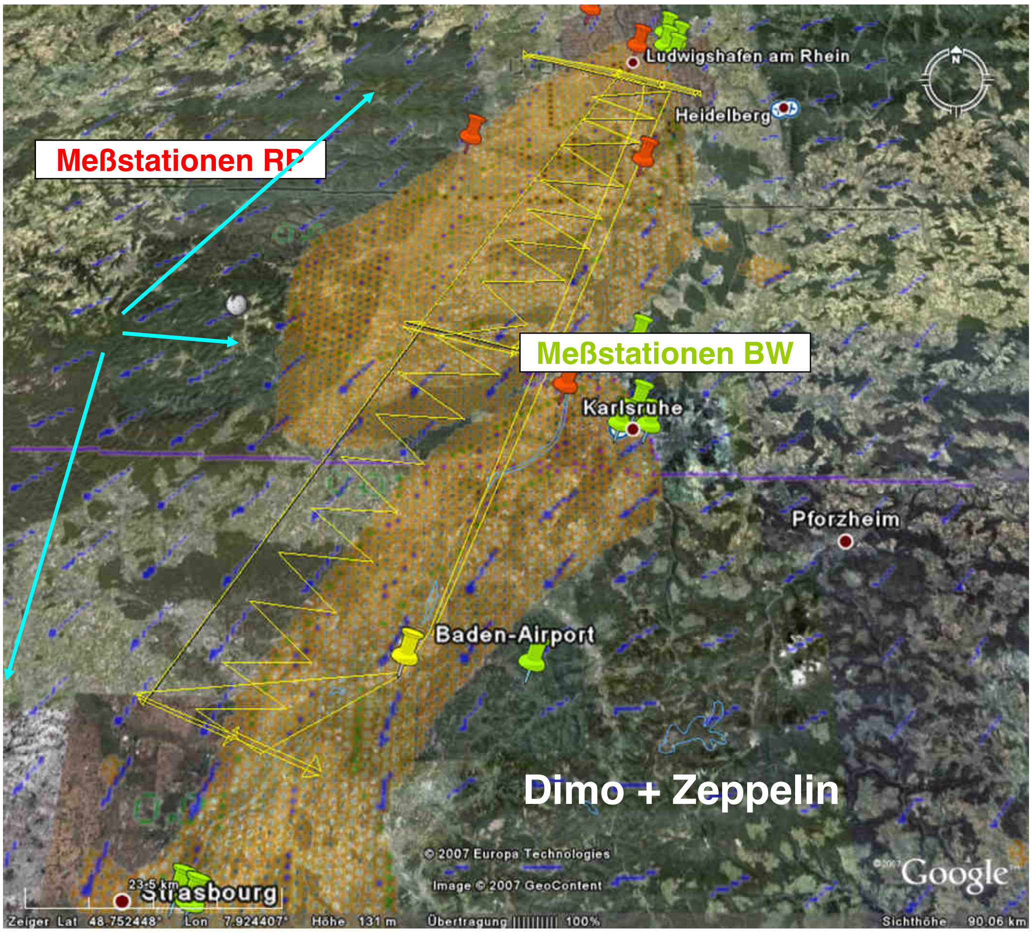
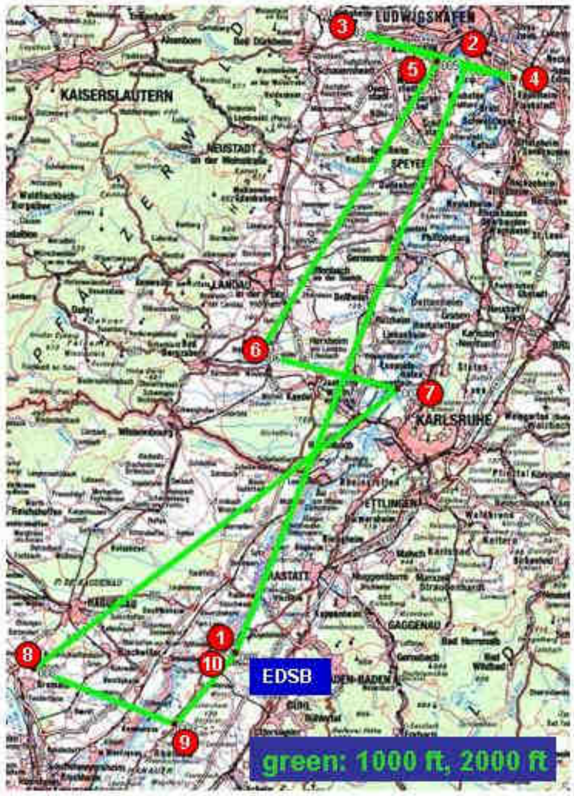


Fig. 7.5 *Overview on measurement platforms involved in the Lagrange study of a city plume. Source area of the plume is Mannheim/Ludwigshafen.*



Scenario: City Plume - Lagrange/South
Platform 7: Dimona
Mission: Lee Cross-Section

Punkt	Wegpunkt	Position	Peilung	Entfernung
1		48.769700° N 8.092630° E		
2		49.445700° N 8.463900° E	19.7° G	79.917 km
3		49.488700° N 8.247900° E	287.1° G	16.371 km
4		49.433300° N 8.550300° E	105.6° G	22.772 km
5		49.451900° N 8.413200° E	281.8° G	10.156 km
6		49.113900° N 8.105400° E	210.9° G	43.756 km
7		49.075900° N 8.349300° E	103.3° G	18.307 km
8		48.748100° N 7.722200° E	231.8° G	58.667 km
9		48.686400° N 7.966800° E	110.8° G	19.262 km
10		48.817500° N 8.118500° E	37.4° G	18.357 km

Fig. 7.6 Dimona flight pattern during mission City Plume

7.7 Stratus-Clouds Physics

Fehler! Es ist nicht möglich, durch die Bearbeitung von Feldfunktionen Objekte zu erstellen.

Fehler! Es ist nicht möglich, durch die Bearbeitung von Feldfunktionen Objekte zu erstellen.

Fig. 7.7 Overview on measurement platforms involved in the mission "Stratus-cloud physic"s, a EUFAR activity within COPS.

Fehler! Es ist nicht möglich, durch die Bearbeitung von Feldfunktionen Objekte zu erstellen.

Fig. 7.8 Partenavia flight pattern during mission Stratus-Cloud Physics

Fehler! Es ist nicht möglich, durch die Bearbeitung von Feldfunktionen Objekte zu erstellen.

Fig. 7.9 ATR 42 flight pattern during mission Stratus-Cloud Physics

8 COPS Operations Center

8.1 Location

The COPS Operations Center (OC) was located at Baden-Airpark, near Baden-Baden. Responsible for the set up of the OC was Christian Barthlott at FZK, Karlsruhe. Its location was near the COPS central region and provided easy access by car and public transport. Another advantage was the closeness to the aircraft crews. The OC was located outside the safety area of the airport, which made it accessible for everyone.

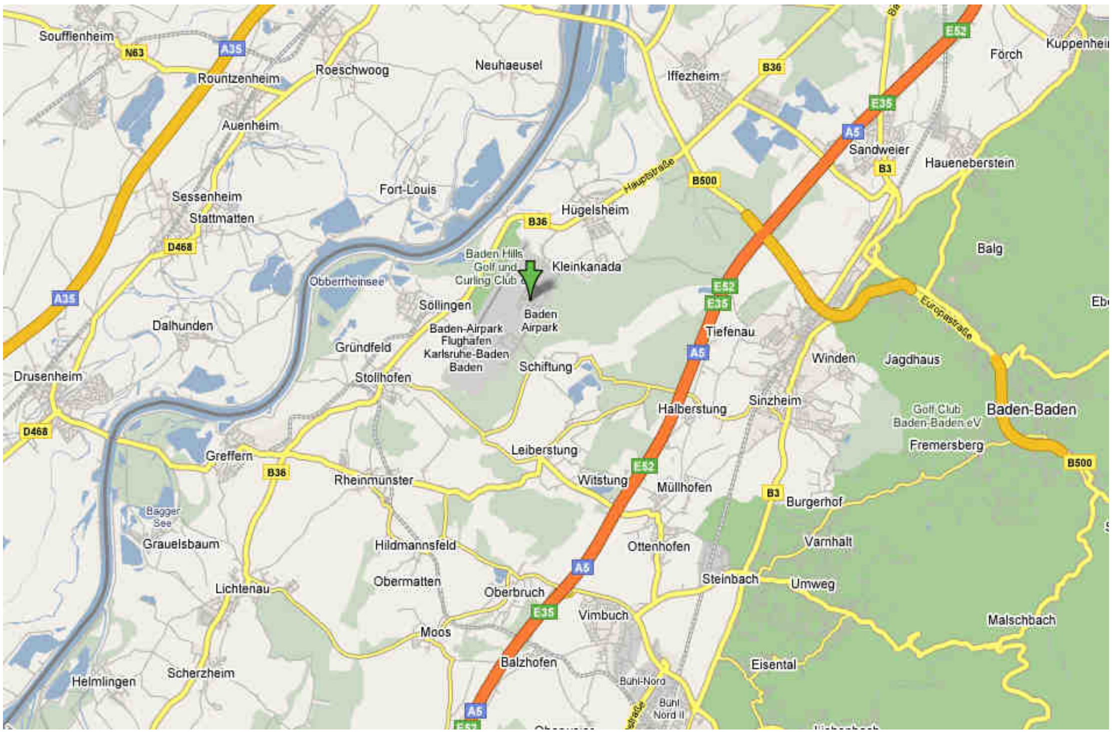


Fig. 8.1 Location of COPS OC at Baden Airpark (http://www.badenairpark.de/).

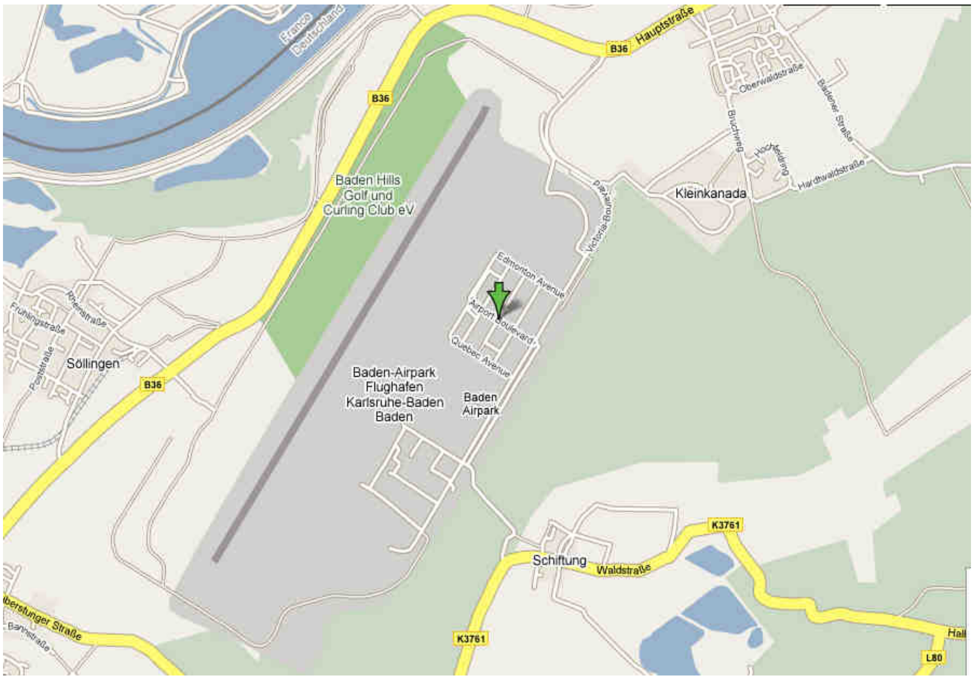


Fig. 8.2 Zoom into Baden Airpark.

Three rooms had been rented in the Airpark Business Center (ABC) from beginning of May until end of August 2007 (adress: Airport Boulevard B210; 77836 Rheinmünster).

Fig. 8.3 *The Airpark Business Center at Baden Airpark. The OC was located in the western part of the ABC in the 4th floor.*

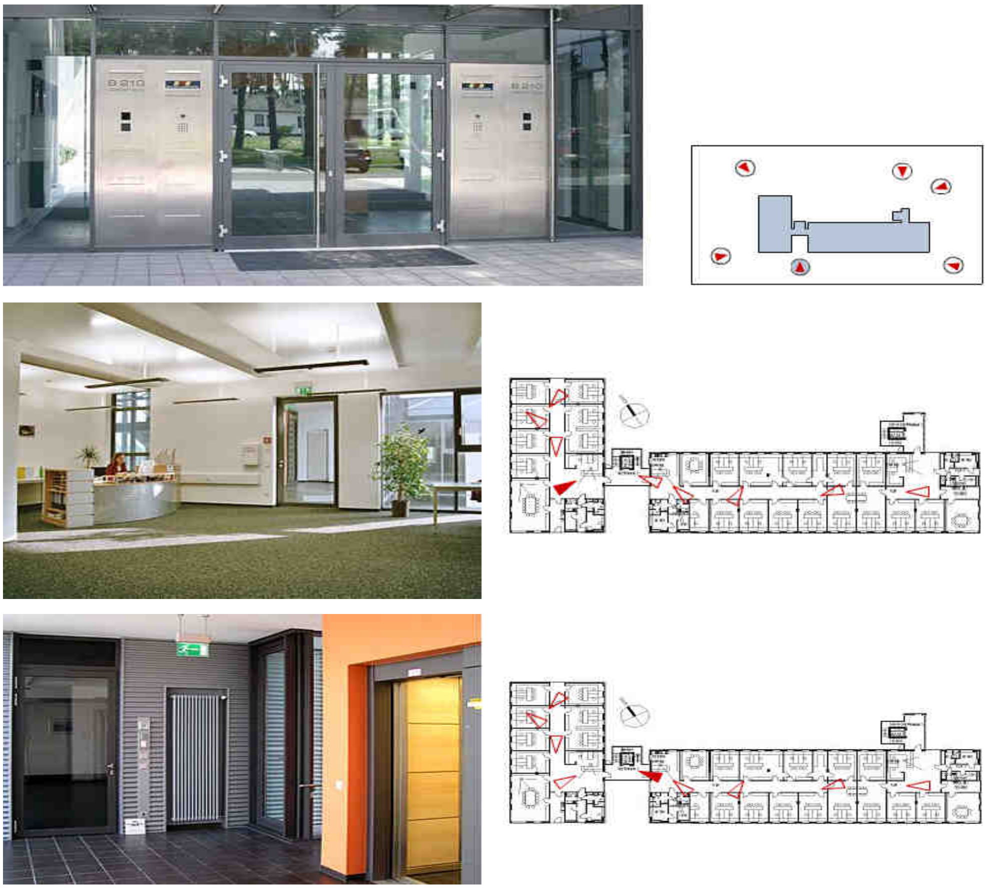


Fig. 8.4 Pictures of the ABC

8.2 Available rooms and layout

Three rooms with up to 63 m^2 were rented which were segmented into the Operations Center and two Internet Café's (Fig. 8-5). Four computers were installed in the Internet Cafe as well as a Wireless LAN for COPS scientists.

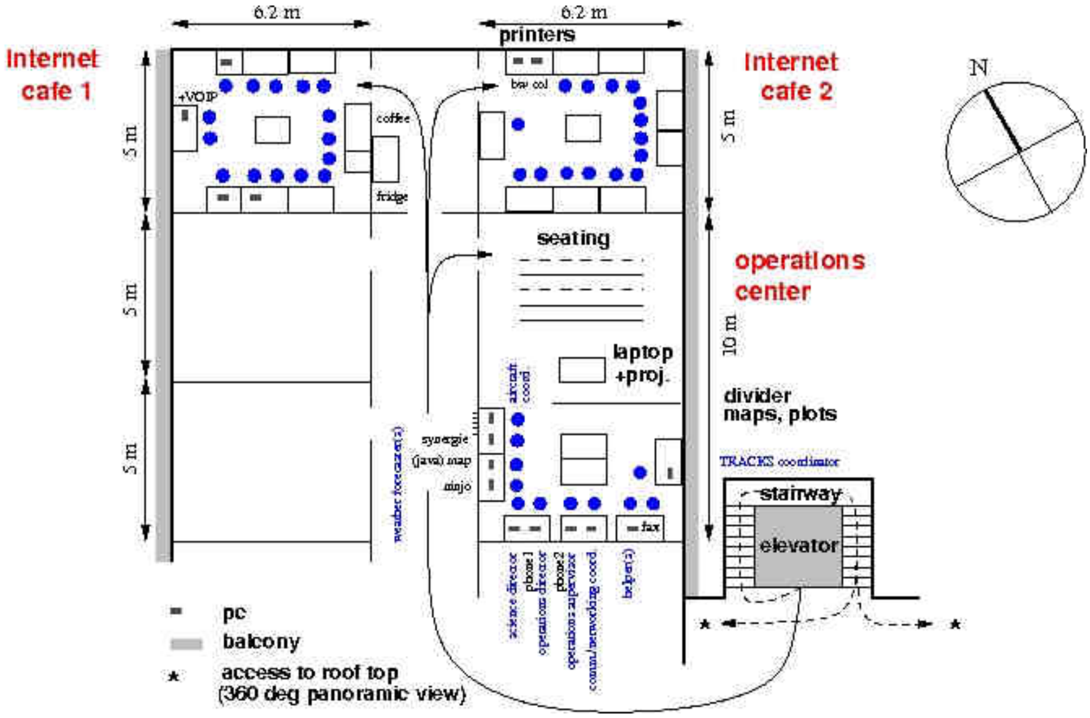
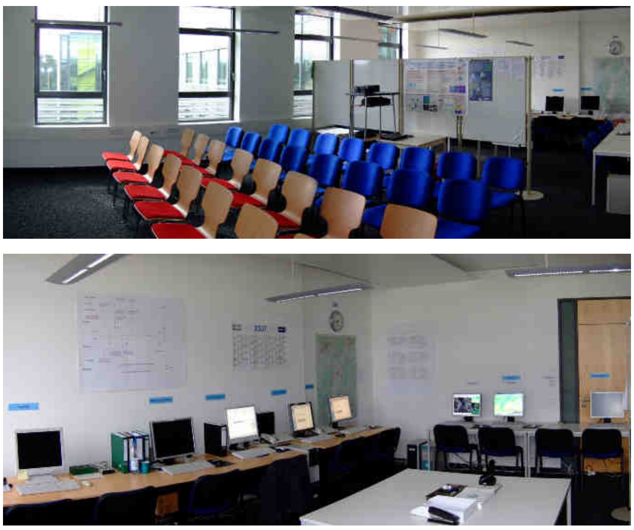
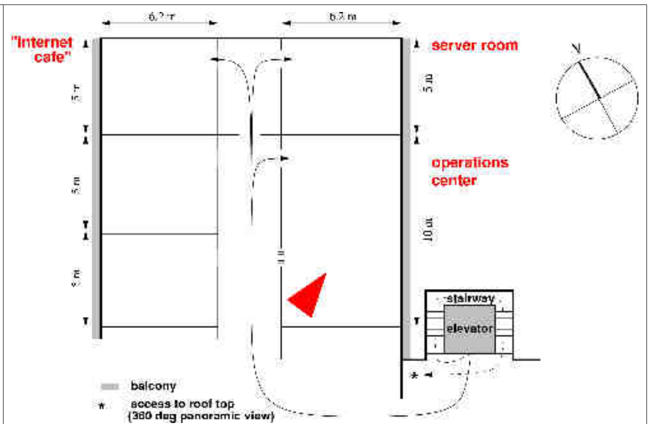
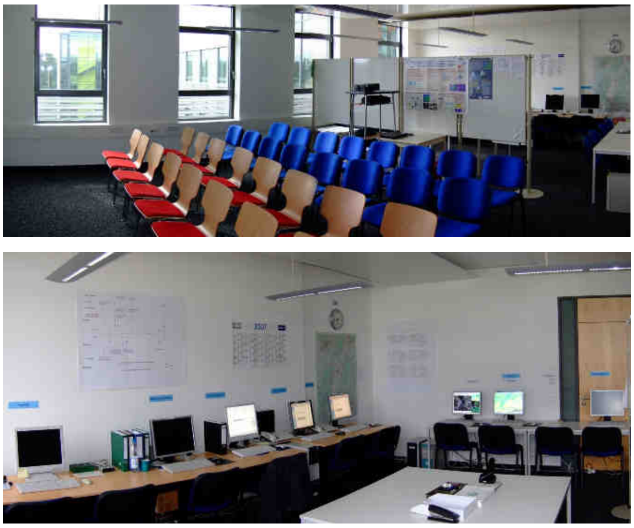


Fig. 8.5 The layout of the COPS Operations Center.

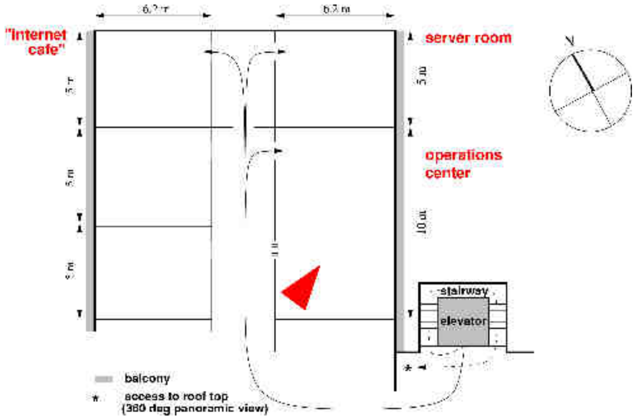




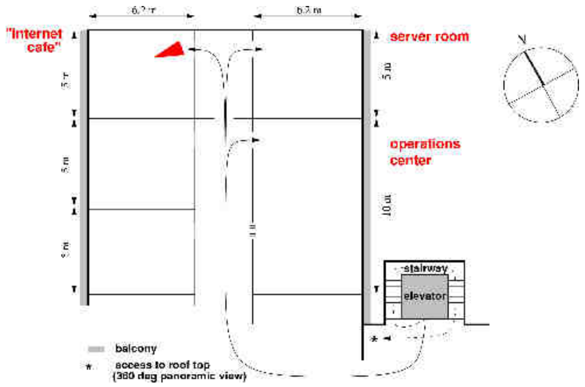
Operations Center



Operations Center



Internet Café 1



Internet Café 2

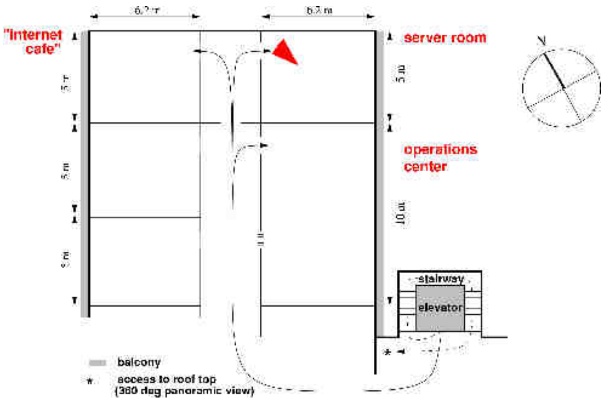


Fig. 8.6 Fotos and sketches of the OC

9 Operations

9.1 Operations Coordination

This chapter describes the process by which science plans had been developed by the COPS Mission Selection Team (MST) and implemented by the Operations Center Team (OCT). It includes detailed descriptions of the functions and responsibilities of the COPS project management staff, the mission planning process, facility coordination, project documentation requirements and the meeting schedules for the COPS Operations Center (OC).

9.2 Mission Staff and Functions

The MST was composed of the Science Director, the Operations Director, the Operations Supervisor, and the mission advisors. The composition of the OCT and the MST is illustrated in Table 9.1.

Table 9.1 Composition of MST and OCT.

MST	OCT	Function	Candidates
x		Mission Advisors	COPS ISSC and WG representatives
x	x	Science Director	ISSC, WG Chairs, Wernli, Kalthoff, Volkert, Craig, Dörnbrack
x	x	Operations Director	ISSC, WG Chairs, Wernli, Kalthoff, Volkert, Craig, Dörnbrack
x	x	Operations Supervisor	Barthlott, Trentmann, Kunz
	x	Aircraft Coordinator	Finkenzeller, COPS Air Crew (Aircraft PIs), 2 DLR members
	x	Weather Forecasters	Mühr, Groenemeijer, Ehmann, 2 x MeteoFrance, Stoll, Dahl
	x	Communications/Networking Coordinator	Brückel, Klinck
	x	Helper	Ehmann, Vonderach, Maisenbacher

The members of the OCT had to be present at the OC throughout the whole day, whereas the Mission Advisors will complement the OCT team at least during the mission selection process of the daily meetings.

The MST had the responsibility to ensure that all COPS scientific objectives were met during the field phase of the experiment. This group had full responsibility for the scientific research activities during the COPS field phase and the decision making that leads to the mission definition. The MST solicited input from participating investigators as part of the mission planning process. The decisions of the MST pertaining to mission objectives were binding to all participating scientists, the Science and Operations Director, OCT and supporting staff. The MST was also responsible for monitoring the scientific progress of the field phase, through debriefing reports received from the Science and Operations Director following each mission and PI feedback provided from special science seminars and personal communications. The MST could also convene special science meetings to discuss the progress toward the scientific objectives and preliminary analysis results. Functionally, the decision process and information flow to and from the MST are illustrated in Fig. 9.1.

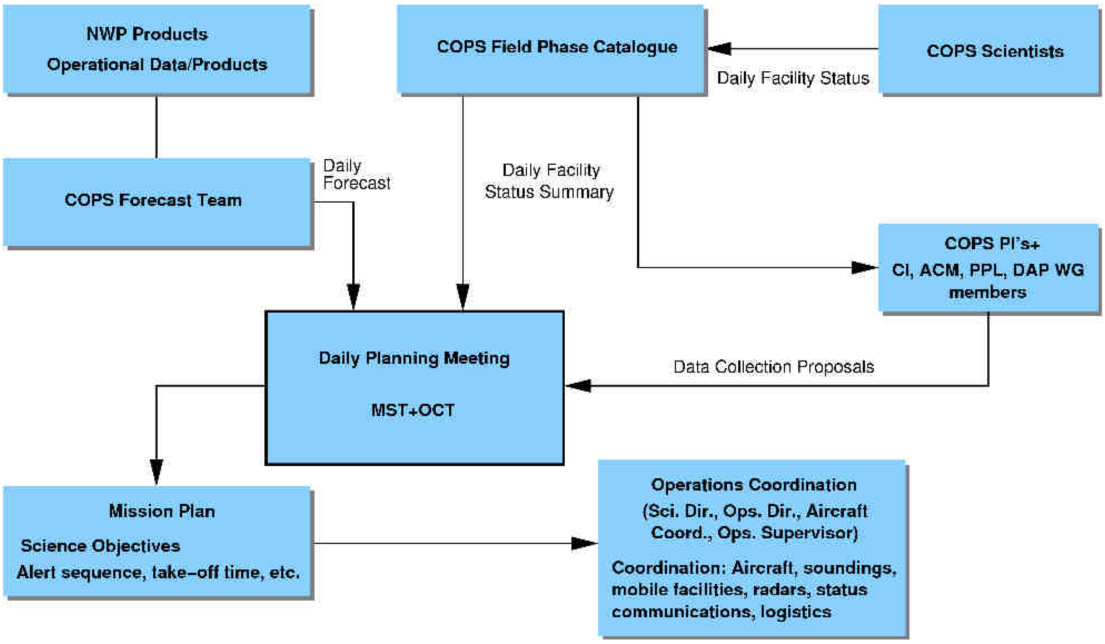


Fig. 9.1 Schematic of COPS interactions and decision sequences.

9.2.1 Science Director

The responsibilities of the Science Director were

To be director for scientific mission decisions

To convene and co-chairs the COPS Daily Planning Meeting

To lead daily mission planning discussion

To make go/no go decision for day's mission

To provide science progress reports to Daily Planning Meeting

To work with Operations Director and Aircraft Coordinator to determine flight plans

To provide daily reports to the MST

To be responsible for form and content of the daily COPS Operations Plan and Science Director's summary (including short summary for OC answering machine and news ticker)

To assign duties to OCT personnel

To be reachable 24h/day via Science Director cell phone

9.2.2 Operations Director

The Operations Director

supported the Science Director in the mission planning and decision process

decided (in consultation with MST) the final deployment of mobile facilities

notified ground-based sites of observing schedules and operating instructions

notifieds mobile platform managers of deployment schedules and target area

coordinated required support activities

conducted debriefings

was responsible for form and content of the Mission's Summary

updated COPS recorded status message

provided mission progress reports to the MST

9.2.2.1

9.2.3 Aircraft Coordinator

The Aircraft Coordinator

acted as single point of contact for all COPS Aircraft Facility Managers

convened Aircraft Briefing and Debriefing

requested and relayed aircraft status change information to Operations Director

provided updated information to aircraft during flight operations as necessary to ensure successful missions

collected mission reports

coordinated all communications between Operations Center and research aircraft

provided advanced notification and alerts to ATC and military groups

coordinated crew alerts and rest cycles with Aircraft Facility Managers

9.2.4 Operations Supervisor

The Operations Supervisor

monitored mobile platform locations

monitored expendable usage (including aircraft flight hours and sounding expendables)

provided daily input on usage and availability of expendable resources

prepared and presented summary status report for Daily Planning Meeting

coordinated facility status input to daily update of on-line COPS field data catalog

routinely monitored COPS Field Catalog reports and products. Assured completeness of daily reports and operational products entered reports and preliminary data to Field Catalog

assisted Operations Director and Facility Coordinators in passing information to aircraft, mobile platforms and remote sites during operations

requested and relayed status change information to Operations Director

arranged seats on research flights for scientific visitors and members of the media by coordinating with individual Aircraft Flight Scientists and Aircraft Facility Managers

coordinated OC space and systems support

took over all tasks of the helper, if the helper was not on duty

9.2.5 Weather Forecasters

Two Weather Forecasters

provided weather analysis and forecast for the next 4 days with respect to COPS sensible questions: time and location of convection initiation, expected type of convection (blue, shallow, deep; single cells, organised cells), precipitation type and amount

established standard forecast content and products for COPS Field Catalog (weather nowcast and summary)

presented weather forecast and outlook at Daily Planning Meeting

presented weather analysis of IOP-days at weekly debriefings

made suggestions for IOPs and down days

made suggestions for possible targeted observations

9.2.6 Communications/Networking Coordinator

The Communications/Networking Coordinator

managed LAN and related computer support

monitored operation of COPS on-line Field Catalog

assisted participants with set up of computer systems on the OC (W)LAN

was the primary point of contact with local Internet Provider and Access Grid

9.2.7 Helper

The Helper

assisted with preparation of summary status report for Daily Planning Meeting

assisted the Science and Operations Director with preparation of daily meetings and debriefings

coordinated facility status input to daily update of on-line COPS field data catalog

assisted scientists with entering reports and preliminary data to Field Catalog assisted Operations Director in passing information to aircraft, mobile platforms and remote sites during operations

recorded OC answering machine with current news

requested and relayed status change information to Operations Director

assisted participants with travel and housing arrangements, including disbursement of airport ID cards and keys

coordinated administrative and clerical needs at the OC in support of the MST and OCT, including FAX and photocopy services

provided contact information for receiving and shipping of material

assisted with printing and installing of weather charts on divider

took phone calls if Science and Operations Directors were not disposable

accomplished driving services if needed

prepared notebook and projector for meetings and briefings

notified Mr. Mössinger from baden-Airpark about debriefings in conference room Venezia

printed and put up weather charts

checked all OC computers for Updates (Virus Scanner, Windows Update)

checked coffee machine: water, milk, coffee…

9.2.8 Outreach Manager

The Outreach Manager coordinated public relations activities including press briefings and requests for interviews of COPS scientists by media.

9.3 Daily COPS Forecasting and Nowcasting Support

9.3.1 General overview

COPS is supported in a unique way by the extensive collaboration with D-PHASE and with weather forecast centers such as Meteo Swiss, Meteo France, and DWD. Furthermore, DLR is providing a visualization of ECMWF forecasts.

Consequently, a huge variety of forecast and nowcasting products was available and linked via the COPS web site www.cops2007.de.

For medium-range forecasts, mainly the ECMWF products provided by DLR, DWD GME, and the GFS system were used. The huge amount of ECMWF material was linked via the COPS web site under forecast products.

Within the NinJo-Workstation, the forecasting team of the Operations Center had access to GME and LME model results of the DWD. In addition, GFS was also available via this system. The former system MAP could be used with a remote connection to the system of IMK at the University of Karlsruhe. Java Map 3.0 was installed on both computers for the forecasters.

The French Workstation SYNERGIE provided access to the French model results during the time of the French COPS contribution.

For short- to medium-range forecasts, the D-PHASE product were used via its visualization platform. D-PHASE forecasts were produced according to the TIGGE+ data table. The visualization table is shown in the D-PHASE Implementation Plan. Further details are provided via the D-PHASE web site (http://www.map.meteoswiss.ch/map-doc/dphase/dphase_info.htm).

Short-range mission planning and guidance was supported by four models from D-PHASE, which are also available via the OC Homepage. These models, COSMOCH2, LMK, AROME, and CMCGEMH, represent the current state-of-the-art of high-resolution mesoscale convection permitting modeling. The forecast time ranged from +18 to +30 h in AROME.

9.3.1.1 Nowcasting

Actual weather data can be displayed with the NinJo-System, (Java) Map, and the SYNERGIE Workstation. DWD gave access to a Radar composit with 1 km resolution, which is called GuST realtime (Guidance System for Severe Thunderstorms). The latest radar data of the precipitation radar of IMK and Poldirad were also available. The following systems provided regularly updated quicklooks and are available via the COPS OC homepage:

IMK Windtracer (Hornisgrinde)

IMK Cloud Camera (Hornisgrinde)

IMK Cloud Radar (Hornisgrinde)

CNR Microwave Profiler (Hornisgrinde)

IMK Radiosonde Stations (FZK, Burnhaupt le Bas)

The lightning activity of the last 60 min was displayed by the LMU Munich and have been updated every 10 min. GOP Quicklooks, Quicklooks of AMF instruments at Supersite H and GPS Integrated Water Vapor (German and French stations) complemented the available special products in the Operations Center.

9.4 Infrastructure for Mission Planning

A wealth of information was available for mission planning, which needed to be carefully used and distributed. The unique information but also the complexity of the planning process is expressed in Fig.9.2.

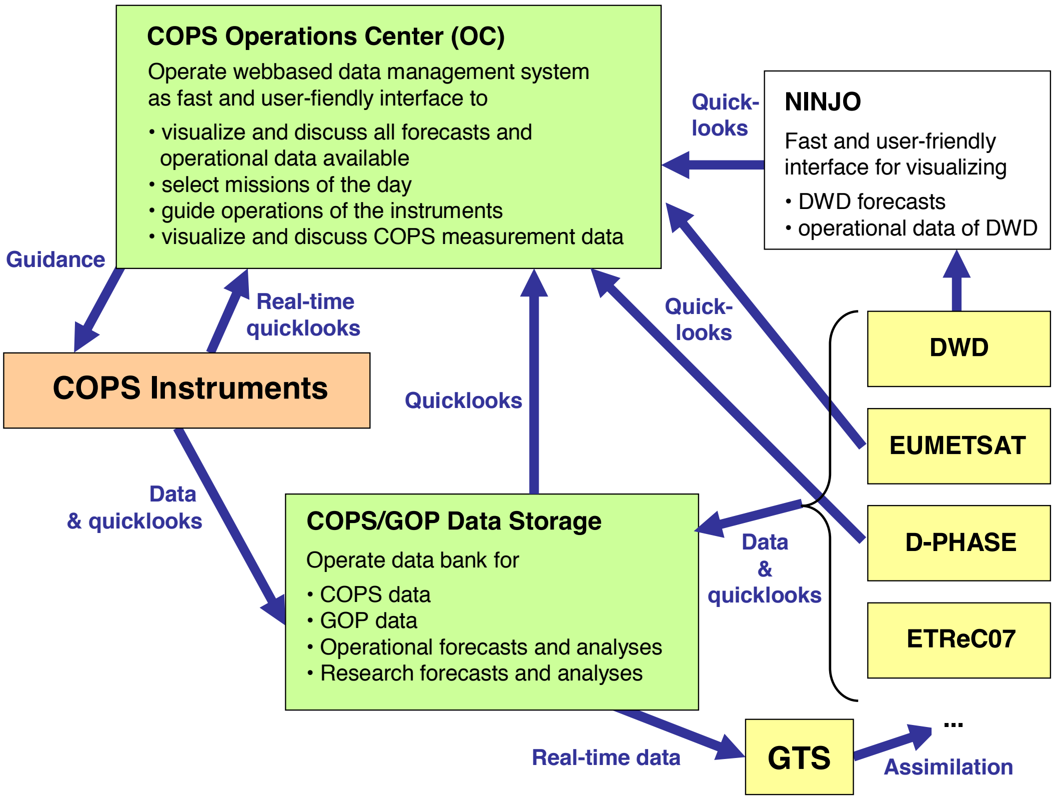


Fig. 9.2 COPS information flow for mission planning and data storage

9.4.1 COPS OC Website

The central information source for COPS was the COPS OC web site www.cops2007.de. This site contains information about contact and location, an introduction in COPS, daily reports, facility status, operational products, forecast products, missions, further generation information, a blog, links, internal issues, and the COPS mailing list.

9.4.2 COPS NinJo Server

NinJo is a meteorological workstation project based on JAVA. The introduction of new observing systems as well as the development of new forecasting techniques increases the amount of meteorological data. For example, numerical weather prediction models are using higher and higher resolutions. Furthermore the latest geostationary weather satellites offer data up to twelve channels in higher temporal and spatial resolution than ever. For a better understanding of weather phenomena these data have to be combined through recently developed algorithms. The current applications stem from the early nineties and became hard to maintain and upgrade. Furthermore they do not interoperate. For these reasons and to consider forthcoming meteorological evolution, the project NinJo was initiated in the beginning of 2000. NinJo was established as an international co-operation between Deutscher Wetterdienst (DWD), Geoinformationsdienst der Bundeswehr (GeoInfoDBw), MeteoSwiss, Danmarks Meteorologiske Institut DMI) and Meteorological Service of Canada (MSC). The goal was to develop a comprehensive, hardware independent and highly performant application which is able to visualize all possible meteorological data in a common desktop for a uniform environment in weather forecast and weather alert system. Besides that NinJo can be used in batch mode generating several products, replacing many graphical programs working separately today.

During COPS, NINJO was used for visualization of forecast products overlaid with observations such as surface, radar, or radiosonde data. Furthermore, real-time access to satellite data and their visualization was used for mission preparation and guidance.

9.4.3 D-PHASE Forecast Products and Visualization Platform

Access to the D-PHASE Visualization Platform (VP) is ensured via a password protected web site.

Special access to global model data such as ECMWF products was provided by DLR using a password protected link.

9.4.4 ETReC07 Targeting Results

Targeting results were analyzed via a link to DLR where targeting results from Meteo France and ECMWF will be collected. These data were used for targeting using the DLR Falcon aircraft.

9.4.5 Nowcasting and Satellite Products

EUMETSAT products were also linked via the COPS web site. This included data access and visualization, the RII index for mission planning, and the SSEC nowcasting tools.

IMK radar data could be visualized in real time via a data link to IMK.

9.5 Mission Planning Process

The planning of a mission involved several steps, such as facility status report, weather forecasting and mission proposals. In the Daily Planning Meeting, the mission plan for the next 4 days was formulated which was the basis for the implementation steps (notifications of COPS scientists, alert sequences and the mission execution itself).

9.5.1 Meetings

There were a general meeting each day of the COPS field program to discuss relevant issues, remaining resources and status, science objective status, current weather and synoptic situations and PI proposals. The COPS Daily Planning Meeting were held at

0500 UTC (day with IOP)

0730 UTC (no IOP planned)

at the COPS OC in Baden-Airpark, seven days per week throughout the field season beginning 1 June 2007 until 31 August 2007 unless down day. Down days were granted if IOPs in the next days could be excluded as a result of the actual weather situation.

The Daily Planning Meeting was co-chaired by the Science and Operations Director. The agenda for the meeting was consistent each day and included the following items:

Report on Facility Status

Report on expendable resources (remaining aircraft flight hours, drop(up)sondes, radiosondes)

Forecast discussion from 24-96 hours:

analysis/forecast of large-scale synoptic controls,

analysis/forecast of synoptic controls in the COPS region,

prediction of time and location of convection initiation,

expected type of convection (blue, shallow, deep; single cells, organised cells), and precipitation type/amount in the COPS region,

evaluate model discrepancies and forecast uncertainties,

suggestions for IOPs and down days,

suggestions for possible targeted observations

Presentation of mission proposals and discussions:

IOP planned for today: Confirmation, modification or cancellation of IOP

no IOP planned today: Formulation of mission plan for the next 4 days

Logistics or administrative matters

Other announcements

We reserved 1.5 h for the Daily Planning Meeting in order to give other PI's or members of the WG's enough time to make data collection proposals. On a day with a planned IOP, however, the tight time schedule only allowed typically a time of 1 h for this meeting. Since the data collection proposals and the flight program had to be made a day before an IOP, 1 h was expected to be sufficient. The details of the mission plan for the next 12-96 hours could either be discussed during the Daily Planning Meeting or immediately after the meeting with other PI's or staff crucial to formulate the details of the mission plan.

The Aircraft Mission Briefing was held every day prior to a planned IOP directly after the Daily Planning Meeting and was chaired by the Aircraft Coordinator. In this meeting, the flight program was determined and coordinated between all participating aircraft. The flight program had to be submitted to Air Traffic Control (ATC) until 1200 CEST.

9.5.2 Daily briefing package

The daily briefing package was distributed via email to the COPS Operations Center mailing list and published in the COPS Field Phase Catalog. Additionally, the most important news were recorded on a separate answering machine and on the news ticker at the starting page of the Operations Center homepage. The daily COPS Operations Plan included a time schedule for the next 4 days which were also outlined by 4 different alert levels:

Alert Level green IOP (ongoing or planned)

Alert Level orange IOP possible

Alert Level red no IOP

Alert Level black down day (fixed)

According to these alert levels, all PI's were asked to define special operation procedures for their instruments and teams (e.g. no maintenance work during an IOP). This timetable for the next days together with the alert levels was be published at the starting page of the COPS OC.

Table 9.2 COPS Alert Table

today (day x) 1/08/07	day x+1 2/08/07	day x+2 3/08/07	day x+3 4/08/07	day x+4 5/08/07
green	red	green	Orange	Black

9.5.3 Facility notification procedure

Once the facility operating schedules for missions were decided at the Daily Planning Meeting, the briefing package was distributed to all participants via the COPS Field Catalog, via email to the COPS Operations Center Mailing list and on a answering machine. The Science Director was responsible for the Operations Plan and the

Science Directors Summary. Official notifications to facility managers were made by the Operations Director or a member of the OCT. The notifications included e.g. the deployment schedule and target areas of mobile platforms, operations schedules for soundings and scan strategies for lidar or radar measurements. The Aircraft Coordinator informed all aircraft facility managers and ATC about aircraft take-off times and flight plans.

Table 9.3 Information flow from COPS OC to COPS PIs

Information	Distribution method	Responsable person for its content	Distributed by
Ops. Plan for next 4 days incl. alert levels	Field Catalog and email	Science Director	Science Director
Science Dir. Summary	Field Catalog	Science Director	Science Director
Ops. Plan of the Day (summary)	News ticker and answering machine	Science Director	Ops. Supervisor
Notification of ground-based sites incl. mobile platform managers	Field Catalog, email, phone	Ops. Director	Ops. Director
Notification of DWD and MeteoSwiss regarding add. Radiosondes (EUCOS)	Email, fax	Ops. Director	Ops. Director
Notification to aircraft crews and ATC	personal or phone	Aircraft coordinator	Aircraft coordinator
Mission summary	Field Catalog	Ops. Director	Ops. Director

9.5.4 Debriefing and reporting

At the completion of a day's mission, post-flight debriefings were held for each aircraft mission. The debriefings were conducted by the Aircraft Coordinator at the Operations Center as soon as possible after landing so that all onboard scientists and selected crewmembers could participate. The latest possible starting time was 1800 UTC. If this was not possible due to later landing times of the aircraft, this meeting was held on the next day after the Daily Planning Meeting. Key issues were the perceived success of a mission, and the status of the facility and crew for next day's operations. The Operations Director or Aircraft Coordinator could also announce the alert and schedule for the next day's operations. The agenda for the Aircraft Debriefing should included the following items:

devolution of flight program

discussion about problems and conflicts

status of facility and crew

presentation of data quicklooks (if possible)

consequences for the next IOP.

For the mobile platforms, when they had returned to their operating base, a debriefing of the Facility Manager was made by the Operations Director, usually by phone. Each COPS scientist, responsible for an instrument was expected to provide a Facility Status Report to the COPS Field Catalog every day until 0700 UTC. If this was not possible due to a missing internet connection or other problems, people from the OCT gave support with this task after having been notified by phone.

9.5.5 Targeted observations

A special feature of COPS were targeting efforts in collaboration with ETReC07. This project required a special planning process. At the OC, access to a PREVIEW web site was available in order to study different targeting results calculated within the scope of ETReC07.

The DLR Falcon performed these targeted observations in sensitive regions. 3 days before a planned IOP, the decision about the execution of targeted observations had to be made. The timetable is summarized in Tab.9.5.

Furthermore, notification of EUCOS was required because additional radiosoundings were always performed in support of ETReC07. This included the MeteoSwiss radiosonde station at Payerne where additional launches at 06 and 18 UTC were made. Upgrades from simple PILOT to full TEMP measurements were performed on 40 days during the 3 COPS months. This included soundings for ETReC at 6 days. Meteo Swiss received notice via fax and e-mail simultaneously the day before each requested ascent.

Similarly, DWD carried out additional 06 and 18 UTC soundings at Meiningen, Stuttgart and Munich on 40 days on demand. DWD also supported ETReC07 with soundings from several more sites (in the requested area: 35°N/10°W to 55°N/10°E), allowing in total a number of 300 additional soundings for both experiments together. DWD prefers alerts via e-mail.

Table 9.4 Timetable for DLR Falcon targeted observations.

Day x-3	Day x-2	Day x-1	Day x (IOP)
Decision about targeted obs.	Flight preparation	Targeted obs. + Model run with data assimilation	IOP (+Model run with data assimilation)

10 Organization of mission performance

Table 10.1 and Fig. 10.1 summarize the time schedule for the planning, mission performance, and debriefing process.

Table 10.1 Planning process time schedule, CEST = UTC + 2 h

Time (UTC)	Participants and responsible persons	Task
	Case A: no IOP tomorrow	
0600	Weather forecaster(s)	Forecast preparation and submission to COPS Field Catalog
until 0700	COPS scientists	Deliver status report from all facilities
0730	COPS PIs + forecasters potential phone conference	Weather briefing Mission proposals
0800	MST + OCT	Daily Planning Meeting
0900	Sci. and Ops. Directors, Ops. Supervisor, helper	Distribute daily briefing package
1000-1600	Sci. and Ops. Directors, Ops. Supervisor, Weather Forecaster(s)	Disposition, control of weather development
1500	Weather forecaster(s)	Forecast update (if necessary)
	Case B: IOP tomorrow	
0600	Weather forecaster(s)	Forecast preparation and submission to COPS Field Catalog
until 0700	COPS scientists	Deliver status report from all facilities
0730	MST+OCT	Daily Planning Meeting
0900	Sci. and Ops. Directors, Aircraft Coordinator, Flight Scientists	Aircraft Mission Briefing
0900	Operations Supervisor, helper	Distribute daily briefing package
1000	Aircraft Coordinator	Provides notification and alerts to ATC
1000	Ops. Director	Notifies ground-based sites of special observing schedules and operating instructions
1000	Sci. and Ops. Directors, Ops. Supervisor, Weather Forecaster(s)	Disposition, control of weather development
1500	Weather forecaster(s)	Forecast update
	Case C: IOP today	
0430	Weather forecasters	Forecast preparation and submission to COPS Field Catalog
0500	MST + OCT	Daily Planning Meeting
0600	Aircraft Coordinator	Provides updates to ATC

0600	Sci. and Ops. Directors, Ops. Supervisor, Helper	Distribute daily briefing package
0600	Ops. Director	Notifies ground-based sites of special observing schedules and operating instructions
until 0700	COPS scientists	Deliver status report from all facilities
end of IOP	OCT (+MST)	Observation/modification of scheduled mission
1800	Operations Director, Aircraft Coordinator, Flight Scientists	Aircraft Debriefing (or the next day after Daily Planning Meeting)
	Case D: IOP yesterday, no IOP tomorrow	
0600	Weather forecaster(s)	Forecast preparation and submission to COPS Field Catalog
until 0700	COPS scientists	Deliver status report from all facilities
0730	MST+OCT	Daily Planning Meeting
0900	Operations Director, Aircraft Coordinator, Flight Scientists	Aircraft Debriefing (or evening of IOP day)
0900	Sci. Director, Ops. Supervisor, Helper	Distribute daily briefing package
1000-1600	Sci. and Ops. Directors, Ops. Supervisor, Weather Forecaster(s), Helper	Disposition, control of weather development
1500	Weather forecaster(s)	Forecast update (if necessary)
	Case E: IOP yesterday and tomorrow	
0600	Weather forecaster(s)	Forecast preparation and submission to COPS Field Catalog
until 0700	COPS scientists	Deliver status report from all facilities
0730	MST+OCT	Daily Planning Meeting
0900	Sci. and Ops. Directors, Aircraft Coordinator, Flight Scientists	Aircraft Mission Briefing + Aircraft Debriefing
0900	Operations Supervisor, Helper	Distribute daily briefing package
1000	Aircraft Coordinator	Provides notification and alerts to ATC
1000	Ops. Director	Notifies ground-based sites of special observing schedules and operating instructions
1000	Sci. and Ops. Directors, Ops. Supervisor, Weather Forecaster(s)	Disposition, control of weather development
1500	Weather forecaster(s)	Forecast update
	Case F: IOP today and tomorrow	
0430	Weather forecasters	Weather analysis and forecast
0500	MST + OCT	Daily Planning Meeting + Aircraft Mission

		Briefing
0600	Aircraft Coordinator	Provides updates to ATC
0600	Sci. and Ops. Directors, Operations Supervisor, Helper	Distribute daily briefing package
0600	Ops. Director	Notifies ground-based sites of special observing schedules and operating instructions
until 0700	COPS scientists	Deliver status report from all facilities
1000	Aircraft Coordinator	Provides notification and alerts to ATC for IOP tomorrow
end of IOP	OCT (+MST)	Observation/modification of scheduled mission
1800	Operations Director, Aircraft Coordinator, Flight Scientists	Aircraft Debriefing + Mission Briefing for tomorrow

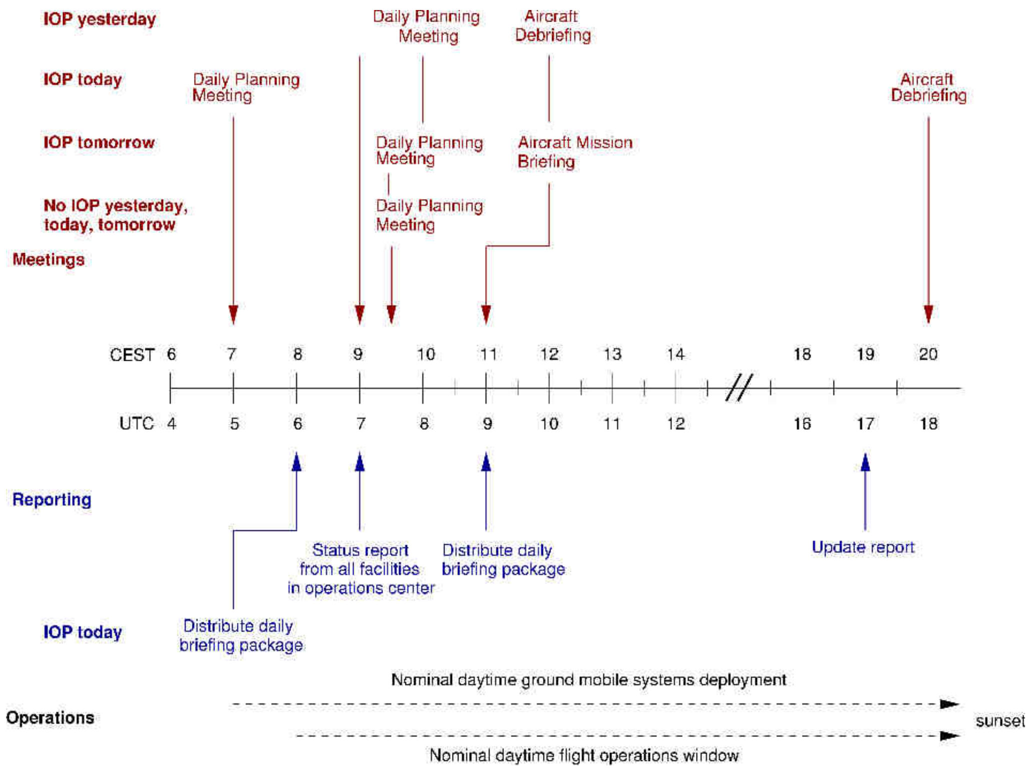


Fig. 10.1 *Daily operations and planning schedule. Valid 7 days/week unless down day. The case "IOP yesterday" in combination with "IOP tomorrow" was be treated as IOP tomorrow". If an IOP was scheduled the day after an ongoing IOP, the Aircraft mission briefing was combined with the Daily Planning Meeting if possible. The absent aircraft PI's were informed about the flight plans during the day by the Aircraft Coordinator. Sunset was around 2130 CEST.*

11 Mission Accomplishment

11.1 General Impression

The design of mission planning as depicted in chapter 10 worked out very well. The detailed and concise description of the planning process turned out to be extremely helpful. Even during the most challenging phases of COPS, as 10 airborne platforms had to be coordinated with more than 50 scientists in the OC during middle to end of July, the decision process was clear and transparent and was supported by all scientists. In fact, not during a single IOP significant disagreement existed concerning mission performance. Obviously the clear definition and description of the science questions and the scientific approach to resolve these questions paid off very well.

The cooperation between the scientists was excellent and the community really grew together during the campaign. An important aspect was the distribution of responsibilities between the COPS PIs. For instance, basically each member of the ISSC enjoyed working as Science Director or Operations Director during the campaign.

A further challenge was the coordination of COPS missions with EUFAR activities. The four EUFAR aircraft, French Falcon, DIMONA, Partenavia, and ATR42 had to be operated between COPS dedicated IOPs, as the science goals of the EUFAR projects were different. This caused a higher workload for the COPS PIs, however, the responsibility of performing additional missions, generally called Special Observations Periods (SOPs), was taken by the COPS OC with the same seriousness as during the IOP.

Fig. 11.1 Operations Director Christian Barthlott and Science Director Reinhold Steinacker during IOP 13.

Table 11.1. Operations Center shift schedule for mission planning. A good comprimize between all participating parties with respect to sharing the responsibilities was found.

	Mission Selection Team										
June	Sci. Dir.	Ops. Dir.	M Adv. Members	Ops. Superv.	Air. Co	Forecasters			Net. Coord.	Helper	
Fri, Jun 1, 07	Kick off : Press Conference at Supersite H										
Sat, Jun 2, 07	VW	UC		CB	-	PG	JD	-	GB	RM	
Sun, Jun 3, 07											down
Mon, Jun 4, 07	UC	AB		CB	-	PG	JD	-	GB	RM	
Tue, Jun 5, 07	UC	AB		CB	-	PG	JD	-	GB	RM	
Wed, Jun 6, 07	UC	AB		CB	-	PG	JD	-	GB	RM	
Thu, Jun 7, 07	UC	AB	VW	CB	-	PG	JD	-	GB	RM	
Fri, Jun 8, 07	AB	VW		CB	-	PG	JD	-	GB	RM	
Sat, Jun 9, 07											down
Sun, Jun 10, 07											down
Mon, Jun 11, 07	VW	NK		CB	-	PG	JD	-	GB	CV	
Tue, Jun 12, 07	UC	NK		CB	-	PG	JD	-	GB	CV	
Wed, Jun 13, 07	NK	AB	VW	CB	-	PG	JD	-	GB	CV	
Thu, Jun 14, 07	NK	AB	VW, UC	CB	UC	PG	JD	-	GB	CV	
Fri, Jun 15, 07	NK	VW	UC	CB	UC	PG	JD	-	GB	CV	
Sat, Jun 16, 07											down
Sun, Jun 17, 07											down
Mon, Jun 18, 07	AB	UC		CB	UC	BM	PG	-	GK	RM	
Tue, Jun 19, 07	VW	UC		CB	UC	BM	PG	-	GK	RM	
Wed, Jun 20, 07	VW	UC	MK	CB	UC	BM	PG	-	GK	RM	
Thu, Jun 21, 07	UC	MK		CB	UC	BM	-	-	GK	RM	
Fri, Jun 22, 07	UC	MK	CH	CB	UC	BM	PG	-	GK	RM	
Sat, Jun 23, 07											down
Sun, Jun 24, 07											down
Mon, Jun 25, 07	AB	CK		CB	UC	BM	PG		GB	CV	
Tue, Jun 26, 07											down
Wed, Jun 27, 07	CK	HV		CB	UC	BM	JD		GB	CV	
Thu, Jun 28, 07	CK	HV	VW	CB	UC	BM	PG	JD	GB	CV	
Fri, Jun 29, 07	CK	HV	VW, ER	CB	UC	PG	JD		GB	CE	
Sat, Jun 30, 07	HV	AB	VW, ER, CH	CB	UC	BM	PG	JD	GB	CE	
Sun, Jul 1, 07	HV	CK	ER	CB	UC	BM	CE	-	GK	CE	
Mon, Jul 2, 07	HV	AB	ER	CB	UC	BM	CE	-	GK	RM	
Tue, Jul 3, 07	AB	GC	ER, ABI	CB	UC	BM	CE	-	GK	RM	
Wed, Jul 4, 07	AB	GC	HR, ABI	CB	UC	BM	CE	-	GK	RM	
Thu, Jul 5, 07											down
Fri, Jul 6, 07											down
Sat, Jul 7, 07	GC	VW	HR, PDG, ABI	CB	UC	BM	JBC	-	GK	RM	
Sun, Jul 8, 07	GC	VW	ABI, HR	CB	UC	BM	JBC	-	GB	CV	
Mon, Jul 9, 07	VW	MK	ABI, HR	CB	HF/UC	BM/MS	JBC	-	GB	CV	
Tue, Jul 10, 07	VW	MK	ER, CF, StM, AB, UC	CB	HF/UC	MS	JBC	-	GB	CV	
Wed, Jul 11, 07	StM	MK	ER, CF, AD, PDG, VW, UC	CB	HF/UC	MS	JBC	-	GB	CV	
Thu, Jul 12, 07	StM	ER	CF, VW, ABI., PDG, UC, AD	CB	HF/UC	MS	JBC/CeH	-	GB	CV	
Fri, Jul 13, 07	StM	ER	CF, ABI, UC, AD	CB	HF/UC	MS	CeH	-	GB	-	
Sat, Jul 14, 07	StM	ER	CF, ABI, UC, AD	CB	UC/HF*	MS	CeH	-	GB	-	
Sun, Jul 15, 07	ER	VW	UC, ABI, AD	CB	UC/HF*	MS	CeH	-	GK	-	
Mon, Jul 16, 07	VW	CB	ABI, CKe, AD, UC	CB	UC/HF*	BM	CeH	CE	GK	CE	
Tue, Jul 17, 07	ER	CB	ABI,UC, CH, CKe, PDG	CB/JT	UC/HF*	BM	CeH	CE	GK	CE	
Wed, Jul 18, 07	VW	CB	ER, ABI, CH, Cke, UC	JT	UC/HF*	BM	CeH/JBC	CE	GK	CE	
Thu, Jul 19, 07	VW	CB	ER, AB, UC, Cke, ABI	JT	UC/HF*	BM	JBC	CE	GK	CE	
Fri, Jul 20, 07	VW	CB	UC, ER, ABI, StM	JT	UC/HF*	BM/PG	JBC	CE	GK	CE	
Sat, Jul 21, 07	ER	CK	UC, HV	JT	UC/HF*	PG	JBC	CE	GK	CE	
Sun, Jul 22, 07	ER	CK	UC, AbI, HV	JT	UC/HF*	BM	JBC	CE	GB	CE	
Mon, Jul 23, 07	VW	CK	ER, AbI, StM, HV, CB	JT	UC/HF*	BM	JBC/JP	CE	GB	CE	
Tue, Jul 24, 07	CK	HV	VW, ER, UC, AbI, AB, CB	JT	UC/HF*	BM	JP	CE	GB	CE	
Wed, Jul 25, 07	CK	HV	ER, UC, StM, AG, CB	JT	UC/HF*	BM	JP	CE	GB	CE	
Thu, Jul 26, 07	CK	HV	ER, UC, AG, StM, CB	JT	UC/HF*	BM	JP	CE	GB	CE	
Fri, Jul 27, 07	HV	SC	VW, ER, RS, AB, ChK, UC	JT	UC/HF*	BM	JP	CE	GB	CE	
Sat, Jul 28, 07	HV	SC	VW, ER, UC, ChK	JT	UC/HF*	BM	JP/JBC	CE	GB	CE	
Sun, Jul 29, 07	SC	JT	VW, ER, HV, ChK, CF, UC	JT	UC/HF*	BM	JBC	CE	GK	CE	
Mon, Jul 30, 07	SC	JT	VW, ER, HV, ChK, CF, GC, UC	JT	UC/HF*	BM	JBC	CE	GK	CE	
Tue, Jul 31, 07	GC	AB	ER, HW, ChK, CF, UC, PDG, VW	JT/CB	UC/HF*	BM	JBC	CE	GK	CE	
Wed, Aug 1, 07	GC	RS	ER, HW, ChK, CF, VW, UC	CB	UC	PG	JBC	-	GK	RM	
Thu, Aug 2, 07	RS	GC	ER, HW, CF, VW	CB	-	PG	JBC/JP	-	GK	RM	
Fri, Aug 3, 07	GC	HW	VW	CB	-	PG	JP	-	GK	RM	
Sat, Aug 4, 07											down
Sun, Aug 5, 07											down
Mon, Aug 6, 07	HW	VW		CB	-	PG	-	-	GB	RM	
Tue, Aug 7, 07	HW	VW		CB	-	PG	-	-	GB	RM	
Wed, Aug 8, 07	HW	CH	VW	CB	-	PG	JD	-	GB	CV	
Thu, Aug 9, 07	HW	CH		CB	-	PG	JD	-	GB	CV	
Fri, Aug 10, 07											down
Sat, Aug 11, 07	VW	CH	PDG	CB	-	PG	JD	-	GB	CV	
Sun, Aug 12, 07	CH	MG		CB	-	PG	JD	-	GK	CV	
Mon, Aug 13, 07	UC	MG		CB	-	-	JD	-	GK	CV	
Tue, Aug 14, 07	UC	MG		CB	-	PG	JD	-	GK	CV	
Wed, Aug 15, 07	UC	MG		CB	-	PG	JD	-	GK	CV	
Thu, Aug 16, 07	UC	MG	VW	CB	-	PG	CE	-	GK	CE	
Fri, Aug 17, 07	PDG	CB	VW	CB	-	PG	CE	-	GK	CE	
Sat, Aug 18, 07											down
Sun, Aug 19, 07											down

Mon, Aug 20, 07	PDG	HSB	VW	CB	-	PG	CE	-	GB	CE	
Tue, Aug 21, 07	PDG	HSB		CB	-	BM	CE	-	GB	CE	
Wed, Aug 22, 07	VW	HSB		CB	-	PG	CE	-	GB	CE	
Thu, Aug 23, 07	VW	MG		CB	-	PG	CE	-	GB	CE	
Fri, Aug 24, 07	VW	MG		CB	-	PG	CE	-	GB	CE	
Sat, Aug 25, 07	VW	MG		CB	-	PG	CE	-	GB	CE	
Sun, Aug 26, 07											down
Mon, Aug 27, 07	VW	MG	PDG	CB	-	PG	CE	-	GK	CE	
Tue, Aug 28, 07	VW	MG		CB	-	PG	CE	-	GK	CE	
Wed, Aug 29, 07	VW	MG		CB	-	PG	CE	-	GK	CE	
Thu, Aug 30, 07	VW	MG		CB	-	PG	CE	-	GK	CE	
Fri, Aug 31, 07	VW	MG		CB	-	PG	CE	-	GK	CE	

Forecasters		IPM Hohenheim		IMK Karlsruhe		Helper	
IMK		Volker Wulfmeyer	VW	Christoph Kottmeier	CK	Christian Ehmann	CE
Bernhard Mühr	BM	Andreas Behrendt	AB	Norbert Kalthoff	NK	Christian Vonderach	CV
Pieter Groenemeijer	PG	Hans-Stefan Bauer	HSB	Ulrich Corsmeier	UC	Ruben Maisenbacher	RM
Christian Ehmann	CE	Matthias Grzeschik	MG	Christian Hauck	CH		
Meteo France				Michael Kunz	MK		
Julien Billault-Chaumartin	JBC			Christian Barthlott	CB		
Cédric Hertzog	CeH			Gerhard Brückel	GB		
Jérome Pauthe	JP			Gabi Klinck	GK		
Meteo Schweiz							
Marco Stoll	MS						
DLR Oberpfaffenhofen							
Johannes Dahl	JD						
DLR Oberpfaffenhofen		University of Mainz		Laboratoire d'Aerologie		NCAS	
Hans Volkert	HV	Jörg Trentmann	JT	Evelyne Richard	ER	Alan Blyth	ABl
George Craig	CG	Heini Wernli	HW			Stephen Mobbs	StM
Andreas Dörnbrack	AD			CNRS			
Christoph Kiemle	ChK			Cyrille Flamant	CF	Alan Gadian	AG
Heinz Finkenzeller	HF (HF* from OP)						
Christian Keil	CKe						
University of Vienna		TU Delft		UNIBAS		University of Cologne	
Reinhold Steinacker	RS	Hermann Russchenberg	HR	Paolo Di G.	PDG	Susanne Crewell	SC

11.2 Operations Center

Work in the Operations Center was pleasant and due to the large space even during crowded periods all PIs found work space and wireless internet connection.

Extremely helpful was the COPS Website www.cops2007.de (see Fig.11-2) for quick exchange of information. As nearly all PIs in the field had access to the internet, the Operations Plan of the Day was rapidly distributed. During beginning of the campaign, the decision process took a bit longer as the forecaster and the scientists had to become familiar with the decision process as well as the overwhelming amount of information, which was available for mission planning. However, after the first week of mission performance, everybody became acquainted with all procedures.

The COPS website covers a huge amount of information not only about mission planning but also about the first results. All Weather Summaries, Operations Plans, and Facility Status Reports are summarized under the button "Daily Reports". The status of all facilities during the campaign is presented under "Facility Status". "Operational Products" are found of all instrumentation, which was capable to provide quicklooks. This covers radar and lidar facilities, satellite products, aircraft, cameras, radiometers, and various other "uncategorized" data sets such as radiosonde data.

The button "Forecast Products" leads the COPS scientists to various information sources, which were important for mission planning such as the D-PHASE models, the DLR COPS website with ECMWF forecasts, and outputs of the French MesoNH model, among other links.

An overview of "Missions" is also given including more detailed information about the performance of instruments during the respective IOPs. Consequently, the COPS website alone prepares the scientists very well for the scientific work with the data.

Fig. 11.2 Morning briefing for mission planning in the COPS OC. Stephen Mobbs (in front) was Science Director during this day.

Another valuable source of quick information exchange was the COPS OC Google Email. Very often, details on mission planning and refinement of mission performance were distributed per email. Lack of information during an IOP was not reported. The Operations Plan was not only put on the COPS Website but also distributed per email in order to make sure that PIs in the field with access to slow connections only were able to download the Operations Plan as well.

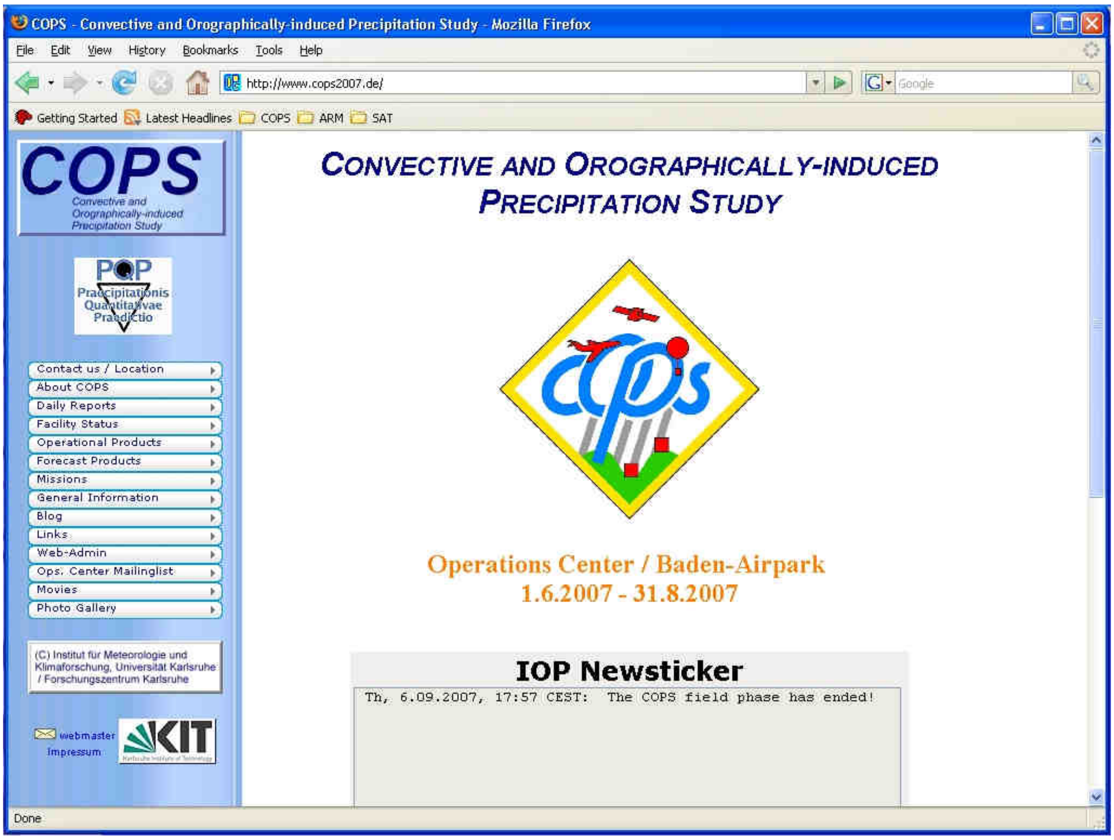


Fig. 11.3 The COPS website

For future campaigns it is highly recommended to invest the time for establishing internet connections at all places were rapid information exchange is critical.

A very important activity during the first weeks was the optimization of the archiving process. It was immediately realized that many products (forecast products, satellite and radar data, and others) were not prepared for archiving. However, it is obvious that the access to these products after the campaign is essential for efficient scientific work. Therefore, during the campaign, several archiving activities were initiated such as the Global Forecast System (GFS) archive at IMK (imkhp8.physik.uni-karlsruhe.de/~cops/gfs_archive.html), the ECMWF products made available via the DLR COPS website (www.pa.op.dlr.de/cops/), and German radar network GUST (imkhp2.physik.uni-karlsruhe.de/~cops/gust/html/gust.html). All these archives are easily accessible via the COPS website.

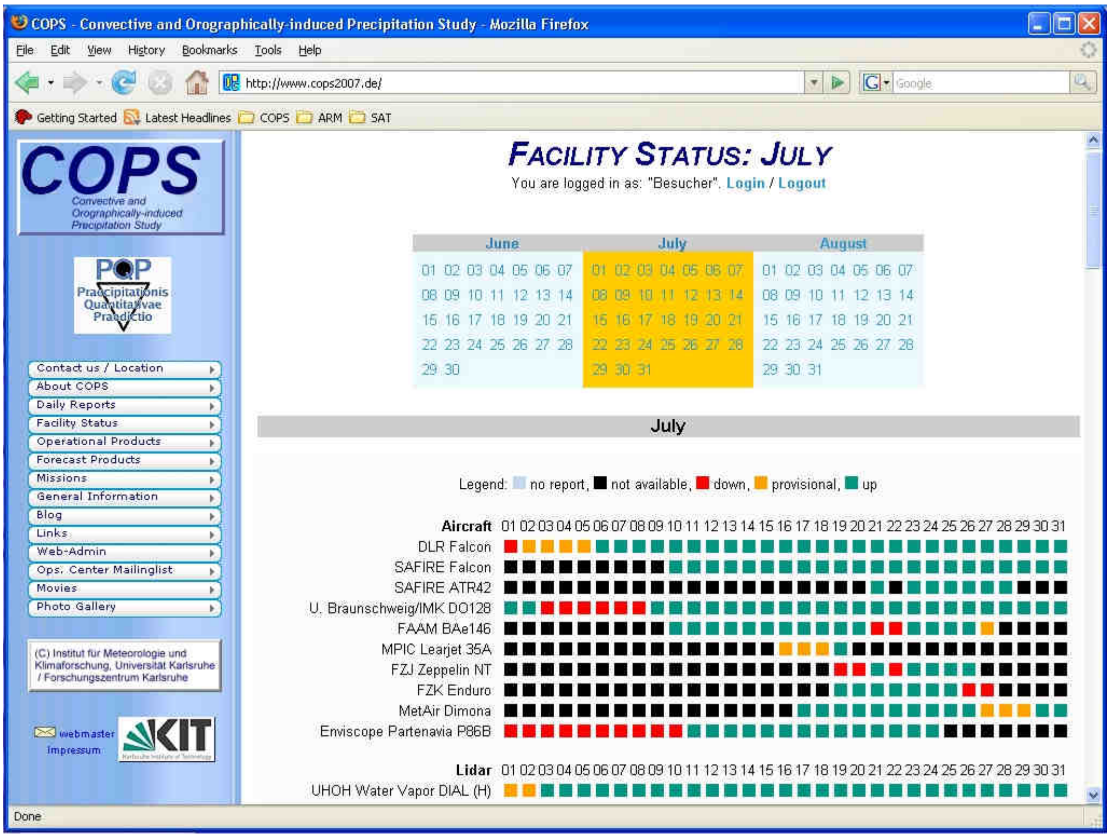


Fig. 11.4 The COPS facility status

Fig. 11.5 Lunch in the COPS OC with Science Director Susanne Crewell, aircraft PI Christoph Kiemle (left) and the forecasters Christian Ehmann and Berhard Mühr (right).

11.3 Forecast products, performance of forecasts

Forecasters from Germany, France, and Switzerland supported COPS throughout the campaign. It was very interesting to see, on what information sources the forecasters were relying. During the beginning of the campaign, the D-PHASE website was not available yet. Consequently, forecasts were mainly based on products of global models, which were easily and quickly accessible. the set up of the forecast products was also very important. For instance, the www.wetter3.de website provide a huge amount of very well designed forecast products, which were used throughout the campaign. The forecasters were familiar with these products very well so that these were used first. During the campaign, the value of ECMWF products made available via DLR was increasingly recognize. For more detailed planning also access to COSMO-EU and –DE products was possible.

The NINJO workstation of DWD was also set up in the COPS OC. A strong limitation was the high bandwidth required for transmitting information to the NINJO system in real time. Additionally, it was difficult to make major use of this machine, as most of the forecasters were not familiar with it and no DWD forecasters was made available for COPS: After getting more acquainted with this system, the forecasters used it more and more during the end of the campaign. The NINJO workstation was mainly used by the Meteo Swiss forecaster Marco Stoll, who was familiar to operate it at the Meteo Swiss forecast center.

A real breakthrough for mission planning was the launch of the D-PHASE website at the end of June (see Fig. 11-5). Whilst short-term forecasts of convection permitting models were available from the beginning of the campaign via the COPS website (see Fig. 11-6), their use was initially limited due to short forecast range up the 24 h. Consequently, these products could not be used for mission planning for the next day.

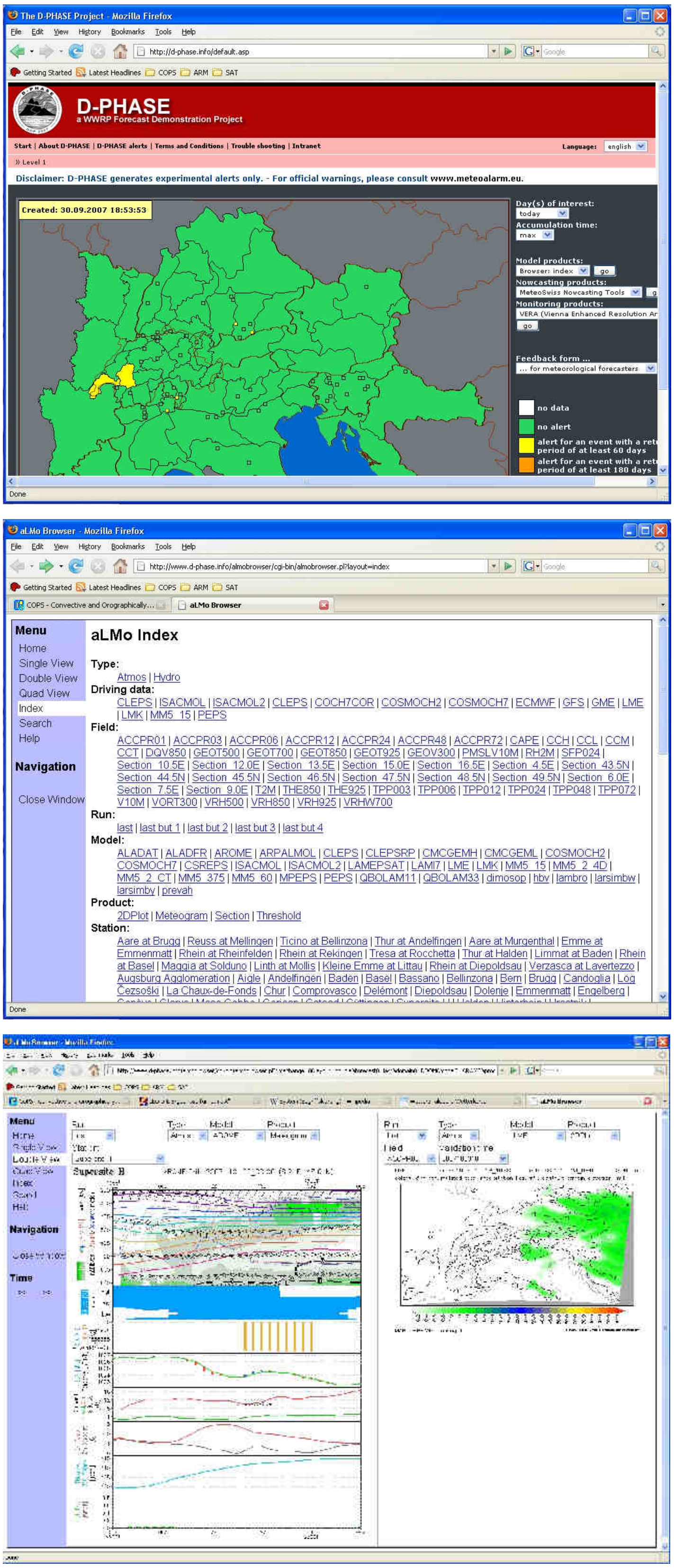


Fig. 11.6 Upper panel: The D-PHASE website. Forecasts of the D-PHASE multi-model ensemble are accessible via the button “Model products” on the right side of the panel. Middle panel: Overview of the huge amount of model products. Lower

panel: Example of forecast products. Left side: AROME meteogram. Right side: COSMO-EU 3-d precipitation forecast

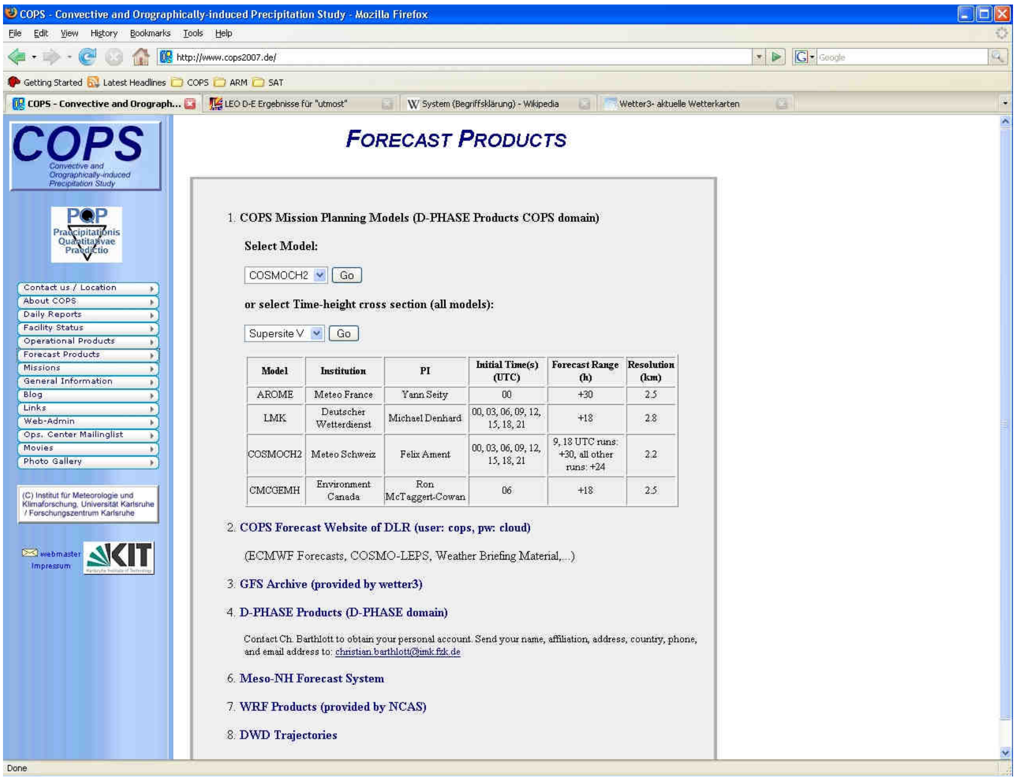


Fig. 11.7 COPS website showing the access to forecast products of four state-of-the-art convection permitting models

A key prerequisite for this work were the efforts at IPM to develop common GrADS script for the visualization of forecast products. As the same scales and colors were used for all models, comparisons were easy. These scripts included the visualization of meridional and longitudinal cross sections, meteograms at important locations such as COPS Supersites, and a variety of 2-d plots according to the TIGGE+ data list. Furthermore, mean values and threshold values of ensemble forecast models were provided.

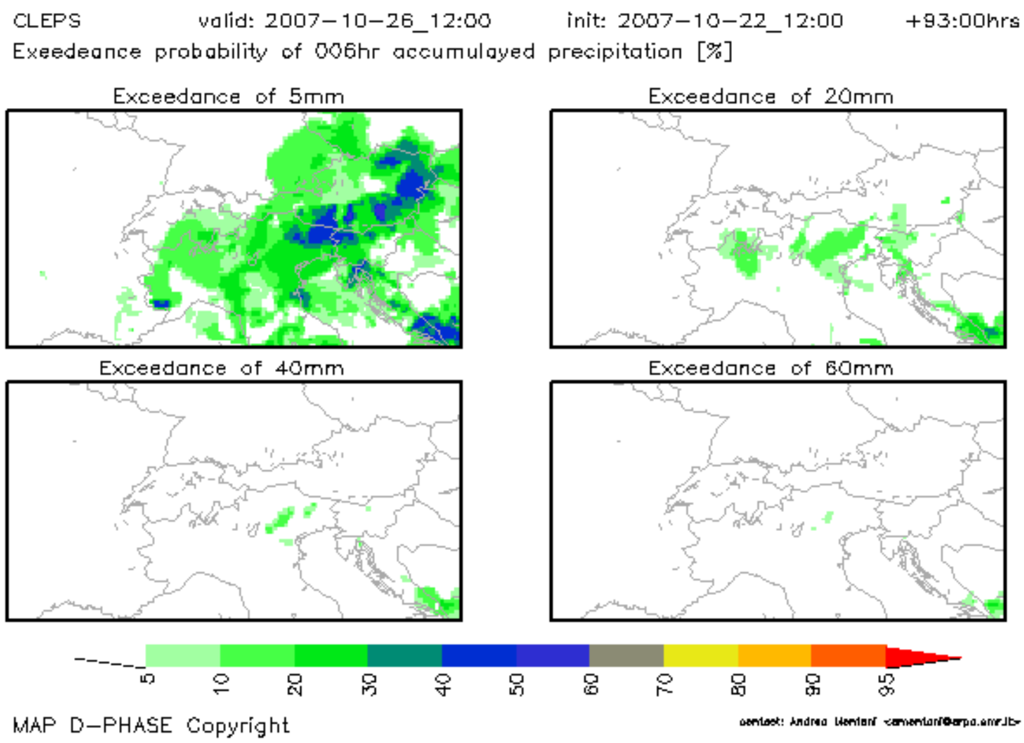


Fig. 11.8 Example of D-PHASE forecast product used for COPS mission planning. The probability of the exceedance of 6-h accumulated precipitation threshold values is shown in the D-PHASE domain for a forecast range of 93h.

As soon as all D-PHASE products came in, the forecaster became familiar with their very valuable information content. Generally, the forecasts for mission planning were performed according to the following steps: For long-term mission planning for more than 2 days, the global models GFS and ECMWF were used supported by the D-PHASE ensemble forecast products (see Fig. 11-7). This information was very important for aircraft mission planning as air traffic control had to be alerted two days ahead. For mission planning during the upcoming day, the forecasts were refined using the D-PHASE multi-model forecast data set of limited area models (LAMs). During several cases, their products were very instructive for mission preparation, as in many cases the location and distribution of clouds was important for assessing the timing and location of CI. It turned out that particularly cloud forecasts are extremely uncertain to date.

11.4 Performance of networks

During COPS, a variety of networks for routine measurements of atmospheric variables was set up and operated. At all Supersites corresponding instrumentation was deployed, too.

These included a weather station network, which was supported by the Universities of Leeds, Innsbruck, and Munich. The data have been logged by each respective institution and will be made available via the COPS data archive.

Also no problems concerning the soil moisture network operated by IMK were reported. The instruments do not provide data for the duration of COPS but it is planned to extend the measurements at least until the end of 2007.

The data of the GPS based water vapour monitoring system at the GFZ Potsdam have been made available during GOP/COPS. The IWV data of approx. 200 permanent German GPS stations and 5 temporal GPS stations at the COPS supersites were available in near real-time and can be accessed via the COPS homepage. The IPM D-PHASE data assimilation project made use of GPS-IWV to improve the humidity fields. Fig. 11.9 shows an example of the IWV field at 2.8. 4:00 h (IOP 13b).

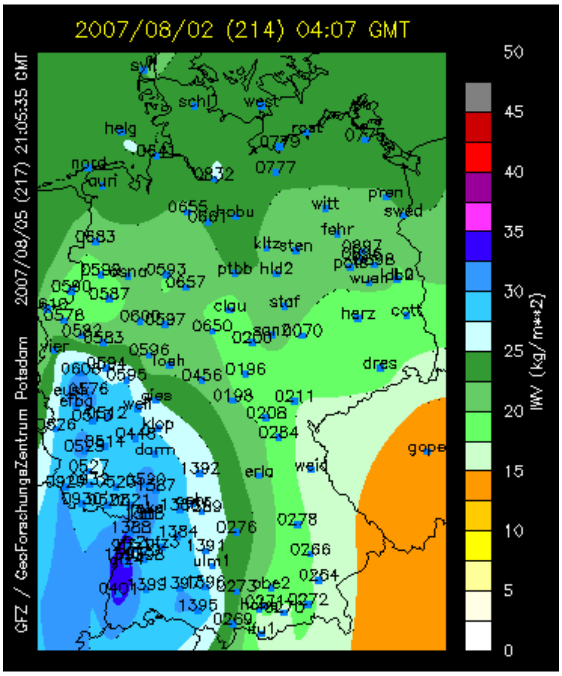


Fig. 11.9 GPS IWV field over Germany during IOP 13b. Increasing water vapor is due to a humid outflow boundary ahead of an MCS passing the COPS domain.

The time series of all stations, processed at the GFZ, are available from January 2007 until December 2007. The zenith total delay (ZTD) and IWV are sampled with a temporal resolution of 15 minutes. The ZTDs observed at the COPS supersites during the period between July 14, 2007, 0:00 UTC (54295,0 MJD) and August 3, 2007, 23:59 UTC (54316,0 MJD) are shown in Fig. 11.10. This period covers the IOPs 8b to 13b.

The ZTD depends on the stations altitude, which leads to an offset between the stations in the Rhine rift (gfz2 at 141.226 m and gfz4 at 187.592 m, see section 5.4.5 for station locations), the stations in the Black Forest (gfz0 at 508.826 m and gfz3 at 578.701 m) and station gfz1 (1163.662 m) on top of the mountain "Hornisgrinde". The temporal variation of the ZTD is dominated by the changing atmospheric humidity.

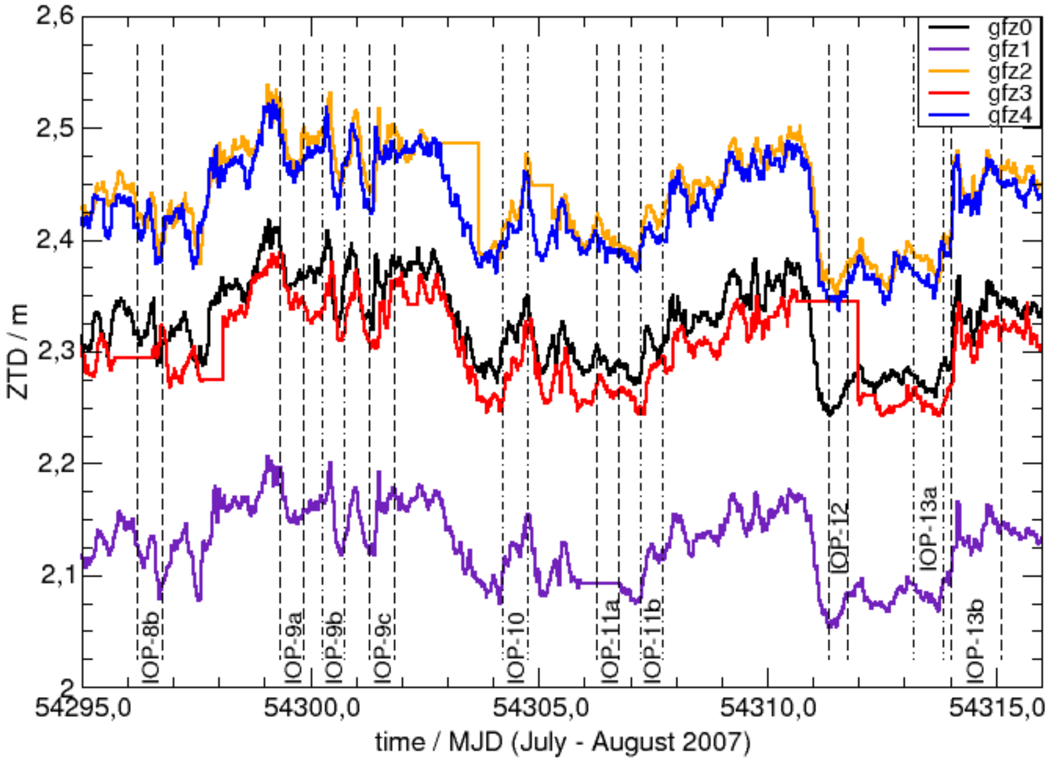


Fig. 11.10 GPS ZTDs observed at the COPS supersites during the period between July 14, 2007, 0:00 UTC (54295,0 MJD) and August 3, 2007, 23:59 UTC (54316,0 MJD).

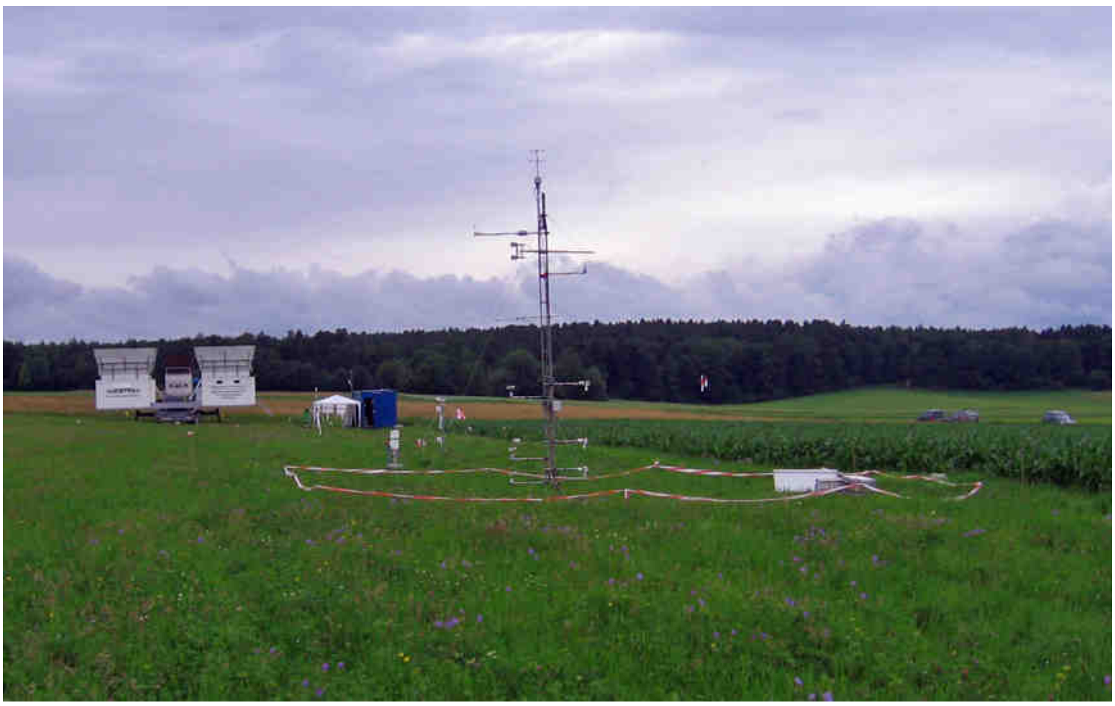


Fig. 11.11 Energy balance station at Supersite S.

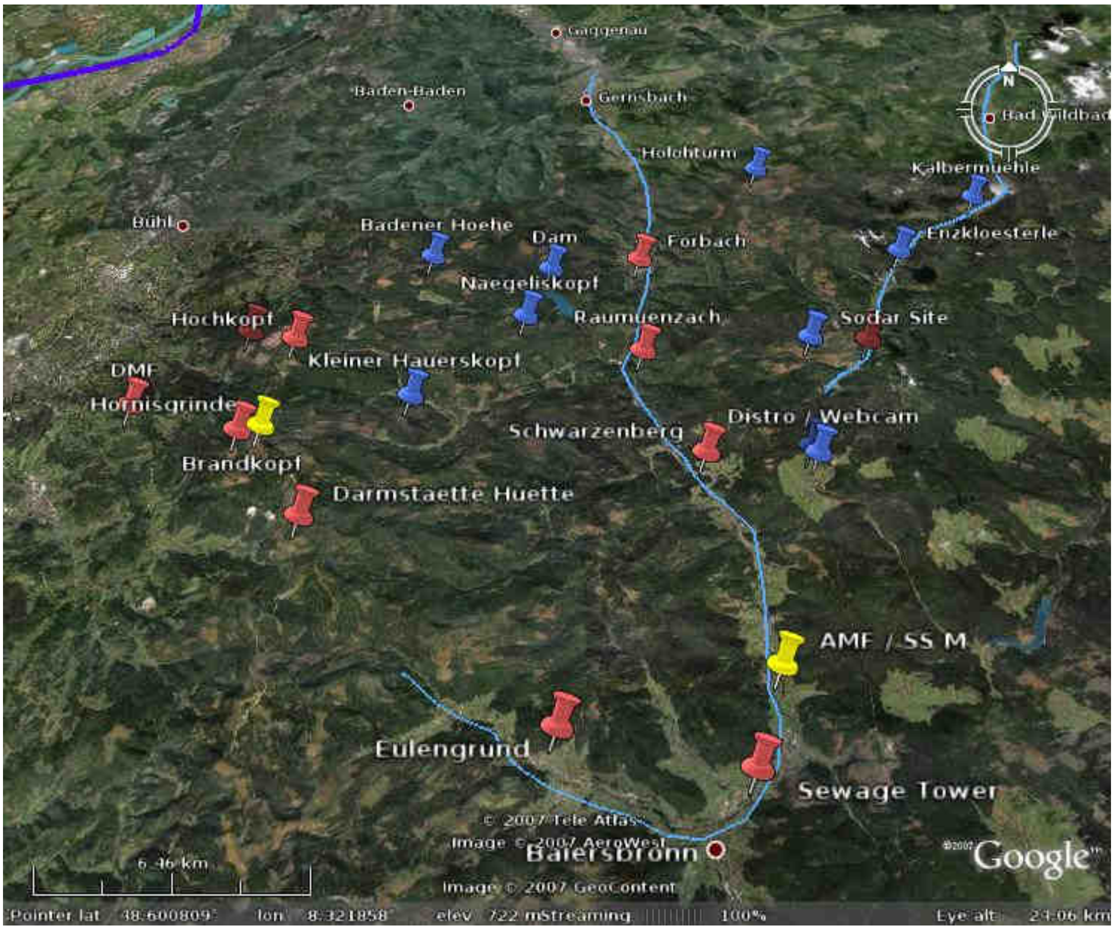


Fig. 11.12 Locations of the automated weather stations of U. Leeds and U. Insbruck.

Fig. 11.13 Left photo: MOMAA7 of U. Insbruck, right photo: AWS09 of U. Leeds.

Table 11.2 Overview of all U. Leeds weather stations.

Date	26.06.03	27.06.03	28.06.03	29.06.03	30.06.03	01.07.03	02.07.03	03.07.03	04.07.03	05.07.03	06.07.03	07.07.03	08.07.03	09.07.03	10.07.03	11.07.03	12.07.03	13.07.03	14.07.03	15.07.03	16.07.03	17.07.03	18.07.03	19.07
Time start		15:48:11						09:42:31		07:09:15													##########	
Time end					11:17:09					06:18:15		16:09:56												
Brandkopf						STATION NOT WOKING							STATION NOT WORKING											
Time start	13:43:36									07:58:36													07:08:37	
Time end										07:56:05		16:15:45												
Buehlertal													STATION NOT WORKING											
Time start		16:45:26									07:08:16											16:21:07		
Time end							22:49:20				16:27:34													
Darmstatte Huette								STATION NOT WORKING				STATION NOT WORKING												
Time start																	14:56:01							
Time end																	17:13:23							
Dead mans field	STATION NOT OPERATIONAL																	STATION NOT WORKING				DAT		
Time start		12:48:54									14:53:24					15:00 ish					09:41:04			
Time end								13:08:01			20:54:35						16:30 ish					07:43:04		
Eulengrund									NOT WORKING			NOT WORKING				POSSIBLY DATA – SEE BLOG								
Time start			12:00:46								13.10.27										12:46:33			
Time end									18:03:51												12:23:25			
Forbarch																								
Time start											12:06:25													
Time end																		09:16:47						
Gompelscheuer	STATION NOT OPERATIONAL																		STATION NOT WORKING					
Time start																15:11:42							08:22:12	
Time end																	11:45:46						15:49:45	
Hochkopf	NO DATA																	STATION NOT WORKING						
Time start		14:24:50						18:09:12											11:04:24		07:40:14			
Time end								17:00:11	12:10:15												06:28:26			
Hornisgrinde										STATION NOT WORKING														
Time start		09:12:21									13:51:01										13:52:03			
Time end											13:50:03										13:06:25			
Raumuenzach																								
Time start							16:00 ish		15:00 ish													14:30:35		
Time end									14:45 ish			14:00 ish										16:18:54		
Sewage Tower													STATION NOT WORKING											
Time start		10:10:30							15:13:16												11:40:58			
Time end									14:18:10								14:59:04							
Schwarzenberg																		STATION NOT WORKING						

Forced Convection	SOP – for 146	Other IOP / SOP
Down Day	High Press Convection	No IOP

07.03	19.07.03	20.07.03	21.07.03	22.07.03	23.07.03	24.07.03	25.07.03	26.07.03	27.07.03	28.07.03	29.07.03	30.07.03	31.07.03	01.08.03	02.08.03	03.08.03	04.08.03	05.08.03	06.08.03	07.08.03	08.08.03	09.08.03	10.08.03	11.08.03	
###													09:50:52							16:41:36					
												09:45:18					11:31:48								
																		STATION NOT WORKING							
08:37													14:16:11												
													14:10:29							04:32:36					
																					CHECK CARD IMAGE				
													16:06:35							15:40:28					
					02:08:40												08:38:19						21:37:41		
						STATION NOT WORKING												NOT WORKING						DEAD	
					08:03:20																08:05:08				
						17:56:19																		13:54:36	
DATA MISSING							STATION NOT WORKING						STATION LEFT UNPLUGGED – SEE BLOG												
								11:47:38	14:29:30											15:11:07					
									06:34:49											15:09:53			04:42:01		
STATION NOT WORKING					DATA MISSING																			DEAD	
							08:29:03		16:27:14											13:25:??		06:01:18			
					12:23:25				07:33:12			20:04:08										05:57:59	06:31:15		
						DEAD							STATION NOT WORKING											DEAD	
			13:43:50						15:55:18											12:45:28					
									15:19:34								14:09:39							01:39:31	
																		NOT WORKING							
22:12						15:27:42															12:44:18				
49:45													13:31:26											03:58:09	
	STATION NOT WORKING													SHOULD BE DATA BUT NONE – SEE BLOG											DI
													12:12:47												
				16:22:03										07:07:03											
					STATION EITHER NOT WORKING, POWER TESTING OR IN LANDROVER – SEE BLOG																				
								11:27:40	16:07:09												14:48:41				
								11:26:57	16:02:59												14:45:21				
					12:03:10									08:32:47						06:40 ish					
							08:32:39									08:50:40							07:00 ish		
STATION NOT WORKING								STATION NOT WORKING									STATION NOT WORKING								
							16:36:38		15:50:43											14:12:53					13;03:4
			10:18:02						15:44:23											08:41:20			11:26:03		
				NO DATA – DON'T UNDERSTAND																				DEAD	

A measurement example of the energy balance network, i.e. a sodar measurement in the Kinzig Valley during IOP 4a (19 June) is shown the figures below.

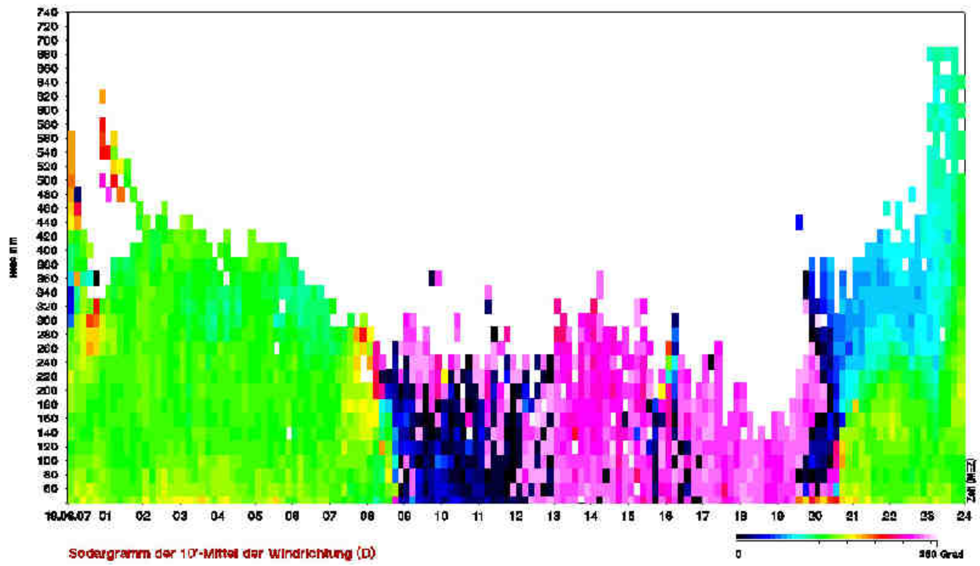


Fig. 11.14 Change of the wind direction in the Kinzig Valley at the Station „Fussbach 1“ on 19 June 2007, i.e. IOP 4a (time in CET).

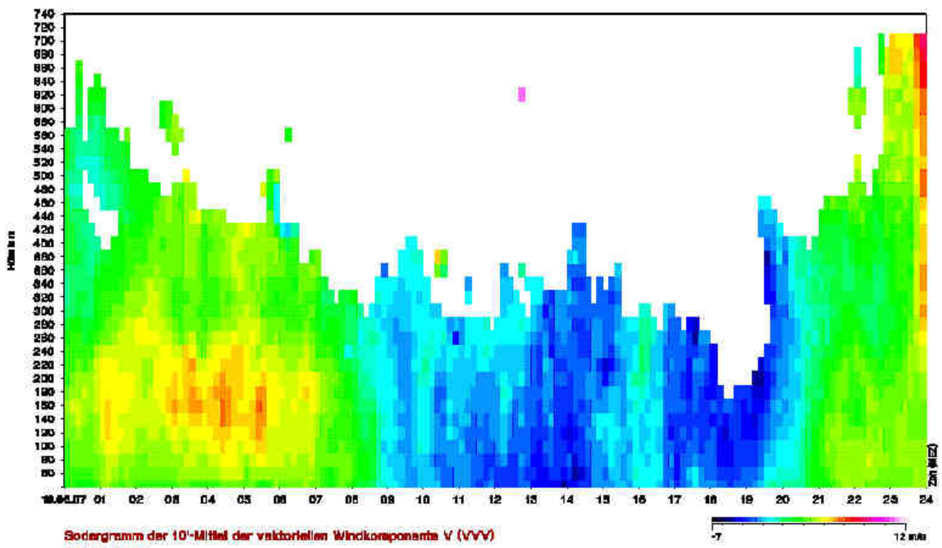
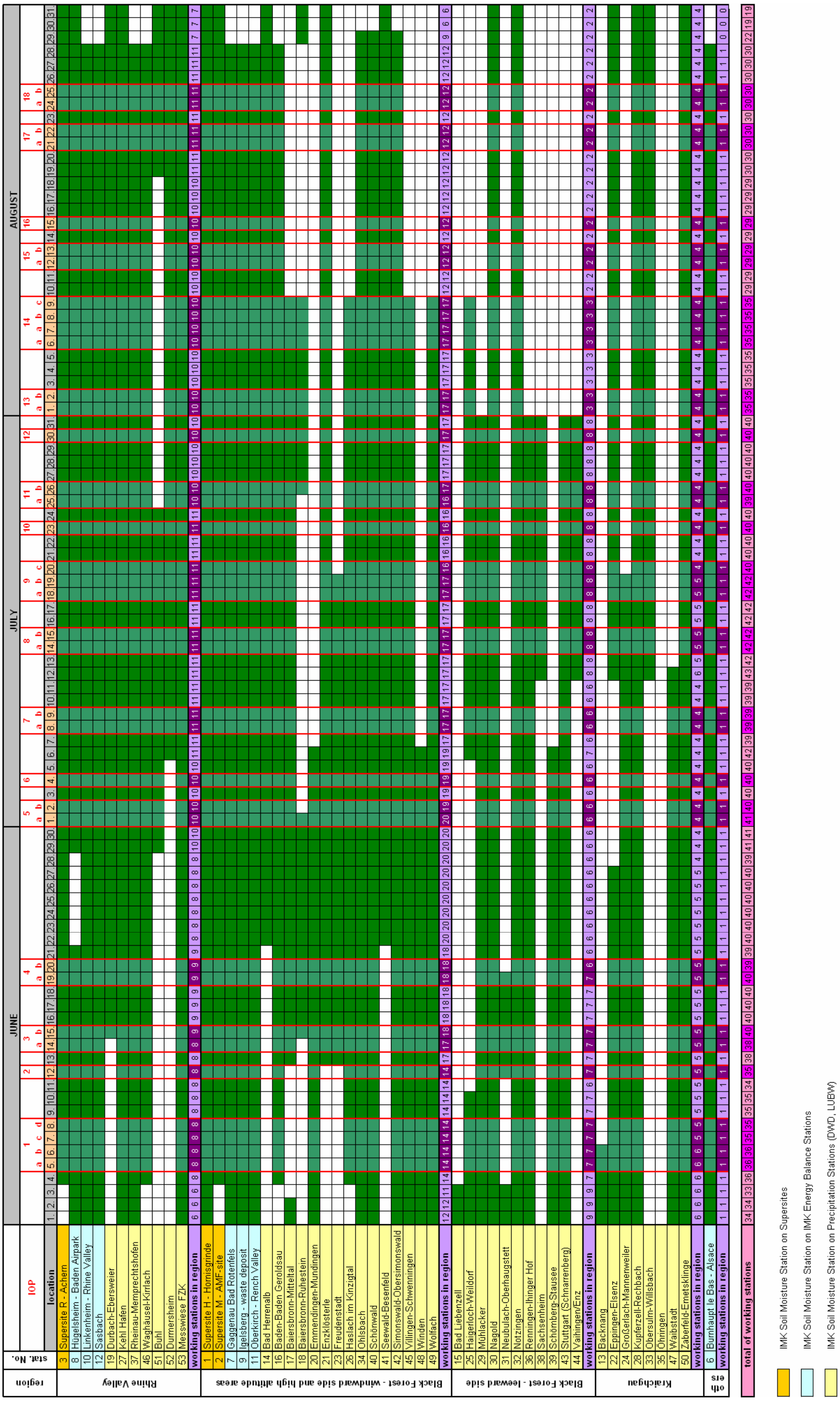


Fig. 11.15 Weakening of wind velocity in the Kinzig Valley at the Station „Fussbach 1“ on 19 June 2007, i.e. IOP 4a (time in CET).

Table 11.3 SISOMOP moil moisture sensors operation times



Instrument's operation on all soil moisture stations. Green: Logger ON, white: Logger OFF.

→ green: Logger ON → Output data are given in a temporal resolution of 10 minutes

→ white: Logger OF (causes by different things.. no power, Logger out of order,…)

The soil moisture network covered 4 distinct regions within the COPS area – the Rhine Valley (RV), the western flank (windward side) of the Black Forest including the high altitude mountain areas (BFW), the Black Forest leeward side (BFE) and the Kraichgau (KR). All soil moisture stations were classified into these 4 regions according to their location.

A typical example of soil moisture measurements in the North (Waghäusel, Station no. 46) and in the South (Simonswald, station no. 42) is shown in Fig. 11.16. The response of the uppermost sensor (at 5 cm) to precipitation events is clearly seen; similarly, soil moisture (SM) in the upper layer usually decreases strongly after the precipitation event due to evaporation and infiltration to deeper layers. SM at 50 cm depth show significantly lower values. Regional differences are seen by analysing the overall trend. Whereas SM at 5 cm depth at Simonswald is increasing towards the end of the COPS campaign, it is decreasing for Waghäusel. Similarly, precipitation events have been more frequent in the South than in the North. Finally, soil moisture response to precipitation is more direct and uniform for Simonswald than for Waghäusel, where only two events have been large enough to create significant responses at larger depth. The latter is due to the soil texture at Waghäusel *(sand)*, having high drainage properties and resulting in fast percolation of the precipitated water to deeper layers.

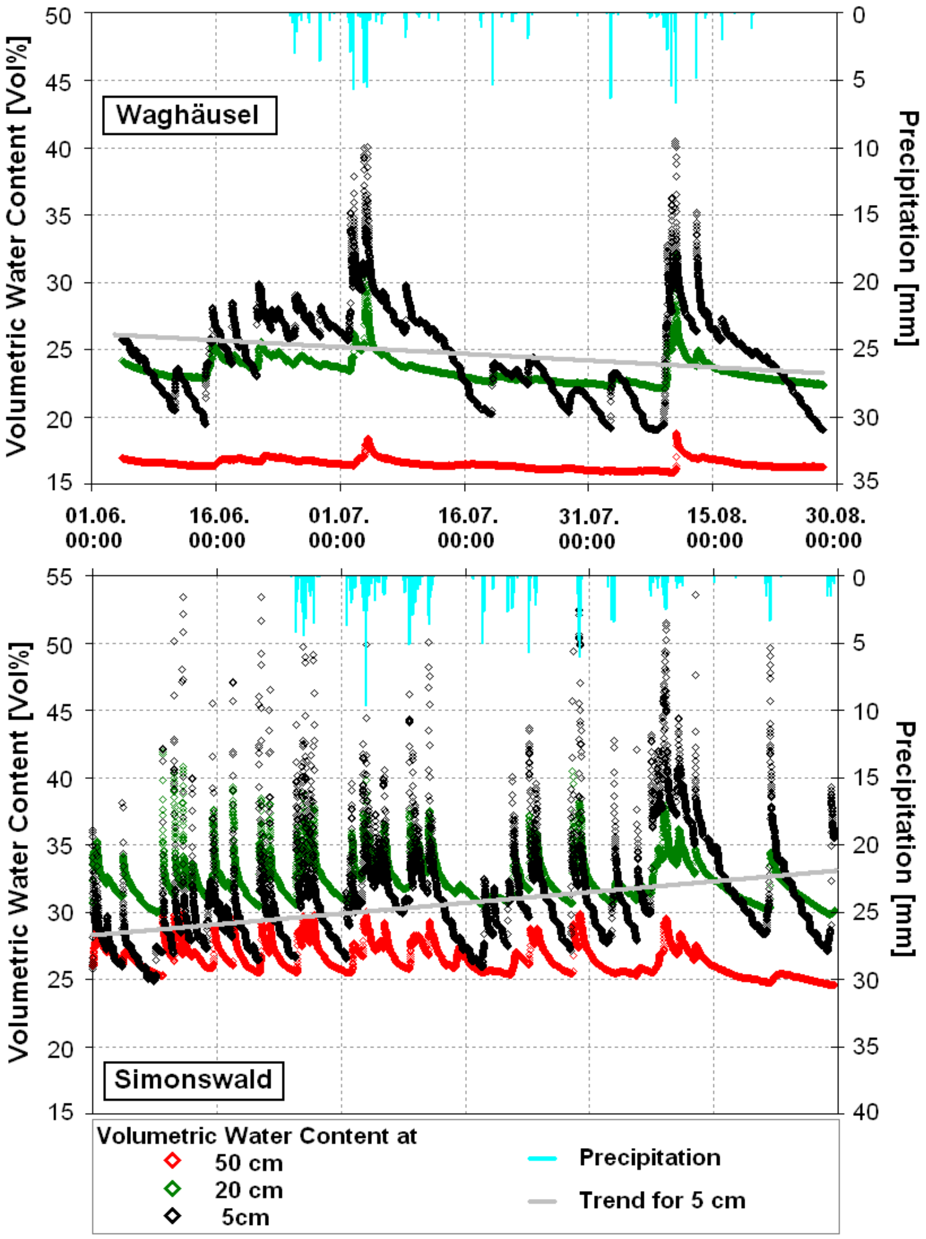


Fig. 11.16 Measurement example of the soil moisture network: Waghäusel (Rhine Valley) and Simonswald (Blackforest windward side)

11.5 Performance of Supersites

11.5.1 General issues

Logistics and communication at the Supersites ensured an excellent performance of the instrumentation. Phone and internet connection were set up at all sites so that rapid communication with the COPS OC was possible. This turned out particularly used during aircraft missions where observation modes were adapted to aircraft flight pattern.

According the COPS scientific approach, each Supersite was equipped with a synergy of state-of-the-art remote sensing instruments (various types of lidars, cloud radars, and radiometer) combined with in-situ sensors. Supersite R (Rhine Valley), H (Hornisgrinde) and M (Murg Valley) are the backbone of the ground-based instrumentation. They were located on one line with the polarization radar POLDIRAD, so that one vertical scan of POLDIRAD (range-height-indicator, RHI scan) could cover these three sites in the Northern Black Forest (see Fig. 11-10). Various surface in-situ and remote sensing systems contributed by partner institutions from Austria, England, USA, Netherlands, France, and Italy have been arranged to complete the supersite instrumentations.

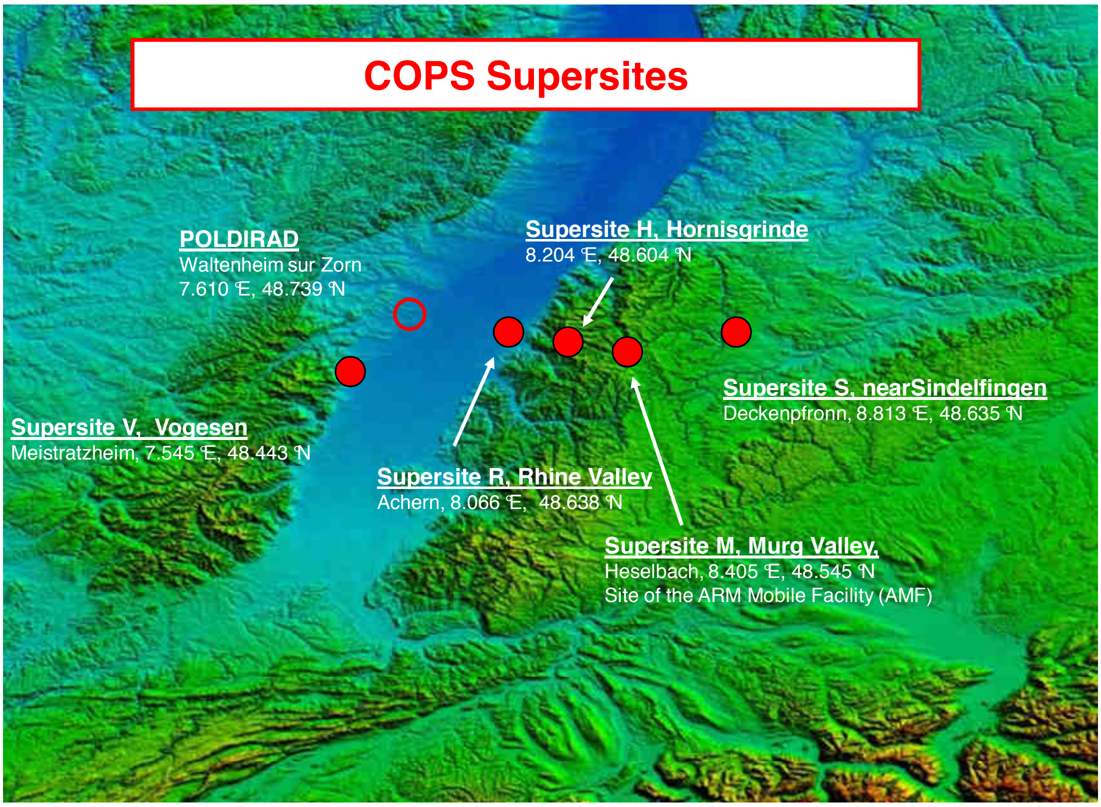


Fig. 11.17 Set up of COPS supersites with orography´.

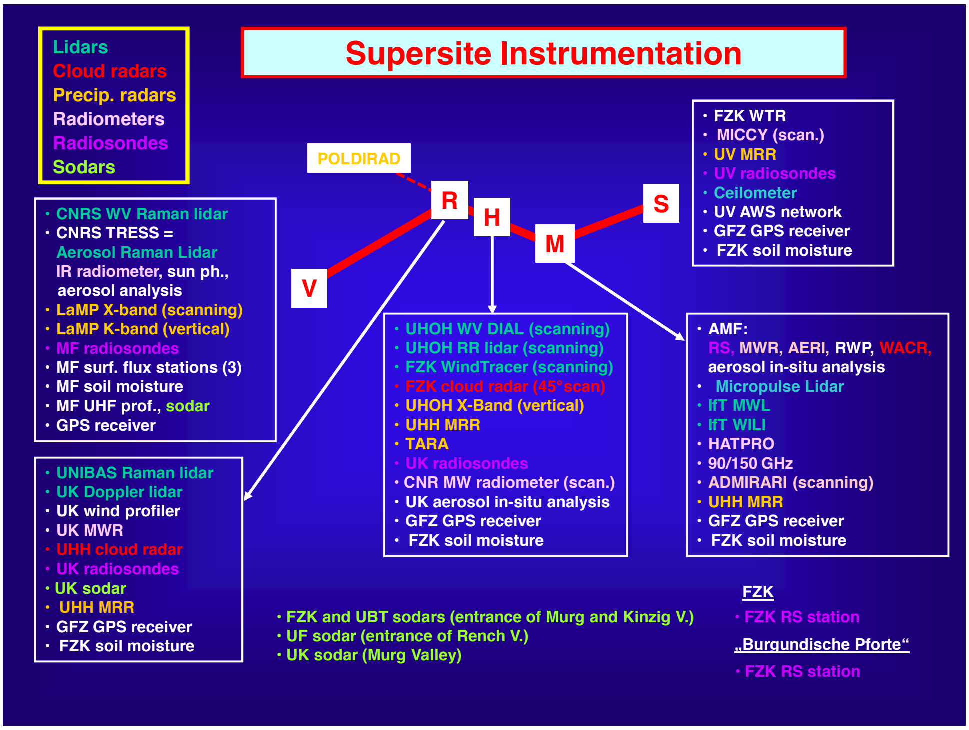


Fig. 11.18. Instrumentation at COPS Supersites.

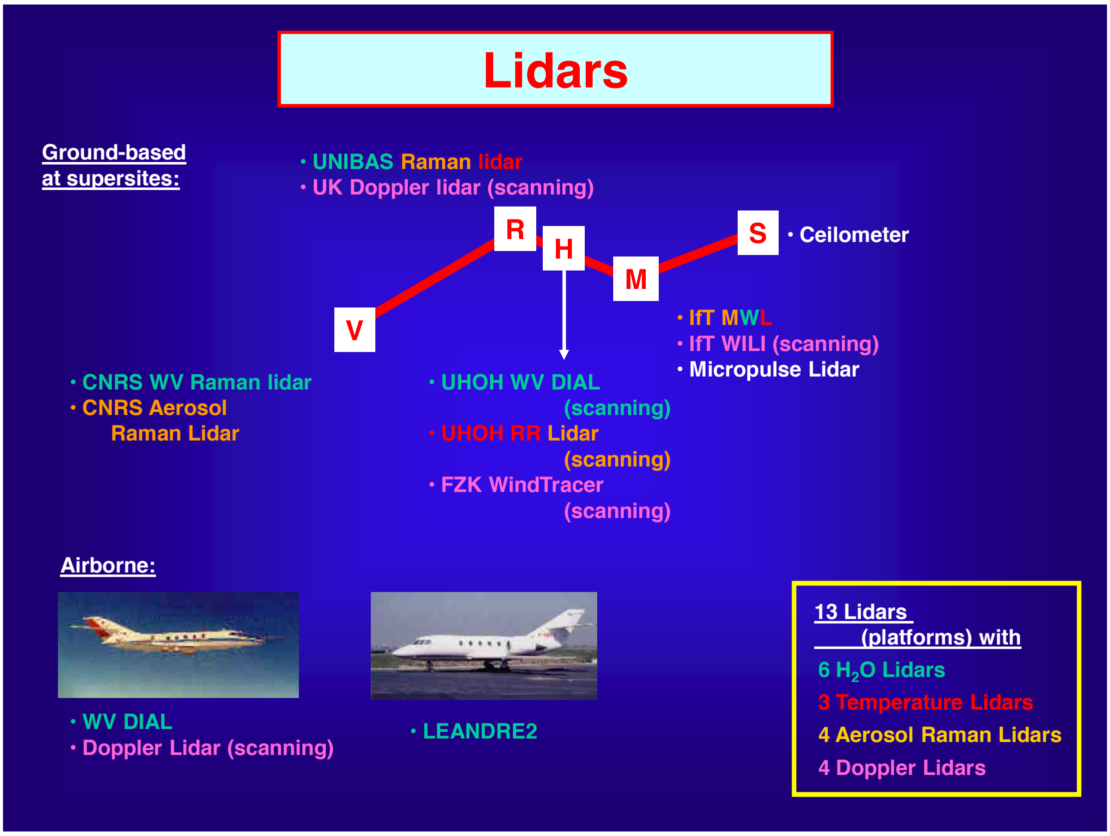


Fig. 11.19 Lidar systems deployed during COPS. Colors indicate different types of lidars..

11.5.2 Coordinated Scan Modes of the Remote Sensing Instruments

Table 11-2 gives an oveview of the different scanning capabilities of the remote sensing instruments of COPS. Coordintaed scan scenarios initialized by IPM and IMK have been perfomed during many IOPs. The details of the scan scenarios which have been developed are listed in Table 11-3 – 6. Depending on the scope of the IOP, the scan scenario of the day was selected.

Table 11.4. Scanning remote sensing instruments of COPS and their scanning capabilities.

Instrument	Operation modus	Wavelength	Averag. time per LOS, s	Dead time between LOS , s	scan speed deg/s	Zenith angle range, deg	Azimuth angle range , deg	variable	speciality
CNR MWR	Cont.	K-Band (22 GHz / 13.6 mm), V-Band (60 GHz / 5 mm)	12 14-15 preferred	1	90	+-90	One angle to R	T, WV, IWV, LWP	Only RHI ->AMF, Supersite R
IMK Doppler lidar (IDL)	Cont.	2 um	0,1	-	6 typ. 0.1-20 possi-ble	+-95	0-360	LOS wind, coherent backscatter, clouds	
IMK Cloud radar (ICR)	Cont.	8.45 mm	10	-	6	+-45	0-360	LOS wind, Z, LDR	
UHOH Raman Lidar (RRL)	IOP	355 nm	10	3 TBD	5	+-90	0-360	T, backscatter, clouds	2D temperature
UHOH DIAL	IOP	820 nm	1	-	6	+-90	0-360	WV, backsc., clouds	3D water vapor
TARA	Cont.	10 cm	1	-	-	0-90	One angle to M	LOS wind, Z	Switched in differ-ent directions
IfT WiLi	IOP	2 um	3	-	6	+-90	0-360	LOS wind, coherent backscatter, clouds	IOP
Salford Doppler Lidar (SDL)	Cont.	2 um	TBD	-	6 TBC	+-90	0-360	LOS wind, coherent backscatter, clouds	
DLR Poldirad	Cont.	C-band, 5.45 cm	PPI: 0, 10, 20, … min RHI: 8, 18, 28, ... min	0.1	PPI: 9°/s RHI: 1.5°/s	0-60	0-360	LOS wind, Z, LDR, ZDR, rhoHV, PDP	
IMK C-band radar	Cont.	C-band, 5.4 cm	0.05	-	25	+-90	0-360	LOS wind, Z	
DOW	IOP	X-band, 3 cm	TBD	-	TBD	+-90	0-360	LOS wind, Z	

Table 11.5. **Scan Scenario 1 (ScaS 1):** Mostly vertical

Idea: see coincident structures as vertical profiles and 4 min per 30 min for 2 PPI and 2 RHI scans with Doppler lidar (mean wind)

Min	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
DIAL + RRL	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
CNR MWR	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
IDL	PPI 4deg PPI 45deg RHI M RHI M+90	Vert.	Vert.	Vert.	Vert.	Vert.	PPI 4deg PPI 45deg RHI M RHI M+90	Vert.	Vert.	Vert.	Vert.	Vert.
ICR	PPI 70deg PPI 45deg RHI M RHI M+90	Vert.	Vert.	Vert.	Vert.	Vert.	PPI 70deg PPI 45deg RHI M RHI M+90	Vert.	Vert.	Vert.	Vert.	Vert.
SDL	Same as IDL											
WiLi	Same as IDL											

Table 11.6. **Scan Scenario 2 (ScaS 2):** supersite cross-section and thermodynamics

Idea: have a cross-section over COPS area with many instruments taking advantage of sensor synergy

2-d cross section through convective systems overpassing the site while getting vertical thermodynamic structure and multiwavelength synergy for microphysical retrievals in clouds and precipitation.

Suggestion at Supersite H:

Min	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
DIAL + RRL	RHI	RHI	RHI	RHI	RHI	RHI	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
CNR MWR	RHI	RHI	RHI	RHI	RHI	RHI	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
IDL	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
ICR	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	Vert.					
SDL	Same as IDL											
WiLi	Same as IDL											

RHI must be identical for all scanning systems!

Table 11.7. **Scan Scenario 3 (ScaS 3):** RHI

Idea: continuous 2-d RHI, have a cross-section over COPS area with many instruments taking advantage of sensor synergy

Min	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
DIAL + RRL	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI
CNR MWR	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI	RHI
IDL	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?
ICR	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?
SDL	Same as IDL											
WiLi	Same as IDL											

Table 11.8. **Scan Scenario 4 (ScaS 4):** along-wind cross-section

Idea: see changes of convective systems moving overhead; Lagrangian tracking possible similar to ScaS 2, but aligned along the wind

Min	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
DIAL + RRL	RHI	RHI	RHI	RHI	RHI	RHI	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
CNR MWR	RHI	RHI	RHI	RHI	RHI	RHI	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
IDL	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
ICR	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	RHI	PPI1, PPI2, RHI1 RHI2 ?	Vert.					
SDL	Same as IDL											
WiLi	Same as IDL											

11.5.3 Supersite H

At Supersite H, which was arranged on Hornisgrinde mountain, the highest peak in the Northern Black Forest, the proposed instrumentation was deployed and operated for the major amount of time. A novel scanning water vapor differential absorption lidar (DIAL) of UHOH was applied and collocated with the Rotational Raman Lidar of UHOH. The synergy of these systems provides water vapor and temperature measurement from close to the ground up to a range of 15 km. In the boundary layer, turbulent processes and convection can be resolved. The scanning Doppler lidar WindTracer of IMK was placed properly to get coincident water vapor, temperature and wind measurements to calculate vertical turbulent water vapor fluxes as well as sensible heat fluxes, and to localize the initiation and timing of convection onset. Further synergetic data products are atmospheric buoyancy, and stability indices like CIN and CAPE. The new scanning cloud radar of IMK was operated to monitor the transition from dry convection to clouds and to get information on cloud particles. The scanning microwave radiometer of CNR IMAA provided profiles of temperature, water vapor and liquid water up to 10 km height. All these 5 scanning remote sensing instruments were synchronized and different types of scan pattern were made depending on the scope of each IOP (see Section 11.5.3). An energy balance station on top and a setup of soil moisture sensors provides information on the importance of soil moisture, evapotranspiration and sensible heat fluxes for the surface induced convection Turbulence measurements with the airborne platforms, especially the DO128 aircraft, provide most valuable data for spatial interpolation of ground-based systems, for aerially averaged turbulent fluxes and boundary-layer heights, and complement the 3D data sets for budget calculations. On Supersite H and all the other 4 supersites, several radiosondes were launched during IOPs (at H and R typically all 3 hours, at M and V all 6 hours, and at S once or twice per day). In addition to these soundings, also drop-up sondes were employed during some IOPs at different locations in the Northern Black Forest and its vicinity.

After the performance of COPS, the moisture sensor, the GPS, and the MRR continued operation until the end of the year in order to cover the GOP.

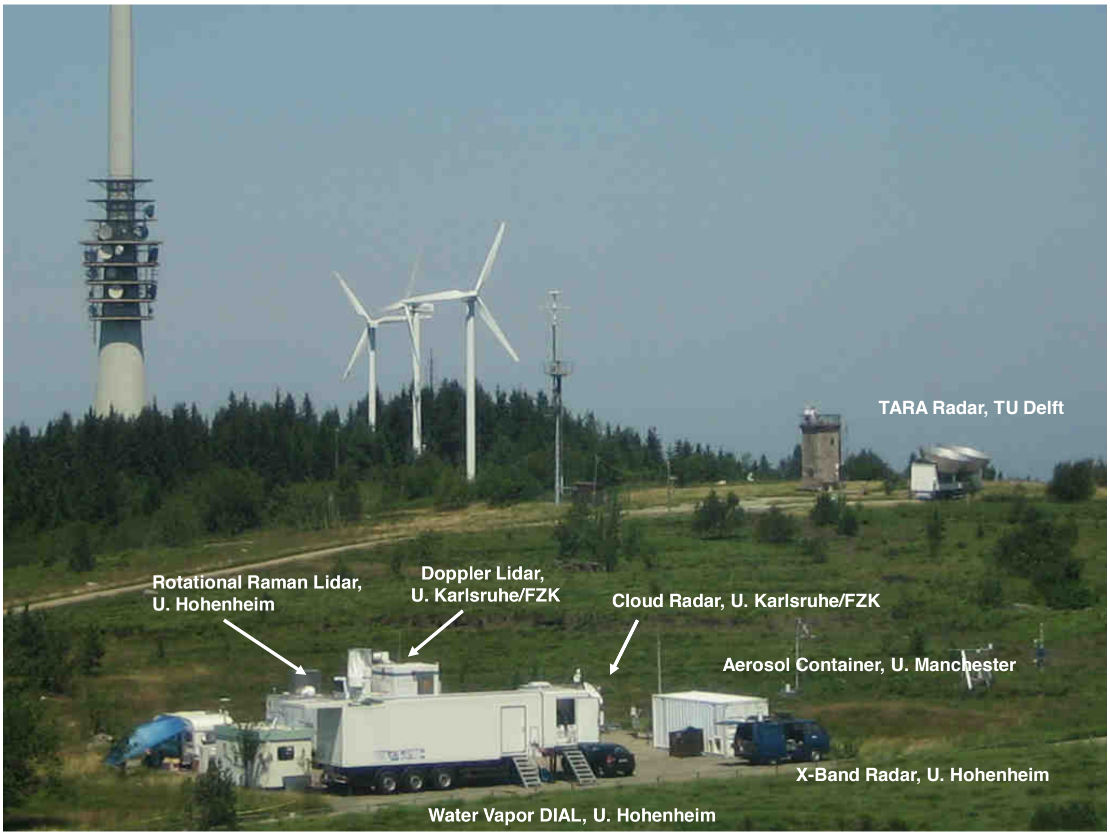


Fig. 11.20. View to COPS Supersite H on Hornisgrinde (from South).

11.5.3.1 UHOH Water Vapor DIAL

The scanning water vapour differential absorption lidar (DIAL) of UHOH is a new instrument which was deployed during COPS for its first time in the field. It is the only scanning water vapour DIAL existing at date. Two scientists were operating the system in semi-manual mode. From 8 July on water vapor measurements have been performed during COPS IOPs and SOPs in different scanning modes. The following table gives an overview of the operation times and modes.

A measurement example of the UHOH DIAL is shown in Fig. 11.21.

Table 11.9. Operation times of the UHOH Water Vapor DIAL.

Date	IOP	Scanning Mode, Time (UTC)	Laser Mode
19.06.	IOP4a	Vertical	Only offline backscatter data
30.06.		Vertical, 16:05-20:50	Only offline backscatter data
01.07.	IOP5a	Vertical, 10:27 - 10:54 Vertical, 20:31 - 20:34	Only offline backscatter data
07.07.		Vertical, 12:49 -16:03	Only offline backscatter data
08.07.	IOP7a	All vertical, 08:21-10:45 10:55-11:12 11:31-11:45 14:35-15:06 15:39-15.55	All DIAL
09.07.	IOP7b	All vertical 13:12-14:38 17:04-18:02	All DIAL
13.07.		All vertical 16:31-18:30	All DIAL
14.07.	IOP8a	All vertical 07:01 – 7:54 09:17-14:56 17:50-19:48	All DIAL
15.07.	IOP8b	All vertical 05:12-09:08 09:42-17:47	All DIAL
16.07.		Vertical, 5:50-9:20	DIAL
18.07.	IOP9a	Vertical, 11:20-18:40	DIAL
19.07.	IOP9b	All vertical 08:23-11:17 13:57-16:38	All DIAL
20.07.	IOP9c	All vertical 5:12-6:53 7:15-9:33 13:52-14:56	All DIAL
23.07.	IOP10	All vertical 6:21-6:28 6:30-8:08 11:22-13:51	 Only On-line DIAL DIAL
25.07.	IOP11a	All vertical, 9:59-15:32 19:11- 22:30	All DIAL
26.07.	IOP11b	All vertical, 7:26-16:35 18:59-20:21	All DIAL
30.07.	IOP12	All vertical, 10:50-11:07 11:50-18:33	All DIAL
01.08.	IOP13a	All vertical, 7:11--24.00	All DIAL

02.08.	IOP13b	All vertical, 0:00-2:47 8:44-12:22 15:38- 17:00	All DIAL
06.08.		Vertical, 15:04-15:05 Scanning, 15:13 RHI (5x) Supersites 15:20 PPI (5x) 20° 15:30 PPI (3x)70° Vertical, 15:57-16:22	All DIAL
11.8.		Test measurements	
12.08.	IOP15a	Vertical, 8:10-12.12 Scanning, 12:27 PPI(45x) 12:55 RHI 13:33 RHI	DIAL Only offline backscatter data
13.08.	IOP15b	All Scanning, 16:37 PPI 16:48 PPI (backgr) 17:41-18:00 PPI 18:11-18.32 PPI (backgr) 18:37-18:51 RHI(Supers) 19:01 RHI(backgr)	 Only offline backscatter data Only offline backscatter data DIAL DIAL DIAL DIAL
14.08.		Test measurements	
15.08.	IOP16	Vertical, 12:51-14.10 Scanning,14:54-17:13 Vertical, 17:18-21:15	All DIAL
17.08.	SOP7	All vertical, 8:18-10:18 13:18-16:34	All DIAL
21.08.	IOP17a	Vertical, 11:09-13:32	All DIAL
22.08.	IOP17b	Vertical, 10:47-17:13 Scanning, 20:22-21:54	All DIAL
23.08.		Scanning,14:40-20:19	All DIAL
24.08.	IOP18a	Scanning,6:27-17:58	All DIAL
25.08.	IOP18b	Scanning,5:53-21:34	All DIAL
28.08.		Scanning,~16:08	All DIAL
30.08.		Scanning,8:44-11:55	All DIAL

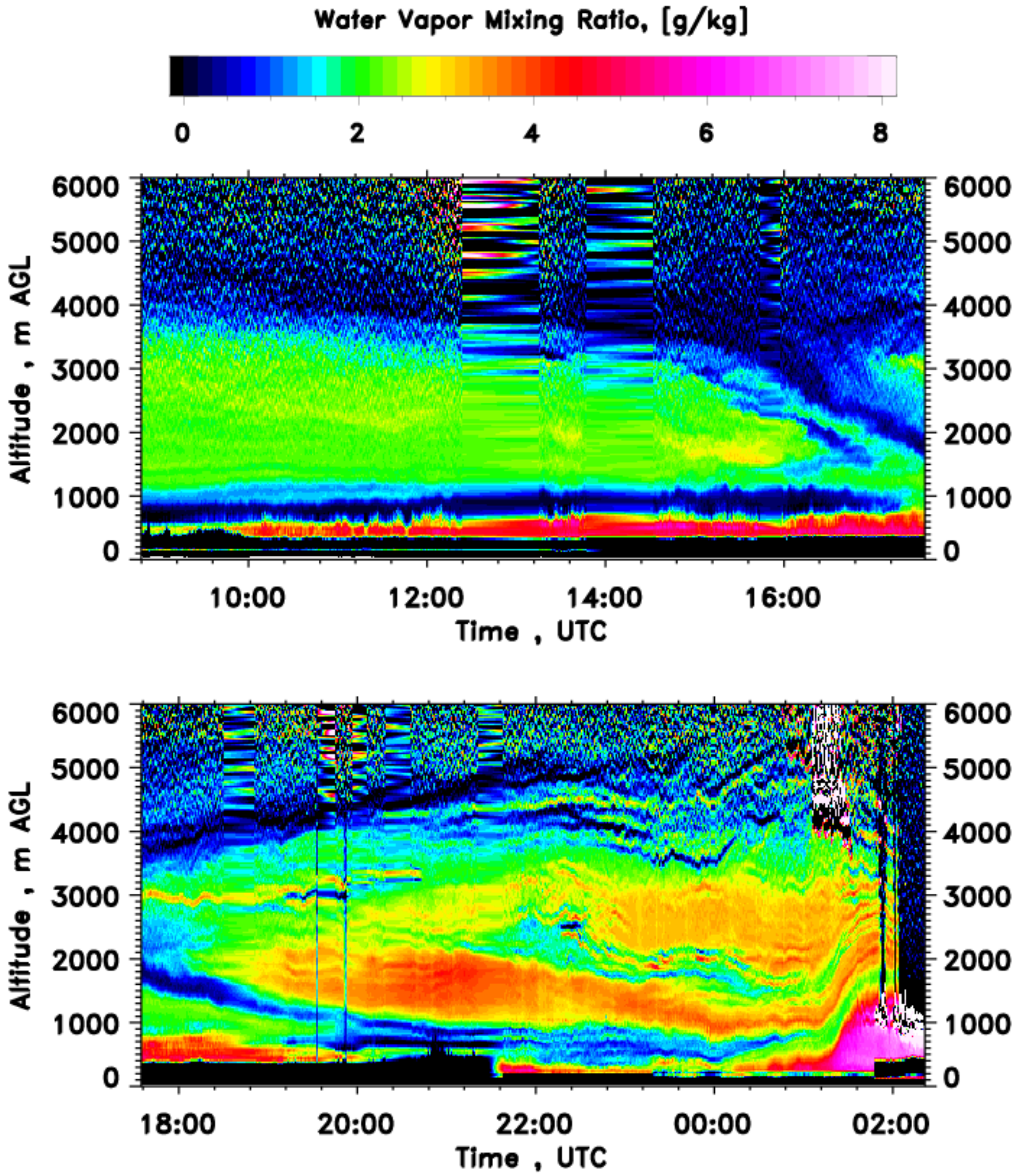


Fig. 11.21. Measurement example of the UHOH DIAL during IOP 13a/b on 1/2 August. The data resolution is 15 m and 10 s with a gliding average of 150 m. Warm moist air reaches the COPS region at 1700 UTC first in ~4 km ASL (corresponding to ~3 km AGL above Supersite H). At the end of the measurement period just before precipitation reached the lidar site a cold moist outflow is seen.

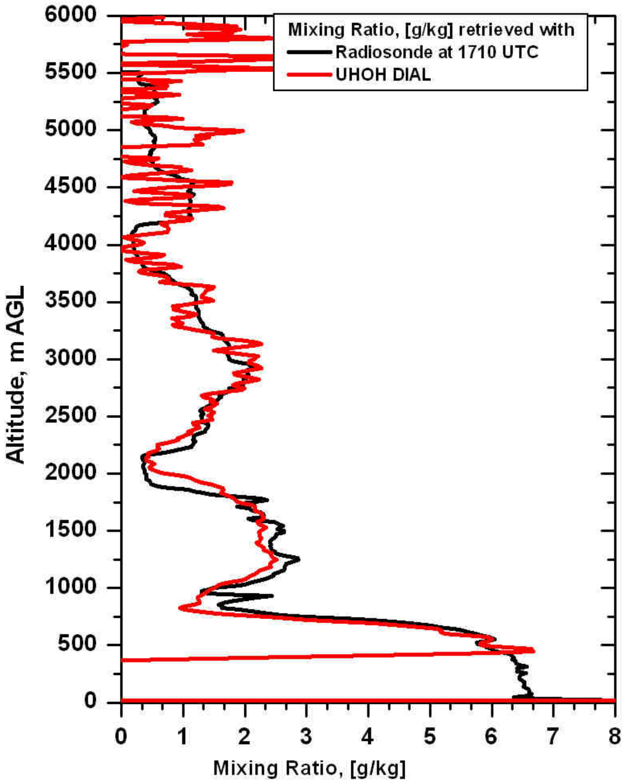


Fig. 11.22. Intercomparison of UHOH DIAL data and data of a collocated radiosonde launched at the lidar site. The DIAL data shown here are only from the large telescope and show overlap effects for heights < ~600 m. Therefore data in this height region are taken from the small lidar telescope (see Fig. 11.21).

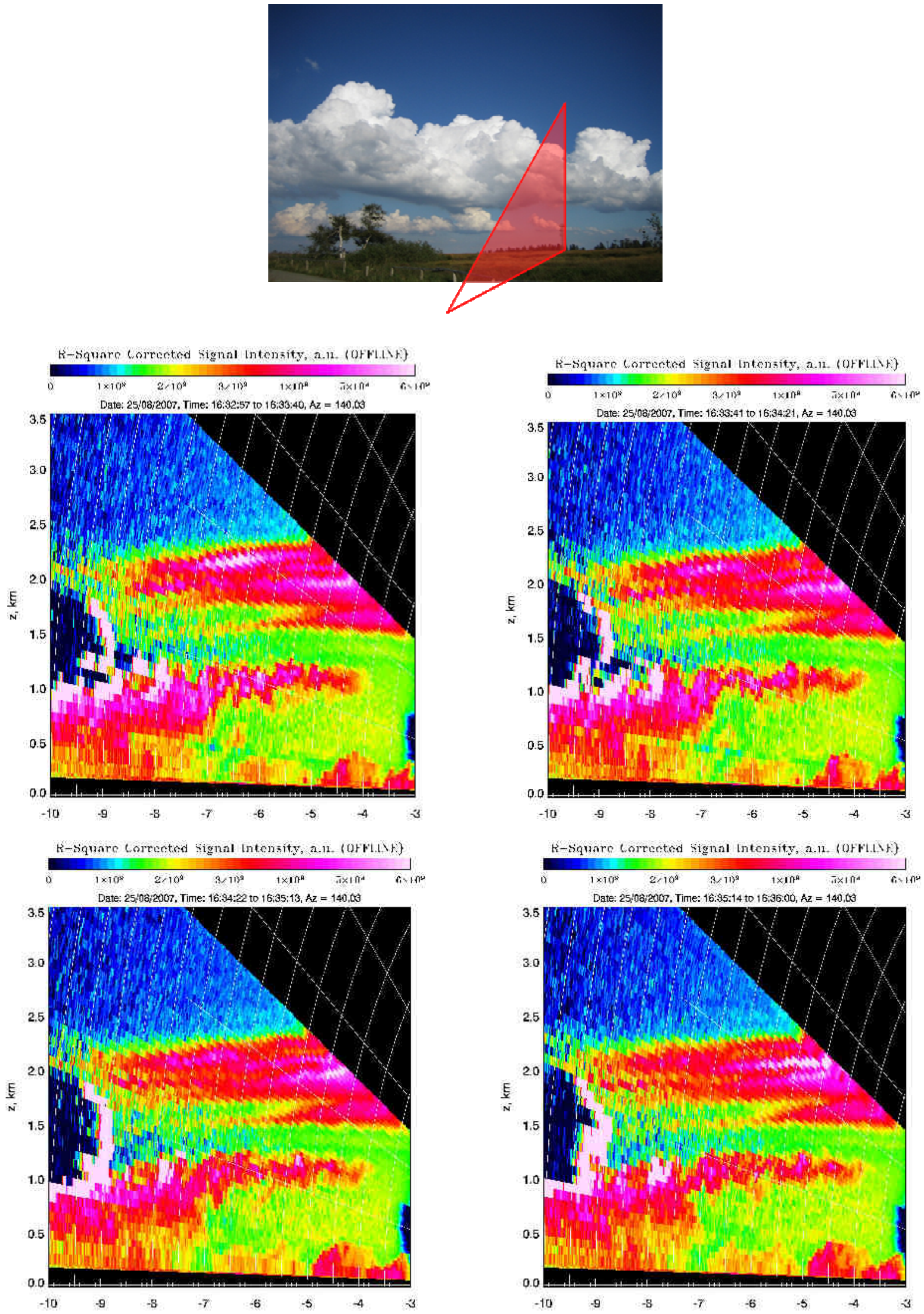


Fig. 11.23. Example of RHI scans with the UHOH DIAL: 4 consecutive plots of range-corrected backscatter intensities showing the aerosol field around a Cumulus mediocris (Cu med) cloud. A photograph of the clouds at 16:53 UTC with the scanning direction marked is shown in the upper panel. The scan speed was 0.5 °/s, each profile is with 1 s average giving an angular resolution of 0.5°. Elevation angles of 2 to 25° are covered. The range resolution is 15 m. The horizontal scale gives the distance to the lidar in km. The scan direction is towards Supersite M.

11.5.3.2 UHOH Rotational Raman Lidar

Like the UHOH DIAL, also the scanning rotational Raman lidar of UHOH is a in-house-develpoed one-of-its-kind instrument which needs two scientists to be operated. It was deployed during COPS IOPs and SOPs in different scanning modes depending on the IOP scenario. Between 25 July and 10 August a laser damage hindered operation. The following tables give an overview of the operation times and modes. More than 150 h of data have been gathered.

Table 11.10. Operation times of the UHOH Rotational Raman Lidar in June. The operation mode is indicated in colors.

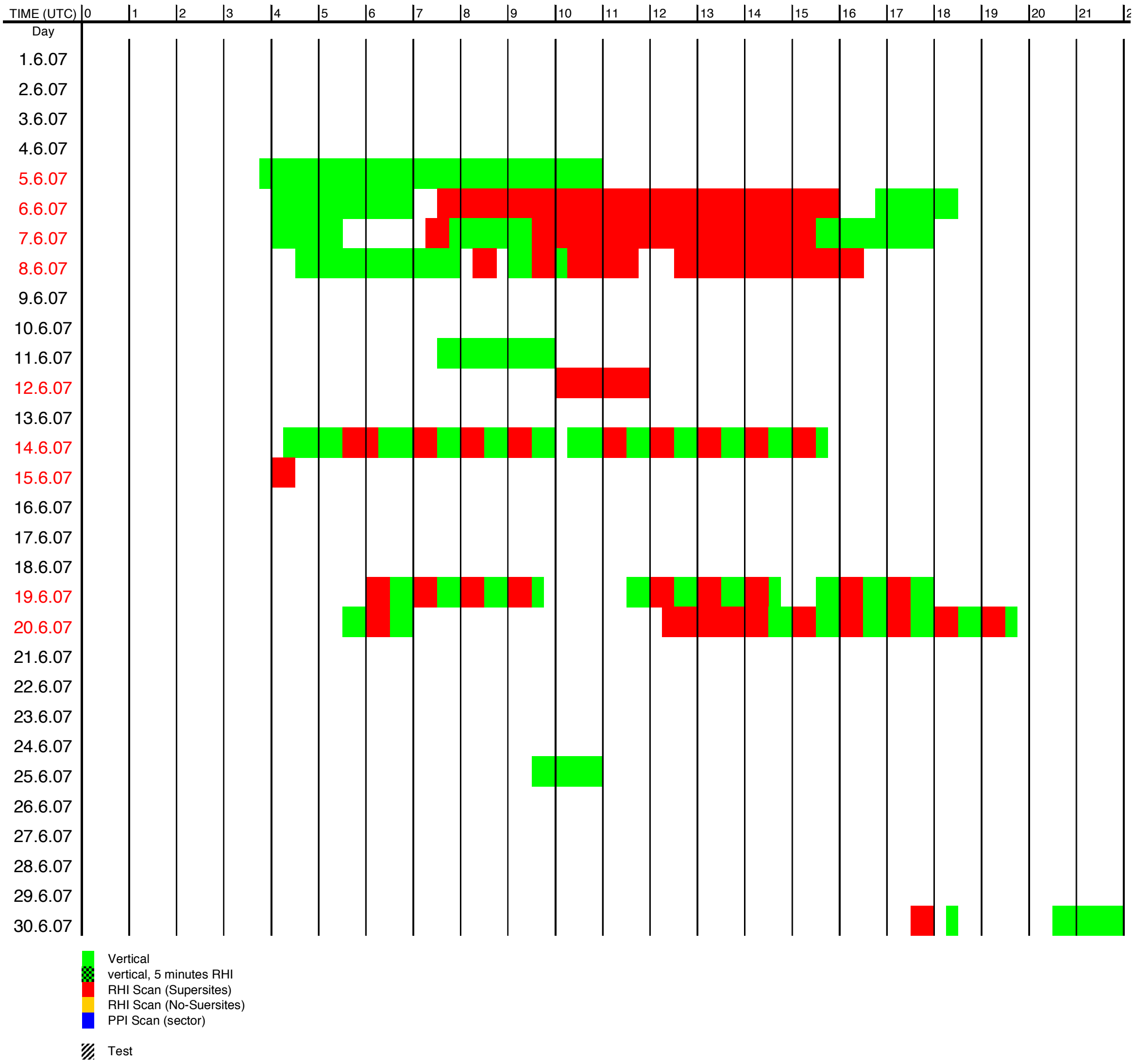


Table 11.11. Operation times and modes of the UHOH Rotational Raman Lidar in July.

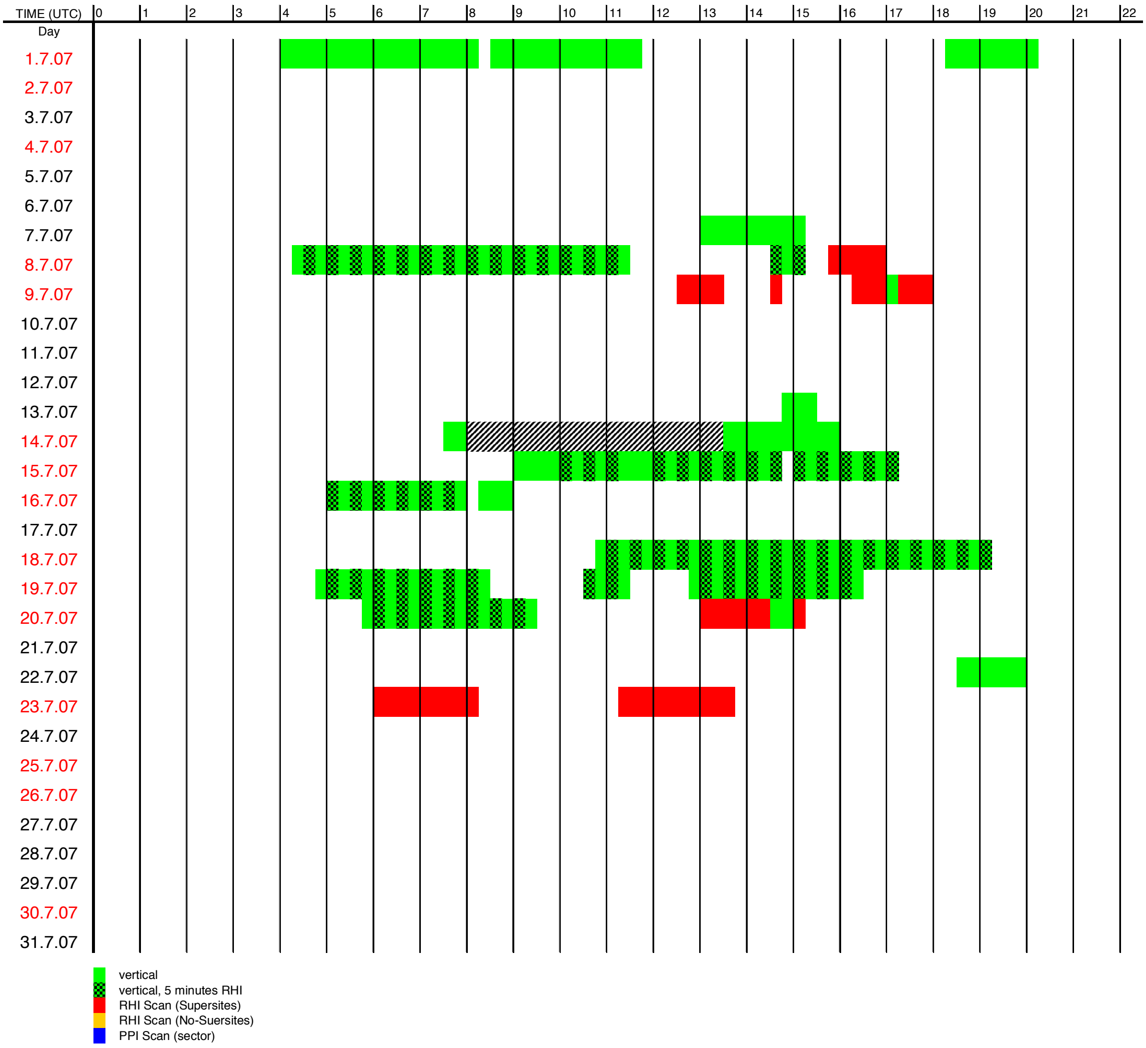
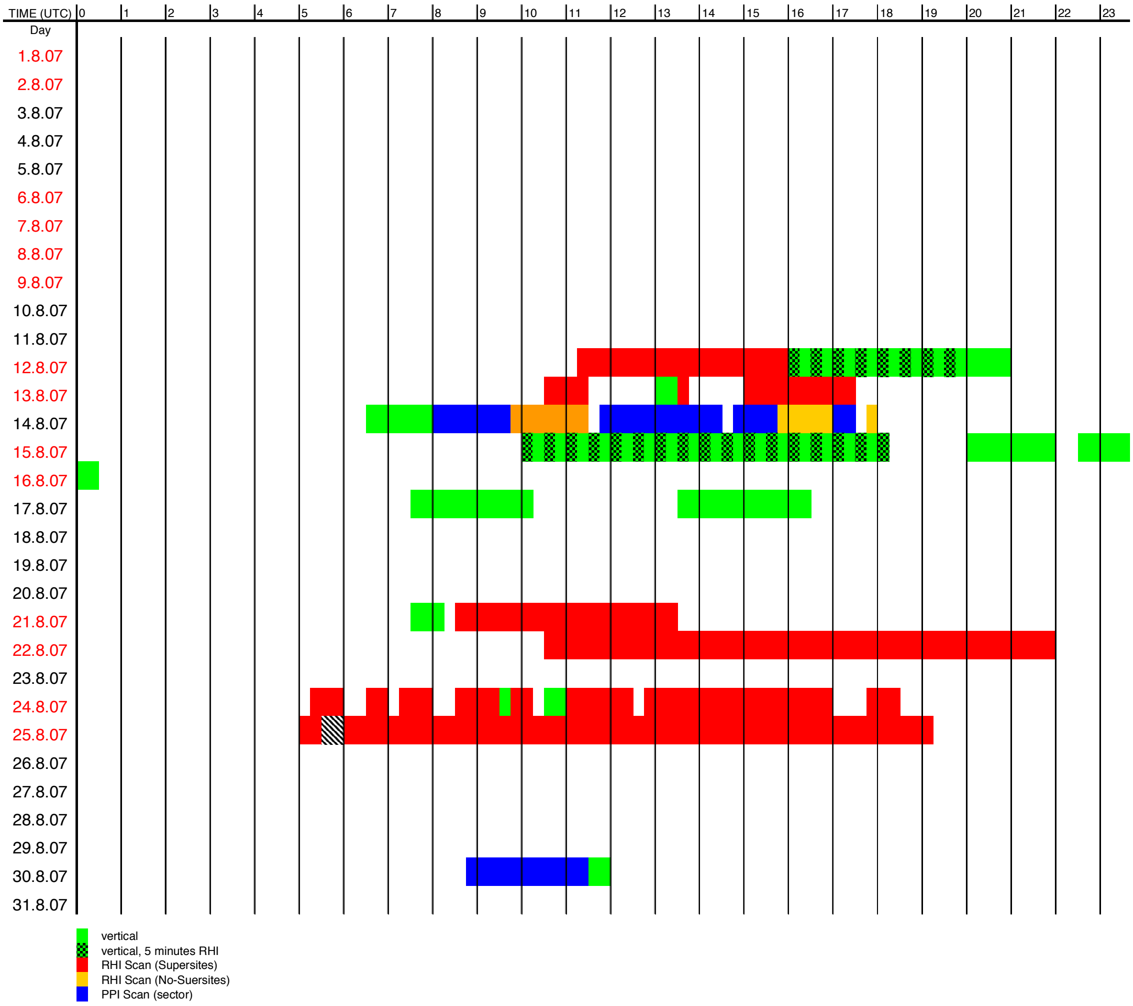


Table 11.12. Operation times and modes of the UHOH Rotational Raman Lidar in August.



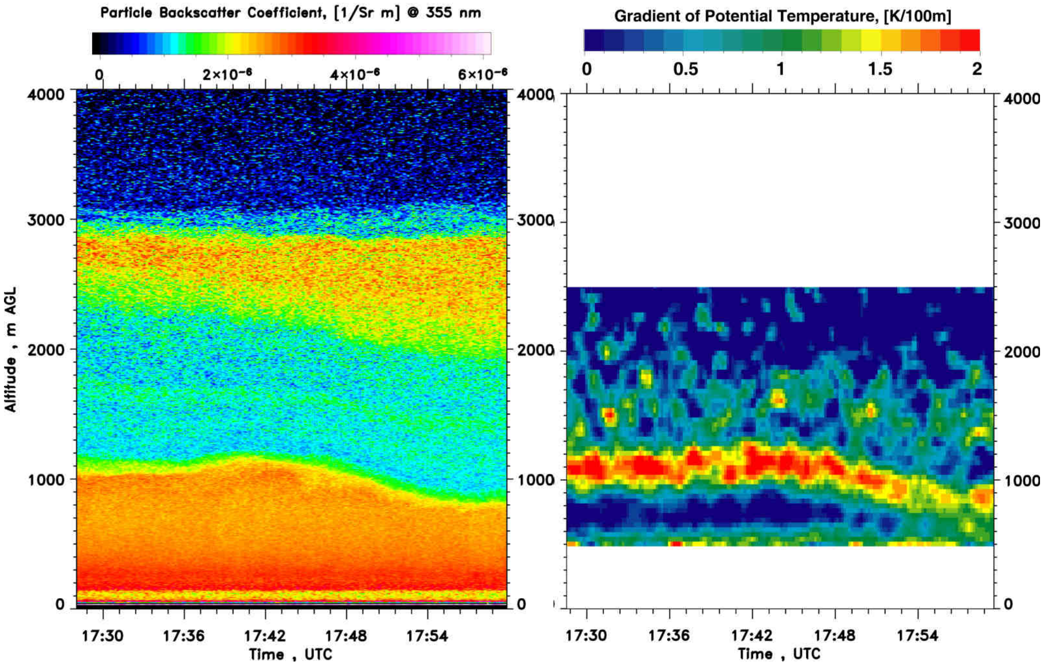


Fig. 11.24. Example of vertical measurements with the UHOH RRL: particle backscatter coefficient at 355 nm (left panel) and gradient of the potential temperature (right panel). The data resolution is 3.75 and 10 s. For temperature measurements, a gliding average of 300 m and 60 s was applied here. A strong tempemperature gradient at the top of a well-mixed convective boundary layer can be seen here.

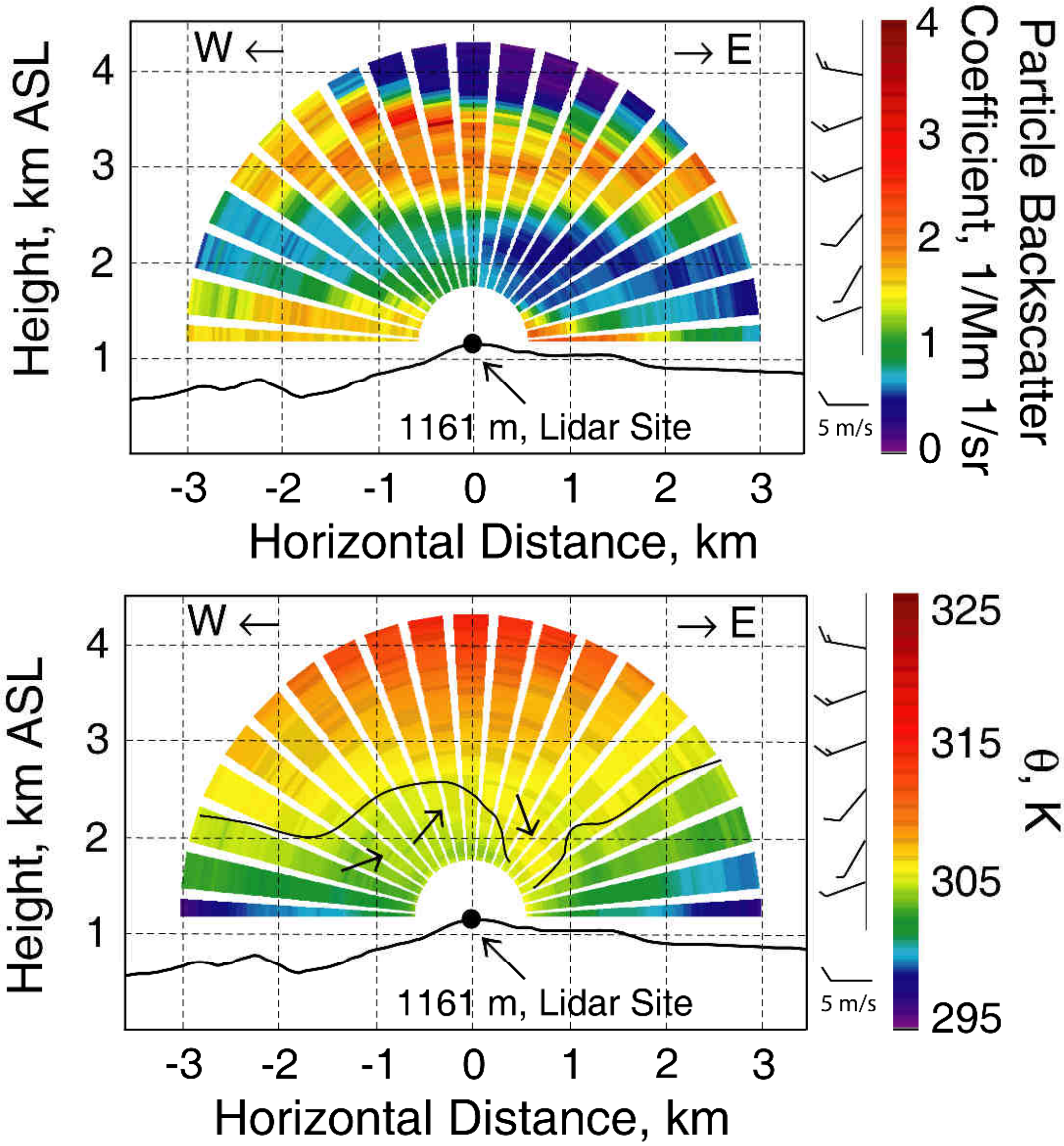


Fig. 11.25. Example of scanning measurements with the UHOH RRL: particle backscatter coefficient at 355 nm (upper panel) and potential temperature (lower panel) on 25 August between 1600 and 1700 UTC. The data resolution is 3.75 and 13 s for each profile. For temperature measurements, a gliding average of 300 m was applied here. 13 scans with 21 profiles in different directions were averaged. Advection and updraft of air from the Rhine Valley as well as downdraft in the lee is revealed. Wind barbs on the right show the horizontal wind direction and velocity as seen by a collocated radiosonde. The scanning direction was along the lines of Supersites. The statistical uncertainty of the temperature data is < 1 K for all data shown.

11.5.3.3 IMK Doppler Lidar

With the exception of a few short breaks (on 1 July, 11 July, 20 July), the automated IMK Doppler radar was operated continuously during the COPS field phase (see Table 11.16). Screenshots of the IMK Doppler Lidar have been provided in near-real time during the field phase. These plots are all available at http://www.cops2007.de/ under “Operational Products”, “Lidar Facilities”, “IMK Windtracer Screenshot”. An example is shown in the figure below.

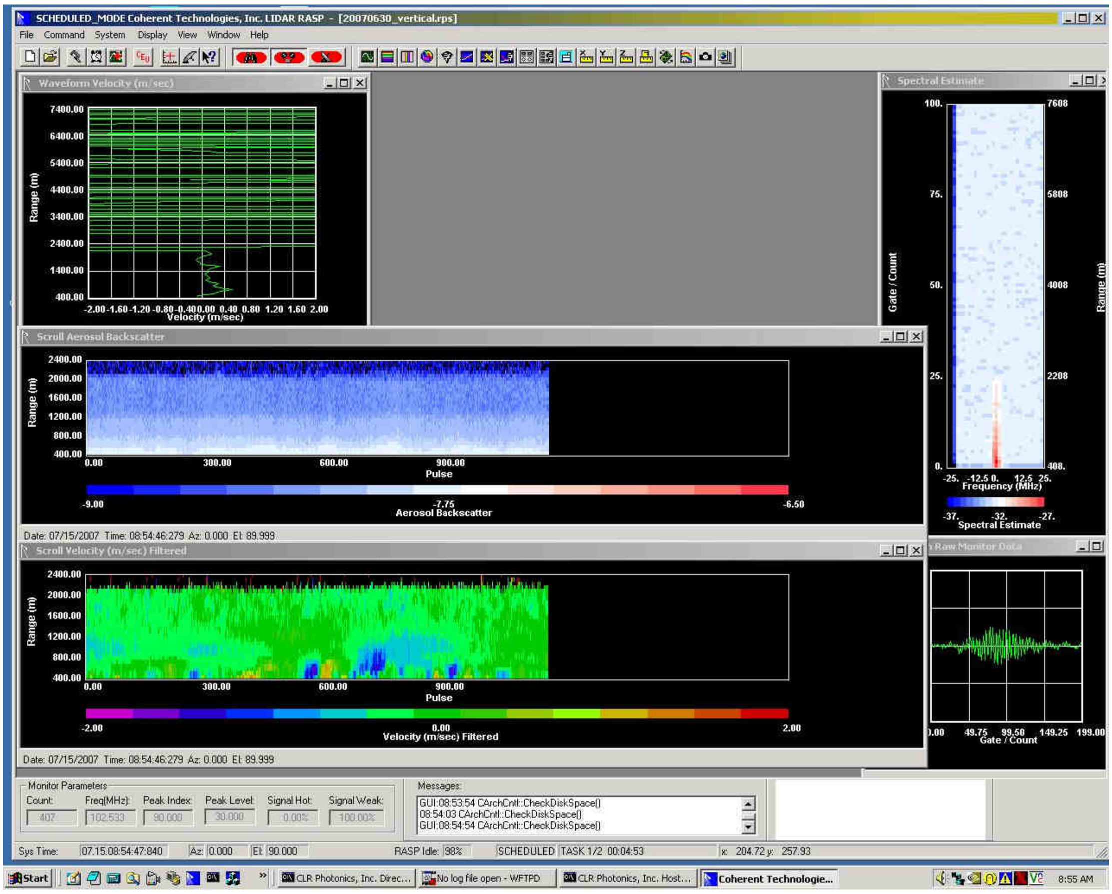


Fig. 11.26. Screenshot of the IMK Doppler Lidar. Up- and downdrafts can be seen in these vertical measurements here indicated by reddish and bluish colors, respectively, in the lower panel.

Table 11.13. Operation times and scanpattern of IMK cloud radar and IMK Doppler-lidar.

Date **(IOP)**	**Scanpattern** **Doppler-lidar**	**Scanpattern** **cloud radar**	**coordinated actions**
01.06.2007	*rhi's ppi's*	*vertical stare from 10.30 to 12 UTC 15°/ 75° ppi's*	*none*
02.06. bis 28.06.	*rhi's ppi's*	*vertical stare*	*none*
29.06.2007	*rhi's ppi's*	*vertical stare* *zw. 10 und 12.30 UTC Tests?*	*none*
30.06.2007	*rhi's ppi's* *starting 22 UTC ScaS1*	*vertical stare*	*starting 22 UTC vertikal stare 25 min per 30 min*
01.07.2007 (IOP5a)	ScaS1	vertical stare	*vertikal stare 25 min per 30 min*
02.07.2007 (IOP5b)	ScaS1	vertical stare	*vertikal stare 25 min per 30 min*
03.07.2007	ScaS1	0 to 10 UTC vertical stare 10 to 14 UTC Tests? starting 14 UTC ScaS2	25 min coordinated vertical stare per hour
04.07.2007 (IOP6)	ScaS1	ScaS2	25 min coordinated vertical stare per hour
05.07.2007	*ScaS1* *starting 7.25UTC rhi's ppi's*	*until 9 UTC ScaS2* *10 to 12.30 UTC ScaS1 without vertical stare (?) later with vertical stare* *starting 16 UTC only vertical stare*	*none*
06.07.2007	*rhi's ppi's*	*vertical stare,* *9 to 14 UTC Tests?* *starting 14 UTC ScaS1*	*none* *during test phase 45 deg. ppi probabely coordinated*
07.07.2007	rhi's ppi's starting 21.30 UTC ScaS1	ScaS1	starting 21.30 UTC coordinated ScaS1: • 45° ppi Doppler-lidar 0->360, cloud radar 295.4->295.4 cloud radar starts when Doppler-lidar is at 295.4, but stops when Doppler-lidar has reached 0° • RHI different angles. (Doppler-lidar 0,67, 90,113 / cloud radar 21 and 111) • vertical staree OK
08.07.2007 (IOP7a)	ScaS1	ScaS1	same as 07.07.2007
09.07.2007 (IOP7b)	ScaS1	ScaS1	same as 07.07.2007
10.07.2007	*until 10 UTC ScaS1*	*unitl 7 UTC ScaS1*	*until 7 UTC ScaS1 see 07.07.2007*

Date (IOP)	Scanpattern Doppler-lidar	Scanpattern cloud radar	coordinated actions
	later. rhi's ppi's	*later vertical stare*	
11.07.2007	until 7.30 UTC ScaS1 starting 12.30 UTC ScaS2	vertical stare	starting 12.30 UTC 30 min per 1 h coordinated vertical stare
12.07.2007	ScaS2	vertical stare (arond 14 UTC short phase with scans)	30 min per hour coordinated vertical stare
13.07.2007	ScaS2 (5 min time shiftt) starting 18 UTC ScaS1	vertical stare, except 10 to 13 UTC ScaS3	due to 5 min time shift ScaS2 und 3 similarity not evaluable. until 10 UTC and 13 to 18 UTC 30 min per 1 h coordinated vertical stare starting 18 UTC 25 min per 30 min coordinated vertical stare
14.07.2007 (IOP8a)	ScaS1	starting 8 UTC ScaS1	• start time not synchoneous • 45° ppi Doppler-lidar 0->360, cloud radar 295.4->295.4 cloud radar starts when Doppler-lidar reaches 295.4, but endst wenn Doppler-lidar reaches 0° (too fast, but same direction of rotaiton) • RHI different angles (Doppler-lidar 0 67 90 113 / cloud radar 21 and 111). Different times • vertical stare OK
15.07.2007 (IOP8b)	ScaS1 ab 21.45 UTC rhi's ppi's	ScaS1 zw. 11 und 16 UTC Probleme mit Elevation (15°)	bis 11 UTC und 16 bis 21.45 UTC vgl. 14.07.2007
16.07.2007	rhi's ppi's starting 9.30 UTC ScaS1	ScaS1 12:10 - 14:30 UTC Tests	ab 9.30 UTC ScaS1 gemeinsam • 45° ppi Doppler-lidar 0->360, cloud radar 295.4->295.4 cloud radar starts when Doppler-lidar reaches 295.4, but endst wenn Doppler-lidar reaches 0° (too fast, but same direction of rotaiton) • RHI different angles (Doppler-lidar 0 67 90 113 / cloud radar 21 and 111). Different times • vertical stare OK
17.07.2007	ScaS1	until 17 UTC ScaS1 later no signal	see 16.07.2007
18.07.2007 (IOP9a)	ScaS1	starting 8 UTC ScaS1 (before no signal)	see 16.07.2007
19.07.2007 (IOP9b)	until 20 UTC ScaS1 starting 22 UTC ScaS2	ScaS1	until 20 UTC see 16.07.2007 starting 22 UTC 25 min coordinated vertical stare per hour
20.07.2007 (IOP9c)	ScaS2	until 5 UTC ScaS1	5 to 7 UTC and 15 to 19.30 UTC coordinated

Date (IOP)	Scanpattern Doppler-lidar	Scanpattern cloud radar	coordinated actions
	7 to 15 UTC Tests starting 15 UTC ScaS2	until 9 UTC Tests until 19:26 UTC ScaS2 later no data	ScaS2 b.cloud radar starts to early Doppler -lidar starts too late. c.slow rhi: same azimuth , gleiche speed., short time shift (see above) d.45° ppi both systems start at and end at 295.4°, cloud radar sooner as Doppler-lidar, same turning direction, same turning speed e.rhi in different directions (Doppler-lidar: 90, wind direction, normal to wind direction / cloud radar: wind direction and normal to wind direction, but different wind directons detected. f.vertical stare OK
21.07.2007	ScaS2	bis 15 UTC no Daten later vertical stare	starting 15 UTC 30min per 1 h coordinated vertical stare
22.07.2007	ScaS2	vertical stare 5:50 – 7:40 supprot of aircraft measurements	30 min per 1 h coordinated vertical stare
23.07.2007 (IOP10)	until 6 UTC ScaS1 later Tests starting 11 UTC ScaS2	until 5 UTC vertical stare until 16 UTC aircraft mission support starting 16 UTC ScaS2	until 5 UTC 25 min per 30 min coordinated vertical stare starting 16 UTC coordinated ScaS2 d.see 20.07.2007 e.rhi (cloud radar 300 und 224° ?)
24.07.2007	until 19 UTC ScaS2 starting 23 UTC ScaS1	vertical stare from 9 to 11 UTC aircraft mission support starting 22 UTC no signal	coordinated vertical stare phases
25.07.2007 (IOP11a)	ScaS1	untl 8 UTC no signal starting 8 UTC ScaS1 *(delayed)* starting 19 UTC ScaS2	coordinated vertical stare phases
26.07.2007 (IOP11b)	starting 5 UTC ScaS3 from 7 to10 UTC minor problems	starting 6 UTC ScaS3	starting 10 UTC coordinated ScaS3 pattern: 1.slow RHI mostly synchronous 2.45° ppi same start and end azimuth positon (295.4°), same direction of rotation, same speed mostly synchronous 3.rhi at different angles (differences in on line calcaulated wind directions)
27.08.2007	ScaS3	ScaS3	see 26.07.2007
28.07.2007	*ScaS3* *between 14.30 and 15.30 UTC minor problems*	*until 2 UTC ScaS3* *until 13:30 aircraft measurement support* *12:30 – 16:00 vertical stare* *starting16 UTC ScaS1*	*none*

Date **(IOP)**	**Scanpattern** **Doppler-lidar**	**Scanpattern** **cloud radar**	**coordinated actions**
		(delayed)	
29.07.2007	*until 11.30 UTC ScaS3 then ScaS1*	*ScaS1 (delayed)*	*none*
30.07.2007 (IOP12)	*ScaS1*	*ScaS1 (delayed)*	*none*
31.07.2007	*ScaS1*	*ScaS1 (delayed)*	*none*
01.08.2007 (IOP13a)	*ScaS1*	*ScaS1 (delayed)*	*none*
02.08.2007 (IOP13b)	ScaS1	ab 11 UTC ScaS1	ab 11 UTC ScaS1 • delay • 45° ppi start und endwinkel azimuth identical but different direction of rotation • rhi azimuth angle different (cloud radar: direction Supresite M, Doppler-lidar: wind direction), synchronous • coordinated vertical stare OK
03.08.2007	ScaS1	ScaS1	see 02.08.2007
04.08.2007	*ScaS1*	*starting7 UTC radar broken (elevation at 45°)*	*until 7 UTC ScaS1*
05.08.2007	ScaS1	from 11 to 19 UTC ScaS1 otherwise *Radar defective (elevation 15° and 45°)*	11 to 19 UTC ScaS1 see. 02.08.2007
06.08.2007	*ScaS1*	*radar defective*	*7 to 9 UTC ScaS1 see. 02.08.2007*
07.08.-23.08.2007		*radar defective*	
24.08.2007		*radar defective,* *from 14 UTC vertikal stare*	
25.08.2007 (IOP18b)	ScaS3 minor probleme between 11 und 11.30 UTC	vertical stare starting 7 UTC ScaS3	starting 7 UTC ScaS3: • time shift • 45° ppi starting angle, diretion and speed of rotation identical • starting time slightly shifted • rhi's at different azimuth angles
26.08.2007	*ScaS3*	*ScaS3* *starting 7 UTC ScaS1*	*until 7 UTC ScaS3 see 25.08.2007*
27.08.2007	*until 8 UTC ScaS3* *then ScaS1*	*until 8 UTC ScaS1* *then ScaS3*	*none*
28.08.2007	until 19 UTC ScaS1 starting 20 UTC ScaS3	untl 8 UTC ScaS3 then ScaS1	8 to 19 UTC ScaS1: • time shift • 45° ppi start and end angel identical.

Date (IOP)	Scanpattern Doppler-lidar	Scanpattern cloud radar	coordinated actions
		starting 21 UTC ScaS3	direction of rotation opposing start time not synchronous ● rhi angles different ● vertical stare OK starting 21 UTC ScaS3 ● slightly time shifted ● slow rhi OK ● 45°ppi same direction of rotation, same start and end angels, same speed of rotation, slightly time shifted ● rhi's at different angels
29.08.2007	ScaS3	ScaS3 aircraft mission support	see 28.08.2007
30.08.2007	ScaS3	ScaS3	see 28.08.2007
31.08.2007	*until 5 UTC ScaS3*	*ScaS3*	*until 5 UTC see 28.08.2007*

Observations:

- The Doppler-Lidar was operational during 92 days, the cloud radar during 75.
- Completely synchronous scan pattern cannot be achieved with the actual hard and software of the systems. (Doppler-Lidar upgrade available by end of 2008)
- Some days (~8) with minor time shift, and rhi scans in wind direction available. Wind direction sometimes different due to different on-line detection methods and input data).
- 31 days with coordinated vertical stare avialable.

Summary:

- Days with vertical stare measurements: 01.07. (IOP5a)-04.07., 07.07.-09.07., 11.07.-19.07., 21.07.-22.07., 24.-25.07., 02.(IOP13b)-03.08., 05.08.
- Days with synchronous scans with good agreement: 20.07. (IOP9c), 23.07. (IOP10) ab 16 UTC, 26.(IOP11b)-27.07., 25.08.(IOP18b), 28.08. ab 21 UTC -31.08. 5 UTC

11.5.3.4 FZK Cloud Radar

The automated IMK cloud radar was operated continuously during the COPS field phase with the exception of 21 and 23 July, and the period between 4 and 24 August (see Table 11.13). Quicklooks of the IMK Cloud radar have been provided in near-real time during the field phase. These plots are all available at http://www.cops2007.de/ under "Operational Products", "Radar Facilities", "IMK Cloud Radar". An example is shown in Fig .

11.5.3.5 CNR-IMAA Microwave profiler MP3014

Measurement examples of the CNR-IMAA Microwave Profiler can be found in section 15.7. The operation times are listed in Table 11.14.

During the field-phase of COPS, the CNR-IMAA microwave profiler worked continuously (24 h - 7 days a per week) from the 12 June up to 4 September 2007, except for a few interruptions related to failures of the general power supply at Hornisgrinde. Unfortunately in the period 1-11 June a failure of the power supply unit of the microwave profiler occurred and its replacement was necessary along with further additional tests. Anyway, h24 measurements are also available on the 7-8 June. The instrument has carried out the measurements in full agreement with the scanning strategies daily suggested in the COPS OP, according to the convective scenarios, starting from the 19 June. Out of IOP periods, the instrument operation mode has been selected in order to be in agreement with the other instruments operational at Hornisginde.

As examples of the measurements, the time series during the IOP-4b (20/06/2007) and IOP-13a (01/08/2007), a forced convective scenario is shown in Fig. 11.27.

At the moment, in agreement with the other groups interested in microwave profiling and involved in COPS, we decided to process the data provided by all the microwave profiler involved in the campaign using a single retrieval algorithm. This will give a strong contribution to the harmonization of the database and to the managing of the data by the end-user. The job is carried out by University of Cologne

Table 11.14. Operation times and scan pattern of CNR-IMAA Microwave profiler MP3014

Date (dd/mm/yy)	Operation mode	Operation time	Date (dd/mm/yy)	Operation mode	Operation time	Date (dd/mm/yy)	Operation mode	Operation time
01/06/2007	zenith mode	0000 - 0120 UT	01/07/2007	ScaS1	0000 - 2400 UT	01/08/2007	ScaS1	0000 - 2400 UT
02/06/2007	mainteinance		02/07/2007	ScaS1	0000 - 2400 UT	02/08/2007	ScaS1	0000 - 2400 UT
03/06/2007	mainteinance		03/07/2007	ScaS1	0000 - 2400 UT	03/08/2007	ScaS1	0000 - 2400 UT
04/06/2007	mainteinance		04/07/2007	ScaS1	0000 - 2400 UT	04/08/2007	ScaS1	0000 - 2400 UT
05/06/2007	mainteinance		05/07/2007	ScaS1	0000 - 2400 UT	05/08/2007	ScaS1	0000 - 2400 UT
06/06/2007	mainteinance		06/07/2007	ScaS1	0000 - 2400 UT	06/08/2007	ScaS1	0000 - 2400 UT
07/06/2007	elevation mode	1300 - 2400 UT	07/07/2007	ScaS1	0000 - 2400 UT	07/08/2007	ScaS1	0000 - 2400 UT
08/06/2007	elevation mode	0000 - 1650 UT	08/07/2007	ScaS1	0000 - 2400 UT	08/08/2007	ScaS2	0000 - 2400 UT
09/06/2007	down		09/07/2007	ScaS1	0000 - 2400 UT	09/08/2007	ScaS2	0000 - 2400 UT
10/06/2007	down		10/07/2007	ScaS1	0000 - 2400 UT	10/08/2007	ScaS1	0000 - 2400 UT
11/06/2007	down		11/07/2007	ScaS1	0000 - 2400 UT	11/08/2007	ScaS1	0000 - 2400 UT
12/06/2007	elevation mode	1600 - 2400 UT	12/07/2007	ScaS1	0000 - 2400 UT	12/08/2007	ScaS1	0000 - 2400 UT
13/06/2007	elevation mode	0000 - 2400 UT	13/07/2007	ScaS1	0000 - 2400 UT	13/08/2007	ScaS1	0000 - 2400 UT
14/06/2007	elevation mode	0000 - 2400 UT	14/07/2007	ScaS1	0000 - 2400 UT	14/08/2007	ScaS1	0000 - 2400 UT
15/06/2007	elevation mode	0000 - 2400 UT	15/07/2007	ScaS1	0000 - 2400 UT	15/08/2007	ScaS2	0000 - 2400 UT
16/06/2007	elevation mode	0000 - 2400 UT	16/07/2007	ScaS1	0000 - 2400 UT	16/08/2007	ScaS2	0000 - 2400 UT
17/06/2007	elevation mode	0000 - 2400 UT	17/07/2007	ScaS1	0000 - 2400 UT	17/08/2007	ScaS1	0000 - 2400 UT
18/06/2007	elevation mode	0000 - 2400 UT	18/07/2007	ScaS1	0000 - 2400 UT	18/08/2007	ScaS1	0000 - 2400 UT
19/06/2007	ScaS1	0000 - 2400 UT	19/07/2007	ScaS1	0000 - 2400 UT	19/08/2007	ScaS1	0000 - 2400 UT
20/06/2007	elevation mode	0000 - 2400 UT	20/07/2007	ScaS2	0000 - 2400 UT	20/08/2007	ScaS1	0000 - 2400 UT
21/06/2007	elevation mode	0000 - 2400 UT	21/07/2007	ScaS2	0000 - 2400 UT	21/08/2007	ScaS1	0000 - 2400 UT
22/06/2007	elevation mode	0000 - 2400 UT	22/07/2007	ScaS1	0000 - 2400 UT	22/08/2007	ScaS1	0000 - 2400 UT
23/06/2007	elevation mode	0000 - 2400 UT	23/07/2007	ScaS2	0000 - 2400 UT	23/08/2007	ScaS1	0000 - 2400 UT
24/06/2007	elevation mode	0000 - 2400 UT	24/07/2007	ScaS1	0000 - 2400 UT	24/08/2007	ScaS3	0000 - 2400 UT
25/06/2007	elevation mode	0000 - 2400 UT	25/07/2007	ScaS1	0000 - 2400 UT	25/08/2007	ScaS3	0000 - 2400 UT
26/06/2007	elevation mode	0000 - 2400 UT	26/07/2007	ScaS3	0000 - 2400 UT	26/08/2007	ScaS3	0000 - 2400 UT
27/06/2007	elevation mode	0000 - 2400 UT	27/07/2007	ScaS1	0000 - 2400 UT	27/08/2007	ScaS1	0000 - 2400 UT
28/06/2007	elevation mode	0000 - 2400 UT	28/07/2007	ScaS1	0000 - 2400 UT	28/08/2007	ScaS1	0000 - 2400 UT
29/06/2007	elevation mode	0000 - 2400 UT	29/07/2007	ScaS1	0000 - 2400 UT	29/08/2007	ScaS1	0000 - 2400 UT
30/06/2007	elevation mode	0000 - 2030 UT	30/07/2007	ScaS1	0000 - 2400 UT	30/08/2007	ScaS1	0000 - 2400 UT
	ScaS1	2030 - 2400 UT	31/07/2007	ScaS1	0000 - 2400 UT	31/08/2007	ScaS1	0000 - 2400 UT

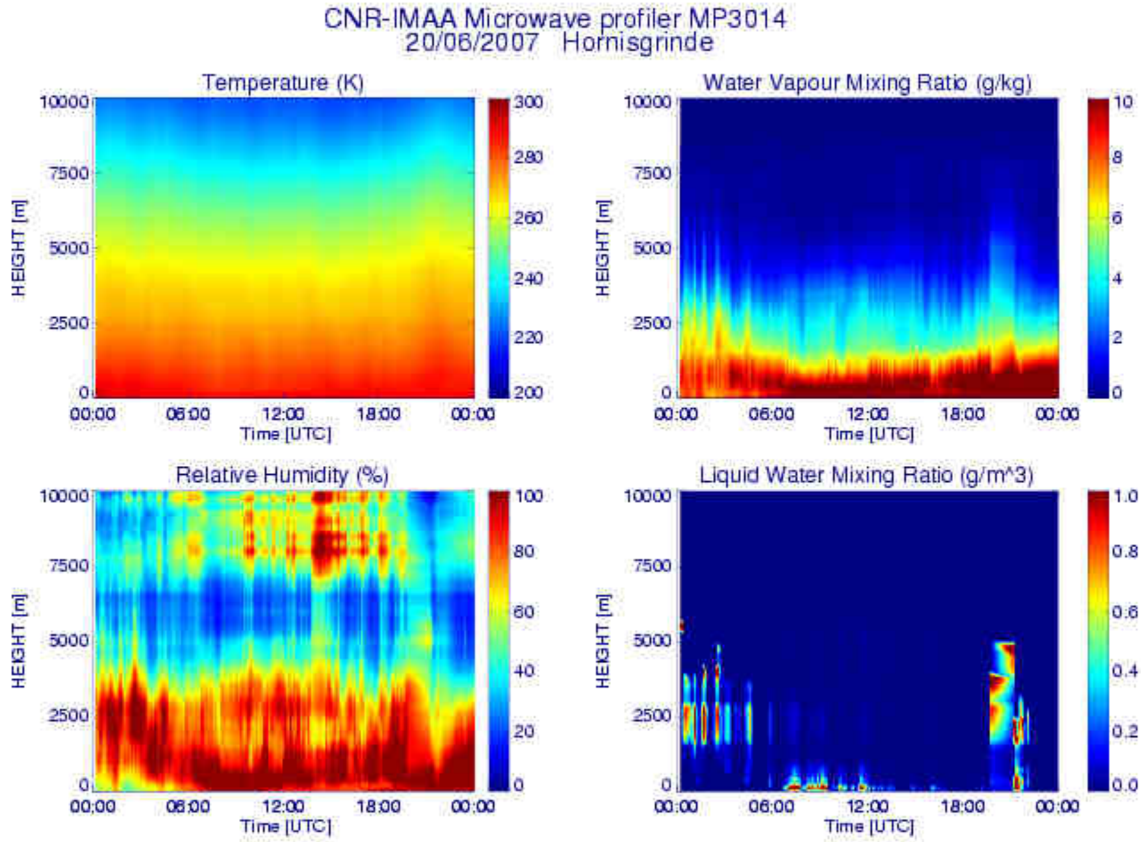


Fig. 11.27. Measurement example of the CNR-IMAA Microwaveradiometer at Superstite H on IOP4b: Time series of the temperature, water vapor, relative humidity and cloud liquid water profiles retrieved by the MP3014 microwave profiler on the 20/06/2007. The profiles are output in 100 m up to 1 km above the ground, and in 250 m from 1 to 10 km. The plots are referred to zenith measurements only. The sampling time is 5 minutes. Cloud liquid water retrieval has been performed using the cloud base temperature, measured with an infrared thermometer, as a constrain.

11.5.3.6 UHOH X-Band Radar

The UHOH X-band radar was operational from 14 June on. The detailed operation times are shown in the following table. The data resolution is 1 s and 15 m and covers heights up to mostly 12.8 km AGL which is ~14 km ASL.

Table 11.15. Operation times of the UHOH X-band radar.

Date	**IOP**	**Time, UTC**
14.06		12:22 - 17:24
15.06		9:22 – 15:42
19.06		5:57 – 17:57

20.06		5:37- 22:39
01.07.	IOP5a	11:50 – 20:50
02.07.		7:02 – 14:00 14:35 – 19:15
03.07		14:27 – 19:27
04.07		5:10 – 19:51
05.07		10:20 – 20:20
06.07		9:30 – 18:58
07.07.		5:30 – 16:13
08.07.	IOP7a	6:25 – 12:18
09.07.	IOP7b	5:09 – 18:08
14.07.	IOP8a	5:24 – 16:21
15.07.	IOP8b	04:50 – 16:43
16.07.		04:40 – 12:56
18.07.	IOP9a	6:20 – 24:00
19.07.	IOP9b	0:00 – 24:00
20.07.	IOP9c	0:00 - 24:00
21.07		0:00 – 20:20
23.07.	IOP10	6:10 – 24:00
24.07		0:00 – 11:17 Radar Distrometer was running overnight
25.07.	IOP11a	4:35 – 24:00
26.07.	IOP11b	0:01 – 18:35
28.07.		6:22 – 10:42 14:40 – 24:00
29.07.	IOP12	0:01 – 24:00
30.07		0:01 – 15:46 18:01 – 24:00
31.07		0:00 – 16:33
01.08.	IOP13a	23:20 – 24:00
02.08.	IOP13b	0:00 – 24:00
03.08.		0:00 – 14:58
06.08.		13:20 – 24:00
07.08		0:00 – 24:00
08.08.		0:00 – 8:10
12.08.	IOP15a	15:40 – 24:00
13.08.	IOP15b	0:00 – 19:11
15.08.	IOP16	
16.08		11:53 – 24:00
17.08.	SOP17	0:00 – 16:40
21.08.	IOP17a	6:48 – 24:00
22.08.	IOP17b	0:00 – 24:00
23.08.		0:00 – 11:18
24.08.	IOP18a	05:48 – 24:00
25.08.	IOP18b	0:00 – 18.52
28.08.		17:30 – 24:00
29.08		0:00 – 7:24 7:53 – 15:23
30.08.		9:58 – 11:58

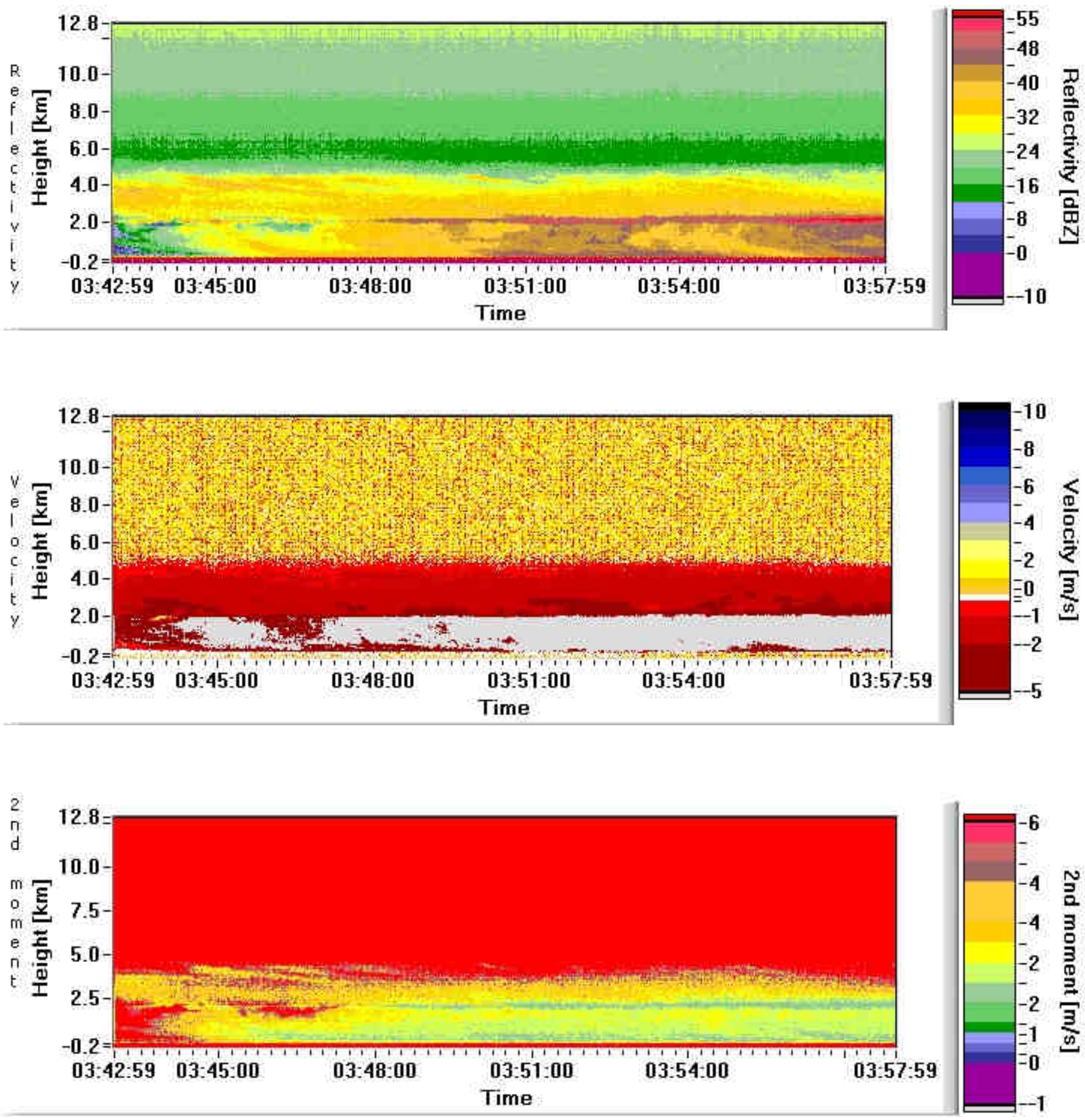


Fig. 11.28 Measurement examples of the UHOH X-band Radar on 2 August (IOP 13b). Upper panel: reflectivity, middle panel: velocity; lower panel: second moment. In this example, a bright band is seen in about 2 km AGL indicating the melting layer.

11.5.3.7 TARA

**To be added

11.5.3.8 Radiosondes

Table 11.16. Radiosondes launched at Supersite H

Number	Date	Time
1	11 June 07	08.34.00

2	12 June 07	05.21.00
3	12 June 07	07.56.00
4	12 June 07	10.56.00
5	12 June 07	13.55.00
6	12 June 07	17.02.00
7	12 June 07	19.54.00
8	14 June 07	04.59.00
9	14 June 07	07.52.00
10	14 June 07	11.01.00
11	14 June 07	13.59.00
12	15 June 07	05.18.00
13	15 June 07	08.09.00
14	15 June 07	10.37.00
15	19 June 07	07.51.00
16	19 June 07	11.02.00
17	19 June 07	14.01.00
18	19 June 07	16.56.00
19	20 June 07	05.52.00
20	20 June 07	07.53.00
21	20 June 07	11.11.00
22	20 June 07	14.20.00
23	20 June 07	17.0200
24	20 June 07	19.52.00
25	20 June 07	22.31.00
26	01 July 07	04.53.00
27	01 July 07	07.47.00
28	01 July 07	10.54.00
29	01 July 07	13.56.00
30	01 July 07	17.02.00
31	01 July 07	20.08.00
32	02 July 07	05.53.00
33	02 July 07	08.06.00
34	02 July 07	11.12.00
35	02 July 07	14.41.00

36	02 July 07	17.05.00
37	02 July 07	19.57.00
38	04 July 07	05.40.00
39	04 July 07	06.56.00
40	04 July 07	08.15.00
41	04 July 07	11.04.00
42	04 July 07	14.04.00
43	04 July 07	16.56.00
44	04 July 07	20.01.00
45	08 July 07	05.08.00
46	08 July 07	07.54.00
47	08 July 07	10.58.00
48	08 July 07	14.03.00
49	08 July 07	17.09.00
50	08 July 07	20.11.00
51	08 July 07	23.04.00
52	09 July 07	02.31.00
53	09 July 07	05.02.00
54	09 July 07	08.00.00
55	09 July 07	10.59.00
56	09 July 07	14.01.00
57	09 July 07	17.00.00
58	09 July 07	17.11.00
59	13 July 07	17.21.00
60	14 July 07	08.22.00
61	14 July 07	11.19.00
62	14 July 07	13.58.00
63	14 July 07	17.05.00
64	15 July 07	06.28.00
65	15 July 07	08.06.00
66	15 July 07	11.11.00
67	15 July 07	13.57.00
68	15 July 07	14.23.00
69	15 July 07	16.59.00

70	16 July 07	06.38.00
71	16 July 07	07.57.00
72	16 July 07	12.00.00
73	17 July 07	12.22.00
74	18 July 07	08.43.00
75	18 July 07	11.14.00
76	18 July 07	14.05.00
77	18 July 07	16.58.00
78	18 July 07	20.08.00
79	19 July 07	05.07.00
80	19 July 07	08.09.00
81	19 July 07	11.10.00
82	19 July 07	14.03.00
83	19 July 07	17.12.00
84	19 July 07	20.13.00
85	19 July 07	23.38.00
86	20 July 07	05.08.00
87	20 July 07	08.08.00
88	20 July 07	11.11.00
89	20 July 07	14.05.00
90	20 July 07	17.06.00
91	23 July 07	08.23.00
92	23 July 07	11.12.00
93	23 July 07	14.04.00
94	23 July 07	17.14.00
95	25 July 07	06.03.00
96	25 July 07	08.16.00
97	25 July 07	11.03.00
98	25 July 07	13.54.00
99	25 July 07	14.40.00
100	25 July 07	17.25.00
101	25 July 07	20.22.00
102	25 July 07	22.19.00
103	26 July 07	05.06.00

104	26 July 07	08.00.00
105	26 July 07	11.12.00
106	26 July 07	14.06.00
107	26 July 07	17.12.00
108	26 July 07	15.03.00
109	26 July 07	17.01.00
110	31 July 07	19.33.00
111	31 July 07	21.08.00
112	01 August 07	08.00.00
113	01 August 07	10.57.00
114	01 August 07	13.58.00
115	01 August 07	17.10.00
116	01 August 07	19.58.00
117	01 August 07	23.10.00
118	02 August 07	05.16.00
119	02 August 07	08.05.00
120	02 August 07	10.58.00
121	02 August 07	14.17.00
122	02 August 07	17.00.00
123	06 August 07	11.00.00
124	06 August 07	14.00.00
125	06 August 07	19.00.00
126	06 August 07	21.00.00
127	07 August 07	05.00.00
128	07 August 07	11.00.00
129	07 August 07	17.00.00
130	08 August 07	05.00.00
131	08 August 07	08.00.00
132	08 August 07	11.00.00
133	08 August 07	14.00.00
134	08 August 07	17.00.00
135	08 August 07	20.00.00
136	12 August 07	05.00.00
137	12 August 07	08.00.00

138	12 August 07	11.00.00
139	12 August 07	14.01.00
140	12 August 07	17.01.00
141	12 August 07	20.00.00
142	12 August 07	20.03.00
143	13 August 07	05.00.00
144	13 August 07	08.00.00
145	13 August 07	11.00.00
146	13 August 07	14.00.00
147	13 August 07	17.03.00
148	15 August 07	09.00.00
149	15 August 07	13.01.00
150	15 August 07	17.00.00
151	15 August 07	20.09.00
152	15 August 07	20.00.00
153	16 August 07	00.00.00
154	17 August 07	08.51.00
155	17 August 07	09.40.00
156	17 August 07	11.23.00
157	17 August 07	14.02.00
158	17 August 07	15.16.00
159	21 August 07	07.57.00
160	21 August 07	10.56.00
161	21 August 07	14.24.00
162	21 August 07	16.42.00
163	22 August 07	08.06.00
164	22 August 07	10.57.00
165	22 August 07	13.54.00
166	22 August 07	16.20.00
167	23 August 07	18.05.00
168	24 August 07	05.30.00
169	24 August 07	07.56.00
170	24 August 07	10.58.00
171	24 August 07	13.56.00

172	24 August 07	17.01.00
173	25 August 07	05.20.00
174	25 August 07	07.56.00
175	25 August 07	10.53.00
176	25 August 07	14.01.00
177	25 August 07	16.54.00
178	29 August 07	08.04.00
179	29 August 07	11.00.00
180	29 August 07	13.56.00
181	30 August 07	10.16.00

11.5.3.9 Pacific Northwest National Laboratory Radiative Flux Analysis System

The PNNL Radiative Flux Analysis System (RFAS) provides the basic measurements needed for the Radiative Flux Analysis methodology for inferring cloud macrophysical properties and the effect of clouds on the downwelling surface radiative energy budget. Measured quantities include the downwelling shortwave (SW) and longwave (LW) irradiance, the SW total and diffuse irradiance, and the ambient air temperature and relative humidity. The following Table lists the measured and calculated quantities that are included in the final data set:

Table 11.17. Parameters available from the Radiative Flux Analysis System.

Parameter	Meas./Retr.	Comments
Downwelling SW	Measured	Eppley model PSP
Clear-sky SW	Retrieved	Long and Ackerman, 2000, JGR
Total SW	Measured	Delta-T Devices model SPN-1
Diffuse SW	Measured	Delta-T Devices model SPN-2
Clear-sky diffuse SW	Retrieved	Long and Ackerman, 2000, JGR
Direct SW	Measured	Calculated, Total minus diffuse SW
Clear-sky direct SW	Retrieved	Long and Ackerman, 2000, JGR
Downwelling LW	Measured	Eppley model PIR
Clear-sky LW	Retrieved	Marty and Philipona, 2000, GRL; Long, 2004, ARM
Clear-sky periods	Retrieved	Long and Ackerman, 2000, JGR [daylight only]
Air Temperature	Measured	Campbell HMP45 T/RH probe
Relative Humidity	Measured	Campbell HMP45 T/RH probe
Total Sky Cover	Retrieved	Long et al., 2006, JGR [daylight only]
LW Effective Sky Cover	Retrieved	Durr and Philipona, 2004, JGR; Long, 2004, ARM [low/mid cloud only]
Cloud Vis optical depth	Retrieved	Barnard and Long, 2004, JAM [Skycover>90% only]
Cloud SW transmissivity	Retrieved	Long and Ackerman, 2000, JGR [daylight only]
sky brightness temperature	Retrieved	Long, 2004, ARM
cloud radiating temperature	Retrieved	Long, 2004, ARM [LW Scv>50% only]
clear-sky LW emissivity	Retrieved	Marty and Philipona, 2000, GRL; Long, 2004, ARM

An RFAS was deployed at the COPS Hornisgrinde site from May 24 through September 3, 2007, mounted on a small tripod located on the vegetated area to the northwest of the other instrument vehicles. The system and instruments are shown in the picture below. During this time, on-site personnel cleaned the radiometer domes each day that site personnel were present. In general, the radiometers performed well. There are some periods where the RH sensor data is missing due to an intermittent sensor problem, times with RH values greater than 100% and air temperature values significantly less than the collocated pyrgeometer case and dome temperatures, all of which worsened as the experiment continued. These periods are listed in the data availability table below, but cause suspicion about the quality of the entire time series of RFAS T/RH data. Hopefully other data sources from on-site can be used as they become available to fill the T/RH gaps and test the quality. The radiometers experienced no problems during the deployment, except for times of power outages at the site.

Prior to the Hornisgrinde deployment, the RFAS was operated for two days at the ARM Mobile Facility site near Heselbech. The data collected during the AMF period served to generate normalization factors for the RFAS instruments with the aim of normalizing the data from both Supersite R and Hornisgrinde to the AMF as a reference. Thus comparison between these three sites should be possible on an "even field" for all.

Fig. 11.29 Picture of Radiative Flux Analysis System instruments and data logger enclosure at COPS Hornisgrinde Site

The following figures show measurement examples of the system.

Table 11.18. Data Availability Table for Hornisgrinde RFAS deployment:

Date	Comment
24-May	Data start 0920 UTC
25-May	3.5 hr data gap
26-May	Good
27-May	Good
28-May	Good
29-May	Good
30-May	Good
31-May	Good
1-Jun	Good
2-Jun	Good
3-Jun	Good
4-Jun	Good
5-Jun	Good
6-Jun	Good
7-Jun	Good
8-Jun	Good
9-Jun	Good
10-Jun	Good
11-Jun	Good
12-Jun	Good
13-Jun	Good
14-Jun	Good
15-Jun	Good
16-Jun	Good
17-Jun	Good
18-Jun	Good
19-Jun	4 hr RH dropout
20-Jun	Significant RH dropout
21-Jun	Minor RH dropout
22-Jun	Good
23-Jun	Good
24-Jun	Good
25-Jun	Good
26-Jun	Good
27-Jun	Good
28-Jun	Good
29-Jun	Good
30-Jun	1.5 hr RH dropout
1-Jul	Good
2-Jul	Good
3-Jul	Good
4-Jul	Good
5-Jul	Good
6-Jul	Good
7-Jul	Good
8-Jul	Significant RH dropouts
9-Jul	Good
10-Jul	Good
11-Jul	Good
12-Jul	Good
13-Jul	Significant RH dropouts
14-Jul	Significant RH dropouts
15-Jul	Good
16-Jul	14 hr T/RH dropout
17-Jul	Significant T/RH dropouts
18-Jul	All T/RH missing
19-Jul	Half T/RH missing
20-Jul	Good
21-Jul	Good
22-Jul	Good
23-Jul	Good
24-Jul	Data ends 2151, power out
25-Jul	Data start 0409, power out
26-Jul	Good
27-Jul	Good
28-Jul	Good
29-Jul	Good
30-Jul	Good
31-Jul	Good
1-Aug	Good
2-Aug	Good
3-Aug	Good
4-Aug	Good
5-Aug	Good
6-Aug	Good
7-Aug	Good
8-Aug	Good
9-Aug	Good
10-Aug	2/3 RH missing, T low
11-Aug	2/3 RH missing, T low
12-Aug	1/2 RH missing, T low
13-Aug	2/3 RH missing, T low
14-Aug	2/3 RH missing, T low
15-Aug	Bad T/RH
16-Aug	Bad T/RH
17-Aug	Bad T/RH, power out 2020 UTC
18-Aug	No data
19-Aug	No data most of day
20-Aug	Data start 1043 UTC, no T/RH
21-Aug	Bad T/RH
22-Aug	Bad T/RH
23-Aug	Bad T/RH
24-Aug	Bad T/RH
25-Aug	Bad T/RH
26-Aug	Bad T/RH
27-Aug	Bad T/RH
28-Aug	Bad T/RH
29-Aug	Bad T/RH
30-Aug	Bad T/RH
31-Aug	Bad T/RH
1-Sep	Bad T/RH
2-Sep	Bad T/RH
3-Sep	Data ends 0829 UTC

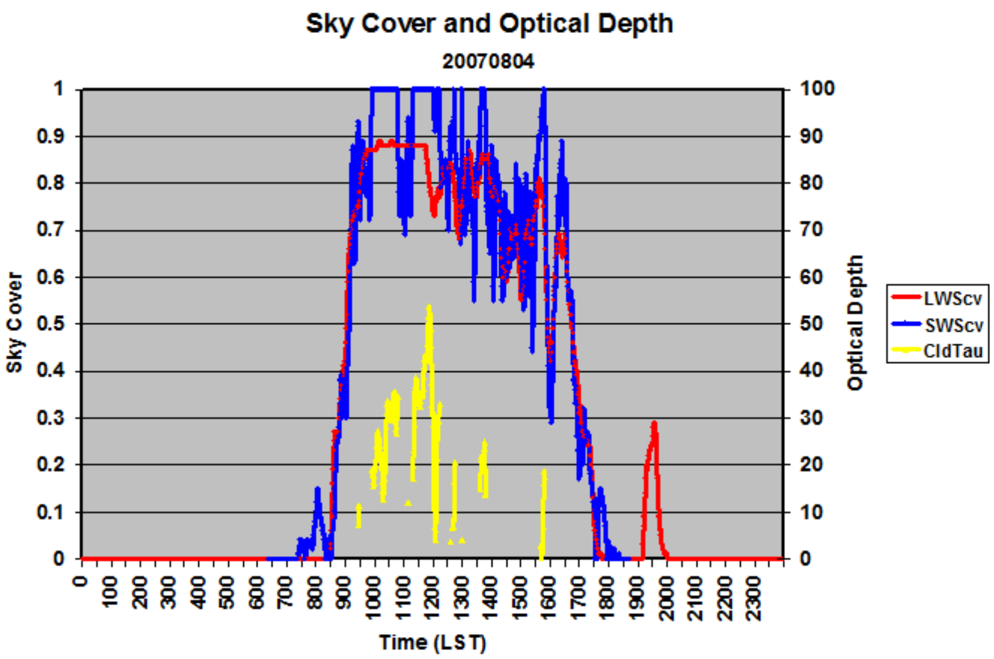


Fig. 11.30 Example retrievals of daylight total sky cover (blue), LW effective sky cover (red), and cloud visible optical depth (only for total sky cover > 90%) (yellow, right axis) for August 4, 2007 at COPS Hornisgrinde.

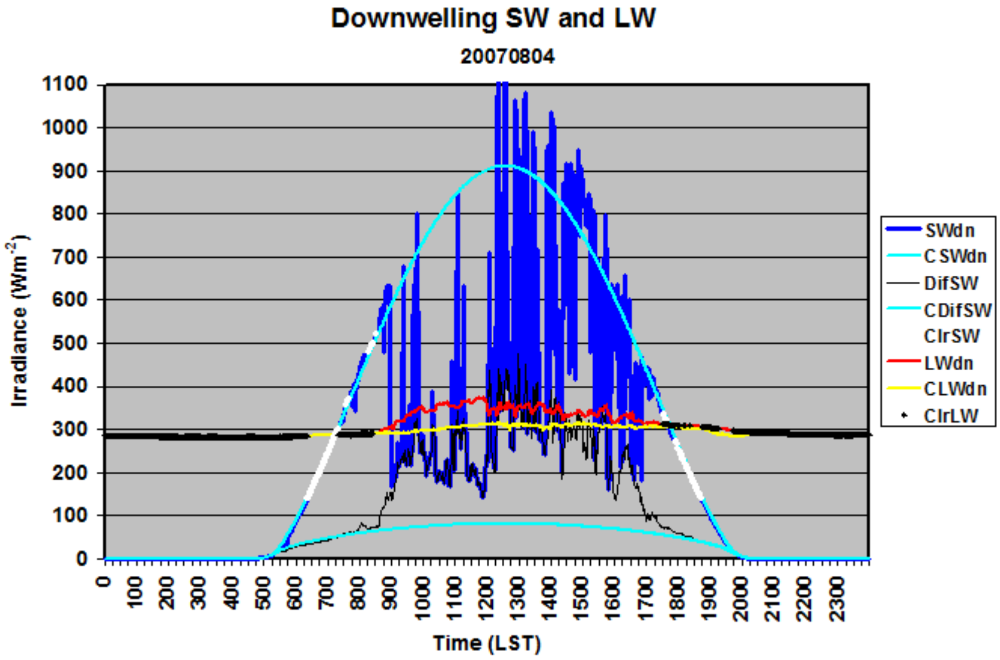


Fig. 11.31 Example of downwelling total SW (blue) and diffuse SW (black) with corresponding clear-sky values (light blue), and downwelling LW (red) with corresponding clear-sky values (yellow) for August 4, 2007 at COPS Hornisgrinde. White dots indicate daylight detected clear-sky data, black dots indicate detected LW effective clear-sky data.

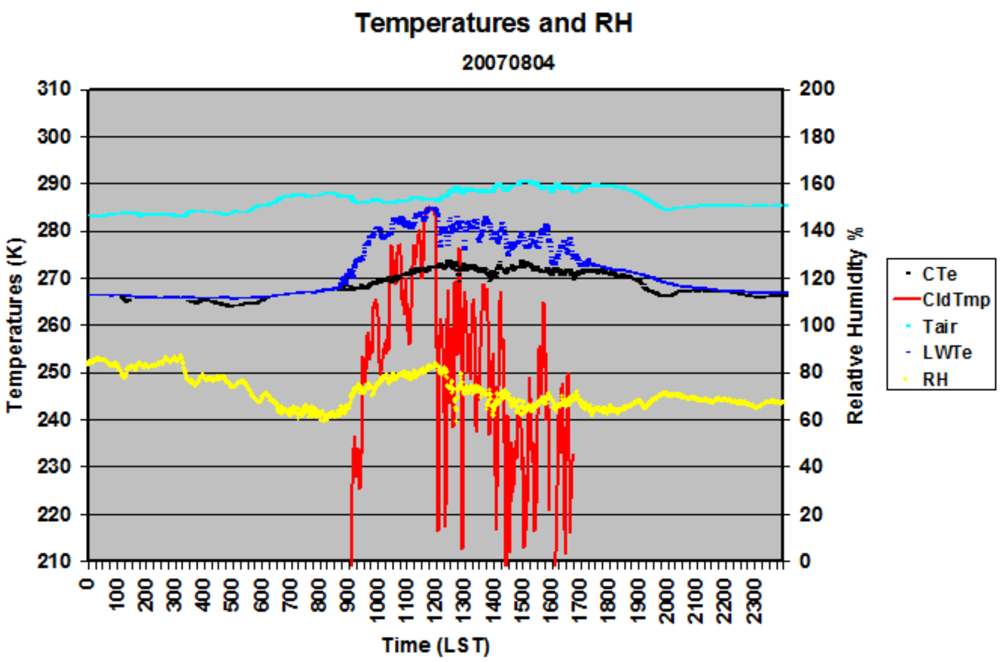


Fig. 11.32 Example of calculated LW effective brightness temperature (blue) and corresponding clear-sky brightness temperature (black), measured air temperature (light blue), calculated cloud radiating temperature when LW sky cover is > 50% (red), and measured relative humidity (yellow, right axis) for August 4, 2007 at COPS Hornisgrinde.

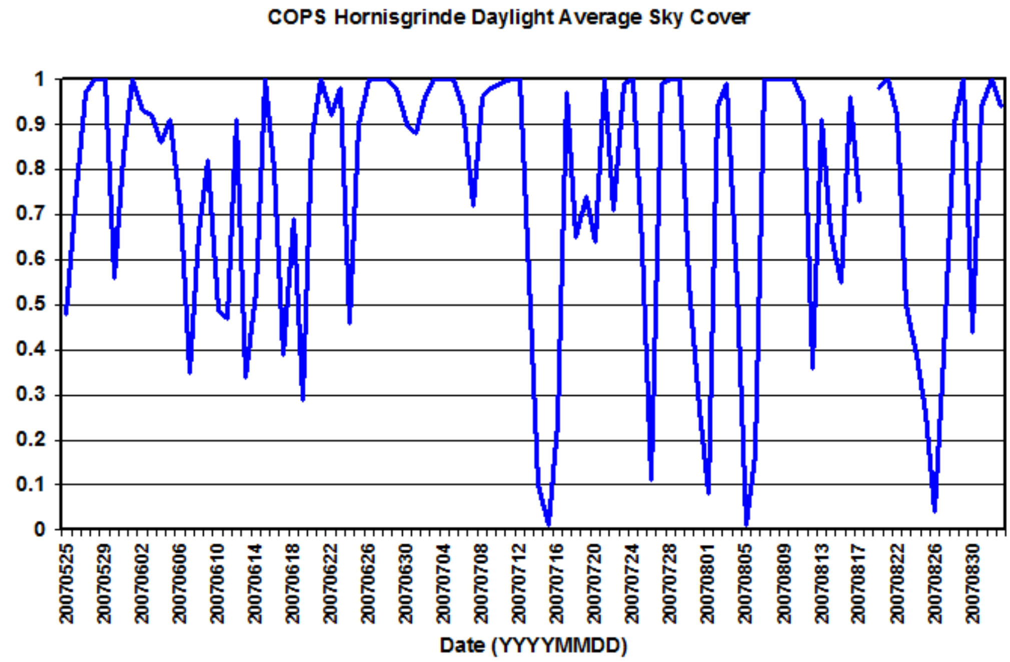


Fig. 11.33 Daylight average total sky cover (blue) for the COPS deployment period at Hornisgrinde.

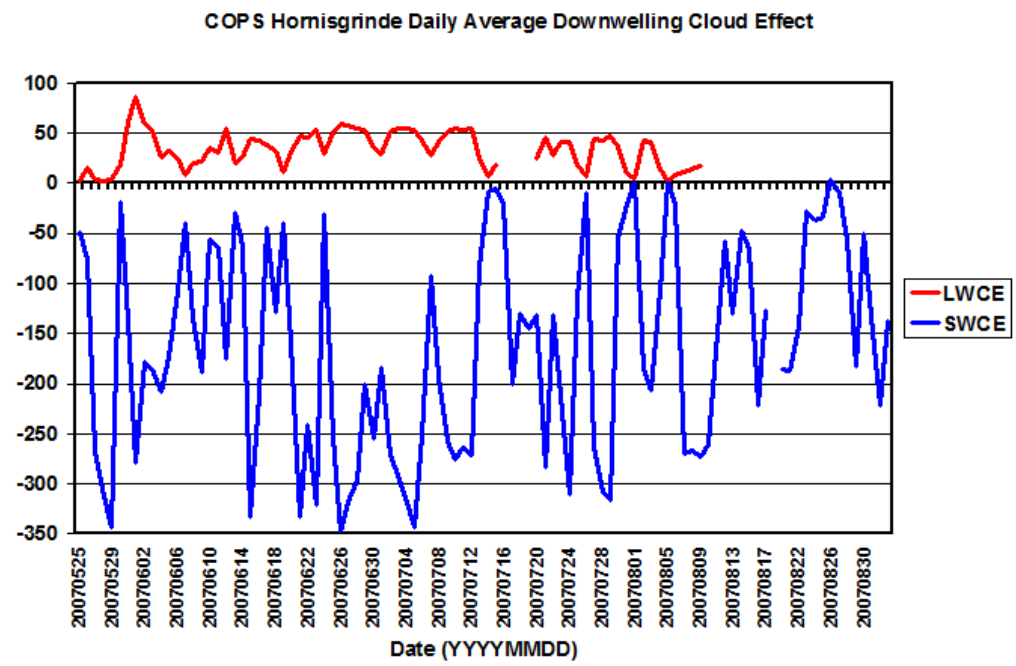


Fig. 11.34 Daily average SW (blue) and LW (red) influence of clouds on the downwelling irradiance for the COPS deployment period at Hornisgrinde, calculated as the all-sky minus clear-sky irradiance difference. The effect of clouds is larger on the SW than the LW portion of the surface radiative energy budget.

11.5.4 Supersite M

At **Supersite M** in the Murg valley about 16 km south-east of Supersite H, the ARM mobile facility (AMF) is operated not only during the COPS field phase but from 1 April to 31 December 2007. The webpage of the AMF deployment in the Black Forest can be found at http://www.arm.gov/sites/amf/blackforest/. This ARM instrument system with an precipitation radar, an automatic radiosonde launcher and various remote sensing perfectly complements Supersite H as it provides in addition to the measurement on top of the Black Forest mountain crest, measurements in a valley. During COPS additional instrumentation was located at the AMF site: For analyzing cloud microphysical properties, the Multi-Wavelength Raman lidar and Doppler lidar of IfT and the scanning microwave radiometer HATPRO of U. Cologne were added.

To derive the mass and moisture budgets (convergence) of the anabatic wind regimes, sodars, as well as three turbulence and wind met stations are installed at different locations in the Murg and Kinzig Valley.

Quicklooks of the IfT lidar measurements can be found at the webpage of the COPS Operations Center at http://www.cops2007.de/ -> Operational Products -> Lidar Facilities -> IfT Lidars.

11.5.5 Supersite R

Operation of **Supersite R** was performed in the lowlands of the Rhine valley. In contrast to the Hornisgrinde site, the location is characteristic for rather homogeneous surfaces, the only landscape differences arising from land use differences. Supersite R was placed on one line with the Supersites H and M with about 10 km distance to Supersite H. This transect of Supersites in the Northern Black Forest was extended to the north-west and the polarization radar POLDIRAD was situated at a distance of about 45 km to Supersite H.

The synergy of these systems provides water vapor and temperature measurement from close to the ground up to a range of 15 km. In the boundary layer, turbulent processes and convection can be resolved.

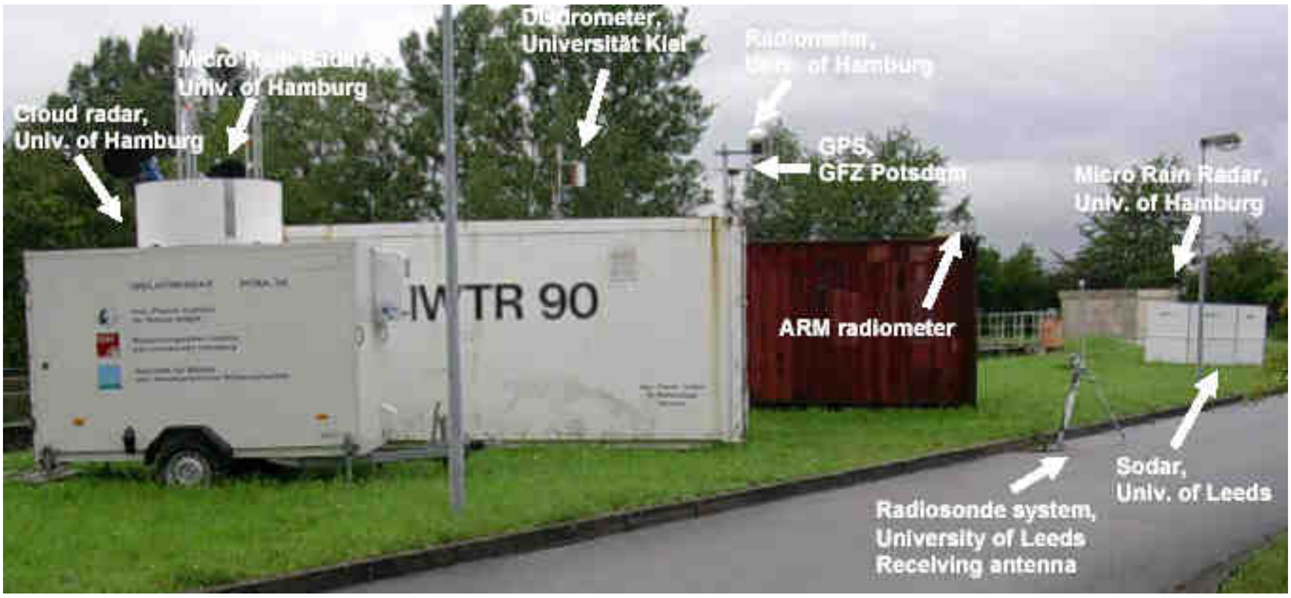


Fig. 11.35 Instruments in the North portion of the facility. University of Munich Weather Station and FZK soil moisture station are not visible in the right portion of the picture.

Fig. 11.36 Instruments in the South portion of the facility.

11.5.5.1 BASIL - Univ. of BASILicata Raman Lidar

Raman lidar measurements were run between 25 May and 30 August 2007. More than 500 hours of measurements distributed over 58 measurement days. Measured parameters include:

particle backscattering coeff. @ 355, 532 and 1064 nm,

particle extintion coeff. @ 355 & 532 nm,

lidar ratio @ 355 nm & 532 nm,

depolarization ratio @ 355 & 532 nm,

atmospheric temperature

water vapour mixing ratio

relative humidity from simultaneous measurements of temperature and water vapor mixing ratio

Vertical resolution of the rough data was set to 30 m. Temporal resolution of the rough data was set to 1 min from start of COPS till 12 June 2007, 20 sec from 14 June till 30 July 2007, and 5 sec from 31 July 2007 till end of COPS.

Data analysis is on progress. Status on December 1st, 2007:

95 % of the particle backscatter coeff. data @ 1064 nm have been analysed,

75 % of the particle backscatter coeff. data @ 532 nm have been analysed,

20 % of the particle backscatter coeff. data @ 355 nm have been analysed,

10 % of the particle extinction coeff. data @ 355&532 nm have been analysed

40 % of the water vapour data have been analysed,

20 % of the atmospheric temperature data have been analysed.

A good portion of the analysed data is available as a quick-look image through the COPS web site (http://www.cops2007.de/), under "operational products", select "BASIL Lidar (Achern)" under "Lidar Facilities". Here you have available quick-looks for particle backscattering coefficent at 532 and 1064 nm, water vapour mixing ratio and atmospheric temperature, as well as an additional box including "Additional Material".

Meta files for both data and instrumentation have been generated. Data transfer to data archive by the end of the year for most data.

Table 11.19 Operation times of BASIL

25-26 May 2007	21:54 - 00:04 UTC
26 May 2007	18:28 - 20:19 UTC
29 May 2007	12:00 – 12:30 UTC
30 May 2007	08:41 - 16:02 UTC
31 May 2007	20:28 – 21:24 UTC
04 June 2007	17:37 - 21:12 UTC
05 June 2007	02:42 - 19:50 UTC
06 June 2007	03:46 - 18:57 UTC
07 June 2007	03:06 - 20:22 UTC
08 June 2007	03:56 - 19:45 UTC
12 June 2007	05:48 - 19:07 UTC
14 June 2007	04:47 - 21:13 UTC
15 June 2007	03:27 - 13:00 UTC
19 June 2007	00:09 - 20.02 UTC
20 June 2007	04:39 - 23:15 UTC
30 June 2007	17:22 - 24:00 UTC
01 July 2007	00:00 - 20:40 UTC
02 July 2007	09:08 - 21:32 UTC
04 July 2007	07:11 - 19:30 UTC
08 July 2007	03:41 - 19:54 UTC
09 July 2007	01:15 – 03:48 UTC, 05:50 - 19:46 UTC
11 July 2007	08:25 - 14:19 UTC
12 July 2007	04:28 - 09:05 UTC
13 July 2007	08:45 - 16:38 UTC

14 July 2007	05:25 - 20:26 UTC
15 July 2007	04:47 - 20:02 UTC
16 July 2007	04:16 - 15:09 UTC
18 July 2007	08.14 - 21:46 UTC
19 July 2007	05:40 - 21:54 UTC
20 July 2007	04:08 - 20:31 UTC
21 July 2007	07:00 - 08:37 UTC
22 July 2007	16:26 - 18:57 UTC
23 July 2007	05:22 - 14:35 UTC
24 July 2007	06:45 - 10:03 UTC
25 July 2007	04:28 - 24:00 UTC.
26 July 2007	00:00 - 19:04 UTC
28 July 2007	09:50 - 11:25 UTC
30 July 2007	07:14 - 19:04 UTC
31 July 2007	17:52 - 23:13 UTC
01 August 2007	06:22 - 24:00 UTC
02 August 2007	00:00 - 18:28 UTC
06 August 2007	10:40 - 24:00 UTC
11 August 2007	21:35 - 24:00 UTC
12 August 2007	00:00 - 21:15 UTC
13 August 2007	03:25 - 19:00 UTC
14 August 2007	09:14 - 18:02 UTC
15 August 2007	09:15 - 21:30 UTC
16 August 2007	00:25 - 01:35 UTC, 07:25 - 09:10 UTC
17 August 2007	04:51 - 18:33 UTC
21 August 2007	04:57 - 18:35 UTC
22 August 2007	06:22 - 17:34 UTC
23 August 2007	17:51 - 19.17 UTC
24 August 2007	04:10 - 19:22 UTC
25 August 2007	04:15 - 20:00 UTC
28 August 2007	12:09 - 18:02 UTC
29 August 2007	07:22 - 15.39 UTC
30 August 2007	09:26 - 13:50 UTC

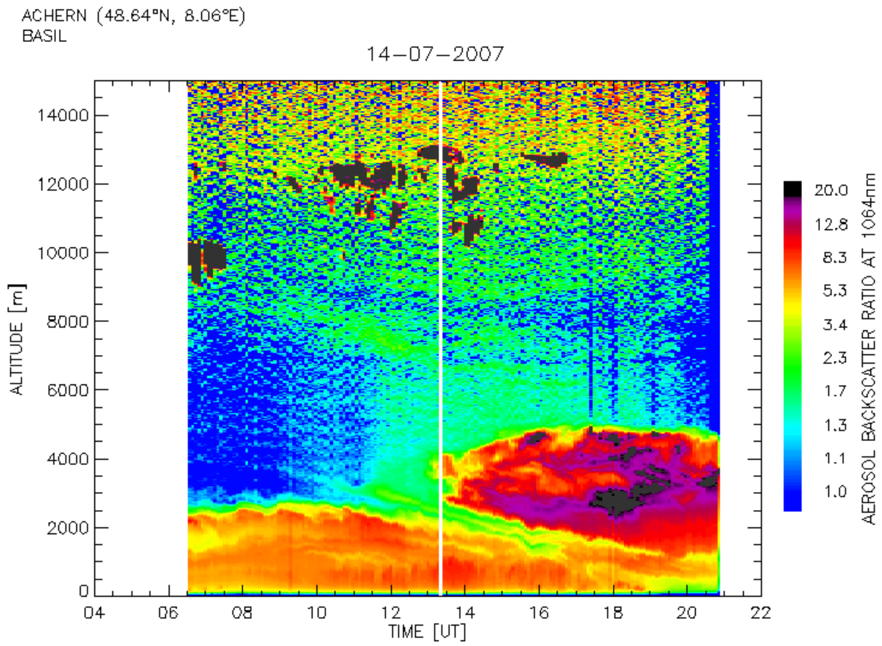


Fig. 11.37 Saharan dust outbreak on 14 July 07 during IOP 8a

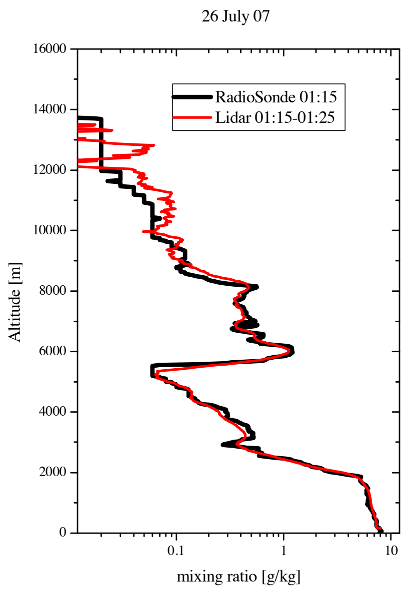


Fig. 11.38 Lidar vs. radiosonde measurement of water vapour mixing ratio on 26 June 2007. RS80H advanced humicap sensor is found to underestimate lidar data in the upper troposphere.

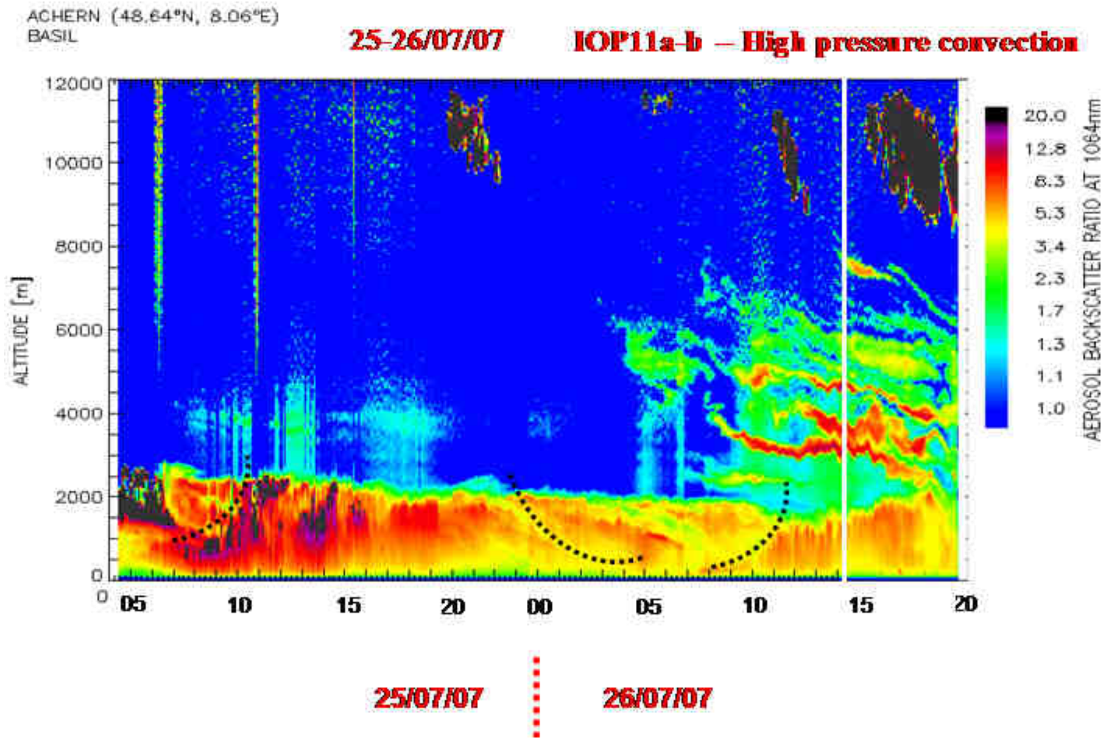


Fig. 11.39 Particle backscatter measurements at 1064 nm on 25-26 July 2007 covering a period of approx. 40 hours with two PBL building phases and one PBL decay phase.

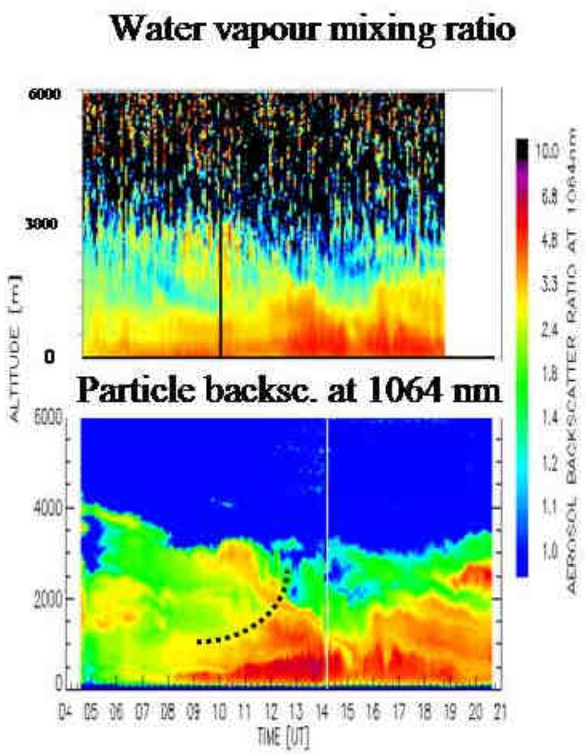


Fig. 11.40 Water vapour mixing ratio (upper panel) and particle backscatter at 1064 nm (lower panel) on 15 July 2007 during . The figure reveals a strong correlation between the two parameters.

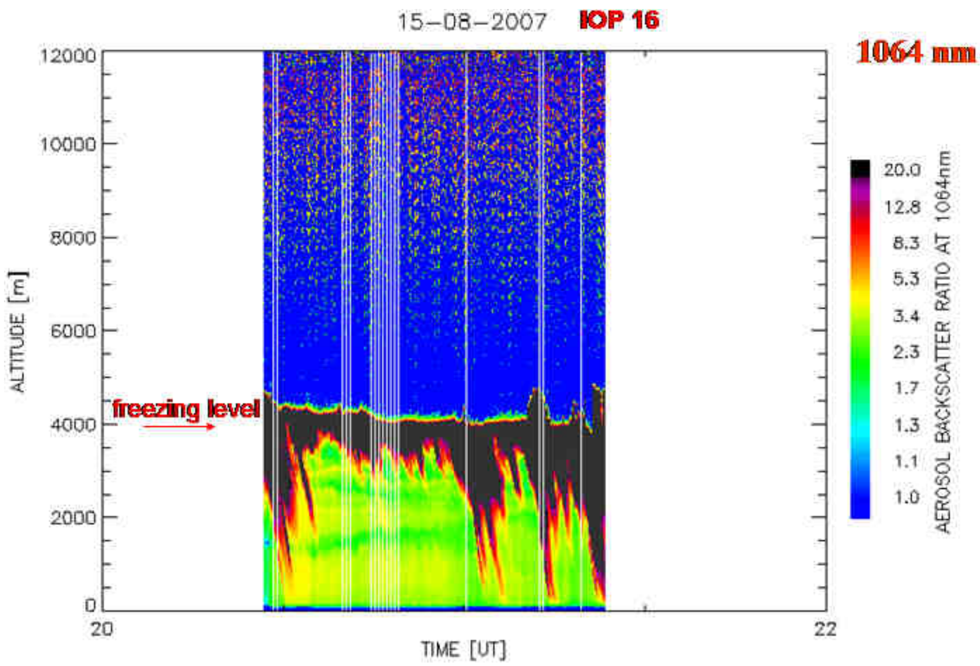


Fig. 11.41 Daily Precipitation measurement of 15 August 2007.

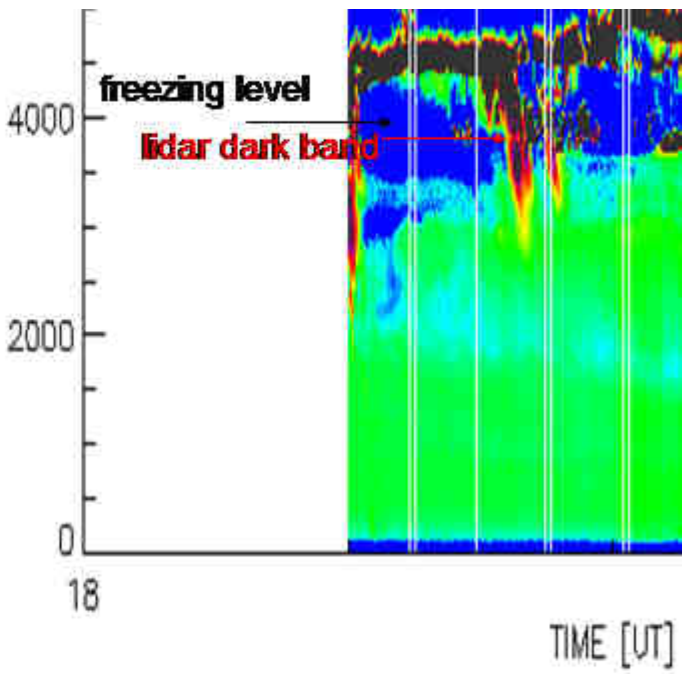


Fig. 11.42 Lidar dark band phenomenon appearing 15 August 2007 in the melting layer below the freezing level.

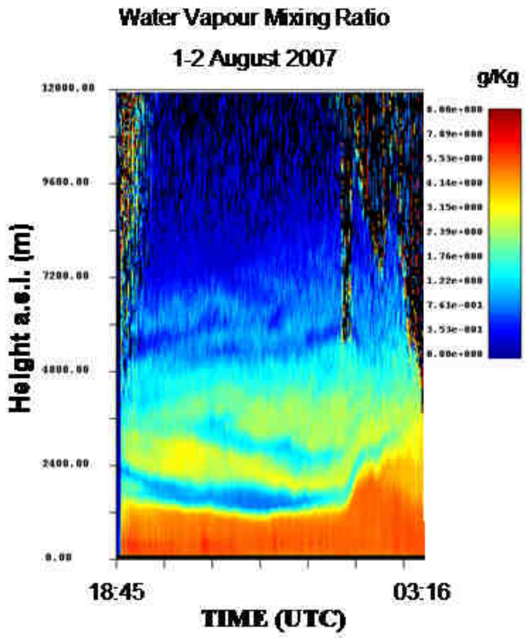


Fig. 11.43 Water vapour mixing ratio on 1-2 August 2007 with of appearance of an out-flow boundary in the final part of the measurement record.

11.5.5.2 University of Salford Doppler Lidar

Measured parameters include:

Radial wind speed,

atmospheric backscatter

The lidar system was switched on: 13/06/2007 at 14:30 UTC and switched off: 16/08/2007 at 09:00 UTC. It was non functional :

From 14:00 UTC on 25/06/2007 to 00:00 on 26/06/2007. Then vertically pointing only from 00:00 to 14:00 on 26/06/2007: because of lightening strike.

From 15:00 to 17:00 on 28/06/2007 due to problems with electronic interference with power supply.

From 9:00 on 29/06/2007 to 21:00 on 30/06/2007 due to problems with electronic interference with power supply *as previous day*.

From: 3:00 UTC on 09/08/2007 to 16:00 UTC on 11/08/2007 due power failure leading to software problem;

Some data analysis done. Data is not yet in NetCDF format and not uploaded.

Here follows a table with operation times, inclusive of the scanning pattern.

Table 11.20 Operation times of University of Salford Doppler Lidar

June

Date	Scan Pattern	Comments
13/06/2007	2 min PPI + 3 min RHI* + 25 min Vertical Stare	half hourly
14/06/2007	As previous to 8am then as next	
15/06/2007	6 min PPI (20° el) + 3 min RHI* + 20 min Vertical	half hourly
16/06/2007	As previous	
17/06/2007	As previous	
18/06/2007	As previous	
19/06/2007	2 min PPI + 3min RHI* +25 min Vertical Stare	half hourly
20/06/2007	As previous	
21/06/2007	As previous	
22/06/2007	40 min PPI (20° el) + 30 min RHI ** +50 min Vertical Stare	Two hourly (10:00-22:00)
23/06/2007	As previously then 2 min PPI (30° el) + 6 min RHI ** + 50 min Vertical stare	Hourly from 21:00
24/06/2007	As previously then 20 min PPI(30° el) + 10 min RHI* + 20 min Vertical stare + 10 min RHI**	Hourly from 10:30
25/06/2007	20 min PPI(30° el) + 20 min RHI** + 20 min vertical	Hourly Up to 14:00 (see comments above)
26/06/2007	Vertical pointing (to 14:00) then 3 min PPI + 27 min vertical stare (2 min RHI* from 19:30)	Half hourly
27/06/2007	3 min PPI + 2 min RHI* +25 min vertical stare	Half hourly
28/06/2007	As previously to 11:00 then vertical pointing to 15:00. From 17:00: 3 min PPI +27 min vertical stare	Half hourly
29/06/2007	3 min PPI + 27 min vertical stare to 09:00.	Half hourly
30/06/2007	From 21:00 3 min PPI + 27 min vertical stare	Half hourly

July

Date	Scan	Comments
01/07/2007	3 min PPI + 27 min vertical stare	Half hourly
02/07/2007	As previously	
03/07/2007	As previously	
04/07/2007	As previously	

05/07/2007	As previously	
06/07/2007	As previously	
07/07/2007	As previously	
08/07/2007	As previously	
09/07/2007	As previously	
10/07/2007	As previously	
11/07/2007	As previously	
12/07/2007	As previously	
13/07/2007	As previously	
14/07/2007	As previously	
15/07/2007	As previously	
16/07/2007	20 min PPI (various elevations) + 10 min vertical stare	Half hourly
17/07/2007	As previously to 08:00 then 3 min PPI (45°) + 27 min vertical stare until 16:30 then 10 min PPI (45°) + 20 min vertical stare	
18/07/2007	As last setting until 10:30 then 3 min PPI (45°) + 27 min vertical stare until 20:00	Half hourly
	then 10 min PPI (30°) + 20 min RHI** + 30 min vertical stare	hourly
19/07/2007	As previous setting	
20/07/2007	As previous setting	
21/07/2007	As previous setting	
22/07/2007	As previous setting	
23/07/2007	As previous setting but PPI at 40°	
24/07/2007	As previous setting	
25/07/2007	As previous setting until 10:00 then 5 min PPI (40°) +25 min vertical stare until 21:30 then 10 min PPI (40°) + 15 min RHI** + 5 min vertical stare	Half hourly
26/07/2007	As previous setting until 21:30 then 5 min PPI (40°) + 25 vertical stare	Half hourly
27/07/2007	As previous setting	
28/07/2007	As previous setting	
29/07/2007	As previous setting	
30/07/2007	As previous setting	
31/07/2007	As previous setting	

August

Date	Scan Pattern	Comments
01/08/2007	As previous setting	
02/08/2007	As previous setting	
03/08/2007	As previous setting	
04/08/2007	As previous setting	
05/08/2007	As previous setting	
06/08/2007	As previous setting	
07/08/2007	As previous setting	
08/08/2007	As previous setting	
09/08/2007	As previous setting to 03:00	
10/08/2007	No data	No data
11/08/2007	Start measuring again 15:30 as previous setting	
12/08/2007	As previous setting	
13/08/2007	As previous setting	
14/08/2007	As previous setting until 19:00 and then 10 min PPI (30°) + 20 min RHI** + 30 min vertical stare	Hourly after 19:00
15/08/2007	As previous setting	
16/08/2007	As previous setting until 09:00	

All times in UTC

RHI – Range Height Indicator – Elevation scan – scan normally made in direction of mean wind as determined by VAD analysis

PPI – Plan Position Indicator – Azimuth Scan – unless otherwise stated PPI done at 60° elevation for VAD analysis.

* RHI in mean wind direction

** Two RHI into mean wind and across mean wind

Note:

RHI's were set up to be parallel and perpendicular to the mean surface wind field.

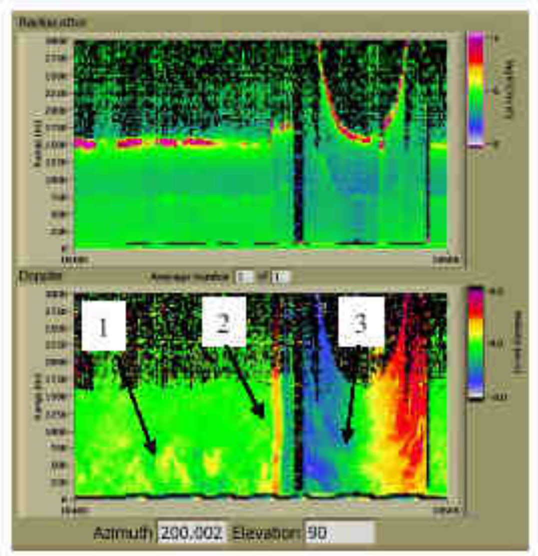


Fig. 11.44 Vertically pointing observations of boundary layer turbulence (1), VAD wind profile (2) and RHI scan (3) (fixed azimuth, 0-180^0 elevation scan).

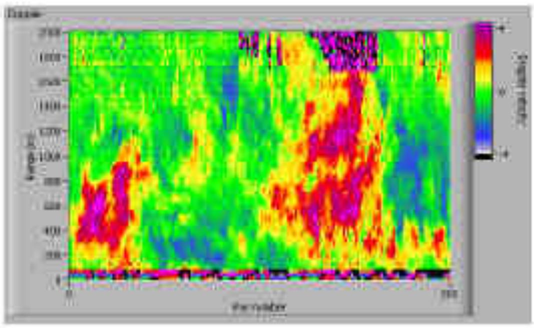


Fig. 11.45 Vertical velocity during convection.

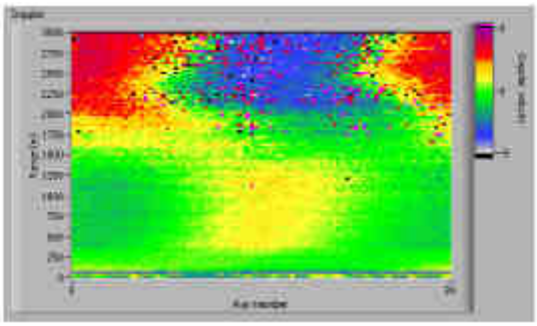


Fig. 11.46 VAD scan: 0-360^0 azimuth, 60^0 elevation. No wind up to 250m & shear at 1700m.

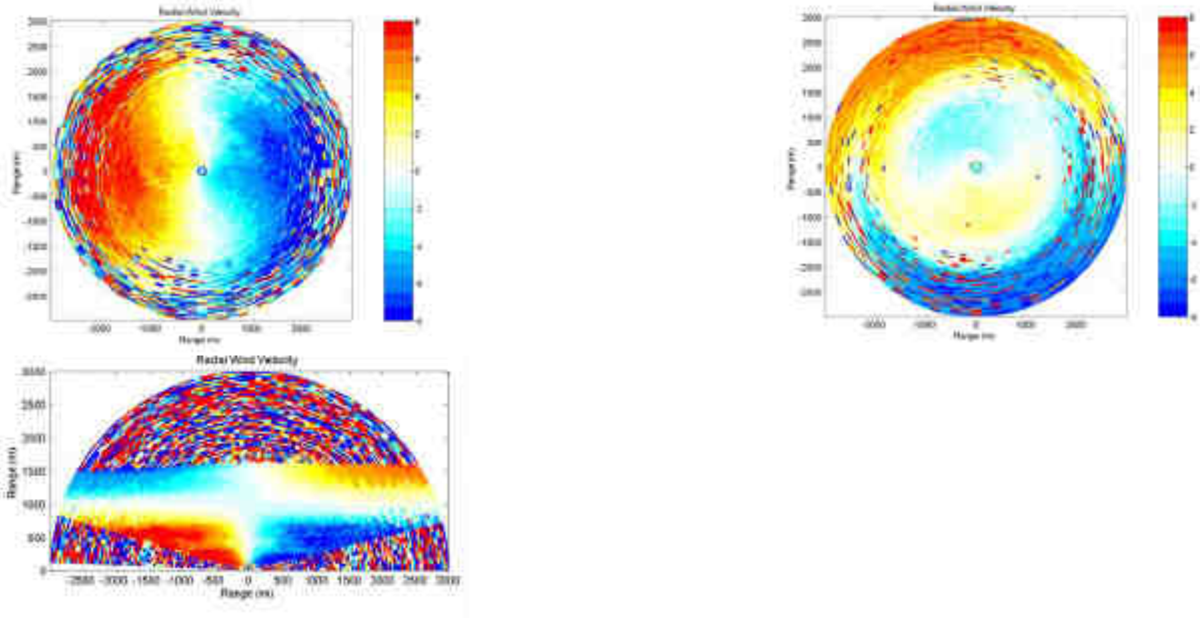


Fig. 11.47 Radial wind velocity at 10:30 UTC on 4th August 2007.

11.5.5.3 University of Salford RPG Microwave Radiometer

Measured parameters include:

tropospheric temperature up to 10 km,

absolute and relative humidity up to 6 km,

boundary layer temperature up to 2 km,

liquid water path and integrated water vapour.

The MW radiometer was switched on: 13/06/2007 at 10:30 UTC and switched off: 15/08/2007 at 23:00 UTC. No gaps in data, but initial analysis shows some problems with excessive condensation on radome screen during the mornings. This was noted on the 28th July and subsequent to this the screen was dried each morning.

Radiometer intercomparison being done by Susanne Crewell (Uni of Koeln) and water vapour line, oxygen line and boundary layer brightness temp data has been set to Susanne who will upload these on the database. Other data is not yet in NetCDF format.

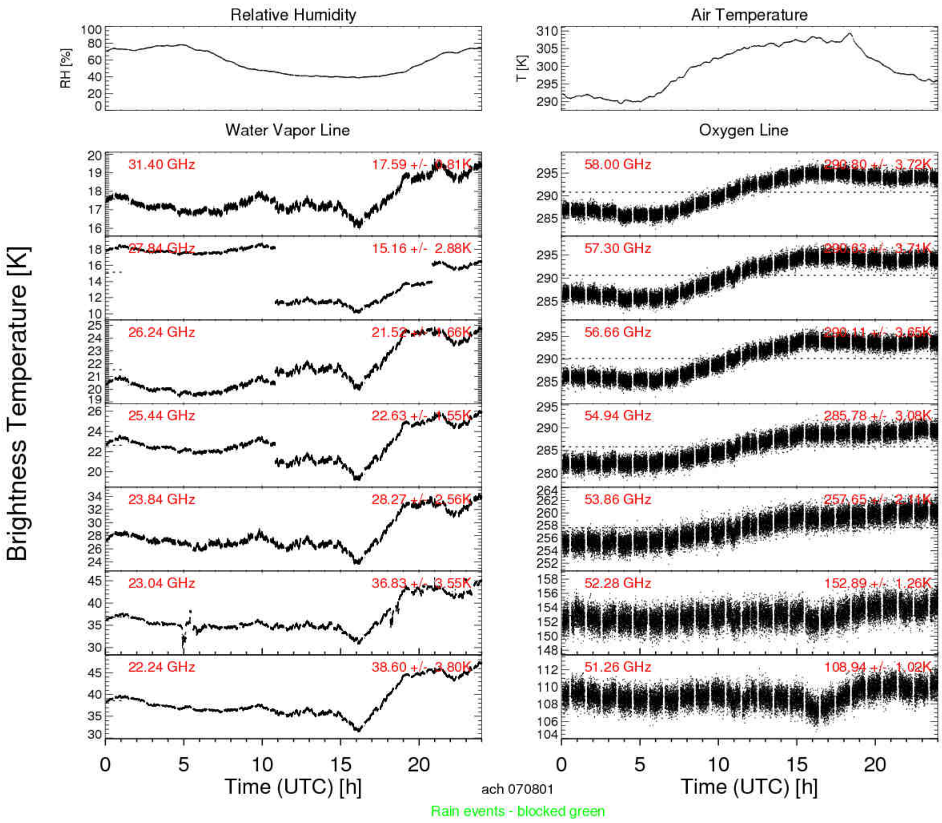


Fig. 11.48 Raw brightness temperatures (level0a data) for 1 August 2007.

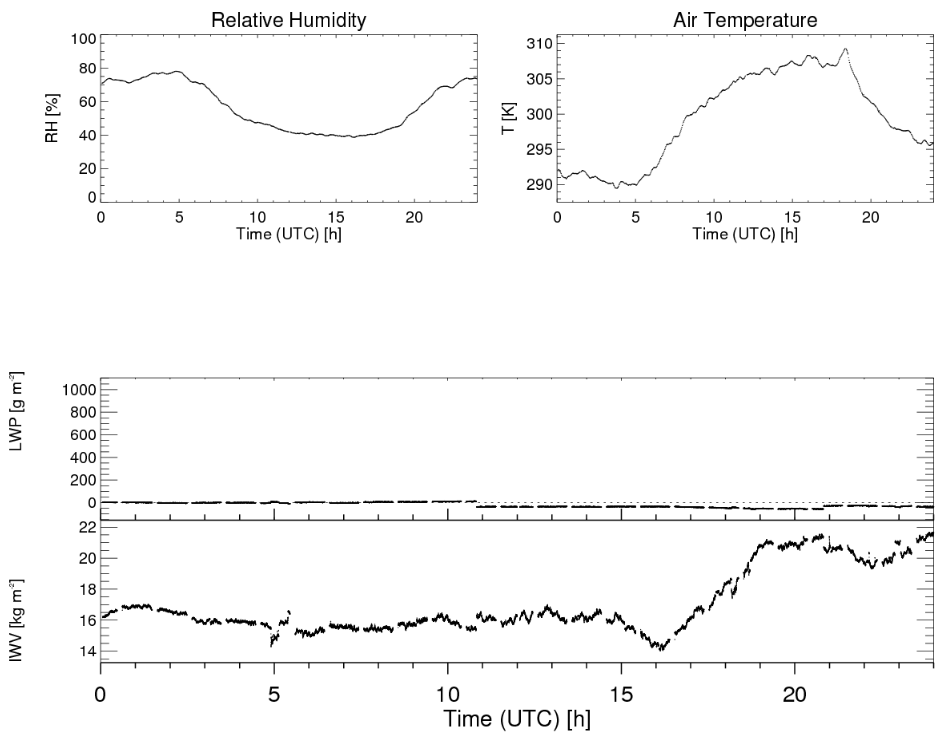


Fig. 11.49 Level 1a data of IWV and LWP for 1 August 2007.

11.5.5.4 University of Manchester Radio Wind Profiler

The 1290 MHz UHF Doppler radar measures both wind speed and direction 24 hours a day under all weather conditions. It operated continuously from 13 June to 8 August. The assessment of the data quality and identification of any gaps is in progress. Most of the data were excellent, but there are a few gaps where the equipment malfunctioned.

Fig. 11.50 University of Manchester Radio Wind Profiler in Achern. A clutter screen was developed in order to properly operate the instrument.

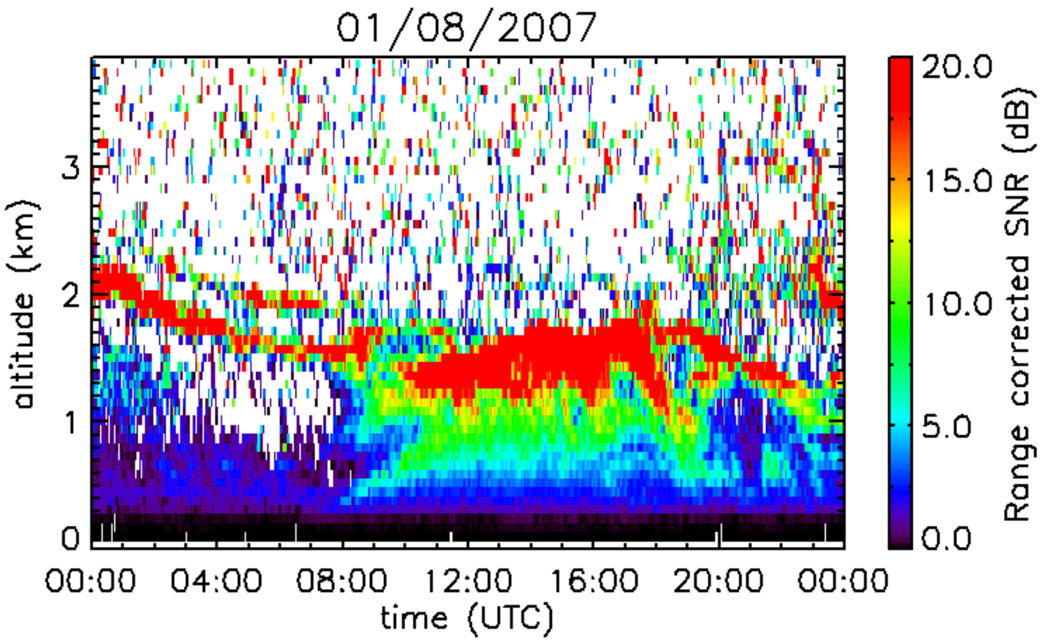


Fig. 11.51 Range corrected signal for 1 August 2007.

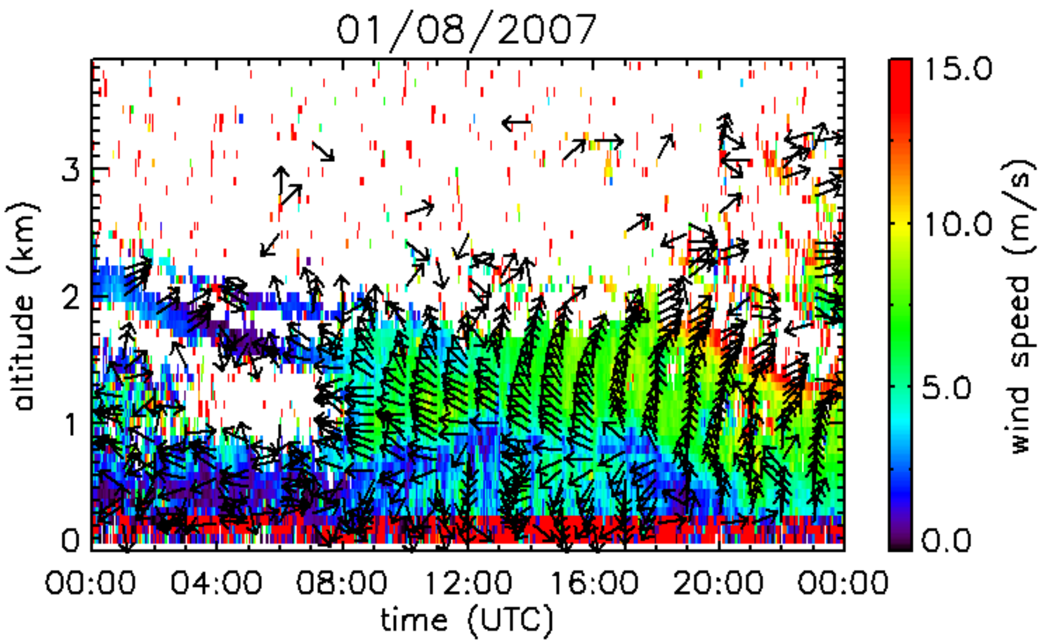


Fig. 11.52 Wind speed measurement for 1 August 2007

11.5.5.5 University of Hamburg cloud radar

University of Hamburg cloud radar was installed on 30-31 May 2007 and operated throughout the COPS period. The system will be operated till February to guarantee the complete coverage of the final portion of General Observation Period (1 January-31 December 2007).The system is operated in vertically pointing mode. Measured parameters include: Z, LDR, first and second spectral moments.

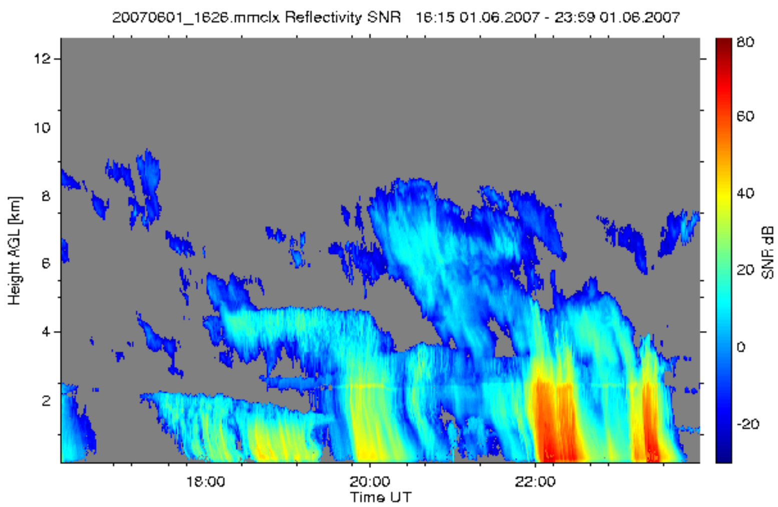


Fig. 11.53 Cloud radar data for 1 June 2007 (16:15-23:59 UTC).

11.5.5.6 University of Hamburg rain radar

University of Hamburg rain radars were installed on 17-18 May 2007 and operated throughout the COPS period. The system will be operated till February to guarantee the complete coverage of the final portion of General Observation Period (1 January-31 December 2007). The operated configuration include one vertically pointing Micro Rain Radar and two tilted Micro Rain Radars with orthogonal polarizations.

11.5.5.7 GFZ Potsdam GPS

GFZ Potsdam GPS was installed on 1 June 2007 and operated throughout the COPS period. The system will be operated till the end of the year to guarantee the complete coverage of the final portion of General Observation Period (1 January-31 December 2007). The instruments operates continuously (24-hour operation). Measured parameters include:

ZPD, 30 minutes time resolution, 5-10 mm, 5 mm (level 0),

IWV, 30 minutes time resolution, 1-2 mm, 1 mm (level1).

11.5.5.8 University of Leeds Radiosonde system

A total of 226 radiosondes were lauched in Achern during COPS. Two types of sondes were launched: RS92 and RS 80. RS92 were launched from July 13th to August 2nd and from August 21st to August 30th and most of August, while RS 80s were launched in all other periods. Several subtypes of RS 80s were considered (18H, 18LH, 15N). The following table includes a list of all launched sondes, with times and subtype specification for RS80s.

Table 11.21 University of Leeds Radiosondes launched at Supersite R.

Number	Date	Time	Type	Comment
1	05 June 07	10.01.00	(RS80-18H)	OK
2	05 June 07	17.09.00	(RS80-18H)	OK
3	06 June 07	5.23.00	(RS80-15G)	OK
4	06 June 07	8.01.00	(RS80-15N)	OK
5	06 June 07	10.49.00	(RS80-15G)	OK
6	06 June 07	14.19.00	(RS80-15N)	OK
7	06 June 07	17.30.00	(RS80-15G)	file corrupted
8	06 June 07	20.03.00	(RS80-15G)	OK
9	07 June 07	5.06.00	(RS80-15G)	OK
10	07 June 07	8.13.00	(RS80-15N)	OK
11	07 June 07	10.57.00	(RS80-15G)	OK
12	07 June 07	14.17.00	(RS80-15N)	OK
13	07 June 07	17.04.00	(RS80-15G)	OK

14	07 June 07	20.12.00	(RS80-15N)	OK
15	08 June 07	5.16.00	(RS80-15G)	no wind data, sonde aborted at 5 km
16	08 June 07	6.12.00	(RS80-15G),	OK
17	08 June 07	8.06.00	(RS80-15H),	OK
18	08 June 07	11.12.00	(RS80-15G)	OK
19	08 June 07	14.02.00	(RS80-15N)	OK
20	08 June 07	17.08.00	(RS80-15G)	OK
21	08 June 07	20.09.00	(RS80-15N)	OK
22	12 June 07	5.12.00	(RS80-15G)	OK
23	12 June 07	7.59.00	(RS80-15N)	OK
24	12 June 07	10.57.00	(RS80-15G)	OK
25	12 June 07	14.00.00	(RS80-15N)	OK
26	12 June 07	17.00.00	(RS80-15G)	OK
27	12 June 07	19.52.00	(RS80-15N)	OK
28	14 June 07	5.07.00	(RS80-15G)	OK
29	14 June 07	8.18.00	(RS80-15H)	OK
30	14 June 07	11.21.00	(RS80-15G)	OK
31	14 June 07	14.02.00	(RS80-15H)	OK
32	14 June 07	17.04.00	(RS80-15G)	OK
33	14 June 07	20.37.00	(RS80-15H)	OK
34	15 June 07	5.10.00	(RS80-15G)	OK
35	15 June 07	8.00.00	(RS80-15H)	OK
36	19 June 07	1.22.00	(RS80-15H)	OK
37	19 June 07	8.00.00	(RS80-15H)	file corrupted
38	19 June 07	11.20.00	(RS80-15G)	OK
39	19 June 07	14.00.00	(RS80-15H)	OK
40	19 June 07	17.03.00	(RS80-15G)	OK
41	20 June 07	5.14.00	(RS80-15G)	OK
42	20 June 07	8.07.00	(RS80-15H)	OK
43	20 June 07	11.07.00	(RS80-15G)	OK
44	20 June 07	14.07.00	(RS80-15H)	OK
45	20 June 07	17.44.00	(RS80-15H)	OK
46	20 June 07	19.56.00	(RS80-15H)	OK
47	20 June 07	22.57.00	(RS80-15G)	OK

48	30 June 07	20.06.00	(RS80-15H)	OK
49	01 July 07	5.12.00	(RS80-15G)	OK
50	01 July 07	8.00.00	(RS80-15H)	OK
51	01 July 07	11.08.00	(RS80-15G)	OK
52	01 July 07	14.01.00	(RS80-15H)	OK
53	01 July 07	17.21.00	(RS80-15H)	OK
54	01 July 07	20.05.00	(RS80-15H)	OK
55	02 July 07	5.13.00	(RS80-15H)	OK
56	02 July 07	8.08.00	(RS80-15A)	OK
57	02 July 07	11.05.00	(RS80-15G)	OK
58	02 July 07	14.07.00	(RS80-15H)	OK
59	02 July 07	17.21.00	(RS80-15G)	OK
60	02 July 07	19.44.00	(RS80-15H)	OK
61	04 July 07	5.07.00	(RS80-15G)	OK
62	04 July 07	8.02.00	(RS80-15H)	OK
63	04 July 07	11.04.00	(RS80-15G)	OK
64	04 July 07	14.00.00	(RS80-15H)	OK
65	04 July 07	16.58.00	(RS80-15G)	OK
66	04 July 07	19.50.00	(RS80-15H)	OK
67	08 July 07	5.14.00	(RS80-15G)	OK
68	08 July 07	7.58.00		OK
69	08 July 07	11.19.00	(RS80-15G)	
70	08 July 07	14.00.00		OK
71	08 July 07	15.36.00		OK
72	08 July 07	16.59.00	(RS80-15G)	OK
73	08 July 07	20.00.00		OK
74	08 July 07	23.00.00	(RS80-15G)	OK
75	08 July 07	23.50.00	(RS80-15G)	OK
76	09 July 07	1.54.00		OK
77	09 July 07	5.26.00		OK
78	09 July 07	6.11.00	(RS80-15G)	OK
79	09 July 07	8.04.00		OK
80	09 July 07	10.57.00	(RS80-15G)	OK
81	09 July 07	14.01.00		OK
82	09 July 07	17.11.00	(RS80-15G)	OK

83	11 July 07	11.57.00	(RS80-15G)	OK
84	11 July 07	12.23.00		OK
85	12 July 07	5.48.00		OK
86	13 July 07	9.05.00	(RS80-18LH)	OK
87	13 July 07	11.02.00	(RS80-18H)	OK
88	13 July 07	11.59.00	(RS80-15N)	OK
89	13 July 07	14.28.00	(RS80-15G)	OK
90	13 July 07	16.08.00	(RS80)	OK
91	13 July 07	9.05.00	(RS92)	using IFT station, radiosonde intercomaparison
92	13 July 07	11.02.00	(RS92)	using IFT station, radiosonde intercomaparison
93	13 July 07	11.59.00	(RS92)	using IFT station, radiosonde intercomaparison
94	13 July 07	14.28.00	(RS92)	using IFT station, radiosonde intercomaparison
95	13 July 07	16.08.00	(RS92)	using IFT station, radiosonde intercomaparison
96	14 July 07	8.13.00	(RS92)	OK
97	14 July 07	11.18.00	(RS92)	OK
98	14 July 07	13.59.00	(RS92)	OK
99	14 July 07	16.55.00	(RS92)	OK
100	15 July 07	5.27.00	(RS92)	OK
101	15 July 07	7.57.00	(RS92)	OK
102	15 July 07	10.59.00	(RS92)	OK
103	15 July 07	13.53.00	(RS92)	OK
104	15 July 07	17.01.00	(RS92)	OK
105	16 July 07	6.36.00	(RS92)	OK
106	16 July 07	7.31.00	(RS92)	OK
107	18 July 07	8.06.00	(RS92)	OK
108	18 July 07	11.04.00	(RS92)	OK
109	18 July 07	14.31.00	(RS92)	OK
110	18 July 07	17.00.00	(RS92)	OK
111	18 July 07	20.00.00	(RS92)	OK
112	19 July 07	4.59.00	(RS92)	OK
113	19 July 07	7.59.00	(RS92)	OK

114	19 July 07	11.05.00	(RS92)	OK
115	19 July 07	14.02.00	(RS92)	OK
116	19 July 07	17.10.00	(RS92)	OK
117	19 July 07	20.00.00	(RS92)	OK
118	19 July 07	23.13.00	(RS92)	OK
119	20 July 07	5.14.00	(RS92)	OK
120	20 July 07	8.01.00	(RS92)	OK
121	20 July 07	9.08.00	(RS92)	OK
122	20 July 07	11.00.00	(RS92)	OK
123	20 July 07	14.03.00	(RS92)	OK
124	20 July 07	16.53.00	(RS92)	OK
125	23 July 07	8.03.00	(RS92)	OK
126	23 July 07	11.22.00	(RS92)	OK
127	23 July 07	14.06.00	(RS92)	OK
128	23 July 07	17.06.00	(RS80-15A)	OK
129	24 July 07	9.18.00	(RS92)	OK
130	24 July 07	13.01.00	(RS92)	OK
131	24 July 07	15.41.00	(RS92)	OK
132	25 July 07	5.01.00	(RS92)	OK
133	25 July 07	8.02.00	(RS92)	OK
134	25 July 07	10.56.00	(RS92)	OK
135	25 July 07	14.01.00	(RS92)	OK
136	25 July 07	16.58.00	(RS92)	OK
137	25 July 07	20.00.00	(RS92)	OK
138	25 July 07	21.36.00	(RS92)	OK
139	26 July 07	1.15.00	(RS80-18LH)	OK
140	26 July 07	4.59.00	(RS92)	OK
141	26 July 07	8.03.00	(RS92)	OK
142	26 July 07	11.01.00	(RS92)	OK
143	26 July 07	14.10.00	(RS92)	OK
144	26 July 07	15.03.00	(RS92)	OK
145	26 July 07	17.01.00	(RS92)	OK
146	30 July 07	11.04.00	(RS92)	OK
147	30 July 07	14.01.00	(RS92)	OK
148	30 July 07	17.04.00	(RS92)	OK

149	31 July 07	19.31.00	(RS92)	OK
150	31 July 07	21.23.00	(RS92)	OK
151	01 August 07	9.38.00	(RS92)	OK
152	01 August 07	11.05.00	(RS92)	OK
153	01 August 07	14.01.00	(RS92)	OK
154	01 August 07	16.57.00	(RS92)	OK
155	01 August 07	20.00.00	(RS92)	OK
156	01 August 07	23.00.00	(RS92)	OK
157	02 August 07	2.05.00	(RS92)	OK
158	02 August 07	5.18.00	(RS92)	OK
159	02 August 07	8.01.00	(RS92)	OK
160	02 August 07	11.10.00	(RS92)	OK
161	02 August 07	13.59.00	(RS92)	OK
162	02 August 07	17.01.00	(RS92)	OK
163	02 August 07	20.00.00	(RS92)	OK
164	06 August 07	14.03.00	(RS80-18LH)	OK
165	06 August 07	17.02.00	(RS80-15G)	OK
166	06 August 07	20.11.00	(RS80-18LH)	OK
167	07 August 07	5.54.00	(RS80-15G)	OK
168	07 August 07	11.10.00	(RS80-18H)	OK
169	07 August 07	17.07.00	(RS80-18H)	OK
170	08 August 07	5.50.00	(RS80-15G)	OK
171	08 August 07	8.13.00	(RS80-18LH)	OK
172	08 August 07	11.06.00	(RS80-15G)	OK
173	08 August 07	14.02.00	(RS80-18H)	OK
174	08 August 07	17.01.00	(RS80-15G)	OK
175	08 August 07	20.01.00	(RS80-18H)	OK
176	09 August 07	11.22.00	(RS80-15G)	OK
177	09 August 07	17.00.00	(RS80-15G)	OK
178	12 August 07	0.25.00	(RS80-15)	OK
179	12 August 07	5.45.00	(RS80-15G)	OK
180	12 August 07	8.00.00	(RS80-18H)	OK
181	12 August 07	11.01.00	(RS80-15G)	OK
182	12 August 07	14.01.00	(RS80-18H)	OK
183	12 August 07	17.00.00	(RS80-15G)	OK

184	12 August 07	20.03.00	(RS80-18H)	OK
185	13 August 07	5.12.00	(RS80-15G)	OK
186	13 August 07	8.00.00	(RS80-18H)	OK
187	13 August 07	11.06.00	(RS80-15G)	OK
188	13 August 07	14.00.00	(RS80-18H)	OK
189	13 August 07	17.03.00	(RS80-15G)	OK
190	14 August 07	12.32.00	(RS80-15G)	OK
191	14 August 07	16.53.00	(RS80-18LH)	OK
192	15 August 07	11.12.00	(RS80-15G)	OK
193	15 August 07	14.01.00	(RS80-18LH)	OK
194	15 August 07	17.02.00	(RS80-15G)	OK
195	15 August 07	20.09.00	(RS80-18H)	OK
196	15 August 07	23.00.00	(RS80-15G)	OK
197	17 August 07	8.15.00	(RS80-15G)	OK
198	17 August 07	11.04.00	(RS80-15G)	OK
199	17 August 07	14.08.00	(RS80-15G)	OK
200	21 August 07	8.08.00	(RS92)	OK
201	21 August 07	11.03.00	(RS92)	OK
202	21 August 07	14.02.00	(RS92)	OK
203	21 August 07	17.01.00	(RS92)	OK
204	22 August 07	8.01.00	(RS92)	OK
205	22 August 07	11.00.00	(RS92)	OK
206	22 August 07	14.10.00	(RS92)	OK
207	22 August 07	15.59.00	(RS92)	OK
208	24 August 07	5.07.00	(RS92)	OK
209	24 August 07	8.04.00	(RS92)	OK
210	24 August 07	11.21.00	(RS92)	OK
211	24 August 07	14.17.00	(RS92)	OK
212	24 August 07	17.00.00	(RS92)	OK
213	24 August 07	20.25.00	(RS80-18LH)	OK
214	25 August 07	5.05.00	(RS92)	OK
215	25 August 07	8.07.00	(RS92)	OK
216	25 August 07	11.07.00	(RS92)	OK
217	25 August 07	14.02.00	(RS92)	OK
218	25 August 07	17.03.00	(RS92)	OK

219	25 August 07	19.22.00	(RS80-18H)	OK
220	28 August 07	12.57.00	(RS80-18H)	OK
221	28 August 07	17.20.00	(RS80-18H)	OK
222	29 August 07	8.00.00	(RS92)	OK
223	29 August 07	11.01.00	(RS92)	OK
224	29 August 07	14.00.00	(RS92)	OK
225	29 August 07	16.22.00	(RS80-18H)	OK
226	30 August 07	10.11.00	(RS92)	OK

11.5.5.9 University of Leeds Sodar

The system was installed in late June. Because of complaining from nearby companies, the instrument was operated only at night or during week-ends. A complete list of operational times will be provided in a later stage.

11.5.5.10 Universität Kiel Disdrometer

The Disdrometer was installed in early June and operated throughout the COPS period. The system will be operated till the end of the year to guarantee the complete coverage of the final portion of General Observation Period (1 January-31 December 2007). The instruments operates continuously (24-hour operation). Measured parameters include:

precipitation rate

drop size distribution

11.5.5.11 University of Munich Weather Station

The weather station was installed in 23 May and operated throughout the COPS period. The system will be operated till the end of the year to guarantee the complete coverage of the final portion of General Observation Period (1 January-31 December 2007). The instruments operates continuously (24-hour operation) and is part of the Mesonet network. Measured parameters include:

wind speed and direction,

temperature

humidity

pressure

precipitation rate through the rain gauges

11.5.5.12 IMK Soil Moisture Station

The Soil Moisture Station was installed on 4 June and operated throughout the COPS period. The system will be operated till the end of the year to guarantee the complete coverage of the final portion of General Observation Period (1 January-31 December 2007). The instruments operates continuously (24-hour operation). Measured parameters include:

soil moisture

soil temperature

heat flux

11.5.5.13 ARM Radiometer at Supersite R

The PNNL Radiative Flux Analysis System (RFAS) provides the basic measurements needed for the Radiative Flux Analysis methodology for inferring cloud macrophysical properties and the effect of clouds on the downwelling surface radiative energy budget. Measured quantities include the downwelling shortwave (SW) and longwave (LW) irradiance, the SW total and diffuse irradiance, and the ambient air temperature and relative humidity. The following Table lists the measured and calculated quantities that are included in the final data set:

Table 11.22 Parameters available from the Radiative Flux Analysis System.

Parameter	Meas./Retr.	Comments
Downwelling SW	Measured	Eppley model PSP
Clear-sky SW	Retrieved	Long and Ackerman, 2000, JGR
Total SW	Measured	Delta-T Devices model SPN-1
Diffuse SW	Measured	Delta-T Devices model SPN-2
Clear-sky diffuse SW	Retrieved	Long and Ackerman, 2000, JGR
Direct SW	Measured	Calculated, Total minus diffuse SW
Clear-sky direct SW	Retrieved	Long and Ackerman, 2000, JGR
Downwelling LW	Measured	Eppley model PIR
Clear-sky LW	Retrieved	Marty and Philipona, 2000, GRL; Long, 2004, ARM
Clear-sky periods	Retrieved	Long and Ackerman, 2000, JGR [daylight only]
Air Temperature	Measured	Campbell HMP45 T/RH probe
Relative Humidity	Measured	Campbell HMP45 T/RH probe
Total Sky Cover	Retrieved	Long et al., 2006, JGR [daylight only]
LW Effective Sky Cover	Retrieved	Durr and Philipona, 2004, JGR; Long, 2004, ARM [low/mid cloud only]
Cloud Vis optical depth	Retrieved	Barnard and Long, 2004, JAM [Skycover>90% only]
Cloud SW transmissivity	Retrieved	Long and Ackerman, 2000, JGR [daylight only]
sky brightness temperature	Retrieved	Long, 2004, ARM
cloud radiating temperature	Retrieved	Long, 2004, ARM [LW Scv>50% only]
clear-sky LW emissivity	Retrieved	Marty and Philipona, 2000, GRL; Long, 2004, ARM

An RFAS was deployed at Supersite R near Achern in the Rhine Valley from May 23 through September 3, 2007, mounted on top of the red seatainer (see Fig. 1). The system instruments are shown in the picture below. During this time, on-site personnel cleaned the radiometer domes each day that site personnel were present (see section 11.5.5.1.2). In general, the system performed well, with some air temperature and RH data periods missing due to an intermittent sensor problem, which worsened toward the end of the experiment. These periods are listed in the data availability table below, and hopefully other data sources such as the University of Munich Weather Station data can be used as they become available to fill the T/RH gaps. The radiometers experienced no problems during the deployment. Prior to the Supersite R deployment, the RFAS was operated for two days at the ARM Mobile Facility site near Heselbech. The data collected during the AMF period served to generate normalization factors for the RFAS instruments with the aim of normalizing the data from both Supersite R and Supersite H to the AMF as a reference. Thus comparison between these three sites should be possible on an “even field” for all.

Fig. 11.54 Picture of Radiative Flux Analysis System instruments and data logger enclosure on top of the red seatainer at Supersite R,

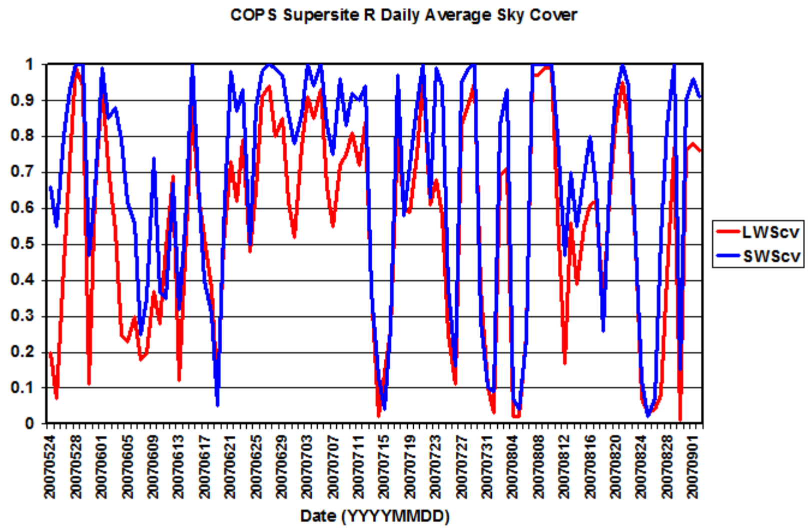


Fig. 11.55 Daylight average total sky cover (blue) and 24-hour average LW effective sky cover (red) for the COPS deployment period at Supersite R.

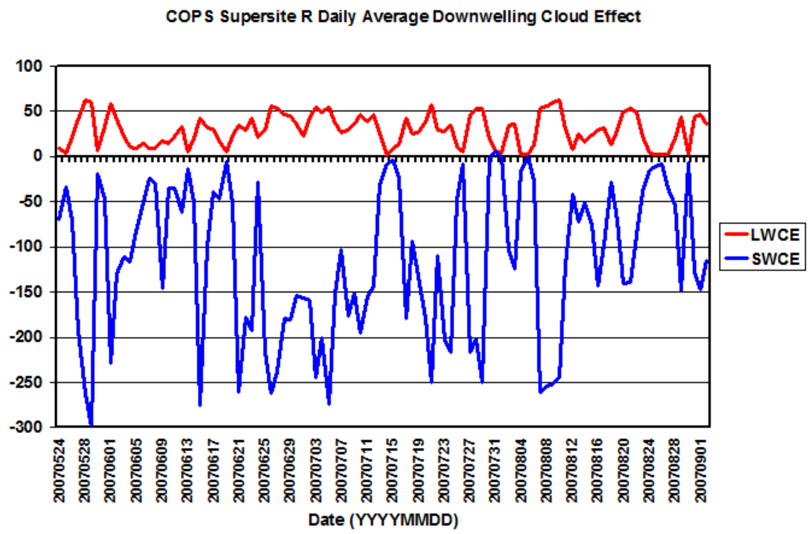


Fig. 11.56 Daily average SW (blue) and LW (red) influence of clouds on the downwelling irradiance for the COPS deployment period at Supersite R, calculated as the all-sky minus clear-sky irradiance difference. The effect of clouds is larger on the SW than the LW portion of the surface radiative energy budget.

Table 11.23 Data Availability Table for Supersite R RFAS deployment.

Date	Comment	Date	Comment	Date	Comment
23-May	Start data at 1256 UTC	27-Jun	Good	1-Aug	Minor T/RH dropouts
24-May	Minor T/RH dropouts	28-Jun	Good	2-Aug	Good
25-May	Good	29-Jun	Good	3-Aug	Minor T/RH dropouts
26-May	Good	30-Jun	Good	4-Aug	Minor T/RH dropouts
27-May	Good	1-Jul	Good	5-Aug	Minor T/RH dropouts
28-May	Good	2-Jul	Good	6-Aug	Minor T/RH dropouts
29-May	Good	3-Jul	Good	7-Aug	Good
30-May	Good	4-Jul	Good	8-Aug	Good
31-May	Good	5-Jul	Good	9-Aug	Good
1-Jun	Good	6-Jul	Good	10-Aug	Minor T/RH dropouts
2-Jun	Good	7-Jul	Good	11-Aug	Minor T/RH dropouts
3-Jun	Good	8-Jul	Good	12-Aug	Minor T/RH dropouts
4-Jun	Good	9-Jul	Good	13-Aug	Good
5-Jun	Good	10-Jul	Good	14-Aug	Minor T/RH dropouts
6-Jun	Good	11-Jul	Good	15-Aug	Minor T/RH dropouts
7-Jun	Minor T/RH dropouts	12-Jul	Good	16-Aug	Minor T/RH dropouts
8-Jun	Good	13-Jul	Minor T/RH dropouts	17-Aug	Good
9-Jun	Good	14-Jul	Minor T/RH dropouts	18-Aug	Significant T/RH dropouts
10-Jun	Good	15-Jul	Significant T/RH dropouts	19-Aug	Significant T/RH dropouts
11-Jun	Good	16-Jul	Good	20-Aug	Good
12-Jun	Good	17-Jul	Minor T/RH dropouts	21-Aug	Minor T/RH dropouts
13-Jun	Good	18-Jul	Minor T/RH dropouts	22-Aug	Significant T/RH dropouts
14-Jun	Good	19-Jul	Minor T/RH dropouts	23-Aug	Good
15-Jun	Good	20-Jul	Good	24-Aug	Good
16-Jun	Good	21-Jul	Good	25-Aug	Good
17-Jun	Good	22-Jul	Good	26-Aug	Good
18-Jun	Good	23-Jul	Good	27-Aug	Good
19-Jun	Minor T/RH dropouts	24-Jul	Good	28-Aug	Good
20-Jun	Good	25-Jul	Good	29-Aug	Data loss 2146 on
21-Jun	Good	26-Jul	Good	30-Aug	Good
22-Jun	Good	27-Jul	Minor T/RH dropouts	31-Aug	Good
23-Jun	Good	28-Jul	Good	1-Sep	Good
24-Jun	Minor T/RH dropouts	29-Jul	Good	2-Sep	Good
25-Jun	Minor T/RH dropouts	30-Jul	Good	3-Sep	Data ends 1120
26-Jun	Minor T/RH dropouts	31-Jul	Good		

11.5.6 Supersite S

Supersite S was established to the east of the Black Forest, south of Stuttgart near the city of Sinsheim, a region where lightning data prove that the probability of occurrence of mature convective cells which were formed over the Black Forest is high. The instrument setup focuses on the surface energy balance. Continuous information on the vertical wind and temperature structure is derived from wind-temperature-radar from both inside and outside of clouds and from a Sodar/RASS for the PBL. Three energy balance stations will be arranged at the supersite to cover different typical types of land-use. A network of low-cost innovative soil moisture sensors is installed at the same location to study the role of moisture storage from previous rainfall and of transpiration on the sensible and latent heat fluxes. These data shall provide insight into the documented shortcomings of LM to get the diurnal cycle of surface air temperatures and moisture correctly. A ceilometer of DWD as well as a radiosonde station of University of Vienna complemented this site. In the close vicinity of Supersite S, a network of more than 100 automated weather stations was installed by University of Vienna.

Also here, after the performance of COPS, it was made possible by the University of Vienna to continue operation of the MRR and by GFZ Potsdam to operated the GPS sensor until the end of 2007.

Figs. 1+2 show the instrument set-up at the supersite. The Large Aperture Scintillometer (UBonn) and the Radiosounde Site (UVienna) are out of view. For the station distribution of the mesonet of the UVienna see fig. 5-8.

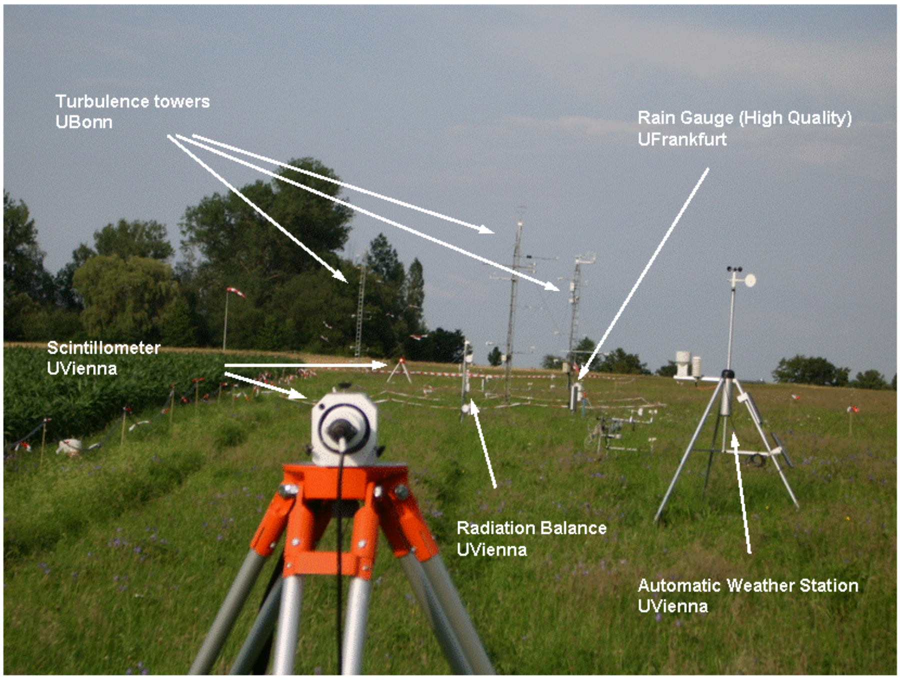


Fig. 11.57 Instrument set-up at supersite S (view to the east).

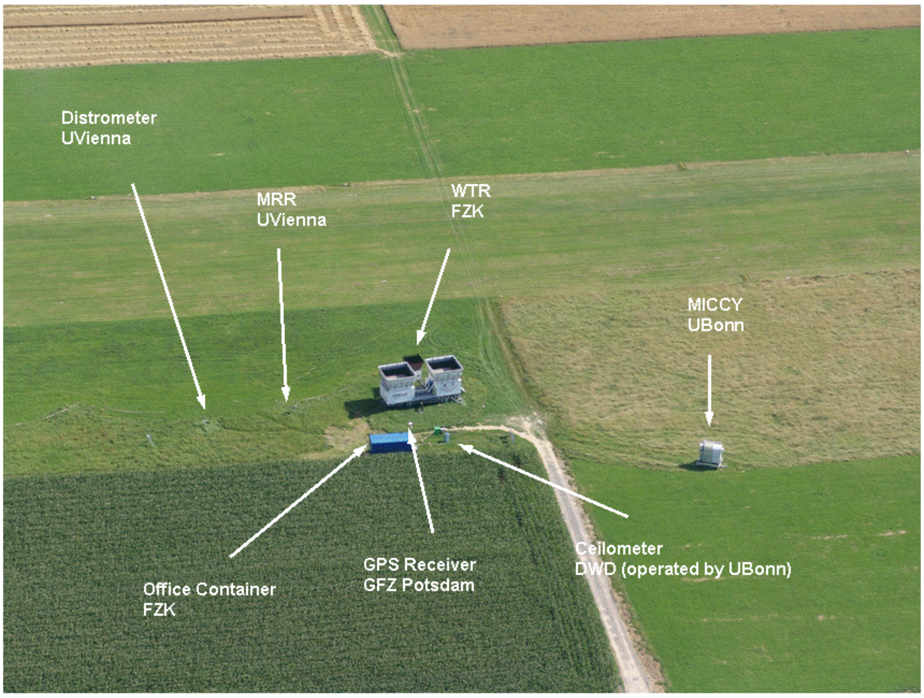


Fig. 11.58 Aerial view of instrument set-up of supersite S (western part).

11.5.6.1 Mesonet UVienna

106 weather stations have been set-up from May 18 to September 4, 2007. The station distribution can be depicted from fig. 5-8. Three different types of weather stations have been in operation. The operation periods of the majority of the stations (100 so called Hobos, see also Fig. 3) are shown in fig. 4 as not reporting stations. The great amount of them at the beginning can be explained by a production error of the loggers, which made a replacement of all loggers necessary. This has been done on 18 June in a first phase and completed on June 27-28.

Fig. 11.59 The weather stations are prepared to go into the field.

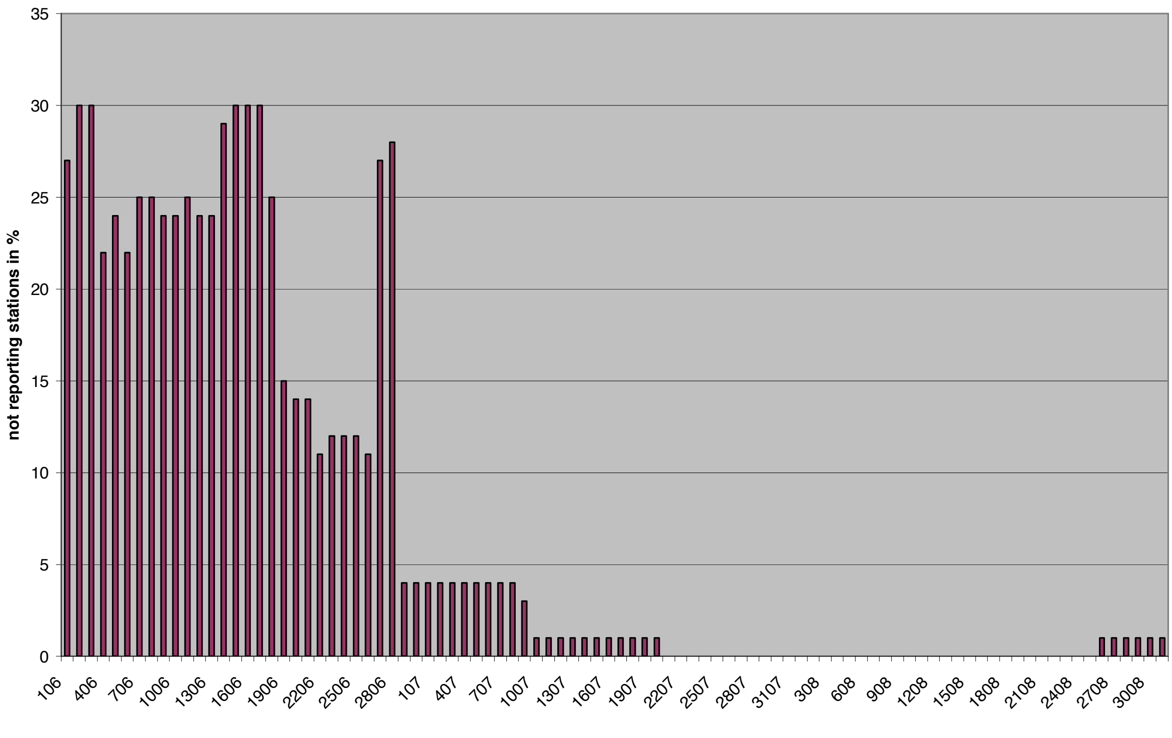


Fig. 11.60 Number of not reporting Hobo stations (parameters: T, q, 2D-wind and pressure) during the COPS period June to August.

The following figure shows the equivalent information for the precipitation sensors (104 Hobo rain gauges).

The second type of weather stations (2 so called MAWS) was in operation at the Supersite S for background weather information and at Lerchenberg to support the Large Aperture Scintillometer measurements of UBonn.

Parameters: T, q, 2D-wind, pressure, precipitation, solar radiation

Time interval: 1 minute

Operation periods: MAWS_S: 1.6.-16.6.; 20.6.-21.7.; 28.7.-23.8.

MAWS_L: 27.6.-12.8.; 14.8.-24.8.

The third type of weather stations (4 so called SONICs) was installed on the valley floor of the Teinach Valley. The stations consist of a 3D sonic anemometer, a temperature sensor and a Hobo raingauge.

Parameters: T, 3D-wind, precipitation

Operation periods (numbering from west to east):

SONIC1: 26.6-27.8.

SONIC2: 26.6.-27.8

SONIC3: 5.6.-22.6.; 30.6.-27.8.

SONIC4: 26.6.-27-8.

All data are currently quality controlled and the files are prepared for the transfer to the data archive. Meta data information is compiled.

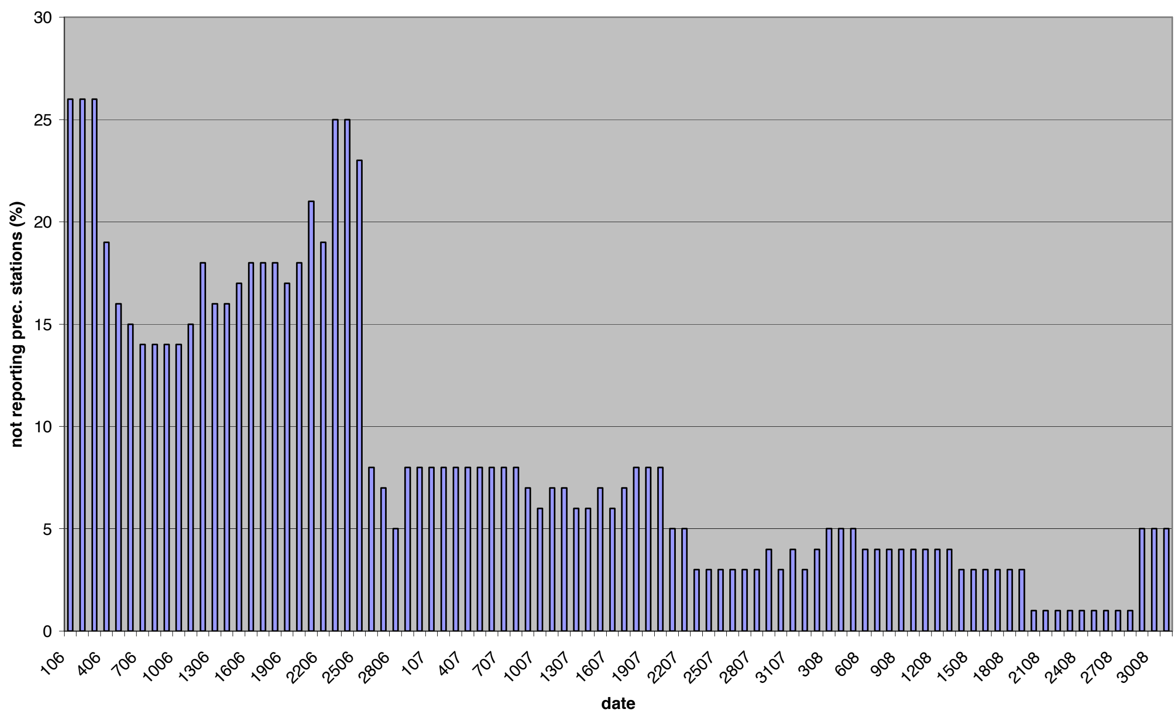


Fig. 11.61 Number of not reporting Hobo stations (parameters: precipitation) during the COPS period June to August.

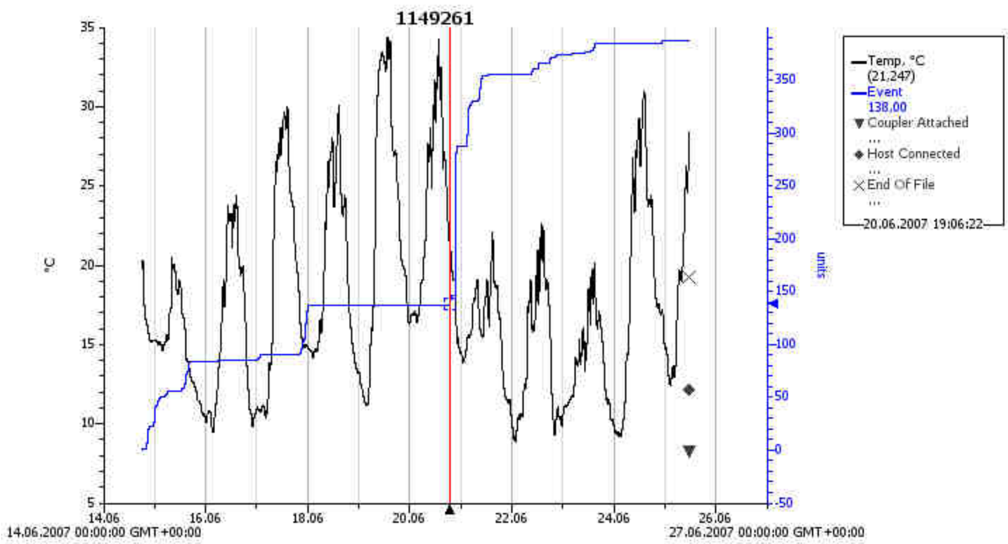


Fig. 11.62 Example of Hobo rain gauge station 5.1 (approximately 3km west of supersite S. Temperature readings are also taken at the rain gauge stations. Remarkable are the huge precipitation intensities on June 20, at around 21h30 UTC (26mm/20min which corresponds to 216mm/3h !)

11.5.6.2 High quality precipitation station network UFrankfurt

The station distribution can be seen from figure 5-8. The sites have been chosen to allow for a comparison between the low cost Hobo raingauges and the high quality stations. Time interval was set to one minute. The stations worked without any problems during the whole COPS period.

11.5.6.3 Distrometer UVienna

At the beginning of the period several problems with the power supply of the supersite existed which affected also this system.

The system measures a number of precipitation parameters.

These are:

- particle spectrum
- number of detected particles
- precipitation intensity
- precipitation amount
- visibility

Operation period: 25.6.-30.8

Fig. 7: Students from the University of Vienna during the installation of the distrometer.

11.5.6.4 Microrainradar

At the beginning of the period several problems with the power supply of the supersite existed which affected also this system.

Parameters measured:

Height	averaged measuring height above ground	[m]
Spectra	spectral volume reflectivity	[dBh]
Drop Spectra	number of drops per volume and diameter	[m-3mm-1]
Radar Reflectivity	integral radar reflectivity	[dBZ]
Rain Rate	amount of rain per time	[mm/h]
Liquid Water Contents	mass of liquid water per volume	[g/m3]
Falling Velocity	characteristic falling velocity of drops	[m/s]

Operation periods: 1.6.-14.6;
16.6.-18.6.;
19.6. (data partially available),
20.6.
21.6.-25.6. (data only partially available for this period)
26.6.-30.6.

1.7.-31.7.

1.8.-31.8.

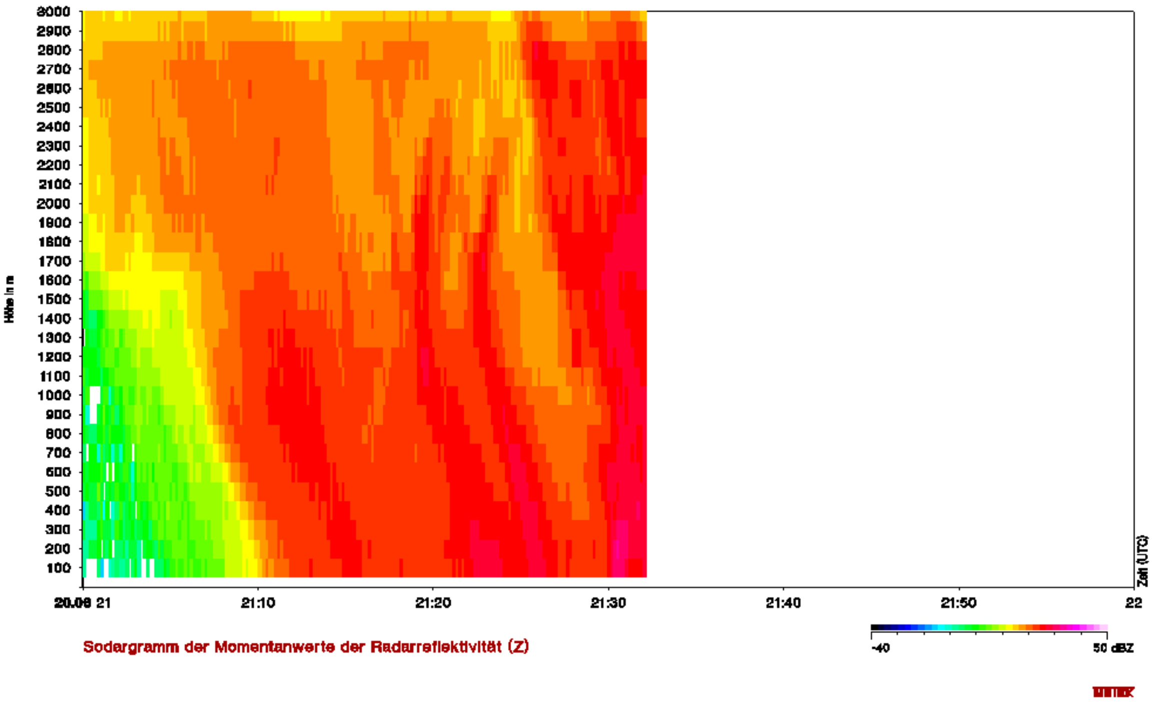


Fig. 11.63 Radar reflectivities for 20 June from 21h00 to 21h34 UTC, afterwards no data due to a power failure at the supersite after a lightning stroke. The picture shows clearly the onset of the precipitation at 21h10 with strong intensities of up to about 40 dBZ which last only for 2-3 minutes.

11.5.6.5 Energy Balance System UVienna

At the beginning of the period several problems with the power supply of the supersite existed which affected also this system. Additionally a lightning stroke affected some electronic components of the system which had to be replaced. Further a bird destroyed the polyethylene dome of the pyrradiometer. All these effects reduced the operation periods of the system.

The system consists of the following sensor components:

- Scintillometer SLS20 system, including
    - Receiver
    - Transmitter
- Schenk Pyrradiometer, model 8111
- Schenk Pyranometer, model 8101
- Two Gill Aspirated Radiation Shields with thermometers PT1000
- Three Hukesflux Soil Heat Flux Sensors, model HFP01SC
- Young Barometric Pressure Sensor 61202V

From the turbulence measurement (scintillometer) the following parameters are determined by the system:

- Structure function constant of refractive index C_n^2
- Inner scale of refractive index l_0
- Structure function constant of temperature C_T^2
- Dissipation rate of turbulent kinetic energy ε
- Sensible heat flux
- Momentum flux
- Monin-Obukhov length

From the radiation measurements and the soil flux measurements the surface energy flux components are determined:

- Global radiation
- Net radiation
- Soil heat flux
- Latent heat flux

Data interval: 2 min

Data availability see following table:

Date	Data availability
20.6.	since 6 UTC
21.6.	partially
22.6.-24.6.	no data
25.6.-27.6.	partially
28.6.	no data
29.6.-6.7.	partially
7.7.	ok.
8.7.	partially
9.7.	ok.
10.7.	no data
11.7.	ok
12.7.	partially
13.7.	ok.
14.7.	partially

15.7.-17-7.	ok.
18.7.	partially
19.7.-20.7.	ok
21.7.-25.7.	no data
26.7.	partially
27.7.-28.7.	ok
29.7.	partially
30.7.-6.8.	ok.
7.8.-11.8.	partially
12.8.-14.8.	ok.
15.8.	no data
16.8.	partially
17.8.-20.8.	ok.
21.8.-22.8.	partially
23.8.-29.8.	ok.
30.8.	partially

11.5.6.6 Radiosonde site UVienna

The radiosonde site was located at Lerchenberg about 1km to the north of the supersite location. We use the Meteolabor SCS-C34 sonde. This is a GPS-sonde with the following sensors:

- Regulated hypsometer for measurement of air pressure
- Temperature sensor with small time constant (thermo element).
- SnowWhite - dew point mirror for the determination of the dew point
- GPS-receiver for wind measurements
- Barometer for the exact pressure reference at the ground

Technical problems at the beginning and restrictions due to air traffic control did not always allow launches when the weather situation was favourable for convection. The following list gives the launch times:

Time in UTC (MMDDhh)	file status
062820	ok
070108	ok
070114	ok
070208	ok

070214	ok
070914	corrupt
071208	ok
071408	ok
071417	ok
071514	ok
071605	corrupt
071811	corrupt
071812	ok
071817	ok
072014	corrupt
072508	ok
072517	ok
080610	corrupt
080614	corrupt
080617	corrupt
080620	ok
080710	ok
080717	ok
080811	ok
081308	ok
081514	ok
081520	ok
081605	ok
082208	ok
082408	ok

All in all 29 sondes have been launched, 23 of them have been successful. Fig. 11.65 gives an example for June 28, 2007, 20h00 UTC.

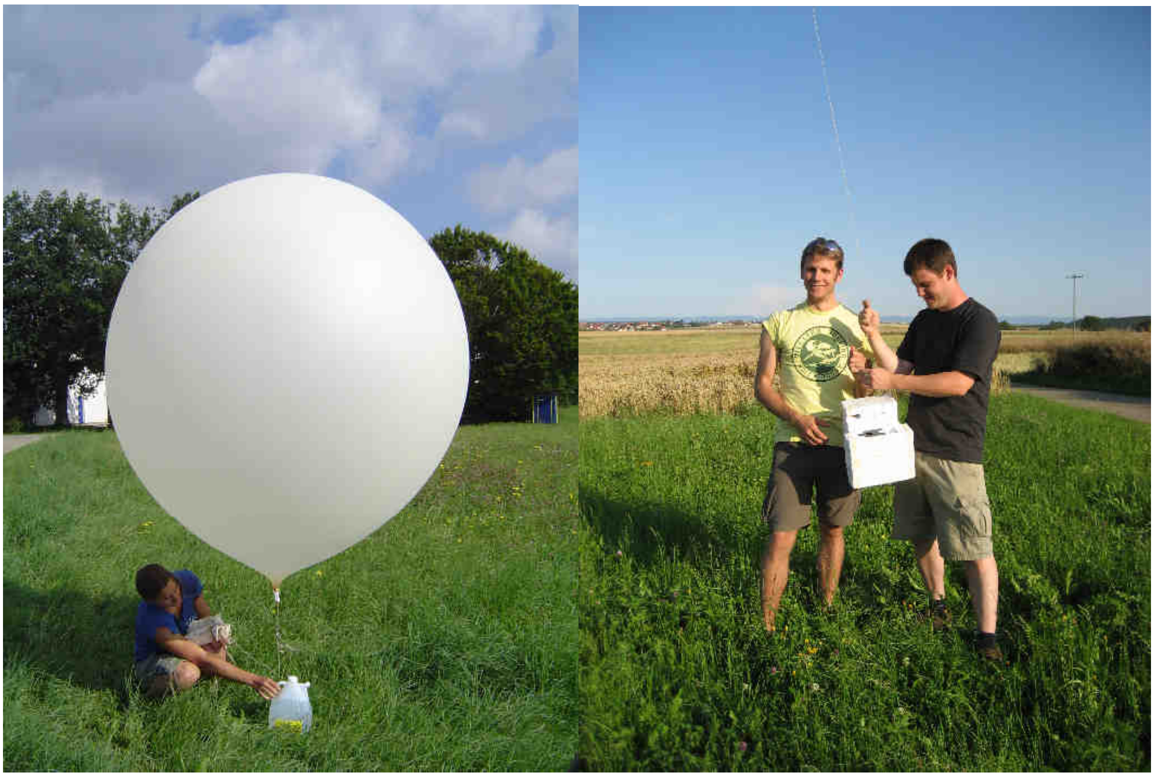


Fig. 11.64 Final preparations for radiosonde launch.

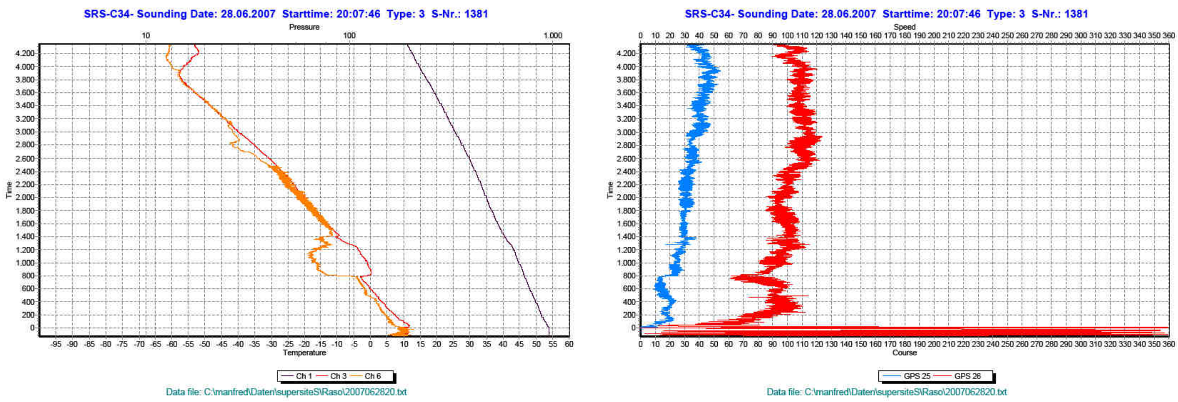


Fig. 11.65 Radiosonde launch for 28 June 2007, 2000 UTC. Left: Temperature, snow white dew point temperature and pressure, right: GPS wind speed and direction. Note: y-axis is time since launch start.

11.5.6.7 Wind-Temperature Radar FZK

Table 11.24 WTR operation times. (**to be translated to English)

Datum	Messbetrieb	Intensivmessphase
22.05.07	WTR-Aufbau	
23.05.07		

24.05.07	Walzerlauf	
25.05.07	Kein Messbetrieb, Rechner aus	
06.06.07	14:10 Uhr Dbs 3. 100m	
07.06.07	14:05 Uhr Dbs 3. 100m	
08.06.07	Kein Messbetrieb	
09.06.07	Kein Messbetrieb	
10.06.07	Kein Messbetrieb	
11.06.07	Kein Messbetrieb	
12.06.07	Kein Messbetrieb	
13.06.07	14:30 Uhr Dbs 3. 100m	
14.06.07	Dbs 3. 60 m/Dbs 3. 100m	IOP 3a
15.06.07	Dbs 3. 100m	IOP 3b
16.06.07	Kein Messbetrieb	
17.06.07	Kein Messbetrieb	
18.06.07	Kein Messbetrieb	
19.06.07	Dbs 3. 100m	IOP 4a
20.06.07	Dbs 3. 100m	IOP 4b
21.06.07	Dbs 3. 100m	
22.06.07	Kein Messbetrieb	
23.06.07	Kein Messbetrieb – Handwerkliche Probl.	
24.06.07	Kein Messbetrieb – stillgelegt	
25.06.07	Kein Messbetrieb – stillgelegt	
26.06.07	Kein Messbetrieb – stillgelegt	
27.06.07	Kein Messbetrieb – stillgelegt	
28.06.07	14:15 Uhr Dbs 3. 100m	
29.06.07	Dbs 3. 100m	
30.06.07	Dbs 3. 100m	
01.07.07	Dbs 3. 100m	IOP 5a
02.07.07	Dbs 3. 100m	IOP 5b
03.07.07	Dbs 3. 100m	
04.07.07	Dbs 3. 100m	IOP 6
05.07.07	Dbs 3. 100m	
06.07.07	Dbs 3. 100m	

07.07.07	Dbs 3. 100m	
08.07.07	Dbs 3. 100m	IOP 7a
09.07.07	Dbs 3. 100m	IOP 7b
10.07.07	Dbs 3. 100m	
11.07.07	Dbs 3. 100m	
12.07.07	Dbs 3. 100m	
13.07.07	Dbs 5. 100m	
14.07.07	Dbs 5. 100m	IOP 8a
15.07.07	Dbs 5. 100m	IOP 8b
16.07.07	Dbs 3. 60m	
17.07.07	Dbs 3. 60m	
18.07.07	Dbs 3. 60m	IOP 9a
19.07.07	Dbs 3. 60m	IOP 9b
20.07.07	Dbs 3. 60m	IOP 9c
21.07.07	Dbs 3. 75m	
22.07.07	Dbs 3. 75m	
23.07.07	Dbs 3. 75m	IOP 10
24.07.07	Dbs 3. 75m	
25.07.07	Dbs 3. 75m	IOP 11a
26.07.07	Dbs 3. 75m	IOP 11b
27.07.07	Dbs 3. 75m	
28.07.07	Dbs 3. 75m	
29.07.07	Dbs 3. 75m	
30.07.07	Dbs 3. 75m	IOP 12
31.07.07	Dbs 3. 75m	
01.08.07	Dbs 3. 75m	IOP 13a
02.08.07	Dbs 3. 75m	IOP 13b
03.08.07	Dbs 3. 75m	
04.08.07	Dbs 3. 75m	
05.08.07	Dbs 3. 75m	
06.08.07	Dbs 3. 75m	
07.08.07	Dbs 3. 75m	IOP 14a
08.08.07	Dbs 3. 75m	IOP 14b
09.08.07	Dbs 3. 75m	IOP 14c

10.08.07	Dbs 3. 75m	
11.08.07	Dbs 3. 75m	
12.08.07	Dbs 3. 75m	IOP 15a
13.08.07	Dbs 3. 75m	IOP 15b
14.08.07	Dbs 3. 75m	
15.08.07	Dbs 3. 75m	IOP 16 ein gemein-
16.08.07	Dbs 3. 75m	IOP 16 samer file
17.08.07	Dbs 3. 75m	SOP 7
18.08.07	Dbs 3. 75m	
19.08.07	Dbs 3. 75m	
20.08.07	Dbs 3. 75m	
21.08.07	Dbs 3. 75m	IOP 17a
22.08.07	Dbs 3. 75m	IOP 17b
23.08.07	Dbs 3. 75m	
24.08.07	Dbs 3. 75m	IOP 18
25.08.07	Dbs 3. 75m um 18 UTC abgeschaltet!	

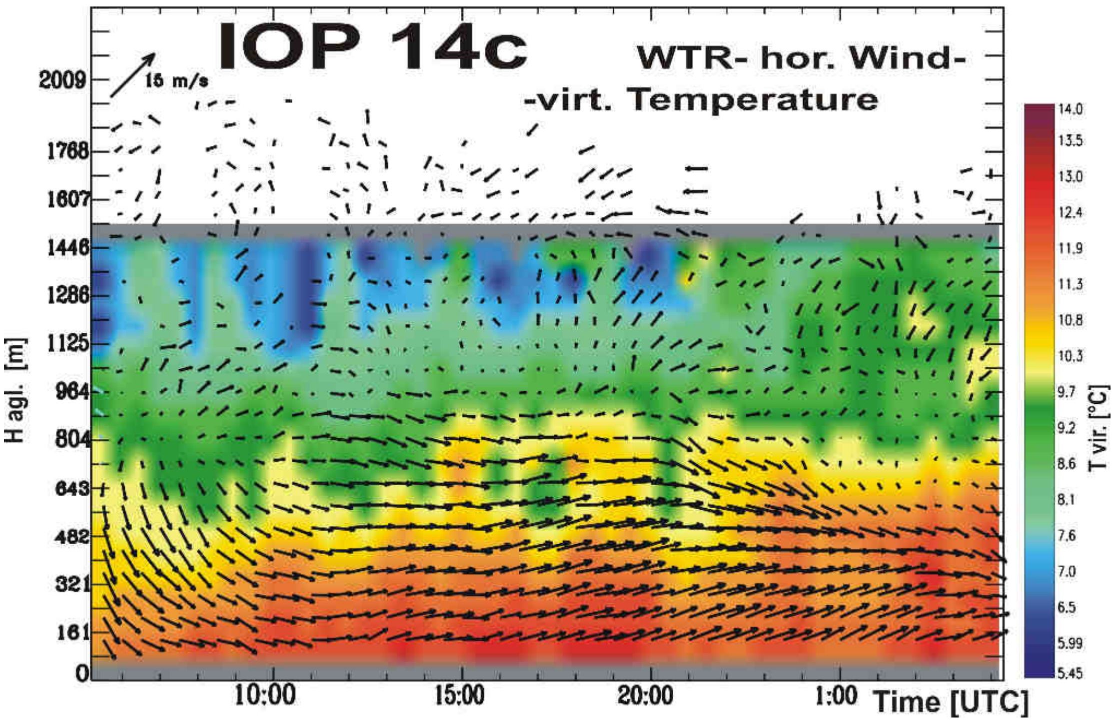


Fig. 11.66 Measurement example of the FZK WTR..

11.5.6.8 Ceilometer UBonn

Operation period: 6.7.2007-6.9.2007

To be completed

11.5.6.9 MICCY UBonn

Operation period: 27.6.2007- 6.9.2007

To be completed

11.5.6.10 Turbulence towers UBonn

Operation period -for temperature, humidity and wind profiles: 9.6.2007-6.9.2007

Operation period for Eddy Covariance (including H, LE, CO2 profiles: 9.6.2007-30.8.2007

To be completed

11.5.6.11 Rain gauges UBonn

Operation period: 9.6.2007-6.9.2007

To be completed

11.5.7 Supersite Vosges

Supersite V in the Vosges Mountains became possible with the French instruments (see SOD, chapter 9). For the instrumentation at Supersite V, see Fig. 11-11..

The X band radar, MRR radar, disdrometer and rain-gage have all be running continuously from June 15 to August 29, except the X band radar for a 16 hour period from July 16 17UTC to July 17 9UTC.

Rain data have been assessed: Rain-gage is OK but disdrometer suffers interferences which produced high level of noise provoking underestimate of rain rates and calculated equivalent reflectivity but the drop size distribution spectra look good.

MRR and X band radar measurements are still under assessment. MRR should be OK full assessment and quality control will be performed in collaboration with the team of Gerhard Peters in Hamburg who was operating the MRR netweork in the German part of the COPS area. Complete data set will be provided to the data base under identical format than all other MRRs in COPS.

X band assessment is ongoing: Preliminary results (quick-looks) will be provided to database but we are still considering best format. Further work might be needed as we have detected possible performance level discrepancy which would need to be addressed before reflectivities be provided to the database.

Quicklooks of the X band radar are available at ftpobs.univ-bpclermont.fr -> EXTERIEUR -> JVB.

These quicklooks are the full resolution (30 seconds, 2° azimuth, 60m range degraded to 120m for display, maximum range 20 km) quick looks of the data without any complementary processing (we are currently considering possible threshold cut-offs, eventual spike removal, and mask blank out applications).

The radar was located at 48° 28' 45.24" N, 7° 28' 28.98" E and 360 m altitude, while beamwidth is 2.4° and elevation 5°.There are a few features on the display (triangles) which represent the V supersites to the S-E, some remarkable crests to the W-S-W (Grendelbruch, Mt Ste Odile, Champ du Feu from N to S), the airport to the N-E and the military Mutzig site to the N. (We will see is we can incorporate a topographical map as background). There is also a zone of important masks (high trees) from azimuth 310 to 350.

11.5.8 FZK C-Band Radar

Quicklooks of all the data are available at www.cops2007.de -> Operational Products -> Radar Facilities -> Archive of IMK Precipitation Radar.

For measurement examples see Fig. 15.7 and Fig. 15.13.

Overview images of tracked convection during the COPS period as seen by the C-Band Doppler radar at the Forschungszentrum Karlsruhe are available at

www.cops2007.de -> Operational Products -> Radar Facilities -> Cell tracks as observed with the IMK Precipitation Radar.

The intention of these data is to support the identification of ``golden days''. Each image contains information about one day. Over the orography (shown as gray coded contour plot) the locations of identified reflectivity cores are shown. A rough definition of a reflectivity core is a volume of contiguous radar bins with a maximum reflectivity above 45 dBZ. Adjacent radar bins are part of the reflectivity core as long as their reflectivity is above the maximum reflectivity minus 10 dB. The idea is, that a reflectivity core should be a convective cell, as seen by the radar.

The size of the dots in the following images indicates the maximum reflectivity within the corresponding reflectivity core -- not the size of the reflectivity core. It should be noted that the maximum reflectivity may be easily biased (e.g. by ground clutter) and is no stable information about the intensity of a certain thunderstorm. Nevertheless, the sizes give a first estimation of the strength of the storms. The color indicates the time, when the storm was observed. See the colortable below each picture. Times are given in local time. 12:00 local time is 10:00 UTC.

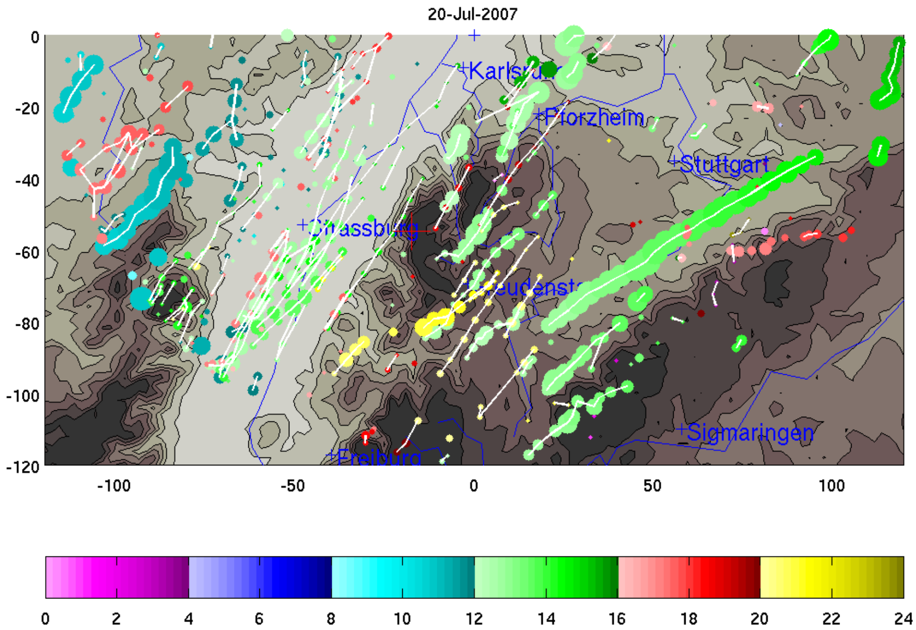


Fig. 11.67 Tracked convection during the COPS period as seen by the C-Band Doppler radar at the Forschungszentrum Karlsruhe on 20 July 2007 (IOP 9c).

11.5.9 Poldirad

Quicklooks of all the data are available at www.cops2007.de -> Operational Products -> Radar Facilities -> DLR Poldirad.

For a measurement example see Fig. 15.8.

11.6 Mobile Teams

11.6.1 Doppler on Wheels

(information to be added)

11.6.2 Drop-up-Sonde Teams

IOP: 3a	**Date: 14.06.2007**
Team 1 Site-No.: 9 Site: Kniebis	Tower: No. 1, from: 09:30 to: 17:25 UTC Sonde-No. Time: 04 11:00 UTC 05 12:30 UTC 06 16:50 UTC

Team 2 Site-No.: 30 Site: Sprollenhaus	Tower: No. 2, from: 08:30 to: 17:15 UTC Sonde-No. Time: 11 11:00 UTC 10 12:30 UTC 12 17 :00 UTC
Team 3 Site-No.: 69 Site: Dornstetten	Tower: No. 3, from: 09:30 to:17:00 UTC Sonde-No. Time: 16 11:40 UTC 17 12:34 UTC 14 17:00 UTC
Team 5 Site-No.: 33 Site: Hirsau (Sportplatz)	Tower: No. 4, from: 09:15 to: 17:25 UTC Sonde-No. Time: 18 11:10 UTC 26 12:30 UTC 24 17:21 UTC

IOP: 4b	**Date: 20.06.2007**
Team 1 Site-No.: 29 Site: between Reichental und Kaltenbronn	Tower: No. 1, from: 09:30 to: 18:15 UTC Sonde-No. Time: 04 11:00 UTC 10 15:29 UTC 05 16:15 UTC 14 17:39 UTC
Team 2 Site-No.: 64 Site: Dürrenmessstetten (1 km north of. Site-No. 64)	Tower: No. 2, from: 09:17 to 17:55 UTC Sonde-No. Time: 09 11:05 UTC 15 15:30 UTC
Team 4	Tower: No. 3, from: 13:10 to 17:56 UTC

Site-No.: 33 Site: Hirsau (Sportplatz)	Sonde-No. Time: 26 11:00 UTC 25 15:30 UTC 24 16:06 UTC 22 17:45 UTC
Team 5	Tower: No. 4, from: 08:30 to: 17:45 UTC
Site-No.: 8 Site: Kniebis	Sonde-No. Time: 27 11:00 UTC 29 15:28 UTC 33 16:30 UTC 31 17:45 UTC

IOP: 5a	**Date: 01.07.2007**
Drop sonde release: Flight No. 7	Sonde-No. Time : 21 15:50 UTC 25 15:51 UTC 27 15:55 UTC 30 15:55 UTC 31 15:56 UTC

IOP: 5b	**Date: 02.07.2007**
Team 2	Tower: No. 2, from: 08:15 to 17:00 UTC
Site-No.: 47 Site: Hausach	Sonde-No. Time: 06 12:30 UTC 10 14:40 UTC 05 16:15 UTC 09 16:37 UTC
Team 3	Tower: No. 3, from: 10:38 to 19:00 UTC
Site-No.: 29 Site: Reichental	Sonde-No. Time: 14 12:36 UTC 11 14:45 UTC

	12 16:17 UTC
Team 5 Site-No.: 41 Site: Pfalzgrafenweiler	Tower: No. 4, from: 08:00 to: 17:10 UTC
	Sonde-No. Time: 20 12:28 UTC 18 14:44 UTC 15 16:30 UTC
Drop sonde release: Flight No. 9	Sonde-No. Time : 26 16:46:13 UTC (48°35’24 N and 08°33’24 E, 5.970 m) 24 16:46:38 UTC (48°35’04 N and 08°32’31 E, 5.977 m) 33 16:47:17 UTC (48°34’04 N and 08°34’01 E, 6.004 m)

IOP: 7b	**Date: 09.07.2007**
Drop sonde release: Flight No. 11	Sonde-No. Time : 25 17:03:57 UTC (48°35’23 N and 08°40’20 E, 6.137 m) 33 17:04:32 UTC (48°34’33 N and 08°41’49 E, 6.153 m) 24 17:05:14 UTC (48°35’50 N and 08°44’05 E, 6.115 m) 26 17:05:46 UTC (48°37’32 N and 08°44’27 E, 6.129 m)

IOP: 9b	**Date: 19.07.2007**
Team 2 Site-No.: 33 Site: Hirsau (Sportplatz)	Tower: No. 2, from: 08:15 to 17:00 UTC
	Sonde-No. Time: No dropping

Team 3 Site-No.: 47 Site: Hausach	Tower: No. 3, from: 9:04 to 17:05 UTC Sonde-No. Time: No dropping
Team 5 Site-No.: 69 Site: Dornstetten	Tower: No. 4, from: 08:00 to: 17:10 UTC Sonde-No. Time: No dropping

IOP: 9c	**Date: 20.07.2007**
Team 2 Site-No.: 69 Site: Dornstetten	Tower: No. 2, from: 07:46 to 16:15 UTC Sonde-No. Time: 15 10:10 UTC 41 10:45 UTC 45 16:14 UTC
Team 3 Site-No.: 33 Site: Hirsau (Sportplatz)	Tower: No. 3, from: 08:45 to 16:00 UTC Sonde-No. Time: 24 10:10 UTC 21 11:36 UTC 46 16:32 UTC
Team 5 Site-No.: 47 Site: Hausach	Tower: No. 4, from: 08:45 to: 16:42 UTC Sonde-No. Time: 33 10:43 UTC 25 11:45 UTC 47 15:40 UTC 26 16:30 UTC
Drop sonde release: Flight No. 22	Sonde-No. Time : 11 14:27:31 UTC 48°36’16’’ N and 08°34’16’’ E, 6.130 m 12 14:28:05 UTC 48°35’07’’ N and 08°34’26’’ E, 6.136 m 14 14:28:16 UTC

	48°34'46'' N and 08°34'29'' E, 6.138 m 20 14:28:24 UTC 48°34'27'' N and 08°34'33'' E, 6.132 m 27 14:28:47 UTC 48°33'41'' N and 08°34'45'' E, 6.117 m 30 14:28:54 UTC 48°33'29'' N and 08°34'50'' E, 6.118 m 31 14:29:06 UTC 48°33'05'' N and 08°35'02'' E, 6.131 m 06 14:29:16 UTC 48°32'46'' N and 08°35'12'' E, 6.137 m

IOP: 13b	**Date: 02.08.2007**
Team 2 Site-No.: 41 Site: Pfalzgrafenweiler	Tower: No. 2, from: 07:54 to 15:42 UTC Sonde-No. Time: 12 11:00 UTC 11 13:00 UTC 10 15:35 UTC
Team 3 Site-No.: 15 Site: Malschbach	Tower: No. 3, from: 08:10 to 15:50 UTC Sonde-No. Time: 20 10:45 UTC 14 12:35 UTC 25 13:59 UTC 26 15:30 UTC
Team 5 Site-No.: 47 Site: Hausach	Tower: No. 4, from: 08:45 to: 16:42 UTC Sonde-No. Time: 29 11:04 UTC 30 13:02 UTC 31 13:58 UTC 33 15:33 UTC

IOP: 14c	Date: 09.08.2007
Team 1 Site-No.: Supersite-No. H Site: Hornisgrinde	No tower active
	Sonde-No. Time: 30 und 47 15:08 UTC (combined)

IOP: 15b	Date: 13.08.2007
Team 1 Site-No.: 41 Site: Pfalzgrafenweiler	Tower: No. 1, from: 08:55 to 16:24 UTC
	Sonde-No. Time: 42 10:09 UTC 48 12:33 UTC 45 13:16 UTC combined with Flying Parsivel
Team 2 Site-No.: 32 Site: Oberreichenbach	Tower: No. 2 From: 08:30 to 16:33 UTC
	Sonde-No. Time: 24 10:00 UTC 52 12:28 UTC 49 13:28 UTC 50 16:25 UTC
Team 3 Site-No.: 8 Site: Kniebis	Tower: No. 3 from: 08:45 to 16:30 UTC
	Sonde-No. Time: 26 12:22 UTC 55 13:26 UTC 54 14:55 UTC
Team 5 Site-No.: 47 Site: Hausach	Tower: No. 4, from: 08:45 to: 16:42 UTC
	Sonde-No. Time: 59 10:05 UTC 33 12:30 UTC 29 13:15 UTC

	58 16:25 UTC

IOP: „no IOP“	Date: 16.08.2007
Team 1 Site-No.: Supersite-No. H Site: Hornisgrinde	No tower active Sonde-No. Time: 56 10:25 UTC

IOP: 17a	Date: 21.08.2007
Team 1 Site-No.: Supersite-No. H Site: Hornisgrinde	No tower active Sonde-No. Time: 42 17:31 UTC combined with Flying Parsivel 57 16:10 UTC combined with Flying Parsivel

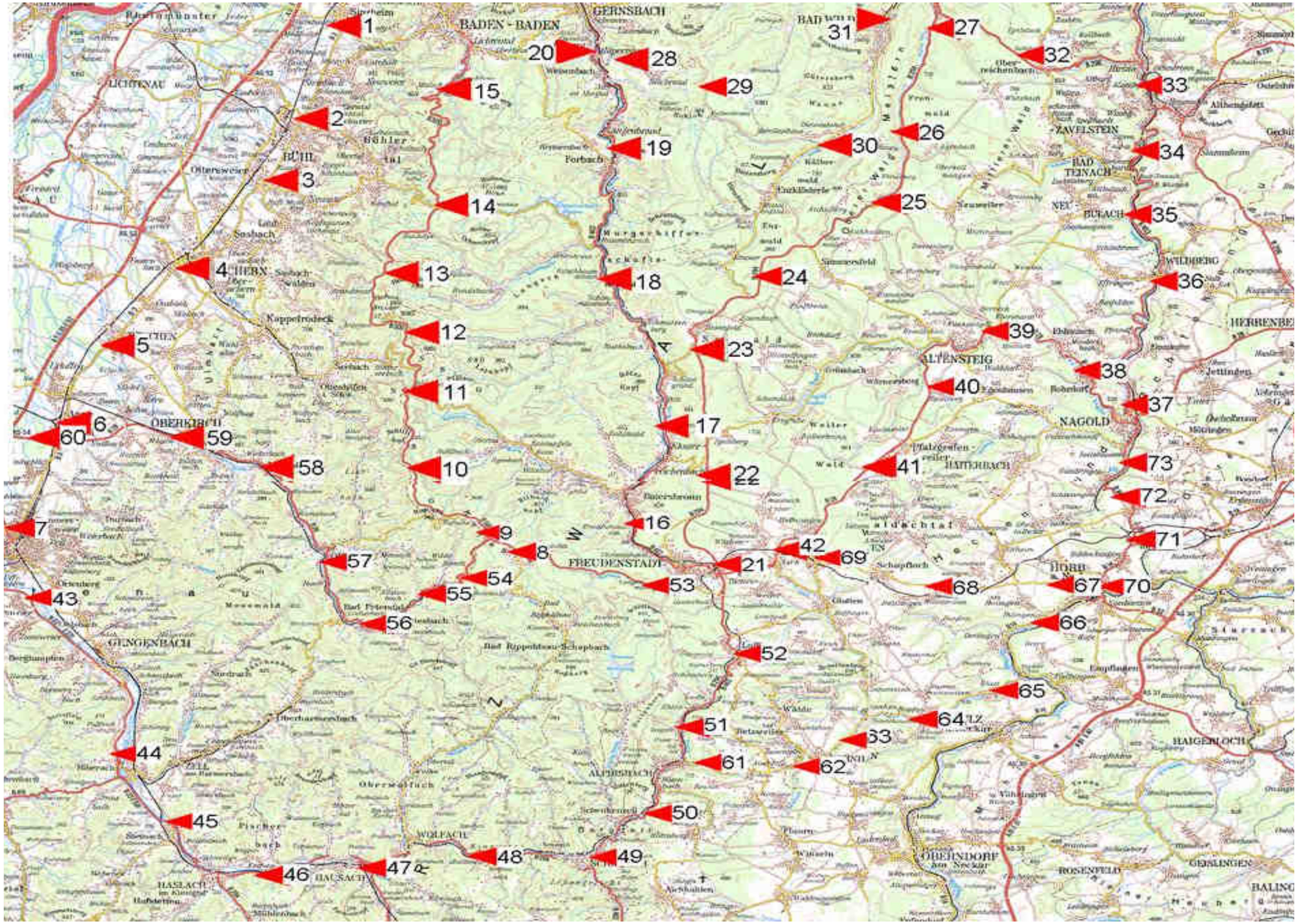


Fig. 11.68 Map of drop-up sonde sites in the northern Black Forest

11.7 Aircraft

11.7.1 DLR Falcon flights

The participation of the DLR Falcon research aircraft in COPS with its novel and unique water vapour and wind lidar payload was very successful: All missions yielded excellent data, as the quicklooks already proved; there were only few and short episodes with missing data. The main drawback was that due to missing air traffic control allowances over Central Europe, the dropping of sondes was only allowed over Spanish territory. Hence only 19 of the initially planned 57 sondes could be dropped. Here is a summary of the campaign flight times:

Total flight time (initial plan 45 h)	48.75 h	
Total block time (incl. warm-up and taxi) without test flight	**49.4 h**	**100%**
Total block time for **map missions**	12.9 h	26%
Total block time for **flux missions**	14.8 h	30%
Total block time for **upstream missions**	21.7 h	44%

Table 11.25 Overview of all DLR Falcon flights during COPS.

Flight Nr.	IOP Nr.	Date	Start (UTC)	Stop (UTC)	Block time (h)	Drop-sondes	Mission
1	5b	**2.7.07**	12:55	16:00	3:05	-	**Test flight**
2	7a	**8.7.07**	07:10	11:10	4:00	3	**Upstream**
3	7a	**8.7.07**	12:15	15:15	3:00	2	**Upstream**
4	8b	**15.7.07**	5:50	9:35	3:45	-	**Flux**
5	9a	**18.7.07**	13:15	17:10	3:55	-	**Map**
6	9b	**19.7.07**	6:25	10:05	3:40	5	**Upstream**
7	9b	**19.7.07**	11:00	14:50	3:50	9	**Upstream**
8	9c	**20.7.07**	6:30	9:45	3:15	-	**Map**
9	9c	**20.7.07**	10:40	13:10	2:30	-	**Map**
10	11a	**25.7.07**	12:20	16:15	3:55	-	**Flux**
11	11b	**26.7.07**	8:35	12:35	4:00	-	**Flux**
12	12	**30.7.07**	9:30	12:40	3:10	-	**Flux**
13	13a	**1.8.2007**	3:50	8:15	4:25	-	**Upstream**
14	13a	**1.8.2007**	8:40	11:25	2:45	-	**Upstream**
15	13a	**1.8.2007**	14:25	17:40	3:15	-	**modified MAP**

The following calendar gives an overview of the DLR Falcon occupation days (Belegtage, labeled B), down days and flights. In total, 29 occupation days were needed; initial plan was 30.

Su. 24/6/2007		
25		
26		
27		mount dropsonde device
28	B1	mount wind lidar
29	B2	mount H2O DIAL
30	DOWN DAY	
Su, 01/7	B3	Test DIAL
02	B4	**Test flight**
03	B5	adjust DIAL
04	B6	adjust DIAL
05	B7	adjust DIAL
06	B8	
07	DOWN DAY	
Su, 08/7	B9	**Upstream: OP-Santiago-OP, 2 Flights**
09	B10	
10	B11	
11	B12	
12	B13	
13	B14	
14	DOWN DAY	
Su, 15/7	B15	**Flux Pattern**
16	B16	
17	B17	
18	B18	**Map Pattern**
19	B19	
20	B20	**Upstream: OP-Faro-OP, 2 Flights**
21	DOWN DAY	
Su, 22/7	DOWN DAY	
23	B21	
24	B22	
25	B23	**Flux Pattern**
26	B24	**Flux Pattern**
27	B25	
28	DOWN DAY	
Su, 29/7	DOWN DAY	

30	B26	**Flux Pattern**
31	B27	
01/8	B28	**Upstream: 2 Flights, 1 MAP**
02	B29	unmount of all systems
03		
04		
Su, 05/8		

Quicklooks of all the data are available at www.cops2007.de -> Operational Products -> Aircraft Quicklooks ->DLR Falcon Flights.

11.7.2 DO128 flights

Quicklooks of all the data are available at www.cops2007.de -> Operational Products -> Aircraft Quicklooks ->DO128 Flights.

Table 11.26 Overview of all DO128 flights during COPS.

19.06.2007 IOP 4a

Flight 1 (1): 09:08 – 12:25 high pressure convection SupDe-HR

Flight 2 (2): 13:29 – 16:52 high pressure convection SupDe-HR

20.06.2007 IOP 4b

Flight 1 (3): 11:00 – 14:20 forced convection SS_MET

Flight 2 (4): 15:00 – 18:20 forced convection SS_MET

01.07.2007 IOP 5a

Flight 1 (5): 06:53 – 09:25 forced convection PreCon-HR

Flight 2 (6): 10:28 – 13:06 forced convection SupDe-HR

Flight 3 (7): 15:16 – 17:50 forced convection SupDe-HR 6 Drops Area B (east)

02.07.2007 IOP 5b

Flight 1 (8): 12:05 – 14:46 forced convection SupDe-HR

Flight 2 (9): 16:00 – 18:30 forced convection SupDe-HR

09.07.2007 IOP 7b

Flight 1 (10): 11:58 – 15:26 forced convection SupDe-HR

Flight 2 (11): 16:35 – 19:02 forced convection SupDe-HR

14.07.2007 IOP 8a

Flight 1 (12): 05:51 – 08:53 forced convection PreCon-RV

Flight 2 (13): 09:51 – 13:13 forced convection SupDe-RV

Flight 3 (14): 14:06 – 17:30 forced convection SupDe-RV

15.07.2007 IOP 8b

Flight 1 (15): 05:45 – 09:16 high pressure convection FLUX pattern

Flight 2 (16): 11:33 – 15:09 high pressure convection FLUX pattern

16.07.2007 no IOP

Flight 1 (17): 04:49 – 08:11 high pressure convection SS-QC and SS-MET

Flight 2 (18): 11:30 – 14:30 high pressure convection

18.07.2007 IOP 9a

Flight 1 (19): 12:54 – 16:24 forced convection SupDe-HR

19.07.2007 IOP 9b

Flight 1 (20): 13:55 – 17:09 forced convection SupDe-HR

20.07.2007 IOP 9c

Flight 1 (21): 07:34 – 10:00 forced convection SupDe-HR

Flight 2 (22): 13:50 – 16:24 forced convection SupDe-HR

23.07.2007 IOP 9c

Flight 1 (23): 10:50 – 14:19 forced convection SupDe-HR

25.07.2007 IOP 11a

Flight 1 (24): 08:57 – 12:19 high pressure convection FLUX pattern

Flight 2 (25): 13:22 – 16:55 high pressure convection City-Plume - Lagrange/North

26.07.2007 IOP 11b

Flight 1 (26): 08:34 – 12:13 high pressure convection FLUX pattern

Flight 2 (27): 12:52 – 16:30 high pressure convection Chaff-HL

30.07.2007 IOP 12

Flight 1 (28): 09:45 – 13:05 high pressure convection FLUX pattern, Chaff

Fig. 11-13. The DO128 aircraft at Baden Airpark.

11.7.3 SAFIRE Falcon Flights

Quicklooks of all the data are available at www.cops2007.de -> Operational Products -> Aircraft Quicklooks ->SAFIRE Falcon Flights.

The flight tracks of the SAFIRE Falcon aircraft are available at ftp://84.37.14.20/COPS/cyrille/

User: ftpclient
Psswd: *ftp*00

Fig. 11-14. The SAFIRE Falcon aircraft at Baden Airpark.

11.7.4 FAAM BAe146 Flights

Fig. 11-15. The FAAM BAe146 aircraft at Baden Airpark.

11.7.5 Partenavia P68B D-GERY flights

The Partenavia aircraft flights are part of the category "Stratus-Cloud-Physics" of the COPS aircraft missions. The main purpose of this experiment is related to microphysical measurements within stratiform low level water clouds simultaneous to ground-based remote sensing observations. Altogether four different flight missions have been operated during SOP-1a, 2 to 4 (Special Observations Periods). The predefined flight pattern is a triangle, which covered the area of the Rhine-valley, Hornisgrinde and Murg-valley, so that several overpasses of the supersites A, H and M could be performed. Alternative flight patterns according to the triangle have been flown during SOP-3 and 4 related to the cloud distribution and development. Additionally to the continuous ground-based observations special requirements of lidar and cloud radar measurements could be coordinated at supersite A, H and M. During IFR (Instrument Flight Rules) operations the minimum flight level was restricted to FL 60 by air traffic control and the maximum by the height level of the zero degree isotherm. In all four flight missions the standard avionic and meteorological instrumentations and the relevant cloud microphysical measurements (CIP, FSSP-300, PVM) have been performed well.

Fig. 11-16. The Partenavia aircraft at Baden Airpark with the EUFAR PI Christina Brandau (left).

Table 11.27 Operation times of the Partenavia P68B aircraft..

SOP	Date	Take off	Landing	Remarks to instrument performance
1a	12/07/2007	05:10	06:53	CPC: failed Nevzorov: poor performance (large offset drifts)
2	21/07/2007	06:10	08:11	Nevzorov: poor performance (large offset drifts)

3	22/07/2007	05:57	07:14	Nevzorov: LWC and TWC data rejected before 06:02 UTC
4	24/07/2007	06:29	09:15	No remarks

11.7.6 ATR42 Flights

The ATR42 flights are part of the 'Stratus-Cloud_Physics' category within the COPS aircraft mission. Five different flights have been performed and combined with ground-based measurements in order to characterize the cloud microphysical properties during mixed-phase cloud events. The predefined flight pattern is a triangle covering part of the Rhine valley and the Black forest and overpassing the supersites V, R, H, and M and the Poldirad location at different flight level.

In all five flight missions the standard avionic and meteorological instrumentation together with microphysical measurements (FSSP100 and 2D probes) have been performed. More details can be found on the EUFAR website (Eufar.net) within the project OSMOC.

Table 11.28 Operation times of the SAFIRE ATR42 aircraft..

I/SOP	Date	Take off	Landing	Remarks to instruments performance
SOP 2	21/07/07	15:12	16:37	One of the 2D-probe did not performed well
IOP 10	23/07/07	12:13	15:18	
SOP 4	24/07/07	09:03	10:35	
SOP 5	28/07/07	08:59	10:20	One of the 2D-probe did not performed well
SOP 5	28/07/07	12:54	14:13	No mixed-phase events (water clouds only)

Fig. 11-17. The SAFIRE ATR42 aircraft at Baden Airpark.

11.7.7 Zeppelin NT Flights

Fig. 11-18. The Zeppelin NT at Baden Airpark.

11.7.8 METAIR DIMO Flights

Table 11.29. Flights of Metair DIMONA Aircraft

Flight-ID from	UTC	to UTC
F070716A	11:25:43	12:10:53
F070716B	14:50:57	15:59:01
F070717A	08:23:47	09:06:50
F070717B	14:08:00	16:45:34
F070718A	09:26:43	11:16:08
F070718B	13:09:39	14:38:18
F070719A	11:15:01	12:32:45
F070722A	12:33:36	16:17:55
F070723A	04:39:19	09:04:01
F070723B	11:03:58	14:50:56
F070725A	09:12:49	12:13:19
F070725B	13:47:10	17:42:21
F070726A	11:32:55	15:42:07
F070731A	08:15:58	09:42:08
F070731B	14:01:10	16:28:21
F070801A	08:30:49	13:09:30
F070801B	14:11:19	15:34:08

ASCII files of the flight paths are available at www.metair.ch/MetAir_tracks_COPS.zip

All flights have been reviewed meanwhile and there is so far no indication for quality problems of the data. Thus, we can expect that all data are available up to the end of February this year.

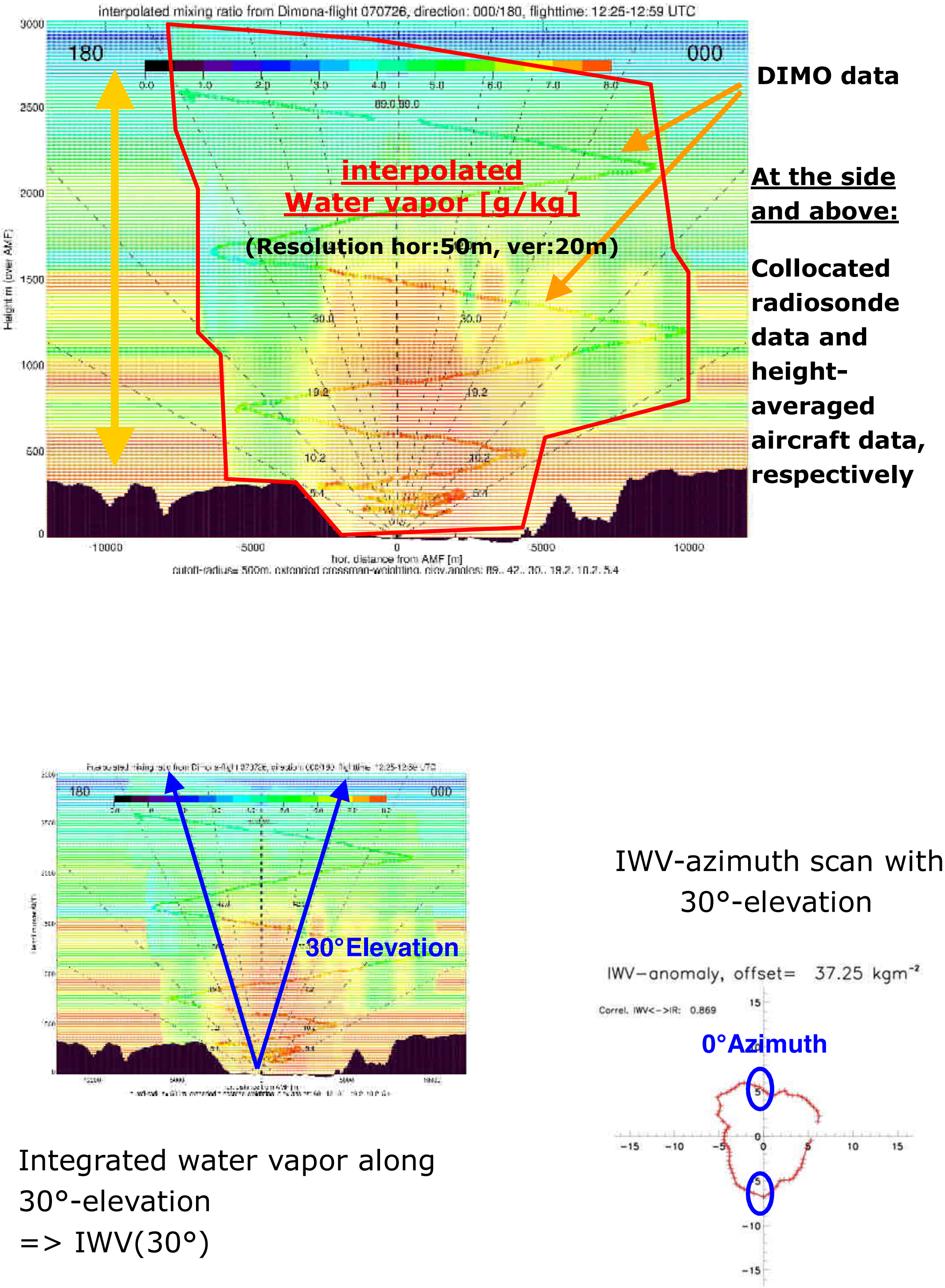


Fig. 11.69 DIMO water vapor measurement above Supersite R (upper panel) and comparison with scanning HATPRO microwave radiometer measurements (lower panel).

11.7.9 UltraLight D-MIFU Flights

Table 11.30. Flights of UltraLight D-MIFU Aircraft above Supersites R and M, all time information UTC

	Supersite Achern		Supersite Heselbach	
19.6.	07:45	08:00	08:15	08:45
	08:55	09:20		
19.6.	14:10	14:40	14:50	15:30
	15:40	16:05		
20.6.	09:00	09:40	10:08	11:35
	11:05	12:00		
24.6.	10:20	11:40	12:30	12:45
25.6.	10:10	10:50		
19.7.	16:10	16:28	17:10	17:25
22.7.	12:30	13:30		
23.7.	08:10	08:20		
	11:20	11:50	12:00	12:40
	13:30	13:45		
25.7.	Lagrange flight, vertical profiles at Baden Baden			

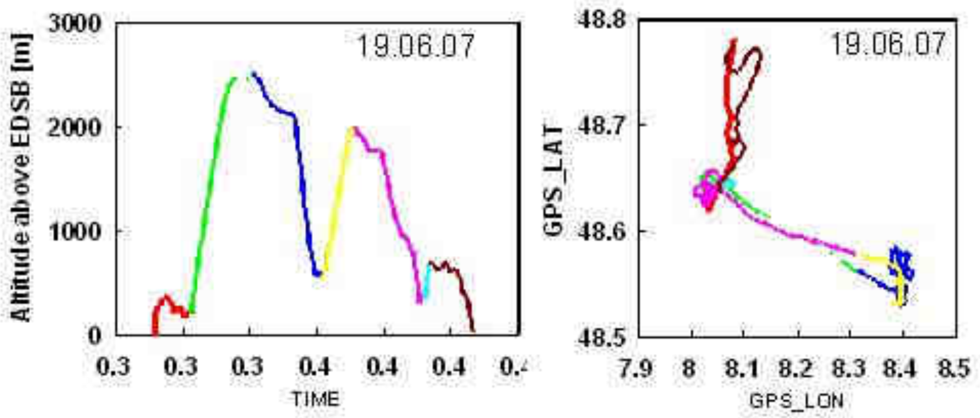


Fig. 11.70 Altitude and GPS coordinates of the D-MIFU on June 19. The same plots are available for all deployment days. Different Colors mark the different tracks of the flight.

11.8 MSG observations provided by EUMETSAT

The MSG satellite data were intensively applied during COPS. The major data sources were the Rapid Scan Service (RSS) and retrievals of clouds and CI properties made available via the Space Science and Engineering Center (SSEC) in Madison, Wisconsin, USA.

The RSS turned out to be extremely helpful for mission guidance. The data were received at a ground-station of IMK and transferred to the COPS OC as quickly as possible. A script was developed to recognize the arrival of a complete new image and to start the program Xrit2Pic. This program produced images for each channel, which were picked to merge them in IR and high-resolution VIS movies. The movies were applied for mission guidance during aircraft operation. Particularly, they turned out very useful to communicate with the UK BAe 146 aircraft where CI was detected. This was essential for the BAe team, as one of the major science goals was the investigation of cloud microphysics of developing convective clouds up to temperature levels of -10°C.

Even first scientific work for detecting and tracking of CI and for studying cloud microphysics has been performed within the scope of a master thesis at IPM. First results are presented in chapter 12. Table 11-1 presents an overview about the availability of RSS during the IOPs.

Table 11-3. IOP numbers, dates and MSG rapid scanning data availability

IOP No.	Date	MSG rapid scanning data availability
1	05 Jun	Yes
	06 Jun	Yes
	07 Jun	Yes
	08 Jun	Yes
2	12 Jun	Yes
3	14 Jun	NO
	15 Jun	NO
4	19 Jun	NO
	20 Jun	NO
5	01 Jul	Yes
	02 Jul	Yes
6	04 Jul	Yes
7	08 Jul	Yes
	09 Jul	Yes
8	14 Jul	Yes
	15 Jul	Yes
9	18 Jul	Yes
	19 Jul	Yes
	20 Jul	Yes
10	23 Jul	Yes
11	25 Jul	Yes
	26 Jul	Yes
12	30 Jul	Yes
13	01 Aug	Yes
	02 Aug	Yes
14	07 Aug	NO
	08 Aug	NO
	09 Aug	Yes
15	12 Aug	Yes
	13 Aug	Yes
16	15 Aug	Yes
	16 Aug	Yes
17	21 Aug	Yes
	22 Aug	Yes
18	24 Aug	Yes
	25 Aug	Yes

12 Public Outreach

There was large public interest in the COPS campaign. More than 80 newspaper articles were published; several radio and TV interviews were given, e.g., in the "Tagesthemen" news magazine of ARD, the 1st programme, and Deutsche Welle World. A webpage for the German public was launched at http://cops.uni-hohenheim.de.

Fig. 12.1 TV team of SWR at Supersite H on 18 July.

Fig. 12.2 COPS in the "Tagesthemen" news magazine on July 19.

01.06.2007
http://www.heute.de/ZDFheute/inhalt/28/0,3672,5545756,00.html

Weltgrößte Niederschlagsmessung startet im Schwarzwald

Bessere Modelle für Wettervorhersagen und Klimaforschung als Ziel

Mit großem Aufwand dem Geheimnis extremer Wetterereignisse auf der Spur: Wissenschaftler der Universität Hohenheim und Karlsruhe starten am Freitag im Schwarzwald das nach ihren Angaben weltgrößte Messprojekt in der Niederschlagsforschung. Drei Monate lang wollen Forscher aus acht Nationen weltweit einzigartige Forschungsgeräte einsetzen, um Niederschläge berechenbarer zu machen.

dpa

Fig. 12.3 COPS headline on the webpage of heute, the news magazine of ZDF.

DW-WORLD.DE
DEUTSCHE
WELLE

YOUR LINK TO GERMANY

TOMORROW TODAY

COPS - The World's Biggest Weather Laboratory

The region between Germany's Black Forest and the Vosges mountains in France is about to become a huge open-air laboratory.

Researchers from eight countries are gathering for the largest field experiment of the decade. The name of the project is COPS and it aims to develope more accurate models for predicting climate and weather. COPS is using nine high-tech research planes and 100 measuring stations, including five so-called super-sites, all loaded with equipment. The scientists will also be getting help from above, in the form of the European weather satellite METEOSAT. Directing the experiment are the universities in Hohenheim and Karlsruhe, as well as the Karlsruhe Research Centre. COPS is also part of the United Nations world weather research programme.

Fig. 12.4 COPS headline on the webpage of Deutsche Welle World.

SWR»
Druckversion

Seebach

Weltgrößtes Wetter-Messprojekt startet im Regen

Bei strömendem Regen hat im Schwarzwald die weltgrößte Messkampagne für Niederschlagsvorhersagen begonnen. Wissenschaftler der Universitäten Hohenheim und Karlsruhe wollen mit Hilfe von Satelliten, Flugzeugen und einem Zeppelin die Wetterprognosen verbessern.

Projekt-Start im Regen

Die Forscher bekamen genau das, was sie für ihr Projekt die nächsten Wochen unbedingt brauchen: Regen. Zum Auftakt des Projekts ließen sie einen Wetterballon in den Himmel steigen. Ab heute werden die Wissenschaftler aus acht Ländern drei Monate lang die grundlegenden Prozesse, die für Regen verantwortlich sind, untersuchen. Nach Angaben der Universität Hohenheim bei Stuttgart sollen dadurch Niederschläge berechenbarer gemacht werden. "Unser Ziel ist eine neue Generation von Computermodellen für eine detaillierte Wettervorhersage und Klimaprognose", sagte Volker Wulfmeyer von der Hochschule. Extreme Wetterereignisse wie schwere Stürme und Starkregen müssten in Zukunft genauer vorhergesagt werden, so Wulfmeyer weiter. Durch die Verfeinerung der Vorhersage könne beispielsweise auch besser vor Hochwasser gewarnt werden.

Größtes Feldexperiment des Jahrzehnts

Fig. 12.5 COPS headline on the webpage of Südwestrundfunk (SWR).

WELT ONLINE

URL: http://www.welt.de/wissenschaft/article889121/Geheimnisvolle_Sommergewitter.html

22. Mai 2007, 17:13 Uhr VON ELKE BODDERA

METEOROLOGIE

Geheimnisvolle Sommergewitter

Die Frage, wann genau ein Gewitterschauer über dem Freiluftkonzert oder der Grillparty niedergehen wird, bringt Meteorologen immer noch in Verlegenheit. Das könnte sich bald ändern. Präzisere Prognosen sind das Ziel eines der größten meteorologischen Experimente Deutschlands.

Gewitterfront im Allgäu: Die Vorhersage von Regen- und Hagelstürme im Sommer entdecken Wetterdienste meist erst dann, wenn es schon zu spät ist Foto: dpa

Fig. 12.6 COPS headline on the webpage of Welt-Online, a national newspaper. A large article appeared also in the newspaper itself.

Fig. 12.7 Public webpage of COPS at http://cops.uni-hohenheim.de.

Fig. 12.8 Champaigne for the first weather balloon of COPS. Persons on the photograph (left to right): Andreas Behrendt, COPS Coordinator; Schmälzle, Mayor of Seebach; Doll, Mayor of Sasbachwalden; Dieter Rapp, Community of Baiersbronn; Volker Wulfmeier, chair of COPS ISSC.

13 Education

Education was also an important focus of COPS. It was realized that a unique research activity like this is a great opportunity for students for get direct contact to leading scientists in the field, observe state-of-art observing systems including different types of research aircraft, and to enjoy special presentations of several scientists from different countries related to the scientific topics of COPS.

Therefore, a COPS Summer School was organized by the University of Bonn. More than 80 students from Germany and several students from other countries participated in this activities. Talks were given in English, all Supersites, the COPS Operations Center, and Baden Airpark with different COPS aircraft were visited. Generally, the resonance of the students was very positive. Furthermore, IPM combined a practical work in the study course "Agricultural Biology" with about 25 students with visits of the AMF and Supersite H. Figures 11-19 shows the students at the AMF where Volker Wulfmeyer and ARM Chief Scientist Warren Wiscombe are giving presentations.

Also students from schools were involved within the scope of the project in teaching and learning "MiA: Meteorology in Action" of the University of Bremen. During this activity with a duration of one week, classes from towns around Supersite H were invited to visit the station, perform several experiments related to condensation and precipitation, and to launch a weather balloon. The results of this study are currently under investigation. The main hypothesis is that the participation in this practical activity in direct contact with scientists leads to increasing competence of the students in the field of meteorology.

Fig. 11-19. Students and Volker Wulfmeyer (center) at Supersite M with the AMF.

Fig. 11-20. Students and ARM Chief Scientist Warren Wiscombe at the AMF.

Fig. 11-21. Students from schools within the scope of the project in teaching and learning “MiA: Meteorology in Action” of the University of Bremen together with MiA PI Meike Wulfmeyer.

14 IOP Overview

14.1 IOP table and meteorological conditions

During three months, 34 IOPs were performed providing a comprehensive data set covering many different atmospheric conditions. IOP days were categorized as defined above: Air mass convection, weakly forced conditions, or strongly forced conditions. If a mixture of these forcing mechanisms was detected, this was also indicated in the Operations Plans.

Information about the COPS IOPs can be recovered as follows:

The COPS website summarizes under the button “Daily Reports” for each COPS day a Weather Summary (ws + date), an Operations Plan (op + date), and the Facility Status (fs + date). These documents give already a detailed overview about the meteorological conditions and all operations of COPS instrumentation including aircraft missions. The same number of an IOP may cover several days, as long as the same forcing conditions were present during the observation of the chain of events. In this case, the IOPs are counted such as IOP13a, IOP13b, ….

An overview of the IOPs performed during COPS is given in Table 12-1.

The facility status of the instrumentation is summarized in Table 12-2.

Table 12-1. IOPs and SOPs during COPS.

IOP	Begin	End	Scenario	Notes	Convective Development
IOP-1a	05/06/2007 0400 UTC	05/06/2007 2000 UTC	High Pressure Convection	# Surface stations partly available # ground based remote sensing partly available # no aircraft # vertical soundings partly # test sequence for radiosounding at H and R	Isolated diurnally-induced showers capped by an inversion at 600 hPa after 9:30
IOP-1b	06/06/2007 0400 UTC	06/06/2007 2000 UTC	High Pressure Convection	# Surface stations partly available # ground based remote sensing partly available # no aircraft # vertical soundings partly # no radiosondes at H	Isolated diurnally-induced showers after 13:30. Dissappearing inversion. After 16:00, clustered showers moving westward off the SwabianJura.
IOP-1c	07/06/2007 0400 UTC	07/06/2007 2000 UTC	High Pressure Convection	# Surface stations partly available # ground based remote sensing partly available # no aircraft # vertical soundings partly # no radiosondes at H	A few deep surface-based convective showers develop across the southern Black Forest after 14:00.

IOP-1d	08/06/2007 0400 UTC	08/06/2007 2000 UTC	High pressure/forced convection	# Surface stations partly available # ground based remote sensing partly available # no aircraft # vertical soundings partly # no radiosondes at H	Scattered surface-based diurnally-induced showers over the Vosges and central and southern Black Forest.
IOP-2	12/06/2007 0600 UTC	12/06/2007 1800 UTC	Weakly forced diurnal convection	# Surface stations partly available # ground based remote sensing partly available # no aircraft # vertical soundings partly	Isolated weak diurnally-induced showers across the hills/mountains of the southern half of the COPS area after 14:00.
IOP-3a	14/06/2007 0400 UTC	14/06/2007 2000 UTC	Weakly forced diurnal convection	# Surface stations partly available # ground based remote sensing partly available # no aircraft # vertical soundings at Burnhaupt, Achern, Hornisgrinde and FZK # 12 dropup sondes launches at 4 sites	After 9:00 relatively strong storms developing between the Black Forest and Swabian Jura. Between 12:00 and 14:00 weak storms in the Rhine Valley. From 15:30, a small squall-line moving northnortheastward through the Rhine Valley. It expands southeastward in the evening.
IOP-3b	15/06/2007 0400 UTC	15/06/2007 1100 UTC	Forced convection	# Surface stations partly available # ground based remote sensing partly available # planned flight was cancelled # vertical soundings at Burnhaupt, Achern, Hornisgrinde and FZK # drop sonde releases cancelled # IOP finished at 11 UTC	Widespread cloudiness and no convective showers.
IOP-4a	19/06/2007 0600 UTC	19/06/2007 2000 UTC	High pressure convection	# most of surface stations available # ground based remote sensing partly available # Research flights by DO 128 and Enduro # vertical soundings at Achern, Hornisgrinde, FZK and Burnhaupt # no drop sonde release # Doppler on wheels operating at DNE1/5 # IOP finished at 20 UTC	No convective showers. Medium-sized cumulus over the mountains.
IOP-4b	20/06/2007 0500 UTC	20/06/2007 2300 UTC	Forced convection	# most of surface stations available # ground based remote sensing partly available # Research flights by DO 128 and Enduro # vertical soundings at Achern, Hornisgrinde, FZK and Burnhaupt	From 13:30 a few diurnally-induced showers forming over the Vosges and northeastern Black Forest. After 17:00 intensification of Eastern

				# release of 15 dropup sondes # Doppler on wheels operating at DNE1/5 # IOP finished at 23 UTC	Vosges/Rhine-Valley storms and initiation of strong storms east of Freudenstadt and east of Feldberg. More widespread initiation and clustering of storms between the Black Forest and Swabian Jura later in the evening.
IOP-5a	01/07/2007 0400 UTC	01/07/2007 2300 UTC	Forced Convection	# most of surface stations operational # most of ground based remote sensing operational # 3 research flights by DO 128: PreCon HR, PreCon HR, SupDe+Dropping # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Deckenpfronn, Meistratzheim # release of 6 drop sondes by DO 128 # Doppler on wheels operating at site Neuried	Typical synoptically-forced set-up with southwesterly flow of moist, warm air. However, convective initiation failure during daytime. Abundant mid- and upper-level cloudiness. Some strong storms form to the NW of the COPS area in the evening, but only weak showers occur in the COPS area.
IOP-5b	02/07/2007 0500 UTC	02/07/2007 0500 UTC	Forced Convection	# most of surface stations operational # most of ground based remote sensing systems operational # 2 research flights by DO 128: SupDe HR, SupDe HR + Dropping (3 sondes) # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Deckenpfronn, Meistratzheim # release of 11 dropup sondes on 3 stations (29, 41, 47) # Doppler on Wheels operating at site Neuried	Behind frontal cloudiness over the eastern part of the COPS area, storms develop within a polar airmass after 9:00, that become more intense during the day and organize linearly.
IOP-6	04/07/2007 0500 UTC	04/07/2007 2100 UTC	Post-frontal Cold Air Convection	# most of surface stations operational # most of ground based remote sensing systems operational # no aircraft # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt (also on Day X-1: 20, 23 UTC), Meistratzheim # no dropup sondes # Doppler on Wheels operating at site Neuried	Stratocumulus fields present at sunrise develop into cumulus and shallow showers during the day.

IOP-7a	08/07/2007 0400 UTC	09/07/2007 0000 UTC	Forced Convection	# most of surface stations operational # most of ground based remote sensing systems operational # DLR Falcon performing ETReC mission upstream of the COPS area # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Deckenpfronn, Meistratzheim # no dropup sondes # Doppler on Wheels operating at site Neuried	Passage of a partially convective precipitation system between 09:00-14:00 over the southeastern half of the COPS region. New partly convective precipitation areas move in after 15:00 from the southwest. Another large system affects the northwestern half after 21:00.
IOP-7b	09/07/2007 0000 UTC	09/07/2007 1800 UTC	Forced Convection	# most of surface stations operational # most of ground based remote sensing systems operational # 2 research flights by DO 128: SupDe HR, SupDe HR + Dropping (4 sondes) # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Deckenpfronn, Meistratzheim # no dropup sondes # Doppler on Wheels operating at site Neuried	In the wake of a large area of clouds and precipitation, development of isolated weak showers across the COPS area, but not near the supersites.
SOP-1a	12/07/2007 0500 UTC	12/07/2007 0700 UTC	EUFAR related	# 1 EUFAR research flight by Partenavia (stratocumulus)	
IOP-8a	14/07/2007 0515 UTC	14/07/2007 1830 UTC	High-pressure convection	# most of surface stations operational # most of ground based remote sensing systems operational # 3 research flights by DO 128, 1 flight by SAFIRE Falcon + Dropping (2 Sondes) # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Deckenpfronn, Meistratzheim # no dropup sondes # Doppler on Wheels operating at site Fessenheim near Freiburg	A few cumulus clouds developed over the NE parts of the COPS area in response to the diurnal cycle. No showers.
IOP-8b	15/07/2007 0500 UTC	15/07/2007 1830 UTC	High-pressure convection	# most of surface stations operational # most of ground based remote sensing systems operational # 2 research flights by DO 128, 2 flights by SAFIRE Falcon, 1 flight by DLR Falcon (stopped earlier due to instrument problems), 1 FAAM BAe flight # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Deckenpfronn, Meistratzheim # no dropup sondes # Doppler on Wheels operating at site	Within otherwise nearly cloud-free skies, an isolated line of towering cumulus clouds developed east of the Black Forest. From this line, one shower developed south of Freudenstadt around 14:00.

				Fessenheim near Freiburg	
SOP-1	16/07/2007 0500 UTC	16/07/2007 0900 UTC	EU-FAR related	# EUFAR water vapor intercomparison # Lidar and Radar operations active from 0500 to 0900 UTC # 1 research flight by SAFIRE Falcon (water vapor mapping), 1 research flight by DO 128 (profiling over all Supersites) # 1 research flight FAAM BAe (afternoon) # 2 vertical soundings at Hornisgrinde and Achern, 1 at Meistratzheim and Deckenpfronn # Doppler on Wheels operating at site Neuried	
IOP-9a	18/07/2007 0800 UTC	18/07/2007 2000 UTC	Forced Convection	# most of surface stations operational # most of ground based remote sensing systems operational # 1 research flights by DO 128, 1 flights by SAFIRE Falcon, 1 flight by DLR Falcon, 1 FAAM BAe flight # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Deckenpfronn, Meistratzheim # no dropup sondes # Doppler on Wheels operating at site Neuried	After cloudiness and precipitation move out of the COPS area, a few short-lived surface-based convective storms initiate east of the Vosges mountains around 17:00.
IOP-9b	19/07/2007 0600 UTC	19/07/2007 1800 UTC	Forced Convection	# most of surface stations operational # most of ground based remote sensing systems operational # 1 research flight by DO 128 (MAP pattern), 1 flight by SAFIRE Falcon, 1 FAAM BAe flight # DLR Falcon performing ETReC mission upstream of the COPS area # 1 Learjet flight sampling convective outflow east of the COPS region # 1 afternoon Enduro flight # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Meistratzheim # no dropup sondes # Doppler on Wheels operating at site Neuried	A weakening MCS moved north-northeastward over the north-western COPS region between 7:00 and 10:00. Later, the remainder of the COPS area is also affected by partially convective precipitation. After clearing during the second half of the afternoon, one new surface-based storm develops downstream of the Kaiserstuhl at 19:00.

IOP-9c	20/07/2007 0500 UTC	20/07/2007 2000 UTC	Forced Con-vection	# most of surface stations operational # most of ground based remote sensing systems operational # 2 research flights by DO 128 (PreCon-HR and SupDe-HR+dropping), 1 flight by SAFIRE Falcon (MAP pattern+dropping), 2 flights by DLR Falcon (MAP pattern, convective activity) # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Deckenpfonn, Meistratzheim # 12 dropup sondes # Doppler on Wheels operating at site Neuried	An weakening old MCS enters the COPS area in the early morning from the southwest. As the evaporatively-cooled air moves over the Black Forest, new cells develop over the northern and eastern Black forest. A very intense and long-lived cell moves northeastward just north of the Swabian Jura range.
SOP 2	21/07/2007 0600 UTC	21/07/2007 1600 UTC	EU-FAR related	# EUFAR missions # 1 EUFAR research flight by SAFIRE ATR42, 1 EUFAR research flight by Partenavia # Transfer flight of the Zeppelin NT from Friedrichshafen to Baden-Airpark	
SOP-3	22/07/2007 0700 UTC	22/07/2007 1700 UTC	EU-FAR + TRACKS	# EUFAR and TRACKS missions # 1 EUFAR research flight by Partenavia (stratocumulus) # Dimona and Ultralight flights in the Rhine valley south of Baden-Airpark	
IOP-10	23/07/2007 0500 UTC	23/07/2007 1800 UTC	Forced Convection, TRACKS, EU-FAR	# COPS, EUFAR and TRACKS missions # most of surface stations operational # most of ground based remote sensing systems operational # 1 EUFAR research flight by ATR42 (OSMOC) # Dimona, Zeppelin NT, Ultralight flights in the Murg valley including vertical profiles # 1 DO 128 research flight (SupDe-HR) # vertical soundings at Achern, Hornisgrinde, Meistratzheim # 2 Doppler on Wheels operating at the eastern and western side of the Black Forest region	A large area of precipitation with a number of embedded convective zones crosses the COPS area during the second half of the afternoon and lingers on well into the evening across the Swabian Jura.
SOP-4	24/07/2007 0600 UTC	24/07/2007 1800 UTC	EU-FAR + BAe mis-sion	EUFAR missions and BAe flight # 1 EUFAR research flight by Partenavia (stratocumulus) # 1 EUFAR research flight by ATR42 (OSMOC) # 1 FAAM BAe research flight # vertical soundings at Achern, Meistratzheim	

IOP-11a	25/07/2007 0600 UTC	25/07/2007 1800 UTC	High-Pressure Convection + EU-FAR	# most of surface stations operational # most of ground based remote sensing systems operational # Lidar operations until 2300 UTC in support of EUFAR H2O mission # 2 research flights by DO 128 (FLUX pattern, Lagrange), 2 flights by SAFIRE Falcon (MAP, EUFAR H2O LIDAR), 1 flight by DLR Falcon (FLUX), 1 FAAM BAe flight, Zeppelin, Dimona, Ultralight # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Deckenpfronn, Meistratzheim # hourly tethersonde soundings starting at 0800 UTC in Freiburg # no dropup sondes # Doppler on Wheels operating at site Neuried and DNE8 (failure of DOW at DNE8 after 1100 UTC)	Cumulus developed under a strong inversion at 2500-3000 m, mostly over the mountains.
IOP-11b	26/07/2007 0500 UTC	26/07/2007 1700 UTC	High-Pressure Convection	# most of surface stations operational # most of ground based remote sensing systems operational # 2 research flights by DO 128 (FLUX pattern, Chaff experiment), 1 flight by SAFIRE Falcon (MAP+droppings), 1 flight by DLR Falcon (FLUX), 1 FAAM BAe flight, Dimona (EUFAR), Ultralight (morning TRACKS mission) # vertical soundings at Achern, Hornisgrinde, FZK, Burnhaupt, Meistratzheim # hourly tethersonde soundings until 1630 UTC in Freiburg # no dropup sondes # Doppler on Wheels operating at site Neuried	A little bit of cumulus and some chaff-echoes.
SOP-5	28/07/2007 0900 UTC	28/07/2007 1400 UTC	EU-FAR related	# 2 EUFAR research flight by ATR42 (OSMOC) # EUFAR supporting ground based remote sensing observations	
IOP-12	30/07/2007 0800 UTC	30/07/2007 1800 UTC		# most of surface stations operational # most of ground based remote sensing systems operational # 1 research flights by DO 128 (FLUX pattern, Chaff release), 1 flight by SAFIRE Falcon (MAP), 1 flight by DLR Falcon (FLUX) # vertical soundings at Achern, Meistratzheim # Doppler on Wheels operating at site Neuried (DNW5) and DNE8	Some small cumulus clouds developed.

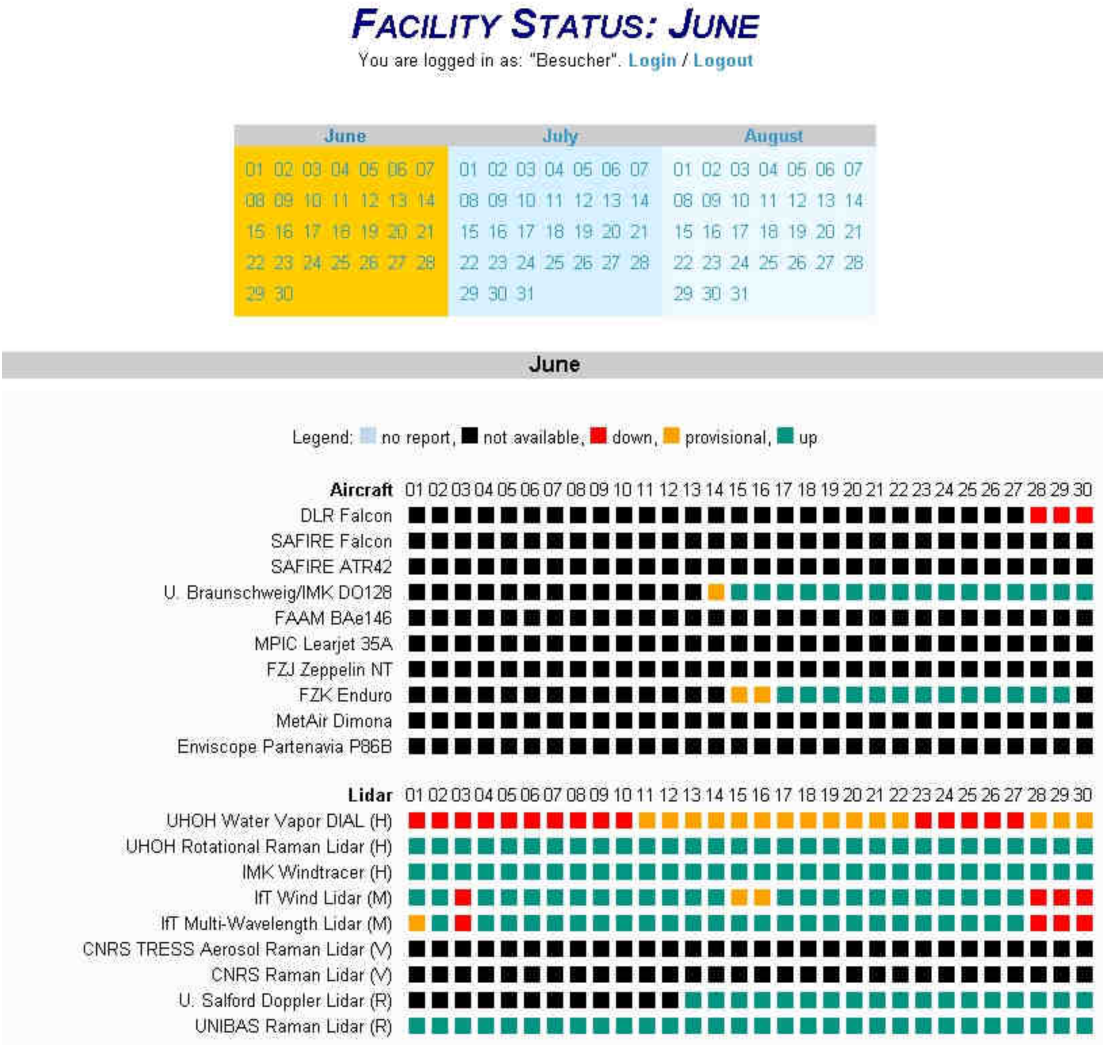
SOP-6	31/07/2007 1900 UTC	31/07/2007 2200 UTC	EU-FAR related	# 1 EUFAR research flight by SAFIRE Falcon, 1900 – 2200 UTC reduced MAP pattern for Lidar intercomparison # EUFAR supporting ground based remote sensing observations # Extra radiosondes launches during the time of the aircraft operation from supersites H, R, and V.	
IOP-13a	01/08/2007 0415 UTC	01/08/2007 2000 UTC	High-pressure convection	# most of surface stations operational # most of ground based remote sensing systems operational # 2 flights by SAFIRE Falcon (MAP), 2 flights by DLR Falcon (targetted mission to Spain, extended leg into France) # vertical soundings at Achern, Hornisgrinde, FZK and Burnhaupt # Doppler on Wheels: no operations, relocation at site Neuried (DNW5) and Oberiflingen (DNE8)	Cloud-free weather under a ridge.
IOP-13b	02/08/2007 0000 UTC	03/08/2007 0300 UTC	Forced Convection	# most of surface stations operational # most of ground based remote sensing systems operational # no aircraft # vertical soundings at Achern, Hornisgrinde, FZK and Burnhaupt # 13 dropup sondes launches at 3 sites (station no: 15, 41, 47) # Doppler on Wheels operating at site Neuried (DNW5) and Oberiflingen (DNE8) starting from 00 UTC # DLR Poldirad operating until 03 UTC the next day	After the passage of an extensive deck of mostly high clouds cool, weakly unstable airflows in from the west. Within this airmass storms develop around 11:30 along a line that initially stretches from Karlsruhe to the central Vosges. More storms develop as this line moves southeastward.
IOP-14a	06/08/2007 1100 UTC	07/08/2007 1800 UTC		# most of surface stations operational # most of ground based remote sensing systems operational # no aircraft # vertical soundings at Achern, Hornisgrinde and Deckenpfronn # Doppler on Wheels operating at site DSW4 (Fessenheim) and DSW2 (Ohnenheim) in the southern side of the COPS area starting at 03 UTC # DLR Poldirad operating from 03 UTC until 18 UTC	Some storms entered the Vosges mountains from the west after 13:30. Convective initiation along the eastern flanks of the Vosges around 16:00. The storms weaken after 17:30 when in the Rhine Valley. A few storms form southeast of the Swabian Jura, too. A small storm system forms 30 km east of Freudenstadt around 16:30 and moves southeastward. The

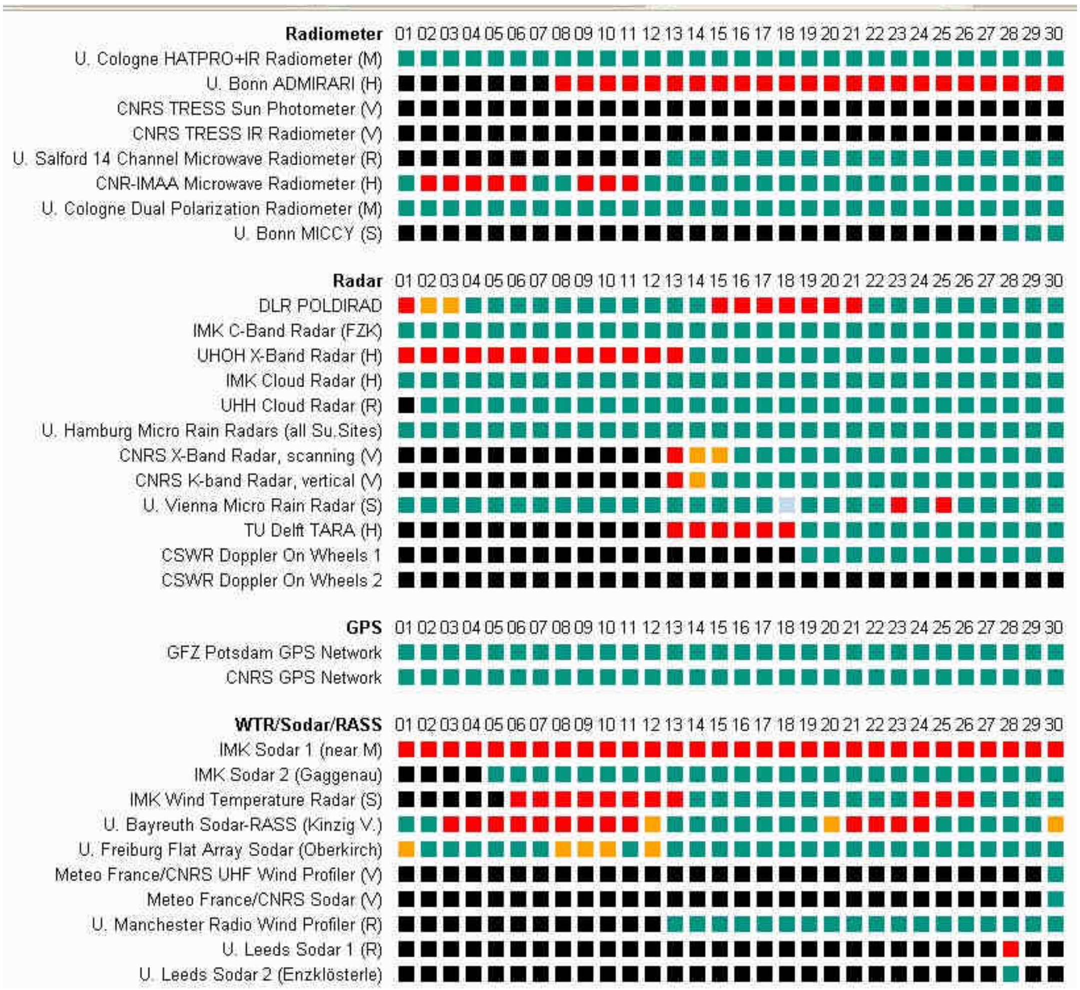
					convection gradually ceases after 18:00, before starting again after 21:30 over the central Black Forest and later the Rhine Valley and eastern Vosges. A large area of elevated precipitation overspreads the Rhine Valley and eastern Vosges from the south during the second half of the night and early morning. The rest of the 7th of August is cloudy with some local rain.
IOP-14b	08/08/2007 0500 UTC	08/08/2007 2100 UTC		# most of surface stations operational # most of ground based remote sensing systems operational # no aircraft # vertical soundings at FZK, Burnhaupt, Achern, Hornisgrinde and Deckenpfronn # no Lidar operations # Doppler on Wheels not operating # DLR Poldirad: standard daytime measurements	Widespread high clouds and stratocumulus between an old MCS is the north and large precipitation system over Switzerland and, later, the SE parts of COPS. One shower initiates in the northeastern Vosges.
IOP-14c	09/08/2007 0700 UTC	09/08/2007 1800 UTC		# IOP addressing heavy precipitation event, only reduced operations required in the COPS area # no aircraft # vertical soundings at Achern # 3-4 launches with IMK Dropup-Sondes and FLYPS between 12 and 16 LT at Supersite H # no Lidar operations # Doppler on Wheels not operating # DLR Poldirad: standard daytime measurements	Southern and central parts of the COPS region are under an area of rain in the early morning. During the mid-morning and early afternoon two new rain areas move from east to west over the COPS area, before the rain ceases for a longer time.
IOP-15a	12/08/2007 0400 UTC	12/08/2007 2100 UTC	High Pressure Convection	# most of surface stations operational # most of ground based remote sensing systems operational # no aircraft # vertical soundings at Achern, Hornisgrinde and Deckenpfronn # Doppler on Wheels operating at DNW3 (Hohbühn) and DNE6 (Hallwangen)	Storm initiation over the eastern Black Forest and Swabian Jura between 16:00 and 19:00. A single storm also formed over the northern Vosges.

IOP-15b	13/08/2007 0400 UTC	13/08/2007 1800 UTC	High Pressure/Weakly Forced Convection	# most of surface stations operational # most of ground based remote sensing systems operational # no aircraft # vertical soundings at Achern, Hornisgrinde, FZK and Deckenpfronn # 15 dropup sondes launches at 4 sites (08 Kniebis, 32 Oberreichenbach, 41 Durrweiler, 64 Hopfau) # Doppler on Wheels operating at DNW3 (Hohbühn) and DNE8 (Oberiflingen)	Behind a partly convective rain system that passed in the previous night, an upper-level shortwave trough passes the COPS area around noon. A few showers form in the relatively clear air ahead of and near the trough. The two most significant storms formed just east of the northern Vosges and moved across the Rhine Valley eastward into the northern Black Forest. Other showers formed south-west and south of Stuttgart.
IOP-16	15/08/2007 0830 UTC	16/08/2007 0800 UTC	Forced Convection	# most of surface stations operational # most of ground based remote sensing systems operational # 1 FAAM BAe 146 flight (1200 UTC - 1630 UTC) # vertical soundings at Achern, Hornisgrinde, FZK and Deckenpfronn # DLR Poldirad operating throughout the night	The instability remained capped for most of the day - longer than forecast- and only one surface-based, possibly rotating storm crossed the far NW of the COPS area in the evening. Later in the evening, elevated convection approached from the west.
SOP-7	17/08/2007 0800 UTC	17/08/2007 1600 UTC	FAAM BAe mission	# 1 FAAM BAe 146 flight (09 UTC - 14 UTC) # vertical soundings at Achern and Hornisgrinde (08, 11, 14 UTC) # supporting ground based remote sensing observations	
IOP-17a	21/08/2007 0700 UTC	22/08/2007 0000 UTC	Weakly-Forced Convection	# most of available surface stations operational # most of available ground based remote sensing systems operational # no aircraft available # vertical soundings at Achern, Hornisgrinde and Deckenpfronn # DLR Poldirad operating throughout the night	In the evening, two small showers form over the northern Vosges and one in the Rhine Valey near Strasbourg within an area of rather high mid- and upper-level clouds.
IOP-17b	22/08/2007 0700 UTC	22/08/2007 1600 UTC	Weakly-forced Convection	# most of available surface stations operational # most of available ground based remote sensing systems operational # 1 FAAM BAe 146 flight (1200	Ahead of extensive mid- and upper clouds over France, towering cumulus developed over the

				UTC - 1530 UTC) # vertical soundings at Achern, Hornisgrinde and Deckenpfronn	northern Black Forest in the morning and early afternoon.
IOP-18a	24/08/2007 0500 UTC	24/08/2007 1800 UTC	High Pressure Convection	# most of available surface stations operational # most of available ground based remote sensing systems operational # 1 FAAM BAe 146 flight (1000 UTC - 1410 UTC) # vertical soundings at Achern, Hornisgrinde and Deckenpfronn	Towering cumulus formed over the mountains, mostly the Vosges and Black Forest, and spreaded out agains an inversion while forming stratocumulus. All in all a few very weak showers were produced.
IOP-18b	25/08/2007 0500 UTC	27/08/2007 1800 UTC	High Pressure Convection	# most of available surface stations operational # most of available ground based remote sensing systems operational # no aircraft available # vertical soundings at Achern, Hornisgrinde and Deckenpfronn	Towering cumulus formed over the mountains, mostly the Vosges and Black Forest,but no showers were detected within the COPS area.
SOP-8	29/08/2007 0800 UTC	29/08/2007 1700 UTC	FAAM BAe mission	# 1 FAAM BAe 146 flight (0845 UTC - 1430 UTC) # vertical soundings at Achern, Hornisgrinde and Deckenpfronn # supporting ground-based remote sensing observations	Rain, partly convective, belonging to a frontal zone feel over central and southern parts of the COPS area.

Table 12-2. COPS facility status June 2007..




Radiometer
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
U. Cologne HATPRO+IR Radiometer (M)
U. Bonn ADMIRARI (H)
CNRS TRESS Sun Photometer (V)
CNRS TRESS IR Radiometer (V)
U. Salford 14 Channel Microwave Radiometer (R)
CNR-IMAA Microwave Radiometer (H)
U. Cologne Dual Polarization Radiometer (M)
U. Bonn MICCY (S)
Radar
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
DLR POLDIRAD
IMK C-Band Radar (FZK)
UHOH X-Band Radar (H)
IMK Cloud Radar (H)
UHH Cloud Radar (R)
U. Hamburg Micro Rain Radars (all Su.Sites)
CNRS X-Band Radar, scanning (V)
CNRS K-band Radar, vertical (V)
U. Vienna Micro Rain Radar (S)
TU Delft TARA (H)
CSWR Doppler On Wheels 1
CSWR Doppler On Wheels 2
GPS
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
GFZ Potsdam GPS Network
CNRS GPS Network
WTR/Sodar/RASS
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
IMK Sodar 1 (near M)
IMK Sodar 2 (Gaggenau)
IMK Wind Temperature Radar (S)
U. Bayreuth Sodar-RASS (Kinzig V.)
U. Freiburg Flat Array Sodar (Oberkirch)
Meteo France/CNRS UHF Wind Profiler (V)
Meteo France/CNRS Sodar (V)
U. Manchester Radio Wind Profiler (R)
U. Leeds Sodar 1 (R)
U. Leeds Sodar 2 (Enzklösterle)

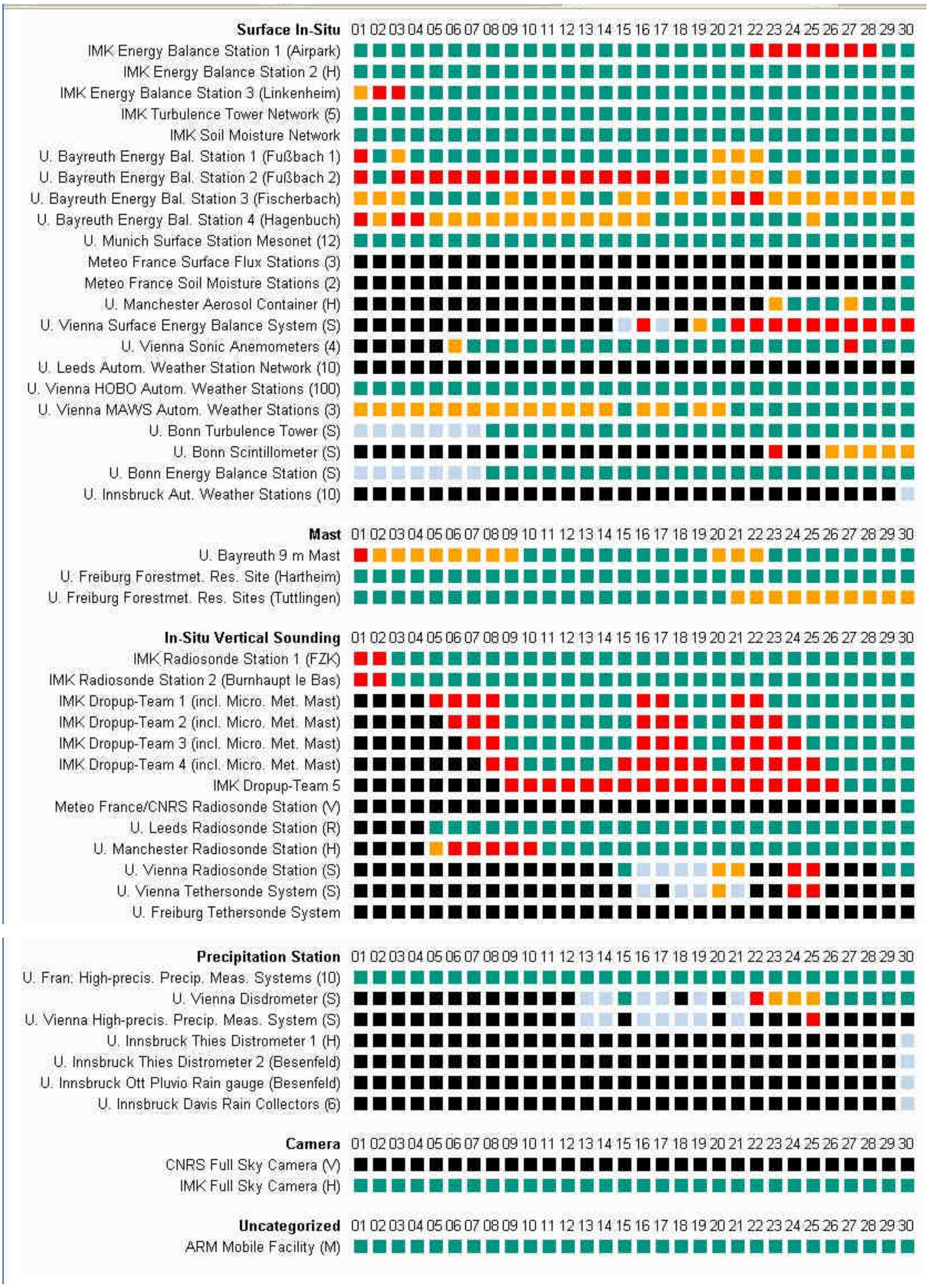
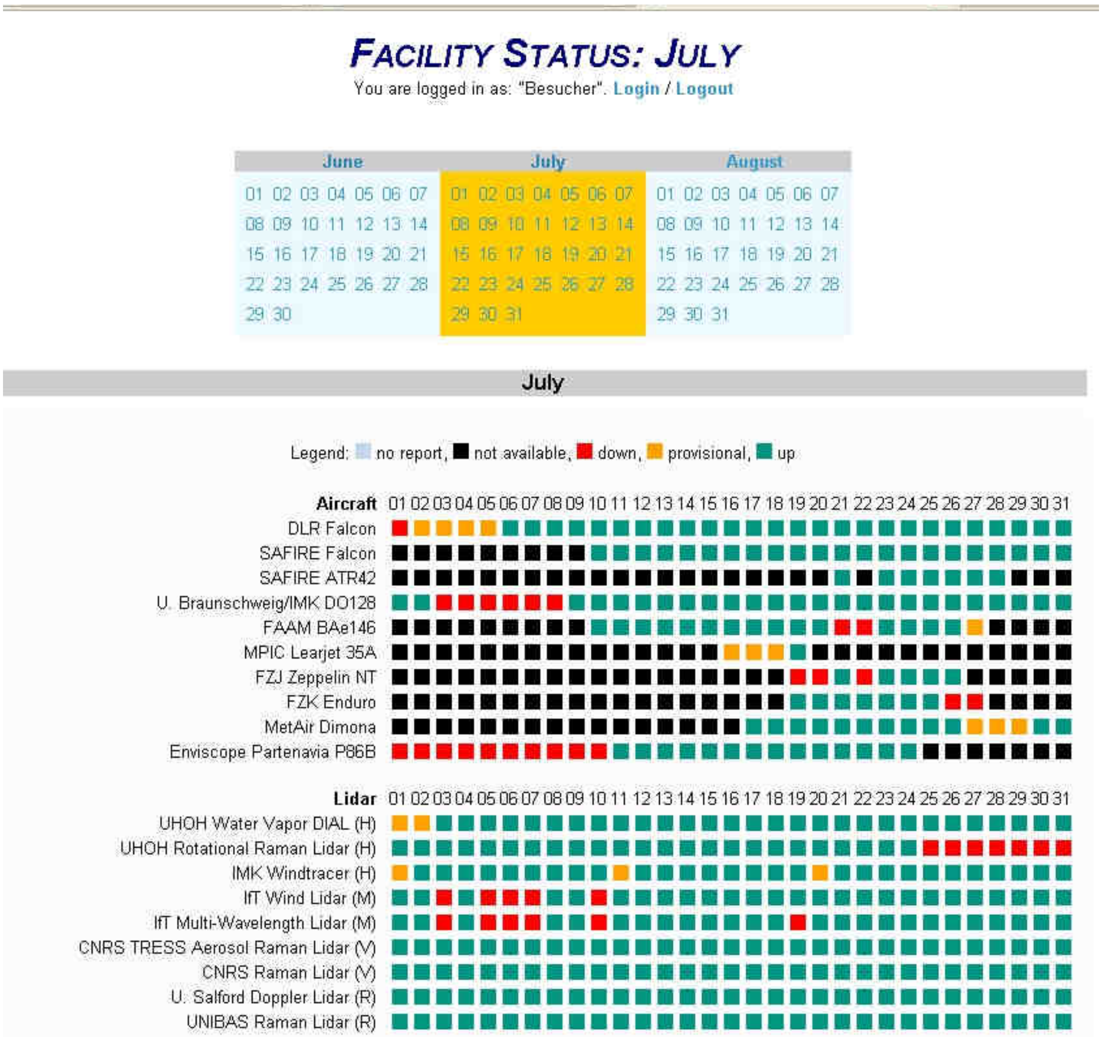
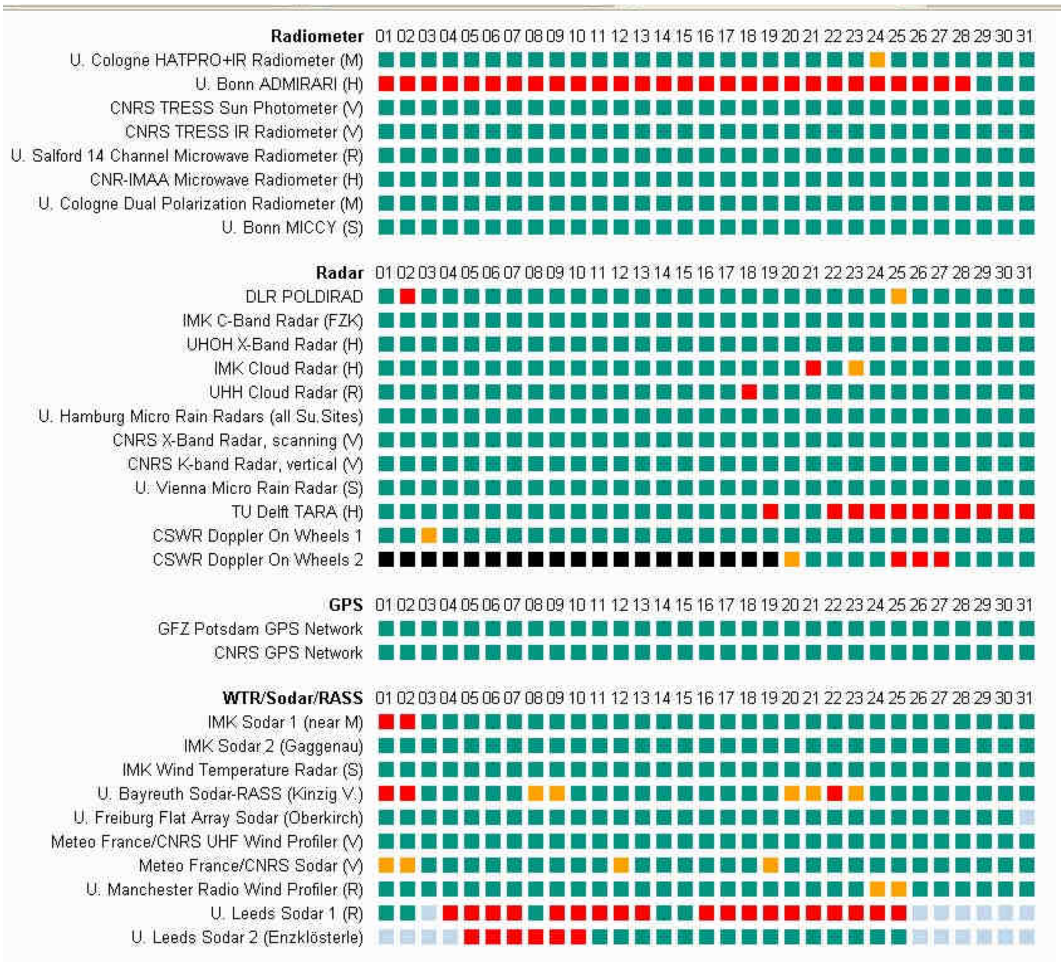

Surface In-Situ
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
IMK Energy Balance Station 1 (Airpark)
IMK Energy Balance Station 2 (H)
IMK Energy Balance Station 3 (Linkenheim)
IMK Turbulence Tower Network (5)
IMK Soil Moisture Network
U. Bayreuth Energy Bal. Station 1 (Fußbach 1)
U. Bayreuth Energy Bal. Station 2 (Fußbach 2)
U. Bayreuth Energy Bal. Station 3 (Fischerbach)
U. Bayreuth Energy Bal. Station 4 (Hagenbuch)
U. Munich Surface Station Mesonet (12)
Meteo France Surface Flux Stations (3)
Meteo France Soil Moisture Stations (2)
U. Manchester Aerosol Container (H)
U. Vienna Surface Energy Balance System (S)
U. Vienna Sonic Anemometers (4)
U. Leeds Autom. Weather Station Network (10)
U. Vienna HOBO Autom. Weather Stations (100)
U. Vienna MAWS Autom. Weather Stations (3)
U. Bonn Turbulence Tower (S)
U. Bonn Scintillometer (S)
U. Bonn Energy Balance Station (S)
U. Innsbruck Aut. Weather Stations (10)
Mast
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
U. Bayreuth 9 m Mast
U. Freiburg Forestmet. Res. Site (Hartheim)
U. Freiburg Forestmet. Res. Sites (Tuttlingen)
In-Situ Vertical Sounding
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
IMK Radiosonde Station 1 (FZK)
IMK Radiosonde Station 2 (Burnhaupt le Bas)
IMK Dropup-Team 1 (incl. Micro. Met. Mast)
IMK Dropup-Team 2 (incl. Micro. Met. Mast)
IMK Dropup-Team 3 (incl. Micro. Met. Mast)
IMK Dropup-Team 4 (incl. Micro. Met. Mast)
IMK Dropup-Team 5
Meteo France/CNRS Radiosonde Station (V)
U. Leeds Radiosonde Station (R)
U. Manchester Radiosonde Station (H)
U. Vienna Radiosonde Station (S)
U. Vienna Tethersonde System (S)
U. Freiburg Tethersonde System
Precipitation Station
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
U. Fran. High-precis. Precip. Meas. Systems (10)
U. Vienna Disdrometer (S)
U. Vienna High-precis. Precip. Meas. System (S)
U. Innsbruck Thies Distrometer 1 (H)
U. Innsbruck Thies Distrometer 2 (Besenfeld)
U. Innsbruck Ott Pluvio Rain gauge (Besenfeld)
U. Innsbruck Davis Rain Collectors (6)
Camera
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
CNRS Full Sky Camera (V)
IMK Full Sky Camera (H)
Uncategorized
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
ARM Mobile Facility (M)

Table 12-3. COPS facility status July 2007..




Radiometer
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
U. Cologne HATPRO+IR Radiometer (M)
U. Bonn ADMIRARI (H)
CNRS TRESS Sun Photometer (V)
CNRS TRESS IR Radiometer (V)
U. Salford 14 Channel Microwave Radiometer (R)
CNR-IMAA Microwave Radiometer (H)
U. Cologne Dual Polarization Radiometer (M)
U. Bonn MICCY (S)
Radar
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DLR POLDIRAD
IMK C-Band Radar (FZK)
UHOH X-Band Radar (H)
IMK Cloud Radar (H)
UHH Cloud Radar (R)
U. Hamburg Micro Rain Radars (all Su.Sites)
CNRS X-Band Radar, scanning (V)
CNRS K-band Radar, vertical (V)
U. Vienna Micro Rain Radar (S)
TU Delft TARA (H)
CSWR Doppler On Wheels 1
CSWR Doppler On Wheels 2
GPS
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
GFZ Potsdam GPS Network
CNRS GPS Network
WTR/Sodar/RASS
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
IMK Sodar 1 (near M)
IMK Sodar 2 (Gaggenau)
IMK Wind Temperature Radar (S)
U. Bayreuth Sodar-RASS (Kinzig V.)
U. Freiburg Flat Array Sodar (Oberkirch)
Meteo France/CNRS UHF Wind Profiler (V)
Meteo France/CNRS Sodar (V)
U. Manchester Radio Wind Profiler (R)
U. Leeds Sodar 1 (R)
U. Leeds Sodar 2 (Enzklösterle)

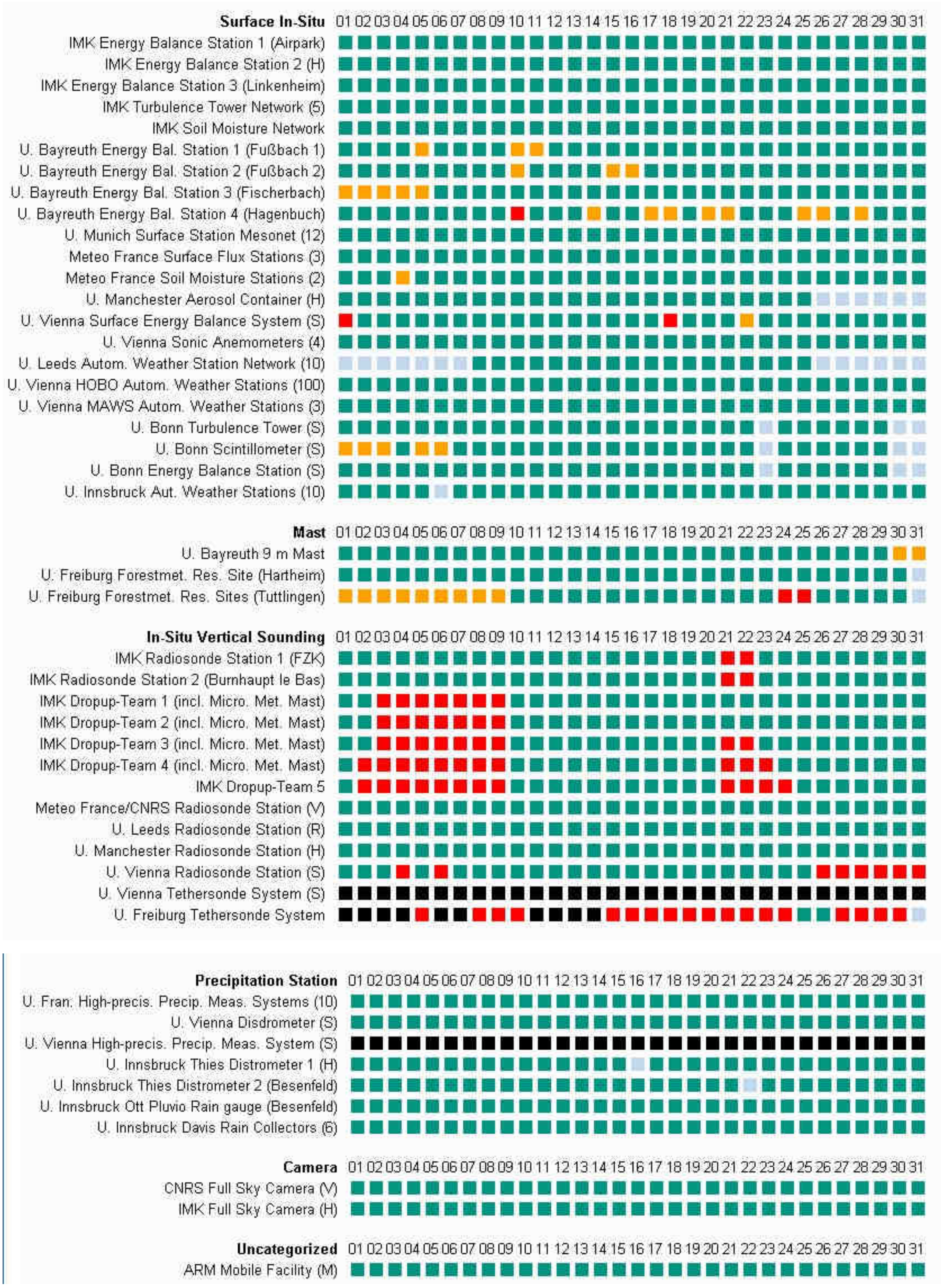
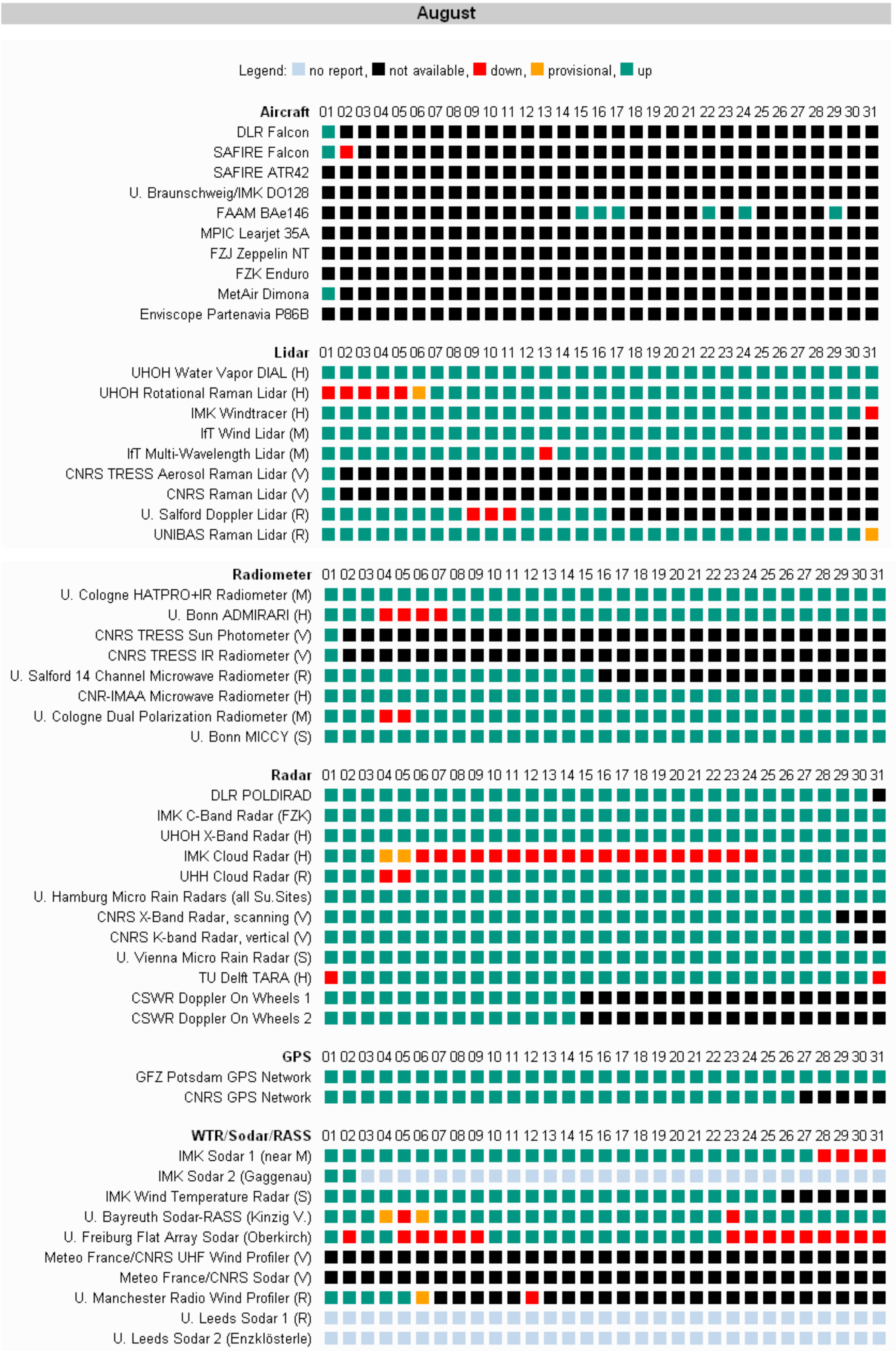

Surface In-Situ
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
IMK Energy Balance Station 1 (Airpark)
IMK Energy Balance Station 2 (H)
IMK Energy Balance Station 3 (Linkenheim)
IMK Turbulence Tower Network (5)
IMK Soil Moisture Network
U. Bayreuth Energy Bal. Station 1 (Fußbach 1)
U. Bayreuth Energy Bal. Station 2 (Fußbach 2)
U. Bayreuth Energy Bal. Station 3 (Fischerbach)
U. Bayreuth Energy Bal. Station 4 (Hagenbuch)
U. Munich Surface Station Mesonet (12)
Meteo France Surface Flux Stations (3)
Meteo France Soil Moisture Stations (2)
U. Manchester Aerosol Container (H)
U. Vienna Surface Energy Balance System (S)
U. Vienna Sonic Anemometers (4)
U. Leeds Autom. Weather Station Network (10)
U. Vienna HOBO Autom. Weather Stations (100)
U. Vienna MAWS Autom. Weather Stations (3)
U. Bonn Turbulence Tower (S)
U. Bonn Scintillometer (S)
U. Bonn Energy Balance Station (S)
U. Innsbruck Aut. Weather Stations (10)
Mast
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
U. Bayreuth 9 m Mast
U. Freiburg Forestmet. Res. Site (Hartheim)
U. Freiburg Forestmet. Res. Sites (Tuttlingen)
In-Situ Vertical Sounding
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
IMK Radiosonde Station 1 (FZK)
IMK Radiosonde Station 2 (Burnhaupt le Bas)
IMK Dropup-Team 1 (incl. Micro. Met. Mast)
IMK Dropup-Team 2 (incl. Micro. Met. Mast)
IMK Dropup-Team 3 (incl. Micro. Met. Mast)
IMK Dropup-Team 4 (incl. Micro. Met. Mast)
IMK Dropup-Team 5
Meteo France/CNRS Radiosonde Station (V)
U. Leeds Radiosonde Station (R)
U. Manchester Radiosonde Station (H)
U. Vienna Radiosonde Station (S)
U. Vienna Tethersonde System (S)
U. Freiburg Tethersonde System
Precipitation Station
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
U. Fran. High-precis. Precip. Meas. Systems (10)
U. Vienna Disdrometer (S)
U. Vienna High-precis. Precip. Meas. System (S)
U. Innsbruck Thies Distrometer 1 (H)
U. Innsbruck Thies Distrometer 2 (Besenfeld)
U. Innsbruck Ott Pluvio Rain gauge (Besenfeld)
U. Innsbruck Davis Rain Collectors (6)
Camera
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
CNRS Full Sky Camera (V)
IMK Full Sky Camera (H)
Uncategorized
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
ARM Mobile Facility (M)

Table 12-3. COPS facility status August 2007..



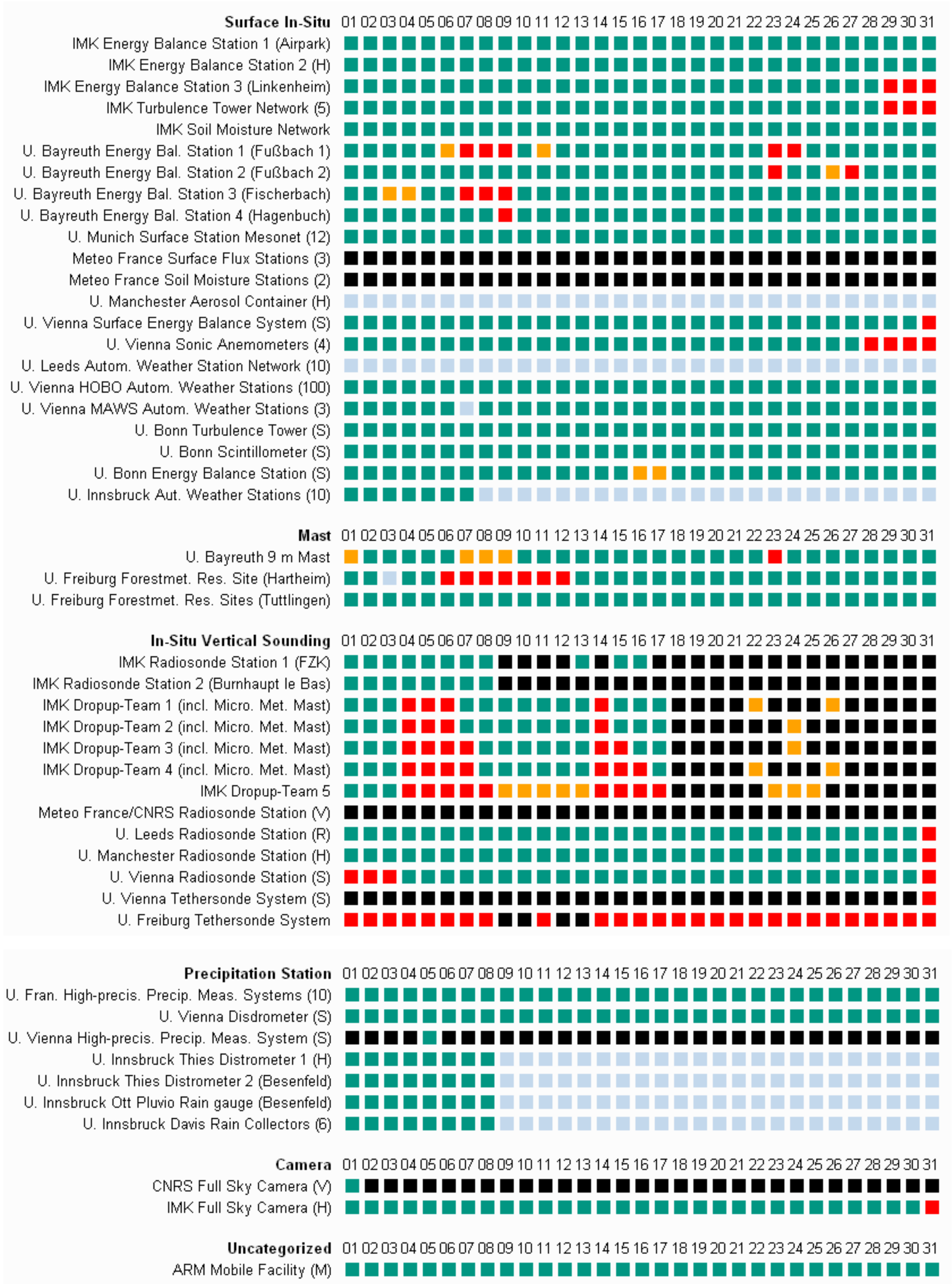

Surface In-Situ
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
IMK Energy Balance Station 1 (Airpark)
IMK Energy Balance Station 2 (H)
IMK Energy Balance Station 3 (Linkenheim)
IMK Turbulence Tower Network (5)
IMK Soil Moisture Network
U. Bayreuth Energy Bal. Station 1 (Fußbach 1)
U. Bayreuth Energy Bal. Station 2 (Fußbach 2)
U. Bayreuth Energy Bal. Station 3 (Fischerbach)
U. Bayreuth Energy Bal. Station 4 (Hagenbuch)
U. Munich Surface Station Mesonet (12)
Meteo France Surface Flux Stations (3)
Meteo France Soil Moisture Stations (2)
U. Manchester Aerosol Container (H)
U. Vienna Surface Energy Balance System (S)
U. Vienna Sonic Anemometers (4)
U. Leeds Autom. Weather Station Network (10)
U. Vienna HOBO Autom. Weather Stations (100)
U. Vienna MAWS Autom. Weather Stations (3)
U. Bonn Turbulence Tower (S)
U. Bonn Scintillometer (S)
U. Bonn Energy Balance Station (S)
U. Innsbruck Aut. Weather Stations (10)
Mast
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
U. Bayreuth 9 m Mast
U. Freiburg Forestmet. Res. Site (Hartheim)
U. Freiburg Forestmet. Res. Sites (Tuttlingen)
In-Situ Vertical Sounding
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
IMK Radiosonde Station 1 (FZK)
IMK Radiosonde Station 2 (Burnhaupt le Bas)
IMK Dropup-Team 1 (incl. Micro. Met. Mast)
IMK Dropup-Team 2 (incl. Micro. Met. Mast)
IMK Dropup-Team 3 (incl. Micro. Met. Mast)
IMK Dropup-Team 4 (incl. Micro. Met. Mast)
IMK Dropup-Team 5
Meteo France/CNRS Radiosonde Station (V)
U. Leeds Radiosonde Station (R)
U. Manchester Radiosonde Station (H)
U. Vienna Radiosonde Station (S)
U. Vienna Tethersonde System (S)
U. Freiburg Tethersonde System
Precipitation Station
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
U. Fran. High-precis. Precip. Meas. Systems (10)
U. Vienna Disdrometer (S)
U. Vienna High-precis. Precip. Meas. System (S)
U. Innsbruck Thies Distrometer 1 (H)
U. Innsbruck Thies Distrometer 2 (Besenfeld)
U. Innsbruck Ott Pluvio Rain gauge (Besenfeld)
U. Innsbruck Davis Rain Collectors (6)
Camera
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
CNRS Full Sky Camera (V)
IMK Full Sky Camera (H)
Uncategorized
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
ARM Mobile Facility (M)

Table 14.1 Operation of the remote sensing instruments suitable for CI studies during the COPS field phase (marked yellow and by x) in **June 2007**. Blue: lidars, orange: radars, magenta: microwave radiometers. The COPS Intensive Operation Periods (IOPs) given with red numbers. The number of CI events in the COPS region is taken from Aoshima 2007.

	June																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
IOP					1a	1b	1c	1d				2		3a	3b				4a	4b										
No. of CI events					5	6	6	18				4		*	*				*	*										
Airborne														* no MSG rapid scan data available on this day																
DLR DIAL																														
Leandre2																														
Mobile																														
DOW1																			x	x	x	x	x	x	x	x	x	x	x	x
DOW2																														
SuSiH																														
WV DIAL																			x											x
RRL					x	x	x	x			x	x		x	x				x	x					x					x
Windtracer	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CloudRadar	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
TARA																			x	x	x	x	x	x	x	x	x	x	x	x
CNR MWR	x						x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SuSiR																														
BASIL																														
Doppler Lidar													x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CloudRadar		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MWR													x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SuSiM																														
BERTHA			x	x	x	x		x			x	x	x	x				x	x	x										x
WiLi		x	x	x	x	x	x							x					x	x										x
MPL	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CloudRadar	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HATPRO	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SuSiV																														
TRESS																														
CNRS RL																														
SuSiS																														
Ceilometer																														
WTR														x	x	x	x	x	x	x	x	x	x				x	x	x	x
MICCY																												x	x	x
POLDIRAD				x	x	x	x	x	x	x	x	x	x	x								x	x	x	x	x	x	x	x	x

Table 14.2 Same as Table 14.1 but for **July 2007**.

	July																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
IOP	5a	5b		6				7a	7b					8a	8b	8c		9a	9b	9c			10		11a	11b				12	
No. of CI event	2	8		1				0	3					0	1	*		3	0	6			5		0	0				1	
Airborne																* no MSG rapid scan data available on this day															
DLR DIAL								x							x			x	x	x					x	x				x	
Leandre2														x	x	x		x	x	x					x	x				x	x
Mobile																															
DOW1	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
DOW2																					x	x	x	x				x	x	x	x
SuSiH																															
WV DIAL	x						x	x	x				x	x	x	x		x	x	x			x		x	x				x	
RRL	x						x	x	x				x	x	x	x		x	x	x		x	x								
Windtracer	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CloudRadar	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
CNR MWR	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SuSiR																															
BASIL																															
Doppler Lidar	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CloudRadar	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
TARA	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x										
MWR	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SuSiM																															
BERTHA	x	x		x				x	x			x	x	x	x			x	x	x	x	x	x		x	x				x	x
WiLi	x	x		x				x	x		x	x		x	x	x		x	x	x		x	x	x	x	x				x	x
MPL	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CloudRadar	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HATPRO	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SuSiV																															
TRESS	x	x		x	x	x	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x
CNRS RL	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SuSiS																															
Ceilometer						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
WTR	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MICCY	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
POLDIRAD	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Table 14.3 Same as Table 14.1 but for **August 2007**.

	August																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
IOP	13a	13b				14a	14b	14c	14d			15a	15b		16a	16b					17a	17b		18a	18b						
No. of CI event	0	5				*	*	*	2			2	0		5	4					0	5		2	0						
Airborne						* no MSG rapid scan data available on this day																									
DLR DIAL	x																														
Leandre2	x																														
Mobile																															
DOW1	x	x	x	x	x	x	x	x	x	x	x	x	x	x																	
DOW2	x	x	x	x	x	x	x	x	x	x	x	x	x	x																	
SuSiH																															
WV DIAL	x	x				x						x	x	x	x		x				x	x	x	x	x			x		x	
RRL												x	x	x	x	x	x				x	x		x	x					x	
Windtracer	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
CloudRadar	x	x	x																						x	x	x	x	x	x	x
CNR MWR	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SuSiR																															
BASIL																															
Doppler Lidar	x	x	x	x	x	x	x	x				x	x	x	x	x															
CloudRadar	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
TARA		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
MWR	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																
SuSiM																															
BERTHA	x	x			x	x						x	x		x							x	x	x	x		x	x			
WiLi	x	x			x	x						x	x		x		x				x	x		x	x						
MPL	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CloudRadar	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HATPRO	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SuSiV																															
TRESS																															
CNRS RL																															
SuSiS																															
Ceilometer	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
WTR	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
MICCY	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
POLDIRAD	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	

In the following, first CI statistics based on MSG tresholding of IR channels shall be presented. This work is very helpful for selecting IOP days with certain CI characteristics. This work has been performed within a Master Thesis at the University of Hohenheim.

A total of 94 CIs (Convection Initiation) on 16 IOP (Intensive Observation Period) days were found (Table12-5). The locations of all CI sites shown in Fig. 14.1, and proportion in accordance with their occurrence sites are shown in Fig. 14.2. There are no clear dominant occurrence areas within the COPS region within this data set.

Table 14.4 Number of CIs for each IOP

IOP No.	Date	No. of CIs
1	05 Jun	5
	06 Jun	6
	07 Jun	6
	08 Jun	18
2	12 Jun	4
5	01 Jul	2
	02 Jul	8
6	04 Jul	1
7	08 Jul	0
	09 Jul	3
8	14 Jul	0
	15 Jul	1
9	18 Jul	3
	19 Jul	0
	20 Jul	6

IOP No.	Date	No. of CIs
10	23 Jul	5
11	25 Jul	0
	26 Jul	0
12	30 Jul	1
13	01 Aug	0
	02 Aug	5
14	09 Aug	2
15	12 Aug	2
	13 Aug	0
16	15 Aug	5
	16 Aug	4
17	21 Aug	0
	22 Aug	5
18	24 Aug	2
	25 Aug	0
Total		94

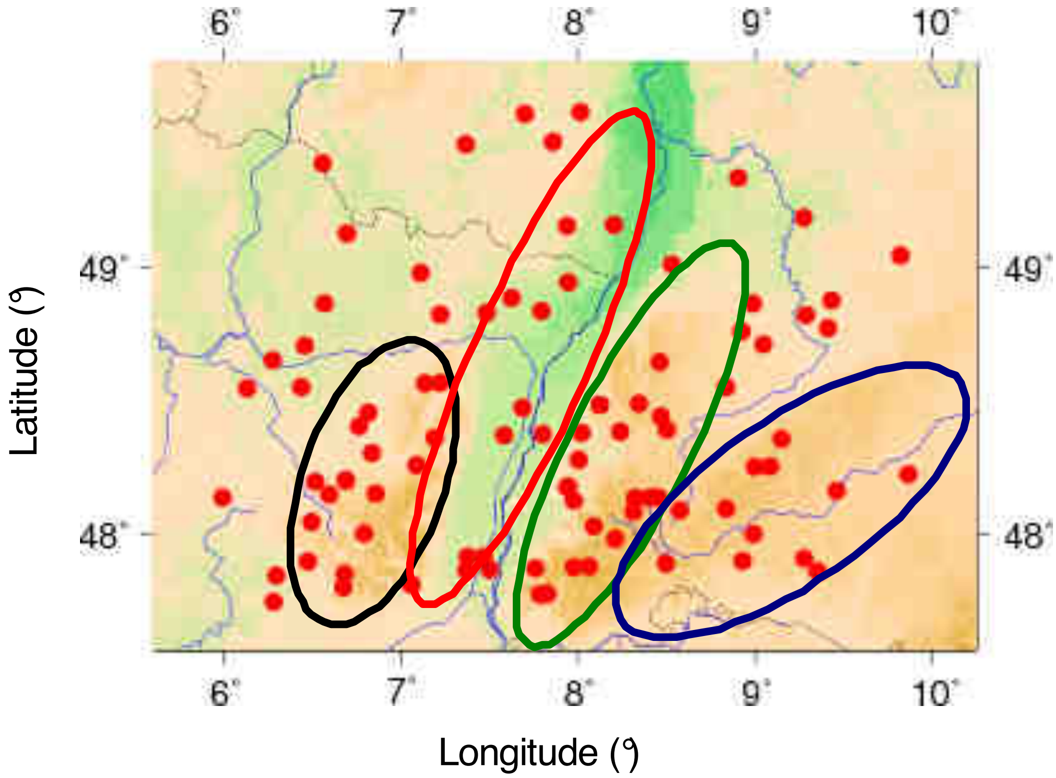


Fig. 14.1. Locations of CI sites. Black: the Vosges, red: the Rhine Valley, green: the Black Forest, blue: the Swabian Jura.

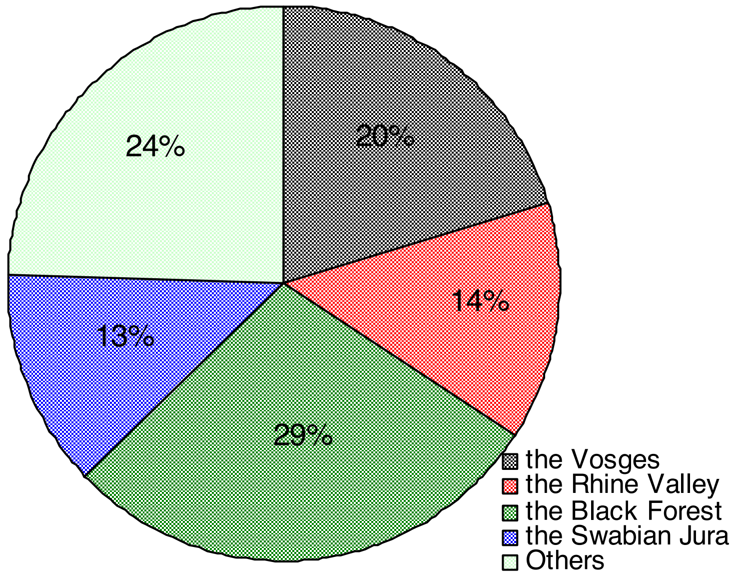


Fig. 14.2. Proportion of the locations of CI sites. There is no preference CI area over the COPS region.

Histograms of CI in accordance with the occurrence time are shown in Fig. 14.3. There is an occurrence peak at 13 UTC (15 CEST, Central Europe Standard Time), and a few convections were found between 22 UTC (00 CEST) and 03 UTC (05 CEST). In Fig. 14.4, the locations of CI sites are plotted according to the occurrence time (Morning: 02-10 UTC, Afternoon: 10-18 UTC, Night: 18-24 and 00-02 UTC). As can also be seen in Fig. 20-5, more than 60 % of CIs were found in the afternoon, and about only 16 % of CIs were found at night.

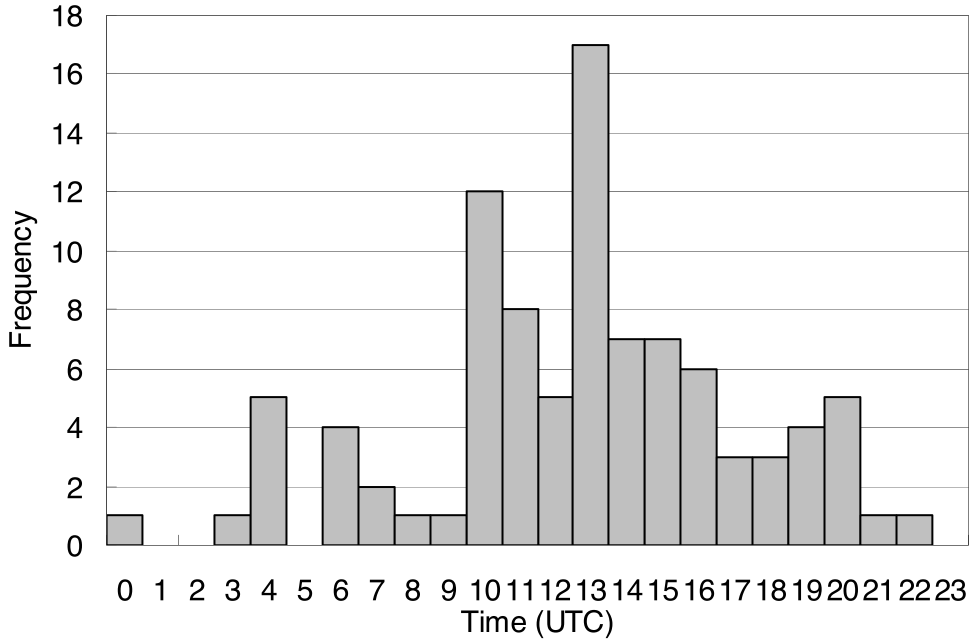


Fig. 14.3. Histogram of Convection Initiations in accordance with their occurrence time. There a peak around at 13 UTC (15 CEST) (Fumiko Aoshima, IPM).

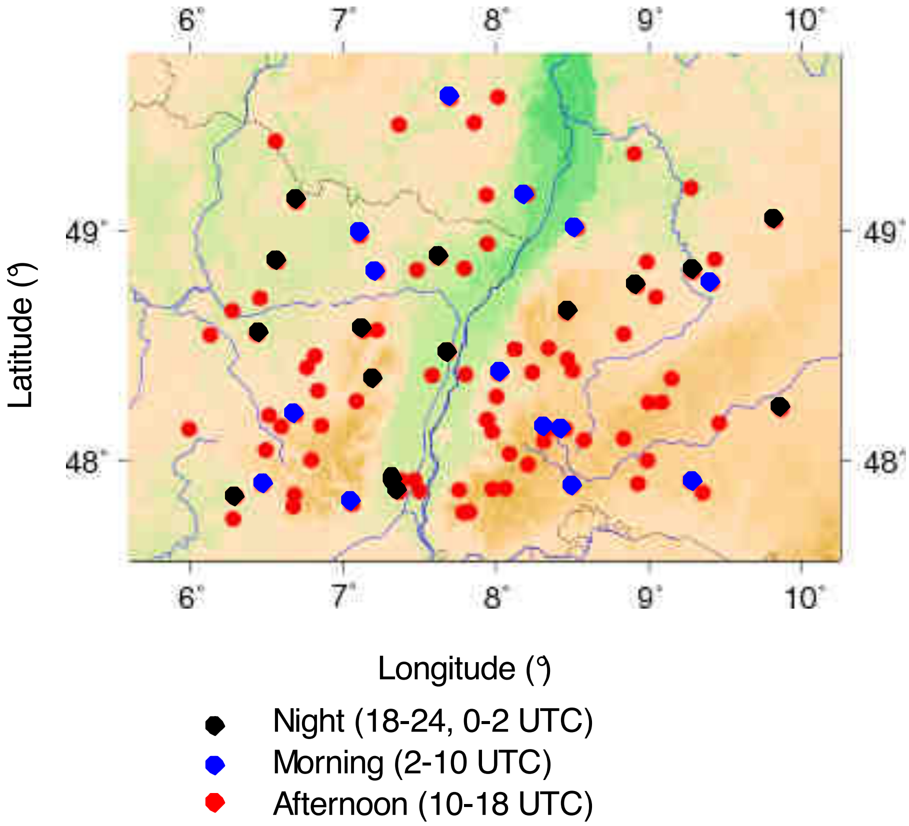


Fig. 14.4. Locations of CI sites in accordance with their occurrence time. Black: Night (18-24 and 0-2 UTC), blue: Morning (2-10 UTC), red: Afternoon (10-18 UTC).

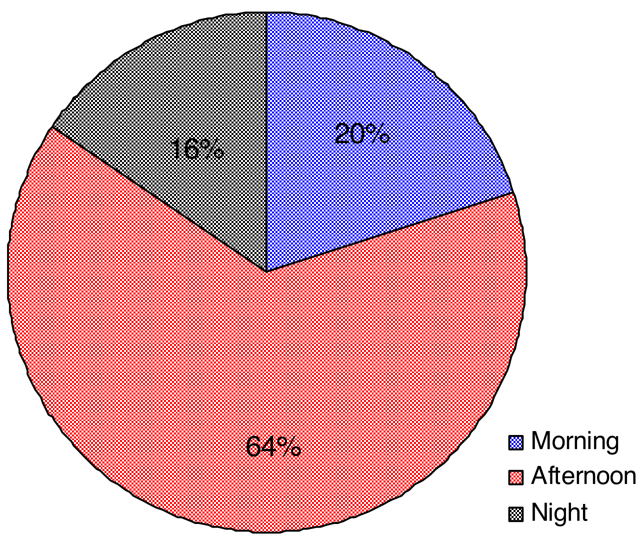


Fig. 14.5.Proportion of the convection initiations in accordance with their occurrence time. Morning: 02-10 UTC (04-12 CEST), Afternoon: 10-18 UTC (12-20 CEST), Night: 18-24 and 00-02 UTC (20-24 and 00-04 CEST). More than half of the convections initiations found in the afternoon.

15 The Case of IOP 9c on 20 July: Overview of Highlights

15.1 Characteristics

The goal of IOP9 was the study of the development of a frontal zone oriented from southwest to northeast over the COPS region and its influence on the intensity of convection. Furthermore, cyclogenesis over France between Thursday and Friday was predicted pretty consistent between global models such as GFS and ECMWF. However, the limited area models (LAMs) predicted different developments and tracks of MCSs associated with the cyclogenesis as well as different precipitation pattern.

IOP9 consisted of a 3-day observations period (IOP 9a-c) from 18 to 20 July where all COPS and ETReC07 resources were exploited and coordinated in a most efficient way. Thus, this IOP realized one of the visions, which were subject of the COPS Science Plan.

Operations included the consideration of forecast uncertainty with respect to the location of the frontal zone, of imbedded MCS, and of the development of the cyclone. The overarching science goals this IOP were:

- Study the interaction of upper-tropospheric instabilities and orographic effect in southwesterly flow along the frontal zone
- Observe the cylogenesis over France and its impact on COPS weather
- Analyze the impact of COPS orography on the modification and organization of mesoscale convective systems

During IOP9c, a vorticity maximum at the east side of a jet initiated over middle eastern France triggered cyclogenesis and a MCS, which propagated northeastwards. The MCS reached the COPS region at 8:45 UTC. Ahead of the weak cold front related to the cyclone, in which the MCS was imbedded, outflow boundaries produced a squall line with severe thunderstorm activity. The structure of the squall looked similar as an event, which took take one day before during IOP9b (slowdown over Rhine valley, transformation over COPS region). However, this time, deep convection was significantly stronger and took place over southeastern Black Forest and Swabian Albs. After merging with the northern part of the MCS, the whole system developed in a bow-like structure ranging from the Netherlands down to central Germany. It is interesting to note that additional cells were triggered in Bavaria at around 14 UTC. These cells prevailed until 22 UTC whereas the other part of the MCS already moved to Eastern Europe. The cyclogenesis caused also huge precipitation amounts leading to flooding events in UK (see Fig.15.1).

The features of this IOP are

- **Whole set up of instrumentation was coordinated very well.**
- **All aircraft operated as planned, excellent synergy and overlap.**
- **Passage of the MCS was well captured by sensor synergy at all Supersites.**
- **During the passage of the squall line, deep convection was triggered in the COPS region modifying the structure of the squall line and of related precipitation pattern.**
- **Severe precipitation with flooding took place in Germany associated with this system.**

- **Consequently, precipitation intensity and development strongly influenced by COPS orography.**
- **Excellent case for studying the performance of mesoscale models.**

Table 15.1. Convection forecast for COPS area for IOP9c.

Time/location of first convective cloud development	Cu to Cb from around noon.
Time/location of convective storm initiation	Showers/thunderstorms with peak activity probably over the eastern parts of the Black Forest in the afternoon.
Mode/coverage/evolution	Thunderstorms likely to organize mainly into multicells. Supercells possible.
Convective cloud base	Rising to 1300 m in the afternoon.
Storm motion	From the southwest with about 15-20 m/s.
Maximum temperature	31 °C to the southeast of the COPS area and in the Rhine Valley.
Precipitation	Up to 40 mm from thunderstorms.
Severe weather threat	Medium to high. Local flash flood, hail and severe wind gusts possible in the afternoon.

Extensive D-PHASE model comparisons have been initiated in order to study this case in detail. Preliminary results show that nearly all models have problems to produce the initiation of convection related to the squall line on the lee side of the Black Forest. Furthermore, it seems that almost all models predicted a propagation speed of the squall line, which was too slow. The merging of model results and observations is subject of future studies. The purpose of this chapter is to summarize most of the key observations, which can be applied for process studies and model evaluation.

SPIEGEL ONLINE

20. Juli 2007, 18:45 Uhr

TURBULENTES WETTER

Es wird ungemütlich

150 Flüge in Heathrow gestrichen, schwere Unwetter in England - und auch in Deutschland sieht es nach Sturm, Wolken, Regen aus. Am Wochenende wird es frisch, feucht und zugig.

Frankfurt am Main - Schwere Unwetter ereigneten sich heute vor allem in Baden-Württemberg, Thüringen, Niedersachsen, Bayern und Nordrhein-Westfalen. Doch nicht nur Deutschland ist betroffen: Nach einem heftigen Unwetter über Großbritannien mussten an Europas größtem Flughafen in London Heathrow fast 150 Flüge gestrichen werden. Im Nordwesten Pakistans sind bei einem Unwetter mindestens 50 Menschen von Blitzen getötet worden.

DPA

Totenkopffiguren vor dem Gewitterhimmel im hessischen Breitenbach: Am Wochenende droht ein Regenfiasko

In Großbritannien haben Wolkenbrüche und Gewitter am Abend vielerorts den Verkehr lahmgelegt. Neben dem Flughafen Heathrow stellte auch die Londoner U-Bahn den Verkehr weitgehend ein: 25 Bahnhöfe wurden nach Angaben eines Sprechers wegen Überflutung geschlossen. Die Eisenbahngesellschaft First Great Western riet Reisenden, nicht den Zug zu nehmen. Auch nach Ende des Regens werde es massive Verspätungen geben, sagte ein Sprecher. In vielen Häusern in England und Wales liefen die Keller voll.

In Deutschland ist bei heftigen Regenfällen in Baden-Württemberg großer Sachschaden entstanden. Plötzlich einsetzender Regen überflutete in Bad Wimpfen Teile der Altstadt zeitweise um mehr als einen Meter. Durch die Wassermassen wurden mindestens drei Fahrzeuge mitgerissen und gegen Gebäude gedrückt. Außerdem wurden 13 Keller und 3 Garagen überflutet.

Auch in Nordrhein-Westfalen hat eine Gewitterfront einige Schäden angerichtet. Im Sauerland setzten Blitze einen Dachstuhl in Schmallenberg und eine Schutzhütte in Sundern in Brand. In den Kreisen Recklinghausen, Borken und Coesfeld musste die Feuerwehr überflutete Straßen und Keller leer pumpen und umgestürzte Bäume beseitigen. Betroffen war auch die Autobahn 43 bei Dülmen.

In Bayreuth blieb von dem starken Regen gestern auch das berühmte Festspielhaus auf dem Grünen Hügel nicht verschont. Wenige Tage vor Beginn der Richard-Wagner-Festspiele drang Wasser durch die offenen Türen auf den Steinfußboden ins Foyer des Gebäudes. Ein größerer Schaden sei aber nicht entstanden, sagte Festspielsprecher Peter Emmerich. Das Wasser lief zwar auch in die Kantine und ein Probenzimmer. Die Instrumente wurden aber rechtzeitig ins Trockene gebracht. Die Eröffnung der Opern-Festspiele am kommenden Mittwoch ist den Veranstaltern zufolge nicht gefährdet.

Fig. 15.1. Spiegel Online report on the “turbulent weather” of IOP 9c.

15.2 Forecast

After the Science Briefing, the COPS PIs expected the initiation of a surface low-pressure system moving from central France over the Benelux towards the North Sea. Its cold front should cross the COPS area between 15 and 18 UTC where the major part of the precipitation was expected. Ahead of this system, warm humid air was present.

Low clouds or fog in the valleys were expected to disappear in the morning hours as surface heating increases, followed by quite fair conditions. From around noon, cumulus cloud development was expected eventually leading to showers/thunderstorms during the afternoon. Given CAPE and wind shear, it was said that they could be severe in places.

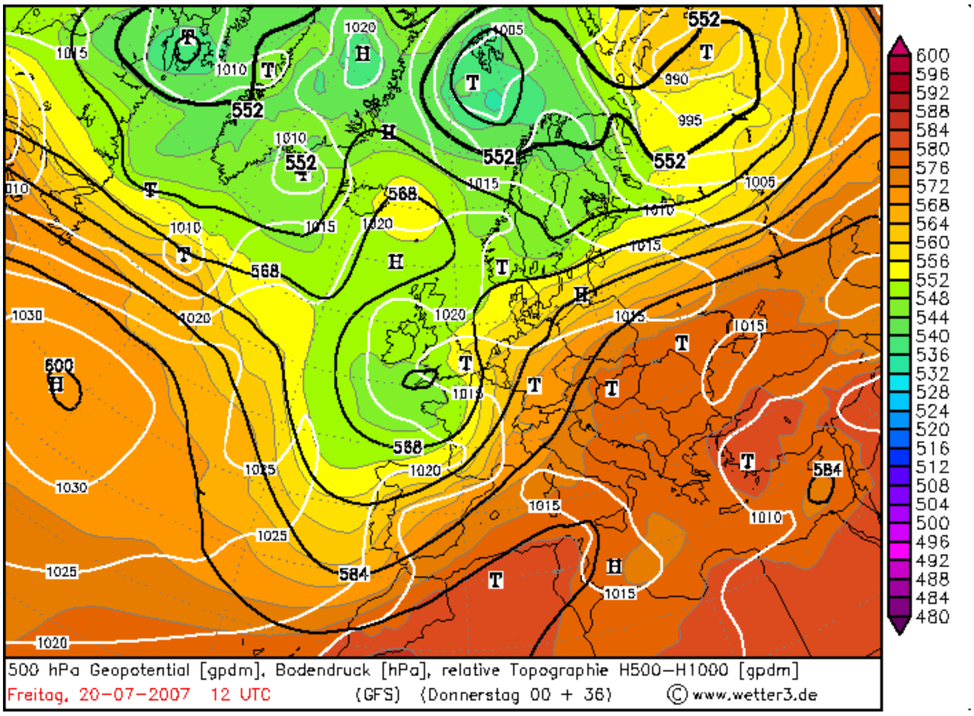


Fig. 15.2. 500 hPa geopotential height, surface pressure and relative topography as analyzed by the GFS model.

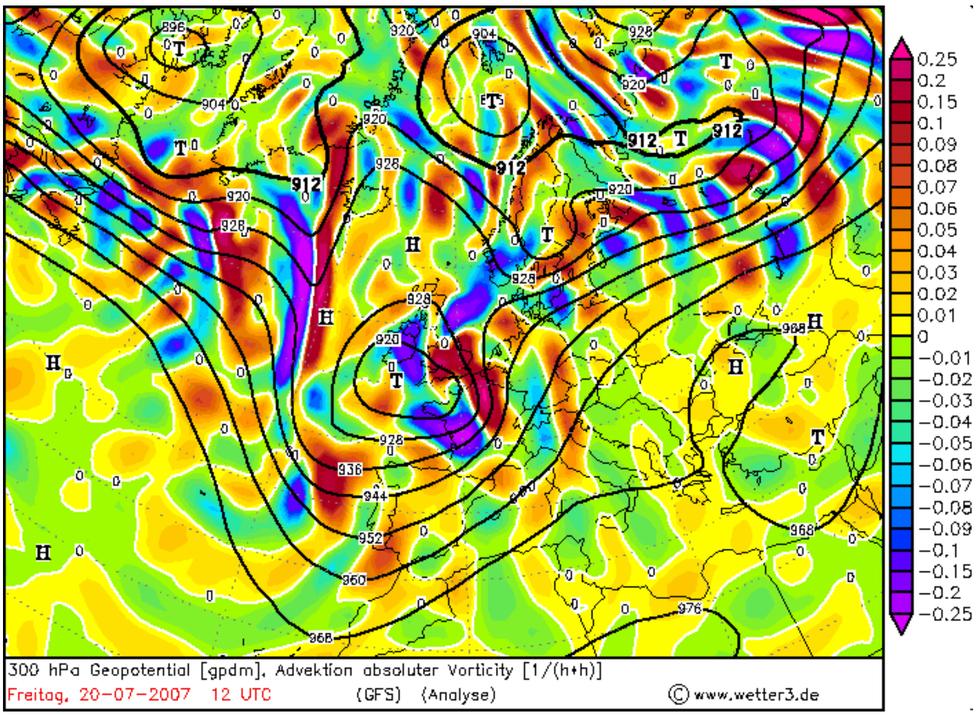


Fig. 15.3. Vorticity advection at 300 hPa as analyzed by the GFS model.

15.3 Facility status for IOP 9c

Aircraft:

DLR Falcon, SAFIRE Falcon, IMK DO 128, FAAM BAe 146, Enviscope Partenavia P86B, MetAir Dimona, FZK Enduro were operational.

Lidar:

UHOH Water Vapor DIAL, UHOH Rotational Raman Lidar, IMK Windtracer, IfT Wind Lidar, IfT Multi-Wavelength Lidar, CNRS TRESS Aerosol Raman lidar, CNRS Raman Lidar, U. Salford Doppler Lidar, UNIBAS Raman Lidar were operational.

Radiometer:

U. Cologne HATPRO+IR Radiometer, CNRS TRESS Sun Photometer, CNRS TRESS IR Radiometer, U. Salford 14 Channel Microwave Radiometer, CNR-IMAA Microwave Radiometer, U. Cologne Dual Polarization Radiometer were operational.

Radar:

DLR Poldirad, IMK C-Band, UHOH X-Band Radar, IMK Cloud Radar, CNRS X-band Radar and CNRS-K-band Radar, U. Vienna Micro Rain Radar, CSWR Doppler on Wheels 1 a were re operational.

GPS:

GFZ Potsdam GPS Network, CNRS GPS Network were operational.

WTR/SODAR/RASS:

Both IMK Sodar, IMK Wind Temperature Radar, U. Bayreuth Sodar-RASS, U. Freiburg Flat Array Sodar, Meteo France/CNRS UHF Wind Profiler, U. Manchester Radio Wind Profiler, U. Leeds Sodar 2 were operational.

Surface in Situ:

All IMK Energy Balance Stations, IMK Turbulence Tower Network, all U. Bayreuth Energy Bal. Stations, all Meteo France Surface Flux Stations, all Meteo France Soil Moisture Stations, U. Manchester Aerosol Container, all U. Vienna Sonic Anemometers, U. Leeds Autom. Weather Station Network, 85 U. Vienna HOBO Autom. Weather Stations, 2 U. Vienna MAWS Autom. Weather Stations, U. Bonn Turbulence Tower, U. Bonn Scintillometer, U. Bonn Energy Balance Station were operational.

Mast:

U. Bayreuth mast, U. Freiburg Forestmet. Res. Site (Hartheim), U. Freiburg Forestmet. Res. Sites (Tuttlingen) were operational.

In-Situ vertical Sounding:

Both IMK Radiosonde Stations, all IMK Dropup-Teams, Meteo France/CNRS Radiosonde Station, both UK Radiosonde Stations, U. Vienna Radiosonde Station were operational.

Precipitation Stations:

U. Vienna Distrometer, U. Innsbruck Thies Distrometer 1/2, U. Innsbruck Ott Pluvio Rain gauge, U. Innsbruck Davis Rain Collectors were operational.

Cameras:

CNRS Full Sky Camera, IMK Full Sky Camera were operational.

Uncategorized:

ARM Mobile Facility was operational.

15.4 Satellite observations

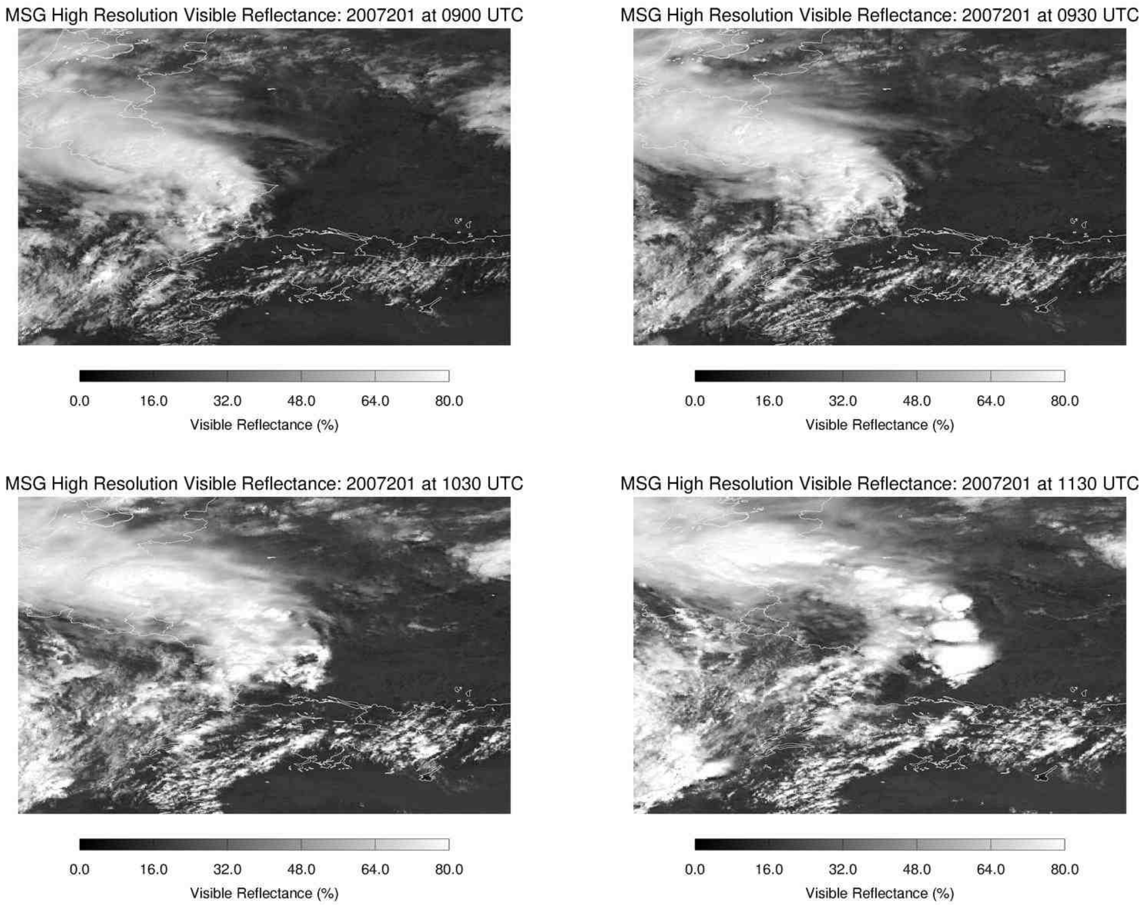


Fig. 15.4. MSG observations. Depp convection was initiated at the east of the Black Forest at around 1030 UTC.

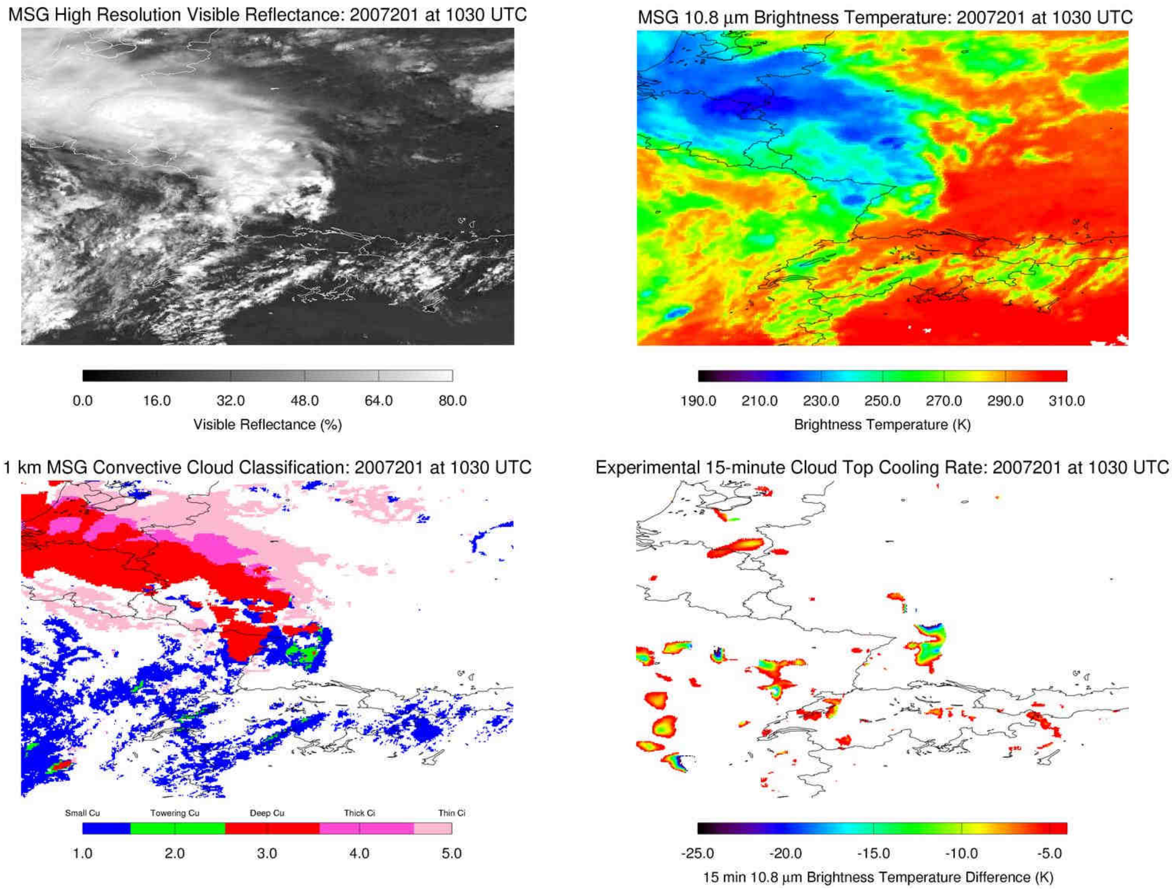


Fig. 15.5. MSG at 1030 UTC.

15.5 Precipitation observations by radar and raingauges as well as lightening observations

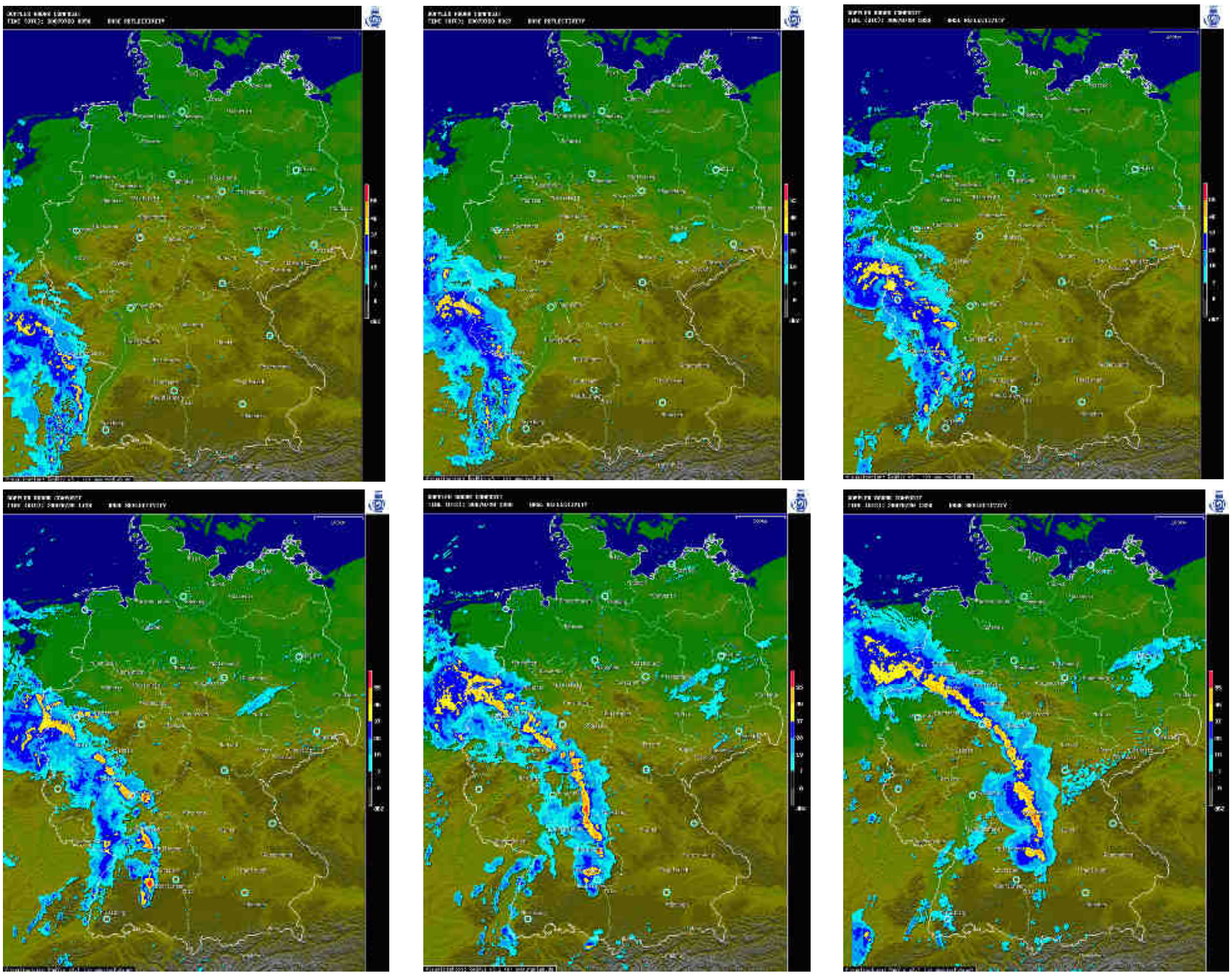


Fig. 15.6. DWD radar composites at 826, 926, 1026, 1126, and 1326 UTC (from upper left to lower right).

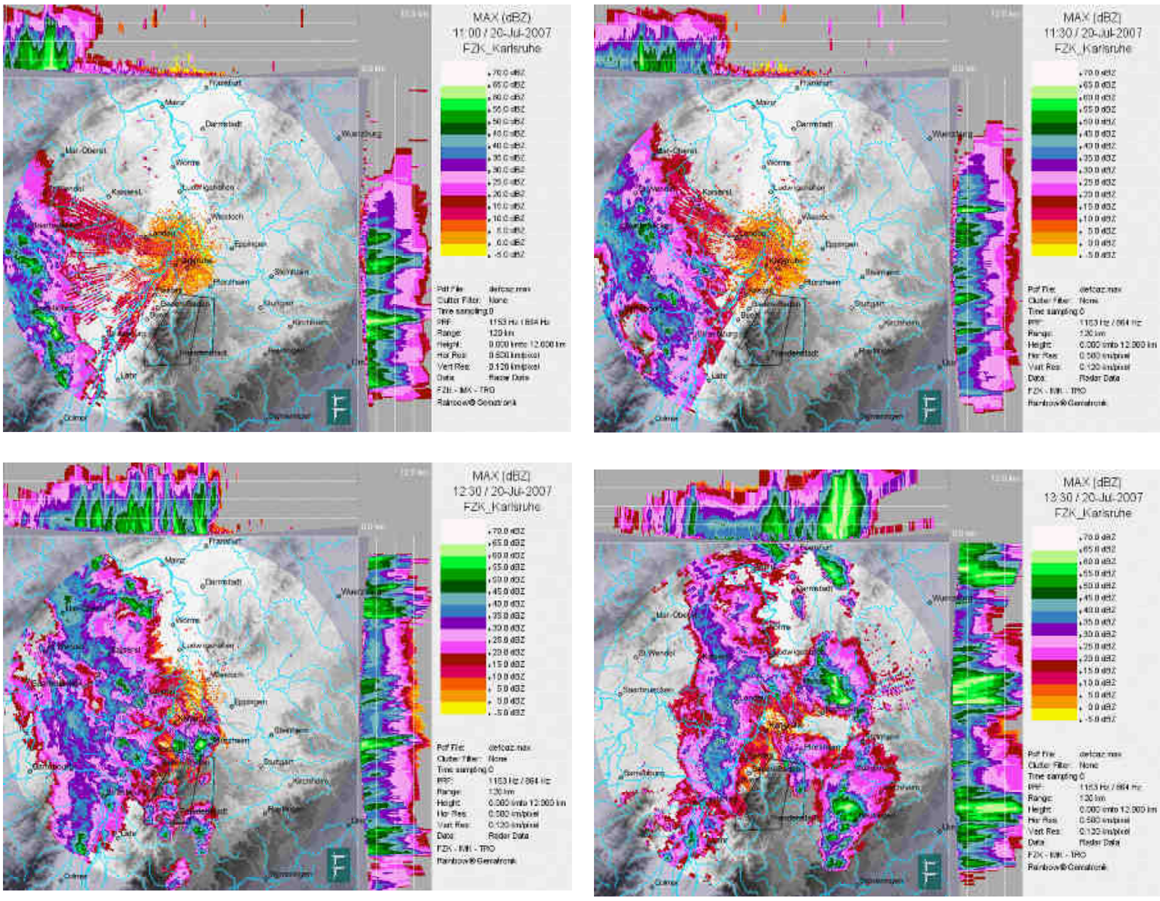


Fig. 15.7. IMK radar at 900, 930, 1030, and 1130 UTC (from upper left to lower right).

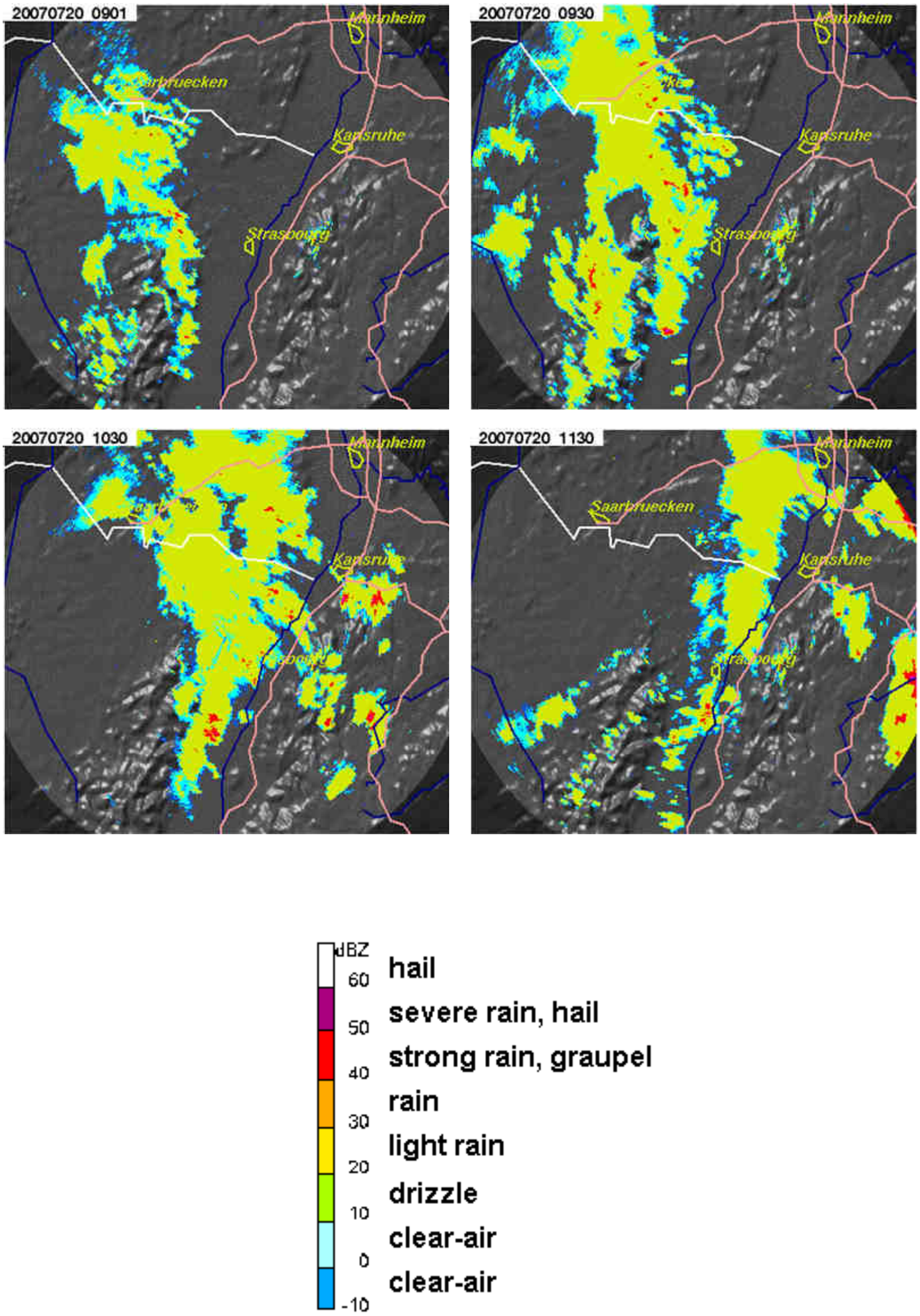


Fig. 15.8. POLDIRAD radar at 900, 930, 1030, and 1130 UTC (from upper left to lower right).

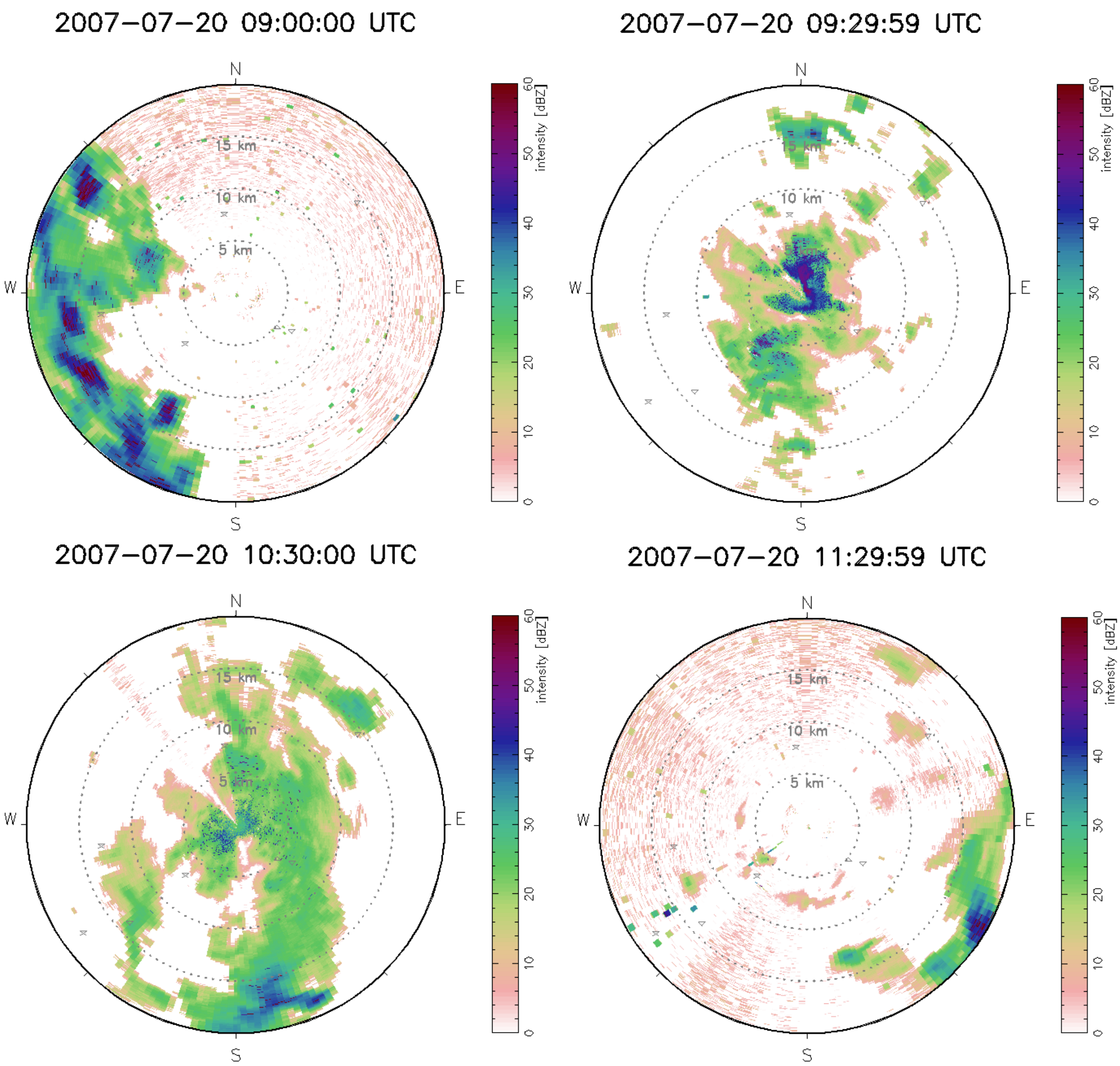


Fig. 15.9. X-band radar measurements at Supersite V.

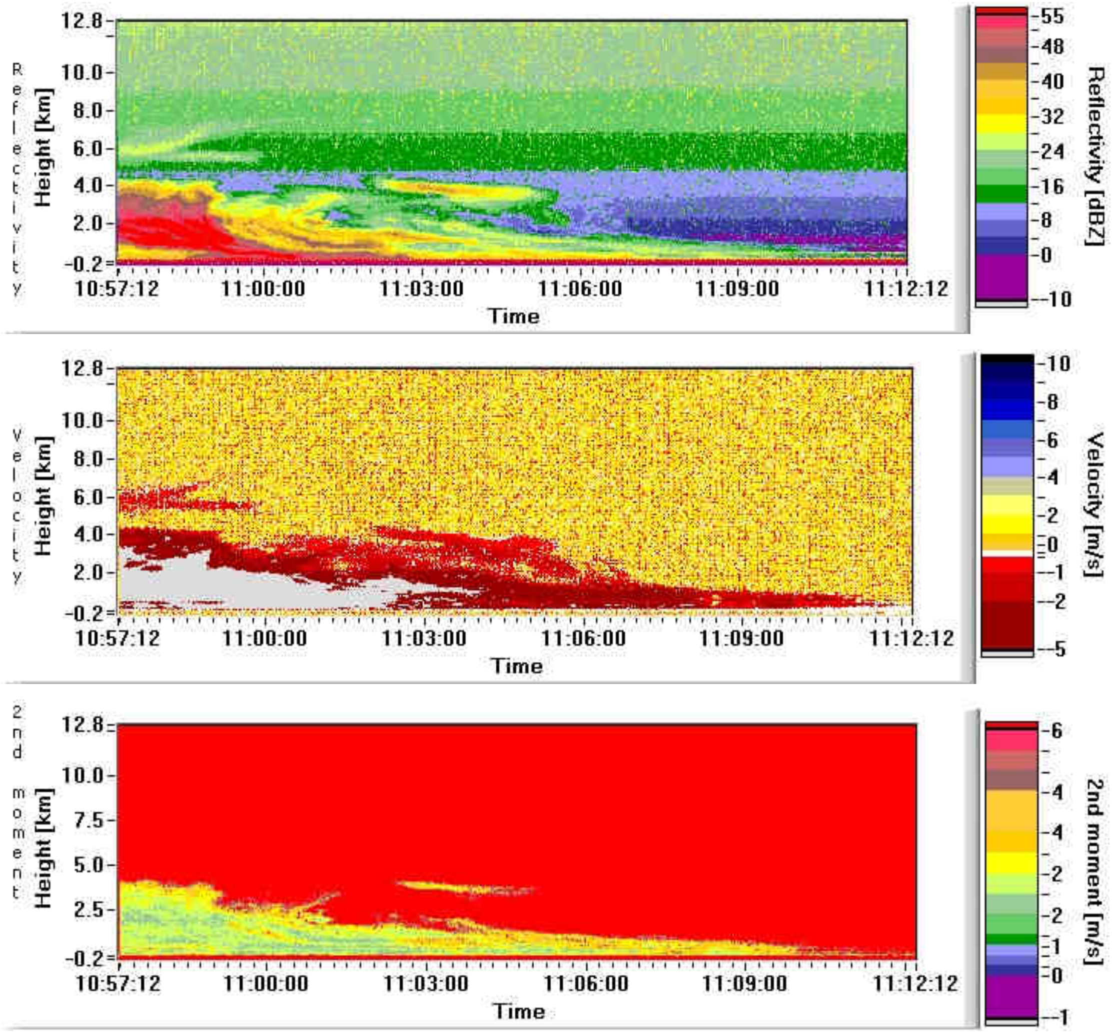


Fig. 15.10. Vertical pointing UHOH X-band radar measurements at Supersite H around 11:00 UTC.

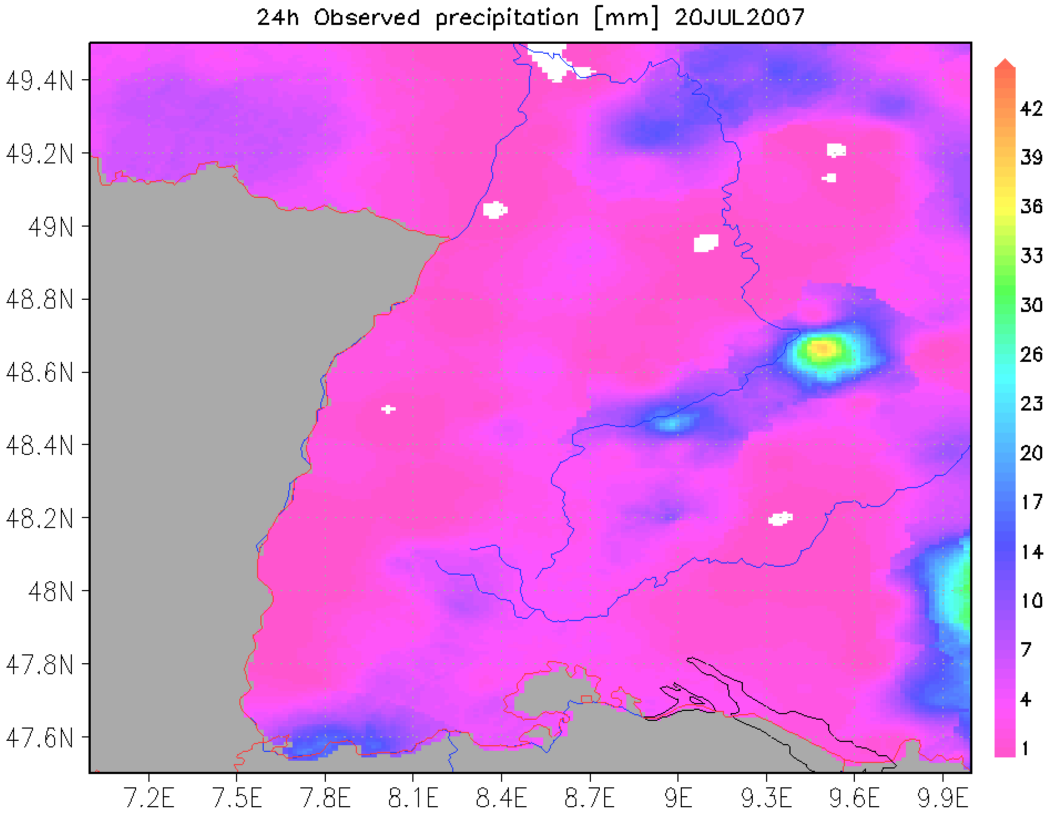


Fig. 15.11. Precipitation sum on 20 July as observed by ground-based operational networks (Regnie product).

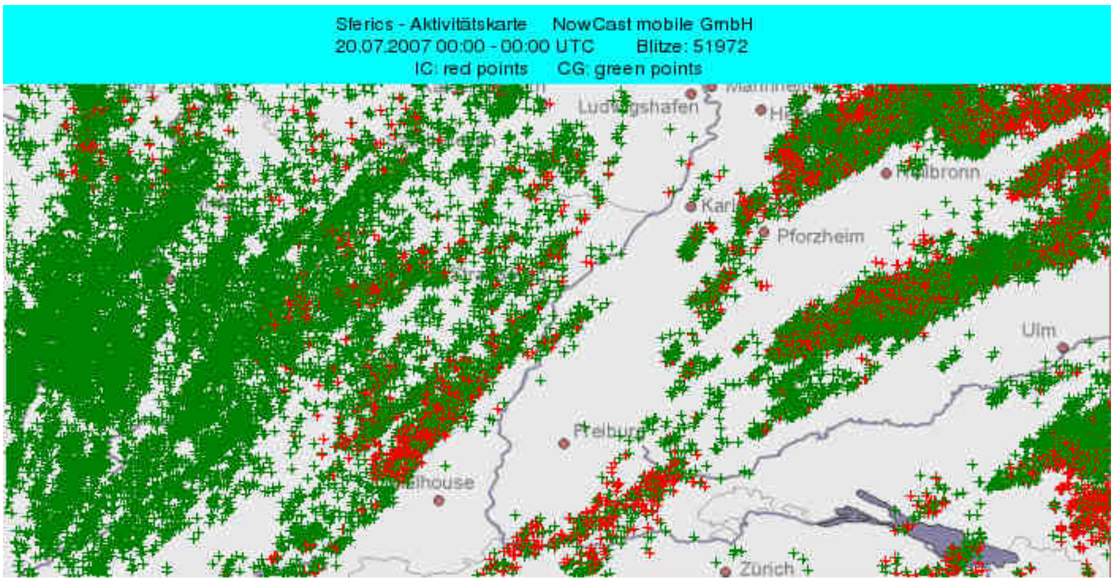


Fig. 15.12. Lightening observations on 20 July.

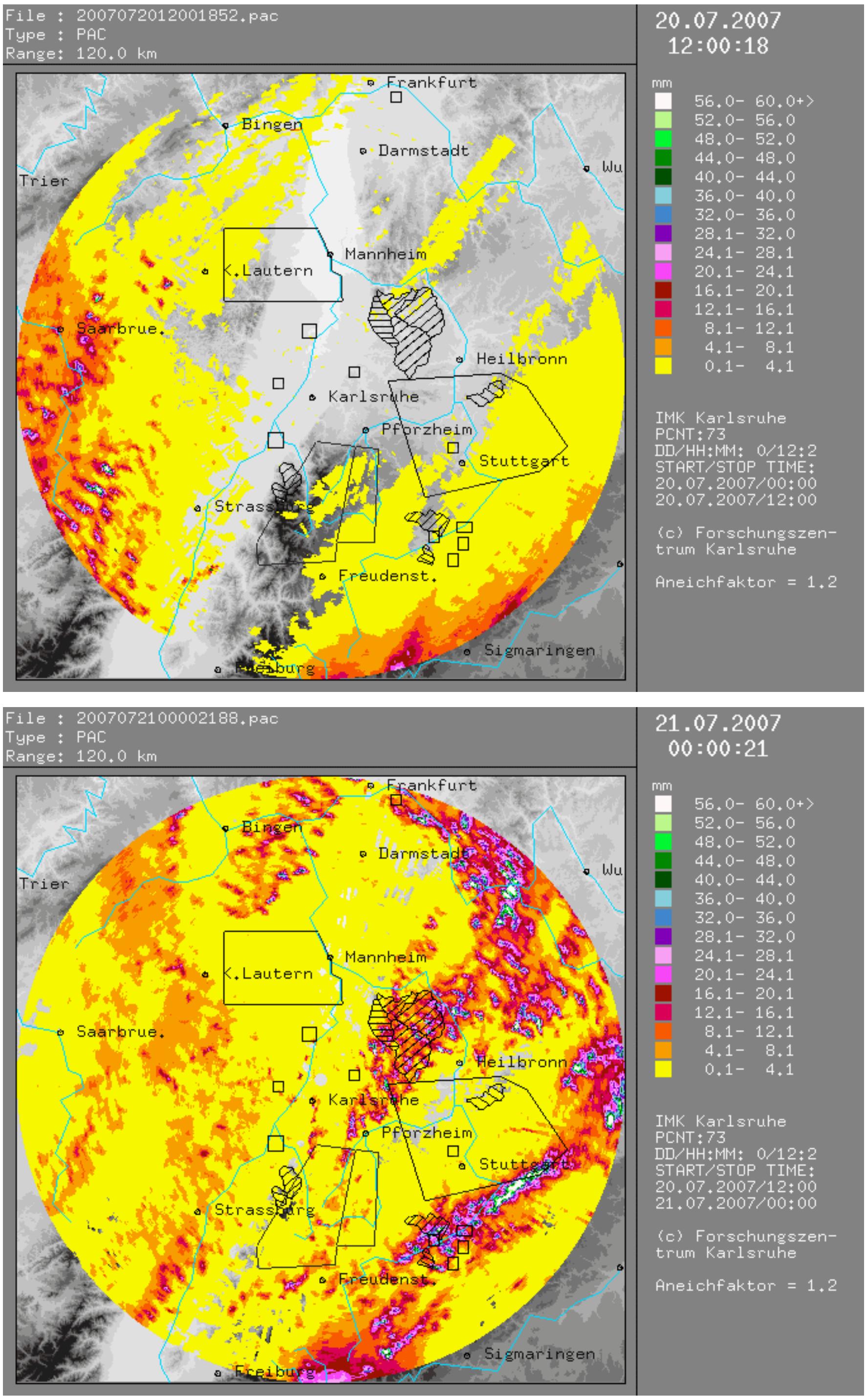


Fig. 15.13. Precipitation sum derived with IMK Radar: Upper panel 19 July, 22 UTC – 20 July 10 UTC, lower panel: 20 July 10 UTC – 22 UTC.

15.6 Aircraft observations

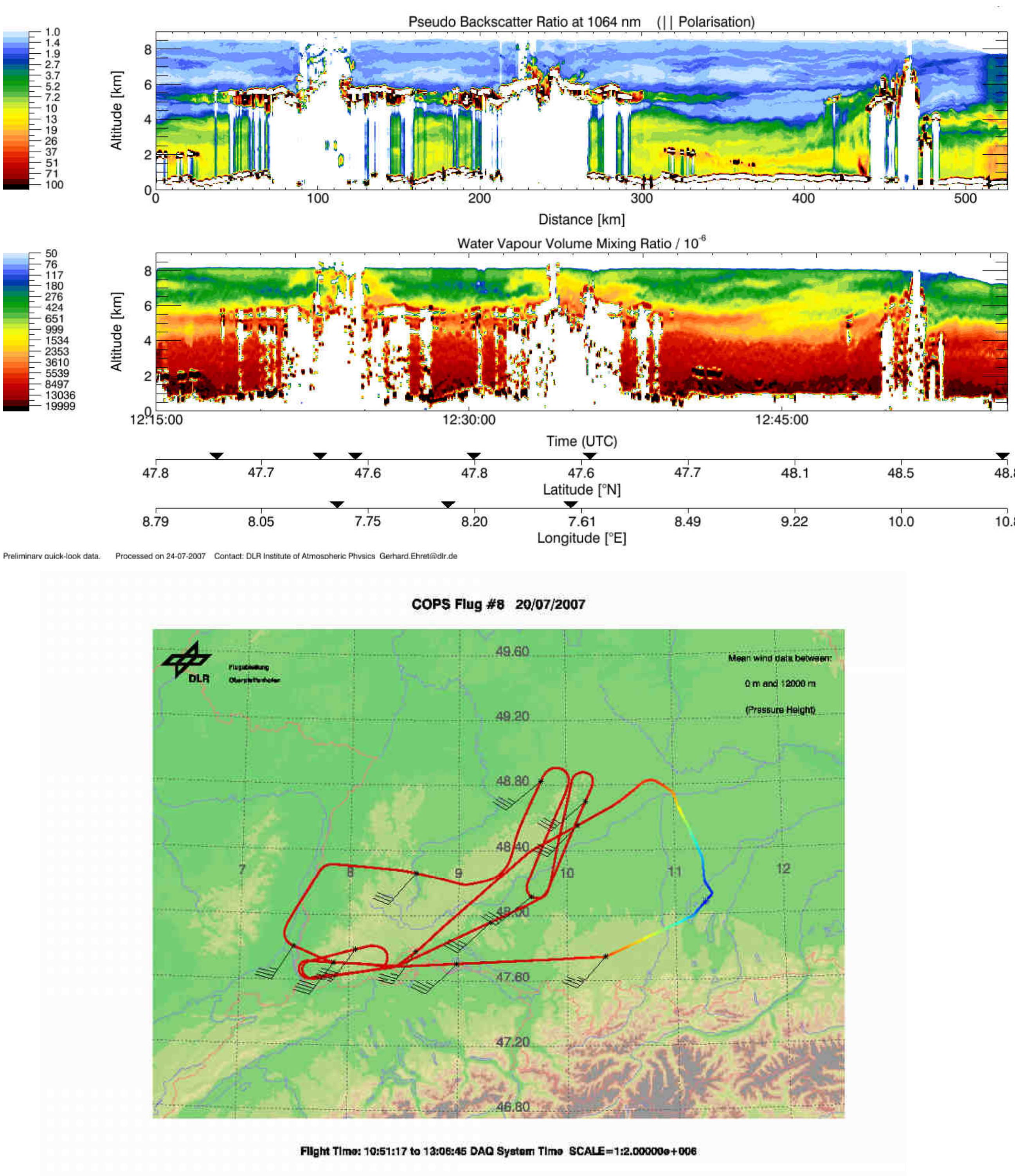
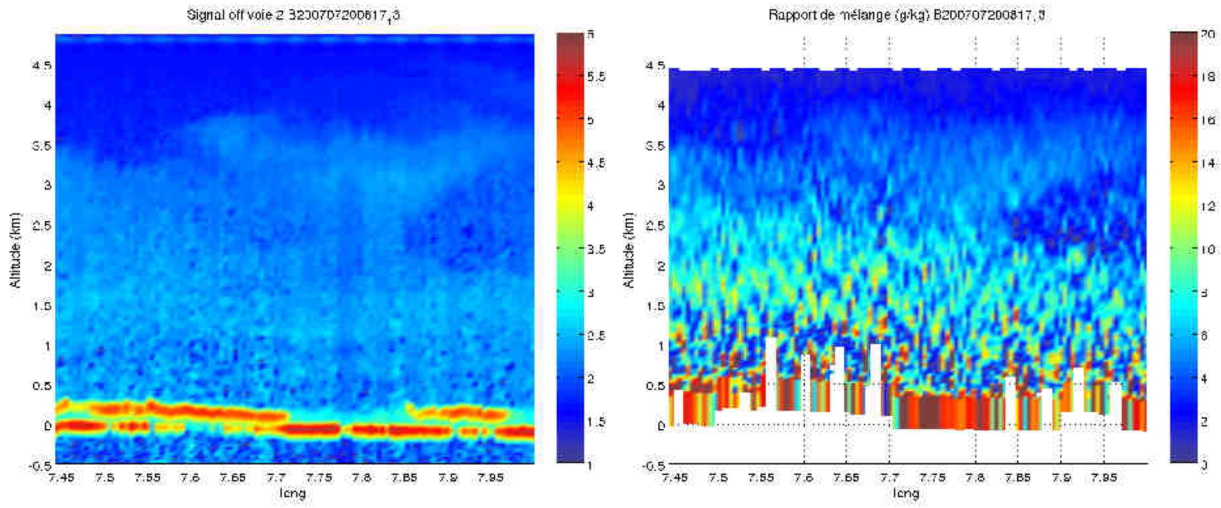


Fig. 15.14. DLR DIAL observations of the afternoon flight (upper panel). The flight track is shown in the lower panel.



**Flight track to be added

Fig. 15.15. LEANDREII observations: backscatter signal (upper left panel) and water vapor mixing ratio (upper right panel). The flight track is shown in the lower panel.

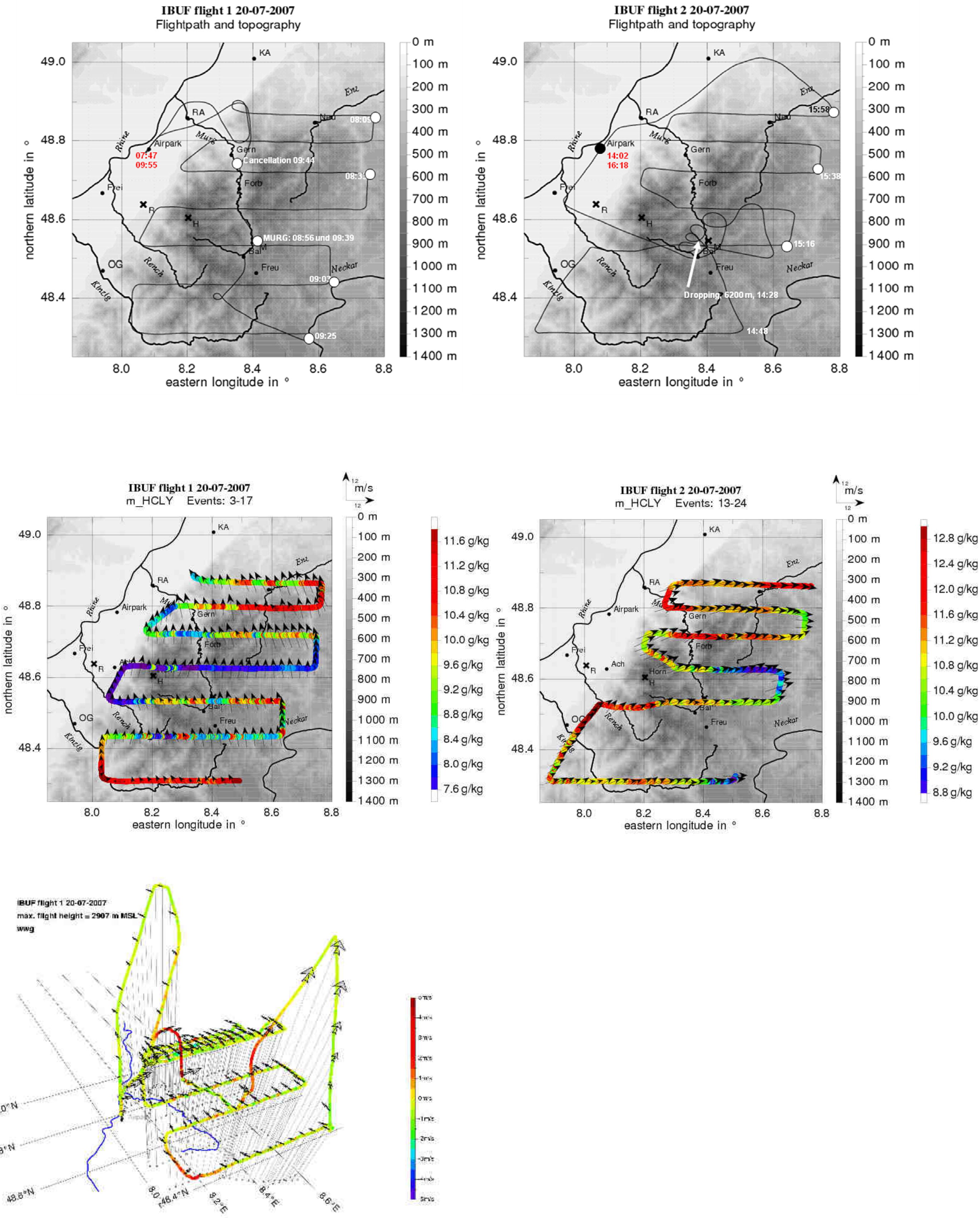


Fig. 15.16. DO128 observations: water vapor mixing ratio and wind.

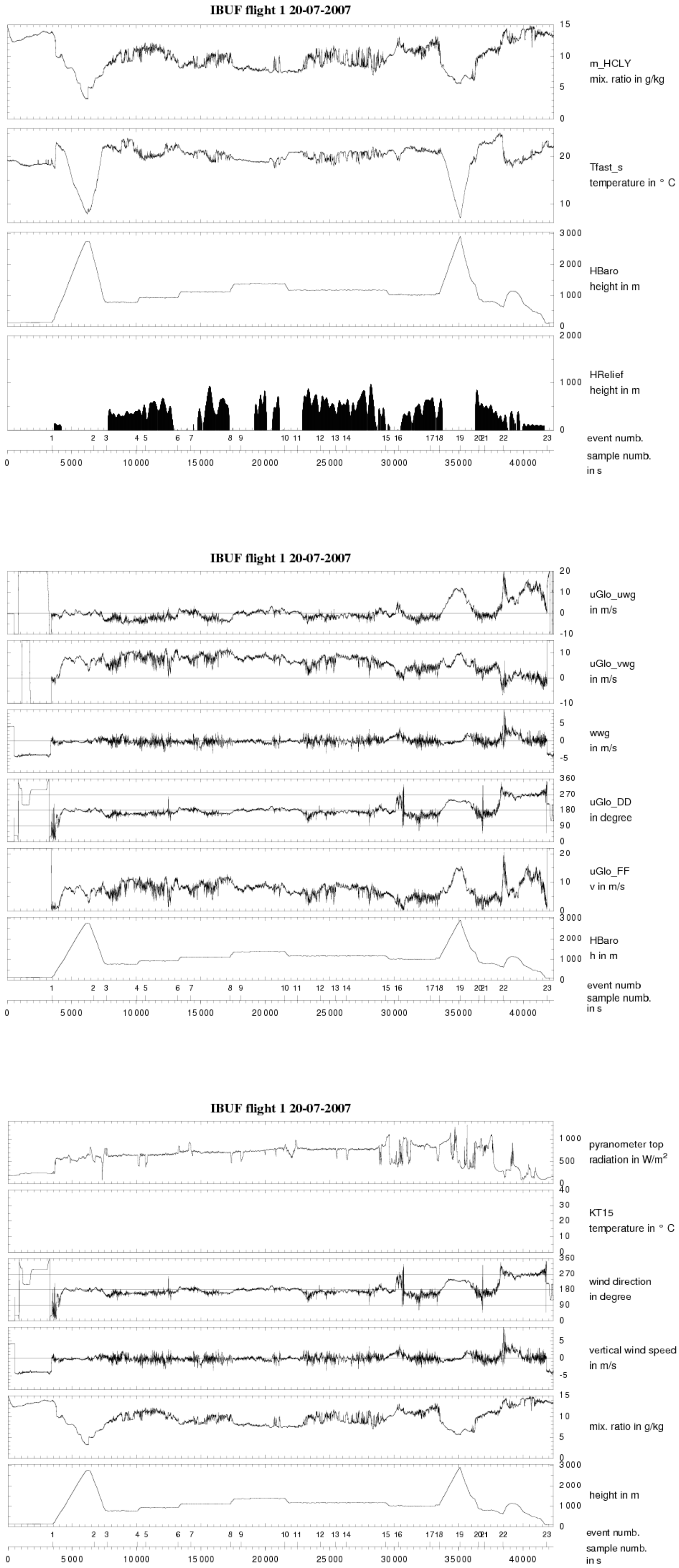


Fig. 15.17. DO128 observations on flight 1 of 20 July.

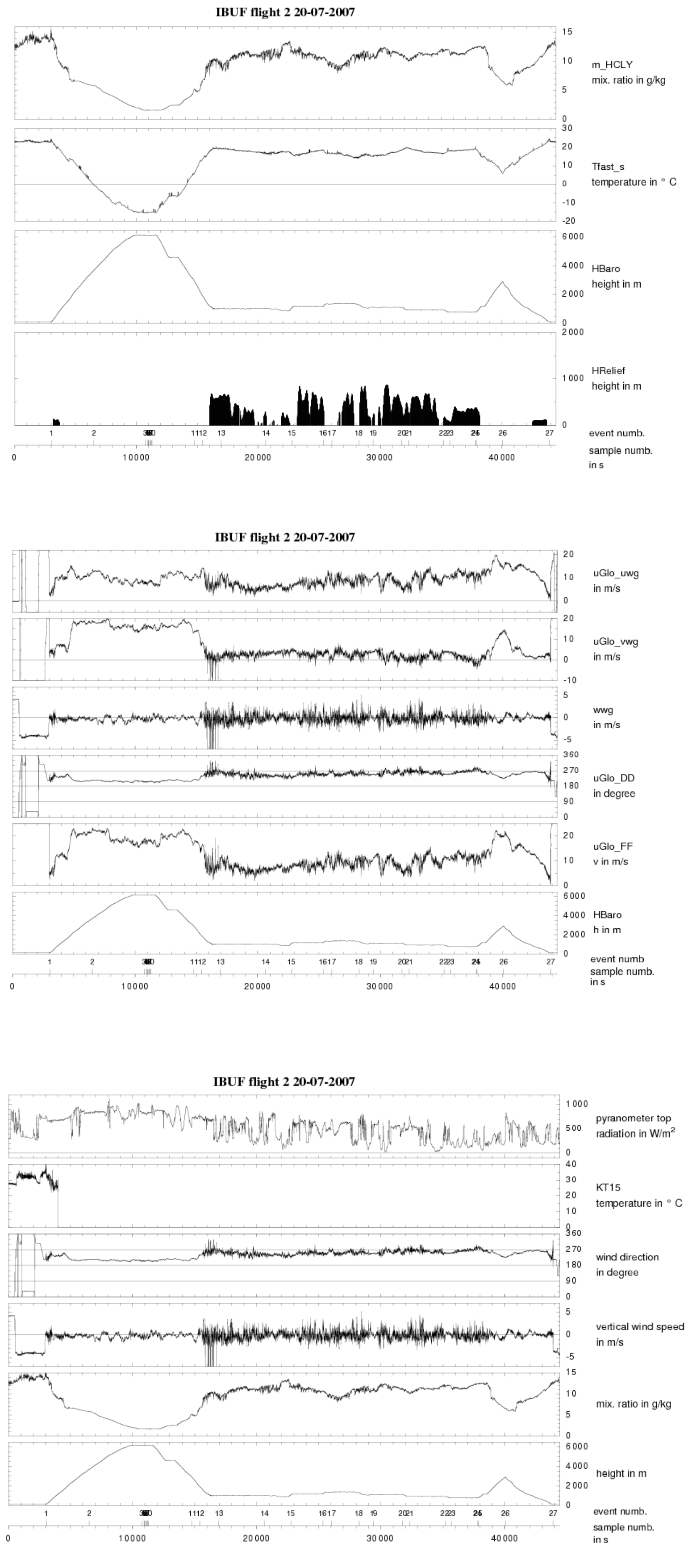


Fig. 15.18. DO128 observations on flight 2 of 20 July.

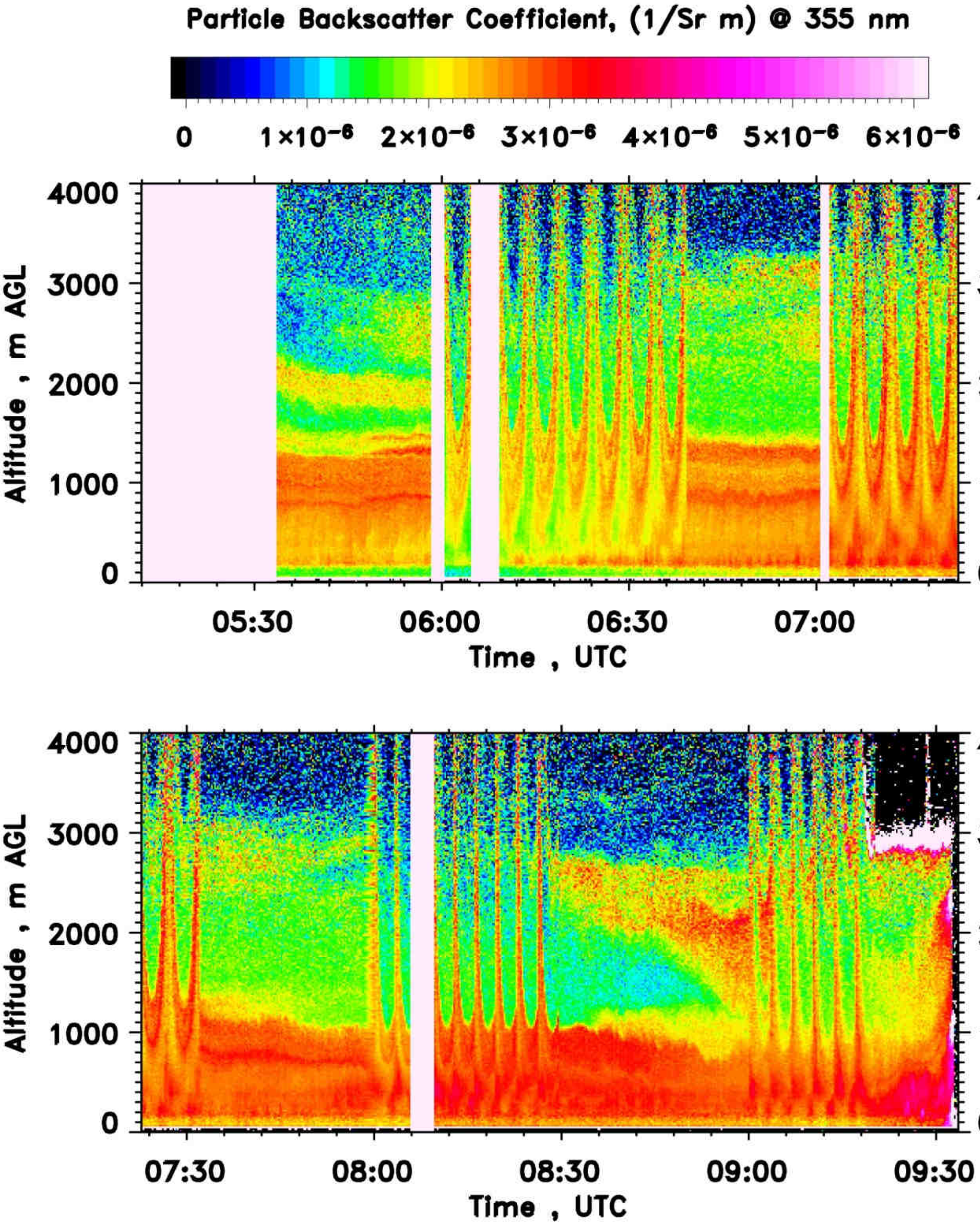


Fig. 15.19. Measurements in the pre-convective period in the morning at Supersite H: Particle backscatter coefficient measured with the UHOH RRL. The data resolution is 10 s and 3.75 m. Repetitive bow-like structures are due to scanning of the system.

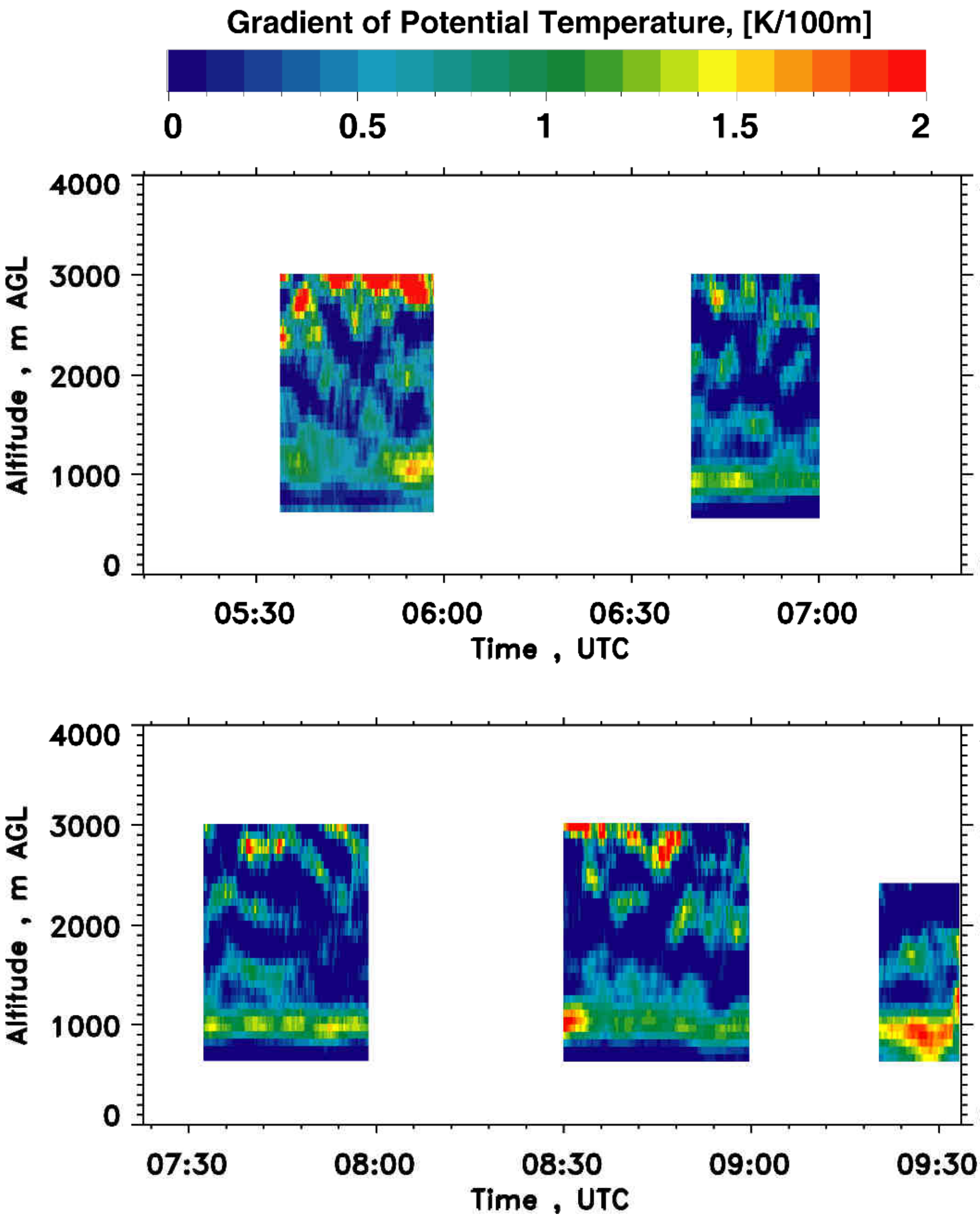


Fig. 15.20. Measurements in the pre-convective period in the morning at Supersite H: Gradient of the potential temperature measured with the UHOH RRL. The data resolution is 10 s and 3.75 m with a gliding average of 300 m.

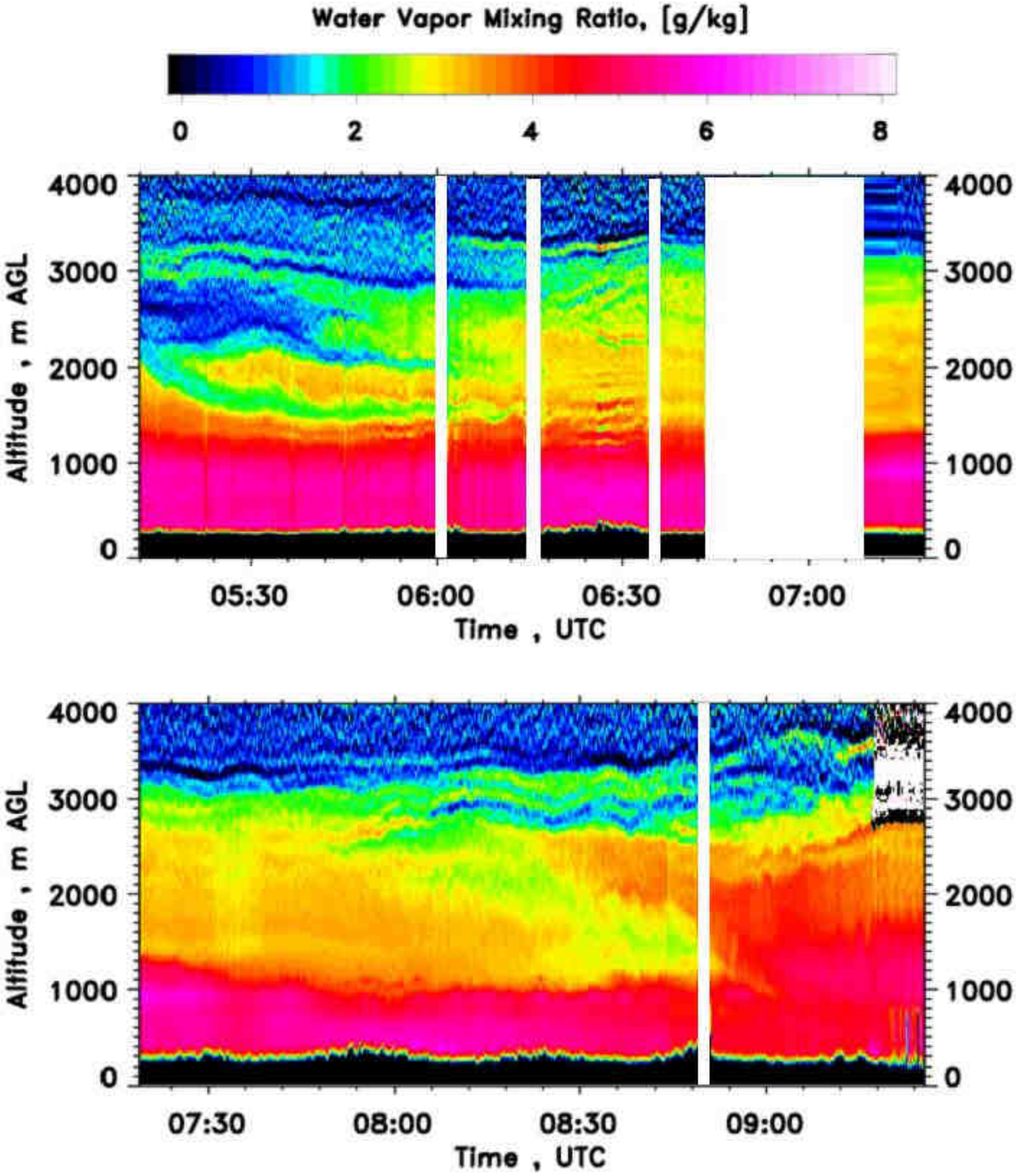


Fig. 15.21. Measurements in the pre-convective period in the morning at Supersite H: Water vapour mixing ratio measured with the UHOH DIAL. The data resolution is 10 s and 15 m with a gliding average of 150 m.

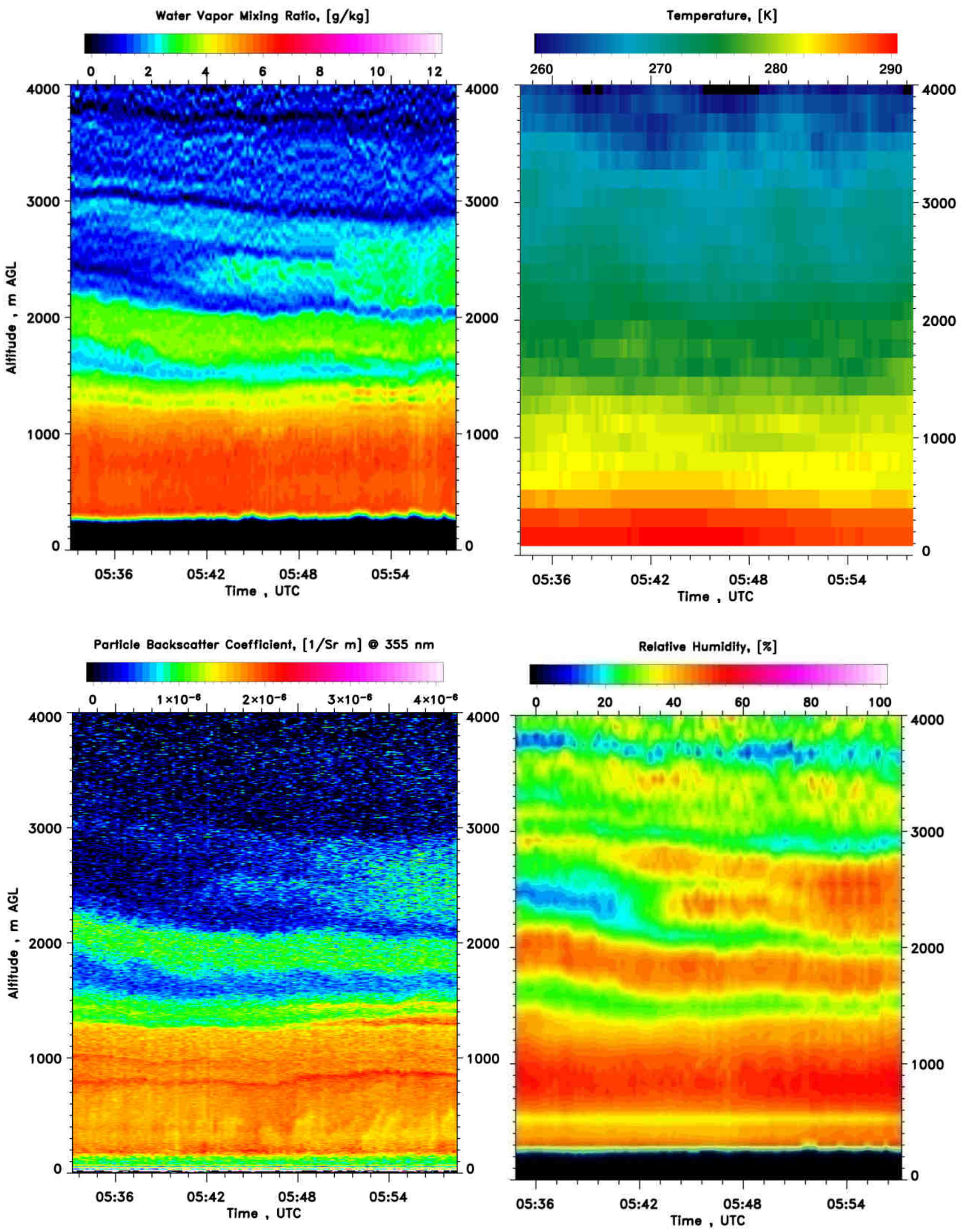


Fig. 15.22. First synergetic data products of the collocated remote sensing instruments at Supersite H. From upper left to lower right: water vapour mixing ratio, temperature, particle backscatter coefficient at 355 nm, relative humidity. For these plots, the data of the UHOH DIAL and UHOH RRL were combined.

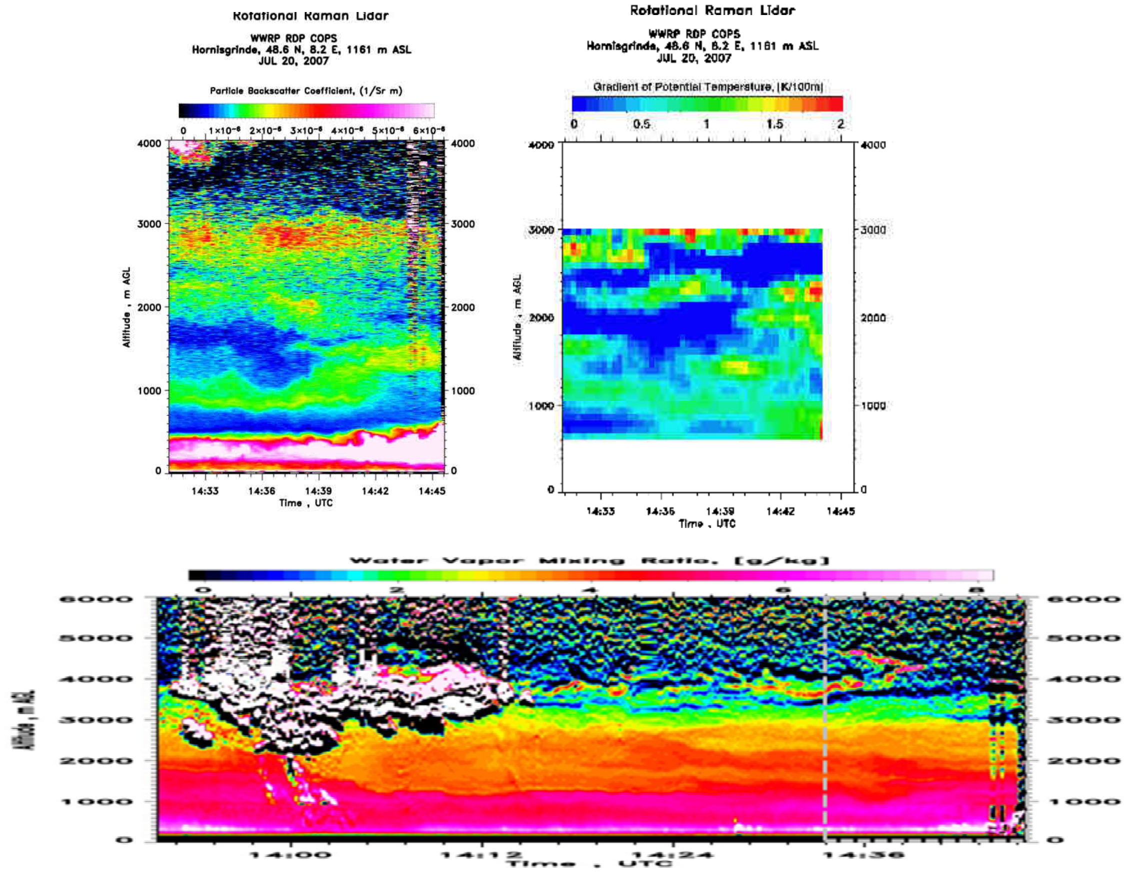


Fig. 15.23. Measurements in the afternoon of IOP 9c at Supersite H: Particle backscatter coefficient (upper left panel), gradient of the potential temperature (upper right panel) and water vapour mixing (lower panel). The dashed gray box in the lower panel marks the measuremenmt period of the upper panels.

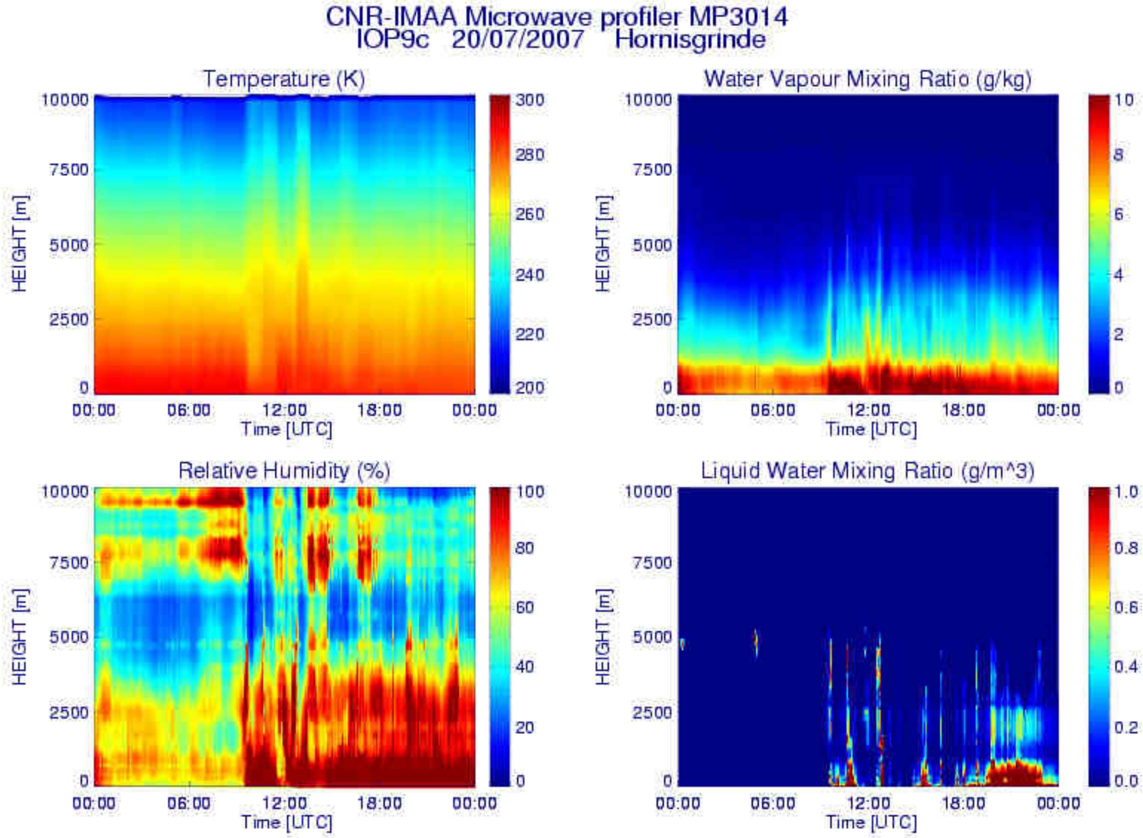


Fig. 15.24. IOP9c (20/07/2007 0500 – 2000 UTC):: Time series of the temperature, water vapor, relative humidity and cloud liquid water profiles retrieved by the MP3014 microwave profiler on the 20/07/2007 at Hornisgrinde. The profiles are output in 100 m up to 1 km above the ground, and in 250 m from 1 to 10 km. The measurements have been performed using ScaS2 scanning strategy The plots are referred to zenith pointing measurements only. In the first half of each measurements hours, the sampling time related to the zenith pointing measurements is 5 minutes, while in the second half the sampling time is 14 seconds. Cloud liquid water retrieval has been performed using the cloud base temperature, measured with an infrared thermometer, as a constrain.

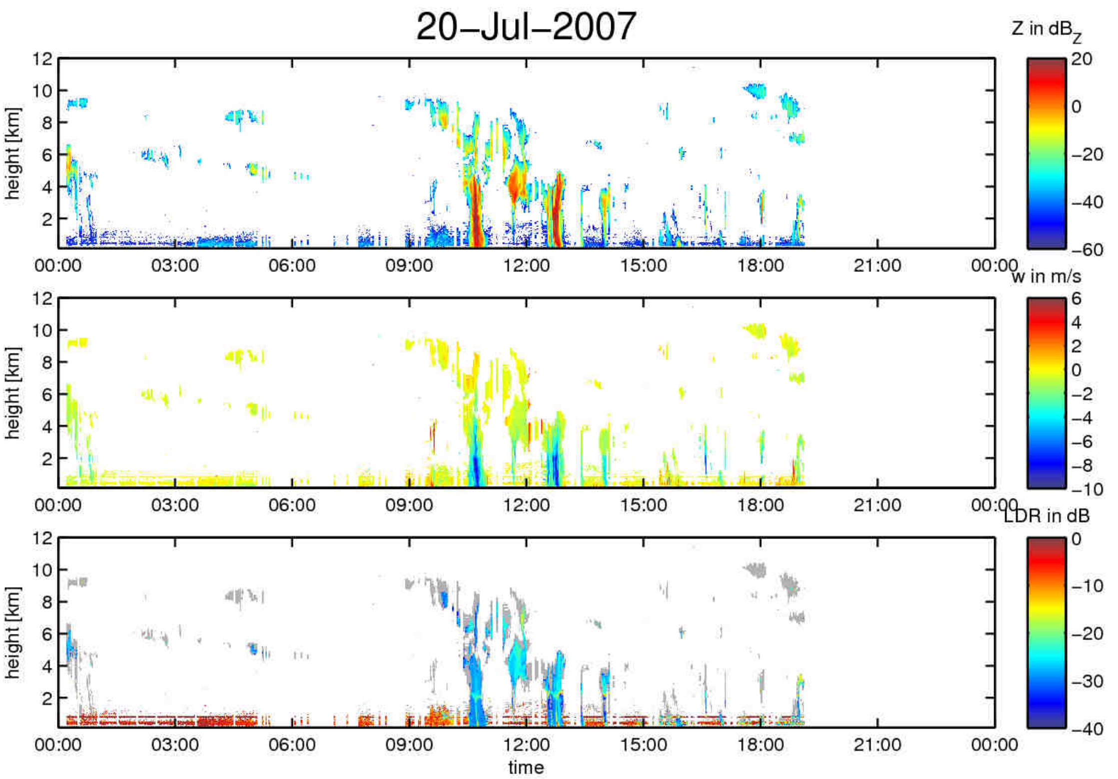


Fig. 15.25. Quicklook of the IMK Cloud Radar. Upper panel: reflectivity, middle panel: vertical wind, lower panel: linear depolarization ratio.

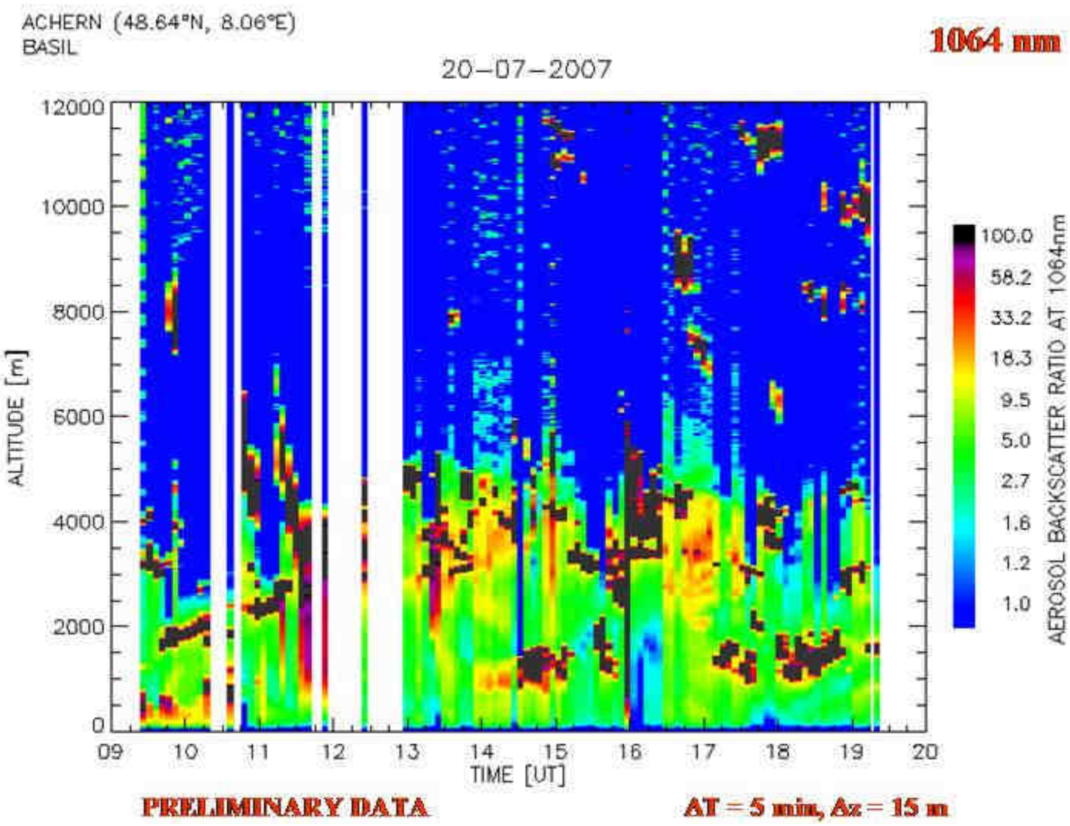


Fig. 15.26. BASIL lidar at Supersite R..

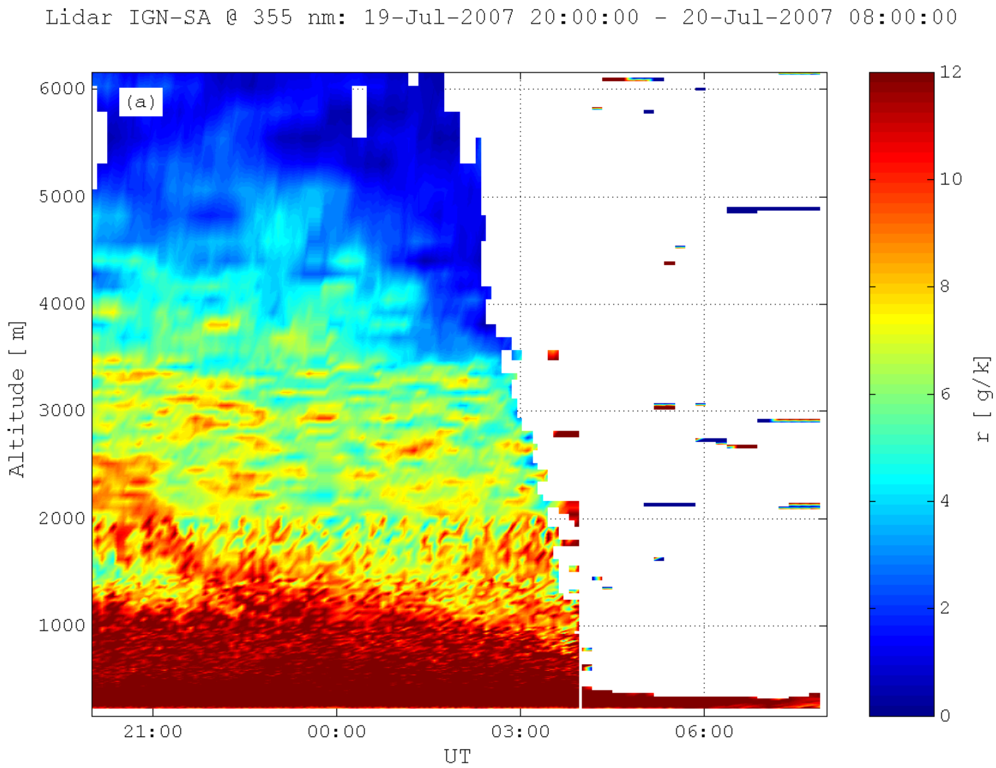


Fig. 15.27. Lidar at Supersite V.

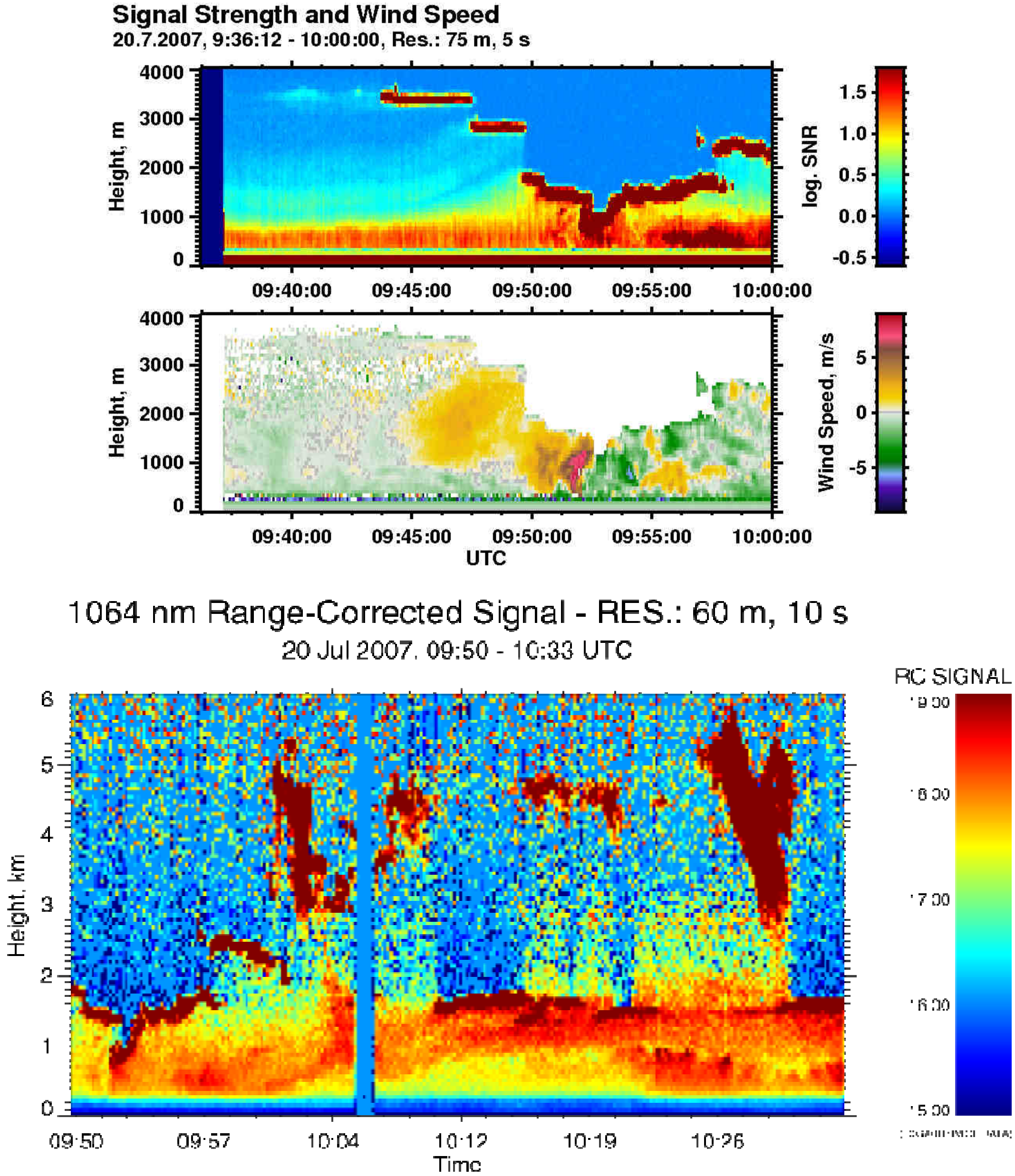


Fig. 15.28. IfT Lidars at Supersite M.

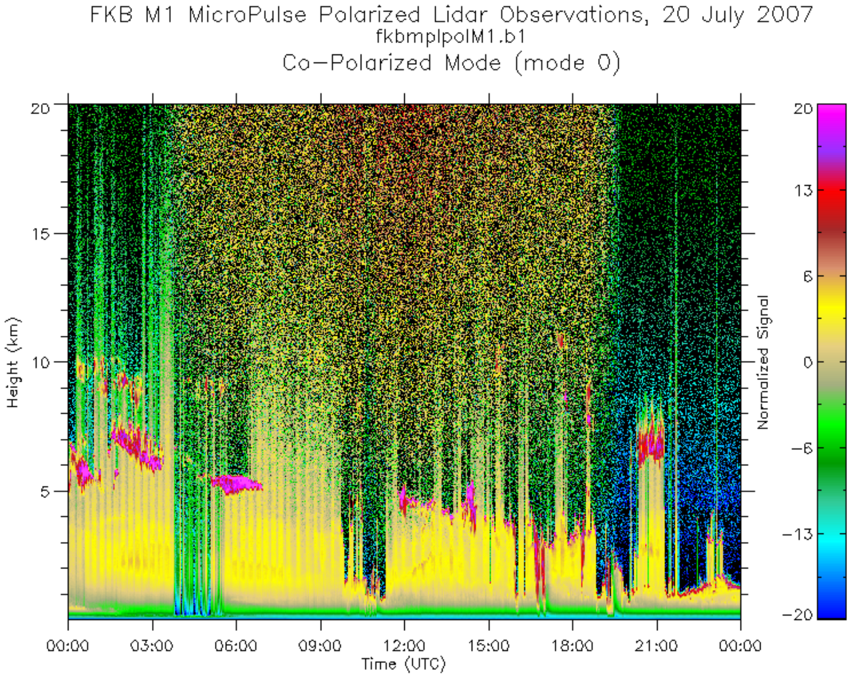


Fig. 15.29. AMF Micropulse lidar at Supersite M.

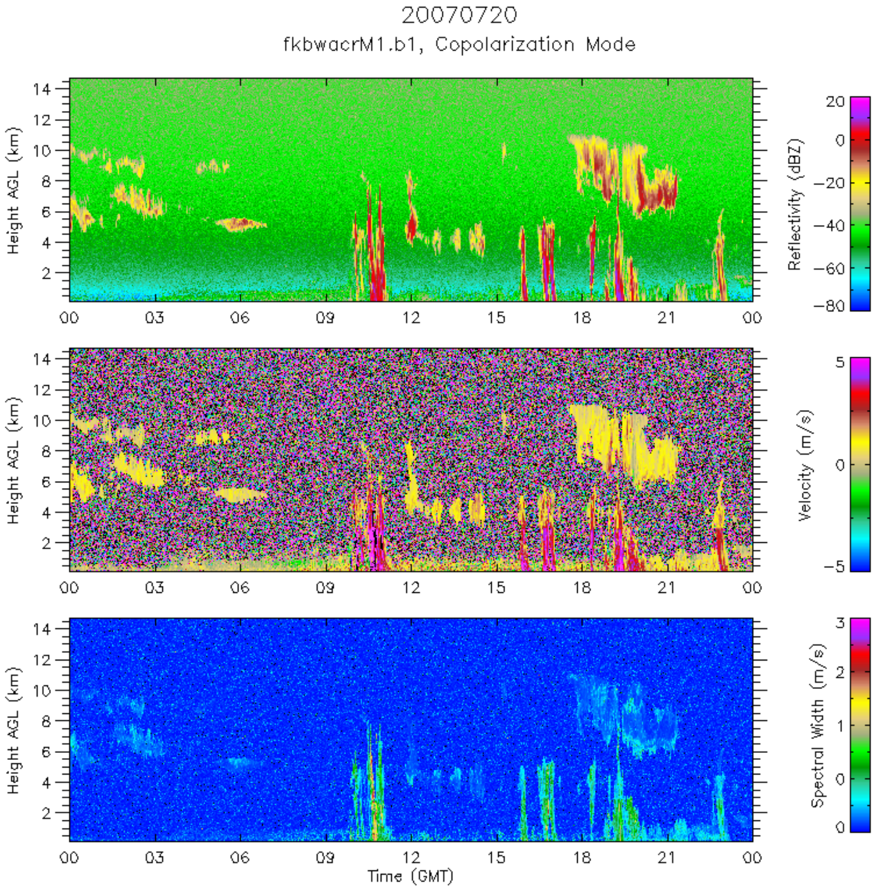


Fig. 15.30. AMF cloud radar at Supersite M.

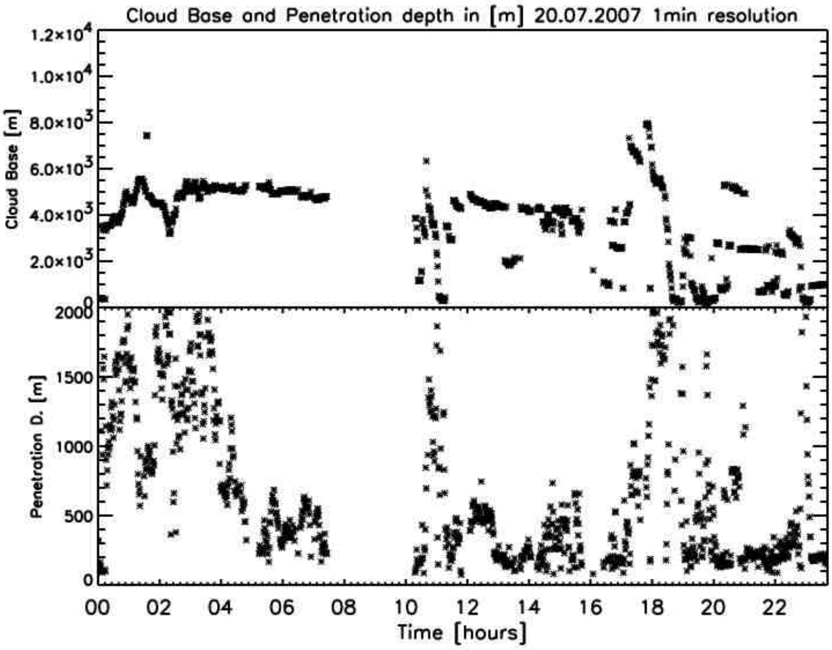


Fig. 15.31. Cloud base height and penetration depth measured with the Ceilometer at Supersite S.

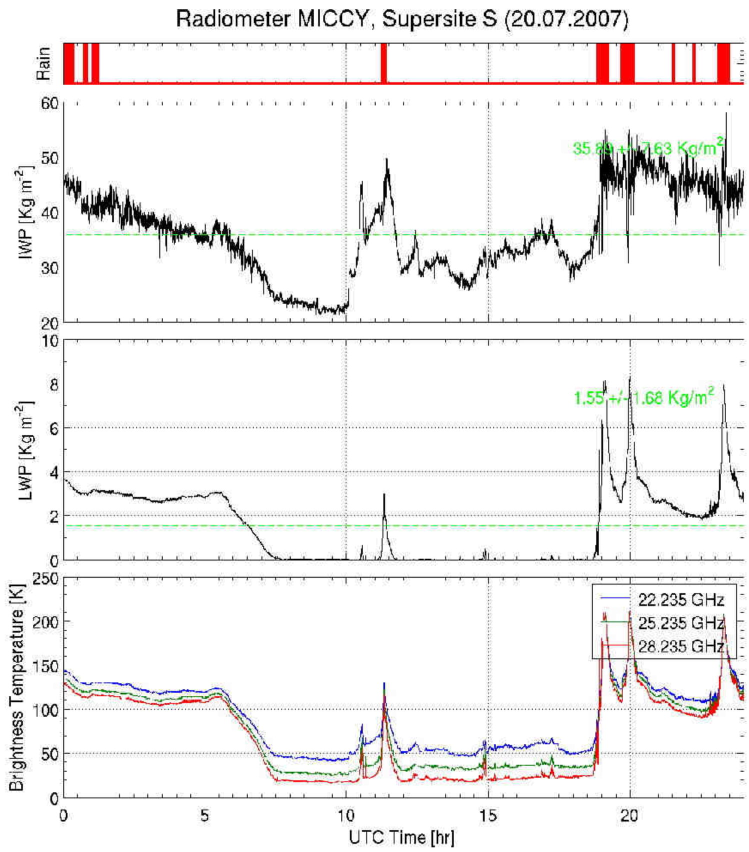


Fig. 15.32. Rain, integrated water path, liquid water path, and brightness temperature measured with the MICCY microwave radiometer at Supersite S.

15.8 Soil moisture

Fig. 15.33 shows results from SISOMOP sensors in 5 cm depth for all measuring stations during IOP 8b and 9c. For better comparison and due to the high number of stations they are classified into 4 regions according to their location.

By analysing the observed soil moisture values for every station differences between the 4 regions, especially for the near-surface sensor (5 cm depth), are clearly seen. It is conspicuous that some stations in BFW display significant differences (up to 40vol%) in their soil moisture values. This applies for stations in BFE too. Besides BFW is the region with the highest soil moisture during IOP 8b and 9c. With an approximate regional average value of 40 vol% soil moisture in the BFW is higher than in KR, BFE and RV (5 to 10vol% in average).

The 7-day period between July 14th and July 20th 2007 which includes IOP 8b and 9c in general shows decreasing soil moisture values.

During the time span from 14th to 17th of July hot and dry conditions caused high evaporation from the uppermost soil layer leading to significant decrease of soil moisture at almost all stations. This time span includes IOP 8b. Times of highest evaporations during one day usually started at 9 a.m. and ended at 6 p.m.

The following frontal rain events (18th till 20th of July) produced an increase in soil moisture visible as peaks in soil moisture time series. But because of fast infiltration soil moisture in the uppermost layer during IOP 9c shows similar or even lower values that at IOP 8b. Stations without rain are characterized by constant soil moisture values in 5 cm depth and therefore show lower soil moisture values than at IOP 8b.

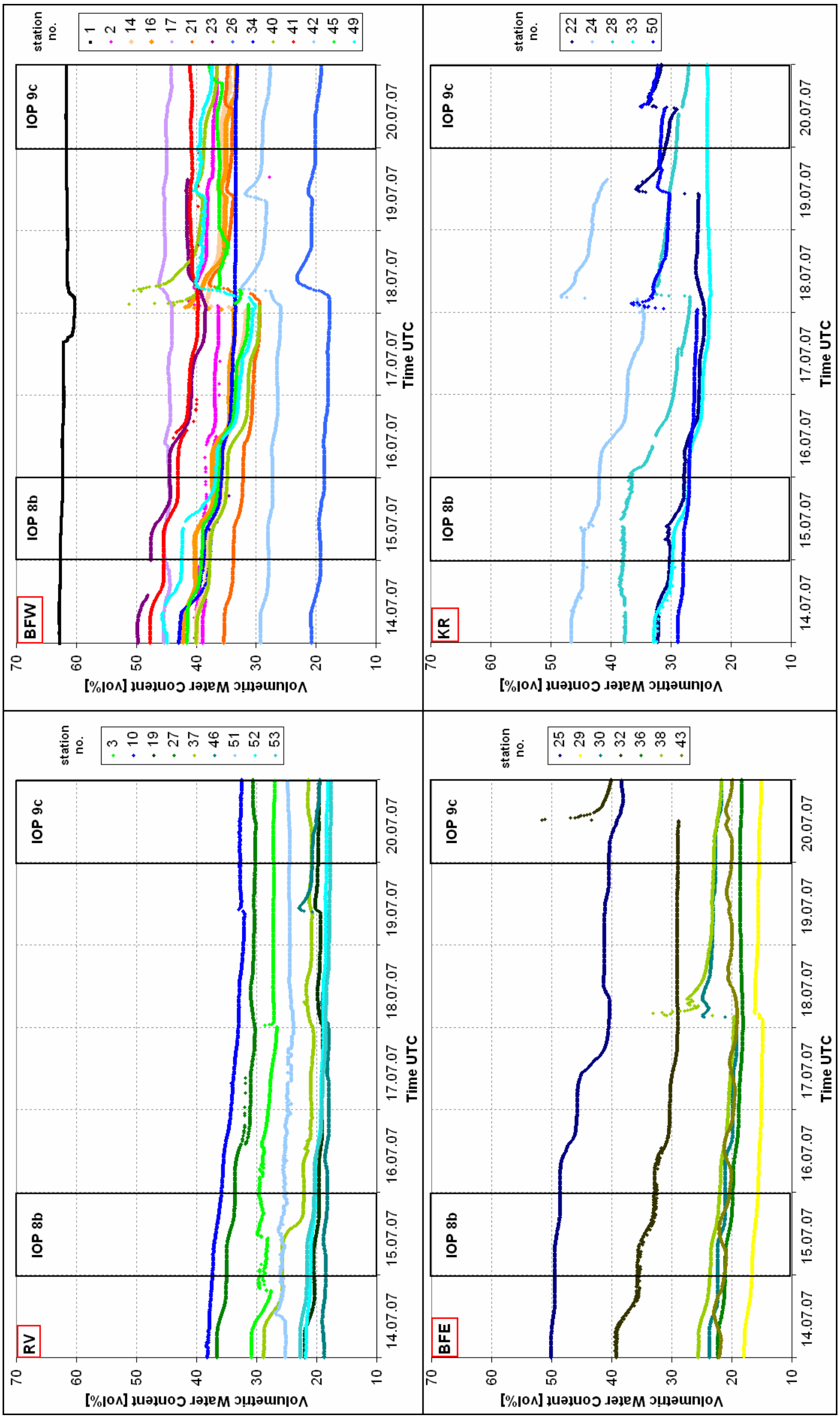


Fig. 15.33. Volumetric Water Content in 5cm depth for all measuring stations during IOP 8b and 9c. All stations are classified into 4 regions according to their location..

16 Appendix I: Abbreviations

1D, 2D, 3D, 4D 1-Dimensional, 2-Dimensional, 3-Dimensional, 4-Dimensional

3DVAR 3 Dimensional Variational Assimilation

4DVAR 4 Dimensional Variational Assimilation

ACM Aerosol and Cloud Microphysics, working group of COPS

ACTOS Airborne Cloud Turbulence Observation System

AERI Atmospheric Emitted Radiance Interferometer

AIRS Atmospheric Infrared Sounder

aLMo Alpine Model (based on LM)

AMF ARM Mobile Facility

AQUA Advances in Quantitative Areal Precipitation Estimation by Radar, DFG project

ARM Atmospheric Radiation Measurement

Arôme New French mesoscale forecast model

ARPA-SIM Agenzia Regionale Prevenzione e Ambiente Dell'Emilla-Romagna – Servizio Idro Meteo

ARPS Advanced Regional Prediction System

ATR 42 Avions de Transport Regional 42 (aircraft)

ATReC Atlantic-THORPEX Regional Campaign

BAe 146 British Aerospace 146 (aircraft)

BALTEX Baltic Sea Experiment

BUFR Binary Universal Form for the Representation

CAPE Convective Available Potential Energy

CAPS Coupled Atmosphere–Plant–Soil (global model)

CART Cloud and Radiation Testbed

CCN Cloud Condensation Nuclei

CEOP Coordinated Enhanced Observing Period

CI Convection Initiation

CLEOPATRA Cloud Experiment Oberpfaffenhofen And Transport (campaign 1991)

CLIWA-NET Cloud Liquid Water Network

CloudNET Research project supported by the European Comission

CLOUDSAT NASA Earth System Pathfinder Satellite mission

CNRS Centre Nationale de la Recherche Scientific

CODI Compact DIAL

COPS Convective and Orographically-induced Precipitation Study (= intensive observations period (IOP) of PQP)

COSI-TRACKS Convective Storm Institute within TRACKS

COSMO-LEPS Consortium On Small Scale MOdelling-Local Ensemble Prediction System

COST-720 European Cooperation in the Field of Science and Technology, Action 720: Integrated Ground-Based Remote Sensing Stations for Atmospheric Profiling

CrIS Cross-Track Infrared Sounder

CSIP Convective Storm Initiation Project (UK, summer 2005)

CVI Counterflow Virtual Impactor

D-PHASE Demonstration of Probabilistic Hydrological and Atmospheric Simulation of flood Events in the Alpine region; MAP Forecast Demonstration Project

DAP Data Assimilation and Predictability, working group of COPS

DAQUA Combined Data Assimilation with Radar and Satellite Retrievals and Ensemble Modelling fort he Improvement of Short Range Quantitative Precipitation, project within PQP

DFG German Research Foundation, Deutsche Forschungsgemeinschaft

DIAL Differential Absorption Lidar

DLR Deutsches Zentrum für Luft- und Raumfahrt

DOE Department of Energy

DOW "Doppler-on-Wheels", mobile radar system

DSD Drop Size Distribution

DWD Deutscher Wetterdienst, German Meteorological Service

EC European Comission

ECHAM5 ECMWF model HAMburg version, release 5

ECMWF European Centre for Medium-Range Weather Forecasts

EMETNET The Network of European Meteorological Services

Envisat Environmental Satellite

EOS Earth Observing System

EPS The Canadian ensemble prediction system

ESA European Space Agency

ETReC07 European THORPEX Regional Campaign 2007

EU European Union

EUCOS EUMETNET Composite Observing System

EULINOX European Lightning Nitrogen Oxides Project

EUMETSAT European Organization for the Exploitation of Meteorological Satellites

FDDA Four Dimensional Data Assimilation

FDP Forecast Demonstration Project

FM-CW Frequency Modulated Continuous Wave

FSL Forecast Systems Laboratory

FTIR Fourier Transformed Infrared

FZJ Research Center Jülich

FZK/UKa Forschungszentrum Karlsruhe, Universität Karlsruhe

GFZ GeoForschungsZentrum Potsdam, Research Centre for Geosciences Potsdam

GME Global Model of the DWD

GOES Geostationary Satellite Server

GOP General Observations Period of PQP

GPCP Global Precipitation Climatology Project

GPS Global Positioning System

GTS Global Telecommunication System

GWA Ground Water Atlas

HATPRO Humidity and Temperature Profiler

HELIPOD Helicopter-borne Turbulence Probe, University of Braunschweig

HGF Helmholtz-Gemeinschaft Deutscher Forschungszentren

HODAR Holographic Particle Recorder, University of Mainz

HRDL High-Resolution Doppler Lidar

HTDMA Humidified Tandem Differential Mobility Analyzer

IASI Infrared Atmospheric Sounding Interferometer

ICG Institut für Chemie der Geosphäre

IFS Integrated Forecast System of ECMWF

IfT Institute for Tropospheric Research

IHOP_2002 International Water Vapor Project 2002 (USA, 2002)

IMAA Istituto di Metodologie per l'Analisi Ambientale

IMK Institut für Meteorologie und Klimaforschung, Karlsruhe

IMPROVE Improvement of Microphysical Prameterization through Observational Verification Experiment

INSU Institut National des Sciences de l'Univers

INT Interstitial Inlet

IOP Intensive Observations Period = COPS

IPA Institute of Atmospheric Physics

IPM Institute of Physics and Meteorology, University of Hohenheim

IPT Integrated Profiling Technique

IR infrared

IRCTR International Research Centre for Telecommunications- Transmission and Radar

ISSC International Science Steering Committee

IWV Integrated columnar Water Vapour

KAMM Karlsruher Mesoscale Model

LaMMA Laboratory for Meteorology and Environmental Modelling

LAUNCH2005 International Lindenberg campaign for assessment of humidity and cloud profiling systems and its impact on high-resolution modelling, Field experiment (Germany & Italy, 2005)

LINOX Lightning produced NO_X (1996)

LM Lokalmodell of DWD

LME LM Europe

LMK Lokal Modell Kürzestfrist

LWC Liquid Water Content

LWP Liquid Water Path

MAP Mesoscale Alpine Programme

MC2 Modèle Mésoéchelle Compressibile Communautaire (Canada)

MERIS Medium Resolution Imaging Spectrometer

Méso-NH french mesoscale model

Met Office UK British Weather Service

Meteo France French Weather Service

MeteoSwiss swiss Weather Service

METRAS Mesoscale Transport and Fluid Model

MICCY Microwave Radiometer for Cloud Cartography

MITRAS Microscale Transport and Fluid Model

MM5 Mesoscale Model Release 5

MMM Micro Meteorological Masts

MODIS Moderate Resolution Imaging Spectroradiometer

MPI Max-Planck-Institute

MPIfC MPI for Chemistry

MPIfM MPI for Meteorology

MRR Micro rain radar

MSC Meteorological Service of Canada

MSG Meteosat Second Generation

MWL Multi-Wavelength Raman Lidar of IfT

NASA National Aeronautics and Space Administration

NCAR National Center for Atmospheric Research

NCAR ATD NCAR Atmospheric Technology Division

NCAR MMM NCAR Mesoscale & Microscale Meteorology Division

NCAS NERC Centres for Atmospheric Science

NCEP National Centers for Environmental Prediction

NERC Natural Environment Research Council

NINJO Meteorological workstation of DWD

NIR near infrared

NOAA National Oceanic & Atmospheric Administration

NSF National Science Foundation (USA)

NVaP NASA Water Vapor Project

NWP Numerical Weather Prediction

OC Operations Center

OP Operations Plan

PBL Planetary Boundary Layer

PEPS Poor Man's EPS

PI Principal Investigator

POLDIRAD Polarization Diversity Doppler Radar, DLR Oberpfaffenhofen

PP priority program (= SPP1167, Schwerpunktprogramm1167 = PQP)

PPL Precipitation Processes and its Life Cycle, working group of COPS

PQP Praecipitationis Quantitativae Praedictio (Latin for "quantitative precipitation forecast"), Priority Program 1167 of DFG

PrI Precipitation Initiation

QPF Quantitative Precipitation Forecast

RAMS Regional Atmospheric Modeling System

RASL Raman Airborne Spectroscopic Lidar

RASS Radio Acoustic Sounding System

RDSD Rain Drop Size Distribution

REAL Raman-shifted Eye-save Aerosol Lidar

REKLIP Regionales Klimaprojekt

RISH Research Center for a Sustainable Humanosphere

RR Rain Rate

RR Rotational Raman

RS Radiosonde

RV Reduction of variance

S-POL S-band Dual Polarization Doppler Radar

S-POL S-Pol radar of NCAR

SAFIRE Surveillance et Alerte Foudre par Interférometrie Radioélectrique; Blitz-Ortungssystem des Instituts für Meteorologie und Klimatologie, Universität Hannover

SETEX Severe Thunderstorms Experiment

SEVIRI Spinning Enhanced Visible and Infra-Red Imager

SFB Sonderforschungsbereich

SGP Southern Great Plains

SISOMOP Simple Soil Moisture Probe

SMPS Scanning Mobility Particle Spectrometer

SOD Science Overview Documentation of COPS

Sodar Sonic Detecting and Ranging

SOP Special Observing Period

SRB Surface Radiation Budget

SRL Scanning Raman Lidar

SRQPF Short-Range QPF, project within PQP

SSC Science Steering Committee

SSM/I Special Sensor Microwave Imager

SYNOP Surface Synoptic Observations

TDR Temperature Data Record

THORPEX The ObservingSystem Research and Predictability Experiment

TIGGE THORPEX Interactive Grand Global Ensemble

TIROS Television Infrared Observation Satellite

TOVS TIROS Operational Vertical Sounder

TRACKS Transport and Chemical Conversion in Convective Systems; HGF project

TRACT TRansport of Air pollutants over Complex Terrain

TreCs THORPEX Regional Campaigns

UCAR University Corporation for Atmospheric Research

UFAM Universities' Facility for Atmospheric Measurement

UHF Ultra High Frequency

UHOH Universität Hohenheim, University of Hohenheim

UK United Kingdom

UM-ELA Unified Model – European Limited Area

UM-G Unified Model - Global

UM-M Unified Model - Mesoscale

US United States

UTC Coordinated Universal Time

UTMS Urban Transportation Modeling System

UV ultraviolet

UWKA University of Wyoming King Air

VERTIKATOR Vertikaler Transport und Orographie, Field experiment, see http://www.vertikator-afo2000.de/ (Germany, 2002)

VIS visible

WCRP World Climate Research Programme

WDCC World Data Center for Climate

WG Working Group of COPS

WiLi Wind Lidar of IfT

WindTracer Scanning Doppler Wind Lidar from IMK/FZK

WMO World Meteorological Organization

WRF Weather Research & Forecasting Model, mesoscale model

WRF-Chem WRF with a chemistry module

WSR-88D Weather Surveillance Radar 88 Doppler

WTR Wind-Temperature Radar

WV Water Vapour

WWRP World Weather Research Programme

WWRP RDP WWRP Research and Development Project

17 Appendix II: COPS ISSC, WG Chairs and Project Office

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Precipitation Processes and Life Cycle (PPL):

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