Convective and Orographically-induced Precipitation Study (COPS)

SPP 1167 Intensive Observations Period (IOP)

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Present data sets describe only the tip of the iceberg of precipitation

- The hidden information can only be extracted by a complementary and synergetic set of multi-wavelength advanced remote sensing systems
- For understanding and prediction of precipitation, the 4D clear-air pre-convective environment must be observed, as this is the beginning of the chain of critical events
- Key variables are all components of the water cycle and dynamics, particularly in the boundary layer, as well as surface properties

Science objectives

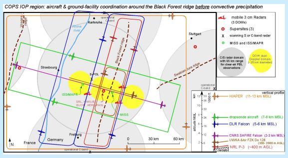
- Identify the most important processes in low-mountain regions which have to be resolved for an improvement of QPF
- Design observing systems and observational strategies for successful model validation and data assimilation efforts
- Assess the most important model deficiencies and test improvements
- Study the predictability of relevant structures responsible for precipitation

System constellations

Location: Southwestern Germany, eastern France

Time and duration: June-August 2007

- Instrument locations, operation modes and platforms will be chosen by merging information from performance models and forecast models
- Choice of optimal constellation for making use of synergy effects



Sample mission for pre-convection studies

Overarching goal of COPS:

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

Which gaps?

Which objectives?

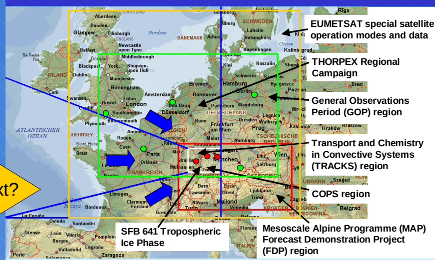
Which setting?

Which context?

Which instruments?

Which hypotheses?

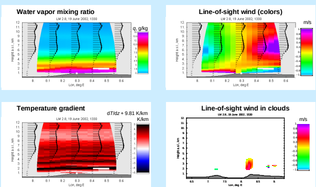
Envisioned international collaboration



- A large proposal has been submitted to the National Science Foundation in the USA for funding to participate in COPS
- A proposal for a Regional Campaign is in preparation by the European THORPEX Regional Committee

Finding the optimal mix of instruments by

a) performance models and forward model analyses



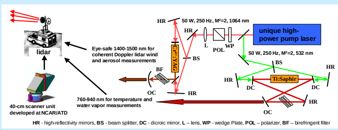
Case study:
RHI scans in east-west direction, scanning systems located near Hornisgrinde

Input: LM results obtained for 19 June 2002, 13:30 –17:30 UTC, 2.8 km resolution

Clear-air fields of line-of-sight wind, water vapor mixing ratio and temperature serve to assess the performance of lidar systems.

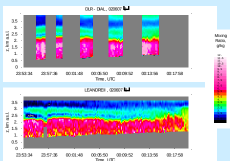
The bottom right panel shows where Doppler-sensitive cloud radar provides data.

b) monitoring of innovative instrument developments, example:



Combined water-vapor and Doppler wind lidar system with 3-d scanning capability on a mobile platform under development at IPM in collaboration with NCAR/ATD.

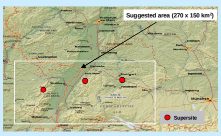
c) quality ensurance



IPM scientists are strongly involved in the Instrument Comparison component of IHOP_2002.

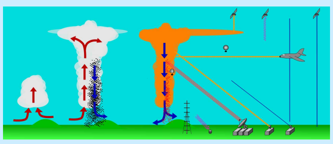
This example shows water vapor mixing ratios measured during a formation flight of the French LEANDREII DIAL and the DLR DIAL on 7/8 June 2002 (Behrendt et al., ISTP2003). These analyses are very beneficial for the preparation of COPS.

d) taking advantage of system synergies



The proposed COPS region and possible locations of supersites where a synergy of remote sensing systems will be deployed are indicated by red circles.

The Supersites will consist 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**. These instruments will be operated from mobile, ground-based, airborne and space-borne platforms. This way, convective processes will be studied in high spatial and temporal resolution and in both clear air and within clouds.



Precipitation radars
X-, C- or S-band,
$\nu = 2 – 10$ GHz, $\lambda \approx 15 – 3$ cm,
⇨ Reflectivity and LOS velocity of hydometeors, refractivity

Cloud radars
Ka- or W-band
$\nu = 35 – 95$ GHz, $\lambda \approx 9 – 3$ mm
⇨ Particle reflectivity factor, depolarisation (→ liquid/ice), LOS velocity in clouds

Lidars
$\lambda \approx 0.3 – 2$ µm, $\nu = 10^{15} – 1.5\times10^{14}$ Hz
⇨ α_{par}, β_{par}, δ (→ liquid/ice), q, T, LOS wind in clear air, aerosol layers and thin clouds

MW and FTIR radiometers ⇨ LWC, q, T, ...

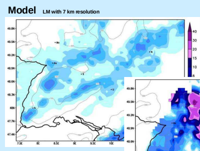
The full potential of synergetic measurements is not explored yet, e.g.:
- R_{eff} in clouds using lidar and cloud radar (Donovan et al. 2001)
- CCN using lidar, cloud radar and MW radiometer (Feingold et al. 1997)

Hypotheses

The following list of hypotheses has been developed for COPS and will be refined in upcoming workshops:

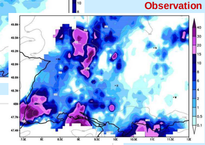
- **Detailed knowledge of the large-scale conditions is a prerequisite for improving QPF in orographic terrain.**
- **Better understanding and high-resolution modeling of the orographic controls of convection such as embedded convection in convergence lines, secondary circulations, and regional-scale potential instability is essential.**
- **The initiation of convection depends mainly on the humidity field structure in the PBL.**
- **Continental and maritime aerosol type clouds develop differently over mountainous terrain, but ice formation and precipitation from convective clouds do not depend on measurable aerosol properties.**
- **The combination of novel instrumentation during COPS can be designed in such a way that critical parameterizations of sub-grid processes in complex terrain can be improved.**
- **Real-time data assimilation of key prognostic variables such water vapor and dynamics is routinely possible and leads to a significant better short-range QPF.**

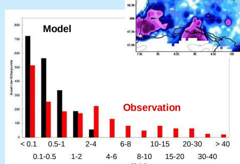
Analysis of QPF skill of the LM



Case study:

Precipitation between June 19, 2002 06 UTC and June 20, 2002 06 UTC





The forecast quality decreases significantly with increasing severity of the precipitation event.

LM-predicted rainfall has been compared with measurements. Distinction between precipitation mainly caused by large scale lifting of pseudo-potentially unstable air, far in front of a trough (6 PVA-cases) and rainfall connected with the passage of a cold front (6 front-cases) was made.

Results:
- The vertical stratification and the position of fronts are properly simulated…

but
- Significant underestimation of the number of grid points with medium and high amount of rainfall (> 6 mm in 24 h, 10 of 12 cases) by the model, especially in PVA-cases.
- Overestimation of the number of grid points with little rain (< 6 mm in 24 h) by the model, more pronounced in non-frontal cases.
- Significant overestimation of the number of grid points with very little rain (< 0.1 mm in 24 h) by the model in frontal-cases.
- Coupling of non-frontal precipitation to the orographic structure.
- Onset of convective rain in the model too early in the morning (2 to 3 hours).
- High spatial variability (var) of the measured rain not reproduced by the model in both, PVA cases and frontal cases:
  PVA: var _measured = 2.5 mm, var_model = 0.8 mm
  Frontal: var_measured = 2.6 mm, var_model = 1.1 mm.

Performed at University of Hohenheim

1) Set up of a project office and International Science Steering Committee (ISSC)

2) International workshops and preparation of Scientific Overview Document and an Operations Plan

3) Scientific performance analysis of advanced remote sensing systems

Interfaces

Performed at Karlsruhe University

1) Extensive LM analyses of different precipitation events

2) Develop preliminary hypotheses for improving QPF in NWP

3) Suggest targeting of key processes to be investigated