Investigation of the process chain leading to the development of convection during COPS IOP 4b

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Motivation

- The severe convection that developed in the evening of June 20th 2007 and over night was not correctly simulated by many of the D-PHASE forecast models.
- This IOP enables the investigation of the complex interplay between lower- and upper troposphere as a well as small- and larger-scale processes since it occurred on the transition between weakly and strongly forced conditions.

Quelle: Internet

Hypothesis

The development of convection during COPS IOP 4b was the result of a complex interaction between lower- and upper troposphere and between small- and larger-scale.

COPS IOP 4b – the synoptic development

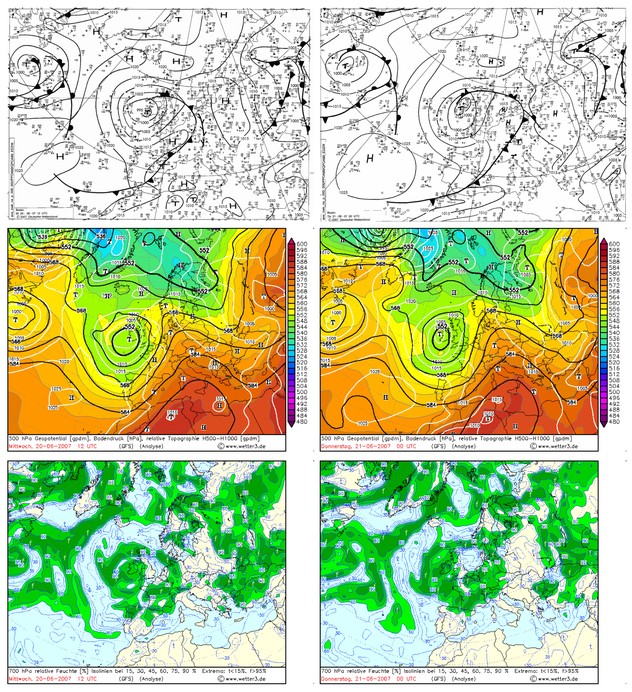

Figure 1: Synoptic development during COPS IOP 4b illustrated by surface weather charts (upper row), GFS forecasts of mean sea level pressure and 1000-500 hPa thickness (middle row) and relative humidity at 700 hPa for 12 UTC June 20 2007 (left column) and 00 UTC June 21 2007.

Quelle: Internet

Between a ridge spreading from southern Scandinavia to the eastern Alps and a closed low over Ireland, moist and humid air is transported to central Europe in a strong southwesterly flow leading to a unstable air mass over the COPS region.

Although the surface front reached the COPS region not before 18 UTC, isolated convection occurred in the afternoon.

In the evening and during night severe convection was triggered and moved to the east.

Data sets

Joint D-PHASE/COPS data set

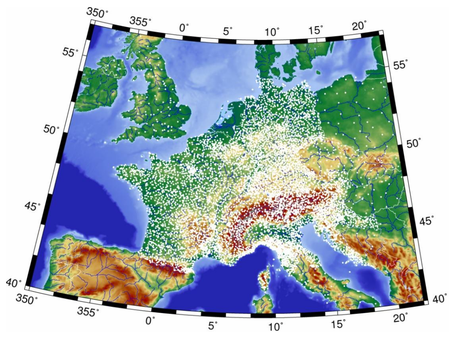

Figure 2: Station locations of the JDC data set in the COPS region. This data is the basis for the VERA analysis of the University of Vienna

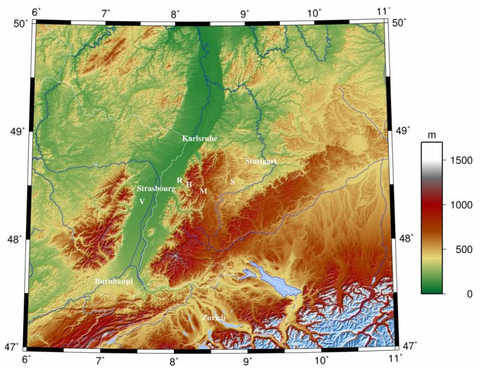

Figure 3: Topography of the COPS region. V, R, H, M and S denote the locations of the COPS supersites.

The point measurements of the JDC data set were fed into the Vienna Enhanced Resolution Analysis (VERA) system to produce high-quality gridded data sets of e.g. potential temperature and mixing ratio at 2 m, wind at 10 m.

For this investigation, the GPS IWV data was interpolated to the DX radar grid.

GPS Zenith Total Delay (ZTD)

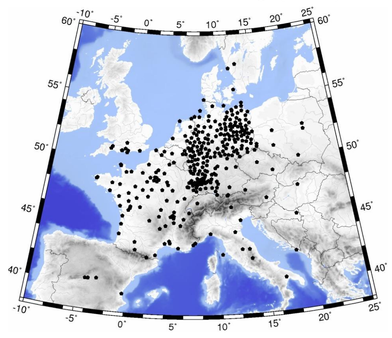

Figure 4: GPS receiver stations in central Europe. Their data was processed by the Helmholtz Center Potsdam, German Geo-research Center (GFZ).

Radar data (radial velocity and reflectivity)

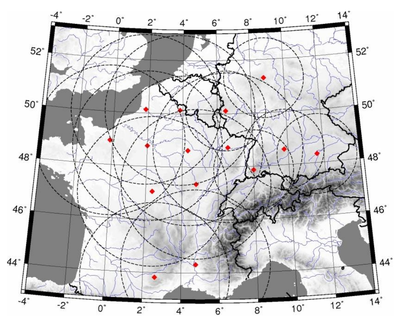

Figure 5: Location and coverage of radar stations in Germany and France.

In this preliminary analysis, only the DX product of DWD is applied. Later when model processes will be investigated, 3D volume data will be assimilated into the WRF model.

In addition, remote sensing and in-situ data collected at the COPS supersites, satellite observations and radiosonde data will be included in this study.

Investigation of the process chain

Aim here is to cross-compare different data sets collected during COPS to reveal the processes leading to the development of severe convection in the late afternoon and overnight to June 21 2007.

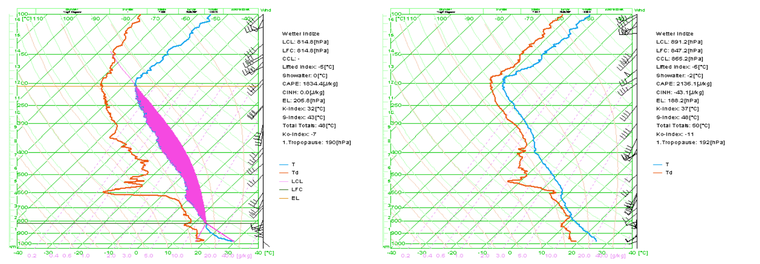

Figure 6: Radiosonde ascends from the IMK Karlsruhe at station Burnhaupt at 14 UTC (left), 17 UTC (middle) and 21 UTC on June 20 2007.

The radiosonde ascents reveal the warm and moist environment present in the COPS region in the afternoon. CAPE values exceed 2000 J/kg in the afternoon. In the evening, after the development of convection, the values are considerably lower.

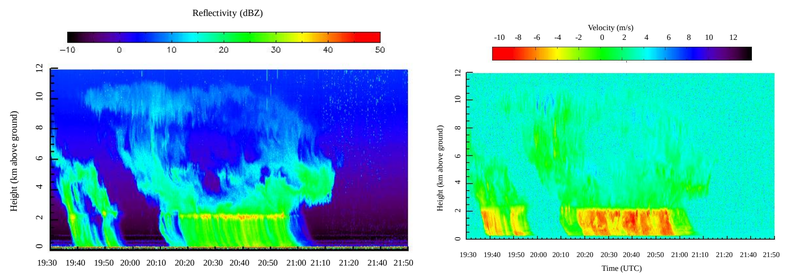

Figure 7: *University of Hohenheim X-Band radar located on the Hornisgrinde showing the precipitation events between 19:30 and 21:30 UTC. The upper panel shows reflectivity and the lower panel the terminal velocity of the precipitation particles.*

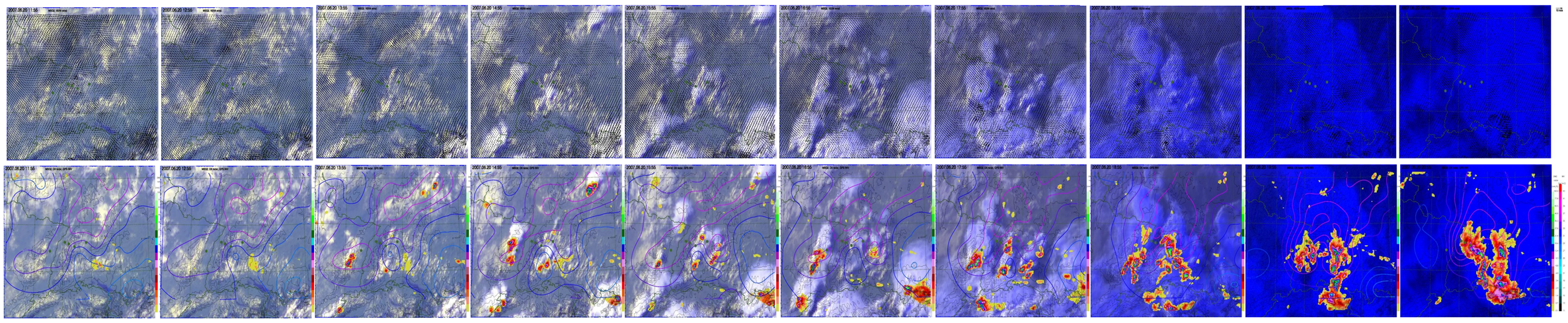

Figure 8*: Comparison of the 2 km VERA wind field (upper row) with a composite combining a high resolution satellite image, the DWD DX radar reflectivity, and GPS IWV (contour lines). Shown is the time period from 12 UTC to 22 UTC in hourly steps.*

- At the beginning of the sequence, the surface front was still to the west of the COPS region. Therefore the orography played an important role in determining the near surface circulation.
- Upslope flow and convergence caused cloud development over the mountains, especially over the Vosges and the southern part of the Swabian Jura.
- First stronger precipitation occurred over the moister environment of the Vosges. This changed the moisture structure in the atmosphere and further increased the instability.
- At about 18 UTC, the retarding surface front reached the COPS region and causes widespread convective initiation further moistening the middle and upper troposphere.
- Over the Alps a mesoscale convective system developed further destabilizing the environment in the southern COPS region.
- The system moved northward and merged with the convection that developed further to the north into a large region of convective activity.
- This region moved eastward during the night to June 21.

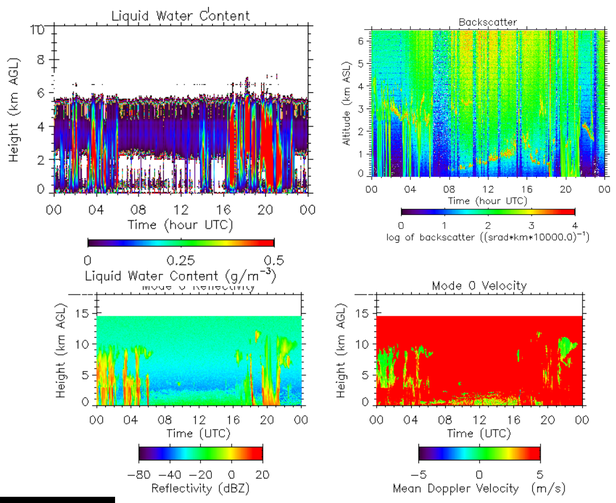

Figure 9*: Observations from the ARM site at supersite M in the Murg valley. Upper left: Liquid water content from a microwave radiometer. Upper right: Ceilometer cloud base height. Lower panels: Reflectivity (left) and vertical velocity from a vertically pointing cloud radar.*

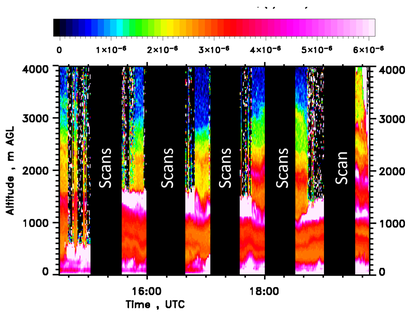

Figure 10*: University of Hohenheim Rotational Raman Lidar located on the Hornisgrinde. It shows low-level clouds and moist aerosol layers*

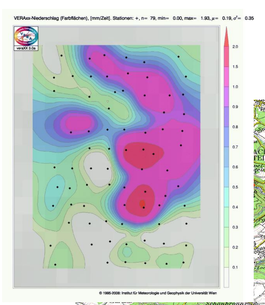

Figure 11*: Vertical wind profile measured with a wind profiler at the ARM site in the Murg valley (right).*

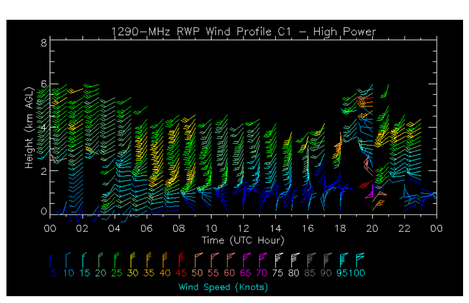

Figure 12*: Location of the COPS-1 km MESONET stations near the COPS supersite S and an example for the distribution of precipitation during IOP 4b.*

Preliminary Conclusions

- A large amount of different and complementing data sets is available for the analysis
- Due to the transition from weakly forced to strongly forced conditions, the process chain encompasses several spatial and temporal scales.
- A key process is the preparation of the environment for the later on developing convection by first convection developing over the Vosges mountains.

Outlook

- Further cross-comparison with additional data sets to reveal the process chain in more detail.
- When the process chain is understood – model simulations with WRF will be investigated for systematic errors.