Convection-resolving model simulations of convective precipitation in low-mountain terrain

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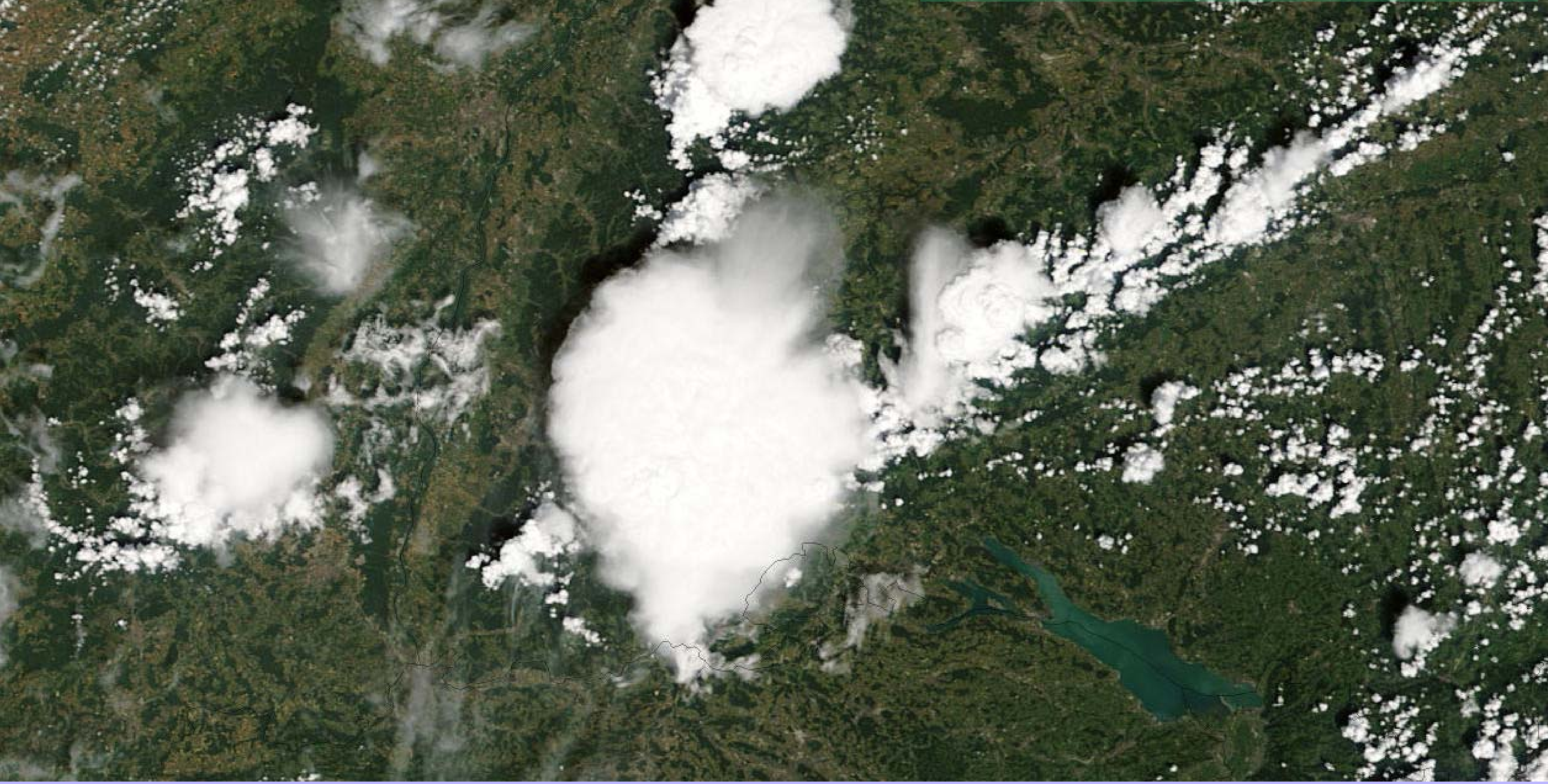
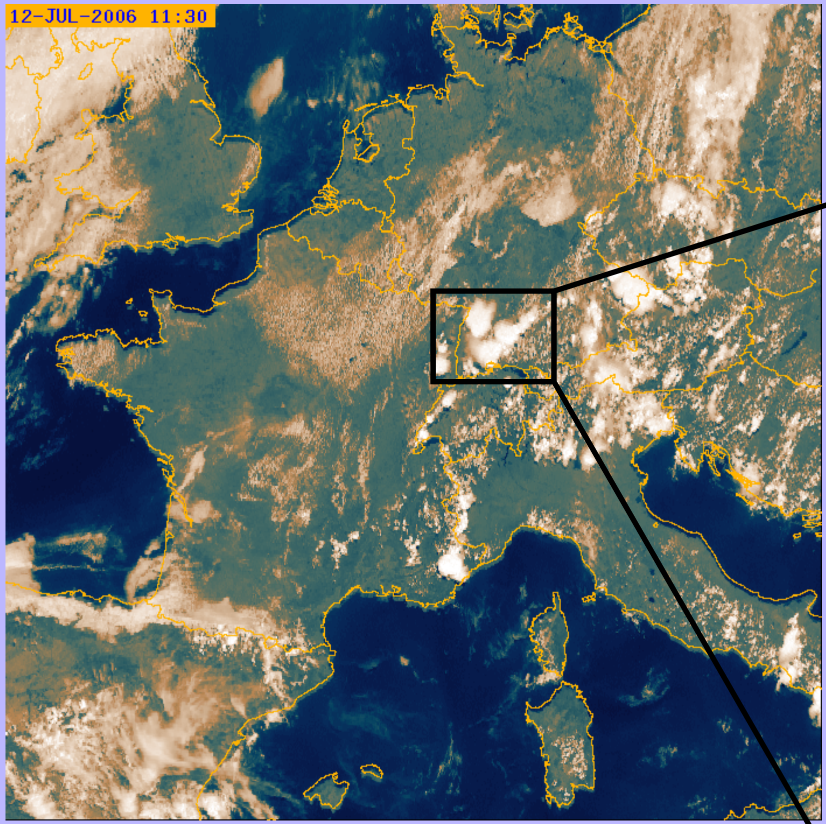


PRINCE
Prediction, **i**dentification and tracki**n**g of **c**onvective c**e**lls

Field experiment to investigate convection, July 2006. A collaboration between the FZK-IMK, University Hohenheim, University Mainz, DLR. Mobile (aircraft, soundings) and stationary (Radar, LIDAR) instrumentation

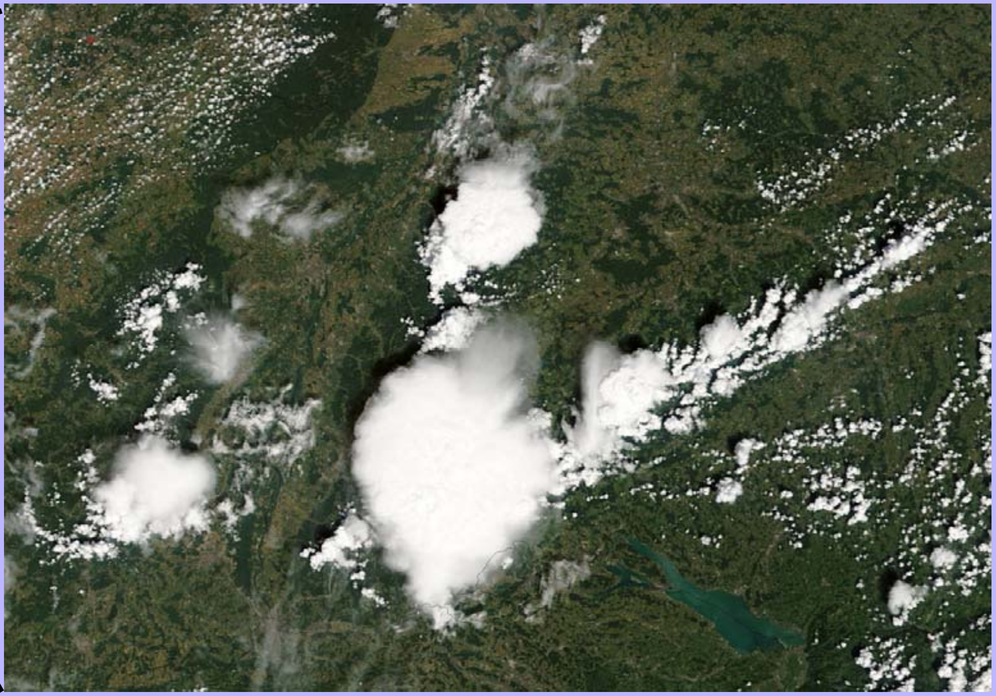
Goal: Observe the pre-convective environment and the evolution of convective cells in orographically-structured terrain.

METEOSAT, 12 July 2006, 1130 UTC



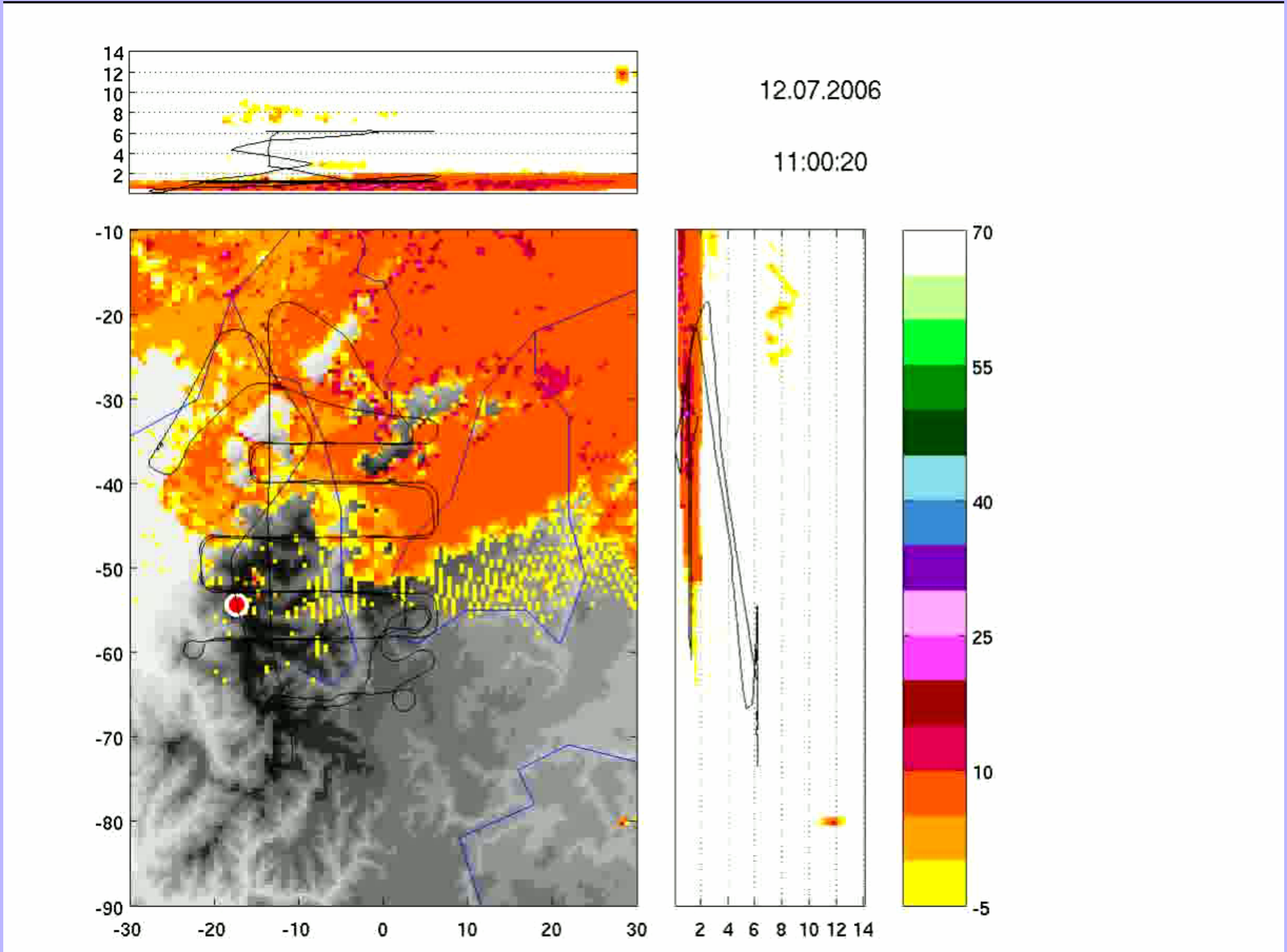
12 July 2006: local formation of single convective cells under weak synoptic forcing

MODIS, 12 July 2006, 1030 UTC

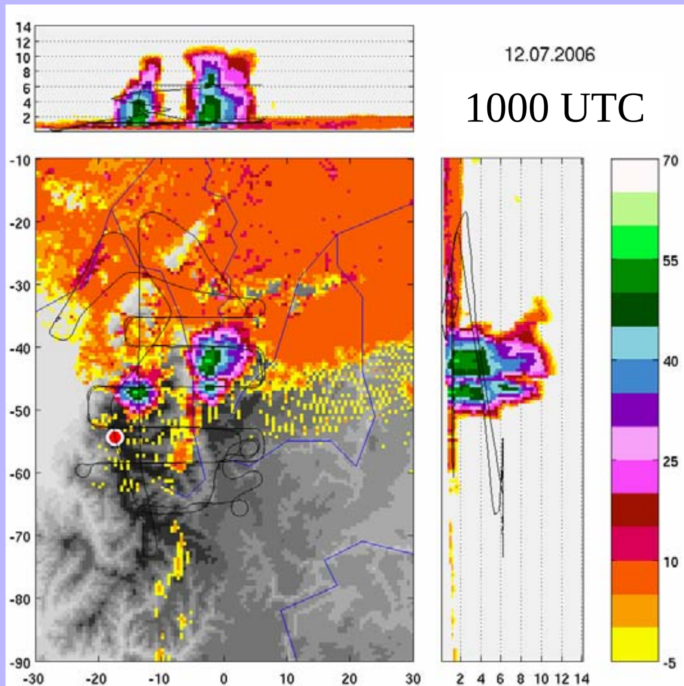


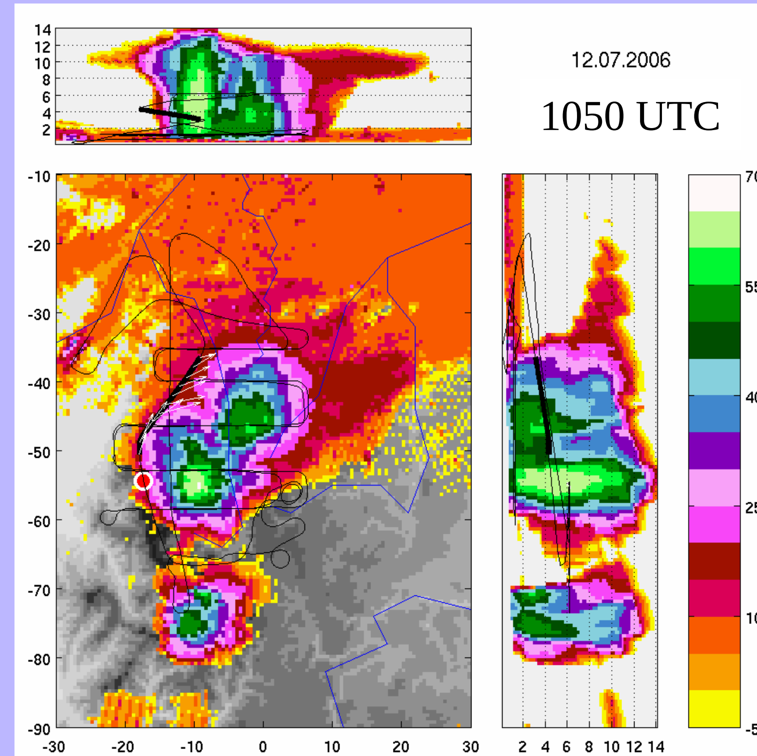
http://rapidfire.sci.gsfc.nasa.gov/realtime

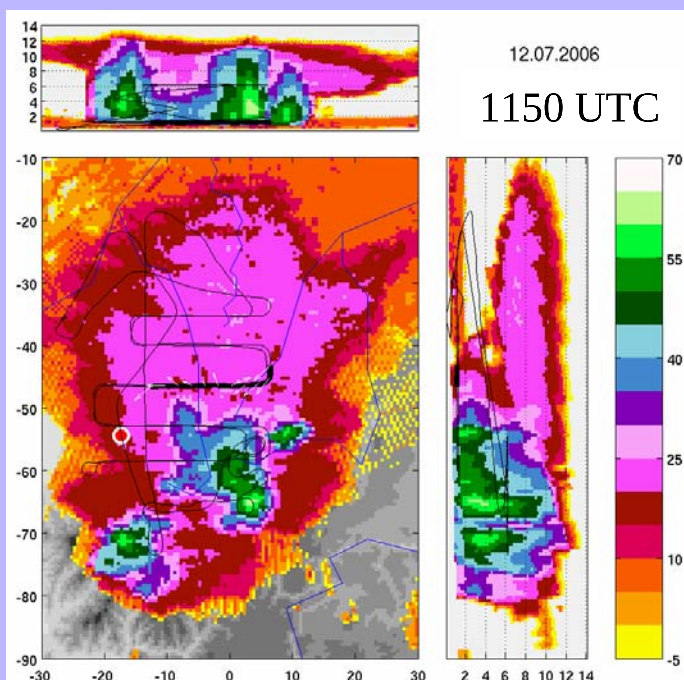
Radar Animation, 12 July 2006, 09 – 13 UTC



Jan Handwerker, IMK Karlsruhe



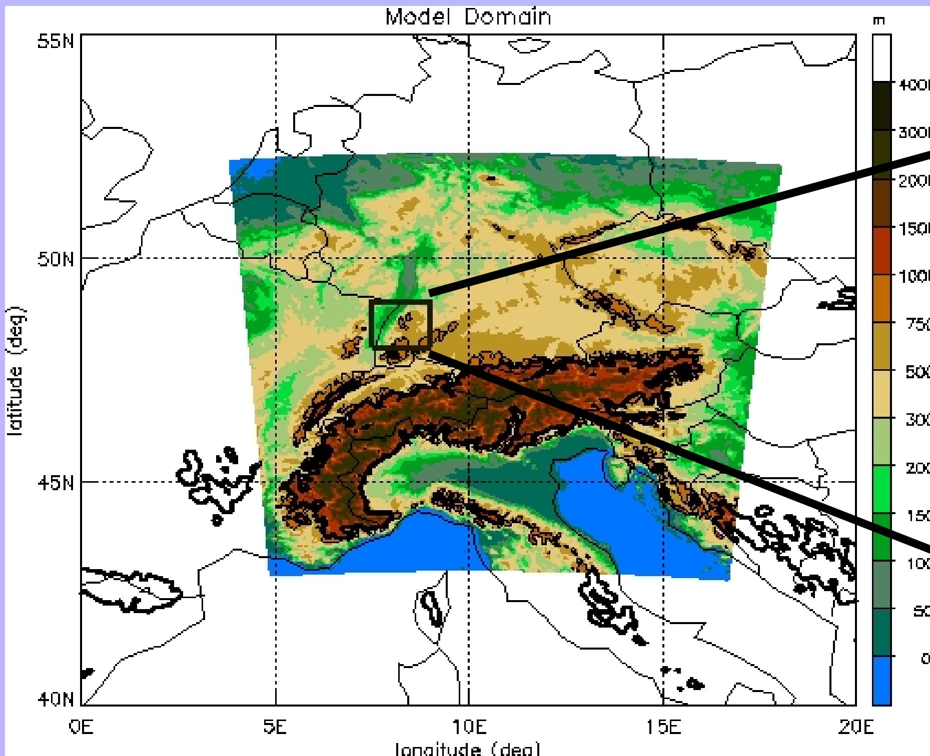




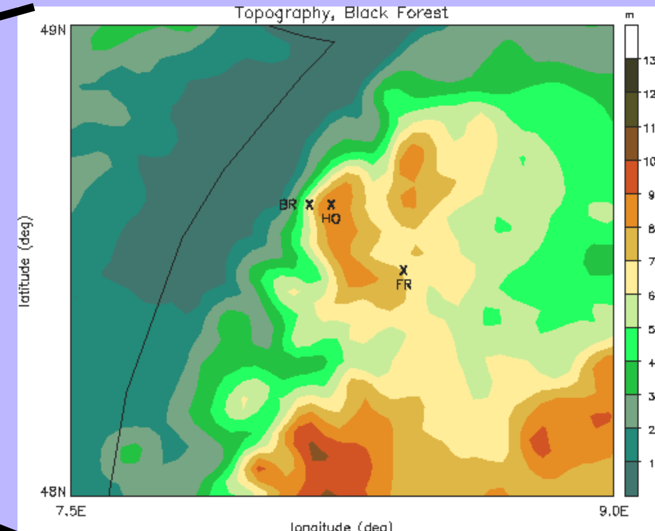
Single convective cells:

- inside Murg valley and along mountain ridge
- 10 to 13 UTC
- reaching up to 14 km

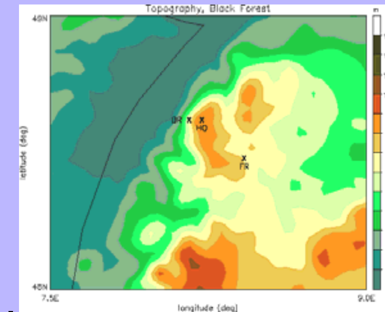
COSMO-Model setup



Northern Black Forest



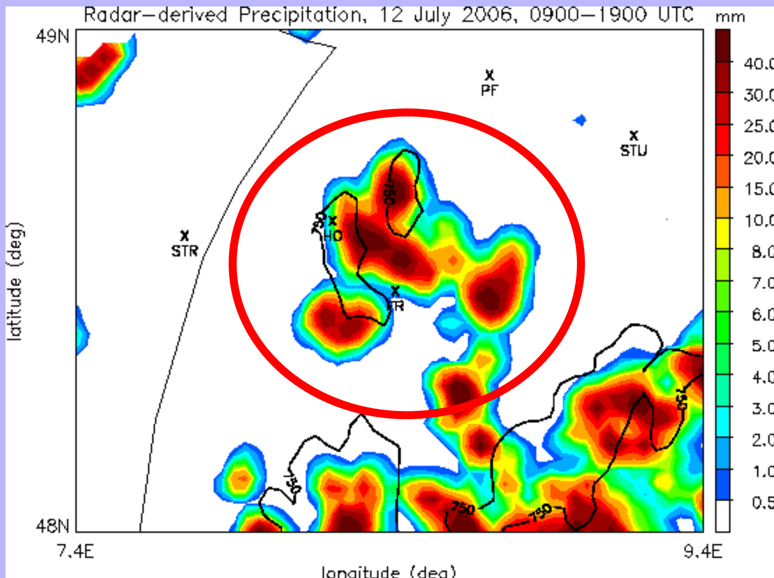
- Operational numerical weather prediction model
- Grid point spacing: approx. 2.8 km
- No parameterisation of deep convection, main motions/processes of deep convection are considered explicitly
- Hourly boundary conditions from LME Analysis
- Start of the model simulations at 07 UTC



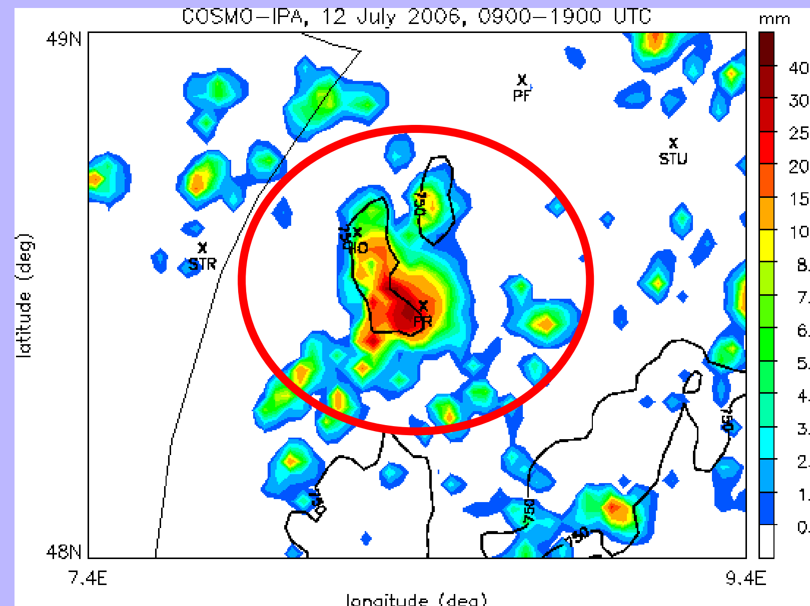
Model Evaluation

10-hour precipitation sum: 09 to 19 UTC

Observations, RW-Product



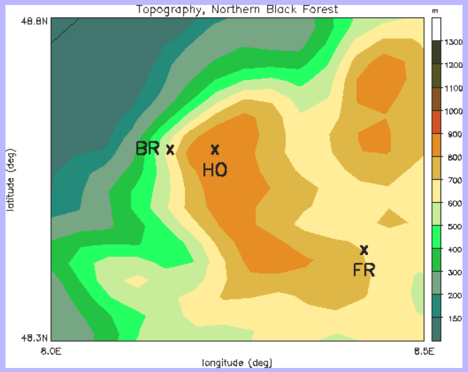
Model result



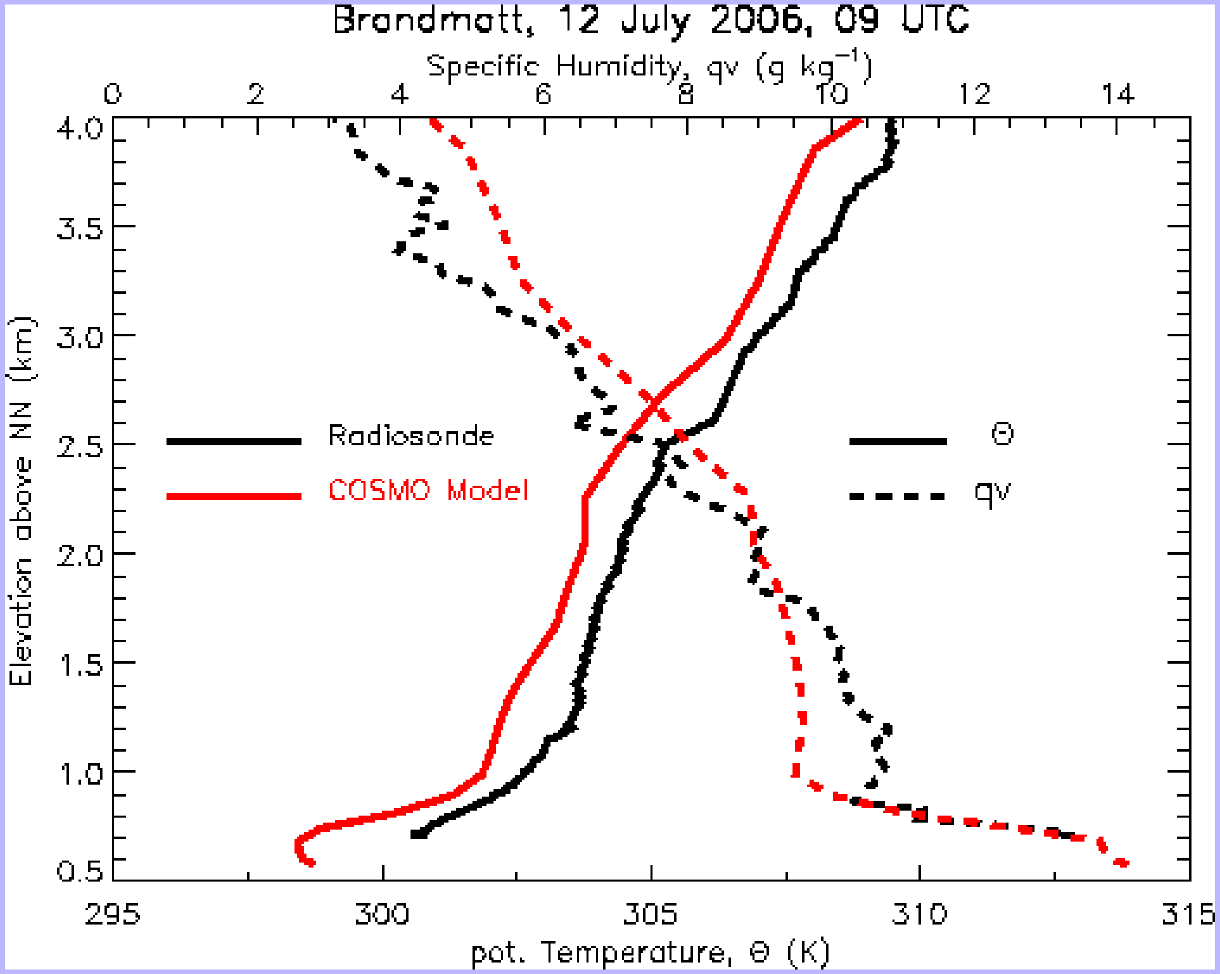
- location of convective precipitation well represented
- intensity of precipitation is underestimated compared to gauge-adjusted radar observations

A process-based model evaluation.....

Boundary Layer Structure



Observations from Brandmatt (09 UTC)....



.... and model result

Observations

3 layers:

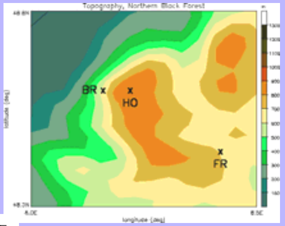
- < 1.2 km: stable, moist
- 1.2 – 2.5 km: well mixed
- > 2.5 km: stable, dry

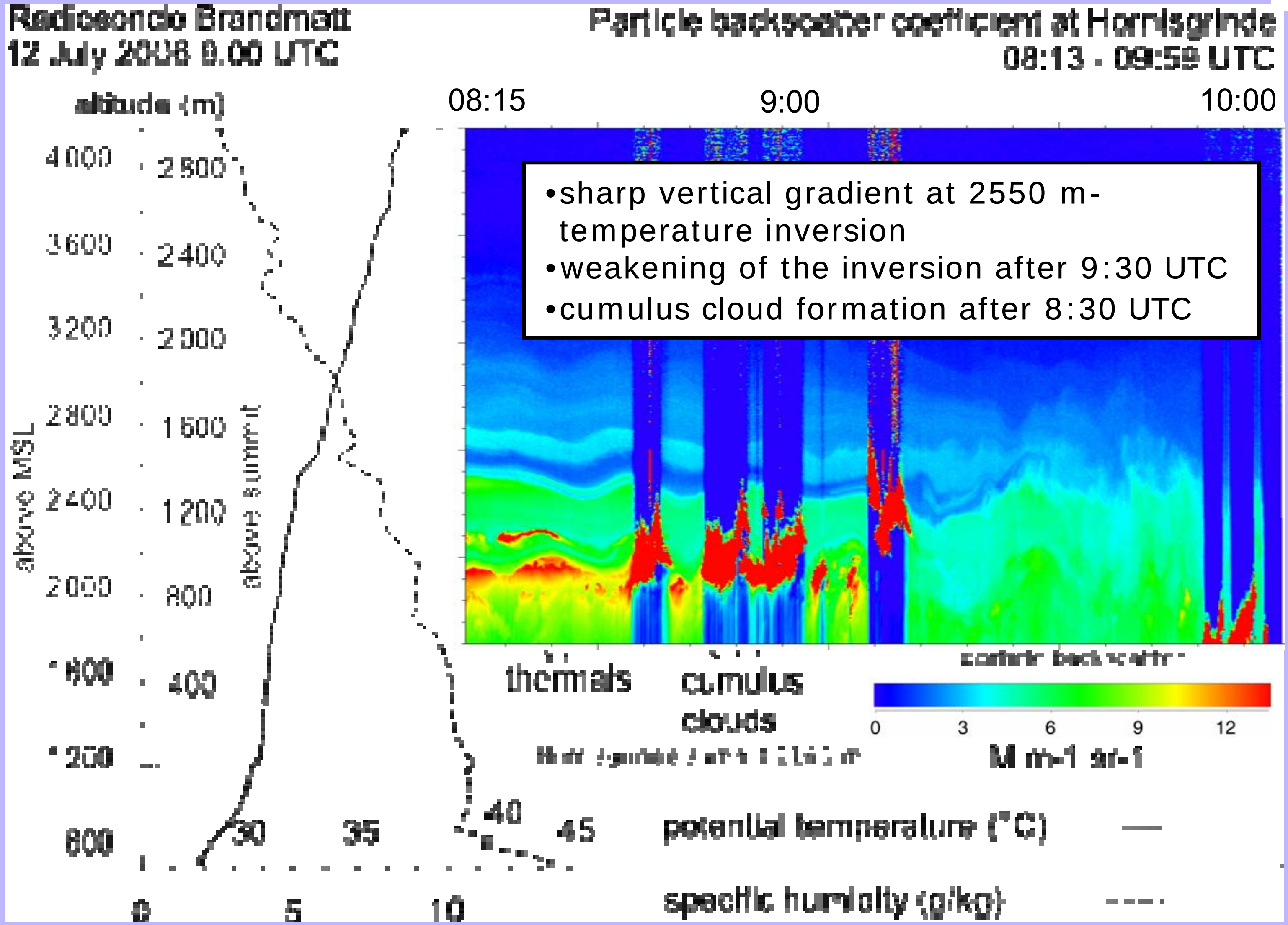
Model

- Vertical structure well reproduced
- Slightly (approx. 1 K) too cold

Boundary Layer Structure, temporal evolution

LIDAR particle backscatter coefficient, Hornisgrinde

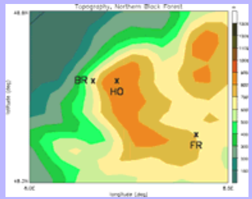




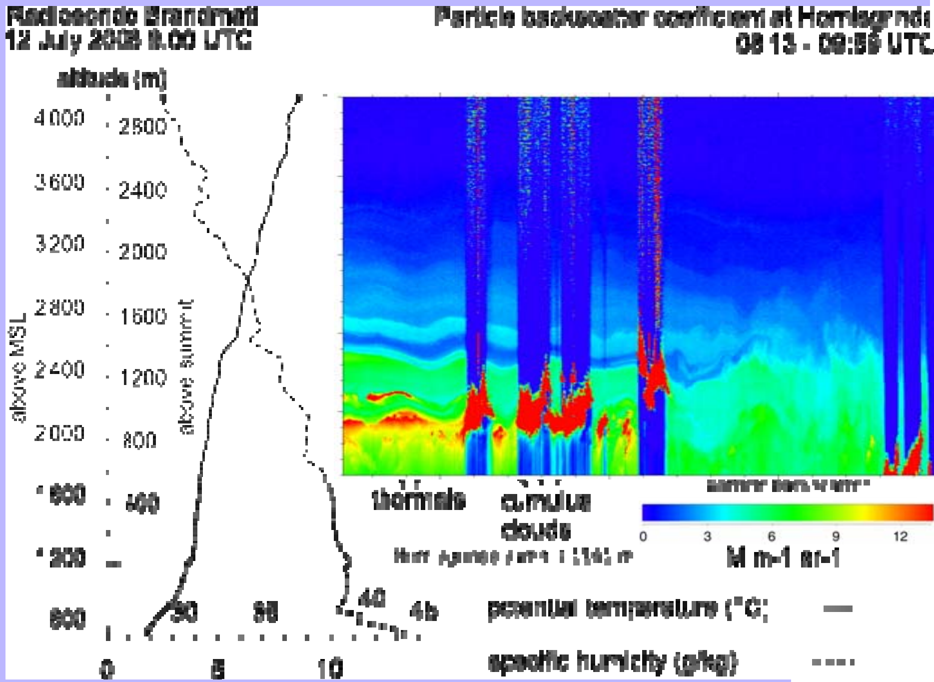
M. Radlach, A. Behrendt, V. Wulfmeyer, Uni Hohenheim

Radlach et al., ACPD, 2007

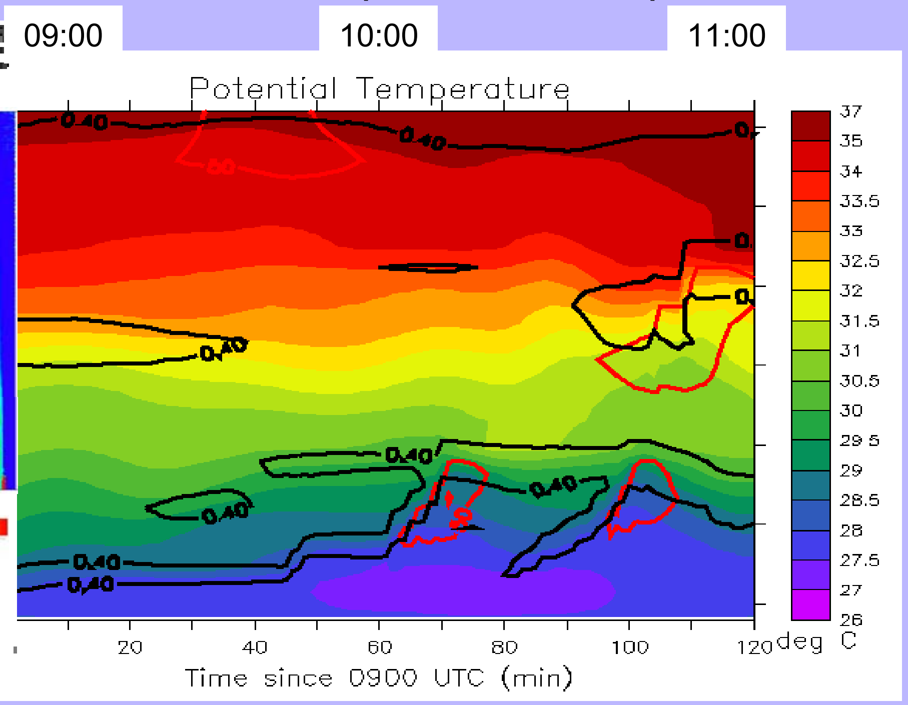
Boundary Layer Structure, temporal evolution



Observations: particle backscatter



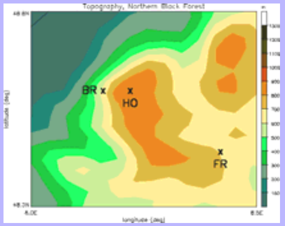
Model result: potential temperature



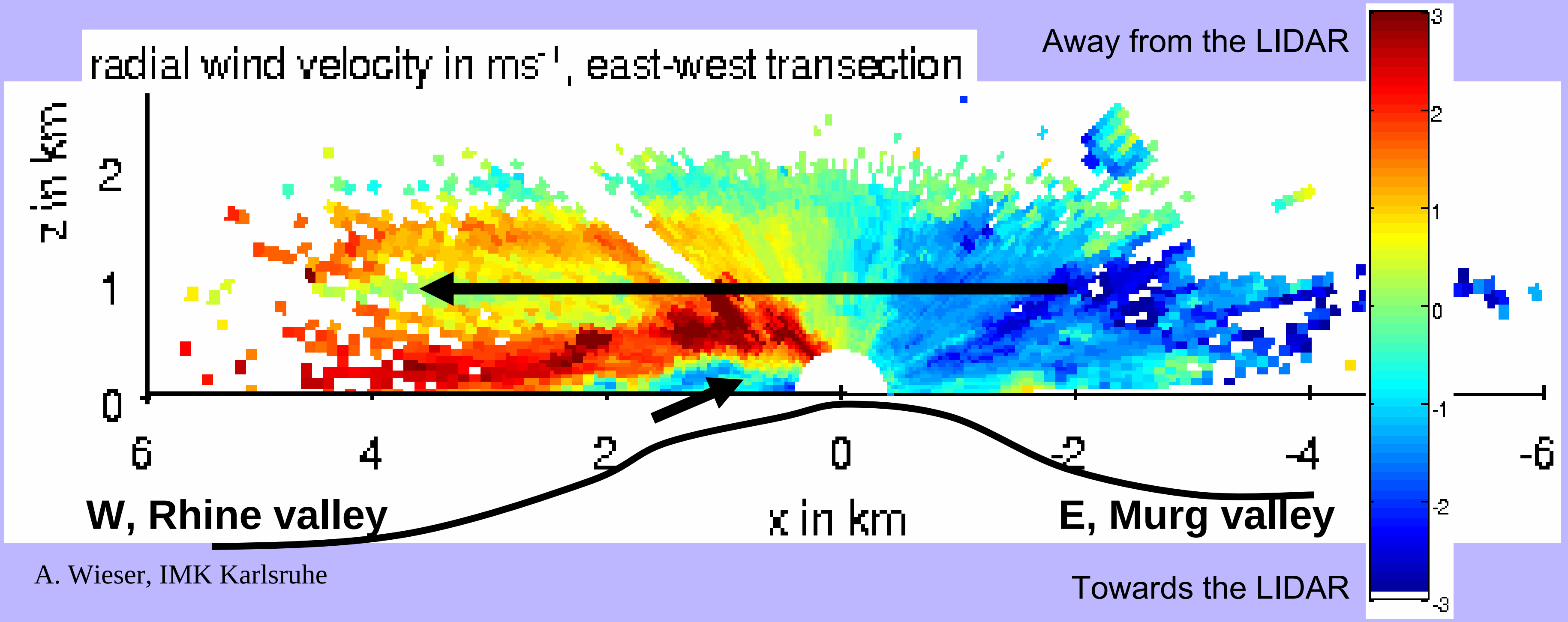
black: dΘ/dz > 4 K/km, red: cloud cover > 50 %

- weakening of the inversion simulated realistically
- no cloud formation in the mixed layer
- overall realistically evolution of the boundary layer

Boundary Layer Structure, zonal wind



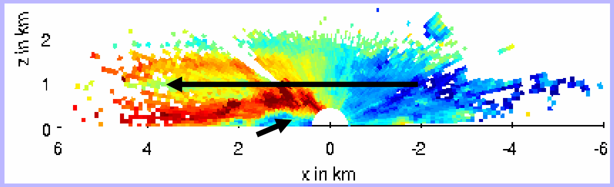
Radial component of the zonal wind from Windlidar Hornisgrinde, 0930 UTC (relative to the LIDAR)



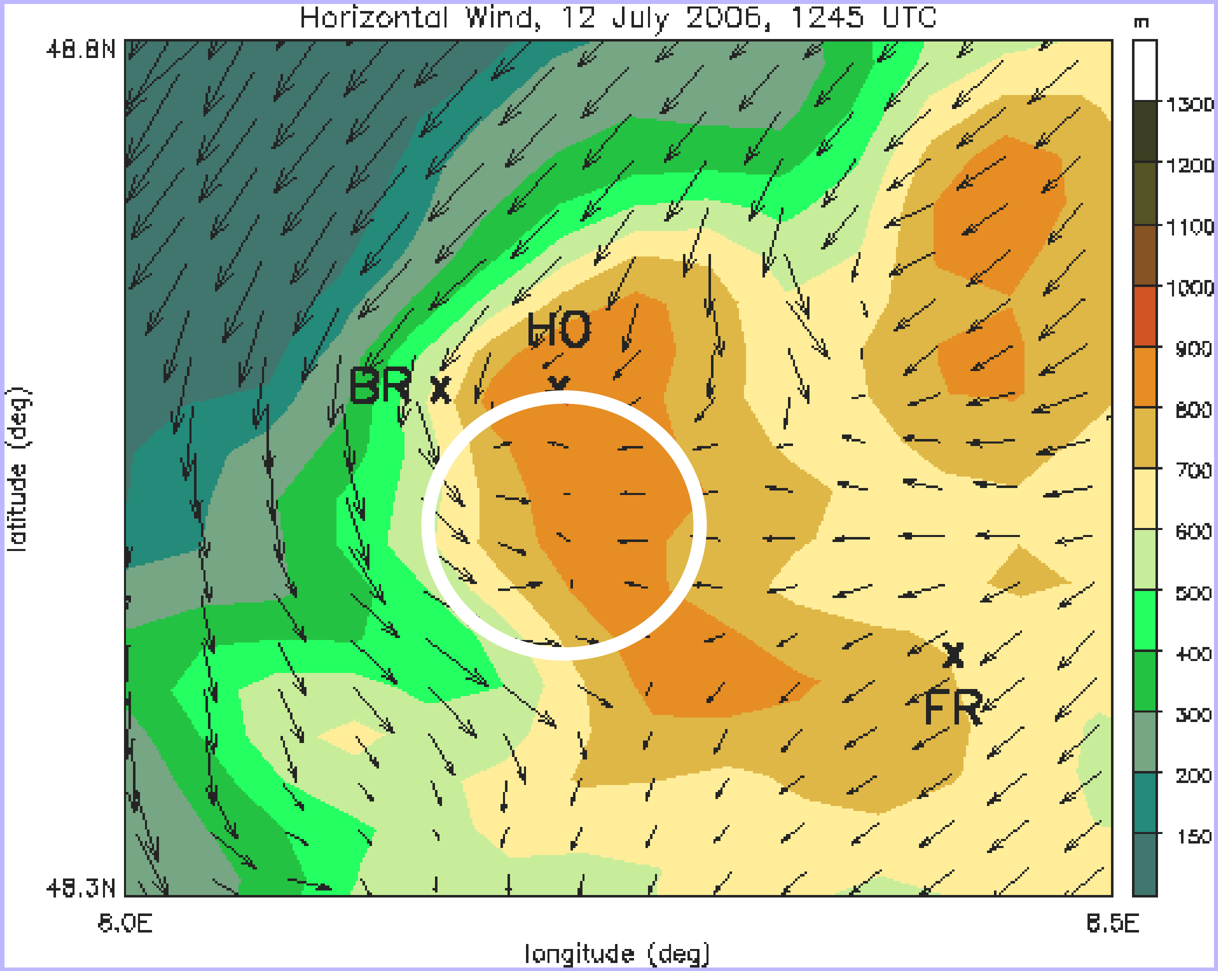
A. Wieser, IMK Karlsruhe

- average zonal-wind about 2.5 m s^{-1} from East
- upslope winds from the Rhine valley in the lowest 300 m

Boundary Layer Structure, wind field

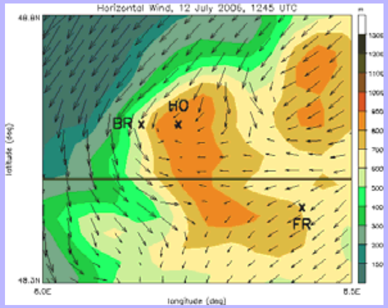


10 m wind, 1245 UTC

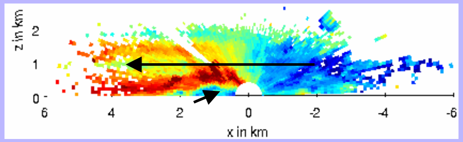


Model result:

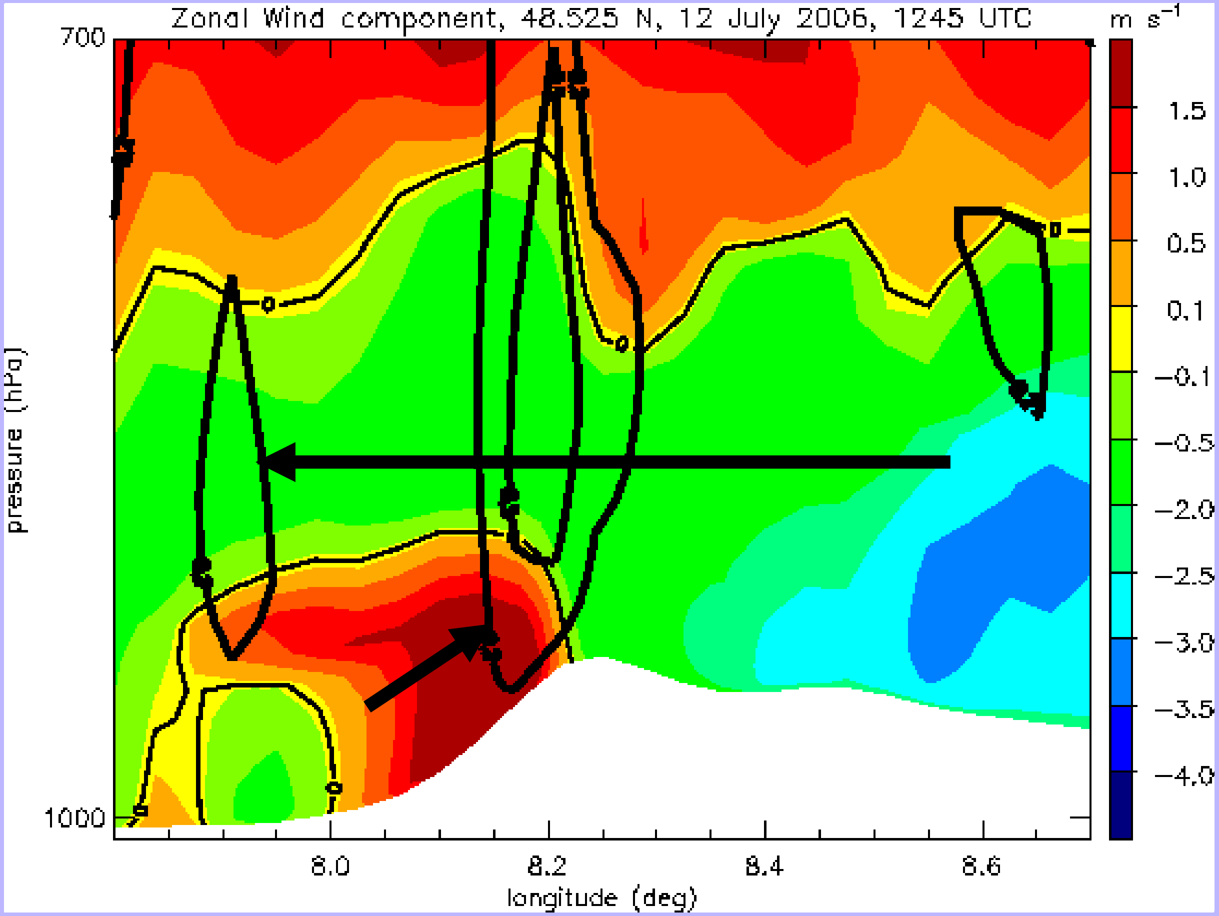
- Upslope wind at 1245 UTC south of Hornis-grinde
- 3 hours later than observed



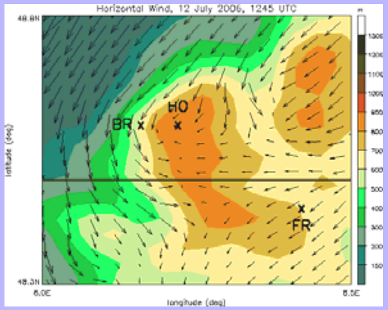
Wind Field, Upslope wind



Vertical cross section, zonal wind, 1245 UTC

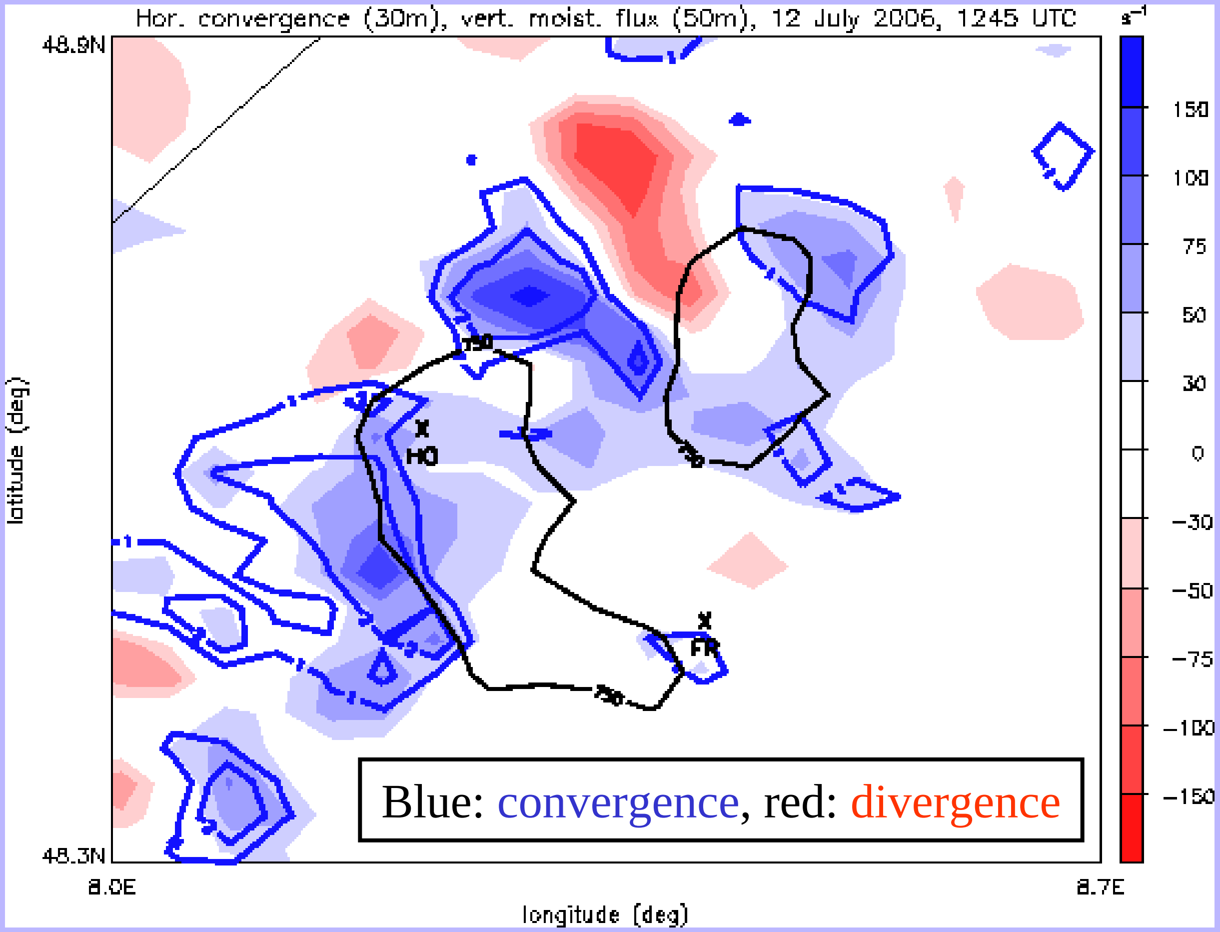


- easterly wind in lower 2 km
- strong westerly upslope wind
- vertical wind along mountain crest



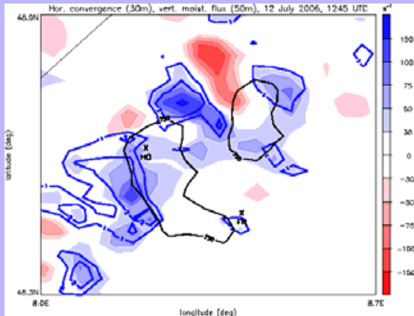
Dynamical forcing from lower levels

Horizontal convergence, 1245 UTC



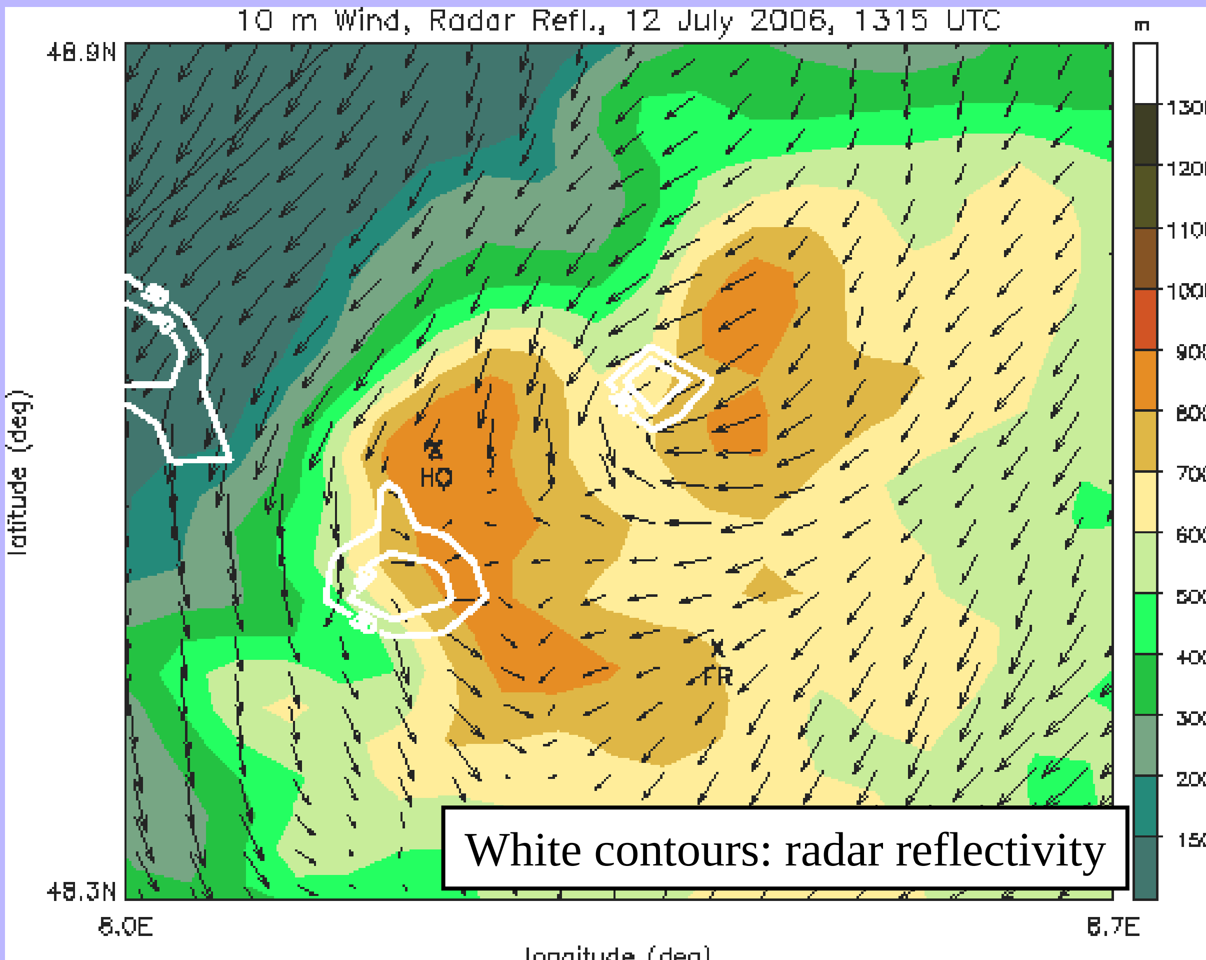
Horizontal convergence:

- east of the Black Forest
- entrance of the Murg valley



Dynamical forcing from lower levels

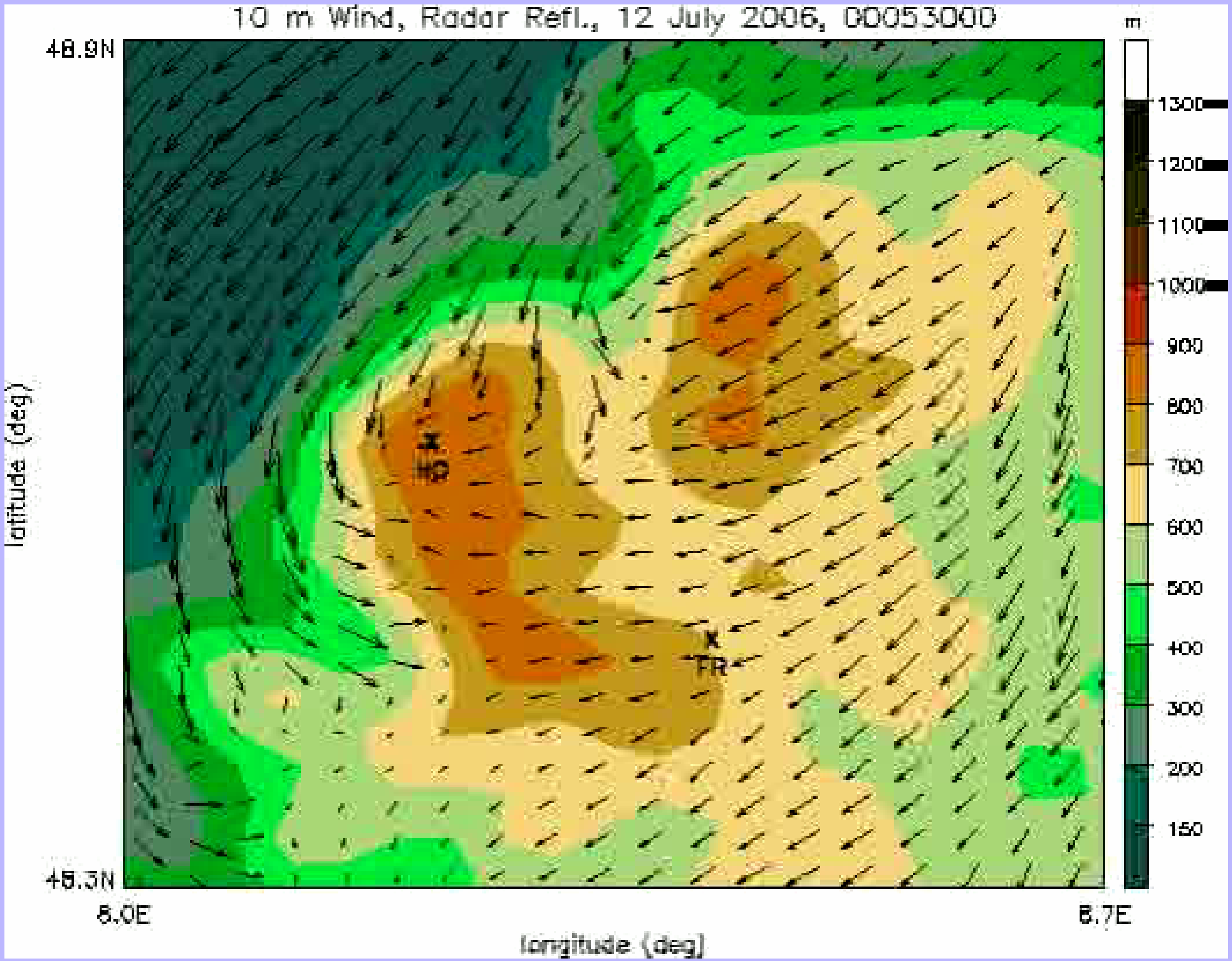
Radar reflectivity, 10 m-wind 1315 UTC



Convection develops in regions with elevated horizontal convergence

Temporal evolution of the convective activity

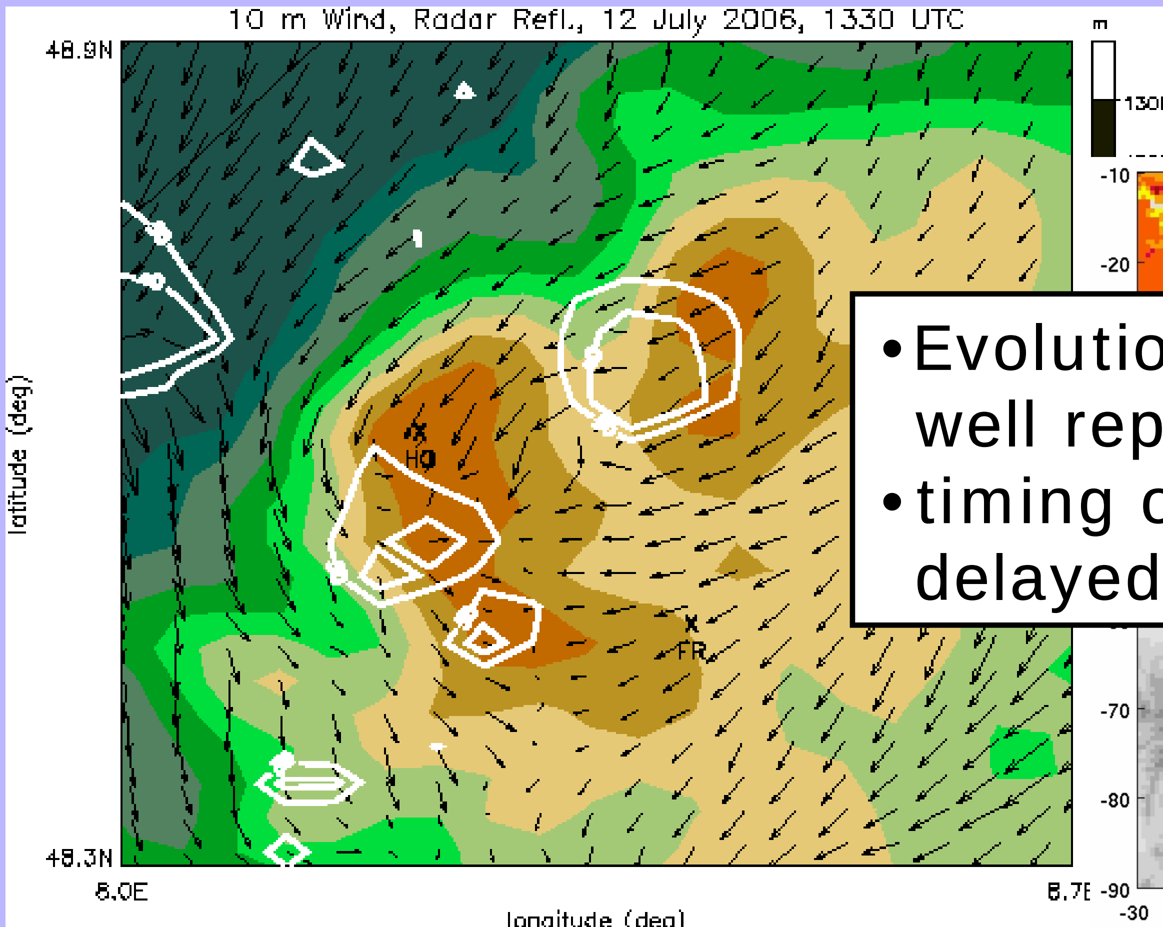
Surface wind, radar reflectivity, 1230 – 16 UTC



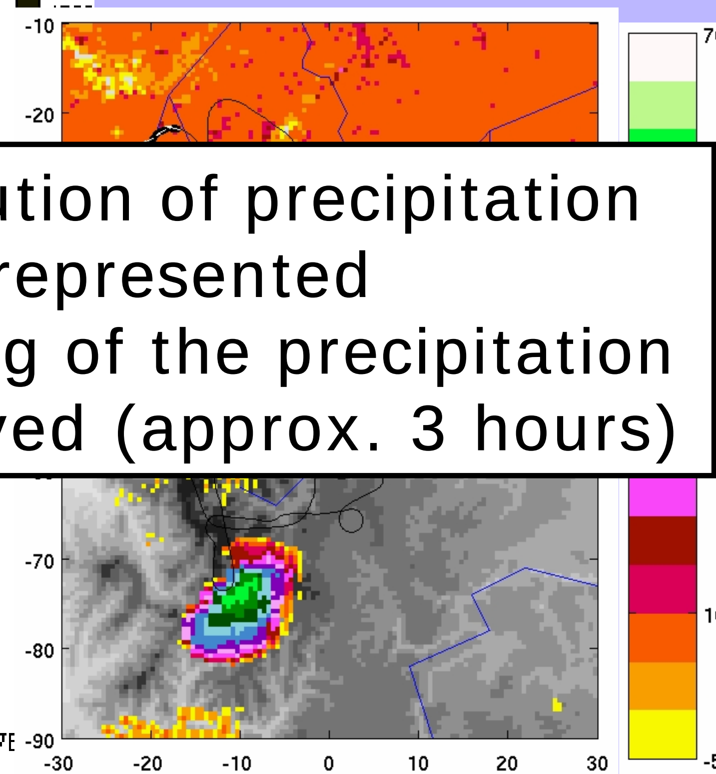
Color coding: topography
arrows: surface wind
white contours: radar reflectivity

Temporal evolution of the convective activity

Simulated surface wind, radar reflectivity, 1330 UTC



1040 UTC



- Evolution of precipitation well represented
- timing of the precipitation delayed (approx. 3 hours)

Color coding: topography
arrows: surface wind
white contours: radar reflectivity

Conclusions and Outlook

- Valuable data was collected during PRINCE to investigate convection initiation
- The COSMO-Model realistically represents the processes leading to the initiation of convection
- The boundary layer structure and its evolution was successfully captured by the model
- Upslope winds initiate horizontal convergence and vertical motions
- Initiation of convection delayed in the model simulation, amount of precipitation underestimated
- Further studies, e.g. based on COPS, will provide further insights on convection initiation and model performance under convective situations


Thank you!