

# Convection-resolving simulations with the COSMO model: Model Evaluation for a convective situation in mountainous terrain

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## Part of COSI-TRACKS



- Investigation of the processes that **initiate convection** and
- the inherent **dynamical and hydrological processes** of convective storms

by using the COSMO-Model for real-case studies of convective situations.

# PRINCE

*P*rediction, *i*dentification and tracking of *c*onvective cells

Field experiment to investigate convection  
in the black forest (10 – 20 July 2006)

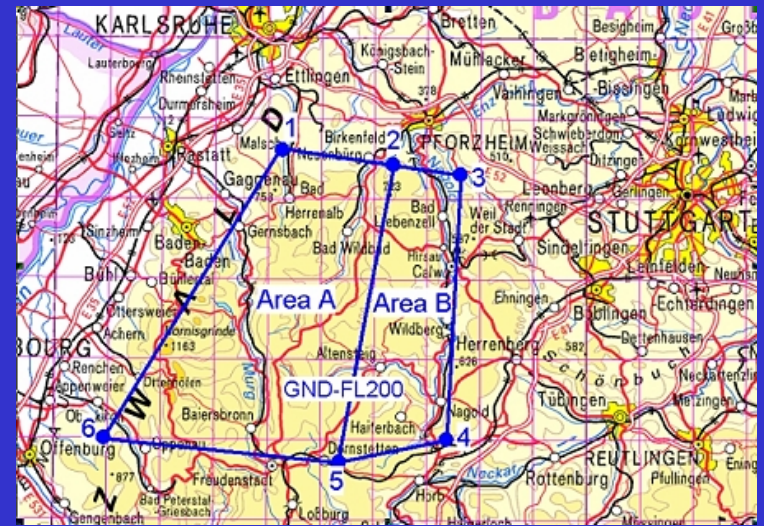
Participating groups:

- University/Research Center Karlsruhe
- University Hohenheim
- University Mainz

Three intensive observational periods (11/12 July and  
20 July)

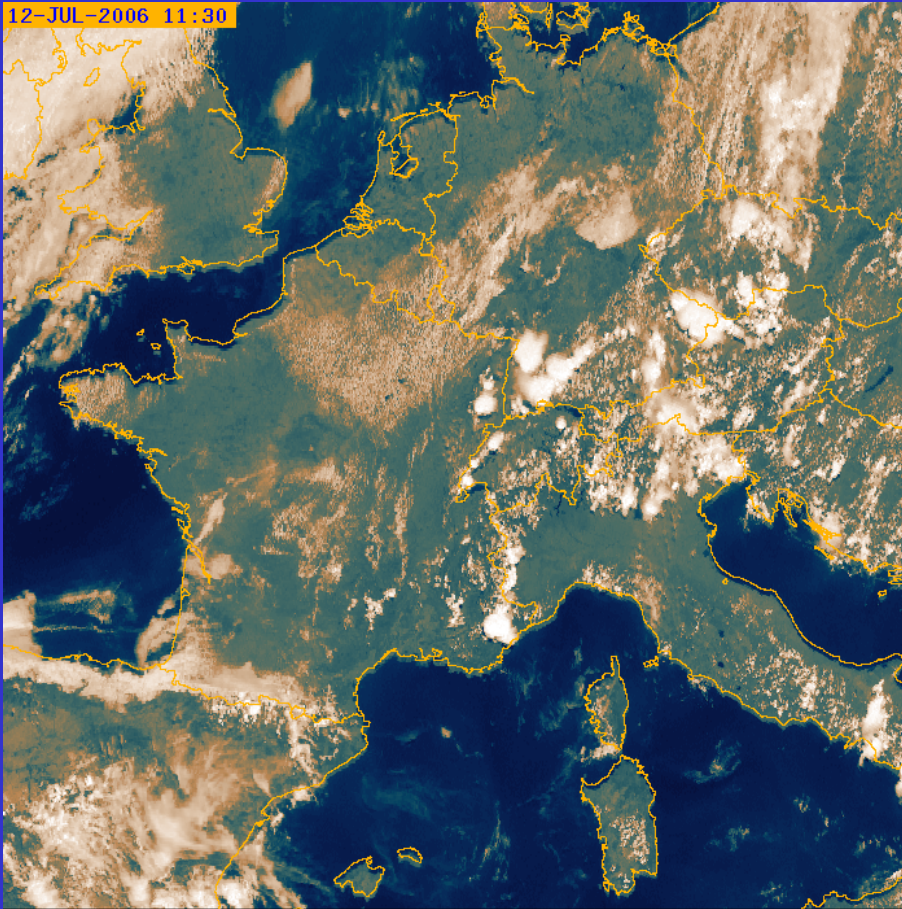
Testrun for COPS (Convective and Orographically-  
induced Precipitation Study), summer 2007

- precipitation radar from Karlsruhe
- radiosondes from Brandmatt
- Hornisgrinde:
  - cloud radar, wind lidar, aerosol and temperature lidar
- aircraft equipped with in situ sensors and drop-sondes
- mobile observation systems:
  - surface observations
  - mobile radiosondes



12 July 2006

METEOSAT, 1130 UTC



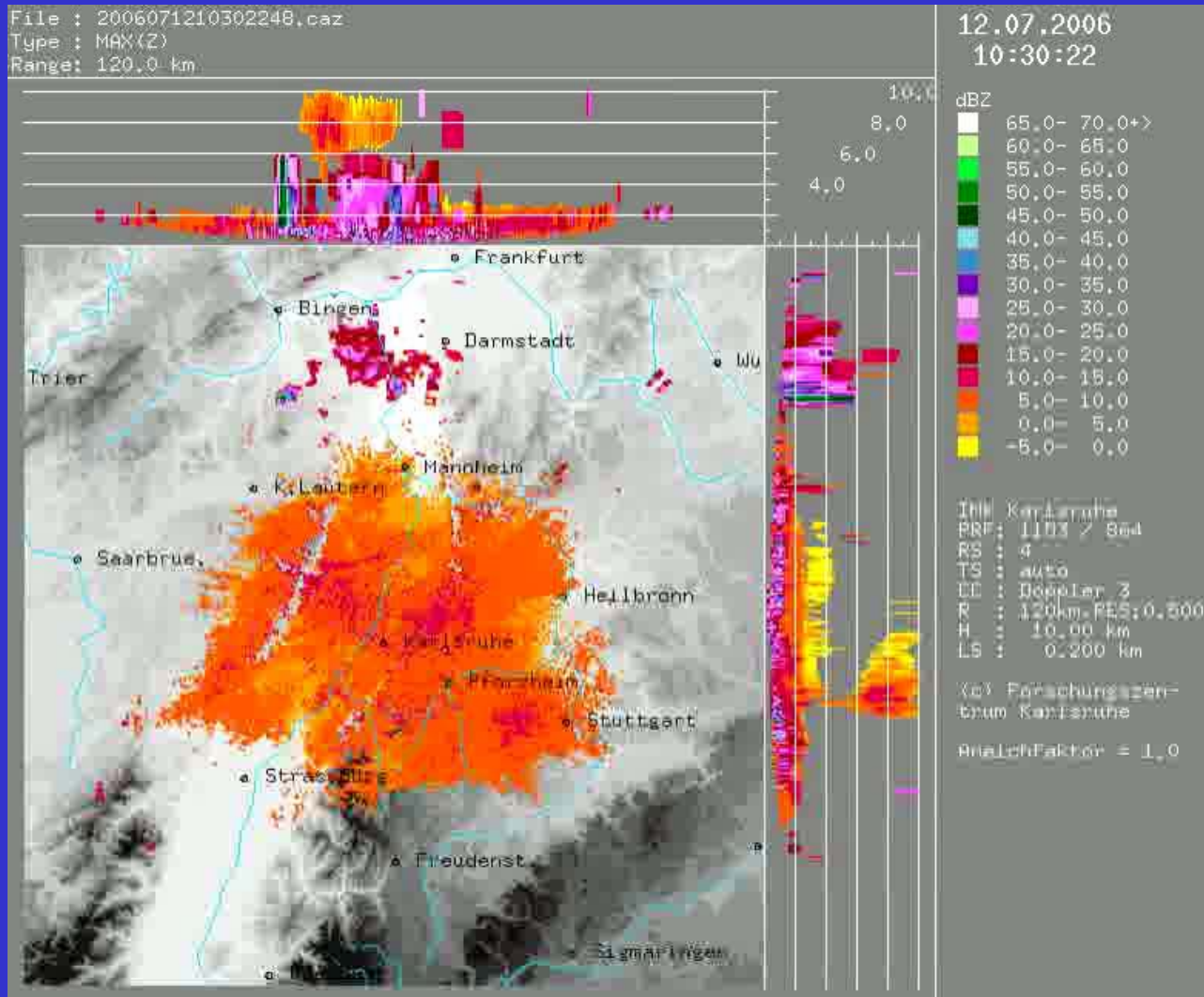
Harald Sodemann, ETH Zürich



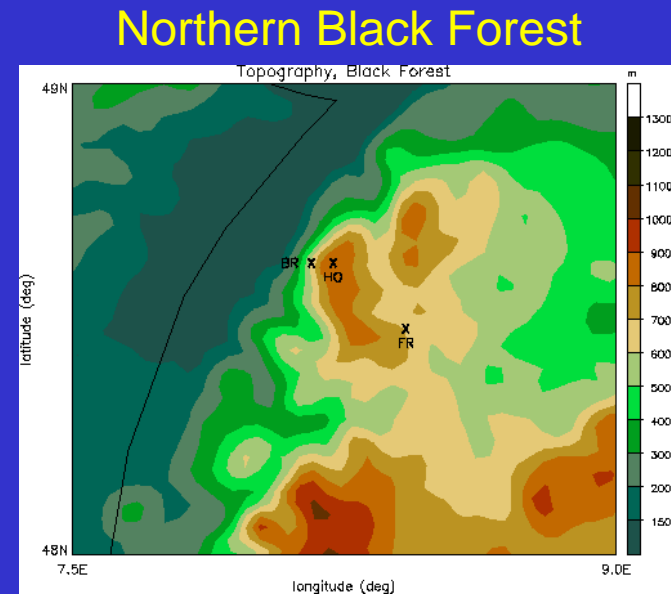
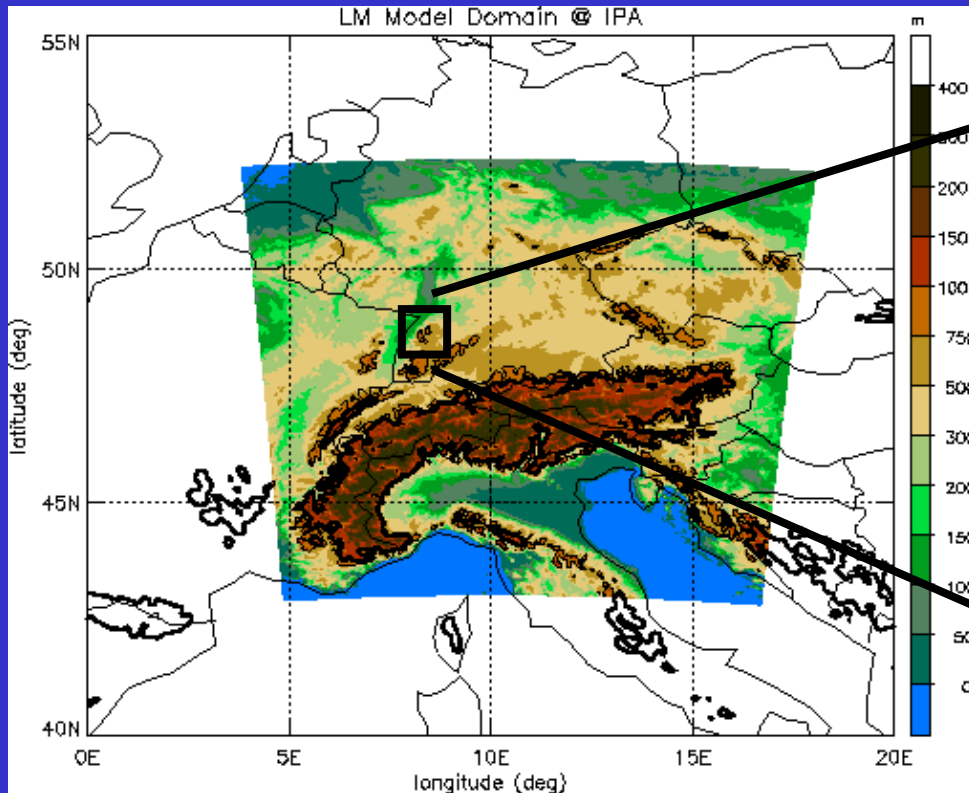
<http://rapidfire.sci.gsfc.nasa.gov/realtime>

# Radar-Loop, 12 July 2006, 08:30 – 14:00 UTC

Single convective cells (Murgtal) between 10 und 14 UTC.



# COSMO-Model domain, Uni Mainz

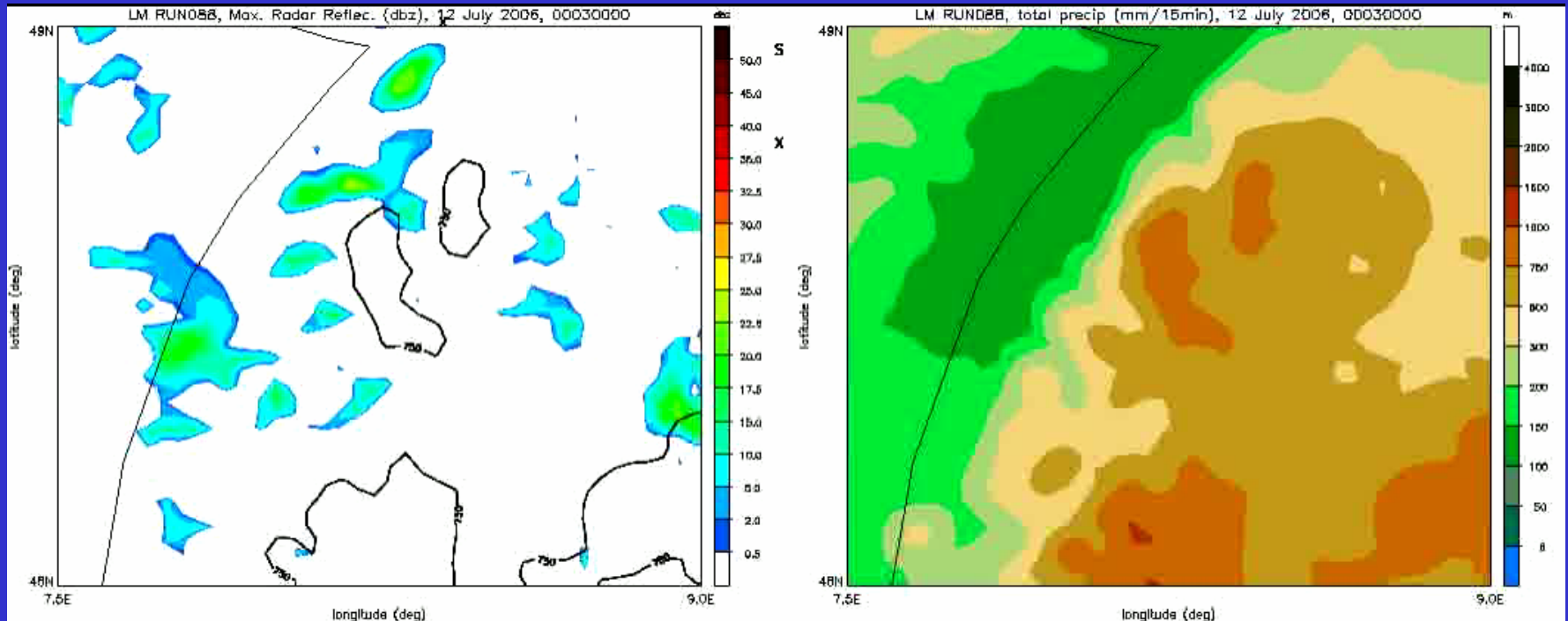


- 0.025 deg (approx. 2.8 km) spatial resolution
- **351 x 375 horizontal grid boxes**, 50 vertical layers
- Initial and boundary conditions from operational **LME Analysis**
- Start of model simulation: **07 UTC**
- COSMO Model **V3.21**

# COSMO Simulation, 10 UTC – 17 UTC

Max. radar reflectivity

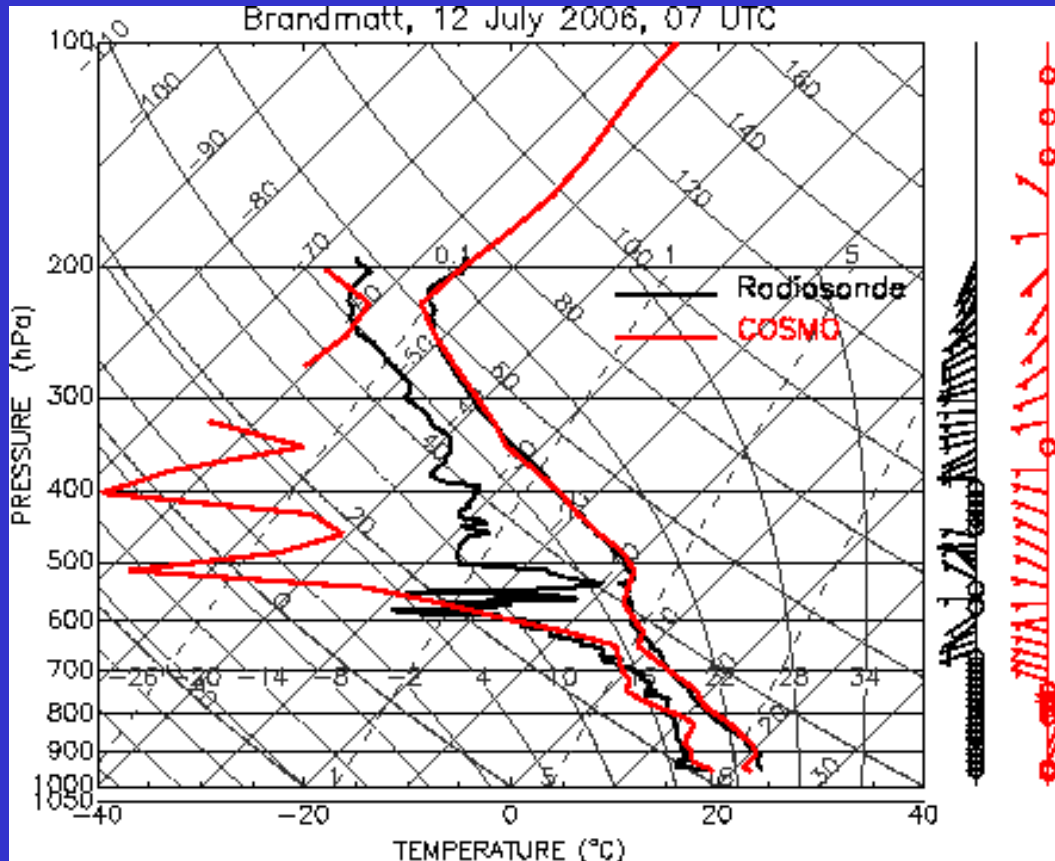
Topography, Precipitation



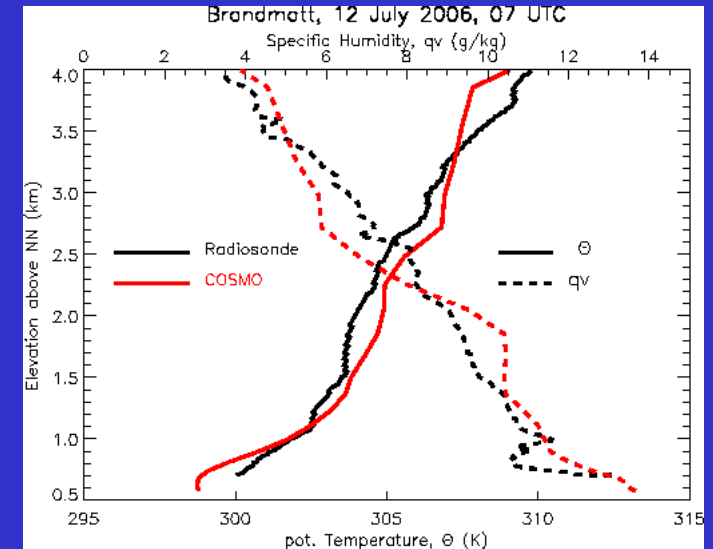
Single convective cell at 11 UTC on west side of the black forest, widespread convection between 13 and 17 UTC.

# Evaluating the model with radiosonde data

07 UTC:



Lower level temperature and humidity



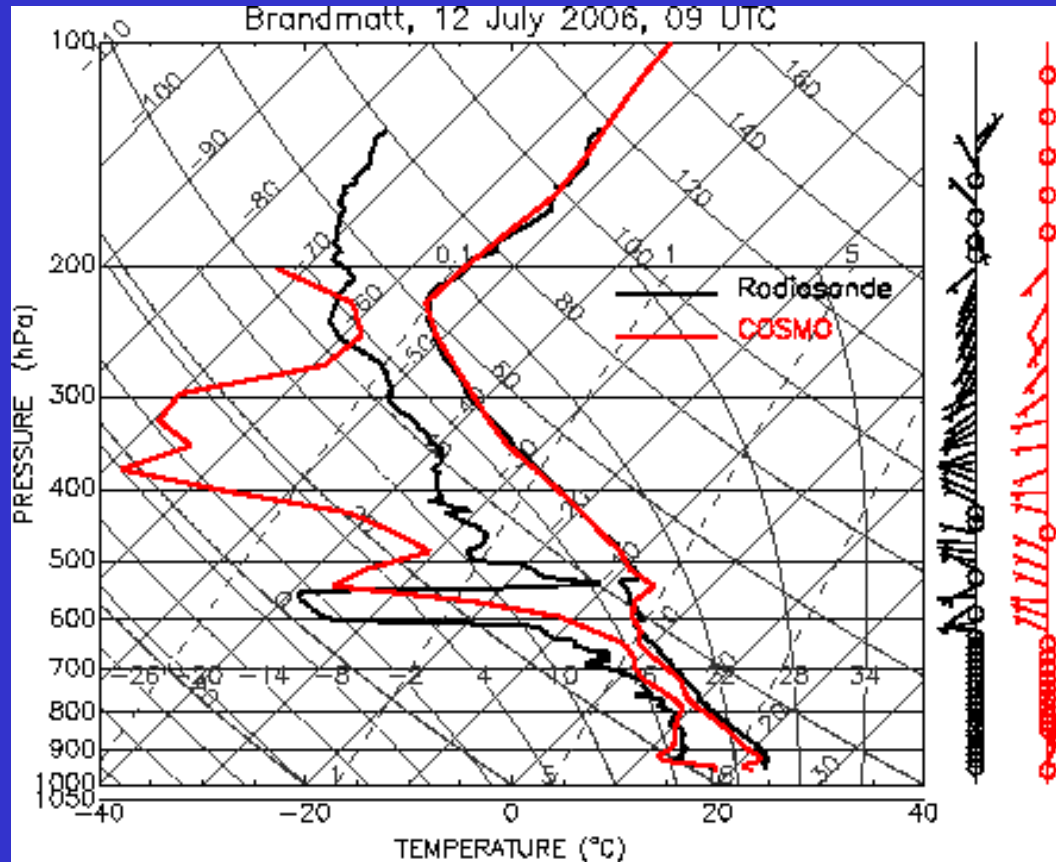
Good representation of the atmospheric stratification at model start

CAPE:  $1500 \text{ J kg}^{-1}$

CIN:  $77 \text{ J kg}^{-1}$

# Evaluating the model with radiosonde data

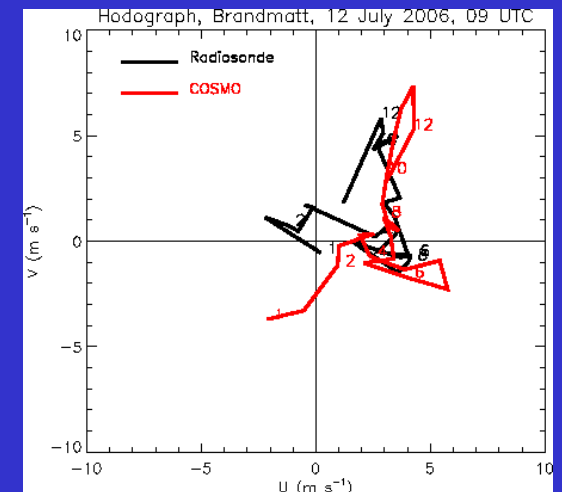
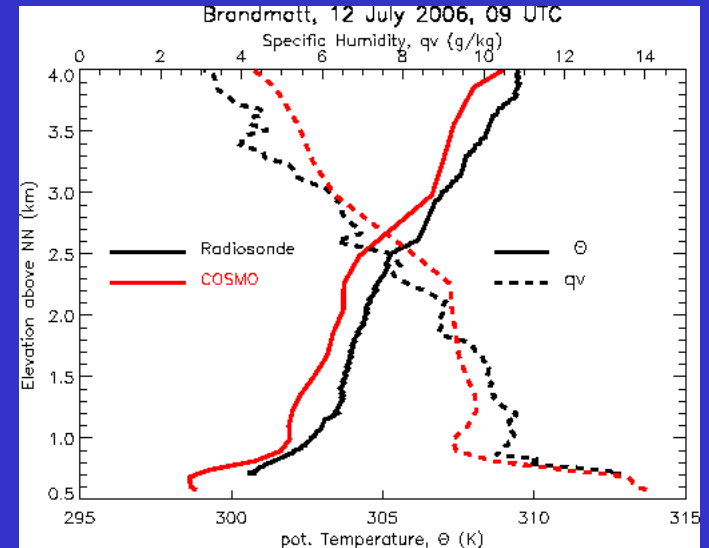
09 UTC:



CAPE:  $2400 \text{ J kg}^{-1}$

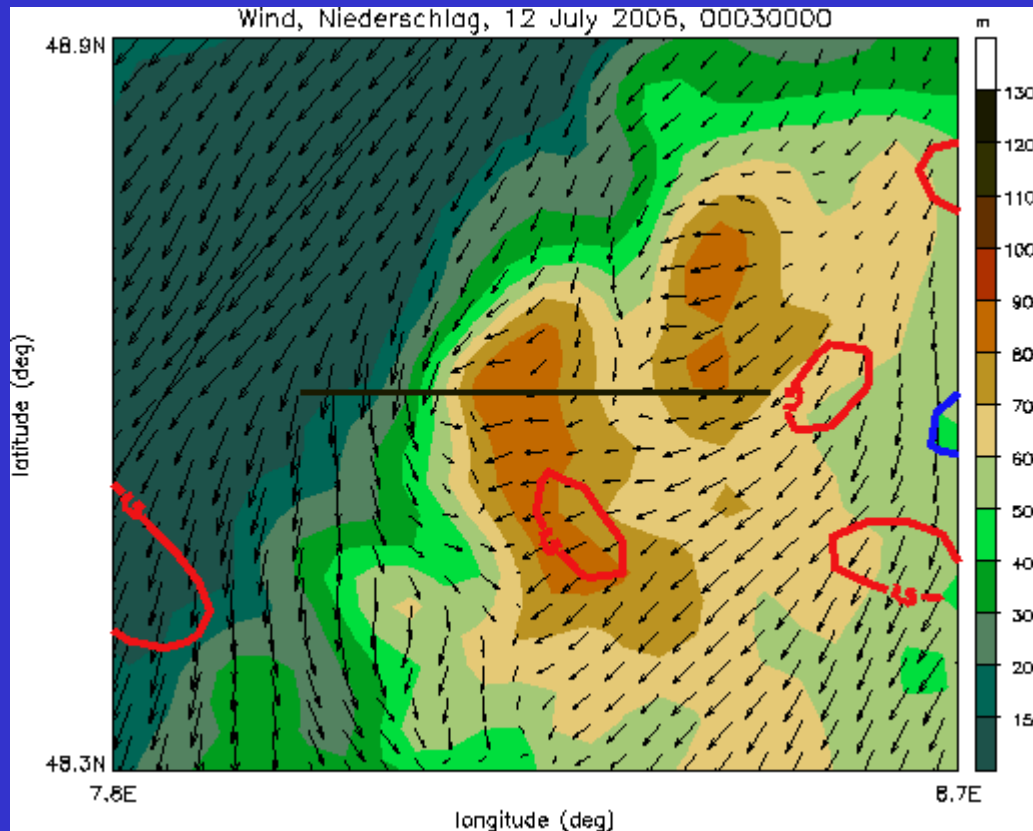
CIN:  $55 \text{ J kg}^{-1}$

Lower level temperature and humidity



# View into the convection

Topography, wind, precipitation, 1000 UTC



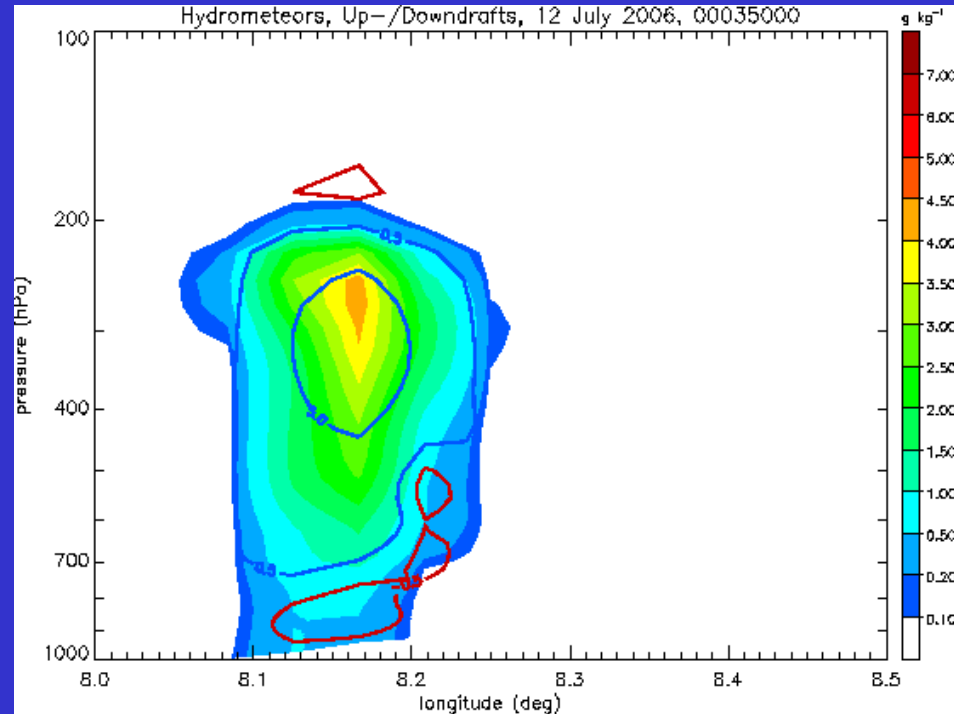
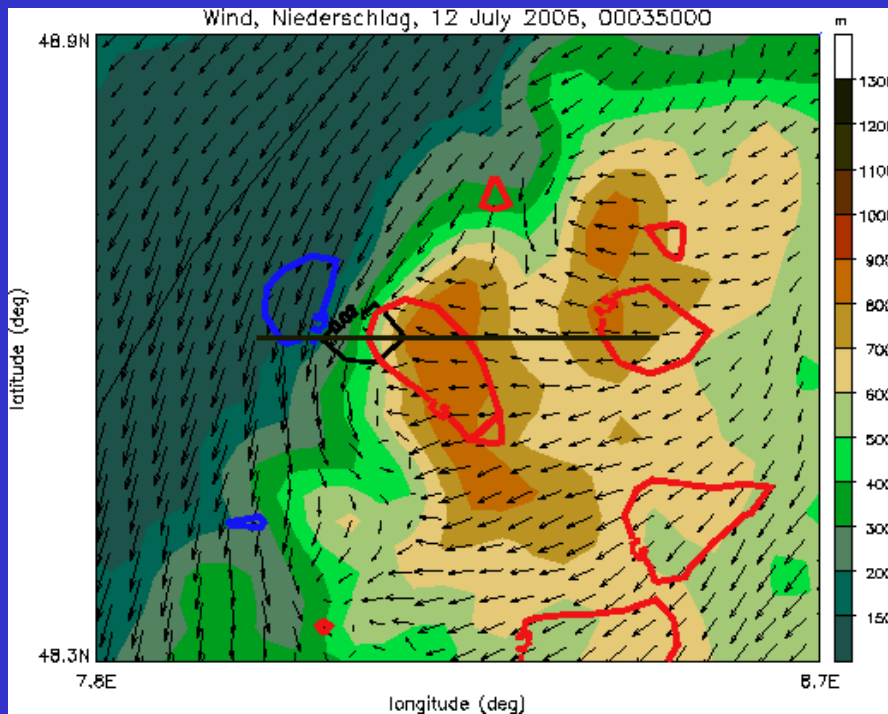
Arrows: 10 m wind

Contour lines: blue: updraft (850 hPa, -1.5 Pa/s),

red: downdraft (850 hPa, 1.5 Pa/s)

# View into the convection

Topography, wind, precipitation, cloud, 1050 UTC



Arrows: 10 m wind

Contour lines: blue: updraft (850 hPa, -1.5 Pa/s),

red: downdraft (850 hPa, 1.5 Pa/s)

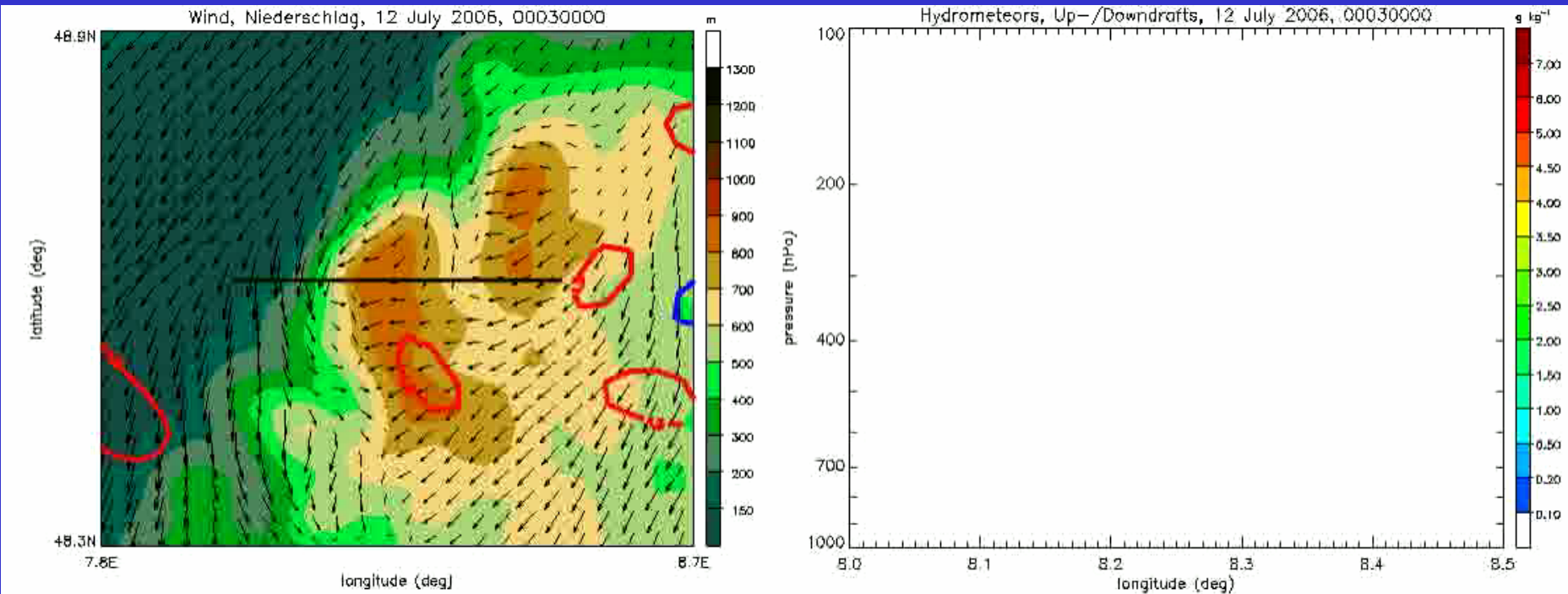
black: precipitation

blue: updraft (0.5 m/s)

red: downdraft (-0.5 m/s)

# View into the convection

Topography, wind, precipitation, cloud, 1000 – 1130 UTC



Arrows: 10 m wind

Contour lines: blue: updraft (850 hPa, -1.5 Pa/s),

red: downdraft (850 hPa, 1.5 Pa/s)

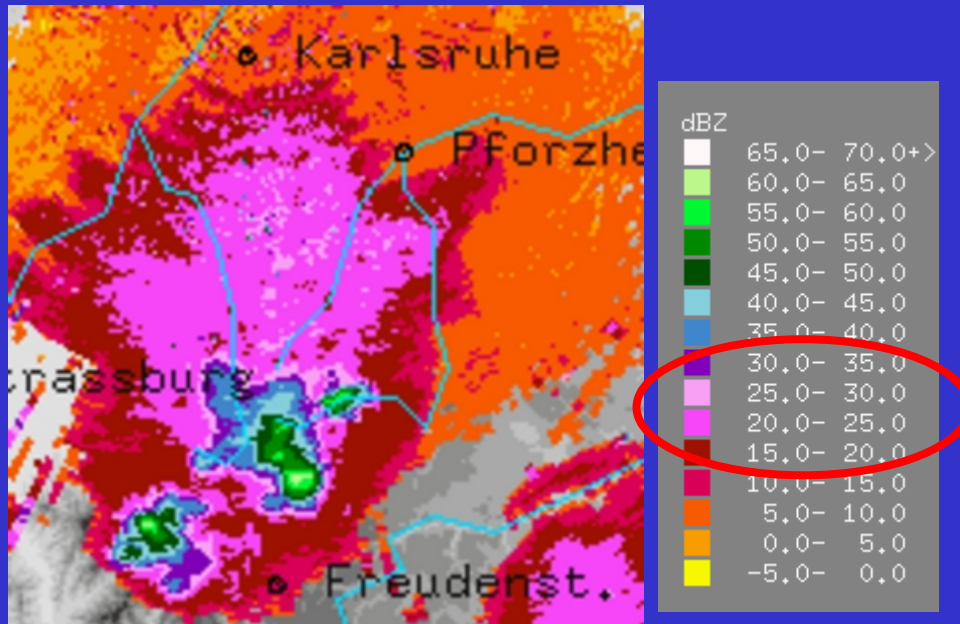
black: precipitation

blue: updraft (0.5 m/s)

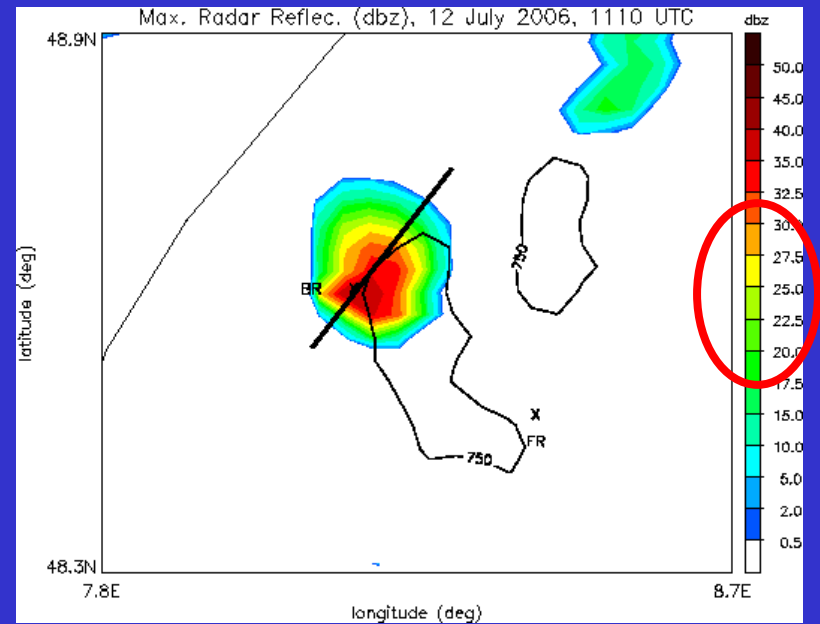
red: downdraft (-0.5 m/s)

# Comparison of radar reflectivity

Radar measurement, 1350 UTC



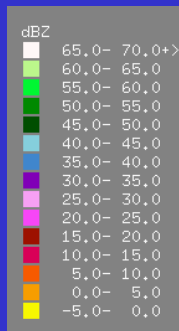
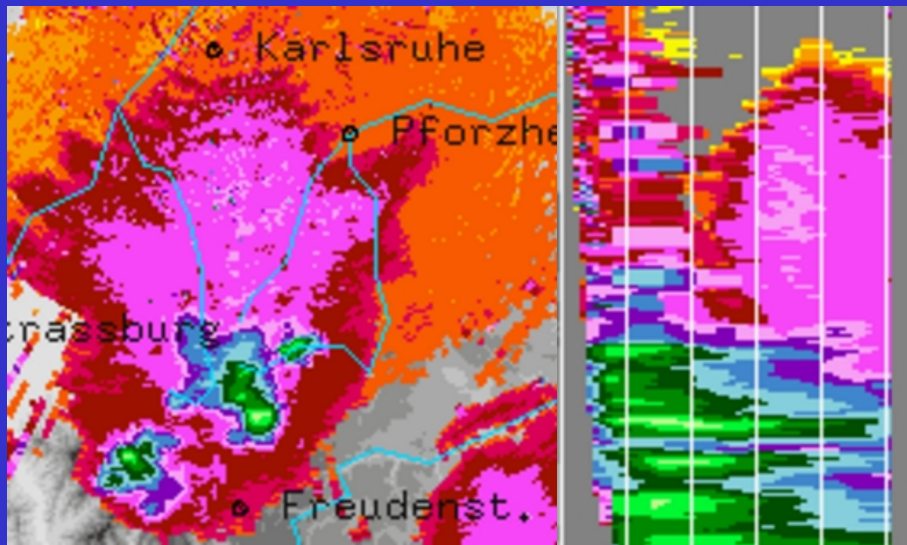
COSMO-Model, 1110 UTC



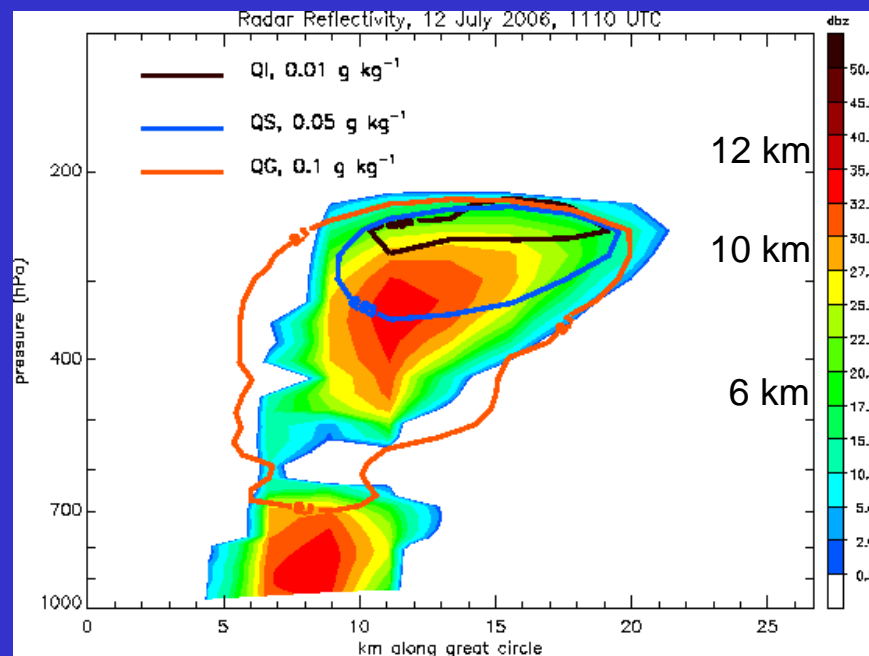
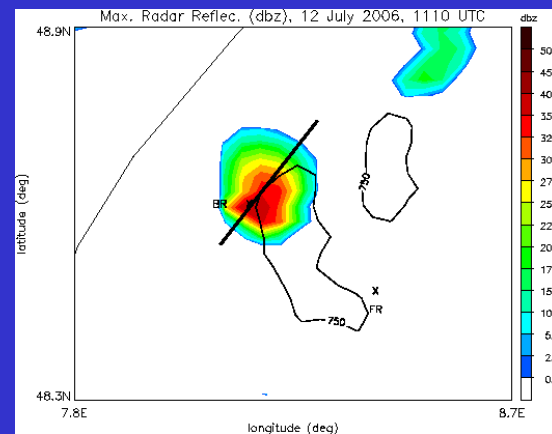
Simulated maximum radar reflectivity in the anvil are comparable to observations: 20 to 30 dbz

# Comparison of radar reflectivity

6 km 10 km

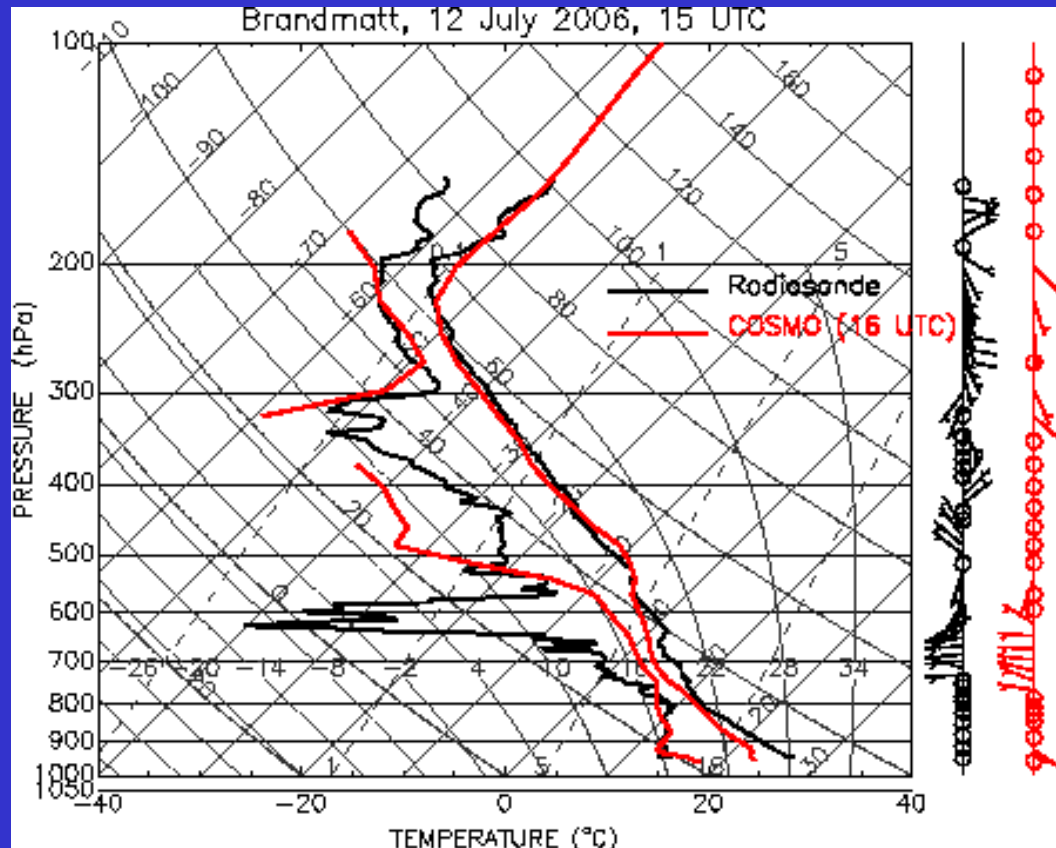


Height and thickness of the anvil is reproduced well in the model simulation



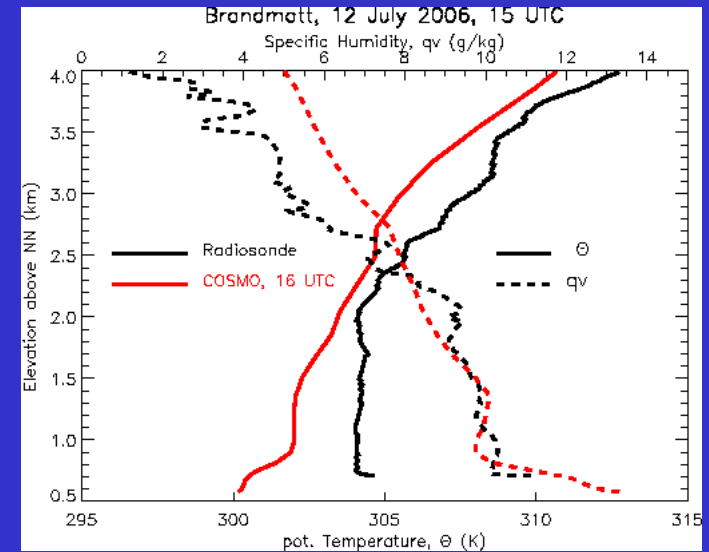
# Evaluating the model with radiosonde measurements after the convection

15 UTC:



CAPE:  $820 \text{ J kg}^{-1}$   
CIN:  $2 \text{ J kg}^{-1}$

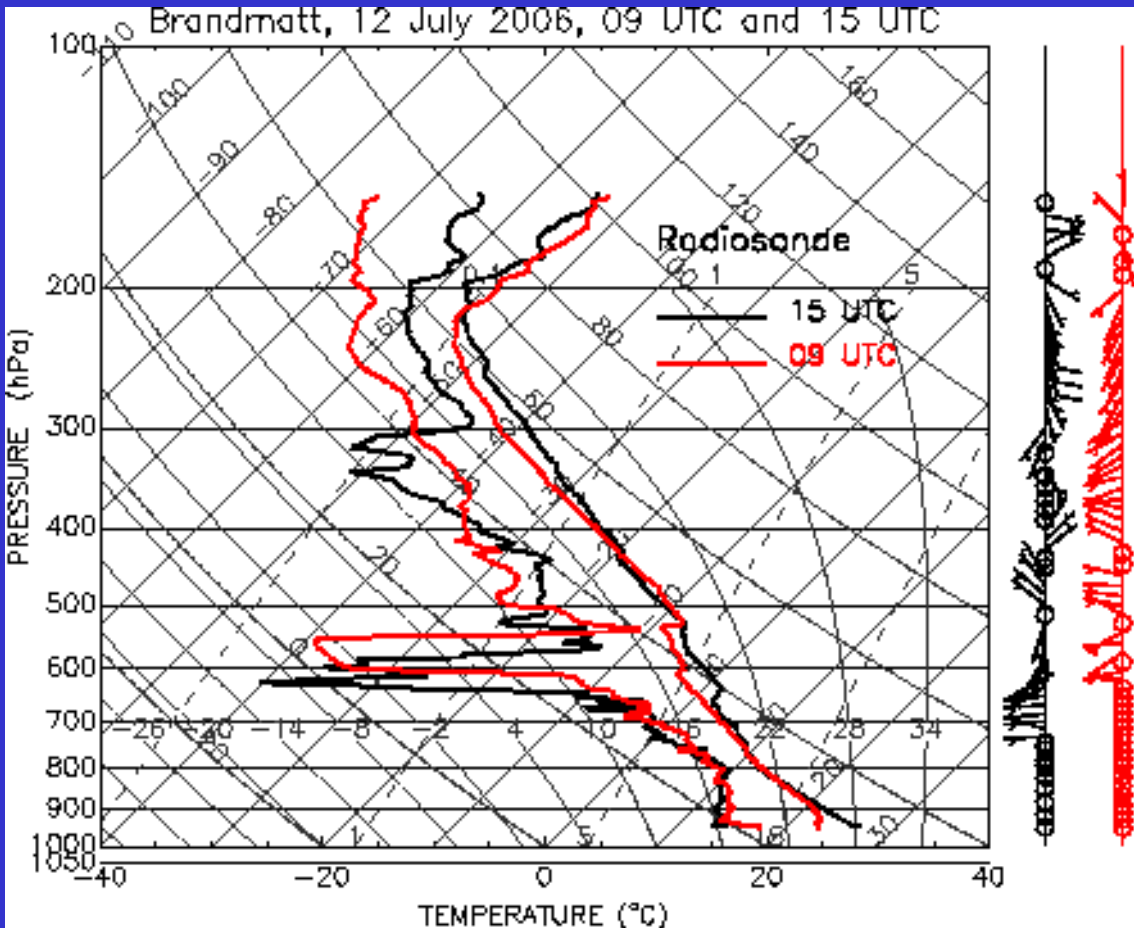
Lower level temperature and humidity



- Well mixed boundary layer in the observation, too low temperature in the simulation
- good representation of the humidity

# Impact of convection on the stratification

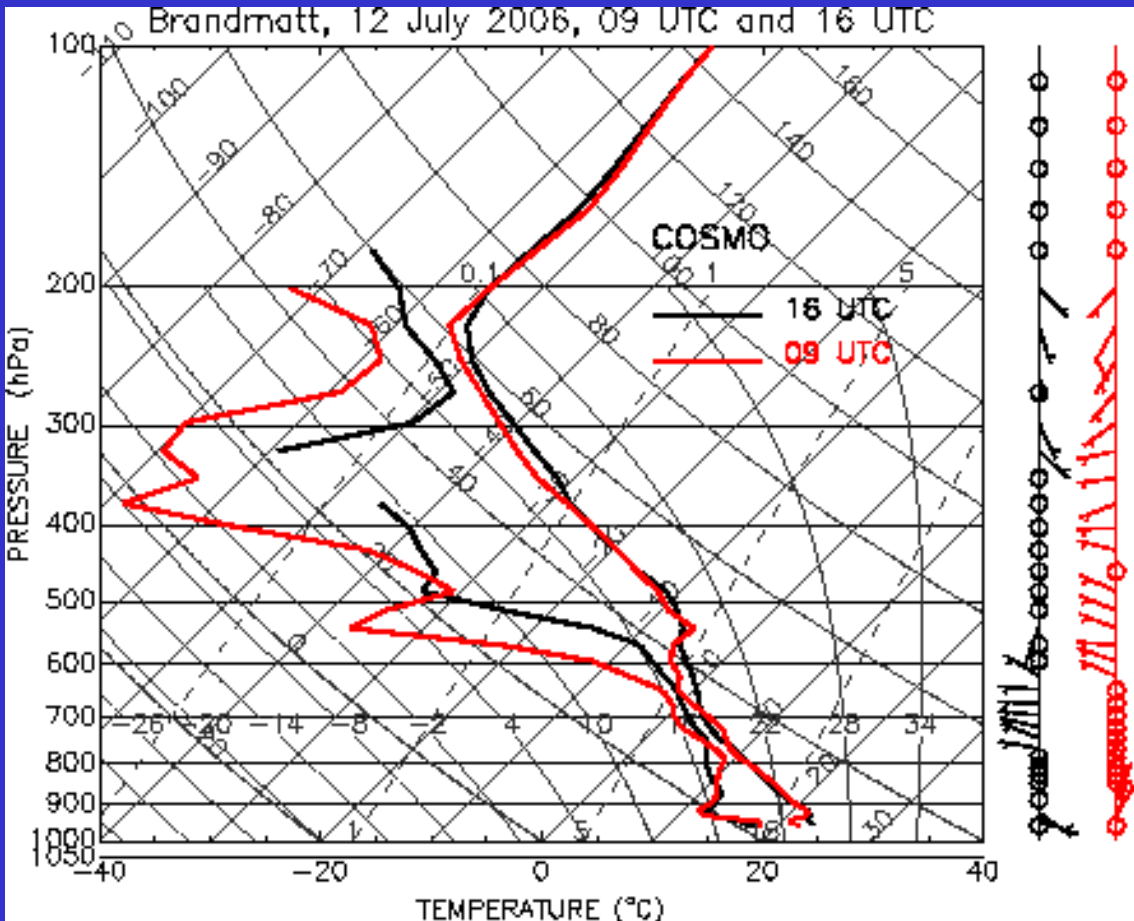
## Observations:



- Small changes in the boundary layer
- Warming of the atmosphere between 650 and 500 hPa and above 350 hPa
- Moistening of the atmosphere above 300 hPa
- Increase of tropopause height

# Impact of convection on the stratification

## Model results:



- Small changes in the boundary layer
- Warming of the atmosphere between 700 and 600 hPa and above 370 hPa
- Moistening of the atmosphere above 300 hPa
- No rise of the tropopause

Effects of convection on the atmospheric stratification are well reproduced

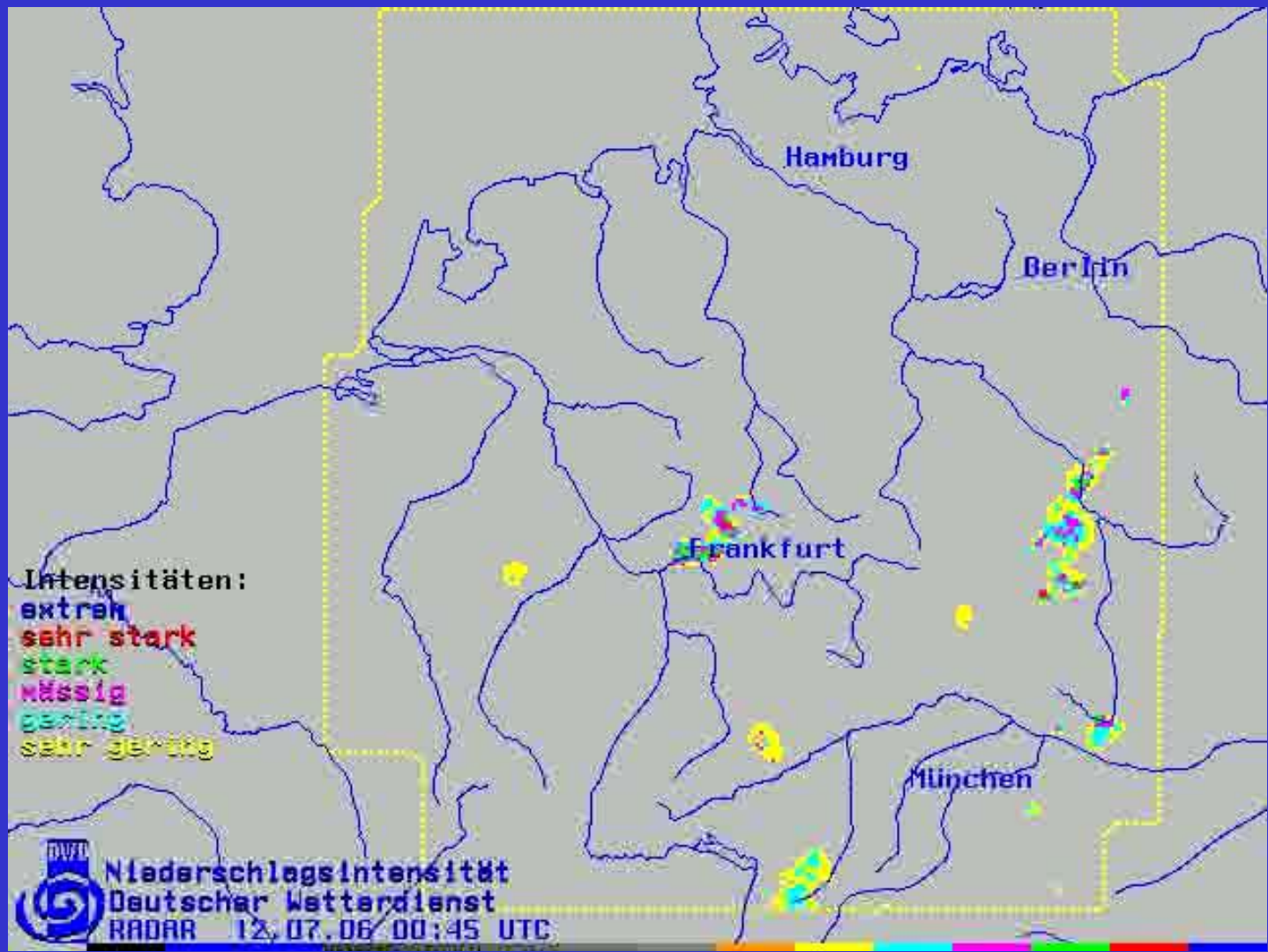
## Conclusions and Outlook

- Successful realization of PRINCE
- The obtained observations can be applied for a process-based evaluation of the COSMO model under convective conditions
- First results include:
  - Convective precipitation is initiated in the model
  - Representation of the processes within convection seems reasonable
  - Overall impact of convection on the atmospheric stratification seems well captured
- Further investigations required to study the processes leading to the initiation of convection
- Future studies using data from the PRINCE data set, preparing for the use of COPS observations

**Thank you for your attention!**

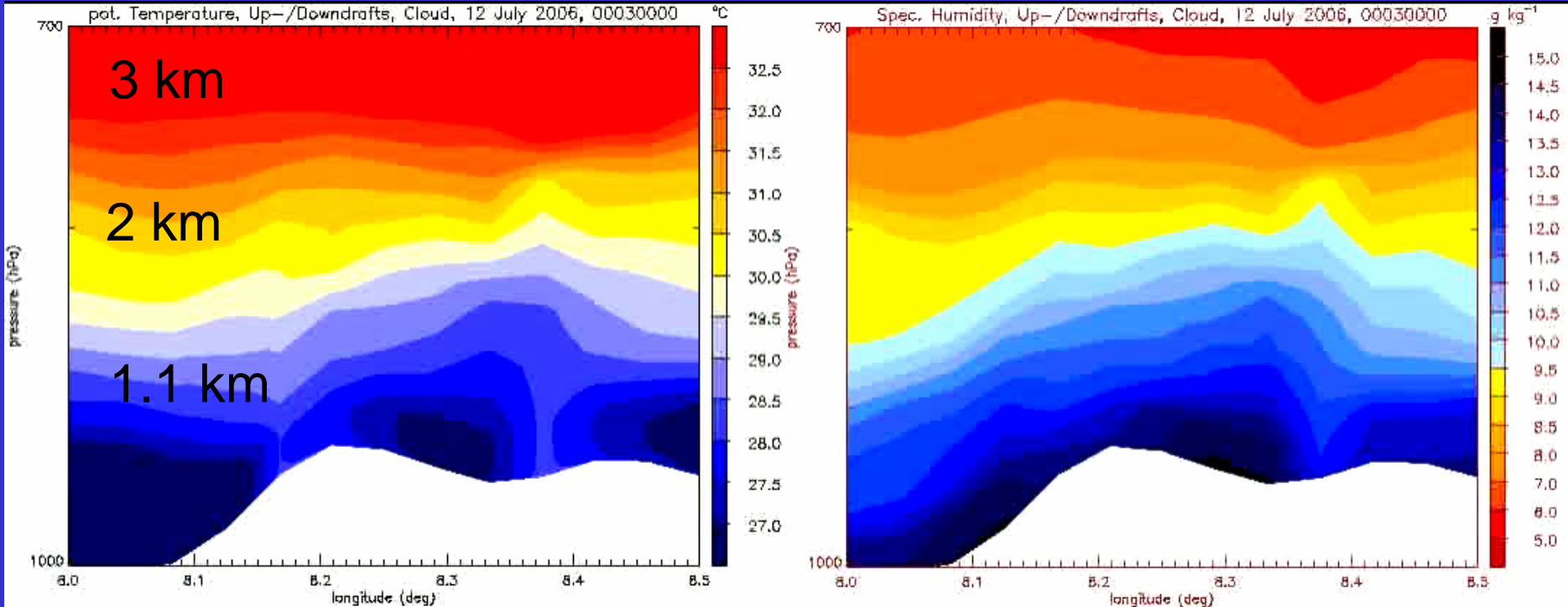






# View into the convection

Topography, wind, precipitation, cloud, 1000 – 1130 UTC



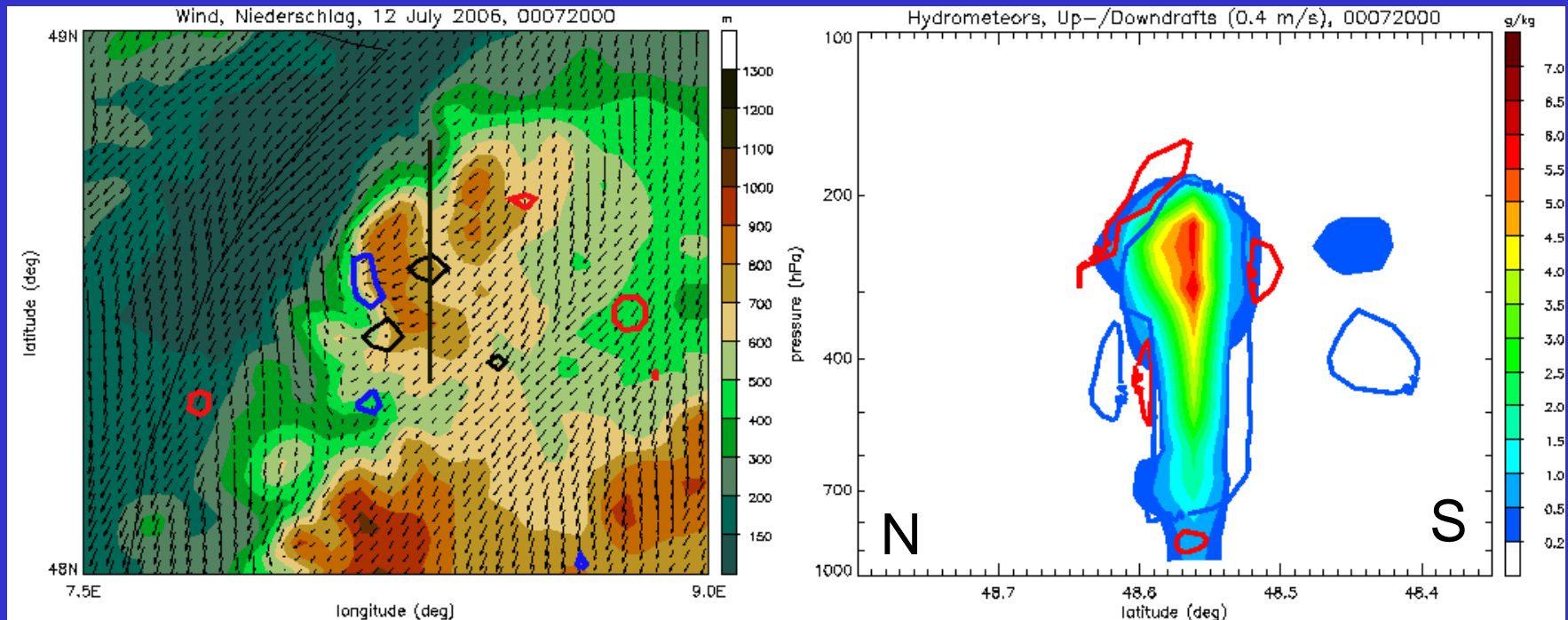
Arrows: 10 m wind

Contour lines: blue: updraft (850 hPa, -1.5 Pa/s),  
red: downdraft (850 hPa, 1.5 Pa/s)  
black: precipitation

blue: updraft (0.5 m/s)  
red: downdraft (-0.5 m/s)

# View into the convection

Topography, wind, precipitation, cloud, 1420 UTC



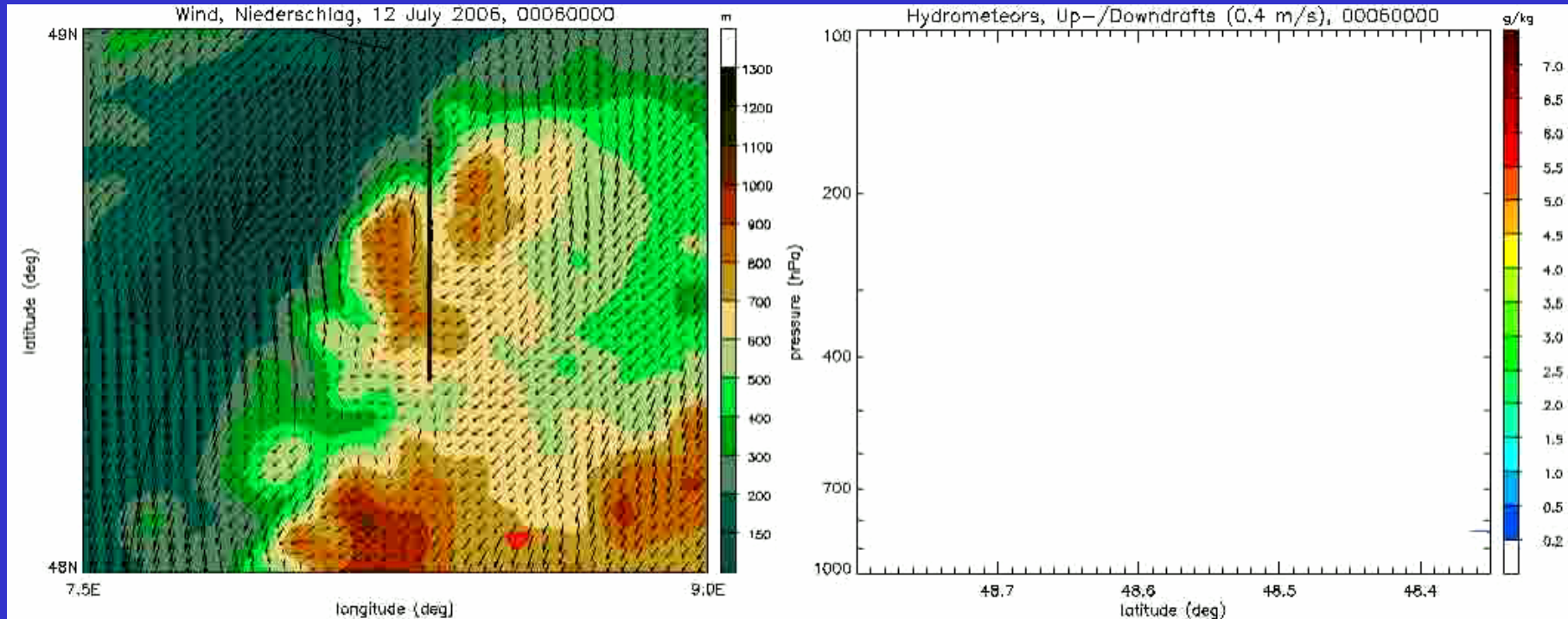
Arrows: 10 m wind

Contour lines: blue: updraft (850 hPa, -1.5 Pa/s),  
red: downdraft (850 hPa, 1.5 Pa/s)  
black: precipitation

blue: updraft (0.4 m/s)  
red: downdraft (-0.4 m/s)

# View into the convection

Topography, wind, precipitation, cloud, 1300 – 1530 UTC



Arrows: 10 m wind

Contour lines: blue: updraft (850 hPa, -1.5 Pa/s),

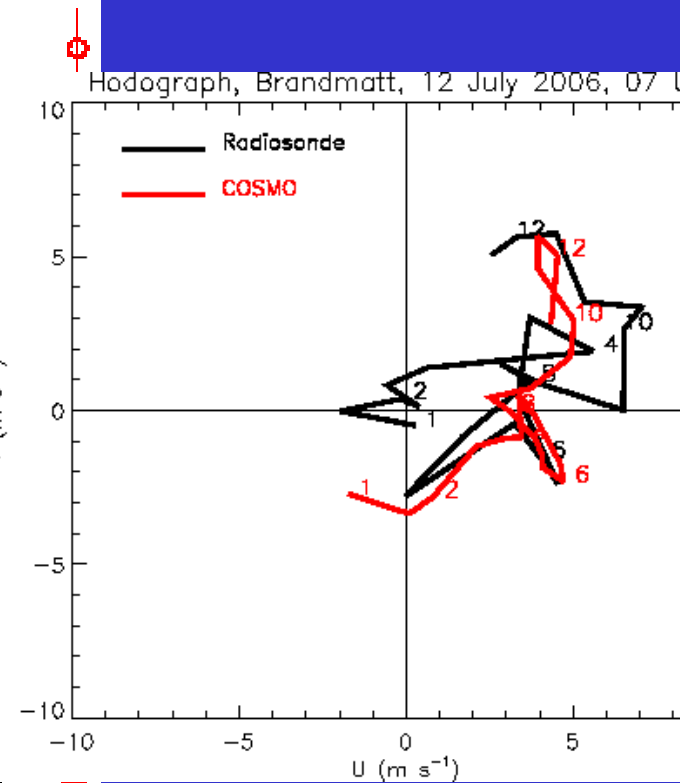
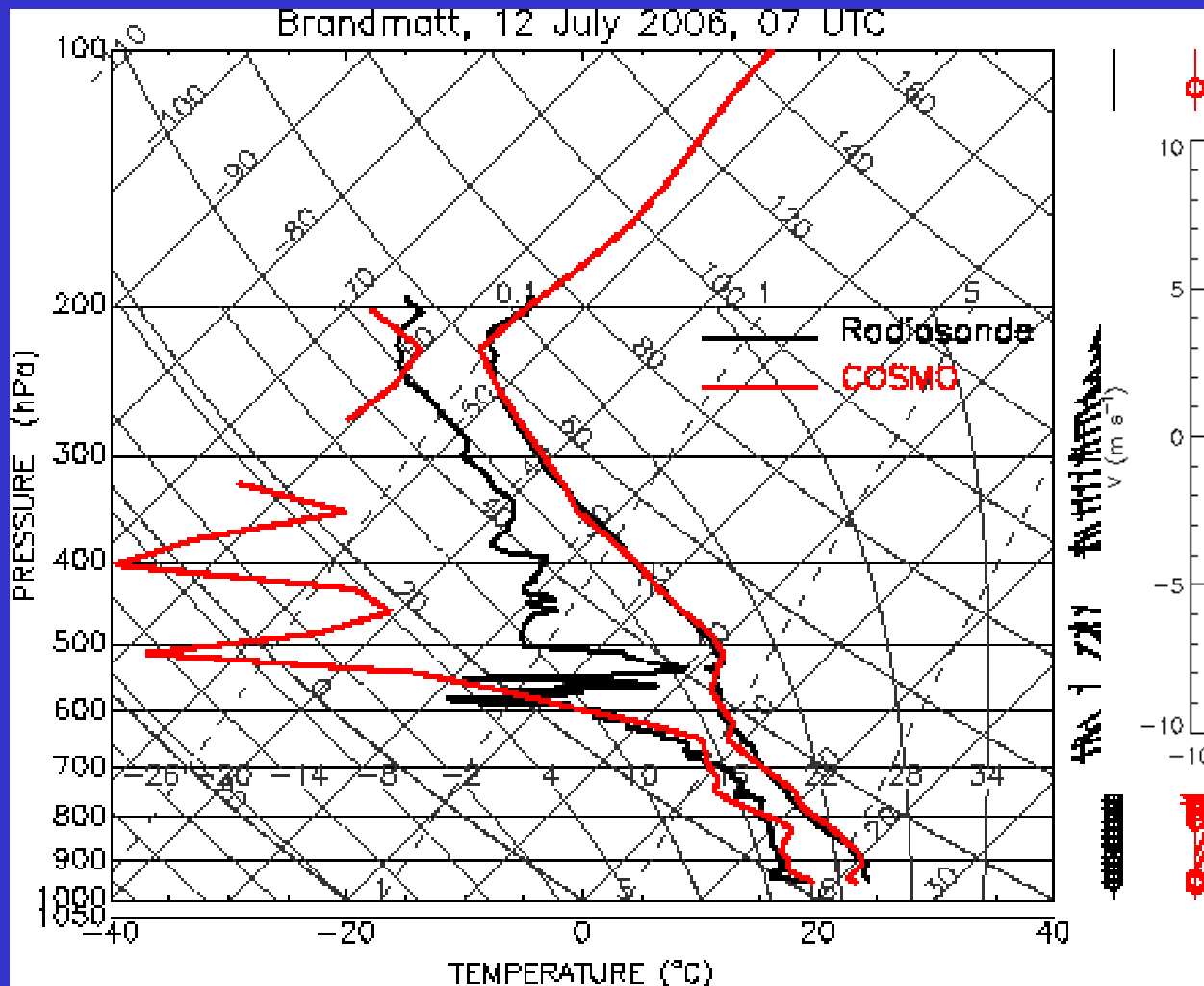
red: downdraft (850 hPa, 1.5 Pa/s)

black: precipitation

blue: updraft (0.4 m/s)

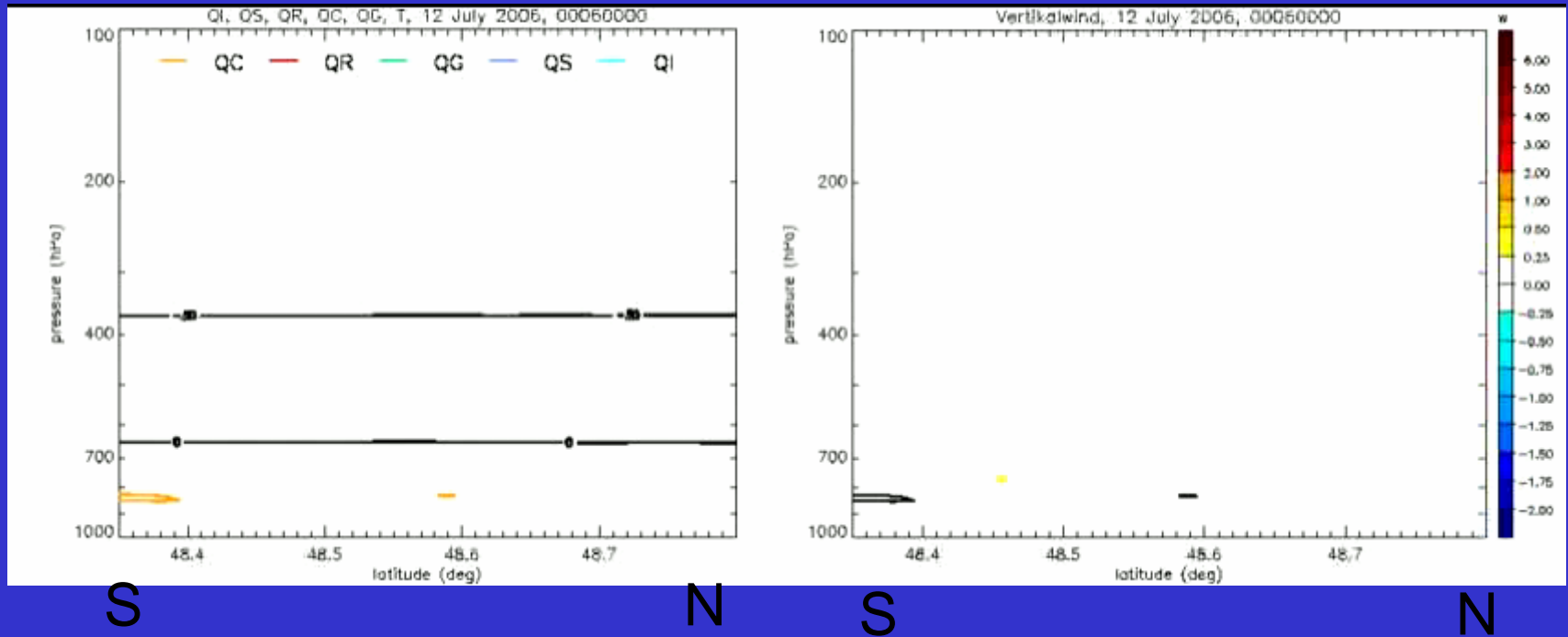
red: downdraft (-0.4 m/s)

# Evaluating the model with radiosonde data



# View into the convection

Hydrometeor classes, vertical wind, 1300 – 1530 UTC



- Early formation of rain
- Production of graupel by freezing of rain
- Significant amount of supercooled cloud water, mixed phase present

## Conclusions:

- The COSMO model is capable of simulating convective situations using realistic initial and boundary conditions
- Sensitivity of the model results to technical and numerical modifications should be investigated
- Modification of the autoconversion threshold does not significantly impact the model result (for one case study)
- The two investigated cases (28 June, 12 July) seem well suited for further studies to investigate the aerosol effect under different conditions