High-resolution simulations over central Europe: Assimilation experiments during COPS IOP9c

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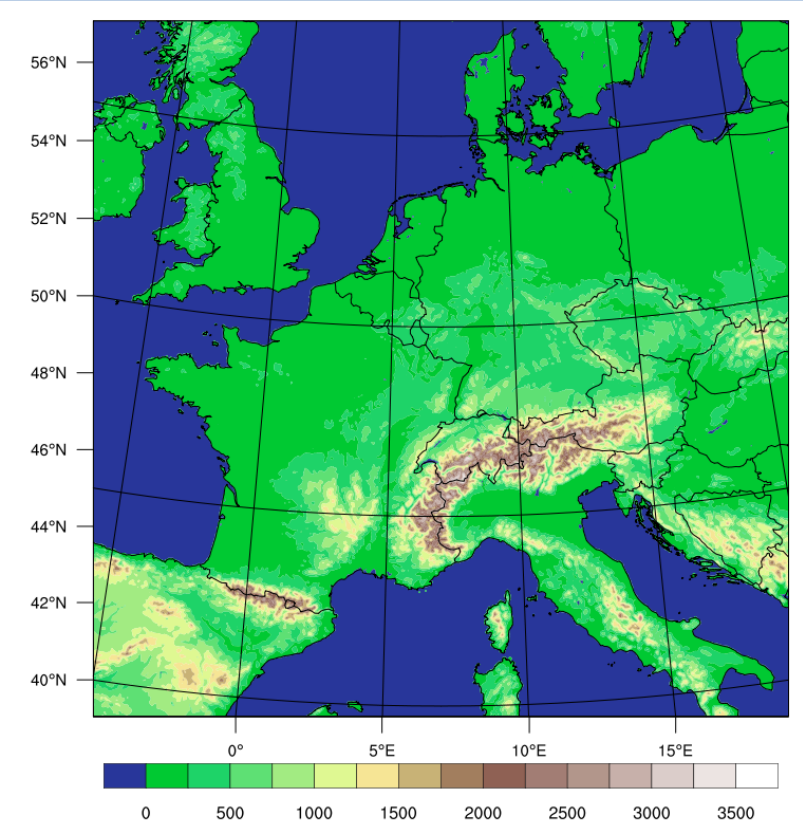
Overview

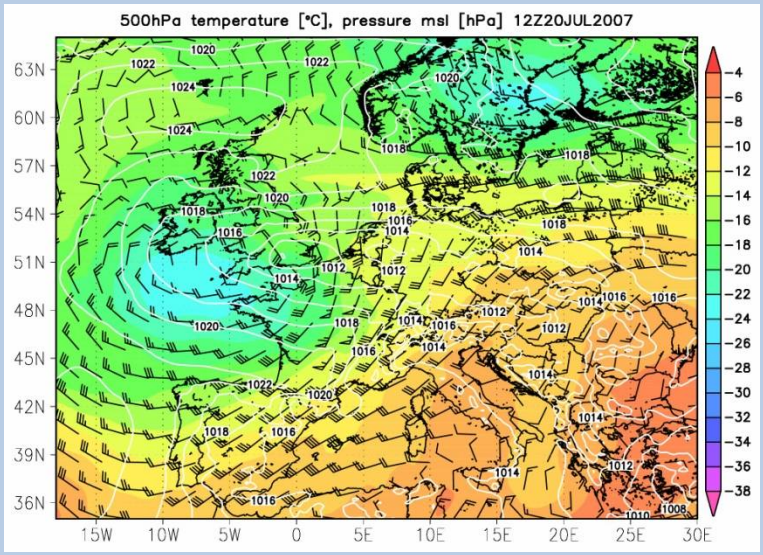
- Model setup
- Case study July 20, 2007 (COPS IOP9c)
- Summary and outlook

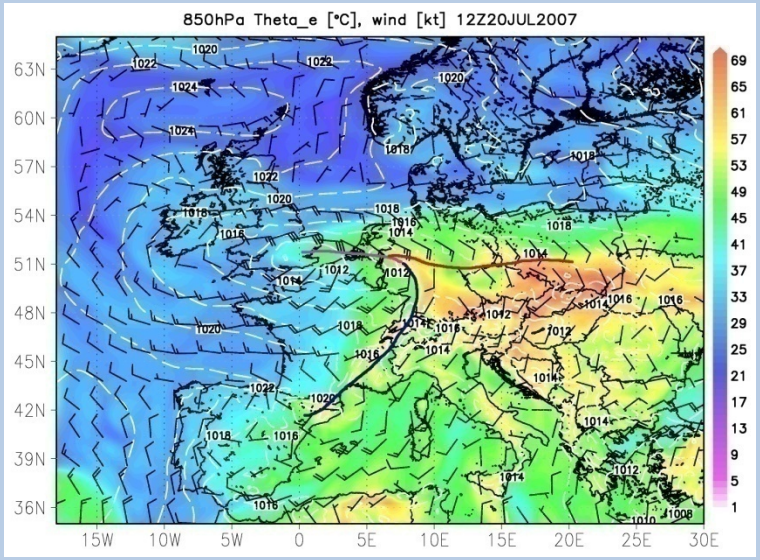
Model configuration



- WRF version 3.1
- Horizontal resolution 3600m
- 50 levels up to 50hPa
- 13 levels up to 700hPa
- Morrison 2-moment cloud microphysics
- RRTM longwave radiation
- Dudhia shortwave radiation
- MM5 similarity surface layer
- NOAH land-surface model
- YSU boundary layer scheme
- No cumulus parameterization
- Cloud water and ice as initial fields.
- Initialization from ECMWF analysis on model levels

Case study July 20, 2007 (COPS IOP9c)

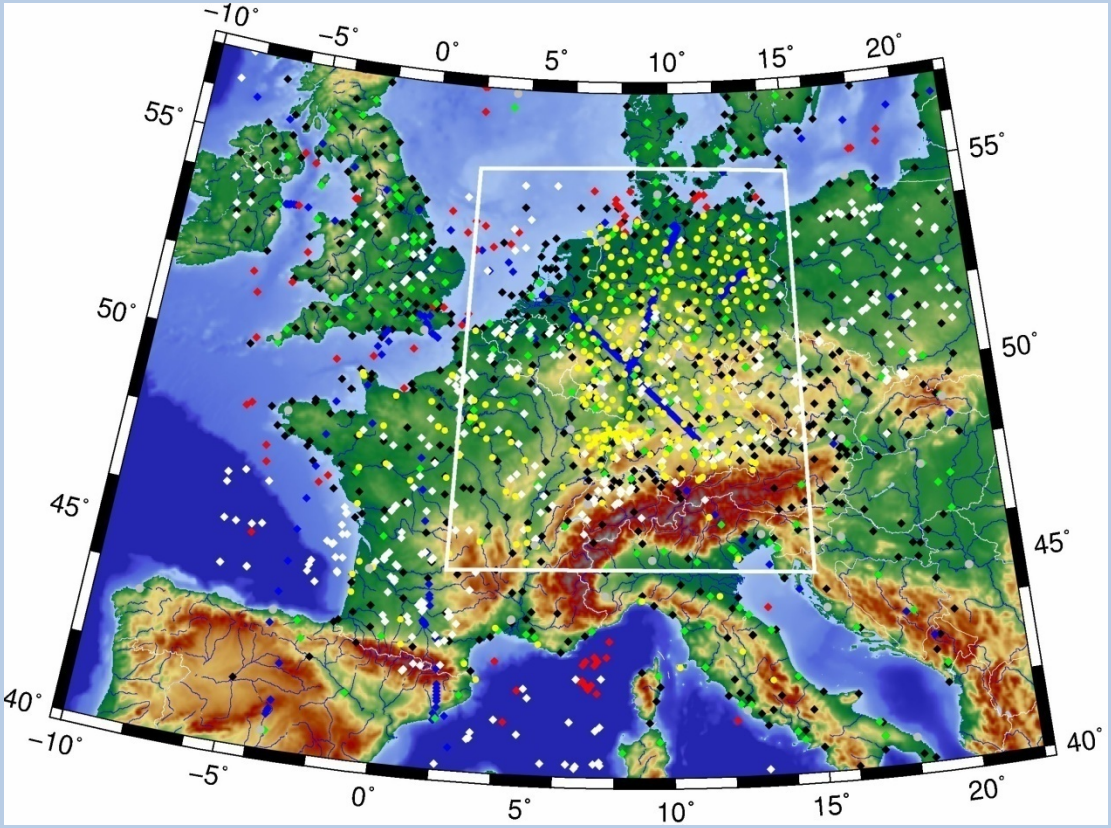




4 Forecasts:

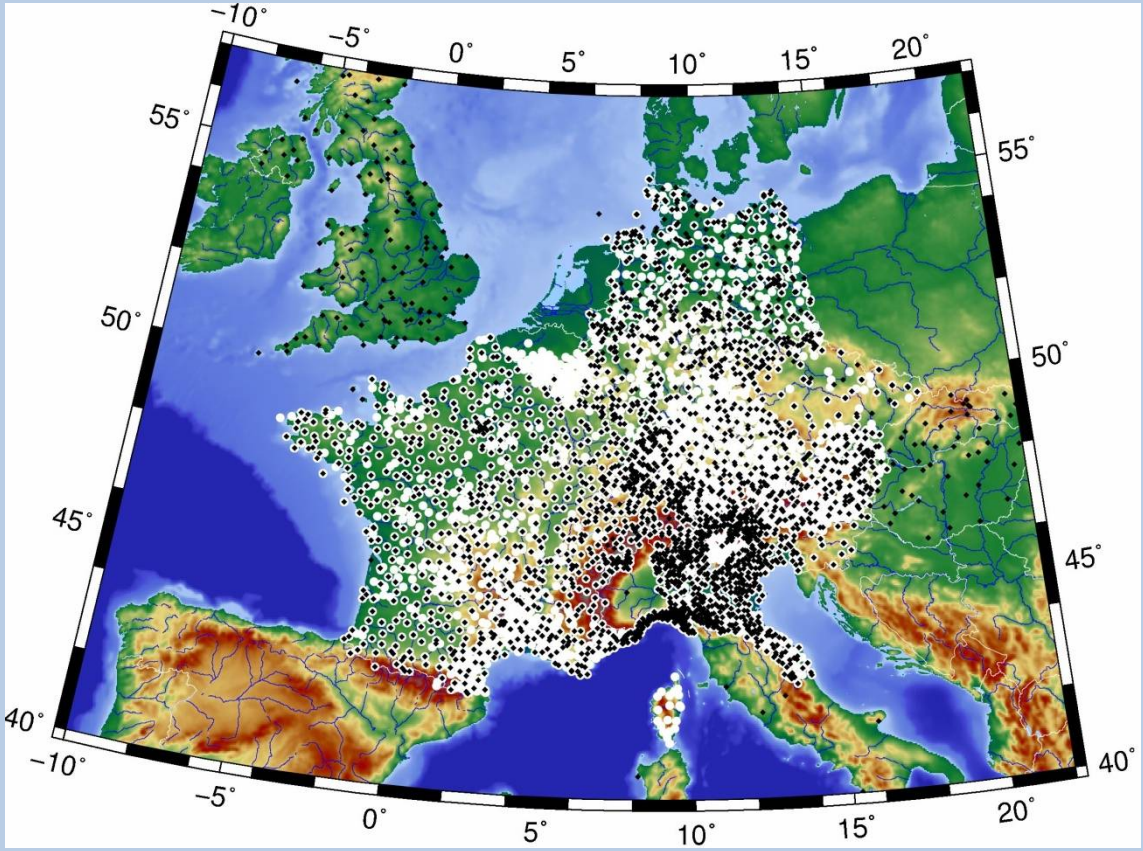
- CTL: Start at 19.07.2007 18UTC from an ECMWF analysis
- NZD: Assimilation of conventional observations including AMV at 00UTC
- FZD: Additional assimilation of GPS-ZTD data over Germany and France
- SURF: Only surface data are assimilated

Selected observations for the 3DVAR



Black=SYNOP, Blue=AMDAR, Green=METAR, red=SHIP, white=AMV, yellow=GPS-ZTD, grey=TEMP, together ~ 2800 measurements.

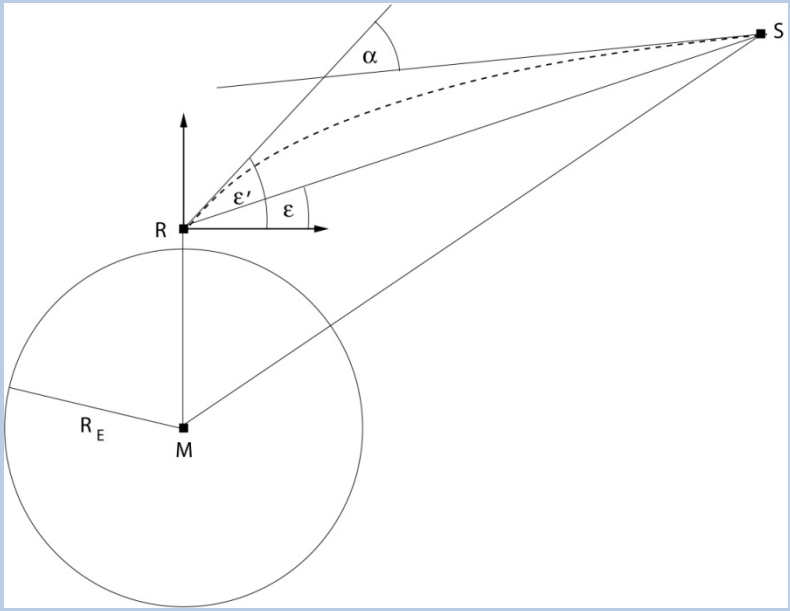
Dataset available for validation



- 4500 stations for hourly precipitation
- 2800 stations for wind, temperature and humidity
- ~250 GPS IWV stations over Germany and eastern France

Why GPS?

- GPS provides data with large spatial coverage and high time resolution (15 minutes) under all-weather conditions
- Before the COPS campaign, the existing network was densified
- A large impact of GPS data assimilation on the improvement of the initial water vapor field can be expected.
- The information content is much higher when slant path delays could be assimilated additionally

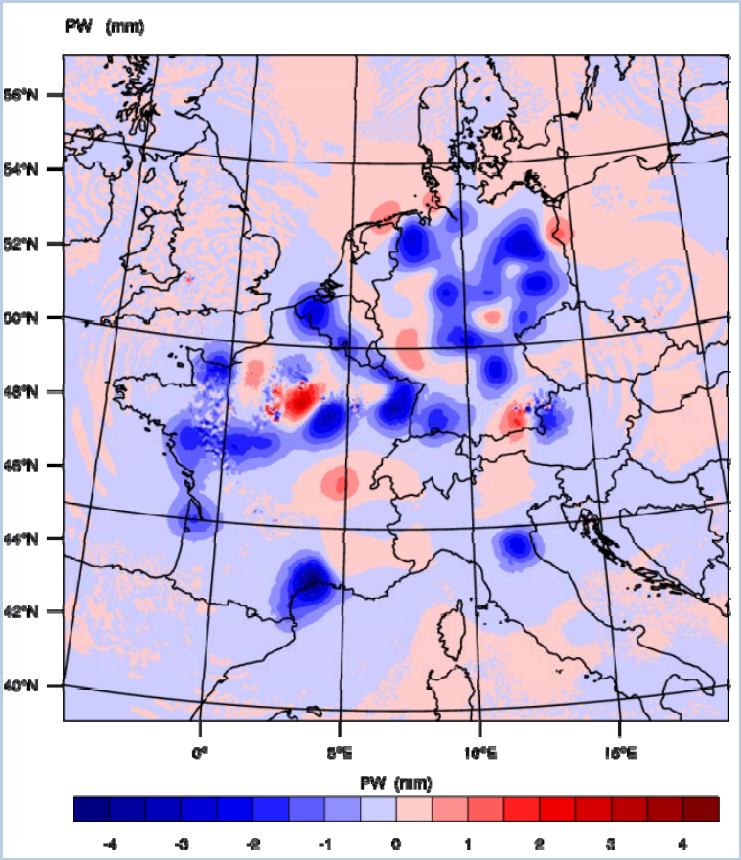


$$STD = 10^{-6} \int_S \left(k_1 \cdot \frac{P}{T} + k_2 \cdot \frac{e}{T^2} \right) ds$$

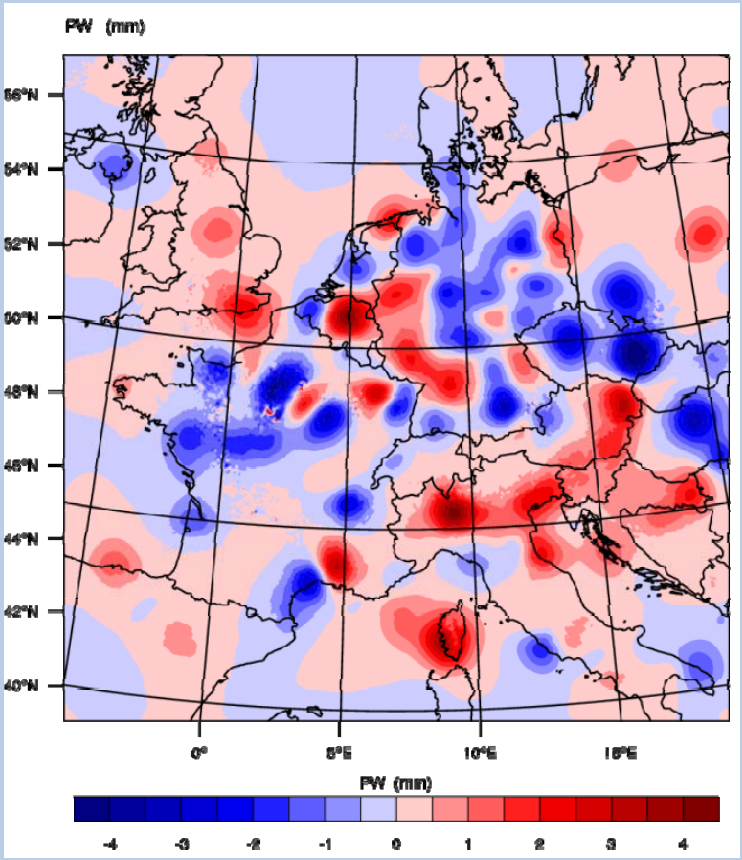
Hydrostatic part of the delay

Wet delay

Integrated water vapor differences at assimilation time step



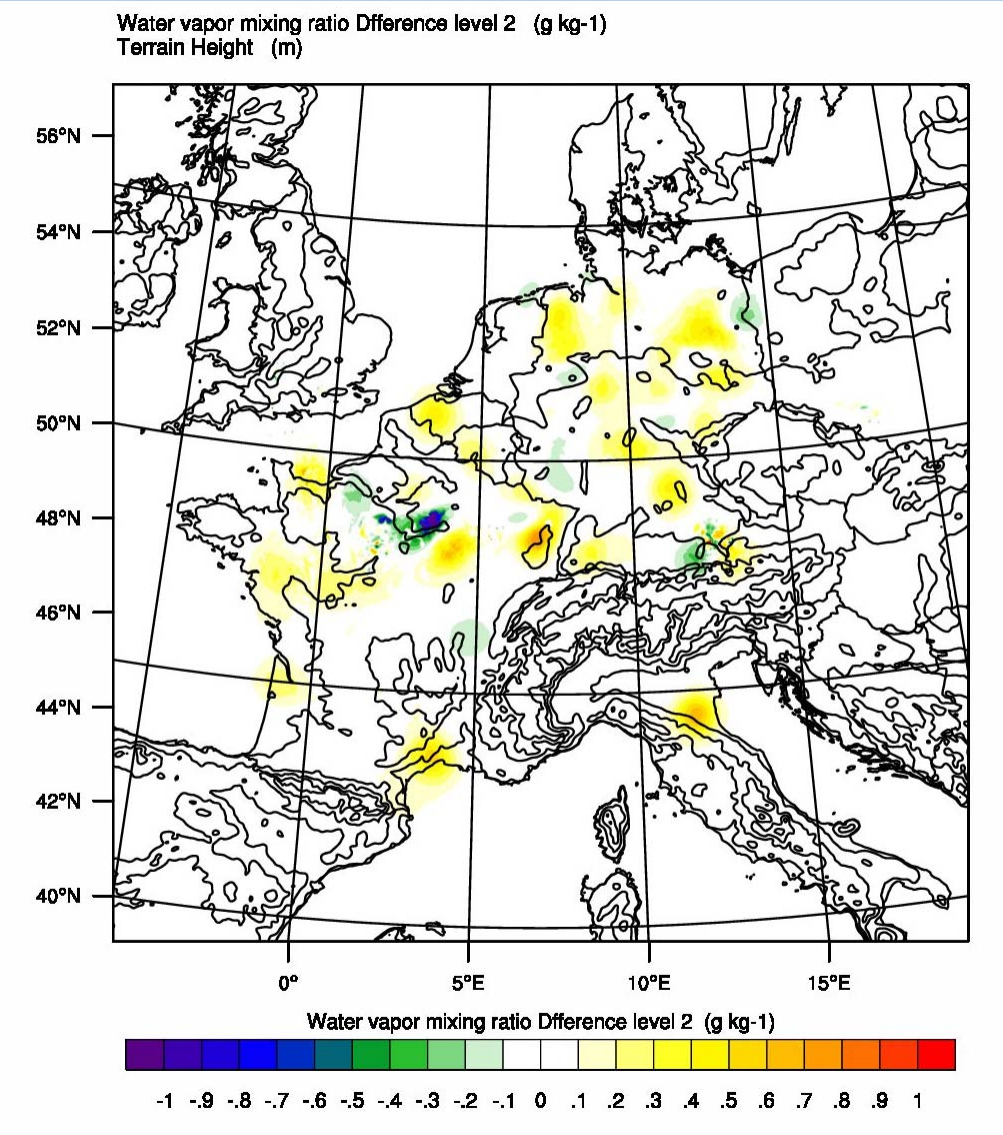
FZD-NZD



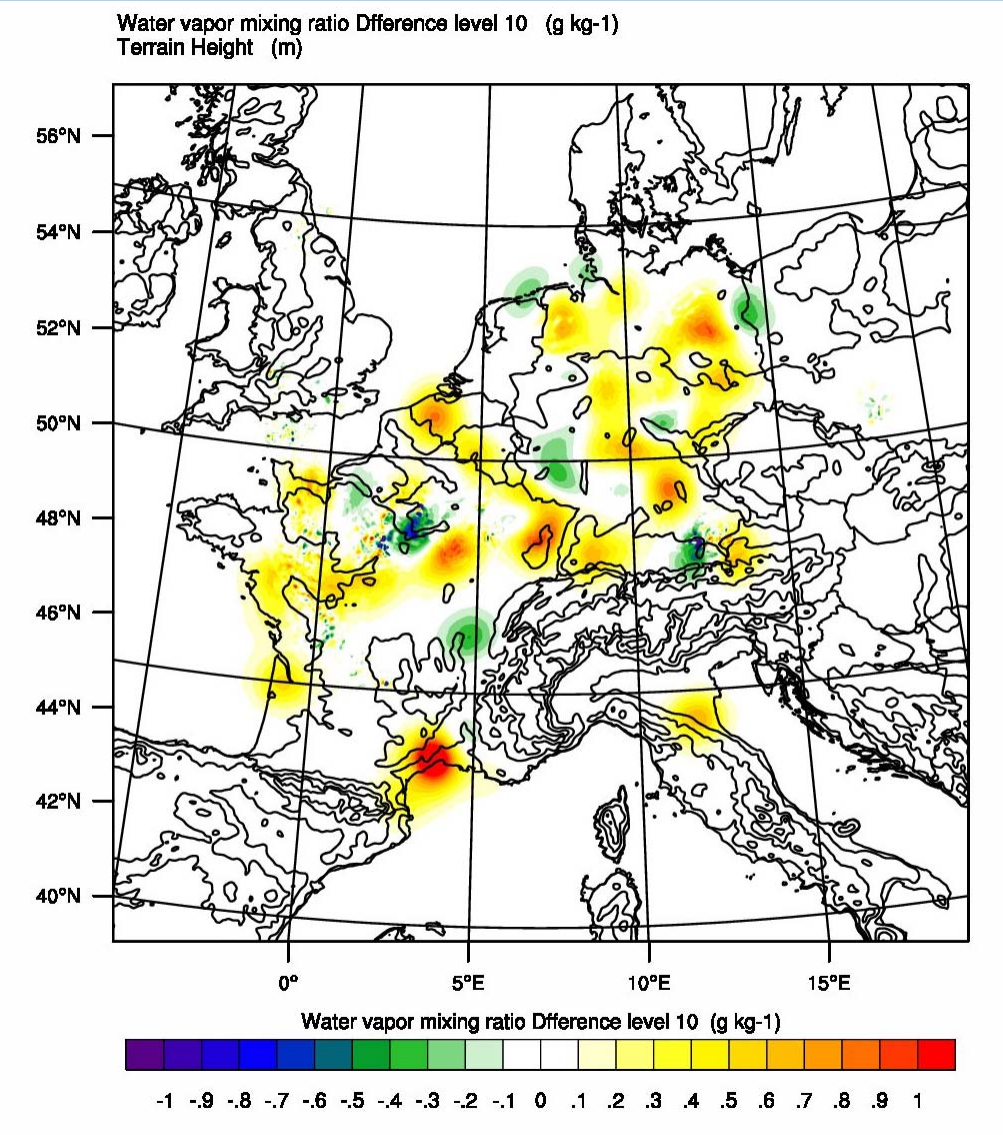
FZD-CTL

Additional ZTD data reduces the amount of IWV

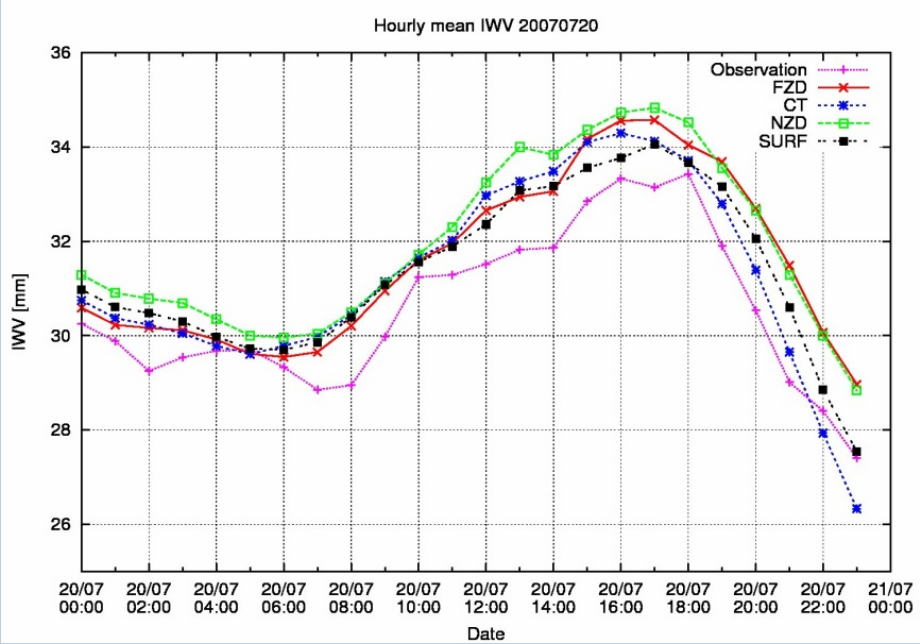
Where is the water vapor removed?



Where is the water vapor removed?



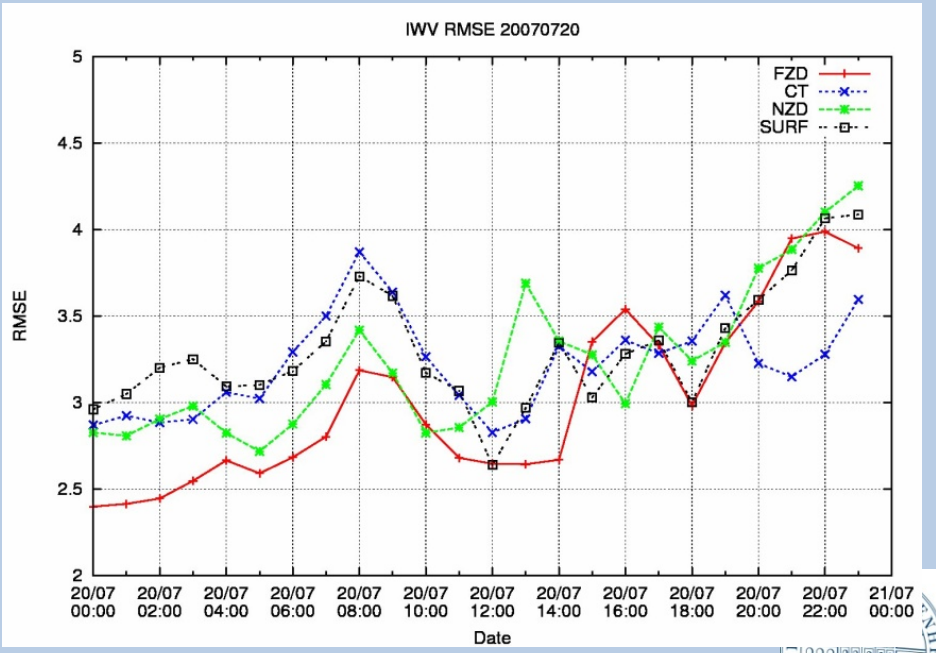
Diurnal cycle of IWV on July 20, 2007



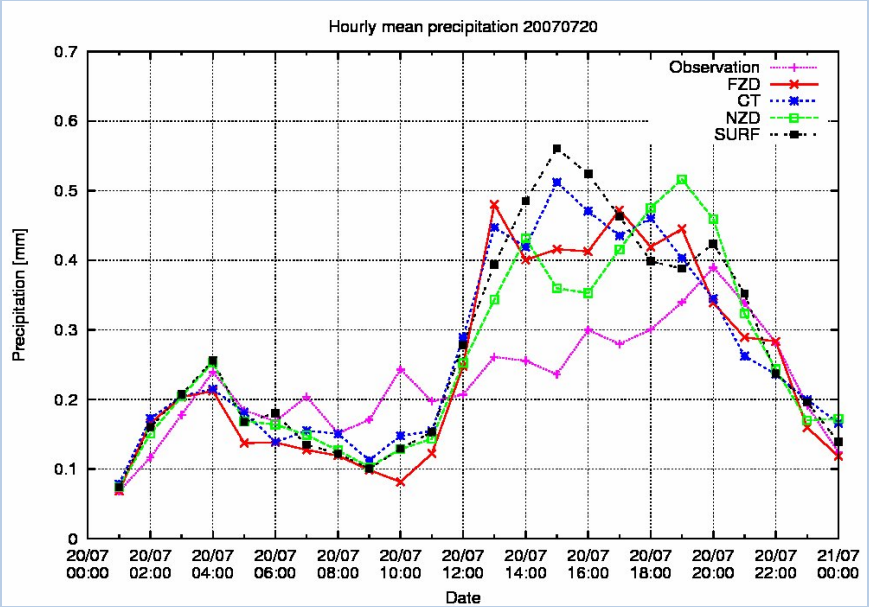
- Good representation of the diurnal cycle
- IWV amount slightly too high
- FZD closest to the observation in the early afternoon

- Smallest RMSE for FZD simulation
- Largest RMSE for the SURF simulation
- Influence vanishes after 12 hours

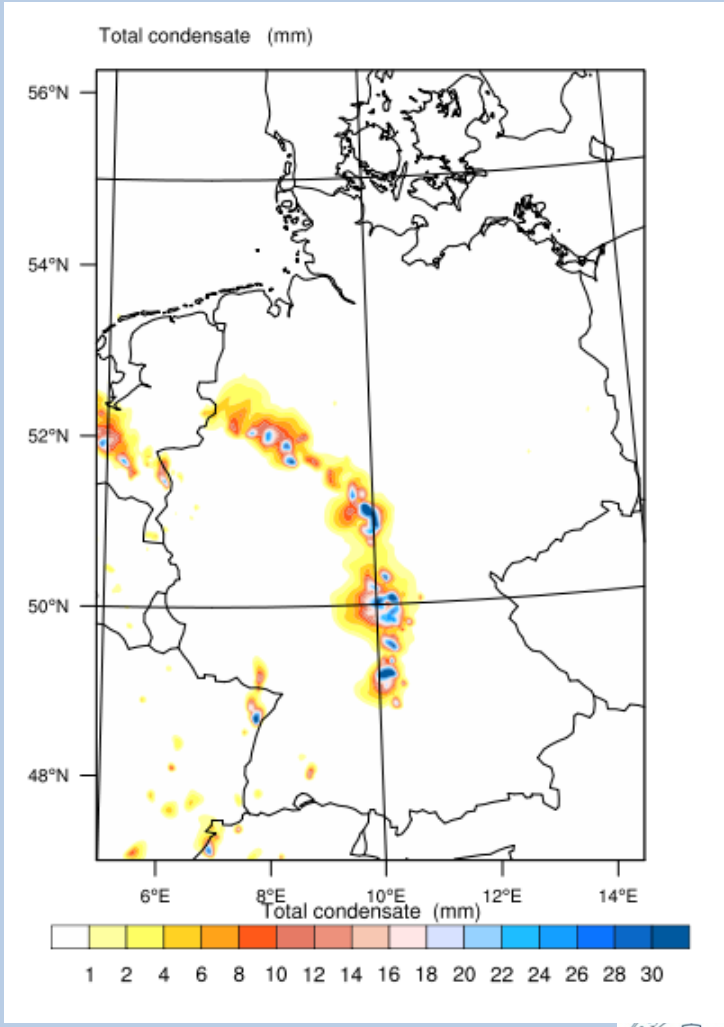
- Highest correlation for the FZD experiment until 12 UTC



Diurnal cycle of precipitation

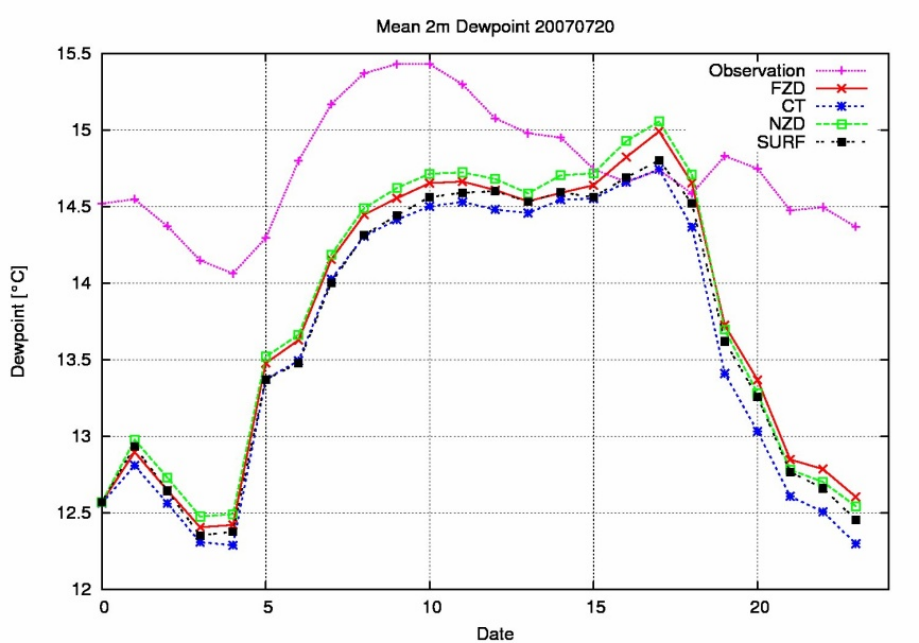


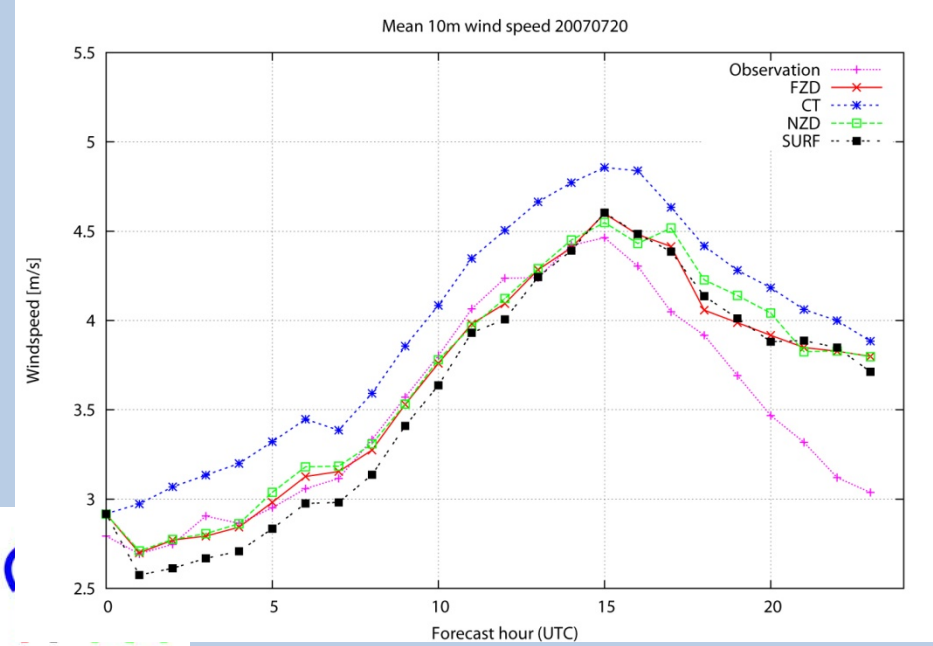
Total cloud condensate



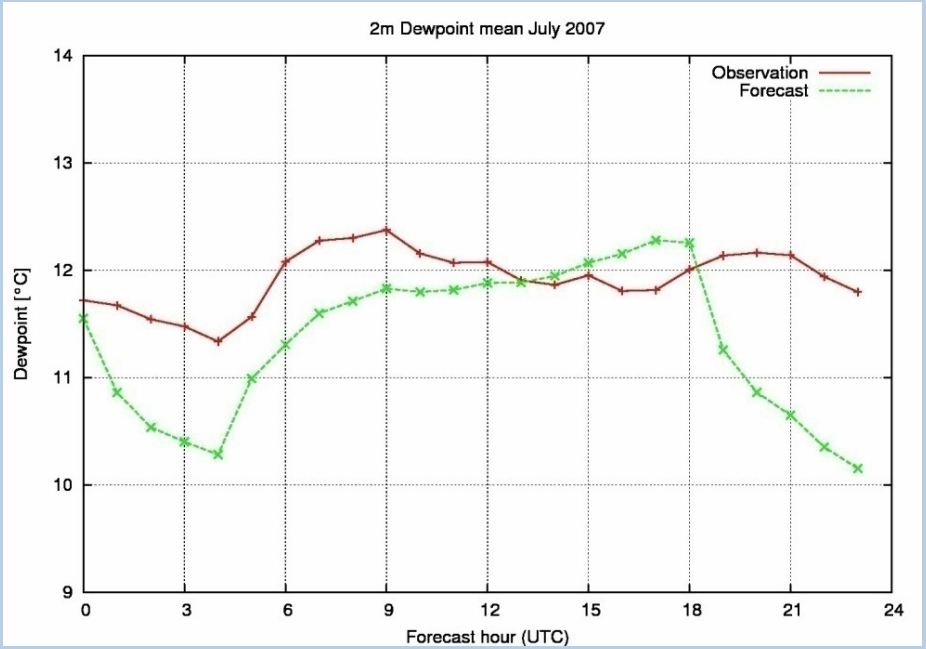
- Until 10UTC good agreement between forecast and observation
- Overestimation of precipitation by all simulations from 12UTC (also seen in a monthly mean)
- SURF with the largest amount of precipitation
- Strong updrafts in the model produce large amounts of graupel and thus too much precipitation
- FZD shows best correlation in the afternoon

Surface fields

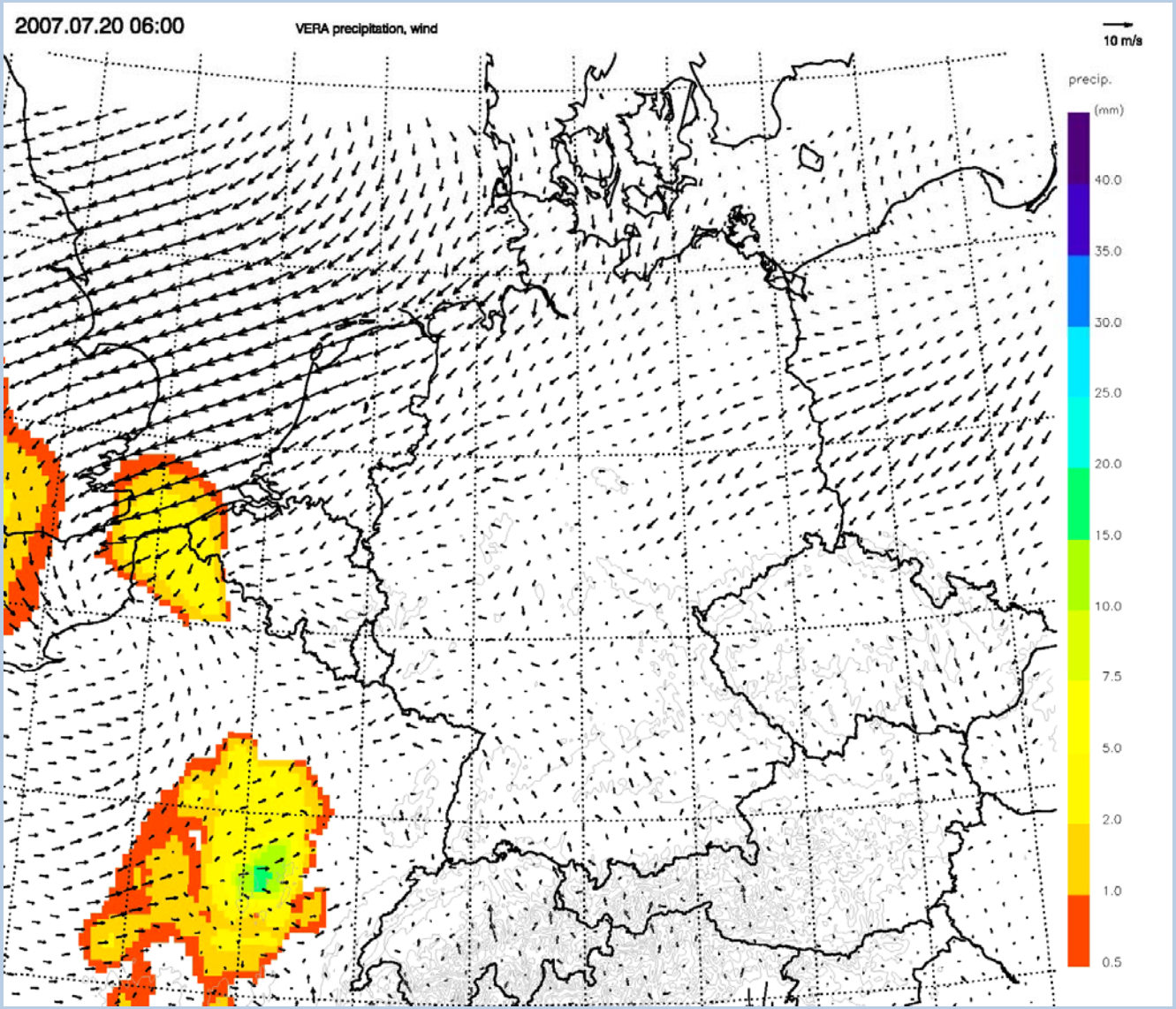


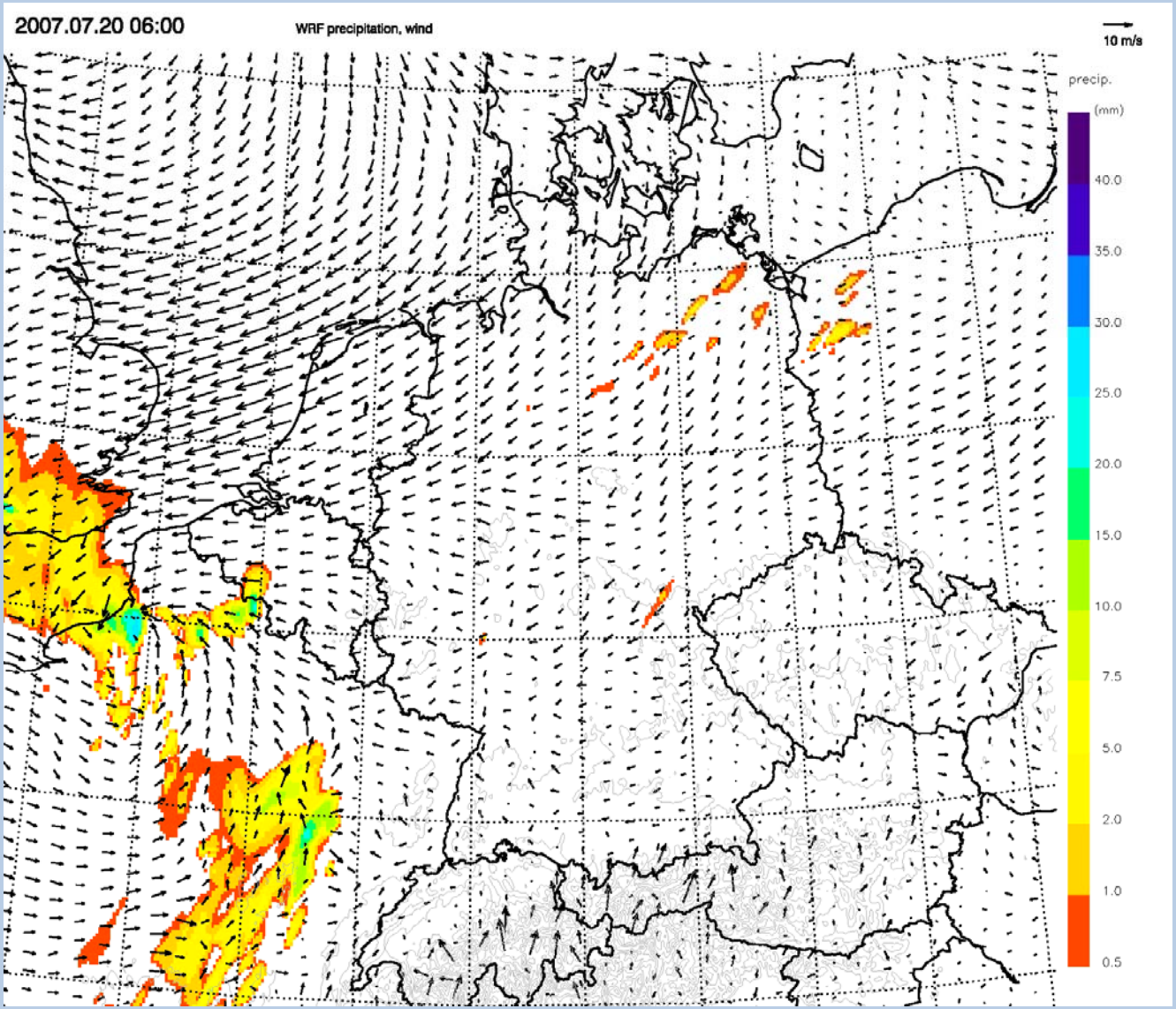


- General problem in diagnosing 2m humidity
- Can be correlated with 10m wind speed
- Not only a problem in this particular case
- Too strong mixing in the stable boundary layer as PBL heights are ~200m during the night.



Further results are described in Schwitalla et al., 2010; submitted to QJRMS, COPS special issue


2007.07.20 06:00
VERA precipitation, wind
10 m/s
precip.
(mm)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
7.5
5.0
2.0
1.0
0.5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7.5
5.0
2.0
1.0
0.5

Summary and outlook

- First high-resolution experiment with WRF over central Europe
- It is important to assimilate surface and upper air observations together
- Additional assimilation of GPS-ZTD data shows a small but positive influence on precipitation
- Influence of the assimilation vanishes after 12 hours
- WRF in this configuration tends to overestimate precipitation
- YSU scheme appears to simulate a too strong mixing during the night

- Statistical evaluation using GPS-ZTD data from France and Germany
- Tests with different quality settings for GPS-ZTD data
- Assimilation of radar radial velocities from French and German Radar network
- More case studies
- Implementation of the STD operator into WRFVAR (prototype exists)

Acknowledgments

- ECMWF for computing time and data access
- Paul Dando from ECMWF for help with BUFR data
- Galina Dick from GFZ for providing GPS data
- WRF developers and support team

Thanks for your attention!