Summary

New Results on the Assimilation of GPS Data at DWD

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From GPS-derived precipitable water (PW), profiles of (pseudo-)observations of specific humidity are obtained by simple scaling of the present model humidity profiles. Quality weights for each level reflect the relative contribution of the model layers to the vertically integrated information. The profiles can then be assimilated like radiosonde profiles.

Half-hourly data from about 80 GPS stations mainly located in Germany have been used in a 9-day parallel assimilation cycle and forecast experiment with two daily forecasts. Compared to a control cycle without using these data, a positive statistical impact is found for PW and upper-air temperature and humidity in forecasts up to about +15 h . The impact on precipitation in individual cases is negative in about as many cases as it is positive.

To discuss the impact on precipitation, results from observation monitoring are to be considered first. In the summer season, the averaged diurnal cycles of PW of the LM assimilation and the GPS observations deviate from that of the internal model climate as defined by the free LM forecasts in opposite directions. A comparison with the Lindenberg radiosonde indicates that the negative deviation around noon in the LM assimilation is probably due to the assimilation of radiosonde humidity which tends to have a dry bias at daytime. The diurnal cycle of the GPS observations agrees well with that of microwave radiometer observations. This may indicate that it is correct, implying that the model climate is too dry around noon. A contributing factor for that may be the convection parameterization, which re-establishes equilibrium by producing rain instantaneously and is therefore well known to cause a strong shift of the diurnal cycle of precipitation forward in time. Therefore, problems are expected from the nudging towards GPS-derived PW even if the data are correct. The extra amount of moisture at noon and in the early afternoon can erroneously trigger the convection parameterization, and this is shown to be likely to occur in the experiment. The solution to this would be, of course, to correct the model climate by improving the model itself. As long as this is not possible, however, it may be necessary to adjust the correct observation values to the erroneous model climate by means of a diurnal bias correction applied to the data. This approach is planned to be tested in the future.

The major problem for the nudging of PW is the vertical distribution of the vertically integrated observed quantity. For one case, it is shown that the assimilation of PW from data more than 15 hours prior to the analysis time is responsible for a different vertical distribution of humidity. This results in strong erroneous precipitation, although the PW values in the analysis are corrected. This indicates, that it will not (always) be possible to solve the vertical distribution problem without other observational information.

NUDGING OF GPS IWV

- If only Total Zenith Delay (TZD) available, Integrated Water Vapour (IWV) is derived from TZD using model pressure and temperature.

- Specific humidity at model level k is derived as:

$$q_v^{obs}(k) = \frac{IWV^{obs}}{IWV^{mod}} q_v^{mod}(k)$$

- Retrieved GPS humidity profile can modify only model levels above antenna and below 500 hPa.

- Quality weight assigned to GPS observation at level k is:

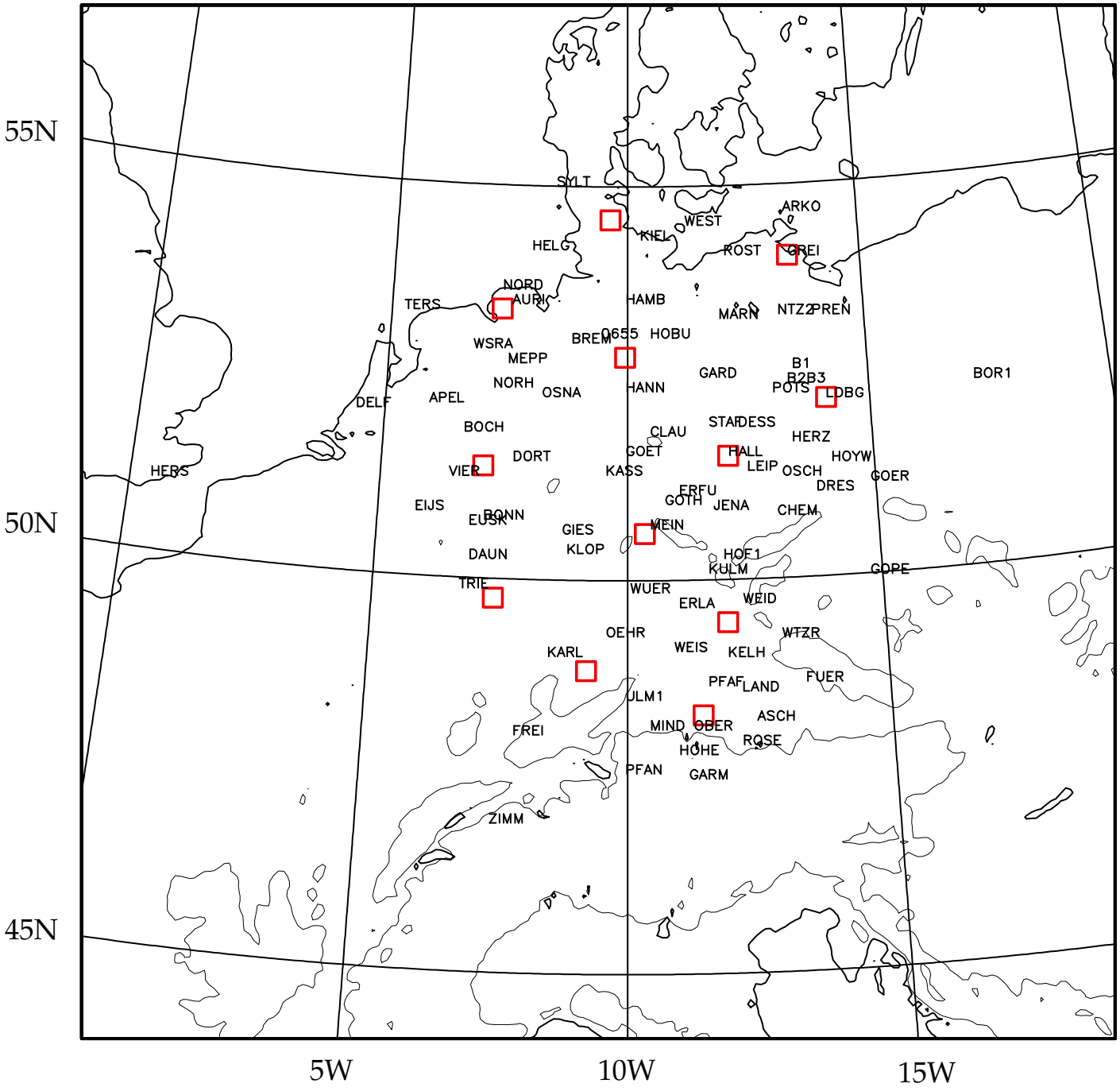
$$w(k) \sim q_v^{sat}(k) \; \Delta p(k)$$

- GPS observation nudged as radiosonde, i.e. 120 km radius of influence.

- Linear temporal interpolation for half-hourly GPS data.

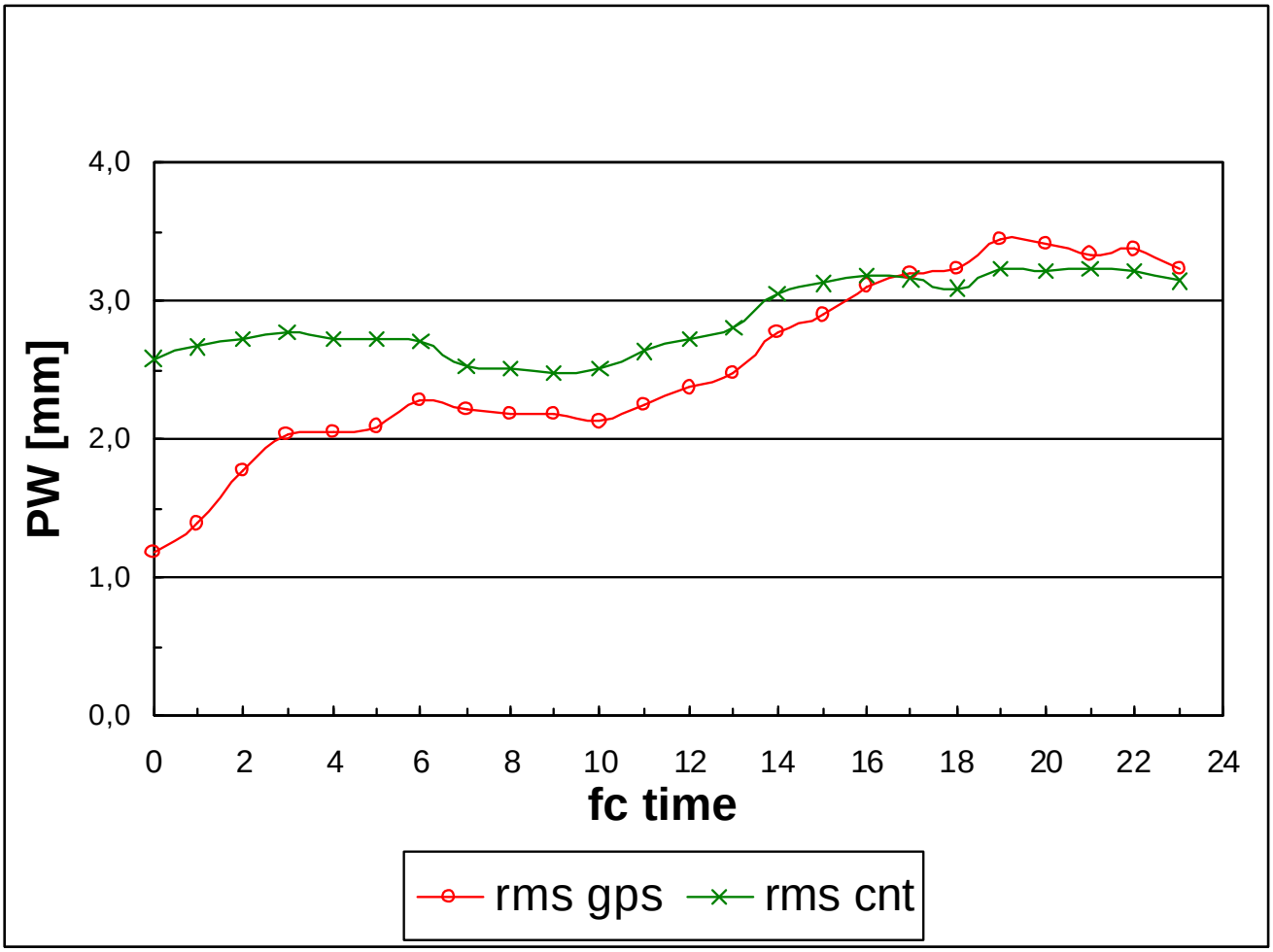
acronyms: horizontal distribution of GPS stations

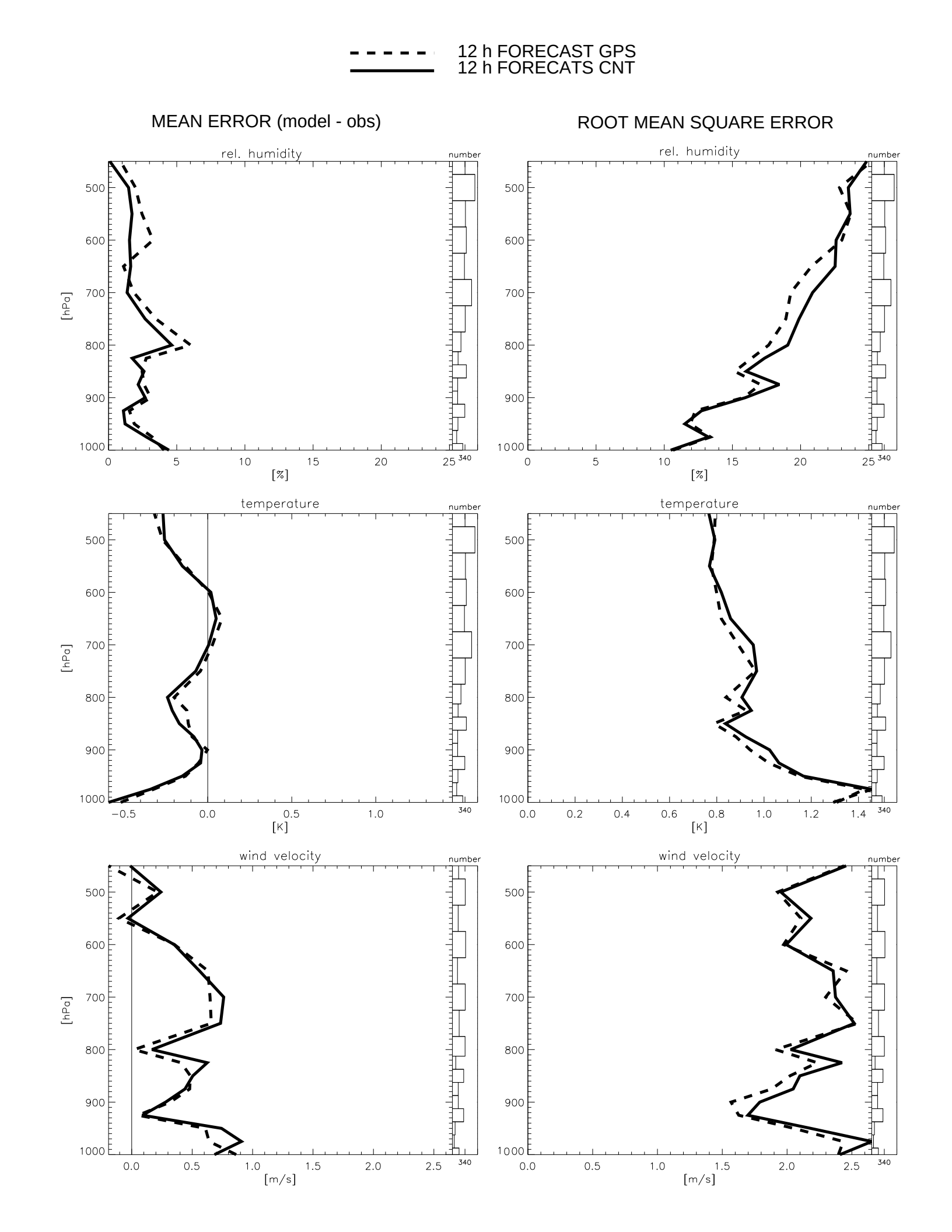
red squares: German radiosonde stations

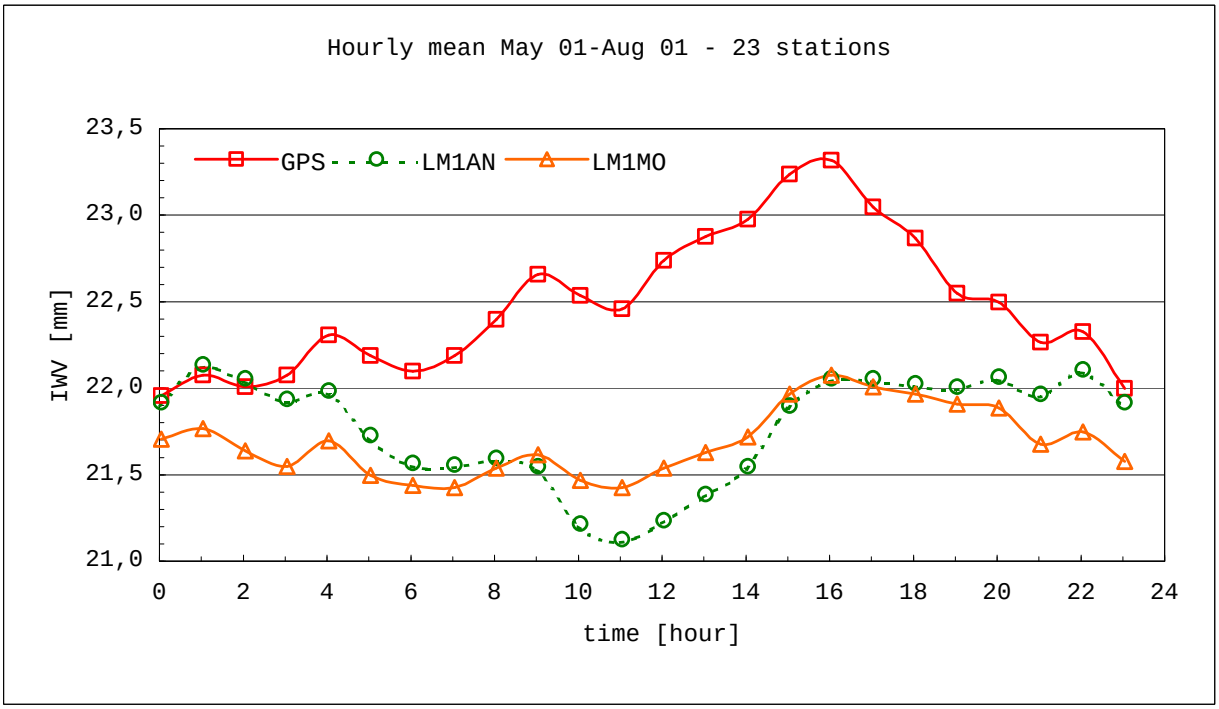


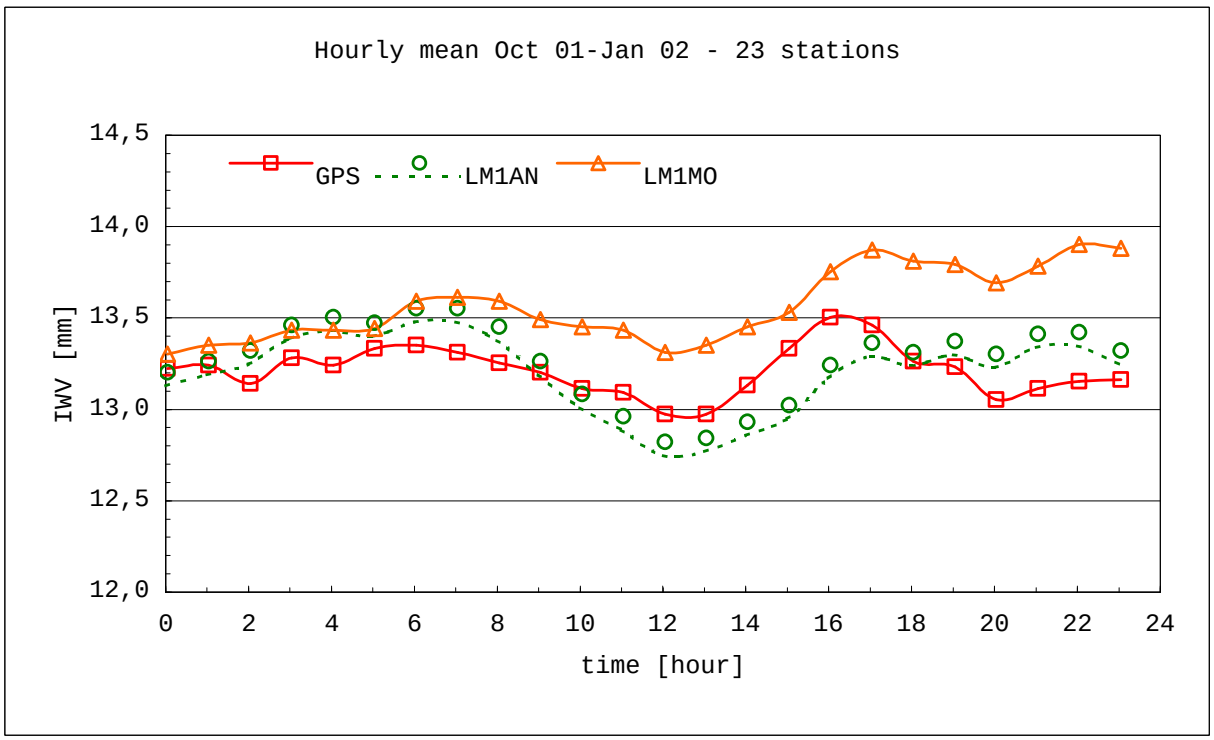
Impact of GPS data on the forecast fields:

- large in the first 6 hours
- negligible after 18 hours.



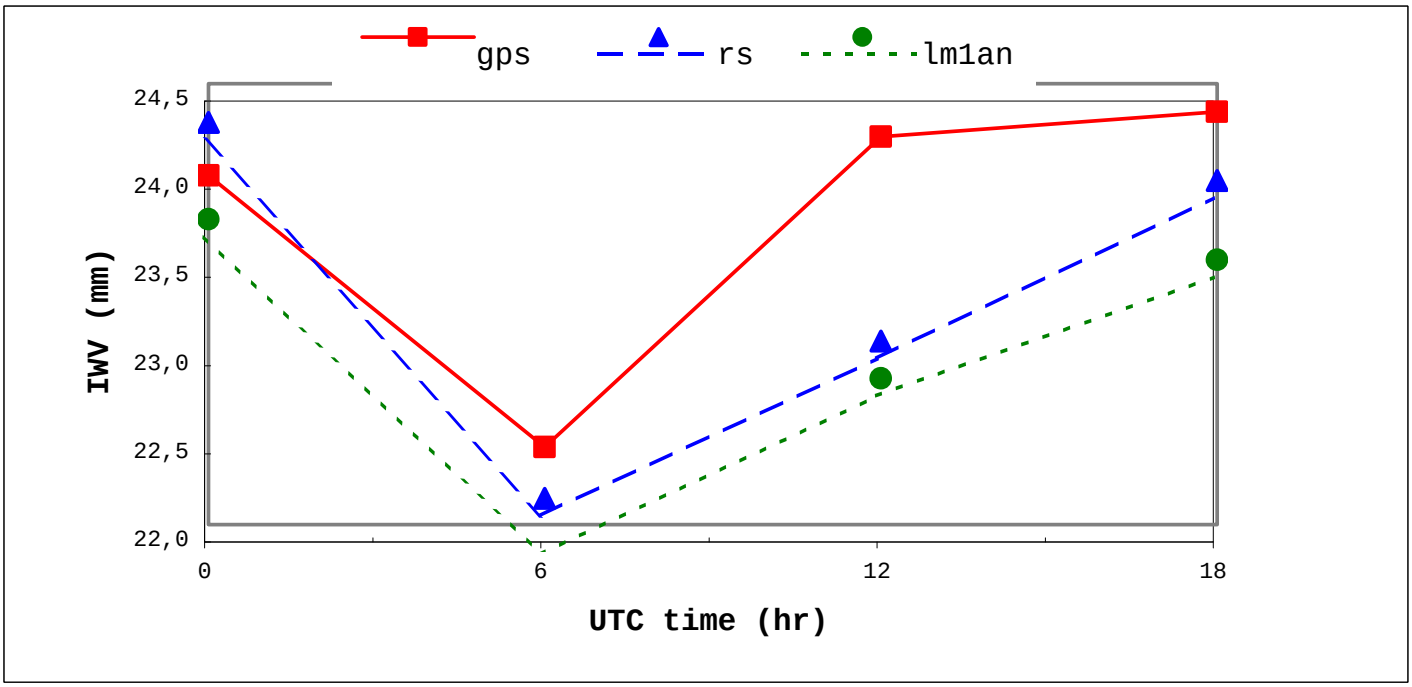

12 h FORECAST GPS
12 h FORECATS CNT
MEAN ERROR (model - obs)
ROOT MEAN SQUARE ERROR
rel. humidity
number
[hPa]
[%]
temperature
[K]
wind velocity
[m/s]
340



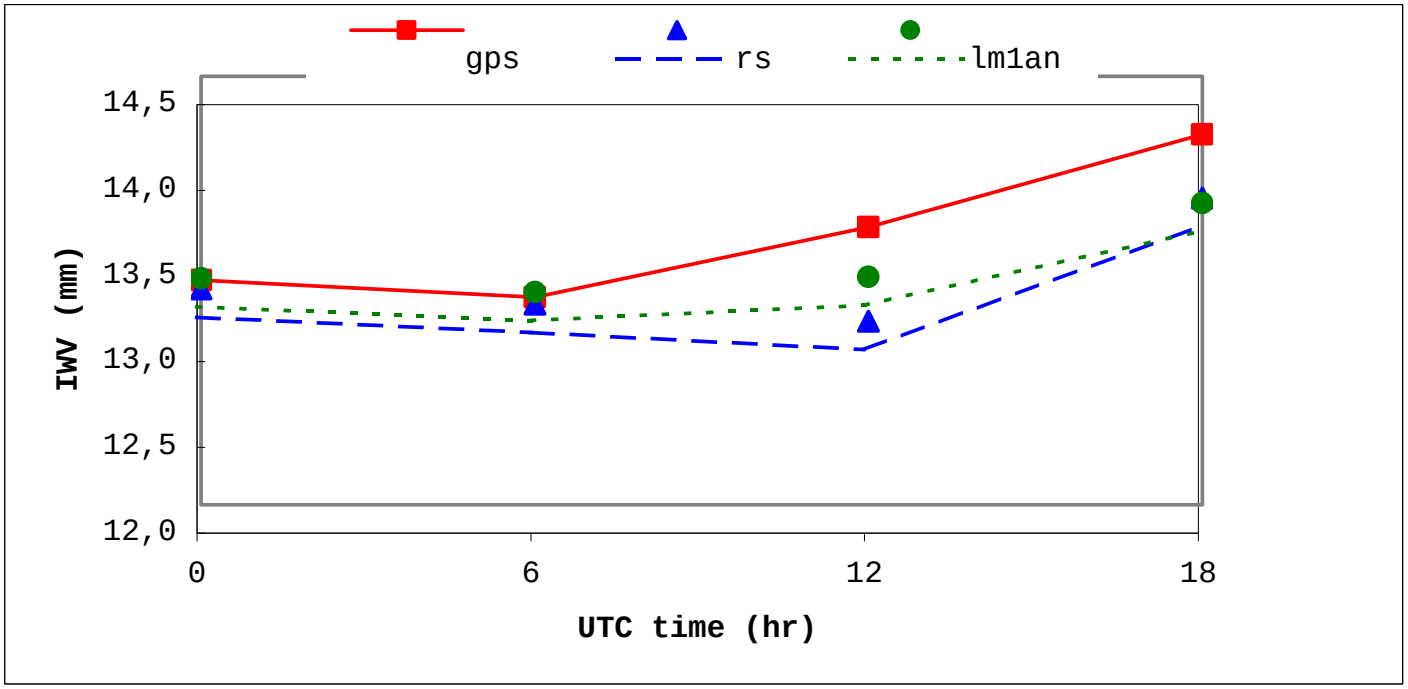


GPS = GPS IWV observations (derived using T & p from lm1an)
LM1AN = IWV from assimilation fields
LM1MO = IWV from 6-30 hour forecast fields - 18UTC run

MAY - AUG 2001



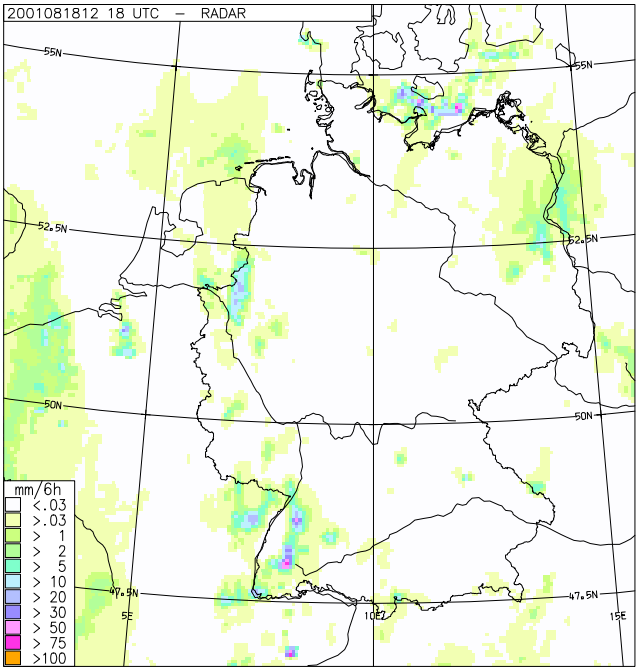
OCT - DEC 2001



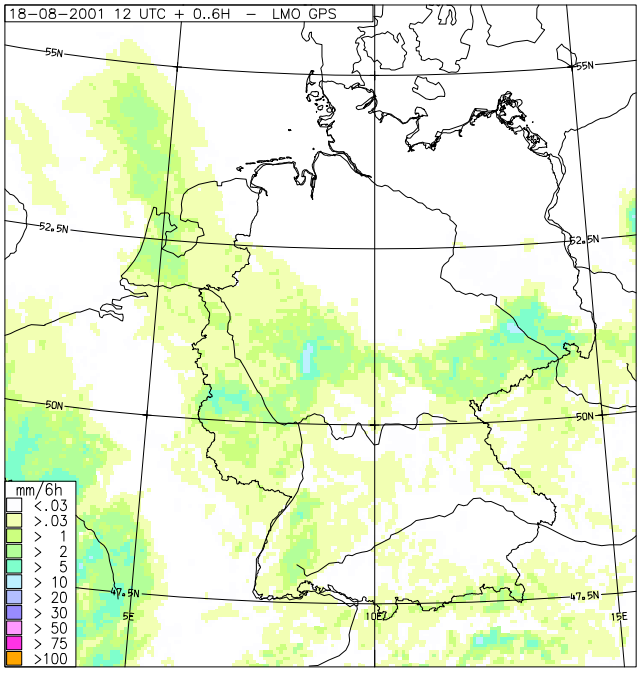
LM-FORECAST

0-6 hour precipitation forecast valid for 2001081818

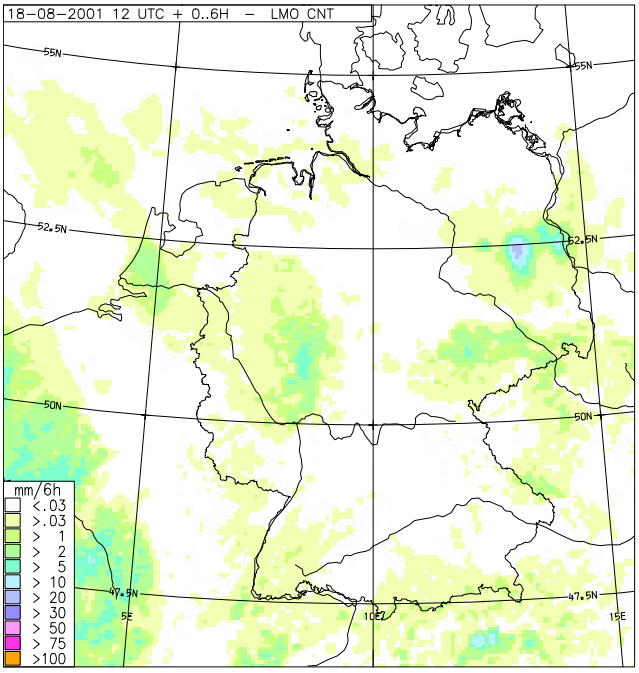
radar



gps



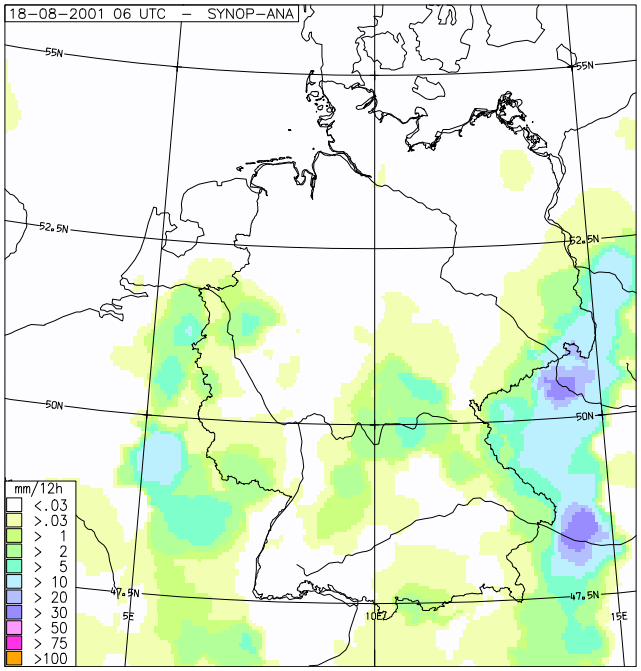
cnt



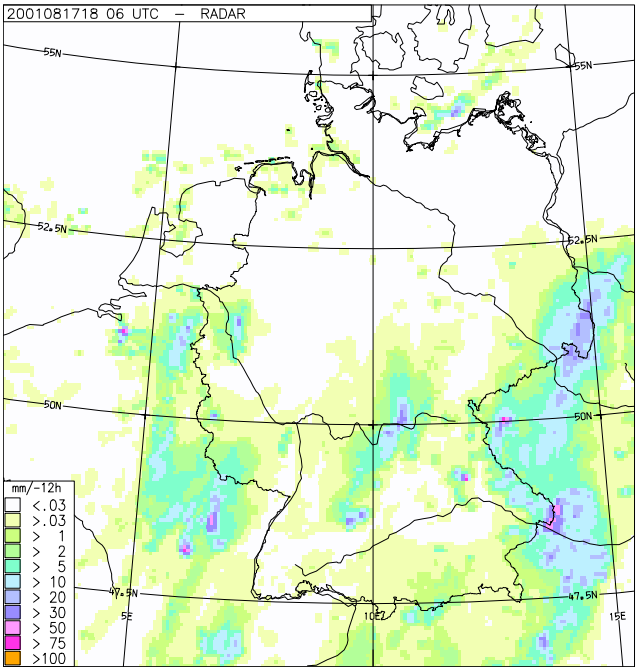
LM ANALYSIS

12 hour precipitation for 2001081806

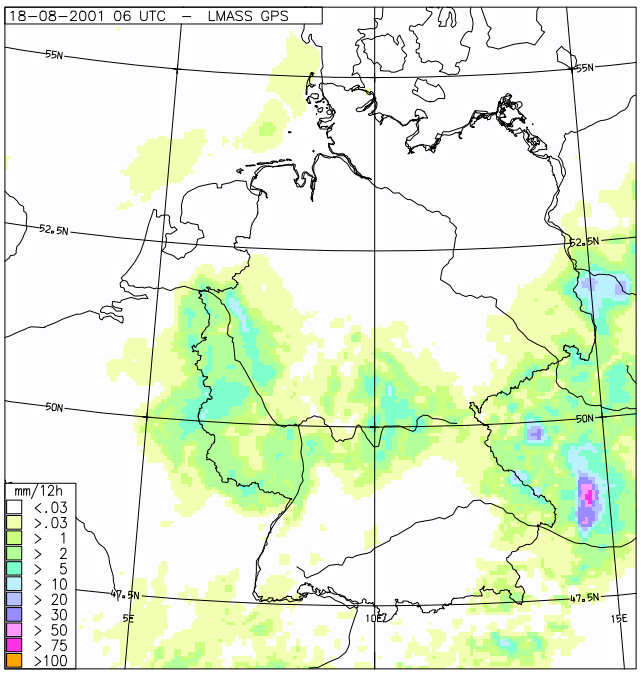
synop



radar



gps



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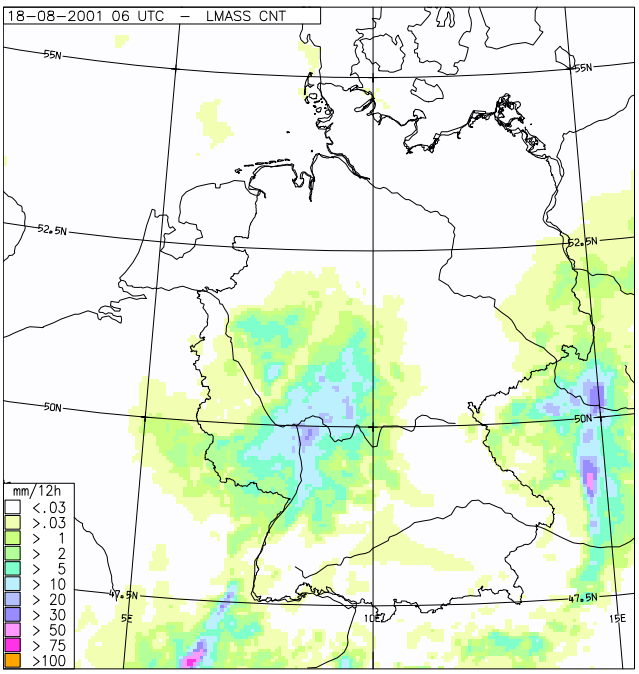
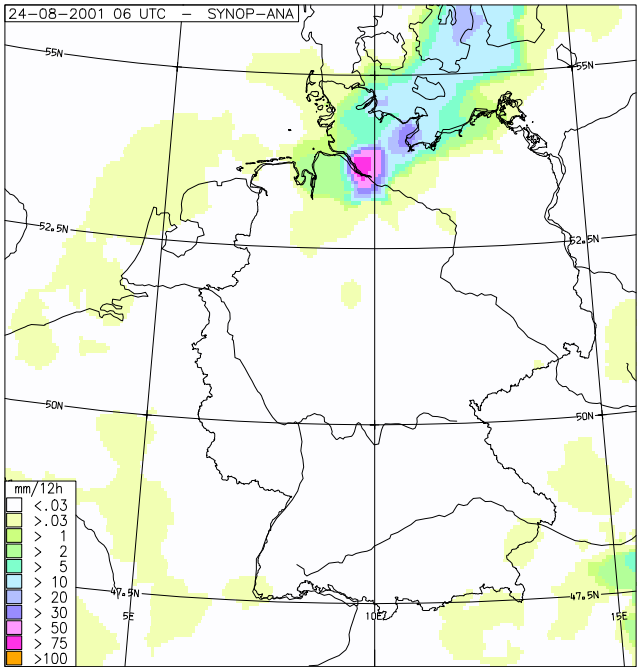


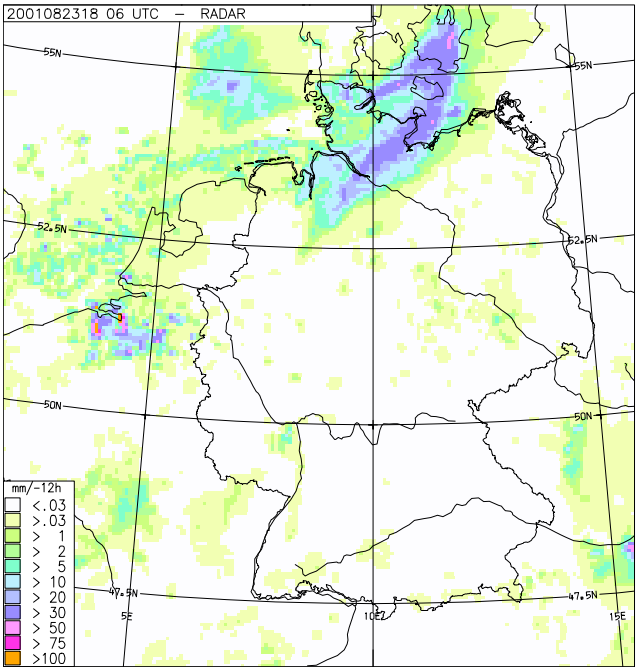
LM-FORECAST

6-18 hour precipitation forecast valid for 2001082406

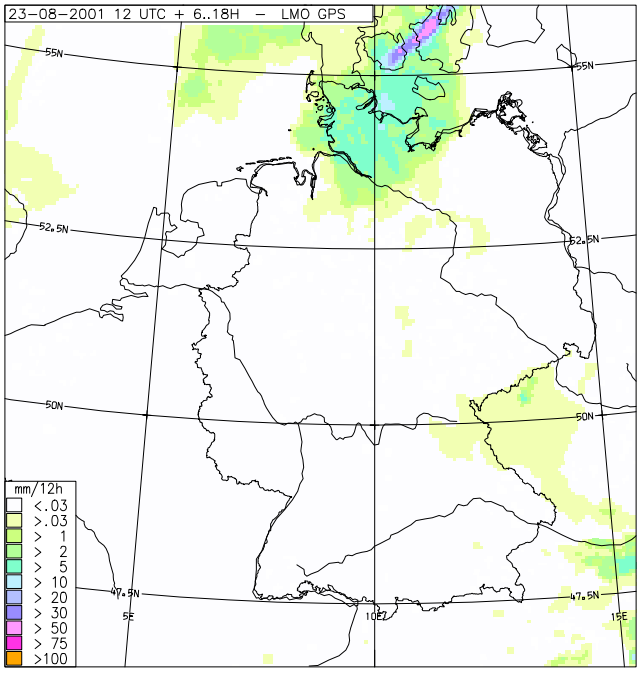
synop



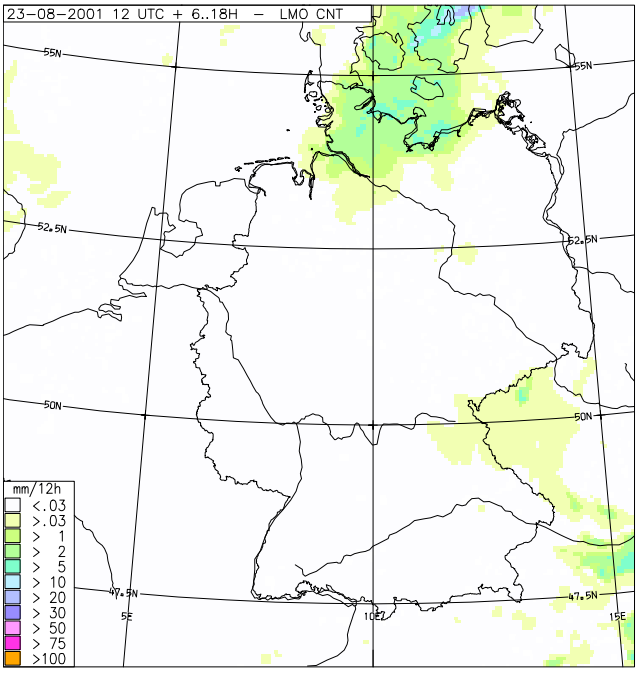
radar



gps



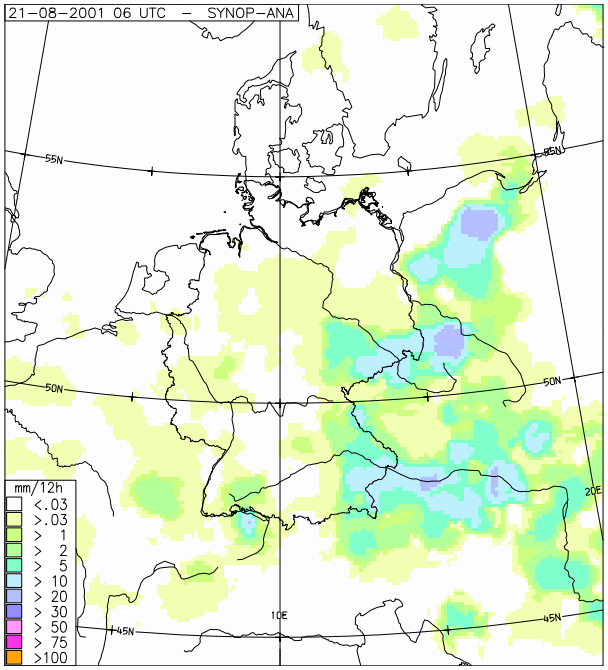
cnt



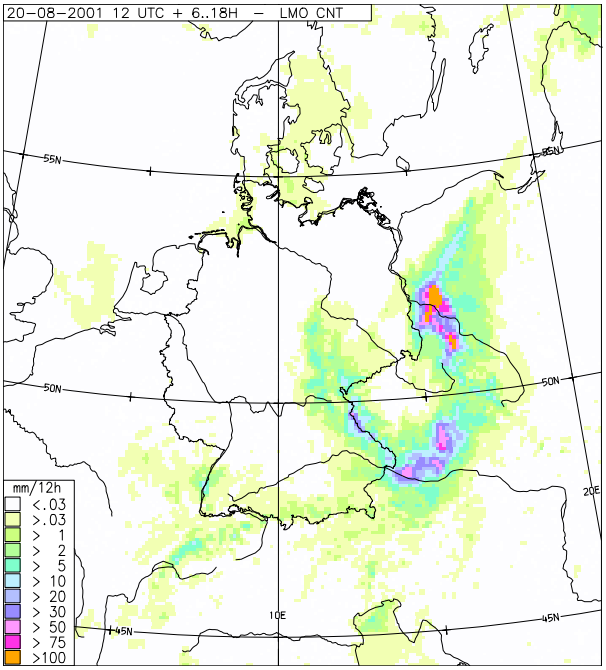
LM-FORECAST

6-18 hour precipitation forecast valid for 2001082106

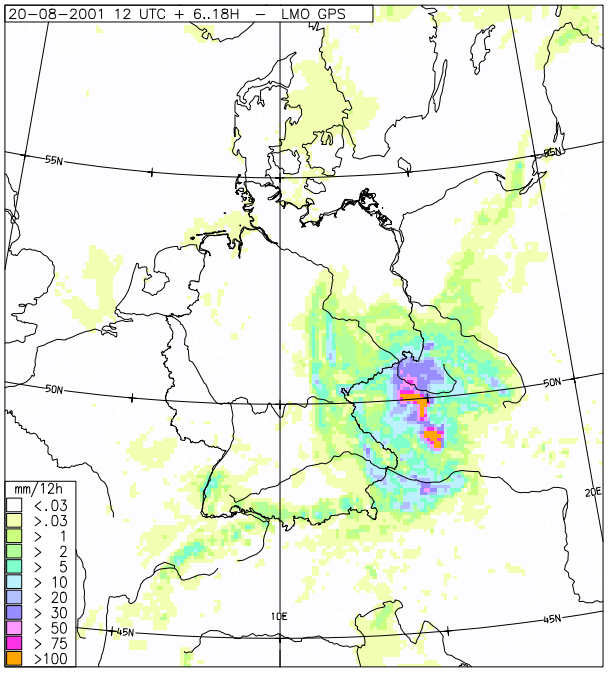
synop



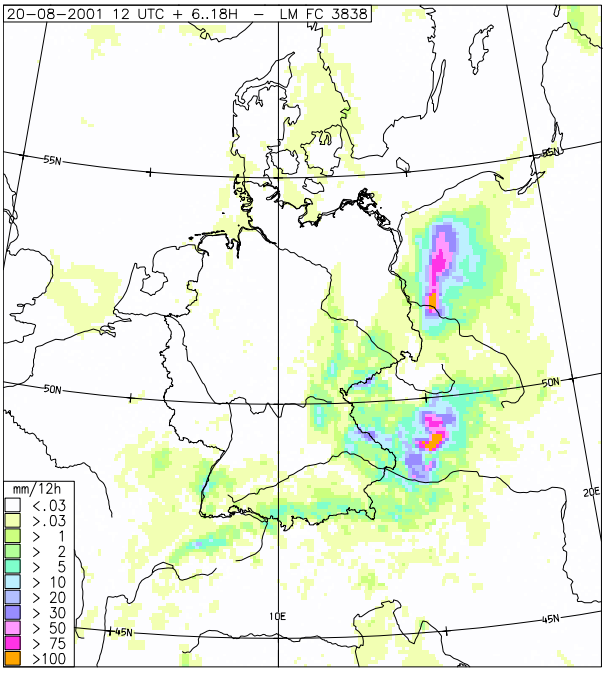
cnt

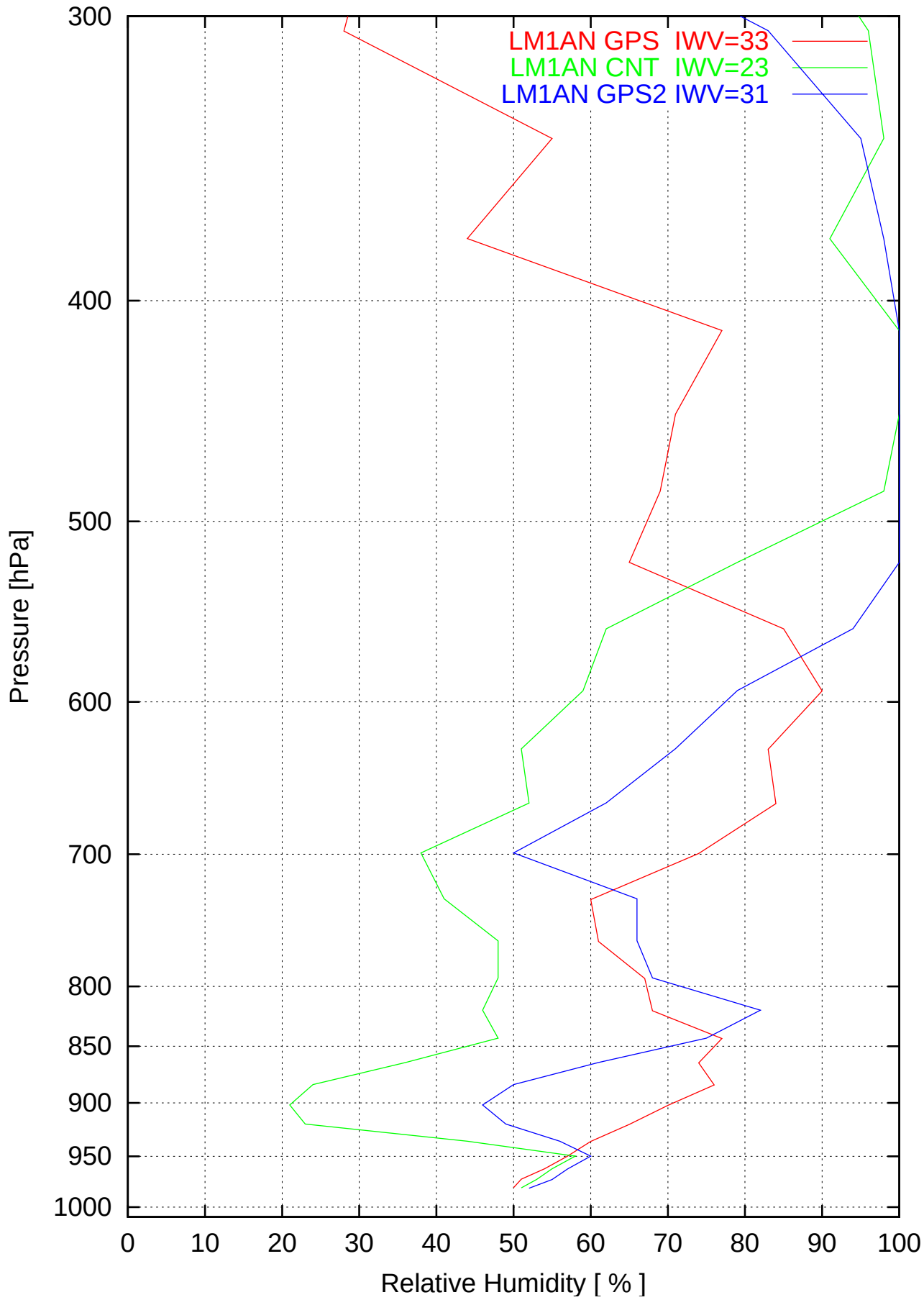


gps



gps only within last 15 hours




20 August 2001 12 UTC - GOERLITZ
LM1AN GPS IWV=33
LM1AN CNT IWV=23
LM1AN GPS2 IWV=31
Pressure [hPa]
300
400
500
600
700
800
850
900
950
1000
0
10
20
30
40
50
60
70
80
90
100
Relative Humidity [%]

Assimilation of GPS-derived PW

Summary of Results

- ⋆ **positive statistical impact on** → **precipitable water**
  → **upper-air temperature & humidity**
  in forecasts up to about +15 h
- ⋆ **mixed / neutral impact on analyzed and predicted precipitation**

Problems and Further Work

- ⋆ **bias of GPS PW relative to LM PW with a diurnal cycle in summer**
  ⇒ *daytime-dependent bias correction*
- ⋆ **vertical distribution of vertically integrated observational information**
  ⇒ *use information from other type of data ?*