ASSIMILATION OF INTEGRATED WATER VAPOUR FROM GROUND-BASED GPS OBSERVATIONS AT DWD

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APPROACH

Integrated Water Vapour (IWV) derived from measurements by ground-based Global Positioning System (GPS) stations have been used in assimilation experiments at the Deutscher Wetterdienst (DWD). The GPS network used for the experiments consists of 76 stations located in Germany and in the Netherlands. Half-hourly GPS data are processed in near real time by the GeoForschungsZentrum (GFZ) and assimilated into the non-hydrostatic limited area model of DWD, namely the Lokal Modell (LM). The horizontal and vertical resolution of the LM used in this study is 7 km and 35 levels. The data assimilation scheme of LM is based on nudging towards observations. At present the LM analysis is produced with a continuous assimilation cycle using observations from synoptic stations, radiosondes and aircraft.
The method chosen for the assimilation of GPS data consists in relaxing the model IWV values towards the observed ones. A “pseudo-observed” profile of specific humidity based on the observed IWV and the vertical structure of the model humidity field is derived and then nudged at each single vertical level of the model.

DATA

Two assimilation experiments GPS and CNT, with and without GPS data respectively, were run during the period from 17 to 25 August 2001. Two 24 hour forecasts were produced every day, starting from the 00 UTC and 12 UTC analysis of the experiments. Unstable, stormy weather conditions, with a strong south-westerly circulation were prevailing in Central Europe until 19 August, and this was followed by a more stable period with a weak anticyclonic circulation. The period was selected because the LM did not perform well in forecasting precipitation.

RESULTS

The assimilation experiments confirm that the model IWV is relaxed towards the GPS IWV successfully during the assimilation cycle. For instance, the rms of the difference observed minus analyzed IWV at 00 UTC is reduced from the CNT value of 2.6 kg m^{-2} to 1.1 kg m^{-2} in the GPS. The forecasts of the experiments have been verified against the GPS IWV observations themselves and against upper-level observations from radiosondes. Both comparisons show that the assimilation of the additional GPS data has an effect within a forecast range of up to 15 hours. The rms error of the 12 hour forecasts (started from 00 UTC) against GPS IWV observations is 2.2 kg m^{-2} for the GPS experiment, 0.3 kg m^{-2} smaller than the CNT forecast.
The verification against radiosondes observations indicates positive impact of GPS in the 12 hour forecast of humidity, temperature, and wind, neutral impact on the geopotential, and neutral impact on all variables after 24 hours. Figure 1 shows the results from the upper-air verification of relative humidity and temperature for the 12 hour forecasts (15 cases). The improvement in the humidity rms error is mostly concentrated between 800 and 600 hPa and it is in the order of 2% relative humidity (10% improvement). A minor improvement is also detectable in the forecast of temperature and wind velocity. The mean error of the relative humidity is slightly larger for the GPS experiment. This can be related to a slight positive bias of the GPS data (0.6 kg m^{-2} for August 2001 with respect to the LM analysis). It is interesting to mention that

most of the improvement occurs in the period after 19 August. The absence of GPS stations upwind, i.e. south-west of Germany can be one cause of the little impact during the first spell.
An evaluation of the results has also been made comparing analyses and forecasts of precipitation with surface observations and radar images. The signal in the precipitation analysis fields is mixed, with the GPS data improving some bad cases but also tending to deteriorate the analysis in some areas without precipitation. The overall impact on the precipitation forecast (6 to 18 hour range) is neutral. In most of the cases the assimilation of GPS data does not considerably change the performance of the model. However, in few cases a small impact was found, not always positive.

Further work has to be dedicated to the tuning of GPS IWV nudging, especially to understand and correct cases of negative impact. For example, information on cloudiness could be used to improve the vertical distribution of the influence of the integrated value. Investigations on a possible bias correction of the GPS data are also required.

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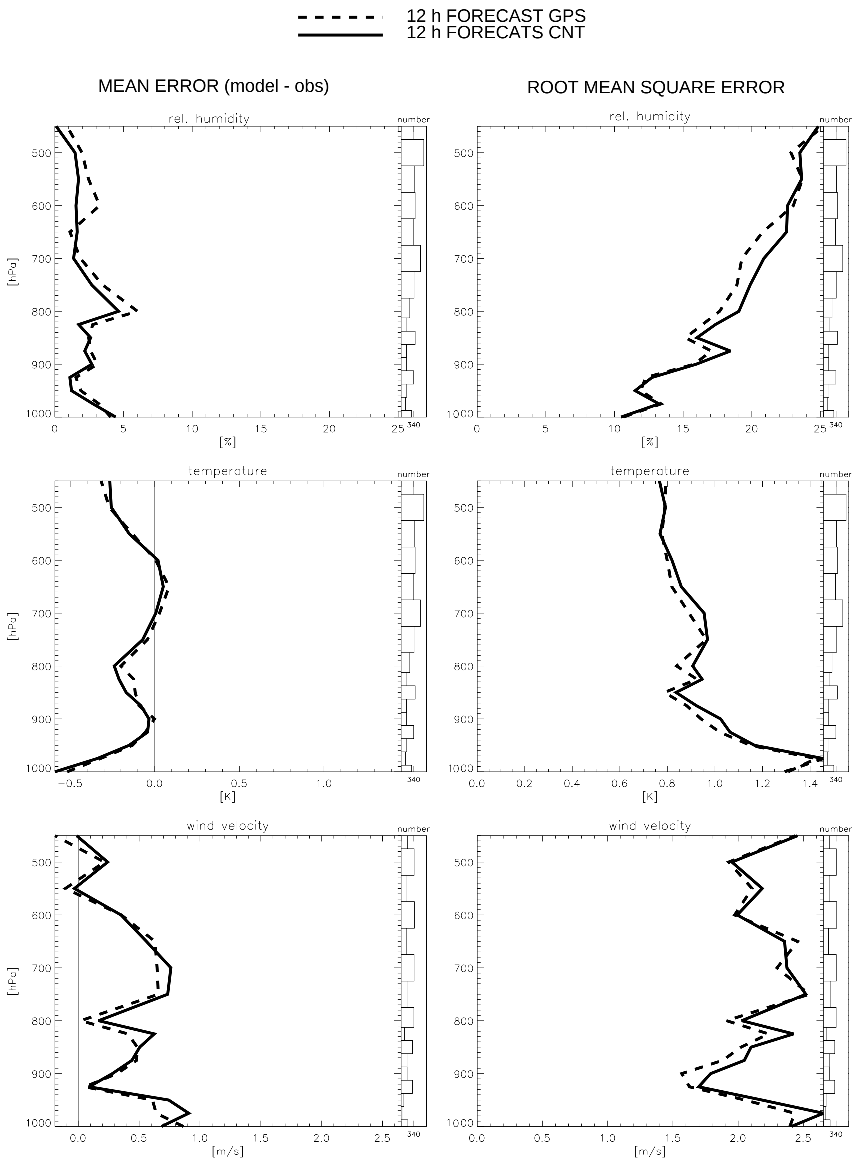

Figure 1. Impact of the assimilation of GPS data on the 12 hour forecast fit to observations. The mean error (left) and the root mean square (right) of the experiment with GPS data (dashed curves) and of the control (solid curves) are showed for relative humidity (top), temperature (middle) and wind velocity (bottom). The statistics have been computed for 15 cases using data from radiosondes in Germany and surroundings.