Reprocessing and Validation of GPS-derived Water Vapor and Slant Delays for COPS

G. Dick, M. Bender, J. Wickert, Z. Deng, M. Ramatschi

Helmholtz Centre Potsdam, German Research Centre for Geosciences, GFZ
Telegrafenberg, 14473 Potsdam, Germany; contact: dick@gfz-potsdam.de

Reprocessing of GPS Observations for COPS

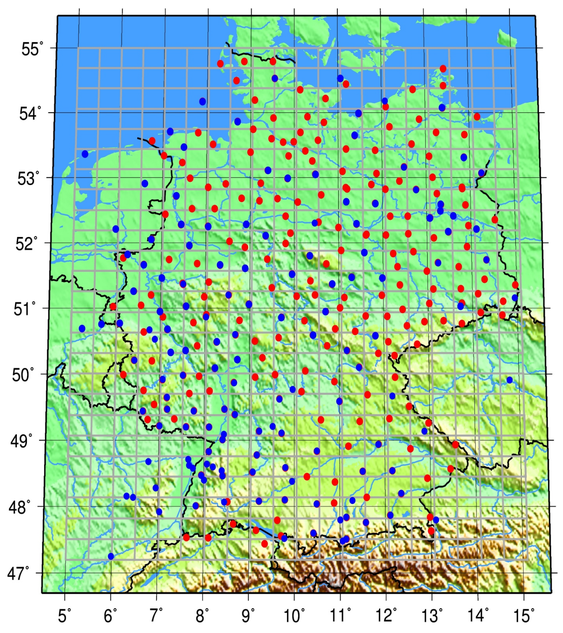

Fig. 1: GPS stations processed by GFZ in near real-time during COPS field campaign (blue) and additional stations, which are available after reprocessing (red). The total number of stations is increased now from about 220 (September 2007) to more than 350.

During the field experiment COPS ('Convective and Orographically Induced Precipitation Study'), carried out in summer 2007 in the region of Black Forrest, GFZ provided to the meteorological community near real-time GPS-derived tropospheric products: Integrated Water Vapor (IWV) with a temporal resolution of 15 minutes, Slant Total Delays (STD) with a resolution of 2.5 minutes as well as meteorological observations. Additionally all available GPS raw data over the region sampled during COPS were collected by GFZ. This includes not only the data from German SAPOS stations but also data from French GPS providers.

Fig.1 presents the configuration of the GPS network: stations processed by GFZ in near real-time during COPS field campaign are given in blue and additional stations, which are available after reprocessing are shown in red. The total number of stations, which are now reprocessed in a consistent way, has been increased to more than 350.

Beside a considerably extended number of stations the reprocessing of the GPS observations has many other advantages in comparison with the near real-time data: most gaps in the time series were filled (Figures 2 and 3) and the latest version of GFZ analysis software (EPOS) could be applied. Figure 4 shows an example of water vapor distribution derived from a data set of reprocessed GPS stations for IOP 8b, July 15, 2007.

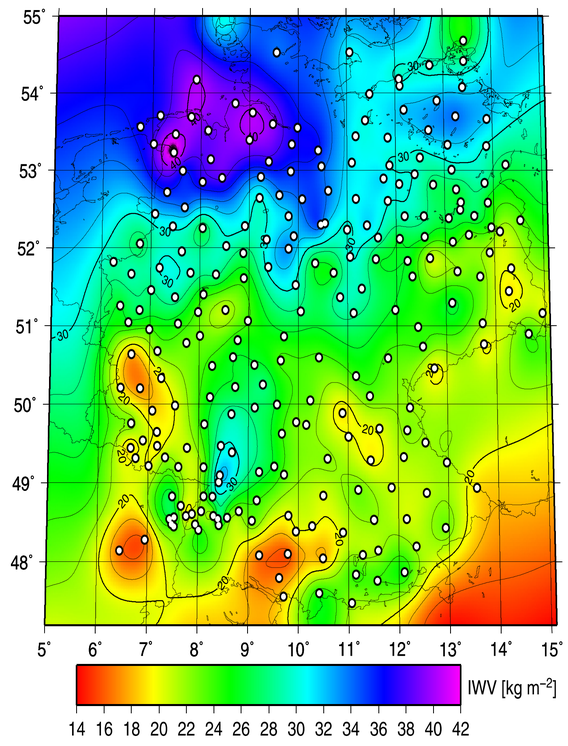

Fig. 4: Water vapor distribution derived from reprocessed data set of GPS stations for IOP 8b, July 15, 2007, 13 UTC.

The GPS processing techniques were considerably refined by implementing absolute PCV antenna models, an improved ocean loading model and new mapping functions to the updated version of EPOS software. The positive impact of PCV corrections on the IWV is shown in Fig. 5, where a bias of 0.7 mm could be removed from the IWV data due to application of absolute PCV antenna models.

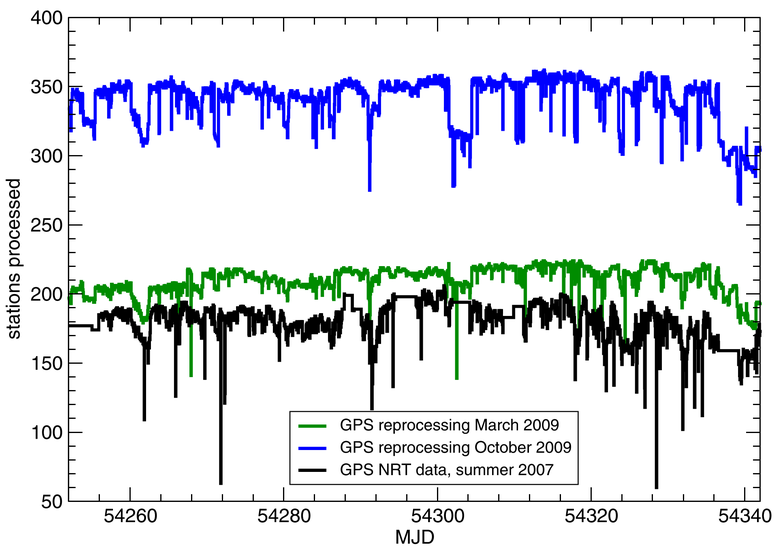

Fig. 2: Number of reprocessed GPS sites for COPS from 2 different reprocessing runs (blue and green). The number of stations available in near real-time is shown in black.

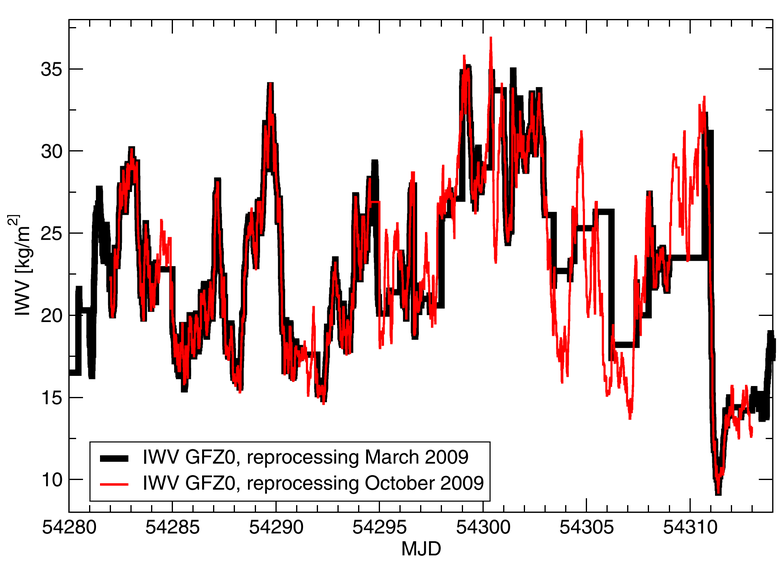

Fig. 3: IWV comparison from 2 different reprocessing runs for GPS station GFZ0 at the AMF facility in Murgtal (COPS supersite M).

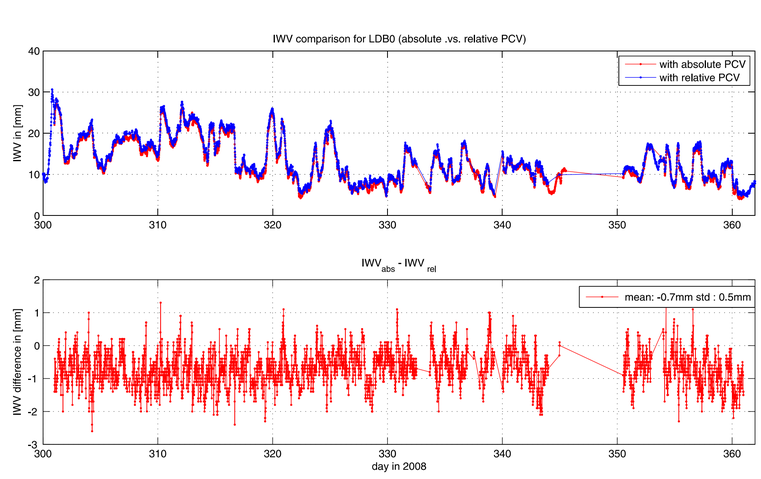

Fig. 5: Impact of antenna phase center variations on the IWV. The IWV time series of one GPS station is shown with (top, in red) and without (top, in blue) PCV corrections. The difference (bottom) shows a mean bias of -0.7 mm and a standard deviation of 0.5 mm.

Slant Delays and Validation Results

The analysis of STDs, i.e. the total delay of the GPS signal due to the neutral atmosphere, at GFZ, which started with the beginning of COPS, is in an experimental state. The derivation of STDs was integrated to the operational EPOS GPS processing software in summer 2007. Hourly files of STDs in a SINEX like ASCII format are now available for all stations. About 8 observations are available every 2.5 minutes for each station leading to 4,000 - 5,000 STDs per station and day. Currently, 1.2 million of STD observations from about 350 German GPS stations are processed per day (Fig. 6).The mean distance between stations is now below 40 km.

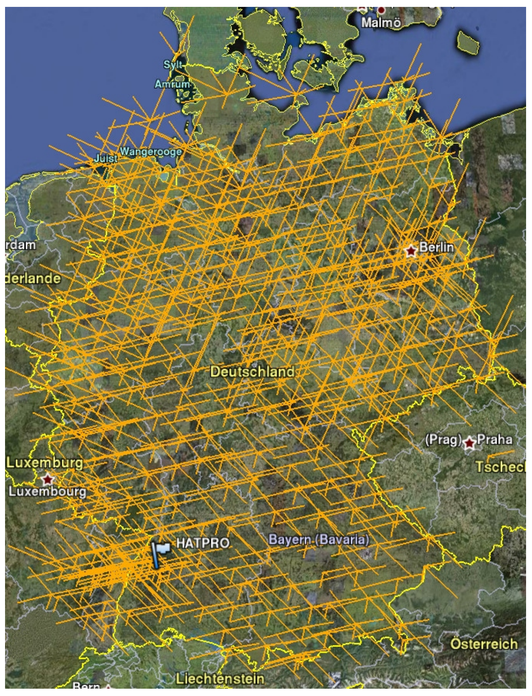

Fig. 6: Visualization (using Google Earth) of the slant delay data, derived from the German GPS network using the GFZ processing software EPOS.

The STDs have been validated using different independent observations, e.g. observations from water vapor radiometers. During COPS and to the end of 2007 the HATPRO radiometer was installed together with a GPS station at the AMF facility in Murgtal (COPS supersite M). Three month of full hemisphere scans between October and December 2007 provided a huge amount of slant IWV data which can be compared to corresponding GPS observations (Fig. 7).

Unfortunately, there are few events where a GPS satellite passed through the radiometer line of sight and only several thousand data pairs can be used. A window of 5 minutes, =5 , =0,02 was chosen to select WVR observations close to the slant observations. Figure 7 shows IWV differences between HATRO radiometer and GPS. Initial validation studies have shown comparable results with an offset of about 1 mm and a RMS of several mm (Bender et al., 2008).

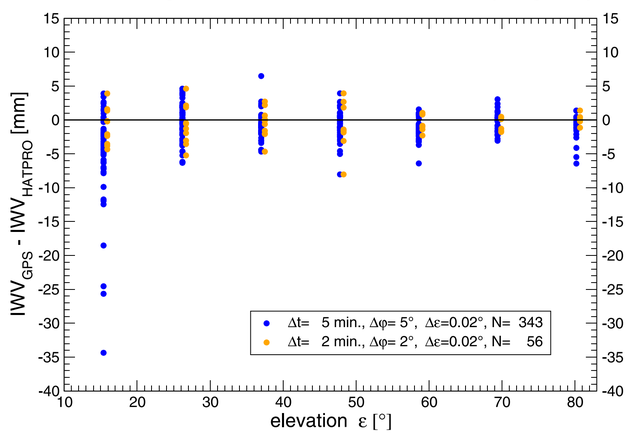

Fig. 7: STD validation using the water vapor radiometer. IWV differences between a HATPRO radiometer and GPS are shown. The radiometer was running atmosphere scans but could not track GPS satellites. Therefore, STD data with an azimuth and elevations close to the WVR observations were selected for the comparison.

References:

Bender, M., G. Dick, J. Wickert, T. Schmidt, S. Song, G. Gendt, M. Ge, and M. Rothacher: Validation of GPS Slant Delays using Water Vapour Radiometers and Weather Models, Meteorologische Zeitschrift, 2008, 17(6): 807-812.

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