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Comparison of Wet Path Delays Observed with Water Vapour Radiometers, Solar Spectrometer, Radiosondes, GPS and VLBI at the Fundamental Station Wettzell

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Abstract

Water vapour in the atmosphere contributes significantly to tropospheric refraction. Geodetic observations, in particular observations in the microwave domain as GPS and VLBI, are suffering from the inhomogeneous distribution of such water vapour. Even if the analysis models take into account the water vapor's influence, it is of interest to observe independently, with Water Vapour Radiometers, the water vapour and its influence on the observations.

In April 2005, five water vapour radiometers (WVR) and one solar spectrometer were co-located at the Fundamental Station Wettzell in order to investigate the resolution of the zenith wet delay (ZWD) observed with radiometers in terms of precision and systematic effects. A solar spectrometer allowed us to determine the zenith wet path delays only during day time, in particular when the sun was out. Such observations provide independently precise results that can be used to calibrate radiometers. In addition, during a period of 10 days, balloons radiosondes were launched, at noon and midnight every day, measuring temperature, pressure, and humidity profiles up to 25 km in height. This allowed us to estimate the zenith path delay for the launch times. As the zenith path delays were also derived from GPS and VLBI observations, a set of interesting ZWD data is available for comparisons.

1. Co-location of Various Water Vapour Radiometers (WVR) and a Solar Spectrometer at Wettzell

In the period from April 4 to 22, 2005 parallel observations with

- 2 Water Vapour Radiometers , type Radiometrics (Figure 1(a)), R42 and R43
- 3 Water Vapour Radiometers, type ETH (Figure 1(b)), ETH WA, - WC and - ZA, and
- 1 Solar Spectrometer GEMOSS (Geodetic Mobile Solar Spectrometer), built by ETH Zürich, in collaboration with the Institute for Analytical Sciences (ISAS) in Berlin (Figure 2)

were organised by Bundesamt für Kartographie und Geodäsie (BKG), Fundamental Station Wettzell, in collaboration with the

- Eidgenössische Hochschule (ETH) in Zürich, Switzerland and
- Universität der Bundeswehr in München, Germany

The goal was to compare the observed results with the results derived from the GPS- and VLBI observations, performed routinely at the FS Wettzell, in order to investigate systematic offsets and the precision of the various techniques.

During the period from April 11 to 20, 2005, in addition, 19 radiosondes were launched at 0:00 and 12:00 UTC (Figure 3). Figure 4 shows the location where the WVR were installed and balloons were launched. GPS- and VLBI- observations were carried out routinely at the

Figure 1. Water Vapour Radiometer built (a) by Radiometrics and (b) by ETH-Zürich.

Figure 2. Solar Spectrometer GEMOSS from ETH-Zürich.

Fundamental Station Wettzell. The Zenith Wet Path Delays are regular products, made available by the services IGS and IVS.

2. Comparison of the Results

Due to several technical problems during the observation period, only the WVR R43 (Radiometrics) and ETH ZA ran without failures. The observations show a repeatability of approximately 3 mm for the Radiometrics system and 6 mm for the ETH system. Figure 5(a) shows good agreement between both the ZWD derived from WVR R43 and from GPS. WVR shows a much higher time resolution (5-min compared to 1-h by GPS). This explains the obviously higher scatter of the

Figure 3. Preparation of a radiosonde launch.

Figure 4. Water Vapour radiometers in front of the 20m-Radiotelescope Wettzell.

R43 time series. The Radiometrics system R42 had an azimuth drive failure. The WVR ETH-ZA showed comparable results, but an offset of 1 to 2 cm, compared to GPS results, occurred. The ETH WA and ETH WC had hardware problems, resulting in unreliable data.

Figure 5(b) shows the comparisons of the radiosondes and solar spectrometer (GEMOSS) versus the GPS and VLBI derived ZWD. Balloon radiosondes provide temperature, pressure and humidity profiles, which allow for the evaluation of independent information about the ZWD. Some profiles were observed continuously, while during some launches the data transmission failed due to disturbances and interruptions of the data link. The function of the solar spectrometer GEMOSS (GEodetic MObile Solar Spectrometer), developed by the ETH and the Institute of Analytical Sciences (ISAS), Berlin [1], is based on differential optical spectroscopy. It makes use of simultaneous observations at numerous selected H_2O absorption lines between 728nm and 915nm. Information about the wet zenith path delays can be derived only during sunshine. Nevertheless, as it is a completely independent technique, GEMOSS provides valuable observations which can be used for calibration of WVR-results. Between the various methods offsets in the order of a few mm up to 2 cm occur, apart from the different resolutions in the time of the various techniques.

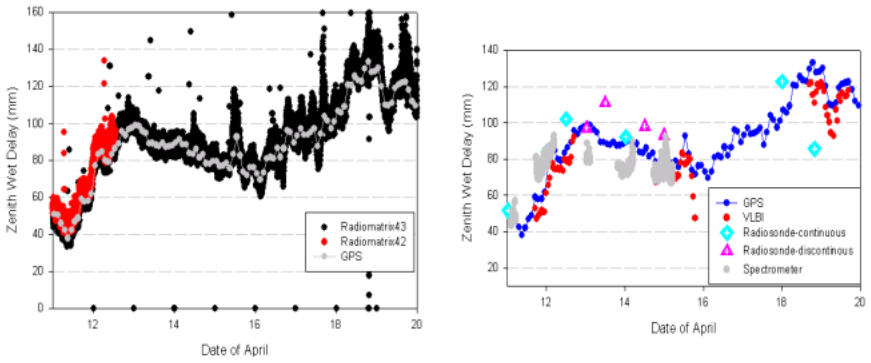

Figure 5. Comparison of the ZWD (a) WVR R42 and 43 versus GPS and (b) radiosondes and GEMOSS versus GPS and VLBI.

3. WVR Observations during CONT05

Based on the comparison, it was decided which of the available WVR should be placed in co-location with the radio telescopes in Kokee Park (USA-Hawaii), Wettzell (Germany) and Hartebeesthoeck (South Africa) during CONT05. For Wettzell, the Radiometrics system R43 was selected. In addition the GEMOSS instrument was made available by ETH and radiosondes were launched as well. For Kokee Park, the Radiometrics R42 system was employed after the repair of the azimuth drive. For Hartebeesthoeck, the best ETH system (ETH-ZA) was made available. Figure 6 shows the data obtained at Wettzell with the Radiometer R42, GEMOSS and radiosondes.

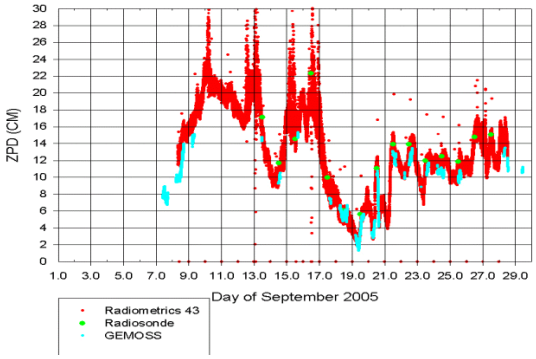

Figure 6. Zenith Weth Path Delay (ZPD) observed in Wettzell during CONT05 with WVR R43, GEMOSS and radiosondes.

References

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