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Real-time and near real-time ZTD from a local network of low-cost dual-frequency GNSS receivers.

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The dynamics of water vapor distribution in the troposphere, measured with Global Navigation Satellite Systems (GNSS), is a subject of weather research and climate studies. With GNSS, remote sensing of the troposphere in Europe is performed continuously and operationally under the E-GVAP (http://egvap.dmi.dk/) program with more than 2000 permanent stations. These data are one of the assimilation system component of mesoscale weather prediction models (10 km scale) for many nations across Europe. However, advancing precise local forecasts for severe weather requires high resolution models and observing system. Further densification of the tracking network, e.g. in urban or mountain areas, will be costly when considering geodetic-grade equipment. However, the rapid development of GNSS-based applications results in a dynamic release of mass-market GNSS receivers. It has been demonstrated that post-processing of GPS-data from a dual-frequency low-cost receiver allows retrieving ZTD with high accuracy. Although low-cost receivers are a promising solution to the problem of densifying GNSS networks for water vapor monitoring, there are still some technological limitations and they require further development and calibration.

We have developed a low-cost GNSS station, dedicated to real-time GNSS meteorology, which provides GPS, GLONASS and Galileo dual-frequency observations either in RINEX v3.04 format or via RTCM v3.3 stream, with either Ethernet or GSM data transmission. The first two units are deployed in a close vicinity of permanent station WROC, which belongs to the International GNSS Service (IGS) network. Therefore, we compare results from real-time and near real-time processing of GNSS observations from a low-cost unit with IGS Final products. We also investigate the impact of replacing a standard patch antenna with an inexpensive survey-grade antenna. Finally, we deploy a local network of low-cost receivers in and around the city of Wroclaw, Poland, in order to analyze the dynamics of troposphere delay at a very high spatial resolution.

As a measure of accuracy, we use the standard deviation of ZTD differences between estimated ZTD and IGS Final product. For the near real-time mode, that accuracy is 5 mm and 6 mm, for single- (L1) and dual-frequency (L1/L5,E5b) solution, respectively. Lower accuracy of the dual-frequency relative solution we justify by the missing antenna phase center correction model for L5 and E5b frequencies. With the real-time Precise Point Positioning technique, we estimate ZTD with

the accuracy of 7.5 – 8.6 mm. After antenna replacement, the accuracy is improved almost by a factor of 2 (to 4.1 mm), which is close to the 3.1 mm accuracy which we obtain in real-time using data from the WROC station.