Geophysical Research Abstracts
Vol. 12, EGU2010-2424, 2010
EGU General Assembly 2010

GNSS-based determination of high-resolution regional atmospheric water vapour distribution using precise point positioning

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Signals of global navigation satellite systems (GNSS) are delayed when propagating through the Earth's electrically neutral atmosphere. The neutrospheric delay (approx. 2.4 m in zenithal direction) can be subdivided into a dry and a complementary wet component. Under the assumption of hydrostatic equilibrium the dry delay term, amounting to approx. 90% of the total neutrospheric delay, can be accurately calculated using ground pressure measurements. In contrast, the wet component, showing strong temporal and spatial variability, is very difficult to determine based on meteorological surface data. A reliable modelling of the wet component within GNSS data processing is fundamental for high-resolution reconstruction of atmospheric water vapour fields. Each improvement in temporal and spatial resolution of atmospheric water vapour determination is a further step towards a better understanding of the Earth's climate system.

This paper presents a GNSS-based extended approach for the high-resolution determination of the regional atmospheric water vapour content. In comparison to the standard procedure, where the neutrospheric wet delay is derived by subtracting the calculated dry delay term from the total delay estimate, this extended approach additionally considers the phase observation residuals resulting from GNSS data processing in the precise point positioning (PPP) mode. Representative data from the GNSS Upper Rhine Graben network (GURN) are processed with the Bernese GPS Software 5.0 whereas the standard PPP processing strategy is improved with respect to outlier detection, cycle slip handling, and estimation of site-specific neutrospheric parameters. Furthermore, the dry neutrospheric delay is calculated under consideration of surface meteorological information, and remaining systematic effects in PPP residuals, e.g. induced by multipath, are sufficiently reduced by applying appropriate stacking techniques. Using single-layer models, the derived atmospheric water vapour fields are visualised in two dimensions with a high temporal resolution. Taking residual information of GNSS observations into account, the spatial variations of reconstructed atmospheric water vapour fields appear richer in detail and more realistic.