Abstract

The present dissertation suggests an innovative reconstruction technique for estimating wet refractivity fields in the lower atmosphere from signals of the Global Navigation Satellite Systems (GNSS). Therewith the aim is to complement existing observing systems, in particular to capture the high temporal and spatial variability of water vapour in the lower atmosphere.

The invented technique is based on the tomography principle as commonly applied in medicine for diagnostic purposes. Major challenges to be solved relate to the unfavourable observation geometry defined by the number and distribution of ground stations and GNSS satellites in view. Moreover, for each GNSS observation the GNSS signal path and the tropospheric signal delay have to be determined; both serve as the principal input data for GNSS tomography.

By making use of dual-frequency GNSS observations and advanced processing strategies, tropospheric delay parameters are estimated with mm to cm-accuracy for a network of ground-based GNSS receivers. The individual components of the tropospheric delay are examined and evaluated. Thereby also the impact of rather small but important effects like hydrostatic gradients, remaining tropospheric signals in post-fit residuals as well as atmospheric bending is further investigated. If the bending is not considered, the tomography solution is deteriorated by misallocations during the reconstruction process of signal paths. Ray-tracing through a priori refractivity fields helps to minimise these effects and allows for the reconstruction of signal paths more accurately than the common straight-line approach.

Further attention is also given to the mathematical formulation of ill-conditioned, inverse problems. In this respect optimisation strategies are devised which allow for minimisation of artefacts introduced by the reconstruction process itself. In addition quality parameters are described for evaluating the accuracy of the reconstructed wet refractivity fields using weighted least squares methods.

With the newly defined approach, wet refractivity fields are generated that coincide with radiometer and radiosonde measurements in an alpine environment significantly better than operational weather models. This makes GNSS tomography interesting for meteorological applications. Furthermore, other disciplines, which relay on accurate modelling of the signal delay in the lower atmosphere, can benefit from improved refractivity fields.