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Combination of GNSS tomography and GNSS radio occultation to establish wet refractivity fields

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The GNSS tomography is a novel technique which uses the GNSS data for resolving a temporal and spatial field of the atmospheric water vapour above a network of receivers. In the GNSS tomography process, the integrated information about the amount of water vapour between a GNSS satellite and each single GNSS ground station, i.e. Slant Total Delay (STD) observations, are required. The tomography works on a spatial grid and tries to spread the integral slant delays on the different grid cells. The state-of-the-art studies are focused on the development of the GNSS tomography solution. Recent research shows that the GNSS tomography results can be improved by an introduction of additional observations, such as vertical profiles of refractivity, into the equation system.
The vertical profile of wet refractivity can be derived, e.g., from GNSS radio occultation (RO) data. The radio occultation is a remote sensing technique for measuring atmospheric properties using GNSS signals. It provides high-resolution vertical soundings that have low sensitivity to clouds and precipitation, over both land and ocean. The space-based GNSS RO technique measures the excess phase delay and Doppler shift of a GNSS radio signal which results from the atmospheric refraction of the signal along the path between the transmitting GNSS satellite and receiver in Low Earth Orbit (LEO). Because of the vertical and temporal resolution, and high precision and accuracy of the RO technique, introducing the wet refractivity profiles derived from the radio occultation data can considerably improve the tomography solution.
In this study, the potential of the use of vertical profiles of refractivity derived from the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) in the 'ATom' GNSS tomography software has been investigated. The COSMIC data are of good quality and penetrate the Earth's surface very close; 70% - 90% of the soundings reach to within 1 km of the surface on a global basis. The GNSS tomography in the domain of Central Europe (Austria, south Germany, south-west Poland), using STD observations of 174 GNSS reference stations, in two weeks from September 1, 2017, to September 15, 2017, has been performed. In this period, 6 GNSS RO events occurred in the domain area. The RO observations have been added to the equation system as constraints. The advantages and benefits of the combination of the GNSS tomography and RO technique for the estimation of atmospheric wet refractivity fields are presented.