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Determination of atmospheric water vapor using GNSS and InSAR measurements with comparison to numerical atmospheric models

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Atmospheric water vapor is a key element in the weather forecasting and climate research. Therefore, different methods have been presented to directly measure or estimate its content. In this work, we use phase measurements from Global Navigation Satellite Systems (GNSS) and Interferometric Synthetic Aperture Radar (InSAR) to estimate the atmospheric precipitable water vapor (PWV). By processing GNSS data, the total cite-specific delay due to the propagation in the neutral atmosphere is estimated. Based on measurements of air pressure and temperature, the dry delay is calculated at the GNSS site and subtracted to produce the wet delay of water vapor, which is transformed into a value of PWV. This value represents the mean of the PWV in a neutrospheric section approximated by a cone centered at the GNSS site. The radius of the cone exceeds 4 km; hence, the short scale water vapor signal is not easily reconstructed using GNSS data. For that purpose, the slant wet delays have to be determined.
In Persistent scatterer InSAR, however, the atmospheric phase delay is separated from other phase components, such as surface displacement and topography, for each point in a map of 100 km * 100 km. These estimates contain only the fraction of the signal with short scale variations, while the largest part is eliminated by building interferograms as well as phase filtering. By processing Envisat images from descending tracks, we extracted 17 water vapor maps with a minimum temporal baseline of 35 days.
In order to check the quality of our estimates, we compare them with PWV maps measured by the optical sensor MERIS and maps simulated by a numerical atmospheric model, i.e. the weather research and forecasting (WRF). The MERIS data are acquired simultaneously with the InSAR data at a spatial resolution of 260 m * 290 m. The WRF maps are simulated at 3 km * 3 km spatial resolution.
The results show a strong agreement between GNSS and MERIS data with uncertainty values of less than 1 mm, which also holds for InSAR.
The WRF model, on the other hand, produces simulates the agree well with the GNSS estimates, mainly in winter. The model data show, however, a bias with respect to the GNSS data, that significantly increases in summer. Since the InSAR data show mainly the spatially short-scale signal, the spatial correlation with the WRF data is often poor.
It is suggested to use the GNSS and InSAR estimates in a proper data assimilation approach to improve the model skills.