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Characteristics of water vapor fluctuations by the use of GNSS signal delays

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Water vapor plays a crucial role in a number of atmospheric processes related to the water cycle. It is also the Earth's most abundant greenhouse gas, thus influencing global climate as well as micrometeorology. Since the phase change of water is associated with large latent heat, water vapor plays an important role in the vertical atmospheric stability. It also influences aerosol aging and removal from the atmosphere. As the temporal and spatial distribution of water vapor is in general highly variable, continuous monitoring at several locations is required to be able to describe the situation in a given terrain configuration. In-situ meteorological measurements provide the information on water vapor concentration at the surface only, while the radiosonde data suffers from poor temporal and spatial (horizontal) resolution. Integrated water vapor content above a certain location on the surface can also be monitored in real time, exploiting the wet delay of GNSS signals, however, it does not yield absolute humidity. In this contribution we present a measurement of average absolute humidity within the Vipava valley (Slovenia), between February 2015 and October 2016. It is based on differential measurement of integrated water vapor content at two adjacent stations, using stationary GNSS receivers, which are horizontally displaced for 6 km, and vertically displaced for 826 m. The integrated water vapor values were derived using the GIPSY-OASIS II software. One of the receivers is located at the valley floor (125 m a.s.l.) and the other on the top of the adjacent mountain ridge (951 m a.s.l.). Visual data from both stations was also stored to evaluate the reliability of the remote sensing results in different weather conditions.

Based on the dataset covering 20 consecutive months, we investigated temporal evolution of the water vapor content within the valley. The results show typical seasonal pattern and are strongly correlated to weather phenomena. Comparison to the absolute humidity values obtained from ground-based measurements of temperature and relative humidity showed good correlation between the two methods. Based on the visual data, we observed that the correlation, which is excellent in clear weather conditions, considerably deteriorates in the presence of rain and clouds. We assume this effect is due to the presence of both water vapor and water droplets. The absolute humidity from GNSS measurements was found to be less biased with respect to weather conditions at a given micro-location and should be a more relevant observable for the study of processes within the planetary boundary layer, such as aerosol hygroscopic properties, then those obtained from ground-based measurements.