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The Potential of Tropospheric Gradients for Regional Precipitation Prediction

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Changes of temperature and humidity in the neutral atmosphere cause variations in tropospheric path delays and tropospheric gradients. By estimating zenith wet delays (ZWD) and gradients using a GNSS reference station network the obtained time series provide information about spatial and temporal variations of water vapour in the atmosphere. Thus, GNSS-based tropospheric parameters can contribute to the forecast of regional precipitation events.
In a recently finalized master thesis at TU Wien the potential of tropospheric gradients for weather prediction was investigated. Therefore, ZWD and gradient time series at selected GNSS reference stations were compared to precipitation data over a period of six months (April to September 2014). The selected GNSS stations form two test areas within Austria. All required meteorological data was provided by the Central Institution for Meteorology and Geodynamics (ZAMG).
Two characteristics in ZWD and gradient time series can be anticipated in case of an approaching weather front. First, an induced asymmetry in tropospheric delays results in both, an increased magnitude of the gradient and in gradients pointing towards the weather front. Second, an increase in ZWD reflects the increased water vapour concentration right before a precipitation event. To investigate these characteristics exemplary test events were processed. On the one hand, the sequence of the anticipated increase in ZWD at each GNSS station obtained by cross correlation of the time series indicates the direction of the approaching weather front. On the other hand, the corresponding peak in gradient time series allows the deduction of the direction of movement as well. To verify the results precipitation data from ZAMG was used.
It can be deduced, that tropospheric gradients show high potential for predicting precipitation events. While ZWD time series rather indicate the orientation of the air mass boundary, gradients rather indicate the direction of movement of an approaching weather front. Additionally our investigations have shown that gradients are able to capture the characteristics of an approaching weather front twenty to thirty hours before the precipitation event, which allows a first indication well in advance. Thus in conclusion, the utilization of GNSS tropospheric parameters, in particular tropospheric gradients, has the potential to contribute substantially to weather forecasting models.