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What we learned for rainfall analysis using tropospheric gradients and slant zenith tropospheric delays

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Precipitable Water Vapor (PWV) from a network of GNSS receivers can be used for the forecasting/nowcasting of heavy rainfall. The PWV at a station is typically computed by combining Zenith Tropospheric Delays (ZTD) estimated from the Global Navigation Satellite Systems (GNSS) data, with observed temperature and air pressure measurements from the ground. However, GNSS processing engines do not only generate ZTD, they can also compute tropospheric gradients and sometimes tropospheric slant delays. Tropospheric gradients give an indication for the magnitude and direction of the azimuthal anisotropy of the tropospheric delay and PWV. Slant delays are more difficult to interpret since their order of magnitude depends mainly on the elevation angle of the satellite. However, re-applying the mapping function coefficients back to the slant delays, gives for individual satellites the so-called Slant Zenith Tropospheric Delay (SZTD), which is of the same order of magnitude as the ZTD. The SZTDs should be treated with caution since they contain unmodeled phase center variations (e.g. multipath). Generating and applying multipath maps before reconstructing the STDs for each GNSS station may increase the utility of this parameter. Using gradients and SZTDs gives a more enhanced spatial picture of the water vapor compared to using only ZTDs. This can be used to identify areas containing higher water vapor content before the humidity reaches the receiver and convection at this location is initiated. In this case study, we will present our impressions on the use of these parameters for heavy rainfall events in 2018 in the Netherlands.