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# The atmospheric information content of GPS Slant Total Delays

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Radio signals which are transmitted by GPS satellites and received by a ground-based station allow the estimation of the Zenith Total Delay (ZTD). Clearly, the ZTD is of limited value in weather forecasting because it does not contain information about horizontal (and vertical) atmospheric gradients. In this work we show that the estimated Slant Total Delays (STDs), i.e. the atmospheric induced signal travel time delays between the GPS satellites in view and the station, contain the desired additional information. To do so, we first determine artificial STDs in a Numerical Weather Model (NWM) by point-to-point raytracing and retrieve NWM refractivity gradients through a non-linear least square analysis. Then, we repeat this exercise but use real STDs instead to retrieve GPS refractivity gradients. This procedure is done station-by-station for $\sim$200 stations in Germany and maps of NWM and GPS horizontal refractity gradients are generated. The remarkable close agreement between the maps (inspection by eye) leads to the conclusion that STDs carry the signature of the atmospheric asymmetry. The statistics supports this finding and since STDs are available in near-real time as well they are considered a valuable new data source for weather forecasting.