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Sparsity-driven tomographic reconstruction of atmospheric water vapor using GNSS and InSAR observations

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An accurate knowledge of the 3D distribution of water vapor in the atmosphere is a key element for weather forecasting and climate research. On the other hand, as water vapor causes a delay in the microwave signal propagation within the atmosphere, a precise determination of water vapor is required for accurate positioning and deformation monitoring using Global Navigation Satellite Systems (GNSS) and Interferometric Synthetic Aperture Radar (InSAR). However, due to its high variability in time and space, the atmospheric water vapor distribution is difficult to model. Since GNSS meteorology was introduced about twenty years ago, it has increasingly been used as a geodetic technique to generate maps of 2D Precipitable Water Vapor (PWV). Moreover, several approaches for 3D tomographic water vapor reconstruction from GNSS-based estimates using the simple least squares adjustment were presented.

In this poster, we present an innovative and sophisticated Compressive Sensing (CS) concept for sparsity-driven tomographic reconstruction of 3D atmospheric wet refractivity fields using data from GNSS and InSAR.

The 2D zenith wet delay (ZWD) estimates are obtained by a combination of point-wise estimates of the wet delay using GNSS observations and partial InSAR wet delay maps. These ZWD estimates are aggregated to derive realistic wet delay input data of 100 points as if corresponding to 100 GNSS sites within an area of 100 km × 100 km in the test region of the Upper Rhine Graben. The made-up ZWD values can be mapped into different elevation and azimuth angles.

Using the Cosine transform, a sparse representation of the wet refractivity field is obtained. In contrast to existing tomographic approaches, we exploit sparsity as a prior for the regularization of the underdetermined inverse system. The new aspects of this work include both the combination of GNSS and InSAR data for water vapor tomography and the sophisticated CS estimation. The accuracy of the estimated 3D water vapor field is determined by comparing slant integrated wet delays computed from the estimated wet refractivities with real GNSS wet delay estimates. This comparison is performed along different elevation and azimuth angles.