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Robust corrections for topographically-correlated atmospheric noise in InSAR data from large deforming regions

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For Interferometric Synthetic Aperture Radar (InSAR) the atmosphere forms one of the biggest challenges when it comes to the extraction of small-magnitude long-wavelength tectonic signals. Spatio-temporal variation of water vapour, pressure and temperature in the troposphere is the main cause of these signals, introducing apparent differential path delays in interferograms of up to 15 cm.

Several correction techniques have been applied in the past that rely on external data from weather models, GPS or spectrometer data, but these are typically limited by the lower spatial resolution of the auxiliary data. Alternatively, time-series InSAR techniques and filtering of the interferometric phase in space and time can be applied, but separating atmospheric delays from non-linear deformation is challenging. Another method, which can be applied to individual interferograms, is to estimate the correlation between interferometric phase and topography, either in a non-deforming area or using a frequency band insensitive to deformation. While this method can be successful for small areas, it does not account for spatial variation of atmospheric properties, which can be significant across regions larger than 100 km. While the slope relating phase and topography can be reliably estimated for subregions, the intercept cannot, as it is biased by the presence of unrelated signals. The intercept cannot however be neglected, as the mean height of each subregion typically varies, leading to a different intercept for each window.

Here we present a new power-law representation of the topographically-correlated phase delay that can be applied locally and which is able to account for these spatial variations in atmospheric properties. We estimate the power-law from sounding data to fit altitudes of up to 4 km, as this includes the topography range in most regions of interest. We also constrain the power-law by specifying the height above which the relative tropospheric delays are approximately zero. To ensure that tectonic deformation is not mapped into the atmospheric correction, we solve for the power-law function in a frequency band insensitive to deformation. In our work we include an analysis for temporal variations of the power-law coefficients by using sounding data. We test the effect of temporal variation in power-law coefficients and errors introduced by wrong a-priori information by using synthetic simulations. We used real data from Envisat interferograms covering Guerrero (Southern Mexico) as well as TerraSAR-X data over El Hierro (Spain) to further test our method. We evaluate the success of our new approach by comparing the estimated atmospheric delays with a conventional linear correction, spectrometer data from MERIS, global ERA-Interim weather model data and weather model data from WRF run at high resolution over our study region. After correction with our new technique, we find a better fit between the deformation maps derived from InSAR and GPS.

The atmospheric correction models presented here, along with methods using MERIS and weather model data, will be made available to the community via a toolbox that is compatible with StaMPS.