D Bekaert, R.J. Walters, A Hooper, T.J Wright, and D.J. Parker

Statistical comparison of troposphere correction methods for InSAR

For Interferometric Synthetic Aperture Radar (InSAR) the atmosphere forms one of the largest sources of error when it comes to the extraction of small-magnitude long-wavelength tectonic signals, and this remains a major problem for analysis of Sentinel-1 data. Spatio-temporal variation of water vapour, pressure and temperature in the troposphere is the main cause of these noise terms, introducing apparent differential path delays in interferograms of up to 15 cm in extreme cases. 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 or availability 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.

We have developed 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 (Bekaert et al., in review, JGR). We estimate the power law from sounding data to fit altitudes of up to 4 km, as this includes most of the topography range in our/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.

While all methods have their advantages and disadvantages, it is unclear whether or not one method consistently outperforms the others. Here we present a statistical comparison of ENVISAT interferograms over Mexico and Italy for different tropospheric correction methods including (1) *spectrometer* observations from MERIS and MODIS, (2) *weather model* outputs from ERA-I at 75 km spatial resolution and the WRF model run at up to 5 km resolution, and from (3) *phase-based estimation* methods including the conventional linear method and our new power-law method. As MERIS is operated simultaneous with the SAR onboard ENVISAT it describes the correct atmospheric state, and is therefore used as reference in our study. Being limited by cloud cover our statistical analysis covers respectively 60% and 55% of our datasets for Mexico and Italy. We found that none of the methods exclusively perform best in reducing tropospheric InSAR signals. MERIS loses its simultaneous acquisition advantage when applied to other SAR sensors.

The selection of the appropriate correction technique therefore remains specific for your region of study, and so as part of this work we will be releasing a tropospheric correction toolbox that includes all the presented methods in a common processing frame.

References:

Bekaert et al., A spatially-variable power-law tropospheric correction technique for InSAR data, in review JGR