Validation and comparison of InSAR atmospheric correction techniques

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Despite over two decades of work, atmospheric contamination due to spatio-temporal changes in tropospheric temperature, pressure and humidity remains the largest source of error for the measurement of ground motions with InSAR. This is a particular problem when attempting to extract very small deformation signals from InSAR datasets.

Correction methods for tropospheric delay using weather model outputs, GNSS and/or spectrometer data have been applied in the past, but are often limited by the spatial and temporal resolution of the auxiliary data. Alternatively an empirical correction can be estimated from interferometric phase by assuming a linear or a power-law relationship between the phase and topography, but this approach can often erroneously remove ground deformation signals as well.

Here we show the results of a statistical comparison of state-of-the-art tropospheric corrections estimated using our Toolbox for Reducing Atmospheric InSAR Noise (TRAIN) – (Bekaert et al., 2015). This includes correction estimated from the MERIS and MODIS spectrometers, a low and high spatial-resolution weather model (ERA-I and WRF), and conventional linear and new power-law empirical methods. Whilst spectrometers give the largest reduction in tropospheric signal over our three test regions, they are severely limited to cloud-free and daylight acquisitions and none of the other tropospheric correction methods consistently perform best.

However, numerical weather models present an opportunity to correct InSAR data systematically using independent information and a standardized approach. One of the most widely used numerical weather model datasets is ERA-Interim (ERA-I), produced by the European Centre for Medium-range Weather Forecasts, and corrections based on these data have seen rapid uptake by the InSAR community. However attempts to validate the correction method on small test sites show conflicting results; that it works well in some regions but not in others.

We show results of a global validation of wet delays derived from ERA-I against MERIS spectrometer measurements of water vapour acquired during 2003-2010. Comparing the two datasets in 10×10 degree regions, we find significant geographical variation in the quality of ERA-I predicted wet delays with ERA-I retrieving wet delays better at mid-high latitudes than at low latitudes.

There are strong global correlations between the quality of the ERA-I wet delays and both temperature and humidity in the tropospheric boundary layer, enabling the prediction of the efficacy of this method for any given SAR acquisition. We suggest that for automated atmospheric correction of SAR data for future missions, ERA-I is currently the most viable option, but uncertainties should also be estimated for these corrections on the basis of temperature and humidity. We propose a new method to estimate and incorporate these uncertainties in time-series analysis of deformation.