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Temporal correlation of atmospheric delay and its mitigation in InSAR time series

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A single Interferometric Synthetic Aperture Radar (InSAR) interferogram provides a measurement of ground movement with centimetric accuracy, and therefore can only detect relatively large ground motions such as those caused by co-seismic slip or volcano eruption. For detecting small amplitude and long term displacement such as post/inter seismic motion or ground subsidence, a time series of interferograms is needed to overcome the errors resulting from the atmosphere, DEM and orbit. In most of the currently available InSAR time series analysis packages, two fundamental assumptions are made, namely that (i) deformation signals are correlated in time, and (ii) atmospheric effects are correlated in space but not in time. Unfortunately, since atmospheric effects can be highly correlated with topography, the second assumption does not hold in most cases. The temporal correlation of atmospheric delays may completely mask or bias the geophysical signals and introduce unpredictable uncertainties on the velocity estimates.

To overcome this, we propose a strategy which (i) employs a generic InSAR atmospheric correction model for each interferogram by using tightly integrated HRES-ECMWF grid model output and GPS ZTD pointwise observations (global and all-time useable in near real-time); (ii) utilizes a series of model performance indicators to identify the date(s) with poor correction performance, including cross validation of ECMWF and GPS ZTD values, observed phase and modelled atmospheric delay correlations and phase standard deviations; (iii) uses an atmospheric phase screening (APS) model using partially corrected interferograms from step (i) to estimate atmospheric delays for each interferogram: higher performance of the correction model and reliable performance indicators will improve the estimation of APS; and (iv) applies the conventional time series analysis approach to extract the mean deformation rate as well as displacement time series. Our experiments with the proposed method suggest it is particularly beneficial for InSAR time series over mountain areas, as the residual atmospheric errors after correction are more likely to be randomly temporally distributed, which allows an easier minimization through time series analysis.