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Generic atmospheric correction models for radar measurements

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Atmospheric effects (especially the part due to tropospheric water vapour) represent one of the major error sources of repeat-pass Interferometric Synthetic Aperture Radar (InSAR), and limit the accuracy of InSAR derived surface displacements. The spatio-temporal variations of atmospheric water vapour make it a challenge to measure small-amplitude surface displacements with InSAR. In previous studies, several InSAR atmospheric correction models have been successfully demonstrated: (1) Ground-based correction models such as those using Global Navigation Satellite System (GNSS) and/or surface meteorological observations, (2) Space-based correction models including those involving NASA Moderate Resolution Imaging Spectroradiometer (MODIS) and/or ESA Medium Resolution Imaging Spectrometer (MERIS), and (3) Numerical Weather Model (NWM) based corrections including those using the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-Interim and/or Weather Research and Forecasting (WRF) models. Each model has its own inherited limitations. For example, ground-based correction models are limited by the availability (and distribution) of ground observations, whilst MODIS/MERIS correction models are sensitive to the presence of clouds and there is often a time difference between space-based water vapour and radar observations. Similar to space-based correction models, NWM correction models might be impacted by the time difference between NWM and radar observations. Taking into account the inherent advantages and limitations of GNSS, MODIS and ECMWF water vapour products, we aim to develop a global and near-real-time mode InSAR atmospheric correction model.

Tropospheric delays can be routinely retrieved from ground-based GNSS arrays in all-weather conditions and also in real-time. We develop an Iterative Tropospheric Decomposition (ITD) interpolation model that decouples the GNSS-estimated total tropospheric delays into (i) a stratified component highly correlated with topography therefore delineates the vertical troposphere profile, and (ii) a turbulent component resulting from disturbance processes (e.g., severe weather) in the troposphere which trigger uncertain patterns in space and time. The decoupled interpolation model can then be employed to generate improved dense tropospheric delay maps compared with previous GNSS-based models. In order to deal with areas with limited (or no) GNSS stations, we introduce the operational high resolution ECMWF (HRES-ECMWF, $\sim$16 km), available in near real-time, as well as MODIS near-IR water vapour data whenever available, as constraints of the ITD model, which makes the correction model globally available in all weather conditions at any time. The application of the ITD model to Sentinel-1 interferograms shows that approximately 68%-78% of noise reduction can be achieved using the generic ITD correction model. Indicators are also demonstrated showing the model performance in each case, to provide users with confidence to apply this generic correction model.