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Corrections of stratified tropospheric delays in SAR interferometry: Validation with global atmospheric models

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The main limiting factor on the accuracy of Interferometric SAR measurements (InSAR) comes from phase propagation delays through the troposphere. The delay can be divided into a stratified component, which correlates with the topography and often dominates the tropospheric signal, and a turbulent component. We use Global Atmospheric Models (GAM) to estimate the stratified phase delay and delay-elevation ratio at epochs of SAR acquisitions, and compare them to observed phase delay derived from SAR interferograms. Three test areas are selected with different geographic and climatic environments and with large SAR archive available. The Lake Mead, Nevada, USA is covered by 79 ERS1/2 and ENVISAT acquisitions, the Haiyuan Fault area, Gansu, China, by 24 ERS1/2 acquisitions, and the Afar region, Republic of Djibouti, by 91 Radarsat acquisitions. The hydrostatic and wet stratified delays are computed from GAM as a function of atmospheric pressure P, temperature T, and water vapor partial pressure e vertical profiles. The hydrostatic delay, which depends on ratio P/T, varies significantly at low elevation and cannot be neglected. The wet component of the delay depends mostly on the near surface specific humidity. GAM predicted delay-elevation ratios are in good agreement with the ratios derived from InSAR data away from deforming zones. Both estimations of the delay-elevation ratio can thus be used to perform a first order correction of the observed interferometric phase to retrieve a ground motion signal of low amplitude. We also demonstrate that aliasing of daily and seasonal variations in the stratified delay due to uneven sampling of SAR data significantly bias InSAR data stacks or time series produced after temporal smoothing. In all three test cases, the InSAR data stacks or smoothed time series present a residual stratified delay of the order of the expected deformation signal. In all cases, correcting interferograms from the stratified delay removes all these biases. We quantify the standard error associated with the correction of the stratified atmospheric delay. It varies from one site to another depending on the prevailing atmospheric conditions, but remains bounded by the standard deviation of the daily fluctuations of the stratified delay around the seasonal average. Finally we suggest that the phase delay correction can potentially be improved by introducing a non-linear dependence to the elevation derived from GAM.