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Interferometric SAR analysis of atmospheric water vapor properties

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In the last decade space-borne Synthetic Aperture Radar Interferometry (InSAR) has been successfully used for geophysical applications such as topographic mapping and deformation measurements. Even if space-borne SAR systems work at frequencies minimizing the atmospheric absorption, the interferometric phase is affected by a delay mainly due to the propagation in the tropospheric layer. Atmospherically induced distortion observed in the above applications has typically been treated as noise. An increase in the amount of atmospheric water vapour between the acquisition times appears as a phase delay and so an apparent increase in the distance to the ground surface, indistinguishable from topography or real ground deformation. An atmospheric mitigation technique that could be applied on a scene-to-scene basis would be highly desirable. Furthermore, the knowledge of spatial distribution of relative change in atmospheric water vapor as furnished by SAR interferometry could be important for climate studies, mesoscale meteorology and numerical forecasting.

Variations of SAR signals propagating through the atmosphere can be measured by using the interferometric combination of two coherent SAR images acquired within a relatively short interval to diminish the change of surface deformation and by eliminating the influence of topography using a reference elevation model. Then, the observed signal can be interpreted uniquely as the superposition of the atmospheric delay signal during the two acquisitions.

The aim of this work is to describe some methods to model and analyse the atmospheric effects in the SAR interferograms.

Examples of maps of the atmospheric water vapour over the regions of Lisbon and Azores Islands (Portugal) are shown. They have been obtained from ERS and ENVISAT SAR data. This two regions were selected since characterized by different wheather conditions and atmospheric properties.

A numeric weather model was used to generate a synthetic interferometric phase image for the acquisition times of SAR images. The hydrostatic and wet components of the interferometric phase delay within the tropospheric layer have been modeled. The hydrostatic component has the larger in magnitude and is less spatially variable than the wet one. The three-dimentional fields of temperature, atmospheric pressure, water vapour and geopotential at the time of SAR acquisitions were computed by means of Weather Research & Forecasting Model (WRF). The synthetic phase was compared to the corresponding real SAR interferograms.

The isotropic properties of the interferometric phase were studied by means of the Radon transform. The existence of a power law in the phase spectrum was verified. The relationship between the interferometric phase delay and the topographic height of the observed area is also investigated.