ATMOSPHERIC WATER VAPOR EFFECTS ON SPACEBORNE INTERFEROMETRIC SAR IMAGING: COMPARISON WITH GROUND-BASED MEASUREMENTS AND METEOROLOGICAL MODEL SIMULATIONS AT DIFFERENT SCALES

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Abstract

Spaceborne Interferometric Synthetic Aperture Radar (InSAR) imaging is a well established technique to derive useful products for several land applications. One of the major limitations of InSAR is atmospheric effects, and in particular the high water vapor variability. On the other hand, these effects might be explored to use InSAR for high-resolution water vapor retrievals.

The InSAR corrections for water vapor can be approached at two different geographic scales, namely regional and local. In the case of the regional scale, no sudden ground motions are to be expected (at least at that scale), so that the InSAR surveys, that are in general multi pass, will be mostly dedicated to the analysis of progressive tectonic motions, or to the improvement of a Digital Terrain Model. In both cases, the atmospheric artifacts, in general of the same order of magnitude of the motions to be measured, or at times even much greater can be abated using the multi pass technique and time averaging. At any time, a running average of the interferograms will available. Neglecting the effects of baseline changes, as it is to be expected with the narrow orbital tubes of the future platforms like Sentinel-1, the interferograms are expected to be all very similar to each other, with the main changes induced by the atmospheric signal, to be estimated and then subtracted. Say, after 20 – 50 passes, the variance of the atmospheric signal is sizably reduced, by the same factor. In other words, as the changes to be measured are more than an order of magnitude inferior to the atmospheric disturbance, the latter will be very well estimated just by comparison with the running interferogram stack. In this case, InSAR atmospheric phase screens (APS) (i.e., time difference of excess path between interferometric acquisitions related to water vapor anomalies) could be exploited by meteorologists, as a new source of high resolution information on water vapor distribution. Conversely, when a long sequence of interferograms does not exists, or sudden movements have been occurred on large areas, such in the case of an earthquake, the water vapor variability still remain a problem for InSAR processing and any information on its distribution could be useful to try to correct, or at least to mitigate such effect.

This work is related to the ESA project METAWAVE (Mitigation of Electromagnetic Transmission errors induced by Atmospheric Water Vapor Effects), where the above mentioned problematic is deeply investigated by a large team composed of SAR experts, meteorologists, atmospheric remote sensing experts. In the frame of such project the local circulation in the urban

area of Rome has been studied using a high-resolution Mesoscale Model (MM5), InSAR maps of excess path length variation between different radar acquisitions (which are strictly related to variation in water vapor content along radar line of sight), a network of microwave radiometers, and Global Positioning System (GPS) estimates of integrated water vapor (IWV). A parallel experiment has been conducted near Como (Northern Italy), where the reference information to be compared to InSAR APS were provided by a fairly dense network of GPS receivers enabling tropospheric water vapor tomography.

The project is presently undergoing and the preliminary results of the multiplatform experiment will be summarized in the paper, together with the general philosophy that has inspired the research project design.

As first step, the high resolution IWV model-derived MM5 forecasts at 1-km resolution and InSAR maps are analyzed. Spatial disaggregation techniques are also applied to downscale the MM5 IWV fields to hundreds of meters, typical scale of InSAR APS product. Several MM5 simulations have been performed for assessing the right Planetary Boundary Layer (PBL) parameterization (high order local or low order non local) for the urban area of Rome. The results show that the high resolution IWV model maps are generally consistent with the InSAR APS maps. Eventually, the impact of the assimilation of InSAR data on to the high resolution model will be also discussed. The preliminary comparisons between InSAR APS maps and water vapor retrievals from GPS receiver and microwave radiometer networks will be also presented to discuss the potential of a dense network to provide atmospheric corrections of the interferograms to better monitor movements at local scale, such as landslides.