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Building a time series of water vapour maps: A first step towards assimilation of Interferometric SAR data in forecasting models

Giovanni Nico, Pedro Mateus, and João Catalão
Universidade de Lisboa, IDL, Lisboa, Portugal (gxnico@fc.ul.pt)

The knowledge of water vapor spatial distribution in the Earth's atmosphere at a given time is an important information for numerical forecasting. In fact this is the most varying atmospheric constituent both in space and in time. The water vapor is basically concentrated in the troposphere, the atmosphere layer where the most important phenomena related to weather occur. This layer is destabilized by radiative heating and vertical wind shear near the surfce. The accuracy of quantitative precipitation forecasting over a given region strongly depends on the knowledge of the temporal and spatial variations in the water vapor spatial distribution.

Currently, measurements based on ground-based and upper-air sounding networks furnish water vapor distribution only at a coarse scales. This could not be enough to capture variations of the local concentrations of water vapor. Spaceborne radiometer observations can observe atmospheric layers above 3 km due to absorption by water vapor and in any case maps of vater vapour density are too coarse. Availability of GPS measurements of on a routine basis is improving numerical forecasting. However, the density of meuserements which can be obtained by a GPS network is too low to capture spatial variations of local concentrations of water vapor. Synthetic Aperture Radar (SAR) interferometry provides maps of temporal variations of the vertically integrated water vapor density with a horizontal resolution as fine as 10-20 m depending on the radar wavelength and over a swath typically 100 km wide. In the past, the availability of the tandem ERS-1/2 interferometric SAR data allowed to get maps of the vertically-integrated with a temporal baseline of 1 day. In those maps it was possible to recognize signature of a precipitating cumulonimbus cloud, the effects of a cold front and the phenomenon of horizontal convective rolls.

Current interferometric spaceborne missions use SAR sensors working at different frequency bands: L (ALOS-PALSAR), C (ENVISAT-ASAR, RADARSAT) and X (TerraSAR, Cosmo-Sky-Med) and with a repetition cycle ranging from 11 (TerraSAR-X) to 35 days (ENVISAT-ASAR). From each SAR sensor, it can be obtained a map of the temporal changes of the IPW occurred between the two subsequent acquisitions by interferometrically processing the SAR data. The accuracy of these maps depends on the radar wavelength and on spatial filtering. A procedure to properly merge all these maps could give information about the temporal evolution of the IPW spatial distribution with a sampling period shorter than the revisiting times of each of the SAR sensors. The main difficulty of this operation is related to the fact that the integration of temporal changes of IPW is not direct when maps are obtained by different SAR sensors. The aim of this work is to describe a methodologiy to merge IPW maps obtained by the different SAR sensor based on the availbality of GPS time series measuring the IPW over the same area.

The Lisbon region, Portugal, was chosen as a study area. This region is monitored by a network of 12 GPS permanent stations covering an area of about squared kilometers. A set of SAR interferograms were processed using data acquired by ENVISAT-ASAR and TerraSAR-X mission over the Lisbon region during the period from 2009 to 2010. A time series with GPS measurement of IPW was processed to cover the time interval between the first and last SAR acquisition. This time series is then used to integrate all maps of temporal changes of IPW obtained by the different interferometric SAR couples. This results in a time series giving with the information about the spatial distribution of the IPW.