Near real-time tropospheric correction of Sentinel-1 data using high resolution numerical weather models

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The accuracy of InSAR derived displacements is strongly affected by spatio-temporal variations of tropospheric water vapour, which can cause errors comparable in magnitude to those associated with crustal deformation. Global, real time and reliable estimates of tropospheric delays are thus desirable for monitoring geohazards. Most of previous studies rely on remote sensing water vapor measurements provided by GPS and/or satellite radiometers. However the application of those methods is strongly limited by their data availability (e.g. lack of a dense network for GPS, or the presence of clouds for satellite radiometers). Numerical weather models hence offer potential for overcoming major limitations of traditional methods.

In this work we demonstrate the use of operational NWM output for tropospheric correction of Sentinel-1 data and quantify the skills of different NWMs and different spatial resolution based on three case studies. We compare tropospheric delays estimated from two global models and one regional model which differ both in the spatial resolution and in their dynamics parameterizations. More specifically we analysed outputs from the operational high resolution ECMWF (HRES-ECMWF, ~16 km), available near real-time and the archived reanalysis products from ERA-Interim (~75 km) which shares most of the parameterizations of HRES-ECMWF and mostly used in the geophysical community. In order to test the sensitivity on the spatial resolution, we also ran the Weather Research and Forecasting model (WRF) at 2 and 5 km resolutions, in a nested configuration with parent and nested domain at 25 km and 5 km resolutions respectively, with meteorological lateral boundary conditions driven from the NCEP Final Analysis.

We quantify model skills based on three case studies representative of different geophysical and meteorological conditions: the Canaries, a region in the Ethiopian rift valley and in west Nepal affected by the 25^{th} April 2015 Mw 7.8 earthquake. In all cases HRES-ECMWF provides an improvement in the satellite retrieval by reducing tropospheric errors more than the commonly used ERA-Interim. The high resolution WRF simulations provide more accurate results over smaller and geographically complex domains (e.g. over the island of Tenerife), although its operational application is limited by the computational facilities and expertise required.

For the first time, this work demonstrates the value added by using the high resolution ECMWF products not only for reducing tropospheric errors but also for the potential for near real-time processing of Sentinel-1 data. A toolbox for applying tropospheric corrections based on HRES-ECMWF is planned to be released after the 2016 ESA Living Planet Symposium.