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On the use of weather models in the mitigation of atmospheric artifacts in X-band SAR interferometry

D. O. Nitti (1,2), R. Nutricato (1,2), F. Intini (1,2), F. Bovenga (3), M. T. Chiaradia (2), R. Pacione (4), and F. Vespe (5)

(1) GAP srl, c/o Dipartimento Interateneo di Fisica, Politecnico di Bari, Via Amendola 173, 70126 Bari, Italy, (2) Dipartimento Interateneo di Fisica, Politecnico di Bari, Via Amendola 173, 70126 Bari, Italy, (3) CNR-ISSIA, Via Amendola 122/D, 70126 Bari, Italy, (4) e-GEOS/ASI-CGS, Contrada Terlecchia - 75100 Matera, Italy, (5) ASI-CGS, Contrada Terlecchia - 75100 Matera, Italy

High resolution numerical weather models (NWM) are being to play a role of increasing importance for atmospheric phase screen (APS) mitigation. Here we present preliminary investigations concerning the estimation of the atmospheric contribution to X-band InSAR phase fields through numerical weather modeling. We selected tandem-like pairs of Stripmap COSMO/SkyMED images acquired over Parkfield (California, USA) with short normal baselines, thus ensuring low sensitivity to elevation. By using a 30m SRTM DEM available for the area of interest, we generated differential phase fields, mainly related to the difference between atmospheric conditions at the times of the two acquisitions.

The interferometric artifacts have been hence compared to independent estimates of the atmospheric phase delay introduced by both wet and dry the components of the troposphere, obtained through Regional Atmospheric Modeling System (RAMS), a finite-difference, primitive equation, three-dimensional mesoscale NWM originally developed at Colorado State University. RAMS is a prognostic model capable of simulating a wide range of atmospheric motions due to the use of a nested grid system. Incorporation of topographic features occurs through the use of a terrain-following vertical coordinate system, while turbulence is parameterized using Mellor and Yamada's level 2.5 scheme, as modified by Helfand and Labraga for growing turbulence.

In order to assess the impact of the boundary conditions, numerical simulations have been repeated by using GFS, ECMWF and NAM data (resolution: 0.5 deg, 0.25 deg and 12km respectively). A spin-up time exceeding 24h was necessary for ensuring a realistic computation of the atmospheric boundary layer depth. Finally, the 3D computation of the scaled-up refractive index and its integration along the Line-Of-Sight (LOS) of the SAR sensor was performed in order to estimate the two-way radar phase delay.

The preliminary results confirm the indications coming from recent similar studies: weather models are good for the long wavelengths (>20 km) and for vertical stratification which depends on the hydrostatic component of the troposphere, while they cannot actually ensure a sub-centimetric accuracy in the estimation of the wet component, as instead required in X-band interferometry.

Finally, we used the GPS daily RINEX available on the Parkfield area to infer the atmospheric Zenith Total Delay (ZTD) and validate the outcomes of the NWM. GPS data were processed at ASI/CGS by using the NASA/JPL GIPSY-OASIS II for data reduction. The Precise Point Positioning approach was applied fixing JPL fiducial-free satellite orbits, clocks and earth orientation parameters, IGS absolute phase center variations and estimating, with a cut-off angle of 7deg, site coordinates, station clock, phase ambiguities, ZTD and tropospheric gradients. ZTD and tropospheric gradients are modeled as random walk processes and estimated with a sampling rate of 5 minutes. Results show correlation between the values computed by NWM and GPS. Furthermore, the differences are not correlated with the topography thus suggesting that the main cause of the mismatches relies on the tropospheric turbulence. This further confirms our previous conclusions.

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