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Fast and robust estimation of water vapor maps from Synthetic Aperture Radar

Andrea Monti Guarnieri (1), Marco Manzoni (1), Giovanna Venuti (2), Stefano Barindelli (2), and Eugenio Realini (3)

(1) Politecnico di Milano, Dipartimento di Elettronica, Informazione e Bioingegneria, Milano, Italy (andrea.montiguarnieri@polimi.it), (2) Politecnico di Milano, Dipartimento di Ingegneria Civile e Ambientale (giovanna.venuti@polimi.it), (3) GReD Geomatics Research & Development srl, Via Cavour, 2, 22074 Lomazzo CO (eugenio.realini@g-red.eu)

The EU project TWIGA ("Transforming Weather Water data into value-added Information services for sustainable Growth in Africa" (TWIGA) – grant agreement No.776691) aims to provide currently unavailable geo-information on weather, water and climate for sub-Saharan Africa by enhancing satellite-based geo-data with innovative in situ sensors and developing related information services that answer needs of African stakeholders and the GEOSS community.
In this SAR could play a leader role for its capability to retrieve water-vapor maps with wide coverage and high sensitivity and spatial resolution. The use of Sentinel-1 data, made freely available by Copernicus scientific hub will push further their use, particularly in the regions of interest (Kenya, Uganda, Ghana, South-Africa).
A recent but growing literature has shown the potentials of SAR in few case-studies, and the aim of the EU project is to provide combined GNSS-SAR water vapor maps at TRL 6, where the idea is to exploit both GNSS temporal continuity and absolute locations and SAR fine space resolution, in the frame of assimilation into meteorological models.
The generation of Atmospheric Phase Screens (APS) maps is indeed on-going since the early Differential Interferometric SAR (DInSAR) stacks processing schemes, like PSInSAR, ADInSAR, STAMPS and SBAS. However, all these methods aimed to the estimation of deformation maps, getting APS as a by-product, mostly regarded like a noise field to get rid of.
Such procedure has two drawbacks: first, being interested in a different signal, the optimal quality of the APS was not in the aim of the methods, second, the methods are quite complex and time consuming, and maybe even un-stable
In the proposed approach, a novel algorithm has been designed, explicitly aimed to be fast and robust, so that, in ta near future, it can run automatically in real time
The method exploits Phase Linking to provide a high quality estimation of the phases by exploiting ground patches whose size compares with the desired spatial accuracy in APS. The method is quite suited to short revisit, C-band system like Sentinel-1, where sufficient coherence is achieved when estimating phases over large areas, compared with the size of the APS correlation. The dense ground coverage of the estimate achieved, allows for direct phase unwrapping, to provide phase screens that are at later step processed to remove residual topography and deformations. Notice that few images need to be processed, to take advantage of distributed targets and, at one time, minimize the impact of deformations. This, together with an efficient implementation of phase linking, makes the method quite fast and robust.
As SAR is capable of providing only differential phase maps, that are eventually affected by large scale errors, like due to orbit uncertainty, a mitigation of such errors Is proposed by exploiting a
Water-vapor maps provided by "Generic Atmospheric Correction Online Service for InSAR" (GACOS) from Newcastle university.
Results achieved in different test cases and compared with GNSS are shown.