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3D displacement time series in the Afar rift zone computed from SAR phase and amplitude information

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Large and rapid deformations, such as those caused by earthquakes, eruptions, and landslides cannot be fully measured by using standard DInSAR applications. Indeed, the phase information often degrades and some areas of the interferograms are affected by high fringe rates, leading to difficulties in the phase unwrapping, and/or to complete loss of coherence due to significant misregistration errors. This limitation can be overcome by exploiting the SAR image amplitude information instead of the phase, and by calculating the Pixel-Offset (PO) field SAR image pairs, for both range and azimuth directions. Moreover, it is possible to combine the PO results by following the same rationale of the SBAS technique, to finally retrieve the offset-based deformation time series. Such technique, named PO-SBAS, permits to retrieve the deformation field in areas affected by very large displacements at an accuracy that, for ENVISAT data, correspond to 30 cm and 15 cm for the range and azimuth, respectively [1]. Moreover, the combination of SBAS and PO-SBAS time series can help to better study and model deformation phenomena characterized by spatial and temporal heterogeneities [2].
The Dabbahu rift segment of the Afar depression has been active since 2005 when a 2.5 km3 dyke intrusion and hundreds of earthquakes marked the onset a rifting episode which continues to date. The ENVISAT satellite has repeatedly imaged the Afar depression since 2003, generating a large SAR archive. In this work, we study the Afar rift region deformations by using both the phase and amplitude information of several sets of SAR images acquired from ascending and descending ENVISAT tracks. We combined sets of small baseline interferograms through the SBAS algorithm, and we generate both ground deformation maps and time series along the satellite Line-Of-Sight (LOS). In areas where the deformation gradient causes loss of coherence, we retrieve the displacement field through the amplitude information. Furthermore, we could also retrieve the full 3D deformation field, by considering the North-South displacement component obtained from the azimuth PO information. The combination of SBAS and PO-SBAS information permits to better retrieve and constrain the full deformation field due to repeated intrusions, fault movements, as well as the magma movements from individual magma chambers.

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[2] Manconi, A. and F. Casu, 2012. Joint analysis of displacement time series retrieved from SAR phase and amplitude: impact on the estimation of volcanic source parameters, Geophysical Research Letters, doi:10.1029/2012GL052202.