15th International Congress of the Geological Society of Greece
Athens, 22-24 May, 2019 | Harokopio University of Athens, Greece
Bulletin of the Geological Society of Greece, Sp. Pub. **7** Ext. Abs. GSG2019-036

# Land Surface Deformations Using SAR Interferometry: Past, Present, and Future Trends

M. Elkamali, and A. Abuelgasim

National Water Center, Department of Geography and Urban Planning, United Arab Emirates University, Al Ain, UAE, 201890072@uaeu.ac.ae.

Synthetic Aperture Radar Interferometry (InSAR) has played an essential role in monitoring changes of Earth's surface in the last few decades (Pepe et al., 2016). This technology relies on measuring the phase difference between two or more complex values SAR images acquired at different times and/or different orbital positions. Primarily, the distributions of the receiving/transmitting antennas will define the interferometric distributions. Mono-static InSAR involves two antennas to produce three interferometric distributions; these are i) across-track interferometry, which acquires SAR images at the same time from different positions, ii) along-track interferometry that acquires SAR images at different times but from the same position, and iii) repeat-pass across-track interferometry that acquires SAR images at different times and from different positions.

The SAR data availability increased rapidly in the recent years operated with various SAR instruments over different platforms, which archived SAR data acquired from different wavelengths, look angle geometries, and acquisition modes. Using different wavelengths allow to reach a different level of information, such as different level of penetration, the longer the wavelength, the stronger the penetration. Satellites use a various wavelength; AIRSAR uses P-band (65 cm), ALOS uses L-band (23 cm), while ERS-1/-2 RADARSAT ENVISAT uses C-band (5 cm), and TerraSAR-X and COSMO-SkyMed use X-band (3 cm). SAR images acquired with different look angle geometries over the same period could allow retrieving complete 3D displacements. Different acquisition modes are available; the main differences are in the way of scanning the Earth's surface like generating a narrow swath when using Stripmap mode, a wide swath from ScanSAR mode, or viewing the scene from multiple angles when using Spotlight mode.

Since SAR systems operate in side-looking geometry and the antenna is not pointed perpendicular to the nadir point but perpendicular to the travel direction, the displacement value measured will be in the RADAR Line-Of-Sight (LOS) direction. Measurements value in LOS direction is composed of vertical, easting and northing components. Decomposing displacement measurement in LOS direction requires multiple angle SAR scenes, but still retrieving the deformation of northing component is very difficult. This because most of the recent SAR satellites operate at near-polar orbits (parallel to N-S direction), so the viewing geometries are blind to N-S displacements. Raucoules et al. (2013b) retrieved 3D deformation from displacement components from azimuth and LOS direction along both ascending and descending orbits obtained by the correlation for each point of the processing grid affected by a certain quality. Another study by used Differential Global Navigation Satellite System (DGNSS) to retrieve the whole 3D deformation named East, North, and Up components.

InSAR techniques have restrictions and limitations that should be considered particularly spatial and temporal decorrelations. These decorrelations occur due to the large gap between two acquisitions in time or space, respectively. There are other limitations such as; surface displacement which depends on the system, surface physical properties, atmospheric condition, and the software used. Some restrictions might vary according to the landcover of the study area. For instance, the InSAR technique depends on finding coherent (stable) pixels during the deformation time to measure surface displacement. Therefore, it is easy to find coherent pixels over urban or mountain areas, but there is an effect of high buildings and mountains on Radar signal; however, it is hard to find coherent pixels over vegetated areas.

This research provides a comprehensive review of the applications of InSAR technology in properly identifying land surface deformations. The review is primarilyfocused on the applications of this technology to different land cover types. Land cover types studied in this research were desert, glaciers, mountain, rural, vegetation, and urban.

Desert area is characterised by similar targets which have less decorrelation to shorter radar wavelengths. Performing PSI on X-band or C-band to observe ground displacement over desert areas is very efficient because there is a great possibility to obtain high PS density. Glacier surfaces are displaying relative faster motion than other landscapes, so there is no significant difference between various radar frequencies for detecting glacier surface motion. In order to detect surface deformation using InSAR technique over mountainous terrain, all available SAR data is applicable (ENVISAT C-band, TerraSAR X-band, ALOS L-band, COSMOSkyMed X-band, and Sentinel-1A C-band).

Rural areas have some aspects from urban areas and others from desert areas. SAR data used for detecting surface deformation over rural areas were found as; ENVISAT C-band, ALOS L-band, TerraSAR X-band, ERS1/2 C-band, and Sentinel-1A C-band. Land surface deformations over vegetation surface considered as the most difficult one due it is high temporal correlation. To reduce this effect multiple SAR data from all available sources is required to over come this error. So most of the studies used a combination between ERS-1/2 C-band, ALOS L-band, Sentinel-1 C-band, TerraSAR X-band, COSMOSkyMed X-band, and ENVISAT C-band.

Most of the scholarly studies in the related literature on retrieving surface deformation over urban areas used more than one radar wavelength because finding coherent pixels are more feasible over urban areas.

**Acknowledgements**

This work is supported by a grant from the National Water Centre of the United Arab Emirates University under Grant number 31R155-Research Centre- NWC -3-2017.