Multi-Image InSAR Time Series Analysis for Planning Future Seismic Acquisitions

Planning future seismic acquisitions in remote regions requires a non-destructive method to demonstrate the subsurface properties and structural framework. Mapping deformation patterns on the surface which are controlled by the underlying subsurface structure, might also be an indication for subsurface parameters which could determine the next seismic survey location. Taking this idea further, we present the recent outcomes of our research which is conducted over a region with diverse anthropogenic activities but fairly simple geological conditions.

Over large mining areas, dynamic behavior of a reservoir due to volume or pressure changes may cause significant surface deformation. To estimate the deformation rate including both downward and upward motions, traditional geodetic measurements gradually are swapped with Differential Interferometric SAR (DInSAR) remote sensing techniques to provide very precise displacement maps along the satellite line-of-sight (LOS).

The current research is undertaken across the Surat Basin, Australia in which for the nature of agricultural and coal mining operations at shallow depth (~300m to 700m), the surface deformation has been observed since 2007 to present day. The advanced multi-image DInSAR processing technique, so called Small Baseline Subset (SBAS) was conducted for both C-band RADARSAT-2 and L-band ALOS PALSAR descending and ascending data with different temporal and spatial baselines. Initially, interferogram stacking results suggested that among four major ALOS PALSAR scenes which cover the proposed area in Surat Basin, two scenes have significant deformation signal patterns after 2007. Based on stacking results, the SBAS processing technique that solves for deformation rate and the residual topographic noise simultaneously was used for coherent (i.e. more than 0.3) interferograms of ALOS scenes which contained the predetermined deformation signals. Time series reconstruction of linear deformation rates in LOS direction, shows four hotspots with significant ground settlement and uplift starting in 2008 which relates to gradual and localized deformation. The localization of these four candidates with surface deformation was also confirmed by implementing SBAS code for descending RADARSAT2 images after 2012 to present day. It is sensible to mention that the rock formation in areas with subsidence is not different from the area with uplift, showing that the sedimentary rocks and young-aged alluvium are not the controlling factors for the deformation signals detected by DInSAR but other man-made interactions can be responsible.

Based on the resultant deformation footprints after advanced DInSAR processing, the subsurface structural simulation using in-situ geological characteristics, well logging, seismic interpretation, along with interferometric observations is the next objective to achieve to project the properties of shallow depth as well as the strain history in relationship with controlling geological structures.