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Development of a land deformation model from InSAR: combination with heterogeneous geodetic measurements in the Latrobe Valley (Australia) test site

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Deformation of the Earth's surface affects the maintenance of geodetic infrastructure and its reference frame to support e.g., construction, mineral exploration, telecommunications, and environmental monitoring. As the land deforms, the 3D coordinates of each position will change within the reference frame. Monitoring these changes is particularly challenging for local deformation occurring between GNSS continuously operating reference stations (CORS), as it is not directly measured. Hence, a deformation model to correct for this deformation is required, using radar interferometry (InSAR) to measure localised deformation occurring between the sparse GNSS CORS. The Australian Intergovernmental Committee for Surveying and Mapping's (ICSM's) Permanent Committee on Geodesy has recently identified the need for such a deformation model, leading to a project to develop a prototype deformation model combining radar interferometry with other geodetic measurements.

We present the first stage of this project where these data are analysed in the Latrobe Valley study area (south east Australia), where we have used 2.7 years (2015-2018) of Sentinel-1 and ~4 years (19 scenes; 2007-2011) of ALOS PALSAR SAR data to provide estimates of line of sight (LOS) velocity and uncertainties. Time series from five local GNSS CORS have been reprocessed in a consistent reference frame (ITRF2014) giving 3D velocities and uncertainties to which the InSAR time series are referenced. The InSAR rates are converted from LOS to vertical within the ITRF2014 reference frame so that the results are comparable to other geodetic measurements. Repeat levelling measurements from 1980 and 2015 and periodic (non-continuous) GNSS measurements were included for 2015.9 - 2018.5, which provided complementary information to constrain the rates in the study area in both time and space. We test methods to combine these data that relate to different time periods, spatial location, temporal and spatial frequency. We find that all of the data contribute to our understanding of deformation in the Latrobe Valley: GNSS data shows temporal variations at specific sites, InSAR gives information about the spatial variation in deformation, periodic GNSS provides information at additional spatial locations but at limited points in time,

and levelling extends the time series several decades into the past. Subsidence rates approaching 30 mm/yr are found near an open cut mining pit, but the deformation is non-linear in time and space across the study area, adding to the challenge of modelling the deformation where the geodetic observations are sparse. An important outcome of the project is to determine which types of observations best constrain the deformation model and how much new data is required.