Progress report

Space geodetic analysis of volcanic activities over the Taupo Volcanic Zone, New Zealand

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The Taupo Volcanic Zone (TVZ) based in the North Island of New Zealand is an area of supervolcanoes with about 300-km-long and 60-km-wide, formed due to the back-arc rifting associated with subduction of the Pacific Plate beneath the Australian Plate. The TVZ is a rifted arc with current extension rate of about 8-15 mm/yr, and its longitudinally segmented nature, high thermal flux and voluminous rhyolitic volcanism make it unique on Earth. Although numerous papers have been presented on the structure, history and evolution of the TVZ, our understanding is still incomplete, and many interpretations require revision and continued investigation. As a result, it is important to monitor spatio-temporal evolutions of the ground displacements of TVZ, particularly with high-spatial resolution.

At this stage, we mainly focus on collecting datasets and doing some initial processes. We acquired both the ScanSAR- (2 tracks including ascending and descending) and Stripmap- (2 tracks cover the lake including ascending and descending) modes of ALOS-2 datasets over TVZ, as well as the C-band Sentinel-1 datasets (2 tracks including ascending and descending), during a period from 2015 to 2023. We did the time-series analysis of both the ALOS-2 and Sentinel-1 data, and evaluated/compared the quality of the results derived from these two Satellite with different wavelengths. Figure 1 shows the averaged InSAR coherence of ALOS-2 (example from ScanSAR) and Sentinel-1 during 2015 to 2022. We can find that the quality of ALOS-2 InSAR is much better than that of Sentinel-1. Low coherence affects both the interferometric phases and the unwrapped results, which will largely limit the quality of time-series analysis over large areas, as the decorrelation noise caused unwrapping errors would be propagated through space, e.g., the quality of time-series would decrease with the increase of the distance from the reference pixel to the pixel of interest.

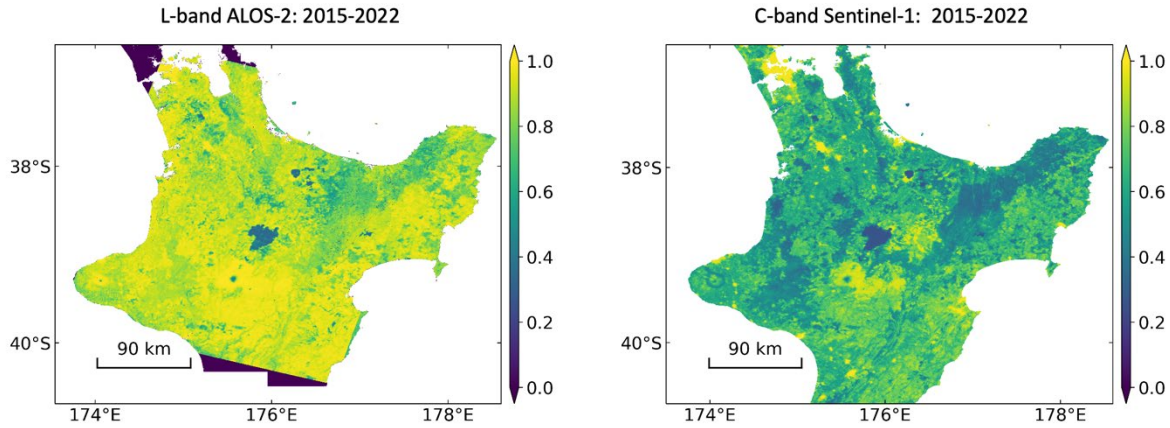

Fig. 1 Averaged InSAR coherence during 2015 to 2022.

From the initial time-series analysis of the ALOS-2 datasets (Figure 2), we find significant subsidence areas over the geothermal regions (Fig. 2b). Around the Taupo lake region, we did not find clear uplift signals during the 2019 and 2022 unrest period, which is consistent with the available GPS observations near the lake zone. In addition, we also find many small-scale local deformations, e.g., near Gisborne regions (Fig. 2c). In addition, at the West-east coast region of the North Island, it is still not easy to find the transient slow-slip-events (SSEs) signals (e.g., The April 2019 period) and the large scale tectonic signals, which may mean the initial results are still seriously affected by the potential atmospheric delays in the region.

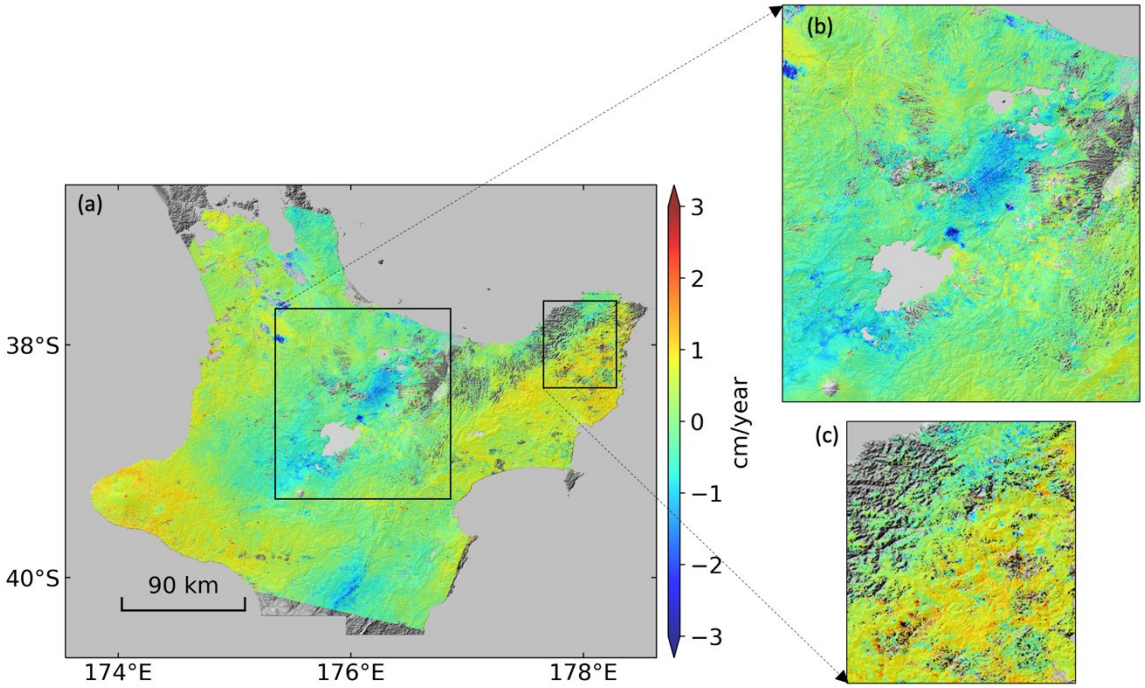

Fig. 2 Averaged deformation velocity from ALOS-2 ScanSAR during 2015 to 2022

From this stage, we find large potential of the L-band ALOS-2 datasets over New Zealand (e.g., TVZ zone), although our results still need further analysis. But we also faced couple of challenges: 1) ALOS-2 ScanSAR still shows some large ramp-like errors, most likely associated the orbital errors, which would affect the large-scale of tectonic deformation monitoring, 2) similar as all other InSAR results, atmospheric effects on ALOS-2 over the North Island regions is still serious, which largely affect the monitoring of small local deformation (e.g., SSEs). The good thing is the atmospheric effects seems like mostly due to the troposphere, and we did not find clear ionospheric effects on the ALOS-2 results.

At the next stage, we will focus on the time-series analysis, and further improving the results (e.g., better tropospheric corrections). Based on the improved time-series analysis, we will try to find the inner correlation between ground displacements, seismic activities, and volcanic unrest over the TVZ regions, and will do some numerical modelling of these activities.