Geophysical Research Abstracts
Vol. 20, EGU2018-10855, 2018
EGU General Assembly 2018

Towards global monitoring of tectonic and volcanic hazards using Sentinel-1

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Sentinel-1 has the potential to transform our ability to monitor Earth's hazardous tectonic and volcanic zones. Here, we present the latest progress from COMET, where we are developing an approach to monitor hazardous regions on a global scale.

There is a high degree of correlation between where earthquakes occur and where strain is accumulating in the crust, and strain rate maps therefore provide useful constraints on seismic hazard. Global strain rate maps currently rely on GNSS networks, but the spatial resolution is generally too coarse to provide a complete picture of strain localisation. Velocities derived from Sentinel-1 InSAR measurements, on the other hand, can be used to derive strain rates almost everywhere above sea level, with a resolution orders of magnitude better. This requires mass processing of Sentinel-1 data, however, to deliver velocities at the required relative accuracy of $\sim$1 mm/yr over distances of 100 km.

Using a bespoke processing chain that we have developed (LiCSAR), we are now producing interferograms systematically for the entire Alpine-Himalayan belt (approximately 9000 x 2000 km) and the majority of subaerial volcanoes. Currently we make interferograms and coherence products available to the community, but we plan to also provide average deformation rates and displacement time series, in the near future. The results are made available through a dedicated COMET portal (http://comet.nerc.ac.uk/COMET-LiCS-portal), and will be linked to the ESA G-TEP and EPOS.

Noise associated with interferometric measurements at long spatial wavelengths is mostly due to the variation in tropospheric delay. We have modelled this noise contribution, assuming that the noise difference between any two points is sampled from a distribution with a constant standard deviation. An analysis of the first three years of data acquired over Turkey fit this model well at all spatial wavelengths. We find that with acquisitions every 12 days, an accuracy of 1 mm/yr is already achieved over a distance of 150 km after three years.

COMET also responds routinely to significant continental earthquakes, larger than $\sim$Mw 6.0. The short repeat interval of Sentinel-1, together with the rapid availability of the data, allows us to do this within a few days for most earthquakes. For example, after the Mw 7.8 Kaikoura earthquake we supplied a processed interferogram to the community just over five hours after the Sentinel-1 acquisition.

Deformation is also a key indicator of volcanic unrest, often being associated with the flow of magma to shallower depths. The operational nature of Sentinel-1, with frequent revisits and rapid data delivery, makes it suitable for monitoring subaerial volcanoes globally. Currently, we include most subaerial volcanoes in our mask for automatic processing at standard resolution, but aim to process sub-frames centred on each volcano at higher resolution in the future. We have also developed automatic detection algorithms that will alert us to new deformation at volcanoes automatically.