Systematic and Automatic monitoring of our deforming planet with Sentinel-1: from colliding continents to subsiding houses

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The Sentinel-1 constellation represents a major advance in our ability to monitor movements of our planet's dynamic surface operationally. Sentinel-1 uniquely offers routine acquisitions with short revisits, a commitment to a long duration mission, systematic wide-area coverage, good orbital control, and a free and open data policy. Together, these give us the unprecedented ability to respond to most earthquakes and eruptions and to build the long
deformation time series that are required to resolve slow deformation. In this talk, I will present the latest progress from COMET-LiCS (*), where we are now providing processed products and derived results to the community for volcanoes and the tectonic belts (**).

COMET's work on earthquakes and volcanoes can be split into response and preparedness. We now respond routinely to most significant earthquakes that occur in the continents, providing interferograms and interpretations to the community rapidly – Sentinel-1 allows us to do this within a few days for most earthquakes. For example, after the M7.8 Kaikoura (New Zealand) earthquake, on 14 November 2016, and with assistance from ESA, we supplied a processed interferogram to the community at 1 pm on 15 November, just 5 hours and 37 minutes after the Sentinel1 acquisition. This data set was used extensively by colleagues at GNS in New Zealand to help them identify faults that had failed in the earthquake – vital in this case as it was one of the most complex earthquakes ever to have occurred. The fault models that resulted from the InSAR data (from Sentinel-1 and ALOS) completely changed the local and USGS estimates of ground shaking, and are likely to lead to modifications to seismic hazard codes worldwide. We are currently automating our response systems to take advantage of the guaranteed acquisitions that Sentinel-1 offers.

Preparing for earthquake and volcanic hazard first requires identification and characterisation of the hazard. Deformation data are now becoming a key piece of information in that process. For example, Biggs et al (Nature Communications 2014) showed that there is a strong diagnostic link between volcanoes that deform and volcanoes

that erupt. Of equal importance, they showed that volcanoes that do not deform only rarely erupt. At fault zones, strain energy accumulates over long periods of time around faults that eventually fail in earthquakes. By mapping the accumulation of strain, we can place constraints on how often earthquakes can occur in a given region. To make an impact for volcano and fault zone monitoring, we need to be able to measure deformation rates on the order of 1 mm/yr or less. This requires mass processing of long time series of radar acquisitions. In COMET, we are currently processing interferograms systematically for the entire Alpine-Himalayan belt, which stretches over 9000 km from Italy through to China, and is up to 2000 km wide, and making interferograms and coherence products available to the community. We are also processing all ~1500 volcanoes on land that have erupted in the Holocene. We plan to provide average deformation rates and time series for all these areas. Results will be made available through our dedicated portal (**), and are being linked to the G-TEP portal and EPOS during 2018.

I will show the latest wide area results for tectonics and volcanism, and discuss how these can be used to build value-added products, including (i) maps of tectonic strain (ii) maps of seismic hazard (iii) volcano deformation alerts. The accuracy of these products will improve as the number of data products acquired by Sentinel-1 increases, and as the time series lengthen. Finally, I will show results from University of Leeds spinout, SATSENSE Ltd, which is using Sentinel-1 data to monitor movements on a much smaller scale in the UK.

*COMET is the UK Natural Environment Research Council's Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics: http://comet.nerc.ac.uk/; LiCS is a NERC large grant that aims to use Sentinel-1 to "Look inside the Continents from Space".
**Data are available for download at http://comet.nerc.ac.uk/COMET-LiCS-portal/