Earthquake relocations and InSAR time series analysis of the June 12th 2011 eruption of Nabro Volcano, Afar

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Nabro volcano sits on the southern part of Danakil block to the east of the Afar depression, on the Arabian plate. It is the largest volcano in the Nabro Volcanic Range (NVR) and sits in the middle of the 110 km long volcanic lineament which trends NNE-SSW, extending from the Afar depression to the Red Sea. On the 12th June 2011, Nabro volcano suddenly erupted after being inactive for 10, 000 years. We installed a network of 8 seismometers around Nabro caldera which began recording on the 31st August and tasked SAR acquisitions from TerraSAR-X and Cosmo-SkyMed satellites to monitor how the ground deformed after the eruption.

In total, 37 stripmap acquisitions from TerraSAR-X were used to create 70 image pairs which span from the 1st July 2011 to the 10th October 2012. Concurrent with the TerraSAR-X acquisitions, the Cosmo-SkyMed satellite also imaged the volcano on a descending track between 26th June 2011 and 18th July 2012 and 64 images were used to produce 171 interferograms. Each dataset were used to create mean velocity maps and a detailed time series of incremental deformation of the Nabro caldera. Velocity maps from both satellites show subsidence up to 25cm/yr centred at Nabro. The subsidence signal from the TerraSAR-X velocity map was initially modelled assuming continuous deflation of a Mogi source at 5 km depth under Nabro, buried in an elastic halfspace. The location and depth of the magmatic source was constrained from a combined interpretation of InSAR and seismic data. The observed subsidence may also be created by a viscoelastic shell surrounding a magma chamber, which has started to contract following depletion after the eruption. Other possible interpretations of the signal include degassing and cooling and contraction of the residing magma. Preliminary results from the Cosmo-SkyMed time series show a fluctuating subsidence unlike the more linear trend established by the TerraSAR-X data. This pattern may be magmatic or caused by a seasonal atmospheric disturbance, future time-series analysis of InSAR and GPS will clarify this.

We processed the seismic signals detected by the network to provide accurate earthquake locations for the period September-October, 2011. We used Hypoinverse2000 to provide preliminary locations for events, which were then relocated using HypoDD. The majority of the earthquakes are located at the active vent and within Nabro caldera, with fewer events located on the flanks. There also appears to be a smaller cluster of events to the south-west of Nabro beneath neighbouring Mallahle volcanic caldera, despite no eruption occurring here nor any post-eruptive deformation. This may imply some stress triggering mechanism or some pressure connection between the magma system of the two calderas. We also investigated temporal patterns in the seismicity, but none were apparent in the short time window processed to date. We also found the fault plane solutions in order to assess the stress regime.