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The 2016 central Italy earthquake sequence: surface effects, fault model and triggering scenarios

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The results of fieldwork performed during the 2016 earthquake sequence around the karstic basins of Norcia and La Piana di Castelluccio, at an altitude of $\sim$ 1400 m, on the Monte Vettore (altitude 2476 m) and Vettoretto, as well as the three mapped seismogenic faults, striking NNW-SSW, are presented in this paper. Surface co-seismic ruptures were observed in the Vettore and Vettoretto segment of the fault for several kilometres ($\sim$7 km) in the August earthquakes at high altitudes, and were re-activated and expanded northwards during the October earthquakes.

Coseismic ruptures and the neotectonic Mt. Vettore fault zone were modelled in detail using images acquired from specifically planned UAV (drone) flights. Ruptures, typically with displacement of up to 20 cm, were observed after the August event both in the scree and weathered mantle (elluvium), as well as the bedrock, consisting mainly of fragmented carbonate rocks with small tectonic surfaces. These fractures expanded and new ones formed during the October events, typically of displacements of up to 50 cm, although locally higher displacements of up to almost 2 m were observed. Hundreds of rock falls and landslides were mapped through satellite imagery, using pre- and post- earthquake Sentinel 2A images. Several of them were also verified in the field.

Based on field mapping results and seismological information, the causative faults were modelled. The model consists of five seismogenic sources, each one associated with a strong event in the sequence. The visualisation of the seismogenic sources follows INGV's DISS standards for the Individual Seismogenic Sources (ISS) layer, while strike, dip and rake of the seismic sources are obtained from selected focal mechanisms. Based on this model, the ground deformation pattern was inferred, using Okada's dislocation solution formulae, which shows that the maximum calculated vertical displacement is 0.53 m. This is in good agreement with the statistical analysis of the observed surface rupture displacement. Stress transfer analysis was also performed in the five modelled seismogenic sources, using seismologically defined parameters. The resulting stress transfer pattern, based on the sequence of events, shows that the causative fault of each event was influenced by loading from the previous ones.