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Possible earthquake precursor and drumbeat signal detected at the Nirano Mud Volcanic Field, Italy

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We used the Nirano mud volcanic field as a natural laboratory to test pre- and post-seismic effects generated by distant earthquakes. Mud volcanoes are geological systems often characterized by elevated fluid pressures at depth deviating from hydrostatic conditions. This near-critical state makes mud volcanoes particularly sensitive to external forcing induced by natural or man-made perturbations.

We first characterized the subsurface structure of the Nirano mud volcanic field with a geoelectrical study. Next, we deployed a broad-band seismic station to understand the typical seismic signal generated at depth. Seismic records show a background noise below 2 s, sometimes interrupted by pulses of drumbeat-like high-frequency signals lasting from several minutes to hours. Drumbeat signal was previously discovered in geysers and at magmatic volcanoes. To date this is the first observation of drumbeat signal observed in mud volcanoes.

In 2013 June we recorded a M4.7 earthquake, that occurred approximately 60 km far from our seismic station. According to empirical estimations the Nirano mud volcanic field should not have been affected by the M4.7 earthquake. Yet, before the seismic event we recorded an increasing amplitude of the signal in the 10–20 Hz frequency band. The signal emerged approximately two hours before the earthquake and lasted for about three hours. We performed an analysis of the 95^{th} percentile of the root mean square amplitude of the waveforms for the day of the earthquake. This statistical analysis suggests the presence of a possible precursory signal about 10 minutes before the earthquake indicating the occurrence of enhanced fluid flow in the subsurface that may be related to pressure build up in the preparation zone of the earthquake.