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Variation of S-wave velocity as an indicator for predicting solid-to-liquid transition in clay landslide

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Clay landslides pose critical problems to the risk management because the slide velocity can vary dramatically (cm/y to m/s), with earthslide evolving to earthflow, depending on the meteorological conditions (rainfall, snowmelt) and water infiltration in the mass. The Pont Bourquin landslide (Swiss Alps) is a small but active clayey earthslide-earthflow which is threatening a cantonal road. Its small dimensions, 250 m in length, 35 m to 65 m wide and about 10 m deep, makes it easy to investigate and to instrument. The landlside has accelerated at the end of the spring of 2010, with displacement rates reaching a few m/month in the feeding zone. An earthflow of a few hundred of m3 was triggered in summer 2010, between the 17th and the 19th of August, after two heavy rainfalls that occurred on the 12th and 15th of August.
In order to detect medium changes in the feeding zone, two short-period 3C seismometers were installed in stable ground on both sides of the landslide in January 2010. Those were connected to the same seismic station operated in continuous acquisition mode. Simultaneously, four concrete studs and eleven vertical 4.5 Hz geophones were installed for active monitoring, along the left and the right sides of the landslide feeding zone, respectively. Signals generated by hammer drops at each stud have been recorded on a monthly basis. Passive seismic data were processed using the crosscorrelation technique to evince Rayleigh wave velocity (VR) variations, which are linked to shear wave velocity changes, in the sliding medium. In the frequency range 10-12 Hz (corresponding to penetration depth of about 10 m), the relative variation of VR exhibits a slight and continuous increase of about 1% between January and July 2010. After the 23rd of July, VR values show a significant decrease (7%) to the 17th of August when measurements stopped because of the damage caused by the earthflow. A higher decrease rate in VR was observed from the 13th of August, 5 days before the earthflow. These results suggest that the evolution of Rayleigh wave velocity (and the shear wave velocity) with time could be a valuable precursor for earthflow events and changes in clay rheology.