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Reactivation of a dormant earthflow documented by field monitoring data

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Large, deep-seated earthflows are common in mountainous areas where clay soils or fine-grained weak rocks are dominant. Distinctive features of these landslides are the relatively slow movements and the complex style of activity, in which mass flow is accompanied by basal sliding along localized shear zones. Earthflows are subjected to periodic reactivations separated by long intervals of dormancy. Although the dynamics of earthflows is widely documented in the literature, field data on the reactivation process are almost absent because of the difficulty of catching the critical acceleration phase.
We document the reactivation of a large, dormant earthflow that occurred in February 2014 in the Northern Apennines of Italy. The Montecchi earthflow is located about 50 km to the south of Bologna, on the left side of the Silla Valley. Slopes are mainly constituted by chaotic sedimentary melanges belonging to the Palombini Shale (lower Cretaceous-Cenomanian). The earthflow first reactivated in November 1994, after an apparently unexceptional precipitation of 95 mm over a week. Surface velocities reached the value of few meters per day during the failure, then the landslide slowed down. One month after the reactivation, the velocity reduced to 1.2 mm/day and five months later it was further decreased to 0.1-0.2 mm/day. In the following years, the landslide became dormant with residual movements in the order of few mm/month.
A monitoring system was installed in July 2004 to investigate the slope response to rainfalls and the displacement rates of the landslide during the dormant phase. The monitoring system has been operational for more than 10 years by adapting the number, type, and location of monitoring sensors to the evolving landslide. The monitoring system was operational when, on the 10th of February 2014, the landslide reactivated again. At the time of the failure two monitored sections were operational in the source area (upper section) and in the central part (middle section) of the 1994 earthflow. The upper section essentially consisted of 1 rain gage, 3 surface wire extensometers installed across the main scarp, and 2 instrumented open-standpipe piezometers at 3.6 m depth. In the middle section, 6 instrumented open-standpipe piezometers and 7 pressure sensors directly buried into the ground were installed in the landslide body at depths ranging between 1 and 9 m (about 2 m above the slip surface). Although several sensors were damaged and others were pulled out from the ground during the movement, the reactivation of the earthflow is well documented. The three surface wire extensometers showed a nearly-perfect exponential growth of the displacement rate, that progressively increased from about 1 mm/day one month before the failure to more than 200 mm/day in the last hours. The initial slide in the crown area then loaded the existing, fully-saturated landslide deposits triggering the downslope propagation of the failure. The pressure sensors buried in the landslide material recorded positive pore pressure excesses due to undrained loading (with hydraulic heads well above the ground surface) generally followed by an abrupt decrease, probably related to mechanical unloading or dilation of the landslide mass. These data indicate that the earthflow was reactivated by a relatively small, drained failure in the source area that propagated downslope as an undrained pulse of mechanical compression and extension.