Groundwater and ground displacement monitoring at the Montecchi earthflow (Northern Apennines, Italy)

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Extended abstract

Earthflows are the most common type of failure in active slopes where fine soils are dominant.They generally have an elongated or lobate shape, and are characterized by a complex style of movement in which mass flow is accompanied by basal sliding along localized shear zonesEarthflows are subjected to periodic reactivations with a strong retrogressive nature. The reactivation mechanism typically consists of an initial drained failure located in the crown area followed by undrained loading of the pre-existing landslide deposits. Although the dynamics of earthflows is widely documented in the literature,field data on these complex phenomena are still limited. In this work we present long-term data collected by a monitoring system installed on a typical earthflow of the Northern Apennines of Italy (the Montecchi landslide, Province of Bologna) in which both the hydrologic response to rainfall and the induced fluctuations of landslide velocity are documented.

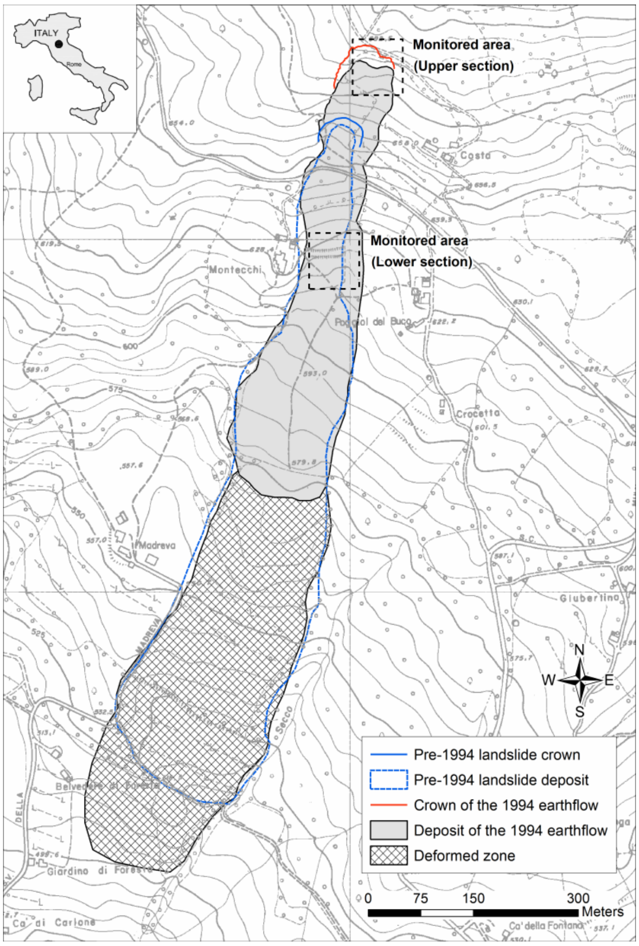

Fig. 1. Map of the Montecchi earthflow.

The Montecchi earthflow is located about 50 km to the south of Bologna (Northern Italy). The landslide has a length of nearly 900 m and a maximum width of 170 m (Fig.1). The material involved is predominantlybrownish-gray silty clay with scattered boulders of limestoneand sandstone. The soil has low to medium plasticity (Liquid Limit=30-50%; Plastic Index=10-30%) and residual friction angle between 10° and 15°.

The last paroxysmalreactivation of the Montecchi earthflow occurred in November 1994 (Fig. 1). The reactivation was caused by an apparently unexceptionalprecipitation of 95 mm over a week which followed more than 500 mm of rain over thepreceding 60 days. The failure originated on the pre-existing landslide scarp (Fig. 1) and caused a retrogression of approximately 100 m up to its present position. The lower part of the failed mass loaded the existing deposits causing its mobilization.The earthflow arrested at an elevation of 550 m butcaused widespread deformations on a large area extending 400 m further downslope (Fig. 1).

In July 2004, a monitoring system was installed in the upper part of the Montecchi earthflow to investigate the slope response to rainfall and the rainfall-displacement relationship.

The Upper section (Fig.1) it is of interest for this work. It is located in the crown area of the 1994 earthflow and consists of10 pressure transducers directly buried into the ground to minimize the response time (z=0.5-10 m); 2 instrumented open standpipe piezometers (z=4 m); 2 soil moisture probes with 3 sensors each (z=0.2-1 m); 3 surface wire extensometers; 1raingage. All the data are sampled every 20 min and stored on site.The data collected during 8 years of nearly-continuous monitoring provide a consistent picture of the landslide behavior. In general, pressure sensors are characterized by fast, transient response to single rainfall events superimposed to a distinctive seasonal trend with positive pore water pressures during the wet season (Fig. 2). The short-term behavior of the clay cover can bewell reproduced using a 1D linear-diffusion model,while cannot be replicatedby a kinematic-wave model based on lateral subsurface stormflow.

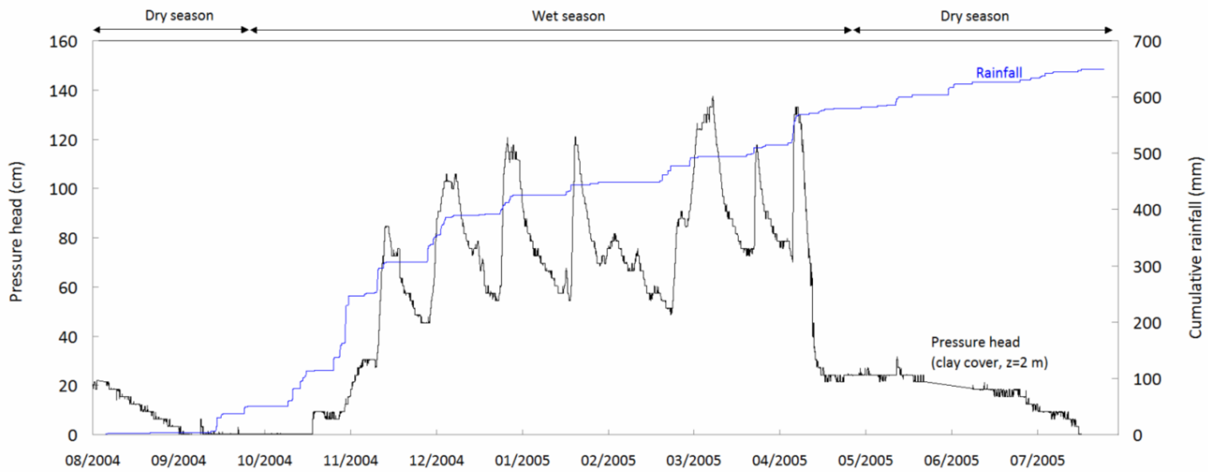

Fig. 2. Pressure head measured in the upper part of the landslide deposit during the first year of monitoring (black line) compared with cumulative rainfall (blue line)

Slope movements show a more complex behavior. The seasonal increase of the landslide velocity is well correlated with the long-term fluctuation of the water table (Fig. 3),but there is not a clear correlation between velocity increase and seasonal rainfall. Moreover, the landslide sometimes accelerates in response to single rainfall events indicating a complex relationship with slope hydrology. The observed displacements can be reproduced using simple viscous models, but the rheological parameters have to be changedfrom time to time in order to fit monitoring data.The Montecchi dataset clearly documents the complexity of earthflows and the need of collecting long-term monitoring data for improving our understanding and prediction capability.

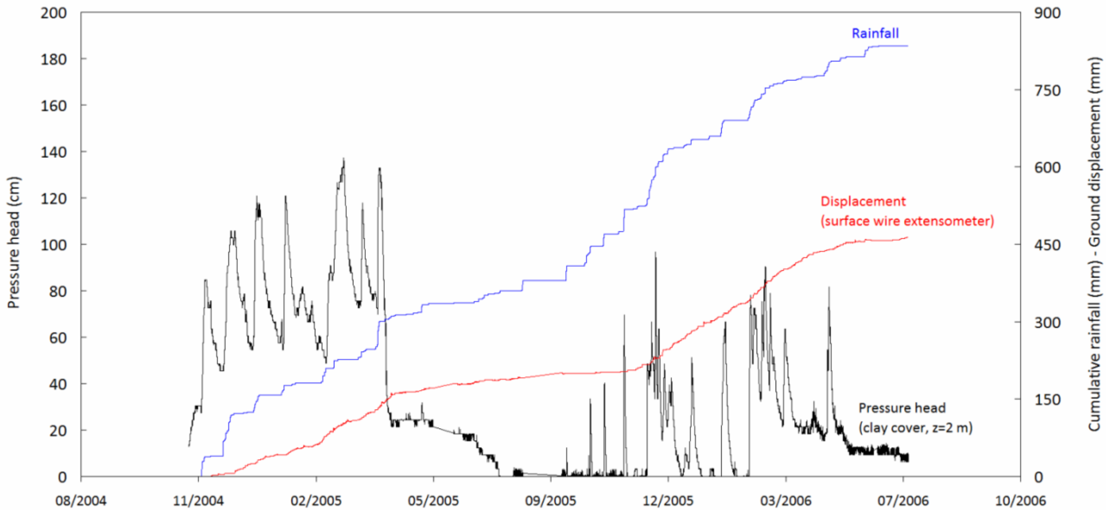

Fig. 3. Comparison of rainfall (blue line), pressure head in the landslide deposit (black line) and ground displacement (red line) during two years of monitoring.