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Hydrogeological and geotechnical monitoring of some large landslides in the Province of Modena (Northern Apennines) for prevention and mitigation purposes

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A geotechnical and hydrogeological investigation project is carried out in the Mt. Modino area (Province of Modena, Northern Apennines) as a joint collaboration between the University of Modena and Reggio Emilia, the Province of Modena and the Emilia-Romagna Region. The project is aimed to the assessment of the link between geotechnical and hydrogeological factors and the reactivation of three large landslides such as rotational rock slides developing into earth flows, very common phenomenon in Northern Apennines, that cause risk to key road connections, houses and also damming of the river. These mass movements affect slopes where the overlap between flysch rock masses and chaotic clayey complexes results in high hydraulic conductivity contrast and complicated groundwater recharge and flow patterns. These factors, together with the poor geotechnical characteristics of the involved materials, are believed to control the onset of landslide reactivation events. In fact, from available archive data and observations, the time lag between peak precipitation periods and reactivation of these mass movements seems to have ranged between week to months, depending on the specific setting of each landslide. This indicates that forecast based solely on precipitation thresholds is not a valid approach for these phenomena, that are rather conditioned by deep seated weakness zones and, also, respond to precipitations over longer time windows and to the consequent recharge of slope aquifers. In the project, underground investigation and monitoring data are collected inside and outside the landslides with boreholes, geophysical methods and sensors recording on

a semi-continuous mode: meteorology data, groundwater data (with measurements of outflow from natural springs or drainage systems, piezometric levels, pore pressure at the sliding surface); and non-continuous mode: displacement rates (from D-GPS benchmarks networks, borehole devices such as inclinometers and TDR cables). Alongside, geochemical analysis of surface and deep seated water is carried out to highlight the depth of groundwater circulation paths. This dataset is used as an input to numerical models (hydrogeologic and stability oriented) that, if coupled, can allow the aliquot of groundwater recharge critical to movements reactivation to be defined starting from precipitation data. The results obtained have obviously a twofold possible usage: the development early warning or alerting systems and the design of mitigation measures such as deep drainage systems. The presentation will illustrate and discuss the landslides considered in the project, the monitoring data collected during 2004, 2005 and partially of 2006, and the first results obtained in the data processing and modelling.