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Integrated utilization of LIDAR and GPS positiong techniques for landslide monitoring

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The combined employment of LIDAR (Light Detection and Ranging) and GPS (Global Positioning System) technologies offers an elevated potentialities in the monitoring of the morphological evolution of landslide phenomena field. Land-based LIDAR allows to get terrain high resolution digital models, very useful to monitoring quantitatively hard reachable areas where modifications occurred. The point cloud generated allows an high precision reconstruction of an unstable area as, for example, a rock slope or a generically landslide phenomenon, permitting to perform comparisons between following surveys in a morphological or analytic (volumetric) point of view. GPS can be moreover used both as stand-alone monitoring tool, than as a support to the execution of the land-based LIDAR surveys for the creation of a reference net benchmarks for the correct positioning of laser shootings. According to the conditions of use and the studied phenomenon typologies, it is in fact possible to combine these two instrumentations in different ways, modifying their operational configuration. In addition, the possibility to use the GPS technology both in a mobile configuration than as permanent measuring station, allows to subsequently enhance the possibilities of mixed monitoring systems creation. The combining of repeated in time measures through LIDAR systems and of GPS sensors installed on the landslide allows to get an interesting compromise between continuous discrete measures and periodic areal surveys able to characterize the behaviour of landslide phenomena in hard reachable areas. By way of example, are here introduced two different study cases where the joined use of land-based LIDAR surveys techniques and GPS static positioning techniques has brought to interesting results: the San Francesco landslide, located in Tuscany (Italy) and the Le Ayas Landslide located in the high mountain zone of Piedmont region(Italy). The San Francesco landslide constitutes a typical example of slide in Appenninic pelitic deposits, where the utilization of terrestrial LI-

DAR techniques really represents one of the few effective systems to monitoring the phenomenon evolution; the Le Ayas landslide, a rock fall that interests the rocky substratum constituted by calcschist in alpine environment, has been studied with a laser scanner used to regularly monitor the evolution of the unstable rocky front, combined to a permanent GPS station that constantly measure the stability of rocky cluster conditions. The integrated experimentation of such systems during last years has allowed to perform innovative investigation methodologies, time by time refined and adapted to the various typologies of studied phenomena.