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Combining high resolution space- and air-borne data with borehole monitoring to investigate surface-subsurface water relations in landslide-prone slopes

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Water still seems to be a relatively little studied environmental factor in applications of multispectral space- and air-borne data to landslide investigations, even though stagnated drainage conditions have long been used as diagnostic elements for landslide recognition and mapping based on airphoto interpretation. Here we use both satellite imagery and airphotos, focusing on water as a critical factor of the recurrent instability of poorly drained slopes in a 15.6 km2 catchment area in the Apennine mountains (Italy) characterized by predominance of clay-rich flysch units and agricultural land use. We expand on our recent study (Wasowski et al., 2012) that exploited high resolution multispectral satellite imagery from early spring of 2006 for mapping active landslides, investigating their close association with seasonally wet zones (areas covered by free surface-water including ponds, migrating surface-water, seeps), and for inferring surface-subsurface relationships in unstable slopes. In particular, we use sub-meter resolution multispectral orthophotos acquired in late winter of 2011 to map the distributions of active landslides and wet zones. Considerable spatial-temporal recurrence of these features is indicated from a comparison of the 2011 and 2006 inventories. Furthermore, using the extensive subsurface dataset from piezometer boreholes (ongoing monitoring since 2009) we show that a number of remotely sensed wet zones are indicative of sites with seasonally persistent very high groundwater levels within landslide-prone slopes and on intermittently active landslides. Where such surface-subsurface water linkage can be established, the appearance of the wet zones (fully saturated ground/soil) resulting from groundwater discharge or seepage can be used as a forewarning signal of the increased susceptibility to landsliding, since the hillslopes with shallow groundwater tables are generally more prone to failure. However, the feasibility of retrieving reliable information about surface-water conditions from high resolution optical data, and the degree of its usefulness can be site-specific. This work suggests that useful results can be obtained in settings with similar topography (shallow slopes), lithology (clay-rich) and land use/land cover (agricultural soils with little woodland). A critical factor that will influence the results is the suitable timing of the imagery acquisition, in our case during wet season and early in vegetation period. Furthermore, acquisitions shortly after intense rainfall should be avoided if the focus is on wet zones indicative of shallow groundwater tables, that is those resulting from groundwater discharge and not just from accumulations of surface-water runoff.

References

Wasowski J., Lamanna C., Gigante G., Casarano D. 2012. High resolution satellite imagery analysis for inferring surface-subsurface water relationships in unstable slopes. Remote Sensing of Environment, 124, 135-148. doi: 10.1016/j.rse.2012.05.007