Detection and measurement of landslide deformation prior to their failure by satellite radar interferometry.

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Landslides are widespread landscape features in the Northern Apennine mountain chain and their activity frequently cause damages to settlements and infrastructures. In such context, slow-moving landslides are very common and typically affect fine-grained weathered rocks. Long periods of sustained slow-movements (cms/year) can be interrupted by rapid acceleration and catastrophic failures (ms/day) that are caused by intense rainfall events. Space-borne synthetic aperture radar interferometry (InSAR) proved effective to detect actively deforming phenomena and monitor their evolution in the periods before and after failures. We present InSAR results derived from the Sentinel 1 satellite constellation for landslide cases that underwent reactivation during 2019. In all cases, the catastrophic failures were unexpected and no ground-based monitoring data are available. We processed pre- and post-failure interferograms of SAR images acquired by Sentinel 1 A/B with time spans ranging from 6 to 24 days, removing those having low coherence by manual inspection. The conventional 2-pass technique allowed us to obtain measurements of surface displacement despite the fact that sparse to none infrastructures nor bare rock outcrops are present on the landslide bodies. Our interferograms show that surface displacements are visible well in advance of the actual failure. They display nearly continuous downslope motion with seasonal velocity changes. Time series between 2015 and 2019 shows that surface displacements can be appreciated throughout most part of the year with snow cover and summer peak of vegetation being the most notable exceptions. Distinct accelerations can be detected in space and time during the weeks and months preceding the reactivation.

We compare time-dependent deformations to precipitation patterns to explore their relationship and to document the transition from stable to unstable deformation. Our work suggests that InSAR interferometry can be successfully used to measure pre-failure displacements and detect slow-moving landslides that are more prone to reactivation in case of rainfall events.