Slope Motion Monitoring by ERS and ASAR Interferometry at Natural Surfaces and Artificial Reflectors

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Abstract

Satellite−borne SAR interferometry (InSAR) has evolved as a useful tool for mapping and monitoring displacements on mountain slopes. However, the requirement of temporal phase stability imposes major limitations on the applicability. Whereas the radar return from sparsely vegetated surfaces and built−up areas often remains coherent over annual to multi−annual intervals, dense vegetation causes decorrelation within short time. The permanent scatterer technique offers a solution to this problem if stable scattering objects are available. Moreover, a considerable number of repeat images is needed, which is not always the case, for example due to conflicting requirements of different SAR applications. In forested areas stable targets are often completely missing, so that the only solution for application of InSAR is the use of artificial targets. We investigated the use of plate reflectors for monitoring the displacement of a mountain slope near Innsbruck above a newly built settlement with about 60 houses that are affected by the slide. Metal plates of 1 x 1 m2 in size were mounted on concrete pillars that were inserted in the soil down to 1.5 m depth to avoid movements due to soil freezing and other near−surface effects. All together six reflectors were deployed in forest clearings and on meadows, partly on the mass waste, partly on stable ground. Displacements of the reflectors were analyzed using 12 Envisat ASAR images acquired between December 2002 and summer 2005. In order to separate the motion−related phase and the topographic phase, the latter is calculated from precise 3D positions of the reflectors determined by differential GPS measurements. Differential phase shifts up to 7mm/year LOS (ca. 2.5cm/year surface parallel) were measured between reflectors on stable ground and on the mass waste. The InSAR displacements agree well with those determined by GPS measurements carried out over a 4−month time span. This solution for obtaining stable targets may appear rather costly. However, any method for accurate geodetic repeat measurement requires very stable targets. The situation, experienced in this case study, is not uncommon in Alpine valleys, where steep slopes above settlements are often forested for protective reasons. In order to demonstrate the InSAR application on other surfaces, we show some results of slope motion analysis in Alpine terrain and in built−up areas. Interannual variations of slope motion have been derived from multi−year time series of ERS SAR and ASAR data. An example is shown where these variations seem to be linked to the hydrological regime. The examples confirm the great value of the SAR repeat pass data for mapping and long−term monitoring slope displacements, with the option of extending the applicability to forested areas by use of reflectors.