Application of Spaceborne SAR Interferometry for Detecting and Monitoring Slope Motion

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Interferometric analysis of repeat pass radar images (InSAR) enables mapping of displacements at the Earth's surface with millimetric accuracy. We report on InSAR methods and applications using satellite-borne synthetic aperture radar (SAR) to detect and monitor slope movements in various parts of the Eastern Alps. The satellite data base used for the analysis includes time series of SAR images from the European satellites ERS-1 and ERS-2, available since 1991, and data of the Advanced Synthetic Aperture Radar (ASAR) operating on Envisat, launched in March 2002. The methodology of InSAR for displacement mapping on the Earths surface is briefly reviewed. A pre-condition for successful InSAR analysis is the temporal coherence of the measured SAR signal. Based on the coherence analysis of repeat pass SAR images over the Austrian Alps the long term phase stability of various surfaces was investigated. Whereas on bare surfaces slopes covered by low vegetation and in built-up areas, the phase of the radar signal is preserved over time periods up to a few years, the signal decorrelates rapidly in densely vegetated areas. An option to monitor terrain motion in forested areas is the use of plate reflectors as control points for InSAR phase analysis. Possibilities and constraints for applying the InSAR technique were studied. For interpretation of the motion measurements it is important to take into account that InSAR is sensitive only to the displacement component in line of sight of the radar beam, but insensitive to any motion in along track direction. Additionally, due to image distortions in mountainous terrain the orientation of the investigation area relative to the radar beam is of relevance for the sensitivity of the InSAR measurements.
Examples for detecting and monitoring mass movements in Alpine areas are presented. Several landslides, with movements of the order of centimetres per year were analysed in detail, including the temporal evolution of the motion over several years. The studied phenomena include mass wastes in high Alpine areas and landslides above traffic lines and inhabited areas, representing potential hazards. In two test sites the InSAR motion maps were compared with ground based geodetic measurements, showing good agreement. Taking into account the capabilities and constraints of the technique, SAR interferometry provides a useful tool for mapping and monitoring surface displacement over extended time periods, an important indicator of slope stability. The InSAR method is of particular interest for regional surveys, for monitoring areas of difficult access and for retrospective studies.