ADVANCES IN TIME SERIES PERSISTENT SCATTERER INSAR

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ABSTRACT

Inference of the temporal evolution of crustal deformation is crucial for understanding geophysical processes. Therefore, a time series of spatially-dense radar images is a useful set of observations for remote sensing studies of the Earth. Successive pairs of radar images may be analyzed interferometrically to retrieve cm-level estimates of how crustal deformation is distributed in space and time. Angular or temporal variability of the radar echoes can limit the applicability of InSAR methods from many natural surfaces, because surfaces whose backscatter phase changes with angle or time yield decorrelated InSAR echoes. Yet many surfaces contain pixel-size regions dominated by reflection from a single scattering center, where the lack of self-interference of the reflected waves reduces the phase variation of the signal echo that we recognize as decorrelation. Persistent scattering (PS) methods have proven to be useful in extracting deformation signatures from these highly decorrelating natural terrains by restricting the analysis to the well-behaved points. For slowly varying deformation fields, such as fault creep, PS approaches work very well. For episodic events such as volcanic events or even variable subsidence applications, PS networks generally underestimate the deformation. The limitations of the technique appear to be mainly related to the sparseness of the data in both space and time. Stated another way, we do not have a robust algorithm for unwrapping sparsely sampled interferogram phase in three dimensions. One approach to overcome the phase unwrapping problem is to densify the sampling of the radar echoes by finding more PS points, easing the requirements on the unwrapping algorithm. Natural surfaces often contain so few coherent points that even if several PS points are found, they are too sparsely distributed to unwrap. Early PS implementations were most successful in examining urban areas with manmade structures, and hence many bright backscattering points. More recently, the development of phase-based persistent scatterer identification approaches has permitted application of the method to geophysical research. We have developed a maximum likelihood method for PS identification that can find even low-amplitude PS points, greatly improving the spatial density of reliable points over even that of the phase coherence approaches. We have applied the new detection methods to several different terrain types for various applications and present here sample PS network interferograms. We have examined several datasets using GPS observations or leveling data and show that the conventionally unwrapped PS solutions are overly smoothed temporally, where the data are still poorly sampled in time. We present here examples of methods we are developing to unwrap these data, so that PS analysis can successfully retrieve time series deformation records. Of particular promise is a new path independent phase unwrapping formulation that allows us to unwrap multi-dimensional data, and in addition providing us a method to constrain these solutions using measurements from other sources including GPS and leveling data. This approach can also be applied to increase spatial coverage by combining the results from PS and SBAS methods, We present here images of fault creep, geothermal activity, and volcanic inflation visible in PS time series and show the improvement in coverage over conventional InSAR methods.