DEVELOPING HIGH RESOLUTION ATMOSPHERIC PHASE SCREENS FOR INSAR TIME SERIES ANALYSIS

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1. INTRODUCTION

The atmospheric artifacts in interferometric synthetic aperture radar (InSAR) measurements are a large error source in accurately estimating terrain deformation signals [1]. For example, the large magnitude, high spatial frequency atmospheric bubbles can easily be misinterpreted as deformation phenomena [2, 3]. Various InSAR time series techniques, such as the Permanent Scatterer (PS) and Small Baseline Subsets (SBAS) algorithms, estimate and remove atmospheric phase screens (APS) from the differential interferograms [4-6]. However, these time series techniques only estimate the low spatial frequency part of the atmospheric signals.

2. NEW ALGORITHM

We present a new InSAR time series algorithm to estimate high resolution APS. Our algorithm initially finds a high density of phase-stable scatterers by examining phase differences between closely neighboring pixels in a stack of short time span differential interferograms. The neighborhood is limited to an area smaller than a typical atmospheric bubble observed in the interferograms and the interferograms span no more than a few orbit repeat cycles to limit the amount of deformation. We then estimate the digital elevation model (DEM) error gradients between neighboring pixels and unwrap the DEM error and linear phase residuals. We generate a time series of cumulative phase via a singular value decomposition, estimate the linear deformation velocity and de-trend the time series. High resolution APS are estimated on the dense set of phase-stable scatterers and interpolated to and removed from all differential interferogram pixels. With the high resolution APS removed, a final exhaustive search for PS in a set of PS differential interferograms can occur.

3. RESULTS

We first test the new algorithm and a PS InSAR algorithm with simulated set of differential interferograms with the same spatial and temporal baseline distribution as actual Radarsat-1 interferograms over a subsiding area in Phoenix, Arizona. The simulation consists of random DEM error between -15 meters and +15 meters, a linear deformation rate between 0 and +5 cm/yr created with the Matlab fractal generator, a nonlinear deformation represented by a sinusoid with 1year period and 1 cm magnitude superimposed on all pixels, and atmospheric phase with values between 0 and 3.14 radians created with the Matlab fractal generator. The APS are estimated from a set of 70 interferograms with temporal baselines less than or equal to 72 days and perpendicular baselines of ±1000 meters. The root mean square error (RMSE) between the estimated and simulated APS is 0.26 radians with our algorithm and 0.4 radians with the PS InSAR algorithm. The simulated deformation time series are estimated with less than 3 mm error with the new algorithm and less than 5.3 mm error with the PS InSAR algorithm.

We also apply the new algorithm to 61 Radarsat-1 Phoenix images spanning 2002 to 2007. The density of initial phase-stable scatterers with our algorithm is 253 PSC/km², whereas the density of detected PSC with the PS InSAR algorithm is 14 PSC/km². The APS embedded in the differential interferograms are estimated with the new algorithm and existing PS InSAR algorithm for comparison. Visual inspection shows that the high spatial frequency atmospheric signals appear in the new algorithm APS but only as a spatially low frequency version in the PS InSAR APS. The overall RMSE between all the differential interferograms and the estimated APS with our algorithm was 1.79 radians, whereas the RMSE was 1.82 radians with the PS InSAR algorithm. Interestingly, the final density of identified PS in a PS InSAR analysis using the high resolution APS is 453 PS/km², whereas the density of detected PS with the PS InSAR low resolution APS is 381 PS/km².

4. REFERENCES

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