Quantitative assessment on the requirements of DESDynI mission for crustal deformation study

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Spatial variation of turbulent tropospheric delay in interferograms has been known to limit the accuracy of InSAR data for deformation study. The atmospheric turbulence has larger energy in longer wavelength component, and the ground deformation often shows strong signal in large scale as well. Thus, it is difficult to distinguish the deformation signal from the atmospheric noise. The two components have to be compared at a wide range of distance scale, and this problem has to be addressed in an InSAR mission design.

In this study, the deformation signal and the atmospheric noise is quantitatively characterized for the requirements of NASA's future L-band InSAR mission, DESDynI. We implement forward calculations of various deformation source models to simulate the ground deformation due to earthquakes and magma migration. Then we formed simulated interferograms (Figure 1a) of the ground deformation and undersampled the synthetic InSAR data using quadtree algorithm (Figure 1b) so that each data point carries similar amount of data variance. The line-of-sight displacement differences of all possible pair of data points are

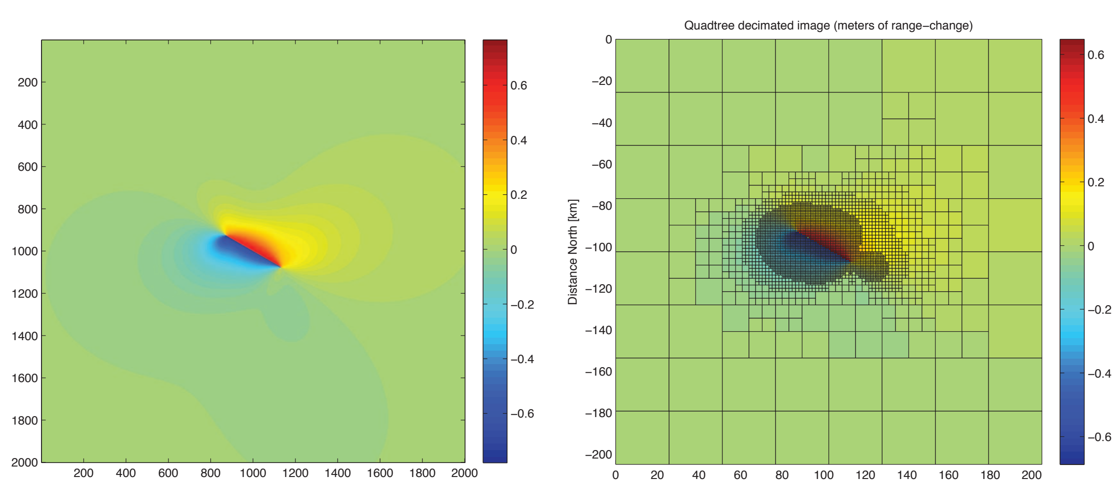

Figure 1. Synthetic interferogram of magnitude 7 strike-slip earthquake (a), and its reduced data using quadtree algorithm (b).

populated as a function of the distance between the two data points. Then the density of the scatter plot is compared with a power spectral density curve. In Figure 2, the blue dots are the scatter plot of the LOS displacement difference between all the possible pair of data points in Figure 1b. The density plot is overlaid on top of the blue dots. The red line shows the atmospheric noise power that has amplitude of 6.3 mm at 2 km distance scale, a value observed at the Western Galapagos Islands (Jónsson 2002, Hanssen 2001). probability density function of atmospheric noise power spectral density curves, which was acquired from many different places in the world including Hawaii, Galapagos, California, Netherlands, and Western Australia. This analysis will set a good example of quantitative and systematic way of achieving scientific requirements for future InSAR missions.

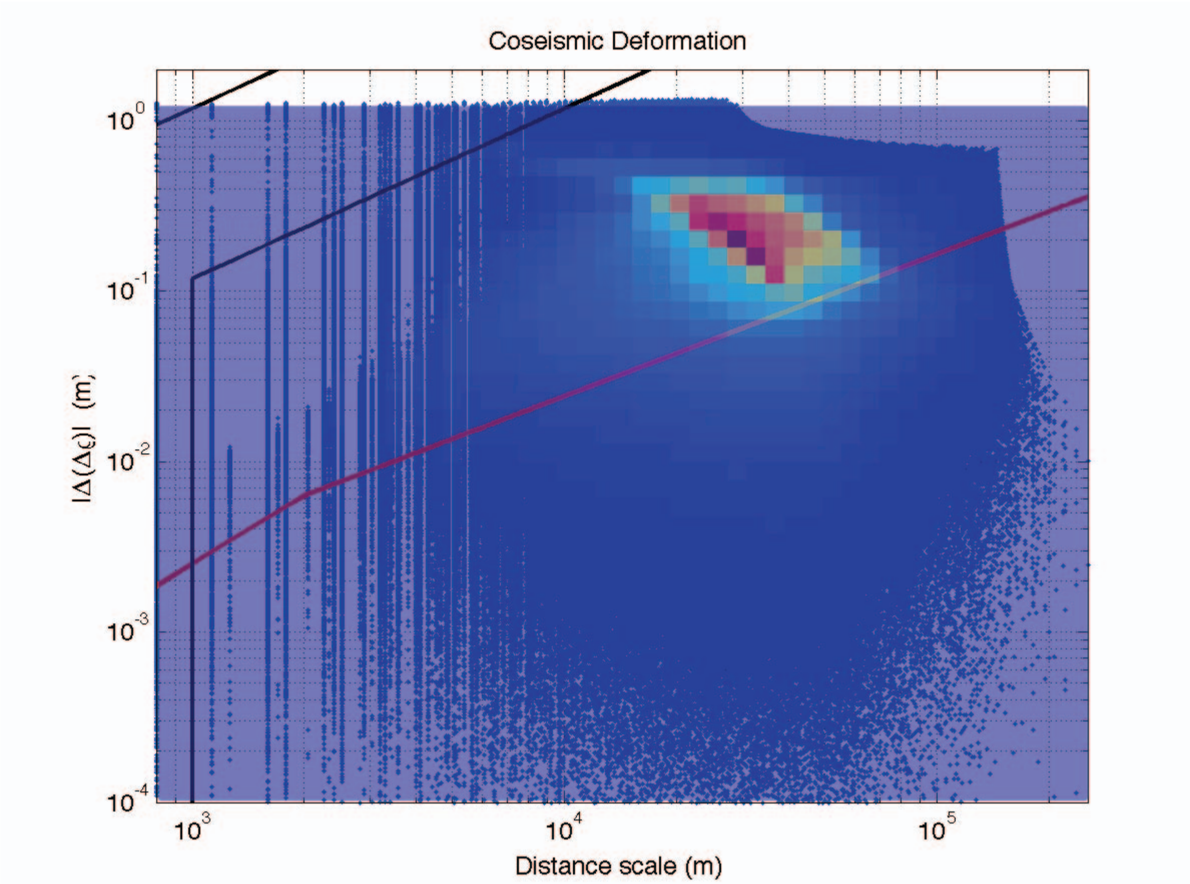

Figure 2. Line-of-sight displacement difference between all possible pairs of data points from Figure 1b are plotted with blue dots and its density plot is overlaid. The red line shows the structure function of turbulent tropospheric spatial variation. The black lines are the theoretical limit of maximum detectable displacement gradient for the case of 1 km pixel spacing (lower line) and 100 m (upper line).

References

Jónsson, S. (2002), Modeling volcano and earthquake deformation from satellite radar interferometric observations, Ph.D. thesis, Stanford University, Department of Geophysics, Stanford, CA.

Hanssen, R. (2001), Radar interferometry - data interpretation and error analysis, Kluwer Academic Press, Dordrecht, The Netherlands, 308 pp.