GRAPH THEORY FOR ANALYZING PAIR-WISE DATA: APPLICATIONS TO INTERFEROMETRIC SYNTHETIC APERTURE RADAR DATA AT OKMOK VOLCANO, ALASKA

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In this work, we apply techniques from graph theory in order to develop a novel technique for inferring time-dependent deformation from interferometric synthetic aperture radar (InSAR) data. Plotting acquisition dates (epochs) as vertices and pair-wise interferometric combinations as edges defines an incidence graph. The edge-vertex incidence matrix and the normalized edge Laplacian matrix are factors in the covariance matrix for the pair-wise data. Using empirical measures of residual scatter in the pair-wise observations, we estimate the variance at each epoch by inverting the covariance of the pair-wise data. We evaluate the rank deficiency of the corresponding least-squares problem via the edge-vertex incidence matrix. We implement our method in a MATLAB software package called GraphTreeTA available on GitHub (https://github.com/feigl/gipht). We apply temporal adjustment to the data set described by Lu, Masterlark, and Durizin (2005, Journal of Geophysical Research) at Okmok volcano, Alaska, which erupted most recently in 1997 and 2008. The data set contains 44 differential volumetric changes and uncertainties estimated from interferograms between 1997 and 2004. Using our method, we estimate that approximately half of the magma volume lost during the 1997 eruption was recovered by the summer of 2003. Our preferred model uses an exponential function followed by a secular interval and provides a reasonable fit that is compatible with viscoelastic relaxation in the five years following the 1997 eruption. Although we demonstrate the approach using volumetric rates of change, our formulation in terms of incidence graphs applies to any quantity derived from pair-wise differences, such as range changes, range gradients, or atmospheric effects.