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A real-time algorithm for detecting transient deformation signals using a particle-based Network Inversion Filter

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We present an online, or real-time, method for detecting transient crustal deformation signals due to transient fault slip episodes using data from large-scale geodetic arrays. Our method builds on the Network Inversion Filter (NIF) approach to time-dependent fault-slip inversion [Segall and Matthews, 1997; McGuire and Segall, 2003]. In the NIF, fault slip-rate is assumed to be steady in time in the absence of requirement from data. Deviations from steady-state slip-rate are parameterized by a temporal smoothing parameter. Fukuda et al. [2004, 2008] extended the NIF by treating the temporal smoothing parameter as a time-varying stochastic variable. The time-dependet posterior probability distribution of the temporal smoothing parameter is estimated as a function of time with an online particle-based filter, Monte Carlo mixture Kalman filter (MCMKF). When the data reflect steady-state fault slip rate, the temporal smoothing parameter tends toward a low value. However, if the data reflect transient fault slip, larger values are favored. This indicates that the temporal smoothing parameter can be used as an indicator for transient slip rate changes. Integrating the posterior probability distribution of the temporal smoothing parameter for values exceeding a maximum value associated with effectively steady deformation provides a measure of the probability that a transient signal had been detected, thereby allowing us to quantify the statistical significance of potential transients in real-time. In this presentation, we outline the theoretical basis for the method and show results from the application of this method to real data sets.