Results from a Model-independent method of monitoring a Geodetic network for patterns of transient deformation

K Hurst, R Granat

California Institute of Technology/Jet Propulsion Laboratory

Contact: Ken.Hurst@jpl.nasa.gov

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA

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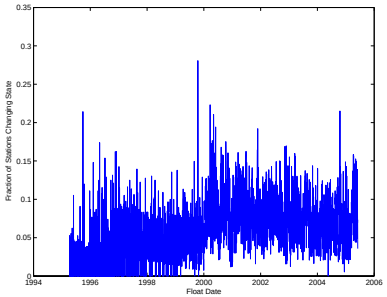
ABSTRACT

We have implemented two multi-station detectors for transient crustal deformation within the Southern California Integrated GPS Network (SCIGN). One of the primary goals of SCIGN is to detect transient deformation associated with the earthquake cycle in Southern California. Our methods are capable of monitoring SCIGN data for motions that would be too subtle to be detectable with data from just a single station. These methods are independent of the deformation mechanism and can be used to monitor a network to highlight areas of deformation for further study.

For both methods we first remove linear and periodic (yearly) signals from the data.

The first method stacks the displacement magnitudes for stations within a given radius of a each grid point, creating a map of areas with stations experiencing simultaneous motion. The analysis is repeated for a suite of radii ranging from 27.5 km to 110 km.

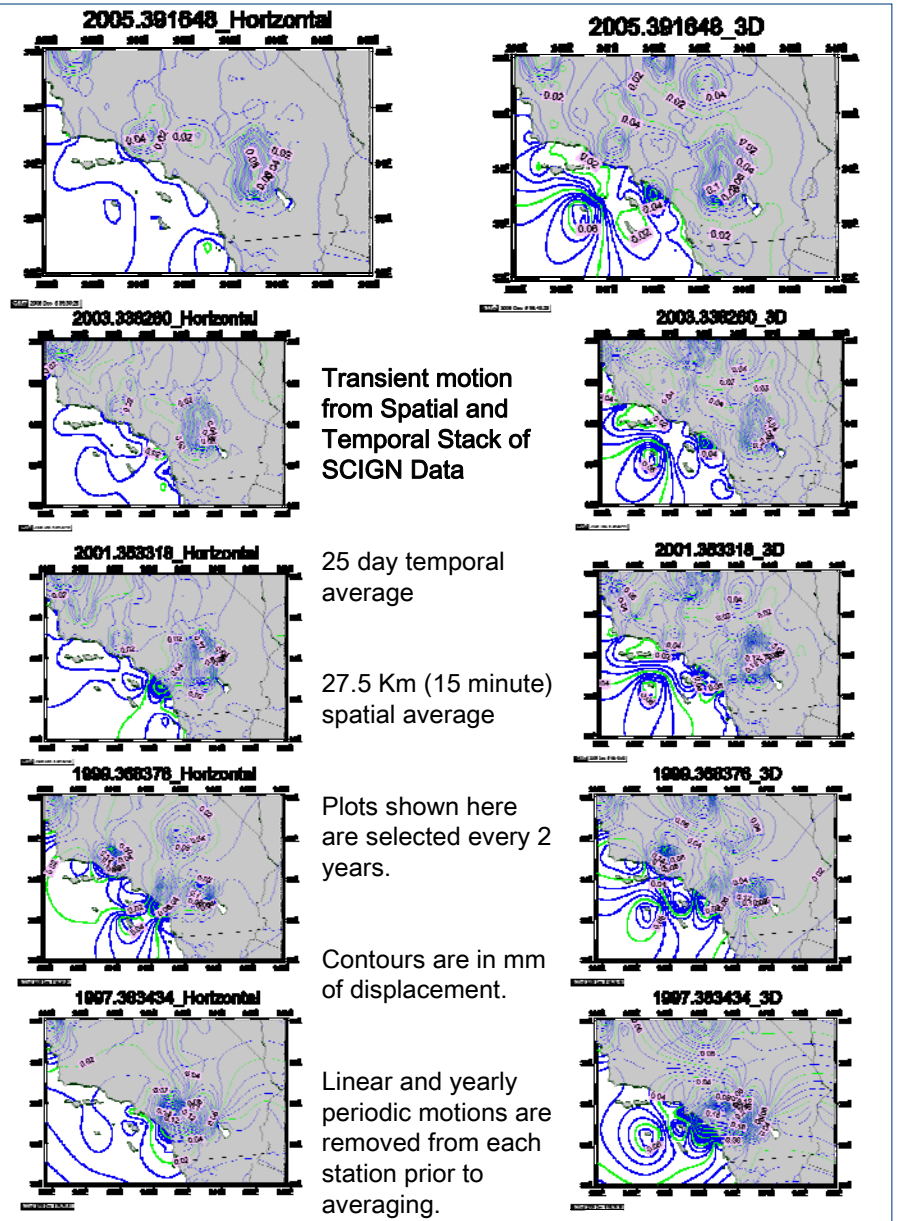
The second method uses a Hidden Markov Model (HMM) to identify mode changes within a time series. Times of coincident mode changes at multiple stations indicate regional deformation activity that may be sub-noise level. The regularized deterministic annealing expectation maximization algorithm is used to perform robust HMM fitting in the absence of a priori information about the source system.



Hidden Markov Model results looking for mode changes for GPS stations in the SCIGN data.

Normalized number of stations changing state on a given day in the SCIGN data.

Total number of stations changing state on a given day in the SCIGN data. The large rise from 1999-2001 is largely due to the increasing number of stations available.



Transient motion from Spatial and Temporal Stack of SCIGN Data

25 day temporal average

27.5 Km (15 minute) spatial average

Plots shown here are selected every 2 years.

Contours are in mm of displacement.

Linear and yearly periodic motions are removed from each station prior to averaging.

CONCLUSIONS: Transient (non-linear, and non periodic) motion is recorded by the SCIGN array. Our model-independent methods are capable of detecting it at well below the noise thresholds for a single station. The motions we have detected are spatially coherent. We would like to compare the maps above with seismic strain maps for the same periods.