Building Services and Web Portal for GPS Time Series Data Analysis

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In recent years, there has been an increasing demand for methods of analyzing geodetic time series data, informed in part by the observation of unusual aseismic deformation events in GPS data collected from Cascadia, Japan, Peru, and Mexico. The QuakeSim project aims to address this demand by developing a set of GPS analysis methods that can be easily accessed and used by the geophysics research community through a Web services and Web portal framework. We present one of these GPS analysis components, which performs hidden Markov model based segmentation of GPS time series. This component, the Daily RDAHMM Service, is built for performing RDAHMM (Regularized Deterministic Annealing Expectation Maximization for Hidden Markov Models) analysis on the daily integrated solutions generated by the GPS member stations of the Plate Boundary Observatory (PBO). By classifying the time series data points into statistically meaningful states, the RDAHMM analysis can detect anomalies in the GPS position observations through state changes, which can indicate geophysical events such as earthquakes or fault movements.

We developed a set of services that can be flexibly used to compose pipeline workflows of different treatments to the GPS data, including missing data treatment, de-trending, de-noising, applying RDAHMM analysis and generating results in both plain text and XML format. We also developed a Web portal to display the analysis results, as well as a set of Web services to facilitate extracting information from the results. The Web portal interface provides a rich set of interactive tools for users to access the analysis results, and presents both a macro-view (whole network) and a micro-view (individual station) of the results. In the macro-view, it provides an interactive Google map interface that can be used to browse the state change situation of the whole network on any date since January 1st, 1994. This network state can also be viewed in movie format, aiding visual identification of anomalous clusters of changed GPS stations. A state change frequency versus time plot provides a quick summary of overall network activity, acting as a focus-of-attention tool by clearly identifying times of increased activity. Macro-view results can also be exported as KML files for easy integration with other measurement data (such as InSAR imagery) and analysis results within the Google Earth environment. In the micro-view, it provides an interactive plot for showing every stations time series data and state change sequence, as well as ways for accessing their RDAHMM model and evaluation files. These analysis and visualization services are robust and flexible, and can be

readily extended to other sources of time series data, not only from the global GPS network, but also from other sensor networks, including seismic sensors, ground water measurements, and strain meters.

We have applied the Daily RDAHMM services and portal interface to analyze the GPS data solutions generated by both SOPAC GLOBK and JPL Gipsy context groups, as provided by the Southern California Integrated GPS Networks (SCIGN) Geophysical Resource Web Services (GRWS). We present several case studies in which the RDAHMM analysis through the portal environment has been able to detect both geophysical signals resulting from events such as earthquakes, and nonphysical data anomalies resulting from scenarios such as mistreatment or incomplete processing. We plan to incorporate more data sources into our analysis framework in the future, such as the UNAVCO solutions from the same stations.