Topic 1: Campaign GPS solutions

Campaign GPS Data Processing for Integrated SCEC Community Geodetic Model

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Campaign GPS Data Compilation and Inspection: Done.

- Searched UNAVCO and SCEC geodetic data archives and downloaded all the southern California campaign GPS data which were not incorporated into the CMM4 and Western US v1.0 solutions previously.

- Solicited and obtained campaign GPS data from various research groups that collected campaign GPS data but had not archived the data at the UNAVCO or SCEC data archives, including data from research groups of UC Riverside, Cal State San Bernardino, University of Arizona, and Scripps.

- Combined the new data with the dataset used in CMM4, checked common sites and unified site IDs, selected sites which had more than 2 years of survey time span for further analysis. 130 new sites have been added for southern California comparing to the CMM4 solutions.
• Inspected the daily observation time spans of the data, and adjusted time windows during daily data processing if the survey epochs of some sites were relatively short and span the UTC daily time boundaries.
840 sites selected in total, with observational time spans 2-23 years.
Daily GPS Data Processing: Done.

- Selected 19 continuous GPS sites in California and surrounding region as the regional fiducials to be included in the campaign data processing.
- Processed all the campaign GPS data together with data from the 19 continuous sites to obtain loosely constrained daily solutions 1986-2014 using the GAMIT software v.10.50.
• Selected 50 North America and 50 non-North America global tracking sites, and reprocessed the data to obtain loosely constrained daily solutions 1986-2014. Inclusion of these solutions helps stabilize the solutions and tie to the SNARF and global ITRF reference frame, particularly for early years.

• Combined all the campaign daily solutions with the North America and global network daily solutions using GLOBK.
Production of campaign GPS station position
time series: **On Going.**

- The QOCA software is used to produce station position time series with respect to a set of reference stations. The time series are then inspected for potential problems, which are then either fixed or have the outlier points discarded, and the process is repeated for further inspection (**the most time consuming part!**).
Problem example: Misidentification of GPS antenna models

Antenna serial numbers and model codes are missing from or incorrectly entered in the RINEX file headers. The problem is discovered for hundreds of Rinex data files by checking inconsistencies between antenna serial numbers and antenna model codes stored in the Rinex headers.

This problem is common for data collected using certain types of ASHTECH and TREMBLE receiver/antenna units 1992-1998, and would result in several millimeter biases if not corrected.
More on data time series inspections

• For some outliers in station position time series, if their daily solutions have high NRMS values, revisit their GAMIT data processings, and remove the satellite data with high postfit residuals, and reprocess the daily solutions. This helps fix some of the outlier data points of early years.

• Track down the possible sources of anomalous data points in time series, whether due to geothermal activities, antenna setup problems, fiducial site errors, or something else. Remove the ones which are not fixable.
Production of Crustal Motion Map: On going.

After the time series data are cleaned up, run QOCA again to solve for station velocities, coseismic offsets, and postseismic logarithmic displacements.

\[ X(t) = X_0 + Vt + D[H(t - T_e) + P[H(t-t_e)*\log(1 + t/T_d)] \]

- \( X_0 \): initial position
- \( V \): velocity
- \( T_e \): time of earthquake
- \( T_d \): postseismic decay time constant
- \( H \): Heaviside function
Constraints on 7 network configuration parameters are applied to tie the solutions to the SNARF reference frame.

Finite a priori constraints are applied to coseismic and postseismic displacements, with the values provided from (a) predictions of published earthquake rupture models, or (b) interpolation of well resolved displacement estimates at nearby continuous or campaign sites. Uncertainties of the constraints are assigned proportional to model predicted coseismic displacement amplitudes.
Problem with Solution of Secular Velocity and Postseismic Deformation in Mojave

\[ X(t) = X_0 + Vt + D H(t - T_e) + P H(t - T_e) \log(1 + t/T_d) \]

- \(X_0\): initial position
- \(V\): velocity
- \(T_e\): time of earthquake
- \(T_d\): postseismic decay time constant
- \(H\): Heaviside function

-- \(V\) and \(P\) are estimated simultaneously using postseismic time series data only

But, how reliable are they?
GPS Station Position Time Series

\[ X(t) = X_0 + V*t + D*H(t - T_e) + P * H(t-t_e) * \log(1 + t/T_d) \]

* \( X_0 \): initial position
* \( V \): velocity
* \( T_e \): time of earthquake
* \( T_d \): postseismic decay time constant
* \( H \): Heaviside function

To recover using triangulation/trilateration data (Liu et al., JGR, 2015).
Comparison Between Tria/Tril Data and GPS (CMM4) Predictions

Trilateration Networks

Triangulation Network
Block-fault models employed

Triangulation and Trilateration data fitting
One way to constrain CMM model in Mojave:

• Use secular velocities from Liu et al. (2015) as a priori to constrain sites located in Mojave Shear Zone, with uncertainty of 2 mm/yr.
• Run QOCA to solve for station velocities, coseismic offsets, and postseismic logarithmic displacements in a Karman filter procedure.
• Add a second long-term logarithmic term for post-Landers and Hector Mine postseismic deformation if necessary, for sites located in Mojave.
Production of station position time series: To be done.

- Use the model parameters obtained to compute the postfit residual time series, with and without the outliers removed. Add the model predicted values back to the time series to produce the station position time series. Advantage of producing the time series in this way is that it will help stabilize the network reference, which is important for the data of early years.
Comparing and Merging Solutions: To be done.

Compare our solutions with the continuous network solution produced by other CGM groups, assess possible sources of the differences. Impose constraints on network configuration parameters of the velocities of chosen fiducial sites through a least-squares procedure. The final solution will be provided for campaign GPS velocities and the coseismic and postseismic displacements, along with their variance/covariance matrices. GPS station time series will also be provided.
Topic 2: Postseismic

Detection of Common Mode Component: Postseismic Signals

Tian and Shen, JGR, in press
Thoughts on Campaign-continuous GPS Combination

• Velocity solution combination: It can be done by aligning campaign velocity solution to continuous velocity solution, by imposing constraints on network configuration of commonly used continuous site velocities.

• Time series combination: It can be done by, for each daily solution, using continuous site positions of that day of commonly used sites as a priori, and imposing 7 network configuration parameters on those sites to reproduce the daily solution and the time series.