UNAVCO GAGE GPS Data Analysis Plan and Products

Updated 12 September 2017

Data analysis plan prepared by Tom Herring, MIT, GAGE Analysis Center Coordinator.

Appendix A prepared by Tim Melbourne and Walter Szeliga, CWU Analysis Center.

Appendix B prepared by Mark Murray, NMT Analysis Center.

Appendices C-G prepared by David A. Phillips, UNAVCO and Tom Herring (Appendix H).

The most current information and resources regarding GAGE GPS data analysis and products, including updates, documentation, ancillary files, products log, technical news articles, and user notices and advisories is available from http://www.unavco.org/data/gps-gnss/derived-products/derived-products.html.

GAGE GPS data product users should read: Herring, T. A., T. I. Melbourne, M. H. Murray, M. A. Floyd, W. M. Szeliga, R. W. King, D. A. Phillips, C. M. Puskas, M. Santillan, and L. Wang (2016), Plate Boundary Observatory and related networks: GPS data analysis methods and geodetic products, *Rev. Geophys., 54*, doi:10.1002/2016RG000529. http://www.unavco.org/data/gps-gnss/derived-products/docs/Herring_et_al_2016_RevGeophys.pdf.

The GAGE GPS data products described in this document are available from ftp://data-out.unavco.org/pub/products.

GAGE GPS Data Analysis Plan

1 Introduction

GPS data analysis for initially the Plate Boundary Observatory (PBO) and currently the Geodesy Advancing Geosciences and EarthScope (GAGE) project is carried out in two phases. Analysis centers (ACs) at the Central Washington University (CWU) and New Mexico Institute of Mining and technology (NMT) process the GPS phase and pseudorange data to generate estimates of the coordinates of the GPS sites averaged over 24 hour periods. The Analysis Center Coordinator (ACC) at the Massachusetts Institute of Technology (MIT) combines the results from these analyses, produced in the SINEX format, to generate the final GAGE station coordinate product. Associated with the generation of these products, files containing the statistics on the phase data and estimates of atmospheric delays are also generated. The site coordinate information is made available both in SINEX format, containing full variance covariance information, and as time series files. The time series results are generated in a North American fixed reference frame and in the ITRF 2008 no-net-rotation reference frame. The results from the daily position estimates are combined to generate long-term velocity estimates of the sites in both the North America fixed frame and ITRF2008. In generating these velocity results, offsets due to earthquakes and equipment changes are estimated and low-quality outliers due to snow, for example, are removed from the velocity estimate solution so as to not corrupt it.

The philosophy in generating the daily position results is to include all results generated by the analysis centers. Even in cases where the daily position estimate is not likely to be correct, for example due to excess snow on the antenna, results are still retained in the time series and SINEX files. This procedure is used to allow users to reach their own conclusions concerning the quality of the data. By retaining the estimates users are aware of the existence of the data at that time although in most cases the estimates would be discarded from normal processing. When velocity fields are generated, these "bad" data are eliminated so as not to corrupt the velocity estimates. Algorithms based on signal-to-noise ratios (SNR), such as that described in Larson *et al.,* 2013) could be used to flag these anomalous position estimates in the time series. These algorithms are not yet implemented but may be in the future.

The methods used for reference frame alignment used in the GAGE processing differ from many other analysis centers. Frame alignment in the GAGE analysis uses only translation and rotation to align the daily solutions to the chosen reference frame. Scale is not included in the alignment parameters because scale changes are proportional to the mean of the height changes at the reference sites and thus scale estimates could absorb large spatial scale height changes across the GAGE network. When the phase center models are fixed in the GPS data processing as they are for the GAGE analyses, scale should be well determined for the GPS network. Users of GAGE results who want to remove scale changes can do so by simply removing the mean of the height differences at their chosen set of the reference frame sites (which will likely depend on the specific regional problem being addressed). In the GAGE estimation of the translation and rotation values for the frame alignment, heights are down-weighted relative to the horizontal components with a variance factor of 1000 so that height changes should have only a small effect on the estimates of the translation and rotation.

Recent analyses, have suggested that errors in the satellite phase center offsets (PCO) can induce "annual" signals in position estimates over large regions due to the changing geometry of satellite orbital plane and the sun through. This effect is not understood currently but seems to be related to the estimation of radiation parameters during the orbit determination. Although this error is not strictly a scale changes, scale change estimates seem to be able to alleviate this class of errors. Since the GAGE analyses do not estimate scale, they could be more sensitive to errors in the satellite PCO values that other analyses that estimate scale.

Appendix A describes the CWU Analysis Center processing specifications.
Appendix B describes the NMT Analysis Center processing specifications.
Appendix C describes position time series (*.pos) file naming and format.
Appendix D describes position time series (*.csv) file naming and format.
Appendix E describes the velocity (*.vel) file naming and format.
Appendix F describes coseismic event (*.evt) file naming and format.
Appendix G describes atmospheric delay (*.met) file naming and format.
Appendix H describes the discontinuity (KFOffset) file naming and format.

2 Analysis models

The analysis methods used by the GAGE analysis centers conform to the IERS 2010 conventions [IERS TN36, 2010]. Two different analysis programs are used to process the phase and range data collected by the GAGE GPS receivers. The analysis group at CWU uses the GIPSY/OASIS-II processing system developed at the Jet Propulsion Laboratory. The analysis group at NMT uses the GAMIT/GLOBK software developed at the Massachusetts Institute of Technology. The processing specifications for each of the analysis centers are given at the end of this document in Appendices A and B.

The GAGE analysis centers adhere to the IERS2010 conventions but there are some differences between the ACs that fall into the options allowed in the conventions. There are also some differences between products generated with very latency (approximately 1 day) and other analyses that process data more than a few days after the data is collected. These differences arise because of the availability of products needed for the longer latency processing.

In terms of IERS2010 conventions, the GAGE analysis centers use the Vienna mapping function VMF1 for determining the mapping function for longer latency products. Both analysis centers use the pressure, mapped to the height of the sites from the VMF1 grid files. To be consistent with the IGS processing standards, atmospheric pressure and water loading signals are not applied during the processing. In general, IGS products are used for the processing, although there are some deviations to ensure the consistency of the products generated by CWU and NMT. For the NMT analysis, IGS final orbits are held fixed (rapid orbits are used for the rapid products). For the CWU analysis JPL final orbits and clocks are used for all recent processing to ensure scale compatibility with the IGS08 reference frame. The transition to the IGS08 frame occurred on Date 2011/04/17, day-of-year 107, GPS Week 1632 [Rebischung et al., 2012] and all data prior to this change have been reprocessed in the IGS08 frame. The specific issue here is that the clock estimates generated by the original IGS processing (using the ITRF 2005 scale and antenna models) implicitly impart a scale change to the point positioning results generated by CWU. This problem does not affect the NMT processing because a double difference method is used to eliminate the clocks from the solution. A similar transition will occur associated with the adoption of the IGS14 reference frame. The IGS adopted this reference frame on Jan 29, 2017 (GPS week 1934) and after this date, there are differences between the rapid short latency processing and the later longer latency processing. These differences and their impacts are discussed in a separate document on the UNAVCO GPS data products website that will updated as efforts progress.

The AC solutions are delivered in SINEX format for the geodetic parameter estimates and tabular files containing information about the root-mean-square (RMS) scatter and number of phase residuals by site for each day. The NMT RMS files also contain information on the elevation angle dependence for the phase residuals. The SINEX file submitted by the AC are directly copied to the UNAVCO archive and are designated as “loose” files. The contents of the RMS files submitted by the ACs are merged into a single file labeled with a .rms extent and sent to UNAVCO. These .rms files have a header that explains the contents of the file. An example of an .rms file from rapid solution is GAGE18030.rapid_nam08.rms.

Format of the RMS file.

```
RMS File from  ../CWU_snx/cwu18030.20140727.a.rms ../NMT_snx/nmt18030.20140727.a.rms
Format Version : 1.1.0
Release Date   : 20140729120137
Start Field Description
Dot#            4-character identifier for a given station
GAGE_#           Number 30-sec phase epochs in 24-hours for combined RMS calculation
PRMS            Root-mean-square (RMS) scatter of combined phase residuals, mm
CWU_#           Number 30-sec phase epochs in 24-hours for CWU RMS calculation
CRMS            Root-mean-square (RMS) scatter of CWU phase residuals, mm
NMT_#            Number 30-sec phase epochs in 24-hours for NMT or BSL (prior to Feb 2006)
RMS calculation
```

```
NRMS            Root-mean-square (RMS) scatter of NMT or BSL phase residuals, mm
A                Coefficient from model fit RMS^2(elev) = A^2 + B^2/sin(elev)^2 where elev
is elevation angle, mm
B               Coefficient from model fit, mm
GPSW            GPS Week for 24-hour processing day
D               GPS Day of week for 24-hour processing day
YYYYMMDD        Year, month, day of month for 24-hour processing day
End Field Description
*Dot#  GAGE_#   PRMS    CWU_#   CRMS     NMT_#  NRMS       A      B GPSW D YYYYMMDD
 1NSU  22668    9.7    21140    8.5     24197   10.9     4.9    4.2 1803 0 20140727
 1ULM  22792    8.1    21030    7.0     24555    9.1     4.2    3.4 1803 0 20140727
 7ODM  22639    9.9    21010    9.4     24268   10.5     5.5    3.9 1803 0 20140727
 AB01  22657    6.4    20950    5.7     24365    7.1     3.0    2.7 1803 0 20140727
 AB02  22127    7.2    20190    5.9     24064    8.4     2.1    3.6 1803 0 20140727
…
 ZME1  22512   12.2    20880   10.9     24145   13.6     6.5    5.0 1803 0 20140727
 ZMP1  22657   11.9    20880   10.2     24434   13.6     6.0    5.2 1803 0 20140727
 ZNY1  22610   10.6    21270    9.4     23950   11.7     5.8    4.3 1803 0 20140727
 ZSE1  22972   11.7    21710   11.3     24235   12.0     6.4    4.2 1803 0 20140727
 ZTL4  22242   10.9    20760    9.7     23724   12.2     5.6    4.7 1803 0 20140727
```

In these files, the A and B coefficients representing the elevation dependence, expressed by the equation in the file header, are supplied by NMT. The number of data points in the CWU column are multiplied by 10 to make the values 5-minute sampled values used to CWU consistent with the 30-second sampled values used by NMT. The GAGE estimates are the averaged values between the NMT and CWU results weighted by the number of data listed.

The SINEX files supplied by the ACs are generated are generated differently. The NMT SINEX are delivered with weak constraints (100 meters) applied to the coordinates and are considered to be fiducial free solutions. These SINEX files have a full variance covariance matrix. The CWU solutions are from point positioning and the standard deviations of site coordinates are small (typically 1-3mm). The covariance matrices for these SINEX files have no site-to-site covariance values. In order to make these SINEX file fiducial free, we add to the block diagonal covariance matrix in the SINEX flies, a covariance matrix, which allows the system to rotate and translate so that we align them to different reference frame realizations. The added covariance matrices allow translation and rotation with standard deviations of ~1 meter at the surface of the Earth. There no earth orientation parameter (EOP) estimates in the CWU SINEX files and so we do not attempt to estimate EOPs in the GAGE analyses.

The procedures used to generate the daily GAGE products are the same for all latency products. There are four different latencies in the GAGE products (see section 3). The rapid solution latency is typically 24-hours and is generated when the IGS rapid products become available. Rapid solutions are generated daily. The final analysis latency is 2-3 weeks and is generated when the IGS final orbits become available. These analyses are performed in 1-week batches. Two other analyses are performed with 12-week and 26-week latency and add to the final analysis, sites whose data was not available at the time the final analysis was run. The long latency solutions are referred to supplemental and supplemental 6-month solutions. In addition, campaign processing may be added as requested by users and there are also reprocessing runs that supersede all previous results. In general, the latest results generated will have the most complete and up to date analyses.

Two different schemes are used by the ACs for weighting the phase and range data and the sampling interval used in the estimation scheme. NMT uses an elevation angle dependent phase data sigma (see RMS file example above) with the values used for each station determined from the post-fit phase residuals. The pseudo-range are not directly used the geodetic parameter estimation in the NMT analysis. Phase measurements are sampled every 2 minutes in the estimator. CWU used a fixed phase sigma independent of the elevation angle and the RMS scatter of the phase data at individual sites. 5-minute phase measurement samples are used in the estimator. This difference in the noise models and sampling rates in the geodetic analysis results in the need to scale the variance covariance matrices from the SINEX files. The scale factors are determined such that the average values of the χ^2/f, where f is the degrees of freedom, of the fits to the reference frame sites (typically 500-600 per day) are near unity. Fixed scale factors for all NMT and CWU solutions of 0.7 and 4.8, respectively, are used. When the two AC results are combined, these factors, applied to variances, are doubled so that the individual AC and combined GAGE solutions have similar standard deviations for the geodetic parameter estimates.

The GAGE individual AC and combined daily solutions are aligned to the GAGE realization of the North American plate using 500-600 reference frame sites. A hierarchical list of sites is used based on grid with 150 km node spacing placed over GAGE geographical region. In each grid cell a sorted list of sites in that cell is generated based on the process noise value associated with each site. During frame alignment only one site from each cell is used. In the current realization, up to 604 sites could be used with a typically number being about 530 sites. The loose frame solutions are rotated and translated to align to the North America reference frame. The heights are down weighted by a variance factor of 1000 in determining the reference frame transformation parameters. An IGS08 no-net-rotation (NNR) frame solution is also generated using similar algorithms but operating on the time series generated in the North America frame. This operation is done using the GAMIT/GLOBK program tscon. The hierarchical list of reference frame sites is given in All_PBO.stab. This file is updated with each annual release of a new velocity and reference frame solution. The current release is 20161203.

The current North America reference frame, NAM08, is based on rotating IGS08 into the North America frame using the Euler pole from Altamimi *et al.* [2012]. The rotation vector used has rotation rates around the X- Y- and Z-axes of 0.0275 -0.6752 -0.0729 mas/yr. This rotation vector corresponds to a rotation pole at longitude/latitude of -87.6655/-6.1542 degs, rotating with a rate of 0.1888 deg/Myr. The GAGE reference frame is center of figure (as is ITRF2008). To generate results in a center of mass system, Altimimi et al., 2012 gives the translation rates as (Tx Ty Tz) = (0.41 0.22 0.41) mm/yr to be used. The initial frame is realized by aligning the GAGE combined velocity solution to IGS08 rotated to North America using 37 IGS08 sites (ALGO, ALRT, AMC2, BAKE, BARH, BILI, BOGT, BREW, BRMU, CHUR, CRO1, DUBO, EISL, EPRT, FLIN, GODE, GUAT, INVK, KELY, KOKB, MANA, MAUI, MDO1, MKEA, NAIN, NANO, NLIB, NRC1, PIE1, PRDS, QIKI, RESO, SCH2, SSIA, STJO, THU3, USNO). The positions and velocities of the GAGE sites generated from this solution are then used as the basis of the daily frame realization. The IGS08 coordinates used for the original position and velocity alignment is igs08_noam.apr. Time series fitting to the NAM08 aligned time series, including earthquake offsets, post-seismic log fits, and antenna discontinuity offsets and annual signal are used to generate the final NAM08 reference frame apriori coordinate file. The current version is All_PBO_nam08.apr for NAM08 and All_PBO_igs08.apr for IGS08. Although annual sine and cosine terms are included in these files, these values are not used during reference frame realization. Discontinuities included in the analyses are given in several GLOBK earthquake/rename files. We also now distribute estimates of these offsets in KFOffset file discussed in Appendix H. In GLOBK, sites are given 8-character site names. The first 4-characters are given the standard 4-character site codes of the GAGE sites. A standard site name would have GPS as the other 4 characters. Sites affected by earthquakes have the last 2 characters of their name (PS by default) to a 2-character code associated with the earthquake. For GAGE these codes are most 2-digit numeric values incremented with each earthquake. For large earthquakes, descriptive 2-character codes are often assigned such a PA for the 2005 Parkfield event. The *EQ_DEF* lines in the earthquake files give the assigned code. For antenna offsets, the 6^{th} character in the name is changed starting with 2 and numerically progressing into the capital letters except G and X (XPS and XCL names denote sites to be removed for the analysis). Antenna offsets are included whenever an antenna or radome is changed at the site. Some offsets are observed in the time series and their origin is often not known. (In some cases, they are due to the onset of damage at a time that can only be determined by examining the time series. The current GAGE earthquake file is All_PBO_eqs.eq, antenna offsets due antenna changes file is All_PBO_ants.eq and the offsets due to unknown reasons (speculations are included in the comments in the file) is All_PBO_unkn.eq.

3 Velocity field generation

GAGE velocity fields are generated by two different methods on two different time scales. On an annual basis, velocity fields are generated using a full SINEX combination. These annual solutions use the discontinuity files given above and process noise models for the sites that account for the temporal correlations in the time series. The process noise models, in the form of random walk time-step variances are given in All_PBO.rw. A list of sites to be used in these solutions is given in All_PBO.use based on the process noise levels at the sites. Sites which have process noise values greater than 2.0 mm^2/yr are not included in this velocity solution so that they do not contaminate nearby sites. The process noise statistics are generated from the time series using the GAMIT/GLOBK script sh_gen_stats based on tsfit fits to the time series with the realistic sigma algorithm used to account for correlated noise. The tsfit solutions also generates a lists of site position estimates not to be used in the velocity solution because they are outliers (either due to bad analyses, antenna failures or snow on antennas). The current list of edited site position estimates is given in All_PBO_edits.eq. These edits can by AC or for both ACs.

Because of the long run time of these SINEX velocity solutions different methods have been used to generate them. Prior to August 2014, they were generated as 7 separate combinations with solutions using 1 day per week on each day of the week. These 14 runs, 7 for CWU and 7 for NMT, can be run parallel and then combined at the end. Each of the 7 solutions is given a 1/7 weight variance to account for the correlated noise in the solutions when the 7 days of solution are combined. Once the velocity solution is completed, the velocity estimates at sites with multiple names are made equal using the equate command in the GAMIT/GLOBK module glorg. IGS08 velocity fields can be generated from the final combination by changing the reference frame alignment with GAMIT/GLOBJK program glorg.

After August 2014 the GAGE velocity solutions are generated differently due to long runs times, even with the decimation, the time needed for the combination was excessively long. These runs are very long because of all of the entries needed in the state vector to accommodate the offsets from equipment changes and earthquakes. When all these offset estimates are included, the GAGE processing of ~1800 sites becomes the equivalent of processing over 4000 sites. The current generation of solutions divides the sites to be combined into sub-networks. The position and velocity are generated for each network (1-day per week is used to speed up these runs) and the complete solution is generated but combining all the sub-networks (which share no common sites) with a sub-network that contains three carefully chosen sites from each subnet. The three sites in each subnetwork are need to all translation and rotation estimates for each subnet to be estimated in the combination. These solutions still take 1-2 days to complete with sub-networks running in parallel.

The other type of velocity solution generated uses the time series directly and this approach is much faster. These solutions are generated monthly and use the same discontinuity and earthquake files as the full velocity solutions. The earthquake and discontinuity files are updated each month to add new entry for the month. These velocity fields are called snapshot velocity fields. All sites are included in these files because there are no interactions between the sites. Two types of time series analyses are used. The snaphot velocity fields for NMT, CWU and PBO combined are created in the NAM08 frame and the PBO combined solution is also created in the IGS08 frame using a weighted least squares estimator with the standard deviations modified based on the realistic sigma algorithm. A Kalman filter is also performed on the PBO combined time series in the NAM08 reference frame. This later solution is used to generate the discontinuity estimates and the time series event files. The Kalman filter analysis with appropriate random walk process noise yields more reliable estimates of the offsets and sigmas in time series that have systematic residuals.

4 Products generated by Analysis Center Coordinator

The ACC uses the Level 2a SINEX files from each Analysis Center to produce a series of combined Level 2b GPS data products, in accordance with standards laid out above.

(a) Daily rapid solutions
Merged SINEX files based on each day's rapid SINEX files. These merged files contain network solutions that are loosely constrained and constrained to a standard reference frame as described in section 2. Additionally, ASCII time series, containing data not yet in the final solutions (see below), are created from the merged and constrained SINEX files. The SINEX alignments are made to the NAM08 reference frame. Normally, the rapid time series files will contain 7-14 days of results depending on the generation of the finals solution. Daily reports are generated that compare the results between the two AC solutions, report metadata errors, and note sites with deviations from the apriori motions of the sites. The IGS08 time series are generated by aligning the NAM08 time series files to the IGS08 no-net-rotation system. The rapid solutions are not used after the final and subsequent solutions are available. The rapid solutions also differ from the solutions below in that the 2nd order ionospheric delay are not applied and the VMF1 mapping functions are not used (see analysis center descriptions in Appendices A and B).

(b) "Final" solutions
Merged SINEX files based on each day's "final" SINEX files. These solutions are generated with IGS final orbit products for NMT and JPL final orbit and clock products for CWU. These merged files contain network solutions that are constrained to a standard North America fixed reference frame. ASCII time series will be derived from this combined solution and these time series files contain the times series for all data processed to date. These products are generated in 7-day batches based on GPS weeks and will become available after the weekly releases of the IGS final orbits. Reports are generated from each day of data in the

week and contain the same information as the rapid processing described above. Time series in North America fixed (NAM08) and the International Terrestrial Frame (ITRF2008 as realized through IGb08 are generated. SINEX files in fiducial free (loose) and NAM08 are generated.

(c) "Supplemental" solutions

SINEX files generated by merging the solution files from the corresponding final solution with supplemental solutions that contain sites not in the original final solution and a small number of overlap sites to allow alignment of the reference frame. ASCII time series files, merged with the final time series files, are generated from these supplemental analyses.

The routine supplemental analyses are run with 12-week and 26-week latencies (SUPPL and SUPP6 labels where the 6 is for 6 months). Since the SUPP6 solution includes all stations with new data since the time the original FINAL solution was run (including those in the 12-week supplemental) the combined final and suppl or suppl6 SINEX files are simply labeled as suppl. The supp6 solutions contain all sites in the suppl solution plus any other whose data have become available since the suppl solution was run. The frame resolved (NAM08) SINEX files contain all stations processed to that time. The loose SINEX files are the ones originally submitted by the ACs except for the GAGE loose solution, which contains all sites.

A supplemental solution called "suppf" was introduced in 2006. The convention in the naming is "suppf" used for a site that was in the original finals runs and "suppl" for a site added in the supplemental solution itself (normally there are 30-40 of these sites per supplemental run). Since there can be small changes in the coordinates of sites between the original final run and the supplemental runs where the original final SINEX files are combined with the (smaller) supplemental SINEX files, it was felt important to change the designation so that users who had been downloading .pos files would know why there are small changes in the coordinates of the sites."

A supplemental solution called "rern6" was introduced in 2015 for a block of GAGE analysis that were being repeated to fix some deficiencies in the original analyses carried in 2013 and early 2014. The reprocessing period is 2013/01/06-2014/03/22 (GPS weeks 1722-1784) for CWU and 2013/04/07-2013/05/04 (GPS weeks 1735- 1738) for NMT. The reprocessing will correct noisy results in height estimates during this period. SINEX files and time series will be re- generated and during the few days needed to re-combine all the reprocessed results there could be a blend of old and new processing results in the GAGE time series. The recombined shoudl be completed by 2015/12/01. Most of these entries have been or will be replaced with repro designations.

(d) "Campaign" solutions

Occasionally, the GAGE analysis centers will process campaign GPS data for UNAVCO users who want their results in the GAGE reference system. These campaign analyses are treated like the supplemental solutions and the result combined SINEX files contain all data processed to that time. If the campaign processing is done before the GAGE AC run the supplemental runs, the campaign sites will be added to the supplemental list of stations and the supplemental SINEX file will replace the campaign one. SINEX files which include campaign data are labeled campd.

(e) "Reprocessed" solutions

When there are large changes to the IGS processing models and the IGS generates a set of reprocessed solutions, GAGE reprocesses all the GAGE data including these new models and products from the IGS. Campaign sites are also included in the reprocessed analyses. The most recent of these solutions used the IGS repro1 reprocessing and the ITRF2008 system. These solutions are labeled repro and replace all prior solutions. By mid-2015, IGS had completed repro2 and the ITRF2014 system will be defined based on this reprocessing and reprocessing from the other space geodetic systems. It is expected that GAGE will be reprocessed in early to mid 2017 when JPL completes its generation of orbits and clocks in the IGS14 system. The IGS has released the repro2 orbits consistent with the ITRF2014 system and these will be used by in the NMT analyses.

Users downloading SINEX files should always take the latest SINEX file for a given day since these files will contain the most complete group of stations. The SINEX files labeled loose from NMT and CWU will contain the SINEX files from which the combined SINEX files are generated.

(f) Velocity solutions

The full velocity solutions derived from the combined SINEX files annually, and these files are updated using fits to the time series on a monthly basis. The annual velocity solutions are provided in both ASCII and SINEX formats in NAM08 and IGS08 reference frames. The velocity field solutions incorporate estimates of offsets from antenna changes, equipment problems (such as broken radomes), and earthquakes. For earthquakes with large post-seismic deformations, time dependent models are estimated, in the form of log functions with earthquake dependent time constants, so that the velocity estimates will not be greatly affected by the earthquake post-seismic motions. Since the post-seismic signals take time to develop, post-seismic log terms may be found to be needed many months after an earthquake and so these parameterizat ions evolve with time. Monthly velocity estimates are also generated based on time series analysis (direct fitting to time series as opposed to the (much more time consuming) rigorous combination of SINEX files) in North America fixed and IGS08 frames. These monthly velocity field estimates are referred to as snapshot velocity fields.

(g) Coseismic offsets and postseismic log terms for significant events

The ACC generates two types of the significant event files. Co-seismic offsets are estimated from a short span of data (normally 2-days) on either side of the event and they are also estimated from Kalman filter time series analyses. For the latter analyses, postseismic log terms are also estimated, if needed, and are made available in the same format as the coseismic offsets.

The ACC generates "rapid" and "final" offset estimates for events that result in station position displacements beyond an agreed upon threshold (currently 1mm), for stations within the footprint of all processing groups. All offsets will be archived (and made available for download) in a centralized place by the ACC and UNAVCO. These initial event files are made available within a few days (rapid) to weeks (finals and later processing). The time series analyses would start being generated as part of the monthly reports after the event occurs.

At times there are reassessments of the significance of events and some event numbers may be removed if later analyses of data suggest that they are not as significant as first thought. In some cases, events can be missed and event number are added at a later time. The time series derived event files contain all events that are considered significant.

Event file estimates are made available rapidly after large earthquakes with the initial estimates based on the difference between position estimates two days before and after the day of the earthquake (thus a 3-day latency). These estimates are updated at the time when the final and supplement runs are submitted by the ACs. These later runs could contain more sites than the initial rapid solutions. Time series analyses are also used to generate event files based on Kalman filter of the entire time series of a given site. During the annual velocity field analyses and at other times as well, the need for postseismic signal modeling is assessed and incorporated in the velocity solution estimates.

An empirical algorithm based on fits to coseismic models and GPS estimates is used to make a preliminary assessment of the likely magnitude of offsets from an earthquake. This algorithm is embedded in the GAMIT/GLOBK script sh_makeeqdef which creates an GLOBK earthquake definition file that can be used (after name modification) in GLOBK and the time series fitting tools tsfit and tsview. Each candidate earthquake is examined in tsview and an assessment made of whether the event contributed a significant coseismic offset. In some cases, this assessment can be difficult due to missing data and snow and/or ice on antennas (especially for some Alaska and volcanic sites). If the event is deemed significant is added to the cumulative GAGE earthquake definition file with, in most cases, a sequential 2-digit number assigned to the earthquake. For large events, a 2-charater code is often assigned (e.g., PA for the 2010 Parkfield earthquake.) Both the NEIC catalog (http://neic.usgs.gov/) and the ISC bulletins are used (http://www.isc.ac.uk) are used to determine earthquakes that may have resulted in coseismic offsets. The algorithm used predicts (a) the distance from the epicenter that 1 mm coseismic displacement could happen, and (b) the magnitude of the possible offsets as a function of distance from the epicenter, based on the magnitude of the earthquake in the catalog. Since this is an approximate algorithm, the magnitude in the catalog, independent of its type, is used. For some earthquakes, we fit single fault plane solutions to the coseismic offsets and use these estimates of the parameters in the eq_def entries in the All_PBO_eqs.eq input file. The file contains comments when then method is used. The entries are generated using the GAMIT/GLOBK sh_eq_model script but since this involved non-linear parameter estimation, some analyst interaction is typically needed to generate a robust result.

Time series of sites with large co-seismic offsets are monitored to assess if a post-seismic non-linear parameterization is needed. In some cases, it may take up to a year for it be clear that post-seismic log estimates are needed. The postseismic log behavior is modeled as $\Delta P(\Delta t) = C \ln\left(1 - \frac{\Delta t}{\tau}\right)$ where Δt is the time since the earthquake, $\Delta P(\Delta t)$ is the position change in north, east or up (N, E or U), C is the log coefficient of N, E, or U in the event file and τ is the time constant for the postseismic motion. The time units are the same between Δt and τ. This time constant is given in the "Event Type" line in the event file header.

In most cases, data two-days before and after the earthquake, excluding the day of the earthquake, are used to compute the initial estimates of the offsets. In some cases when data near the earthquake are missing, an extended number of days will be used. This feature is sometimes needed for sites with low telemetry rates. In later processing, we also generate results from the analysis of the full-time series (see event file description in Appendix H). These time series are generated with a Kalman filter which tends to generate more reliable estimates of offsets when there is systematic noise in the time-series. Post-seismic log coefficients are also generated and reported in the time-series event files.

5 GLOBK documentation

The GLOBK processing scripts and control files are given in GAGE_ACC_export.tar file. The GAGE_export_README.txt file explains how to use the files contained in the tar file. The control and tables directories included the export tar are included here as well. (The export tar file is large because it contains example data sets as well). The contents of this file are given here.

```
Notes on use of GAGE processing scripts

These scripts assume that GAMIT/GLOBK is installed and the standard gg
link exists.  The scripts included here are the operational scripts.
These scripts can be used to reference to an ftp area where
subdirectories NMT and CWU would contain SINEX and RMS files generated
by the GAGE Acs.  For most users, the simpler method is to put the
SINEX and RMS files in the subdirectories NMT_snx and CWU_snx.  The RMS
files are not needed to generate position time-series but some of the
summary scripts will report errors if the RMS files do not exist (these
errors can be ignored if phase RMS values are not of interest).

A small number of SINEX files generated by the AC have been saved in
the NMT_snx and CWU_snx files for testing.  These files are for 2012 12
31 (all solutions) and 2013 01 01 rapid solution.  This latter file is
included because the sh_rapid_ts shell script that generates rapid time
series files will only generate values for dates that are after the
last final orbit solution processed.  The scripts also contain features
unlikely to be used by other users such as the ldm option which queues
solution to LDM to be transferred to UNAVCO.

To test the solutions, use the following commands to be executed in the
export/control directory.
csh PBO_final.cmd -d 2012 366 -m `whoami` -clear >&! FIN_12366.out
sh_final_ts -w 1721
csh PBO_rapid.cmd -d 2013 6 -m `whoami` -clear -ts >&! RAP_13006.out
Other solutions that can run are
csh PBO_suppl.cmd -d 2012 366 -m `whoami` -clear >&! SUP_12366.out
csh PBO_supp6.cmd -d 2012 366 -m `whoami` -clear >&! SU6_12366.out
csh PBO_repro.cmd -d 2012 366 -m `whoami` -clear >&! REP_12366.out

After each of these runs, the corresponding sh_<type>_ts script is used
to generate the time-series files.

Notes on above solutions:
Since final, suppl, supp6 and repro solutions are usually processed one
week batches, the time series files are created after the last day of
the week has been processed and so above we explicitly show the use the
time series generation script/
```

When using these scripts, you should regularly update the earth orientation parameter (EOP) a priori values using GAMIT script sh_update_eop.

In the export/tables directory use:
sh_update_eop -ser usno

Information after station meta data should be kept update by down loading station.info from the GAMIT/GLOBK ftp site into the export/tables directory. In general, the tables directory for your GAMIT/GLOBK installation should be updated regularly. (The station.info file in export/control could be linked to ~/gg/tables/station.info to ensure it is kept up to date.

Meta data errors are reported in the processing scripts and the example data given show how changes in the antenna phase center models can affect the results. (Models for two antennas were changed between the original finals processing and the values used now).

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APPENDIX A. Central Washington University Analysis Parameters.

```
|============================================================================
|                                                                           |
|                                                                           |
|                      PLATE BOUNDARY OBSERVATORY (GAGE)                    |
|                                                                           |
|                    CWU Analysis Center Strategy Summary                   |
|                                                                           |
|                                                                           |
|===========================================================================|
|ANALYSIS CENTER     | Central Washington University (CWU)                  |
|                    | Geodesy Lab & PANGA Facility                         |
|                    | 400 East University Way                              |
|                    | Ellensburg, WA 98926                                 |
|                    | USA                                                  |
|                    | Fax: +1 509 963 1109                                 |
|                    | Data Archive:                                        |
|                    |    ftp://sideshow.jpl.nasa.gov/pub/JPL_GPS_Products  |
|                    |    ftp://ftp.panga.cwu.edu/pub/GAGE_ac               |
|---------------------------------------------------------------------------|
|CONTACT PERSON(S)   | Dr. Tim Melbourne                                    |
|                    |   E-mail: tim (at) geology.cwu.edu                   |
|                    |   Phone:  +1-509-963-2799                            |
|                    |                                                      |
|                    | Dr. Walter Szeliga                                   |
|                    |   E-mail: walter (at) geology.cwu.edu                |
|                    |   Phone:  +1-509-963-2705                            |
|                    |                                                      |
|                    | M.S. Marcelo Santillan                               |
|                    |   E-mail: marcelo (at) geology.cwu.edu               |
|                    |   Phone:  +1-509-963-1107                            |
|                    |                                                      |
|---------------------------------------------------------------------------|
|SOFTWARE USED       | GIPSY/OASIS-II Version 6.4 developed at JPL          |
|                    | GOAT (GIPSY OASIS Toolkit) developed at CWU          |
|---------------------------------------------------------------------------|
|List of JPL's       | YYYY-MM-DD.pos  GPS orbits for all satellites        |
|analysis products   | YYYY-MM-DD.tdp  Satellite clocks + yaw rates         |
|                    | YYYY-MM-DD.eo   Earth orientation parameters         |
|Rapid Products      | YYYY-MM-DD.shad Shadow events                        |
|generated daily     | YYYY-MM-DD.ant  Receiver/Transmitter                 |
|in fiducial frame   |                 antenna calibration used             |
|                    | YYYY-MM-DD.frame Reference frame for provied orbits  |
|                    | YYYY-MM-DD.wlpb Global set of wide-lane biases       |
|                    |                 used for bias fixing (PPP-AR)        |
|                    |                                                      |
|                    | YYYY-MM-DD_nf.pos GPS orbits for all satellites      |
|                    | YYYY-MM-DD_nf.tdp Satellite clocks + yaw rates       |
|                    | YYYY-MM-DD_nf.eo  Earth orientation parameters       |
|Final Products      | YYYY-MM-DD.shad   Shadow events                      |
|generated weekly    | YYYY-MM-DD.ant    Receiver/Transmitter               |
|in non-fiducial     |                   antenna calibration used           |
|frame               | YYYY-MM-DD.frame  Reference frame for provided orbits|
|                    | YYYY-MM-DD.x       7 parameter Helmert's transform from|
|                    |                 fiducial frame to the frame in       |
|                    |                  .frame file                         |
|YYYY : 4 digit year | YYYY-MM-DD_nf.wlpb Global set of wide-lane biases    |
|MM   : 2 digit month|                    used for bias fixing (PPP-AR)     |
|DD   : 2 digit day  |                                                      |
|                    |                                                      |
|---------------------------------------------------------------------------|
|PREPARATION DATE    | June  26, 2013                                       |
|---------------------------------------------------------------------------|
```

MODIFICATION DATES	2 Jul. 2015: Update to reflect recent PBO reprocessing 14 Mar. 2017: Update to reflect transition to IGS14
EFFECTIVE DATE FOR DATA ANALYSIS	Week 1934 onwards

MEASUREMENT MODELS	
Preprocessing	Carrier Phase: Decimated to 5 minutes Pseudorange: Decimated to 5 minutes Cycle slip detection
Basic Observable	Undifferenced ionosphere-free carrier phase, LC Undifferenced ionosphere-free pseudorange, PC
	Elevation angle cutoff: 15 degrees Sampling rate: 5 minutes Data weight, LC: 1 cm Data weight, PC: 1 m
Modeled observable	Undifferenced LC and PC combinations CA-P1 biases from CODE applied
RHC phase rotation corr.	Applied
Marker -> antenna ARP eccentricity	dN, dE, dU eccentricities from CWU sinex file applied to compute station marker coordinates
Ground antenna phase center cal.	Final Orbits PCV model from igs08_wwww.atx applied Rapid Orbits PCV model from igs14_wwww.atx applied
Troposphere	A priori model: Dry delay Final Orbits VMF1 Rapid Orbits Exponential wrp height Wet Delay Final Orbits VMF1 Rapid Orbits 10 cm Mapping Function: Vienna Mapping Function (VMF1) in weekly runs Niell Mapping Function (NIELL) in daily runs Estimation: Zenith delay and horizontal gradients
Ionosphere	1st order effect: Removed by LC and PC combinations 2nd order effect: Modeled using a 600 km shell height and Slant TEC from IONEX files after 01 JAN 1999 and using IRI prior to 1999. NOT Applied with rapid orbits
Plate motions	
Tidal	Solid earth tide: IERS 2010 Conventions
	Permanent tide: NOT removed from model, so NOT in estimated site coordinates
	Pole tide: IERS 2010 Conventions

	Ocean Tide Loading corrections: Tide Model: FES2004 Tides: M2 S2 N2 K2 K1 O1 P1 Q1 MF MM SSA Computed using OLCMC plus OLFG by H G Scherneck http://holt.oso.chalmers.se/loading Frame origin is the joint mass center of the solid earth and ocean.
	Ocean Pole Tide Loading: Not applied
Non-tidal loading	Atmospheric Pressure: Not applied
	Ocean Bottom Pressure: Not applied
	Surface Hydrology: Not applied
	Other Effects: None applied
Earth Orientation Parameter (EOP) Model	IERS 2010 Conventions for diurnal, semidiurnal, and long period tidal effects on polar motion and UT1
Satellite center of mass correction	Final Orbits Phase centers offsets from igs08_wwww.atx applied Rapid Orbits Phase centers offsets from igs14_wwww.atx applied
Satellite antenna phase variations	Final Orbits PCV model w.r.t. phase center from igs08_wwww.atx applied Rapid Orbits PCV model w.r.t. phase center from igs14_wwww.atx applied
Relativistic corrections	Periodic Clock Corrections, (-2*R*V/c): Applied Gravity Bending: Applied
GPS Attitude model	GYM95 nominal yaw rate model from Bar-Sever (1996) and yaw rates for Block II satellites

ESTIMATED PARAMETERS (APRIORI VALUES & SIGMAS)	
Adjustment	Stochastic Kalman filter/smoother implemented as square root information filter with smoother
Station coordinates	Daily Point Positioning estimates with rapid orbits Weekly free-network estimates with final orbits Weekly free-network supplemental processing with 13 and 26 week lag
Satellite clock	Not estimated
Receiver clock	Estimate every 5 minutes
Orbital parameters	Not estimated
GPS Attitude parameters	Not estimated

Troposphere	Zenith delay: random walk 5.0d-8 km/sqrt(sec) Horizontal delay gradients: random walk 5.0e-9 km/sqrt(sec)
	Mapping function: VMF1 (finals) NIELL (rapids)
Ionosphere	1st order effects removed by LC and PC combinations and 2nd order effects modeled
Ambiguity	Ambiguities resolved using JPL WLPB products

REFERENCE FRAMES

Terrestrial	Final Orbits IGS08 station coordinates and velocities Rapid Orbits IGS14 station coordinates and velocities

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Appendix B. New Mexico Tech Analysis Parameters.

PLATE BOUNDARY OBSERVATORY
NMT Processing Strategy Summary

Analysis Center	New Mexico Tech (NMT) Dept Earth & Environmental Sciences 801 Leroy Place New Mexico Institute of Mining and Technology Socorro, NM 87801 Phone: ++ 1 575 835 6930 Fax: ++ 1 575 835 6436
Contact Person(s)	Mark Murray e-mail: murray@nmt.edu phone : ++ 1 575 835 6930
Software Used	GAMIT v. 10.5, GLOBK v. 10.5, developed at MIT/SIO
Preparation Date	March 5, 2014
Modification Dates	New
Effective Date for Data Analysis	January 5, 2014

MEASUREMENT MODELS	
Observable	Doubly differenced, ionosphere-free combination of L1 and L2 carrier phases. Pseudoranges are used only to obtain receiver clock offsets and in ambiguity resolution.
Data weighting	Sigma on doubly difference LC phase: Site and elevation dependent based on iterated analysis. Cleaning at 30-second rate. Sampling rate: 2 minutes Elevation angle cutoff : 10 degrees
Data Editing	Cycles slips detected and fixed. Unresolved cycle slips estimated in solution. Postfit editing using 4 times RMS deletion.
RHC phase rotation corr.	Phase polarization effects applied (Wu et al, 1993)
Ground antenna phase center calibrations	Elevation- and azimuth-dependent phase center corrections are applied according to the model IGS08. The corrections are given relative to the Dorne Margolin T antenna.
Troposphere	Atmospheric mapping functions and hydrostatic zenith delays from VMF1 numerical model (Boehm et al., 2006b) 2-hour piecewise linear function estimated, 2 NS and EW gradient per day.
	Met data input: VMF1 global numerical model (Boehm et al., 2006b)

	Mapping functions: VMF1 (Boehm et al., 2006b)
Ionosphere	Not modeled (ionosphere eliminated by forming the ionosphere-free linear combination of L1 and L2).
Plate motions	ITRF2008 velocities
Tidal displacements	Solid earth and tidal displacement: constant Love number tides frequency dependent radial tide (K1)
	Pole tide: Applied to Mean IERS pole position
	Ocean loading: FES2004 (Lyard et al., 2006)
Atmospheric loading	Not applied
Earth orientation	IERS Bulletin A plus diurnal and semidiurnal variations in x,y, and UT1 models (EOP) R. Ray [1995], IERS Tech. Note 21 [1996]
Satellite center of mass correction	Block I x,y,z: 0.2100, 0.0000, 0.8540 m
	Block II/IIA x,y,z: 0.2790, 0.0000, 0.9519 m
	Block IIRA/IIRB x,y,z: -0.0031, -0.0012, 0.0000 m
	Block IIRM x,y,z: 0.0000, 0.0000, 0.0000 m
	Block IIF x,y,z: 0.3940, 0.0000, 1.6000 m
Satellite phase center calibrat	Not applied
Relativity corrections	Relativistic corrections applied
GPS attitude model	Yaw computed using model of Bar-Sever (1996), using nominal rates or estimates supplied by JPL

ORBIT MODELS	
Geopotential	EGM08 degree and order 9 (Pavlis et al., 2012)
	GM = 398600.4415 km**3/sec**2
	AE = 6378.1363 km
Third-body	Sun and Moon as point masses
	Ephemeris: CfA PEP NBODY 740
	GMsun = 132712440000 km**3/sec**2
	GMmoon = 4902.7989 km**3/sec**2
Solar radiation pressure	A priori: nominal block-dependent constant direct acceleration; corrections to direct, y-axis, and B-axis constant and once-per-rev terms estimated (Beutler et al., 1994; Springer et al. 1998)

	Earth shadow model: umbra and penumbra
	Earth's albedo: not applied
	Satellite attitude model not applied
Tidal forces	Solid earth tides: frequency independent Love number K2= 0.300
	Ocean tides: None
Relativity	Applied (IERS 1996, Chapter 11, Eqn.1)
Numerical Integration	Adams-Moulton fixed-step, 11-pt predictor-corrector with Nordsieck variable-step starting procedure (see Ash, 1972 and references therein)
	Integration step-size: 75 s; tabular interval: 900 s
	Arc length: 24 hours

ESTIMATED PARAMETERS (A PRIORI VALUES & SIGMAS)	
Adjustment	Weighted least squares plus Kalman filter
Station coordinates	~40 networks of ~45 stations per network. 2-3 common sites between networks. Weak constraints applied to site coordinates.
Satellite clocks bias	Initial values from linear fit to Broadcast emphemeris. Values estimated during data cleaning.
Receiver clock bias	Time estimated from pseudoranges.
Orbital parameters	Initial Position and Velocity (IC) plus 9 radiation-pressure terms: constant and sin/cos once-per-rev terms for a direct,y-axis, and b-axis acceleration. ICs estimated each day. Radiation parameters treated as random walk with process noise based on independent daily estimates. ICs fixed to IGS Final orbit values.
Troposphere	Piece-wise linear function in zenith delay estimated once per 2-hr for each station constrained by a random-walk process to 20mm/sqrt(hr); one N-S and one E-W gradient parameter per day for each station, constrained to 10 mm at 10 deg elevation angle
Ionospheric correction	Not estimated (first-order effect eliminated by linear combination of L1 and L2 phase)
Ambiguity	Resolution attempted for all baselines but resolving Melbourne-Webena Widelines for L2-L1 using pseudo-ranges with differential code biases applied, and then L1 from geodetic solution using ionosperic free observable.
Earth Orient. Parameters (EOP)	Pole X/Y and their rates, and UT1 rate estimated once per day.
GPS attitude model	Not estimated

REFERENCE FRAMES	
Inertial	Geocentric; mean equator and equinox of 2000 Jan 1 at 12:00 (J2000.0)
Terrestrial	ITRF2008, No constrained sites coordinates.
Interconnection	Precession: IAU 1976
	Nutation: IAU 2000

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APPENDIX C. Position Time Series File Naming and Format (*.POS)

Created by the Analysis Center Coordinator.
Available from ftp://data-out.unavco.org/pub/products/position/

File Naming

<STATION_ID>.<AC_ID>.<SOLUTION_ID>_<FRAME_ID>.pos

where

- <STATION_ID> 4-character station identifier
- <AC_ID> Analysis Center from whose work the time series is derived. Values are one of
    - cwu (Central Washington University)
    - nmt (New Mexico Tech)
    - pbo (Combined solution from MIT)
- <SOLUTION_ID> Solution type identifier. Values are one of
    - rapid (daily rapid orbit solutions; described section 4a)
    - final (weekly final orbit solutions; described in section 4b)
    - suppl (supplemental 12-week final orbit solutions; described in section 4c)
    - supp6 (supplemental 26-week/6-month final orbit solutions; described in section 4c)
    - suppf (supplemental final orbit solution revised from an original final orbit solution; described in sectin 4c)
    - rern6 (temporary solutions from a partial processing rerun in 2015)
    - repro (reprocessed solution as described in section 4e above)

- <FRAME_ID> Reference frame identifier. Values are one of
    - nam08
    - igs08
    - snf01 (discontinued)
    - igs05 (discontinued)

Additionally, UNAVCO generates concatenated *pos files that include ALL solution types (rapid, final, etc.) in a single file. These concatenated *pos files omit the <SOLUTION_ID> from the file name.

Examples:

P513.cwu.final_igs08.pos
...is the time series for station P513 derived from final solutions generated by the Central Washington University Analysis Center in the IGS08 reference frame.

P513.nmt.rapid_nam08.pos
…is the time series for station P513 derived from rapid solutions generated by the New Mexico Tech Analysis Center in the NAM08 reference frame.

P513.pbo.final_nam08.pos

…is the time series for station P513 derived from final solutions combined by the MIT Analysis Center Coordinator in the NAM08 reference frame.

P513.pbo.nam08.pos
…is the time series for station P513 containing both final and rapid solutions combined by the MIT Analysis Center Coordinator in the NAM08 reference frame.

File Format

Station position time series files are made available in ASCII format and contain a descriptive header that defines the fields.

Example:

```
PBO Station Position Time Series. Reference Frame : NAM08
Format Version: 1.1.0
4-character ID: P513
Station name  : Point_Sal_CS2007
First Epoch   : 20070322 120000
Last Epoch    : 20170127 120000
Release Date  : 20170216 090407
XYZ Reference position :  -2669569.05613 -4504986.54067  3629597.39768 (NAM08)
NEU Reference position :    34.9072632191  239.3498271380  284.58671 (NAM08/WGS84)
Start Field Description
YYYYMMDD      Year, month, day for the given position epoch
HHMMSS        Hour, minute, second for the given position epoch
JJJJJ.JJJJJ   Modified Julian day for the given position epoch
X             X coordinate, Specified Reference Frame, meters
Y             Y coordinate, Specified Reference Frame, meters
Z             Z coordinate, Specified Reference Frame, meters
Sx            Standard deviation of the X position, meters
Sy            Standard deviation of the Y position, meters
Sz            Standard deviation of the Z position, meters
Rxy           Correlation of the X and Y position
Rxz           Correlation of the X and Z position
Ryz           Correlation of the Y and Z position
Nlat          North latitude, WGS-84 ellipsoid, decimal degrees
Elong         East longitude, WGS-84 ellipsoid, decimal degrees
Height (Up)   Height relative to WGS-84 ellipsoid, m
dN            Difference in North component from NEU reference position, meters
dE            Difference in East component from NEU reference position, meters
du            Difference in vertical component from NEU reference position, meters
Sn            Standard deviation of dN, meters
Se            Standard deviation of dE, meters
Su            Standard deviation of dU, meters
Rne           Correlation of dN and dE
Rnu           Correlation of dN and dU
Reu           Correlation of dEand dU
Soln          "rapid", "final", "suppl/suppf", "campd", or "repro" corresponding to
              products  generated with rapid or final orbit products, in supplemental
              processing, campaign data processing or reprocessing
End Field Description
*YYYYMMDD HHMMSS JJJJJ.JJJJ         X             Y             Z            Sx        Sy
Sz     Rxy   Rxz    Ryz            NLat         Elong         Height         dN        dE
dU         Sn       Se       Su      Rne    Rnu    Reu  Soln
 20070322  120000  54181.5000  -2669569.00197  -4504986.66587    3629597.28826    0.00357
    0.00610  0.00436  0.800 -0.789 -0.819       34.9072619971  239.3498283462  284.58978
    -0.13603   0.11029   0.00307    0.00210  0.00195  0.00779 -0.220 -0.242  0.147 repro
 20070323  120000  54182.5000  -2669568.99965  -4504986.66464    3629597.28930    0.00207
    0.00328  0.00255  0.805 -0.765 -0.847       34.9072620164  239.3498283611  284.58854
    -0.13389   0.11166   0.00183    0.00112  0.00108  0.00437 -0.006 -0.118  0.050 repro
```

APPENDIX D. Position Time Series File Naming and Format (*.CSV)

Created by UNAVCO, sourced from *.pos files created by the GPS Analysis Center Coordinator.
Available from ftp://data-out.unavco.org/pub/products/position/

These files contain ALL solution types (rapid, final, etc.) in a single file. These files contain only a subset of the most commonly used data columns from the original *.pos files.

One major difference between *.csv and *.pos files is that the N/E/U daily position offsets begin at "0.00 mm" for the first epoch in the *.csv file. The actual motion of the station through time relative the reference coordinate is the same in corresponding *.csv and *.pos files. This format was implemented based on user feedback, as having zero values for the first epoch can make the position offsets though time easier for some users and applications.

File Naming

<STATION_ID>.<AC_ID>.<FRAME_ID>.csv

where

- <STATION_ID> 4-character station identifier
- <AC_ID> Analysis Center from whose work the time series is derived. Values are one of
    - cwu (Central Washington University)
    - nmt (New Mexico Tech)
    - pbo (Combined solution from MIT)
- <FRAME_ID> Reference frame identifier. Values are
    - nam08
    - igs08
    - snf01 (discontinued)
    - igs05 (discontinued)

Examples:

P513.cwu.nam08.csv
...is the time series for station P513 containing both final and rapid solutions generated by the Central Washington University Analysis Center in the NAM08 reference frame.

P513.nmt.igs08.csv
...is the time series for station P513 containing both final and rapid solutions generated by the New Mexico Tech Analysis Center in the IGS08 reference frame.

P513.pbo.nam08.csv
…is the time series for station P513 containing both final and rapid solutions combined by the MIT Analysis Center Coordinator in the NAM08 reference frame.

File Format

Station position time series files are made available in ASCII comma separated value (CSV) format and contain a descriptive header that defines the fields.

Example:

```
PBO Station Position Time Series.
Format Version, 1.2.0
Reference Frame, NAM08
4-character ID, P513
Station name, Point_Sal_CS2007
Begin Date, 2007-03-22
End Date, 2017-02-14
Release Date, 2017-02-16
Source file, P513.pbo.nam08.pos
Offset from source file, 136.03 mm North, -110.29 mm East, -3.07 mm Vertical
Reference position, 34.9072632191 North Latitude, -120.650172862 East Longitude, 284.58671 meters elevation
Date, North (mm), East (mm), Vertical (mm), North Std. Deviation (mm), East Std. Deviation (mm), Vertical Std. Deviation (mm), Quality,
2007-03-22,0.00, 0.00, 0.00, 2.1, 1.95, 7.79, repro,
2007-03-23,2.14, 1.37, -1.24, 1.12, 1.08, 4.37, repro,
```

APPENDIX E. Velocity (*.VEL) File Naming and Format.

Created by the Analysis Center Coordinator.
Available from ftp://data-out.unavco.org/pub/products/velocity/

File Naming

<AC_ID>.<SOLUTION_ID>_<FRAME_ID>.vel

where

- <AC_ID> Analysis Center from whose work the time series is derived. Values are one of
  - cwu (Central Washington University)
  - nmt (New Mexico Tech)
  - pbo (Combined solution from MIT)
- <SOLUTION_ID> Solution type identifier. Values are one of
  - rapid (described in section 3 of analysis plan above)
  - final (described in section 3 of analysis plan above)
  - snaps (described in section 3 of analysis plan above)
  - snips (contains the subset of stations in the “snaps” solution with velocities that have changed in some significant fashion since the most recent “final” solution)
- <FRAME_ID> Reference frame identifier. Values are one of
  - nam08
  - igs08
  - snf01 (discontinued)
  - igs05 (discontinued)

Examples:

cwu.final_nam08.vel
...is the final (annual) velocity field derived from the solutions generated by the Central Washington University Analysis Center in the NAM08 reference frame.

nmt.snaps_nam08.vel
...is the snapshot velocity field derived from the solutions generated by the New Mexico Tech Analysis Center in the NAM08 reference frame.

pbo.snips_nam08.vel
...is the snapshot velocity field derived from the combined solutions generated by the Analysis Center Coordinator in the NAM08 reference frame, containing just the subset of stations with velocities that have changed significantly since the most recent “final” solution.

pbo.final_igs08.vel
…is the final (annual) velocity field derived from the combined solutions generated by the Analysis Center Coordinator.

File Format

Network velocity files are in ASCII format and contain a descriptive header that defines the fields.

A given station may have more than one entry in a given velocity file, for example if the station is near a large earthquake and is affected by postseismic deformation. In this case, there will be multiple velocity lines in the given file, with different first_epoch and last_epoch for each entry, but will still have the same velocity for each entry.

Example:

```
PBO Velocity file from PBO_vel_161203_NAM08.org Reference Frame : NAM08
Format Version: 1.1.0
Release Date  : 20161230095029
Start Field Description
Dot#        4-character identifier for a given station
Name        16-character station name
Ref_epoch    Date  and  time  at  which  the  station  position  is  as  given  in  ref_XYZ  and
ref_NEU. Format is YYYYMMDDhhmmss.
Ref_jday    Reference epoch, represented as Modified Julian Day number (MJD)
Ref_X       Reference X coordinate at Ref_epoch, meters
Ref_Y       Reference Y coordinate at Ref_epoch, meters
Ref_Z       Reference Z coordinate at Ref_epoch, meters
Ref_Nlat    Reference North latitude WGS-84 ellipsoid, decimal degrees
Ref_Elong   Reference East Longitude WGS-84 ellipsoid, decimal degrees
Ref_Up      Referemce Height  WGS-84 ellipsoid, meters
dX/dt       X component of station velocity, meters/yr
dY/dt       Y component of station velocity, meters/yr
dZ/dt       Z component of station velocity, meters/yr
SXd         Standard deviation of X velocity,  meters/yr
SYd         Standard deviation of Y velocity,  meters/yr
SZd         Standard deviation of Z velocity,  meters/yr
Rxy         Correlation of X and Y velocity
Rxz         Correlation of X and Z velocity
Ryz         Correlation of Y and Z velocity
dN/dt       North component of station velocity, meters/yr
dE/dt       East component of station velocity, meters/yr
dU/dt       Vertical component of station velocity, meters/yr
SNd         Standard deviation of North velocity, meters/yr
SEd         Standard deviation of East velocity, meters/yr
SUd         Standard deviation of vertical velocity, meters/yr
Rne         Correlation of North and East velocity
Rnu         Correlation of North and vertical velocity
Reu         Correlation of East and vertical velocity
first_epoch Epoch of first data used to derive the station velocity, in the same format
as ref_epoch.
last_epoch  Epoch of last data used to derive the station velocity, in the same format as
ref_epoch.
End Field Description
*Dot#       Name               Ref_epoch        Ref_jday        Ref_X              Ref_Y
Ref_Z          Ref_Nlat         Ref_Elong      Ref_Up...      dX/dt    dY/dt    dZ/dt    SXd
SYd      SZd     Rxy      Rxz      Rzy       dN/dt      dE/dt     dU/dt    SNd      SEd      SUd
Rne    Rnu    Reu   first_epoch     last_epoch
 1LSU  Louisiana_St          20161130120000  57722.5000      -113402.86155  -5504361.32180
3209404.21177     30.4074248318   268.8197384036    -6.56004      0.00038   0.00317 -0.00063
0.00023 0.00050 0.00036  0.040 -0.007 -0.580    0.00105  0.00031 -0.00306 0.00026 0.00023
0.00056  0.027 -0.005  0.003 20030423000000 20080621000000
 1LSU  Louisiana_St          20161130120000  57722.5000      -113402.85625  -5504361.31533
3209404.21172     30.4074248615   268.8197384573    -6.56575      0.00038   0.00317 -0.00063
0.00023 0.00050 0.00036  0.040 -0.007 -0.579    0.00105  0.00031 -0.00306 0.00026 0.00023
0.00056  0.027 -0.005  0.003 20080623000000 20100415000000
 1LSU  Louisiana_St          20161130120000  57722.5000      -113402.86032  -5504361.31285
3209404.20650     30.4074248318   268.8197384145    -6.57045      0.00038   0.00317 -0.00063
0.00023 0.00050 0.00036  0.040 -0.007 -0.580    0.00105  0.00031 -0.00306 0.00026 0.00023
0.00056  0.027 -0.005  0.003 20100415000000 20140115000000
```

APPENDIX F. Coseismic/Postseismic Event (*.EVT) File Naming and Format.

Created by the Analysis Center Coordinator.
Available from ftp://data-out.unavco.org/pub/products/event/

File Naming

<AC_ID>_<EVENT_DATE>_<EVENT_TIME>_<EQ_CODE>_<TYPE>_<SOLUTION_ID>.evt

where

- <AC_ID> Analysis Center from whose work the time series is derived. Values are one of
  - cwu (Central Washington University)
  - nmt (New Mexico Tech)
  - pbo (Combined solution from MIT)
- <EVENT_DATE> UTC date of earthquake that caused coseismic offset, in yymmdd format
- <EVENT_TIME> UTC time of earthquake that caused coseismic offset, in hhmm format
- <EQ_CODE> 2-character code assigned to earthquake by Analysis Center Coordinator currently preceded by "eq" i.e., event number 31 is eq31. In future other types of events may be added.
- <TYPE> Type of event. Currently "coseis" for co-seismic offsets or "postln" for post-seismic log coefficient estimates (only available for time series analyses).
- <SOLUTION_ID> Solution type identifier. Values are one of
  - rapid (described in section 4g of analysis plan above)
  - final (described in section 4g of analysis plan above)
  - suppl/repro for other longer latency results
  - kalts/wlsts for time series analyses based Kalman filtering or weight-least-squares. Currently only kalts results are distributed since these are more reliable in the presence of systematic noise in the time series.

Associated with event files, there are also automatically generated and scaled postscript files with plots of the results (.ps replaces .evt in file name).

Examples:

pbo_140424_0311_eq31_coseis_final.evt
...is the file containing final coseismic offsets for GPS stations affected by an earthquake identified as "EQ31" which occurred on April 24, 2014, at 03:11 UTC.

pbo_160124_1031_eq37_coseis_rapid.evt
...is the file containing rapid coseismic offsets for GPS stations affected by an earthquake identified as "EQ37" which occurred on January 24, 2016, at 01:24 UTC.

pbo_160124_1031_EQ37_coseis_kalts.evt
Estimates of coseismic offsets for event 37 based on Kalman filter time series analyses.

File Format

Coseismic event files are in ASCII format and contain a descriptive header that defines the fields.

Example: pbo_140424_0311_EQ31_coseis_final.evt

```
PBO Coseismic Offsets for EQ code 31, Date 2014 04 24 (ymd) Time 03 11 (hr min)
Format Version         : 1.00
EQ Location (lat/long) :  49.8459 -127.4440 deg
Release Date           : 20140515145905
Data Analyzed          : ../COM/com17892.b.glb ../COM/com17893.b.glb ../COM/com17895.b.glb
../COM/com17896.b.glb
Analysis Center        : PBO
Analysis Type          : final
Event Type             : Coseismic
Event Code             : EQ31
Event Date             : 201404240311
GLOBK Solution file    : ../COM/pbo140424_EQ31.b.org
.  Long        Lat        dE        dN        E +-      N +-    RhoEN      dH       H +-  Site
.   deg        deg        mm        mm         mm        mm      --        mm        mm    --
 233.15736  50.54428     0.07     -2.28      1.28      1.69   0.000     -4.25      3.90  BCOV_431
 232.87734  49.87305    -2.08     -6.70      1.48      2.13   0.000     -4.58      6.53  ELIZ_231
 233.87267  49.68149     2.23     -0.75      1.59      1.92   0.000     -0.07      4.04  GLDR_G31
 231.86500  50.64035    -0.65     -0.01      1.18      1.51   0.000      0.27      3.21  HOLB_831
…
```

Example of time series generated co-seismic offset file
pbo_140424_0311_EQ31_coseis_kalts.evt

```
PBO Coseismic Offsets for EQ code 31, Date 2014 04 24 (ymd) Time 03 11 (hr min)
Format Version         : 1.01
EQ Location (lat/long) :  49.8459 -127.4440 deg
Release Date           : 20170405161336
Data Analyzed          : Time Series
Analysis Center        : PBO
Analysis Type          : Kalman Filter
Event Type             : Coseismic
Event Code             : EQ31
Event Date             : 201404240311
TSFIT Command file     : tsfit_SNAPKF.cmd
.  Long        Lat        dE        dN        E +-      N +-    RhoEN      dH       H +-  Site
.   deg        deg        mm        mm         mm        mm      --        mm        mm    --
 234.86490  48.83533     1.96      0.11      0.31      0.35   0.000     -3.78      1.03  BAMF_G31
 233.15736  50.54428    -1.12     -2.42      0.22      0.27   0.000      0.47      0.74  BCOV_G31
 232.87734  49.87305    -2.48     -7.96      0.26      0.41   0.000      0.36      0.82  ELIZ_G31
 233.87267  49.68149     1.63     -1.01      0.38      0.36   0.000     -1.50      1.18  GLDR_G31
 231.86500  50.64035    -0.95     -0.87      0.30      0.31   0.000     -2.80      1.00  HOLB_G31
 233.38339  49.59236     4.06     -1.63      0.27      0.35   0.000     -4.11      0.88  NTKA_G31
 235.13904  49.25633     1.17     -0.53      0.22      0.26   0.000     -0.17      0.66  PTAL_G31
 234.66917  50.13250     0.33     -0.24      0.24      0.28   0.000     -0.65      0.90  QUAD_G31
 234.09216  49.15414     1.89     -0.44      0.37      0.41   0.000     -5.80      1.32  TFNO_G31
 234.45836  48.92564     1.47     -0.18      0.20      0.29   0.000     -2.55      0.85  UCLU_G31
…
```

Example of time series generated postseismic log coefficient event file
pbo_120905_1442_EQ21_postsm_kalts.evt

```
PBO Postseismic Log for EQ code 21, Date 2012 09 05 (ymd) Time 14 42 (hr min)
Format Version         : 1.01
EQ Location (lat/long) :  10.1000 -85.3100 deg
Release Date           : 20170405161336
Data Analyzed          : Time Series
Analysis Center        : PBO
Analysis Type          : Weighted Least Squares
Event Type             : Postseismic Log Tau 2.0 days
Event Code             : EQ21
Event Date             : 201209051442
TSFIT Command file     : tsfit_SNAPKF.cmd
.  Long        Lat        dE        dN        E +-      N +-    RhoEN      dH       H +-  Site
.   deg        deg        mm        mm         mm        mm      --        mm        mm    --
 279.82689   7.41473    -1.46      1.68      0.42      0.35   0.000      2.74      1.25  ACHO_G21
 280.05014   9.37139    -0.08     -0.44      0.21      0.17   0.000      2.80      0.75  ACP1_G21
 280.59218   9.23848    -0.09      0.61      0.22      0.19   0.000      1.65      1.55  ACP6_G21
 269.70865  15.81225    -4.22      1.65      4.20      2.50   0.000    -25.89      8.65  CHIS_G21
 272.95531  12.38409    -0.16     -1.03      0.69      0.57   0.000      4.69      1.38  CN22_G21
 271.22124  17.26061    -0.48     -0.50      0.28      0.24   0.000      1.22      1.55  CN23_G21
```

280.96628	8.62506	-2.21	-0.48	1.26	1.77	0.000	0.43	4.24	CN28_G21
276.62536	14.04880	5.05	11.63	14.32	14.64	0.000	49.71	36.81	CN29_G21
276.22795	11.99355	-2.59	-2.09	0.47	0.38	0.000	1.96	1.14	CN30_G21
279.67333	8.48724	0.26	-0.55	0.43	0.47	0.000	1.22	1.17	CN33_G21

APPENDIX G. Atmospheric Delay (*.MET) File Naming and Format.

Created by the Analysis Centers.
Available from ftp://data-out.unavco.org/pub/products/troposphere/

File Naming

<AC_ID><GPS_WEEK_DAY><DATE><PRODUCT_ID>.met

where

- <AC_ID> Analysis Center from whose work the time series is derived. Possible values:
    - cwu (Central Washington University)
    - nmt (New Mexico Tech)
- <GPS_WEEK_DAY> The GPS Week (week 0000 began on 1/6/1980) and GPS Day (0 = Sunday, 6 = Saturday) of the data contained in the file, in the format WWWWD
- <DATE> UTC date of the data contained in the file, in the format YYYYMMDD
- <PRODUCT_ID> A string that identifies the data product whose processing generated the tropospheric estimates. Possible values:
    - a (rapid)
    - b (final)
    - c (supplemental)

Examples:

nmt19300.20170101.a.met
…is the file containing tropospheric data derived from the New Mexico Tech processing using rapid orbits for data on GPS Week 1930, GPS Day 0, January 1, 2017 UTC.

cwu19300.20170101.b.met
…is the file containing tropospheric data derived from the Central Washington University processing using final orbits for data on GPS Week 1930, GPS Day 0, January 1, 2017 UTC.

File Format

PBO tropospheric parameter files are in a different ASCII format for each Analysis Center.

Central Washington University generates files consisting of tropospheric parameter estimates from GIPSY posted every 5 minutes for each GPS station processed. Files begin with the header lines:

```
#For more information about Troposphere Parameters, in a system with GOA 5.0
type: ... gd2p.pl -h_wash
# GRADDRIFT = 5.0D-9 km/sqrt(sec)
# TROPDRIFT = 5e-8 km/sqrt(sec)
#   SECS[J2000]   ZD[m]   TROP_DRY[m]   WETZ[m]   WETZ_SIG[m]   TRPAZSIN[km]
TRPAZCOS[km]... TRPAZSIN_SIG[km] TRPAZCOS_SIG[km] SITE SNET MAP_FUNC
```

The GRADDRIFT parameter refers to the a priori random walk scaling for the Wet Z gradient, and the TROPDRIFT parameter is the a priori random walk scaling for Wet Z. The last header line is a list of fields in the individual line entries that follow the header.

```
SECS[J2000]     Time in seconds from standard epoch "J2000" (~12:00UTC, January 1, 2000)
ZD[m]           Zenith delay, in meters.
TROP_DRY[m]     Hydrostatic zenith delay, in meters.
WETZ[m]         Wet zenith delay, in meters.
WETZ_SIG[m]     Wet zenith delay standard error, in meters.
TRPAZSIN[km]    The sine component of the wet tropospheric gradient in kilometers.
TRPAZCOS[km]    The cosine component of the wet tropospheric gradient in kilometers.
TRPAZSIN_SIG[km]  The uncertainty in the sine component of the wet tropospheric gradient
                in kilometers.
TRPAZCOS_SIG[km]   The uncertainty in the cosine component of the wet tropospheric
                gradient in kilometers.
SITE            PBO GPS station 4-character ID.
SNET            Subnetwork in which SITE was processed (no longer meaningful).
MAP_FUNC        Tropospheric mapping function ((NIELL for rapid orbits, VMF1GRID for final
                orbits).
```

New Mexico Tech generates files from GAMIT consisting of tropospheric parameter estimates posted every 2 hours for each GPS station processed. Files begin with a single header line describing the list of fields in the line entries that follow.

* Yr Doy Hr Mn Sec TotalZen WetZen SigZen PW SigPW(mm) Press(hPa) Temp(K) ZHD(mm) GradNS SigNS GradEW SigEW(mm) Site Net

The individual fields are:

```
Yr              Year of interval start
DOY             Day of year of interval start
Hr              Hour of interval start
Mn              Minute of interval start
Sec             Second of interval start
Total Zen       Total zenith delay, in mm
Wet Zen         Wet zenith delay, in mm
Sig Zen         Uncertainty of wet zenith delay, in mm
PW              Precipitable water, in mm
Sig PW (mm)     Uncertainty of precipitable water, in mm
Press (hPa)     Barometric pressure, in hPA
Temp (K)        Temperature, in K
ZHD (mm)        Zenith hydrostatic ("dry") delay, in mm
Grad NS         North-south component of the gradient of the total zenith delay, in mm **
Sig NS          Uncertainty of Grad NS, in mm **
Grad EW         East-west component of the gradient of the total zenith delay, in mm **
Sig EW          Uncertainty of Grad EW, in mm  **
SITE            PBO GPS station 4-character ID
NET             Subnetwork in which SITE was processed

** gradients are rescaled to represent the difference between the
north (or east) and south (or west) delay at 10 degrees elevation.
```

APPENDIX H. Kalman filter discontinuity (.OFF) File Naming and Format.

Created by the Analysis Center Coordinator
Available from ftp://data-out.unavco.org/pub/products/event/

File Naming

<AC_ID>.<SOLUTION_ID>_<FRAME_ID>.off

where

- <AC_ID> Analysis Center from whose time series the offsets have been extracted. Current possibilities are pbo, nmt or cwu. Currently only offsets from the combined series are generated.
- <SOLUTION_ID> Solution type identifier. Values are one of
    - final (described in section 4g of analysis plan above)
    - kalts for time series analyses based Kalman filtering. Currently only kalts results are distributed since these are more reliable in the presence of systematic noise in the time series.
- <FRAME_ID> Reference frame identifier. Values are one of
    - nam08 (only one currently distributed. Frame should not affect results)
    - igs08

Examples:

pbo.kalts_nam08.off
Estimates generated from the PBO combined time series on April 03, 2017. The finals time series available on that date would be used to generate these values.

File Format

The format is described in the header records along with notes and cautions about the use of this product. Valid data lines start with a blank in column one. Non-blank characters in column 1 denote a comment. The types of breaks given are by "Break" which would arise from an antenna or radome change, or from an unknown reason. An "OffEq" discontinuity is due to an earthquake or other spatially dependent rapid position change. There is a free form description of reason for the break which are derived from the GLOBK earthquake files used in the GAGE processing. In these descriptions, AN is an antenna or radome change determined from meta data change. The first entries in the descriptions give the antenna or radome information that changed. UN are unknown types determined from discontinuities in the time series. The descriptions are notes made at the time the discontinuity was noted. There are no particular formats for these comments. EQ <CD> gives the 2-character earthquake code <CD> and the latitude and longitude of central point of the earthquake used in the GLOBK processing.
Some entries have large standard deviations and these can arise because of missing data or earthquakes for which post-seismic model parameters are estimated but which have no data before the earthquake. Earthquakes with large standard deviations are not output because these are generally associated with stations not having data before the earthquake. If there is a large gap in the data and both an earthquake and antenna change occur in the gap, only the antenna offset (which will have a large uncertainty) will be reported.

Example: (note lines are wrapped)

```
PBO Offset estimates from SNAPKF/kf_<site>.pbo.final.det Reference Frame : NAM08
Format Version: 1.0.0
Release Date  : 201705230001
Start Field Description and Notes
NOTES
Extracted using sh_extOffsets Date Tue May 23 09:43:01 EDT 2017
This file is created from Kalman Filter fits to the GAGE time-series.  The process
noise values used in the Kalman filters are computed for each site as described in
Herring et al., 2016.  Offsets can be of Break type due to antenna change or due
to unknown reasons or of type OffEq due an earthquake at the time.  If the standard
deviation of the offset estimates (sN, sE, sU) are large, the offset can not be
accurately determined.  In some cases this is due to there being no usable data
prior to the offset or, in some cases, multiple offsets with no usable data between
the offsets.
Earthquakes with large coseismic standard deviations are not reported
This product is not quality checked to see if the estimated offsets remove the
apparent discontinuities in the time series.  For sites with very systematic
residuals, the estimates might not remove the discontinuities.
The columns are
Site               : GAGE 4-character site ID
YYYY MM DD  HR MN : Year, month, day, hour, minute of the time of the offset
dN (mm)  sN (mm)  : Change in North,  1-sigma standard deviation (mm)
dE (mm)  sE (mm)  : Change in East,   1-sigma standard deviation (mm)
dU (mm)  sU (mm)  : Change in Height, 1-sigma standard deviation (mm)
TYPE               : Either Break (equipment) or OffEq (earthquake)
Description        : Free format comments specific to offset type
.                    Types are
.                    EQ -- Earthquake with GAGE code (from All_PBO_eqs.eq)
.                    AN -- Antenna or radome change (from All_PBO_ants.eq)
.                    UN -- Unknown reason or from damage (from All_PBO_unkn.eq)
Reference:
Herring, T. A., T. I. Melbourne, M. H. Murray, M. A. Floyd, W. M. Szeliga,
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End Field Description and Notes
.Site  YYYY MM DD  HR MN      dN (mm)  sN (mm)      dE (mm)  sE (mm)     dU (mm)  sU (mm)
TYPE  ! Description
1LSU  2008 06 20  18 00          2.89     0.42         4.30     0.46      -9.40     1.09
Break ! AN Antenna  swap     ASH701945E_M     to     TRM57971.00      Receiver ASHTECH
UZ-12        to TRIMBLE NETRS        Dome SCIS  to NONE
 1LSU  2010 04 14  16 00         0.13     0.38        -3.82     0.42      -2.46     1.04
Break ! AN Antenna  swap     TRM57971.00      to     TRM41249.00      Receiver TRIMBLE
NETRS        to TRIMBLE NETRS        Dome NONE  to NONE
 1LSU  2014 01 14  18 31        -0.79     0.34         0.71     0.39       3.69     0.95
Break ! AN Antenna  swap     TRM41249.00      to     TRM57971.00      Receiver TRIMBLE
NETRS        to TRIMBLE NETR9        Dome NONE  to NONE
 1NSU  2010 07 30  00 00         1.84     0.43         1.41     0.24      -1.29     1.14
Break ! AN Antenna  swap     ASH701945E_M     to     TRM57971.00      Receiver ASHTECH
UZ-12        to TRIMBLE NETR8        Dome SCIS  to NONE
 1ULM  2010 07 30  00 00        -1.42     0.22         1.98     0.23      -0.34     0.85
Break ! AN Antenna  swap     ASH701945E_M     to     TRM57971.00      Receiver ASHTECH
UZ-12        to TRIMBLE NETR8        Dome SCIS  to NONE
 7ODM  2011 08 24  01 06        44.83     0.36        36.34     0.54     -18.24     1.09
Break ! AN Antenna  swap    ASH701945B_M     to     ASH701945B_M     Receiver ASHTECH Z-
XII3       to TPS NET-G3A         Dome SCIT  to SCIT
 7ODM  2012 05 04  00 00        -0.76     0.35         0.99     0.49      -1.15     1.02
Break ! AN Antenna  swap     ASH701945B_M     to     TPSCR.G3         Receiver TPS NET-
G3A          to TPS NET-G3A          Dome SCIT  to SCIT
7ODM  2013 11 07  22 23          1.67     0.33         0.76     0.47     -11.14     1.00
Break ! AN Antenna  swap     TPSCR.G3         to     TRM57971.00      Receiver TPS NET-
G3A          to TRIMBLE NETR9        Dome SCIT  to SCIT
 7ODM  2015 07 05  00 00         3.99     0.34         0.36     0.49      13.87     1.00
Break ! UN TRM57971.00  SCIT PCV update Week 1848
 7ODM  2010 04 04  22 40        -4.09     0.39         0.01     0.56      -8.04     1.18
OffEq ! EQ GU Location   32.14485  244.62646
 AB01  2013 08 30  16 25        -7.04     0.51        -0.44     0.34       3.49     0.65
OffEq ! EQ 28 Location   51.60960 -175.36110
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 AB01  2014 06 23  20 54        -1.60     0.47        2.09     0.33      -1.08     0.65
OffEq ! EQ 32 Location   51.79720  178.76040
 AB02  2010 07 18  05 56        11.37     0.60       14.80     0.48      -2.35     0.64
OffEq ! EQ 27 Location   52.87600 -169.84800
 AB02  2015 07 27  04 50        -6.81     0.58       -0.98     0.46       0.03     0.61
OffEq ! EQ 36 Location   52.37600 -169.44580
 AB06  2009 08 23  00 00        -2.24     0.26        3.29     0.20      -0.45     0.67
Break ! AN Antenna  swap     TRM29659.00       to     TRM59800.00      Receiver TRIMBLE
NETRS        to TRIMBLE NETRS        Dome SCIT  to SCIT
 AB08  2009 09 29  21 30         4.64     0.38        1.16     0.47      -2.00     0.86
Break ! AN Antenna  swap     TRM29659.00       to     TRM59800.00      Receiver TRIMBLE
NETRS        to TRIMBLE NETRS        Dome SCIT  to SCIT
…
ACP6  2012 09 05  14 42        -1.58     0.64       -1.57     0.77      -5.31     3.94
OffEq ! EQ 21 Location   10.24172  274.16050
 ACSO  2014 07 30  16 18         1.52     0.21       -2.28     0.20       2.68     0.64
Break ! AN Antenna  swap     TRM29659.00       to     TRM59800.80      Receiver TRIMBLE
NETRS        to TRIMBLE NETR9        Dome SCIT  to SCIT
 ACU6  2006 12 22  00 00       -17.94     0.26      -38.03     0.22      -1.55     0.67
Break ! UN Un-documented offset of order -15,-40 mm NE
 ADRI  2014 03 24  17 07         0.37     0.21        1.53     0.25      -1.34     0.75
Break ! AN Antenna  swap      LEIAT504          to      LEIAT504GG        Receiver LEICA
RS500         to LEICA GRX1200PRO     Dome LEIS  to LEIS
 AGMT  2010 04 04  22 40        -2.34     0.30        0.44     0.28       2.46     1.14
OffEq ! EQ GU Location   32.14485  244.62646
 AIRS  2013 12 12  17 17         2.83     0.71       -6.24     0.84       8.17     2.69
Break ! AN Antenna  swap     ASH701945B_M      to     TRM59800.80      Receiver ASHTECH
UZ-12        to TRIMBLE NETR9        Dome SCIT  to SCIT
 AIS1  2008 02 02  00 00         9.45     0.95        5.45     0.68      95.41     2.79
Break ! UN  Height offset (unexplained)
 AIS5  2013 01 05  08 58       -20.19     0.33       14.59     0.29      -0.87     1.05
OffEq ! EQ 24 Location   55.39352  224.55061
 AIS6  2013 01 05  08 58        -8.15     0.51       14.76     0.33      -0.83     1.05
OffEq ! EQ 24 Location   55.39352  224.55061
 AL30  2006 10 20  00 00        -1.48     0.31        0.21     0.29      -0.27     1.06
Break ! AN Antenna  swap      LEIAX1202         to      LEIAX1202GG       Receiver LEICA
GRX1200PRO     to LEICA GRX1200GGPRO   Dome NONE  to NONE
 AL30  2010 08 18  19 30        -0.63     0.28       -0.84     0.26       3.15     0.74
Break ! AN Antenna  swap      LEIAX1202GG       to      LEIAX1203+GNSS    Receiver LEICA
GRX1200GGPRO   to LEICA GRX1200+GNSS   Dome NONE  to None
…
ZMP1  2003 05 06  00 00         1.46     0.31       -6.20     0.27      -0.79     1.29
Break ! AN Antenna  swap      MPL_WAAS_2224NW   to      NOV_WAAS_600       Receiver NOV
WAASGII          to NOV WAASGII          Dome NONE  to NONE
 ZMP1  2007 06 07  00 00        -9.83     0.28        6.50     0.25      -0.12     1.22
Break ! AN Antenna  swap      NOV_WAAS_600      to      MPL_WAAS_2225NW   Receiver NOV
WAASGII          to NOV WAASGII          Dome NONE  to NONE
 ZNY1  2003 05 16  00 00        -0.69     0.29       -8.65     0.26       4.49     0.94
Break ! AN Antenna  swap      MPL_WAAS_2224NW   to      NOV_WAAS_600       Receiver NOV
WAASGII          to NOV WAASGII          Dome NONE  to NONE
 ZNY1  2007 05 11  00 00        -4.56     0.25        5.53     0.23      10.80     0.75
Break ! AN Antenna  swap      NOV_WAAS_600      to      MPL_WAAS_2225NW   Receiver NOV
WAASGII          to NOV WAASGII          Dome NONE  to NONE
 ZSE1  2003 04 19  00 00        -5.06     0.45      -14.12     0.31      14.62     1.29
Break ! AN Antenna  swap      MPL_WAAS_2224NW   to      NOV_WAAS_600       Receiver NOV
WAASGII          to NOV WAASGII          Dome NONE  to NONE
 ZSE1  2007 05 17  00 00        15.15     0.39       10.90     0.26      11.16     1.04
Break ! AN Antenna  swap      NOV_WAAS_600      to      MPL_WAAS_2225NW   Receiver NOV
WAASGII          to NOV WAASGII          Dome NONE  to NONE
 ZTL4  2003 05 02  00 00         0.69     0.34       -6.20     0.27      26.29     1.01
Break ! AN Antenna  swap      MPL_WAAS_2224NW   to      NOV_WAAS_600       Receiver NOV
WAASGII          to NOV WAASGII          Dome NONE  to NONE
 ZTL4  2006 12 05  00 00        -8.90     0.31       14.76     0.22       4.63     0.84
Break ! AN Antenna  swap      NOV_WAAS_600      to      MPL_WAAS_2225NW   Receiver NOV
WAASGII          to NOV WAASGII          Dome NONE  to NONE
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