Quarterly Report
Massachusetts Institute of Technology
GAGE Facility GPS Data Analysis Center Coordinator
And
GAGE Facility GAMIT/GLOBK Community Support

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Period: 2018/01/01-2018/03/31

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Summary

Under the GAGE Facility Data Analysis subaward, MIT has been combining results from the New Mexico Tech (NMT) and Central Washington University (CWU). In this report, we show analyses of the data processing for the period 2017/12/10 to 2018/03/10, time series velocity field analyses for the GAGE reprocessing analyses (1996-2018). Several earthquakes were investigated this quarter and some generated coseismic displacements > 1mm. Three event files were created this month. Event 43, M7.6 44km E of Great Swan Island, 2018/01/10 02:52, latitude17.4693°, longitude -83.5197°, displaced GCEA, GCFS by a few millimeters. ROA0 has sparse data after the event. Event 44. M7.9 280km SE of Kodiak, 2018/01/23 09:32, latitude 56.0464° longitude -149.0728° generated displacements up to 30 mm in N and 15 mm in East. Event 45. M7.2 3km S of San Pedro Jicayan, 2018/02/16 23:40, latitude 16.3887°, longitude -97.9789°, displaced one station with data available (TNCY) by 100 mm. Other stations are likely to have been displaced but no data has been reported from these station yet. Other stations in the area with data were displaced by less than 10 mm.

For this quarter, the last finals results were for March 10, 2018. Associated with the report are the ASCII text files that are sent with this document.

Our monthly reports now contain the estimates of the offsets in the time series due to equipment changes and earthquakes and we generate events files for coseismic offsets and postseismic log terms (when needed) using a Kalman filter time series analysis.

Under the GAGE Facility GAMIT/GLOBK Community Support we report on activities during this quarter.

GPS Analysis of Level 2a and 2b products

ITRF2014 transition

The GAGE analyses are in a transition between the ITRF2008 and ITRF2014 systems but this transition has been delayed by the lack of historical and current final orbit and clock estimates from JPL.

Level 2a products: Rapid products

Final and rapid level 2a products have been in general generated routinely during this quarter. The description of these products, the delivery schedule and the delivery list remain unchanged from the previous quarter and will not be reported here. The rapid products continue to be generated in IGS14 by CWU while NMT uses IGS08 to be consistent with the methods used for the final products.

Level 2a products: Final products

The final products are generated weekly and are based on the final IGS and JPL (CWU) orbits. The IGS08 ANTEX phase center model is used by both ACs. The description of these products, the delivery schedule and the delivery list remain unchanged from the previous quarter and will not be reported here. Data volumes being transferred remains about the same. In this quarter 1863 stations were processed which is 29 less than last quarter. The CWU finals and other products are generated with IGb08 consistent orbits and clocks generated by JPL. NMT results are generated using the IGS14 orbits but still retaining the IGb08 antenna model file to be consistent with the CWU analyses.

Level 2a products: 12-week, 26-week supplement products

Each week we also process the Supplemental (12-week latency) and six months supplemental (26-week latency) analyses from the ACs. The delivery schedule for these products is also unchanged.

Analysis of Final products: December 10, 2017 and March 10, 2018

Each month, we submit reports of the statistics of the PBO combined analyses and estimates of the latest velocity fields in the NAM08 reference frame based on the time series analysis of data between 1996 and month preceding the report (we need to allow 2-3 weeks for the generation of the final products). For this report, we generated the statistics using the ~3 months of results generated between December 10, 2017 and March 10, 2018. These results are summarized in Table 1 and figures 1-3.

For the three months of the final position time series generated by NMT, CWU and combination of the two (PBO), we fit linear trends and annual signals and compute the RMS scatters of the position residuals in north, east and up for each station in the analysis. Our first analysis of the distribution of these RMS scatters by analysis center and the combination. Table 1 shows the median (50%), 70% and 95% limits for the RMS scatters for PBO, NMT and CWU. The median horizontal RMS scatters are less than or equal 0.96 mm for all centers and as low as 0.73 mm for NMT North and 0.77 mm for PBO east components. The up-RMS scatters are less than or equal 4.9 mm for all analyses and as low as 4.36 mm for the NMT solution. These statistics are similar to last quarter. Seasonal changes in atmospheric delay properties will introduce small variations in these values quarter to quarter. In the NAM08 frame realization, scale changes are not estimated. If scale changes were estimated, the up scatter would be reduced but the sum of scale change RMS and the lower height scatter would equal the values shown in Table 1. The detailed histograms of the RMS scatters are shown in Figures 1-3 for PBO, NMT and CWU.

Table 1: Statistics of the fits of 1863, 1861 and 1862 stations for PBO, NMT and CWU analyzed in the finals analysis between December 10, 2017 and March 10, 2018. Histograms of the RMS scatters are shown in Figure 1-3.

Center	North (mm)	East (mm)	Up (mm)
Median (50%)			
PBO	0.77	0.78	4.38

NMT	0.73	0.79	4.36
CWU	0.96	0.92	4.87
70%			
PBO	0.99	1.00	5.26
NMT	0.96	1.02	5.36
CWU	1.18	1.16	5.82
95%			
PBO	2.27	2.25	8.14
NMT	2.22	2.33	8.24
CWU	2.53	2.47	9.37

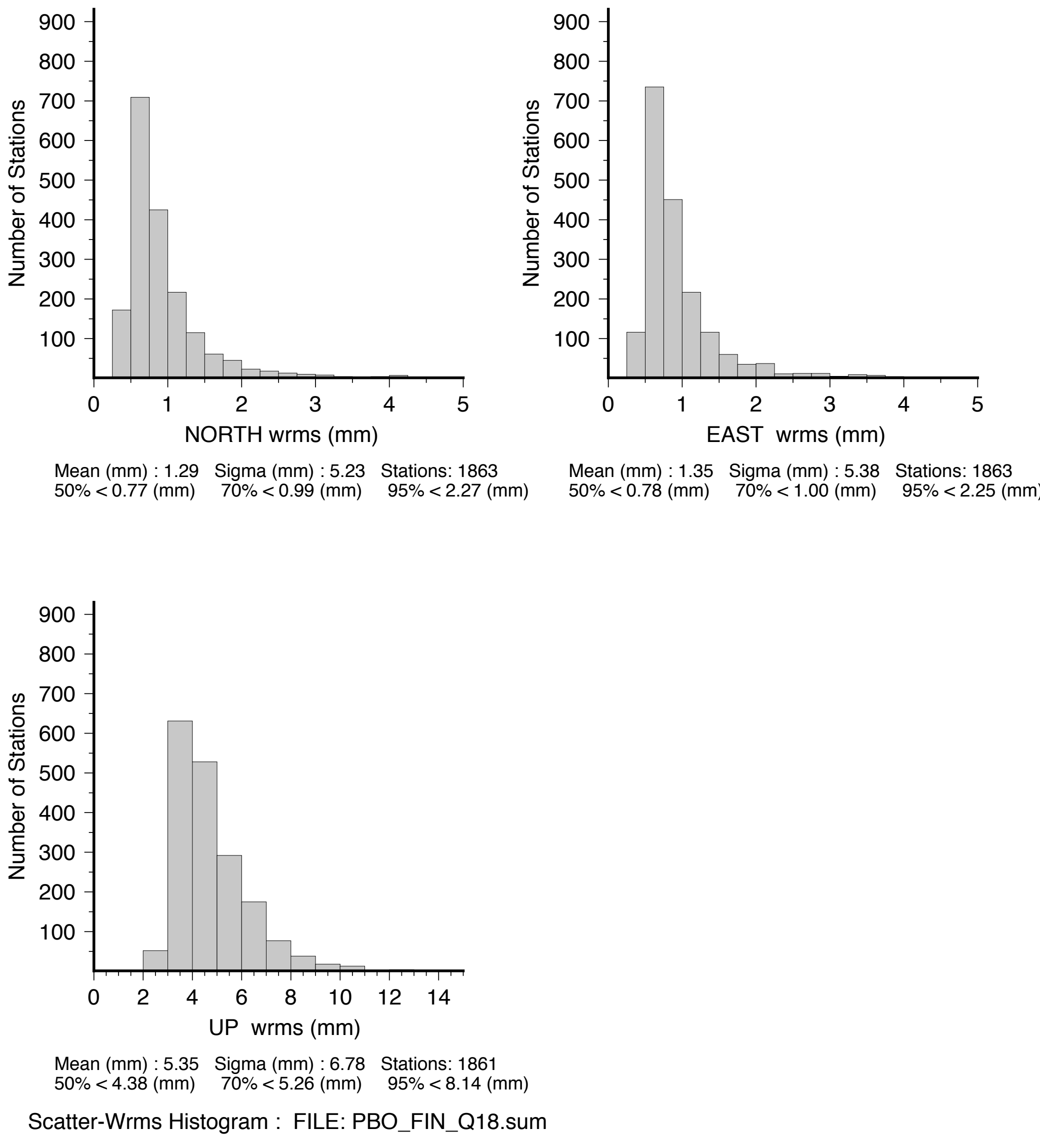

Figure 1: PBO combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1863 stations analyzed between December 10, 2017 and March 10, 2018. Linear trends and annual signals were estimated from the time series.

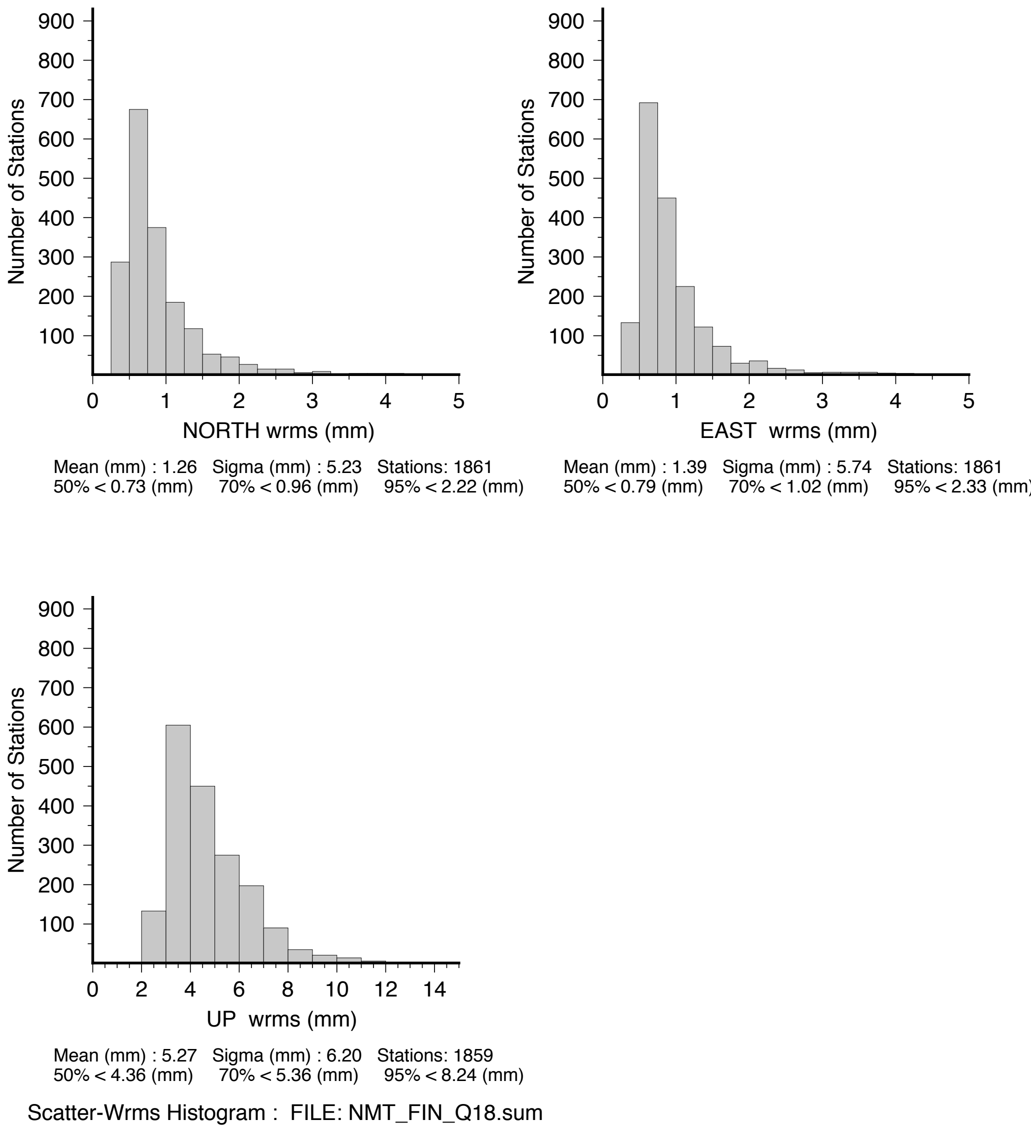

Figure 2: NMT combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1861 stations analyzed between December 10, 2017 and March 10, 2018. Linear trends and annual signals were estimated from the time series.

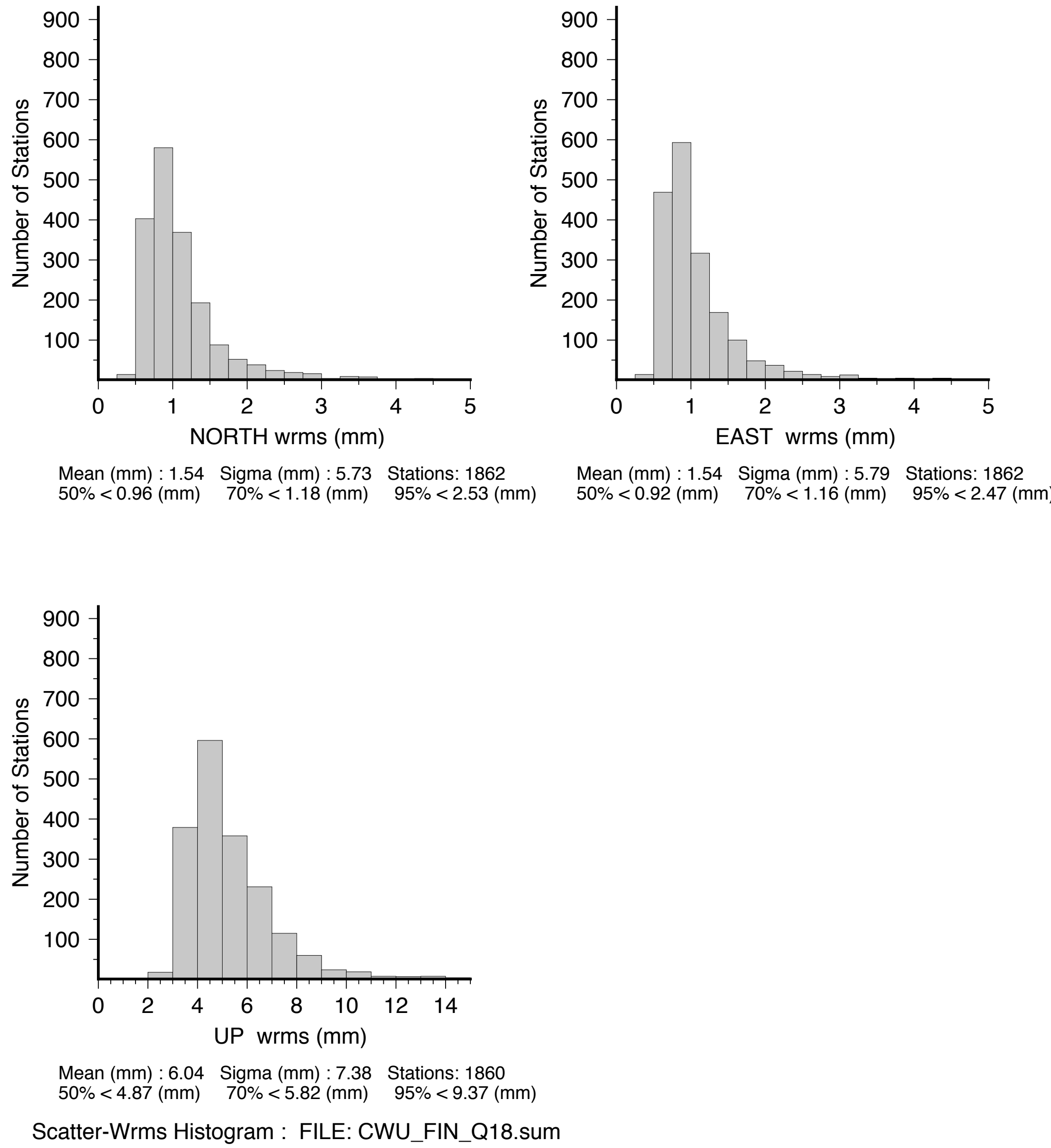

Figure 3: CWU combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1862 stations analyzed between December 10, 2017 and March 10, 2018. Editing removes two stations for North and Up. Linear trends and annual signals were estimated from the time series.

For the PBO combined analysis, we also evaluate the RMS scatters of the position estimates by network type. The figures below are based on our monthly submissions but here we use nominally 3 months of data to evaluate the RMS scatters. In Table 2, we give the median, 70 and 95 percentile limits on the RMS scatters. The geographical distributions of the RMS scatters by network type are shown in Figures 4-9. The values plotted are given in PBO_FIN_Q18.tab. There are 1859 stations in the file for sites that have at least 2 measurements during the month. The contents of the files are of this form:

```
Tabular Position RMS scatters created from PBO_FIN_Q18.sum
ChiN/E/U are square root of chisquared degree of freedom of the fits.
```

```
Values of ChiN/E/U near unity indicate that the estimated error
bars are consistent the scatter of the position estimates

.Site     #     N (mm)  ChiN      E (mm)  ChiE   U (mm)  ChiU      Years
 1LSU    86       0.9   0.44       1.0    0.49     5.9   0.62      14.88
 1NSU    86       0.6   0.37       0.8    0.49     5.6   0.81      14.15
 1ULM    86       0.7   0.45       0.7    0.48     5.1   0.80      14.74
 7ODM    86       0.6   0.36       0.6    0.41     3.6   0.56      16.89
…
  BW1    86       1.1   0.58       0.9    0.61     7.8   1.24      14.77
 ZDC1    86       0.7   0.40       0.8    0.52     4.7   0.71      14.77
 ZDV1    86       0.9   0.42       1.2    0.72     5.6   0.78      14.77
 ZKC1    86       0.8   0.47       0.7    0.47     5.7   0.90      14.77
 ZLA1    84       0.9   0.42       0.9    0.49     4.1   0.55      14.77
 ZME1    86       0.9   0.47       0.6    0.37     5.8   0.81      15.00
 ZMP1    86       1.1   0.57       0.6    0.39     6.7   1.03      15.24
 ZNY1    86       0.8   0.44       0.7    0.45     4.8   0.71      15.15
 ZSE1    86       0.9   0.40       0.8    0.48     4.7   0.68      15.15
 ZTL4    86       0.6   0.34       0.7    0.44     4.7   0.65      15.34
```

Table 2: RMS scatter of the position residuals for the PBO combined solution between December 10, 2017 and March 10, 2018 divided by network type. The division of networks is based on the JAVA script unavcoMetdata.jar with network codes PBO, Nucleus, Mid- SCIGN_USGS, America GAMA, COCONet and Expanded PBO

Network	North (mm)	East (mm)	Up (mm)	#Sites
Median (50%)				
PBO	0.72	0.74	4.14	869
NUCLEUS	0.66	0.66	3.74	204
GAMA	0.52	0.57	6.09	15
COCONet	1.29	1.26	5.79	89
USGS_SCIGN	0.64	0.66	3.50	131
Expanded	0.86	0.85	5.22	555
70%				
PBO	0.92	0.96	4.75	
NUCLEUS	0.78	0.78	4.28	
GAMA	0.56	0.59	6.71	
COCONet	1.47	1.56	6.61	
USGS_SCIGN	0.80	0.80	3.69	
Expanded	1.08	1.07	5.98	
95%				
PBO	2.28	2.18	7.76	
NUCLEUS	1.36	1.38	6.08	
GAMA	0.76	0.73	7.68	
COCONet	2.47	2.76	9.89	
USGS_SCIGN	1.94	1.85	7.85	
Expanded	2.42	2.86	8.68	

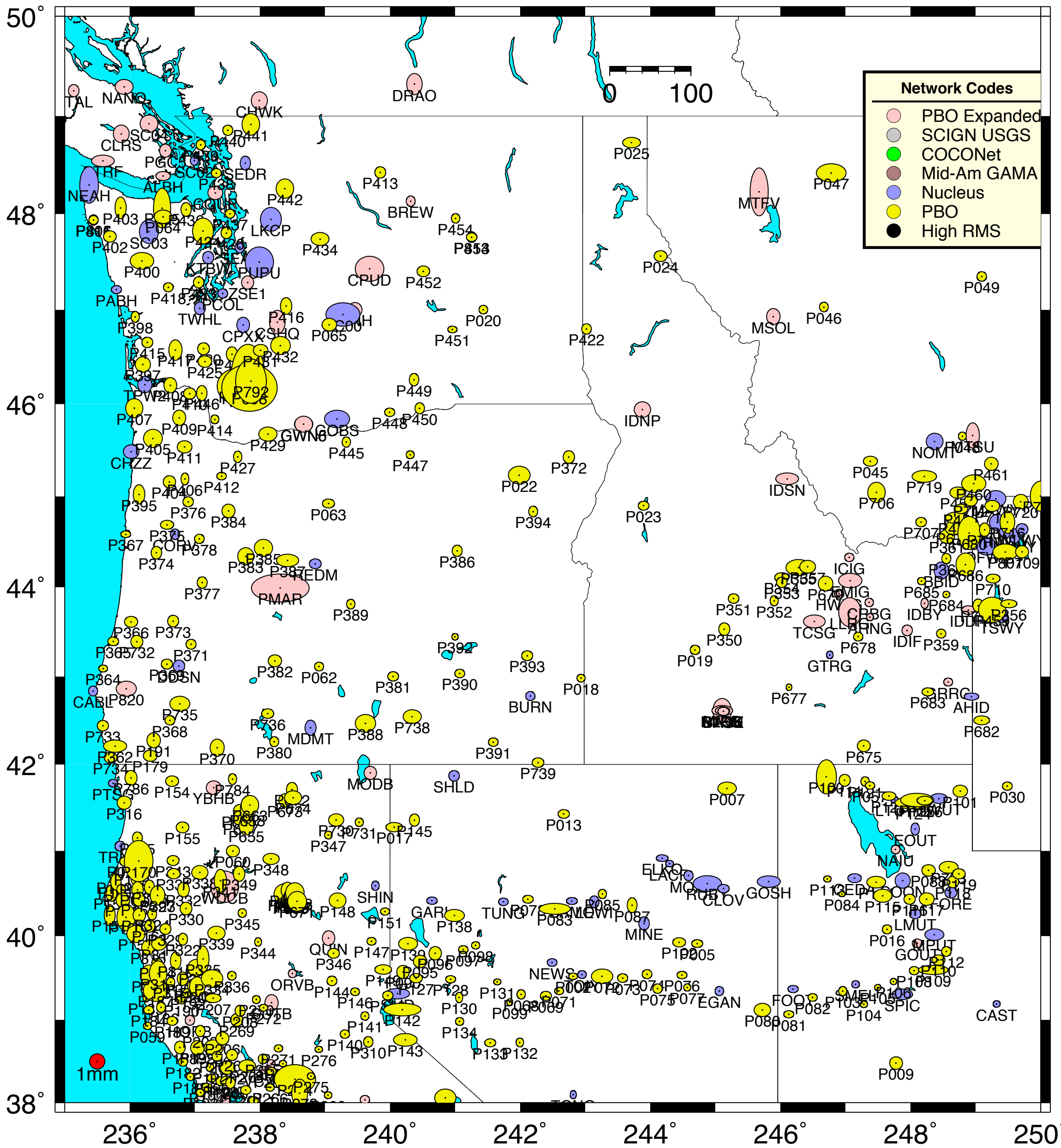

Figure 4: Distribution of the RMS scatters of horizontal position estimates from the PBO combined analysis for the Northern Western United States. The color of the ellipses that give the north and east RMS scatters denotes the network given by the legend in the figure. The small red circle shows the size of 1 mm scatters. Sites shown with black circles have combined RMS scatters in north and east greater than 5 mm or are sites that have no data during this 3-month interval.

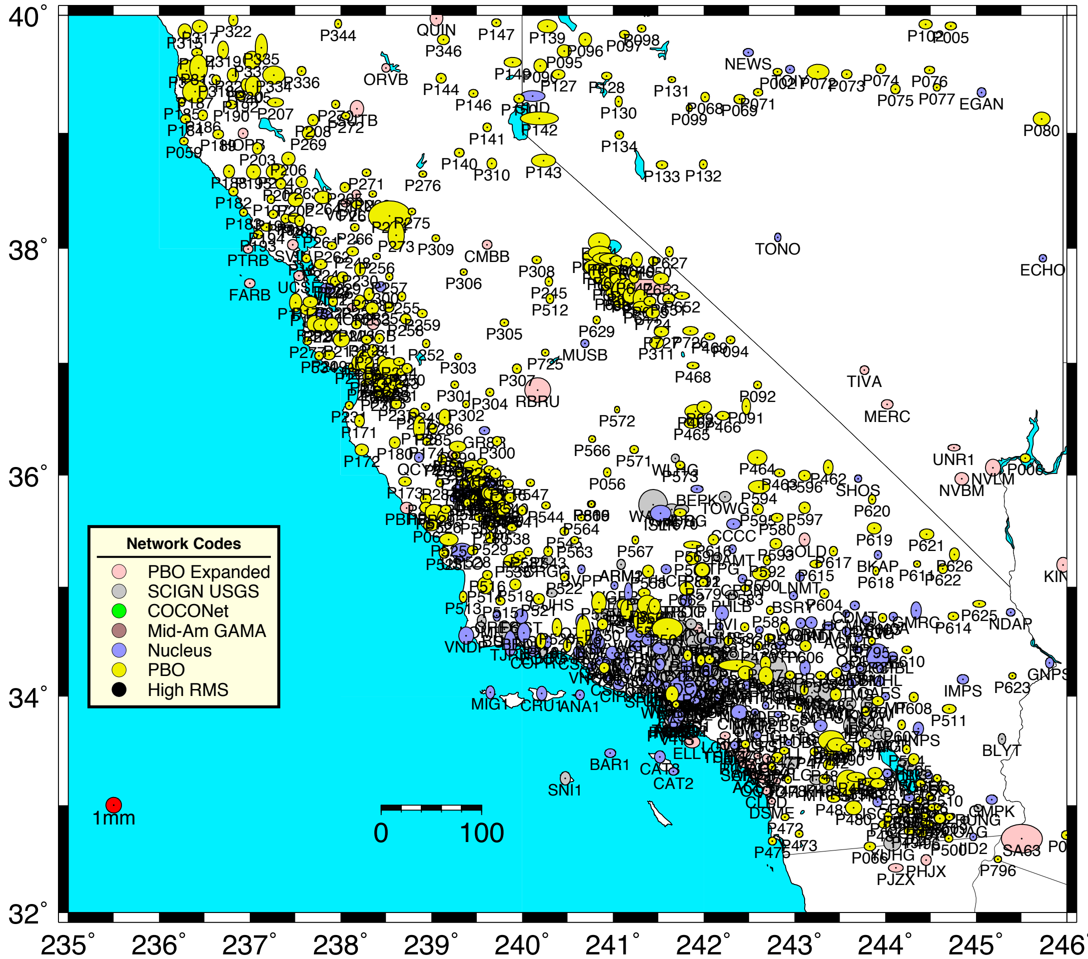

Figure 5: Same as Figure 4 except for the Southern Western United States. Black circles in the Yucca mountain region have no data during this 3-month period.

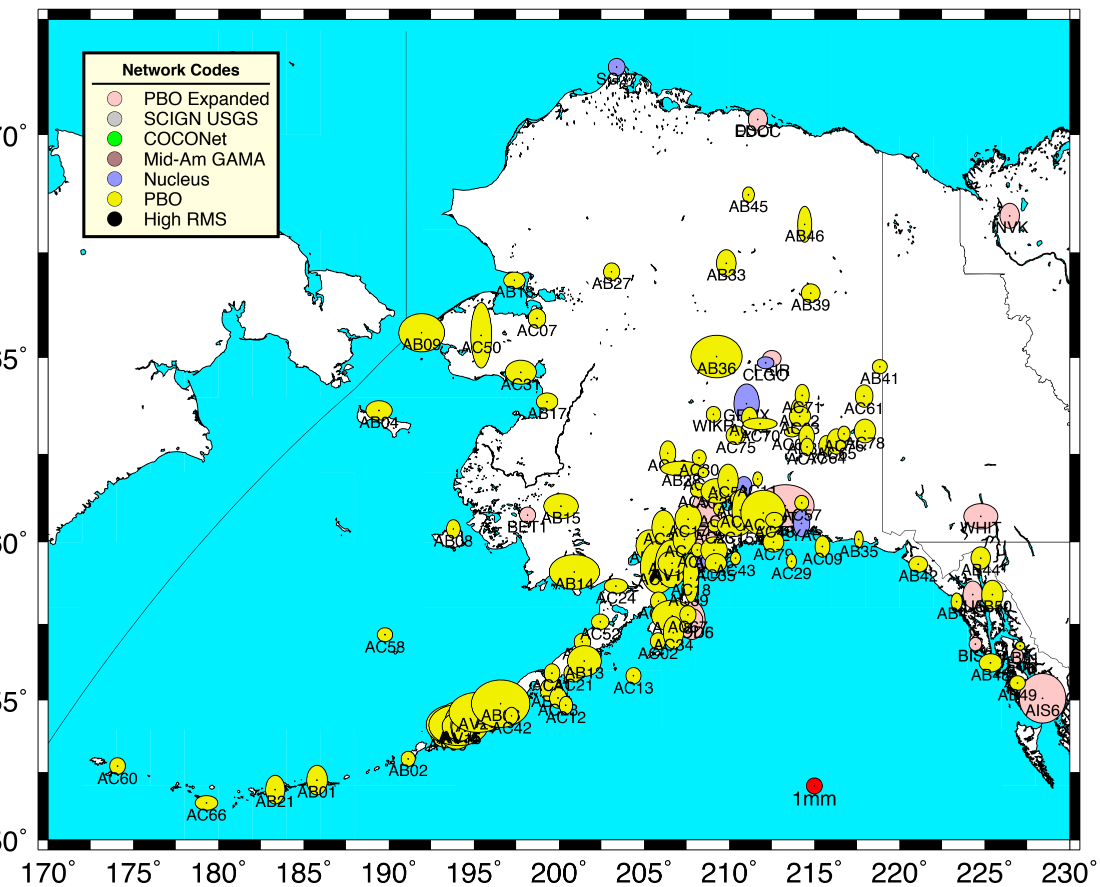

Figure 6: Same as Figure 4 except for the Alaskan region.

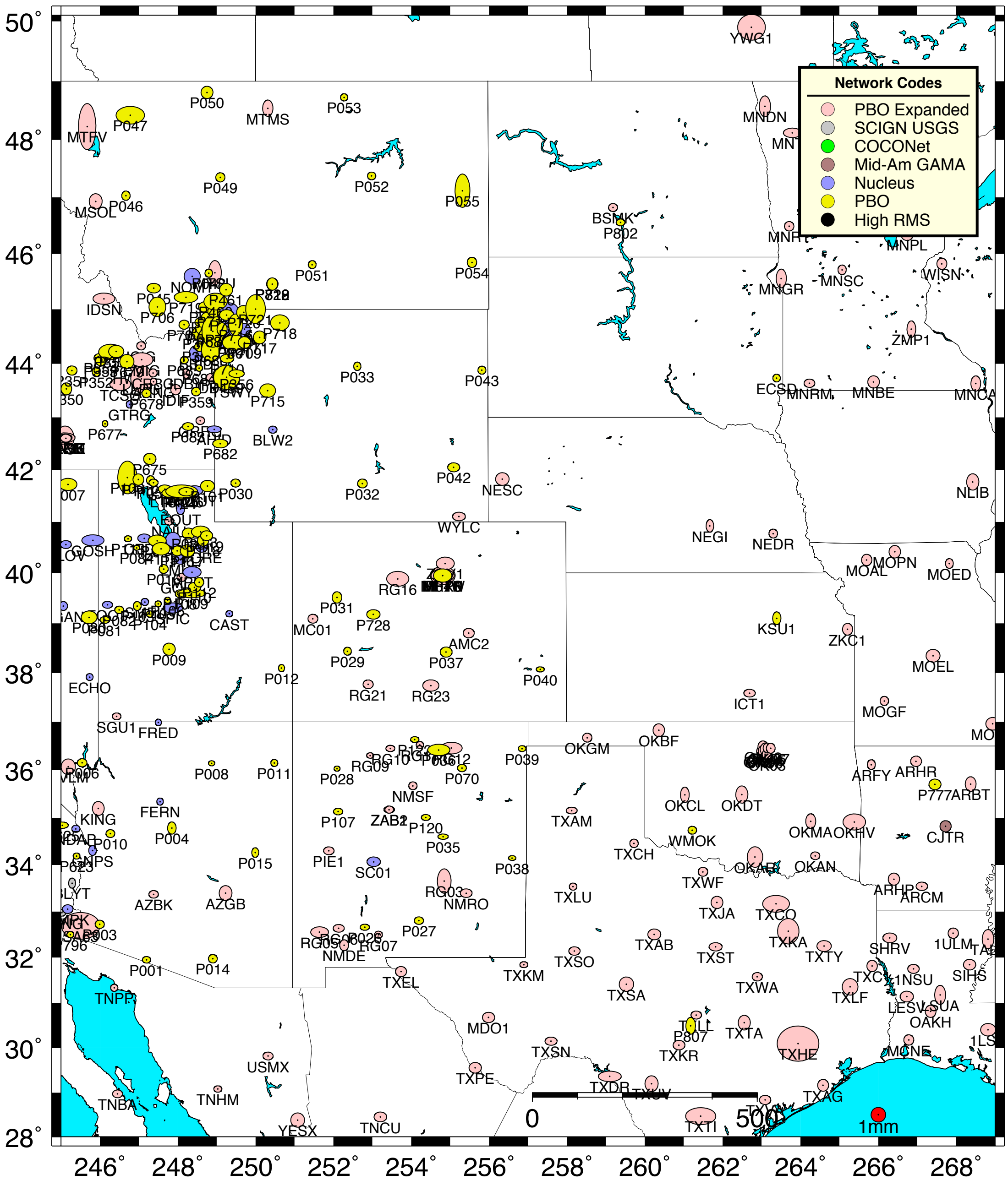

Figure 7: Same as Figure 4 except for the Central United States

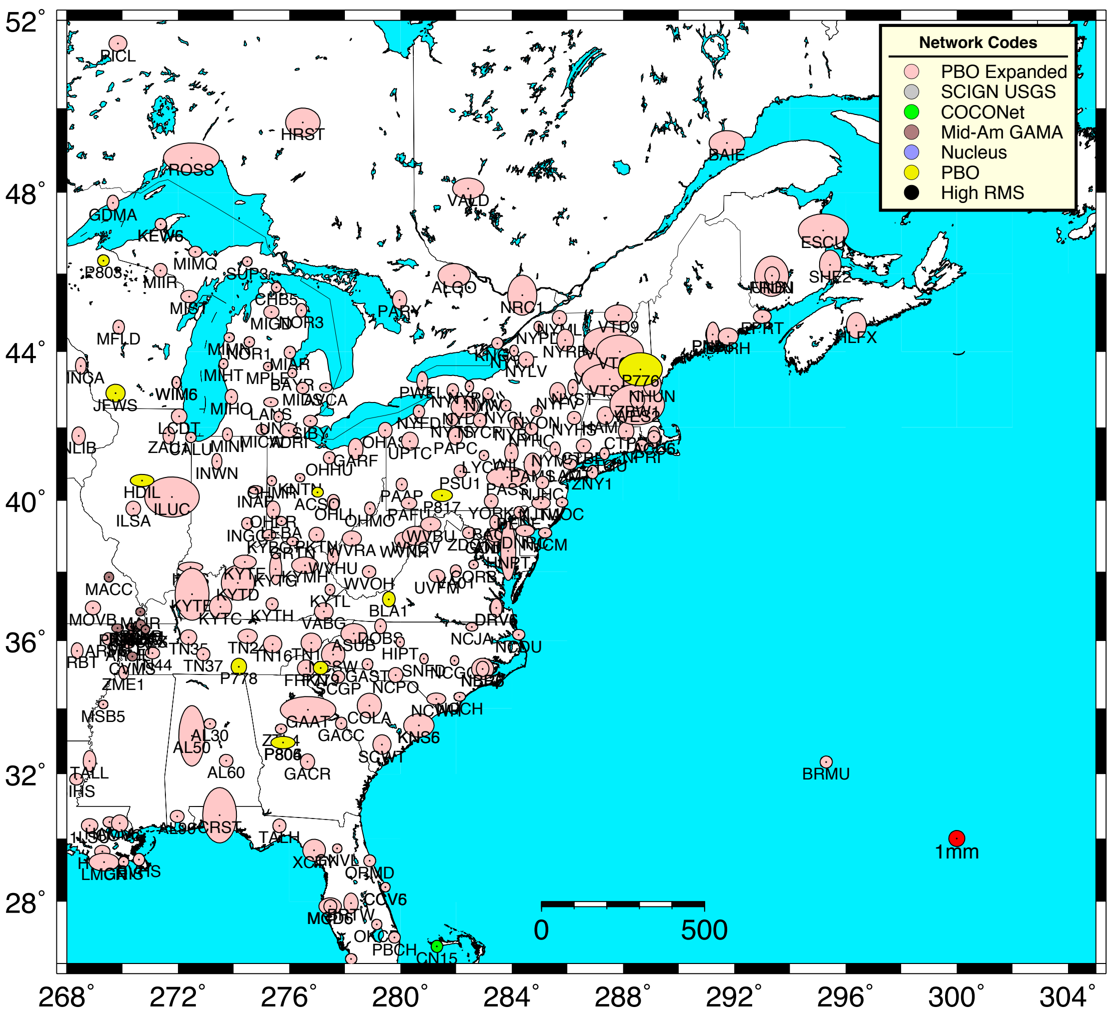

Figure 8: Same as Figure 4 except for the Eastern United States

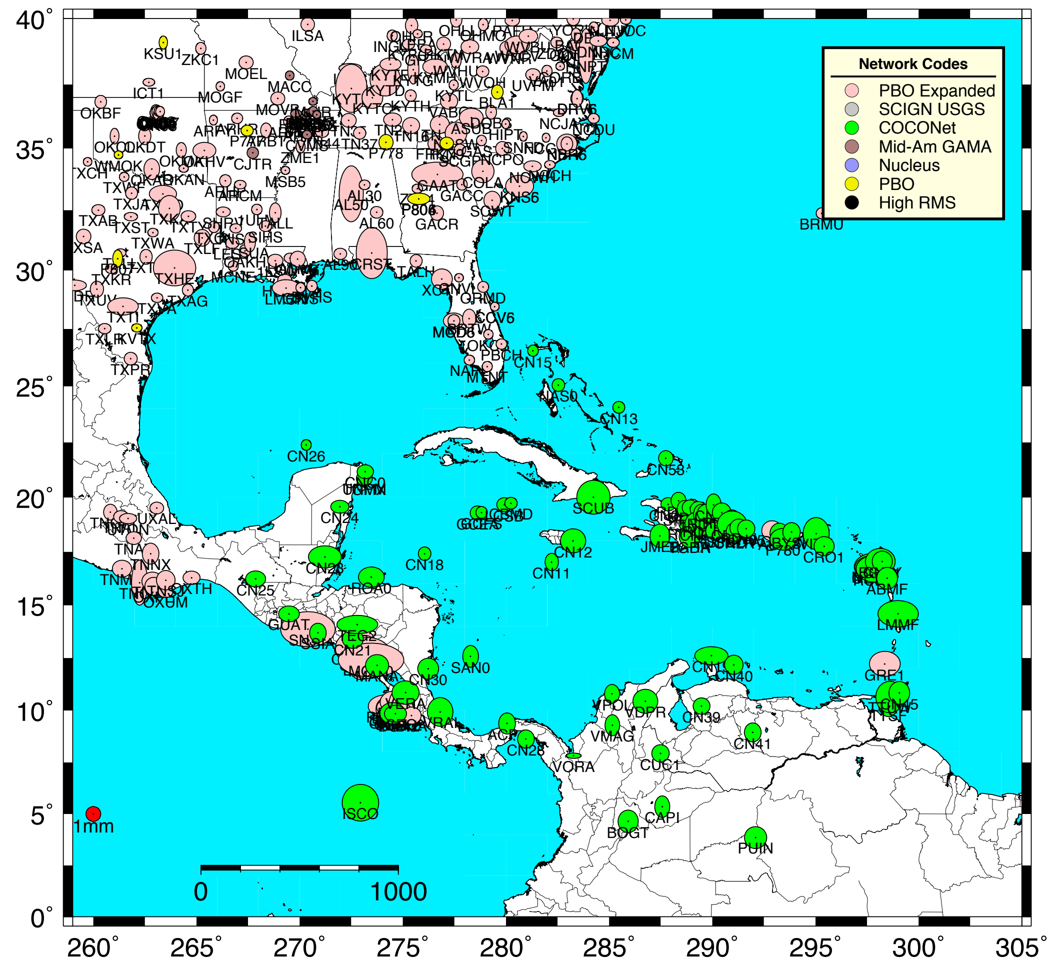

Figure 9: Same as Figure 4 except for the Caribbean region.

GLOBK Apriori coordinate file and earthquake files

As part of the quarterly analysis we run complete analysis of the time series files and generate position, velocity and other parameter estimates from these time series. These files can be directly used in the GLOBK analysis files sent with the GAGE analysis documentation. These links point to the current earthquake and discontinuity files used in the GAGE ACC analyses: All_PBO_eqs.eq All_PBO_ants.eq All_PBO_unkn.eq. The GLOBK apriori coordinate file All_PBO_nam08.apr is the current estimates based on data analysis in this quarterly report. Starting in Q06, we added a GLOBK apriori coordinate file based on the latest SNIPS PBO velocity file that are generated monthly. The SNIPS file updates the coordinates and velocities of stations that have changed in some significant fashion since the generation of the primary apriori coordinate file. The current file is All_PBO_nam08_snips.apr. Both of these apriori files are read with the –PER option in GLOBK (i.e., no periodic terms are applied). In these files, comments have a non-blank character in the first column and text after a ! in lines is treated as a comment. The apriori file contains Cartesian XYZ positions and velocities in meters with the epoch of the position in decimal years (day of year divided by days in the

specific year). The comments contain the standard deviations of the estimates and are not specifically used in GLOBK (yet). The GEOD lines give geodetic coordinates and not directly used (information only). The EXTENDED lines give the extended parts of the model parameters. Specifically, OFFSETS are NEU position and velocity offsets at the times of discontinuities. The velocity changes are all zero in the PBO analyses. The Type in the comment at the end of line indicates the type of offset. If a name is given, then this is an antenna or unknown origin offset. For earthquakes, EQ is the type and two characters after is the code for the earthquake. If postseismic motion is model, then LOG or EXP EXTENDED lines will appear. The time constant of the function is given after the date (days) and the amplitudes in meters in NEU frame is given after that. The comment contains the standard deviations in mm. PERIODIC terms give the period (days) after the date and then cosine and sine terms in NEU. The periodic terms are not used in the standard GLOBK analyses. The comment contains the standard deviations. The GLOBK apriori coordinate file contains annual periodic terms but these are not used in the daily reference frame realization.
When interpreting the offsets in the apriori file, it is important to note that these are obtained for a simultaneous analysis of all data from a site. If the residuals to the fit are systematic, the offsets often will not be the same as an offset computed from analysis of shot spans of data on either side of the offset. We are considering adding such an analysis type in the future.
The Kalman filter estimated offsets are now supplied monthly as part of the monthly reports.

Snapshot velocity field analysis from the reprocessed PBO analysis.

In our monthly reports, we generate "snapshot" velocity fields in the NAM08 reference frame based on the time series analysis of all data processed to that time. We have now started to distribute the snapshot fields (SNAPS) and the significant updates to the standard PBO velocity file (SNIPS file) in standard PBO velocity field format. These files are distributed in the monthly reports. For this quarterly report, we generate these velocity estimates for the reprocessed results and the current GAGE analyses that are in the NAM08 reference frame. There are 2251 stations in the combined PBO solution which is somewhat larger than the 2239 stations reported in the last quarter. The statistics of the fits to results are shown in Table 3. In this analysis, offsets are estimated for antenna changes and earthquakes. Annual signals are estimated and for some earthquakes, logarithmic post-seismic signals are also estimated. The full tables of RMS fit along with the duration of the data used are given in the following linked files: pbo_nam08_180310.tab, nmt_nam08_180310.tab and cwu_nam08_180310.tab. The velocity estimates are shown by region and network type in Figures 10-16. The color scheme used is the same as Figures 4-9. The snapshot velocity field files are linked as: pbo_nam08_180310.snpvel, nmt_nam08_180310.snpvel and cwu_nam08_180310.snpvel.

Table 3: Statistics of the fits of 2251, 2250 and 2241 stations analyzed by PBO, NMT and CWU in the reprocessed analysis for data collected between Jan 1, 1996 and March 10, 2018.

Center	North (mm)	East (mm)	Up (mm)
Median (50%)			
NMT	1.14	1.23	5.84
CWU	1.35	1.35	6.08
PBO	1.15	1.20	5.41
70%			
NMT	1.50	1.61	6.57
CWU	1.68	1.67	6.86
PBO	1.48	1.52	6.08
95%			
NMT	3.47	3.39	9.58
CWU	3.51	3.45	10.37
PBO	3.43	3.37	9.45

Different tolerances are used for maximum standard deviation in each of the figures so that regions with small velocity vectors can be displayed at large scales without the plots being dominated by large error bar points. The standard deviations of the velocity estimated are computed using the GLOBK First-order-Gauss-Markov Extrapolation (FOGMEX) model that aims to account for temporal correlations in the time series residuals. This algorithm is also called the "Realistic Sigma" model.

A direct comparison of the NMT and CWU solutions shows the weighted root-mean-square (WRMS) difference between the two velocity fields is 0.08 mm/yr horizontal and 0.73 mm/yr vertical from differences of all stations in the two solutions that have velocity sigmas that sum to less than 100 mm/yr. The χ^2/f of the difference is $(1.17)^2$ for the horizontal and $(1.85)^2$ for the vertical component. These comparisons are summarized in Table 4. As noted in previous reports, adding small minimum sigmas (added in a root-sum-squared sense), computed such that χ^2/f is near unity changes the statistic slightly (Table 4). With the FOGMEX correlated noise model used to compute the velocity sigmas, the comparison statistics are close but still 17-85% optimistic over expectations. The 10-worst stations, in the order they are removed, are OXPE, P497, P502, P599, RG03, P509, P588, AC59, P483, MYT2 when the added sigmas are not applied and ELMA, OXPE, P497, P599, P502, P588, MYT2, P509, AC59, P483 when the values given in Table 4 are sum-squared into the velocity sigma estimates. This list is similar to the list in the previous quarter although this time we have split the list into two parts. Some stations have been added and others removed.

Table 4: Statistics of the differences between the CWU and NMT velocity solutions with no transformation between them. The stations common to the CWU and NMT solutions are used which is a slightly smaller number than in either solution. The PBO, NMT and CWU solutions themselves have 2251, 2250 and 2241 stations whose velocities can be determined to better than 100 mm/yr. WRMS is weighted-root-mean-scatter and NRMS is $\sqrt{(\chi^2/f)}$ where f is the number of comparisons.

Solution	#	NE WRMS (mm/yr)	U WRMS (mm/yr)	NE NRMS	U NRMS
All_Normal	2227	0.08	0.73	1.17	1.85
Edited-10_worst	2217	0.08	0.72	1.10	1.83
Less_than_median (0.15 0.52 mm/yr)	1214	0.06	0.67	1.17	2.04
Added minimum sigma NE 0.03 U 0.55 mm/yr					
All_Normal	2227	0.10	0.97	1.07	0.98
Edited-10_worst	2217	0.09	0.95	1.00	0.95
Less_than_median (0.15 0.76 mm/yr)	1214	0.07	0.76	1.00	0.84

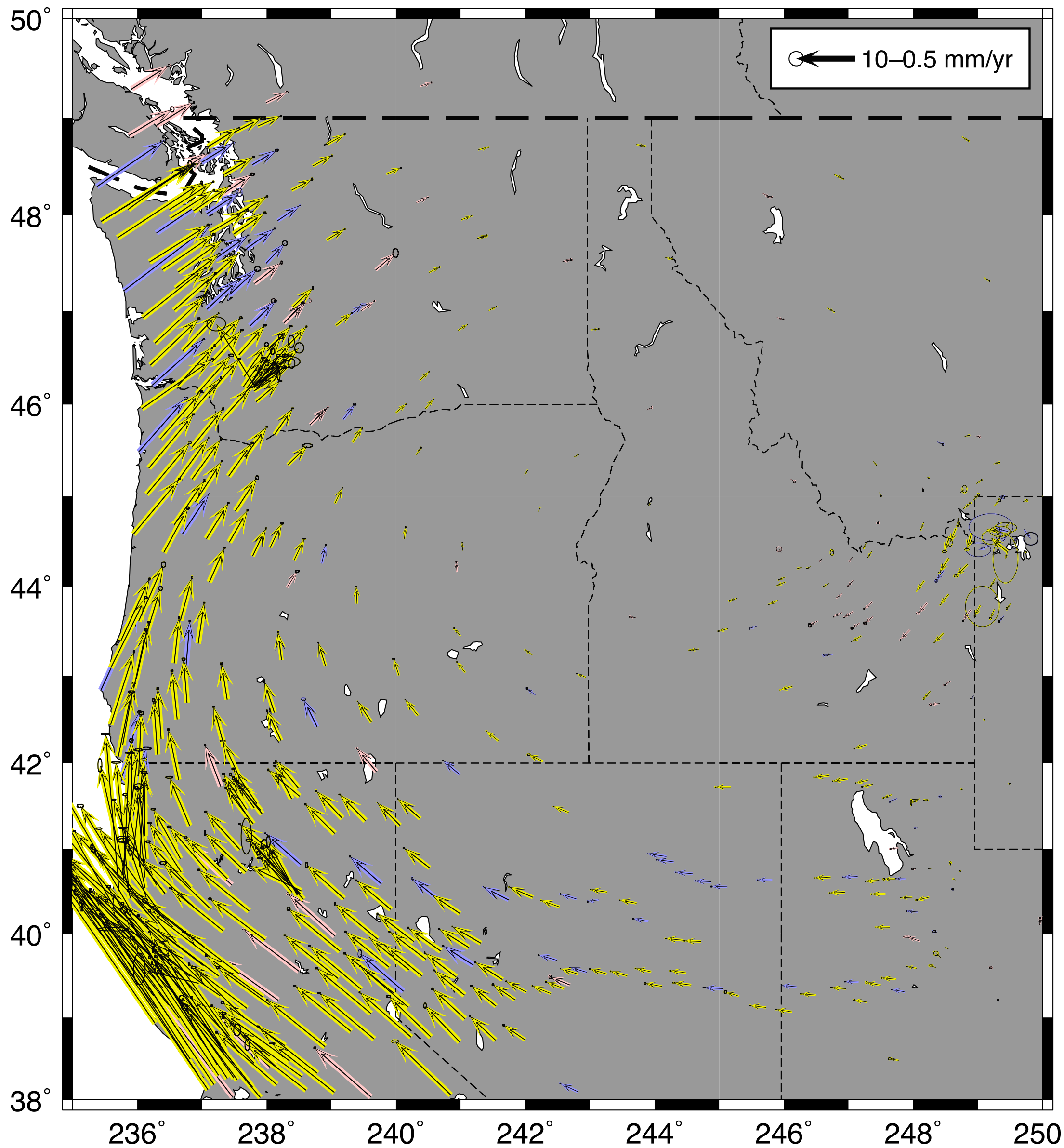

Figure 10: Velocity field estimates from the combined PBO solutions generated using time series analysis and the FOGMEX error model. 95% confidence interval error ellipses are shown. The color scheme of the vectors matches the network type legend in Figure 4. Only velocities with horizontal standard deviations less than 2 mm/yr are shown (this value is reduced from previous reports due the improved velocity sigmas).

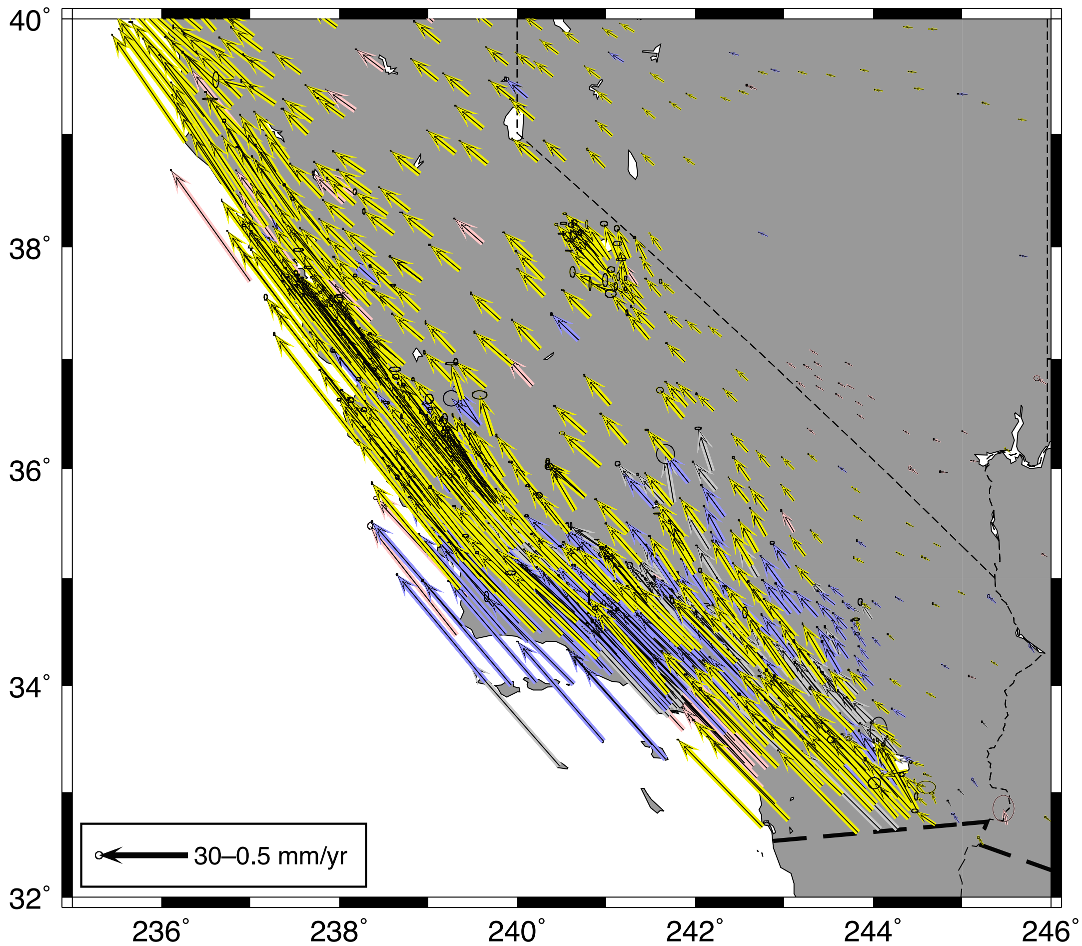

Figure 11: Same as Figure 10 except for South Western United States. Only velocities with horizontal standard deviations less than 2 mm/yr are shown.

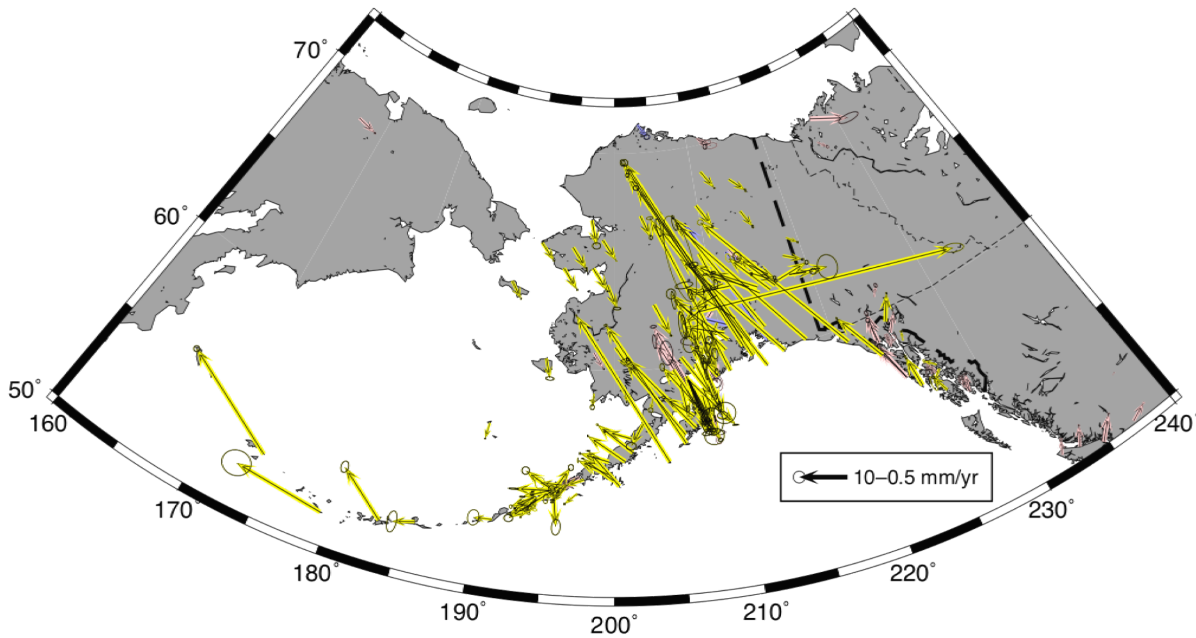

Figure 12: Same as Figure 10 except for Alaska. Only velocities with horizontal standard deviations less than 5 mm/yr are shown

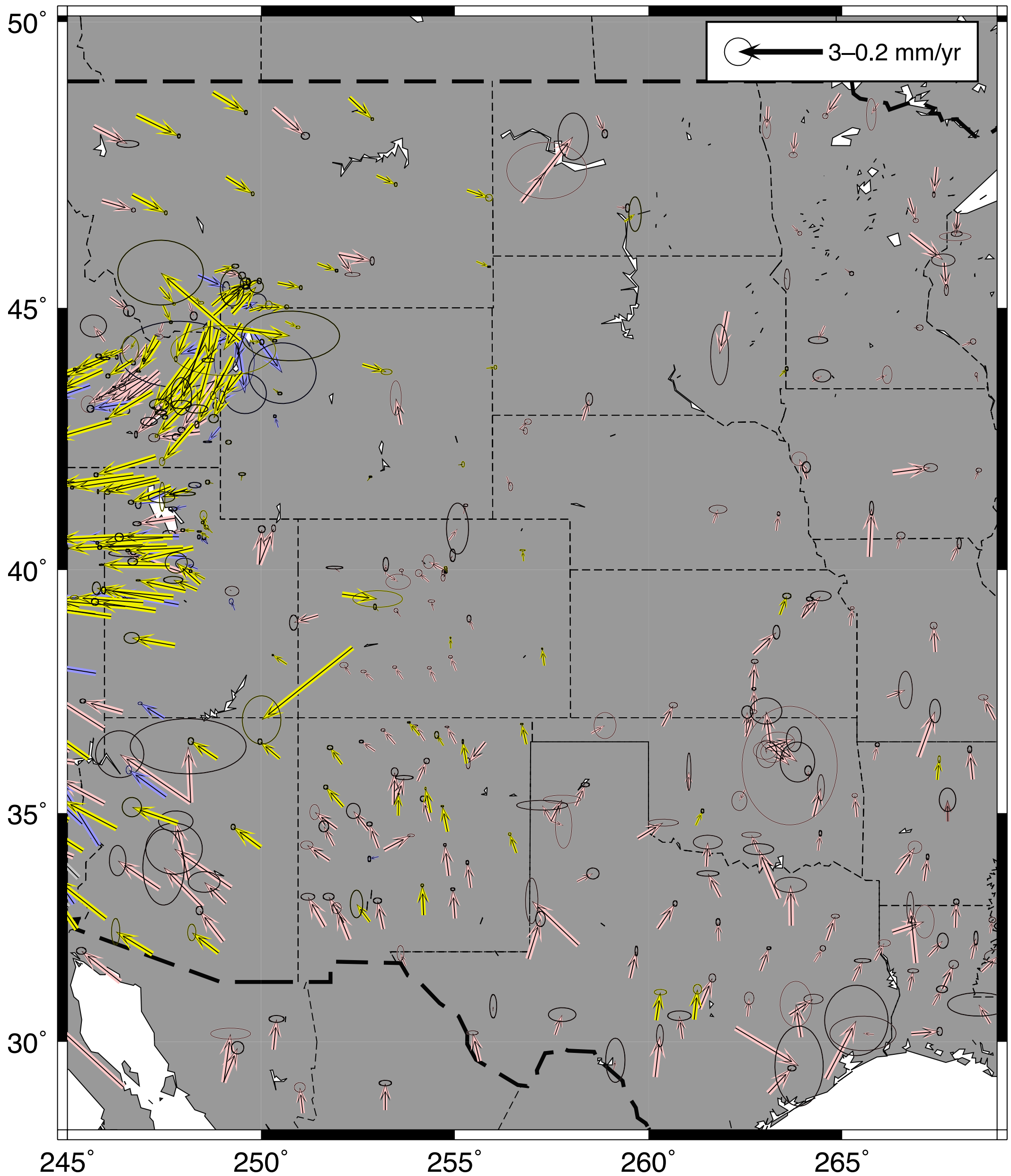

Figure 13: Same as Figure 10 except for Central United States. Only velocities with horizontal standard deviations less than 1 mm/yr are shown.

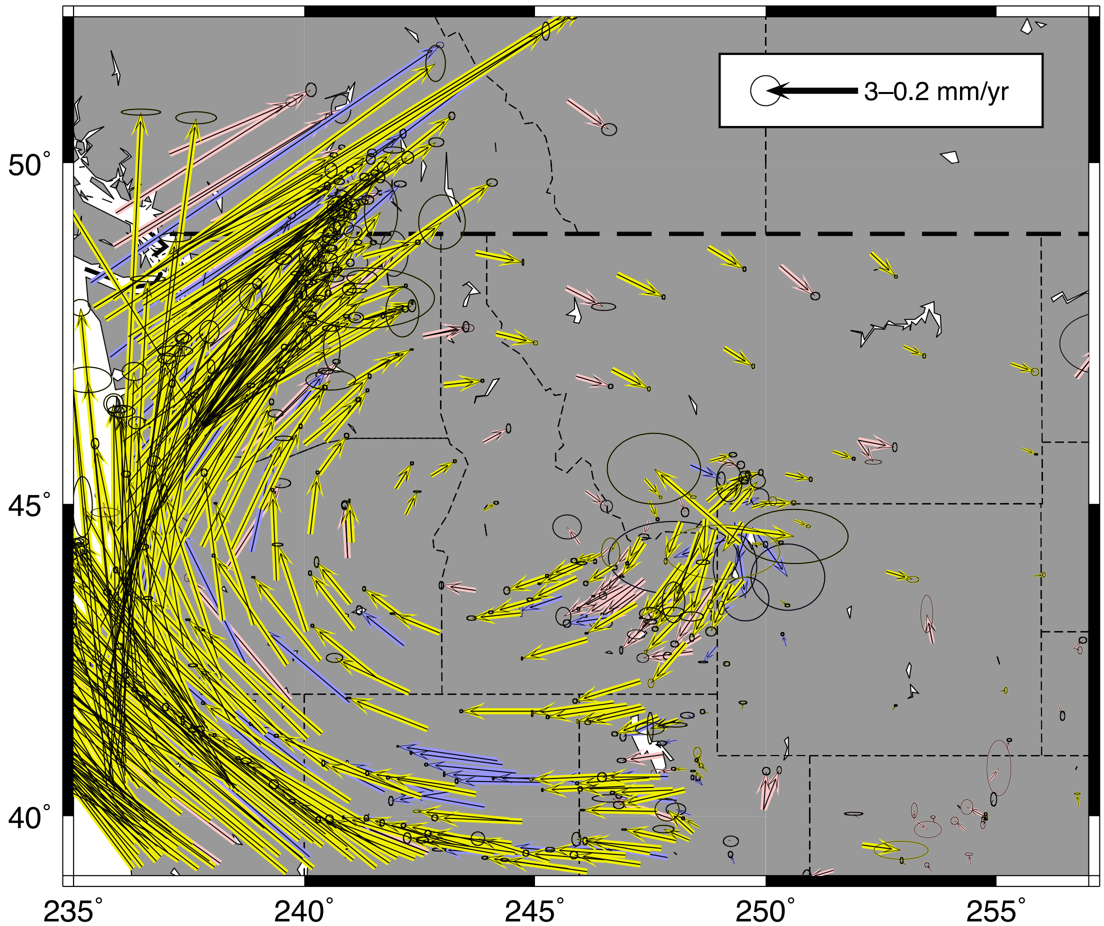

Figure 14: Same as Figure 10 except for Western Central United States. Only velocities with horizontal standard deviations less than 1 mm/yr are shown. Anomalous vectors at longitude 250° are in the Yellowstone National Park and most likely are showing volcanic processes.

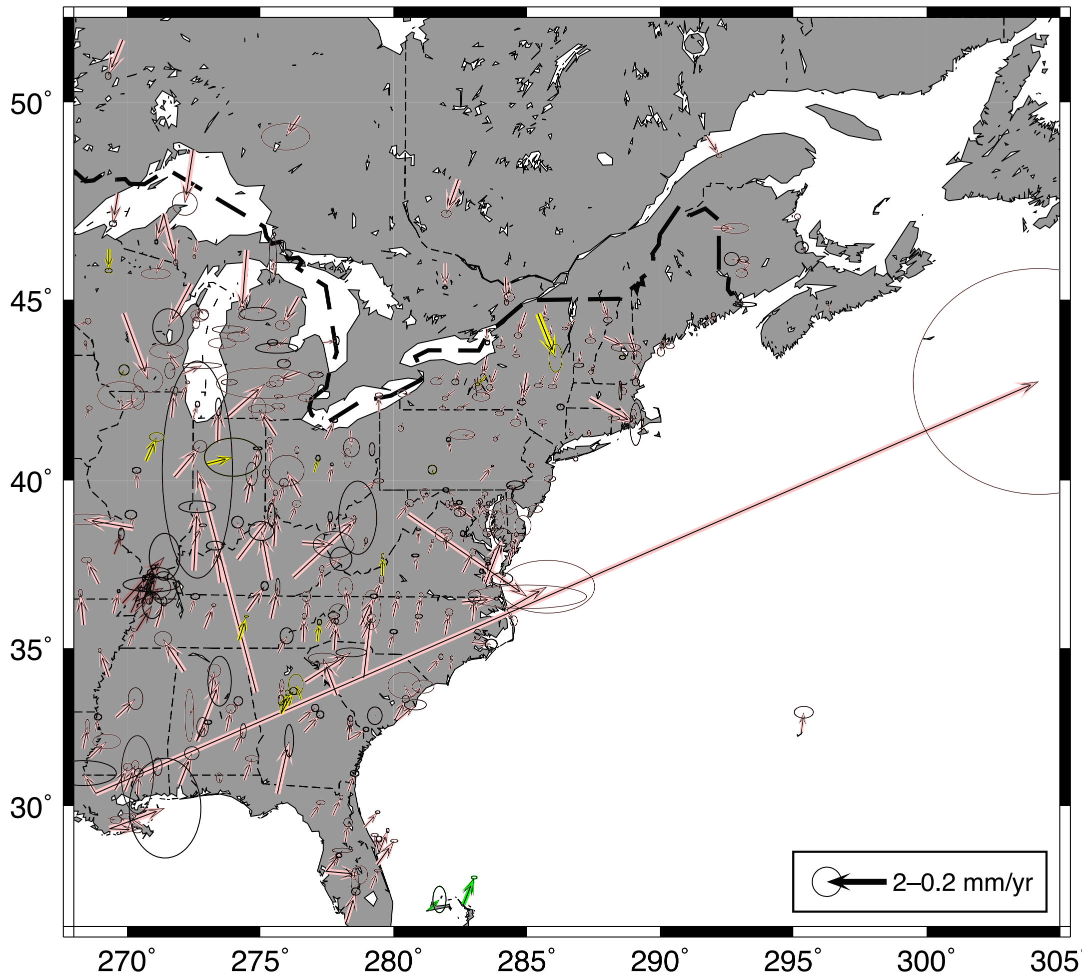

Figure 15: Same as Figure 10 except for the Eastern United States. Only velocities with horizontal standard deviations less than 2 mm/yr are shown. The systematic velocity of sites in the Northeast and central US show deviations for current GIA models in the horizontal velocities. The large outlier is LST1 which has only a short amount of data (less than 1 year). The vertical motions match quite well but geodetic vertical motions are already included in the development of the models. Horizontal GIA motions will affect the North America Euler pole from ITRF2008.

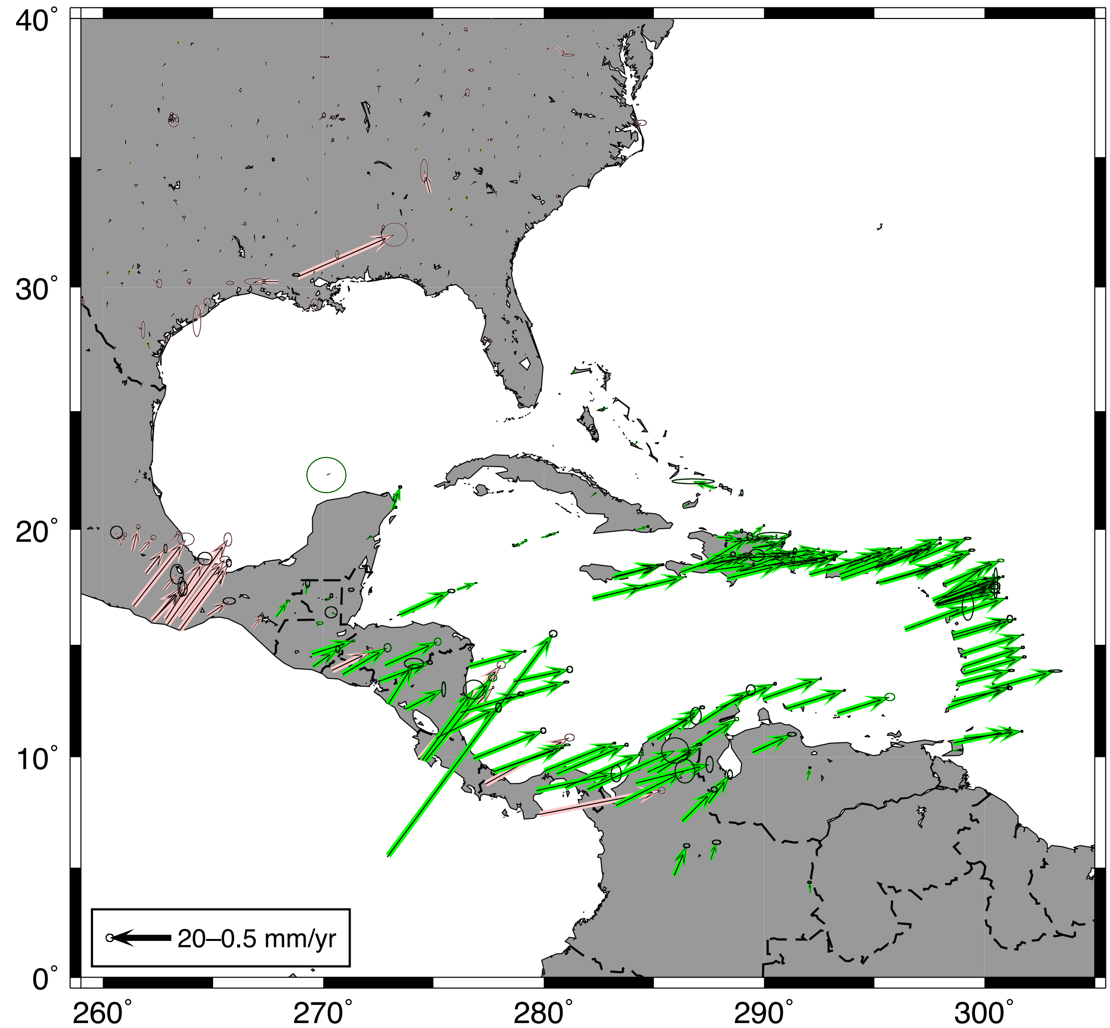

Figure 16: Same as Figure 10 except for the Caribbean region. Only velocities with horizontal standard deviations less than 5 mm/yr are shown.

Earthquake Analyses: 2017/12/14-2018/03/15.

We use the NEIC catalog to search for earthquakes that could cause coseismic offsets at the sites analyzed by the GAGE analysis centers. We examined the following earthquakes. In these output, each earthquake that might have generated coseismic displacements is numbered and the "SEQ Earthquake # n" starts the block of information about the earthquake. The EQ MM lines, give station name, distance from hypocenter (km), maximum distance that could cause coseismic offsets > 1 mm, and the "CoS" (coseismic offset) value is the possible offset in the mm. The eq_def lines give the event number, latitude, longitude, radius of influence, and depth of event followed by the date and time of the event. If an event is found to be significant, the event number is modified to reflect the total number of events so far included in the PBO analyses. Large events are often given a two-character code to reflect their location (e.g., PA is Parkfield).

Events investigated in December 2017/January 2018.

```
* EQDEFS for 2017 12 14 to 2018 01 15 Generated Tue Jan 16 10:30:51 EST 2018
* Proximity based on Week_All.Pos file
* ----------------------------------
* SEQ Earthquake # 1
* EQ 7 P312_GPS      9.89      10.40 CoS       1.1 mm
* EQ 7 P313_GPS      9.07      10.40 CoS       1.3 mm
* EQ 7 P314_GPS     10.20      10.40 CoS       1.0 mm
* EQ_DEF M4.3 17km WSW of Laytonville
 eq_def   01   39.6077 -123.6458     10.4  8  2017 12 14 04 58    0.0017
 eq_rename 01
 eq_coseis 01  0.0010 0.0010 0.0010     0.0017     0.0017     0.0017
* ----------------------------------
* SEQ Earthquake # 2
* EQ 112 ACHO_GPS      8.62      12.80 CoS       4.5 mm
* EQ_DEF M4.7 27km SW of Pedasi
 eq_def   02    7.3377  -80.1821     12.8  8  2017 12 17 06 36    0.0052
 eq_rename 02
 eq_coseis 02  0.0010 0.0010 0.0010     0.0052     0.0052     0.0052
* ----------------------------------
* SEQ Earthquake # 3
* EQ 113 ACHO_GPS      3.24      11.50 CoS      18.9 mm
* EQ_DEF M4.5 22km SW of Pedasi
 eq_def   03    7.3857  -80.1761     11.5  8  2017 12 17 06 54    0.0031
 eq_rename 03
 eq_coseis 03  0.0010 0.0010 0.0010     0.0031     0.0031     0.0031
* ----------------------------------
* SEQ Earthquake # 4
* EQ 330 RDHI_GPS      3.27       8.80 CoS       1.8 mm
* EQ_DEF M3.6 6km SSW of Salvaleon de Higuey
 eq_def   04   18.5765  -68.6986      8.8  8  2017 12 25 10 37    0.0003
 eq_rename 04
 eq_coseis 04  0.0010 0.0010 0.0010     0.0003     0.0003     0.0003
* ----------------------------------
* SEQ Earthquake # 5
* EQ 476 GRNR_GPS      4.43       9.80 CoS       3.6 mm
* EQ 476 GRNX_GPS      4.41       9.80 CoS       3.6 mm
* EQ_DEF M4.1 6km SSW of Healy
 eq_def   05   63.8011 -149.0240      9.8  8  2017 12 30 11 44    0.0011
 eq_rename 05
 eq_coseis 05  0.0010 0.0010 0.0010     0.0011     0.0011     0.0011
* ----------------------------------
* SEQ Earthquake # 6
* EQ 565 P701_GPS      9.09       9.30 CoS       0.5 mm
* EQ 565 P704_GPS      6.43       9.30 CoS       0.9 mm
```

* EQ 565 P792_GPS 6.43 9.30 CoS 0.9 mm
* EQ_DEF M3.9 37km SSE of Morton
eq_def 06 46.2557 -122.0563 9.3 8 2018 01 03 08 37 0.0006
eq_rename 06
eq_coseis 06 0.0010 0.0010 0.0010 0.0006 0.0006 0.0006
* ----------------------------------
* SEQ Earthquake # 7
* EQ 591 P224_GPS 3.34 10.90 CoS 13.2 mm
* EQ_DEF M4.4 2km SE of Berkeley
eq_def 07 37.8552 -122.2568 10.9 8 2018 01 04 10 40 0.0023
eq_rename 07
eq_coseis 07 0.0010 0.0010 0.0010 0.0023 0.0023 0.0023
* ----------------------------------
* SEQ Earthquake # 8
* EQ 661 GRNR_GPS 6.11 9.00 CoS 0.7 mm
* EQ 661 GRNX_GPS 6.10 9.00 CoS 0.7 mm
* EQ_DEF M3.7 5km ESE of Healy
eq_def 08 63.8342 -148.8553 9.0 8 2018 01 07 13 16 0.0004
eq_rename 08
eq_coseis 08 0.0010 0.0010 0.0010 0.0004 0.0004 0.0004
* ----------------------------------
* SEQ Earthquake # 9
* EQ 710 CBMD_GPS 470.23 521.00 CoS 2.5 mm
* EQ 710 CBSB_GPS 462.05 521.00 CoS 2.6 mm
* EQ 710 CN18_GPS 45.76 521.00 CoS 268.1 mm
* EQ 710 CN29_GPS 381.08 521.00 CoS 3.9 mm
* EQ 710 CN35_GPS 511.03 521.00 CoS 2.1 mm
* EQ 710 GCEA_GPS 303.86 521.00 CoS 6.1 mm
* EQ 710 GCFS_GPS 320.84 521.00 CoS 5.5 mm
* EQ 710 LCSB_GPS 437.42 521.00 CoS 2.9 mm
* EQ 710 ROA0_GPS 345.12 521.00 CoS 4.7 mm
* EQ 710 TGMX_GPS 516.78 521.00 CoS 2.1 mm
* EQ 710 UNPM_GPS 516.91 521.00 CoS 2.1 mm
* EQ_DEF M7.6 44km E of Great Swan Island
eq_def 09 17.4693 -83.5197 521.0 8 2018 01 10 02 52 8.7718
eq_rename 09
eq_coseis 09 0.0010 0.0010 0.0010 8.7718 8.7718 8.7718
* ----------------------------------
* SEQ Earthquake # 10
* EQ 750 SSIA_GPS 6.08 10.20 CoS 2.4 mm
* EQ_DEF M4.2 2km NE of Soyapango
eq_def 10 13.7504 -89.1303 10.2 8 2018 01 11 18 20 0.0014
eq_rename 10
eq_coseis 10 0.0010 0.0010 0.0010 0.0014 0.0014 0.0014

EQ01: No offsets seen but P313 and P314 are missing data. P312 has apparent

vegetation issue as reported last month.
EQ02: No data at possibly effected site since mid 2013.
EQ03: Aftershock to EQ02 20-minutes later (M 4.7 and 4.5).
EQ04: No apparent offset although data somewhat noisy (1.5 mm NE RMS).
EQ05: GRNX site skewed in N and U. Kalman filter offset estimates <1 mm in all components.
EQ06: No offset. No data P701 since 11/2017; P704 since 2013. P792 shows large snow effect in early 2016 and 2017.
EQ07: No apparent offset although long term systematics and time variable seasonal amplitude. Kalman filter horizontal offsets <1mm.
EQ08: Aftershock to EQ05. No offset
EQ09: No data at CN18 since October 2017. GCEA, GCFS are displaced by a few millimeters. ROA0 has only one rapid after event, and CN29 has no data.
This earthquake will be event 43. An event file will be prepared and sent.
EQ10: No offset

Events investigated in January/February, 2018.

```
* EQDEFS for 2018 01 14 to 2018 02 15 Generated Thu Feb 15 13:48:43 EST 2018
* Proximity based on Week_All.Pos file
* ----------------------------------
* SEQ Earthquake # 1
* EQ 99 MCTY_GPS      5.10      8.90 CoS      0.7 mm
* EQ_DEF M3.6 4km SW of Caruthersville
 eq_def    01   36.1632  -89.6860      8.9  8  2018 01 16 16 58    0.0003
 eq_rename 01
 eq_coseis 01  0.0010 0.0010 0.0010      0.0003     0.0003     0.0003
* ----------------------------------
* SEQ Earthquake # 2
* EQ 280 AB07_GPS    718.88    839.40 CoS      2.3 mm
* EQ 280 AB12_GPS    822.56    839.40 CoS      1.8 mm
* EQ 280 AB13_GPS    584.73    839.40 CoS      3.5 mm
* EQ 280 AB14_GPS    687.37    839.40 CoS      2.6 mm
* EQ 280 AB15_GPS    836.67    839.40 CoS      1.7 mm
* EQ 280 AB22_GPS    542.11    839.40 CoS      4.1 mm
* EQ 280 AB28_GPS    706.16    839.40 CoS      2.4 mm
* EQ 280 AB35_GPS    596.36    839.40 CoS      3.4 mm
* EQ 280 AB37_GPS    796.79    839.40 CoS      1.9 mm
* EQ 280 AB42_GPS    706.54    839.40 CoS      2.4 mm
* EQ 280 AB43_GPS    787.13    839.40 CoS      2.0 mm
* EQ 280 AC02_GPS    329.72    839.40 CoS     11.1 mm
* EQ 280 AC03_GPS    446.18    839.40 CoS      6.1 mm
* EQ 280 AC06_GPS    427.52    839.40 CoS      6.6 mm
* EQ 280 AC08_GPS    421.51    839.40 CoS      6.8 mm
* EQ 280 AC09_GPS    502.90    839.40 CoS      4.8 mm
* EQ 280 AC11_GPS    642.67    839.40 CoS      2.9 mm
```

* EQ 280 AC12_GPS	677.16	839.40 CoS	2.6 mm
* EQ 280 AC13_GPS	409.10	839.40 CoS	7.2 mm
* EQ 280 AC14_GPS	538.20	839.40 CoS	4.2 mm
* EQ 280 AC15_GPS	495.16	839.40 CoS	4.9 mm
* EQ 280 AC16_GPS	501.06	839.40 CoS	4.8 mm
* EQ 280 AC17_GPS	549.46	839.40 CoS	4.0 mm
* EQ 280 AC18_GPS	372.62	839.40 CoS	8.7 mm
* EQ 280 AC19_GPS	764.86	839.40 CoS	2.1 mm
* EQ 280 AC20_GPS	543.80	839.40 CoS	4.1 mm
* EQ 280 AC21_GPS	625.86	839.40 CoS	3.1 mm
* EQ 280 AC23_GPS	504.17	839.40 CoS	4.8 mm
* EQ 280 AC24_GPS	541.01	839.40 CoS	4.1 mm
* EQ 280 AC25_GPS	839.00	839.40 CoS	1.7 mm
* EQ 280 AC26_GPS	390.22	839.40 CoS	8.0 mm
* EQ 280 AC27_GPS	468.10	839.40 CoS	5.5 mm
* EQ 280 AC28_GPS	698.65	839.40 CoS	2.5 mm
* EQ 280 AC29_GPS	410.02	839.40 CoS	7.2 mm
* EQ 280 AC30_GPS	431.28	839.40 CoS	6.5 mm
* EQ 280 AC32_GPS	611.65	839.40 CoS	3.2 mm
* EQ 280 AC33_GPS	743.07	839.40 CoS	2.2 mm
* EQ 280 AC34_GPS	288.79	839.40 CoS	14.5 mm
* EQ 280 AC35_GPS	384.48	839.40 CoS	8.2 mm
* EQ 280 AC36_GPS	553.68	839.40 CoS	4.0 mm
* EQ 280 AC37_GPS	563.64	839.40 CoS	3.8 mm
* EQ 280 AC38_GPS	321.64	839.40 CoS	11.7 mm
* EQ 280 AC39_GPS	348.18	839.40 CoS	10.0 mm
* EQ 280 AC40_GPS	594.46	839.40 CoS	3.4 mm
* EQ 280 AC41_GPS	705.44	839.40 CoS	2.4 mm
* EQ 280 AC43_GPS	388.23	839.40 CoS	8.0 mm
* EQ 280 AC44_GPS	579.10	839.40 CoS	3.6 mm
* EQ 280 AC45_GPS	320.69	839.40 CoS	11.8 mm
* EQ 280 AC46_GPS	675.87	839.40 CoS	2.7 mm
* EQ 280 AC47_GPS	495.33	839.40 CoS	4.9 mm
* EQ 280 AC48_GPS	521.82	839.40 CoS	4.5 mm
* EQ 280 AC51_GPS	627.35	839.40 CoS	3.1 mm
* EQ 280 AC52_GPS	544.71	839.40 CoS	4.1 mm
* EQ 280 AC53_GPS	639.59	839.40 CoS	3.0 mm
* EQ 280 AC55_GPS	721.88	839.40 CoS	2.3 mm
* EQ 280 AC57_GPS	598.66	839.40 CoS	3.4 mm
* EQ 280 AC59_GPS	474.40	839.40 CoS	5.4 mm
* EQ 280 AC62_GPS	798.49	839.40 CoS	1.9 mm
* EQ 280 AC64_GPS	789.40	839.40 CoS	1.9 mm
* EQ 280 AC65_GPS	813.45	839.40 CoS	1.8 mm
* EQ 280 AC67_GPS	281.43	839.40 CoS	15.3 mm
* EQ 280 AC70_GPS	809.49	839.40 CoS	1.8 mm
* EQ 280 AC74_GPS	825.89	839.40 CoS	1.8 mm

* EQ 280 AC75_GPS 774.58 839.40 CoS 2.0 mm
* EQ 280 AC77_GPS 767.40 839.40 CoS 2.1 mm
* EQ 280 AC79_GPS 450.70 839.40 CoS 6.0 mm
* EQ 280 AC80_GPS 722.93 839.40 CoS 2.3 mm
* EQ 280 ATW2_GPS 617.98 839.40 CoS 3.2 mm
* EQ 280 AUGL_GPS 449.00 839.40 CoS 6.0 mm
* EQ 280 AV01_GPS 451.58 839.40 CoS 5.9 mm
* EQ 280 AV02_GPS 448.20 839.40 CoS 6.0 mm
* EQ 280 AV03_GPS 452.81 839.40 CoS 5.9 mm
* EQ 280 AV04_GPS 451.38 839.40 CoS 5.9 mm
* EQ 280 AV05_GPS 450.66 839.40 CoS 6.0 mm
* EQ 280 AV11_GPS 449.05 839.40 CoS 6.0 mm
* EQ 280 AV16_GPS 456.55 839.40 CoS 5.8 mm
* EQ 280 AV17_GPS 455.30 839.40 CoS 5.8 mm
* EQ 280 AV18_GPS 452.70 839.40 CoS 5.9 mm
* EQ 280 AV19_GPS 449.67 839.40 CoS 6.0 mm
* EQ 280 AV20_GPS 449.47 839.40 CoS 6.0 mm
* EQ 280 AV21_GPS 449.00 839.40 CoS 6.0 mm
* EQ 280 BIS1_GPS 835.98 839.40 CoS 1.7 mm
* EQ 280 BIS5_GPS 835.98 839.40 CoS 1.7 mm
* EQ 280 BIS6_GPS 835.96 839.40 CoS 1.7 mm
* EQ 280 BMCP_GPS 812.49 839.40 CoS 1.8 mm
* EQ 280 EYAC_GPS 537.37 839.40 CoS 4.2 mm
* EQ 280 KEN5_GPS 532.08 839.40 CoS 4.3 mm
* EQ 280 KEN6_GPS 532.05 839.40 CoS 4.3 mm
* EQ 280 KOD1_GPS 258.31 839.40 CoS 18.2 mm
* EQ 280 KOD5_GPS 258.31 839.40 CoS 18.2 mm
* EQ 280 KOD6_GPS 258.32 839.40 CoS 18.2 mm
* EQ 280 POT5_GPS 574.40 839.40 CoS 3.7 mm
* EQ 280 POT6_GPS 574.39 839.40 CoS 3.7 mm
* EQ 280 QUIC_GPS 810.72 839.40 CoS 1.8 mm
* EQ 280 SELD_GPS 409.44 839.40 CoS 7.2 mm
* EQ 280 TLKA_GPS 701.19 839.40 CoS 2.5 mm
* EQ_DEF M7.9 280km SE of Kodiak
eq_def 02 56.0464 -149.0728 839.4 8 2018 01 23 09 32 18.9354
eq_rename 02
eq_coseis 02 0.0010 0.0010 0.0010 18.9354 18.9354 18.9354
* ----------------------------------
* SEQ Earthquake # 3
* EQ 440 P211_GPS 7.32 8.80 CoS 0.4 mm
* EQ_DEF M3.6 6km NNW of Aromas
eq_def 03 36.9373 -121.6610 8.8 8 2018 01 24 06 03 0.0003
eq_rename 03
eq_coseis 03 0.0010 0.0010 0.0010 0.0003 0.0003 0.0003
* ----------------------------------
* SEQ Earthquake # 4

```
* EQ 511 LMHG_GPS       9.13       9.50 CoS        0.6 mm
* EQ 511 LMSG_GPS       9.46       9.50 CoS        0.6 mm
* EQ_DEF M4.0 12km NE of Trabuco Canyon
 eq_def    04   33.7410 -117.4912      9.5  8  2018 01 25 10 10    0.0008
 eq_rename 04
 eq_coseis 04  0.0010 0.0010 0.0010      0.0008     0.0008     0.0008
* ---------------------------------
* SEQ Earthquake # 5
* EQ 865 SSIA_GPS      10.38      11.00 CoS        1.4 mm
* EQ_DEF M4.4 6km SSW of Tecoluca
 eq_def    05   13.7340  -89.0298     11.0  8  2018 02 03 01 03    0.0024
 eq_rename 05
 eq_coseis 05  0.0010 0.0010 0.0010      0.0024     0.0024     0.0024
* ---------------------------------
* SEQ Earthquake # 6
* EQ 1085 ECFS_GPS       6.63       8.70 CoS        0.4 mm
* EQ 1085 ELSG_GPS       7.94       8.70 CoS        0.3 mm
* EQ_DEF M3.5 2km N of Lakeland Village
 eq_def    06   33.6528 -117.3418      8.7  8  2018 02 11 09 03    0.0003
 eq_rename 06
 eq_coseis 06  0.0010 0.0010 0.0010      0.0003     0.0003     0.0003
```

EQ01: This event has been designated 44 and an event file for the rapid solution has already been sent. The event file for the final orbit solutions can now be generated and will sent shortly (2/15/2018). Displacements up to 30 mm in N and 15 mm in East were seen in the rapid solution. There will also be a Kalman filter time series event file submitted with the monthly report.
EQ02-06: No apparent offsets for any of these events. Data are available at the sites around the times of the earthquakes.

Events investigated in February/March, 2018.

```
* EQDEFS for 2018 02 14 to 2018 03 15 Generated Thu Mar 15 18:50:55 EDT 2018
* Proximity based on Week_All.Pos file
* ---------------------------------
* SEQ Earthquake # 1
* EQ 103 OXPE_GPS     111.38     277.50 CoS       16.2 mm
* EQ 103 OXTU_GPS      43.54     277.50 CoS      106.1 mm
* EQ 103 OXUM_GPS     177.66     277.50 CoS        6.4 mm
* EQ 103 TNAT_GPS     193.98     277.50 CoS        5.3 mm
* EQ 103 TNCY_GPS      43.54     277.50 CoS      106.2 mm
* EQ 103 TNMQ_GPS      76.55     277.50 CoS       34.3 mm
* EQ 103 TNNP_GPS      94.16     277.50 CoS       22.7 mm
* EQ 103 TNNX_GPS     138.95     277.50 CoS       10.4 mm
* EQ 103 TNSJ_GPS     160.81     277.50 CoS        7.8 mm
* EQ_DEF M7.2 3km S of San Pedro Jicayan
```

```
 eq_def    01   16.3887  -97.9789    277.5  8  2018 02 16 23 40    3.1442
 eq_rename 01
 eq_coseis 01  0.0010 0.0010 0.0010      3.1442     3.1442     3.1442
* ---------------------------------
* SEQ Earthquake # 2
* EQ 107 OXTU_GPS      24.24      36.30 CoS       9.4 mm
* EQ 107 TNCY_GPS      17.07      36.30 CoS      19.1 mm
* EQ_DEF M5.8 14km SSE of Santa Maria Huazolotitlan
 eq_def    02   16.1583  -97.8817     36.3  8  2018 02 17 00 37    0.0867
 eq_rename 02
 eq_coseis 02  0.0010 0.0010 0.0010      0.0867     0.0867     0.0867
* ---------------------------------
* SEQ Earthquake # 3
* EQ 180 OXTU_GPS      39.60      41.30 CoS       4.6 mm
* EQ_DEF M5.9 32km NE of Santa Catarina Mechoacan
 eq_def    03   16.4993  -97.5790     41.3  8  2018 02 19 06 58    0.1120
 eq_rename 03
 eq_coseis 03  0.0010 0.0010 0.0010      0.1120     0.1120     0.1120
* ---------------------------------
* SEQ Earthquake # 4
* EQ 301 TNCY_GPS      12.45      13.70 CoS       2.8 mm
* EQ_DEF M4.8 30km S of Santiago Jamiltepec
 eq_def    04   16.0084  -97.8646     13.7  8  2018 02 23 05 44    0.0067
 eq_rename 04
 eq_coseis 04  0.0010 0.0010 0.0010      0.0067     0.0067     0.0067
* ---------------------------------
* SEQ Earthquake # 5
* EQ 315 P229_GPS       8.57       8.70 CoS       0.2 mm
* EQ_DEF M3.5 2km ENE of Danville
 eq_def    05   37.8263 -121.9845      8.7  8  2018 02 23 20 20    0.0002
 eq_rename 05
 eq_coseis 05  0.0010 0.0010 0.0010      0.0002     0.0002     0.0002
* ---------------------------------
* SEQ Earthquake # 6
* EQ 473 P490_GPS       8.43       8.90 CoS       0.4 mm
* EQ 473 P741_GPS       8.76       8.90 CoS       0.3 mm
* EQ_DEF M3.7 18km ESE of Anza
 eq_def    06   33.4825 -116.5037      8.9  8  2018 02 26 18 45    0.0004
 eq_rename 06
 eq_coseis 06  0.0010 0.0010 0.0010      0.0004     0.0004     0.0004
* ---------------------------------
* SEQ Earthquake # 7
* EQ 899 P488_GPS       5.41       8.80 CoS       0.7 mm
* EQ_DEF M3.6 10km ENE of Ocotillo Wells
 eq_def    07   33.1778 -116.0292      8.8  8  2018 03 11 12 46    0.0003
 eq_rename 07
```

eq_coseis 07 0.0010 0.0010 0.0010   0.0003   0.0003   0.0003

EQ01: This event has been designated 45 and an event file for the rapid solution has already been sent. Only one station with data available (TNCY) saw a large displacement (~100 mm). Other sites saw displacements of less than 10 mm but there are some close station that have no post-earthquake data.
EQ02-04; Are aftershocks of EQ01.
EQ05-07: All earthquakes have data from the possibly affected sites and no offsets could be detected.

Antenna Change Offsets: 2018/01/01-2018/03/31.

The follow antenna changes were investigated and reported on in the MIT ACC monthly reports.

```
Station  Date           From          To
NVLM  2017 12  4 19 40  LEIAT504      LEIAR10
P011  2017 12 21  0  0  TRM29659.00   TRM59800.80
P032  2017 12  2  0  0  TRM29659.00   TRM59800.80
TXAG  2017 12  6 17  0  TRM55971.00   TRM57971.00

LINH  2018  1 10 22 50  TPSCR.G3      TRM115000.00
RMVJ  2018  1 26  0  0  TRM59800.00   TRM59800.80

P175  2018  2  8 22 20  TRM29659.00   TRM59800.80
P590  2018  2 12  0  0  TRM59800.00   TRM59800.80

Analysis

NVLM: WLS dNEU    7.64 +- 3.92,  -2.44 +- 3.09,  19.71 +- 22.50 mm,
       KF dNEU    7.34 +- 0.47,  -2.18 +- 0.43,  18.10 +- 1.71 mm
Offsets clear in data.  North offset "balances" change from 2016/12/07
antenna change.
P011: WLS dNEU    0.51 +- 0.73,   6.31 +- 0.53,   3.07 +- 5.12 mm,
       KF dNEU    0.43 +- 0.36,   6.55 +- 0.33,   4.35 +- 1.23 mm .
There is a gap in the data but the East offset is quite clear.
P032: WLS dNEU   -2.00 +- 0.47,   0.15 +- 0.63,   0.82 +- 6.63 mm,
       KF dNEU   -1.84 +- 0.26,   0.15 +- 0.22,   2.11 +- 0.86 mm
North offset is clear in the time series.
TXAG :WLS dNEU  -14.61 +- 7.47, -11.51 +- 6.64,  15.31 +- 8.89 mm,
       KF dNEU  -11.52 +- 0.66, -10.31 +- 0.63,  12.60 +- 1.72 mm
These offsets are clear in the time series.  We also found breaks on
2013/06/17 receiver change after a short gap in the data and 2007/09/11
with no known meta-data entry.  Adding these breaks (mostly in east) by
0.4+- 0.4 mm/yr.

LINH: WLS dNEU   -2.58 +- 1.46,  -0.49 +- 1.96,  -3.49 +- 7.15 mm,
       KF dNEU   -1.71 +- 0.40,   0.04 +- 0.32,  -4.39 +- 1.22 mm
Any break in the data looks small.
RMJV: WLS dNEU    3.57 +- 0.99,  -3.18 +- 1.46,   3.03 +- 7.35 mm,
       KF dNEU    4.09 +- 0.35,  -2.45 +- 0.34,   4.13 +- 1.35 mm
Break in North is very clear.  East can also be seen by eye.

LINH: WLS dNEU   -2.58 +- 1.46,  -0.49 +- 1.96,  -3.49 +- 7.15 mm,
```

```
       KF dNEU   -1.71 +- 0.40,   0.04 +- 0.32,  -4.39 +- 1.22 mm
Any break in the data looks small.
RMJV: WLS dNEU    3.57 +- 0.99,  -3.18 +- 1.46,   3.03 +- 7.35 mm,
       KF dNEU    4.09 +- 0.35,  -2.45 +- 0.34,   4.13 +- 1.35 mm
Break in North is very clear.  East can also be seen by eye.

P197: WLS dNEU    5.50 +- 1.97,  -0.96 +- 2.91,  -0.98 +- 9.26 mm,
       KF dNEU    5.94 +- 0.29,  -1.18 +- 0.28,   2.28 +- 1.03 mm
The north break is clear in the data
P590: WLS dNEU    1.51 +- 3.32,  -2.73 +- 1.15,  -1.99 +- 6.54 mm,
       KF dNEU    2.04 +- 0.33,  -3.90 +- 0.29,   1.56 +- 1.08 mm
The east break is clear in the data.  The previous antenna change in
2017/07/14 caused an even large jump in the east component.
```

New offsets of unknown origin and data anomalies

P313 Seems to be show vegetation growth. Lots of missing data starting end of November 2017.
P314 Missing rapid solutions starting at the end of 2017.
P792 Systematic snow effect clear in early 2016 and 2017. Not as large in earlier years.
P224 "Quadratic" in North +- 3 mm. Larger annual amplitude in since 2016. Subsidence started about this time as well.
TXAG Breaks at 2013/06/17 16:39 and 2007/09/11. First is associate with receiver serial number change. No obvious reason for second jump. The second jumps looks slow in North (between 2007/08/13 and 2007/09/11) although it could be a pair of jumps in North.

GAMIT/GLOBK Community Support

We have updated tables to support added new receivers and antennas and continued to provide regular updates for differential code biases (DCBs), mapping functions (VMF1), and atmospheric loading required by GAMIT users.

We continue to spend 5-10 hours per week in email support of users. During the quarter, we issued 18 additional royalty-free licenses to educational and research institutions.

GNSS software developments

We have made substantial progress in implementing GNSS processing capability into the GAMIT/GLOBK processing software. Specifically, we are now able to process Glonass in GAMIT for static positioning and in track for kinematic positioning. In track, full simultaneous processing of all GNSS systems is implemented although we are still examining the impact of intersystem biases on the results and ambiguity resolution. We have also extended our pseudo-range point and differential positioning software to be fully GNSS compatible with simultaneous processing of pseudo-range data from all and combinations of GNSS constellations. We are using this software to analyze the timing offsets between the different GNSS systems and for Glonass between the different frequency channels.

The preliminary analyses of our GNSS GAMIT/GLOBK processing will be presented at the EGU 2018 in an invited talk by Herring and King in the G1.3 session "High-precision GNSS: methods, open problems and geoscience applications". The talk is EGU2018-8381 "Development of GNSS capability in the 'GNSS at MIT' software GAMIT". To test the GNSS capabilities, we have been processing GNSS data from PBO and will present these results. Currently, it is difficult to assess from the UNAVCO web site which sites have which GNSS capability and we have relied on downloading data from the RINEX3 directory and then looking at headers to determine the data contents for each station. We have chosen 20 stations spread across the network where the stations are clustered so that we cover both short and long baselines. Nearly all of the stations are Septentrio and only 2 Trimble NetR9 have been found. An easy way to search for stations tracking different GNSS systems would be useful and move UNAVCO towards fully supporting GNSS.

Our test data sets, cover 31 days between 2017 day 300 and day 330. We have processed each GNSS system, GPS, Glonass, and Galileo with orbits fixed and with the orbit integration constants (ICs) free to adjust. These solutions were run with ambiguities free and with as many fixed to integers are possible. Each GNSS was run separately and we combined the separate solutions in GLOBK with common estimates for station coordinates, Earth orientation parameters and average zenith delays. This solution is referred to as the combined (ALL) solution. We used the RINEX 2.11 data files which do not include the Chinese Beidou system although we can process these data as well. (As noted an earlier report, the small number of medium-Earth satellites in the current constellation makes the Beidou results inferior at the current time.) The RINEX 3 files for the sites processed do not include Beidou, and the five OK0 the stations chosen because of their close spacing, do not record Galileo signals. Hence there are in-consistencies in the data sets at UNAVCO.   Table G1 summaries the results from this preliminary analysis in the form of the median weighted root-mean-squares scatter (WRMS) of the position time series from these analyses. As expected, the orbit free solutions have higher scatter (and higher formal standard deviations) but we ran these analyses to make sure there were no large systematic errors in the a priori orbits we obtained from the CODE GNSS analysis center. The encouraging sign is that the combined analysis generates the lowest WRMS scatter results when the orbits are fixed to their apriori values. It would be useful if the NGEO-selected GNSS processing center could verify these results.

We are continuing to implement features for GNSS processing including better accounting for of inter-system and differential code biases and improved radiation force modeling for non-GPS systems.

Table G1: Median weighted root-mean-squares scatter (WRMS) of GNSS processed results based on 31 days of data between 2017 day 300 and day 330.   The legend explains the codes for the analysis. The lowest RMS values are highlighted in yellow and in all cases are for the combined ALL solution.

Analysis	N (mm)	E (mm)	U (mm)	# stations
GPS BR OX	1.03	1.30	3.36	20
GPS BX OX	1.04	1.00	3.48	20
GPS BR OR	1.32	1.76	3.38	20
GPS BX OR	1.00	0.98	3.46	20
GLO BR OX	1.35	1.82	4.27	20
GLO BX OX	1.75	1.81	4.66	20
GLO BR OR	2.41	2.64	5.80	20
GLO BX OR	1.58	2.43	4.93	20
GAL BR OX	1.61	2.23	5.71	15
GAL BX OX	1.89	1.28	5.05	15
GAL BR OR	2.72	5.09	6.69	15
GAL BX OR	1.61	1.63	5.65	15
ALL BR OX	0.97	1.41	3.34	20
ALL BX OX	0.99	0.91	3.26	20
ALL BR OR	1.49	2.06	3.71	20
ALL BX OR	1.24	1.22	3.59	20

Legend: GPS – GPS, GLO – Glonass, GAL – Galileo, ALL – Combined GPS, Glonass and Galileo, BR – Bias Free, BX – Bias Fixed, OR – Orbit IC Free, OX – Orbit IC Fixed.