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: 2018/07/01-2018/09/30

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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 2018/06/17 to 2018/09/09, time series velocity field analyses for the GAGE reprocessing analyses (1996-2018). Several earthquakes were investigated this quarter but none generated coseismic displacements > 1mm. We did processing of Antarctica stations to the analyses and this resulting in adding 4 earthquakes, denoted A1-A4, to the PBO earthquake file.

For this quarter, the last finals results were for September 09, 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.

This will be the last quarterly report including NMT solutions. After Oct 1, 2018, NMT is no longer funded to generate GAMIT solutions and GAGE products after the last date of NMT generating solutions will be solely based on CWU submissions. Plans are being developed to incorporate time series from other analysis centers into a combined time series product.

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. Both ACs have submitted reprocessed IGS14 solutions with CWU solutions going back to 2002 when JPL IGS14 products start to be available and NMT going back to 1996 when IGS products are available. When all of the repro SINEX files are combined into a standard GAGE velocity solution, a NAM14 frame will be developed and time series and frame references SINEX files created in the new reference frame.

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.

Level 2a products: Final products

The final products are generated weekly and are based on the final IGS and JPL (CWU) orbits. Finals and rapid solutions are now being generated in the IGS14 system. In this quarter 2140 stations were processed which is 281 more than last quarter because of the addition of GNET and other sites North America. In addition 77 sites are being processed in the ANET solutions.

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: June 17, 2018 and September 09. 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 June 17, 2018 and September 09. 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 1.03 mm for all centers and as low as 0.83 mm for PBO North and 0.80 mm for PBO east components. The up-RMS scatters are less than or equal 4.3 mm for all analyses and as low as 3.71 mm for the PBO solution. These statistics are similar to last quarter although the number of stations has increased from ~1800 to ~2140 due to the increase in the size of the network being processed. 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 2140, 2139 and 2140 stations for PBO, NMT and CWU analyzed in the finals analysis between June 17, 2018 and September 09. 2018. Histograms of the RMS scatters are shown in Figure 1-3.

Center	North (mm)	East (mm)	Up (mm)
Median (50%)			
PBO	0.83	0.80	3.71
NMT	0.89	0.94	4.17
CWU	1.03	0.93	4.28
70%			
PBO	1.02	1.01	4.31
NMT	1.11	1.18	4.78
CWU	1.22	1.13	5.06

95%			
PBO	1.81	1.85	6.67
NMT	1.94	2.26	7.55
CWU	2.12	2.12	7.92

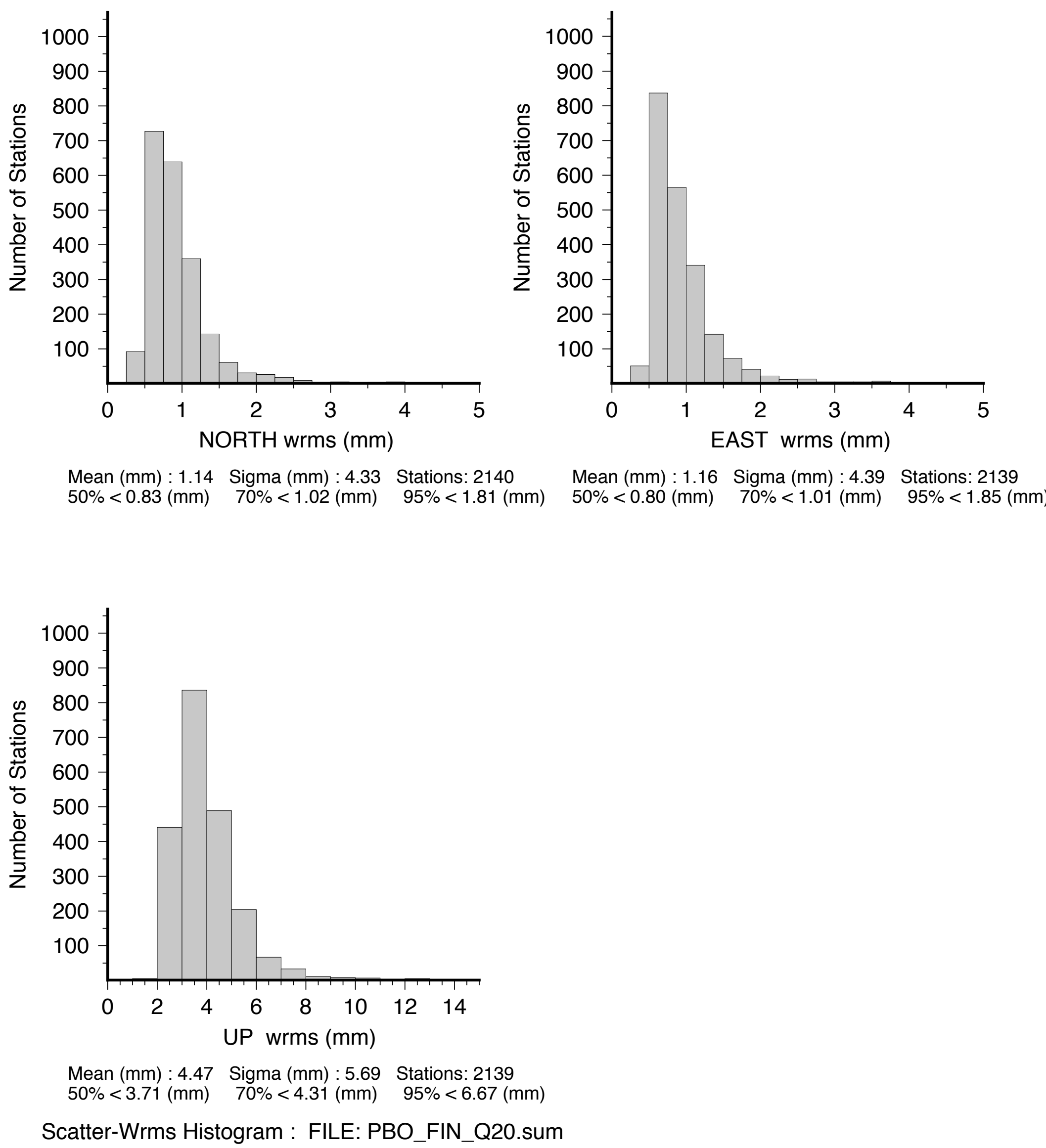

Figure 1: PBO combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1859 stations analyzed between June 17, 2018 and September 09. 2018. Linear trends and annual signals were estimated from the time series.

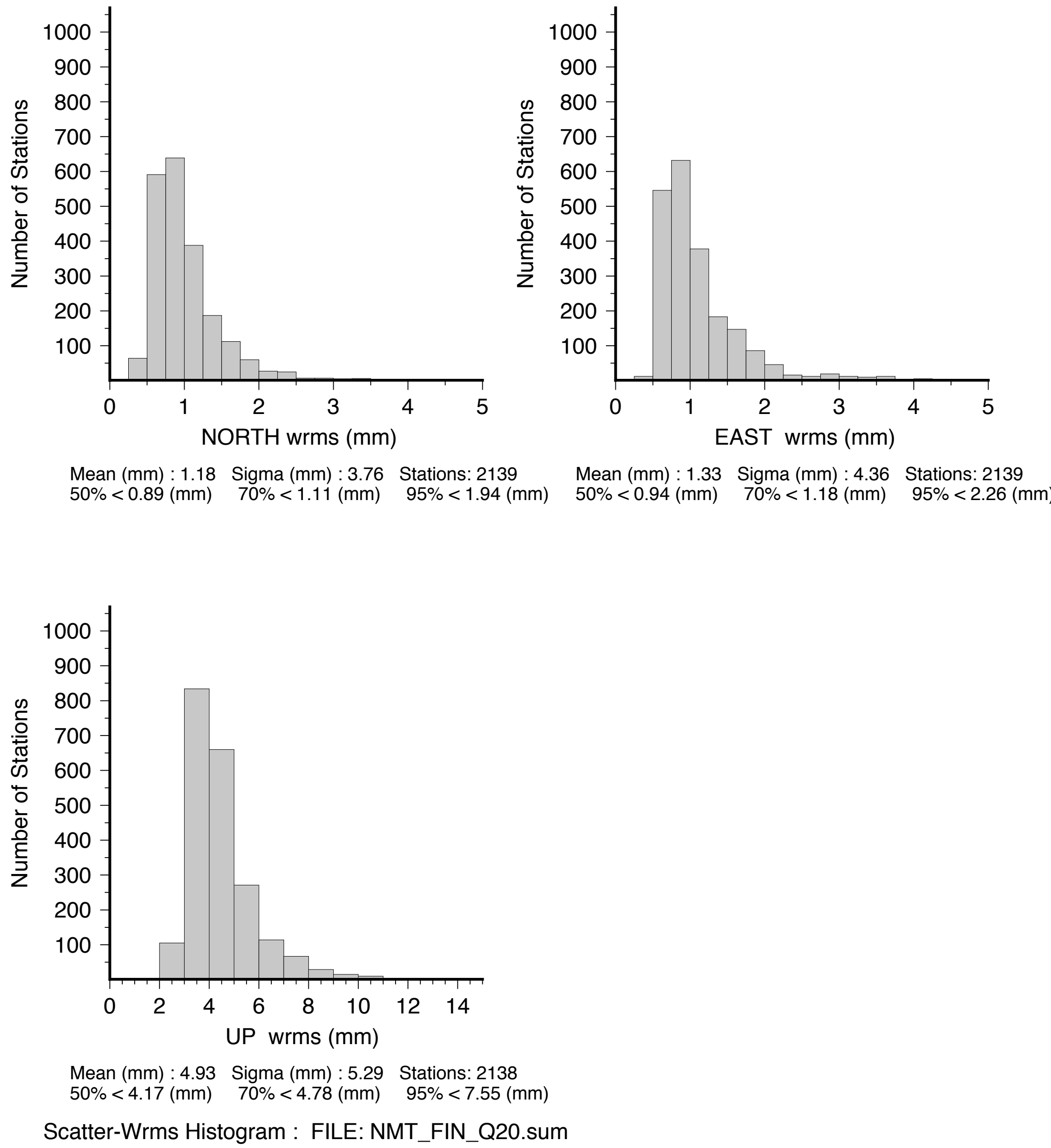

Figure 2: NMT combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1857 stations analyzed between June 17, 2018 and September 09. 2018. Linear trends and annual signals were estimated from the time series.

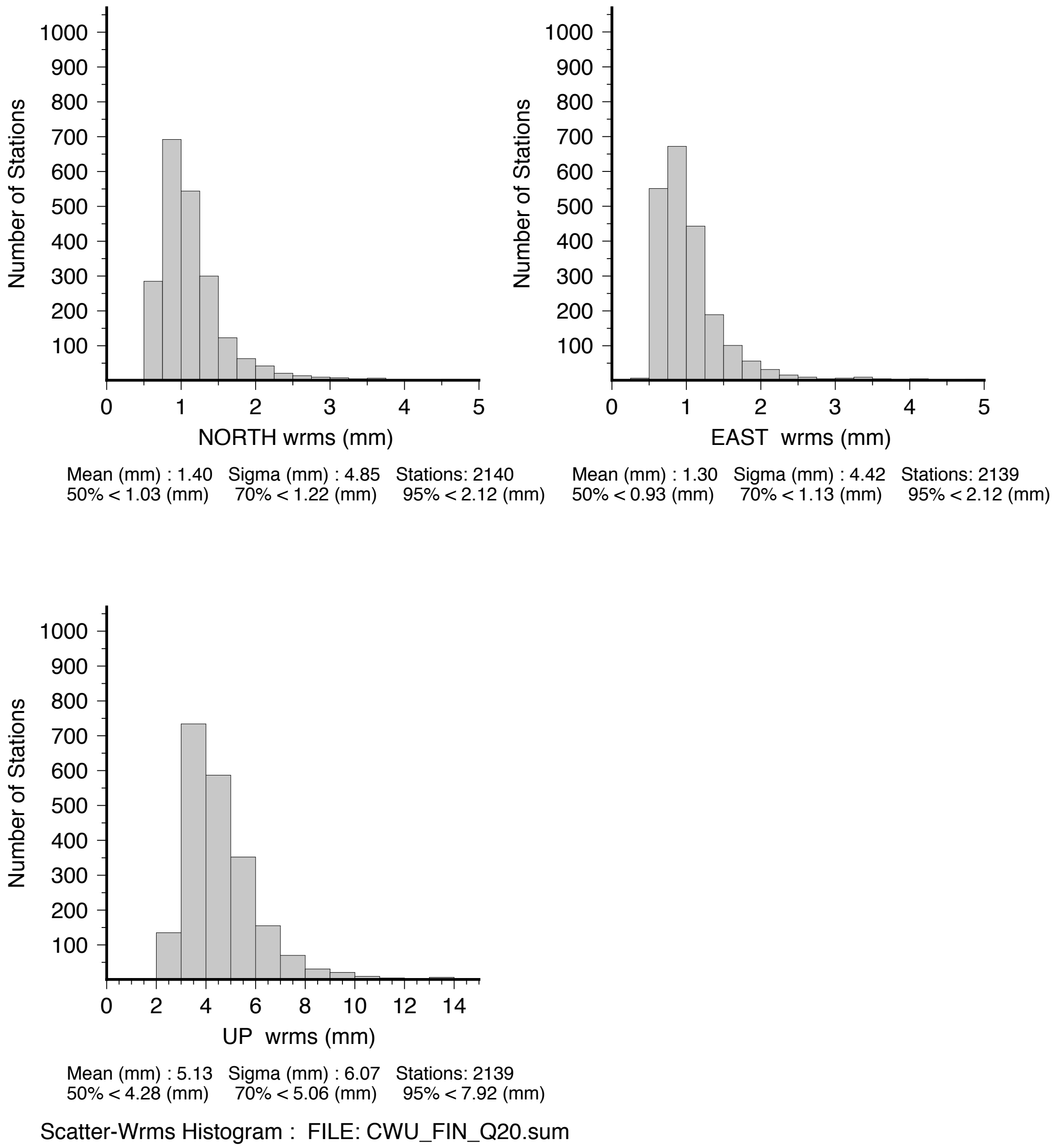

Figure 3: CWU combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1858 stations analyzed between June 17, 2018 and September 09. 2018. Editing removes two stations for North and Up. Linear trends and annual signals were estimated from the time series.

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_Q20.tab. There are 2140 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_Q20.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     93      1.6   0.62       1.5   0.56      6.6   0.54      15.40
 1NSU     93      0.9   0.49       0.9   0.48      4.9   0.62      14.66
 1ULM     93      0.9   0.50       1.1   0.60      4.0   0.53      15.26
 7ODM     81      0.8   0.40       0.9   0.51      4.5   0.63      17.40
 …
 ZDV1     93      0.8   0.40       0.6   0.34      4.4   0.60      15.29
 ZKC1     93      0.9   0.42       0.8   0.44      4.8   0.64      15.29
 ZLA1     93      0.9   0.43       0.8   0.46      3.9   0.52      15.29
 ZLC1     93      0.9   0.46       0.7   0.45      3.6   0.53       0.67
 ZME1     93      1.0   0.50       1.0   0.54      5.4   0.68      15.51
 ZMP1     93      0.9   0.41       0.8   0.48      4.2   0.58      15.76
 ZNY1     93      0.9   0.44       0.9   0.53      4.5   0.61      15.67
 ZOA1     93      0.5   0.29       0.7   0.40      2.9   0.43       0.67
 ZSE1     93      0.8   0.36       0.7   0.39      3.4   0.49      15.67
 ZTL4     93      1.0   0.49       1.1   0.58      5.3   0.66      15.86
```

Table 2: RMS scatter of the position residuals for the PBO combined solution between June 17, 2018 and September 09. 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	0.73	0.71	3.27	880
NUCLEUS	0.66	0.67	3.27	204
GAMA	0.81	0.86	4.64	14
COCONet	1.21	1.36	5.88	81
USGS_SCIGN	0.70	0.72	3.47	128
Expanded	0.97	0.97	4.18	833
70%				
PBO	0.85	0.84	3.77	
NUCLEUS	0.77	0.80	3.62	
GAMA	0.91	0.87	4.75	
COCONet	1.37	1.57	6.19	
USGS_SCIGN	0.79	0.83	3.81	
Expanded	1.14	1.13	4.81	
95%				
PBO	1.55	1.43	5.68	
NUCLEUS	1.17	1.19	5.16	
GAMA	1.09	0.95	5.06	
COCONet	2.28	3.57	10.21	
USGS_SCIGN	1.42	1.68	6.05	
Expanded	2.10	2.13	7.85	

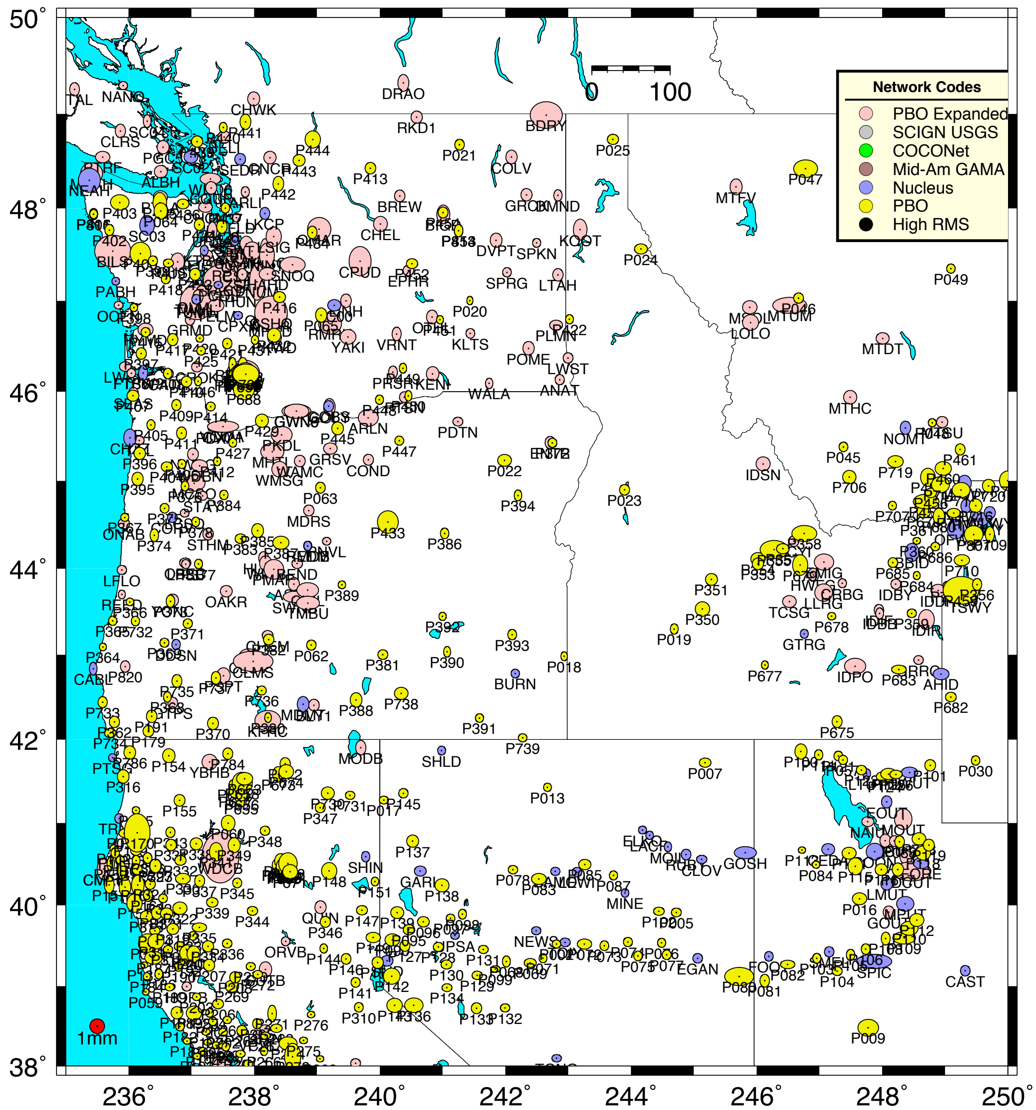

Figure 4: Distribution of the RMS scatters of horizontal position estimates from the PBO combined analysis for the Northern Western United States. The color of the ellipses that give the north and east RMS scatters denotes the network given by the legend in the figure. The small red circle shows the 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.

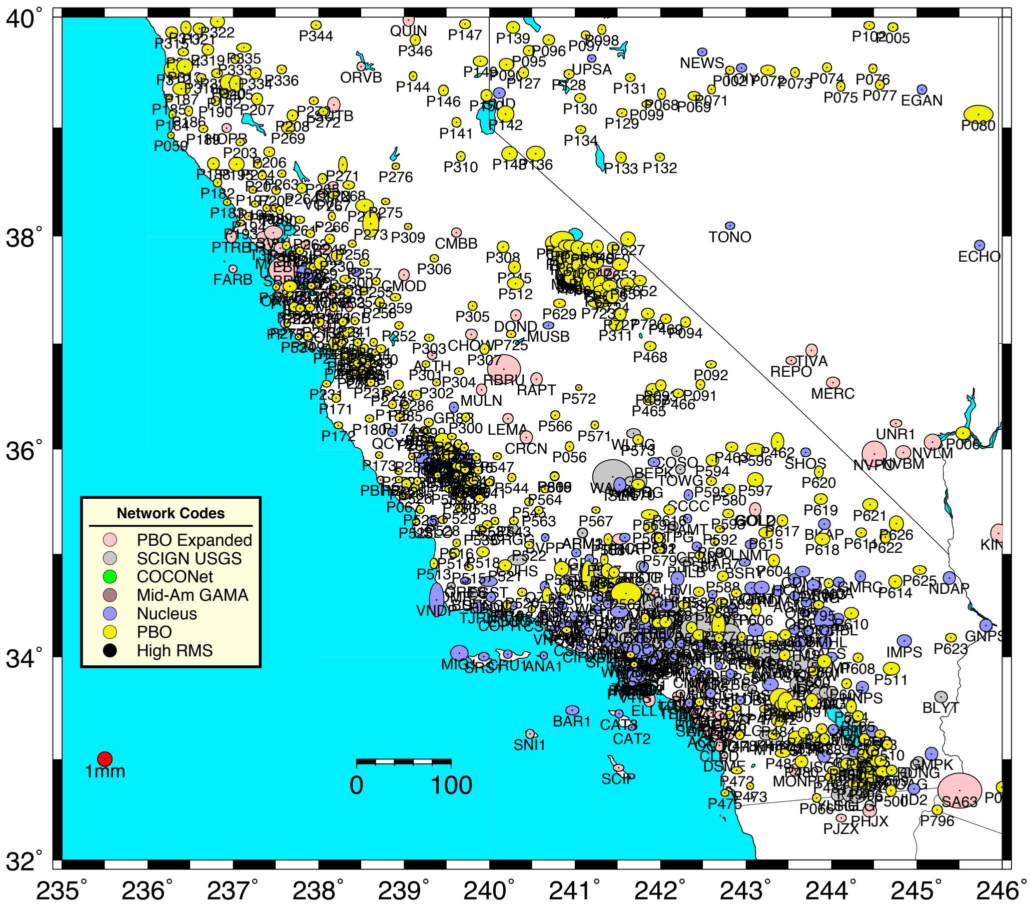

Figure 5: Same as Figure 4 except for the Southern Western United States. Black circles show large RMS scatter sites.

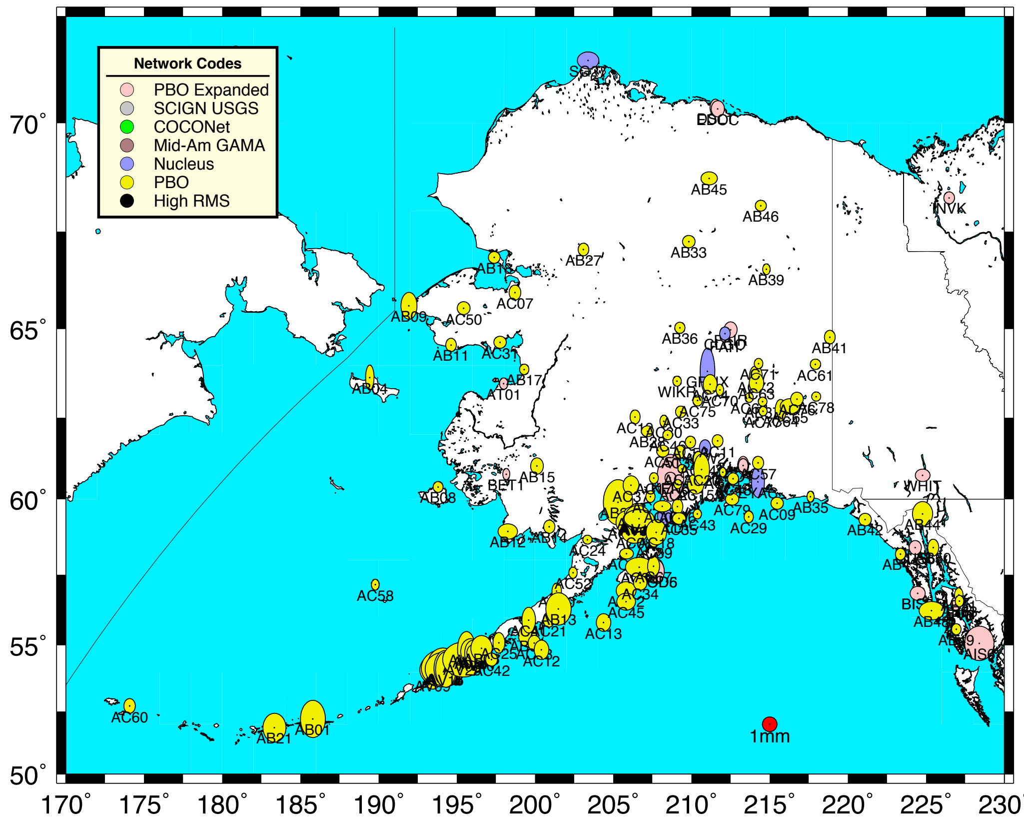

Figure 6: Same as Figure 4 except for the Alaskan region.

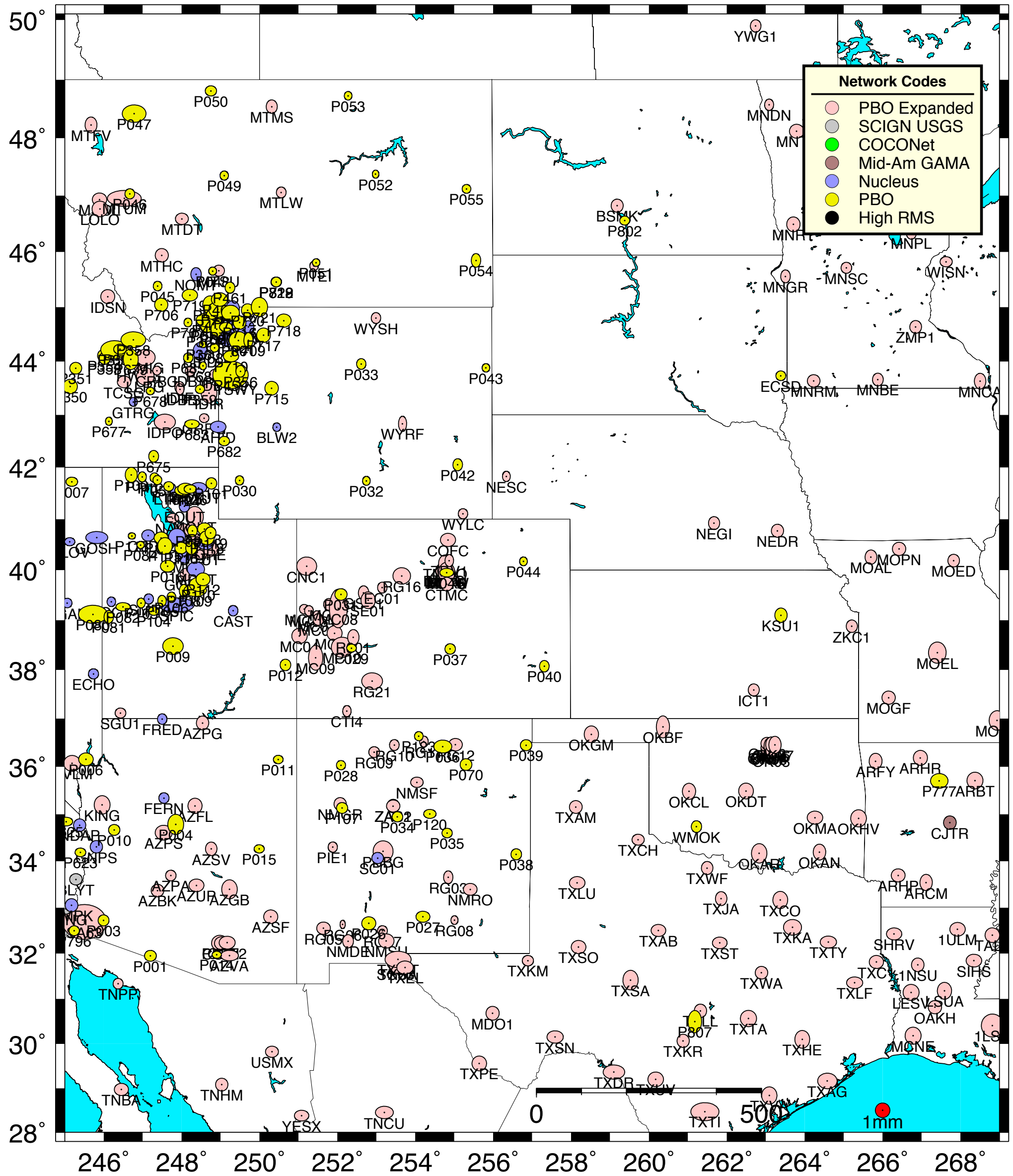

Figure 7: Same as Figure 4 except for the Central United States

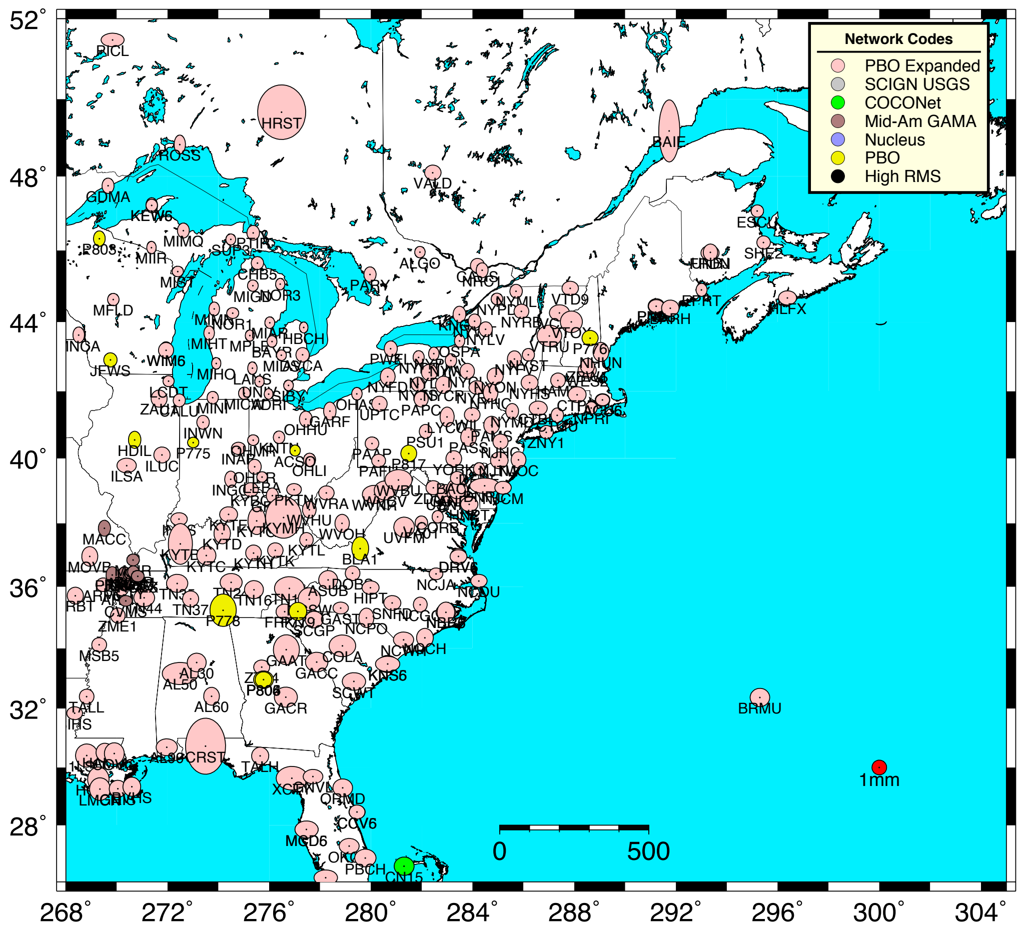

Figure 8: Same as Figure 4 except for the Eastern United States

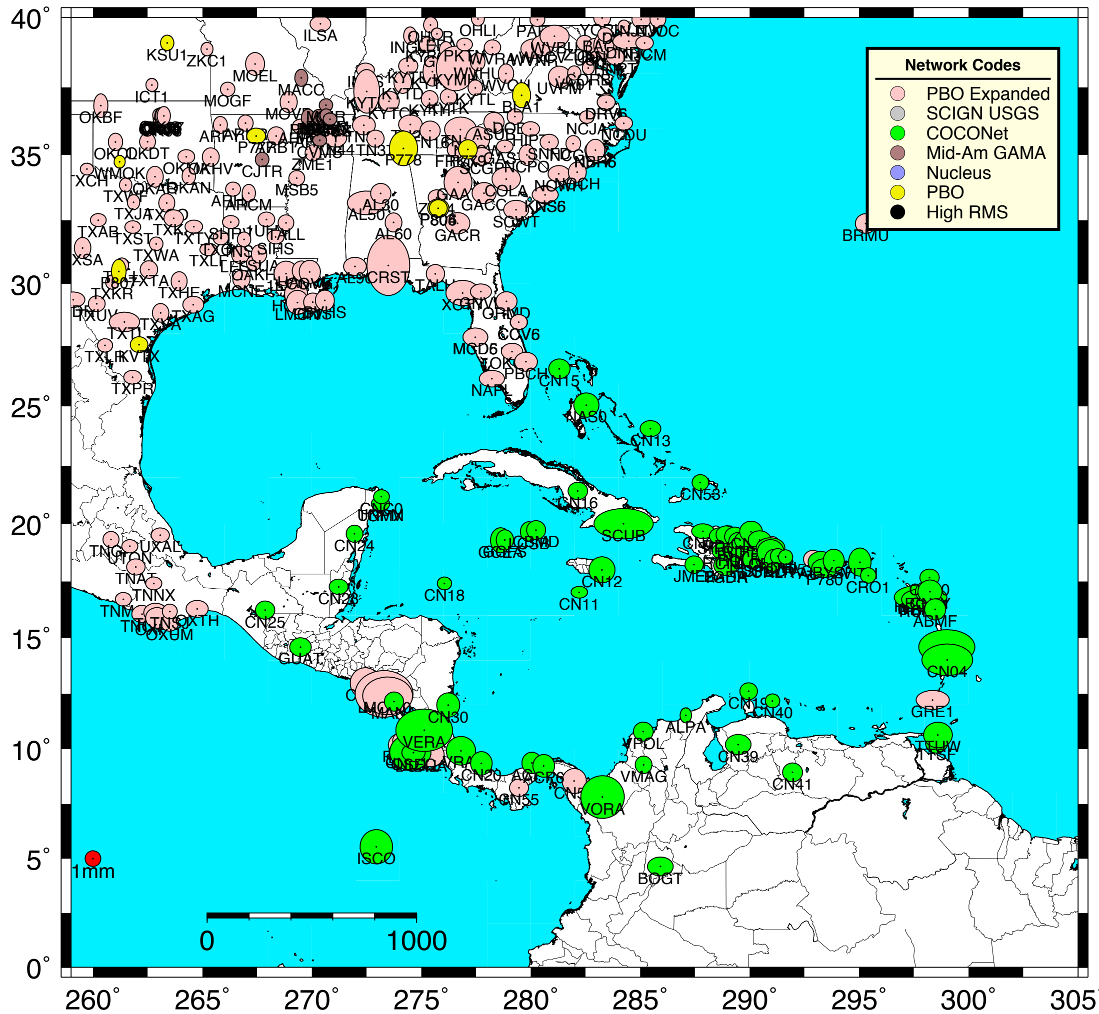

Figure 9: Same as Figure 4 except for the Caribbean region.

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. The current earthquake and discontinuity files used in the GAGE ACC analyses are 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.

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 2544 stations in the combined PBO solution which is one more than 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_180909.tab, nmt_nam08_180909.tab and cwu_nam08_180909.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_180909.snpvel, nmt_nam08_180909.snpvel and cwu_nam08_180909.snpvel.

Table 3: Statistics of the fits of 2544, 2542 and 2534 stations analyzed by PBO, NMT and CWU in the reprocessed analysis for data collected between Jan 1, 1996 and September 09. 2018.

Center	North (mm)	East (mm)	Up (mm)
Median (50%)			
NMT	1.15	1.25	5.74
CWU	1.34	1.31	5.97
PBO	1.15	1.19	5.36
70%			
NMT	1.51	1.63	6.50
CWU	1.65	1.63	6.78
PBO	1.47	1.50	6.06
95%			
NMT	3.30	3.43	9.80
CWU	3.37	3.42	10.29
PBO	3.26	3.21	9.75

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 0.10 mm/yr horizontal and 0.84 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 $(1.36)^2$ for the horizontal and $(2.04)^2$ 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 15-92% optimistic over expectations. The 10-worst stations, in the order they are removed, are HJOR, MIK2, AC59, QAQ1, PLPK, KBUG, MYT2, ONSA, SAJU, PNE2 when the added sigmas are not applied and VAAS, HJOR, AC59, MIK2, QAQ1, PLPK, KBUG, ONSA, SAJU, PNE2 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 increased a little due to the additional stations which have shorter time spans until the repro combinations are complete.

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 2252, 2251 and 2242 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	2506	0.10	0.84	1.36	2.04
Edited-10_worst	2496	0.09	0.82	1.29	2.00
Less_than_median (0.20 0.62 mm/yr)	1489	0.06	0.72	1.16	2.12
Added minimum sigma NE 0.03 U 0.55 mm/yr					
All_Normal	2506	0.13	1.33	1.28	1.27
Edited-10_worst	2496	0.12	1.27	1.22	1.21
Less_than_median (0.20 0.83 mm/yr)	1489	0.08	0.85	1.01	0.92

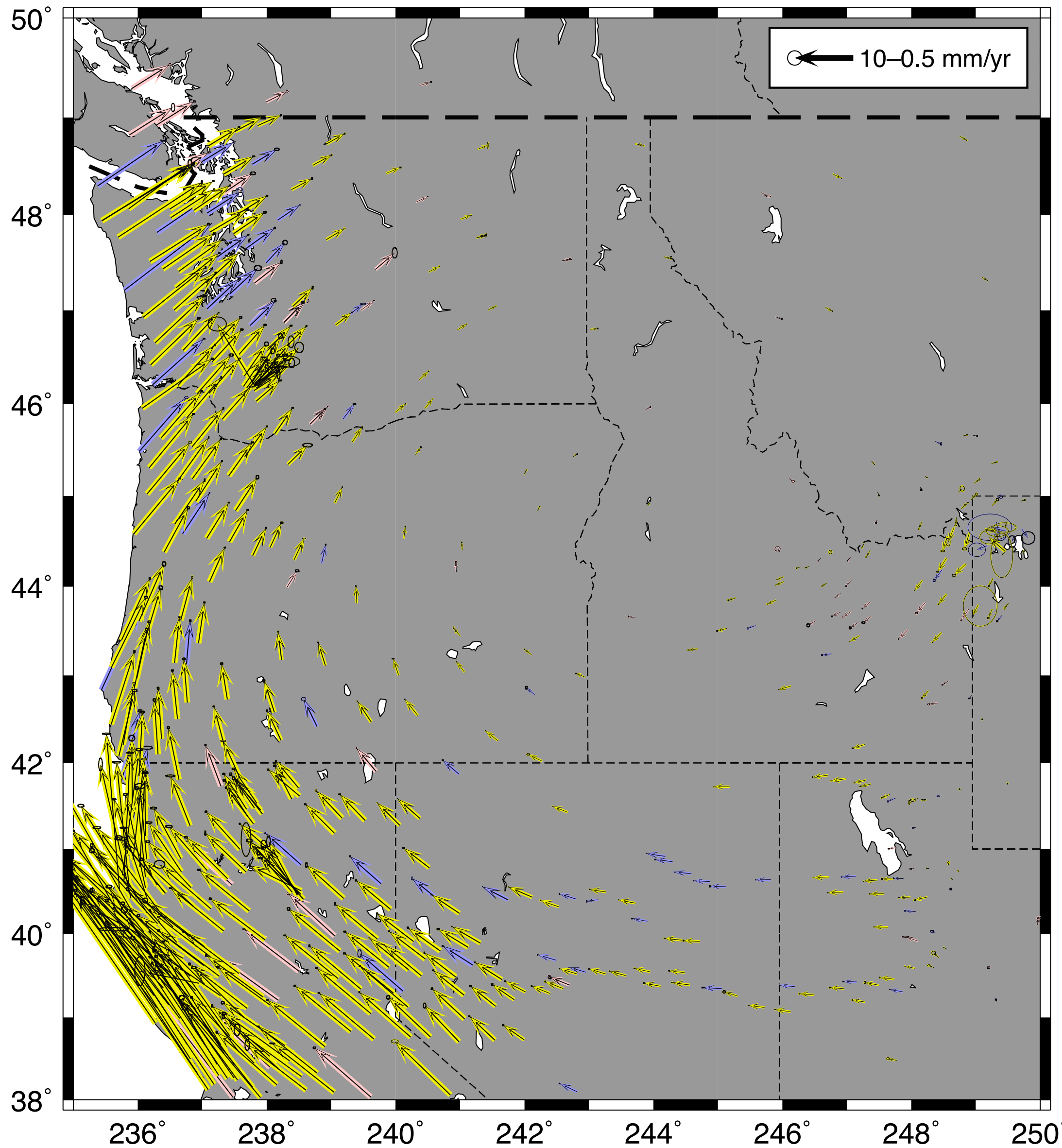

Figure 10: Velocity field estimates for the Pacific north-west from the combined PBO solutions generated using time series analysis and the FOGMEX error model. 95% confidence interval error ellipses are shown. The color scheme of the vectors matches the network type legend in Figure 4. Only velocities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

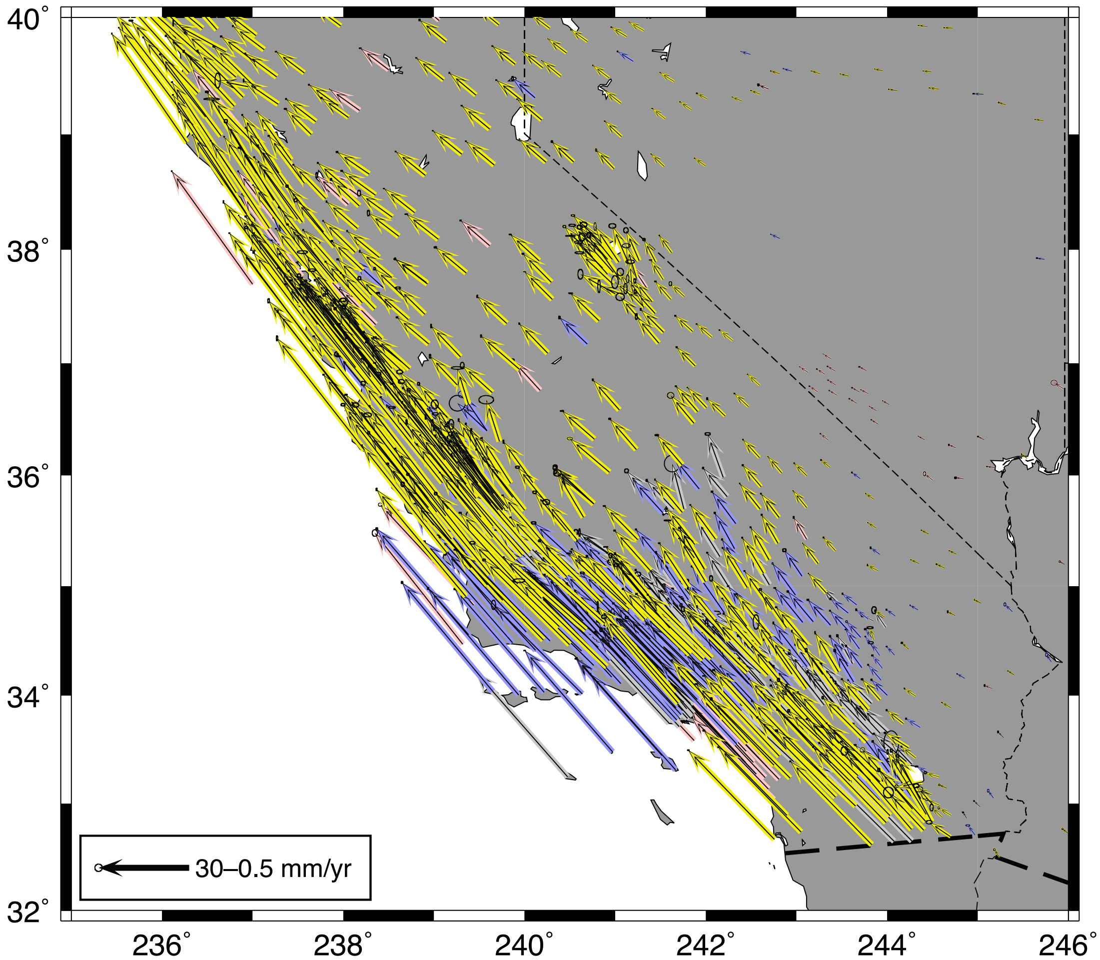

Figure 11: Same as Figure 10 except for South Western United States. Only velocities with horizontal standard deviations less than 2 mm/yr are shown.

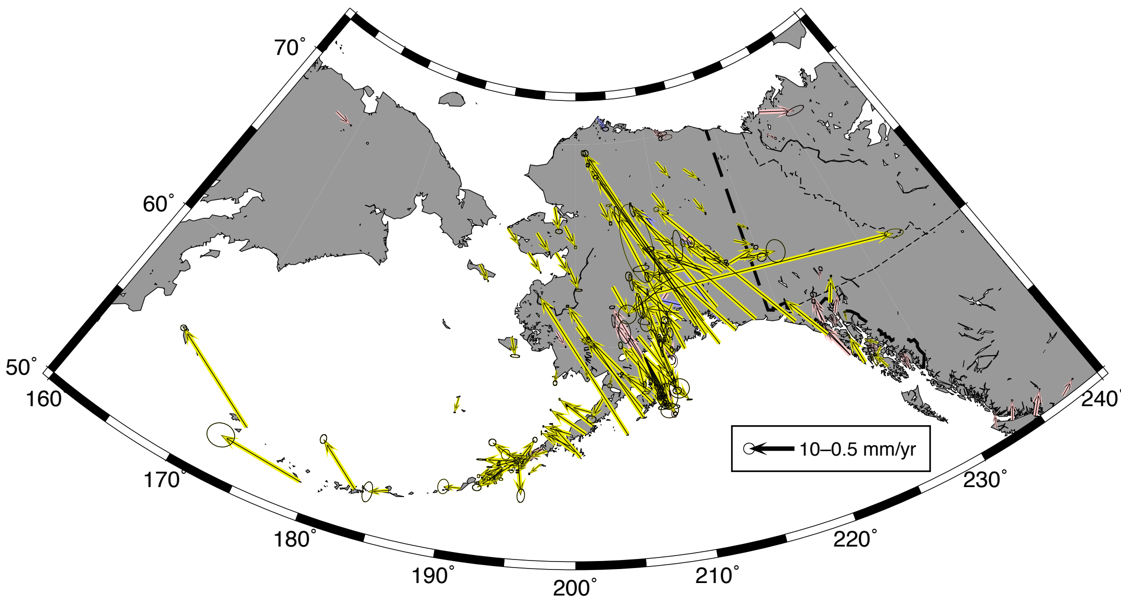

Figure 12: Same as Figure 10 except for Alaska. Only velocities with horizontal standard deviations less than 5 mm/yr are shown

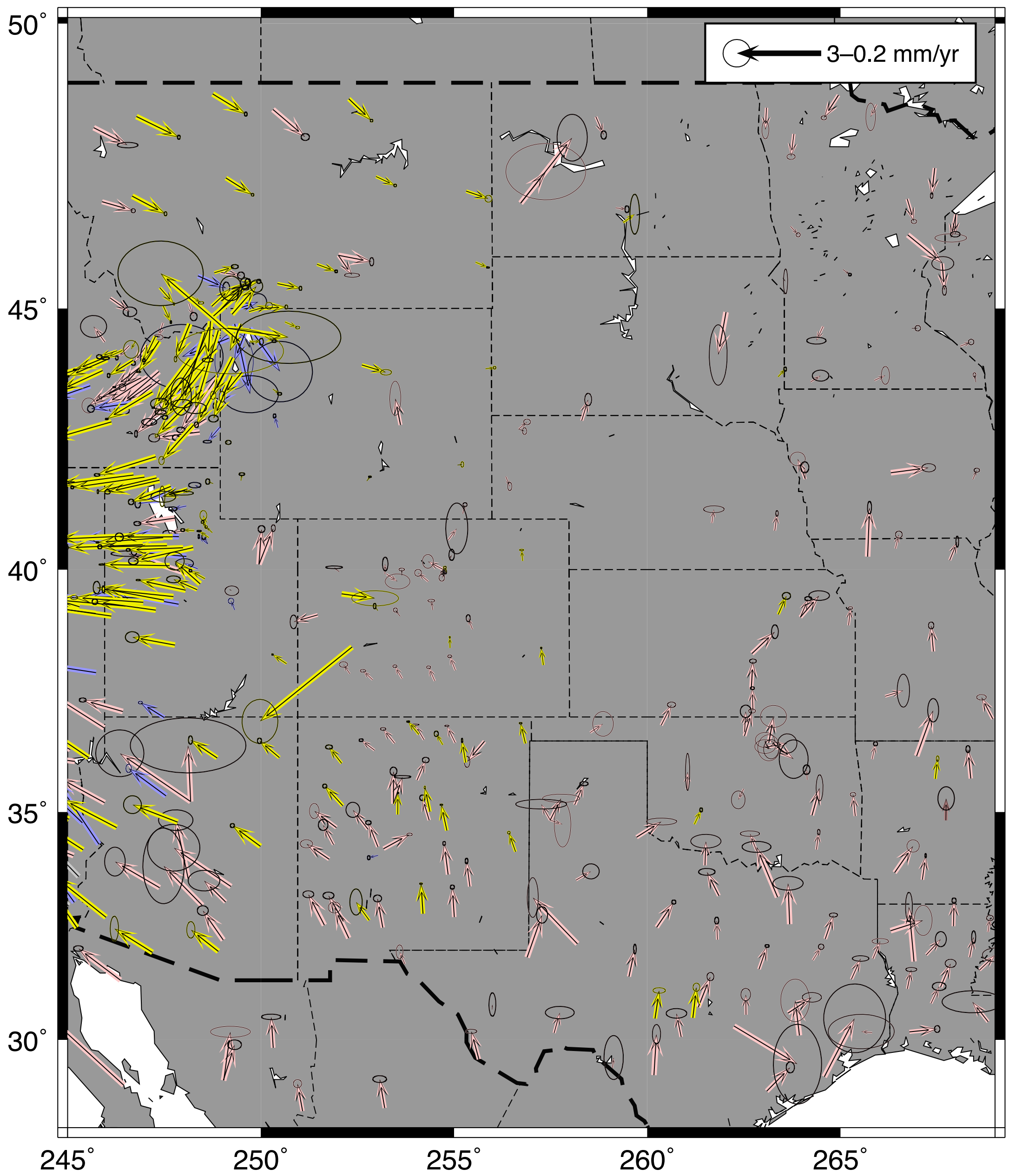

Figure 13: Same as Figure 10 except for Central United States. Only velocities with horizontal standard deviations less than 1 mm/yr are shown.

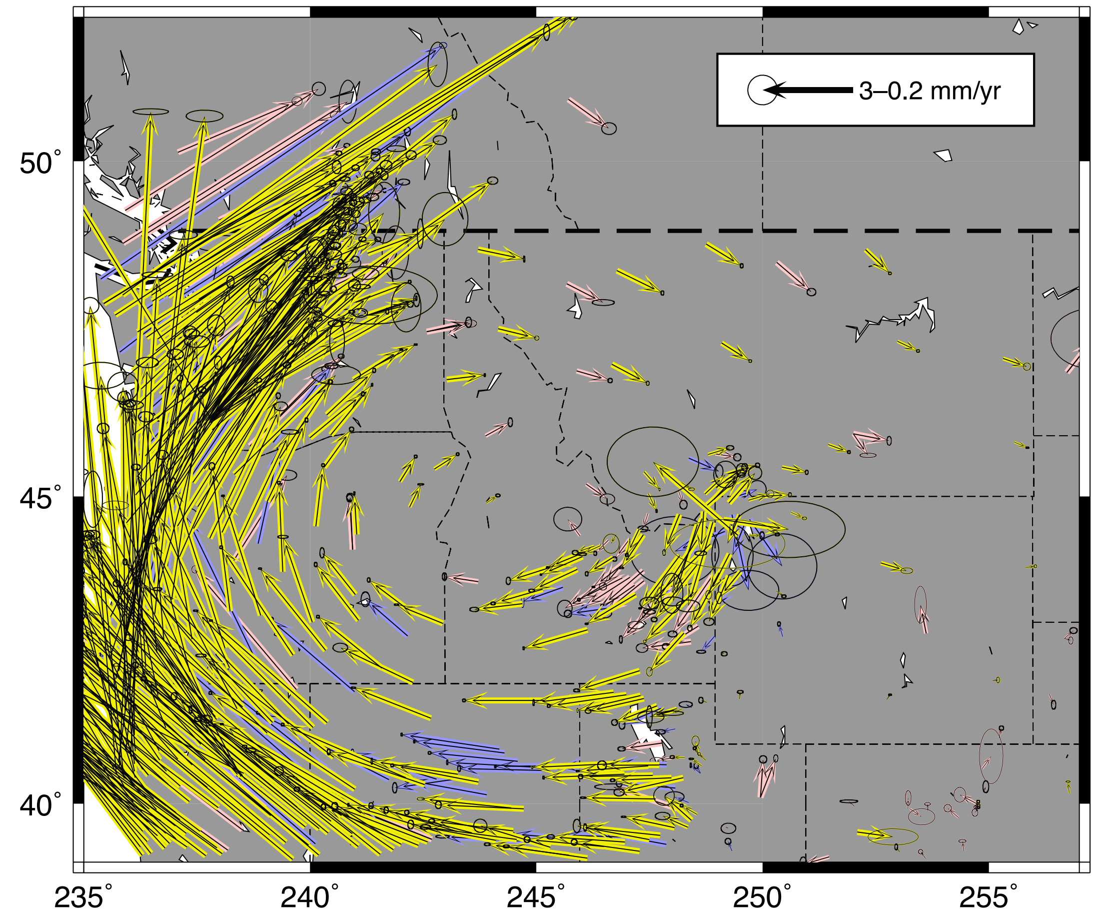

Figure 14: Same as Figure 10 except for Western Central United States. Only velocities with horizontal standard deviations less than 1 mm/yr are shown. Anomalous vectors at longitude 250^o are in the Yellowstone National Park and most likely are showing volcanic processes.

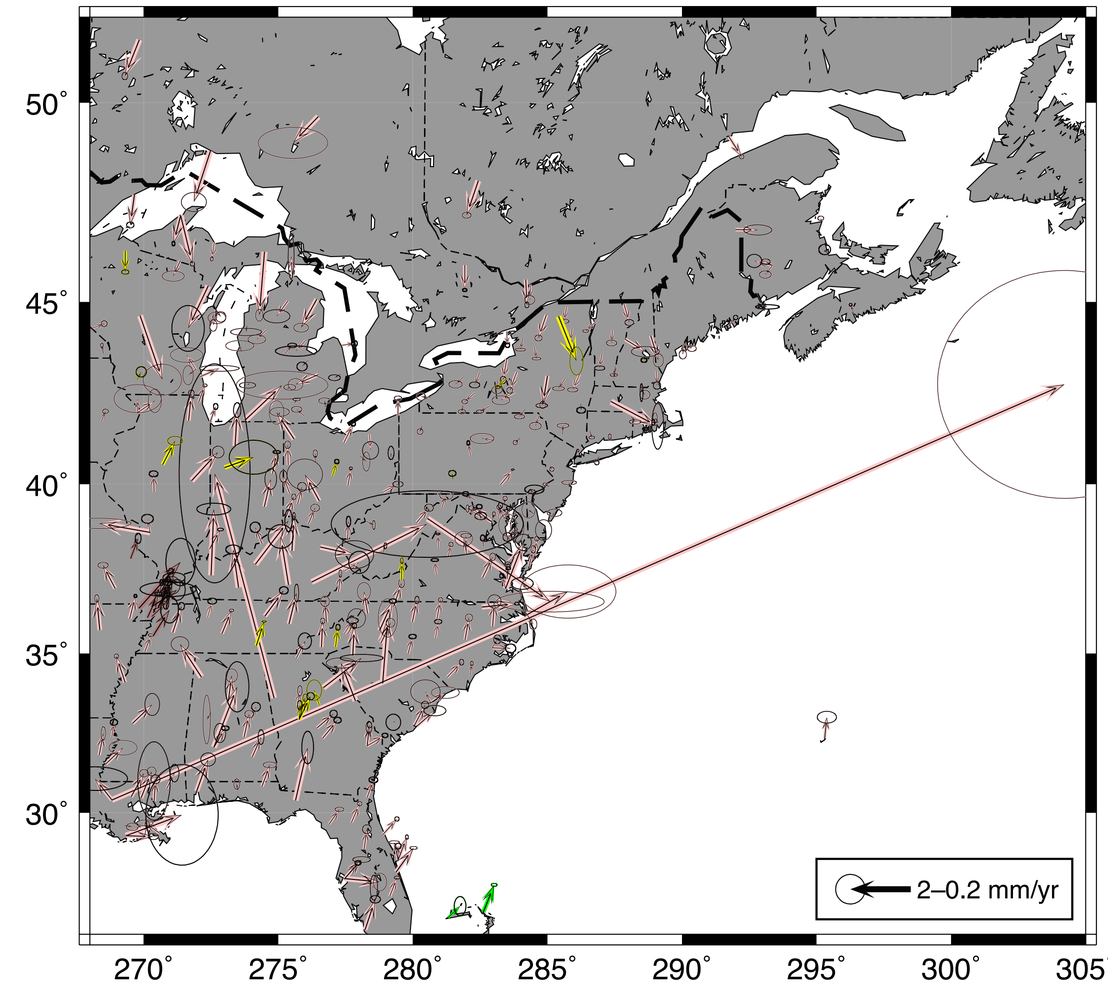

Figure 15: Same as Figure 10 except for the Eastern United States. Only velocities with horizontal standard deviations less than 2 mm/yr are shown. The systematic velocity of sites in the Northeast and central US show deviations for current GIA models in the horizontal velocities. The large outlier is 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.

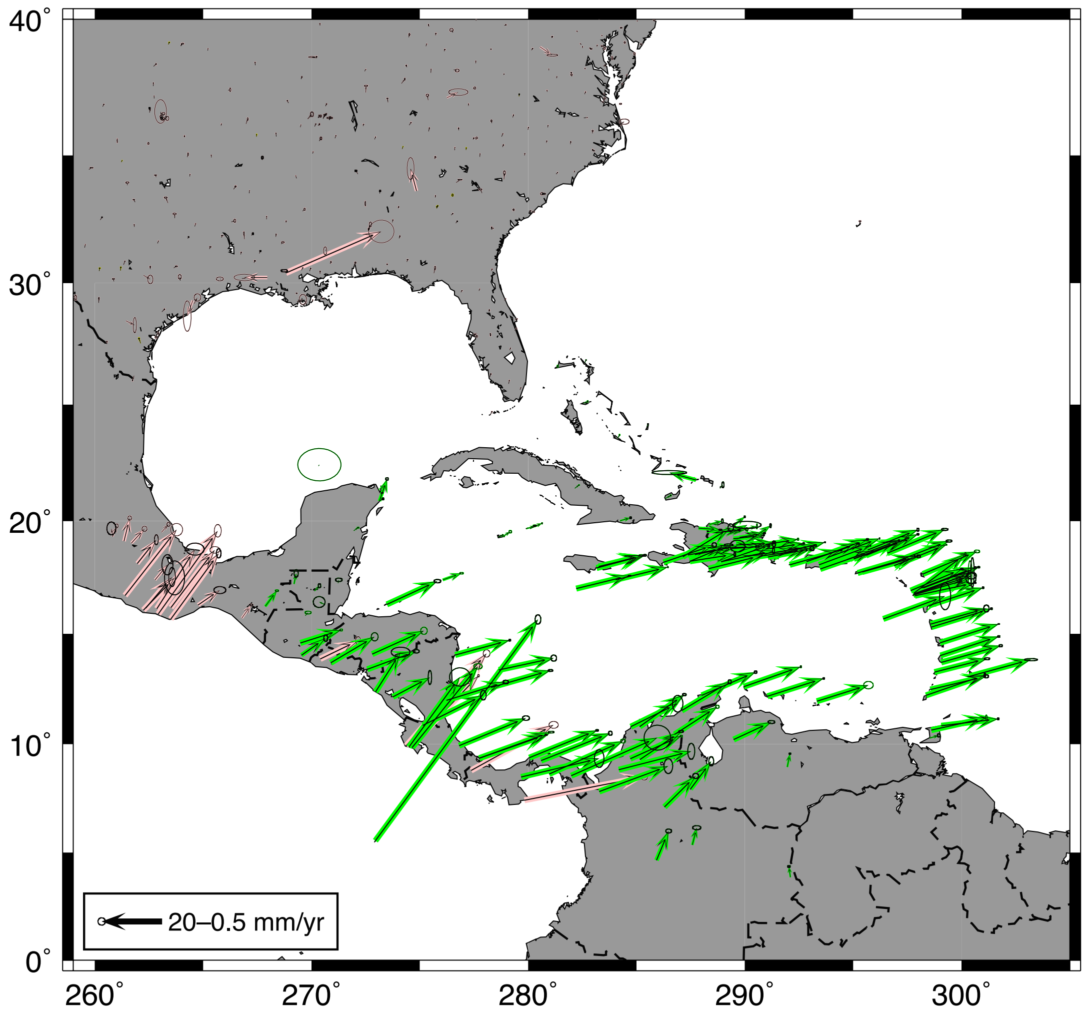

Figure 16: Same as Figure 10 except for the Caribbean region. Only velocities with horizontal standard deviations less than 5 mm/yr are shown.

Earthquake Analyses: 2018/06/16-2018/09/15.

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 June/July 2018.

```
* Earthquake definition file created with sh_makeeqdef by Tom Herring on 2018-07-16
* for events from 2018-06-14 to 2018-07-15 (inclusive)
* from http://earthquake.usgs.gov/fdsnws/event/1/.
* Empirical model for radius of influence of earthquake:
* radius = scale*(a*z + b*x^M) + c
* where scale = 1, a = 0, b = 2.5e-3, c = 8, x = 5,
* z is earthquake depth and M is magnitude.
* Proximity based on Week_All.Pos
* ---------------------------------------
* Earthquake catalog search result # 151
* Approximate predicted coseismic displacements (epicentral distance):
* P507_GPS ~     0.4 mm (~ 7.34 km)
* EQ_ID A1 ANSS(ComCat) ci38199368
* EQ_DEF mw3.6 11km W of Calipatria (5.15 km depth)
 eq_def A1   33.1352 -115.6273     8.9    8.0  2018 06 17 18 35    0.0003
 eq_rename A1
 eq_coseis A1  0.0010 0.0010 0.0010    0.0003   0.0003   0.0003
* ---------------------------------------
* Earthquake catalog search result # 156
* Approximate predicted coseismic displacements (epicentral distance):
* TAXI_GPS ~     5.2 mm (~ 28.63 km)
* EQ_ID A2 ANSS(ComCat) us1000eu39
* EQ_DEF mww5.7 12km SW of Guanagazapa (98.25 km depth)
 eq_def A2   14.1304  -90.7119    32.1    8.0  2018 06 18 02 33    0.0671
 eq_rename A2
 eq_coseis A2  0.0010 0.0010 0.0010    0.0671   0.0671   0.0671
* ---------------------------------------
* Earthquake catalog search result # 208
* Approximate predicted coseismic displacements (epicentral distance):
* VERA_GPS ~     2.0 mm (~ 9.91 km)
* EQ_ID A3 ANSS(ComCat) us1000eviu
* EQ_DEF mb4.5 13km SE of Upala (170.58 km depth)
 eq_def A3   10.7967  -84.9391    11.5    8.0  2018 06 19 14 42    0.0031
 eq_rename A3
 eq_coseis A3  0.0010 0.0010 0.0010    0.0031   0.0031   0.0031
* ---------------------------------------
* Earthquake catalog search result # 227
* Approximate predicted coseismic displacements (epicentral distance):
* AC70_GPS ~     2.4 mm (~ 3.29 km)
* EQ_ID A4 ANSS(ComCat) ak19786492
* EQ_DEF ml3.7 42km ESE of Cantwell (71.9 km depth)
 eq_def A4   63.3048 -148.1228     9.0    8.0  2018 06 20 09 35    0.0004
 eq_rename A4
 eq_coseis A4  0.0010 0.0010 0.0010    0.0004   0.0004   0.0004
```

* --------------------------------------
* Earthquake catalog search result # 569
* Approximate predicted coseismic displacements (epicentral distance):
* TNTM_GPS ~   4.6 mm (~ 39.32 km)
* EQ_ID A5 ANSS(ComCat) us2000frwr
* EQ_DEF mww5.9 46km WSW of San Patricio (15 km depth fixed)
 eq_def A5   19.0644 -105.1156   41.3   8.0 2018 06 30 03 57   0.1120
 eq_rename A5
 eq_coseis A5 0.0010 0.0010 0.0010   0.1120   0.1120   0.1120
* --------------------------------------
* Earthquake catalog search result # 631
* Approximate predicted coseismic displacements (epicentral distance):
* GUAT_GPS ~   4.1 mm (~ 4.13 km)
* EQ_ID A6 ANSS(ComCat) us2000ft3z
* EQ_DEF mb4.1 6km SW of Guatemala City (200.67 km depth)
 eq_def A6   14.5990 -90.5575   9.8   8.0 2018 07 01 17 22   0.0011
 eq_rename A6
 eq_coseis A6 0.0010 0.0010 0.0010   0.0011   0.0011   0.0011
* --------------------------------------
* Earthquake catalog search result # 833
* Approximate predicted coseismic displacements (epicentral distance):
* CDMT_GPS ~   0.5 mm (~ 6.02 km)
* EQ_ID A7 ANSS(ComCat) ci37275802
* EQ_DEF ml3.5 14km NW of Ludlow (3.14 km depth)
 eq_def A7   34.8028 -116.2788   8.8   8.0 2018 07 07 15 38   0.0003
 eq_rename A7
 eq_coseis A7 0.0010 0.0010 0.0010   0.0003   0.0003   0.0003

Analysis:

A1: No offset can be seen is the time series.
A2: No data since 2015 at the one site possible affected by this earthquake.
A3: No offset can be seen is the time series but site VERA shows evidence of vegetation growth and
removal.
A4: No offset but interesting possible snow effects (only 811 m high)
A5: No clear offset at TNTM. Only about a year of data from the site; North is systematic
A6: No offset can be seen
A7: No offset can be seen.

No new earthquakes this month.

Events investigated in July/August, 2018.

* Earthquake definition file created with sh_makeeqdef by Tom Herring on 2018-08-15

```
* for events from 2018-07-14 to 2018-08-15 (inclusive)
* from http://earthquake.usgs.gov/fdsnws/event/1/.
* Empirical model for radius of influence of earthquake:
* radius = scale*(a*z + b*x^M) + c
* where scale = 1, a = 0, b = 2.5e-3, c = 8, x = 5,
* z is earthquake depth and M is magnitude.
* Proximity based on Week_All.Pos
* --------------------------------------
* Earthquake catalog search result # 124
* Approximate predicted coseismic displacements (epicentral distance):
* CN27_GPS ~     4.8 mm (~ 4.89 km)
* EQ_ID A1 ANSS(ComCat) us2000g7pw
* EQ_DEF mb4.3 1km SSW of Cabrera (10 km depth fixed)
 eq_def A1   19.6314  -69.9125    10.5    8.0  2018 07 18 05 23    0.0018
 eq_rename A1
 eq_coseis A1  0.0010 0.0010 0.0010    0.0018   0.0018   0.0018
* --------------------------------------
* Earthquake catalog search result # 469
* Approximate predicted coseismic displacements (epicentral distance):
* AUGL_GPS ~     0.6 mm (~ 5.63 km)
* AV11_GPS ~     0.6 mm (~ 5.67 km)
* AV21_GPS ~     0.6 mm (~ 5.63 km)
* EQ_ID A2 ANSS(ComCat) ak19977197
* EQ_DEF ml3.6 93km WSW of Anchor Point (92.2 km depth)
 eq_def A2   59.3765 -153.2557     8.8    8.0  2018 07 28 14 23    0.0003
 eq_rename A2
 eq_coseis A2  0.0010 0.0010 0.0010    0.0003   0.0003   0.0003
* --------------------------------------
* Earthquake catalog search result # 598
* Approximate predicted coseismic displacements (epicentral distance):
* PRCO_GPS ~     0.2 mm (~ 8.30 km)
* EQ_ID A3 ANSS(ComCat) us2000giuy
* EQ_DEF mb_lg3.5 13km SSE of Blanchard (5 km depth fixed)
 eq_def A3   35.0312  -97.5857     8.7    8.0  2018 08 01 10 12    0.0002
 eq_rename A3
 eq_coseis A3  0.0010 0.0010 0.0010    0.0002   0.0002   0.0002
* --------------------------------------
* Earthquake catalog search result # 849
* Approximate predicted coseismic displacements (epicentral distance):
* PNE2_GPS ~     3.0 mm (~ 7.17 km)
* EQ_ID A4 ANSS(ComCat) us1000g6fh
* EQ_DEF mb4.4 24km W of Santa Cruz (44.85 km depth)
 eq_def A4   10.2561  -85.8059    11.0    8.0  2018 08 10 16 26    0.0024
 eq_rename A4
 eq_coseis A4  0.0010 0.0010 0.0010    0.0024   0.0024   0.0024
* --------------------------------------
```

* Earthquake catalog search result # 1007
* Approximate predicted coseismic displacements (epicentral distance):
* P479_GPS ~   24.2 mm (~ 2.62 km)
* EQ_ID A5 ANSS(ComCat) ci38245496
* EQ_DEF mw4.4 7km NE of Aguanga (1.89 km depth)
 eq_def A5   33.4772 -116.8033   11.1   8.0 2018 08 15 01 25   0.0026
 eq_rename A5
 eq_coseis A5 0.0010 0.0010 0.0010   0.0026   0.0026   0.0026
Analysis:

A1: No offset can be seen is the time series
A2: Only AV11 is currently collecting data and it shows no offset > 1mm.
(earlier Jan 23 2018 event can be seen.)
A3: No data at PRCO since mid-2014.
A4: No offset >1 mm in horizontal components.
A5: No rapid processing yet. This event will be looked at next month.

No new earthquake event files were created this month.

Events investigated in August/September, 2018.

* Earthquake definition file created with sh_makeeqdef by Tom Herring on 2018-09-17
* for events from 2018-08-14 to 2018-09-15 (inclusive)
* from http://earthquake.usgs.gov/fdsnws/event/1/.
* Empirical model for radius of influence of earthquake:
* radius = scale*(a*z + b*x^M) + c
* where scale = 1, a = 0, b = 2.5e-3, c = 8, x = 5,
* z is earthquake depth and M is magnitude.
* Proximity based on Week_All.Pos
* --------------------------------------
* Earthquake catalog search result # 38
* Approximate predicted coseismic displacements (epicentral distance):
* P479_GPS ~   24.2 mm (~ 2.62 km)
* EQ_ID A1 ANSS(ComCat) ci38245496
* EQ_DEF mw4.4 7km NE of Aguanga (1.89 km depth)
 eq_def A1   33.4772 -116.8033   11.1   8.0 2018 08 15 01 25   0.0026
 eq_rename A1
 eq_coseis A1 0.0010 0.0010 0.0010   0.0026   0.0026   0.0026
* --------------------------------------
* Earthquake catalog search result # 68
* Approximate predicted coseismic displacements (epicentral distance):
* AB21_GPS ~   3.7 mm (~ 108.14 km)
* EQ_ID A2 ANSS(ComCat) us1000ga0z
* EQ_DEF mww6.6 51km S of Tanaga Volcano (20 km depth fixed)
 eq_def A2   51.4215 -178.0516   110.6   8.0 2018 08 15 21 57   0.6748
 eq_rename A2

```
 eq_coseis A2  0.0010 0.0010 0.0010    0.6748   0.6748   0.6748
* -------------------------------------
* Earthquake catalog search result # 540
* Approximate predicted coseismic displacements (epicentral distance):
* CN44_GPS ~    20.2 mm (~ 113.34 km)
* CN45_GPS ~     5.8 mm (~ 212.42 km)
* CN46_GPS ~     4.5 mm (~ 240.13 km)
* GRE0_GPS ~     6.3 mm (~ 202.83 km)
* GRE1_GPS ~     6.3 mm (~ 202.82 km)
* SVGB_GPS ~     2.5 mm (~ 320.97 km)
* TTSF_GPS ~     9.3 mm (~ 167.64 km)
* TTUW_GPS ~     9.7 mm (~ 163.88 km)
* EQ_ID A3 ANSS(ComCat) us1000gez7
* EQ_DEF mww7.3 30km NE of Rio Caribe (154.27 km depth)
 eq_def A3   10.8553  -62.8829   324.5    8.0  2018 08 21 21 32    4.0636
 eq_rename A3
 eq_coseis A3  0.0010 0.0010 0.0010    4.0636   4.0636   4.0636
* -------------------------------------
* Earthquake catalog search result # 662
* Approximate predicted coseismic displacements (epicentral distance):
* CN27_GPS ~     0.8 mm (~ 8.54 km)
* EQ_ID A4 ANSS(ComCat) us1000gh5w
* EQ_DEF mb4.0 4km ESE of Cabrera (10 km depth fixed)
 eq_def A4   19.6324  -69.8671     9.6    8.0  2018 08 25 06 05    0.0009
 eq_rename A4
 eq_coseis A4  0.0010 0.0010 0.0010    0.0009   0.0009   0.0009
* -------------------------------------
* Earthquake catalog search result # 783
* Approximate predicted coseismic displacements (epicentral distance):
* CLAR_GPS ~     3.5 mm (~ 6.73 km)
* LORS_GPS ~    43.1 mm (~ 1.93 km)
* MRDM_GPS ~     1.4 mm (~ 10.78 km)
* PSDM_GPS ~     4.8 mm (~ 5.75 km)
* EQ_ID A5 ANSS(ComCat) ci38038071
* EQ_DEF mw4.4 4km N of La Verne (5.46 km depth)
 eq_def A5   34.1363 -117.7747    11.0    8.0  2018 08 29 02 34    0.0025
 eq_rename A5
 eq_coseis A5  0.0010 0.0010 0.0010    0.0025   0.0025   0.0025
* -------------------------------------
* Earthquake catalog search result # 836
* Approximate predicted coseismic displacements (epicentral distance):
* P150_GPS ~     0.4 mm (~ 8.96 km)
* EQ_ID A6 ANSS(ComCat) nc73078235
* EQ_DEF mw3.8 5km W of Tahoe Vista (2.09 km depth)
 eq_def A6   39.2372 -120.1093     9.0    8.0  2018 08 30 22 09    0.0005
 eq_rename A6
```

eq_coseis A6 0.0010 0.0010 0.0010   0.0005   0.0005   0.0005
* Only new entries after 2018 8 1 0 0 will be output
Analysis:

A1: No offset
A2: No offset although there are missing days
A3: No offsets although no recent data at CN44.
A4: No offset
A5: No offsets
A6: No offset.

No new earthquake event files were created this month.

Antenna Change Offsets: 2018/07/01-2018/09/30.

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

```
Station  Date             From            To
AC03   2018   6 10 15 12  TRM29659.00    TRM59800.80
AC09   2018   6  5  0  0  TRM29659.00    TRM59800.80
AV19   2018   6  7 21 36  TRM29659.00    TRM59800.80
LEBA   2018   6  1  0  0  TRM59800.00    TPSCR.G5
OHLI   2018   6 13 11 51  TRM55971.00    TRM59800.00
P411   2018   6 26 18 48  TRM29659.00    TRM59800.80
P367   2018   7 30 18 48  TRM29659.00    TRM59800.80
P685   2018   7 19  0  0  TRM29659.00    TRM59800.80
P715   2018   7 20  0  0  TRM29659.00    TRM59800.80
BVHS   2018   8 17  0  0  TRM57971.00    TRM115000.00
HUSB   2018   8  8 19 20  TRM29659.00    JAVRINGANT_DM
MCNE   2018   8 14  0  0  TRM57971.00    TRM115000.00
P029   2018   8 23  0  0  TRM29659.00    TRM59800.80
P417   2018   8  1 18 51  TRM29659.00    TRM159800.00
P417   2018   8 14  0  0  Dome NONE      SCIS
P657   2018   8  8 16 35  TRM29659.00    TRM59800.80
P744   2018   8 16 17 17  TRM29659.00    TRM59800.80
P812   2018   8 18  0  0  TRM59800.00    TRM59800.80
```

```
AC03: KF  KF dNEU    0.78 +- 0.77,   2.96 +- 0.66,   4.54 +- 1.26 mm .
     Site is systematic.  The east offset can be seen; the height offset
     is not clear.
AC09: KF dNEU   -0.05 +- 1.03,   1.06 +- 0.56,   5.63 +- 0.90 mm .
     Site is systematic with large excursion starting early 2016 and
     lasting 3-4 months, amplitude 60 mm peak-to-peak.  Sites around
AC09 (EYAC, AB35 and AC29) do not show large deviations although AC29
     shows some deviations and was offset by the 1/23/2018 earthquake.
AV19:  KF dNEU    8.53 +- 0.54,  -8.98 +- 0.44,  -2.42 +- 1.21 mm.  Gap
     is data and systematic snow events make offset difficult to assess.
LEBA:  KF dNEU   -2.08 +- 0.35,   2.17 +- 0.39,   2.93 +- 1.36 mm .
     Values are not clearly seen in the time series.
OHLI: KF dNEU    2.28 +- 0.41,  -3.37 +- 0.35,  18.75 +- 1.46 mm.
     Values are reasonably clear in the time series.
P411: KF dNEU    1.21 +- 0.55,  -2.90 +- 0.43,   9.28 +- 1.73 mm.
     Values not so clear and estimates complicated by ETS events.
```

```
P367: KF dNEU    3.97 +- 0.38,   3.16 +- 0.33,   2.73 +- 1.25 mm.
     Break can be seen in components although there is a gap before
     break.
P685: KF dNEU    1.02 +- 0.35,  -4.95 +- 0.29,   3.11 +- 1.20 mm.
     East break is clear although there is some missing and large error
     bar date before the break.
P715: KF dNEU    2.94 +- 0.40,  -3.51 +- 0.33,   6.23 +- 1.36 mm.
     Break is clear in north and east and not so clear in height.
BVHS KF dNEU    0.27 +- 0.43,   1.61 +- 0.47,  18.54 +- 1.69 mm
     The vertical offset is high here but that may be due to an unknown
     break on
2018/05 /25.  Due to the proximity of the breaks we have not added an
     unknown break entry.
HUSB Only one data point before break, so no estimate.
MCNE: KF dNEU   -4.63 +- 0.36,  -0.64 +- 0.35,  15.69 +- 1.39 mm
     There is a much larger break 2008/11/11 when the antenna was
     changed from TRM29659.00 to TRM57971.00.  Based on the change in
     the annual signal, the earlier antenna appears broken.
P029 KF dNEU    2.23 +- 0.35,  -1.69 +- 0.31,   6.95 +- 1.16 mm
     Break is clear in the data, although there is a gap in data ending
     a ~week before the antenna change.
P417 Two breaks that in the east partially cancel each other.  This
     could be partly due to meta data not being updated at the time of
     the changes.
2018  8  1 18 51 KF dNEU   -0.66 +- 0.54,   2.03 +- 0.43,  17.14 +-
     1.70 mm
2018  8 14  0  0 KF dNEU   -0.24 +- 0.61,  -1.41 +- 0.48,  -2.18 +-
     1.95 mm
P657  KF dNEU    2.61 +- 0.30,  -4.28 +- 0.26,  11.51 +- 0.95 mm
     Breaks are clear in the time series
P744 KF dNEU   -0.68 +- 0.35,  -1.23 +- 0.33,   4.36 +- 1.28 mm
     Offsets are small and not clear.  Apart from post-seismic
     deformation there is a strange anomaly centered on 2011/09/19.
     There is an oscillation in position but no obvious long term
     offset.
P812 KF dNEU   -4.11 +- 0.30,   3.62 +- 0.29,   4.98 +- 1.07 mm
     Offsets are clear. Site does show isolated outliers over time.
```

New offsets of unknown origin and data anomalies

No new anomalies except as noted in the descriptions above.

ANET Processing

The ANET additional sites are being processed as a separate network and the frame resolved SINEX files will be given in the Antarctica 2014 reference frame (Altamimi *et al.,* 2016, 2017). We label this frame ant14. Time series and SINEX files are generated only for final orbit solutions and are labeled as fanet (instead of final to avoid name conflicts with loose solutions). A new Euler pole has been added with rotation rates given below. The values are from Altamimi *et al.,* 2017.

```
*  #   Name           wx         wy         wz  (deg/Myr)
*  62 ANTA_I14  -0.068800  -0.090000   0.187400
```

Sites UTHW, LTHW and KHLR are on ice and have annual height changes of ~2 m to keep the sites above the ice.

In the processing there are fast moving ice sites which we have treated carefully so that they are not excluded from the processing. (Default analysis methods would consider these outlier sites to be rejected because of their large deviations from linear motions.)

Figure A1 shows the initial estimate of the secular velocity for the ANET sites in an Antarctica fixed frame based on the ITRF2014 system.

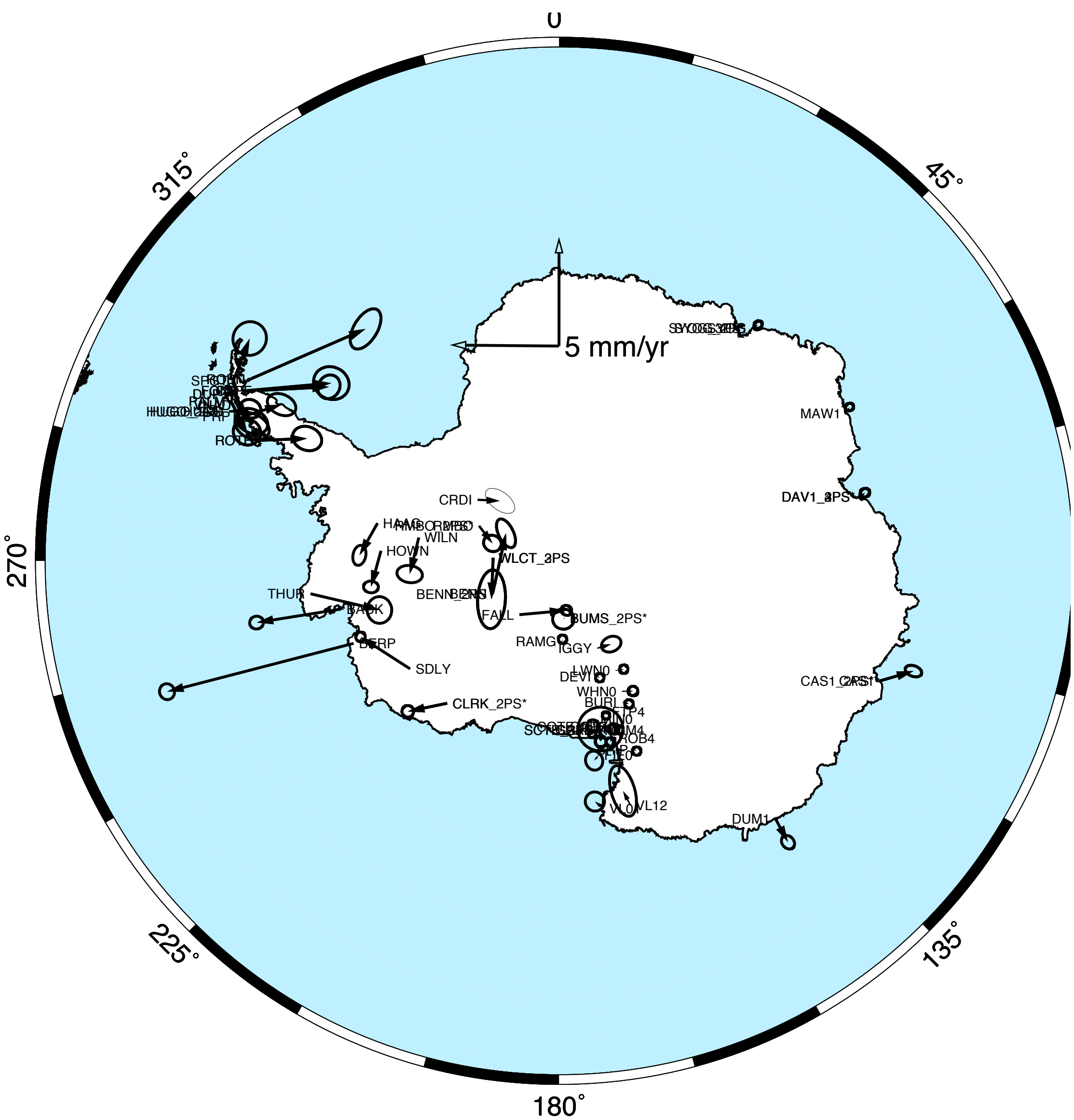

Figure A1: Preliminary Antarctica fixed reference solution based on the ANET analyses using data from Oct 2004 to June 2018.

References

Altamimi, Z., P. Rebischung, L. Metivier, and X. Collilieux (2016), ITRF2014: A new release of the International Terrestrial Reference Frame modeling nonlinear station motions, *J. Geophys. Res. Solid Earth*, 121, 6109-6131, doi: 10.1002/2016JB013098.

Altamimi, Z., L. Metivier, P. Rebischung, H. Rouby, X. Collilieux; ITRF2014 plate motion model, *Geophysical Journal International, Volume 209*, Issue 3, 1 June 2017, Pages 1906-1912, https://doi.org/10.1093/gji/ggx136

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, July-September, 2018, we issued 21 additional royalty-free licenses to educational and research institutions (same as last quarter). The list licensees and their institutions is given in Table C1.

Table C1: Licensees and their institutions issued with GAMIT/GLOBK licenses between July and September, 2018.

Date	Contact	Institution	Country
180711	Dr Rogelio de la Vega Panizo	Universidad Politecnica de Madrid (UPM)	Spain
180712	Dr Andrew Sole	Department of Geography and Sustainable Development	UK
180719	LI Sen	Urban Spatial Engineering Key Lab of Beijing	China
180723	ZHOU BoYang	Guangdong Universit of Technology'	China
180724	Anita Rijal	Trinity International College	Nepal
180725	Navarro Juan Carlos	Department of Geophysics and Astronomy, Universidad Nacional de San Juan.	Argentina
180731	Prof. Agrim. Karina Neuman	Departamento de Ingeniera, Universidad Nacional del Sur	Argentina
180731	Prof Maria Viviana Godoy Guglielmone	Decana de Facultad de Ciencias Exactas y Naturales y Agrimensura, Universidad Nacional del Nordeste	Argentina
180802	Prof FANG ZhenLong	Institute of Space Science, Anhui Agricultural University	China
180802	Andreas Richter	Universidad Nacional de La Plata, Facultad de Ciencias Astronómicas y Geofísicas	Argentina
180806	Efrita Lusy Andriany Saragih	Center for Volcanology and Geological Hazard Mitigation (CVGHM)	Indonesia
180807	Dr. Patrick Mungufeni	Department of Physics, Mbarara University of Science and Technology	Uganda
180808	Manuel Rodriguez Maradiaga	Universidad Nacional Autonoma de Honduras	Honduras
180810	Dra. Mar\ufffda Virginia Mackern	Facultad de Ingenier, Universidad Nacional de Cuyo	Argentina
180821	Mr Ramon Llorens	Department of Geodesy and Surveying,	Argentina]

		Facultad de Ciencias Exactas y Tecnologa	
180823	Claudio Andrés Reyes Norambuena	Instituto Geografico Militar (IGM-Chile)	Chile
180907	Prof.B. Veeraih	Osmania University	India
180910	CHEIN Jengming	Industrial Technology Research Institute (Material and Chemical Research Laboratories)	Taiwan
180914	Eko Rahmadi	Department Geodesi, Universitas Lampung	Indonesia
180921	Dr. Y. D. Opaluwa	Department of Surveying & Geoinformatics, Federal University of Technology, Minna	Nigeria.
180926	Prof. Dr. Maike Schumacher	University of Hohenheim, Institute of Physics and Meteorology	Germany