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: 2014/07/01-2014/09/30

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Summary

Under the GAGE Facility Data Analysis subcontract, 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 06/15/2014 to 09/14/2014, time series velocity field analyses for the GAGE reprocessing analyses (1996-2014), earthquake effects during the interval (3 detectable events, 32-34, but only one effecting a large number of stations), comparison between results from the previous quarter. Because the quarterly reports are due near the start of the month and the data used in the finals processing has an age between 2-3 weeks, early in the month the finals results the last two weeks of the previous month are not available. For this quarter the last finals results were for September 13, 2014. Associated with the report are ASCII text files that are linked into this document.

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

GPS Analysis of Level 2a and 2b products

Level 2a products: Rapid products

Final and rapid level 2a products have been 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 orbits. 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 also remains the same since the average number of sites is about the same. In this quarter 1888 sites were processed compared to 1863 for the previous quarter.

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

Each week we also process the Supplemental (12-week latency) and six month supplemental (26-week latency) analyses from the ACs. The delivery schedule for these products is also unchanged. All supplement products are now up to date and have been transmitted to the UNAVCO GAGE archive. The 12-week and 26-week supplemental time series are included with the finals time series since the orbit used for these solutions is the IGS final orbit. (The rapid solution uses the IGS rapid orbit solution and these are replaced with final orbit solutions when the final orbits become available.)

Analysis of Final products: June 15, 2014 and Sept 13, 2014

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 15, 2014 and Sept 13, 2014. 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 site 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 1.2 mm for all centers and as low as 0.9 mm for NMT and PBO north component. The up RMS scatters are less than 4.7 mm and as low as 4.2 mm. These statistics are similar to last quarter. It is encouraging to see that in heights, the combined solution continues to have smaller WRMS than either of the two input series. 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 1888, 1887 and 1885 sites for PBO, NMT and CWU analyzed in the finals analysis between June 15, 2014 and Sept 13, 2014. Histograms of the RMS scatters are shown in Figure 1-3.

Center	North (mm)	East (mm)	Up (mm)
Median (50%)			
PBO	0.9	0.9	4.2
NMT	0.9	0.9	4.4
CWU	1.1	1.1	5.0
70%			
PBO	1.1	1.1	4.7
NMT	1.0	1.1	4.8
CWU	1.3	1.4	5.6
95%			
PBO	1.7	1.8	6.8
NMT	1.7	1.9	6.7
CWU	2.1	2.1	8.2

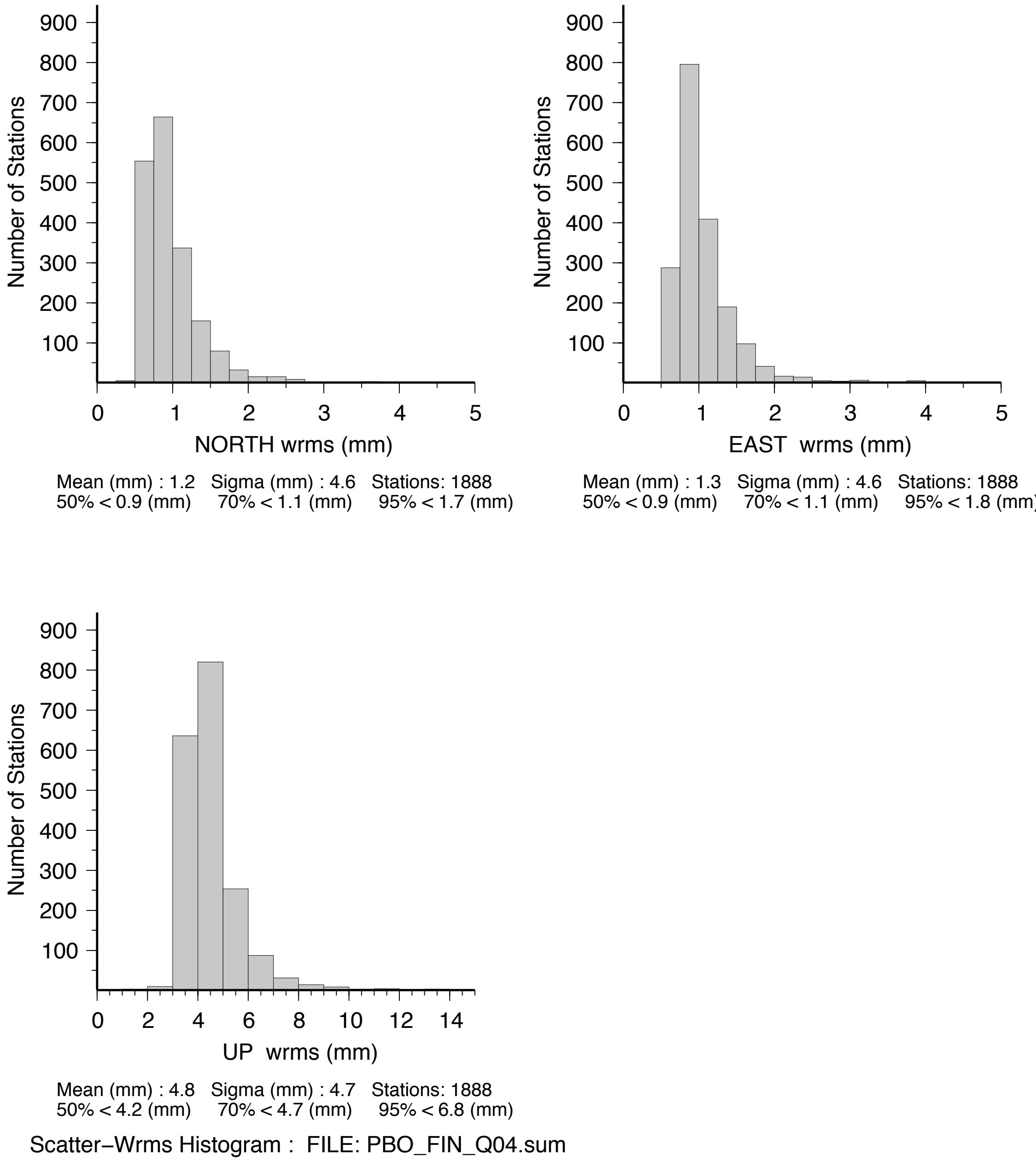

Figure 1: PBO combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1888 sites analyzed between June 15, 2014 and Sept 13, 2014. Linear trends and annual signals were estimated from the time series.

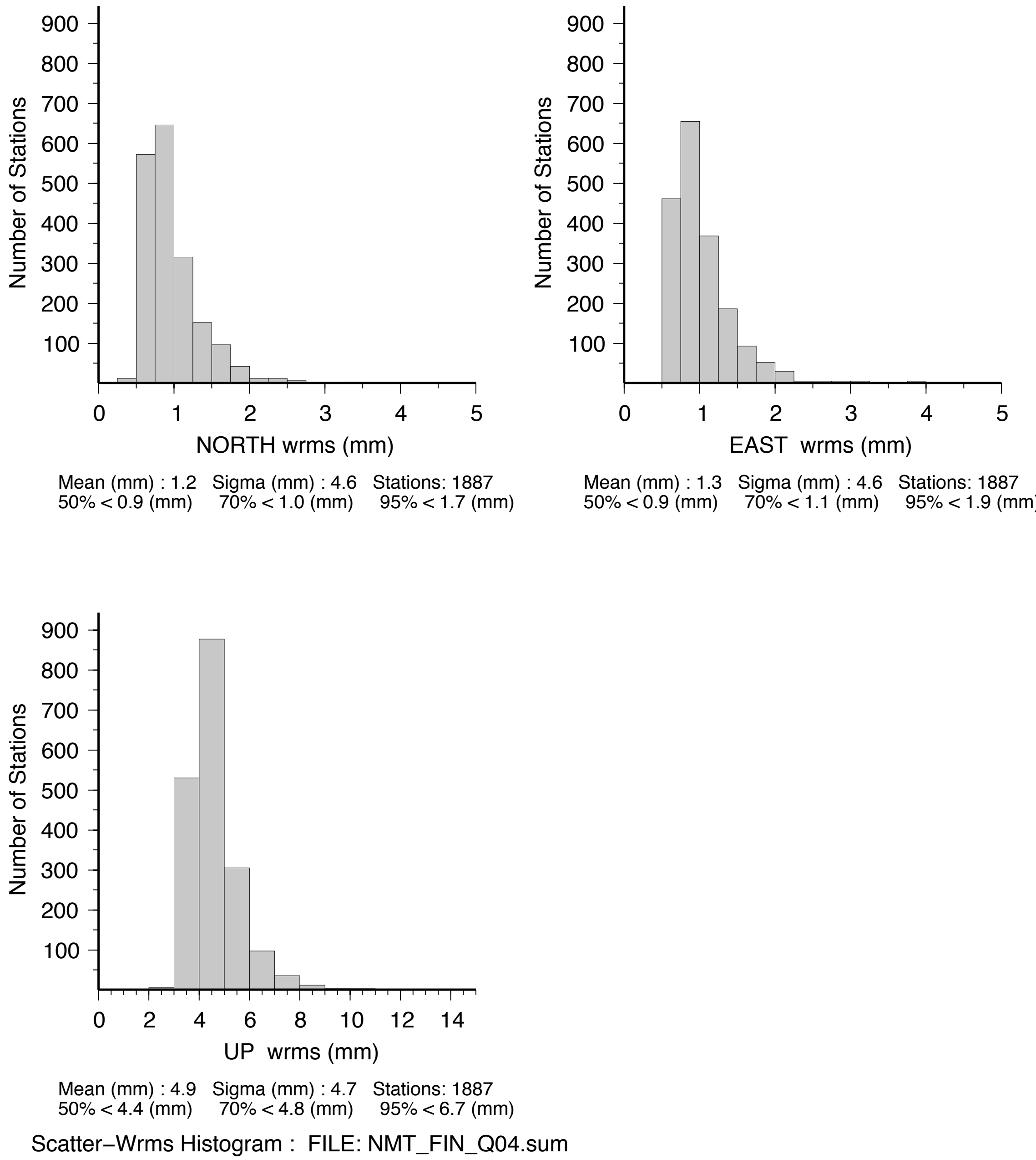

Figure 2: NMT combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1887 sites analyzed between June 15, 2014 and Sept 13, 2014. Linear trends and annual signals were estimated from the time series.

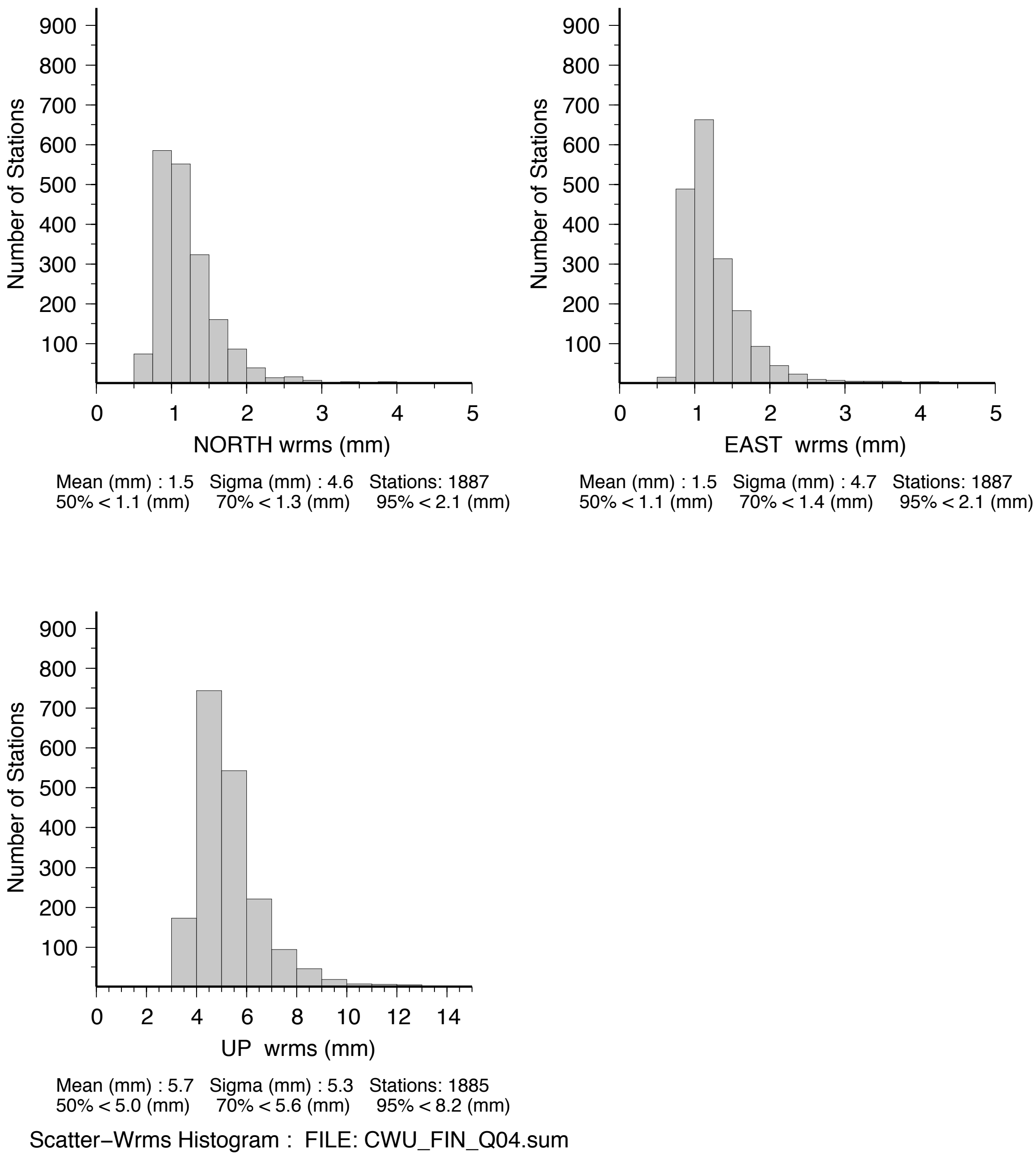

Figure 3: CWU combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1885 sites analyzed between June 15, 2014 and Sept 13, 2014. Linear trends and annual signals were estimated from the time series.

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 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_Q04.tab. There are 1888 sites in the file. The contents of the files is of this form:

```
Tabular Position RMS scatters created from PBO_FIN_Q04.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     70      1.4   0.73      1.5    0.72     4.8    0.60      11.39
 1NSU     91      1.1   0.60      1.4    0.73     5.4    0.72      10.66
 1ULM     91      1.1   0.61      1.1    0.61     5.1    0.71      11.25
 7ODM     91      0.9   0.45      1.0    0.61     4.9    0.68      13.40
…
 ZME1     91      1.3   0.65      1.4    0.70     5.4    0.67      11.51
 ZNY1     91      1.1   0.56      1.1    0.62     4.1    0.55      11.66
 ZSE1     91      1.1   0.43      0.9    0.54     4.1    0.54      11.66
 ZTL4     91      1.6   0.79      1.3    0.64     5.8    0.72      11.85
```

Table 2: RMS scatter of the position residuals for the PBO combined solution between June 15, 2014 and Sept 13, 2014 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, Expanded_PBO, COCONet and Expanded_PBO

Network	North (mm)	East (mm)	Up (mm)	#Sites
Median (50%)				
PBO	0.8	0.8	4.0	899
NUCLEUS	0.8	0.8	4.1	209
USGS SCIGN	0.8	1.0	4.5	104
Expanded	1.0	1.1	4.6	578
GAMA	0.9	1.2	4.9	13
COCO Net	1.6	1.7	6.6	85
70 %				
PBO	0.9	1.0	4.3	
NUCLEUS	0.9	1.0	4.5	
USGS SCIGN	1.0	1.1	4.8	
Expanded	1.2	1.3	5.1	
GAMA	1.0	1.3	5.1	
COCO Net	1.9	1.9	7.2	
95%				
PBO	1.5	1.4	5.6	
NUCLEUS	1.4	1.4	5.8	
USGS SCIGN	1.7	1.5	5.9	
Expanded	1.8	1.9	7.1	
GAMA	1.2	1.9	5.7	
COCO Net	2.7	3.9	11.1	

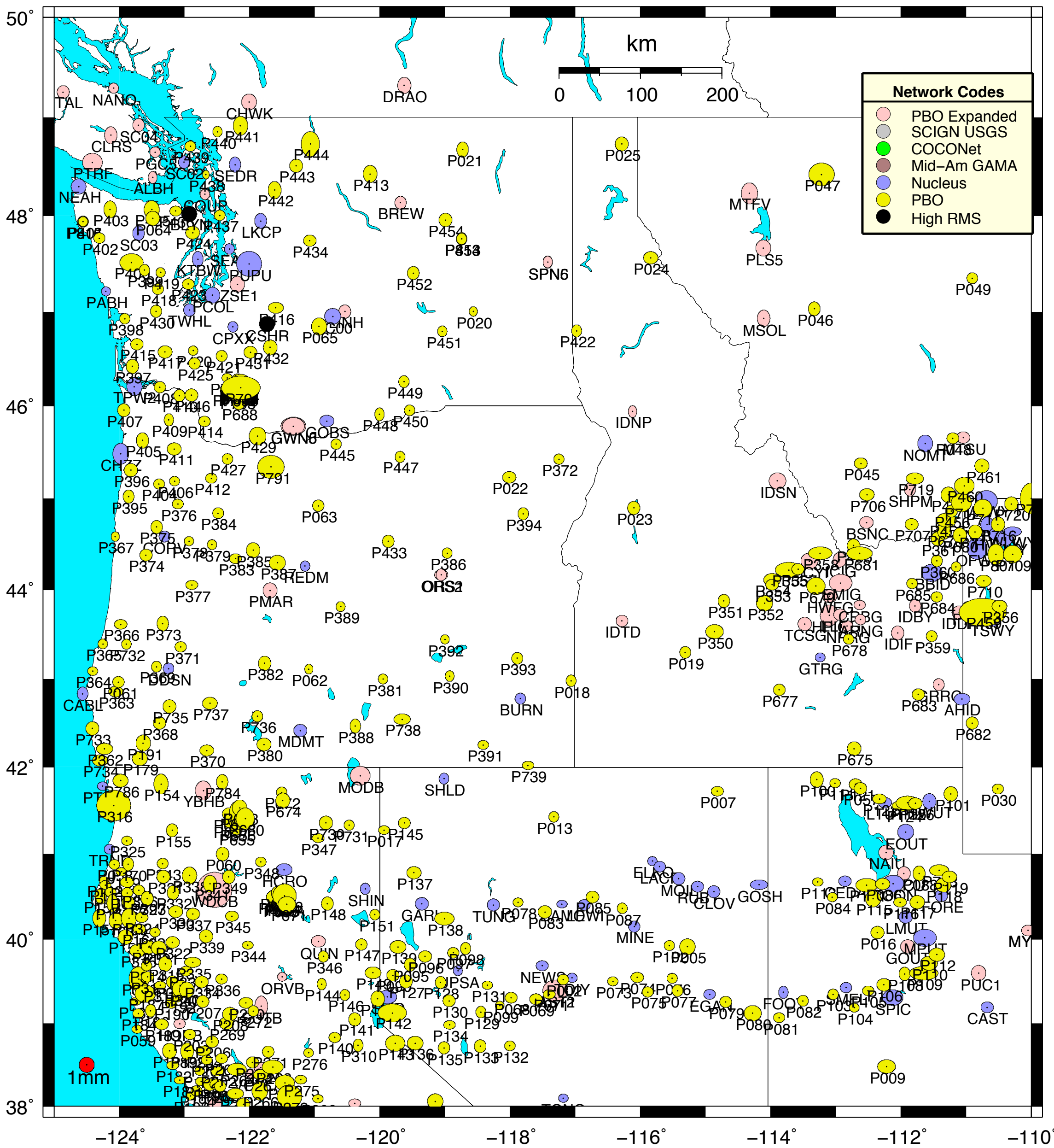

Figure 4: Distribution of the RMS scatters of horizontal position estimates from the PBO combined analysis for the Northern Western United States. The color of the ellipses that give the north and east RMS scatters denotes the network given by the legend in the figure. The small red circle shows the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

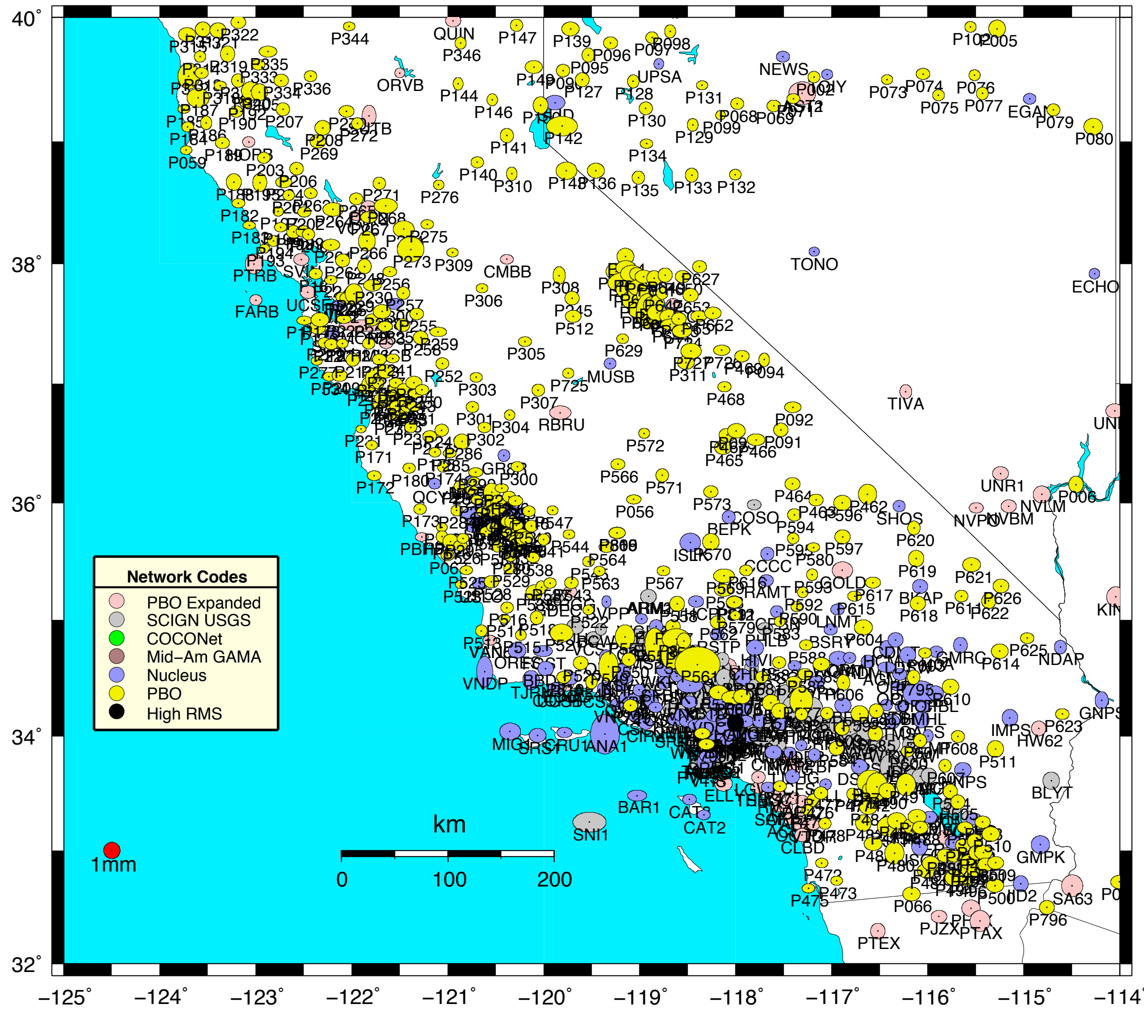

Figure 5: Same as Figure 4 except for the Southern Western United States. Black circles in the Yucca mountain region have no data during this 3-month period.

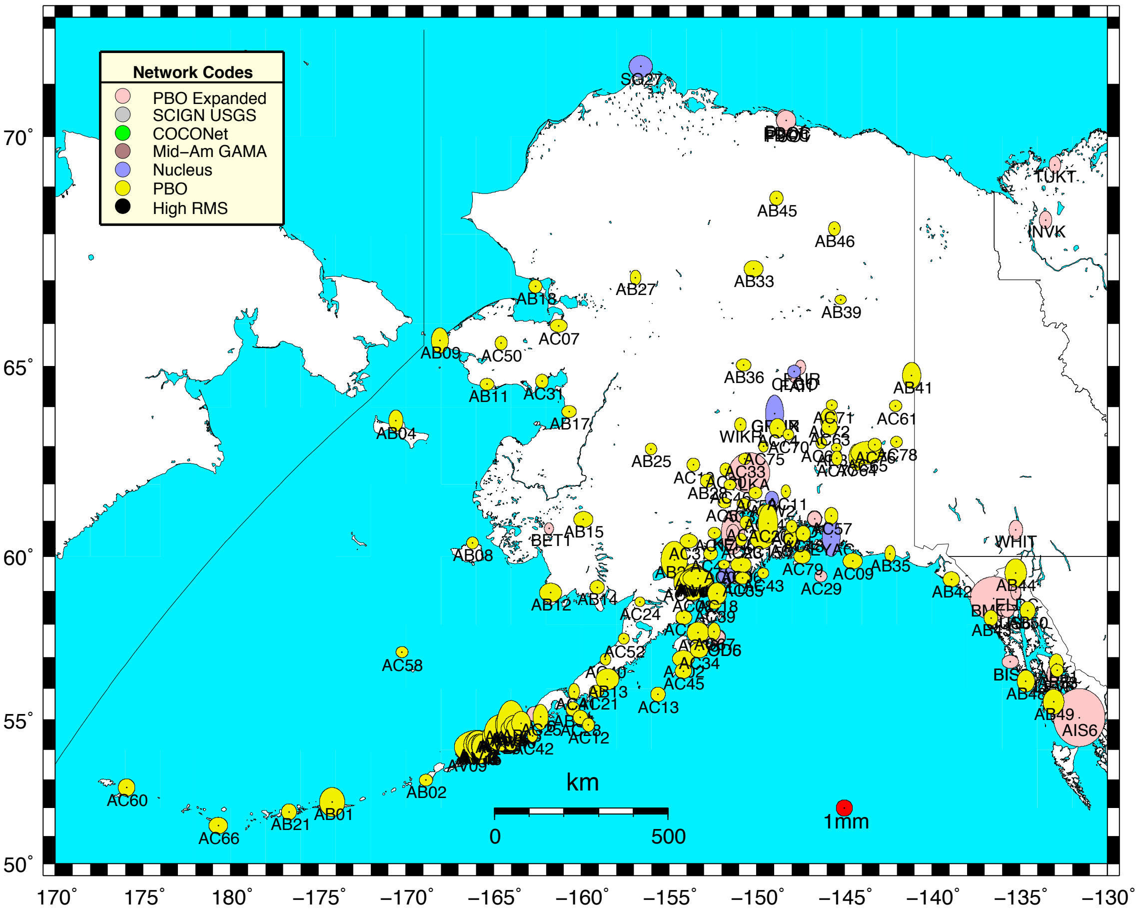

Figure 6: Same as Figure 4 except for the Alaskan region.

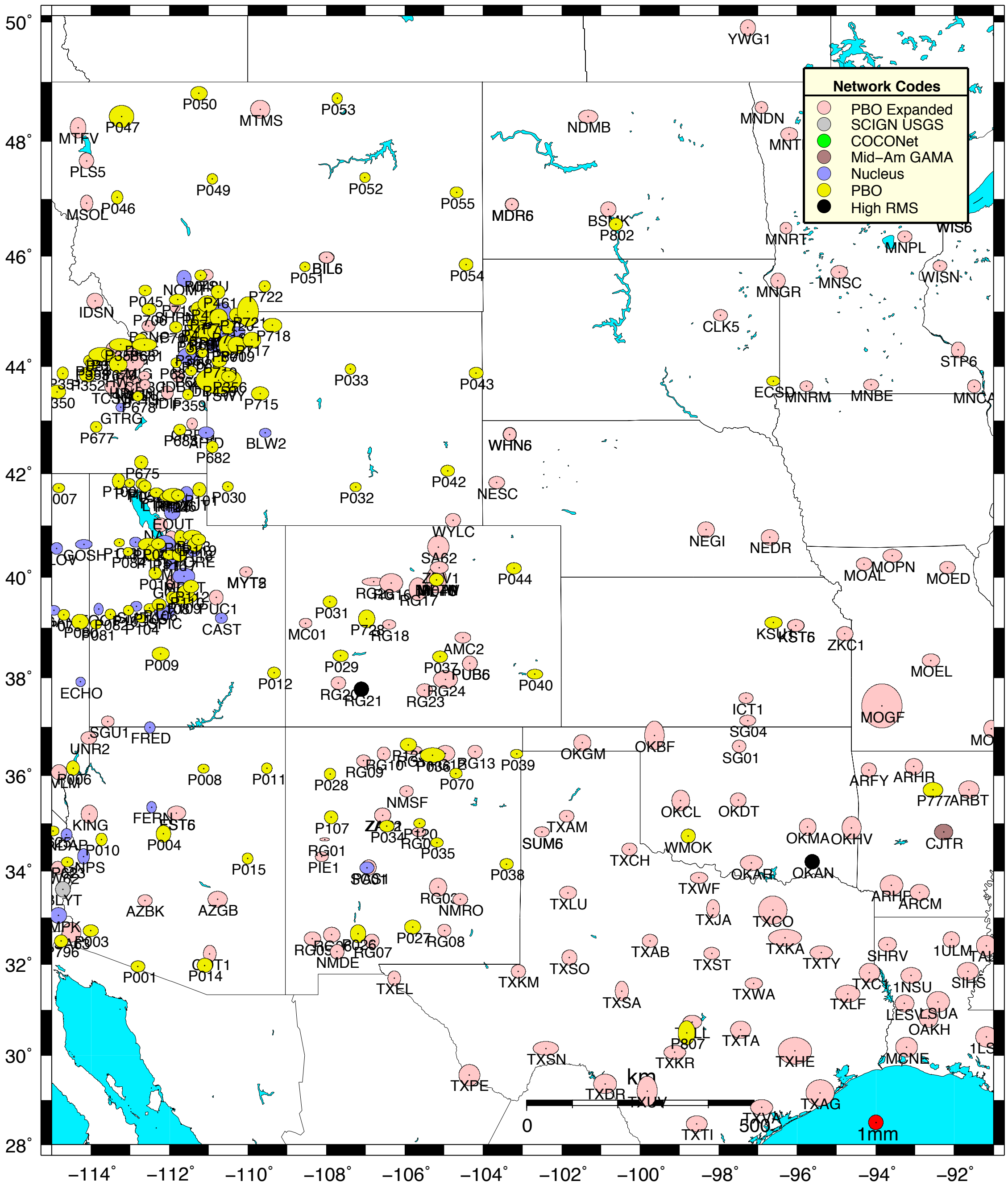

Figure 7: Same as Figure 4 except for the Central United States

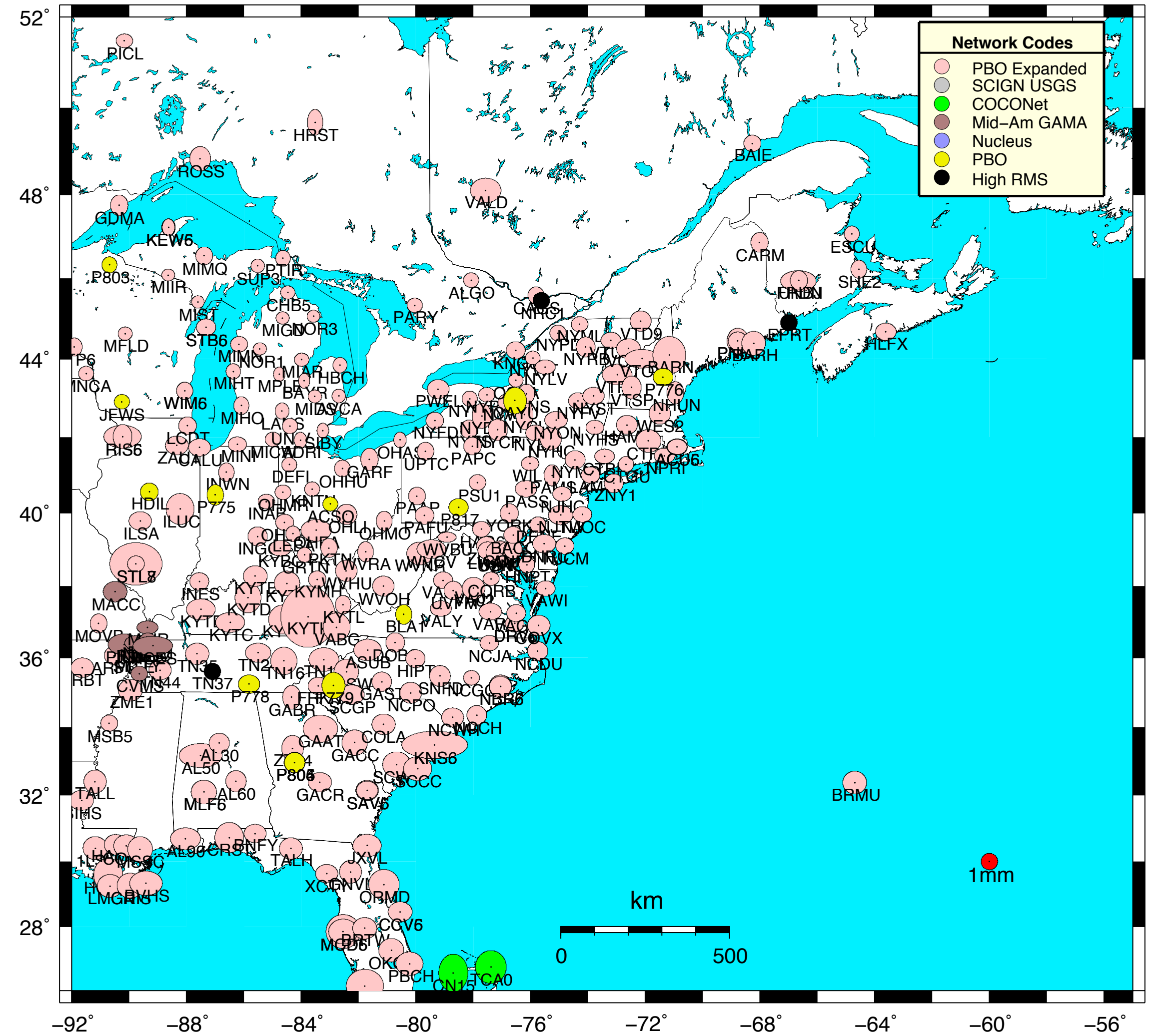

Figure 8: Same as Figure 4 except for the Eastern United States

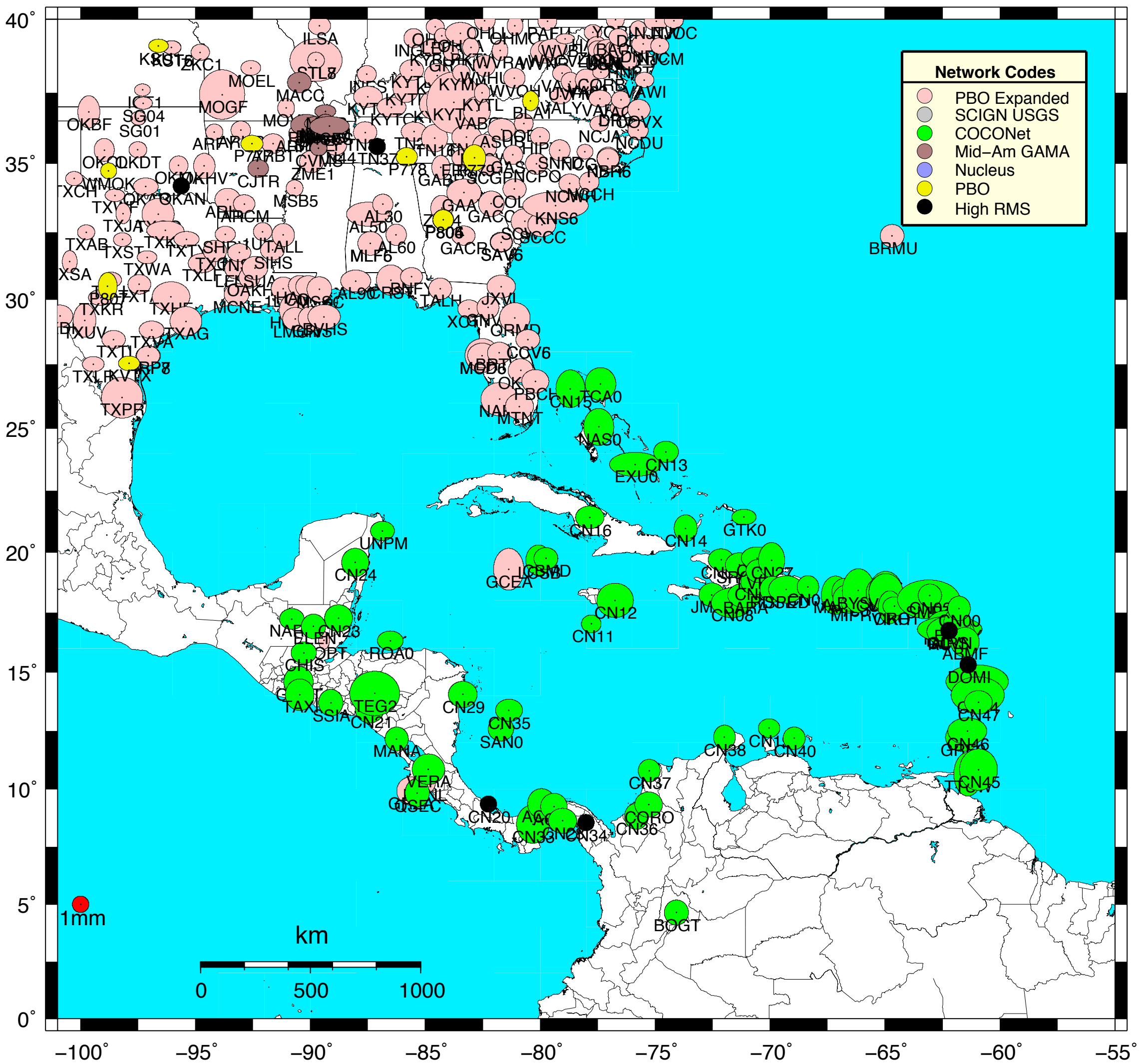

Figure 9: Same as Figure 4 except for the Caribbean region.

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. 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 comment contains the standard deviations.

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.

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. 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 2074 sites, 20 more than last quarter, in the analyses and 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 fits along with the duration of the data used are given in the following linked files: pbo_nam08_140913.tab, nmt_nam08_140913.tab and cwu_nam08_140913.tab. The velocity estimates are shown by region and network type in Figures 10-15. The color scheme used is the same as Figures 4-9. The snapshot velocity field files are linked as: pbo_nam08_140913.snpvel, nmt_nam08_140913.snpvel and cwu_nam08_140913.snpvel.

Table 3: Statistics of the fits of 2074 sites analyzed in the reprocessed analysis for data collected between Jan 1, 1996 and Sept 13, 2014.

Center	North (mm)	East (mm)	Up (mm)
Median (50%)			
PBO	1.2	1.3	5.5
NMT	1.2	1.3	5.6
CWU	1.4	1.4	6.5
70%			
PBO	1.5	1.6	6.1
NMT	1.6	1.7	6.4
CWU	1.8	1.7	7.5
95%			
PBO	3.4	3.1	9.1

NMT	3.4	3.2	8.8
CWU	3.8	3.5	11.4

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 which 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 0.54 mm/yr vertical in direct difference of all sites in both solutions (2049 sites). The χ^2/f of the difference is $(1.23)^2$ for the horizontal and vertical components. Since the RMS is weighted, sites with small standard deviations with tend to dominate the WRMS. Establishing a lower bound on the standard deviation of the velocity estimates 0.07 mm/yr (summed squared into the horizontal velocity standard deviations) and 0.35 mm/yr in heights generates and RMS difference of 0.15 mm/yr with a χ^2/f of unity horizontal only and 0.71 mm/yr for height. These RMS differences are much smaller than last quarter and reflect the improvements to the CWU solution after the new reprocessing. When we use only sites with small uncertainties so that about only half the sites are used (minimum NE sigma 0.15 mm/yr and U sigma 0.62 mm/yr such that all sigma components must satisfy these limits in both solutions), 1060 sites are compared the WRMS differences are 0.11 and 0.5 mm/yr in NE and Up. The NRMS values (sqrt(χ^2/f) are 0.82 and 0.77 indicating the re-weighting factors could be too large and a simple additive baseline variance for the velocity estimates is not complete enough. Most likely there could also be a scale to be applied to the sigmas as well.

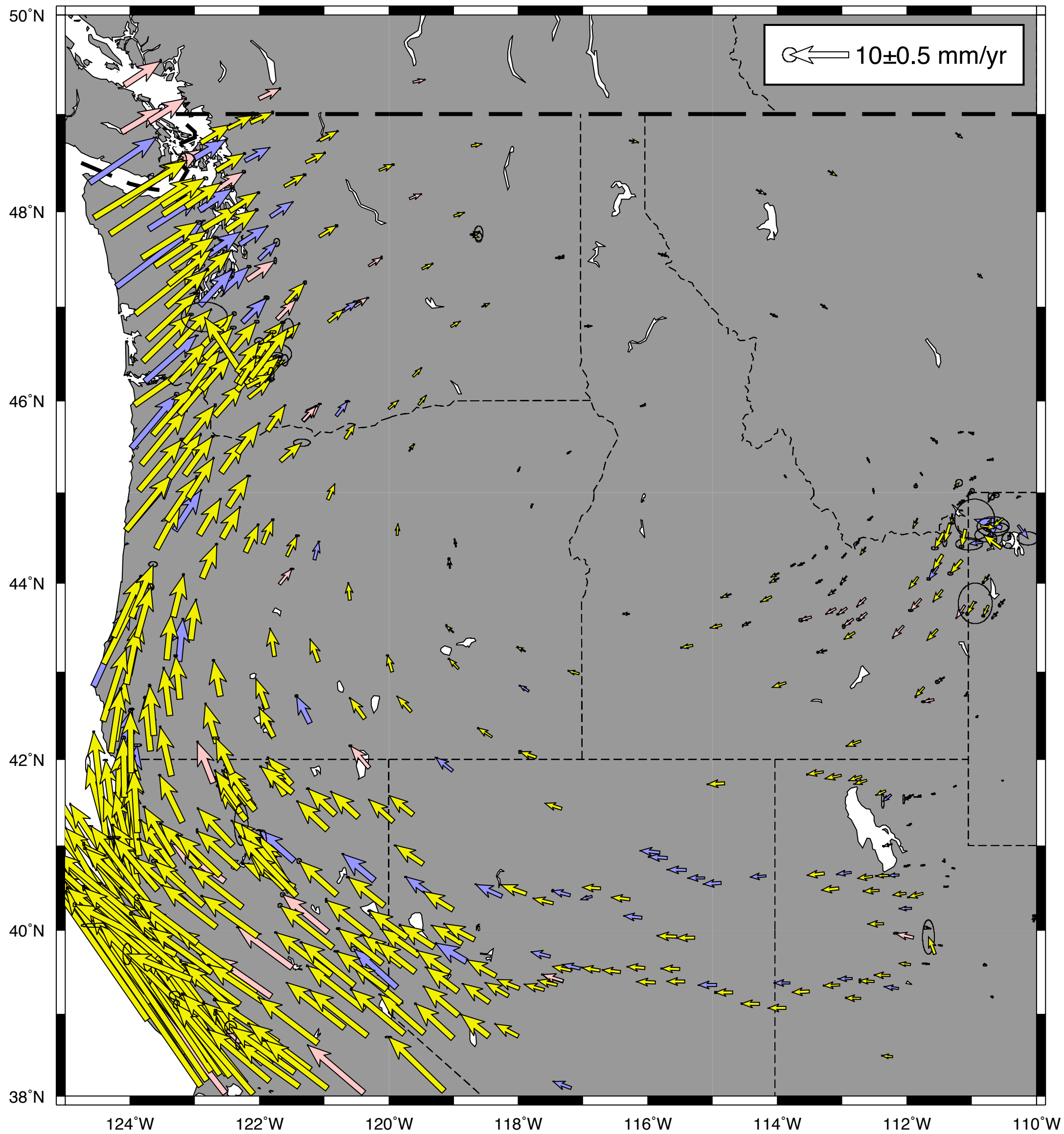

Figure 10: Velocity field estimates from the combined PBO solutions generated using time series analysis and the FOGMEX error model. 95% confidence interval error ellipses are shown. The color scheme of the vectors matches the network type legend in Figure 4. Only velocities with horizontal standard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

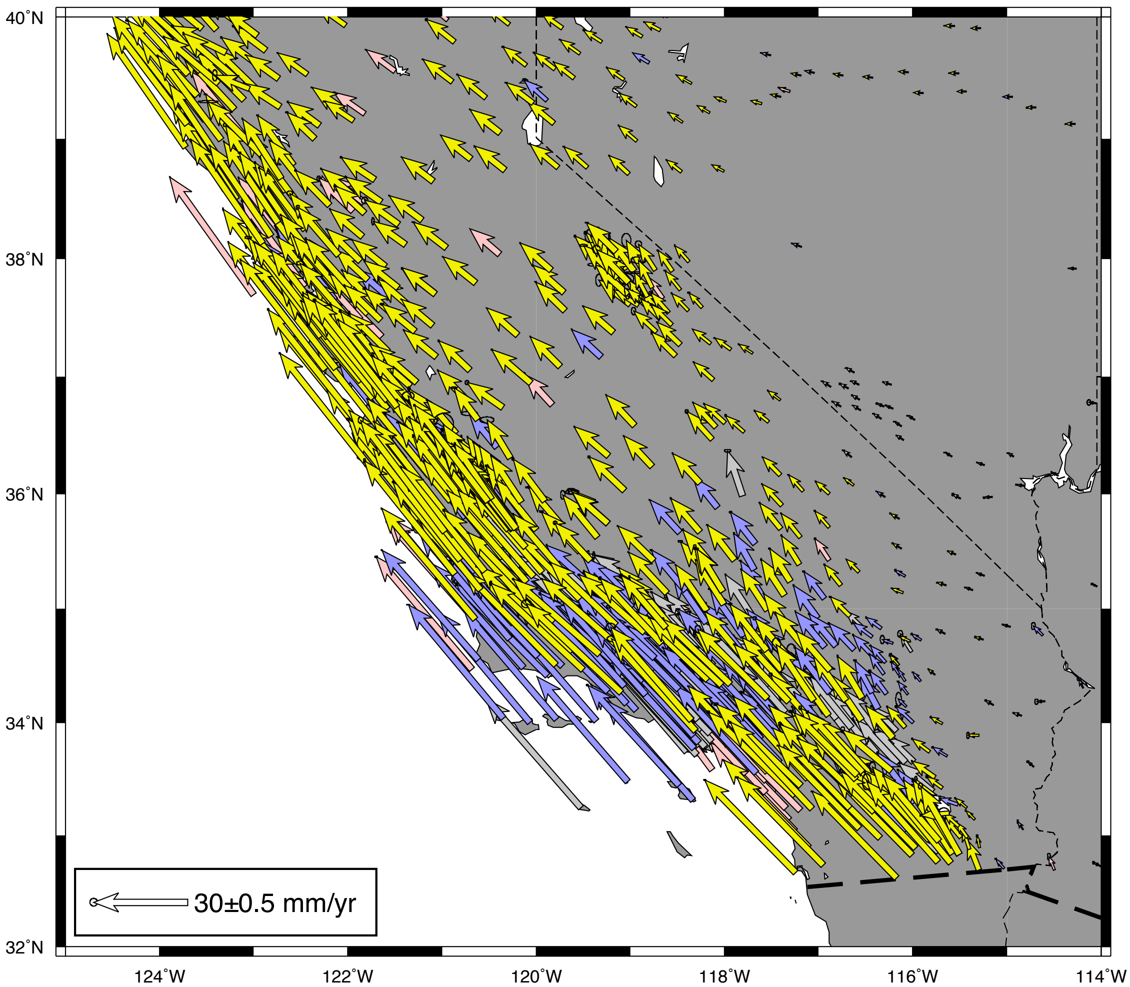

Figure 11: Same as Figure 10 except for South Western United States. Only velocities with horizontal standard deviations less than 2 mm/yr are shown. The anomalous site at latitude 34, longitude -117 is P613 and is effected by the estimation of post-seismic motion after the 2010 Apr 4 El Major Cucupah earthquake.

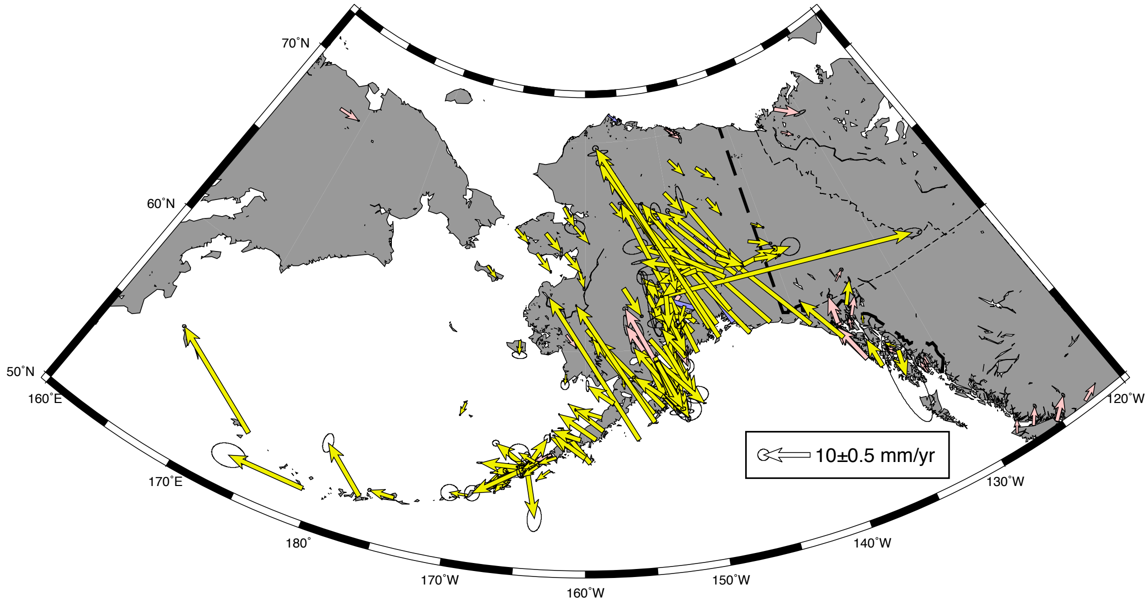

Figure 12: Same as Figure 10 except for Alaska. Only velocities with horizontal standard deviations less than 5 mm/yr are shown. The anomalous vector in Central Alaska is AC55 as the sites does move with anomalous motion. The site was discontinued in mid-2010.

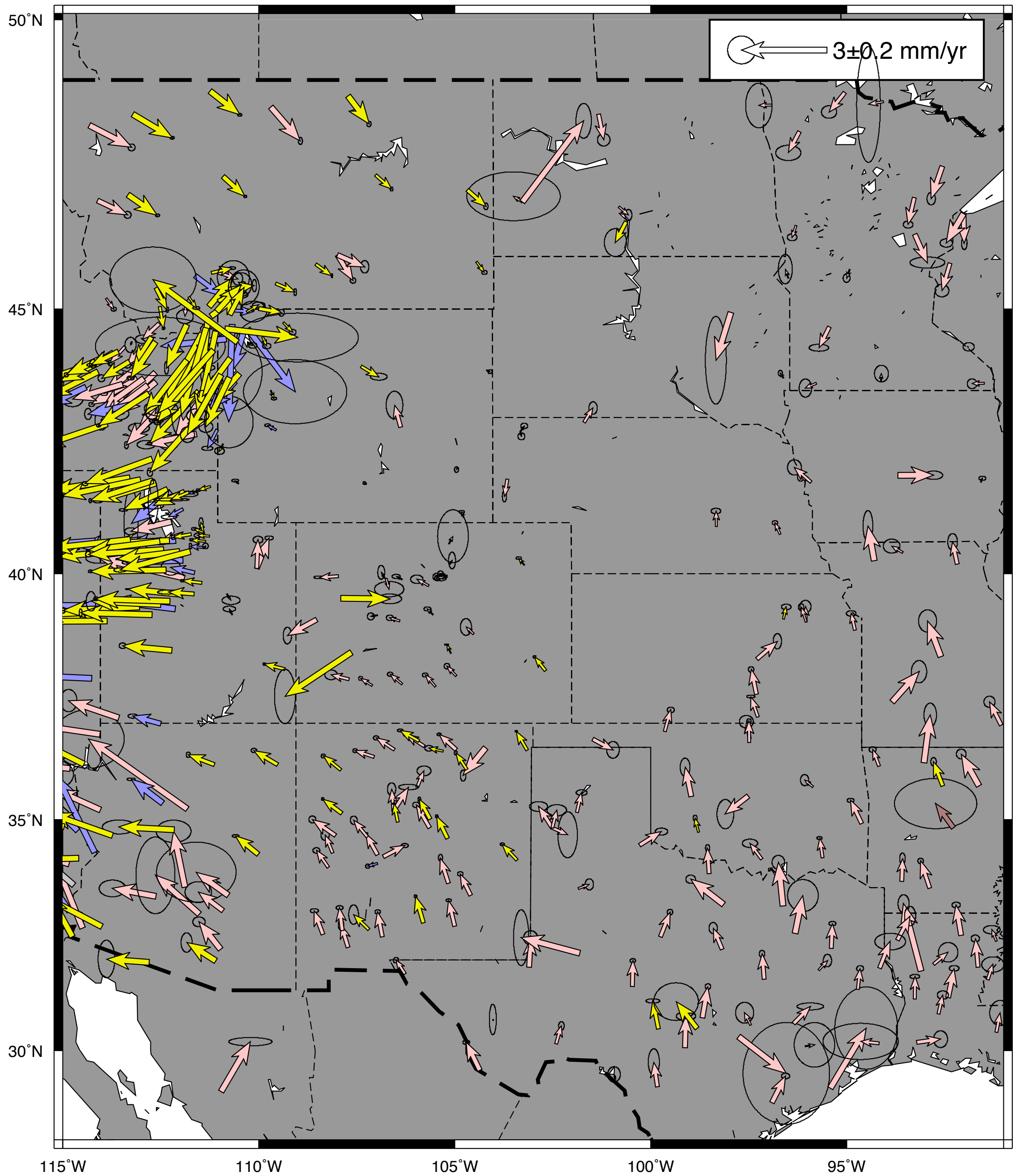

Figure 13: Same as Figure 10 except for Central United States. Only velocities with horizontal standard deviations less than 1 mm/yr are shown.

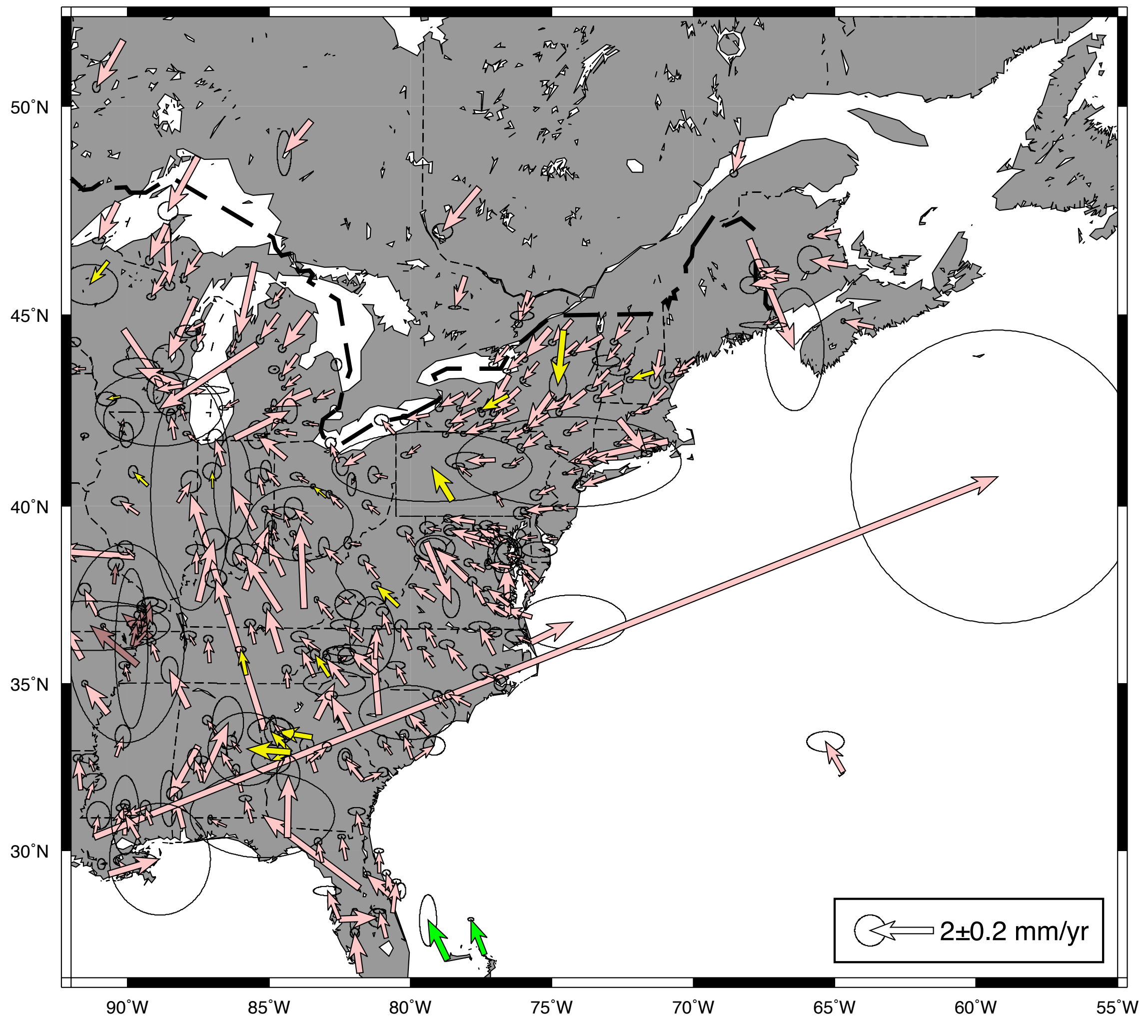

Figure 14: Same as Figure 10 except for the Eastern United States. Only velocities with horizontal standard deviations less than 2 mm/yr are shown. The systematic western velocity of sites in the Northeast is being investigated although profiles from Canada to the Gulf of Mexico indicate that horizontal glacial isostatic adjustment (GIA) horizontal signals may be seen in the velocity results. If this is the case, the North America Euler pole from ITRF2008 may be affected by these motions. The large vector is LST1 which has only a short span of data.

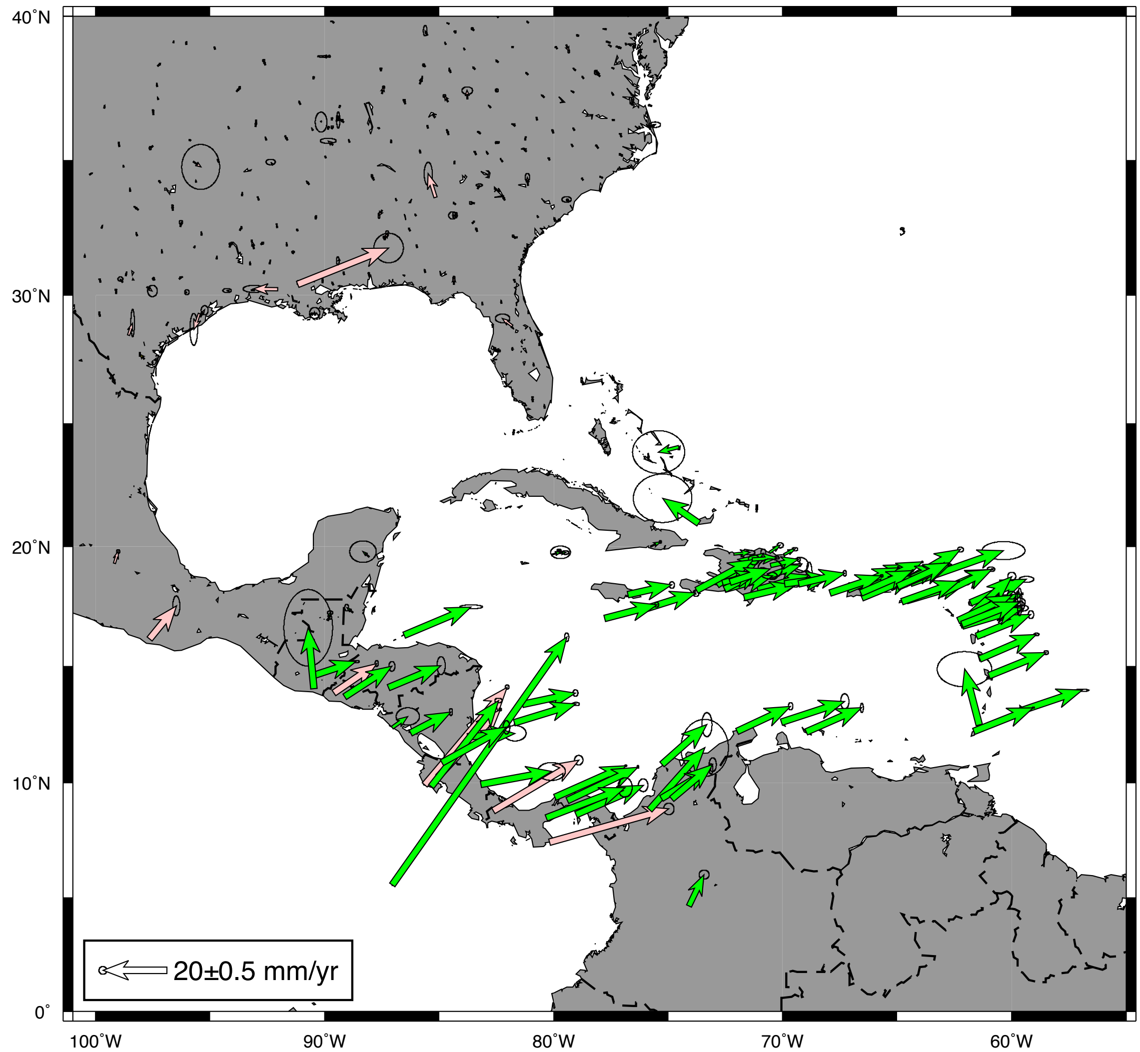

Figure 15: Same as Figure 10 except for the Caribbean region. Only velocities with horizontal standard deviations less than 5 mm/yr are shown (reduced from last quarter). The site in pink in Louisiana is LST1 which has a very span of data in 2006.

Earthquake Analyses: 2014/07/01-2014/09/30.

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 site 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).

In June 2014 we investigated the following events.

```
* EQDEFS for 2014 06 13 to 2014 07 14 Generated Tue Jul 15 10:21:34 EDT 2014
* Proximity based on Week_All.Pos file
* ---------------------------------
* SEQ Earthquake # 1
* EQ 249 AB01_GPS     484.09     839.40 CoS        5.2 mm
* EQ 249 AB21_GPS     314.90     839.40 CoS       12.2 mm
* EQ 249 AC60_GPS     335.06     839.40 CoS       10.8 mm
* EQ 249 AC66_GPS      59.80     839.40 CoS      338.9 mm
* EQ_DEF M7.9 24km SE of Little Sitkin Island
 eq_def 32   51.7972  178.7604    839.4 8 2014 06 23 20 54   18.935
 eq_rename 32
 eq_coseis 32  0.001 0.001 0.001     18.935     18.935     18.935
* ---------------------------------
* SEQ Earthquake # 2
* EQ 529 P613_GPS       9.58      12.00 CoS        2.8 mm
* EQ_DEF M4.6 10km NE of Running Springs
 eq_def 02   34.2800 -117.0278     12.0 8 2014 07 05 16 60    0.004
 eq_rename 02
 eq_coseis 02  0.001 0.001 0.001      0.004      0.004      0.004
* ---------------------------------
* SEQ Earthquake # 3
* EQ 542 LMNL_GPS      13.52      14.70 CoS        3.1 mm
* EQ_DEF M4.9 19km SSW of Canas
 eq_def 03   10.2742  -85.1780     14.7 8 2014 07 06 11 43    0.009
 eq_rename 03
 eq_coseis 03  0.001 0.001 0.001      0.009      0.009      0.009
* ---------------------------------
* SEQ Earthquake # 4
* EQ 557 CN25_GPS     168.44     174.30 CoS        3.3 mm
* EQ_DEF M6.9 2km NNE of Puerto Madero
 eq_def 04   14.7418  -92.4089    174.3 8 2014 07 07 11 24    1.457
 eq_rename 04
 eq_coseis 04  0.001 0.001 0.001      1.457      1.457      1.457
```

The M7.9 24km SE of Little Sitkin Island event on June 23, 2014 will likely produce a large offset at AC66 but this station has a large data gap (manual download) and only recently has data become available. The finals will be the first analysis that will allow an assessment of the co-seismic offset. AC60 does shown an offset of -14 mm East, and AB01 may show a small east offset. No data is available for AB21. The event is labeled 32 and when the finals are processed after the event time, an event file will be sent to UNAVCO.

For the other events considered, there is no apparent offset at P619 from event 02; LMNL has no data after event 03; and there is no apparent offset at CB25 from event 04.

In July 2014, the following events were investigated

```
* EQDEFS for 2014 07 13 to 2014 08 12 Generated Wed Aug 13 11:22:32 EDT 2014
* Proximity based on Week_All.Pos file
* ---------------------------------
* SEQ Earthquake # 1
* EQ 63 AC66_GPS       3.65       9.80 CoS        4.8 mm
* EQ_DEF M4.1 68km SSW of Semisopochnoi Island
 eq_def 01   51.3558  179.3398      9.8 8 2014 07 16 21 11    0.001
 eq_rename 01
 eq_coseis 01  0.001 0.001 0.001      0.001      0.001      0.001
```

```
* ----------------------------------
* SEQ Earthquake # 2
* EQ 224 AB43_GPS      33.61      41.30 CoS        6.3 mm
* EQ_DEF M5.9 81km W of Gustavus
 eq_def 02   58.3580 -137.1301     41.3 8 2014 07 25 10 55    0.112
 eq_rename 02
 eq_coseis 02  0.001 0.001 0.001      0.112      0.112      0.112
* ----------------------------------
* SEQ Earthquake # 3
* EQ 295 P045_GPS       4.84       9.30 CoS        2.7 mm
* EQ_DEF M3.9 13km N of Dillon
 eq_def 03   45.3400 -112.6080      9.3 8 2014 07 28 12 52    0.001
 eq_rename 03
 eq_coseis 03  0.001 0.001 0.001      0.001      0.001      0.001
* ----------------------------------
* SEQ Earthquake # 4
* EQ 367 SSIA_GPS      10.08      11.50 CoS        1.9 mm
* EQ_DEF M4.5 7km SSW of Tecoluca
 eq_def 04   13.7276  -89.0302     11.5 8 2014 08 03 00 24    0.003
 eq_rename 04
 eq_coseis 04  0.001 0.001 0.001      0.003      0.003      0.003
```

Of these earthquakes, the M4.1 68km SSW of Semisopochnoi Island may have affected AC66 but there are no recent data to test this. The M5.9 81km W of Gustavus on 2014 07 25 did seem to displace the one site AB43.
This become event 33 and an event file is being created and sent to UNAVCO. None of the other target earthquakes generated detectable coseismic offsets.

In August 2014, the following events were investigated but none show co-seismic offsets.

```
* EQDEFS for 2014 08 11 to 2014 09 14 Generated Mon Sep 15 09:46:50 EDT 2014
* Proximity based on Week_All.Pos file
* ----------------------------------
* SEQ Earthquake # 1
* EQ 105 LDES_GPS       3.92       9.10 CoS        4.2 mm
* EQ_DEF M3.8 20km N of Yucca Valley
 eq_def 01   34.3018 -116.4428      9.1 8 2014 08 15 03 58    0.001
 eq_rename 01
 eq_coseis 01  0.001 0.001 0.001      0.001      0.001      0.001
* ----------------------------------
* SEQ Earthquake # 2
* EQ 272 GRNR_GPS       7.78       8.70 CoS        0.0 mm
* EQ 272 GRNX_GPS       7.79       8.70 CoS        0.0 mm
* EQ_DEF M3.5 5km ENE of Healy
 eq_def 02   63.8809 -148.8586      8.7 8 2014 08 21 03 42    0.000
 eq_rename 02
 eq_coseis 02  0.001 0.001 0.001      0.000      0.000      0.000
* ----------------------------------
* SEQ Earthquake # 3
* EQ 353 P181_GPS      34.50      47.10 CoS        7.8 mm
* EQ 353 P194_GPS      44.33      47.10 CoS        4.7 mm
* EQ 353 P196_GPS      38.68      47.10 CoS        6.2 mm
* EQ 353 P197_GPS      46.08      47.10 CoS        4.4 mm
* EQ 353 P198_GPS      26.26      47.10 CoS       13.5 mm
* EQ 353 P199_GPS      17.47      47.10 CoS       30.4 mm
* EQ 353 P200_GPS      12.46      47.10 CoS       59.8 mm
* EQ 353 P202_GPS      27.79      47.10 CoS       12.0 mm
* EQ 353 P224_GPS      40.48      47.10 CoS        5.7 mm
* EQ 353 P261_GPS      11.11      47.10 CoS       75.1 mm
* EQ 353 P262_GPS      28.76      47.10 CoS       11.2 mm
* EQ 353 P263_GPS      41.10      47.10 CoS        5.5 mm
* EQ 353 P264_GPS      26.92      47.10 CoS       12.8 mm
* EQ 353 P265_GPS      46.50      47.10 CoS        4.3 mm
```

```
* EQ 353 P266_GPS      41.13      47.10 CoS        5.5 mm
* EQ 353 P267_GPS      46.22      47.10 CoS        4.3 mm
* EQ 353 SVIN_GPS      28.06      47.10 CoS       11.8 mm
* EQ 353 VCVL_GPS      37.29      47.10 CoS        6.7 mm
* EQ_DEF M6.0 6km NW of American Canyon
 eq_def 03   38.2202 -122.3128     47.1 8 2014 08 24 10 21    0.145
 eq_rename 03
 eq_coseis 03  0.001 0.001 0.001      0.145      0.145      0.145
* ------------------------------------
* SEQ Earthquake # 4
* EQ 389 P261_GPS       7.75       9.30 CoS        1.1 mm
* EQ_DEF M3.9 3km W of American Canyon
 eq_def 04   38.1782 -122.3015      9.3 8 2014 08 26 12 34    0.001
 eq_rename 04
 eq_coseis 04  0.001 0.001 0.001      0.001      0.001      0.001
* ------------------------------------
* SEQ Earthquake # 5
* EQ 448 P708_GPS       4.33       9.10 CoS        3.4 mm
* EQ 448 P798_GPS       6.72       9.10 CoS        1.4 mm
* EQ_DEF M3.8 18km ENE of Driggs
 eq_def 05   43.7630 -110.8920      9.1 8 2014 08 30 20 10    0.001
 eq_rename 05
 eq_coseis 05  0.001 0.001 0.001      0.001      0.001      0.001
* ------------------------------------
* SEQ Earthquake # 6
* EQ 609 SFDM_GPS       6.92       8.90 CoS        0.0 mm
* EQ 609 WKPK_GPS       6.69       8.90 CoS        0.0 mm
* EQ_DEF M3.6 12km N of Piru
 eq_def 06   34.5180 -118.7825      8.9 8 2014 09 08 04 19    0.000
 eq_rename 06
 eq_coseis 06  0.001 0.001 0.001      0.000      0.000      0.000
* ------------------------------------
* SEQ Earthquake # 7
* EQ 642 P237_GPS       8.46       8.80 CoS        0.0 mm
* EQ_DEF M3.6 15km SSE of Ridgemark
 eq_def 07   36.6813 -121.3112      8.8 8 2014 09 09 18 18    0.000
 eq_rename 07
 eq_coseis 07  0.001 0.001 0.001      0.000      0.000      0.000
```

SEQ Earthquake # 3 is the South Napa event and it has been added to the earthquake file as event #34. The co-seismic offsets associated with this event were sent to UNAVCO as pbo_140824_1021_EQ34_coseis_rapid.evt.20140828102554. Earthquake #4 is an aftershock to #3 and does not generate any large offset. This earthquake is generating post-seismic motions and will eventually be modeled with a log function. The initial estimates suggest a 2-day log time constant (simular to Parkfield post-seismic).
SEQ Earthquake #5 has no data after the event at site P708 but no offset is seen at P798 which is expected to have the larger signal. None of the other earthquakes examined generated detectable co-seismic offsets.

Antenna Change Offsets: 2014/07/01-2014/09/31

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

```
 Site      Date             From            To
 AB42  2014   6  1  0  0  TRM59800.80      TRM59800.80
 EPRT  2014   6 30  0  0  TRM29659.00      ASH701945E_M
 LMCN  2014   6 12  0  0  TRM41249.00      TRM57971.00
 P609  2014   6  2  1 46  TRM59800.80      TRM59800.00
```

P736	2014	6	8	0	0	TRM29659.00	TRM59800.80
WES2	2014	6	25	0	0	AOAD/M_TA_NGS	JAVRINGANT_DM
ACSO	2014	7	30	16	18	TRM29659.00	TRM59800.80
NYMD	2014	7	3	14	15	LEIAT504	LEIAR10
P140	2014	7	24	21	57	TRM29659.00	TRM59800.00
CN45	2014	8	16	0	0	TRM59800.00	TRM59800.00
NMSF	2014	8	11	19	0	TRM41249.00	TRM57971.00
NYHS	2014	8	26	13	28	LEIAT504	LEIAR10
NYST	2014	8	19	16	13	LEIAT504	LEIAR10
OPCL	2014	8	14	17	24	SCIS	SCIT Dome change
P647	2014	8	19	19	59	TRM29659.00	TRM59800.80

The AB42 data are sparse and of low quality starting in late 2013 and it is difficult to determine the size of the offset.
Data from EPRT end at the start of 2012 and with the large gap it is difficult to determine the size of the offset.
For LMCN, there are data available at the time of the antenna and receiver change. Systematic deviations in the time series make the offset difficult to estimate. Using data from just 2014 and estimating an annual as well as rate, the offset estimates are dN 2.26 +- 0.47 dE 2.95 +- 0.83 dU -1.32 +- 2.17 mm.
For P609, systematic deviations make the offset difficult to estimate. There is a 12-day gap in the data before the new antenna is installed. Using 2014 data only with rate and annual estimated the offsets are dN 5.07 +- 0.46 dE -0.65 +- 0.45 dU 0.07 +- 3.39 mm.
P736 has clean data with little systematic variation. Offset estimates are dN 3.34 +- 0.46 dE -1.27 +- 0.40 dU 2.19 +- 5.95 mm. There are long term systematic variations in height which is why the sigma on the estimate is large.
Data quality at WES2 seems to have degraded, particularly in the CWU solution, since the antenna change. Using data since late March 2014 to date, the offset estimates are dN 4.08 +- 0.64 dE 6.60 +- 0.73 dU 4.83 +- 3.87 mm. Analysis of the MIT IGS analysis results shows offsets of dN 6.35 +- 0.48 dE 6.55 +- 0.55 dU -1.27 +- 2.29 mm.

The ACSO antenna change did not seems to generate any position offset. The NYMD changed 2.9, -0.5 and 13.4 mm NEU. This offset is added to our discontinuity file. At P140 there is a gap in the data prior to the antenna change and some systematic drift in the east coordinate before the change. The estimated offsets are -0.0, 2.0 and 5.3 mm in NEU with sigmas of 0.2 and 1.9 mm.

There is only one data point at CN45 before the antenna swap and there is no apparent offset. At NMSF: The antenna change mostly generated a height shift. dNEU was -0.44 +- 0.20; 2.10 +- 0.22; -15.40 +- 1.15 mm. The east offset may be spurious due to systematic east motion before the antenna change mid-May 2014.
At NYHS: The antenna changed caused offsets of dNEU 6.84 +- 0.45; -5.81 +- 0.78; 9.85 +- 2.54 mm. There a some data points in rapids with 10cm height offsets before the meta data was updated. The finals runs will removed this spurious offset.
OPCL has small changes associated with the radome and receiver change dNEU -0.96 +- 0.15 2.13 +- 0.21 2.29 +- 1.22 mm.
P647 has small changes associated with the antenna change dNEU -0.36 +- 0.32 -1.27 +- 0.35 3.00 +- 1.52 mm determined from data after June 2014 (systematic variations in the time-series effect the estimates when all data are used).
All offsets were added except CN45 due to lack of data

P316 was reported in our monthly of developing problems based on increased noise and error bars over the last month. This trend continued returned to normal operation on 2014 08 11. The metadata and maintenance reports publicly available through the UNAVCO web site give no indication of what happened at the sites. Personal communication with UNAVCO engineers revealed that vegetation has grown around the site and was cleared. This type of information needs to be included in the public maintenance reports if it is to be useful.

Based on feed back from Christine Puskas as UNAVCO we had added the following new breaks whose origins at this time are uknown. If the site maintenance reports were available publically, the origin of some of these events might be more apparent.

```
# ADDED TAH Wed Oct  8 10:11:58 EDT 2014
 rename OPCP_GPS OPCP_APS 2014  2 19  0  0   ! tsview break : Unknown
 rename OHFA_GPS OHFA_APS 2011  7 13  0  0   ! tsview break : Unknown; centered
may take 3-days
 rename BILL_GPS BILL_APS 2012  8 30 24  0   ! tsview break : Unknown
 rename DYHS_GPS DYHS_APS 2008  9 10  0  0   ! tsview break : Unknown but data
bad between 2004 and 2008

# ADDED TAH Wed Oct  8 16:13:30 EDT 2014
 rename CLK5_GPS CLK5_APS 2012  9 22 24  0   ! tsview break : Unknown
 rename RG17_GPS RG17_APS 2009 11 11  0  0   ! tsview break : Unknown
 rename OKDT_GPS OKDT_APS 2006  5 18 24  0   ! tsview break : Unknown
```

CWU re-reprocessing

CWU has now completed their reprocessing and all results have been delivered to UNAVCO. As seen the RMS tables above compared to the previous quarter, the results are improved considerably.

Script updates

No major changes have been to the scripts. All the reprocessed SINEX files have been transferred to UNAVCO using scp rather than LDM. Regular product deliveries are still be made with LDM. Full time series files (containing data back to 1996) are now delivered just once per week when the final solution is running. Earlier 12- and 26-week supplemental results are delivered in the time series files. The short rapid files are still delivered daily when the ACs send their solutions.

We have developed a set conversion codes (part of the tscon program) that allow us to convert Cartesian time series files with standard deviations and correlations into PBO format pos files. So far we have converted results from the University Nevada, JPL (two different formats for IGS08 and fiducial free solutions, USGS and the NASA Measures program although the latter time series ends near the end of the 2013. The common files can then be compared in tsview and parameter fits made with tsfit. A new program tscomp allows differencing and meaning of time series files. All these programs are part of the GAMIT/GLOBK distributions or will soon be added to the incremental_updates directory.

GAMIT/GLOBK Community Support

During this quarter we began the modifications to support GNSS observations other than GPS. The initial code will allow only one type of GNSS at a time to be processed with GAMIT, but the solution (h-) files from the GAMIT processing can be combined in GLOBK, thus allowing multiple-system contribut6ions to the estimation of site coordinates.   We plan to complete the structural changes by the end of the next quarter, and then work on system-specific models for the satellites' motion and yaw.

There were no UNAVCO-sponsored data-analysis workshops during this period, but Mike Floyd conducted a workshop in Baku, Azerbaijan, attended by 10 analysts from Azerbaijan, Georgia, Russia, and Turkey. Presentation materials and feedback from this workshop will support future workshops conducted with NSF funding.   We continue to spend 5-10 hours in email support of users..   During the quarter we issued 22 royalty-free licenses to educational and research institutions, including three to US university departments (U New Hampshire Hydrographic Center, U Maryland Atmospheric and Ocean Sciences, Utah State U Geology).