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

**Thomas Herring, Robert King and Mike Floyd**

**Period: 2015/04/01-2015/06/30**

**Table of Contents**

## 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 04/01/2015 to 06/13/2015, time series velocity field analyses for the GAGE reprocessing analyses (1996-2015), earthquake effects during the interval (only one detected event that effected only one site, M6.7 111km NNW of Chirikof Island at 2015 05 29 07 01), position offsets from antenna changes, 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 June 13, 2015. No new "bad" sites were added this quarter. Currently there are 94 sites in the list. We have retained the list and explanation from previous quarters for completeness of this report. Associated with the report are the 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 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 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 is slowly increasing since a number of new sites are being added. In this quarter 1917 sites were processed compared to 1882 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.

*Analysis of Final products: March 15, 2015 and June 13, 2015*

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 March 15, 2015 and June 13, 2015. 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 or equal 0.9 mm for all centers and as low as 0.7 mm for NMT and PBO north and PBO east components. The up RMS scatters are less than or equal 4.3 mm and as low as 3.7 mm. These statistics are similar to last quarter. Seasonal changes in atmospheric delay properties will introduce small variations in these values quarter to quarter with this quarter being overall better than last 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 1917, 1916 and 1916 sites for PBO, NMT and CWU analyzed in the finals analysis between March 15, 2015 and June 13, 2015. Histograms of the RMS scatters are shown in Figure 1-3.

| Center | North (mm) | East (mm) | Up (mm) |
|---|---|---|---|
| *Median (50%)* | | | |
| PBO | 0.7 | 0.7 | 3.7 |
| NMT | 0.7 | 0.8 | 3.7 |
| CWU | 0.9 | 0.9 | 4.3 |
| *70%* | | | |
| PBO | 0.9 | 0.9 | 4.2 |
| NMT | 0.9 | 1.0 | 4.2 |
| CWU | 1.2 | 1.1 | 5.0 |
| *95%* | | | |
| PBO | 1.7 | 1.7 | 6.5 |
| NMT | 1.7 | 1.8 | 6.3 |
| CWU | 2.0 | 2.0 | 7.6 |

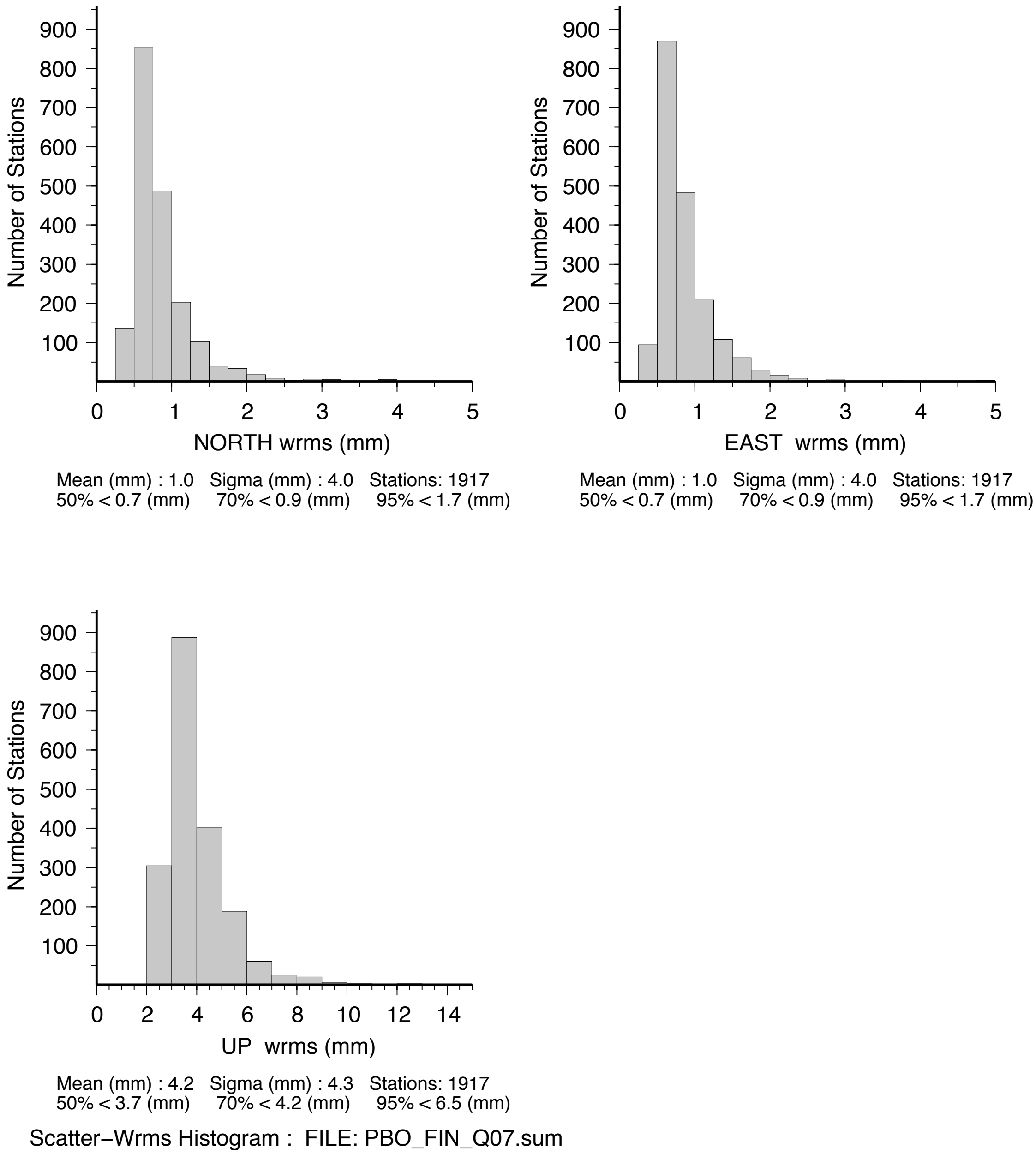


**Figure 1:** PBO combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1917 sites analyzed between March 15, 2015 and June 13, 2015. Linear trends and annual signals were estimated from the time series.

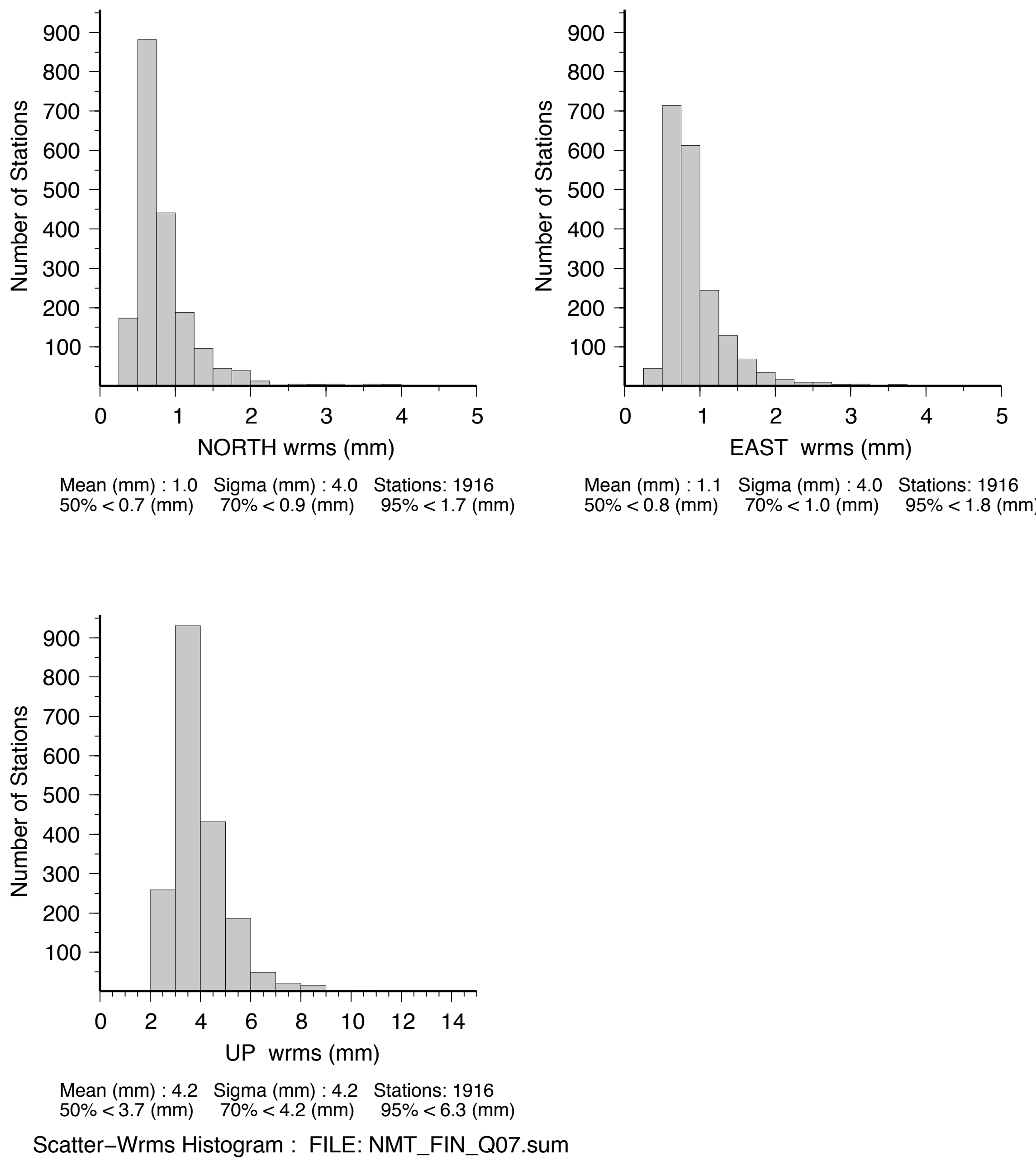


**Figure 2:** NMT combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1916 sites analyzed between March 15, 2015 and June 13, 2015. Linear trends and annual signals were estimated from the time series.

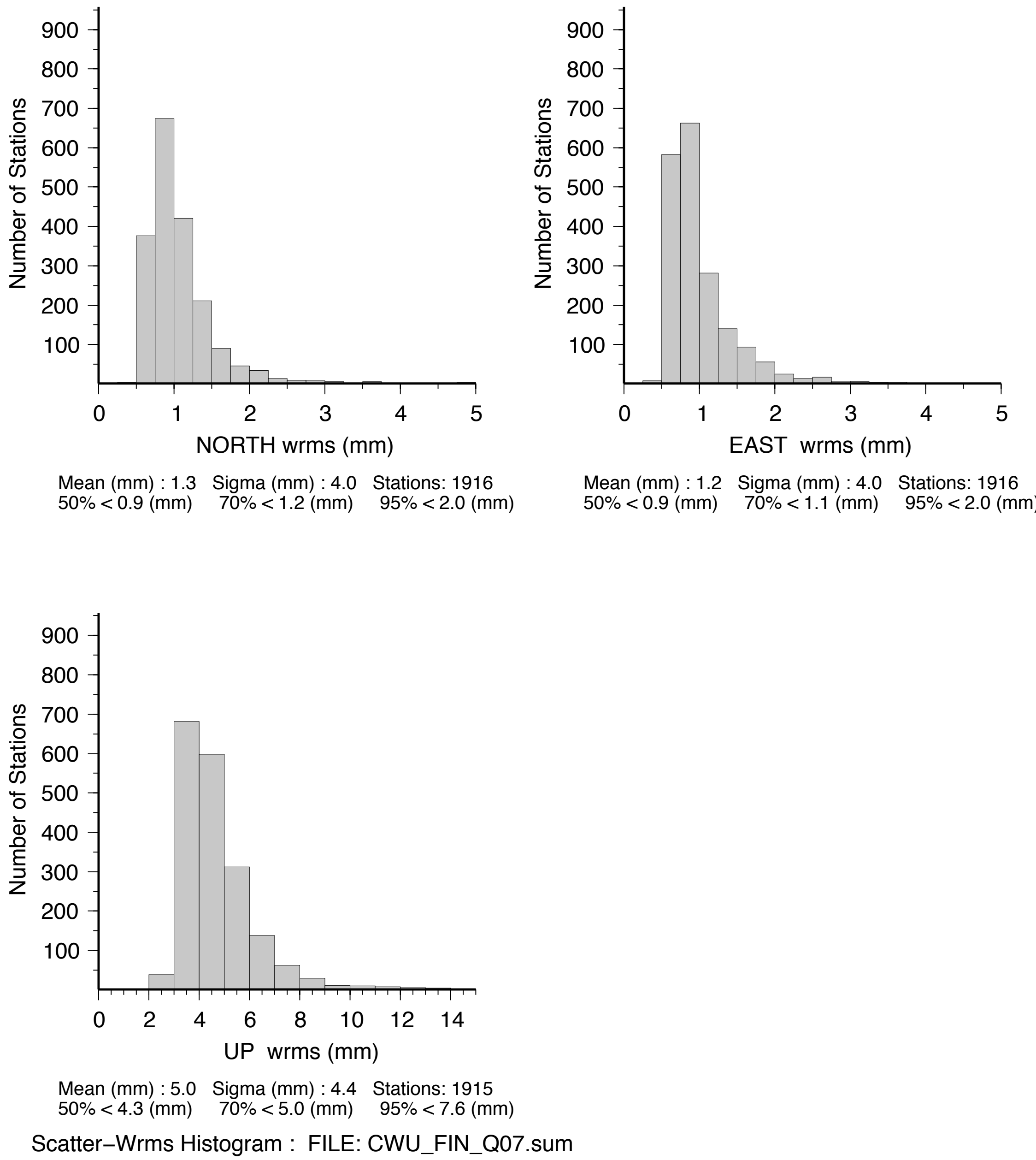


**Figure 3:** CWU combined solution histograms of the North, East and Up RMS scatters of the position residuals for 1916 sites analyzed between March 15, 2015 and June 13, 2015. Linear trends and annual signals were estimated from the time series.

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_Q07.tab. There are 1917 sites in the file. The contents of the files is of this form:

```
Tabular Position RMS scatters created from PBO_FIN_Q06.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   0.52      1.4   0.79      4.7   0.66     12.14
 1NSU    90      1.0   0.54      1.0   0.55      4.1   0.57     11.41
 1ULM    90      0.8   0.47      0.8   0.47      3.7   0.56     12.00
 7ODM    90      0.7   0.38      0.6   0.42      4.0   0.60     14.15
 …
 ZLA1    88      1.0   0.46      1.0   0.57      4.3   0.56     12.03
 ZME1    90      1.0   0.50      0.9   0.48      4.3   0.55     12.25
 ZMP1    90      0.7   0.34      0.7   0.45      4.4   0.65     12.50
 ZNY1    90      0.8   0.41      0.7   0.42      3.5   0.50     12.41
 ZSE1    90      0.8   0.35      0.8   0.45      3.8   0.52     12.41
 ZTL4    90      0.8   0.43      1.1   0.61      4.1   0.54     12.60
```

**Table 2**: RMS scatter of the position residuals for the PBO combined solution between March 15, 2015 and June 13, 2015 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 | 0.7 | 0.7 | 3.4 | 889 |
| NUCLEUS | 0.6 | 0.7 | 3.2 | 209 |
| USGS SCIGN | 0.7 | 0.8 | 3.5 | 129 |
| Expanded | 0.8 | 0.8 | 4.1 | 576 |
| GAMA | 0.7 | 0.8 | 4.2 | 13 |
| COCO Net | 1.3 | 1.4 | 5.7 | 101 |
| *70 %* | | | | |
| PBO | 0.8 | 0.8 | 3.8 | |
| NUCLEUS | 0.7 | 0.7 | 3.5 | |
| USGS SCIGN | 0.8 | 1.0 | 3.9 | |
| Expanded | 1.0 | 1.0 | 4.5 | |
| GAMA | 0.8 | 0.8 | 4.4 | |
| COCO Net | 1.6 | 1.7 | 6.7 | |
| *95%* | | | | |
| PBO | 1.5 | 1.4 | 6.0 | |
| NUCLEUS | 1.3 | 1.1 | 5.6 | |
| USGS SCIGN | 1.5 | 1.4 | 4.9 | |
| Expanded | 1.7 | 1.7 | 6.0 | |
| GAMA | 1.0 | 0.9 | 4.5 | |
| COCO Net | 2.9 | 3.0 | 10.0 | |

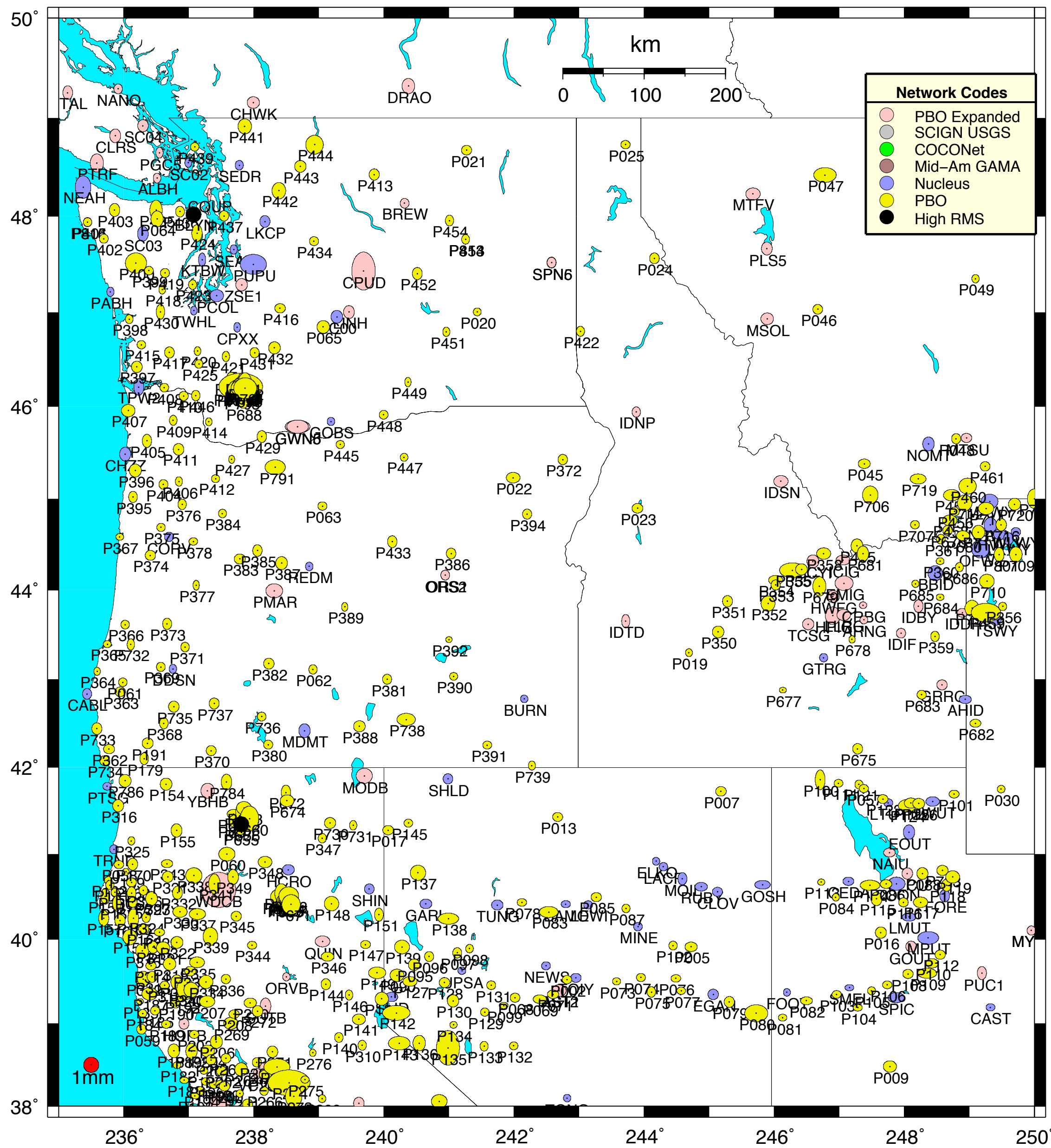


**Figure 4:** Distribution of the RMS scatters of horizontal position estimates from the PBO combined analysis for the Northern Western United States. The color of the ellipses that give the north and east RMS scatters denotes the network given by the legend in the figure. The small red circle shows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

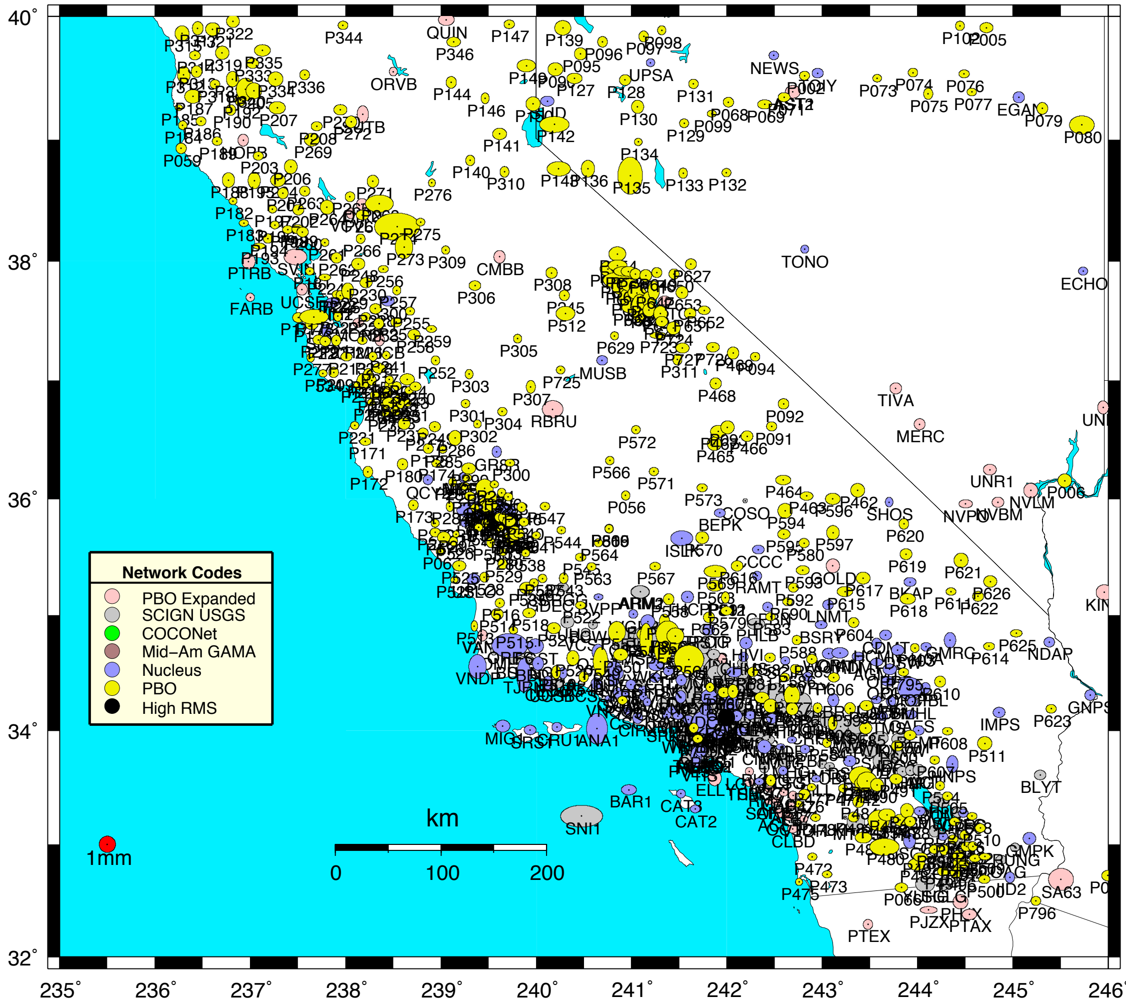


**Figure 5**: Same as Figure 4 except for the Southern Western United States. Black circles in the Yucca mountain region have no data during this 3-month period.

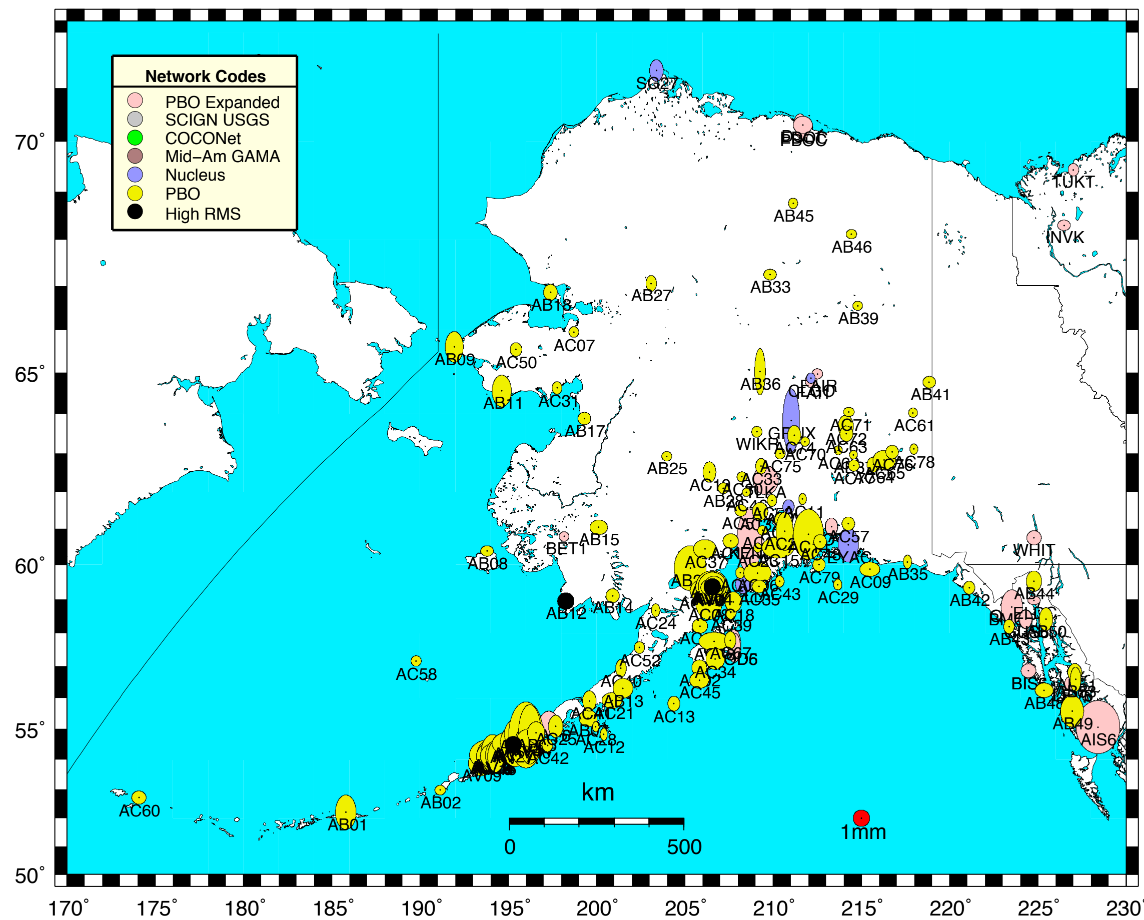


**Figure 6**: Same as Figure 4 except for the Alaskan region.

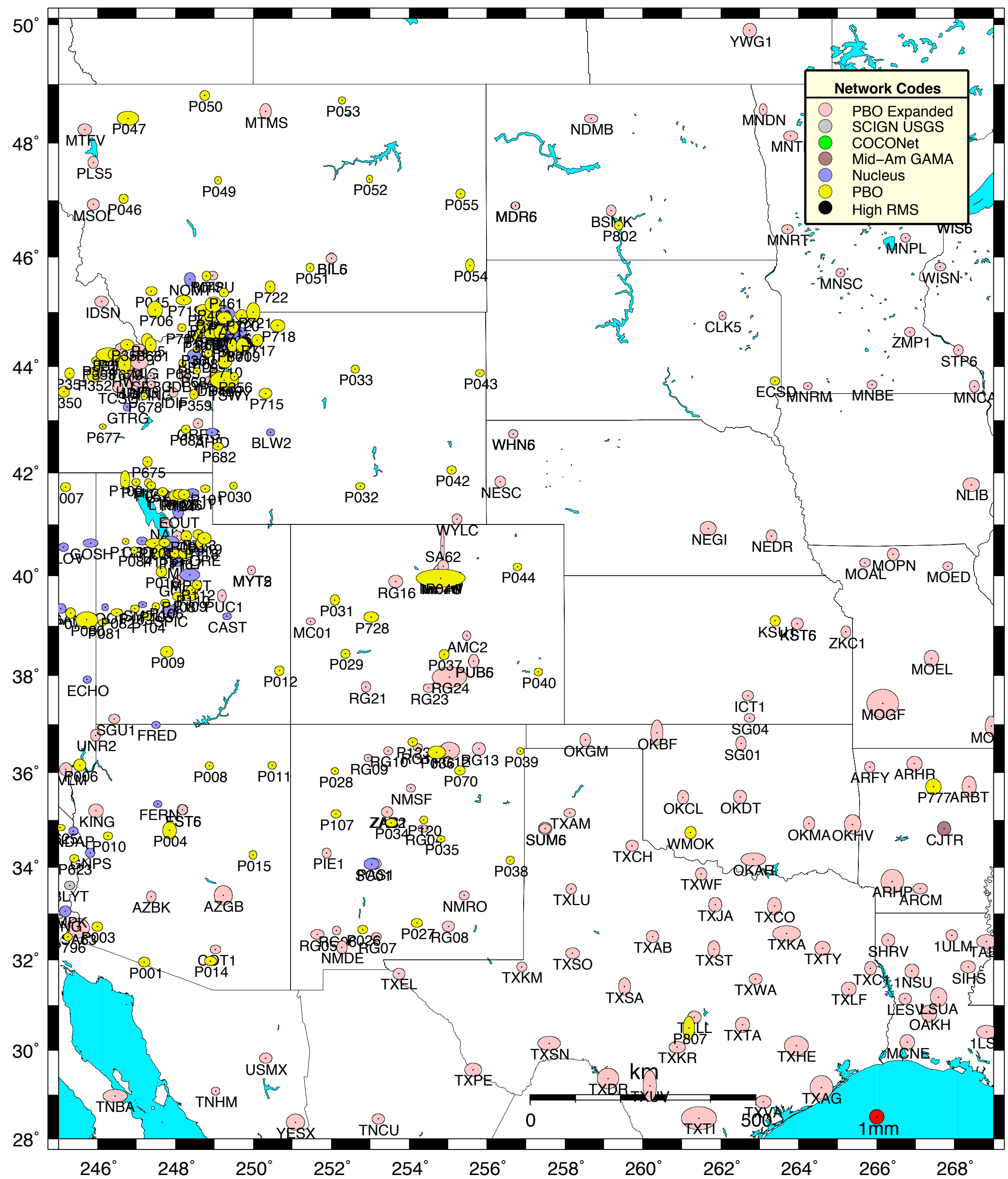


**Figure 7:** Same as Figure 4 except for the Central United States

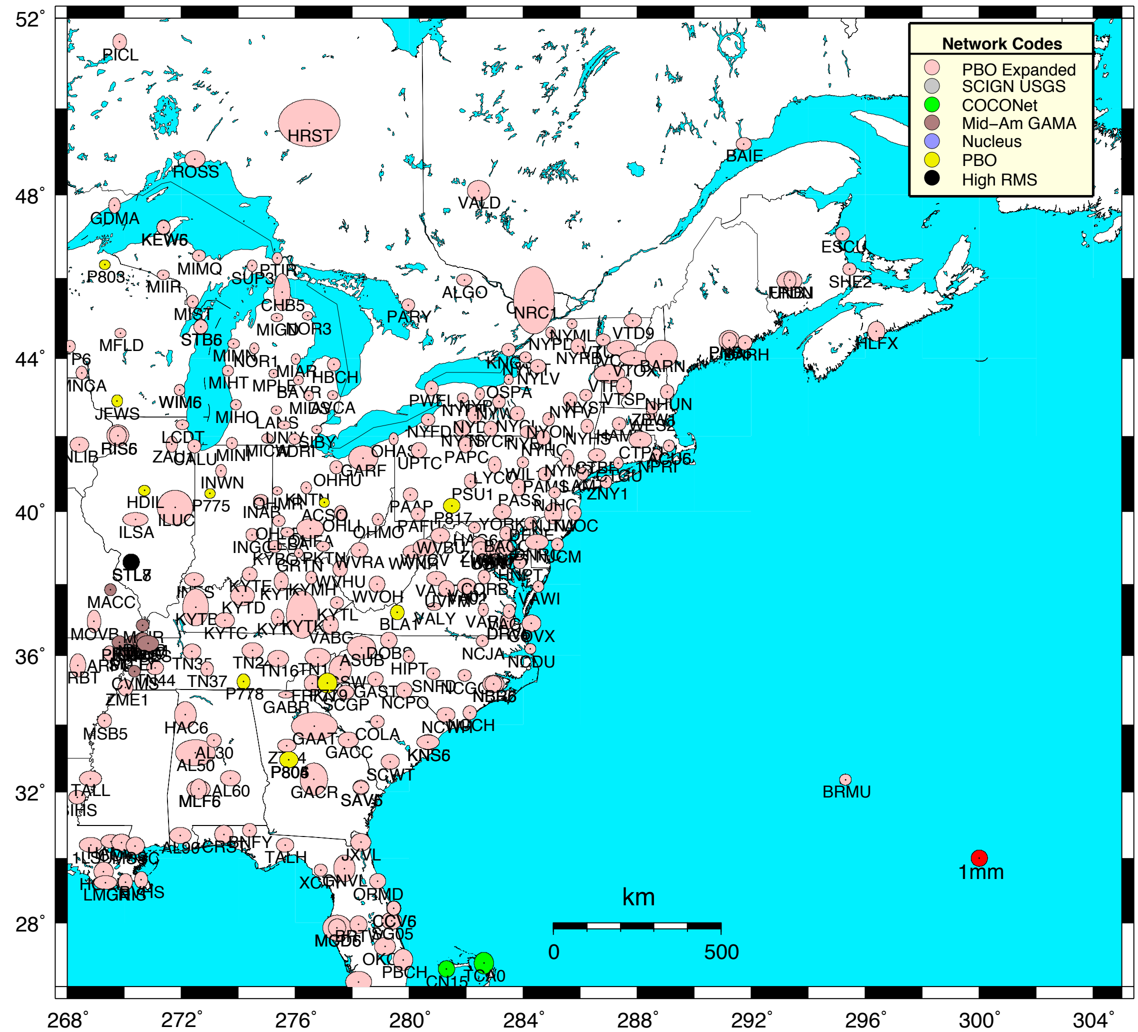


**Figure 8:** Same as Figure 4 except for the Eastern United States

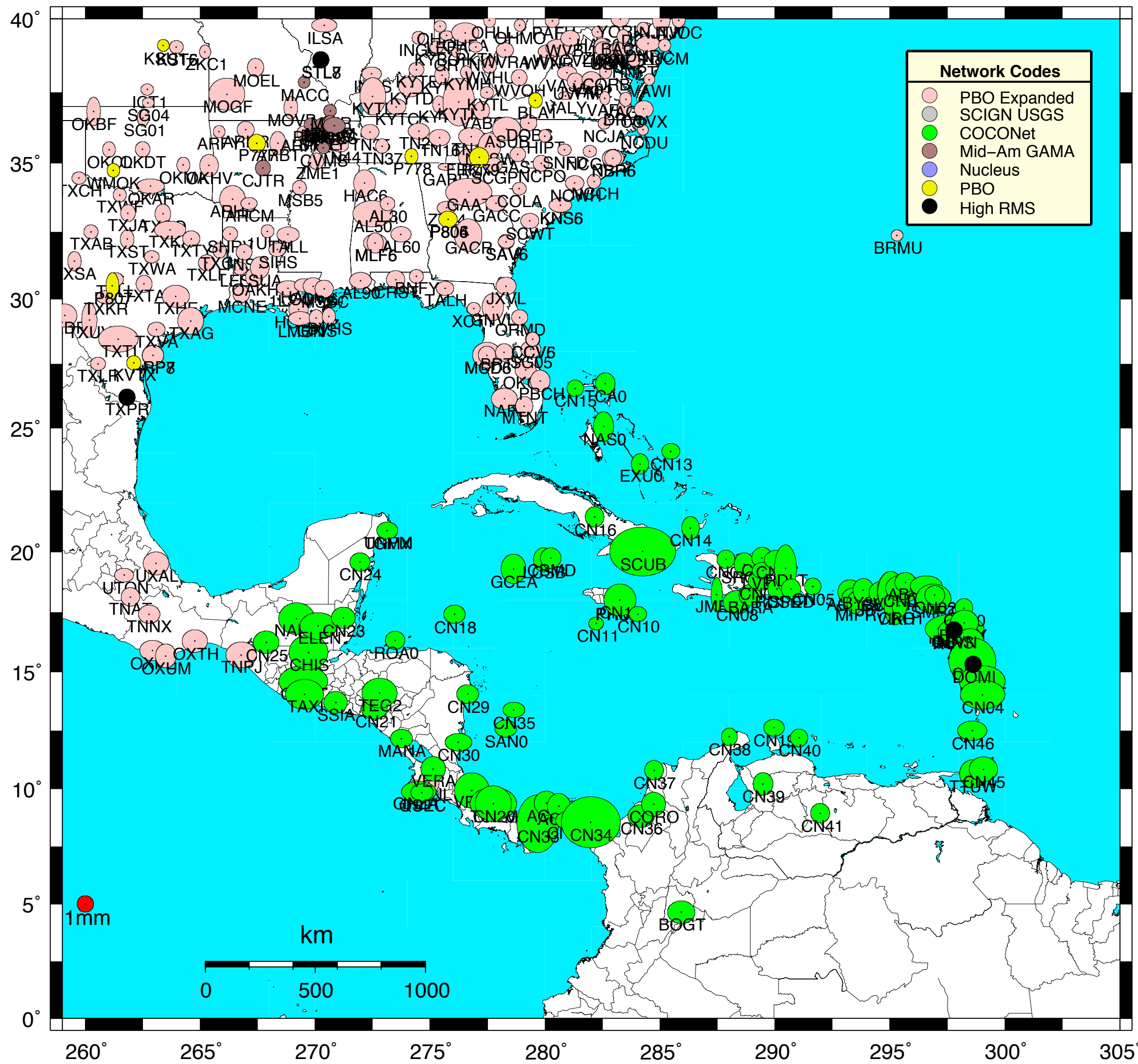


**Figure 9:** Same as Figure 4 except for the Caribbean region.

*Analysis of large RMS sites*

In Table 3, reproduced from earlier quarters, gives a summary of the qualitative description of the nature of the times series of all the sites with large RMS scatters (black circles shown in Figures 4-9). Snow is often the reason and falls into types: one class where the snow is systematic for a period of time with normal looking results in between and the other class where it is difficult to see any good data in the time series. For example P665 in in first category and P690 is in the second category. For some sites, it is not clear what is happening at the site. No new sites were added this quarter. There are 94 sites in the table.

**Table 3:** Description of time series characteristics of sites with high RMS scatter (black symbols on figures above)

| Long (deg) | Lat (deg) | Site | Description |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 198.2537 | 58.9508 | AB12 | Snow with some periods of OK data |
| 197.3865 | 66.8584 | AB18 | Strange long period systematics with excursions in 2008 and 20012 (10-15 mm in east) |
| 209.2560 | 65.0304 | AB36 | Strange annual |
| 227.1328 | 56.5848 | AB53 | Snow events and may be systematic between events. |
| 215.4762 | 59.8685 | AC09 | Evolving Rate change 2012-2013 |
| 212.0004 | 60.8487 | AC14 | Snow events; NE look flat in between but height may have curvature |
| 211.9068 | 60.5182 | AC16 | Snow events; but OK in between but height may have curvature as for AC14 (probably annual) |
| 210.6475 | 60.9292 | AC20 | Long period N systematic |
| 212.2608 | 59.8558 | AC30 | Little data 2007.7-2009.1 with large gap and snow systematic |
| 209.3149 | 62.6712 | AC33 | Snow with flat in between (systematic snow). |
| 209.2068 | 59.3758 | AC35 | Long period N and E systematic |
| 207.3761 | 60.0815 | AC47 | Generally systematic; long lived snow. |
| 179.3013 | 51.3781 | AC66 | Curvature offset 14/06/23 |
| 289.1134 | 41.7433 | ACU6 | Offset 06/12/21 |
| 297.7861 | 16.7408 | AIRS | Multi-year variations |
| 228.4008 | 55.0689 | AIS6 | Bi-modal data separated by ~5-10 mm NE, EQ like log 2012/10/28 N, 13/01/06 E offset |
| 297.6595 | 82.4943 | ALRT | Lots of variations, does not quite look like snow but maybe. |
| 264.5149 | 29.3015 | ANG1 | Slow event ~22 mm N, 6 mm E between 2004/05/26-2004/06/14, offset near end |
| 210.8677 | 61.5978 | ATW2 | Clear E offset from Denali Earthquake, 2002 11 3 22 12, but much larger decadal systematic |
| 262.2437 | 30.3117 | AUS5 | Unknown break 2002 10 12 |
| 206.5553 | 59.3626 | AV04 | Bad snow but flat in between |
| 206.5773 | 59.3629 | AV05 | Little data between 2004.6-2005 and 2005.6-2006.1, run off at end |
| 194.1022 | 54.1531 | AV13 | Some snow intervals each year |
| 206.5718 | 59.3474 | AV20 | Snow; bad winter 2008 and 2010 |
| 195.4195 | 54.5717 | AV26 | Heavily skewed in U and E |
| 195.2768 | 54.4924 | AV27 | Maybe snow. Bad in 2009 winter, systematic 2014. |
| 195.4139 | 54.4724 | AV29 | Lots of snow |
| 195.6131 | 54.8467 | AV35 | Snow but more random in nature. Looks noisy between snow times. |
| 196.2191 | 54.8315 | AV38 | Very skewed in N and U. Unknown break: 2011 6 15 6-7 mm in East. |
| 196.0015 | 54.8113 | AV39 | Also skewed, systematic, gap 2010.8-2011.5, |
| 300.3909 | 13.0880 | BDOS | Multi-year trends; E 2007-2011 15 mm |
| 223.5204 | 58.7829 | BMCP | Snow most likely but noisy in nature |
| 244.2703 | 33.3646 | BOMG | Multiyear systematic; break 2011 8 18 (looks slow; |

| | | | |
|---|---|---|---|
| | | | EQ Postseismic?); offset at El Mayor Cucapah (10/04/04). |
| 291.9863 | 46.8684 | CARM | Un-modeled breaks |
| 277.7437 | 9.3517 | CN20 | Noisy CWU processing; NMT seems OK. |
| 281.9852 | 8.5489 | CN34 | Systematic with maybe a tree growing nearby. |
| 240.3261 | 34.9426 | CUHS | Strong loading signal with change around 2011.0 |
| 270.3565 | 35.5414 | CVMS | Bad "antenna" 2013/03/18- 2014/02/26. Firm ware update on 2014/02/26; +8N,-12E offset. |
| 298.6109 | 15.3062 | DOMI | Noisy site. NMT missing at start of data. |
| 250.6167 | -27.1482 | EISL | Noisy site |
| 297.8057 | 16.7948 | GERD | Slow slip 2006 and 2010. |
| 242.6021 | 34.2039 | GHRP | Some snow but slow slip in 2007-2007.5 |
| 249.4640 | 44.6136 | HVWY | Multiyear systematic: Yellowstone. |
| 240.9918 | 34.3985 | KBRC | Even with bad antenna between 2002/12/04-2004/05/25 removed, still multiyear systematic. |
| 208.6498 | 60.6751 | KEN5 | Strange multimodal positions in N and E. |
| 208.6498 | 60.6748 | KEN6 | Similar behavior to KEN5 suggesting motions are real (on same USCG tower apparently). |
| 267.9549 | 30.2214 | KJUN | Maybe bad antenna between 2004/07/29-2005/01/25 but no log entries. Offset at end of data 2008/08/12, |
| 207.8066 | 57.6177 | KOD1 | Strange deviations in 1999.1-1999.9. |
| 207.8066 | 57.6177 | KOD5 | No overlap with KOD1 but has similar excursion 2012.1-2012.3 (but KOD6 only partially sees event). USCG site |
| 276.2404 | 37.1515 | KYTK | Systematic with bad antenna: 2013/08/12-2014/01/31; then offset |
| 241.7967 | 33.7878 | LBCH | Bad antenna 2000/01/03-2003/02/03 and replaced. Still multiyear systematic. |
| 278.1928 | 28.8262 | LEES | Un-modeled offset 2011/09/15. |
| 249.5998 | 44.5651 | LKWY | Yellowstone multiyear systematic changes |
| 241.9966 | 34.1119 | LONG | Probably a failing antenna starting Jan 2007. CWU having problems processing data. |
| 285.4171 | 44.6197 | LOZ1 | Noisy with N U annual (removed late 2013). |
| 247.7532 | 41.5921 | LTUT | Bad antenna from start 2002/10/23-2008/04/18 large annual in all components |
| 273.7510 | 12.1489 | MANA | Large slow slip events in 2004/10 and 2012/08/27+2012/09/05 (fast EQ) |
| 241.7559 | 33.9391 | MHMS | Most likely bad antenna from 2000/01/12 to 2012/02/15 when it was replaced. ASH701945B_M during bad times. |
| 254.7377 | 39.9954 | NISU | Antenna offsets but no log (ends 2009.5). |
| 243.9323 | 34.1410 | OAES | Failed antenna. 1999/03/05-2007/09/11: Maybe some data until 2000/10/13. |
| 249.1688 | 44.4511 | OFW2 | Long period systematic (Yellowstone) |

| | | | |
|---|---|---|---|
| 297.7723 | 16.7504 | OLVN | Skewed in E&U, slow type event in 2009.5 |
| 262.3462 | 16.1512 | OXTU | Systematic; 2009.8; break 2012/04/23 (gap) ends early 2013. |
| 239.2898 | 36.2568 | P299 | Strong ground water signal in all components. |
| 239.7230 | 36.3044 | P300 | Very large multiyear deviations (creep on San Andreas?) |
| 237.0366 | 39.8457 | P323 | Starts 2007.6 and fails 2008.0; ends 2008.1 |
| 244.2679 | 32.7597 | P494 | Washer on antenna until 2011/09/21 when removed (no log entry). Strange height systematic. |
| 240.9996 | 37.6130 | P630 | Strong N seasonal with trend change mid-2011. |
| 241.0841 | 37.6053 | P631 | Very skewed, strong seasonal all components, trend change 2011.8 dNv 11 mm/yr, dUv 13 mm/yr |
| 241.1833 | 37.5914 | P642 | Similar to P631 but not soo skewed. Same rate changes. |
| 241.1800 | 37.6770 | P646 | Large systematic in East and Up (±10 mm deviations from linear) |
| 237.8042 | 41.3448 | P656 | Large gaps and big snow in 2010, 2011. |
| 238.4742 | 40.4561 | P665 | Snow events most years |
| 238.5326 | 40.4658 | P667 | Snow events most years |
| 237.8101 | 46.1800 | P690 | Snow events: Different in nature to P665 and P667 (more radon and longer % of year) |
| 237.7977 | 46.2103 | P693 | Similar to P690 (these sites will be hard to edit) |
| 237.8358 | 46.1990 | P695 | Similar to P690 but with long period rate change. |
| 237.8234 | 46.1876 | P697 | Similar to P690 but less extreme; long term east variations. |
| 237.7968 | 46.1898 | P699 | Similar to P690. Offset in east in mid 2006 (gap) already in All_PBO_unkn.eq file. |
| 249.0664 | 43.7864 | P708 | Snow events most years but could be edited (similar to P665) |
| 249.4885 | 44.7183 | P716 | Long-term curvature in NE from 2006-2014. Change in rate after gap. |
| 237.8631 | 46.2446 | P792 | Gaps in time series with snow events; skewed in N. Maybe break in 2012-04 but hard to tell due gap in data. |
| 269.8248 | 36.3703 | PIGT | Strange bi-modal in 2000 (start until Apr 2001) and then systematic since then with possible rate change Apr 2009 (1 mm/yr N largest) |
| 270.6546 | 36.4742 | RLAP | Bad antenna 2005/10/06-2009/08/10 (replaced at end) |
| 250.3118 | 31.3683 | SA24 | Strange seasonal signal plus broken antenna. |
| 321.5405 | 72.5796 | SMM1 | Greenland Summit ice site. Trend change after 29 m antenna move 2013/07/09 |
| 270.8834 | 13.6971 | SSIA | Data 2000/09/28-2010/07/18 has variable large offset; rate change in 2012 after large gap. |
| 141.8448 | 43.5286 | STK2 | Earthquake looking offset 2003/09/25 with "log", |

| | | | |
|---|---|---|---|
| | | | unknown offset 2011/03/11 undocumented. |
| 270.2411 | 38.6113 | STL7 | Noisy in NE; STL8 looks fine. |
| 209.5797 | 62.3077 | TLKA | Long term systematics and strange seasonal; possible break 2002/11/04 (not documented). |
| 297.8367 | 16.7643 | TRNT | Major slow slip events in 2007, 2010 (same as GERD) |
| 227.0057 | 69.4382 | TUKT | Lots of systematic strange seasonal signals; slow offset E 2013. |
| 261.4357 | 28.4680 | TXTI | Strange multiyear deviations in the North (10mm deviations from linear) |
| 249.7133 | 44.6395 | WLWY | Deviations associated with Yellowstone. |

*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 sites 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.

*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 2135 sites in the combined PBO solution, 23 more than last quarter, in the analyses and the statistics of the fits to results are shown in Table 4. 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_150613.tab, nmt_nam08_150613.tab and cwu_nam08_150613.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_150613.snpvel, nmt_nam08_150613.snpvel and cwu_nam08_150613.snpvel.

**Table 4:** Statistics of the fits of 2135, 2128 and 2134 sites analyzed by PBO, NMT and CWU in the reprocessed analysis for data collected between Jan 1, 1996 and June 13, 2015.

| Center | North (mm) | East (mm) | Up (mm) |
|---|---|---|---|
| *Median (50%)* | | | |
| PBO | 1.1 | 1.2 | 5.3 |
| NMT | 1.1 | 1.2 | 5.6 |
| CWU | 1.4 | 1.4 | 6.0 |
| *70%* | | | |
| PBO | 1.5 | 1.5 | 6.0 |
| NMT | 1.4 | 1.6 | 6.2 |
| CWU | 1.7 | 1.7 | 6.8 |
| *95%* | | | |
| PBO | 3.2 | 3.1 | 8.9 |
| NMT | 3.2 | 3.1 | 9.1 |
| CWU | 3.5 | 3.4 | 10.3 |

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 0.09 mm/yr horizontal and 0.59 mm/yr vertical in direct difference of all sites with in 0.5 meters of each other (2144 comparisons). The $\chi^2/f$ of the difference is $(1.22)^2$ for the horizontal and $(1.57)^2$ vertical components. These comparisons are summarized in Table 5. As noted in previous reports, adding small minimum sigmas, computed such that $\chi^2/f$ is near unity changes the statistic slightly (Table 5). With the FOGMEX correlated noise model used to compute the velocity sigmas, the comparison statistics are close but still 22-57% optimistic over expectations. The 10-worst sites are P801_GPS, AC59_GDN, P613_GHT, MCD1_GPS, NARA_GPS, P486_GHT, SAV1_GPS, JNPR_GPS, SAV5_GPS, and LST1_GPS. The GHT and GND extensions to the 4-character code indicate that these sites are affected by postseismic motion after the 1999 Hector Mine and the 2002 Denali earthquakes. The difference in velocity estimates arises from different treatments of the Hector Mine and Denali postseismic between the two analyses. The tsfit program has tolerances on the uncertainties on the postseismic log estimates that determine if the parameter is estimated or not. If the uncertainty is too large then it is assumed that there is not enough sensitivity to the parameter (due to the elapsed time from the earthquake to the first data at the site) and the log estimate is removed. For the _GHT sites above, the Hector mine postseismic was treated differently in the two analyses i.e., one case they were estimated and the other not estimated. Similarly for AC59_GDN site, the postseismic treatment is different between then NMT and CWU analyses. The SAV5 site appears because there are multiple sites at this location that do not overlap in time. The difference occurs between the (non-overlapping in time) SAV5 and SAV1 sites. LST1 is a site used only a small number of times by NMT (92 days) and is close to 1LSU which is used in both the NMT and CWU analyses. The P801_GPS appears because it has a short span of systematic data compared to the nearby P713 site.

**Table 5:** Statistics of the differences between the CWU and NMT velocity solutions with no transformation between them. In these comparisons sites with the same names and within 0.5 meters of each other are included and the total number of comparisons is larger than the number of stations. The PBO, NMT and CWU solutions themselves have 2127, 2127 and 2118 sites. WRMS is weighted-root-mean-scatter and NRMS is sqrt($\chi^2/f$) where f is the number of comparisons. Larger numbers of sites appear below because sites with 500 meters of each other are included in the counts.

| Solution | # | NE WRMS (mm/yr) | U WRMS (mm/yr) | NE NRMS | U NRMS |
|---|---|---|---|---|---|
| All | 2144 | 0.09 | 0.59 | 1.22 | 1.57 |
| Edited -10 worst | 2127 | 0.08 | 0.57 | 1.11 | 1.52 |
| Less than median (0.14 0.44 mm/yr) | 1174 | 0.07 | 0.51 | 1.20 | 1.60 |
| Added minimum sigma NE 0.06 U 0.40 mm/yr | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| All | 2144 | 0.14 | 0.78 | 0/96 | 1.00 |
| Edited -10 worst | 2127 | 0.12 | 0.72 | 0.96 | 1.00 |
| Less than median (0.15 0.0.59 mm/yr) | 1174 | 0.08 | 0.57 | 0.74 | 0.83 |

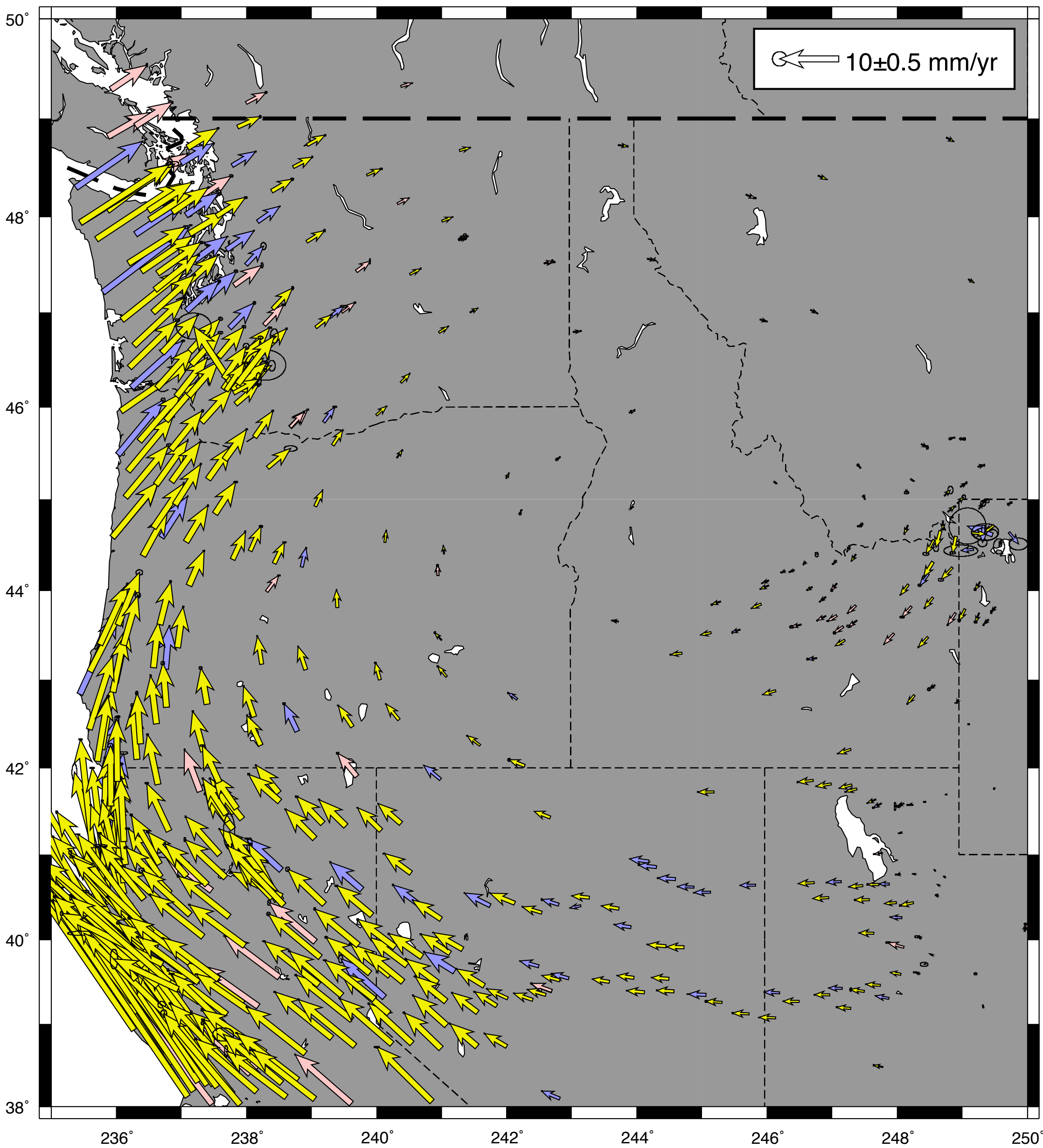


**Figure 10**: Velocity field estimates from the combined PBO solutions generated using time series analysis and the FOGMEX error model. 95% confidence interval error ellipses are shown. The color scheme of the vectors matches the network type legend in Figure 4. Only velocities with horizontal standard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

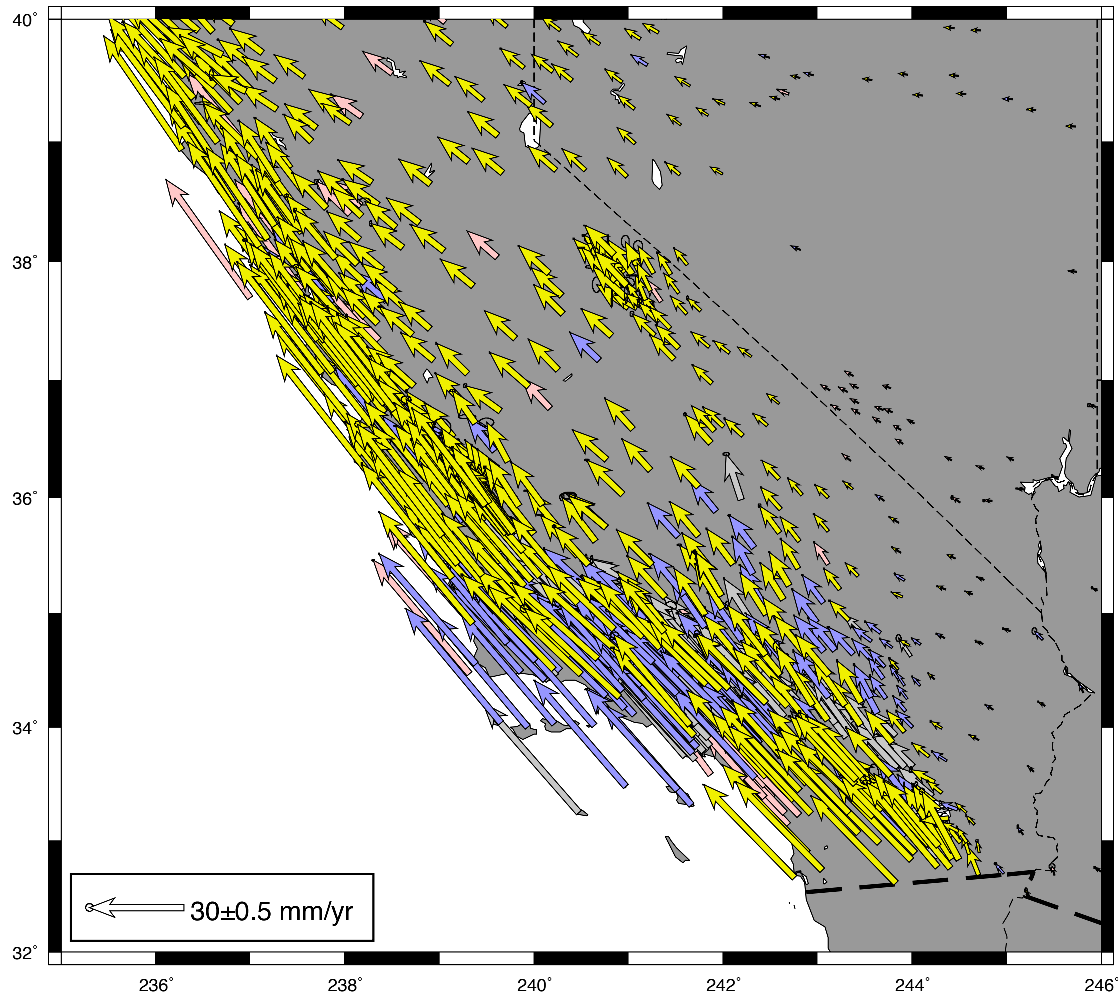


**Figure 11:** Same as Figure 10 except for South Western United States. Only velocities with horizontal standard deviations less than 2 mm/yr are shown.

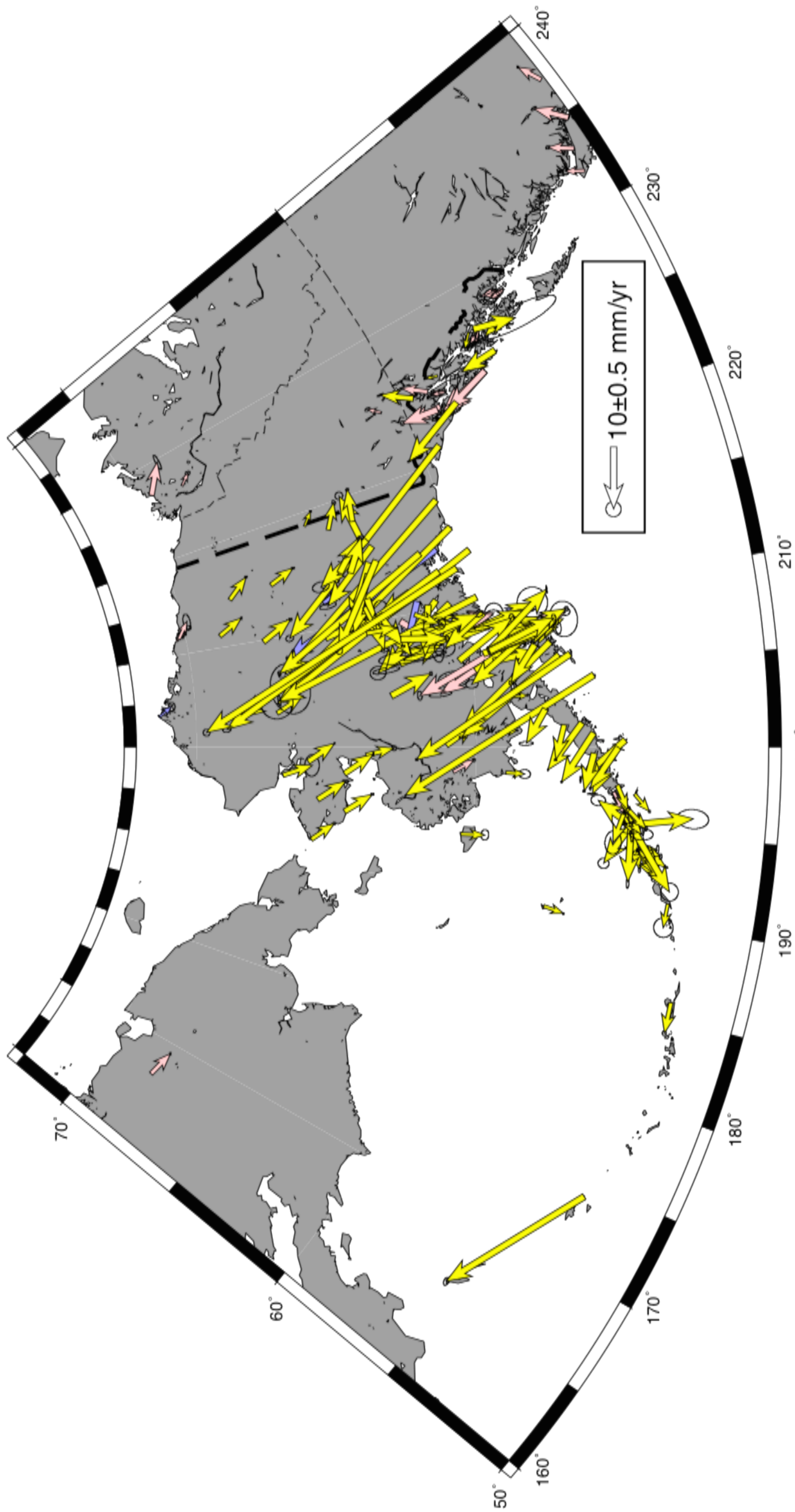


**Figure 12:** Same as Figure 10 except for Alaska. Only velocities with horizontal standard deviations less than 5 mm/yr are shown

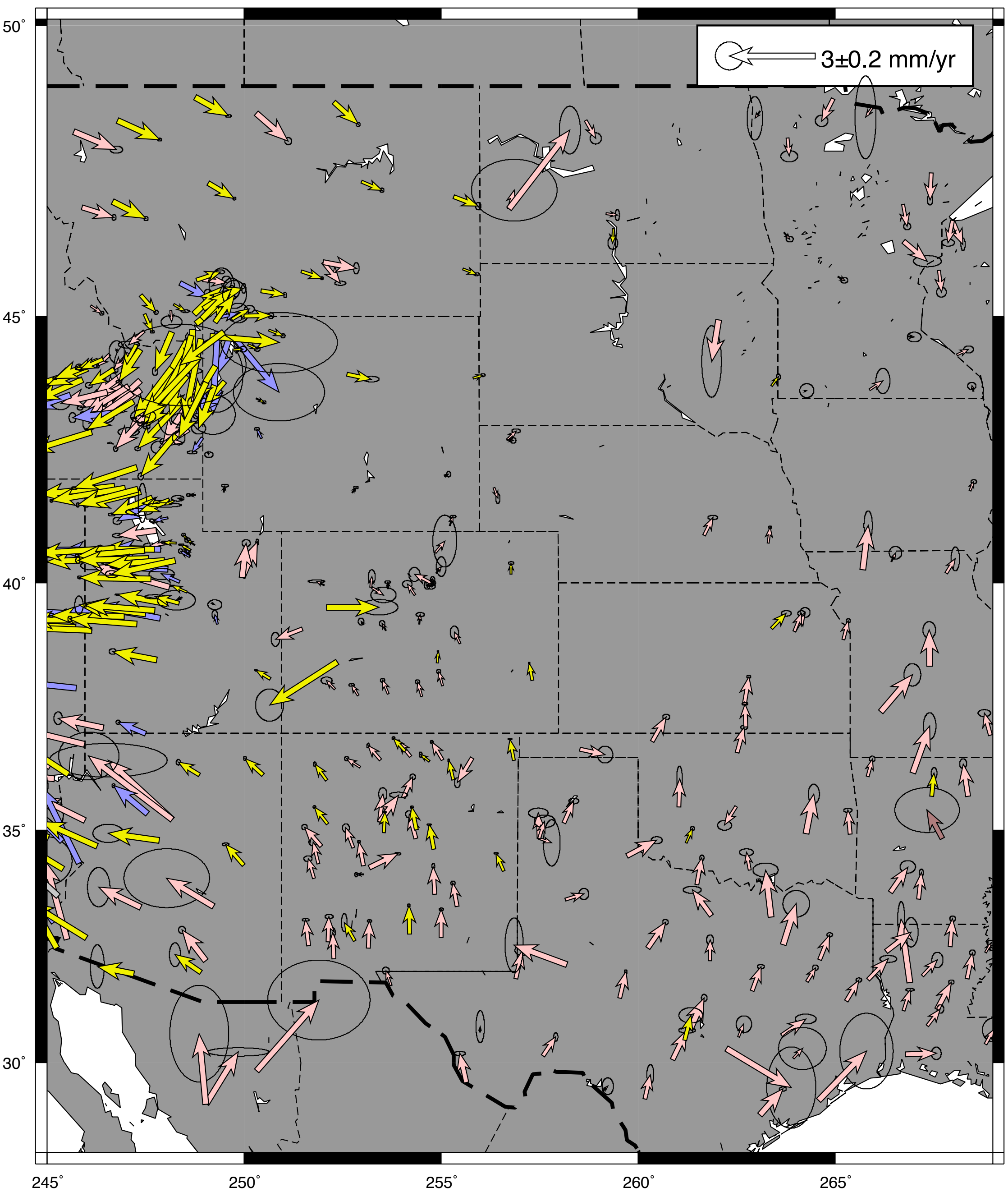


**Figure 13:** Same as Figure 10 except for Central United States. Only velocities with horizontal standard deviations less than 1 mm/yr are shown.

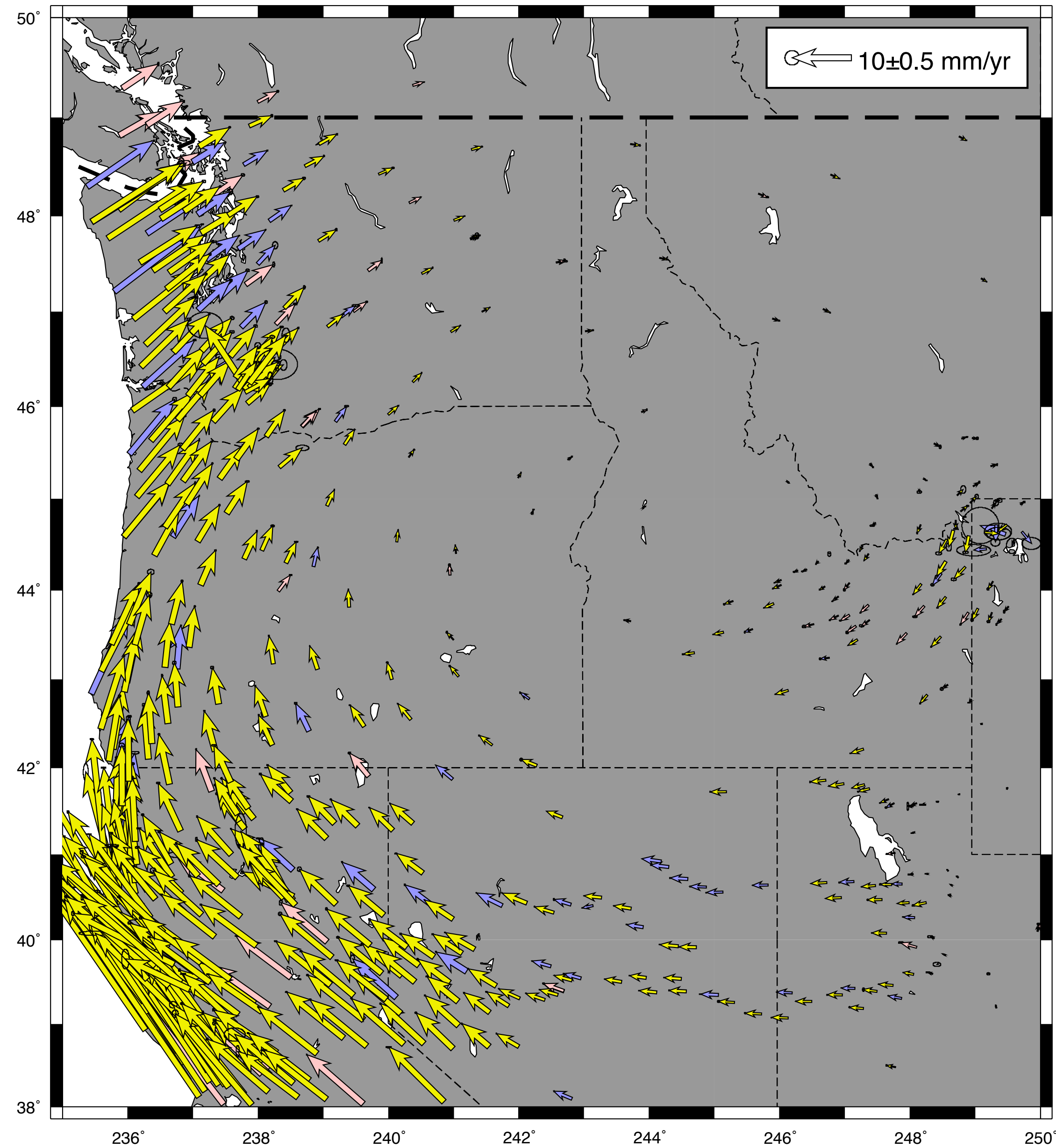


**Figure 14:** Same as Figure 10 except for Western Central United States. Only velocities with horizontal standard deviations less than 1 mm/yr are shown. Anomalous vectors at longitude 250$^o$ are in the Yellowstone National Park and most likely are showing volcanic processes.

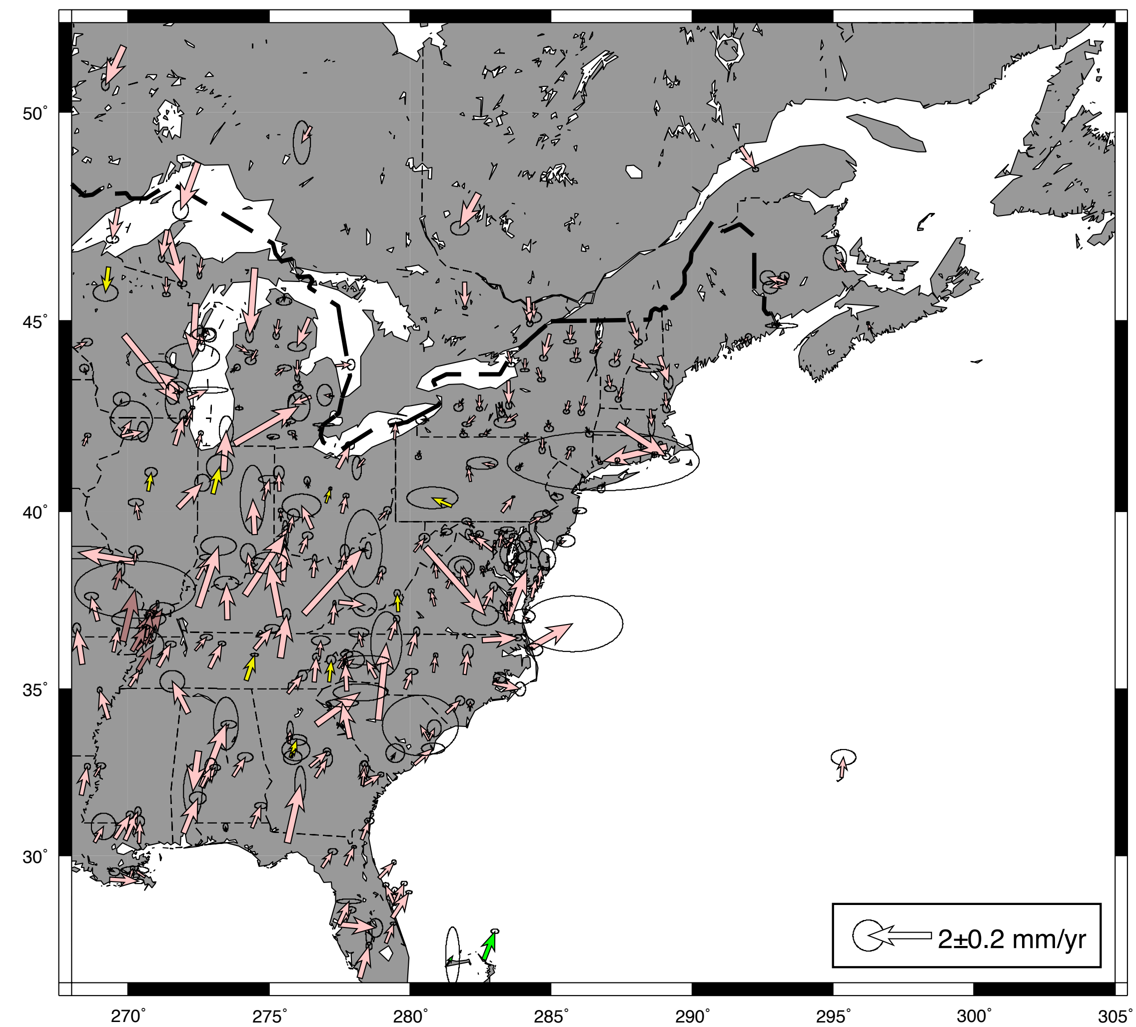


**Figure 15:** Same as Figure 10 except for the Eastern United States. Only velocities with horizontal standard deviations less than 2 mm/yr are shown. The systematic western velocity of sites in the Northeast is being investigated although profiles from Canada to the Gulf of Mexico indicate that horizontal 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.

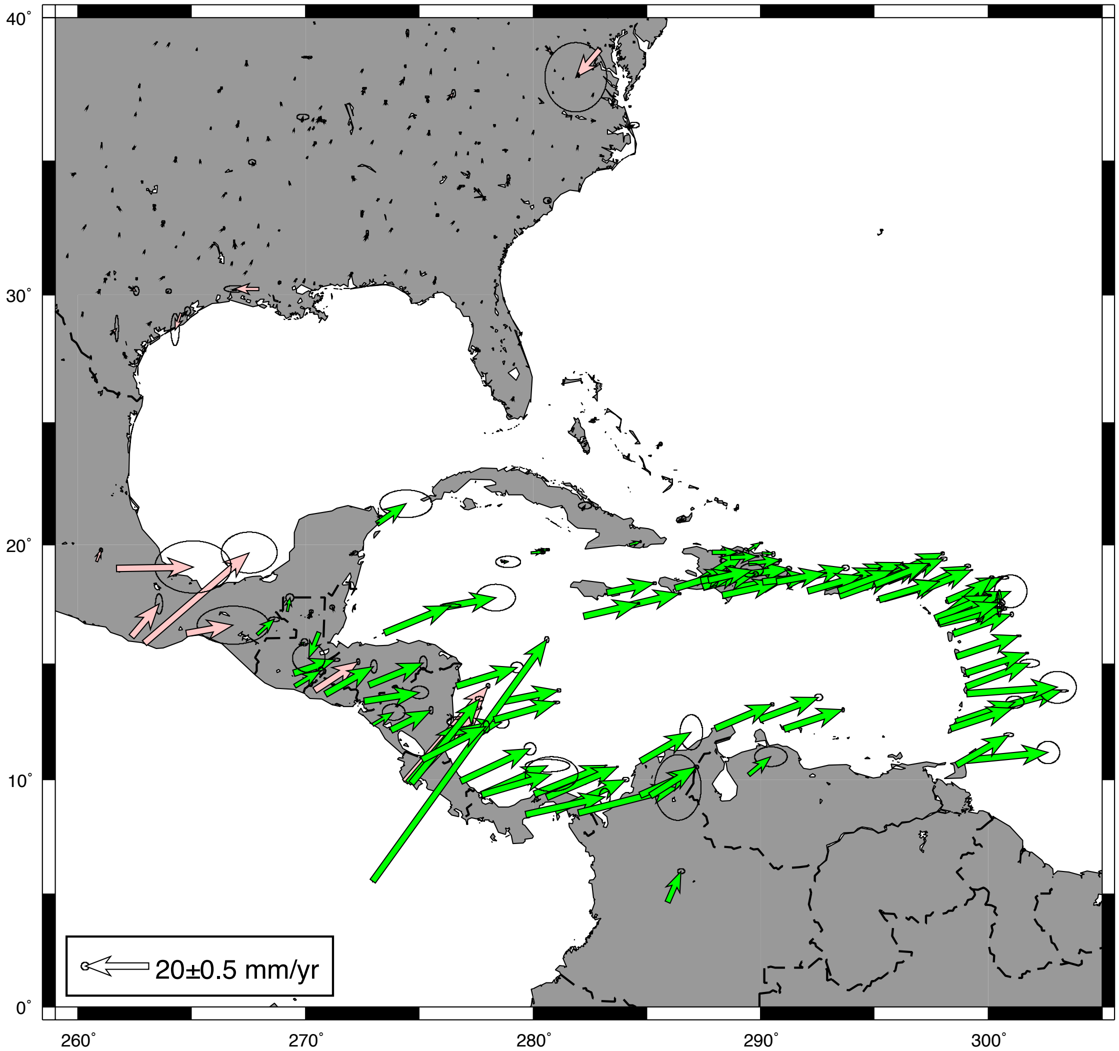


**Figure 16:** Same as Figure 10 except for the Caribbean region. Only velocities with horizontal standard deviations less than 5 mm/yr are shown.

*Earthquake Analyses: 2015/04/01-2015/06/30.*

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 March/April 2015 we investigated the following events.

```
* EQDEFS for 2015 03 12 to 2015 04 15 Generated Mon Apr 20 13:08:09 EDT 2015
* Proximity based on Week_All.Pos file
* ------------------------------------
* SEQ Earthquake # 1
* EQ 464 BEMT_GPS       8.42       8.90 CoS        0.0 mm
* EQ 464 P601_GPS       5.64       8.90 CoS        0.0 mm
* EQ_DEF M3.7 24km S of Twentynine Palms
 eq_def 01   33.9298 -116.0320      8.9 8 2015 03 27 15 37    0.000
 eq_rename 01
 eq_coseis 01  0.001 0.001 0.001      0.000      0.000      0.000
* ------------------------------------
* SEQ Earthquake # 2
* EQ 549 CDMT_GPS       8.16       9.70 CoS        1.0 mm
* EQ_DEF M4.0 12km NW of Ludlow
 eq_def 02   34.7912 -116.2612      9.7 8 2015 03 30 09 22    0.001
 eq_rename 02
 eq_coseis 02  0.001 0.001 0.001      0.001      0.001      0.001
* ------------------------------------
* SEQ Earthquake # 3
* EQ 577 AC12_GPS      10.88      11.00 CoS        1.1 mm
* EQ_DEF M4.4 11km W of Chernabura Island
 eq_def 03   54.7814 -159.7371     11.0 8 2015 03 31 06 37    0.002
 eq_rename 03
 eq_coseis 03  0.001 0.001 0.001      0.002      0.002      0.002
* ------------------------------------
* SEQ Earthquake # 4
* EQ 632 STLE_GPS       5.23       8.80 CoS        0.0 mm
* EQ_DEF M3.6 3km S of Steele
 eq_def 04   36.0510  -89.8252      8.8 8 2015 04 02 03 52    0.000
 eq_rename 04
 eq_coseis 04  0.001 0.001 0.001      0.000      0.000      0.000
* ------------------------------------
* SEQ Earthquake # 5
* EQ 638 P229_GPS       4.78       8.80 CoS        0.0 mm
* EQ_DEF M3.6 1km NNW of San Ramon
 eq_def 05   37.7920 -121.9868      8.8 8 2015 04 02 07 07    0.000
 eq_rename 05
 eq_coseis 05  0.001 0.001 0.001      0.000      0.000      0.000
```

No offsets were seen form these earthquakes. However there are no rapid results for AC12 and so we can test this event. Given the small magnitude and expected offsets, it is unlikely a significant co-seismic offset occurred.

Overall: No significant earthquake events this month.

In April/May 2015, the following events were investigated

```
* EQDEFS for 2015 04 12 to 2015 05 14 Generated Fri May 15 08:33:08 EDT 2015
* Proximity based on Week_All.Pos file
* ------------------------------------
* SEQ Earthquake # 1
* EQ 273 QSEC_GPS       4.98      10.20 CoS        2.6 mm
* EQ_DEF M4.2 17km E of Samara
 eq_def 01    9.8849  -85.3629     10.2 8 2015 04 22 03 40    0.001
 eq_rename 01
 eq_coseis 01  0.001 0.001 0.001      0.001      0.001      0.001
* ------------------------------------
* SEQ Earthquake # 2
* EQ 292 OXPE_GPS       7.93      10.20 CoS        1.0 mm
```

```
* EQ_DEF M4.2 9km NE of Puerto Escondido
 eq_def 02   15.9095  -97.0058     10.2 8 2015 04 23 04 25    0.001
 eq_rename 02
 eq_coseis 02  0.001 0.001 0.001      0.001      0.001      0.001
* ------------------------------------
* SEQ Earthquake # 3
* EQ 448 CN22_GPS       2.80      11.00 CoS       16.3 mm
* EQ_DEF M4.4 19km WSW of Leon
 eq_def 03   12.3601  -87.0384     11.0 8 2015 04 27 14 28    0.002
 eq_rename 03
 eq_coseis 03  0.001 0.001 0.001      0.002      0.002      0.002
* ------------------------------------
* SEQ Earthquake # 4
* EQ 574 DSHS_GPS       2.86       9.10 CoS        7.8 mm
* EQ 574 FXHS_GPS       9.03       9.10 CoS        0.8 mm
* EQ 574 NOPK_GPS       2.39       9.10 CoS       11.2 mm
* EQ 574 P800_GPS       2.61       9.10 CoS        9.4 mm
* EQ 574 USC1_GPS       7.27       9.10 CoS        1.2 mm
* EQ 574 WRHS_GPS       7.90       9.10 CoS        1.0 mm
* EQ_DEF M3.8 1km WNW of View Park-Windsor Hills
 eq_def 04   33.9995 -118.3595      9.1 8 2015 05 03 11 08    0.001
 eq_rename 04
 eq_coseis 04  0.001 0.001 0.001      0.001      0.001      0.001
* ------------------------------------
* SEQ Earthquake # 5
* EQ 583 P262_GPS       8.04       8.90 CoS        0.0 mm
* EQ_DEF M3.6 2km SW of Concord
 eq_def 05   37.9647 -122.0473      8.9 8 2015 05 03 22 14    0.000
 eq_rename 05
 eq_coseis 05  0.001 0.001 0.001      0.000      0.000      0.000
* ------------------------------------
* SEQ Earthquake # 6
* EQ 667 P262_GPS       8.02       8.70 CoS        0.0 mm
* EQ_DEF M3.5 1km NNE of Pleasant Hill
 eq_def 06   37.9612 -122.0555      8.7 8 2015 05 06 14 33    0.000
 eq_rename 06
 eq_coseis 06  0.001 0.001 0.001      0.000      0.000      0.000
* ------------------------------------
* SEQ Earthquake # 7
* EQ 758 WGPP_GPS       7.72       9.20 CoS        1.1 mm
* EQ_DEF M3.8 16km NW of Grapevine
 eq_def 07   35.0312 -119.0660      9.2 8 2015 05 10 15 43    0.001
 eq_rename 07
 eq_coseis 07  0.001 0.001 0.001      0.001      0.001      0.001
```

No offsets were seen form these earthquakes.
QSEC from eq_def 01 is undergoing large post-seismic motions for a 2012 9 5 earthquake but there is no clear offsets from this event. There appears to be small east offset 1 week before the event that will map into an apparent co-seismic if one were estimated.
There is no rapid data from CN22 so we can not test eq_def 03 event.
For eq_def 04, there are not offsets at NOPK or P800 at the time of the earthquake. There is no recent data from DSHS but it is unlikely that this site was displaced if NOPK and P800 were not displaced.
Overall: No significant earthquake events this month.

In May/June 2015, the following events were investigated but none show co-seismic offsets.

```
* EQDEFS for 2015 05 12 to 2015 06 14 Generated Tue Jun 16 11:59:58 EDT 2015
* Proximity based on Week_All.Pos file
```

```
* ------------------------------------
* SEQ Earthquake # 1
* EQ 336 P507_GPS       6.27       9.80 CoS        1.6 mm
* EQ_DEF M4.1 14km NNW of Westmorland
 eq_def 01   33.1623 -115.6638      9.8 8 2015 05 21 03 16    0.001
 eq_rename 01
 eq_coseis 01  0.001 0.001 0.001      0.001      0.001      0.001
* ------------------------------------
* SEQ Earthquake # 2
* EQ 363 P264_GPS       4.87       9.80 CoS        2.7 mm
* EQ_DEF M4.1 10km ENE of Yountville
 eq_def 02   38.4317 -122.2502      9.8 8 2015 05 22 02 54    0.001
 eq_rename 02
 eq_coseis 02  0.001 0.001 0.001      0.001      0.001      0.001
* ------------------------------------
* SEQ Earthquake # 3
* EQ 537 AC13_GPS      99.39     128.50 CoS        5.6 mm
* EQ_DEF M6.7 111km NNW of Chirikof Island
 eq_def 03   56.5940 -156.4300    128.5 8 2015 05 29 07 01    0.872
 eq_rename 03
 eq_coseis 03  0.001 0.001 0.001      0.872      0.872      0.872
* ------------------------------------
* SEQ Earthquake # 4
* EQ 555 KYVW_GPS       5.77       9.00 CoS        0.0 mm
* EQ 555 P600_GPS       6.00       9.00 CoS        0.0 mm
* EQ_DEF M3.7 18km NNE of Indio
 eq_def 04   33.8778 -116.1500      9.0 8 2015 05 30 05 24    0.000
 eq_rename 04
 eq_coseis 04  0.001 0.001 0.001      0.000      0.000      0.000
* ------------------------------------
* SEQ Earthquake # 5
* EQ 591 P486_GPS       7.10       8.80 CoS        0.0 mm
* EQ_DEF M3.6 11km NE of Borrego Springs
 eq_def 05   33.3135 -116.2817      8.8 8 2015 05 31 13 03    0.000
 eq_rename 05
 eq_coseis 05  0.001 0.001 0.001      0.000      0.000      0.000
```

P264 was affected by the Aug 24 2014 M6.0 6km NW of American Canyon earthquake but the aftershock here did not seem to displace the site.

AC13 does seem to be offset M6.7 111km NNW of Chirikof Island at 2015 05 29 07 01 but there are no data around the time of the earthquake. There are no equipment changes in the UNAVCO data base. We will label this event #35. The estimated offsets are:
WLS dN -6.38 +- 2.22 mm, dE 3.26 +- 2.50 mm, dU 4.09 +- 10.51 mm
KF dN -6.31 +- 1.23 mm, dE 3.01 +- 0.92 mm,.dU 3.46 +- 3.89 mm.
Since one one site is affected and there are no data within a week of the event, we cannot generate a standard Event file for this earthquake.

The other earthquakes generated no measurable offsets. We did note that the CWU rapid solutions for KYVW are noisy compared to NMT (~2 mm NE scatter compared with 1 mm; 7.3 verus 3.4 mm in height).

*Antenna Change Offsets: 2015/04/01-2015/06/30*

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

| Site | Date | | | | | From | To |
|---|---|---|---|---|---|---|---|
| CN35 | 2015 | 3 | 6 | 0 | 0 | TRM57971.00 | TRM59800.00 |
| LL01 | 2015 | 3 | 6 | 21 | 29 | TRM57971.00 | TPSCR.G3 |
| MACC | 2015 | 3 | 26 | 20 | 54 | ASH700936D_M | TRM57971.00 |
| NYFD | 2015 | 3 | 25 | 13 | 16 | LEIAT504 | LEIAR10 |
| NYFS | 2015 | 3 | 24 | 16 | 42 | LEIAT504 | LEIAR10 |
| P263 | 2015 | 3 | 27 | 0 | 0 | TRM29659.00 | TRM59800.80 |
| P432 | 2015 | 3 | 28 | 0 | 0 | TRM29659.00 | TRM59800.00 |
| P462 | 2015 | 3 | 11 | 22 | 20 | TRM29659.00 | TRM59800.80 |
| P471 | 2015 | 3 | 10 | 22 | 14 | TRM29659.00 | TRM59800.80 |
| P555 | 2015 | 3 | 12 | 0 | 0 | TRM29659.00 | TRM59800.80 |
| P619 | 2015 | 3 | 10 | 0 | 16 | TRM29659.00 | TRM59800.80 |
| PSDM | 2015 | 3 | 17 | 2 | 15 | ASH701945B_M | TPSCR.G3 |
| MKEA | 2015 | 4 | 8 | 0 | 0 | AOAD/M_T | JAVRINGANT_DM |
| P014 | 2015 | 4 | 19 | 19 | 33 | TRM29659.00 | TRM59800.80 |
| P041 | 2015 | 4 | 9 | 0 | 0 | TRM29659.00 | TRM59800.80 |
| P312 | 2015 | 4 | 29 | 19 | 21 | TRM29659.00 | TRM59800.80 |
| P444 | 2015 | 4 | 28 | 17 | 47 | TRM29659.00 | TRM59800.80 |
| P729 | 2015 | 4 | 24 | 16 | 5 | TRM29659.00 | TRM59800.00 |
| SC02 | 2015 | 4 | 29 | 19 | 5 | TRM29659.00 | TRM59800.80 |
| IDDR | 2015 | 5 | 6 | 15 | 0 | LEIAX1202GG | LEIAR10 |
| KYTH | 2015 | 5 | 6 | 13 | 29 | TRM55971.00 | TRM57971.00 |
| NYLV | 2015 | 5 | 20 | 15 | 28 | LEIAT504 | LEIAR10 |
| NYWT | 2015 | 5 | 21 | 15 | 36 | LEIAT504 | LEIAR10 |
| P182 | 2015 | 5 | 6 | 0 | 0 | TRM29659.00 | TRM59800.80 |
| P183 | 2015 | 5 | 6 | 0 | 0 | TRM29659.00 | TRM59800.80 |
| P215 | 2015 | 5 | 15 | 0 | 0 | TRM29659.00 | TRM59800.80 |
| P689 | 2015 | 5 | 8 | 0 | 0 | TRM29659.00 | TRM59800.00 |
| P694 | 2015 | 5 | 7 | 19 | 48 | TRM29659.00 | TRM59800.80 |
| P701 | 2015 | 5 | 8 | 0 | 0 | TRM29659.00 | TRM29659.00 |
| P701 | 2015 | 5 | 21 | 0 | 0 | TRM29659.00 | TRM59800.80 |

Analysis

CN35: WLS dNEU 2.26 +- 0.84, -1.82 +- 0.84, 15.28 +- 2.61 mm, KF dNEU 2.04 +- 0.34, -2.18 +- 0.40, 14.79 +- 1.38 mm . The height offset is clear, the horizontal terms are not obvious

LL01: WLS dNEU -2.60 +- 2.25, 0.89 +- 1.61, 5.84 +- 6.31 mm , KF dNEU -1.13 +- 0.26, 0.25 +- 0.23, 10.80 +- 0.88 mm. The height offset is clear, the horizontal terms are not obvious.

MACC: WLS dNEU 5.19 +- 4.06, 5.35 +- 2.73, -8.00 +- 9.17 mm, KF dNEU 5.53 +- 0.43, 5.17 +- 0.38, -8.76 +- 1.52 mm. The offsets can be seen in all components. A few data were removed at the time of the change due to processing with the incorrect antenna type.

NYFD: WLS dNEU 2.01 +- 2.54, -0.20 +- 2.69, 4.49 +- 8.15 mm, KF dNEU 1.66 +- 0.47, 0.36 +- 0.40, 6.71 +- 1.64 mm. Annual signals were estimated for this site as well.

NYFS: WLS dNEU -0.16 +- 1.13, 4.38 +- 2.01, 4.48 +- 3.66 mm, KF dNEU -0.31 +- 0.44, 5.03 +- 0.38, 4.55 +- 1.54 mm. Annual signals were estimated and some values at the time of the break have been removed.

P263: WLS dNEU -3.77 +- 3.38, 0.34 +- 3.40, -1.08 +- 7.49 mm, KF dNEU -0.59 +- 0.39, 2.67 +- 0.34, -2.53 +- 1.29 mm. Annual estimated, the KF estimates with significant East offset and insignificant North offset match the visual impressions of the time-series.

P432: WLS dNEU -5.12 +- 1.96, 4.97 +- 1.89, 7.41 +- 6.60 mm, KF dNEU -5.31 +- 0.41, 4.79 +- 0.33, 4.47 +- 1.26 mm. Annual estimated, offsets are clear.

P462: WLS dNEU 1.90 +- 1.88, 2.45 +- 0.47, 0.55 +- 3.47 mm, KF dNEU 0.86 +- 0.32, 2.73 +- 0.26, -0.66 +- 1.04 mm. Annual estimated (small), North residuals are skewed to the South. East offset visible in time-series.

P471: WLS dNEU 2.61 +- 0.56, 2.59 +- 3.05, 3.77 +- 4.67 mm, KF dNEU 2.36 +- 0.30, 2.39 +- 0.30, 2.71 +- 1.15 mm. No Annual: There seems to another break 2015 3 24 that partly removes the North offset seen on 2015 3 10. If the second offset is estimated, the north offset increases to 4.78 mm followed by a -3.57 mm offset (KF estimates, +- 0.5 mm). The east offset is only partly reduced (3.19 mm and -1.19mm, +- 0.5 mm)

P555: WLS dNEU 5.55 +- 1.00, 7.66 +- 1.67, 1.27 +- 4.04 mm, KF dNEU 5.46 +- 0.27, 6.02 +- 0.27, -0.37 +- 0.97 mm. No annual: North positions skewed north and height skewed down. Small east skewness.

P619: WLS dNEU 1.24 +- 2.37, -3.56 +- 0.48, -2.12 +- 2.70 mm, KF dNEU 0.13 +- 0.33, -3.19 +- 0.26, -2.51 +- 1.00 mm. East offset clear in time-series.

PSDM: WLS dNEU -2.52 +- 3.21, 2.59 +- 1.20, 2.79 +- 7.38 mm, KF dNEU -2.09 +- 0.30, 2.09 +- 0.27, -0.68 +- 1.03 mm. Some bad data in ;late 2009 removed so as to not bias estimates.

MKEA: WLS dNEU -1.77 +- 8.49, -0.83 +- 12.35, -1.67 +- 30.10 mm, KF dNEU -4.86 +- 0.52, -2.22 +- 0.66, -8.76 +- 2.10 mm. Large gap until new antenna installed so difficult to judge robustness.

P014: WLS dNEU 0.34 +- 1.98, -3.49 +- 3.85, -4.08 +- 2.32 mm, KF dNEU 0.57 +- 0.35, -1.89 +- 0.36, -3.95 +- 1.20 mm. East offsets looks clear. Height might be due to sytematics.

P041: WLS dNEU -4.52 +- 0.68, 0.05 +- 0.72, 0.23 +- 3.44 mm, KF dNEU -4.06 +- 0.21, 0.23 +- 0.20, 2.11 +- 0.70 mm. North offset very clear. CWU solutions in east are corrupt after the antenna change and these bad estimates corrupt the PBO solution. The above estimates are from the NMT solution.

P312: WLS dNEU 4.02 +- 4.95, -6.21 +- 1.47, -10.03 +- 13.90 mm, KF dNEU 2.89 +- 0.81, -6.72 +- 0.63, -6.47 +- 3.32 mm. Offsets are clear in the time-series. Height has large amplitude oscillation after mid-2014. There is not enough datayet to see if the new antenna rectifies this oscillation.

P444: WLS dNEU -1.19 +- 2.30, -2.77 +- 1.71, 2.28 +- 13.86 mm, KF dNEU -1.24 +- 0.64, -2.80 +- 0.51, -1.20 +- 2.00 mm. Offset look small in the time-series.

P729: WLS dNEU -4.86 +- 10.06, -2.26 +- 6.91, -24.29 +- 32.71 mm, KF dNEU -0.88 +- 0.48, -0.87 +- 0.41, -9.65 +- 1.78 mm. Systematic height seasonal and trend changes make WLS estimate too large in height. The KF estimate is closer to the appearance in the time-series.

SC02: WLS dNEU  1.32 +- 2.99,  2.49 +- 3.75, -3.41 +- 8.27 mm, KF dNEU  2.32 +- 0.59,  1.25 +- 0.45, -4.51 +- 1.79 mm. ETS events make the WLS estimate here somewhat unreliable.

IDDR: WLS dNEU  18.27 +- 3.61, -10.48 +- 5.25, -20.28 +- 7.34, mm, KF dNEU  16.92 +- 0.38, -8.62 +- 0.35, -18.96 +- 1.13, mm. Very apparent large break at this site

KYTH: WLS dNEU  -4.21 +- 2.70,  6.29 +- 4.12, -4.44 +- 4.69, mm, KF dNEU  -2.27 +- 0.46,  1.22 +- 0.52, -2.93 +- 1.41, mm. Antenna seems to go bad on ~March 01 and so we have added a removed data command for 2015  3  1  0  0  2015  5  6 13 29

NYLV: WLS dNEU  4.90 +- 2.34, -2.33 +- 2.57,  4.24 +- 9.42, mm, KF dNEU  5.06 +- 0.49, -1.47 +- 0.41,  5.66 +- 1.68, mm.  Some outliers while the ACs implemented the antenna change.(should be OK in finals run)

NYWT: WLS dNEU  -0.29 +- 1.53, -6.84 +- 3.44,  4.33 +- 12.61, mm, KF dNEU  -0.45 +- 0.69, -6.10 +- 0.57,  5.77 +- 2.40 mm. As with NYLV, some outliers especially in height (should be OK in finals run).

P182: WLS dNEU  4.14 +- 1.38, -5.58 +- 0.87, -4.18 +- 4.24, mm, KF dNEU  2.97 +- 0.25, -4.82 +- 0.22, -4.97 +- 0.85, mm. East offset can be seen in data.

P183: WLS dNEU  4.24 +- 1.43,  0.14 +- 0.97, -7.78 +- 5.26, mm, KF dNEU  3.11 +- 0.26,  1.24 +- 0.22, -8.61 +- 0.88, mm.  Both North and East offsets are clear.

P215: WLS dNEU  1.84 +- 3.76, -2.03 +- 2.84, -9.91 +- 11.99, mm, KF dNEU  1.75 +- 0.37, -1.95 +- 0.32, -9.92 +- 1.35, mm. Sites show evidence on degradation leading up to the site being cleared in late 2014 (no data Dec 17 and Jan 14).  Added and unknown break (2015 01 01) for the change at this time.

P689: WLS dNEU  2.33 +- 1.12,  2.46 +- 3.85, -0.01 +- 3.65, mm, KF dNEU  3.02 +- 0.26,  2.07 +- 0.27, -2.43 +- 0.78, mm.  Evidence of snow effects at site as well. Systematics in east with ~5-10 mm slows event in June/July 2009 and 21011.

P694: Break from Oct 30 2014 to antenna switch.  Offset can't be reliably estimated (snow effects at site as well).

P701: WLS dNEU  1.15 +- 1.40,  2.32 +- 5.50,  0.50 +- 5.88, mm, KF dNEU  1.54 +- 0.52,  3.61 +- 0.43, -0.38 +- 1.64, mm and WLS dNEU  3.28 +- 1.76, -0.39 +- 6.88, -4.08 +- 7.41, mm, KF dNEU  3.29 +- 0.63, -0.37 +- 0.50, -4.09 +- 2.03, mm. The first offset is a change of serial number of the same antenna type (offset in north). The second change is a  change in antenna type (offset in east).

We have added the following unknown cause discontinuities and data edits to the PBO analyses.  If there is no end date in time range, the change is ongoing. In some cases here these entries will record the failure time of an antenna that is later noted in the site logs to have changed.

| Rename | Date Range | Explanation |
|---|---|---|
| SA63     SA63_APS | 2010  4  5<br>2012  4 18 | 27 mm E No log entries |
| SA63     SA63_BPS | 2012  4 18<br>2014 12 17 | few mm NE, -11 mm U |
| SA63     SA63_CPS | 2014 12 17 | Very large jump -142 N,216 E 5 U mm. |

| | | |
|---|---|---|
| YWG1 YWG1_APS | 2012 7 4 | Mostly a height change of 87 mm (N trend change recenty (2013) as well) |
| KYTH KYTH_APS | 2015 3 10 | North (10 mm), Height (-47 mm) mostly |
| CSHR CSHR_XCL | 2014 8 11<br>2014 10 20 | Antenna seems to go bad and then fail. |
| P238 P238_APS | 2012 4 17 | -9 mm North, East and Up are very small. Large annual signals in East mostly. |
| NOCO_GPS<br>NOCO_APS | 2000 10 20<br>2001 4 23 | Most likely event before antenna change. Long term curvature in North |
| EOCG EOCG_APS | 2014 12 13<br>2015 1 11 | Unknown large break in North (-31 mm), smaller east break at second epoch |
| EOCG EOCG_BPS | 2015 1 11 | Smaller east break |
| KYTH KYTH_XPS | 2015 3 1<br>2015 5 6<br>13 29 | Antennas apparently goes bad before replacement |
| P215 P215_APS | 2015 1 3<br>2015 1 15 | Looks like vegetation being cut |

*Reanalysis with updated NMT Yucca Mountain sites*

We have now completed incorporating the NMT updates to the reprocessing that added the Yucca mountain sites between GPS weeks 1004 to 1646 (1999/04/04-2011/07/30). This update also fixed some but not all the metadata problems in the original NMT reprocessing results during this interval. All of the times series have now been updated and updated results sent to UNAVCO. The updated SINEX files have been queued with LDM to UNAVCO but crossing files between MIT and UNAVCO shows that many SINEX files have not yet been successfully transferred. Even with repeated LDM transfers the files do not seem to make the transfer to the UNAVCO FTP area. We have a new system for LDM (replacement everest.mit.edu machine) and it is currently being configured and files transferred from the old raids to the new raids.

We have noticed that the height RMS scatters with this updated processing seem to have degraded a little while the horizontal RMS scatters have improved by a small amount. There is nothing specific that can be seen in the time series that explains the differences. We have nearly completed the new complete PBO velocity field based on SINEX analyses rather than time series analyses and when this is complete we will look again the height RMS fits when the NAM08 frame is aligned to the new realization.

*Script updates*

No major changes have been to the scripts.

## GAMIT/GLOBK Community Support

During this quarter we finished a new release (10.60) of the software and distributed the source files, scripts, and tables to the over 1000 institutions currently holding licenses.

(Many of these are likely not actively using the software, but we have no easy way of tracking that.) This release included the structural modifications to support GNSS observations other than GPS and changes to plotting scripts to be compatible with GMT 5, as well as the usual bug fixes, minor feature enhancements, and additions of supported receivers and antennas described in previous quarterly reports.

There were no UNAVCO-sponsored data-analysis workshops during this period, but we continue to spend 5-10 hours per week in email support of users. During the quarter we issued 16 royalty-free licenses to educational and research institutions,