

Earthscope's Plate Boundary Observatory (PBO) use of IGS products.

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Overview

- Review of US Plate Boundary Observatory (PBO) processing as part of the NSF Geodesy Advancing Geosciences and EarthScope (GAGE) facility
- Processing methods:
 - New Mexico Tech (NMT): GAMIT double difference processing
 - Central Washington University (CWU): GIPSY Precise Point Positioning
- Impacts of scale changes
- Future use of additional IGS products
- Processing details in Herring et al., Plate Boundary Observatory and Related Networks: GPS Data Analysis Methods and Geodetic Products, (2016) *Rev. Geophys.*, 54, doi:10.1002/2016RG000529.

GAGE/PBO Processing

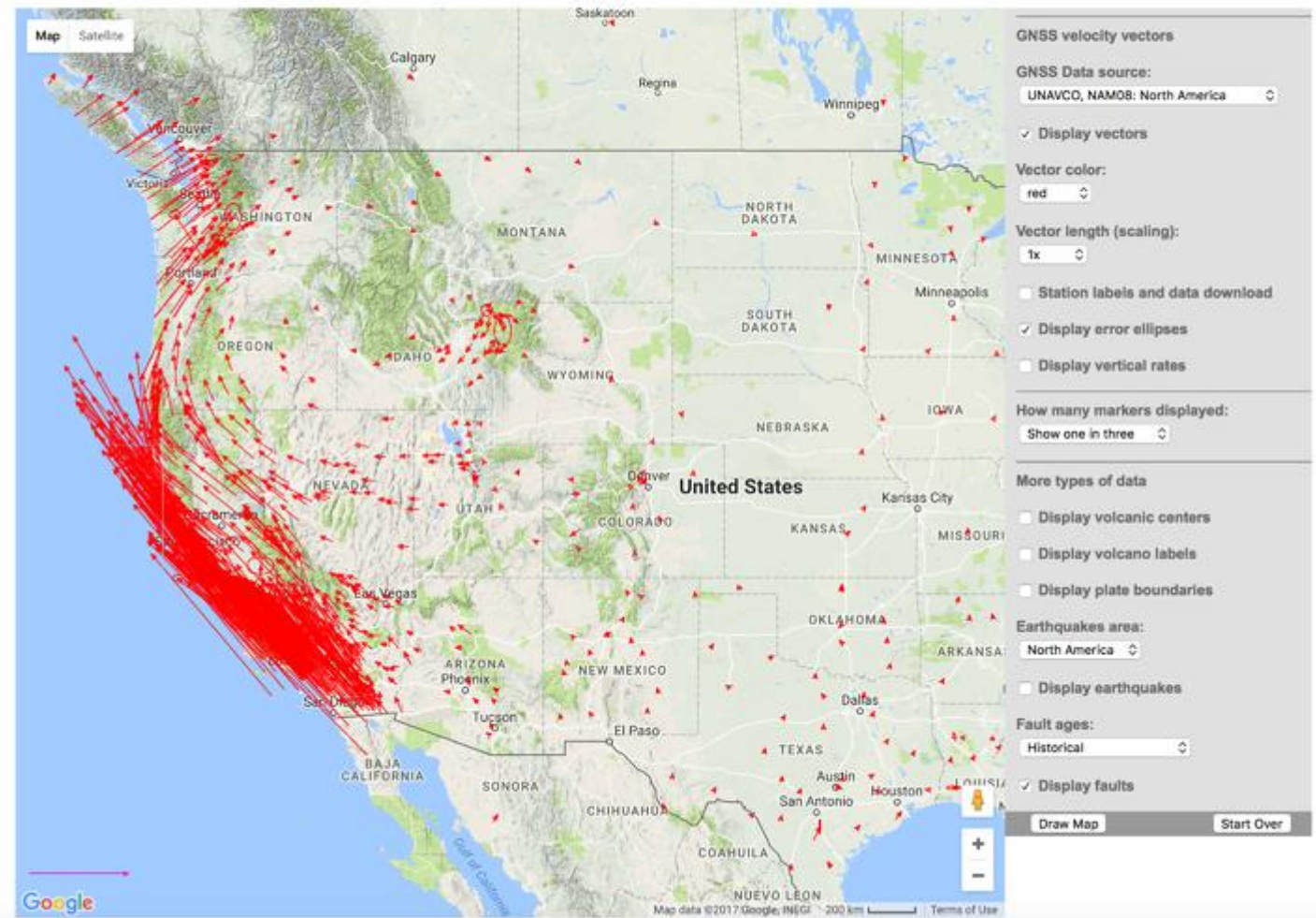
- Time tables of results:
 - Rapid solutions: latency 1 day
 - Final solutions (used IGS final orbits) 2-3 weeks
 - Supplemental runs at 12 and 24 weeks to add stations missed in finals
 - Reprocessing runs. Next will start soon for ITRF2014/IGS14
- Products: All available through UNAVCO [http/ftp/php](http://ftp.php) and web services (soon)
 - Time series: North America “Fixed” and IGS08
 - Secular velocity fields (released monthly based on time series analyses).
 - SINEX files: Full covariance files
 - Event files for earthquakes
 - Atmospheric delay estimates, phase RMS scatters and other quality metrics

Tools

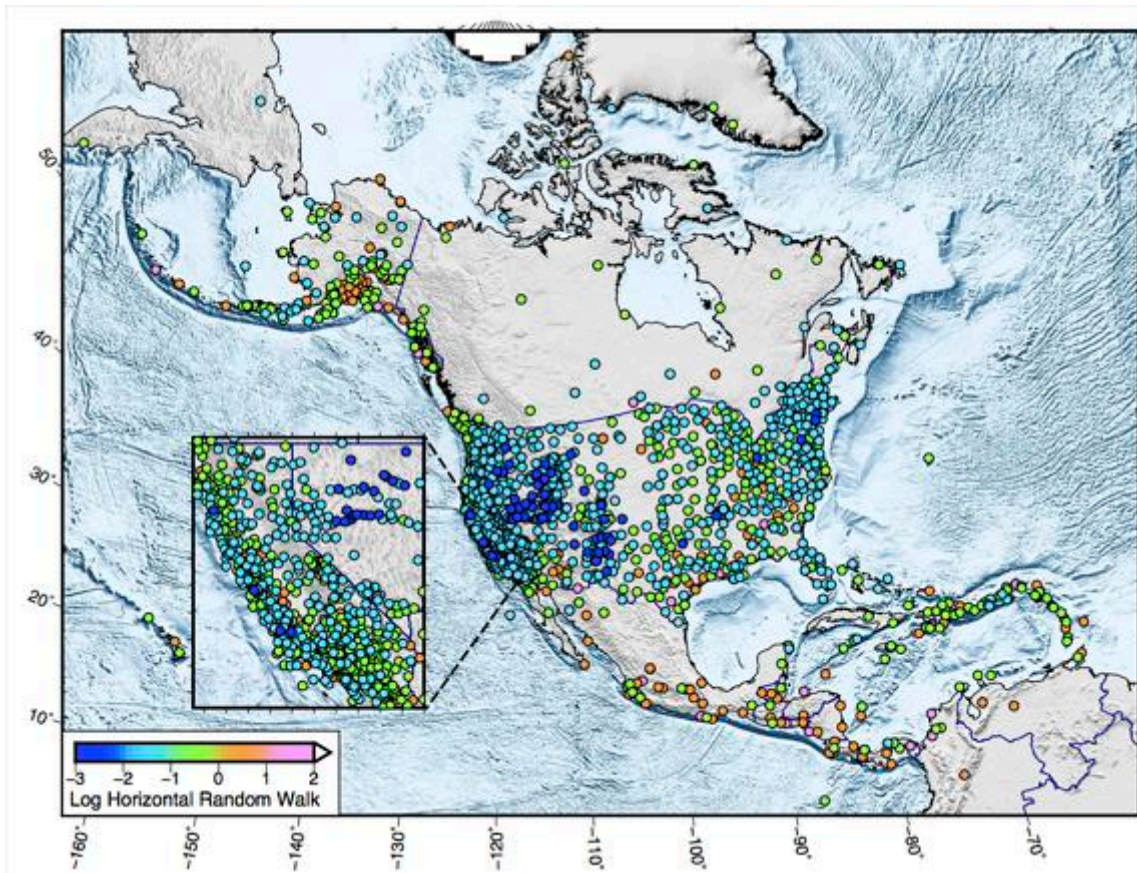
<http://www.unavco.org/software/visualization/GPS-Velocity-Viewer/GPS-Velocity-Viewer.html>

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GPS Velocity Viewer



Characterization of non-secular variations



One method of characterizing non-secular motions: Horizontal position variations parameterized as a random walk.

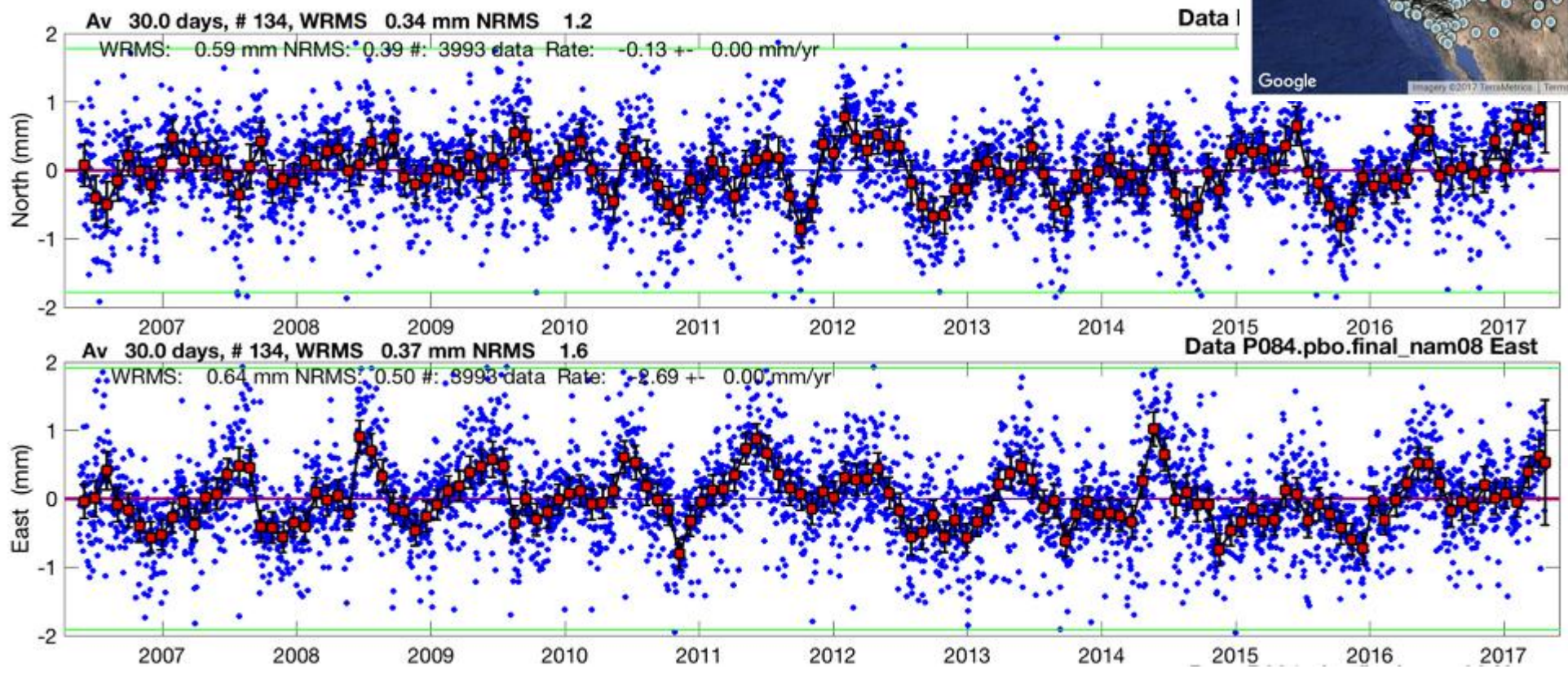
Plot of log of value in mm^2/yr
Standard deviation over a decade:
Dark blues: 0.3 mm
Light greens: 3 mm
Browns: 4.5 mm
Pinks: 30 mm

Each sites needs careful examination to assess nature of signal

Statistics computed with annual and in some cases post-seismic log terms estimated

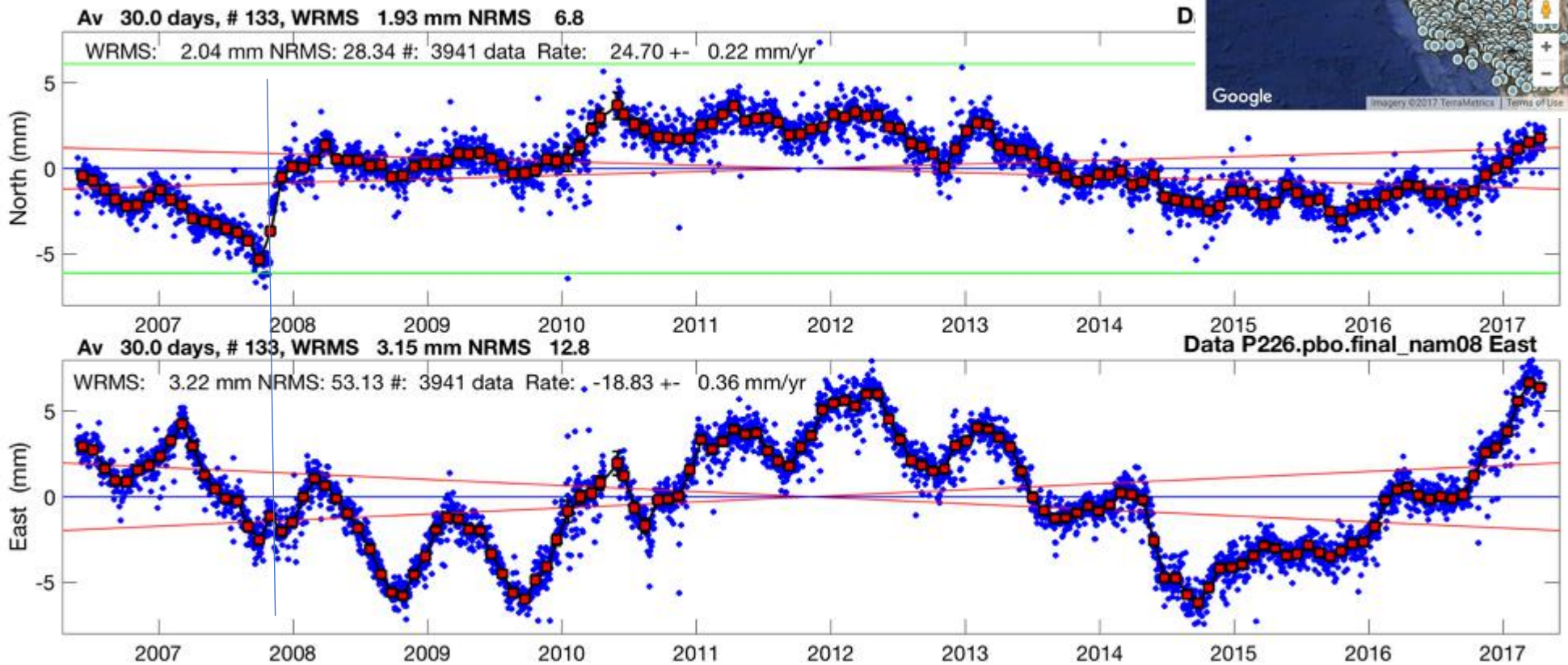
Low Level of systematic noise

Red squares are 30-day averages. RMS <0.4 mm; daily RMS <0.7 mm



High level of systematics

RMS scatters are now 2-4 mm. (Earthquake offset 2007 10 31 Mw 5.6, Event 12)



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UNAVCO GDS Technical News

This page is meant to encourage 2-way communications between UNAVCO staff, GAGE, other analysis centers, and community users.

ASK TO JOIN

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About Community

The GDS Technical News Community is now open and accepting membership requests.

This page technical news pertaining to UNAVCO Geodetic Data Services and the larger geodetic community that interacts with UNAVCO.

Our goal is to encourage 2-way communications between UNAVCO staff, GAGE, other analysis centers, and community users. It is not meant to be just another place to post new articles, but rather a clearinghouse for information on a wide range of data product topics, serving as an easy-to-access resource for the community.

Beth Bartel Owner • Community News 18w

UNAVCO's data response to the M6.5 earthquake 160km west of Ferndale, California on 2016-12-08 at 14:49:46 UTC, includes high rate GPS/GNSS data from 214 PBO stations within 500 km of the epicenter and a fully processed 1-sps borehole strainmeter data set.

<https://www.unavco.org/highlights/2016/ferndale.html>

Data Event Response to the December 8, 2016 M6.5 Earthquake 160km W of...

USGS ShakeMap : OFF THE COAST OF NORTHERN CALIFORNIA
Dec 8, 2016 14:49:46 UTC M 6.5 160.48 39.126 15 Depth: 12 km ID:u2000776f

unavco.org

Beth Bartel Owner • Community News 23w

The low-down on UNAVCO activities at AGU next week:

<http://www.unavco.org/highlights/2016/agu.html>

Beth Bartel Owner • Community News 26w

UNAVCO's data response to the M7.8 Kaikoura, New Zealand earthquake includes a full processed high-rate data set from EarthScope Plate Boundary Observatory strainmeters. This page also includes links to community products including rapid GPS displacements and high-rate time series.

<http://www.unavco.org/highlights/2016/kaikoura.html>

Data Event Response to the 13 November 2016 M7.8 Kaikoura, New Zealand...

USGS ShakeMap : SOUTH ISLAND OF NEW ZEALAND
Nov 13, 2016 11:02:36 UTC M 7.8 162.75 E-173.08 Depth: 23 km ID:u1000776f

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P656: On the Slopes of Mount Shasta

<http://www.unavco.org/highlights/2016/gsa.html>

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ORES: Trees in Southern California

ORES was originally installed in 1999 as part of the Southern California Integrated GPS Network (SCIGN), at the Olga Reed Elementary School in Los Alamos, California (Figure 1). The station was transferred to UNAVCO as part of the Nucleus sub-network of the Plate Boundary Observatory (PBO). At this time the station was upgraded to PBO standards, with a new receiver and cellular communications equipment.

2016-07-26
7 Photos - View Album

Note the relatively sparse vegetation around the site.

Differences between NMT and CWU

- NMT uses a double difference network processing; CWU uses a precise point positioning (PPP) approach.
- The difference makes a major difference in use of IGS products.
- NMT: Uses all IGS products (next slide)
- CWU: Use no IGS products because scale from previous ITRF realization is inherited in current realization through the clocks. Clocks need to be consistently re-computed by (in this case) JPL.

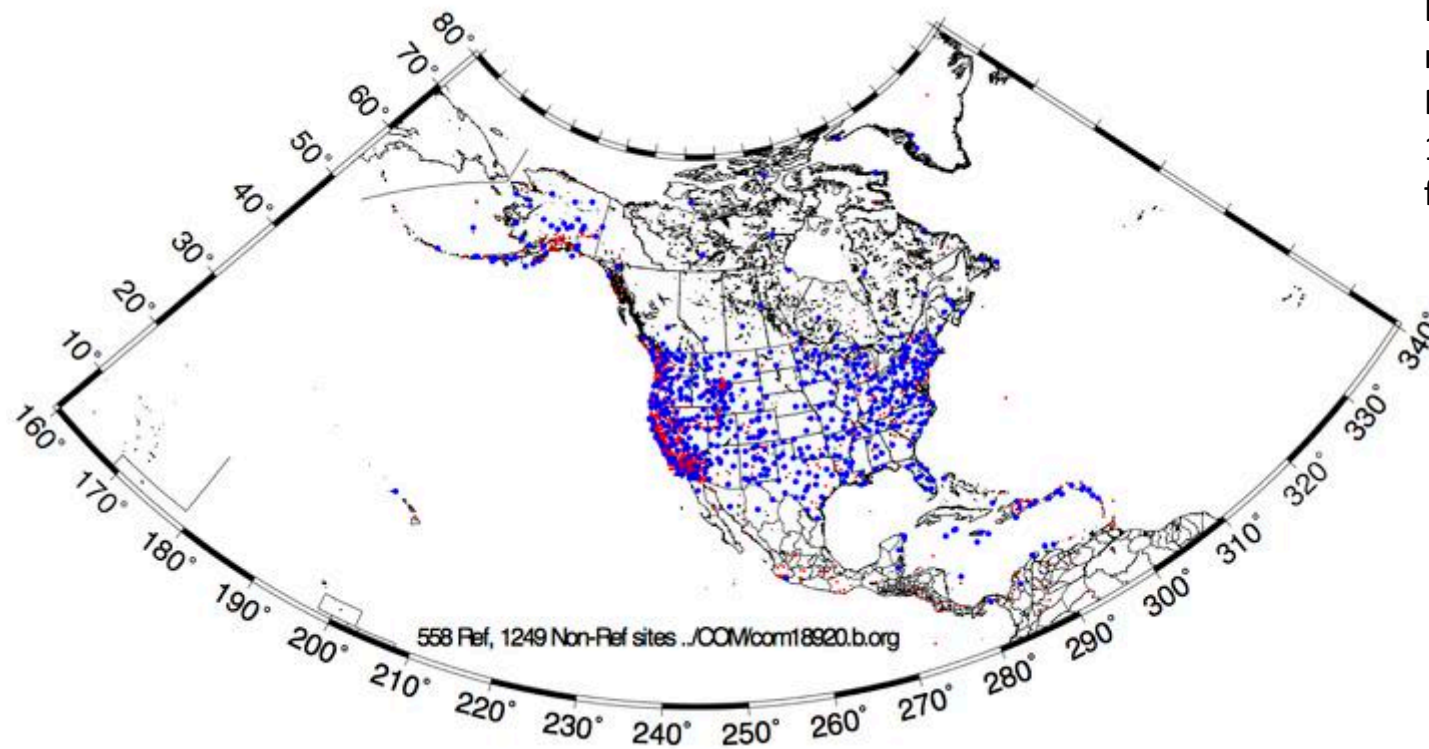
Products used by NMT

- Orbits (SP3 files, refitted to Bern ECOM model due to interpolation edges)
- TEC models for higher order ionospheric models). Not always available, default back to JPL
- Differential code biases (DCB) for ambiguity resolution. Wide-lane-ambiguity files from JPL used by CWU.
- ANTEX files (both NMT and CWU)
- ITRF results (NAM08 currently) to be mapped to PBO system.
- No loading files used to stay consistent with IGS

PPP versus Network solutions

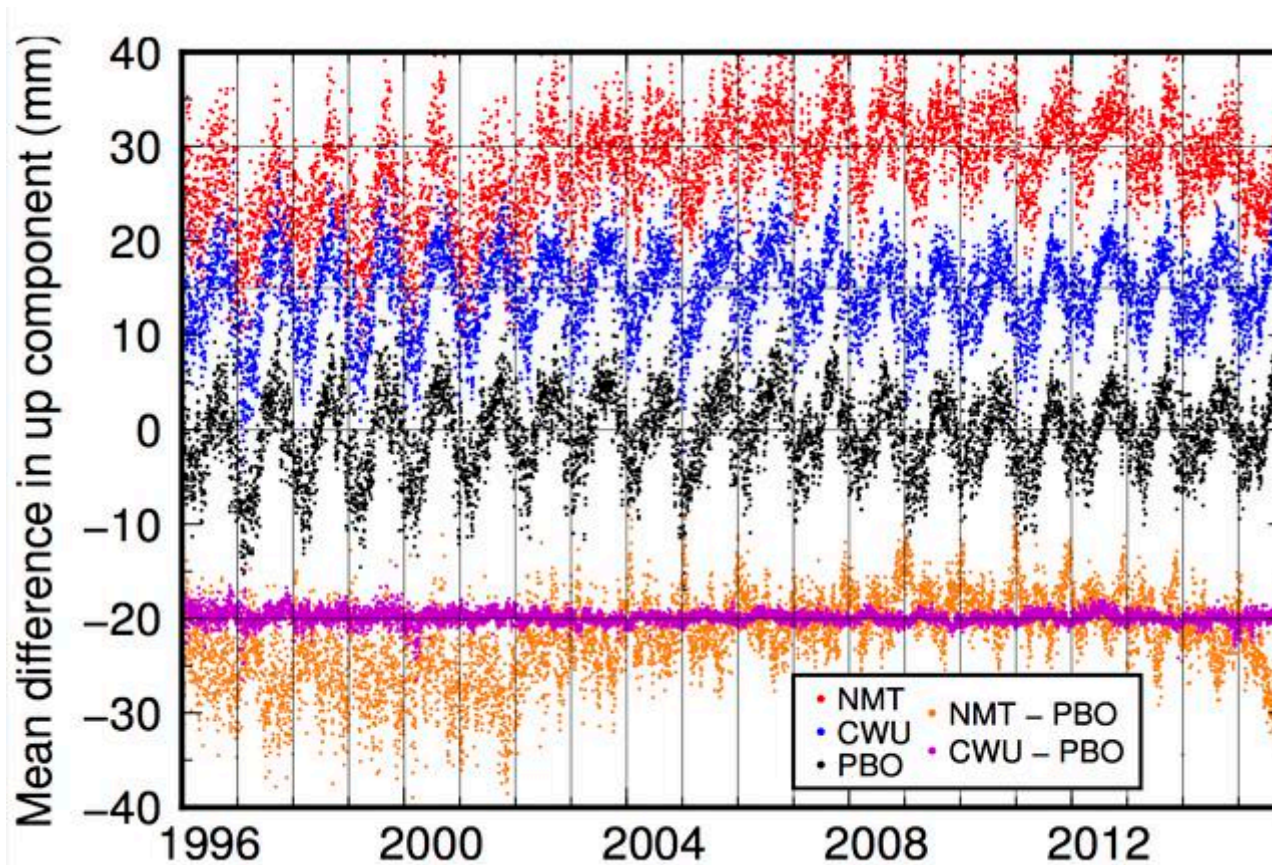
- We examine the analysis of the UNAVCO GAGE network (~1800 stations across North America which includes 1100 Plate boundary observatory (PBO) stations).
- Precise point positioning (PPP) processes each station separately and no station-station correlations are computed. Network solutions estimate satellite clocks and the uncertainty on the satellite clocks correlates the errors in the position estimates.
- The correlations in the network solutions leads to scale estimates from combined PPP and network solutions to be dominated by the PPP solution.

Typical Reference Frame Sites and GAGE Network



Blue dots are 558
reference frame sites
Red are remaining
1249 non-reference
frame sites

Scale estimates (converted to height changes) from NMT and CWU GAGE analyses

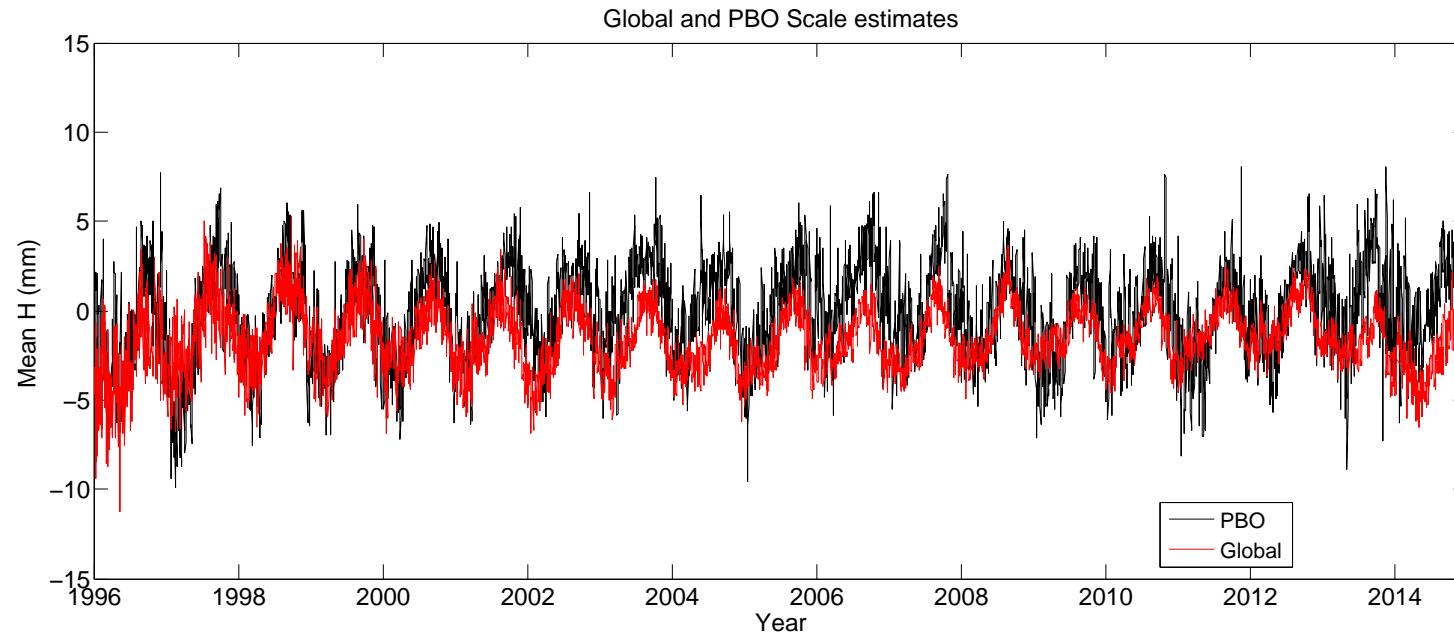


The network solution (NMT) has larger scatter than the PPP solution (CWU).

The combination of network and PPP solutions is dominated by the PPP solution (blue and black are almost identical).

Differences between the combined and the individual solutions show small differences to PPP (purple) and large differences to network (orange).

Estimates of scale (dH) from PBO and Global IGS network

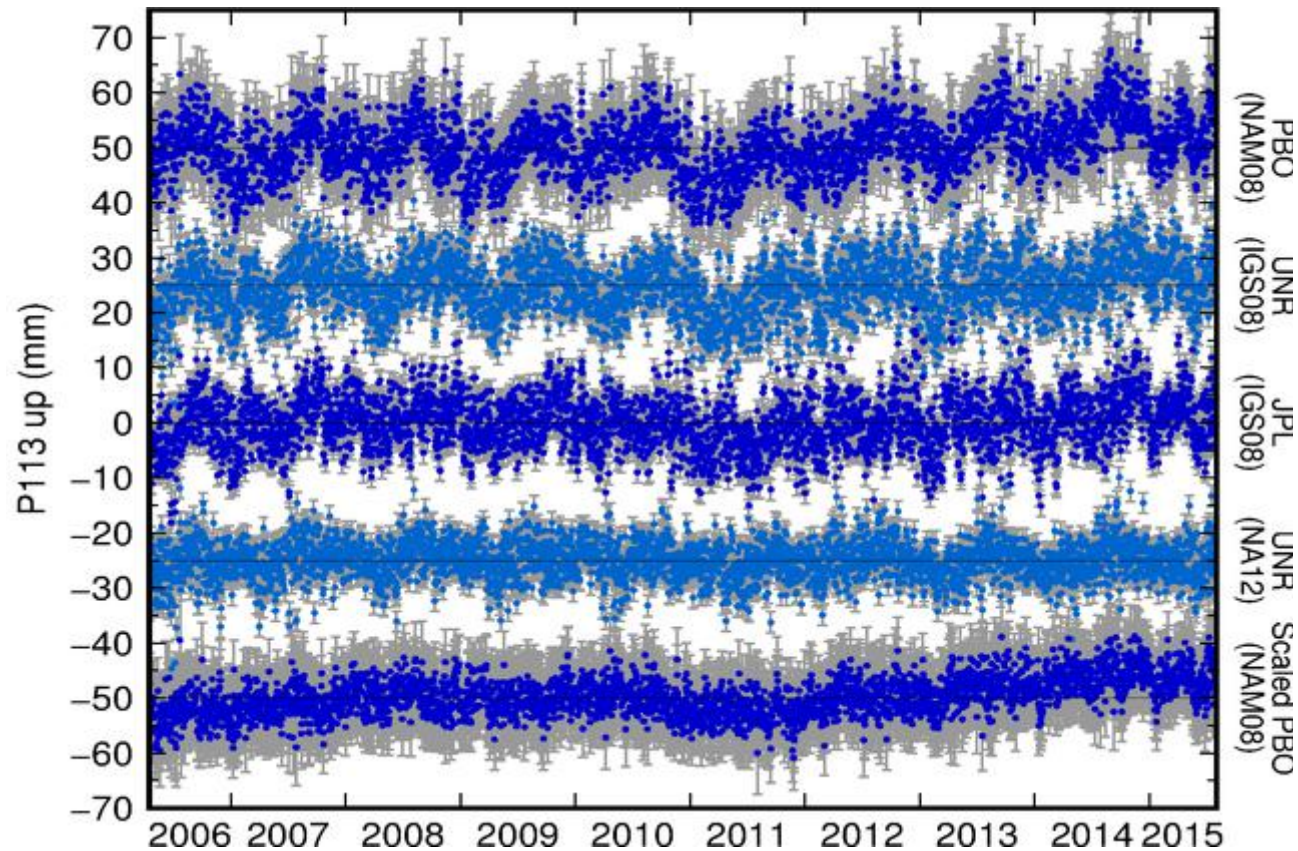


Red line shows scale estimate from GLOBAL IGS network

Black line shows PBO estimates (dominated by PPP solution) realized with regional frame definition.

Annual signal seen in global IGS scale is controlled by Northern hemisphere. Some part of the “annual” scale may be artifacts of satellite antenna location errors.

P113: Example of effects of scale treatment



Lower two curves (NA12 results from University of Nevada, Reno (UNR) and PBO with scale estimates) show much smaller annual signals.

Height correlation matrices

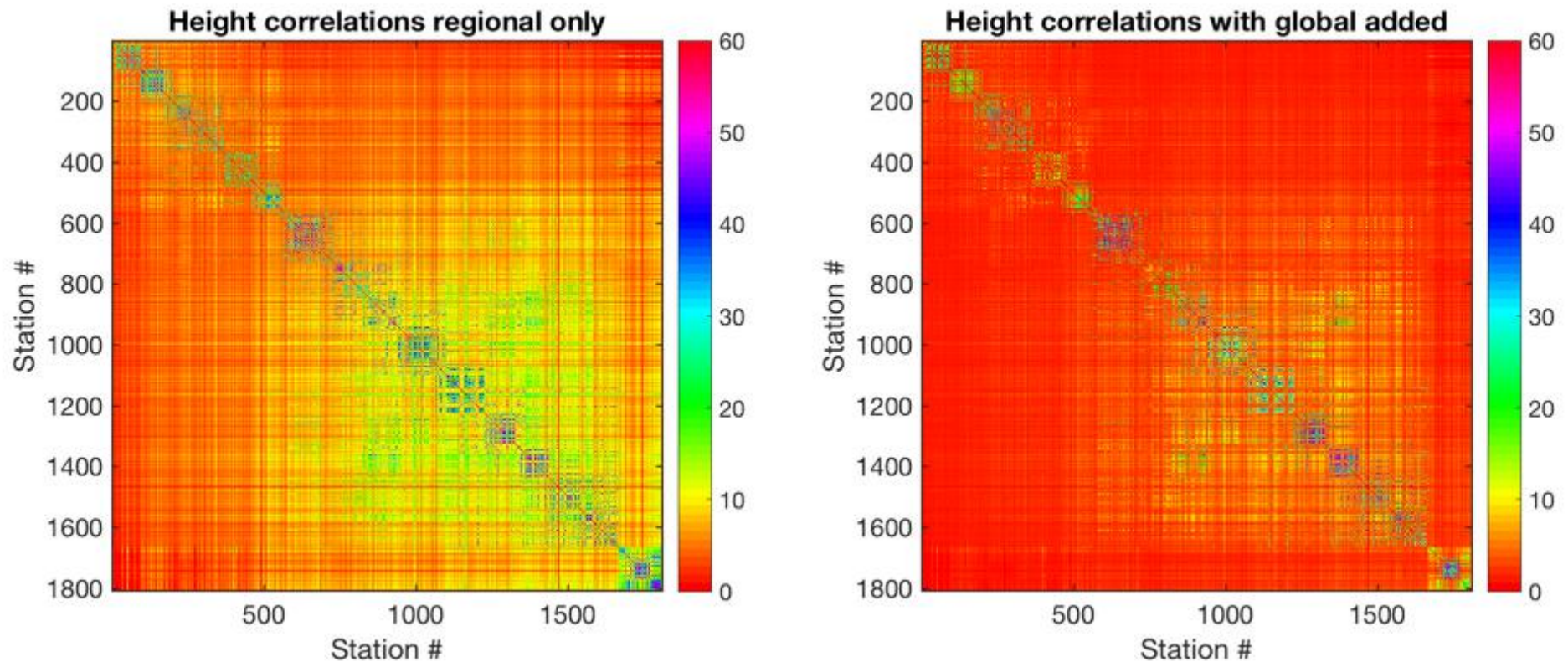
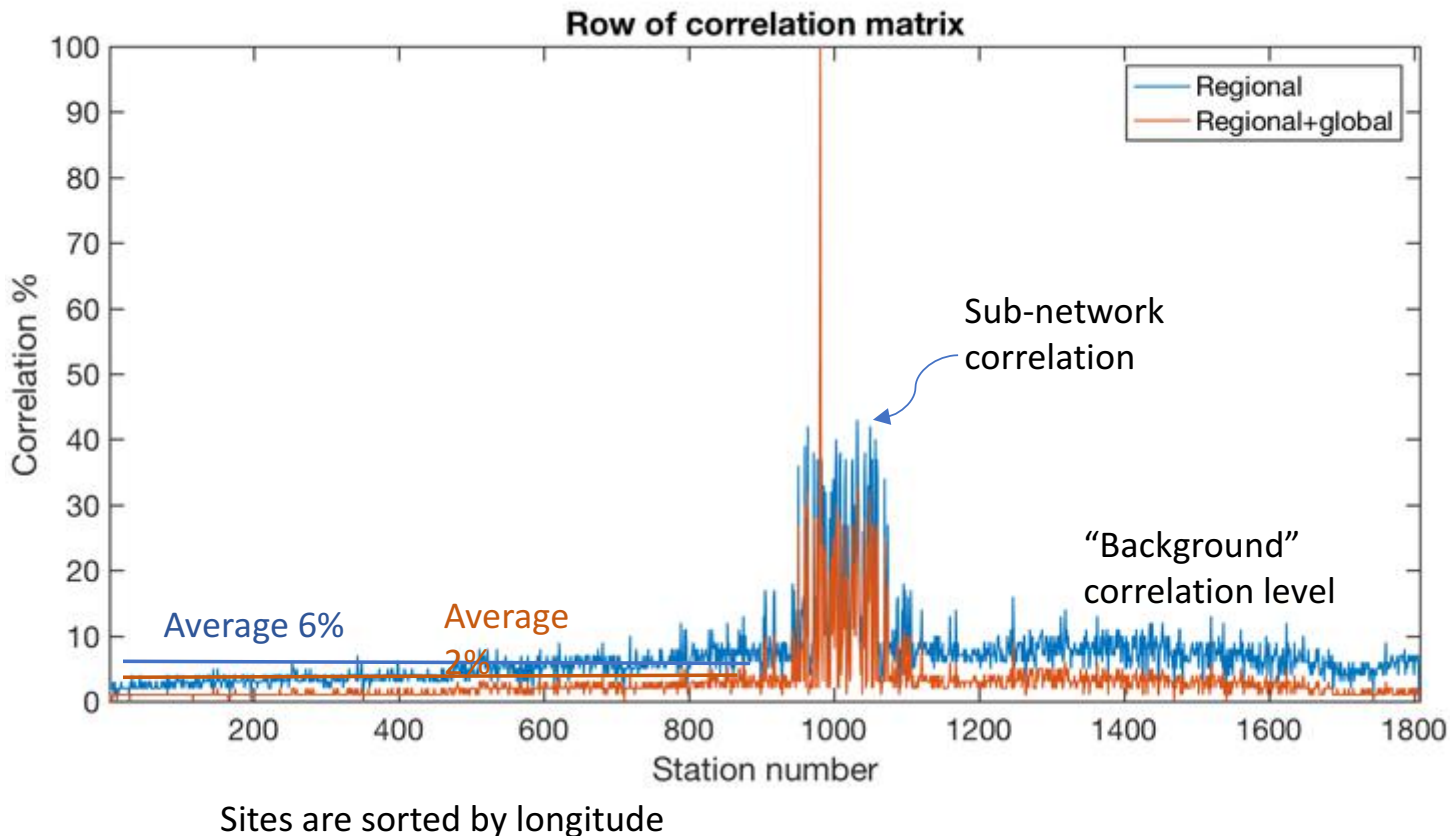


Image of height correlation matrix from regional and regional and global. Note color difference. Some of the structure due to sub-networks used to construct full network solution. Need for IGS combined SINEX file although these results generated with MIT global SINEX files.

Example row of correlation matrix



Impact of correlations:

Standard deviation of mean of N stations (large N)

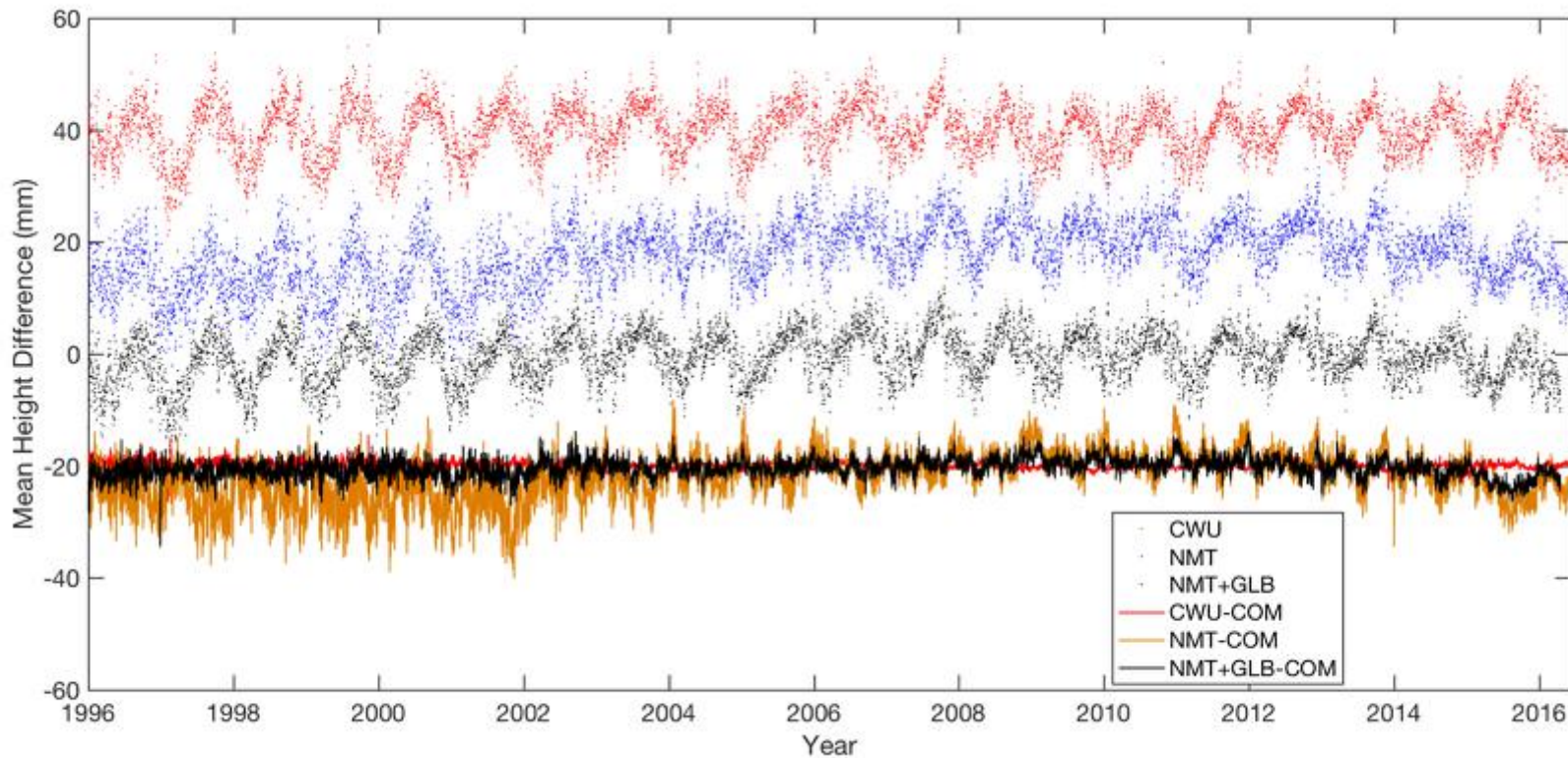
$$\sigma_{mean} \approx \sqrt{\frac{\sigma^2}{N} (1 + N\rho)}$$

With ~560 reference frame sites, Regional average 6% correlation increases sigma of mean by factor of 6;
 Added global 2% correlation increases sigma by 3.5.

Consistent with scale estimate sigmas:

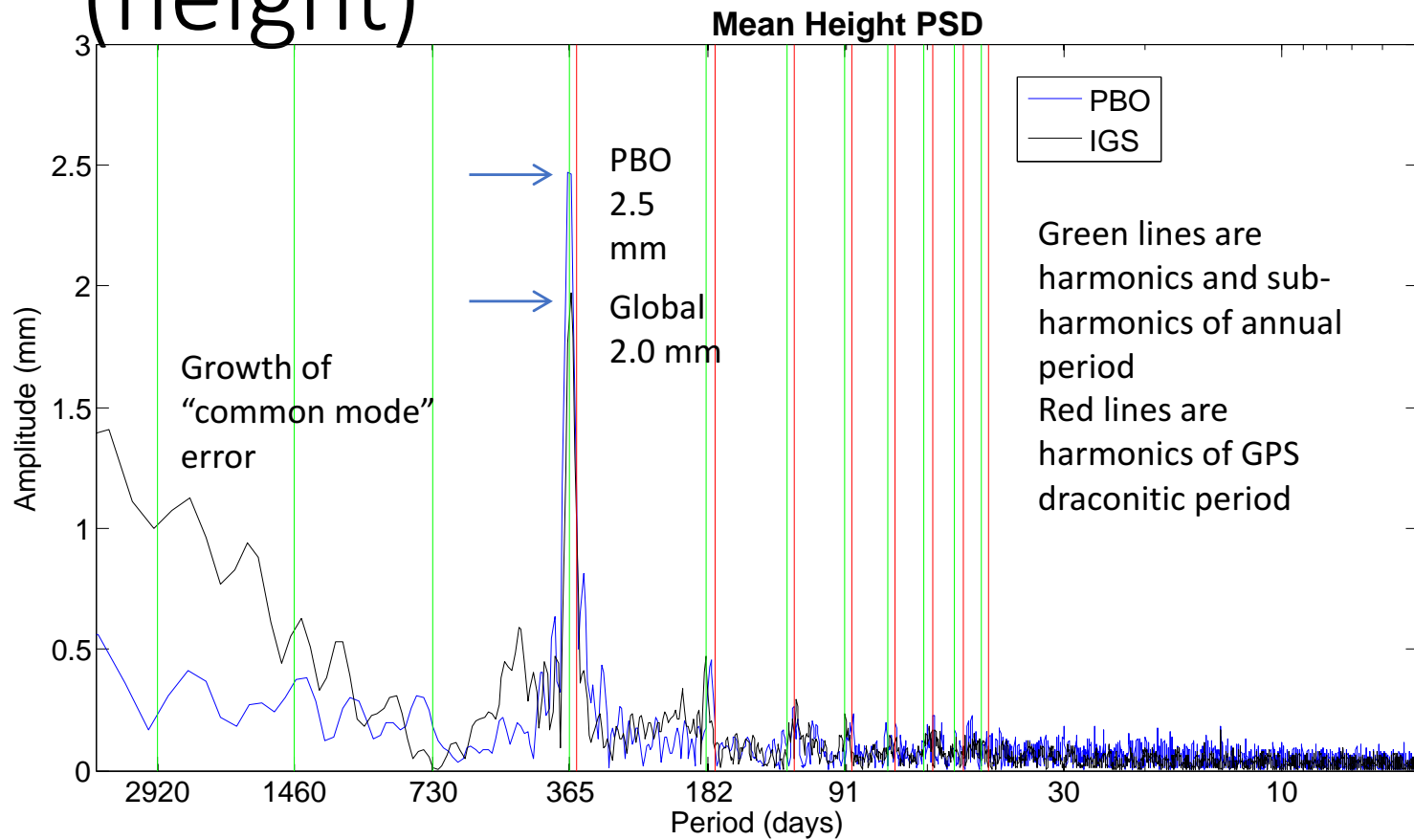
PPP	±0.06 ppb
Regional	±0.24 ppb
Regional+Global	±0.15 ppb

Impact of adding stations from global solution



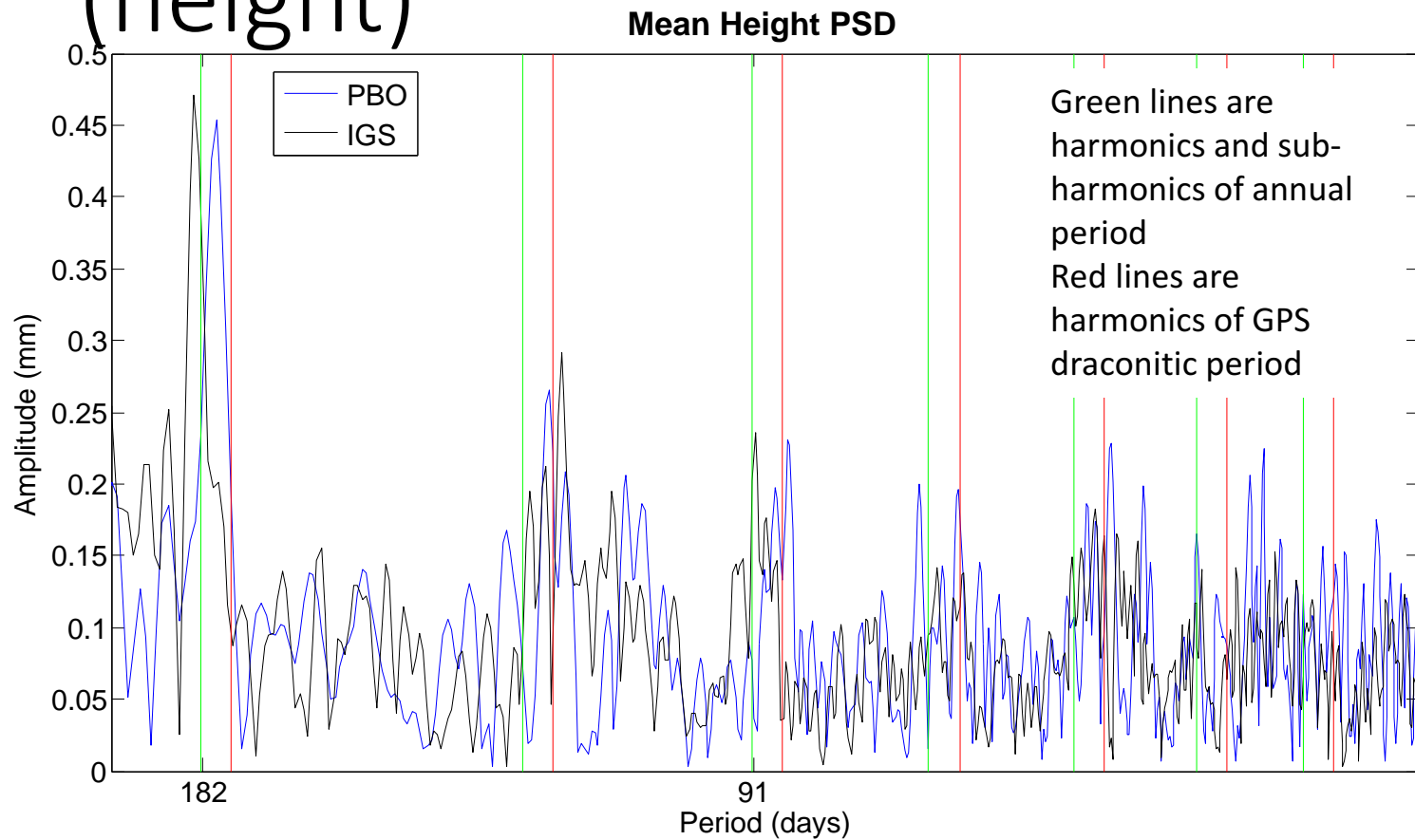
Adding stations from global network gives greater weight to network solution (black line) although PPP with no correlations still (red line) still has higher weight.

Scale Amplitude Spectra (height)



Main peak is dominated by annual period for both PBO and Global.
Harmonics are not so clear (next figure).

Scale Amplitude Spectra (height)



PBO solution is combination of GIPSY and GAMIT processing. Blend of harmonics of annual and draconitic varies

Summary

- Review of US Plate Boundary Observatory (PBO) processing as part of the NSF Geodesy Advancing Geosciences and EarthScope (GAGE) facility
- Processing methods:
 - New Mexico Tech (NMT): GAMIT double difference processing
 - Central Washington University (CWU): GIPSY Precise Point Positioning: Needs ITRF specific results. Clocks from repro convey the scale in the earlier ITRF.
- Impacts of scale changes: Regional effect and impact on double-difference introduction on global processing.
 - Importantly this is just the stations in the regional network not the whole world. Use of IGS combined SINEX files in addition to orbits etc.
- Processing details in Herring et al., Plate Boundary Observatory and Related Networks: GPS Data Analysis Methods and Geodetic Products, (2016) *Rev. Geophys.*, 54, doi:10.1002/2016RG000529.