

Surveying, Mapping, and Geosciences Session or the CORS User Forum

- Two talks
 - Giovanni Sella - CORS Products and Services
 - Andria Bilich – Antenna Calibrations
- Short 15 min break
- Open discussion

CORS Program Updates FY2010- 2011

Especially New Revised Coordinates

Giovanni Sella
CORS Program Manager
NOAA-National Geodetic Survey

CGSIC - Portland, OR
19 September, 2011

CORS News for FY10-11

- New CORS coordinates released September 6
- New absolute antenna calibrations released
- Updated HTDP to 3.1.2
- Passive network adjustment in the works
- Network grows to +1,800 stations
- OPUS supports two reference frames

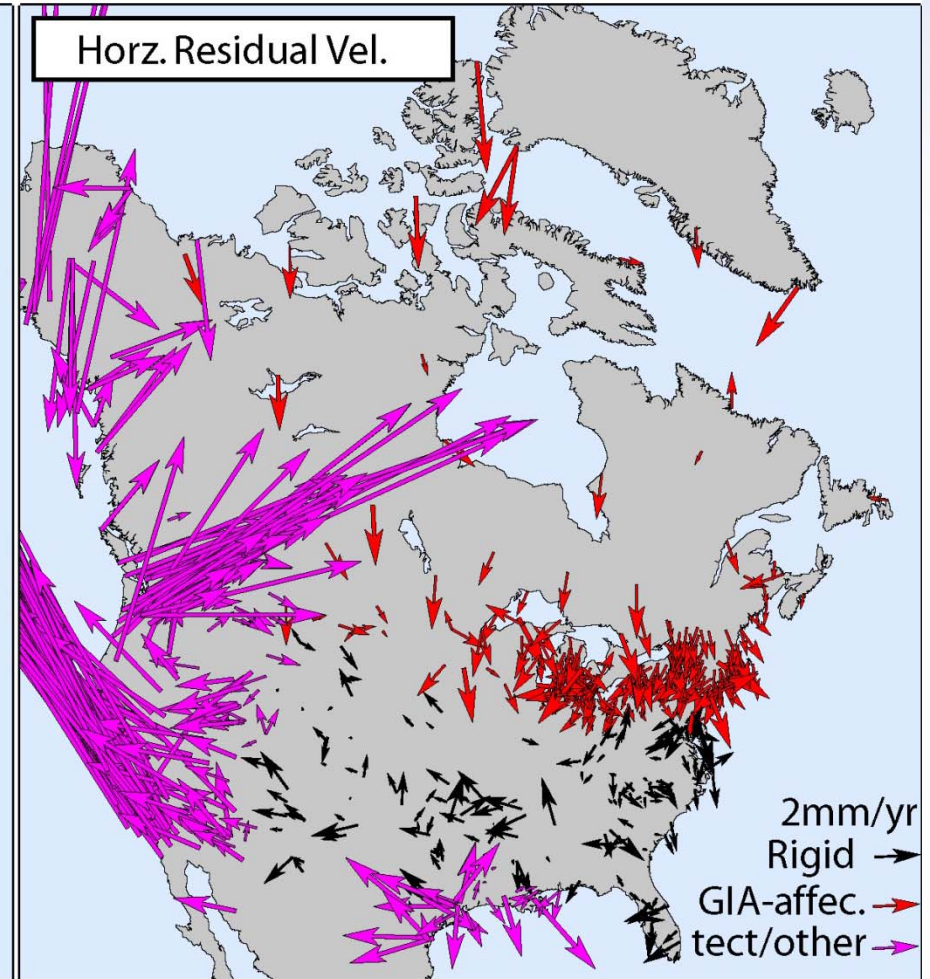
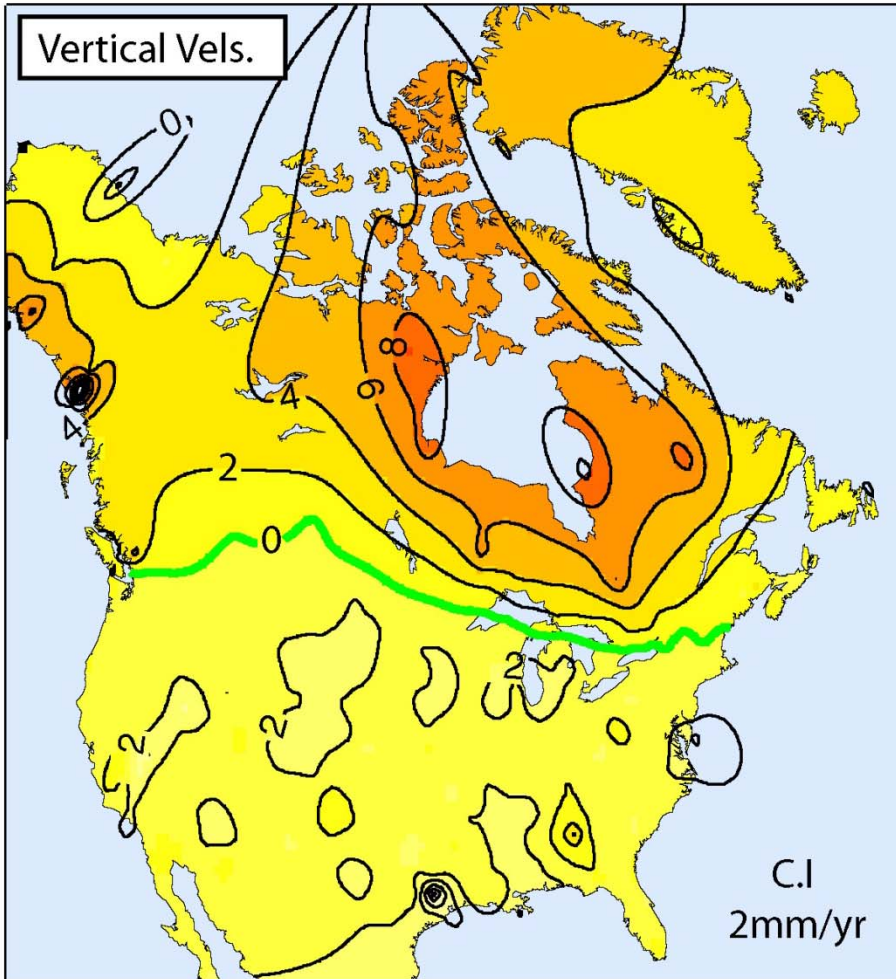
Previous CORS Coordinates

- Mixed coordinates and velocities from: last reprocessing (1994-2002), and adjustments using 8-3 IGS ref. sites
- Mixed HTDP vs. computed vel.; Vertical vel. = 0 mm/yr
- NGS's global frame was ITRF00 epoch 1997.0 projecting 14 yrs is unreliable; NAD 83(CORS96,MARP00,PACP00) epoch 2002.0 projecting 9 yrs becoming a problem
- Metadata issues, discontinuities/offsets
- Significant software changes
- Absolute vs relative antenna phase center values
- **Need to revise CORS coordinates and velocities**

Positions and Velocities Change!

CORS Multiyear soln.

Plate fixed



Reference Frame Definitions

- ITRF frame (global) multi-technique—vlbi, slr, doris, gnss
- IGS frame (global) GNSS only
- NAD frame (plate fixed) related to ITRF/IGS
- **Critical** to pay attention to **frame tags** and **epoch dates** and **antenna calibration values**

Frame Name	Epoch	Antenna PCV*	Data Duration
ITRF2000	1997.00	Rel	1994.0-2002.0
ITRF00 (NGS's soln)	1997.00	Rel NGS	1994.0-present
NAD 83(CORS96,MARP00,PACP00)	2002.00	Rel NGS	1994.0-present
IGS08	2005.00	Abs IGS08	1997.0-2009.5
IGS08 (NGS's soln)	2005.00	Abs IGS08	1994.0-2011.5 (ongoing)
NAD 83(2011,MA11,PA11)	2010.00	Abs IGS08	1994.0-2011.5 (ongoing)

*PCV – phase center value; Abs-Absolute, Rel-Relative

Reference Frames Used

- Basis is global frame inherited from ITRF2008 but not the same as ITRF2008
 - Name: **IGS08**
 - Epoch date: **2005.00** (same as ITRF2008, IGS08)
 - NGS has more discontinuities and weekly solutions than ITRF2008; and has applied IGS05_ATX -> IGS08_ATX corrections to be consistent with IGS08
- Related to ITRF, but plate fixed (NAD 83)
 - Name: **NAD 83(2011,MA11,PA11)**
 - Epoch date: **2010.00**
 - NAD 83(CORS96,MARP00,PACP00) to NAD 83(2011,MA11,PA11) identity transformation (i.e. same axes)
 - NAD 83(2011) axes origin different (~2m) from ITRF/IGS08 (expect reconciliation ~2022)

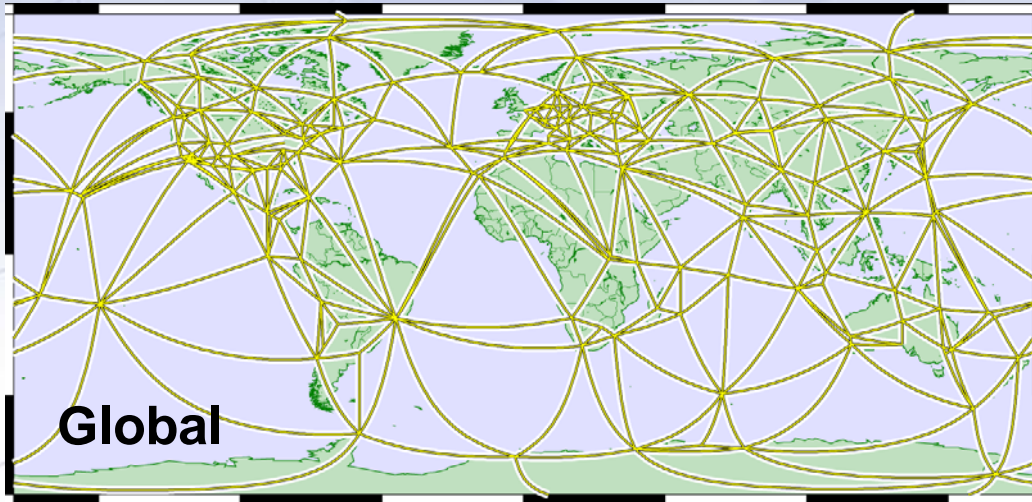
Reference Frames Used

- NAD 83(2011) epoch 2010.00
 - “2011” is datum tag i.e. year adjustment complete
 - “2010.00” is “epoch date” (January 1, 2010)
 - Date associated with coordinates of control station
 - Frame fixed to North American tectonic plate
 - Includes California, Alaska, Puerto Rico, and US Virgin Islands
- NAD 83(PA11) epoch 2010.00
 - Frame fixed to Pacific tectonic plate (Hawaii and American Samoa, and other islands)
- NAD 83(MA11) epoch 2010.00
 - Frame fixed to Mariana tectonic plate (Guam and CNMI)

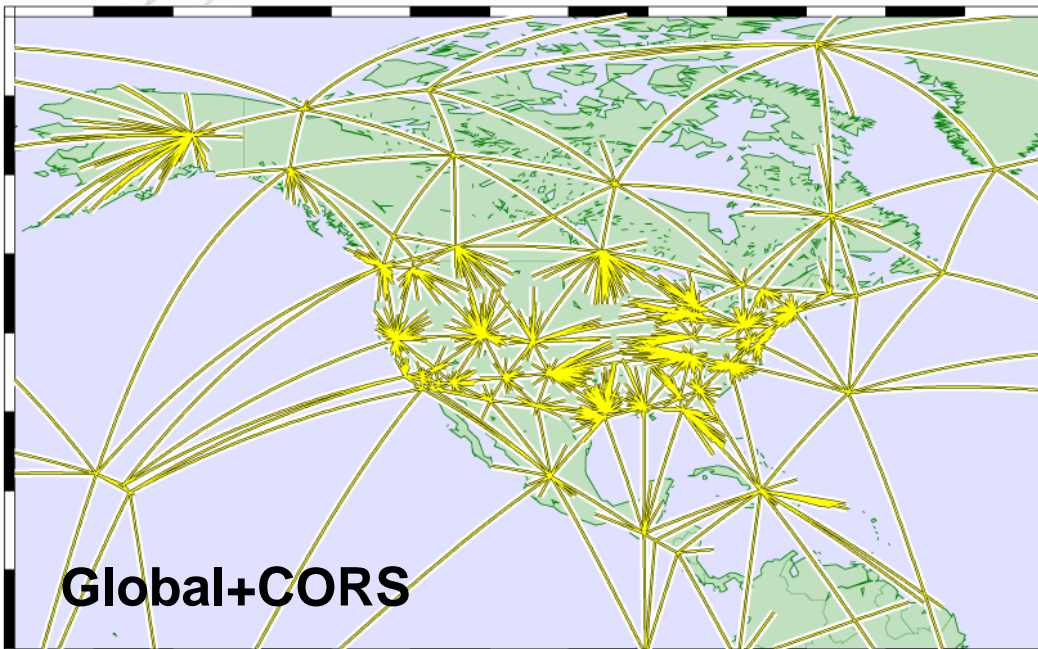
Reference Frames and Orbits

- IGS08 positions are not equal to ITRF2008
- ITRF2008 is multi-technique solution VLBI, SLR, DORIS, GPS
- IGS08 is a GPS only solution
- ITRF2008 GPS's component was processed using IGS05 absolute antenna calibrations
- To create IGS08 IGS took the ITRF2008 positions and applied a station specific correction to account for differences between IGS05 and IGS08 absolute antenna calibrations. Corrections of up to 5 cm
- All IGS orbit products in NGS online storage from 1994-Jan-1 to 2011-Apr-16 are aligned to IGS05 and then to IGS08. For most non-research applications the orbits can be mixed

Tying CORS to Global Frame

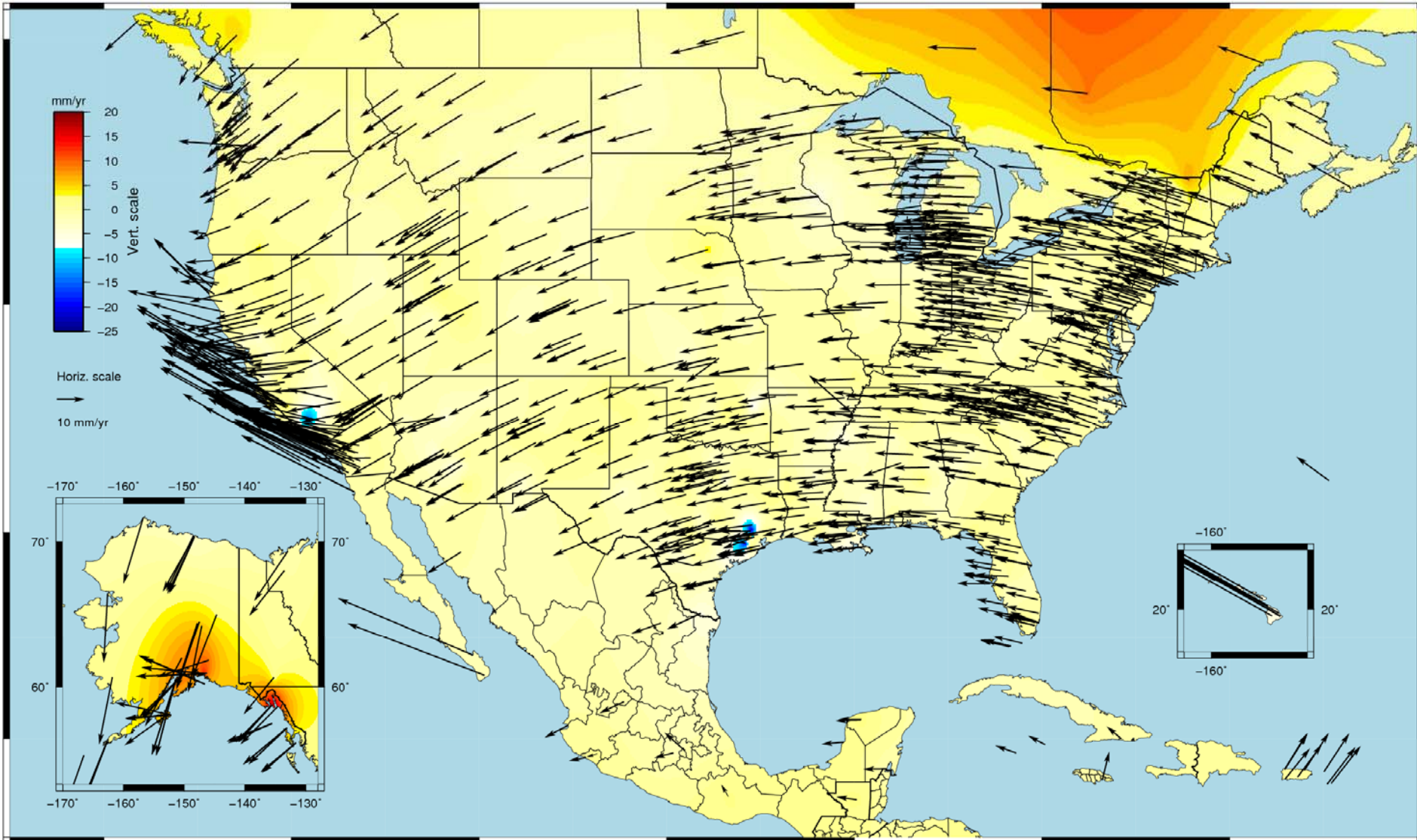


- global tracking network used for estimating:
 - GPS satellite orbits (15-min intervals)
 - terrestrial framework
 - Earth Orientation (EOPs)
 - global station positions (weekly averages)



- CORS tied to global framework via single baselines radiating from global stations
 - minimizes frame distortions from local effects in dense regional networks

CORS IGS08 Velocity Field



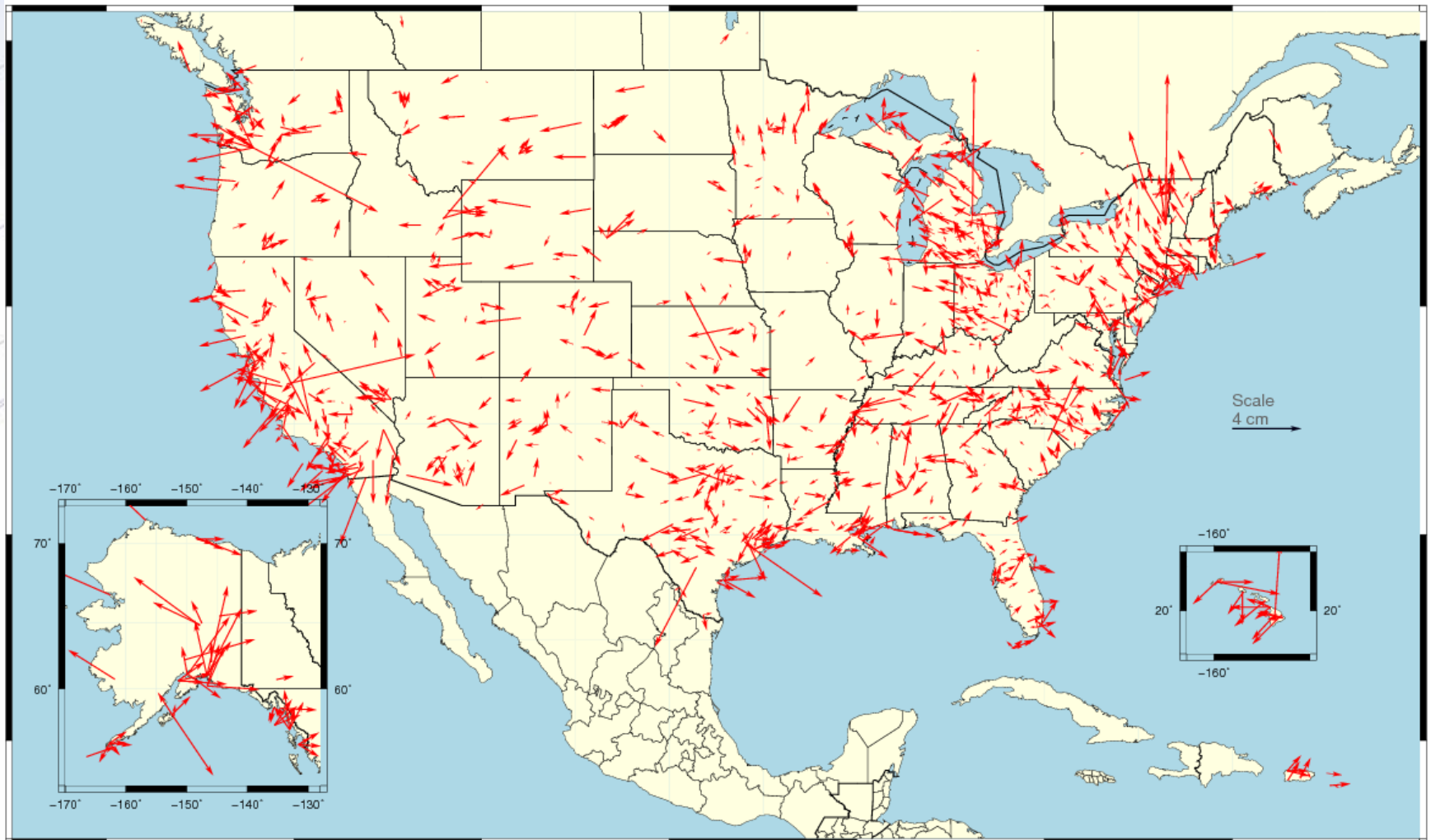
What is the new NAD 83?

- Same datum, so no transformation between NAD 83(CORS96,MARP00,PACP00) epoch 2002.00 and NAD 83(2011,MA11,PA11) epoch 2010.00
 - NAD 83 (2011,MA11,PA11) velocities should be used to move positions through time
- To assess differences in frames, need to compare positions at same epoch date (2002.00).
 - Will do this by taking new positions at CORS at 2010.00 and using NAD 83(2011,MA11,PA11) velocities to move to 2002.00

Changes in *Horizontal* NAD 83 Positions

NAD 83(2011) epoch 2002.00 – NAD 83(CORS96) epoch 2002.00

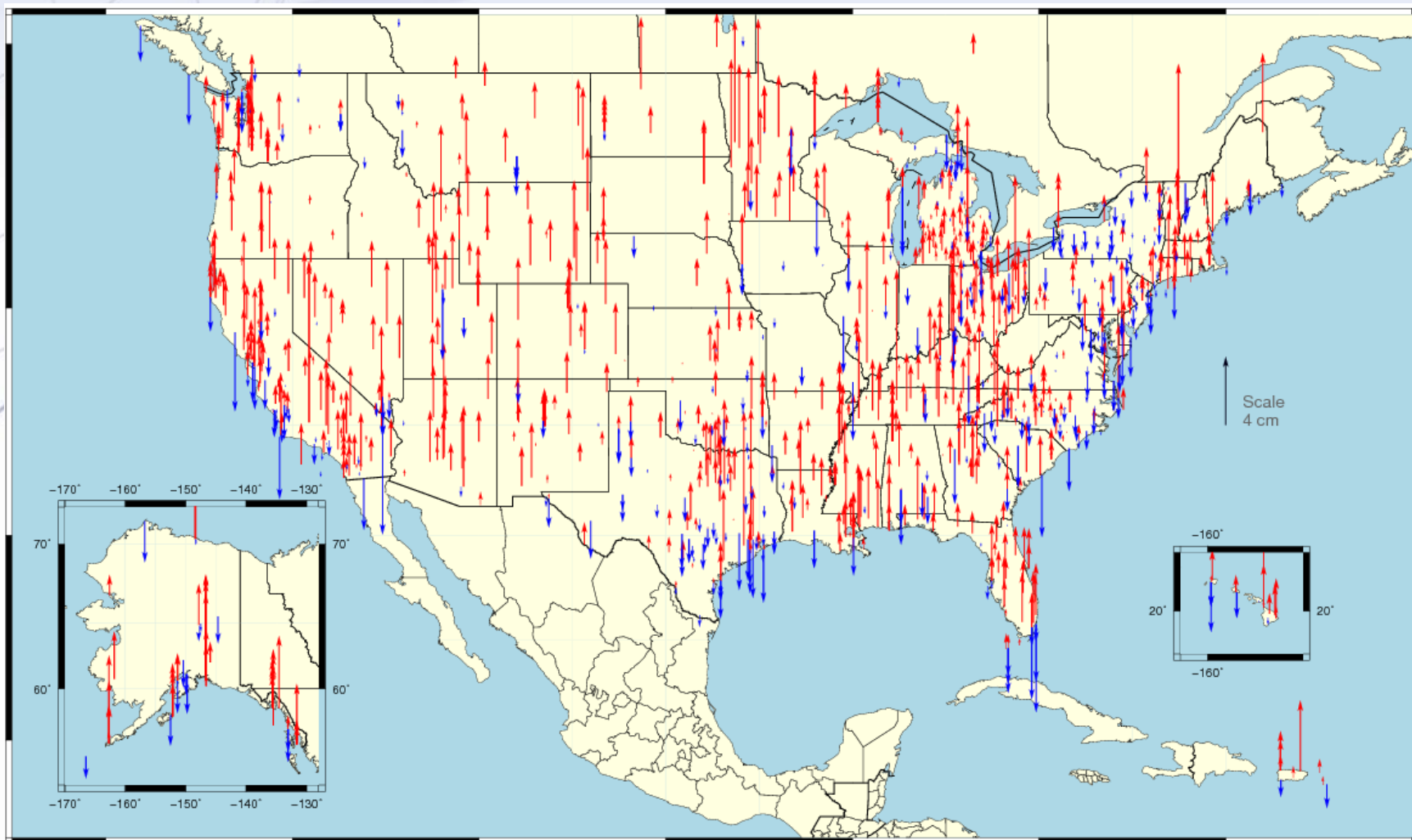
- Avg. shifts: $\Delta E = -0.14 \pm 1.04$ (ME -0.10) cm $\Delta N = 0.19 \pm 0.94$ (ME 0.20) cm
 - prescribing velocities using numerical models (i.e. HTDP)
 - smaller random part probably caused by change to absolute antenna calibrations



Changes in *Vertical* NAD 83 Positions

NAD 83(2011) epoch 2002.0 – NAD 83(CORS96) epoch 2002.0

- avg. shift: $\Delta U = 0.80 \pm 1.89$ (ME -0.70) cm
 - random part mostly caused by switch to absolute antenna calibrations
 - shifts also caused by assuming $V_u = 0$ in NAD 83(CORS96)



The NAD 83 datum is the same.

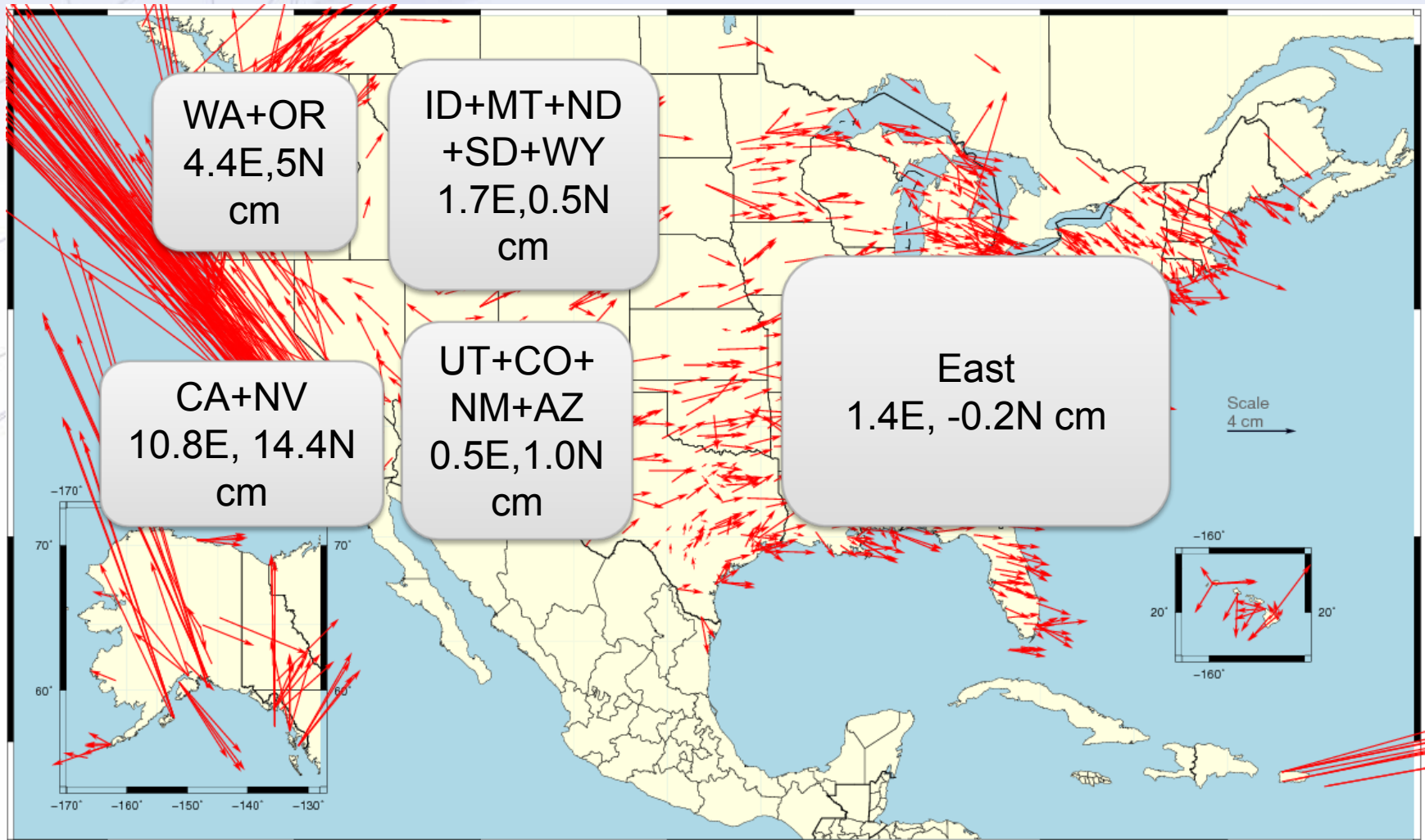
So what are the shifts caused by changing reference epoch to 2010?

- Previous 2 slides show consequences of new realization:
 - approx. 1-2 mm avg. horiz. shift
 - less than 1 cm avg. vert. shift
- **BUT** reference epoch has changed from 2002.00 to 2010.00
 - velocities are therefore critical
- Let's compare NAD 83(CORS96) positions @ 2002.00 to NAD 83(2011) positions @ 2010.00
 - differences dominated by effects of crustal motion, i.e., NAD 83 velocities are non-zero
 - **e.g. 2 mm/yr velocity after 8 years = 1.6 cm change in position**

Changes in *Horizontal* NAD 83 Positions Different Epochs

NAD 83(2011) epoch 2010.0 – NAD 83(CORS96) epoch 2002.0

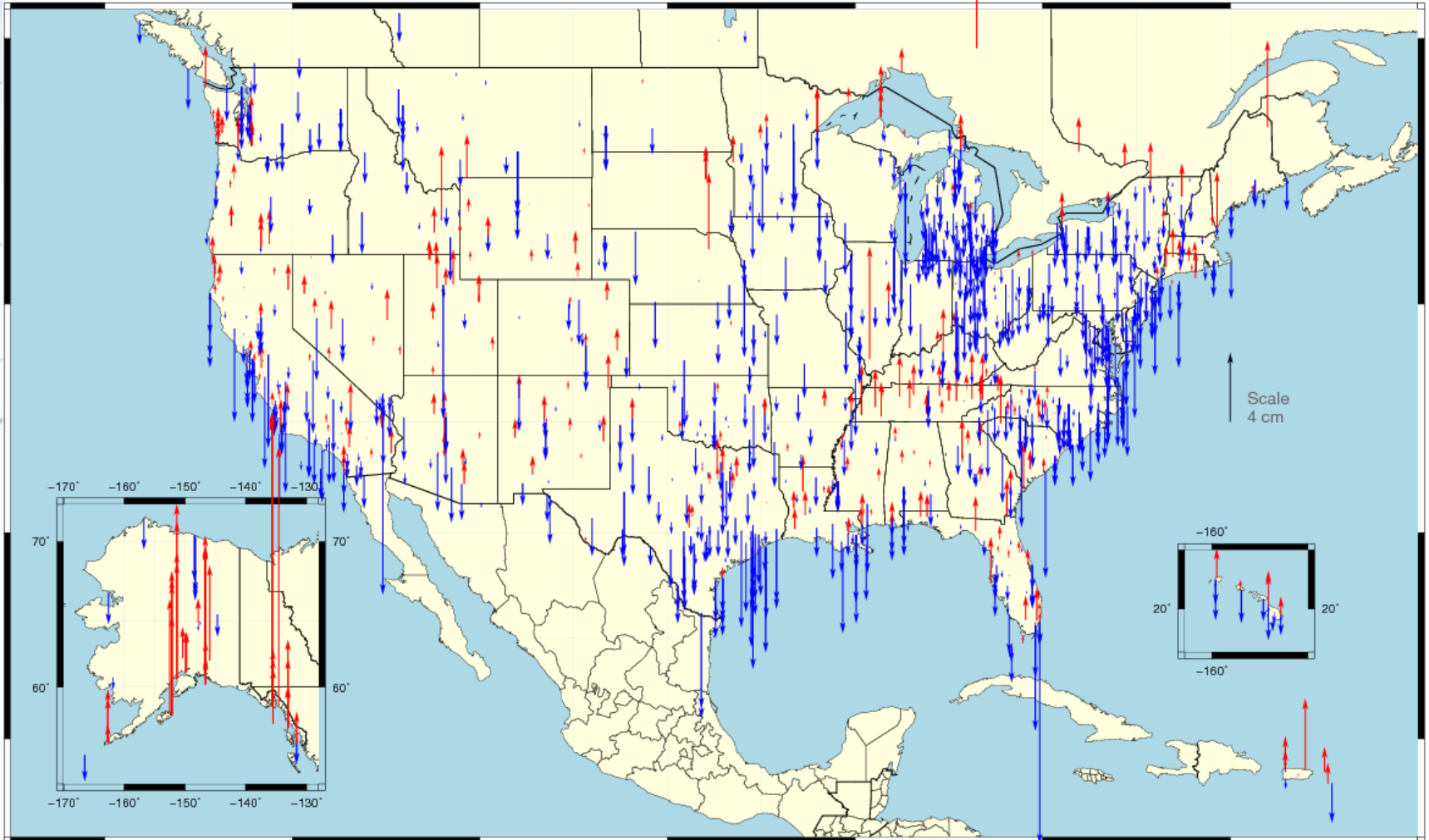
- Avg. shifts: $\Delta E = 0.05 \pm 5.25$ (ME -0.12) cm $\Delta N = 2.12 \pm 6.08$ (ME 0.00) cm
 - combination of position and velocity differences
 - due mostly to updated velocities (including up to 8 more years of data)



Changes in *Vertical* NAD 83 Positions Different Epochs

NAD 83(2011) epoch 2010.0 – NAD 83(CORS96) epoch 2002.0

- Avg. shifts: $\Delta U = -0.66 \pm 2.24$ (ME -0.80) cm
 - combination of position and velocity differences from additional data, tectonics
 - assuming vertical velocity ≈ 0.00 in NAD 83(CORS96)



Changes with New Frames

- Change from relative to IGS08 absolute antenna phase center values (PCV)
- The global frame (IGS08) pos/vel are aligned to full global frame >100 sites
- Change in epoch from 2002.00 to 2010.00 in NAD 83(2011/MA11/PA11)
- No longer support coordinates in ITRF00 or NAD 83 (CORS96,MARP00,PACP00)
- What amount of change/tolerance are permitted?
 - No change 2 cm horizontal, 4 cm vertical

Changes with New Frames

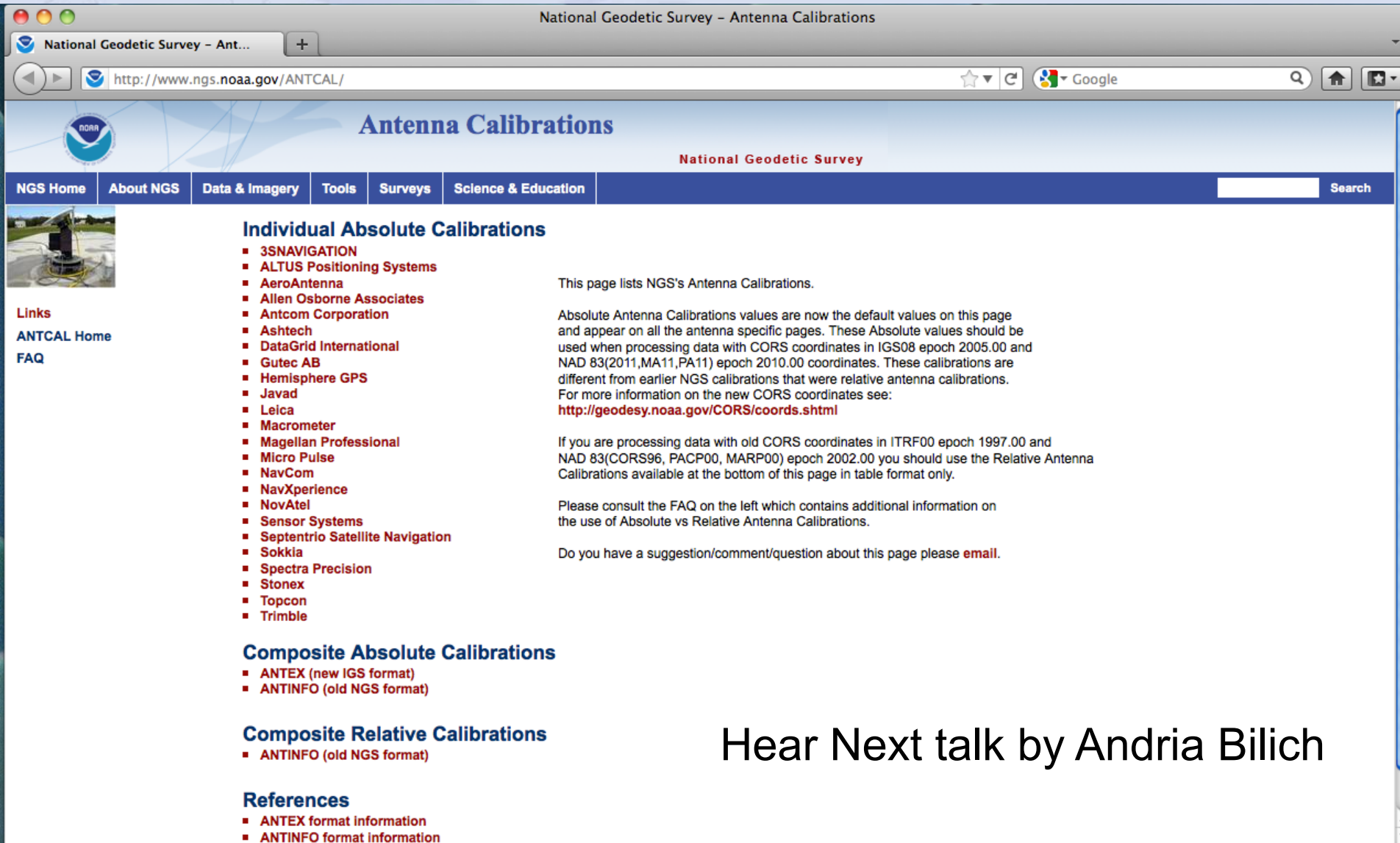
CORS coordinates clearly divided

- >2.5 yrs of data with positions and velocities from stacked solution (i.e. **computed**). Valid for “fixed” coordinates.
- <2.5 yrs of data positions from stacked solution, but velocities via HTDP (i.e. **modeled**).
- Users encouraged **not** to use CORS with **modeled** velocities, until computed vels. are avail. (may take up to 3 yrs). Important if holding coordinates fixed.
- CORS with unexplained coordinates changes marked as “questionable” until resolved/stable.

HTDP 3.1.2

- HTDP supports new frames
- Includes a basic gridded velocity field for Alaska
- A detailed and robust velocity and block model for Alaska should be available next year
- Preliminary work on a 3-dimensional has been completed, but more work is needed before it a beta version is ready

Antenna Calibrations




National Geodetic Survey - Antenna Calibrations

http://www.ngs.noaa.gov/ANTCAL/

Antenna Calibrations

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Individual Absolute Calibrations

- 3SNAVIGATION
- ALTUS Positioning Systems
- AeroAntenna
- Allen Osborne Associates
- Antcom Corporation
- Ashtech
- DataGrid International
- Gutec AB
- Hemisphere GPS
- Javad
- Leica
- Macrometer
- Magellan Professional
- Micro Pulse
- NavCom
- NavXperience
- NovAtel
- Sensor Systems
- Septentrio Satellite Navigation
- Sokkia
- Spectra Precision
- Stonex
- Topcon
- Trimble

This page lists NGS's Antenna Calibrations.

Absolute Antenna Calibrations values are now the default values on this page and appear on all the antenna specific pages. These Absolute values should be used when processing data with CORS coordinates in IGS08 epoch 2005.00 and NAD 83(2011,MA11,PA11) epoch 2010.00 coordinates. These calibrations are different from earlier NGS calibrations that were relative antenna calibrations. For more information on the new CORS coordinates see: <http://geodesy.noaa.gov/CORS/coords.shtml>

If you are processing data with old CORS coordinates in ITRF00 epoch 1997.00 and NAD 83(CORS96, PACP00, MARP00) epoch 2002.00 you should use the Relative Antenna Calibrations available at the bottom of this page in table format only.

Please consult the FAQ on the left which contains additional information on the use of Absolute vs Relative Antenna Calibrations.

Do you have a suggestion/comment/question about this page please [email](#).

Composite Absolute Calibrations

- ANTEX (new IGS format)
- ANTINFO (old NGS format)

Composite Relative Calibrations

- ANTINFO (old NGS format)

References

- ANTEX format information
- ANTINFO format information

Links

- ANTCAL Home
- FAQ

Hear Next talk by Andria Bilich


Information on New Coordinates

CORS Project Data Products - National Geodetic Survey

http://geodesy.noaa.gov/CORS/data.shtml

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CORS Data Products

GPS data collected at CORS sites are available to download for "post-processing."
Data Availability and Retention Policy

Methods of Obtaining CORS Data

1. Customized
User Friendly CORS (UFCORS)
2. Standard
standard1.shtml
3. Anonymous FTP
Primary server <ftp://www.ngs.noaa.gov/cors/> - [Directory Tree](#)
Alternate server <ftp://alt.ngs.noaa.gov/cors/> - [Directory Tree](#)

CORS Coordinates
Published coordinates at CORS **Explained**
Predict horizontal displacements with **HTDP**

Metadata / Station Logs
Station/site log files contain all the historical equipment (receiver/antenna) used at that site, approximate location, owner and operating agency, etc. We must stress that the the position/coordinates listed in the log file like that in the RINEX header files should be considered APPROXIMATE. When a user downloads data they should at the same time download the published NGS coordinate (position and velocity) file for that site. You can find that file [here](#).
Show Directory of All Logfiles

For a sortable list of all CORS sites and their status go [here](#)

CORS Site List (kml) The coordinates listed in this KML file are for reference frame ITRF00, epoch 1997.0 which are assumed equivalent to WGS84 (G1150).
..... In absolute positioning, the frame WGS84 (G1150) is materialized not by the coordinates of marks on the surface of the Earth - as the NAD83 (CORS96) is - but by the coordinates of points in space, namely, the 3-D location of the GPS satellites (given by their precise or broadcast satellite ephemerides). Recent investigations (True, 2004) have shown that for all practical purposes, the WGS84 (G1150) frame is identical

CORS

Enter 4-char SiteId

Enter partial string to find SiteId, Site Name, or City

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http://www.ngs.noaa.gov/CORS/coords.shtml

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CORS Coordinates

This page describes the current coordinates published at CORS sites by NGS as well as links to information about older coordinates.

IGS08 epoch 2005.00 Coordinates

Since April 17, 2011, the National Geodetic Survey (NGS) and the other Analysis Centers of the International GNSS Service (IGS) have been providing GPS satellite orbits (ephemerides) that are referred to a new terrestrial reference frame, called IGS08 and defined by the IGS. This new frame is based on GPS observations and was designed to be consistent with the International Terrestrial Reference Frame of 2008 (ITRF). ITRF2008 is the latest frame realization of the International Earth Rotation and Reference Systems Service (IERS) and is a multi space-based geodetic technique solution, combining Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) and GPS data. Although, the best fitting Helmert transformation between IGS08 and ITRF2008 for a set of well-established, international GNSS satellite tracking sites is the identity function, the transformed ITRF2008 positions have a site specific "correction" applied to them to create IGS08 positions (for additional details on IGS08 consult the following IGSMAILs [6354](#), [6355](#), [6356](#), [6374](#)). Thus the IGS08 position for a particular site may differ from its corresponding ITRF2008 position; however, the velocities remain identical. By using IGS08 coordinates and the associated absolute antenna calibrations in combination with IGS orbits a consistent frame is realized. In addition, NGS has updated the IGS orbits from January 1, 1994 to April 16, 2011 in its online storage with the recently released IGS reprocessed (repro1) orbits that are all aligned consistently with IGS05. For most non-research applications, users can freely mix IGS05 and IGS08 orbits to compute coordinates for control points.

NAD83(2011,MA11,PA11) epoch 2010.00 Coordinates

On September 6, 2011, NGS updated the National Spatial Reference System NAD 83 (CORS96, MARP00, PACP00) positions and velocities for all CORS sites, to NAD 83 (2011, MA11, PA11). The NAD 83 (2011) frame, which is relative to the fixed North American plate, is used to define the coordinates for sites located in the CONterminous United States (CONUS), Alaska and US territories in the Caribbean. The NAD 83 (MA11) frame is realized with respect to the fixed Marianas plate and is used to define coordinates in the Marianas. The NAD 83 (PA11) is a Pacific plate fixed frame and is used to define coordinates in Hawaii, American Samoa, the Marshall Islands and other US territories residing on the Pacific Plate. For informative articles about NAD 83 see [Snay and Soler, 2000](#), [Snay, 2003](#). The new realization of NAD 83 involves no datum change, which means that, the origin, scale and orientation of NAD 83(2011) are identical to those of NAD 83(CORS96), and the same for the two other frames. The coordinates are not the same in the old and new realizations for multiple factors including the switch to absolute antenna calibrations, new/revised processing algorithms, improved discontinuity identification, several years of additional GPS data, change in reference epoch, and an improved definition of the global reference frame, IGS08. For a description of how NAD 83 is related to the global reference frame see [Craymer et al., 1999](#), [Snay and Soler, 1999](#). Users working in Canada should consult [Craymer , 2006](#) for a review of how NAD 83 is implemented in Canada. Concisely, the two biggest changes are caused by the change in reference epoch and the move from relative to absolute antenna calibrations.

Change in reference epoch

The new reference epoch has changed by 8 years from 2002.00 to 2010.00. The published NAD 83 coordinates correspond to the position of the site at January 1 2010 (or equivalently, epoch 2010.00), and if a position at a different time is required then the published velocity must be applied and a new position computed. By using a more recent epoch, systematic errors that occur when points are positioned relative to CORS without applying to them appropriate site velocities are reduced. This more current reference epoch date will especially benefit those involved in

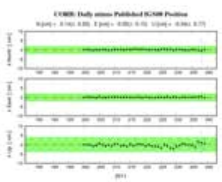
Info on New Coordinates



CORS

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CORS Repeatability Plots

60-day plots show the repeatability of a site for the last 60-days with respect to the published IGS08 position corrected for the effect of the published velocity. These plots are updated daily. For a detailed explanation of these plots go [here](#).

Long-term plots show the show weekly residual positions with respect to the published IGS08 coordinates from our stacked solution. Newer sites may not have a long-term plot if they were added after 16 April 2011. For a detailed explanation of these plots go [here](#).

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Enter SiteID

Enter 4-char SiteID

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Enter partial string to find SiteID, Site Name, or City

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ab11 60-day long-term	ab12 60-day long-term		
ab14 60-day long-term	ab15 60-day long-term	ab17 60-day long-term	ab18 60-day long-term
ab22 60-day long-term	ab27 60-day long-term	ab33 60-day long-term	
ab37 60-day long-term	ab39 60-day long-term	ab41 60-day long-term	ab45 60-day long-term
ab48 60-day long-term	abq5 60-day long-term	abq6 60-day long-term	
abvi 60-day long-term	ac07 60-day long-term	ac09 60-day long-term	
ac24 60-day long-term	ac26 60-day long-term	ac31 60-day long-term	
ac38 60-day long-term	ac39 60-day long-term	ac40 60-day long-term	ac47 60-day long-term
ac52 60-day long-term	ac57 60-day long-term		
acso 60-day long-term	acu5 60-day long-term	acu6 60-day long-term	
adks 60-day long-term	adri 60-day long-term	ahid 60-day long-term	ais5 60-day long-term
ais6 60-day long-term	al20 60-day long-term	al30 60-day long-term	al35 60-day long-term

What About the Passive Network?

- National Adjustment of 2011 (NA2011)
 - New adjustment of GPS passive control
 - GPS vectors tied (and constrained) to CORS NAD 83(2011/MA11/PA11) epoch 2010.00
 - Approximately 80,000 stations and more than 400,000 GPS vectors
- Realization will be the same for CORS **and** passive marks
- National Adjustment of 2011
 - Goal: Complete by end of CY 2011/early 2012
 - Deadline for submitted projects: Aug 31, 2011

What About the Passive Network?

- Optimally align passive control with new CORS
- Add >1000 projects submitted since 2007
 - Also observations for Hawaii, other Pacific islands
- Network and local accuracies on all stations
 - Including future submitted projects
- More consistent results in tectonically active areas
 - More current data, better tectonic modeling (HTDP 3.1.2)
- Better computations and analysis techniques
 - Improved outlier detection
 - Incorporation of lessons learned from previous national adjustment

Orthometric Heights and Geoid Model

- New hybrid geoid model (GEOID12)
 - Use NAD 83(2011) epoch 2010.00 ellipsoid heights on NAVD 88 benchmarks
 - Might also use OPUS-Database results on NAVD 88 benchmarks
- Available after passive adjustment is completed
- **Considering** performing a national vertical adjustment
 - Constrain vertically to NAVD 88 benchmarks
 - Perform a simultaneous nationwide adjustment
 - GNSS-derived orthometric heights
 - NAD 83(2011) ellipsoid heights with GEOID12
 - **NOT** a readjustment of NAVD 88 leveling

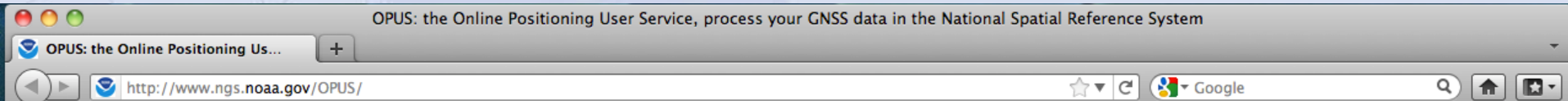
New Datasheets

- Update to new Datasheet version (8.00)
 - Changed location, length, and text for many fields
 - Added new fields, deleted fields, augmented existing fields
 - Implemented by end of calendar year 2011
 - Will add announcement and prototype to NGS web site soon

OPUS

- No changes in processing engines (OPUS-S and OPUS-RS)
- User can choose to get results in either old or new frames
 - Old frame available till passive adjustment is completed
- OPUS-DB results currently available in both frames.
 - When passive adjustment is completed all COR96/MARP00/PACP00 will be recomputed to 2011/MA11/PA11
- OPUS-Projects still beta hopefully operational next year

OPUS cont'd



OPUS: Online Positioning User Service

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On September 6, 2011 NGS's CORS group released **revised coordinates** for all CORS sites. The new coordinates update both the global frame and the National Spatial Reference Frame as follows.

<u>New Frames</u>		<u>Previous Frames</u>	
IGS08	Epoch 2005.00	ITRF00	Epoch 1997.00
NAD 83(2011)	Epoch 2010.00	NAD 83(CORS96)	Epoch 2002.00
NAD 83(MA11)	Epoch 2010.00	NAD 83(MARP00)	Epoch 2002.00
NAD 83(PA11)	Epoch 2010.00	NAD 83(PACP00)	Epoch 2002.00

NGS is in the process of completing an **adjustment of the passive control network**. Until the adjustment is complete, OPUS will allow users to choose getting coordinates in either the new or previous reference frames. Once the passive network is adjusted to NAD 83(2011, MA11, PA11) then the OPUS support for ITRF00 and NAD 83(CORS96, MARP00, PACP00) will end.

Choose one of the following buttons to upload your data.

NAD 83(2011,MA11,PA11)
epoch 2010.00

IGS08

NAD 83(CORS96,MARP00,PACP00)
epoch 2002.00

ITRF00

- **Q:** Which button/reference frame should I choose to get my solution?
 - **A:** Most users should start using the new reference frame, especially for users who are only interested in the global reference frame i.e. IGS08. Users who are in the middle of a project, will probably want to continue using their original reference frame.

- **Q:** How much will OPUS coordinates change if I use the new reference frame?
 - **A:** The biggest changes in the coordinates are caused by the change from relative to absolute antenna calibrations and the change in reference epoch as defined at the top of this page. OPUS coordinate changes should mimic those of the CORS namely: Difference of NAD 83(2011) epoch 2010.00 minus NAD 83(CORS96) epoch 2002.00: mean East 0.05±5.25 cm; North 2.12±6.08 cm; Up -0.66±2.24cm and median values of: East -0.12 cm; North 0.00 cm; Vertical -0.80 cm. For maps showing differences in CORS coordinates see this [FAQ](#).

- **Q:** Has the OPUS processor changed?
 - **A:** No. The OPUS processor simply points to the new set of CORS coordinates and absolute antenna calibrations.

Summary

- Users must use appropriate antenna calibrations with particular reference frames
- All NGS Products and Services will be in consistent frames in 2012:
 - IGS08 epoch 2005.00
 - NAD 83(2011,MA11,PA11) epoch 2010.00
- User should start thinking that transforming between frames is problematic need to plan to reprocess with new frames

Questions/Comments

- We recognize that NGS and the public want CORS to be the primary access to the NSRS, but **accuracy and constancy are not always possible.**
- We are keen to hear your comments/concerns
- Check: geodesy.noaa.gov/CORS/news.shtml
geodesy.noaa.gov/CORS

Choose **Data Products**

giovanni.sella@noaa.gov