

New Coordinates for CORS Sites

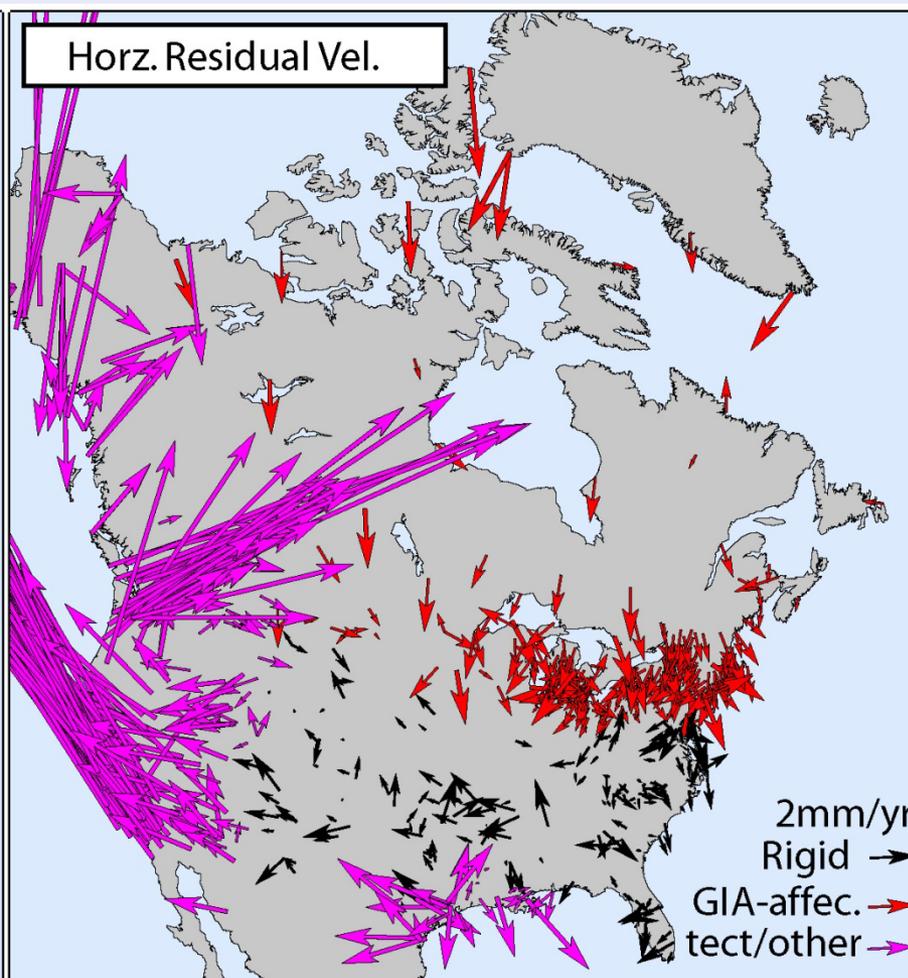
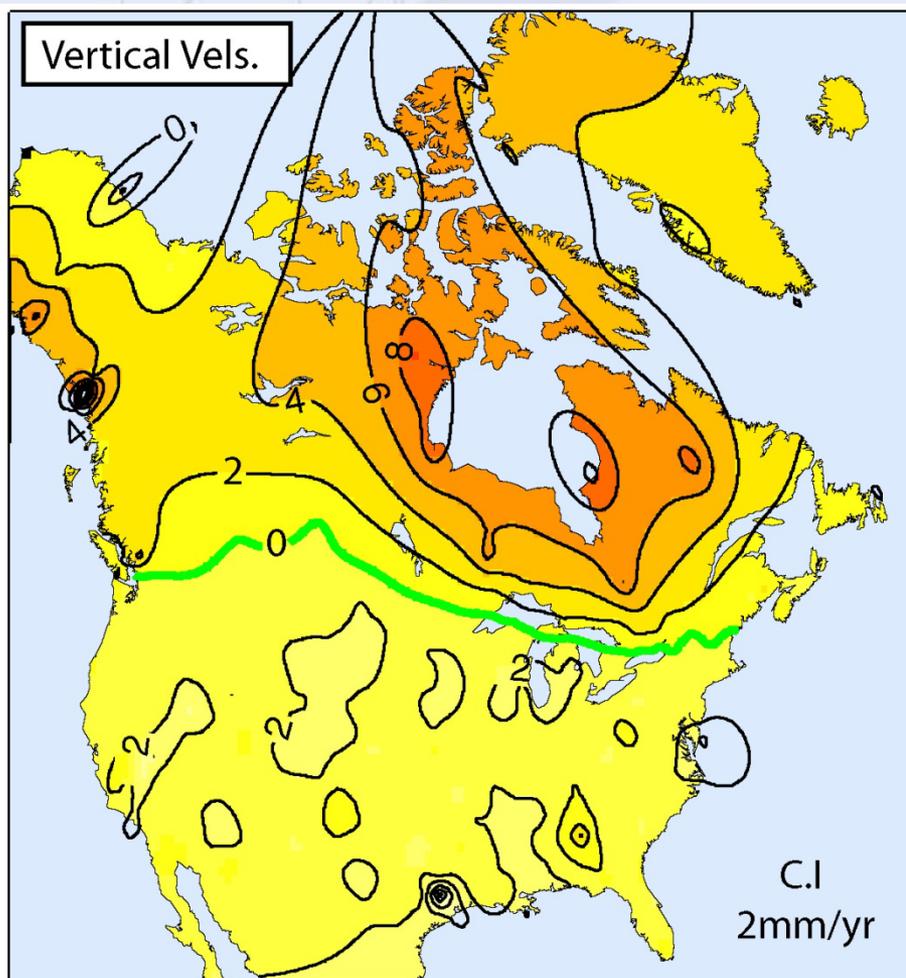
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NOAA-National Geodetic Survey

Silver Spring, MD
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Coordinates and Velocities they move!

Preliminary CORS Multiyear soln.

Plate fixed



Current CORS Coord. and Vel.

- 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 current global frame is ITRF00 epoch 1997.0 projecting 13 yrs is unrealistic; NAD 83(CORS96) epoch 2002.0 projecting 8 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**

Solution: “multiyear”

- “Multiyear” effort began 5 years ago
- Began with a revision of PAGES and processing strategy driven by weak NGS orbit contribution to IGS.
- IGS proposed re-processing all data to re-compute station coordinates, orbits and EOPs from 1994-present
- **Richard Snay** provided resources and managed the effort of the “multiyear” effort till May 2010
- Team: K. Choi, M. Cline, B. Dillinger, B. Dulaney, J. Griffiths, S. Hilla, B. Kass, J. Ray, J. Rohde, G. Sella, R. Snay, T. Soler, M. Schenewerk, and G. Ray

Frame Definition and Nomenclature

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

Frame Name	Epoch	Antenna PCV*	Data Duration
ITRF2000	1997.0	Rel ANTEX	1994.0-2002.0
ITRF00 (NGS's soln)	1997.0	Rel NGS ANTEX	1994.0-present
NAD 83(CORS96)	2002.0	Rel NGS ANTEX	1994.0-present
ITRF2008	2005.0	Abs IGS05 ANTEX	1997.0-2009.5
IGS08	2005.0	Abs IGS08 ANTEX	1997.0-2009.5
IGS08 (NGS's tentative)	2005.0	Abs IGS08 ANTEX	1994.0-2010.5 (ongoing)
NAD 83(2011) (tentative)	2010.0	Abs IGS08 ANTEX	1994.0-2010.5 (ongoing)

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

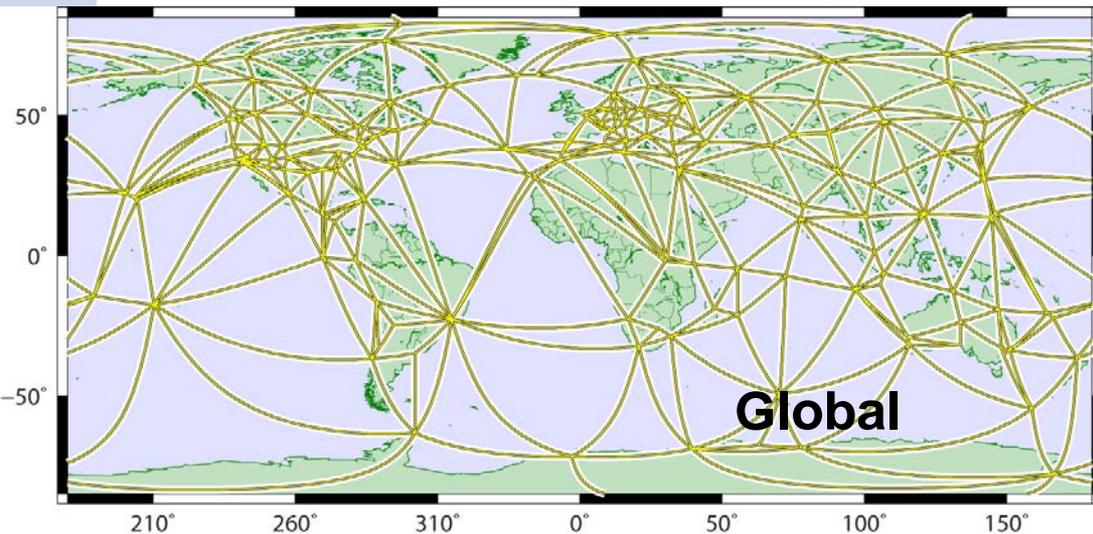
Jake Griffiths will now describe our reprocessing strategy and the results for CORS coordinates

Work Completed

- CORS RINEX observations from 1994 thru 2010.5 processed in fully consistent global framework
 - evaluated approx. 90 billion double-difference observation eqs.
 - using latest IERS models and processing methods
 - switch to absolute antenna calibrations
 - reduced positioning errors and distortions of global frame
- 860 weekly (full history) CORS+global SINEX files containing X,Y,Z positions and full variance-covariance information
- used CATREF software from Institut Géographique National (IGN) to stack weekly CORS+global SINEX files in three steps:
 - step 1: focused on attenuating aliasing of Helmerts from local non-linear motions
 - step 2: impose “unbiased” Helmert parameters on whole network & stack
 - step 3: obtain MYCS—i.e., align “unbiased” stacked TRF to ITRF2008 via GPS sites common to both SNXs
- resulted in a set of new positions and velocities for CORS
 - 4,906 position and velocity estimates for 2,264 CORS+global stations
 - solution aligned to ITRF2008 with negligible distortions of the frame
 - solution calibrated to be used with impending **igs08.atx**

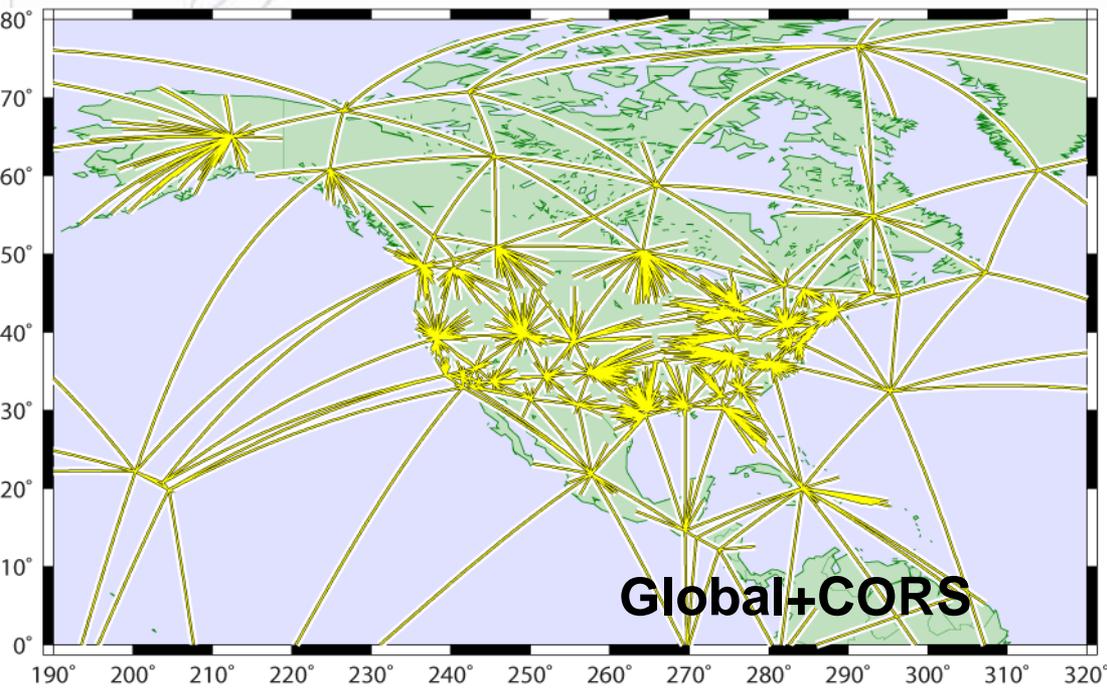
Tying CORS to Global Network

(~1600 sites in recent weekly CORS+gbl SNX files)



- **global tracking network used for estimating:**

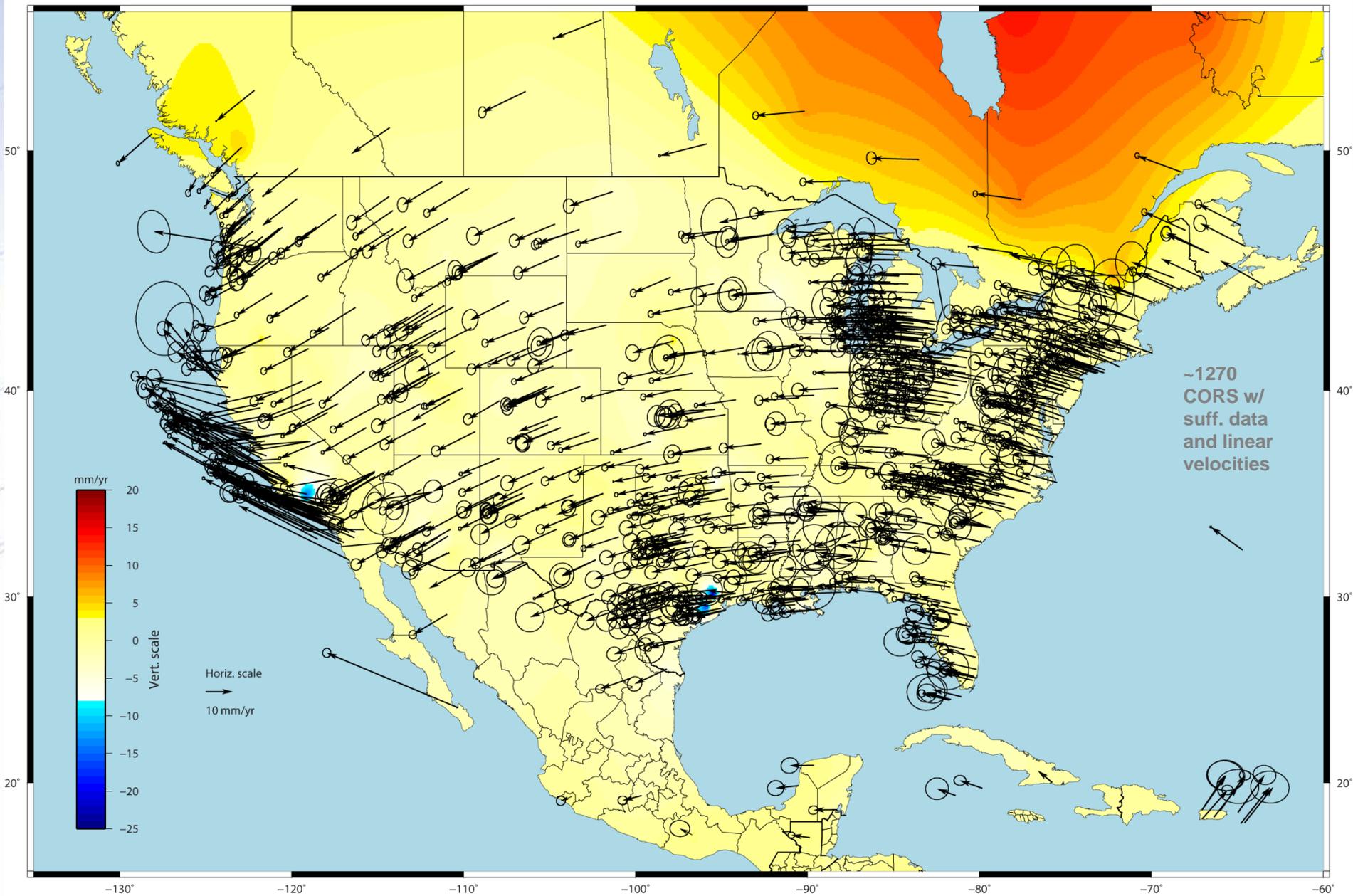
- GPS satellite orbits (15-min intervals)
- terrestrial framework
 - Earth Orientation (EOPs)
 - global station positions (weekly averages)



- **U.S. 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



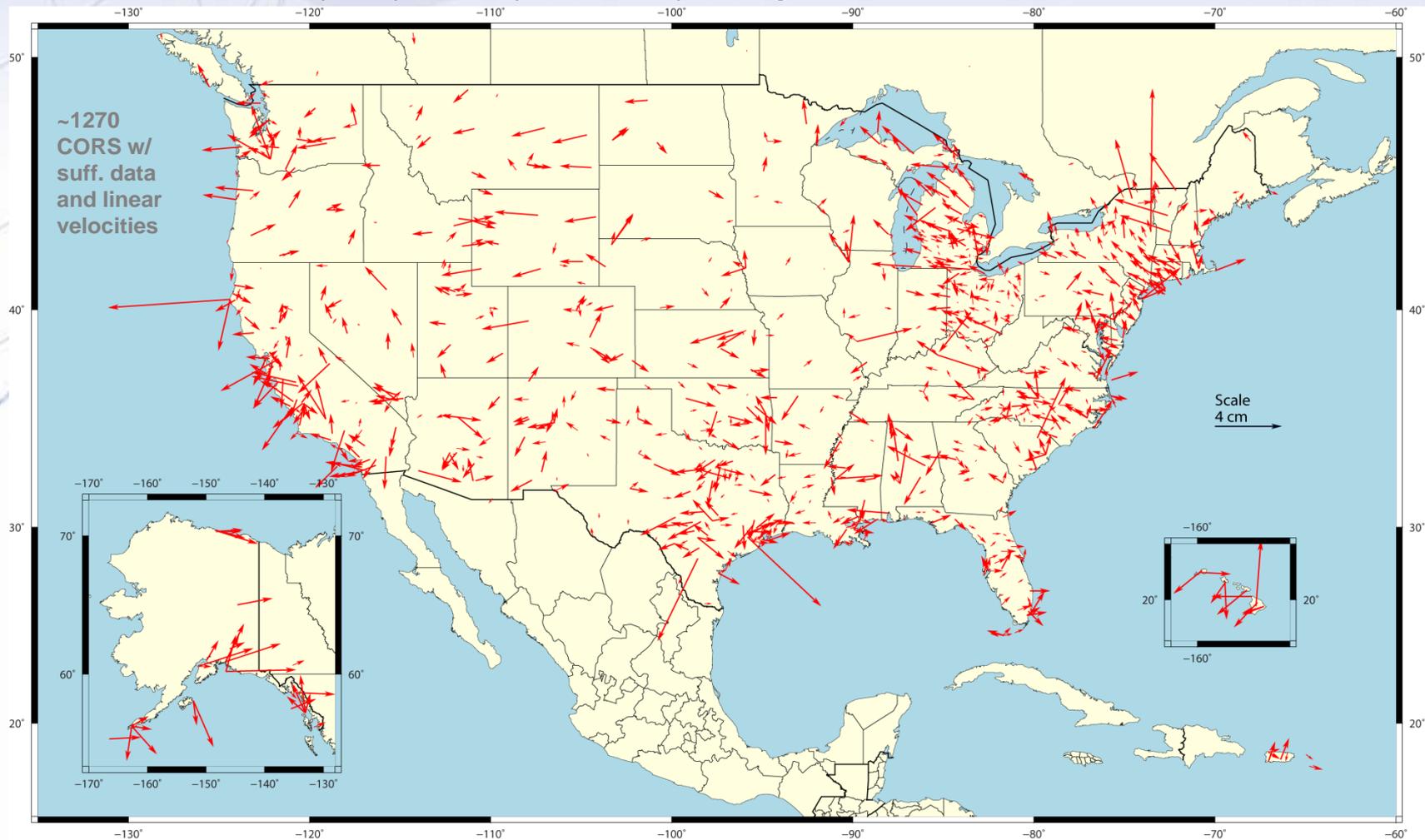
What is the new NAD 83 frame?

- Same datum, so no need for transformation between NAD 83(CORS96) epoch 2002.0 and NAD 83(2011) epoch 2010.0
 - NAD 83 (2011) velocities should be used to move positions through time
- So, first to assess differences, need to compare at same epoch date (2002.0) using NAD 83(2011) velocities to move new positions to 2002

Changes in *Horizontal* NAD 83 Positions

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

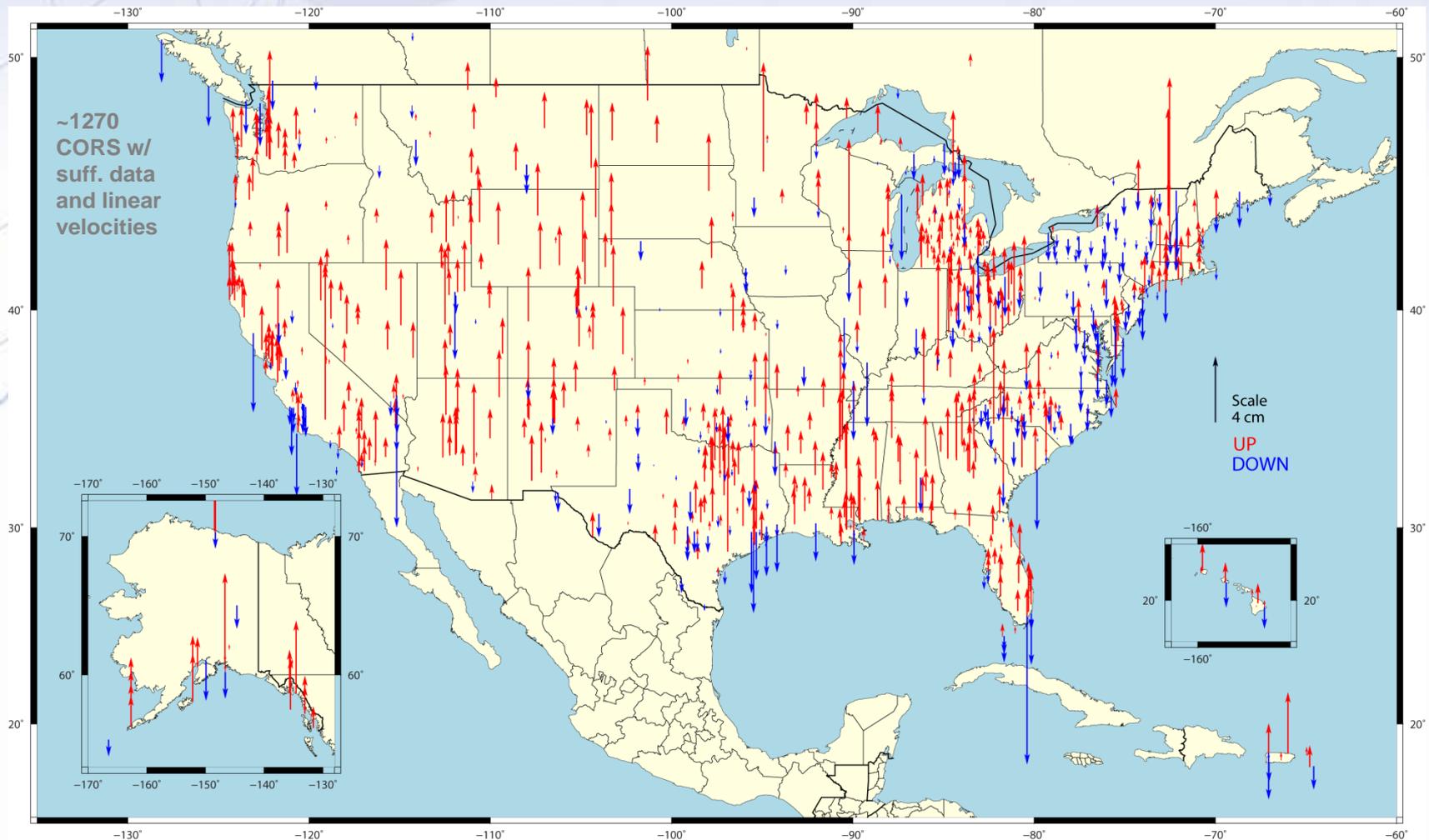
- approx. 2 cm error expected @ 2005.0 (based on σ in old solution)
- avg. horizontal shifts: $\Delta E = -0.18 (\pm 1.86) \text{ cm}$ $\Delta N = 0.14 (\pm 1.07) \text{ cm}$
 - prescribing velocities using numerical models (i.e. HTDP)
 - smaller random part probably caused by change to absolute antenna calibrations



Changes in *Vertical* NAD 83 Positions

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

- avg. vertical shift: $\Delta U = 0.71 \text{ cm} (\pm 2.11) \text{ cm}$
 - 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.

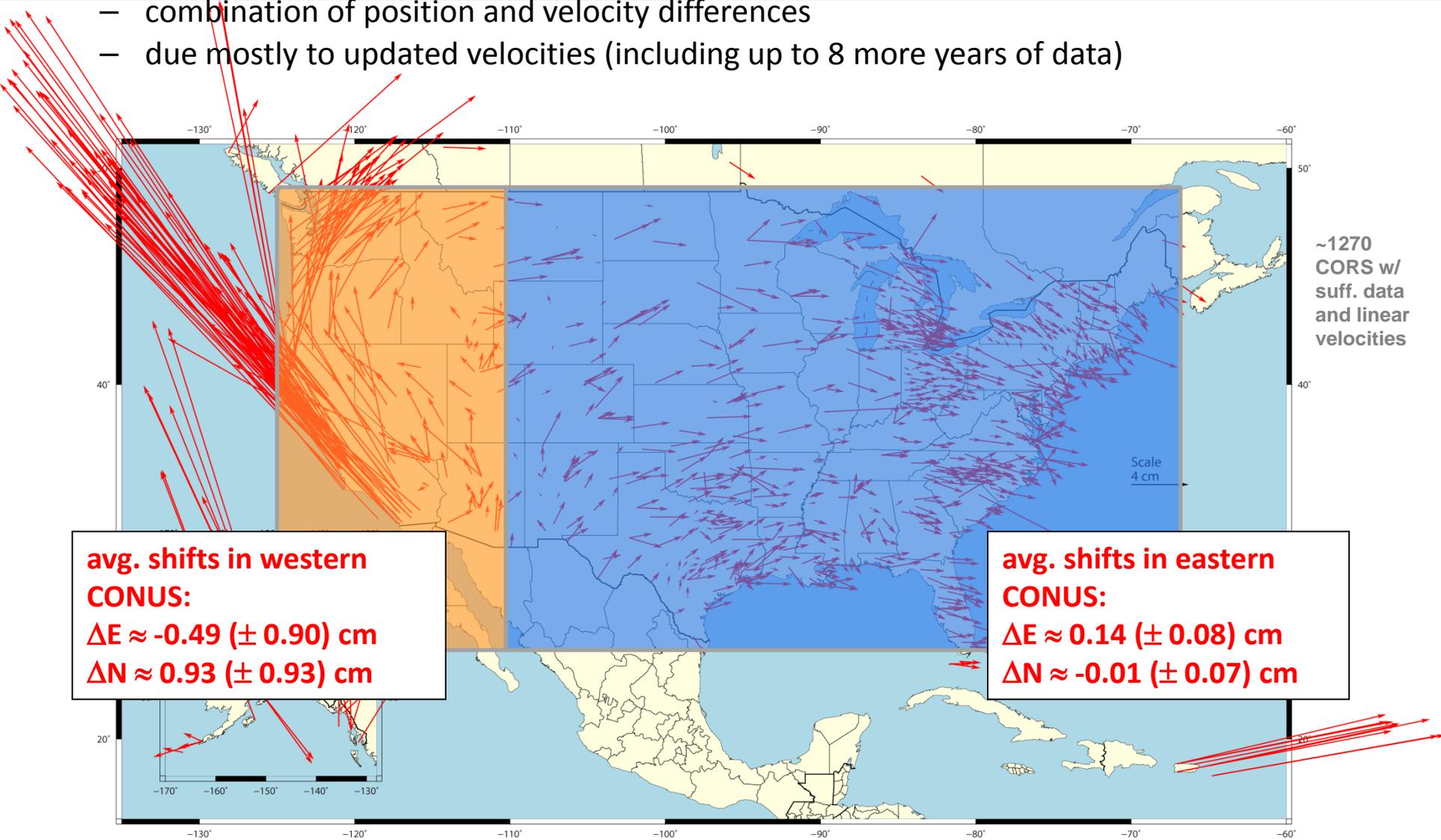
So what will be the shifts caused by changing reference epoch to 2010?

- 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 will change from 2002.0 to 2010.0
 - velocities are therefore critical
- let's compare NAD 83(CORS96) positions @ 2002.0 to NAD 83(2011) positions @ 2010.0
 - 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

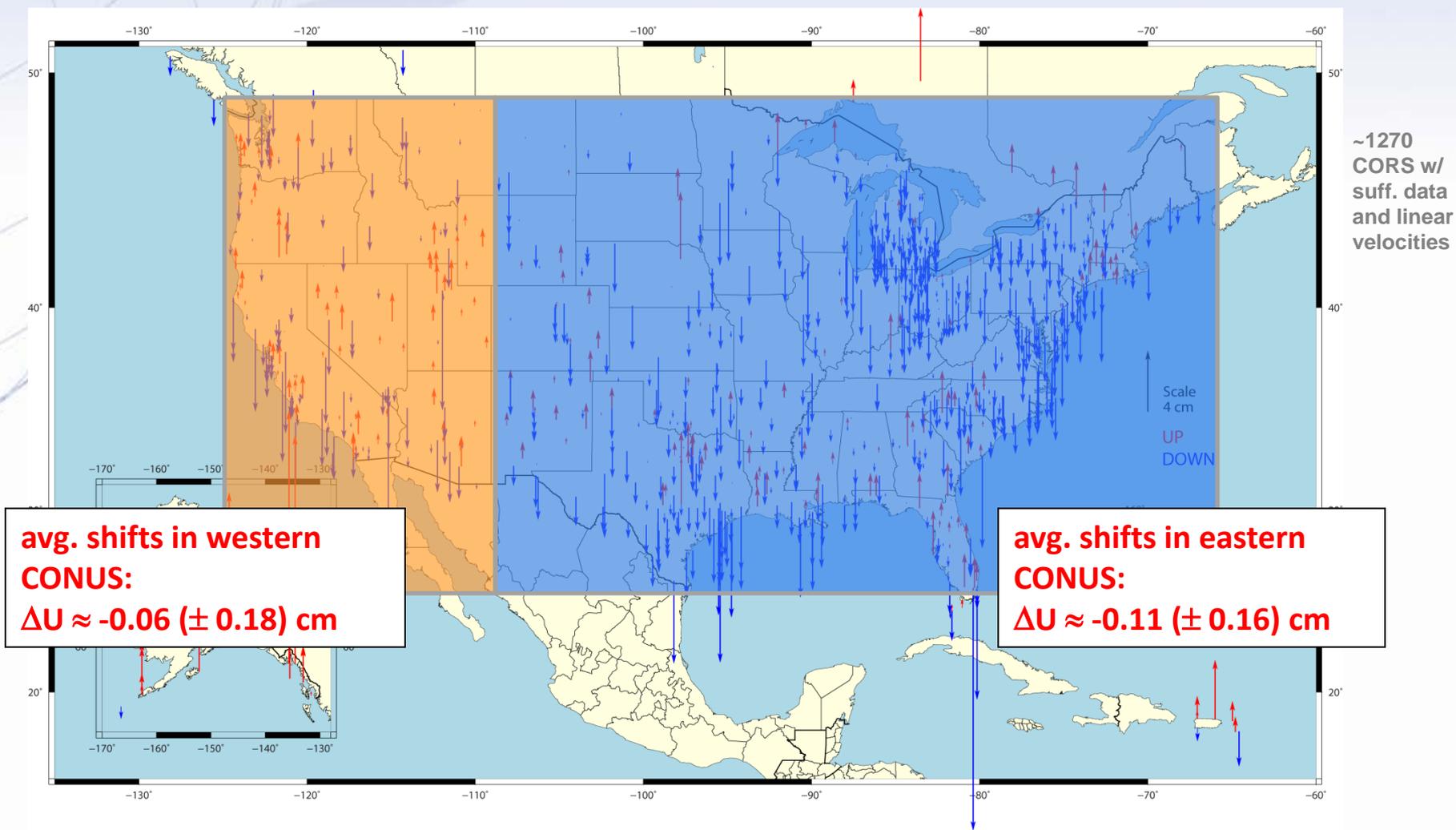
- approx. 2 cm error expected @ 2005.0 (based on σ in old solution)
- overall avg. horizontal shifts: $\Delta E = 0.09 (\pm 5.84)$ cm $\Delta N = 2.03 (\pm 5.98)$ cm
 - combination of position and velocity differences
 - due mostly to updated velocities (including up to 8 more years of data)



Changes in *Vertical* NAD 83 Positions Different Epochs

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

- overall avg. vertical shifts: $\Delta U = -0.79 (\pm 2.09)$ cm
 - combination of position and velocity differences from additional data, tectonics
 - assuming vertical velocity ≈ 0.00 in NAD 83(CORS96)



Done and To Do

- **Fall 2005:** First discussion and start of software overhaul
- **Mar 2008:** Start of re-analysis of orbits and CORS data
- **Feb 2009:** First results
- **Feb 2010:** NGS submits final solution to IERS
- **Apr 2010:** Full solution and frame discussion begin
- **May 2010:** IERS publishes ITRF2008
- **Jun-Oct:** Verification of time-series for discontinuities
- **Nov-Feb:** Incorporate IGS08 absolute antenna calib., adjust ITRF2008-aligned coordinates for IGS08 calib.
- **Mar-Apr:** Update tools in and out of NGS, and get final IGS08
- **May-Jun:** Coord. beta site, feedback 😊😞, modify?
- **July:** Publish and integrate coord. into NGS prods.

Key Changes

- Change from relative to absolute antenna phase center values (PCV)
- NGS global frame pos/vels are aligned to full global frame (IGS08)
- Distinction between computed and modeled velocities must be maintained and ***emphasized*** to users
- Ability to robustly/consistently re-compute pos/vels
- More robust discontinuity identification and resolve metadata issues quickly (**site operators are key**)
- Change in pos/vel NAD 83(2011) change epoch from 2002.0 to 2010.0

Reference Frames Used

- Basis is global and inherited from ITRF2008
 - NGS has more discontinuities and weekly solutions than ITRF2008; and has applied IGS05_ATX -> IGS08_ATX corrections to be consistent w/ IGS08
 - Name **IGS08** (tentative)
 - Epoch date **2005.0** (same as ITRF2008, IGS08)
- Related to ITRF, but plate fixed (NAD 83)
 - Name **NAD 83(2011)** (tentative)
 - Epoch date **2010.0**
 - NAD 83(CORS96) to NAD 83(2011) is identity transformation (i.e. same axes)
 - NAD 83(2011) axes origin different (~2m) from ITRF (expect 2022)

Transition Multiyear to Operations

- Multiyear processing method will become operational method, old method stops after beta period
- 2 sets of processing:
 - Fast next day, to produce “60 day plots” and catch metadata errors, aligned to same frame (not stacked) so noisier
 - Slow ~24 days later final solution (metadata issues resolved), stacked weekly solutions, used to define positions and velocities

Changes with New Frame

Two types of CORS coordinates

- >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.

Changes with New Coordinates

- Coordinates will be rigorously reviewed every 6 months.
- On a weekly basis if a problem with a site is identified, site flagged as problem, e.g. currently do not have an automated way to deal with earthquake offsets/velocity changes, undocumented/unexplained equipment change
- What amount of change/tolerance are permitted?
 - Current 2 cm horizontal, 4 cm vertical
 - Considering 1 cm horizontal, 2 cm vertical
- All users should use IGS08 consistent absolute antenna PCV values (see next slide)

Outstanding Items

tentative timeline

- **Next 1-2 weeks** revise New Coordinates web page
geodesy.noaa.gov/CORS
Click on “Data Products,
Scroll to bottom and follow “Beta Products” links
- **March-April**, Update NGS IDB, test NGS prod. & serv.,
provide beta Antenna Calibration page with IGS08
consistent PCV's both ANT_INFO and ANTEX format,
final check on coordinates and consistency with IGS08
- **May-June**, Release beta coordinates, update all
coordinates through May 2011, implement HTDP 3.1
- **July** release new coordinates and update NGS products
to be consistent

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**
Scroll down to Beta Products
Choose **New Realization of NAD 83**

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Questions?

- What does NGS intend to do about the relationship between CORS and passive networks?
- What is the reliability of new velocities compared with current published values - especially in the vertical?
- If the new reference frame is called NAD 83(2011) epoch 2010.0 what efforts will NGS make to educate the user to minimize confusion with NAD 83(CORS96) epoch 2002.0?
- What period of overlap will occur with solutions in both NAD 83(CORS96) epoch 2002.0 and NAD 83(2011) epoch 2010.0?
- What format changes occur to NGS products e.g. data sheets, coordinate page, OPUS output?
- Will there be a transformation between NAD 83(CORS96) and NAD 83(2011)?