Status of the current multi-year CORS solution--ITRF2008P(NGS)

- why reprocess?
- quality of reprocessed NGS orbits and TRF
- obtaining ITRF2008P(NGS)—P is for "provisional"
- assessment of ITRF2008P(NGS) velocity field
- estimated impact on users of CORS in switch to ITRF2008(NGS)

by

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with contributions from

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Why Reprocess?

- generate fully consistent orbits, EOPs and global station coordinates using latest models and methods—existing history is inadequate for modern realizations of TRFs
  - absolute antenna calibrations
    - satellite transmitting and ground receiving antennas
    - most significant change
  - new network design—added redundancy
    - Delaunay triangulation over global sites and CORS backbone
    - tie remaining CORS to backbone as stars
  - IERS 2003 Conventions generally implemented
  - updated model for station displacements due to ocean tidal loading
  - updated models for troposphere propagation delays
  - use current frame; first attempt to obtain a full history of products in a fully consistent framework
- contribute NGS reprocessed orbits, EOPs and global SINEX files to International GNSS Service (IGS) repro1 campaign
- generate ITRF2008(NGS) CORS coordinates and velocities in global framework using new orbits, EOPs and global station coords

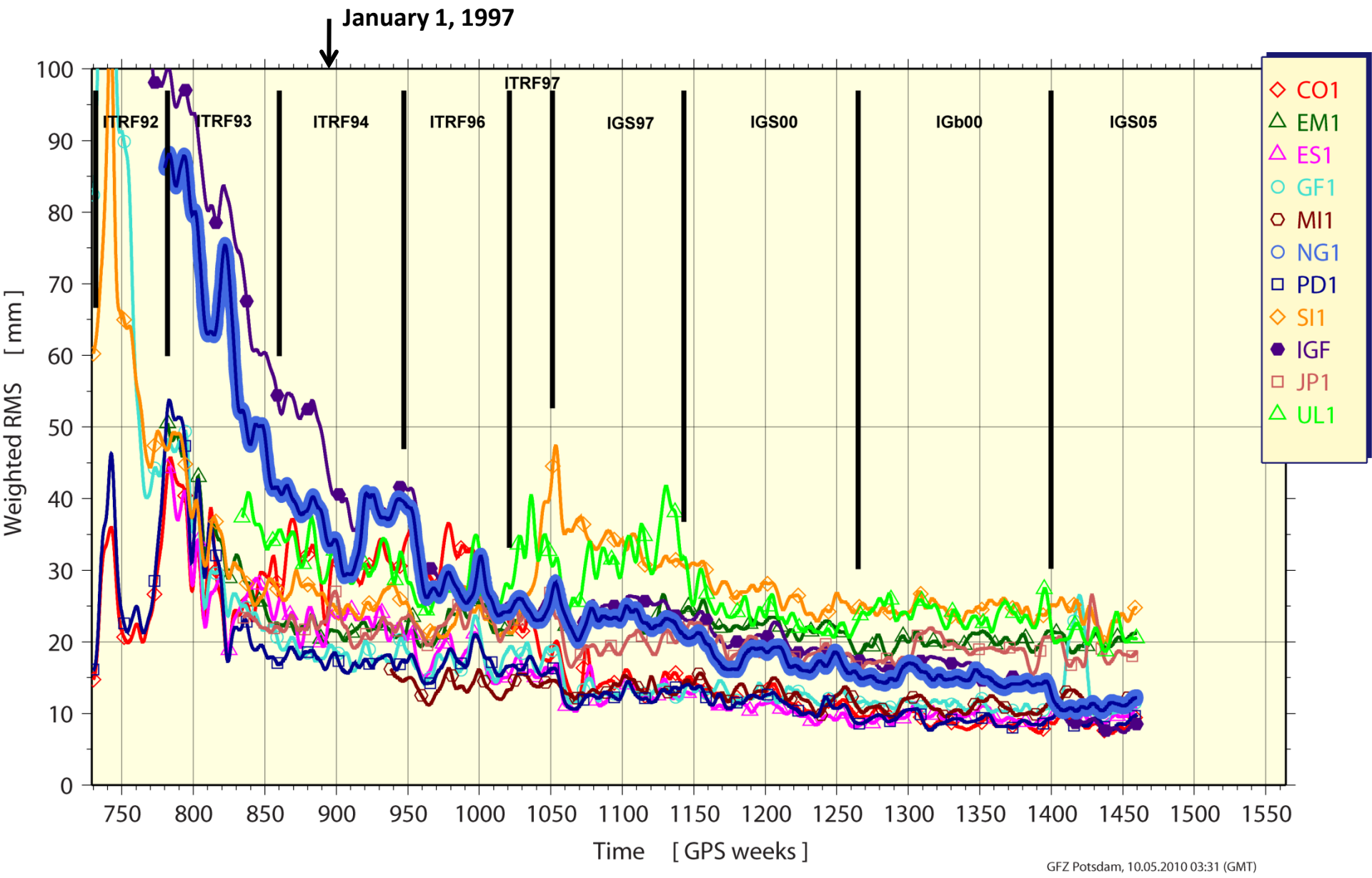
Contributors to IGS repro1 campaign

- **all IGS Final-product Analysis Centers:**
  - **COD/AIUB – Switzerland**
  - **EMR/NRCan – Canada**
  - **ESA/ESOC – Germany**
  - **GFZ – Potsdam, Germany**
  - **JPL – USA**
  - **MIT – USA**
  - **NGS/NOAA – USA**
  - **SIO – USA**

- **plus 2 reprocessing Centers**
  - **PDR – Potsdam/Dresden Reprocessing, Germany**
  - **ULR – University of La Rochelle TIGA (tide gauges), France**

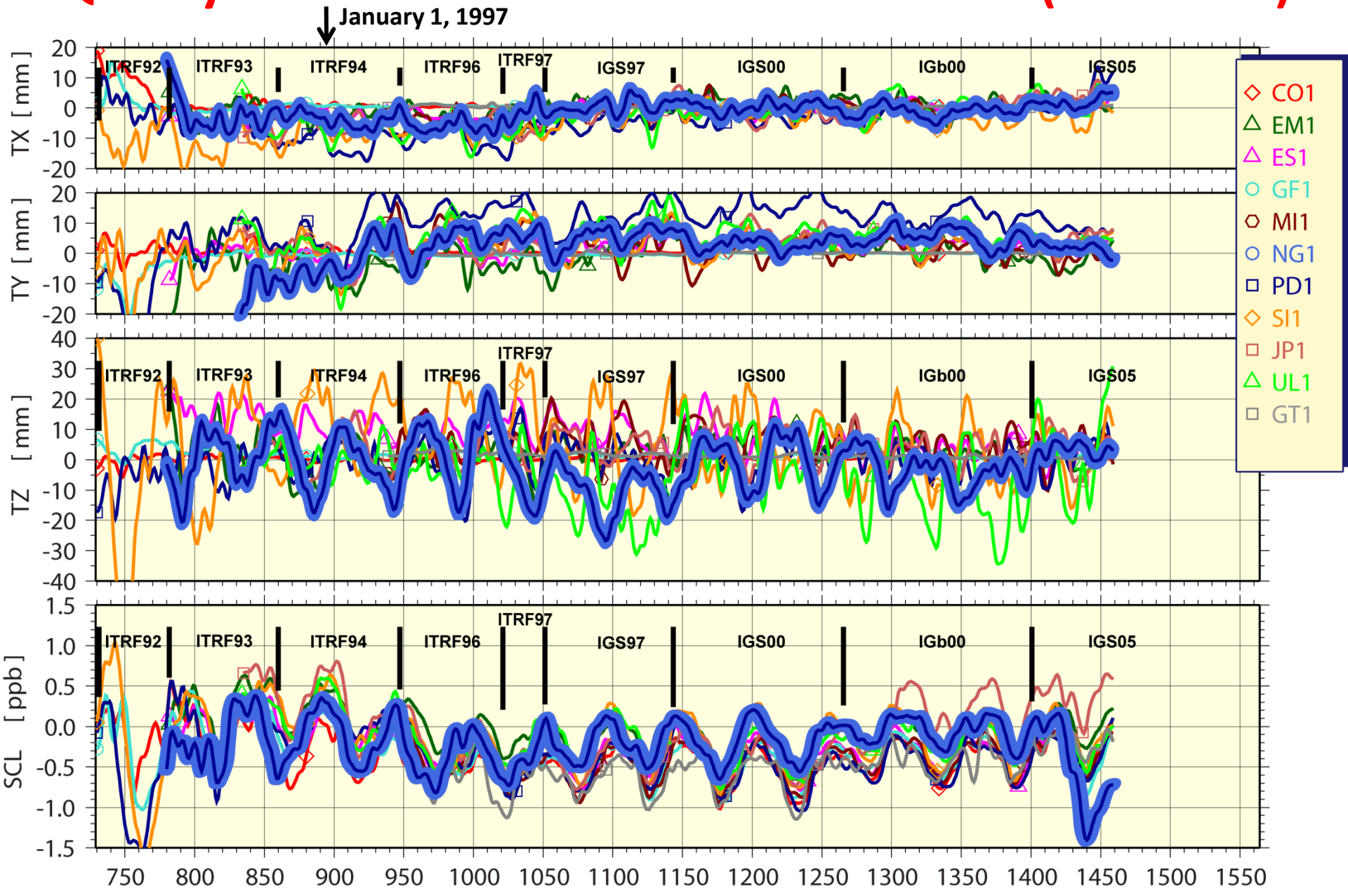
- **plus 1 Center contributing to TRF only:**
  - **GFT/GFZ TIGA – Potsdam, Germany**

Quality of Orbits: WRMS of AC Orbits (w.r.t. IG1)



Courtesy: IGS Analysis Center Coordinator [2010]

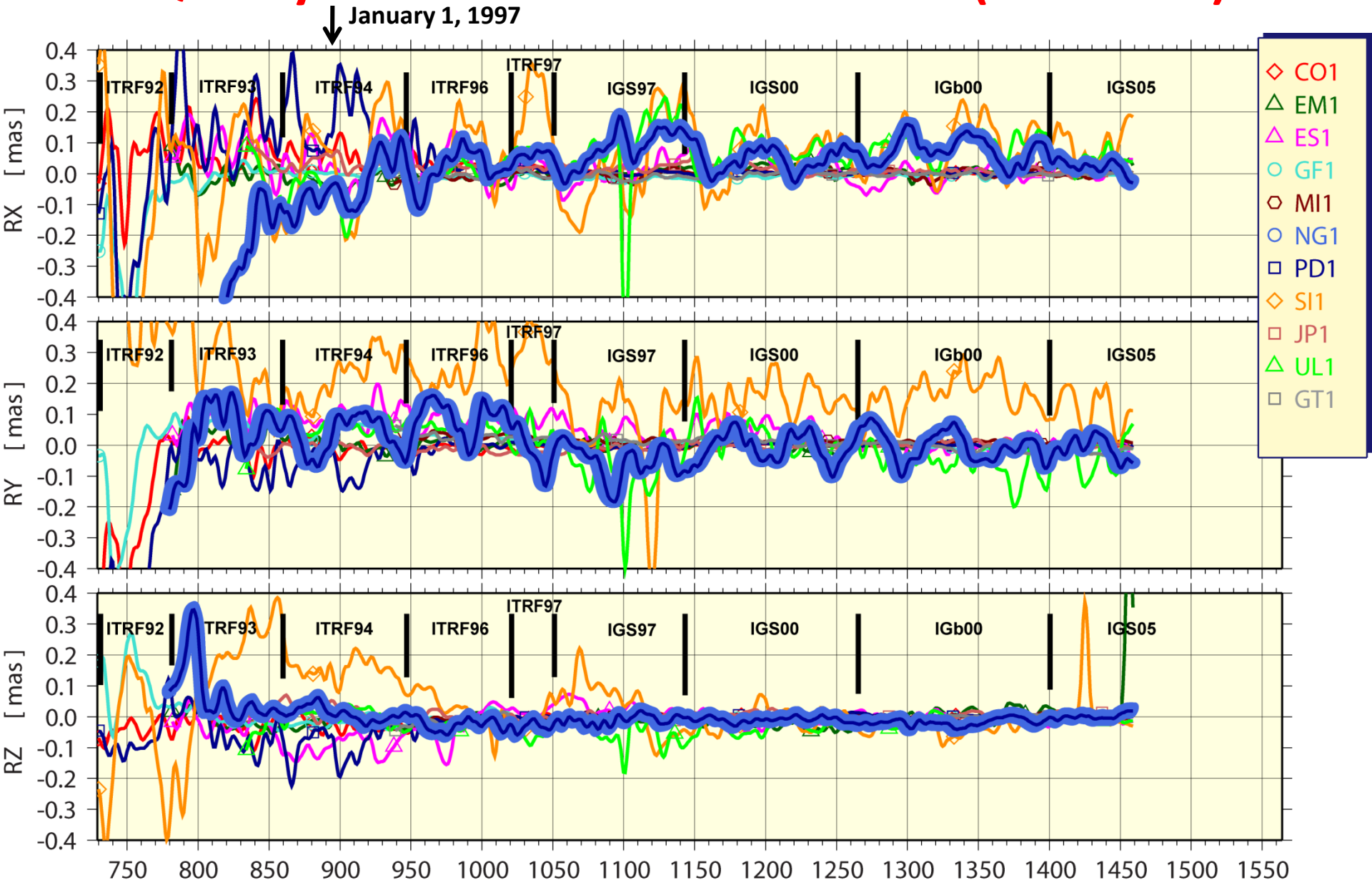
Quality of framework: Geocenter & Scale (w.r.t. IG1)



Courtesy: IGS Analysis Center Coordinator [2010]

GFZ Potsdam, 10.05.2010 03:31 (GMT)

Quality of framework: Orientation (w.r.t. IG1)



Courtesy: IGS Analysis Center Coordinator [2010]

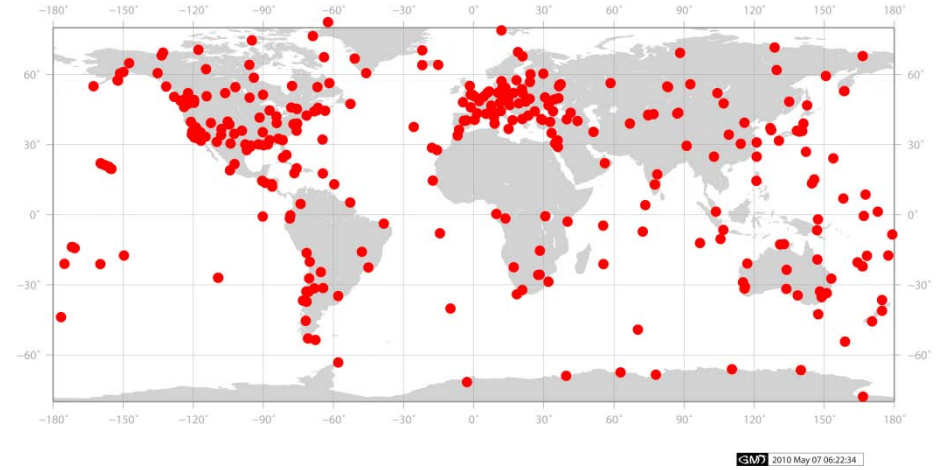
GFZ Potsdam, 10.05.2010 03:31 (GMT)

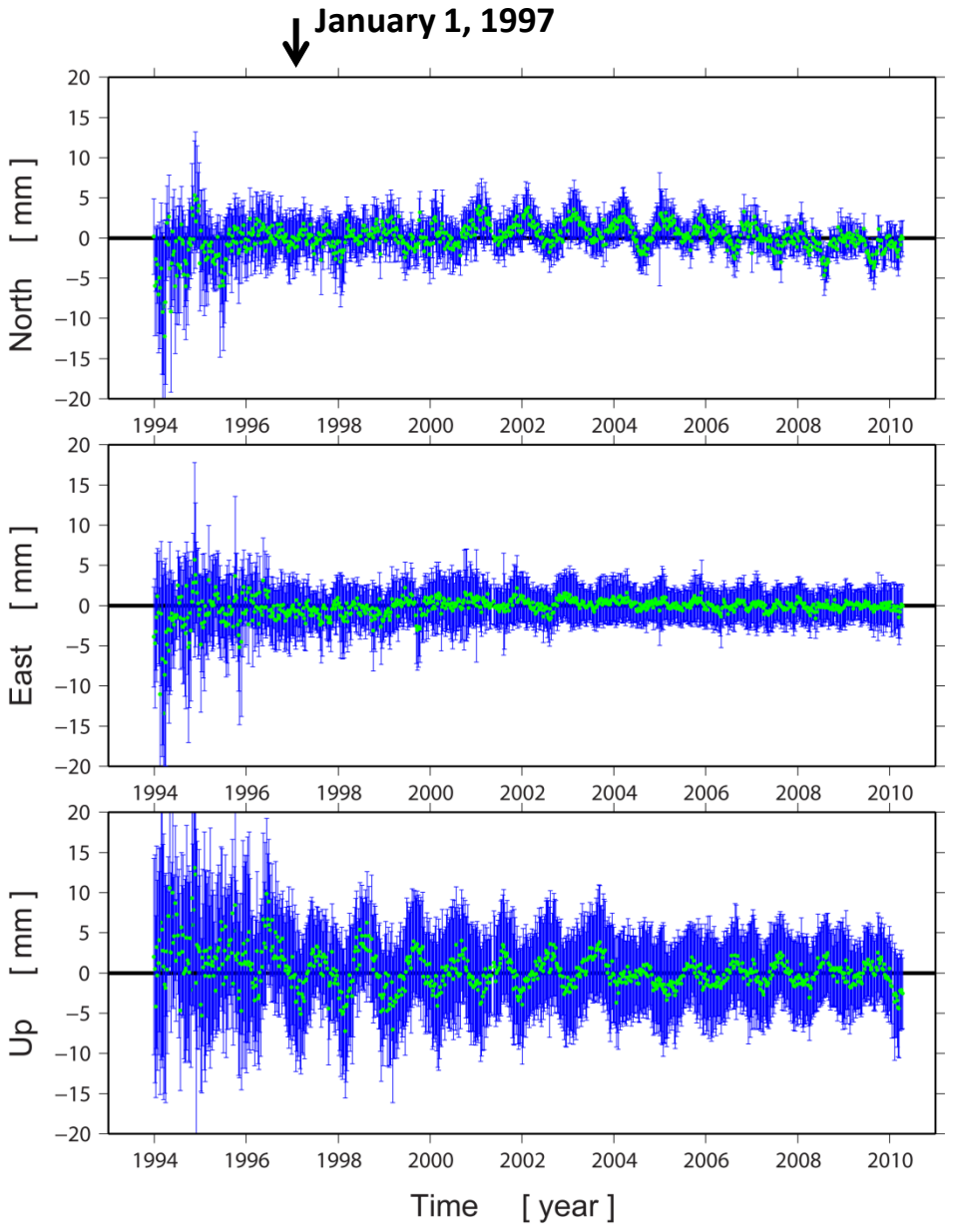
How is ITRF2008P(NGS) obtained?

- CORS RINEX observations processed in global framework using NGS reprocessed orbits, EOPs and global station coordinates
- resulting in full history of weekly SINEX files containing X,Y,Z positions and full variance-covariance information
- use CATREF software from Institut Géographique National (IGN) to stack weekly CORS SINEX files in three steps:
  - step 1: attenuate aliasing effects caused by local non-linear motions
    - sub-network of ~35 sites chosen for their global distribution, long time-series and small/negligible non-linear motions
    - obtain "unscented" weekly Helmert parameters over sub-network
    - weekly scale changes are assumed to be zero
  - step 2: impose "unscented" Helmert parameters on whole network & stack
  - step 3: obtain ITRF2008P(NGS)—i.e., align "unscented" stacked TRF to ITRF2008P via GPS sites common to both SNXs
  - more details of procedure at http://beta.ngs.noaa.gov/myear/
- in stacking, undocumented positional discontinuities are detected using SIGSEG [Vitti, 2009] and Change-point Analysis [Taylor, 2000]

Stability of ITRF2008P(NGS)

- weighted average of coordinate residuals taken over ITRF2008P sites shown in map below
- amplitude of annual signal:
  - ~3 to 5 mm in vertical
  - <3 mm in N-S
  - ~0 mm in E-W
- early years are noisy, but overall stability quite good

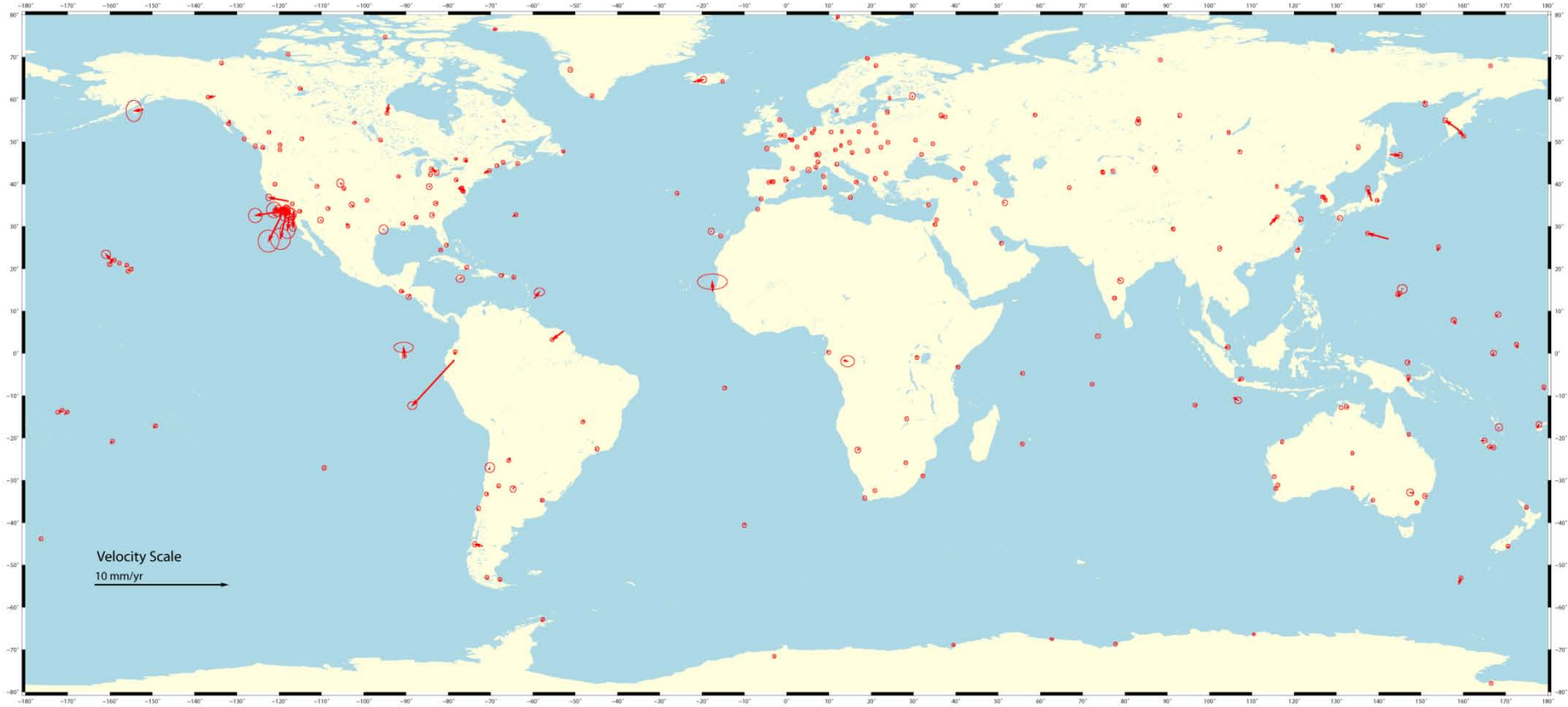




Assessment of Horizontal Velocities:

ITRF2008P - ITRF2008P(NGS)

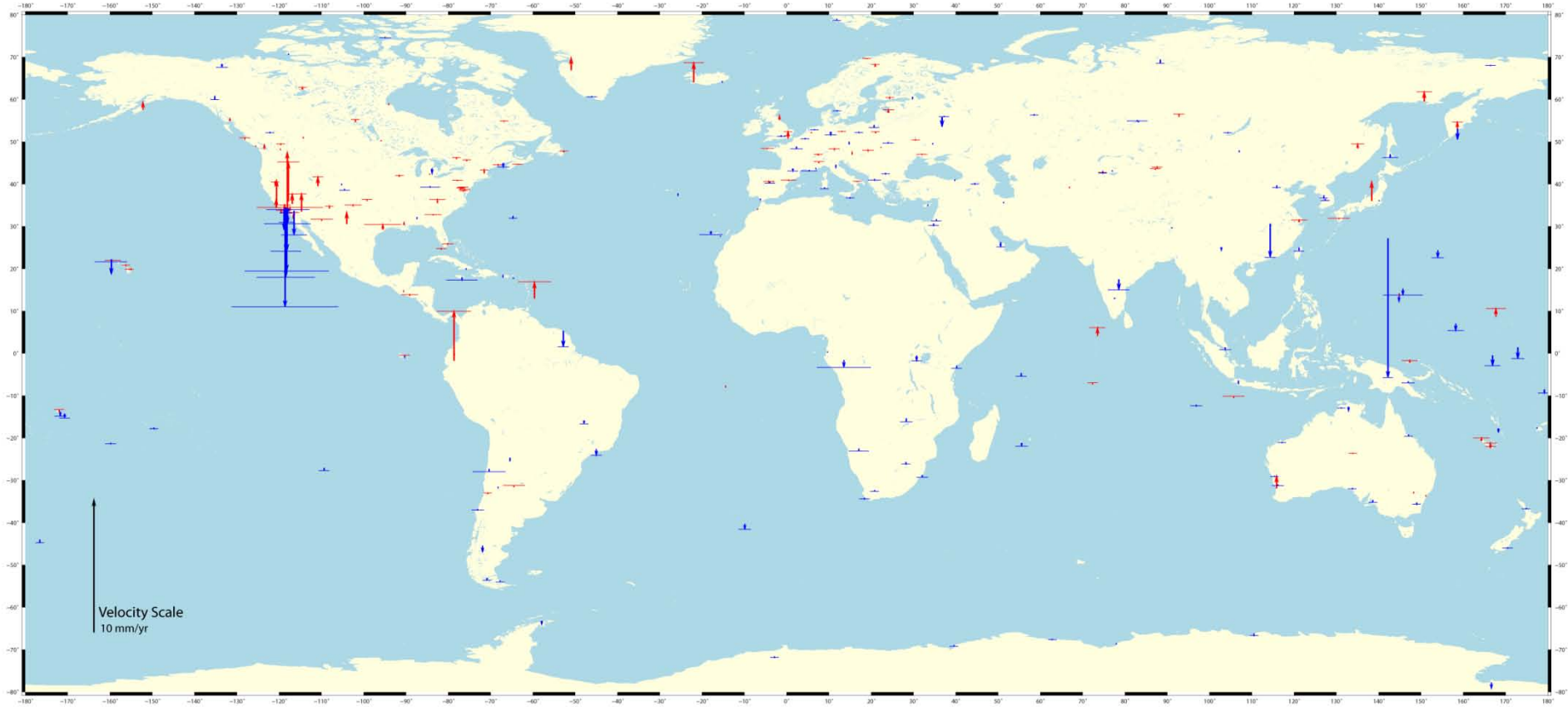
- good agreement between ITRF and CORS solution
- a few sites in western U.S. with large (up to 0.4 cm/yr) horizontal differences



Assessment of Vertical Velocities:

ITRF2008P - ITRF2008P(NGS)

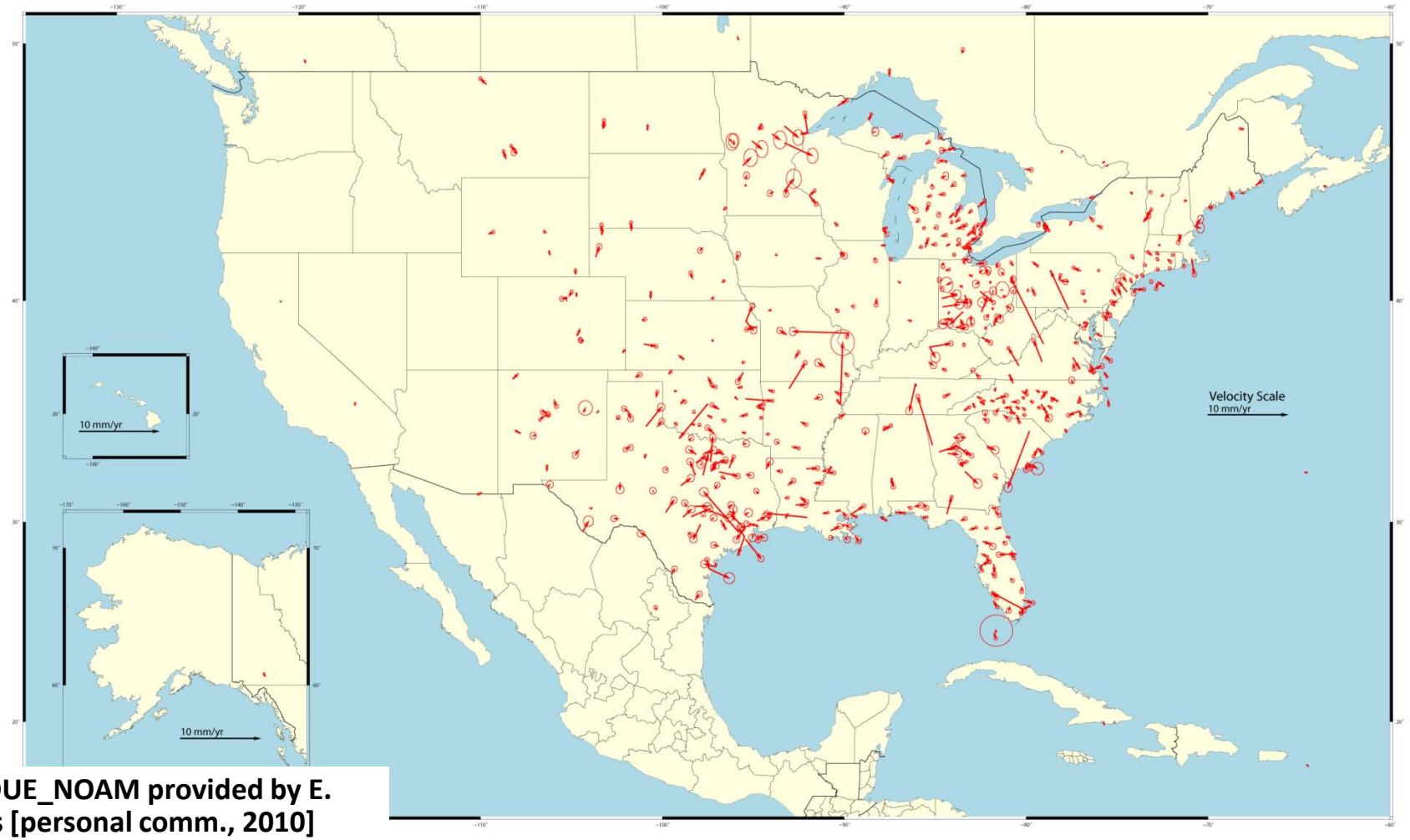
- **good agreement for most sites**
  - sites with large (up to 0.4 cm/yr) horiz. differences also have large vert. differences
- **overall good agreement with ITRF2008P**
  - assess specific cases of large velocity differences
  - consider not using sites with large velocity differences for final alignment



More on Velocities (1/2):

ITRF2008P(NGS) – [PURDUE_NOAM]$_{\text{aligned to ITRF2008}}$

- most differences in horizontal velocities < 5 mm/yr
- few sites have significant velocity differences, presumably caused by applying different sets of discontinuities

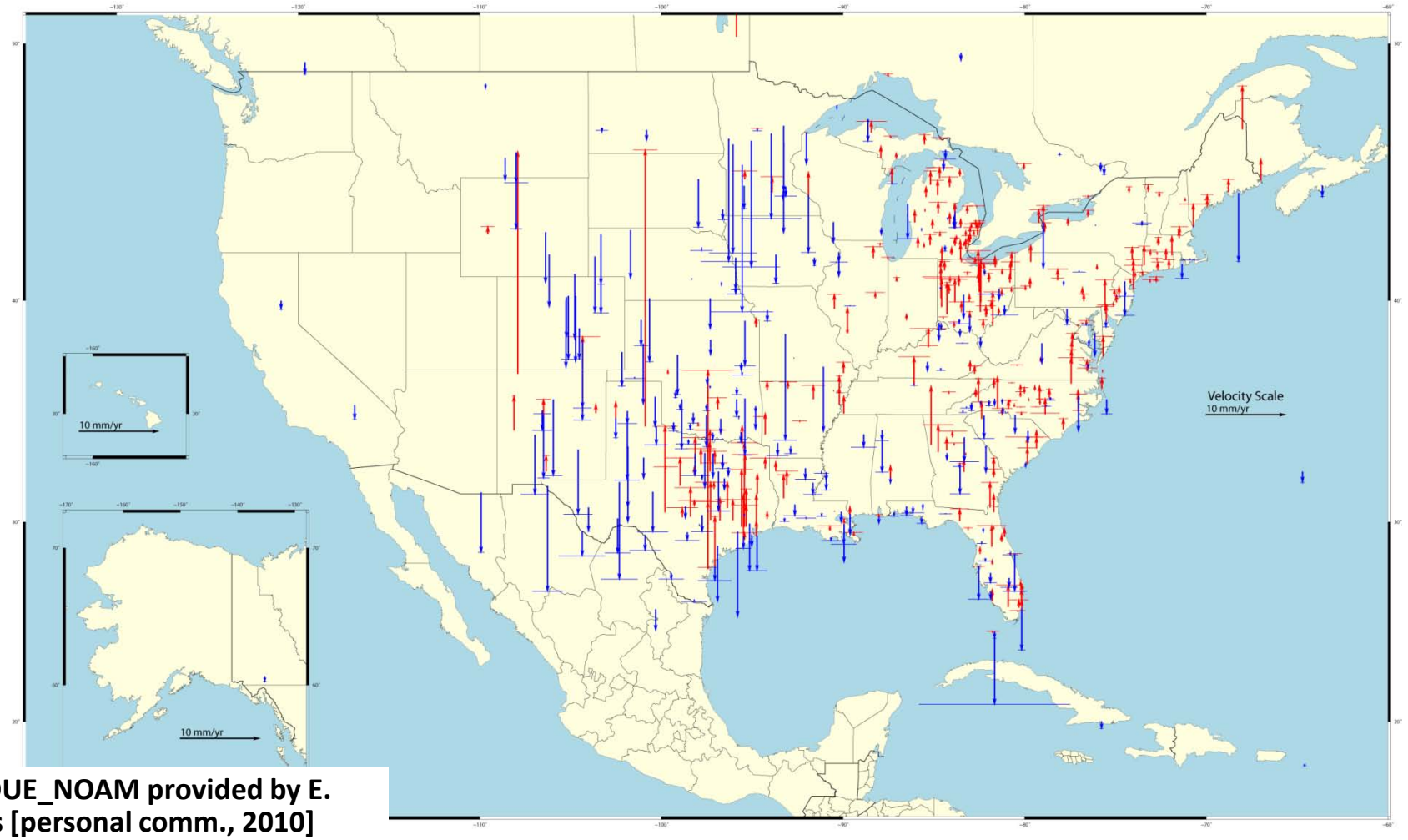


PURDUE_NOAM provided by E. Calais [personal comm., 2010]

More on Velocities (2/2):

ITRF2008P(NGS) – [PURDUE_NOAM]$_{\text{aligned to ITRF2008}}$

- most differences in vertical velocities < 10 mm/yr
- NOTE: a comparison with NRCan solution [M. Craymer] in Great Lakes region shows negligible velocity differences

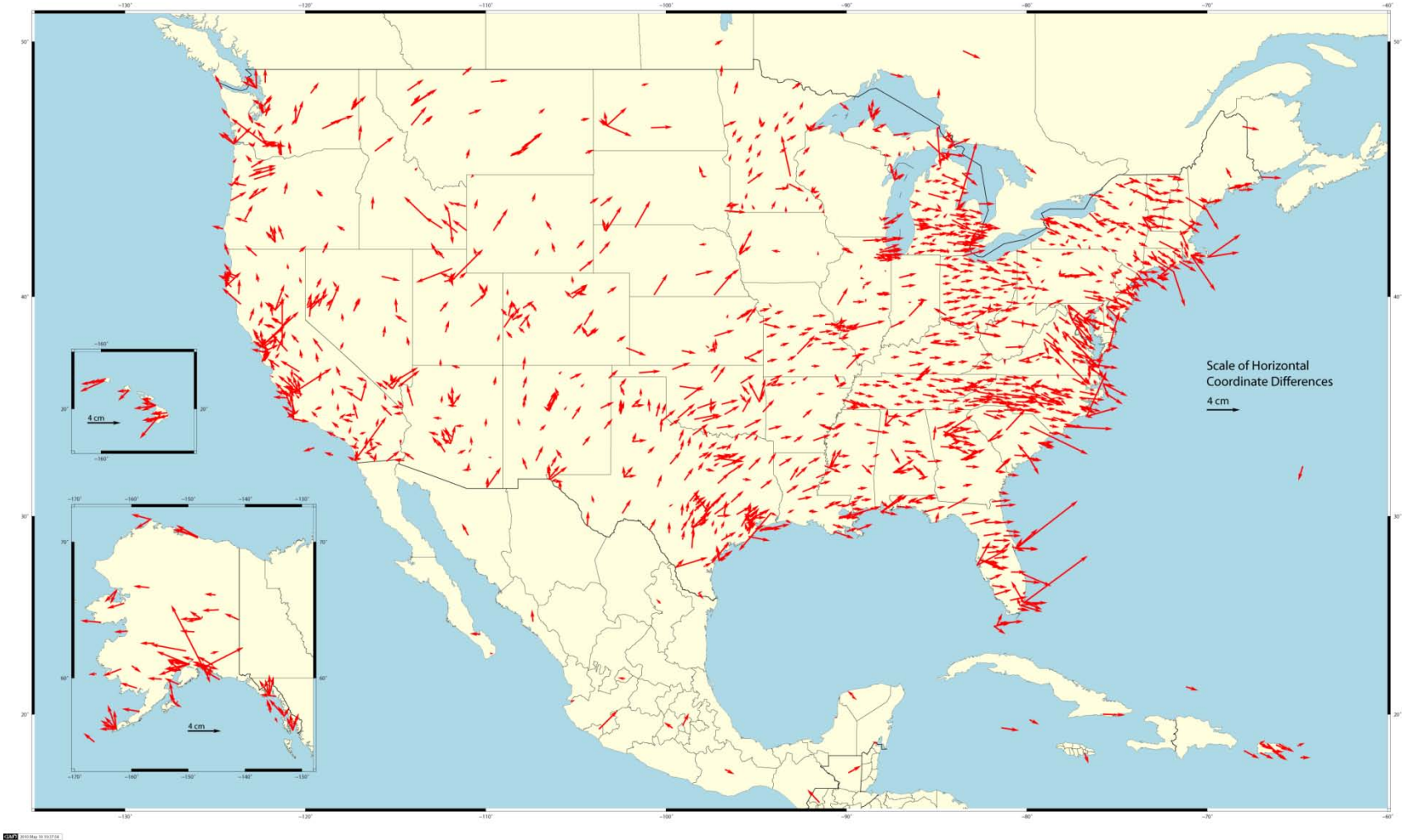


PURDUE_NOAM provided by E. Calais [personal comm., 2010]

Impact on CORS Users: Change in Horizontal Coordinates

ITRF2008P(NGS) – [ITRF2000(NGS)]$_{\text{transformed to ITRF2008P}}$ @ 2010.00

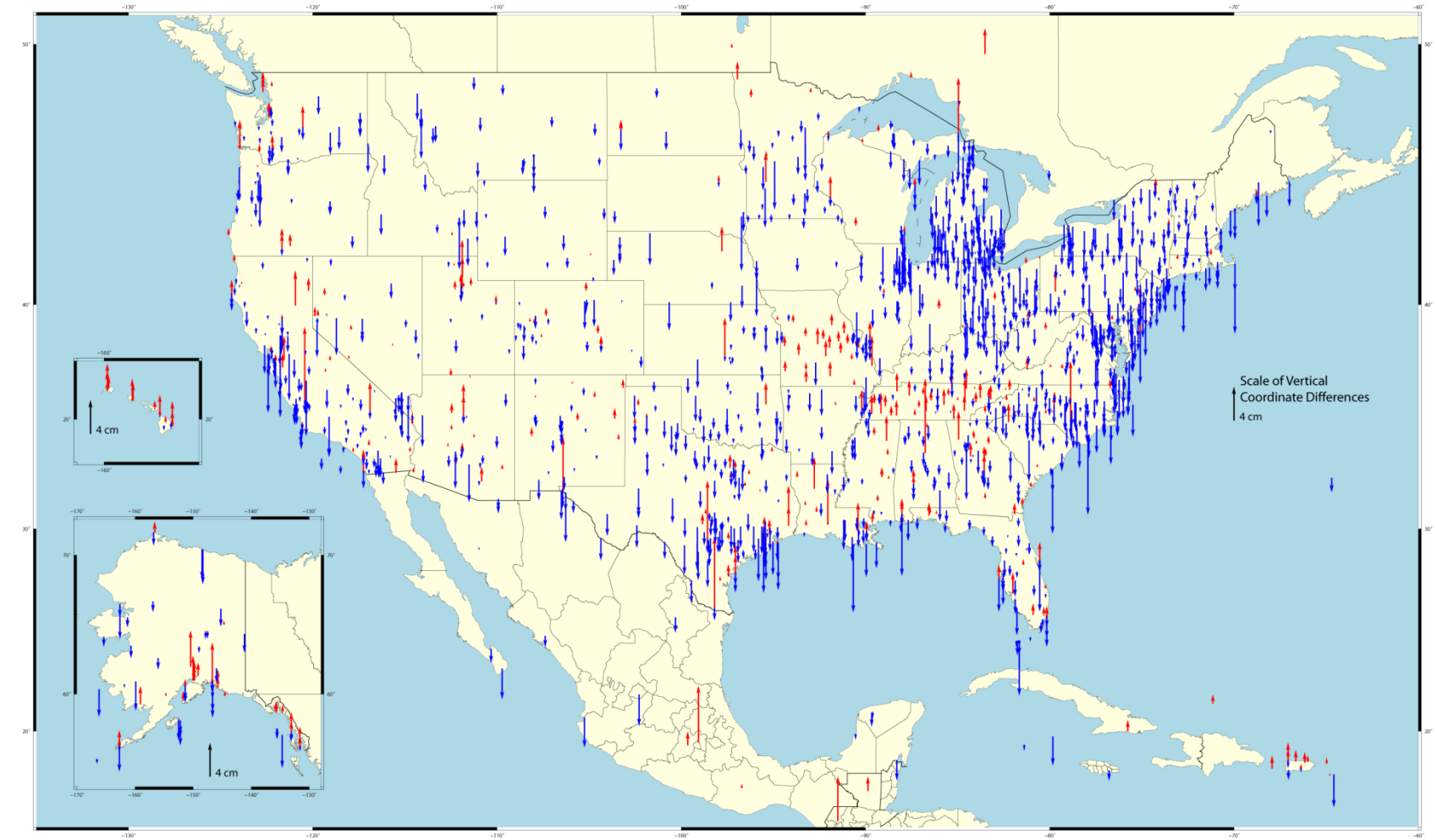
- **average horizontal coordinate differences = 1.0 cm (± 1.5 cm)**
  - sigmas in NGS submission to ITRF2000 indicates ~4 cm error @ 2010.00
  - probably mostly caused by prescribing velocities using HTDP and NUVEL-1A
  - random part should be caused by to change to absolute antenna calibrations



Impact on CORS Users: Change in Vertical Coordinates

ITRF2008P(NGS) – [ITRF2000(NGS)]$_{\text{transformed to ITRF2008P}}$ @ 2010.00

- **average vertical coordinate differences = -1.1 cm (± 2.6 cm)**
  - **mostly caused by assuming V_u = 0 in ITRF2000(NGS)**
  - **again, a random part caused by switch to absolute antenna calibrations**



Conclusions

- 1st reprocessing of global and CORS GPS data collected since 1994 is complete
- Overall good agreement with sites common to ITRF2008P
  - for final version, need to address cases where velocity differences are large
    - review discontinuity list
    - perhaps use a subset of sites for alignment—e.g., do not use sites with large (~1 cm) velocity differences for alignment
- Good agreement with sites common to PURDUE_NOAM.SNX and with NRCan in Great Lakes region
- Average coordinate offsets of ~ 1 cm will be experienced by most users when evaluating observations at 2010.00
- Users must prepare for change from relative to absolute antenna calibrations, which causes site-specific position changes up to a few cm
- ITRF2008(NGS) expected to be complete by mid 2010
  - target date for implementing solution into NGS operations (e.g., OPUS) is late 2010 / early 2011