



# ***Update and Refinement of the North American Datum of 1983***

## **NAD 83(2011/PA11/MA11) epoch 2010.00**



***The 2011 national  
adjustment of  
passive control and  
its impact on NGS  
products and  
services...***

***...and on your work***

**CGSIC  
Nashville, TN**

September 17, 2012

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# The Plan

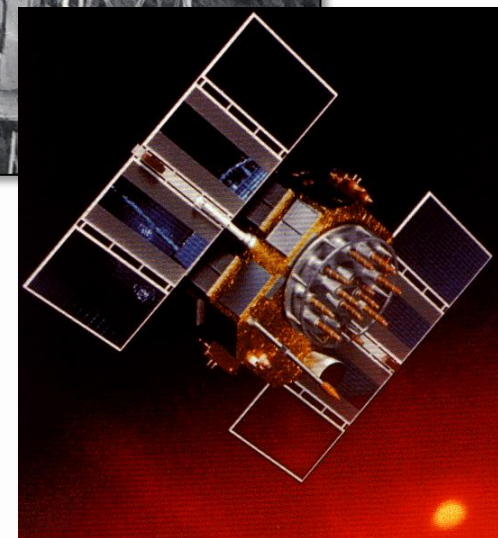
- The ***National Spatial Reference System (NSRS)***
  - A (very) brief history of NAD 83
  - The latest realization: ***NAD 83(2011) epoch 2010.00***
- ***National adjustment of passive control***
- Related and dependant NGS products & services
  - The Multi-Year CORS Solution (MYCS)
  - Online Positioning User Service (OPUS)
  - New hybrid geoid model (GEOID12A)
  - New process for Bluebooking GPS project
  - ***New NAD 83 coordinate transformations***
  - ***New NGS Datasheet format***
- What about *orthometric* heights (aka “elevations”)?

# The Basics

- When will it be done?
  - Publication completed on ***June 30, 2012***
    - ***Intent: Simultaneous with release of GEOID12A***
- How many stations? ***80,872***
- How much did the coordinates change?
  - Median: ***1.9 cm horiz, 2.1 cm ellipsoid ht***
- How accurate are the results?
  - Median: ***0.9 cm horiz, 1.5 cm ellipsoid ht***  
(at 95% confidence level)

# A (very) brief history of NAD 83

- Original realization completed in 1986
  - Consisted (almost) entirely of classical (optical) observations
- “High Precision Geodetic Network” (HPGN) and “High Accuracy Reference Network” (HARN) realizations
  - Observed 1989-2004, essentially state-by-state
  - Based on GPS, but classical stations included in adjustments
- National Re-Adjustment of 2007
  - NAD 83(CORS96) and (NSRS2007)
  - Simultaneous nationwide adjustment (GPS only)
- ***New realization: NAD 83(2011) epoch 2010.00***





# Introducing...

## NAD 83(2011) epoch 2010.00

- **Multi-Year CORS Solution (MYCS)**
  - Continuously Operating Reference Stations
  - Reprocessed all CORS GPS data Jan 1994-Apr 2011
  - 2264 U.S. & global stations
  - NAD 83 computed by *transformation* from IGS08
- **2011 national adjustment of passive control**
  - New adjustment of GPS passive control
  - GPS vectors tied (and constrained) to CORS NAD 83(2011) epoch 2010.00
  - Over 80,000 stations and 400,000 GPS vectors
- **Realization SAME for CORS and passive marks**
- **This is *NOT* a new datum! (still NAD 83)**



# Why a new NAD 83 realization?

- Multi-Year CORS Solution
  - Previous NAD 83 CORS realization needed many improvements
  - Consistent coordinates *and* velocities from global solution
  - Aligned with most recent realization of global frame
  - Major processing, modeling, and metadata improvements
    - Including new *absolute phase center antenna calibrations*
- National adjustment of passive control
  - Optimally align passive control with “active” CORS control
    - *Because CORS provide the geometric foundation of the NSRS*
  - Incorporate new data, compute accuracies on all stations
  - Better results in tectonically active areas
- **Bottom line**
  - **Must meet needs of users for highly accurate *and* consistent coordinates (*and* velocities) using *Best Available Methods***

# Approach

- Used a Helmert blocking strategy for CONUS
  - Over 80,000 points (> 240,000 unknowns)
  - Over 400,000 GPS vectors (> 1.2 million observations)
- Individual projects weighted to account for variable error
  - Horiz and vertical std deviation scale factors computed for all projects
- Outlier detection (for rejecting vectors)
  - Used threshold 4 cm horizontal, 5 cm up
- Challenges:
  - Mixing old and new observations (e.g., pre-1994)
  - CORS complications
  - Horizontal and vertical tectonic motions
  - No-check stations
  - Duplicate stations, duplicate vectors



# What's in a name?

*That which we call a datum*

*By any other name would smell as sweet...*

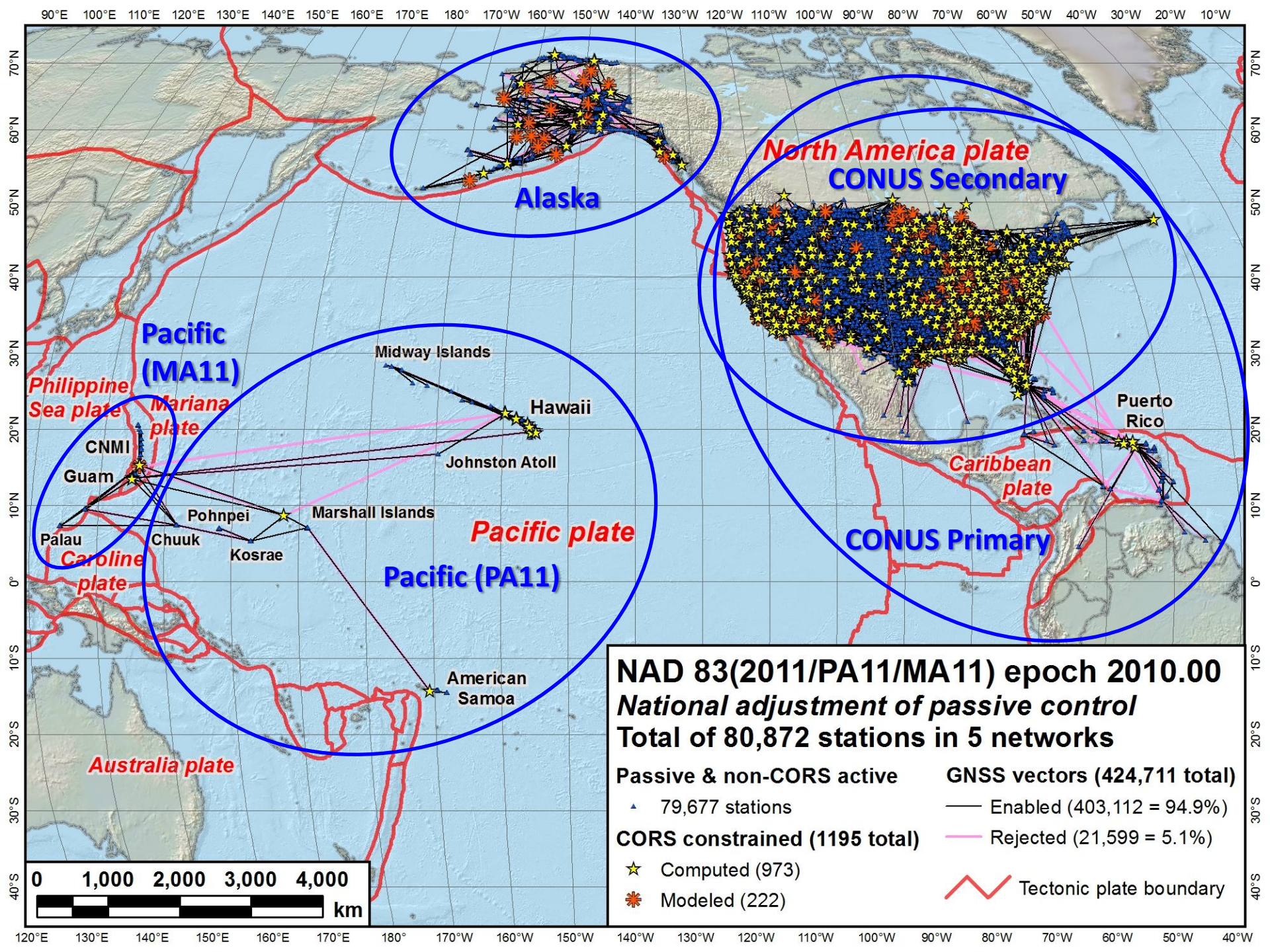
- **NAD 83(2011) epoch 2010.00**
  - “2011” is datum tag → year adjustment complete
  - “2010.00” is “epoch date” (January 1, 2010)
    - Date associated with coordinates of control station
  - Frame fixed to North America tectonic plate
    - Includes California, Alaska, Puerto Rico, and US Virgin Islands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



# National adjustment of passive control

- 4267 GPS projects; 80,872 stations; 424,711 vectors
  - Observations from April 1983 thru Dec 2011
  - Includes 1195 CORS with Multi-Year CORS Solution coordinates
- CONUS and Caribbean adjusted together (79,364 stations)
  - Both referenced to North America tectonic plate
  - Split into Primary (62,024 stations) and Secondary (17,340 stations)
- AK adjusted separate from CONUS and Caribbean (968 stations)
  - No useable ties to CONUS
  - Also referenced to North America tectonic plate
- Pacific region also adjusted separately (540 stations)
  - Referenced to different tectonic plates
    - Hawaii, American Samoa, Marshall Is., etc. → **Pacific plate** (363 stations)
    - Guam, Northern Mariana Islands, Palau → **Mariana plate** (177 stations)
  - ***Pacific not included in 2007 national adjustment***



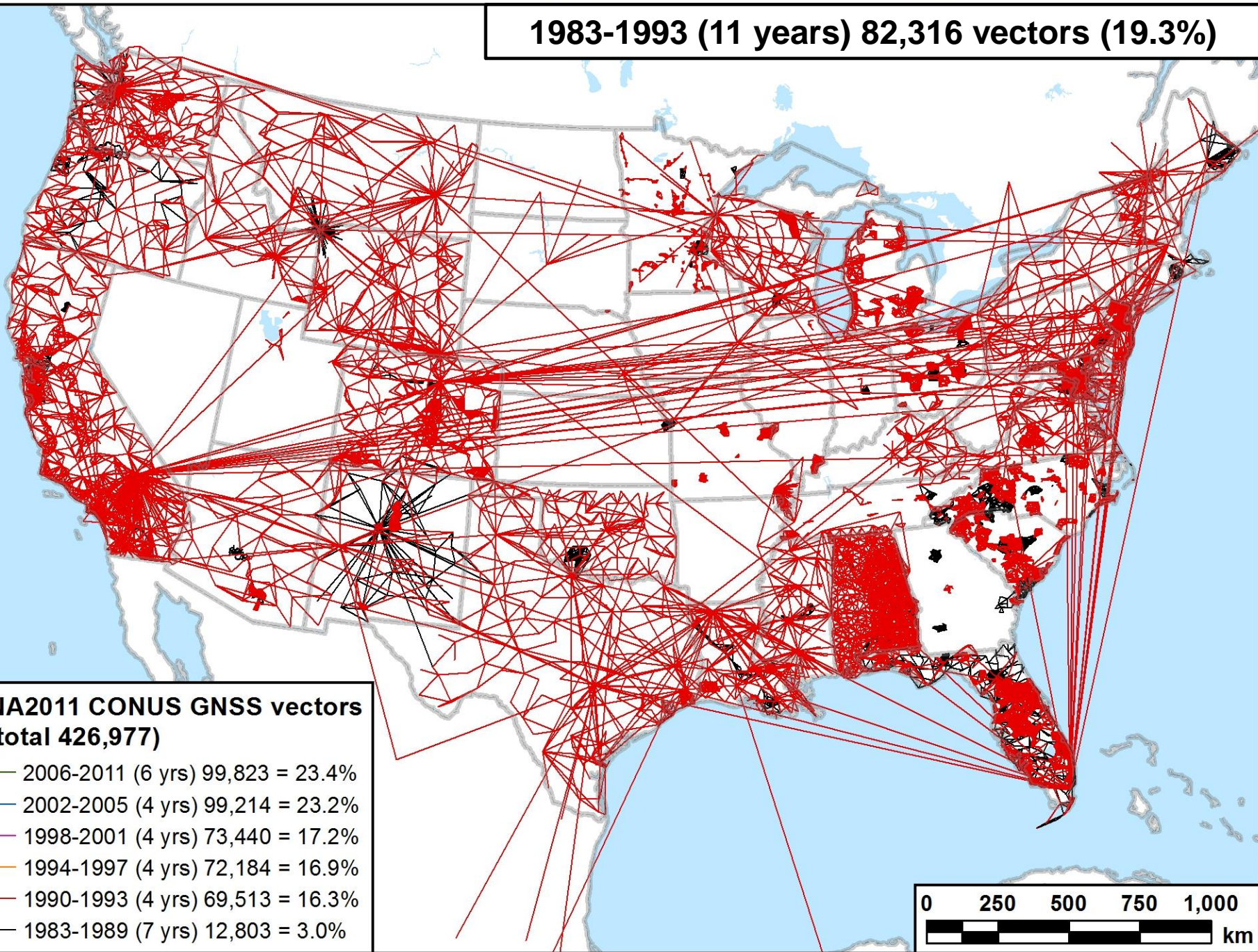
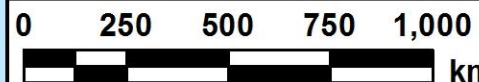




1983-1993 (11 years) 82,316 vectors (19.3%)

**NA2011 CONUS GNSS vectors  
(total 426,977)**

- 2006-2011 (6 yrs) 99,823 = 23.4%
- 2002-2005 (4 yrs) 99,214 = 23.2%
- 1998-2001 (4 yrs) 73,440 = 17.2%
- 1994-1997 (4 yrs) 72,184 = 16.9%
- 1990-1993 (4 yrs) 69,513 = 16.3%
- 1983-1989 (7 yrs) 12,803 = 3.0%

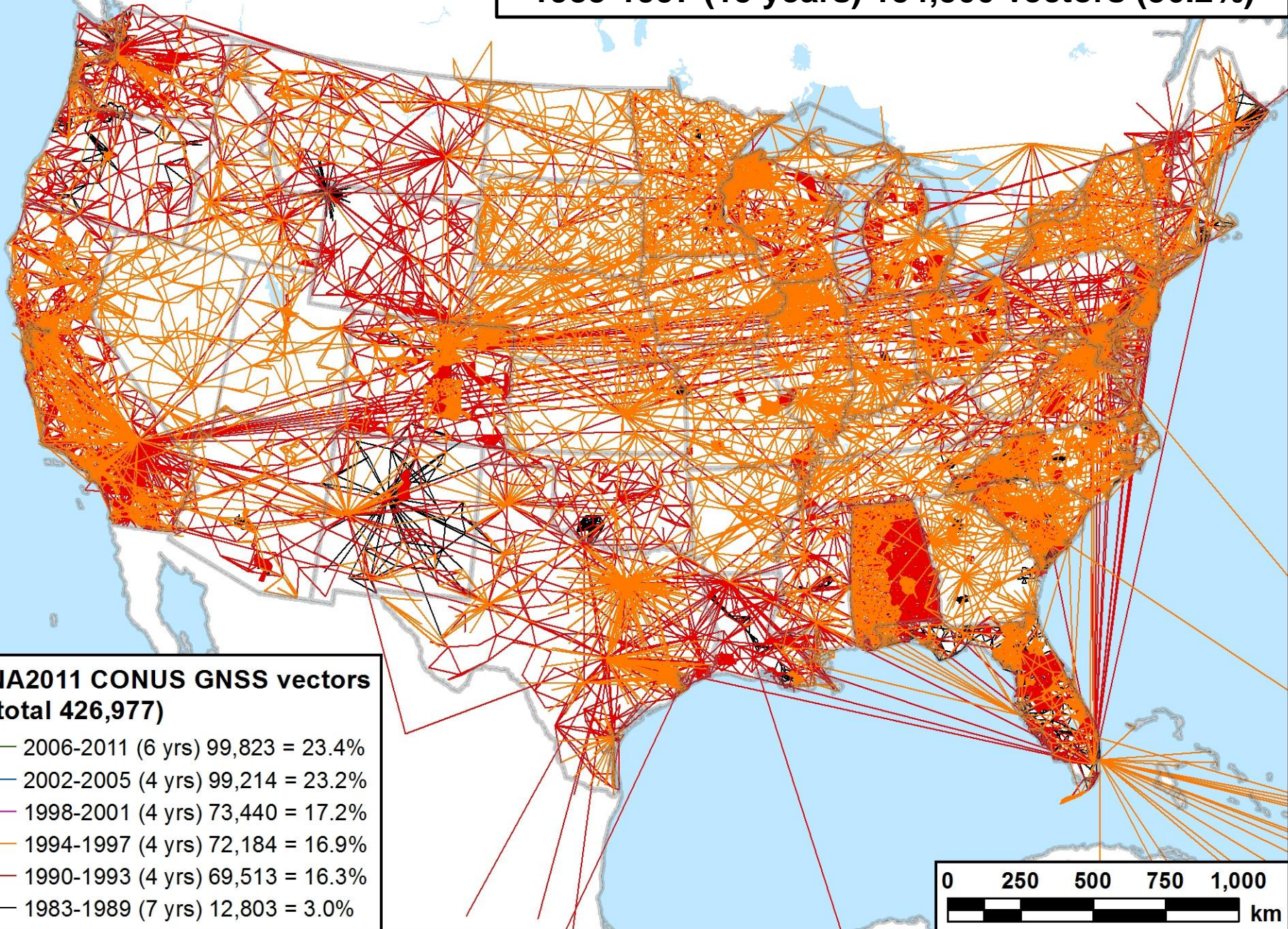
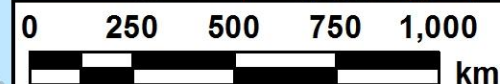




1983-1997 (15 years) 154,500 vectors (36.2%)

**NA2011 CONUS GNSS vectors  
(total 426,977)**

- 2006-2011 (6 yrs) 99,823 = 23.4%
- 2002-2005 (4 yrs) 99,214 = 23.2%
- 1998-2001 (4 yrs) 73,440 = 17.2%
- 1994-1997 (4 yrs) 72,184 = 16.9%
- 1990-1993 (4 yrs) 69,513 = 16.3%
- 1983-1989 (7 yrs) 12,803 = 3.0%

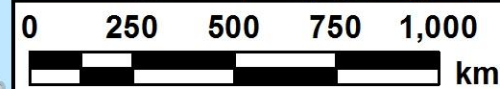




1983-2001 (19 years) 227,940 vectors (53.4%)

**NA2011 CONUS GNSS vectors  
(total 426,977)**

- 2006-2011 (6 yrs) 99,823 = 23.4%
- 2002-2005 (4 yrs) 99,214 = 23.2%
- 1998-2001 (4 yrs) 73,440 = 17.2%
- 1994-1997 (4 yrs) 72,184 = 16.9%
- 1990-1993 (4 yrs) 69,513 = 16.3%
- 1983-1989 (7 yrs) 12,803 = 3.0%

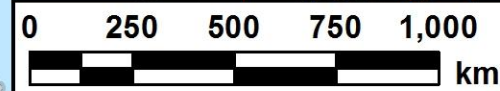




1983-2005 (23 years) 327,154 vectors (76.6%)

**NA2011 CONUS GNSS vectors  
(total 426,977)**

- 2006-2011 (6 yrs) 99,823 = 23.4%
- 2002-2005 (4 yrs) 99,214 = 23.2%
- 1998-2001 (4 yrs) 73,440 = 17.2%
- 1994-1997 (4 yrs) 72,184 = 16.9%
- 1990-1993 (4 yrs) 69,513 = 16.3%
- 1983-1989 (7 yrs) 12,803 = 3.0%

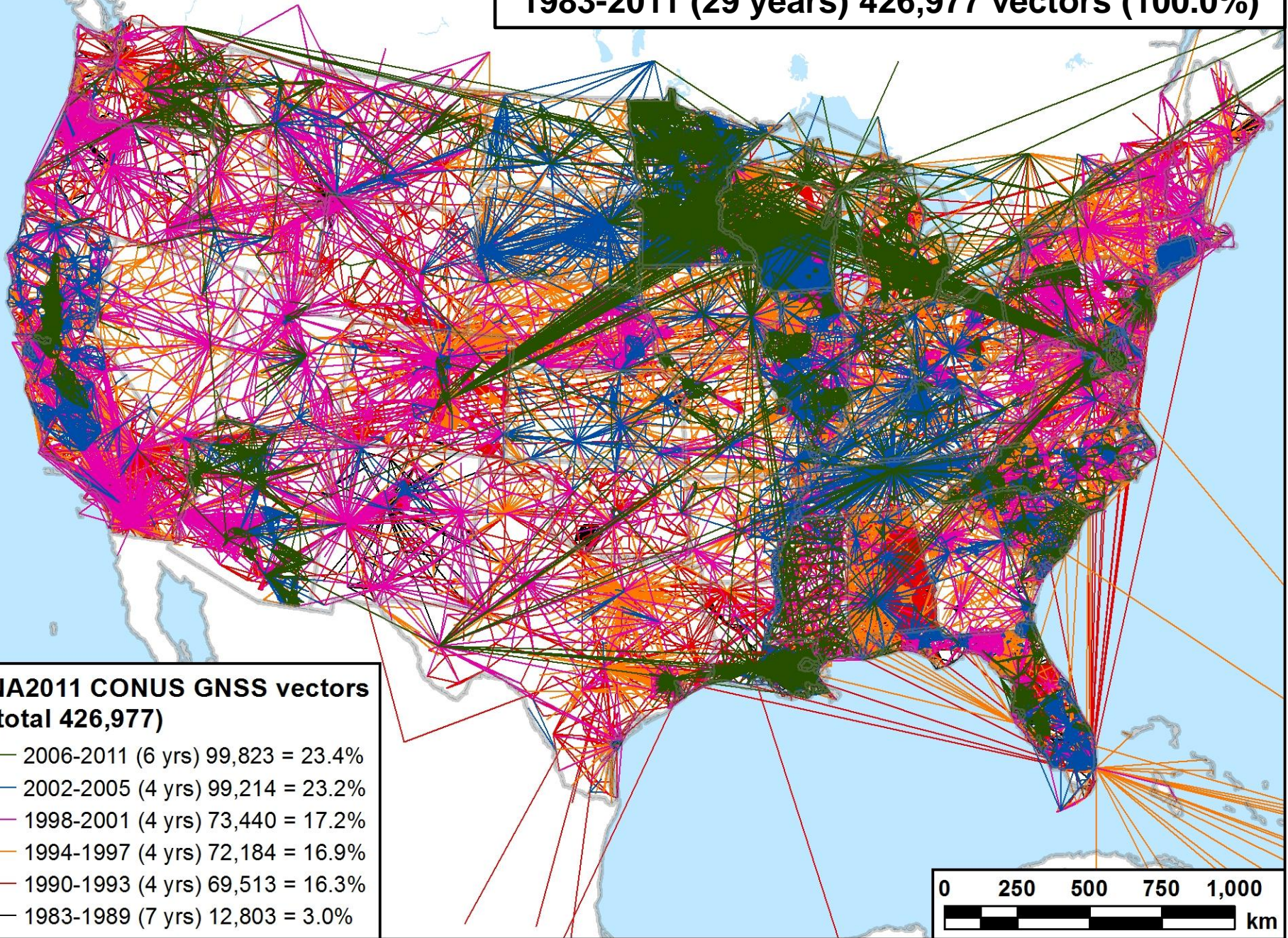
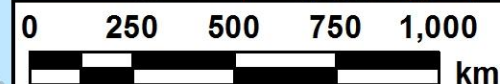




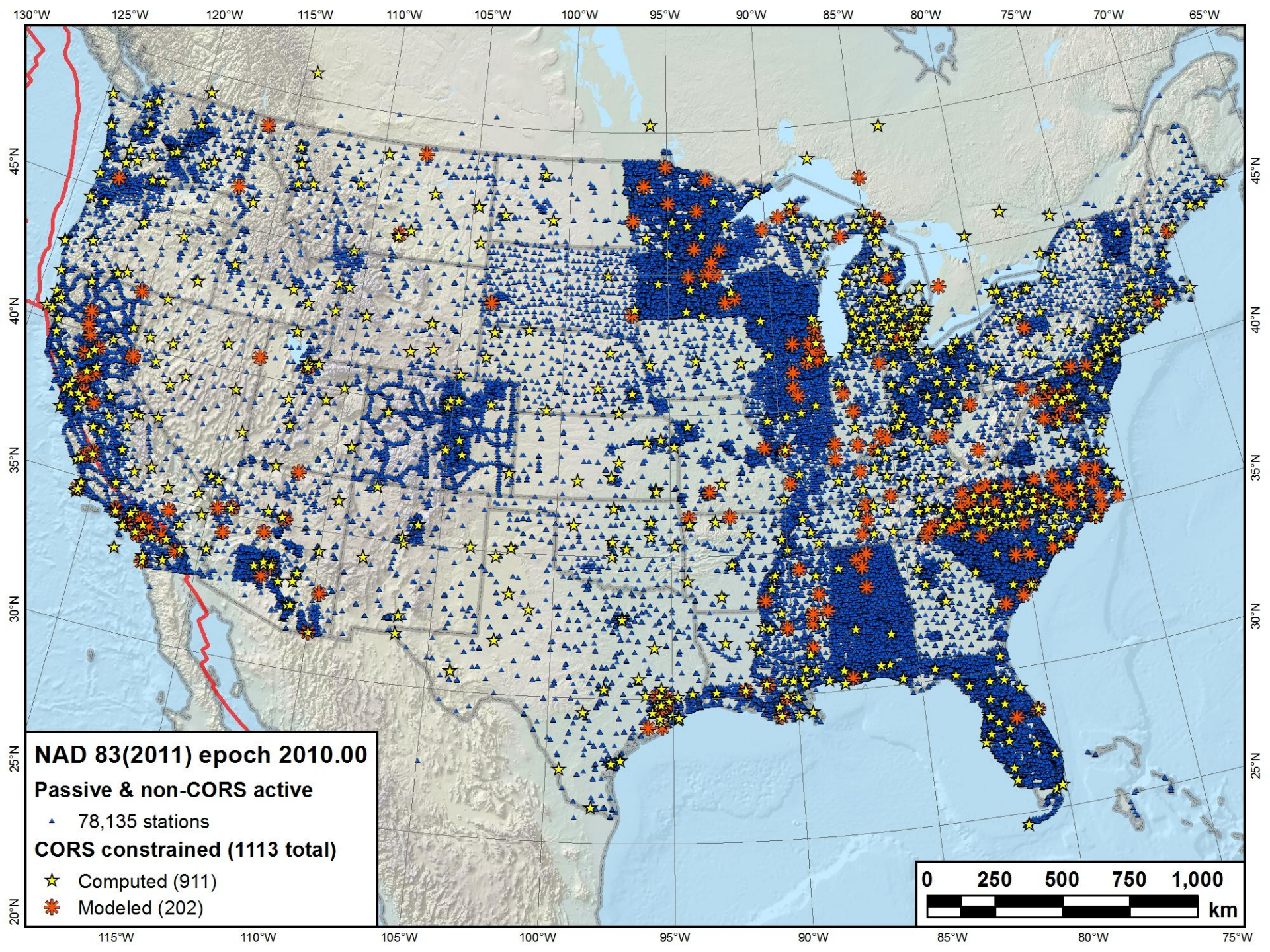
1983-2011 (29 years) 426,977 vectors (100.0%)

**NA2011 CONUS GNSS vectors  
(total 426,977)**

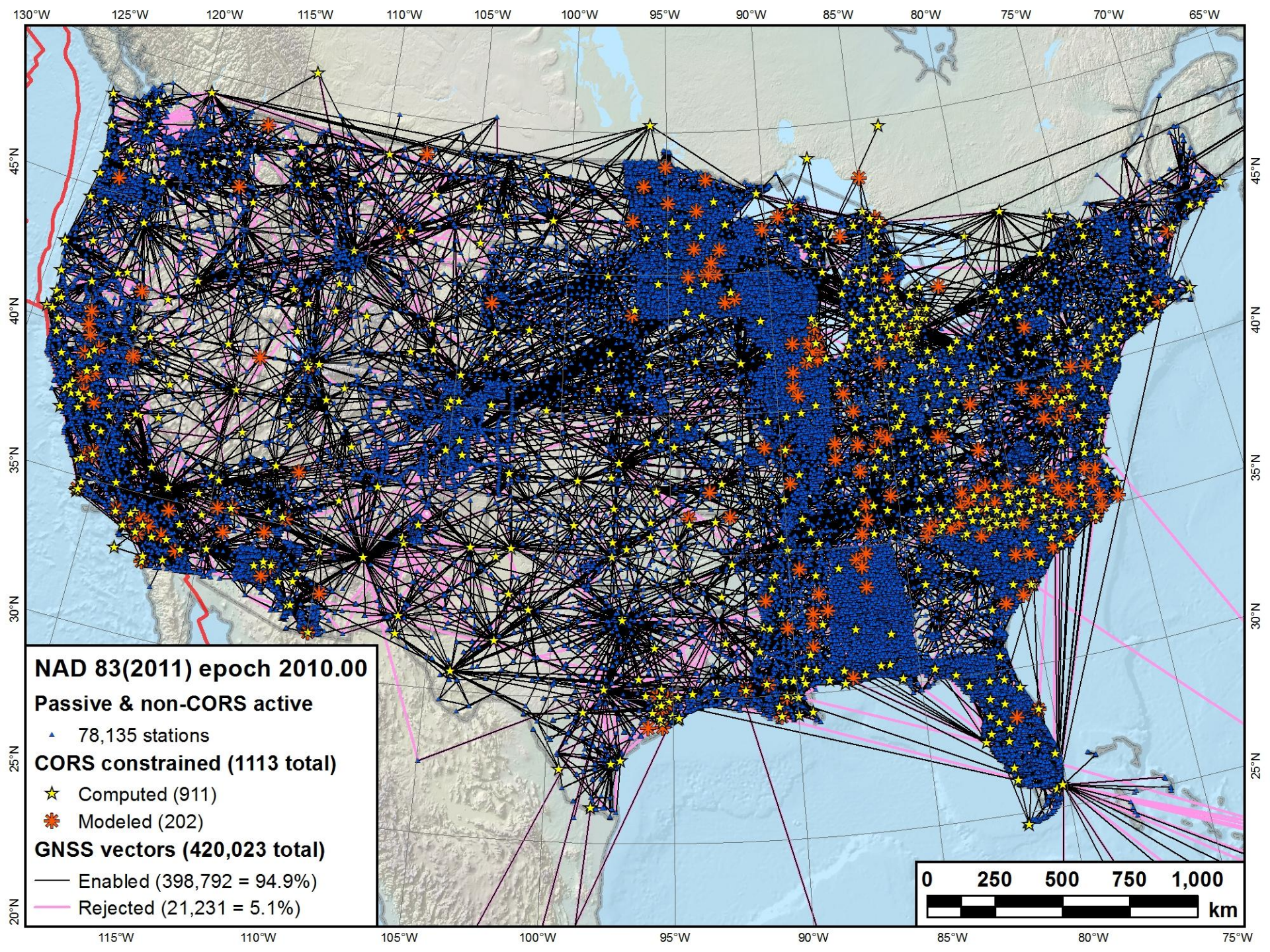
- 2006-2011 (6 yrs) 99,823 = 23.4%
- 2002-2005 (4 yrs) 99,214 = 23.2%
- 1998-2001 (4 yrs) 73,440 = 17.2%
- 1994-1997 (4 yrs) 72,184 = 16.9%
- 1990-1993 (4 yrs) 69,513 = 16.3%
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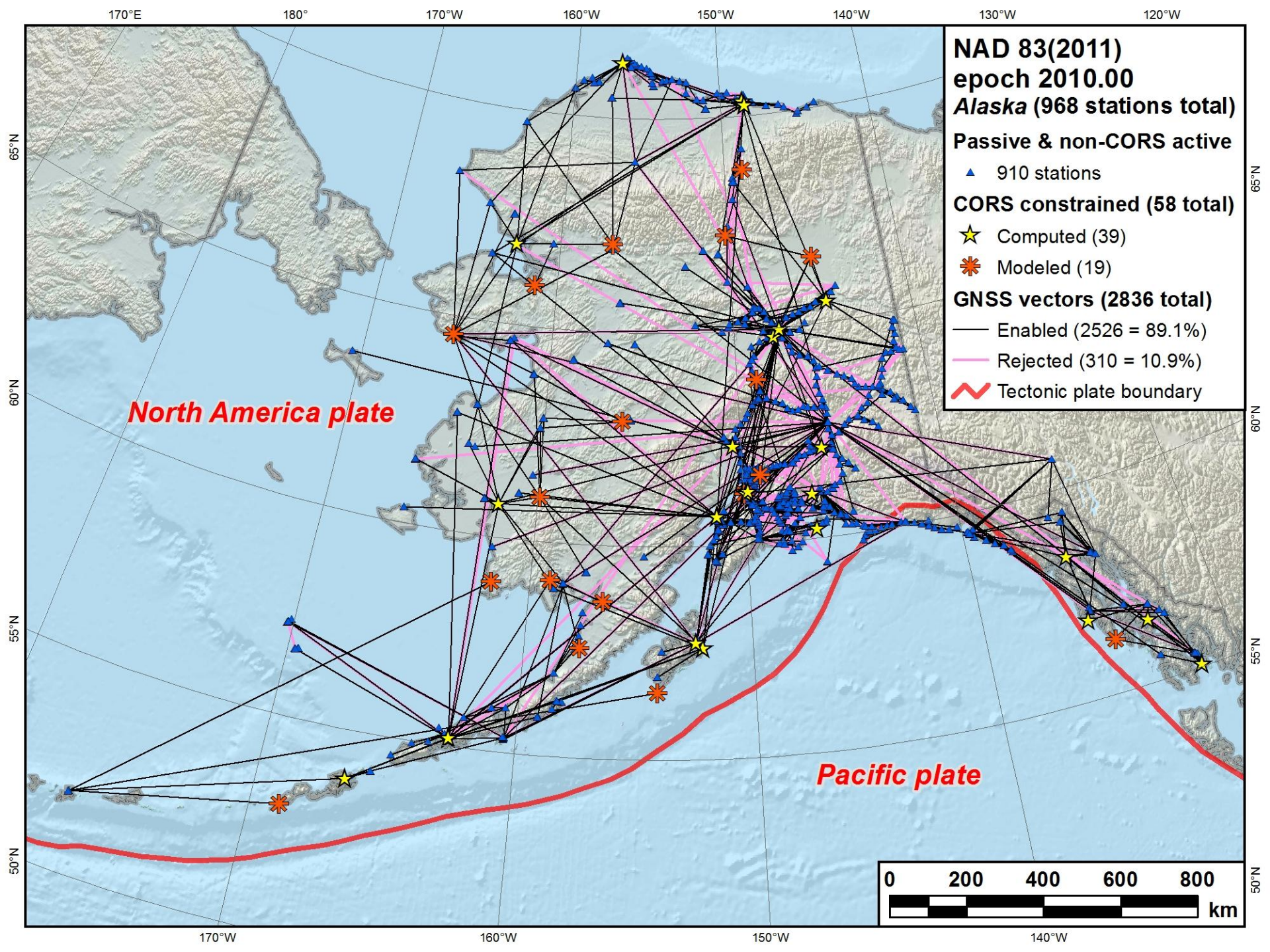




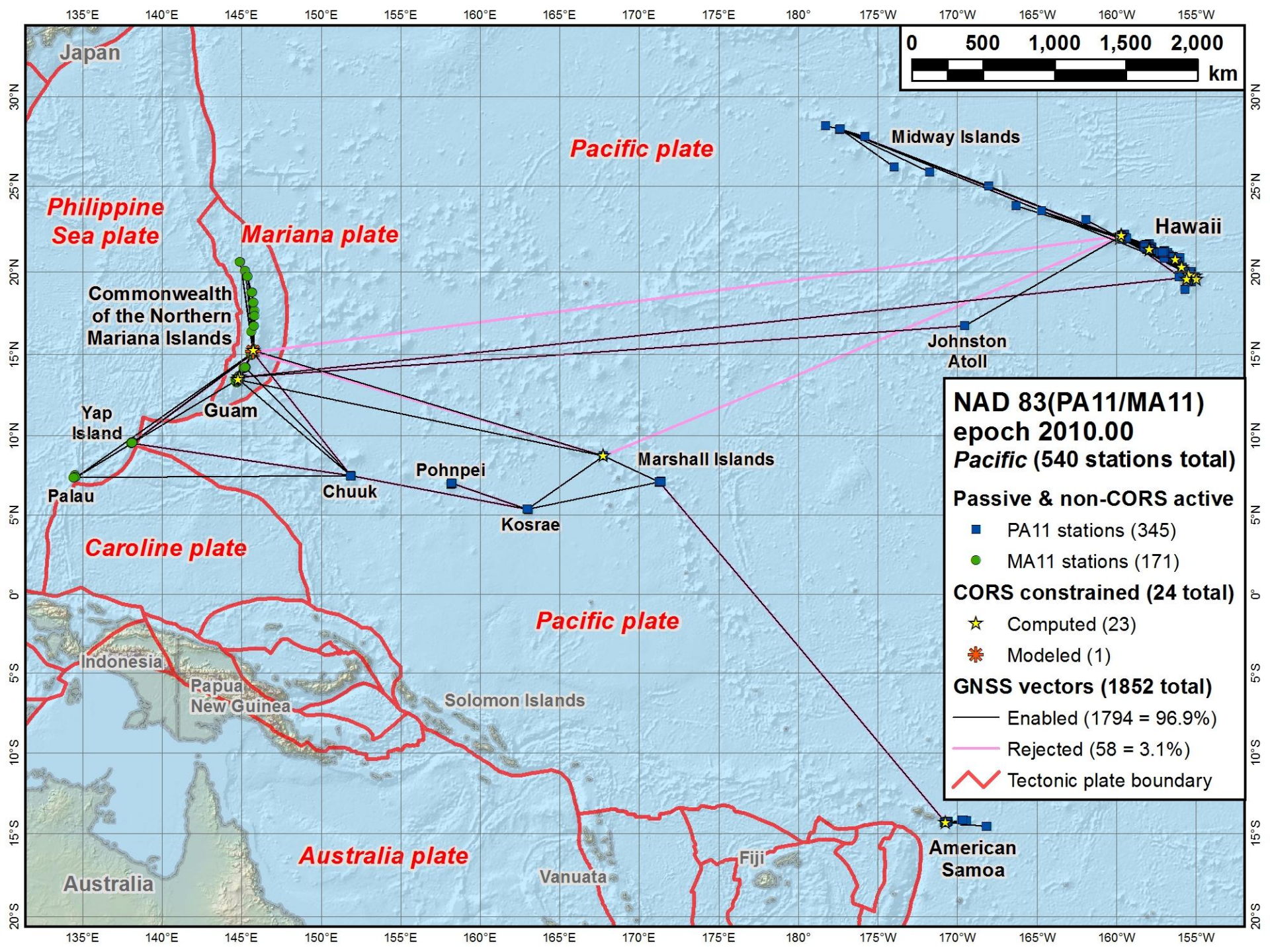












# NAD 83(2011/PA11/MA11) epoch 2010.00

## *Passive control results summary*

- Station network accuracies (95% confidence)
  - Overall median: ***0.9 cm horiz, 1.5 cm height*** (78,709)
    - ***90% < 2.3 cm horizontal and 4.8 cm ellipsoid height***
    - 2163 no-check stations excluded
  - Median accuracies by network
    - CONUS Primary: ***0.7 cm horiz, 1.2 cm height*** (61,049)
    - CONUS Secondary: ***1.6 cm horiz, 3.4 cm height*** (16,441)
    - Alaska: ***3.2 cm horiz, 5.7 cm height*** (814)
    - Pacific (PA11): ***2.2 cm horiz, 5.0 cm height*** (282)
    - Pacific (MA11): ***1.8 cm horiz, 3.8 cm height*** (123)

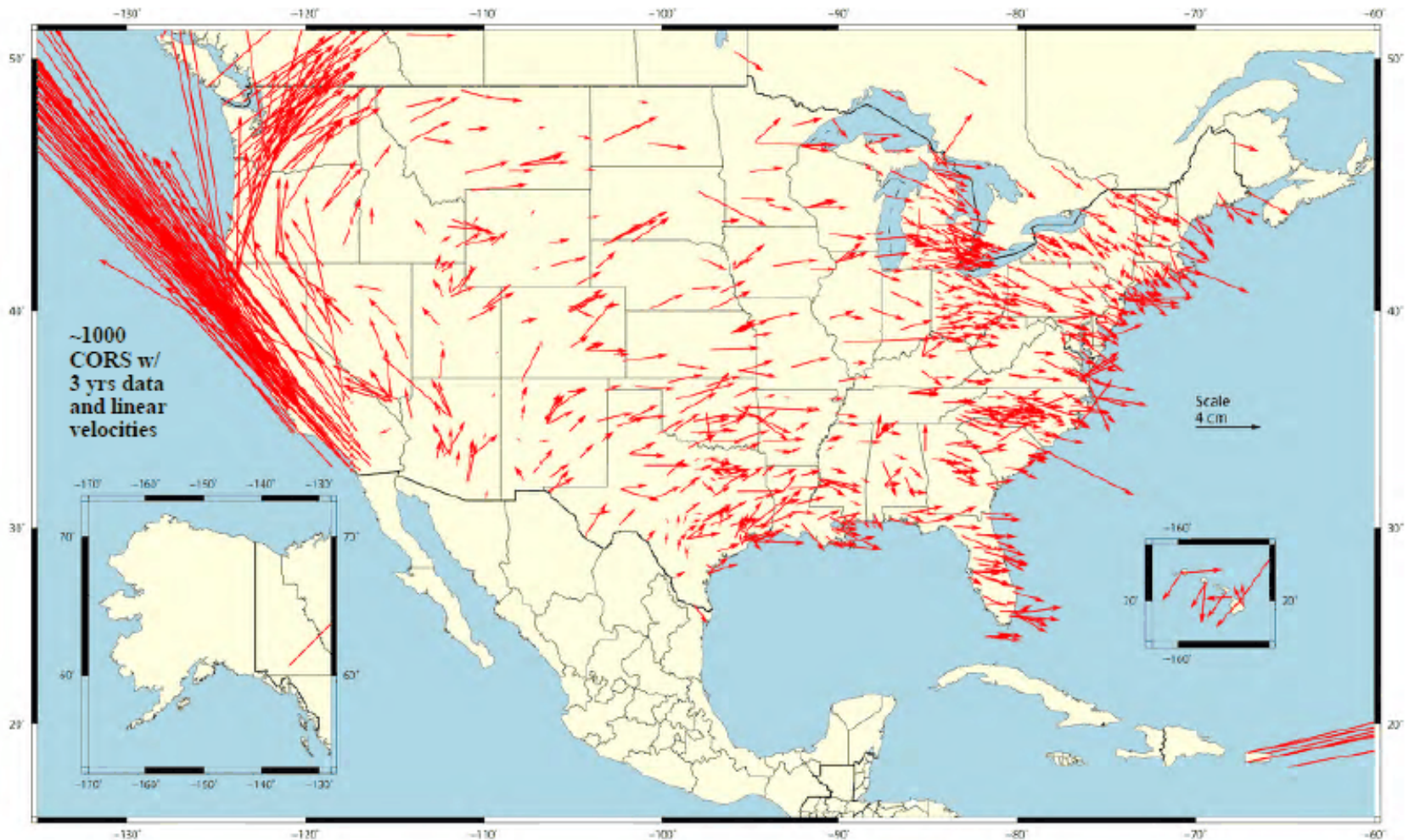


# Change in horizontal NAD 83 CORS coordinates

NAD 83(CORS96) epoch 2002.00 → NAD 83(2011) epoch 2010.00

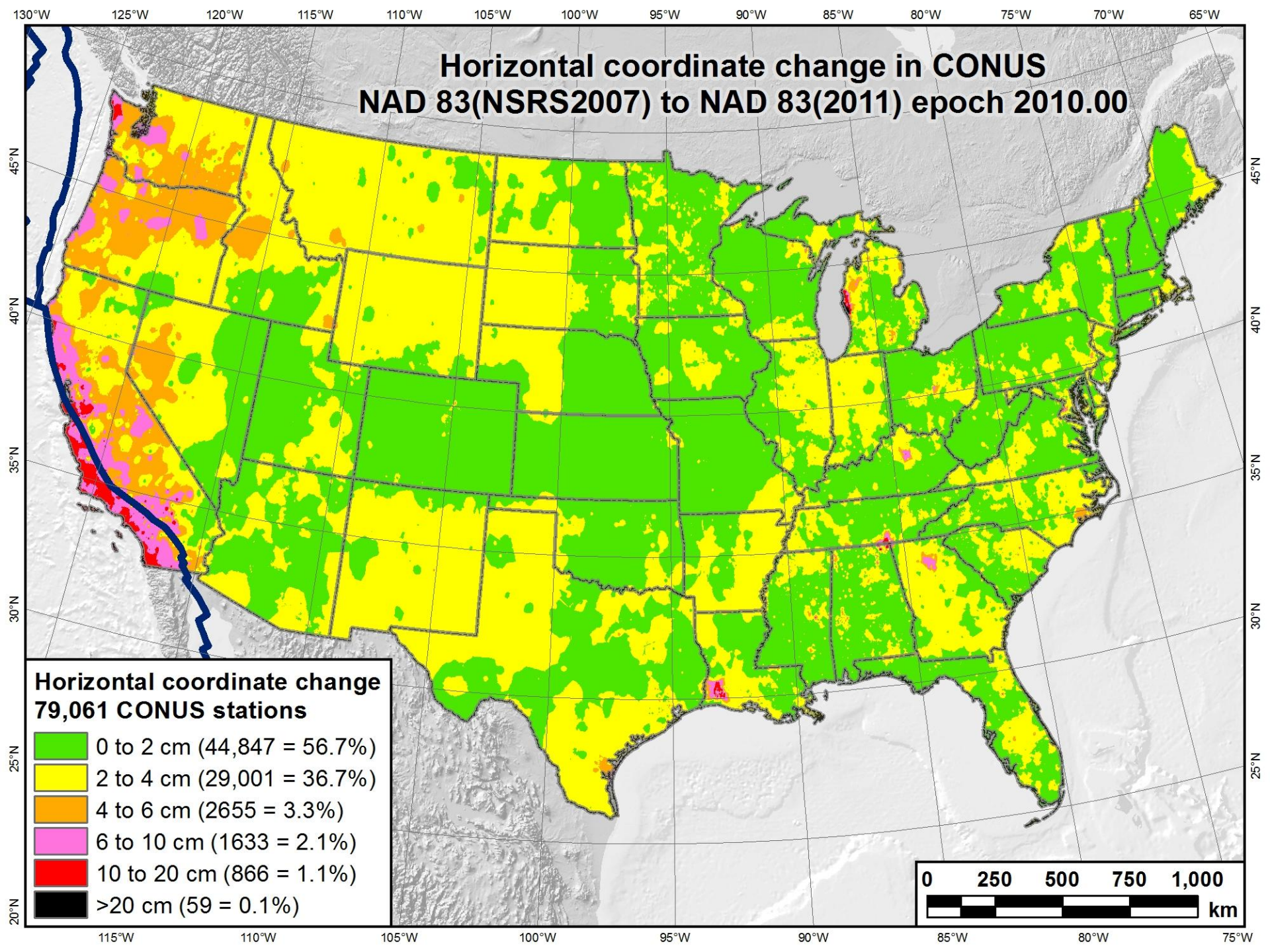
**Avg shifts (cm):**  $\Delta N = 2.0 (\pm 6.4)$ ;  $\Delta E = 0.2 (\pm 5.9)$ ;  $\Delta U = -0.9 (\pm 2.0)$

- large shifts in western U.S. due to crustal deformation
- apparent rotation in “stable” U.S. likely due to errors in NUVEL-1A (used in HTDP)



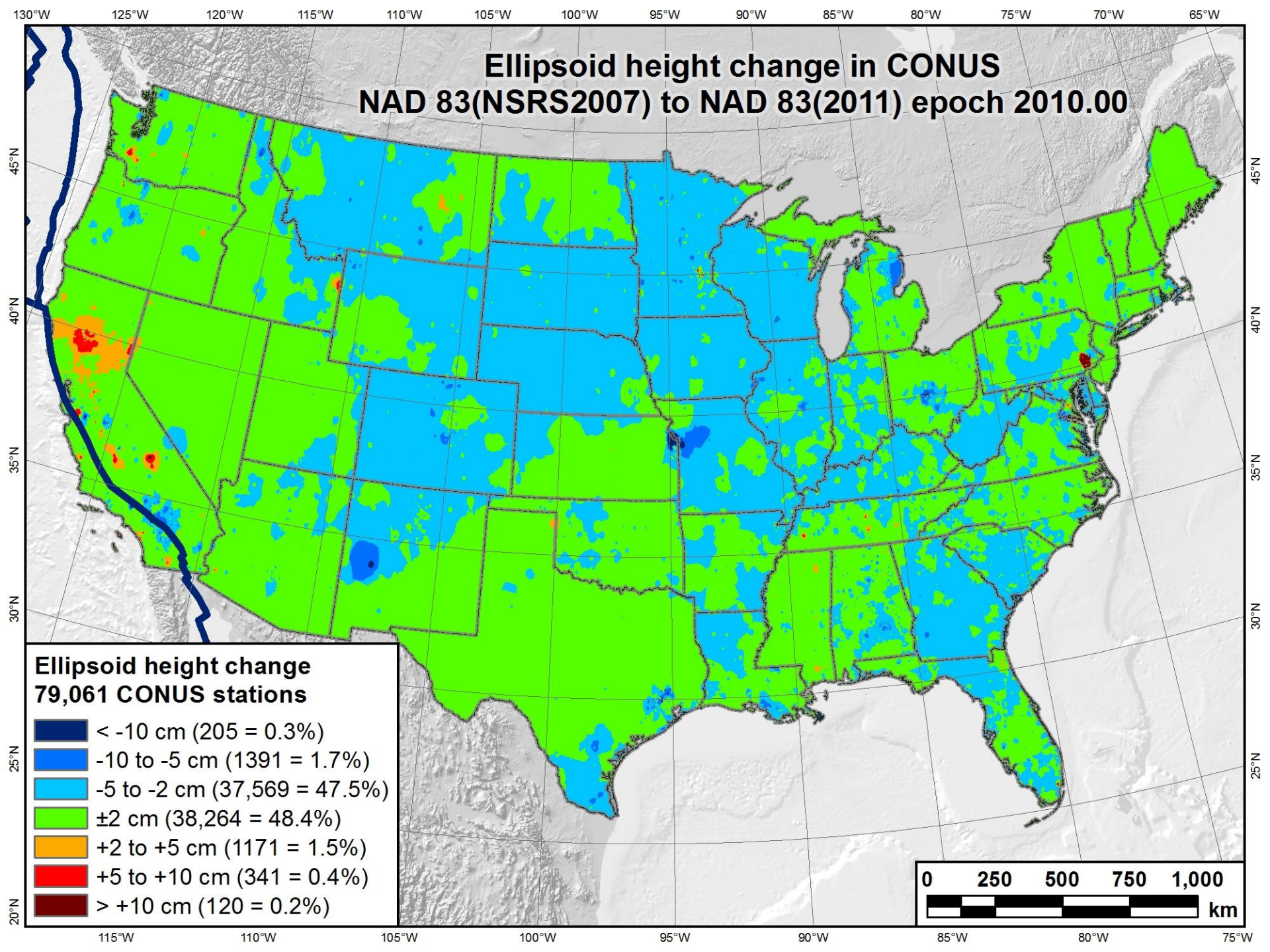


# Horizontal coordinate change in CONUS NAD 83(NSRS2007) to NAD 83(2011) epoch 2010.00





# Ellipsoid height change in CONUS NAD 83(NSRS2007) to NAD 83(2011) epoch 2010.00



# Related Tasks, Products & Deliverables

- OPUS (Online Positioning User Service)
  - Solutions now NAD 83(2011/PA11/MA11) epoch 2010.00
- New hybrid geoid model (GEOID12A)
  - NAD 83(2011) ellipsoid heights on leveled NAVD 88 BMs
- New process for Bluebooking GPS projects
  - Currently under development
  - New version of “ADJUST” program
  - Includes new GIS tools as part of adjustment process
- New NAD 83 coordinate transformation tools
  - HARN  $\leftrightarrow$  NSRS2007  $\leftrightarrow$  2011
  - Tools created but still needs to be implement



# New NGS Datasheet Format

- **New Datasheet version**
  - Changed location, length, and text for many fields
  - Added new fields, deleted fields, augmented existing fields
  - Production release in ***May 2012***
- **Summary of content changes**
  - Added country (e.g., USA) where control station located
  - Hyperlinked vertical datum designation to datum web page
  - Ortho height epoch date, if applicable (e.g., subsidence areas)
  - Note for geoid model used on Ht Mod stations if not current geoid
  - Network and (median) local accuracies
    - Horizontal and ellipsoid height accuracy at 95% confidence (per FGDC)
    - Includes link to detailed accuracy info, list of all local accuracies



1 National Geodetic Survey, Retrieval Date = APRIL 26, 2012

BJ0831 \*\*\*\*\*

BJ0831 HT\_MOD - This is a Louisiana Height Modernization Survey Station.

BJ0831 FBN - This is a Federal Base Network Control Station.

BJ0831 DESIGNATION - G 293

BJ0831 PID - BJ0831

BJ0831 STATE/COUNTY- LA/IBERVILLE

BJ0831 USGS QUAD - BAYOU SORREL (1992)

BJ0831

BJ0831 \*CURRENT SURVEY CONTROL

BJ0831

BJ0831\* NAD 83(2007)- 30 07 51.21248(N) 091 19 20.37359(W) ADJUSTED

BJ0831\* NAVD 88 - 6.81 (meters) 22.3 (feet) GPS OBS(2006.81)

BJ0831 \*\*This station is located in a suspected subsidence area (see below).

BJ0831

BJ0831 EPOCH DATE - 2002.00

BJ0831 X - -127,406.838 (meters) COMP

BJ0831 Y - -5,519,499.719 (meters) COMP

BJ0831 Z - 3,182,921.288 (meters) COMP

BJ0831 LAPLACE CORR- 0.80 (seconds) DEFLEC09

BJ0831 ELLIP HEIGHT- -20.072 (meters) (02/10/07) ADJUSTED

BJ0831 GEOID HEIGHT- -26.88 (meters) GEOID09

BJ0831

BJ0831 ----- Accuracy Estimates (at 95% Confidence Level in cm) -----

| Type    | PID    | Designation | North | East | Ellip |
|---------|--------|-------------|-------|------|-------|
| NETWORK | BJ0831 | G 293       | 0.47  | 0.59 | 1.43  |

BJ0831 -----

BJ0831 NETWORK BJ0831 G 293 0.47 0.59 1.43

BJ0831 -----

BJ0831

BJ0831.The horizontal coordinates were established by GPS observations

BJ0831.and adjusted by the National Geodetic Survey in February 2007.

BJ0831

BJ0831.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).

BJ0831.See [www.ngs.noaa.gov/NationalReadjustment](http://www.ngs.noaa.gov/NationalReadjustment) for more information.

BJ0831

BJ0831.The horizontal coordinates are valid at the epoch date displayed above

BJ0831.which is a decimal equivalence of Year/Month/Day.



1 National Geodetic Survey, Retrieval Date = SEPTEMBER 11, 2012

BJ0831 \*\*\*\*\*

BJ0831 HT\_MOD - This is a Height Modernization Survey Station.

BJ0831 FBN - This is a Federal Base Network Control Station.

BJ0831 DESIGNATION - G 293

BJ0831 PID - BJ0831

BJ0831 STATE/COUNTY- LA/IBERVILLE

BJ0831 COUNTRY - US

BJ0831 USGS QUAD - BAYOU SORREL (1992)

BJ0831

BJ0831 \*CURRENT SURVEY CONTROL

BJ0831

BJ0831\* NAD 83(2011) POSITION- 30 07 51.21287(N) 091 19 20.37290(W) ADJUSTED

BJ0831\* NAD 83(2011) ELLIP HT- -20.085 (meters) (06/27/12) ADJUSTED

BJ0831\* NAD 83(2011) EPOCH - 2010.00

BJ0831\* [NAVD 88](#) ORTHO HEIGHT - 6.81 (meters) 22.3 (feet) GPS OBSBJ0831\* [NAVD 88](#) EPOCH - 2006.81

BJ0831 \*\*This station is located in a suspected subsidence area (see below).

BJ0831

BJ0831 NAVD 88 orthometric height was determined with geoid model GEOID03

BJ0831 GEOID HEIGHT - -26.93 (meters) GEOID03

BJ0831 GEOID HEIGHT - -26.83 (meters) GEOID12A

BJ0831 NAD 83(2011) X - -127,406.819 (meters) COMP

BJ0831 NAD 83(2011) Y - -5,519,499.702 (meters) COMP

BJ0831 NAD 83(2011) Z - 3,182,921.292 (meters) COMP

BJ0831 LAPLACE CORR - 0.80 (seconds) DEFLEC09

BJ0831

BJ0831 FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)

BJ0831 Type Horiz Ellip Dist(km)

BJ0831 -----

BJ0831 NETWORK 0.48 2.69

BJ0831 -----

BJ0831 MEDIAN LOCAL ACCURACY AND DIST (094 points) 0.63 3.28 53.96

BJ0831 -----

BJ0831 NOTE: Click [here](#)  information on individual local accuracy

BJ0831 values and other accuracy information.



National Geodetic Survey, Retrieval Date = SEPTEMBER 11, 2012

BJ0831 \*\*\*\*\*

BJ0831 ACCURACIES - Complete network and local accuracy information.  
 BJ0831 HT\_MOD - This is a Louisiana Height Modernization Survey Station.  
 BJ0831 FBN - This is a Federal Base Network Control Station.  
 BJ0831 DESIGNATION - G 293  
 BJ0831 PID - BJ0831

BJ0831

BJ0831 Statistical Information, in cm, for point BJ0831 follows.

BJ0831

BJ0831 Note that Horz and Ellip values are the official 95%  
 BJ0831 FGDC accuracy standards. The values of StdN, StdE and Stdh are the  
 BJ0831 standard deviations (one sigma) of the coordinates (NETWORK) or  
 BJ0831 of the difference in the coordinates (LOCAL) in Latitude, Longitude  
 BJ0831 and Ellipsoid Height. The value CorrNE is the correlation  
 BJ0831 coefficient between the latitude and longitude components of either  
 BJ0831 the coordinate (NETWORK) or coordinate difference (LOCAL).

BJ0831

| Type/PID | Horz | Ellip | Dist(km) | StdN | StdE | Stdh | CorrNE |
|----------|------|-------|----------|------|------|------|--------|
|----------|------|-------|----------|------|------|------|--------|

BJ0831

|         |      |      |      |      |      |      |             |
|---------|------|------|------|------|------|------|-------------|
| NETWORK | 0.48 | 2.69 | 0.00 | 0.13 | 0.23 | 1.37 | -0.07662508 |
|---------|------|------|------|------|------|------|-------------|

BJ0831

BJ0831 LOCAL:

|               |      |      |       |      |      |      |             |
|---------------|------|------|-------|------|------|------|-------------|
| BJ0831 DH3202 | 0.60 | 3.06 | 16.18 | 0.16 | 0.29 | 1.56 | -0.05219128 |
| BJ0831 BJ0579 | 0.57 | 2.98 | 19.56 | 0.17 | 0.27 | 1.52 | -0.07273522 |
| BJ0831 BJ1021 | 0.87 | 4.02 | 20.77 | 0.19 | 0.43 | 2.05 | -0.04467546 |
| BJ0831 BJ1111 | 0.64 | 3.19 | 25.64 | 0.17 | 0.31 | 1.63 | -0.03670410 |
| BJ0831 DJ9379 | 0.68 | 3.16 | 25.99 | 0.19 | 0.33 | 1.61 | -0.03573330 |
| BJ0831 BJ1001 | 0.59 | 3.35 | 26.32 | 0.17 | 0.28 | 1.71 | -0.06366254 |
| BJ0831 AU0077 | 0.66 | 3.27 | 26.72 | 0.18 | 0.32 | 1.67 | -0.04990073 |
| BJ0831 DI4042 | 0.56 | 3.25 | 29.43 | 0.16 | 0.27 | 1.66 | -0.06820650 |
| BJ0831 BJ2052 | 0.64 | 3.29 | 30.02 | 0.18 | 0.31 | 1.68 | -0.05649048 |
| BJ0831 BJ1067 | 1.03 | 4.45 | 31.07 | 0.23 | 0.51 | 2.27 | -0.05692438 |
| BJ0831 BJ0993 | 0.53 | 3.00 | 32.33 | 0.17 | 0.25 | 1.53 | -0.07524511 |
| BJ0831 BJ0634 | 0.57 | 3.02 | 32.56 | 0.18 | 0.27 | 1.54 | -0.07909136 |
| BJ0831 BJ5321 | 1.15 | 6.70 | 33.56 | 0.30 | 0.56 | 3.42 | +0.15488640 |



BJ0831

BJ0831.The ellipsoidal height was determined by GPS observations  
BJ0831.and is referenced to NAD 83.

BJ0831

BJ0831.The geoid height was determined by GEOID09.

BJ0831

| BJ0831;         |   | North         | East          | Units | Scale      | Factor | Converg.   |
|-----------------|---|---------------|---------------|-------|------------|--------|------------|
| BJ0831;SPC LA S | - | 180,775.280   | 1,001,060.584 | MT    | 0.99992831 |        | +0 00 19.8 |
| BJ0831;SPC LA S | - | 593,093.56    | 3,284,312.93  | sFT   | 0.99992831 |        | +0 00 19.8 |
| BJ0831;UTM 15   | - | 3,334,477.320 | 661,606.549   | MT    | 0.99992222 |        | +0 50 32.4 |

BJ0831

|                 |   |             |   |              |   |                 |
|-----------------|---|-------------|---|--------------|---|-----------------|
| BJ0831!         | - | Elev Factor | x | Scale Factor | = | Combined Factor |
| BJ0831!SPC LA S | - | 1.00000315  | x | 0.99992831   | = | 0.99993146      |
| BJ0831!UTM 15   | - | 1.00000315  | x | 0.99992222   | = | 0.99992537      |

BJ0831

BJ0831

SUPERSEDED SURVEY CONTROL

BJ0831

|        |                    |                |     |        |          |              |     |
|--------|--------------------|----------------|-----|--------|----------|--------------|-----|
| BJ0831 | ELLIP H (06/20/00) | -20.090        | (m) |        |          | GP ( )       | 3 1 |
| BJ0831 | NAD 83(1992)-      | 30 07 51.23112 | (N) | 091 19 | 20.37006 | (W) AD ( )   | 1   |
| BJ0831 | NAD 83(1992)-      | 30 07 51.21235 | (N) | 091 19 | 20.37230 | (W) AD ( )   | B   |
| BJ0831 | ELLIP H (09/10/92) | -20.004        | (m) |        |          | GP ( )       | 4 1 |
| BJ0831 | NAVD 88 (08/12/94) | 6.97           | (m) |        | 22.9     | (f) LEVELING | 3   |
| BJ0831 | NAVD 88 (02/14/94) | 6.971          | (m) |        | 22.87    | (f) ADJUSTED | 1 1 |
| BJ0831 | NAVD 88 (09/10/92) | 7.1            | (m) |        | 23.      | (f) GPS OBS  |     |
| BJ0831 | NGVD 29 (??/??/??) | 7.003          | (m) |        | 22.98    | (f) ADJUSTED | 1 1 |

BJ0831

BJ0831.Superseded values are not recommended for survey control.

BJ0831.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

BJ0831.[See file dsdata.txt](#) to determine how the superseded data were derived.

BJ0831

BJ0831\_U.S. NATIONAL GRID SPATIAL ADDRESS: 15RXP6160634477(NAD 83)

BJ0831

BJ0831\_MARKER: DV = VERTICAL CONTROL DISK

BJ0831\_SETTING: 36 = SET IN A MASSIVE STRUCTURE

BJ0831\_SP\_SET: RIVER LOCK

BJ0831\_STAMPING: G 293 1976

BJ0831\_MARK LOGO: NGS



BJ0831

BJ0831.The ellipsoidal height was determined by GPS observations  
BJ0831.and is referenced to NAD 83.

BJ0831

BJ0831. The following values were computed from the NAD 83(2011) position.

BJ0831

| BJ0831;         |   | North         | East          | Units | Scale      | Factor | Converg.   |
|-----------------|---|---------------|---------------|-------|------------|--------|------------|
| BJ0831;SPC LA S | - | 180,775.292   | 1,001,060.603 | MT    | 0.99992831 |        | +0 00 19.8 |
| BJ0831;SPC LA S | - | 593,093.60    | 3,284,313.00  | sFT   | 0.99992831 |        | +0 00 19.8 |
| BJ0831;UTM 15   | - | 3,334,477.332 | 661,606.568   | MT    | 0.99992222 |        | +0 50 32.4 |

BJ0831

| BJ0831!         |   | Elev Factor | x | Scale Factor | = | Combined Factor |
|-----------------|---|-------------|---|--------------|---|-----------------|
| BJ0831!SPC LA S | - | 1.00000315  | x | 0.99992831   | = | 0.99993146      |
| BJ0831!UTM 15   | - | 1.00000315  | x | 0.99992222   | = | 0.99992537      |

BJ0831

BJ0831

SUPERSEDED SURVEY CONTROL

BJ0831

|        |                    |                    |                     |          |     |
|--------|--------------------|--------------------|---------------------|----------|-----|
| BJ0831 | NAD 83(2007)-      | 30 07 51.21248 (N) | 091 19 20.37359 (W) | AD ( )   | 0   |
| BJ0831 | ELLIP H (02/10/07) | -20.072 (m)        |                     | GP ( )   |     |
| BJ0831 | ELLIP H (06/20/00) | -20.090 (m)        |                     | GP ( )   | 3 1 |
| BJ0831 | NAD 83(1992)-      | 30 07 51.23112 (N) | 091 19 20.37006 (W) | AD ( )   | 1   |
| BJ0831 | NAD 83(1992)-      | 30 07 51.21235 (N) | 091 19 20.37230 (W) | AD ( )   | B   |
| BJ0831 | ELLIP H (09/10/92) | -20.004 (m)        |                     | GP ( )   | 4 1 |
| BJ0831 | NAVD 88 (08/12/94) | 6.97 (m)           | 22.9 (f)            | LEVELING | 3   |
| BJ0831 | NAVD 88 (02/14/94) | 6.971 (m)          | 22.87 (f)           | ADJUSTED | 1 1 |
| BJ0831 | NAVD 88 (09/10/92) | 7.1 (m)            | GEOID90 model used  | GPS OBS  |     |
| BJ0831 | NGVD 29 (??/??/??) | 7.003 (m)          | 22.98 (f)           | ADJUSTED | 1 1 |

BJ0831

BJ0831.Superseded values are not recommended for survey control.

BJ0831

BJ0831.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

BJ0831.[See file dsdata.txt](#) to determine how the superseded data were derived.

BJ0831

BJ0831\_U.S. NATIONAL GRID SPATIAL ADDRESS: 15RXP6160634477(NAD 83)

BJ0831

BJ0831\_MARKER: DV = VERTICAL CONTROL DISK

BJ0831\_SETTING: 36 = SET IN A MASSIVE STRUCTURE

BJ0831\_SP SET: RIVER LOCK



# Recap: The fundamental questions

- When was it done?
  - Publication completed on ***June 30, 2012***
    - ***Intent: Simultaneous with release of GEOID12A***
- How many control stations? ***80,872***
- How much did the coordinates change?
  - Median: ***1.9 cm horiz, 2.1 cm vertical***
- How accurate are the results?
  - Median: ***0.9 cm horiz, 1.5 cm vertical***  
(at 95% confidence level)
- How do I make use of the results?
  - Key is ***metadata***: Know and identify what you have
  - Be consistent (i.e., don't mix realizations)
  - Understand your software (e.g., relationship to "WGS 84")
    - Latest WGS 84 is G1674 (week of Feb 5, 2012), epoch 2005.00





# More information...

## National Geodetic Survey

# geodesy.noaa.gov

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September 11, 2012

### Announcements

#### NOTICE: NGS Update, September 4, 2012

##### GEOID12A Model Nearly Finalized

The National Geodetic Survey has modified the **GEOID12A model on the NGS Beta website**. After further analysis of the existing control data, we have modified several additional control points in Alabama, as well as a few points in Wisconsin. Click **here** for more information. NGS expects these points to be the final changes, however the GEOID12A model will continue to be posted on the NGS Beta website for any final comments until around September 10, 2012, after which we expect the model to be released for production.

#### NOTICE: NGS Update, August 17, 2012

##### Revision of GPS Project Adjustment and Submission Process

NOAA's National Geodetic Survey (NGS) is revising the adjustment and submission process (i.e., "Bluebooking") for GPS projects. NGS asks users to wait until the revision is complete before submitting new projects using the **NAD 83(2011/PA11/MA11) epoch 2010.00** realization and geoid model **GEOID12A**. We estimate the revision will be finalized by September 30, 2012. Please check the NGS website for updates and additional information.

#### The National Geodetic Survey Improves the National Spatial Reference System with Simultaneous Major Product Releases

In the first week of July, NOAA's National Geodetic Survey (NGS) released the

NRC Highlights Importance of NGS Products...



### Most Popular

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Geodetic Tool Kit

NAD 83(2011) epoch 2010.00



OPUS

LOCUS

Publications

Geodetic Advisors

Storm Imagery

UFCORS

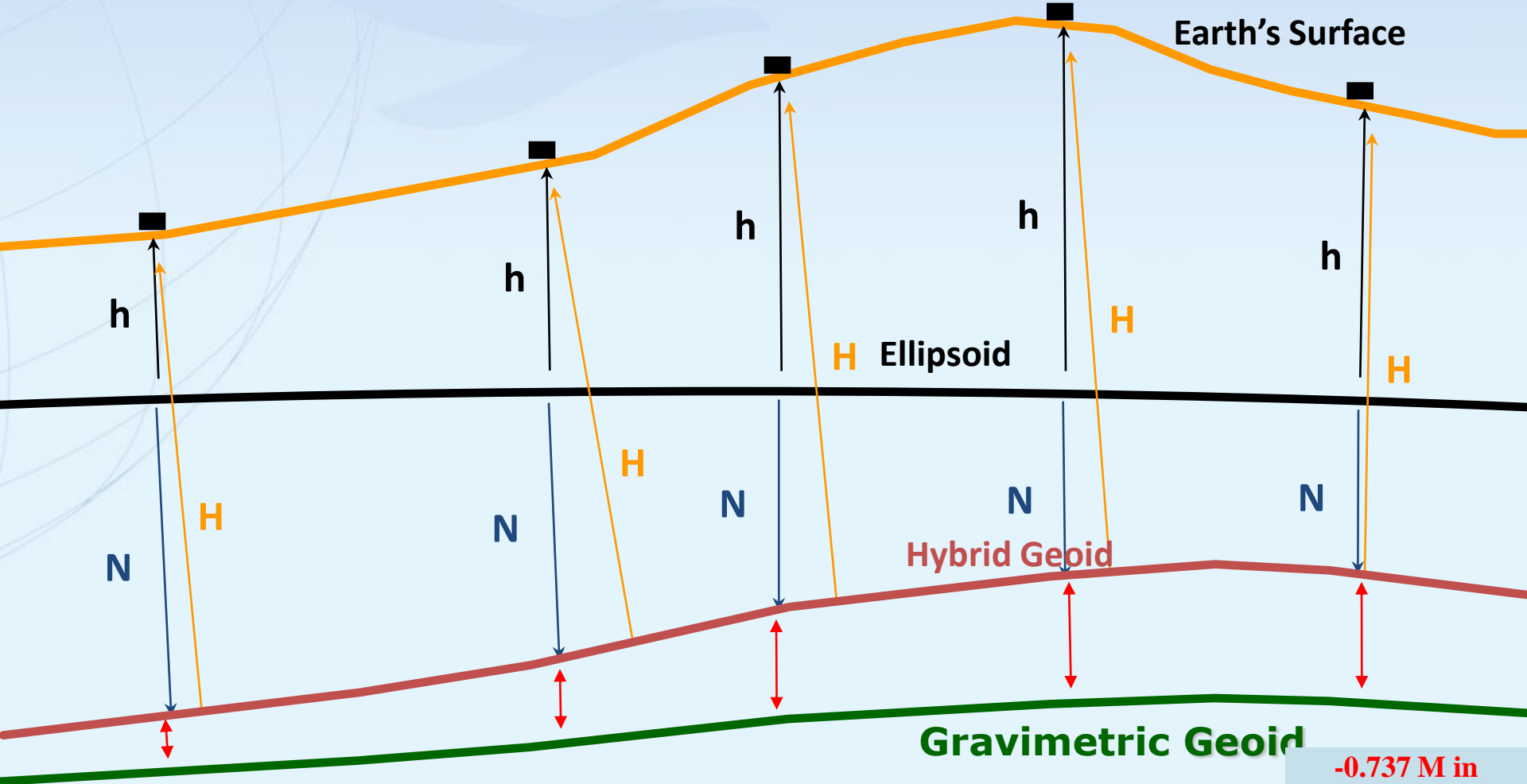
### Upcoming Events

# Basic Concepts on Modeling

- Start with a gravimetric geoid (USGG2012)
- Use control data to fit to local datums
  - Appropriate versions of NAD 83
  - Respective local Vertical Datum (if one exists)
- Use LSC to determine correlated signal
- For complex areas (e.g., CONUS), use MMLSC
- Apply grid of correlated signal to USGG2012
- Results in GEOID12 with high frequency nature from USGG2012 but fit to local control



Hybrid Geoid Height Models (e.g., GEOID12), Gravimetric Geoid Height Models (e.g., USGG2012) and Conversion Surfaces using GPS on BM data



-0.737 M in Salt Lake – 2009 model

- Gravimetric Geoid systematic misfit to BM's but best fits "true" heights
- Hybrid Geoid "converted" to fit local BM's, so best fits NAVD 88 heights
- Conversion Surface model of systematic misfit derived from BM's in IDB

# Control Data for GEOID12 Modeling

| Region              | Reference Frame | Vertical Datum  | # GPSBM used<br>(# Rejected) | # OPUSDB used<br>(# Rejected) |
|---------------------|-----------------|-----------------|------------------------------|-------------------------------|
| CONUS               | NAD 83 (2011)   | NAVD 88         | * 24,003 (868)               | 478 (258)                     |
| - VTDP Region       | NAD 83 (2011)   | NAVD 88/VTDP    | 357 (153)                    | 1 (17)                        |
| Alaska              | NAD 83 (2011)   | NAVD 88         | ** 105 (4)                   | 2 (1)                         |
| Puerto Rico         | NAD 83 (2011)   | PRVD 02         | 38                           | 0                             |
| U.S. Virgin Islands | NAD 83 (2011)   | VIVD 09         | 21 (3)                       | 0                             |
| Hawaii              | NAD 83 (PA11)   | Geoid ( $W_0$ ) | n/a                          | n/a                           |
| American Samoa      | NAD 83 (PA11)   | ASVD 02         | 19 (3)                       | 0                             |
| Guam                | NAD 83 (MA11)   | GUVD 04         | 33                           | 0                             |
| CNMI                | NAD 83 (MA11)   | NMVD 03         | 55                           | 0                             |

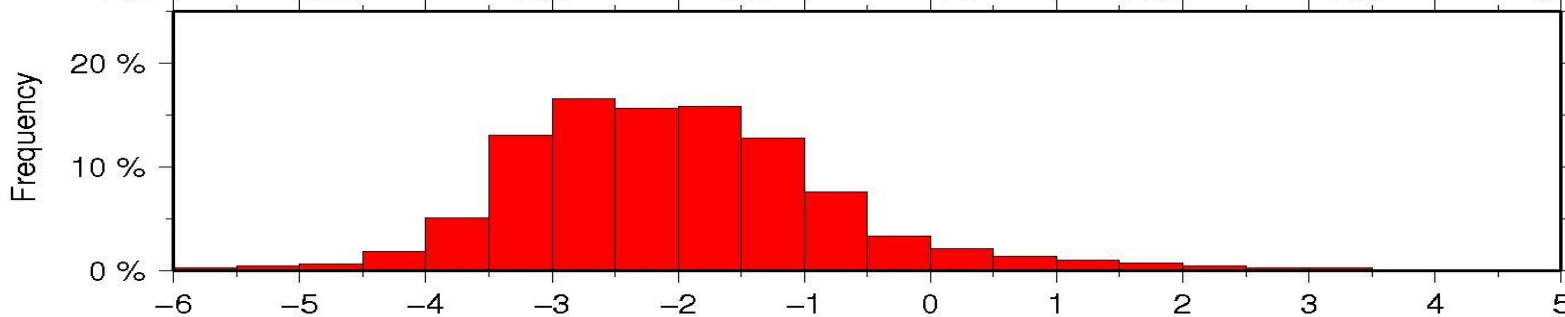
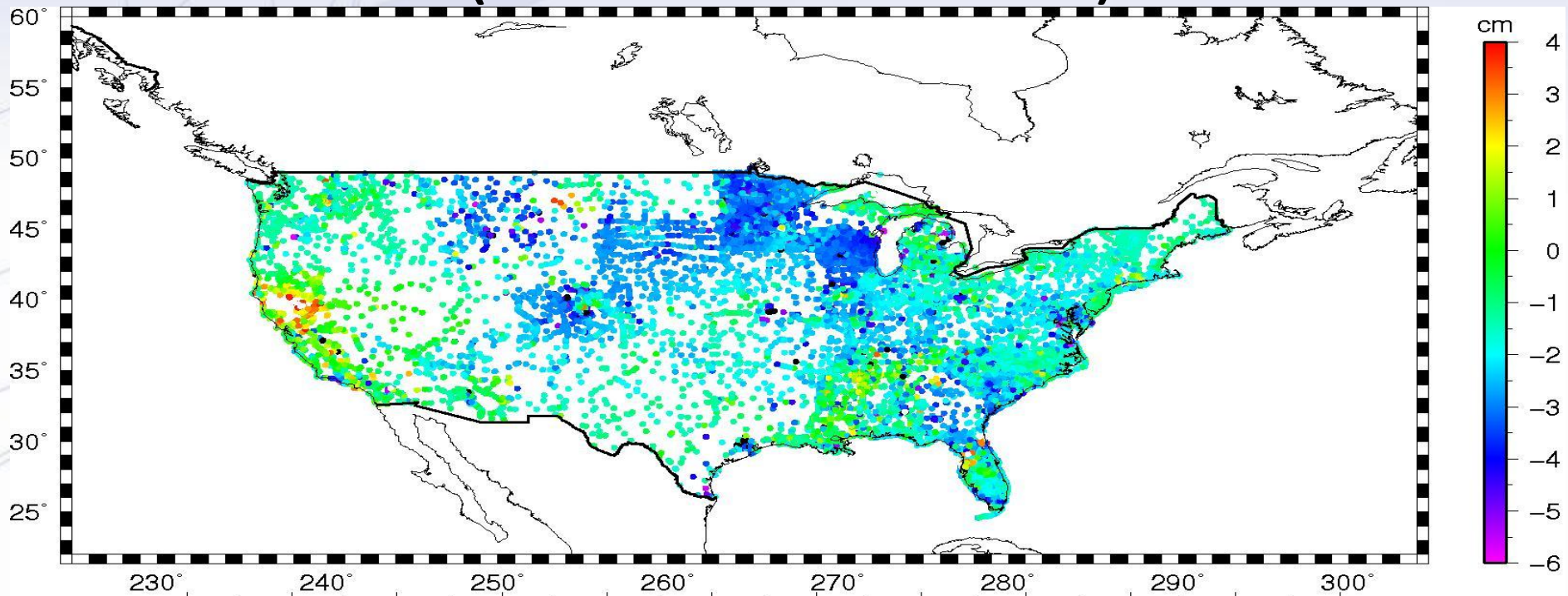
\* Supplemented by 574 (5 rejected) in Canada and 674 (70 rejected) in Mexico

\*\* Supplemented by 88 (2 rejected) in Canada

<http://www.ngs.noaa.gov/GEOID/GEOID12/GPSonBM12.shtml>

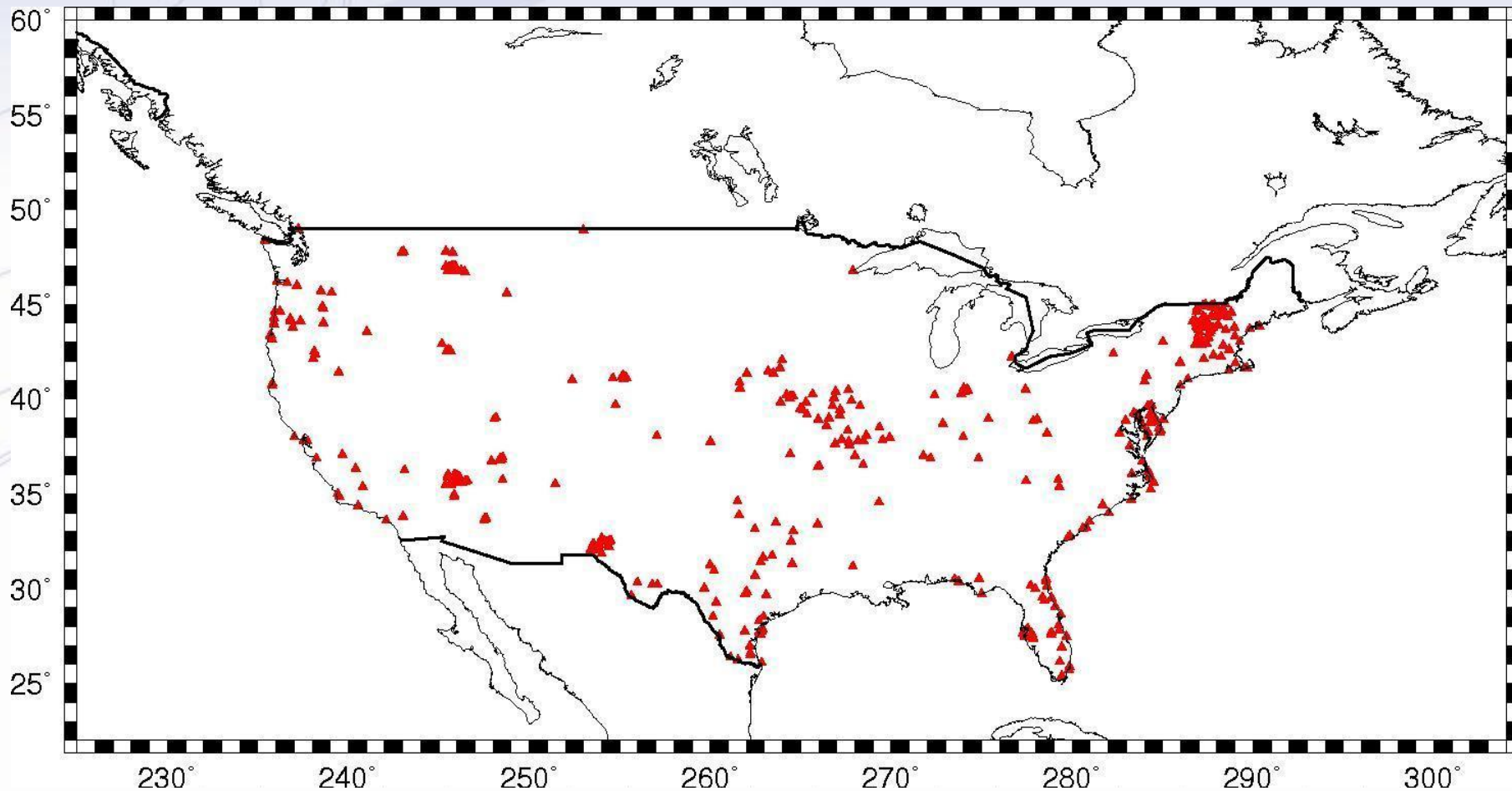


# Ellipsoid Height Changes (NA2011-NA2007)



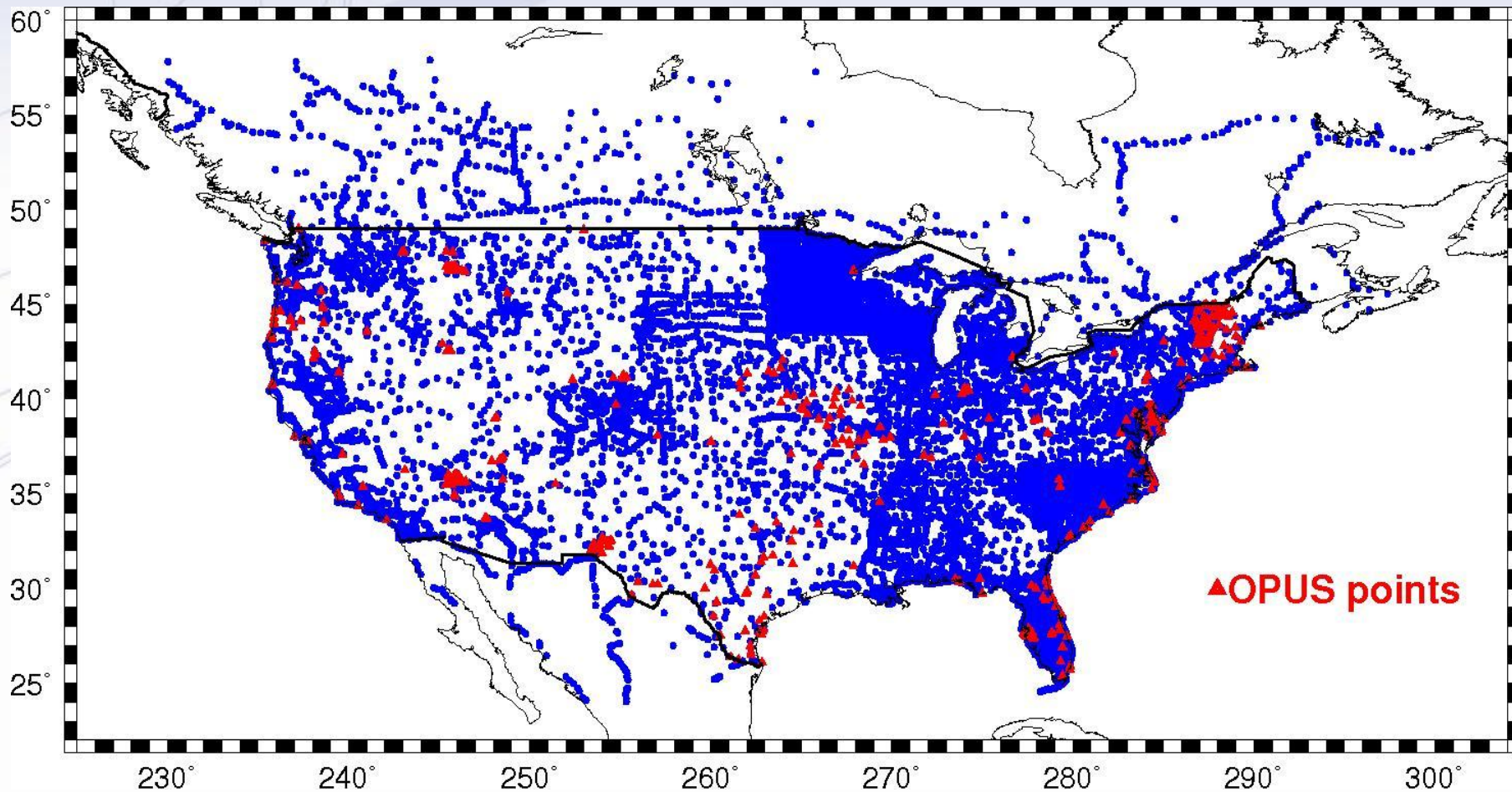
**Mean=-2.09**  
**STD=1.69**  
**Max=18.60**  
**Min=-55.10**

# Distribution of OPUSDBBM12

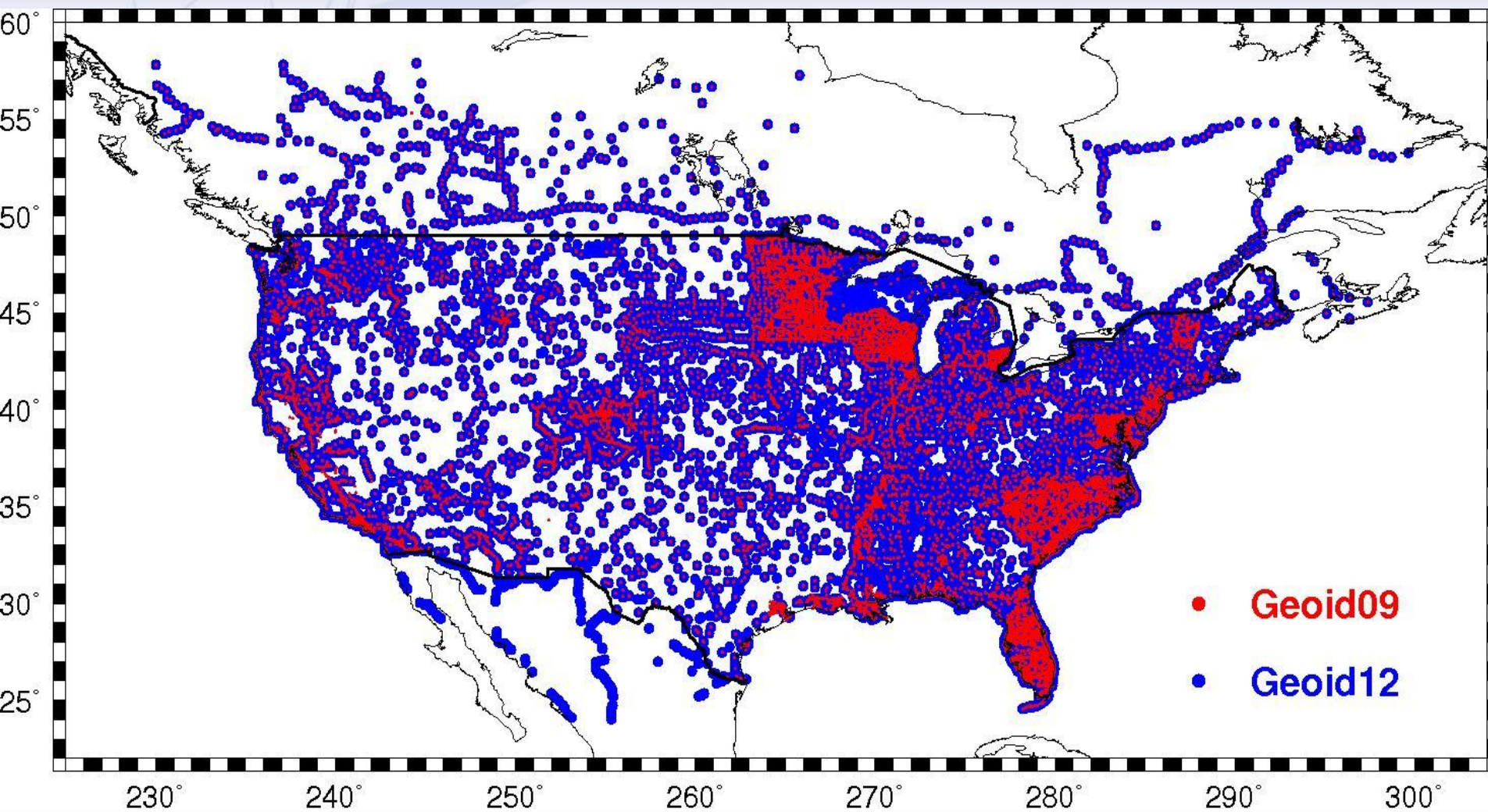




# Distribution of OPUSDBBM12



# An additional 6,000 points?





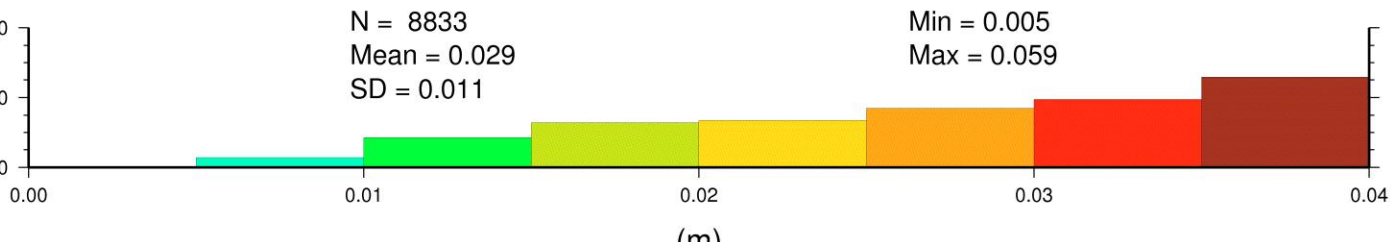
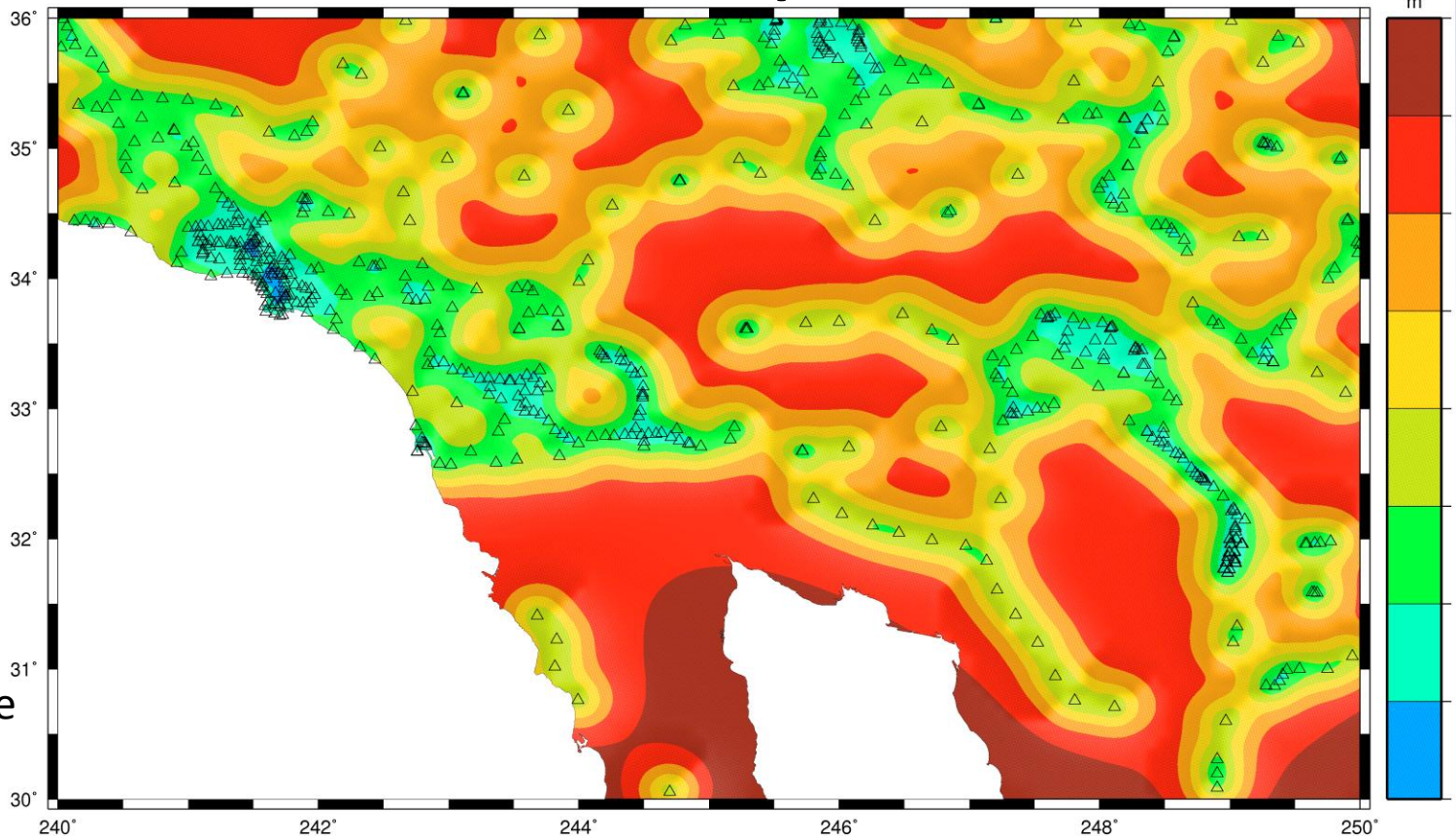
# GEOID12 Error Map for Southwest

Triangles show locations of GPSBM2012 & OPUSDBBM12 control points.

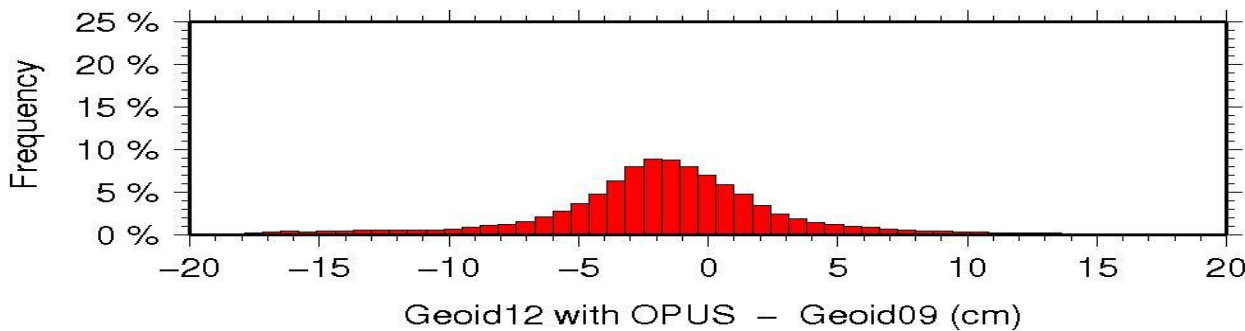
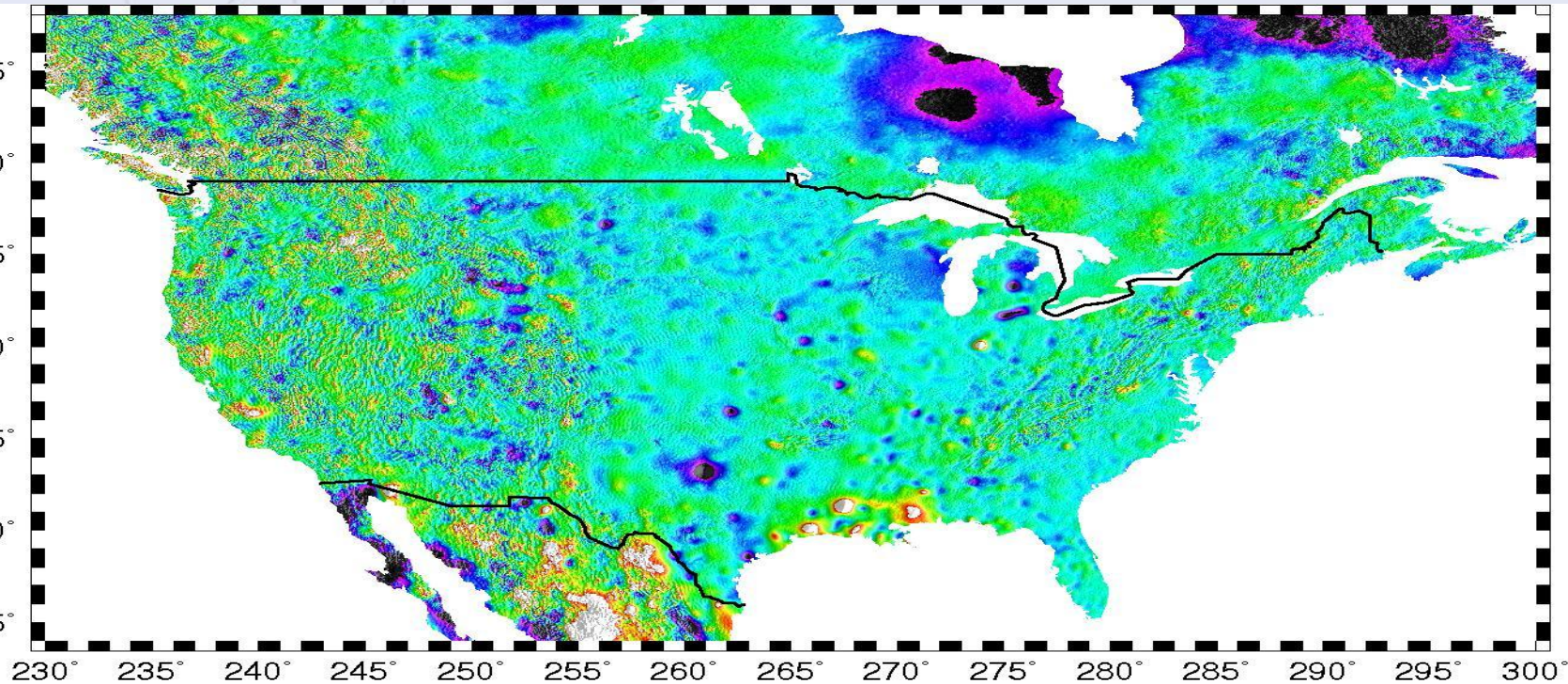
Error increases based on the size of the gap.

Dense coverage yields < 1 cm.

Errors will be provided with GEOID12 hts. %



# GEOID12 – GEOID09



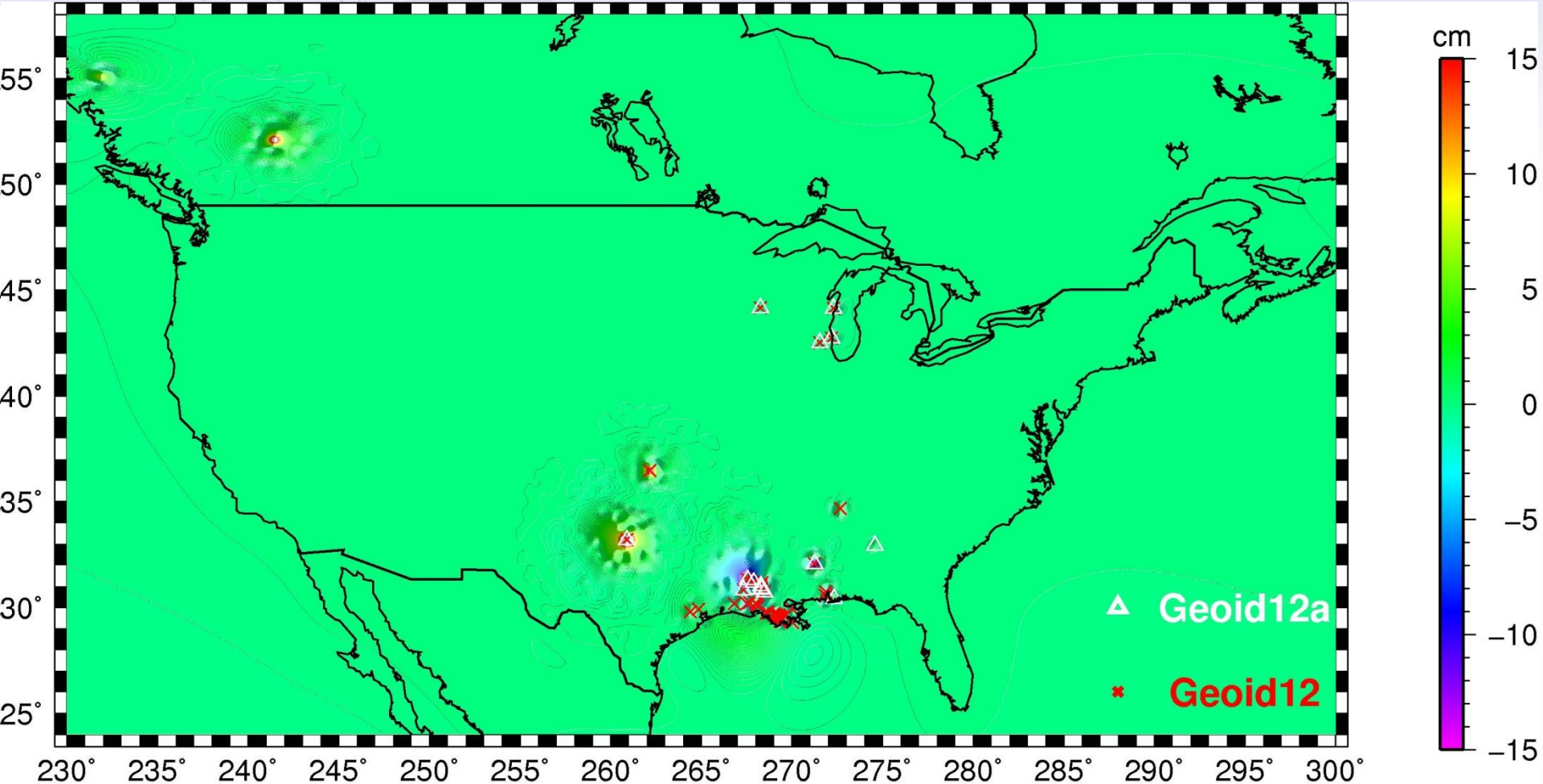
**Mean=-1.78**  
**STD=5.64**  
**Max=54.05**  
**Min=-45.43**



# So ... What Went Wrong?

- Erroneous Data
  - VTDP exclusion region – what's in/out? (MS, LA)
  - Transposed numbers (AL)
  - Recent adjustment and superseding data (WI)
  - Miscoded error flags (Canada)
  - Judgment call – keep or reject? (OK)
- Miscommunication/Misunderstanding
  - No-check GPS: NGSIDB vs. OPUS-DB (TX)
  - Hybrid to use minimal number of points (LA)

# What Went Wrong: A Picture's Worth a 1000 Words





# What Went Right?

- Big changes in Alexandria, LA & Meridian, MS were reported shortly after GEOID12's release
- These were quickly checked and GEOID12 was found to be consistent with the control data
- The control data (GPSBM2012) were then re-checked and a number of errors detected
- Notices went up quickly & GEOID12 pulled
- A new SOP was developed for a more public vetting of the final product (Beta release)

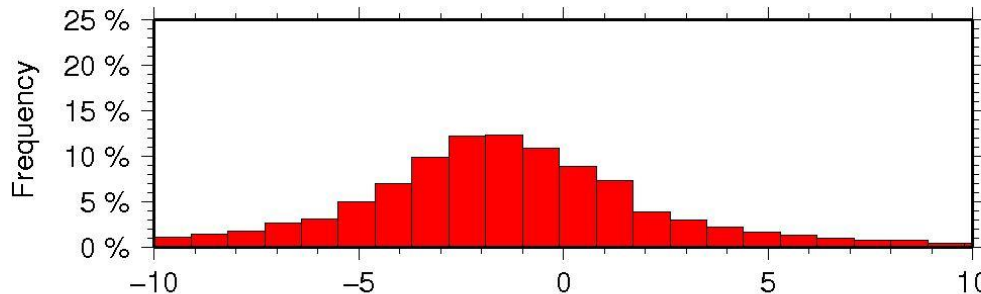
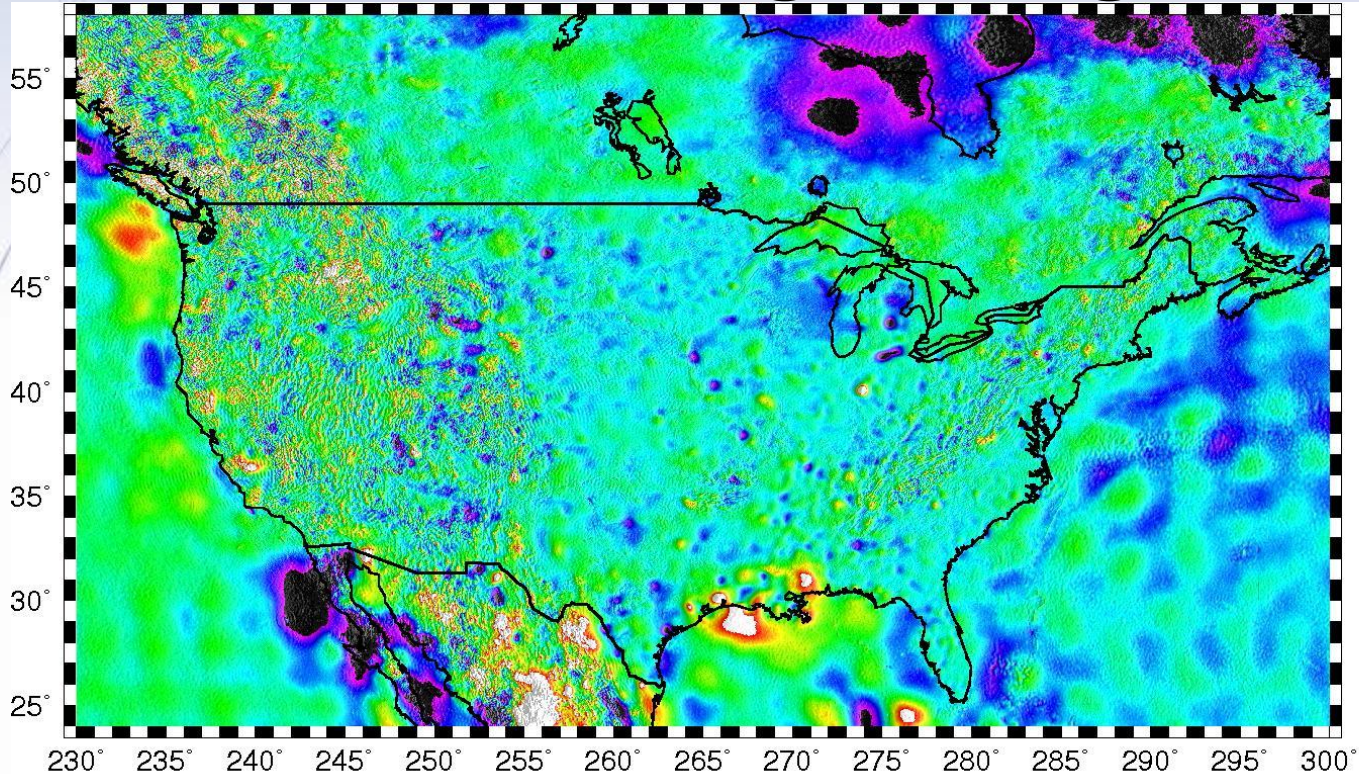
# There are Valid Big Changes

Ignore changes outside CONUS

VTDP region does see 50 cm change

Can see the effect of 3"-5' RTM in the mountains

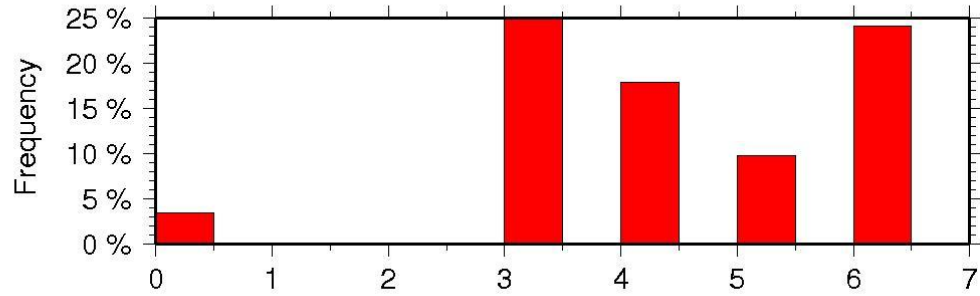
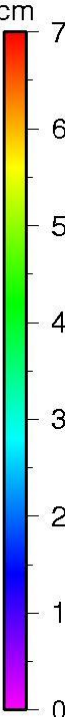
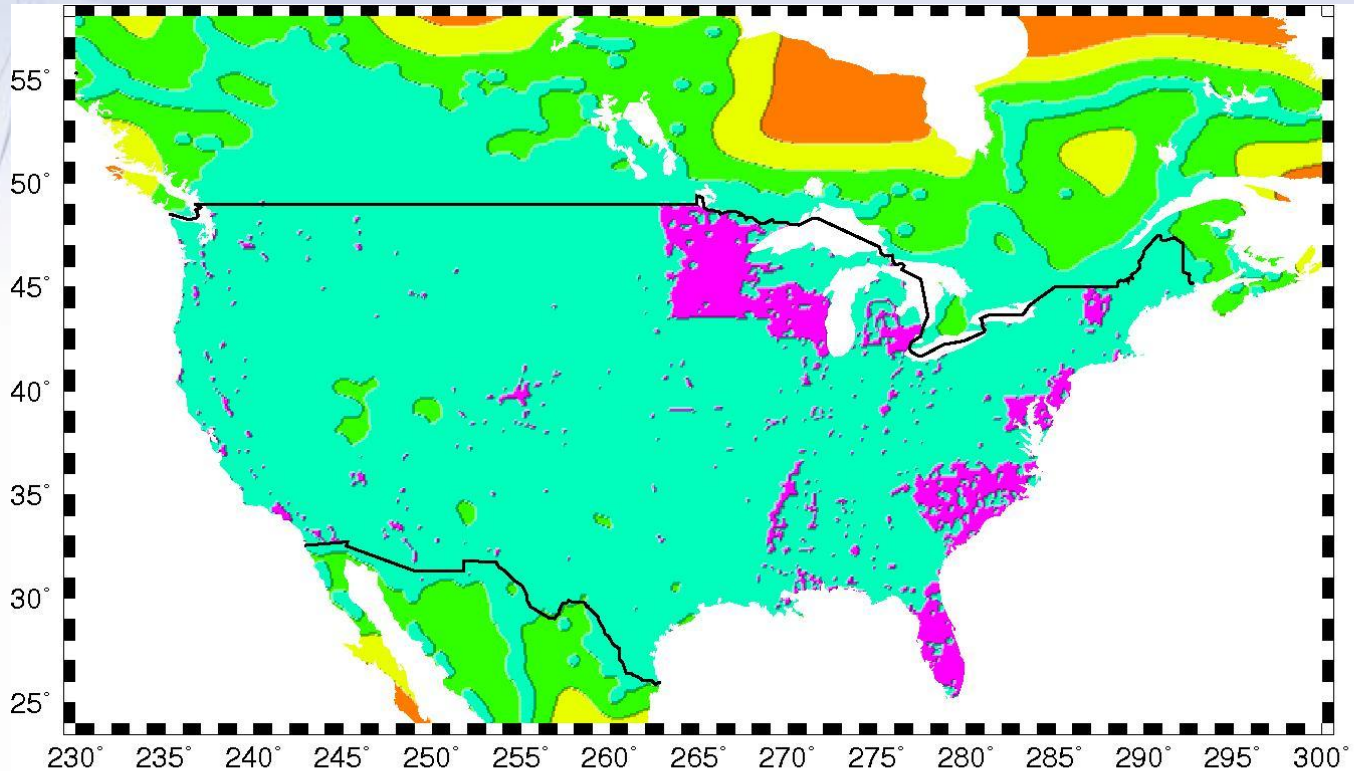
200-400 km features are due to GOCE in USGG2012



**Mean=-1.78**  
**STD=5.60**  
**Max=54.05**  
**Min=-45.44**



# Coming Soon: Error Maps ...



**Mean=4.28**  
**STD=1.53**  
**Max=6.32**  
**Min=0.00**

GEOID03 made using a Cholesky Decomposition

Rigorous LSC was used in GEOID12A

This ensured we had a var-cov matrix to estimate errors on a regular grid

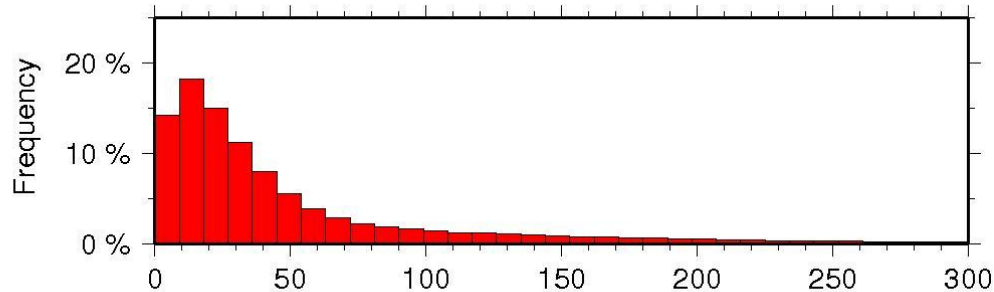
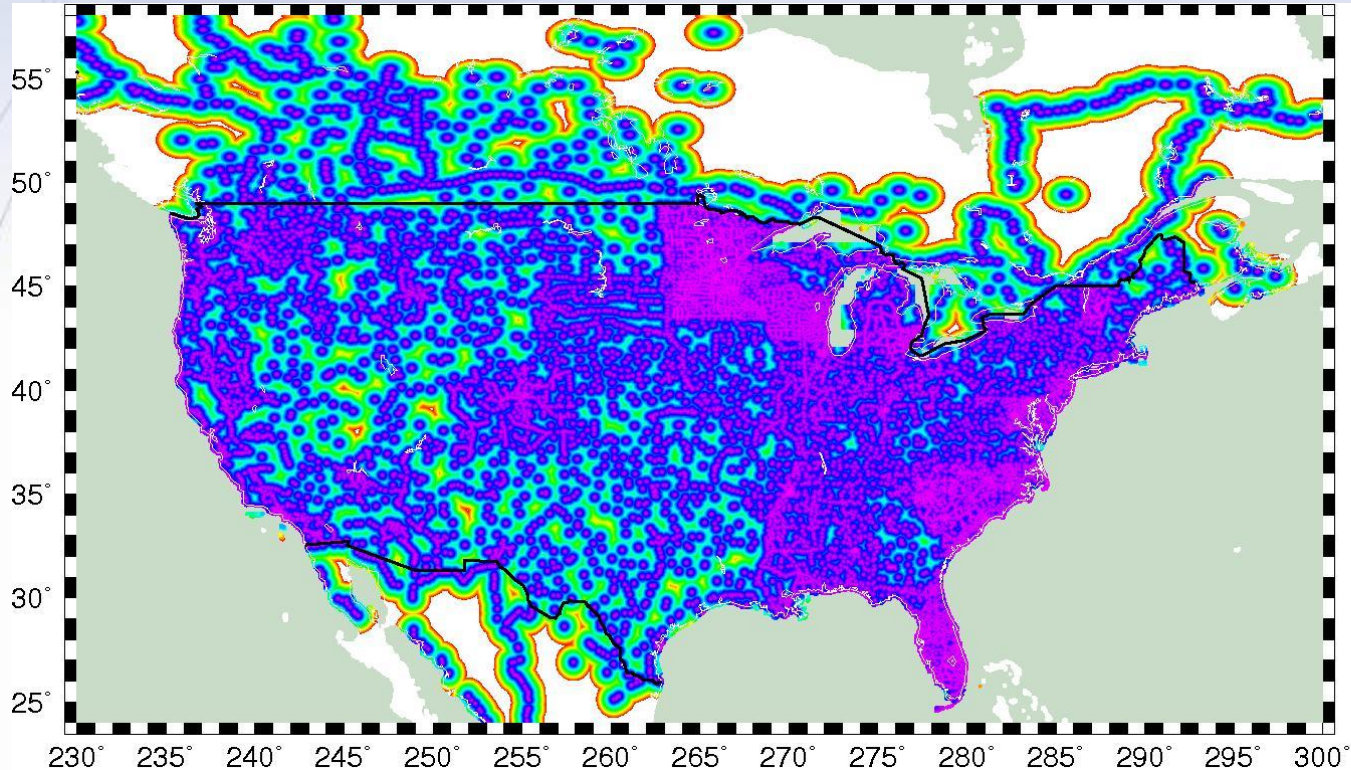
This means errors can be provided with geoid heights

# ... Minimum Distance to Control Data

One of the main factors affecting errors is distance to control

This plot will provide the distance to the closest point

This provides an estimate of interpolation error impact



**Mean=60**  
**STD=78**  
**Max=1050**  
**Min=0.006**  
**# of points =5,673,708**

Distance map of Geoid12a (km)



# Summary

- GEOID12 is complete for all regions
- It converts between NAD 83 (\*\*11) and the local vertical datum (NAVD 88 in CONUS)
- Modeling is much the same as before (MMLSC)
- Incorporation of data in Mexico and OPUSDBBm12 is new and has had an impact
- Error maps will be available to provide estimated errors along with geoid heights

# Near Term Goals

- DEFLEC12A (made from GEOID12A)
- USDOV2012 (made from USGG2012)
- Error and interpolation grids
  - Online interpolation geodetic tool
  - OPUS results
- Updates to FAQ and Technical Details
- Paper, likely on GEOID09, USGG2012, GEOID12 & GEOID12A



# Questions?

*NAD 83(2011/PA11/MA11) epoch 2010.00*

