

National Geodetic Survey

Latest Developments in NGS

**CDOT
Region 2
May 3, 2012**



National Oceanic and Atmospheric Administration

Agenda

- Improvements in the NSRS
- MultiYear CORS Solution ->NAD83 (2011)
- Geoid12/Heights/GRAV-D
- New Data Sheets
- DS-World
- CDOT CORS/OPUS Team Efforts
- OPUS
- CBLs
- LOCUS
- RTN
- NGS Advisor Program
- New Datums (2022)

CHANGE
Improvements



NGS

National Spatial Reference System(NSRS) Improvements

| NETWORK | TIME SPAN | NETWORK ACCURACY | LOCAL ACCURACY |
|---------------------------|-----------|------------------|---|
| NAD 27 | 1927-1986 | 10 meters | (1 part in 100,000) |
| NAD83(86) | 1986-1990 | 1 meter | (1 part in 100,000) |
| NAD83(199x)* HARN | 1990-2007 | 0.1 meter | B-order (1 part in 1 million) A-order (1 part in 10 million) |
| NAD83(NSRS2007) (CORS) | 2007 - | 0.01 meter | 0.01 meter |

* CO was completed and adjusted in 2007



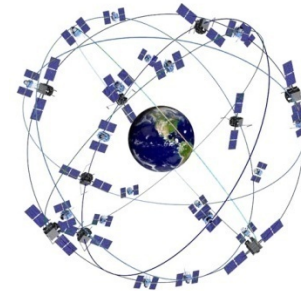
National Spatial Reference System (NSRS)

The NSRS is a consistent coordinate system that defines latitude, longitude, height, scale, gravity, and orientation throughout the United States.



One common datum

**Evolving from passive →
active →
real-time augmentations**



The NSRS has evolved



1 Million
Monuments
(Separate
Horizontal and
Vertical
Systems) →

70,000
Passive Marks
(3-Dimensional)



Passive Marks
(Limited Knowledge
of Stability) →

1,800+ CORS
(Time Dependent
System Possible;
4-Dimensional)



GPS CORS → GNSS CORS



“PASSIVE” NETWORK

marks in the ground

1.5 million marks in the
National Geodetic Survey database

NSRS

These marks provide:

- Horizontal position, or
- Horizontal position and ellipsoid height, or
- Orthometric Heights, or
- Both Horizontal and Vertical values
- Tidal Information



"ACTIVE" Geodetic Network

Continuously Operating Reference Stations

CORS

NSRS

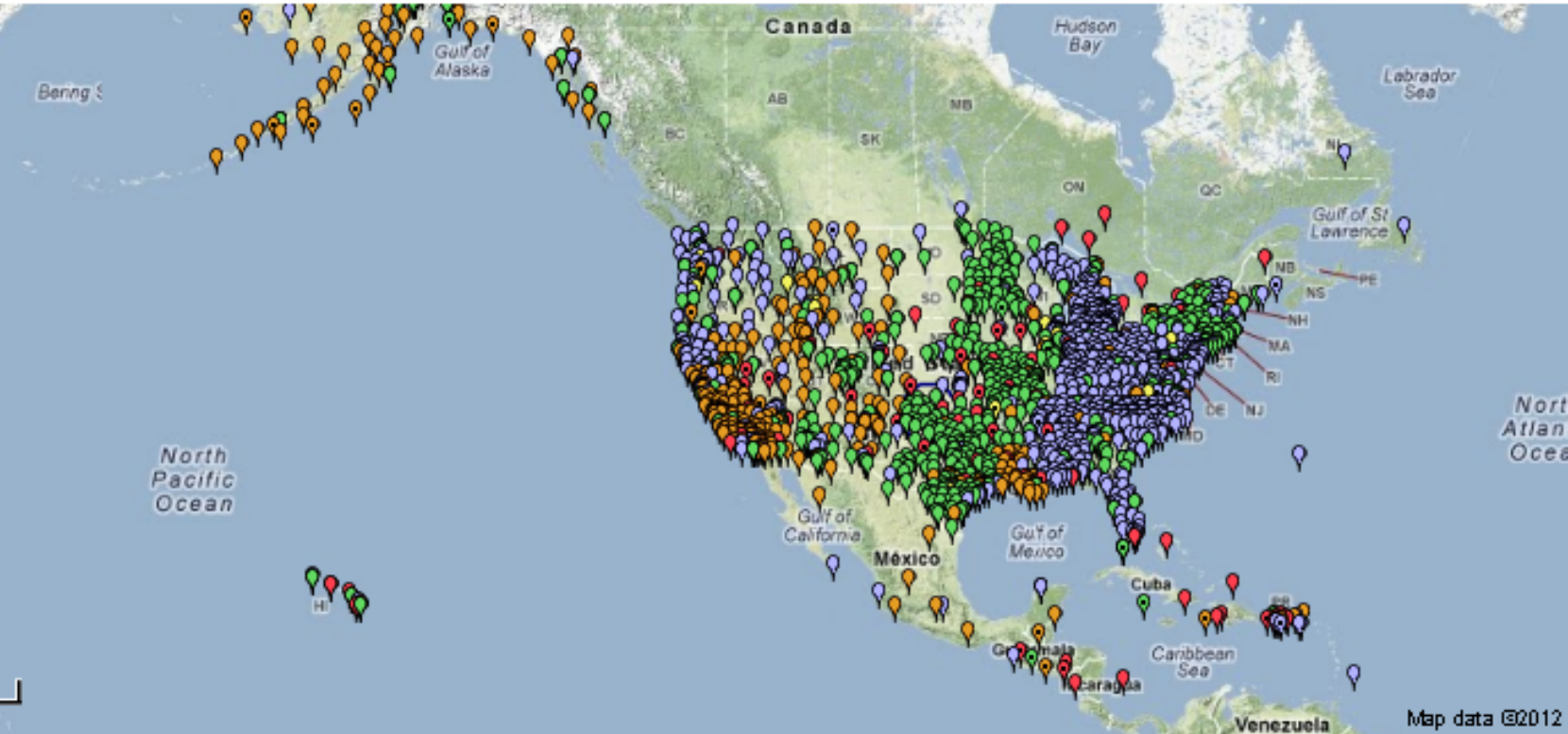


Current/Future Activities of the NSRS

1. Multi-Year CORS solution - 2011
2. National Adjustment (geometric) of passive control - 2012
3. Hybrid Geoid Model using new ellipsoid heights -2012
4. New Data Sheets - 2012
5. National Adjustment (vertical) of GPS passive marks
 - Under consideration; This not adjusting the leveling network
6. Adoption of new datums



CORS



Map data ©2012

Website

[HCE Home](#) ■ [HCE Reviews](#) ■ [Debian Distro](#) ■ [Miscelmar](#) ■ [H&A now](#) ■ [Read now](#) ■ [Site Map](#) ■ [Contact Webmaster](#)



NAD83 (2011) and the MultiYear CORS Solution

Previous/Current Reference Frame

NAD 83(CORS96)

Epoch 2002.00

ITRF00

New Reference Frame

NAD 83(2011)

Epoch 2010.00

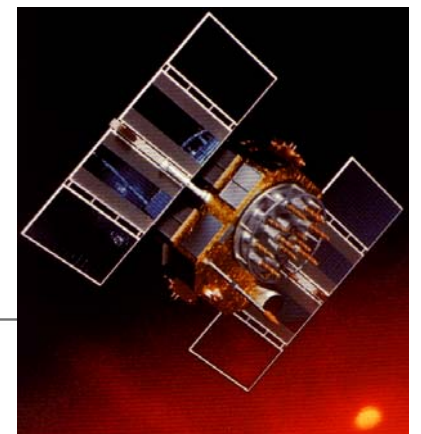
IGS08

Epoch of Observation



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
 - Most done in 1990s, essentially state-by-state
 - Based on GNSS but classical stations included in adjustments
- National Re-Adjustment of 2007
 - NAD 83(CORS96) and (NSRS2007)
 - Simultaneous nationwide adjustment (GNSS only)
- *New realization: NAD 83(2011) epoch 2010.00*



Multi-Year CORS Solution

- Longer data spans
- 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



Why a Multi-Year CORS Solution?

- Consistent coordinates and velocities from combined solution
 - Previous a mix of station and velocity sources, few ties to global frame
 - Previous vertical velocities of zero for most CORS
- Aligned with most recent realization of global frame (IGS08)
 - **IGS08 epoch 2005.0** (previous aligned at epoch 1997.0)
 - **NAD 83 epoch 2010.0** (previous epochs of 2002.0 and 2003.0)
- Major processing algorithm, modeling, metadata improvements
 - Conformance with current international conventions (IERS)
- Absolute phase center antenna calibrations
 - Both ground (receiving) and satellite (transmitting) antennas
 - Previous (CORS96) used relative calibrations (significant change)
- **Highly accurate *and* consistent CORS coordinates *and* velocities determined using Best Available Methods**
 - ***Needed because CORS network is foundation of NSRS***



Why a Multi-Year CORS Solution?

- Absolute phase center antenna calibrations used
- More data used in adjustment
 - Includes Velocities
 - Longer data spans
 - Reprocessed all CORS GPS data Jan 1994-Apr 2011
 - 2264 CORS & global stations
 - first attempt to obtain a full history of products in a fully consistent framework
- Consistent coordinates and velocities from combined solution
 - Previous a mix of station and velocity sources
 - Previous few ties to global frame
 - Previous vertical velocities of zero for most CORS
- Aligned with most recent realization of global frame (IGS08)
 - **IGS08 epoch 2005.0** (previous aligned at epoch 1997.0)
 - **NAD 83 epoch 2010.0** (previous epochs of 2002.0 and 2003.0)



Why a Multi-Year CORS Solution?

- Major processing algorithm, modeling, metadata improvements
 - Conformance with current international conventions (IERS)
 - Highly accurate *and* consistent CORS coordinates *and* velocities determined using *Best Available Methods*
- Updated model for station displacements due to ocean tidal loading
- Updated models for troposphere propagation delays

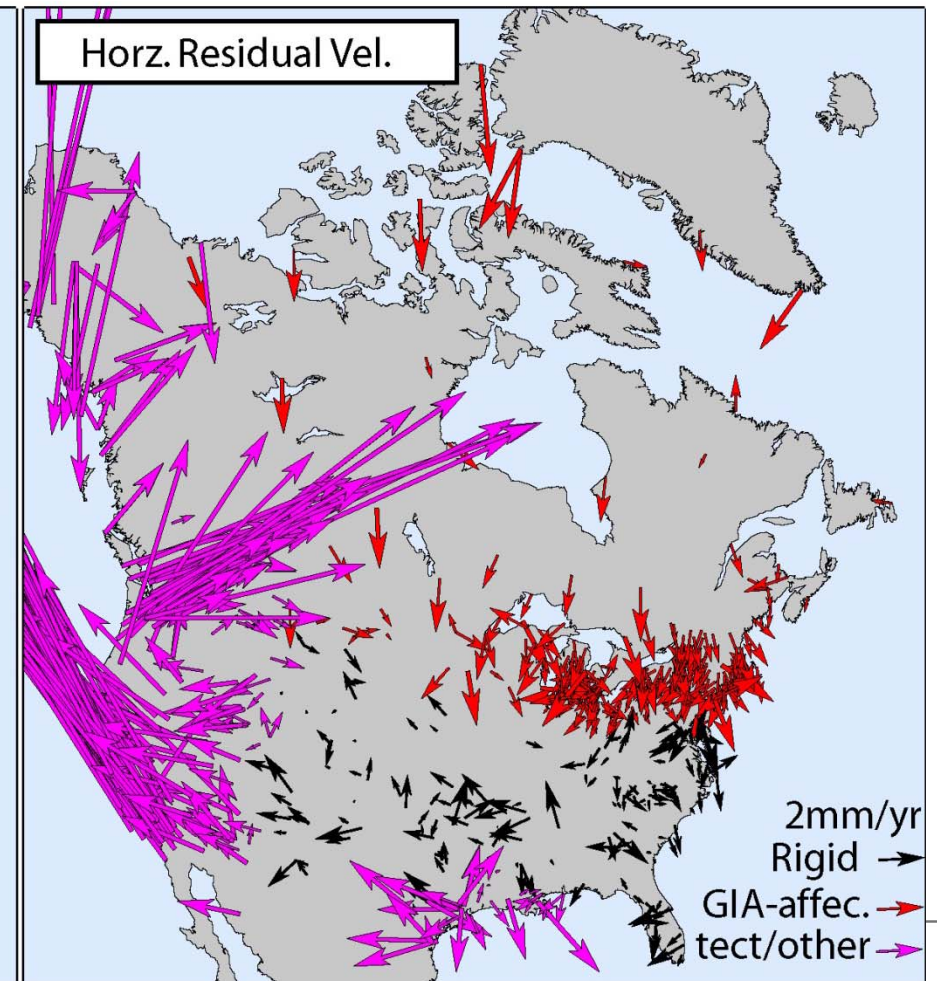
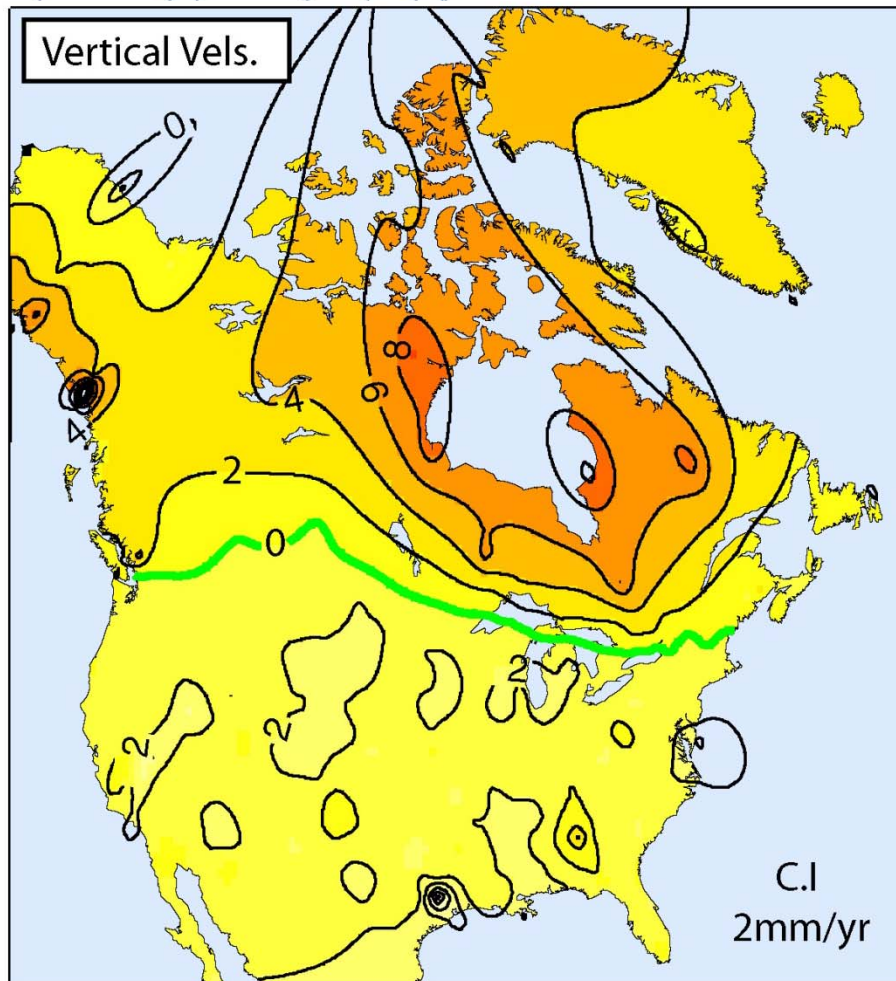
Needed because CORS network is foundation of NSRS



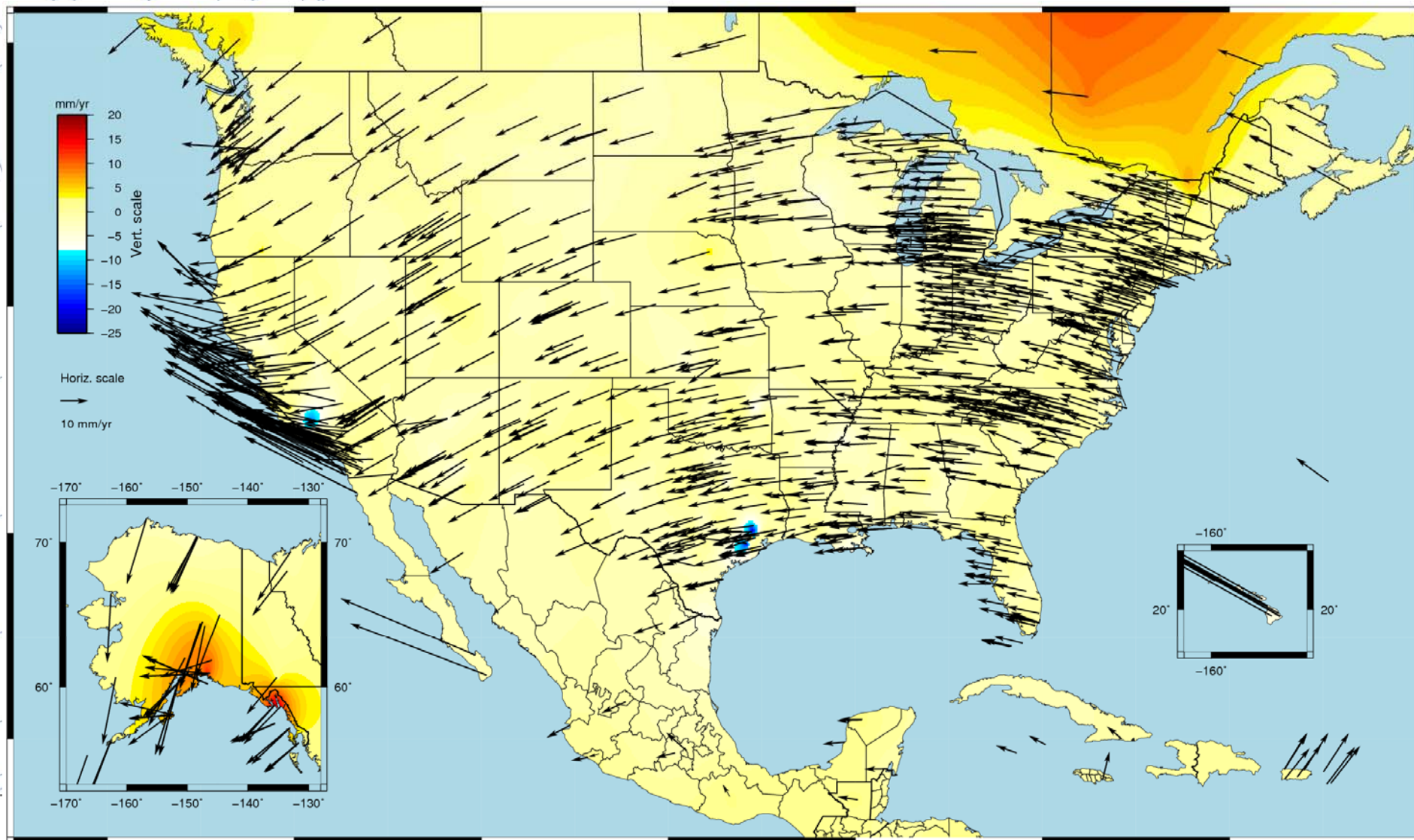
Positions and Velocities Change!

CORS Multiyear soln.

Plate fixed

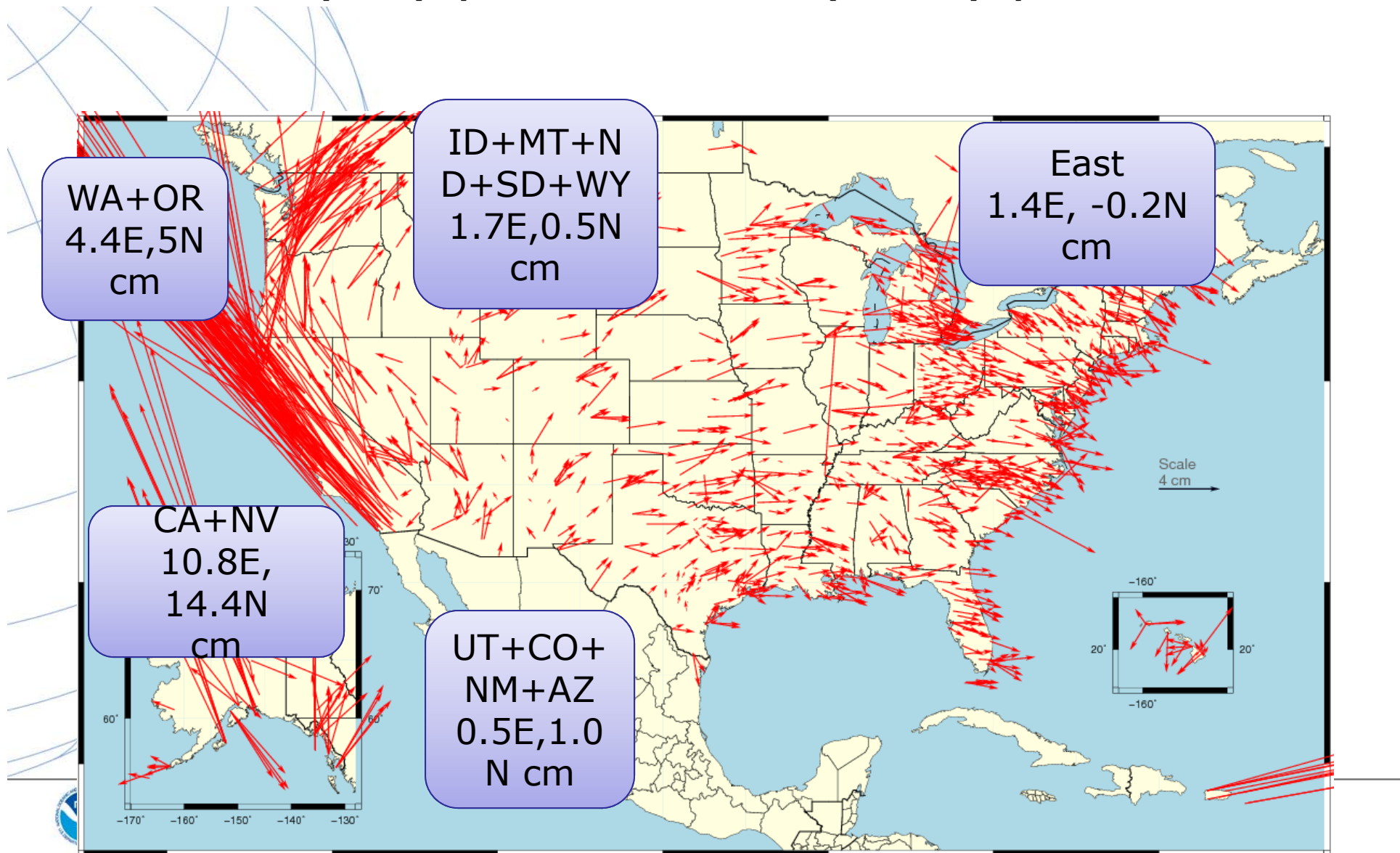


CORS IGS08 Velocity Field



Changes in *Horizontal* NAD 83 Positions Different Epochs

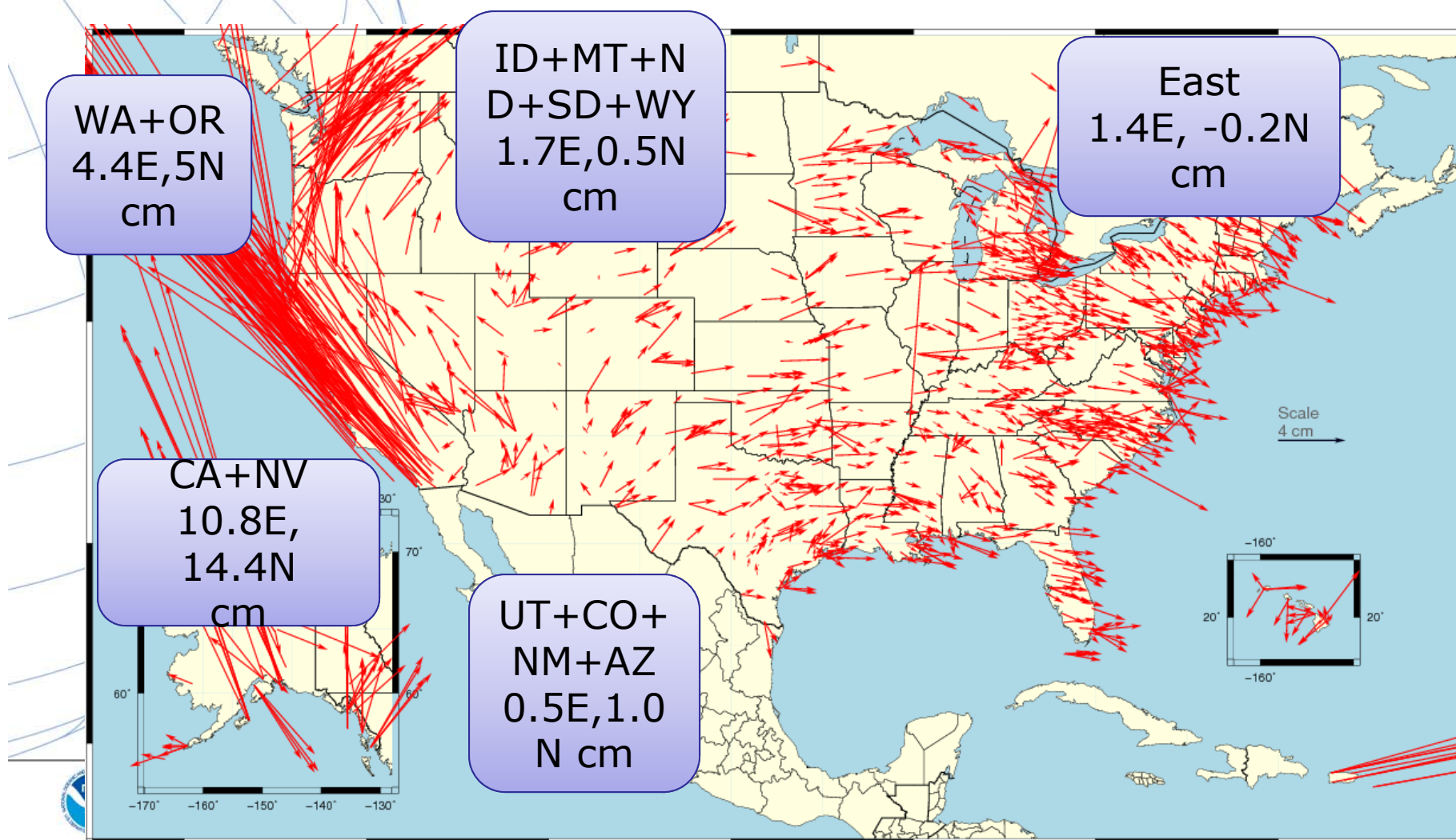
NAD 83(**2011**) epoch **2010.0** – NAD 83(**CORS96**) epoch **2002.0**



Changes in *Horizontal* NAD 83 Positions **Different Epochs**

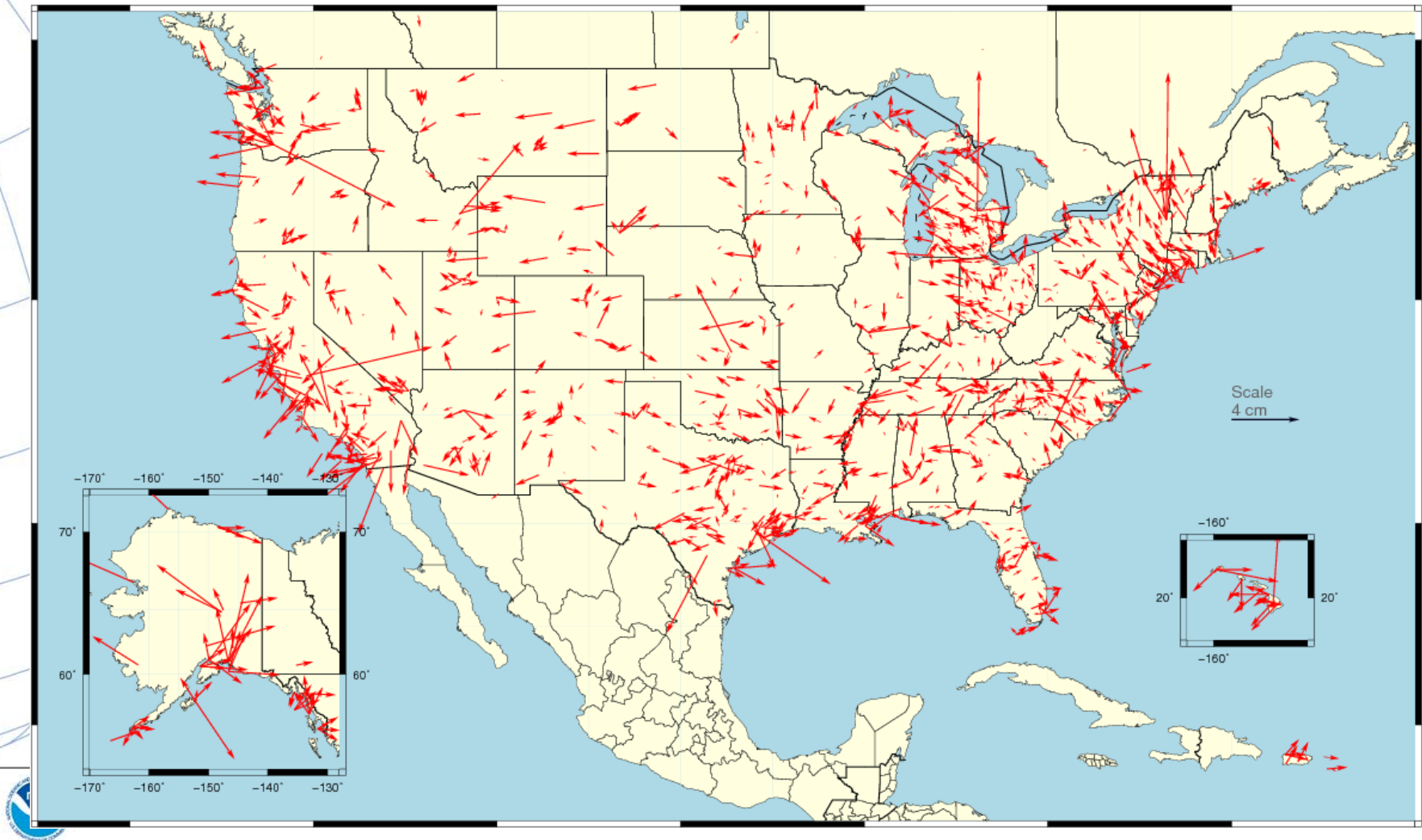
NAD 83(2011) epoch 2010.0 – NAD 83(CORS96) epoch 2002.0

- 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 *Horizontal* NAD 83 Positions Same Epoch

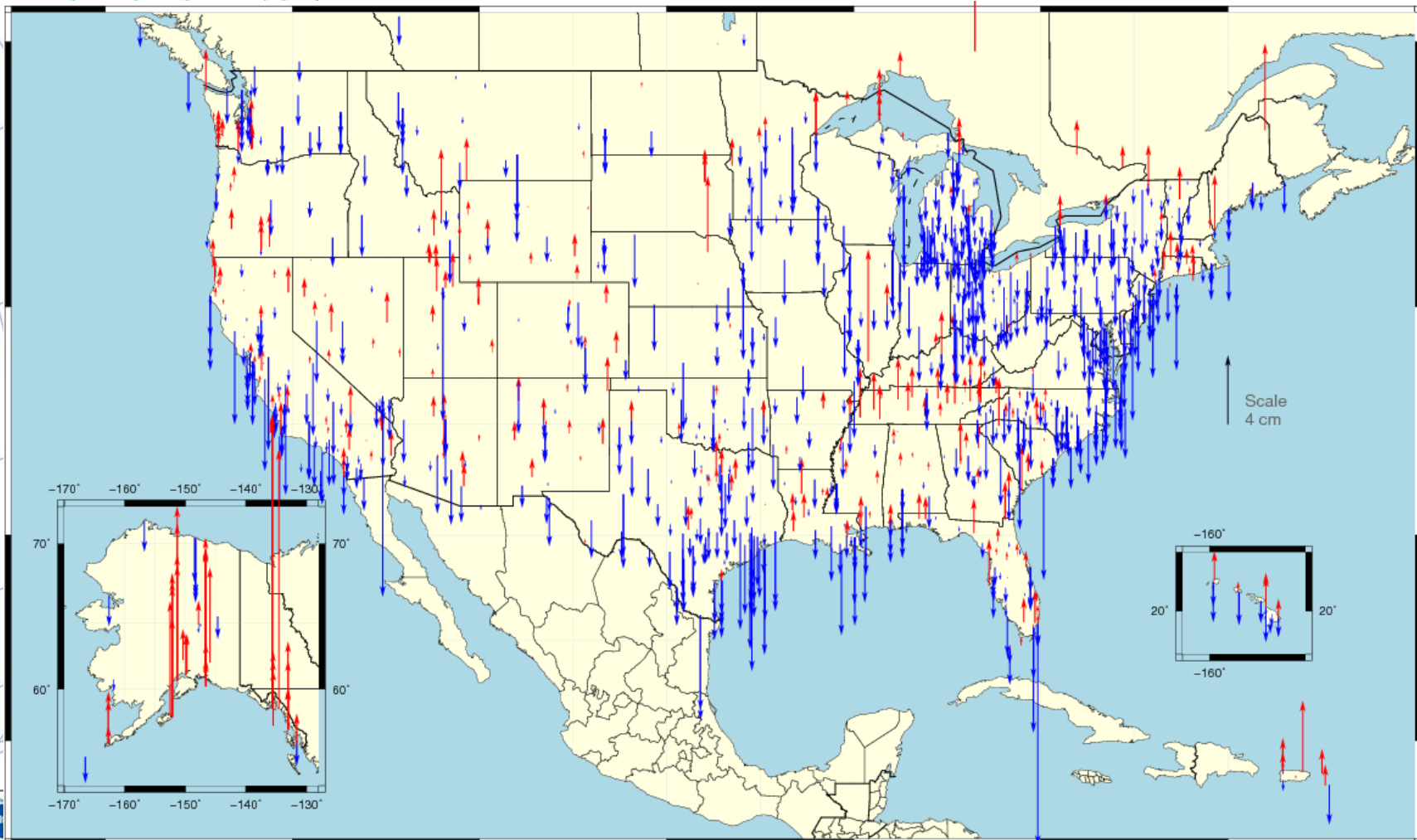
NAD 83(**2011**) epoch **2002.00** – NAD 83(**CORS96**) epoch **2002.00**



Changes in *Vertical* NAD 83 Positions

Different Epochs

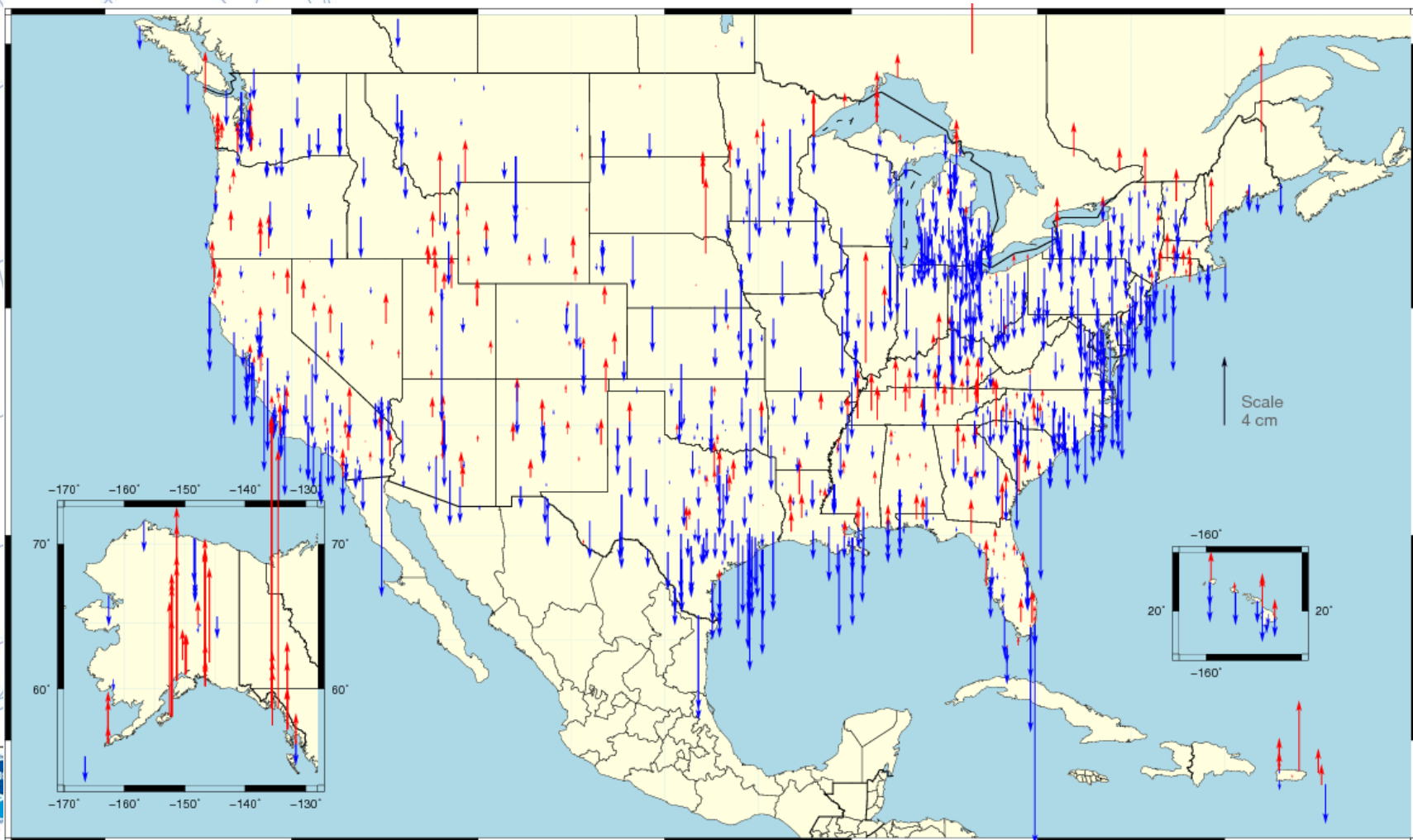
NAD 83(2011) epoch 2010.0 – NAD 83(CORS96) epoch 2002.0



Changes in *Vertical* NAD 83 Positions **Different Epochs**

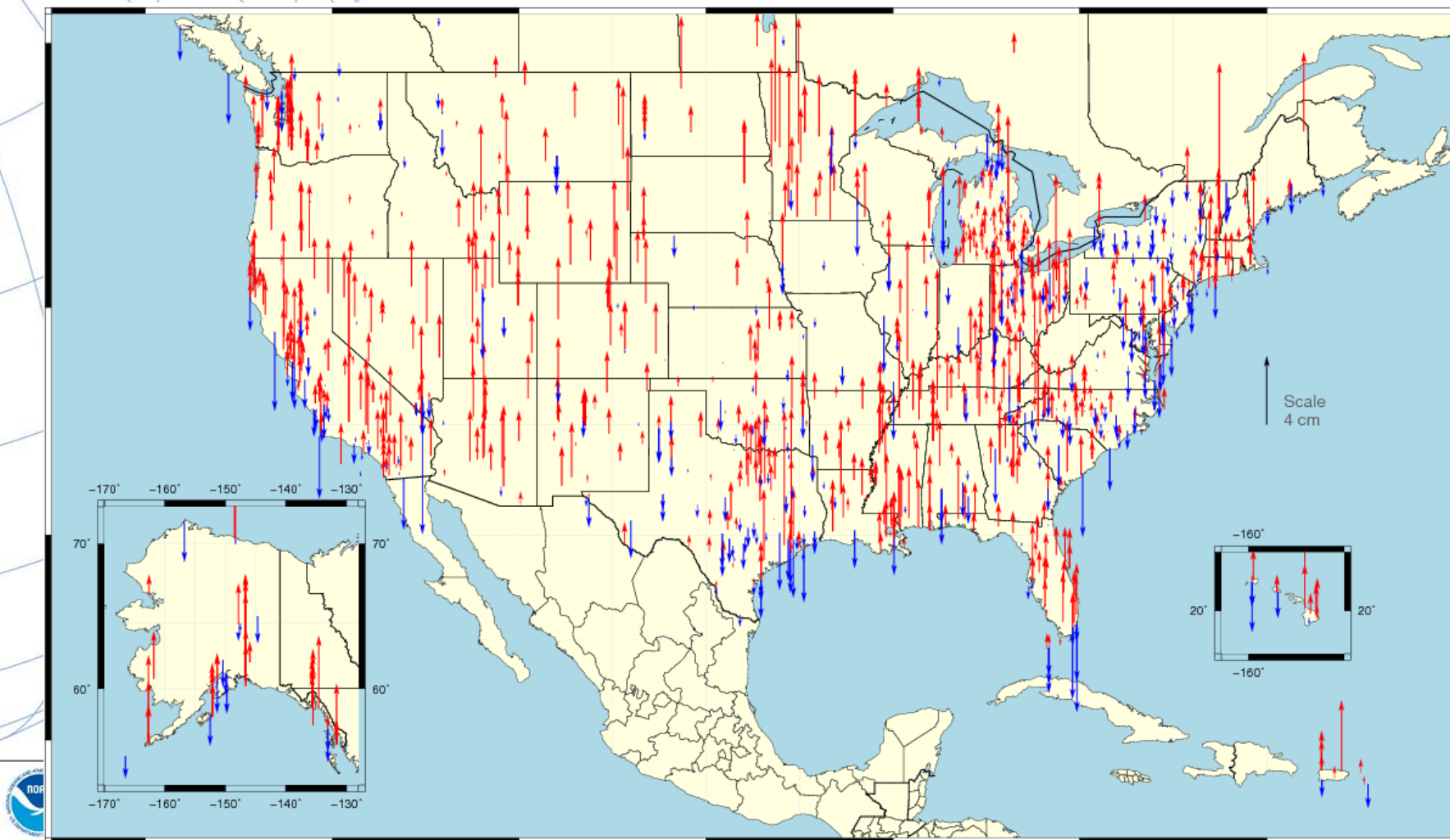
NAD 83(2011) epoch 2010.0 – NAD 83(CORS96) epoch 2002.0

- 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 in *Vertical* NAD 83 Positions

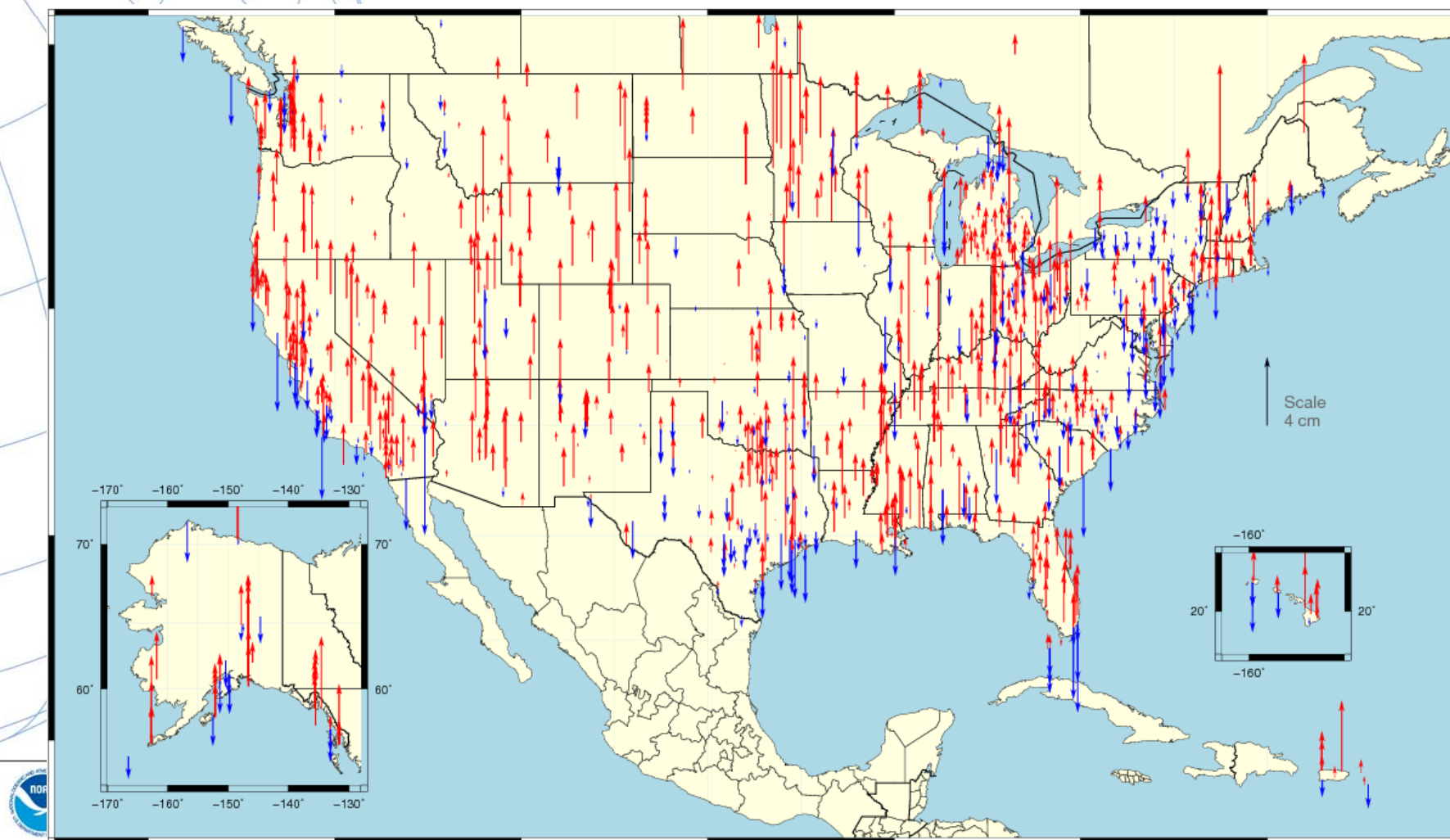
- **NAD 83(2011) epoch 2002.0 – NAD 83(CORS96) epoch 2002.0**
 - avg. shift: $\Delta U = 0.80 \pm 1.89$ (ME -0.70) cm
 - random part mostly caused by switch to absolute antenna calibrations
 - shifts also caused by assuming $V_u = 0$ in NAD 83(CORS96)



Changes in *Vertical* NAD 83 Positions

Same Epochs

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



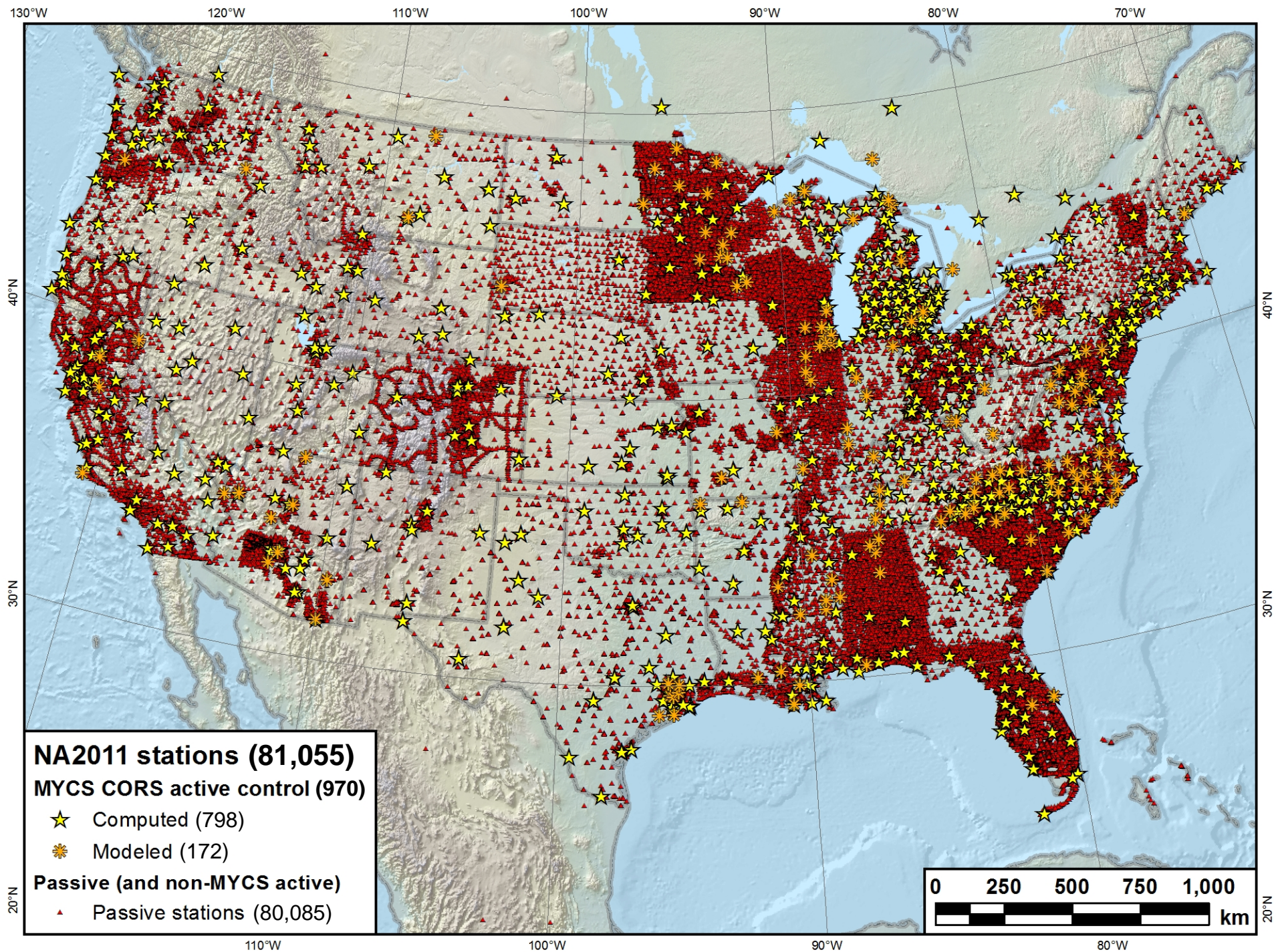
NAD 83(2011) epoch 2010.00

- **Multi-Year CORS Solution (MYCS)**
 - NAD 83 computed by *transformation* from IGS08
- **National Adjustment of 2011 (NA2011)**
 - New adjustment of GNSS passive control
 - GNSS vectors tied (and constrained) to CORS

NAD 83(2011) epoch 2010.00

 - Approximately 80,000 stations and more than 400,000 GNSS vectors
- **Realization** SAME for CORS *and* passive marks
- **This is *NOT* a new datum! (still NAD 83)**





NAD 83(2011) epoch 2010.00

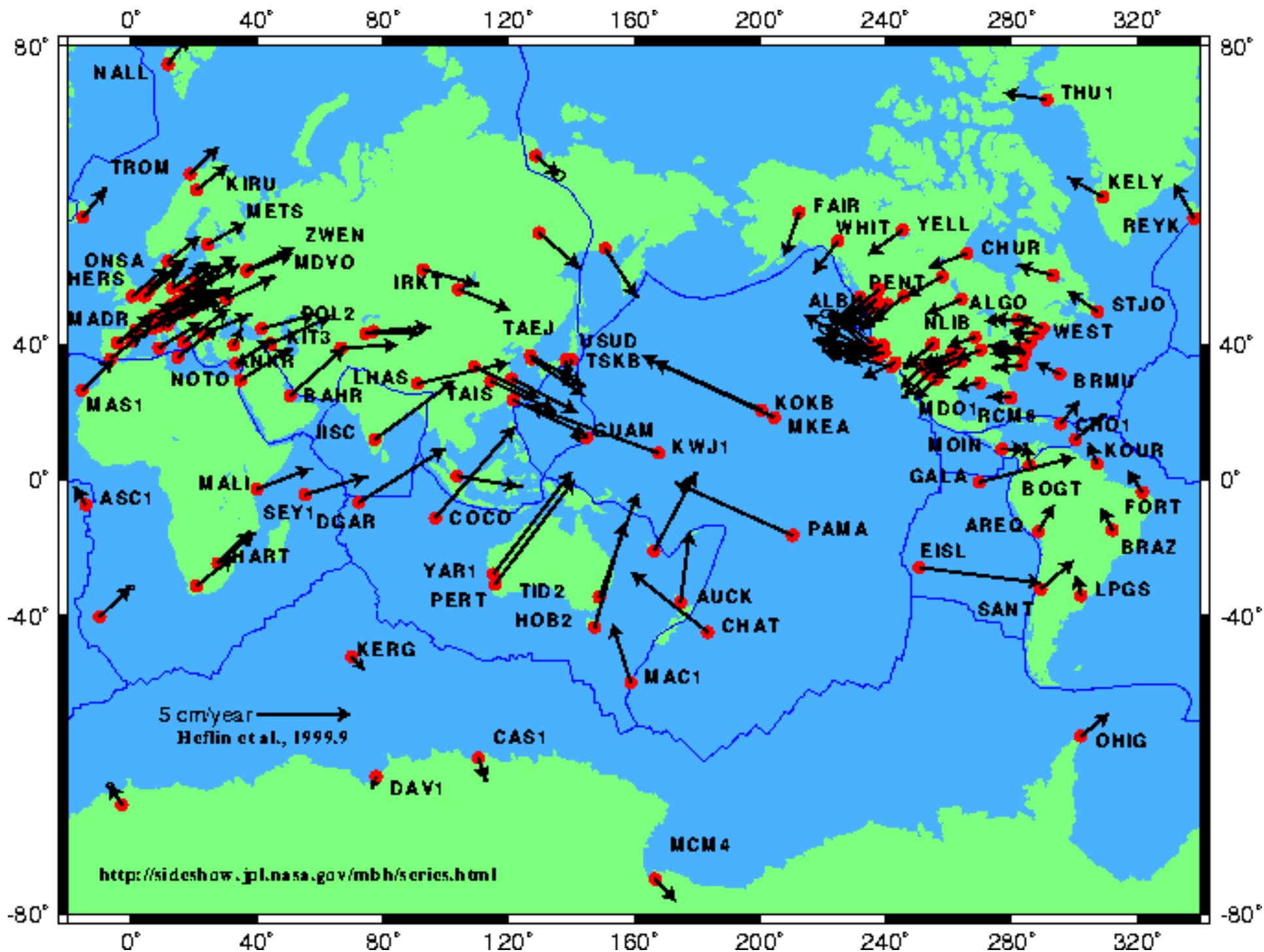
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 - Reprocessed all CORS GPS data Jan 1994-Apr 2011
 - 2264 CORS & global stations
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 - New adjustment of GNSS passive control
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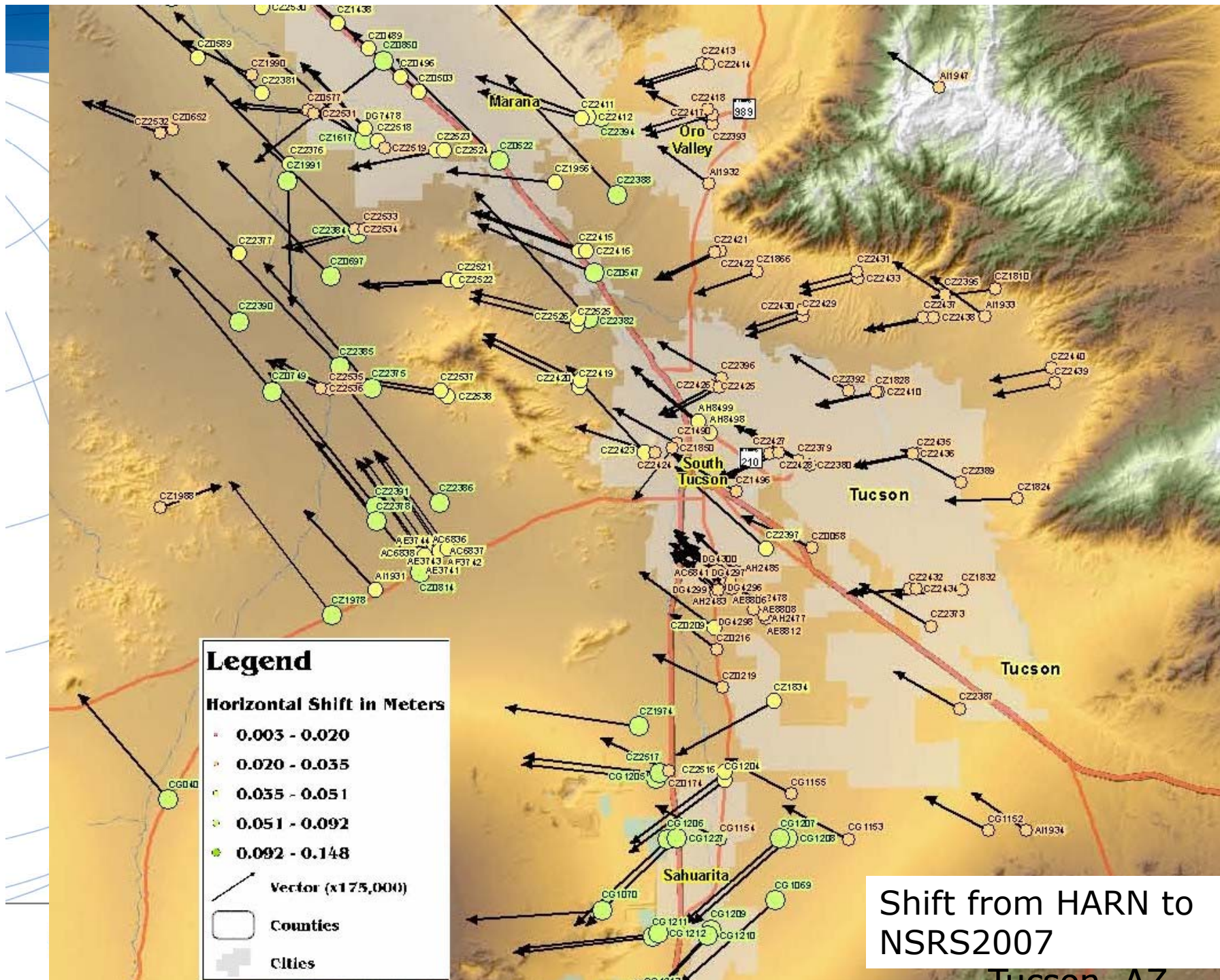


Why a New National Adjustment?

- Optimally align passive control with new CORS
- Add >1000 projects submitted since 2007 project
 - 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
- Better computations and analysis techniques
 - E.g., improved outlier detection
 - Incorporation of lessons learned from previous national adjustment

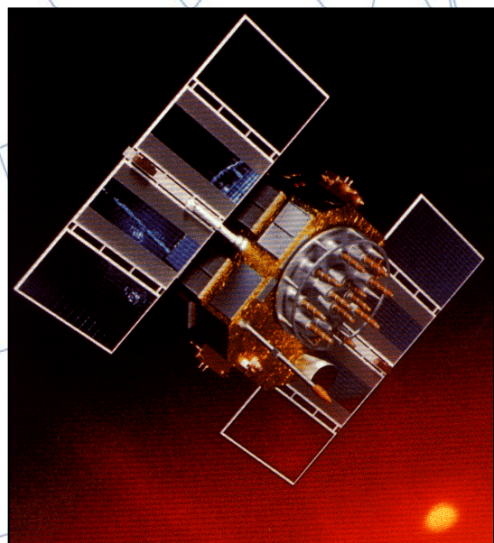






National Adjustment of 2011

Project Update



National Geodetic Survey
Observations and Analysis Division
April 25, 2012 • Silver Spring, MD

Michael L. Dennis,
RLS, PE
NA2011 Project

Transformation & Tectonic Complications

- NAD 83(2011) transformation tools?
 - NAD 83(2011) \leftrightarrow (NSRS2007/CORS96) \leftrightarrow (HARN)
 - Under study by NGS
- When is North America not North America?
 - Not all stations on the North American tectonic plate
 - Pacific plate: Hawaii and American Samoa
 - Mariana plate: Guam and CNMI
 - Caribbean plate: Referenced to North American plate
 - Can relate frames (and epoch dates) with HTDP



Current/Future Activities of the NSRS

1. Multi-Year CORS solution - 2011
2. National Adjustment (geometric) of passive control - 2012
3. Hybrid Geoid Model using new ellipsoid heights -2012
 - Use NAD 83(2011) epoch 2010.00 ellipsoid heights on NAVD 88 benchmarks
 - Might also use OPUS-Database results on NAVD 88 BMs
4. New Data Sheets - 2012
5. National Adjustment (vertical) of GPS passive marks
 - Under consideration; This not adjusting the leveling network
 - Constrain vertically to NAVD 88 benchmarks
 - GNSS-derived orthometric heights
 - NAD 83(2011) ellipsoid heights with GEOID12
6. Adoption of new datums -
 - Geometric, could happen any time
 - Vertical, requires completion of GRAV-D



Current/Future Milestones of the NSRS

1. Multi-Year CORS solution –
 - Completed (for all intents and purposes)
2. National Adjustment (geometric) of passive control
 - 2012
3. Hybrid Geoid Model using new ellipsoid heights
 - 2012
4. National Adjustment (vertical) of GPS passive marks
 - Under consideration
 - This not adjusting the leveling network
5. Adoption of new datums
 - Geometric, could happen any time
 - Vertical, requires completion of GRAV-D



How to Plan for the Future

- Use most recent realization of NAD 83
- Move away from passive marks to GNSS
- Move off of NGVD 29 to NAVD 88
 - Understand the accuracy of VERTCON in your area
- Collect OPUS-DB on NAVD 88 bench
- Require/provide complete metadata for all survey/mapping contracts
 - How did they get the positions/heights?
 - Survey Manual/Spatial Data Accuracy and Georeferencing Standards



How to Plan for the Future

- Move to a contemporary realization of NAD 83
 - No NAD 83(HARN) <-> NAD 83(NSRS2007) tool
- Obtain precise ellipsoid heights on NAVD 88 bench marks (OPUS, contact NGS Geodetic Advisor(s))
 - Improves hybrid geoid models and provides “hard points” in new vertical datum
- Move off of NGVD 29 to NAVD 88
 - Understand the accuracy of VERTCON in your area
- Move away from passive marks to GNSS
 - Especially move off of classical passive control
- Require/provide complete metadata for all survey/mapping contracts
 - How did they get the positions/heights?
 - Survey Manual/Spatial Data Accuracy and Georeferencing Standards



A Question to Consider:

*What is good enough
with respect to the NSRS,
i.e. have we reached a level of precision
and accuracy where further realizations
(adjustments) are unnecessary?*



Near-future plans & possibilities

- **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 BMs
- ***May*** perform national vertical adjustment
 - Constrain vertically to NAVD 88 benchmarks
 - Perform as simultaneous nationwide adjustment
 - GNSS-derived orthometric heights
 - NAD 83(2011) ellipsoid heights with GEOID12
 - ***NOT*** a readjustment of NAVD 88 leveling



Heights Bottom Line

Using GNSS is cheaper, easier than leveling

To use GNSS we need a good geoid model

GNSS – Global Navigation Satellite System



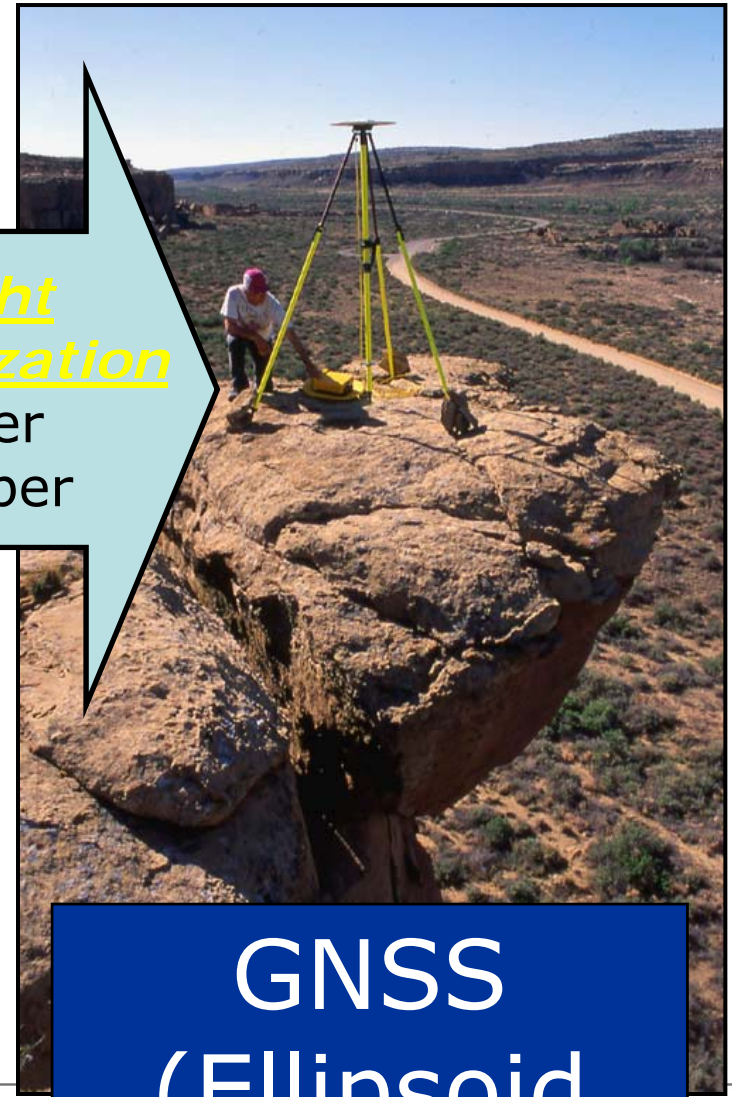
Height Modernization



Differential
Leveling
(Orthometric

Height
Modernization

-faster
-cheaper



GNSS
(Ellipsoid

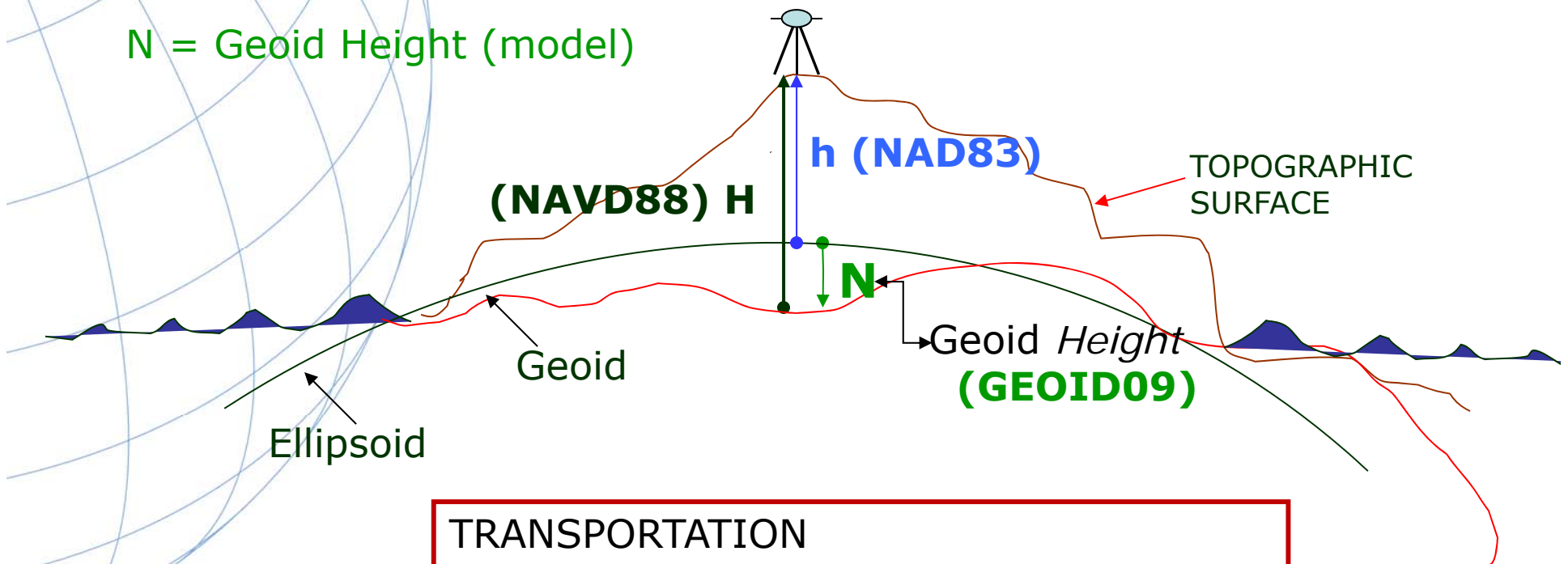
Ellipsoid, Geoid, and Orthometric Heights

H = Orthometric Height (leveling)

h = Ellipsoidal Height (GPS)

N = Geoid Height (model)

$$H = h - N$$

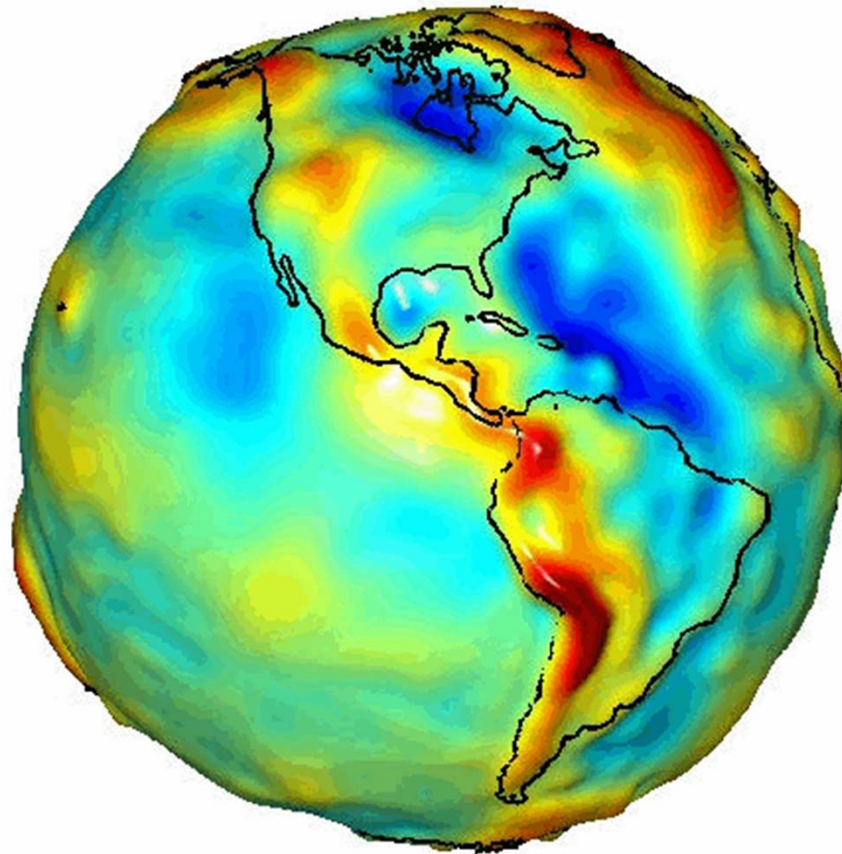


TRANSPORTATION

1660.6 = 1643.354 - (-17.23*) METERS

1660.6 = 1643.4 + 17.2

Exaggerated view of the Earth's Gravity Measure.

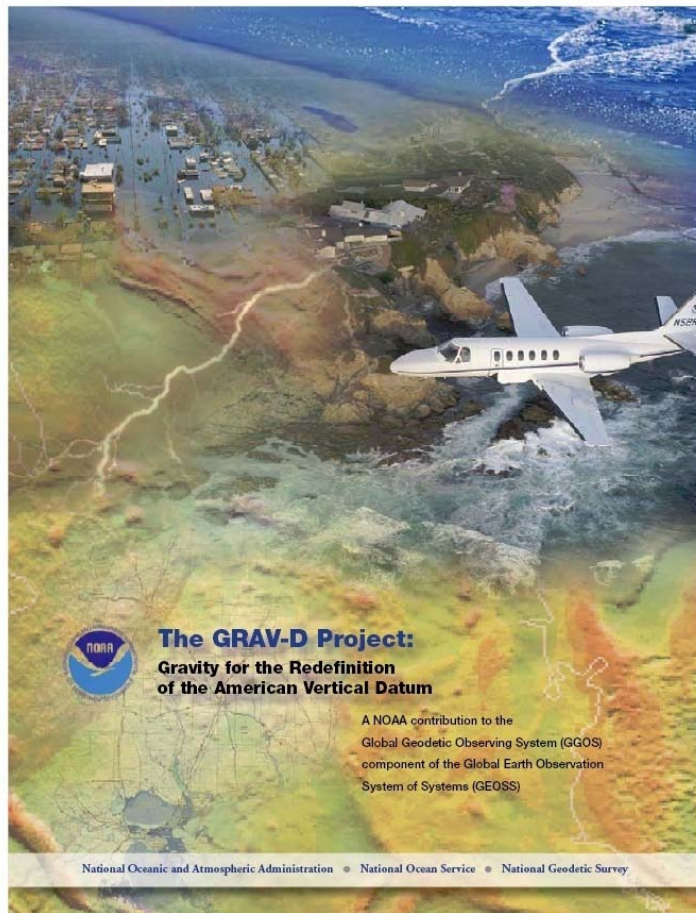


Problems in NAVD 88

- A North American realization through spirit leveling networks
- Pre-satellite era product (625,000 km of leveling added to the NGVD29)
- Height information through passive bench marks whose positions change constantly in our changing world (e.g., PGR, subsidence, earthquakes, ...)
- The geoid differences between NAVD 88 and GRACE are in meter range: compare to ± 2 -3 cm error in typical GPS ellipsoidal heights



GRAV-D

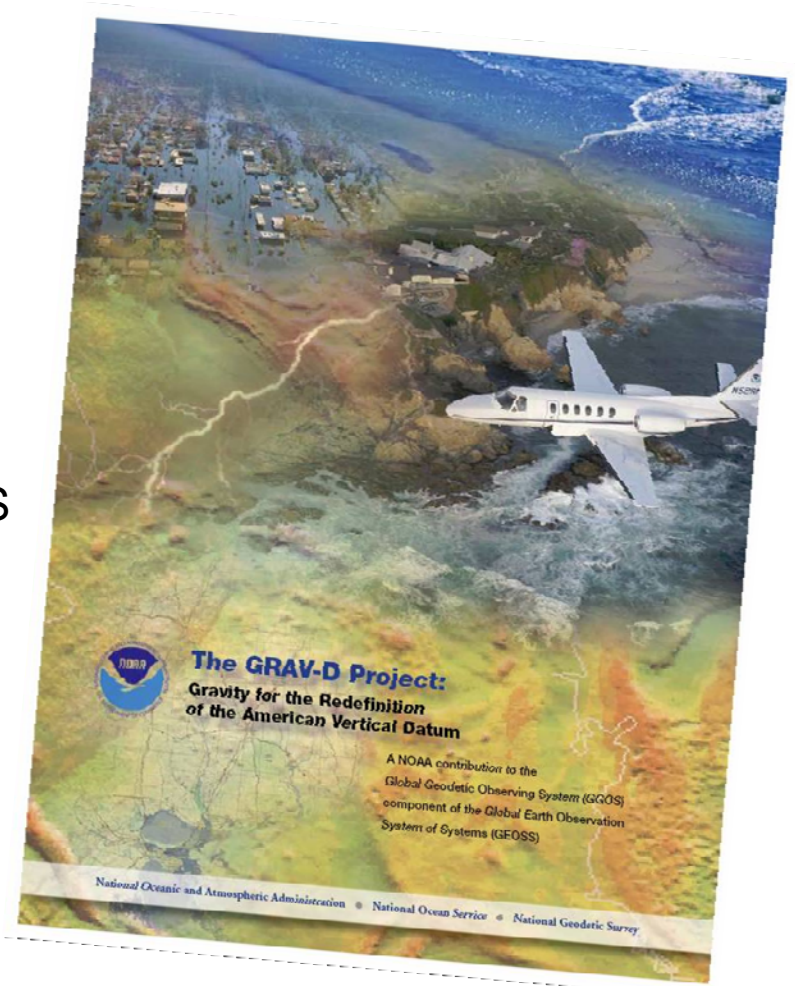


- GRAV-D **means fast, accurate, consistent orthometric heights** everywhere in the USA
- GPS already gives fast accurate *ellipsoid* heights
- If the geoid were **modeled** (and **monitored**) to highest accuracy...
- Voila... Fast, accurate orthometric heights, anywhere, anytime
- No need to use leveling to “bring in the datum”

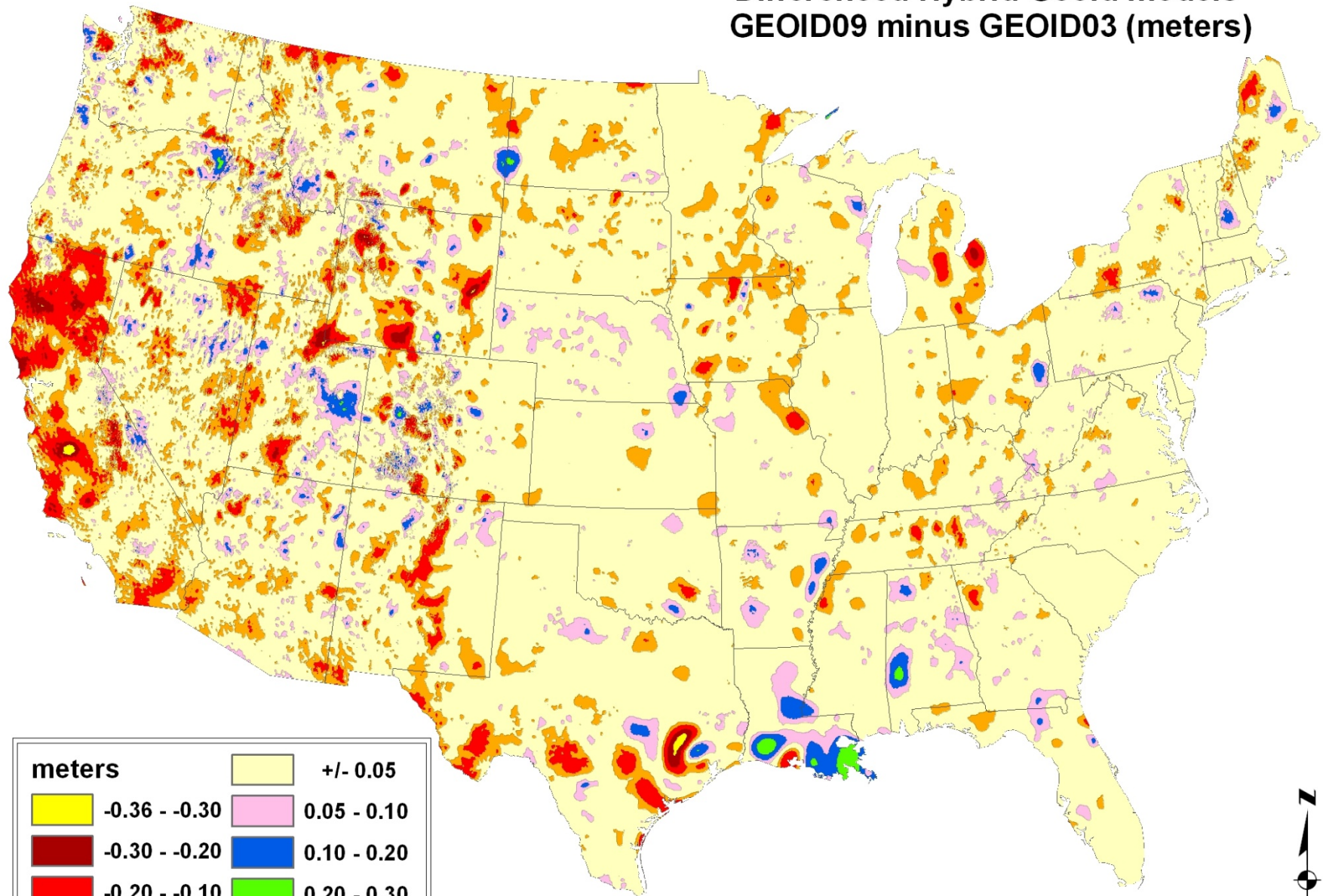
The Future of Height Mod: **GRAV-D**

Gravity for the **R**edefinition of the **A**merican **V**ertical **D**atum

- GRAV-D
 - Airborne gravity survey (10 years)
 - Gravity monitoring into the future
 - Coastal areas surveyed first
 - All USA states and territories
 - www.ngs.noaa.gov/GRAV-D
- 2018-2022 Targets:
 - Orthometric heights (“elevations” on maps) good to 2 cm anywhere, anytime from GNSS technology
 - Height changes easily monitored using new vertical datum
- Gravity for the Nation’ benefits
 - **Imagery for the Nation**
 - **Lidar for the Nation**
 - **Elevation for the Nation**



Differenced Hybrid Geoid models GEOID09 minus GEOID03 (meters)

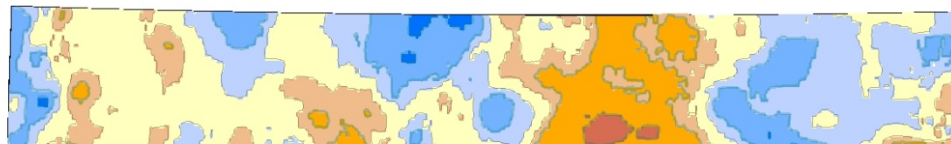


-1.18 ft to +1.28 ft

750 1,000
Kilometers



Geoid Height Differences (m)
GEOID03 - GEOID09



GPS-derived orthometric heights Warning #1

$$H \approx h - N$$

NAVD 88 height \approx NAD 83 ellipsoid height - GEOID03

NAVD 88 height \approx NAD 83 ellipsoid height - GEOID09

Provide, to client(s), datum & realization, ellipsoid heights, geoid model used, methodology (e.g. OPUS or adjusted survey), along with orthometric heights.

-0.10 - -0.05

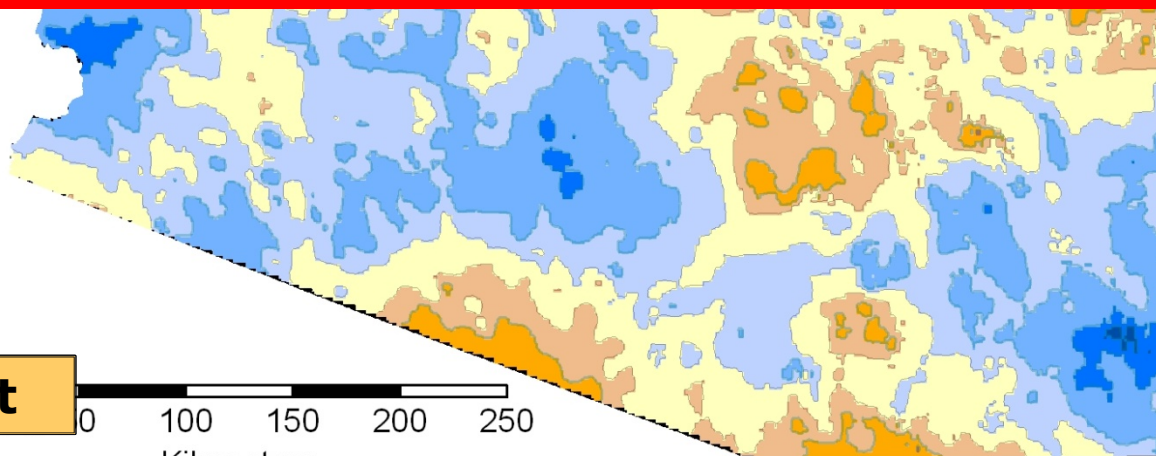
-0.15 - -0.10

-0.17 - -0.15

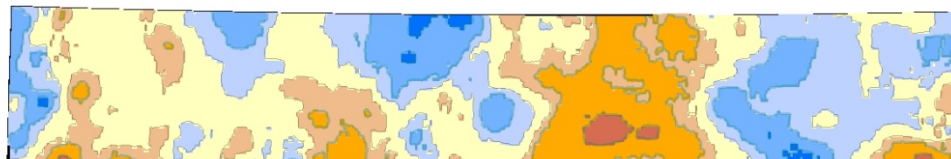


-0.49 ft to +0.72 ft

0 100 150 200 250
Kilometers



Geoid Height Differences (m) GEOID03 - GEOID09



GPS-derived orthometric heights Warning #2

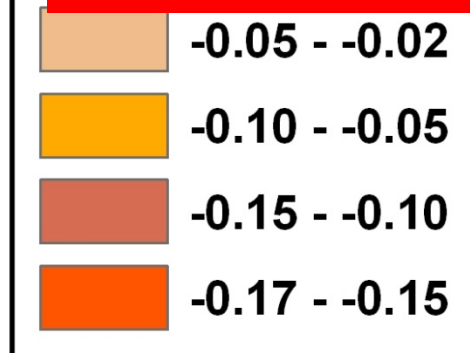
$$H \approx h - N$$

The Hybrid GEOID model is defined with respect to a particular realization of NAD 83.

GEOID09 should only be used with NAD 83(NSRS 2007)

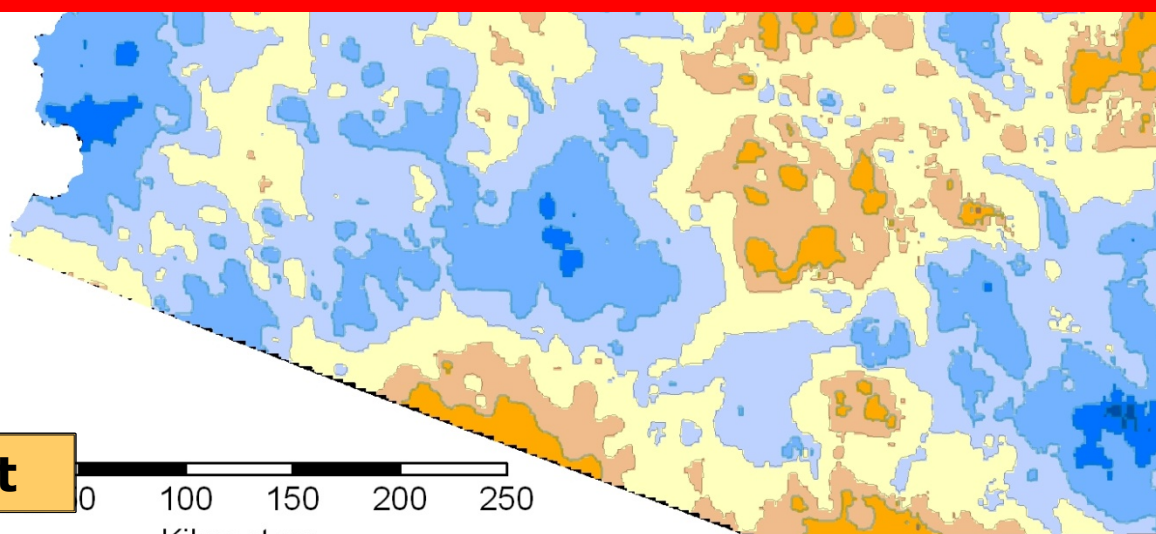
GEOID03 should only be used with NAD 83(1992 aka HARN)

**NAD 83(HARN) – NAD 83(NSRS2007) in Arizona:
Heights -> min = -20.1 cm, max = 11.5 cm, avg = -2.4 cm**



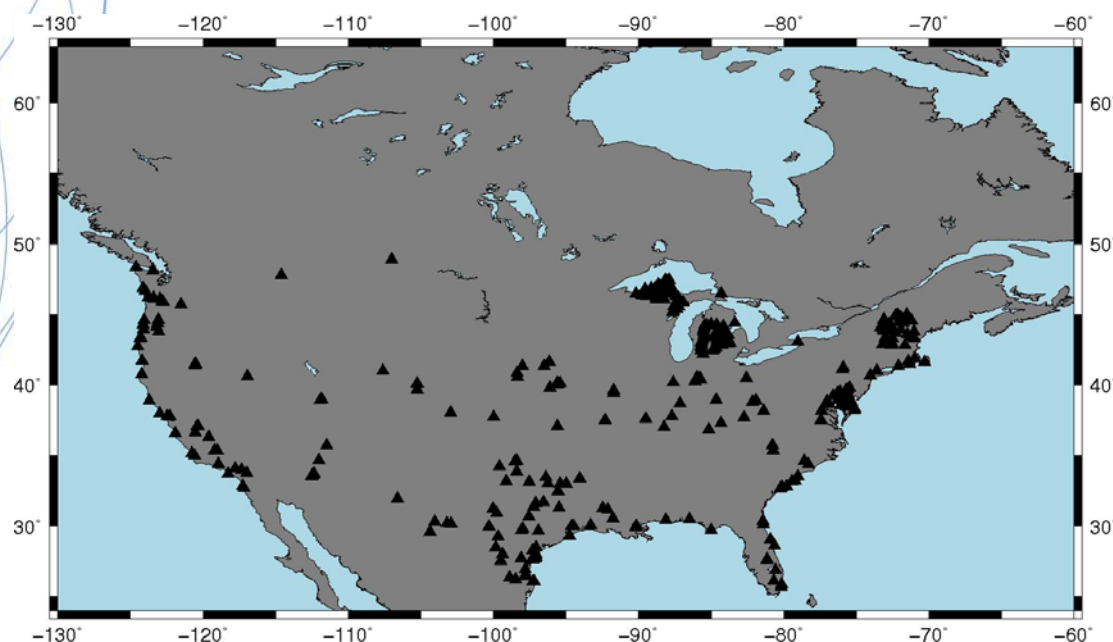
-0.49 ft to +0.72 ft

0 100 150 200 250
Kilometers



Leveled Bench Marks Occupied by GPS and stored in OPUS-DB

OPUS-DB shows great promise for filling gaps



Work to be Done (Ht Modernization) *Big Picture*

- Assessment of Vertical Issues in CO
- Gap Analysis of Where we need better vertical measurements, whether orthometric or ellipsoidal
- Collect Data in those Key areas, using OPUS-DB, and determine what other means (leveling)
- In the meantime, collect what you can using OPUS-DB
- Write a report capturing all of this



Announcing...

A New NGS Datasheet Format

- **Update to new Datasheet version (8.00)**
 - Changed location, length, and text for many fields
 - Added new fields, deleted fields, augmented existing fields
 - To be Implemented in 2012
 - Will add announcement and prototype to NGS web site soon
- **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
 - Superseded Ht Mod ortho heights indicate geoid model used



```

DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.87.4
1      National Geodetic Survey,  Retrieval Date = AUGUST 19, 2011
AC6803 *****
AC6803 HT_MOD      -   This is a Height Modernization Survey Station.
AC6803 PACS        -   This is a Primary Airport Control Station.
AC6803 DESIGNATION -   AZC A
AC6803 PID         -   AC6803
AC6803 STATE/COUNTY-   AZ/MOHAVE
AC6803 USGS QUAD   -   LOST SPRING MTN EAST (1988)
AC6803
AC6803                                     *CURRENT SURVEY CONTROL
AC6803
AC6803* NAD 83(2007)- 36 57 59.55377(N)    113 00 32.22917(W)    ADJUSTED
AC6803* NAVD 88      -      1485.56    (meters)    4873.9    (feet)  GPS OBS
AC6803
AC6803 EPOCH DATE   -      2007.00
AC6803 X            -   -1,994,789.496 (meters)                      COMP
AC6803 Y            -   -4,697,388.731 (meters)                      COMP
AC6803 Z            -   3,815,306.819 (meters)                      COMP
AC6803 LAPLACE CORR-      3.37    (seconds)                      DEFLEC09
AC6803 ELLIP HEIGHT-      1462.787 (meters)                      (02/10/07) ADJUSTED
AC6803 GEOID HEIGHT-      -22.80   (meters)                      GEOID09
AC6803
AC6803 ----- Accuracy Estimates (at 95% Confidence Level in cm) -----
AC6803 Type      PID      Designation                      North    East    Ellip
AC6803 -----
AC6803 NETWORK AC6803 AZC A                      0.74    0.61    1.37
AC6803 -----
AC6803
AC6803.This mark is at Colorado City Municipal Airport (AZC)
AC6803
AC6803.The horizontal coordinates were established by GPS observations
AC6803.and adjusted by the National Geodetic Survey in February 2007.
AC6803
AC6803.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
AC6803 See National Readjustment for more information

```


DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 8.00

1 National Geodetic Survey, Retrieval Date = JANUARY 1, 2012

AC6803 *****

AC6803 HT_MOD - This is a Height Modernization Survey Station.

AC6803 PACS - This is a Primary Airport Control Station.

AC6803 DESIGNATION - AZC A

AC6803 PID - AC6803

AC6803 STATE/COUNTY- AZ/MOHAVE

AC6803 COUNTRY - USA

AC6803 USGS QUAD - LOST SPRING MTN EAST (1988)

AC6803

AC6803 *CURRENT SURVEY CONTROL

AC6803

AC6803* NAD 83(2007) POSITION- 36 57 59.55377(N) 113 00 32.22917(W) ADJUSTED

AC6803* NAD 83(2007) ELLIP HT- 1462.787 (meters) (02/10/07) ADJUSTED

AC6803* NAD 83(2007) EPOCH - 2007.00

AC6803* NAVD 88 ORTHO HEIGHT - 1485.56 (meters) 4873.9 (feet) GPS OBS

AC6803* NAVD 88 EPOCH - 2006.81 (for example only, n/a for AC6803)

AC6803

AC6803 NOTE: NAVD 88 ortho height was determined from prior model GEOID03.

AC6803 GEOID03 HEIGHT - -22.75 (meters)

AC6803 GEOID09 HEIGHT - -22.80 (meters)

AC6803 NAD 83(2007) X - -1,994,789.496 (meters) COMP

AC6803 NAD 83(2007) Y - -4,697,388.731 (meters) COMP

AC6803 NAD 83(2007) Z - 3,815,306.819 (meters) COMP

AC6803 LAPLACE CORR - 3.37 (seconds) DEFLEC09

AC6803

AC6803 FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)

AC6803 Type Horiz Ellip Dist(km)

AC6803 -----

AC6803 NETWORK ACCURACY 0.86 1.37

AC6803 MEDIAN LOCAL ACCURACY AND DIST (11 points) 0.67 1.22 1.64

AC6803 -----

AC6803 NOTE: Individual local accuracy values and other accuracy information

AC6803 are available [here](#).

AC6803



DATABASE = ,PROGRAM = datasheet, VERSION = 8.00

1 National Geodetic Survey, Retrieval Date = January 1, 2012

AC6803 *****

AC6803 ACCURACIES - Complete network and local accuracy information.

AC6803 HT_MOD - This is a Height Modernization Survey Station.

AC6803 PACS - This is a Primary Airport Control Station.

AC6803 NAME - AZC A

AC6803 PID - AC6803

AC6803

AC6803 FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)

AC6803 Type/PID Horiz Ellip Dist(km) Std N Std E Std h Correltn NE

AC6803 -----

AC6803 NETWORK 0.86 1.37 0.38 0.31 0.70 -0.29917912

AC6803 -----

AC6803 MEDIAN LOCAL ACCURACY AND DIST (11 points)

AC6803 AE3181 0.36 0.69 0.07 0.17 0.11 0.35 -0.05276934

AC6803 AC6804 0.22 0.20 0.98 0.10 0.08 0.10 -0.02295189

AC6803 AE3183 0.57 0.90 1.27 0.26 0.19 0.46 -0.24478497

AC6803 AE3184 0.67 1.22 1.35 0.32 0.20 0.62 -0.05253846

AC6803 AE3182 0.66 0.90 1.60 0.30 0.21 0.46 -0.48667427

AC6803 AC6805 0.29 0.24 1.64 0.13 0.10 0.12 -0.07383703

AC6803 HO0112 1.21 2.29 42.91 0.53 0.45 1.17 0.07206508

AC6803 HO0076 0.94 1.71 45.99 0.42 0.34 0.87 -0.05592834

AC6803 AC6806 0.83 1.47 136.10 0.37 0.30 0.75 -0.14246214

AC6803 AC6816 0.82 1.51 139.26 0.33 0.34 0.77 -0.00353532

AC6803 FQ0454 0.86 1.35 230.42 0.38 0.31 0.69 -0.30702358

AC6803

AC6803 MEDIAN 0.67 1.22 1.64

AC6803 -----

AC6803 NOTE: Documentation for the accuracy information is available [here](#).

AC6803

*** retrieval complete.

Elapsed Time = 00:00:00

AC6803.part of the NAVD 88 network.

AC6803

AC6803.The X, Y, and Z were computed from the position and the ellipsoidal ht.

AC6803

AC6803.The Laplace correction was computed from DEFLEC09 derived deflections.

AC6803

AC6803.The ellipsoidal height was determined by GPS observations

AC6803.and is referenced to NAD 83.

AC6803

AC6803.The geoid height was determined by GEOID09.

AC6803

AC6803;

| | | North | East | Units | Scale Factor | Converg. |
|--|--|-------|------|-------|--------------|----------|
|--|--|-------|------|-------|--------------|----------|

| | | | | | | |
|-----------------|---|-------------|-------------|----|------------|------------|
| AC6803;SPC AZ W | - | 662,036.150 | 279,346.877 | MT | 0.99998696 | +0 26 44.3 |
|-----------------|---|-------------|-------------|----|------------|------------|

| | | | | | | |
|-----------------|---|--------------|------------|-----|------------|------------|
| AC6803;SPC AZ W | - | 2,172,034.61 | 916,492.38 | iFT | 0.99998696 | +0 26 44.3 |
|-----------------|---|--------------|------------|-----|------------|------------|

| | | | | | | |
|---------------|---|---------------|-------------|----|------------|------------|
| AC6803;UTM 12 | - | 4,093,046.689 | 321,162.779 | MT | 0.99999401 | -1 12 30.2 |
|---------------|---|---------------|-------------|----|------------|------------|

AC6803

AC6803! - Elev Factor x Scale Factor = Combined Factor

AC6803!SPC AZ W - 0.99977049 x 0.99998696 = 0.99975746

AC6803!UTM 12 - 0.99977049 x 0.99999401 = 0.99976451

AC6803

| PID | Reference Object | Distance | Geod. Az ddmmss.s |
|--------|-------------------|---------------|----------------------|
| AE3181 | AZC CL END RWY 20 | 68.963 METERS | 15655 |

AC6803

AC6803 SUPERSEDED SURVEY CONTROL

AC6803

AC6803 ELLIP H (01/12/01) 1462.805 (m) GP() 4 1

AC6803 NAD 83(1992)- 36 57 59.55345(N) 113 00 32.22767(W) AD() B

AC6803 ELLIP H (03/14/97) 1462.873 (m) GP() 3 1

AC6803 NAVD 88 (03/14/97) 1485.51 (m) 4873.7 (f) GPS OBS

AC6803

AC6803.Superseded values are not recommended for survey control.

AC6803.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

AC6803.[See file dsdata.txt](#) to determine how the superseded data were derived.

AC6803.The X, Y, and Z were computed from the position and the ellipsoidal ht.
AC6803

AC6803.The Laplace correction was computed from DEFLEC09 derived deflections.
AC6803

AC6803.The ellipsoidal height was determined by GPS observations
AC6803.and is referenced to NAD 83.
AC6803

AC6803.The geoid height was determined by GEOID09. (remove line)

AC6803

AC6803.The following values were computed from NAD 83(2007).

AC6803

| AC6803; | | North | East | Units | Scale Factor | Converg. |
|-----------------|---|---------------|-------------|-------|--------------|------------|
| AC6803;SPC AZ W | - | 662,036.150 | 279,346.877 | MT | 0.99998696 | +0 26 44.3 |
| AC6803;SPC AZ W | - | 2,172,034.61 | 916,492.38 | iFT | 0.99998696 | +0 26 44.3 |
| AC6803;UTM 12 | - | 4,093,046.689 | 321,162.779 | MT | 0.99999401 | -1 12 30.2 |

AC6803

| | | | | | | |
|-----------------|---|-------------|---|--------------|---|-----------------|
| AC6803! | - | Elev Factor | x | Scale Factor | = | Combined Factor |
| AC6803!SPC AZ W | - | 0.99977049 | x | 0.99998696 | = | 0.99975746 |
| AC6803!UTM 12 | - | 0.99977049 | x | 0.99999401 | = | 0.99976451 |

AC6803

| AC6803 | PID | Reference Object | Distance | Geod. Az |
|--------|--------|-------------------|---------------|----------|
| AC6803 | | | | dddmss.s |
| AC6803 | AE3181 | AZC CL END RWY 20 | 68.963 METERS | 15655 |

AC6803

AC6803 SUPERSEDED SURVEY CONTROL

AC6803

| | | | | | |
|--------|--------------------|-------------------|--------------------|-----|-----|
| AC6803 | ELLIP H (01/12/01) | 1462.805 (m) | GP(|) | 4 1 |
| AC6803 | NAD 83(1992)- | 36 57 59.55345(N) | 113 00 32.22767(W) | AD(|) B |
| AC6803 | ELLIP H (03/14/97) | 1462.873 (m) | GP(|) | 3 1 |

AC6803 NAVD 88 (03/14/97) 1485.51 (m) GEOID96 model used GP(epoch if appl)

AC6803

AC6803.Superseded values are not recommended for survey control.

AC6803.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

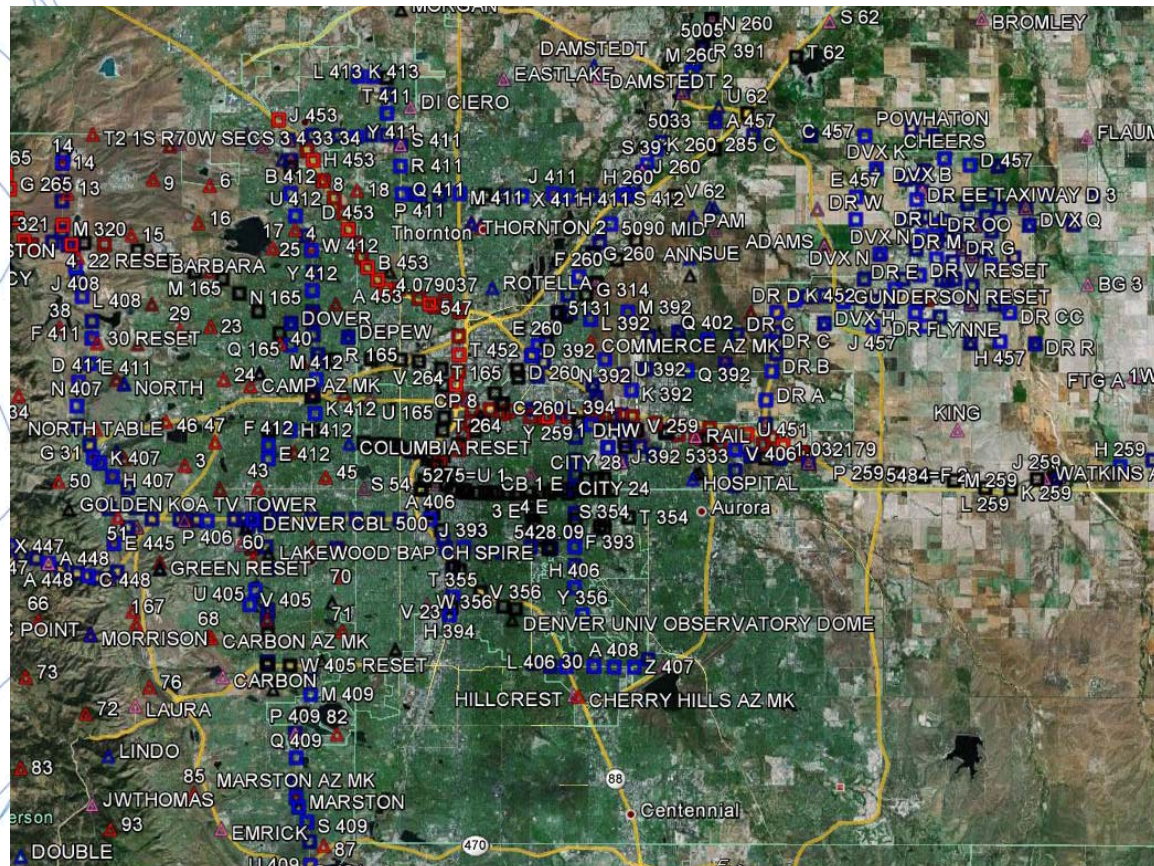
AC6803.[See file dsdata.txt](#) to determine how the superseded data were derived.

“DSWorld” Software Program

- Highly rated new NGS software tool
- Developed to search the NGS database
- Easy to learn/use
- Multiple search options available
- Displays search results using Google Earth



Geodetic Control Near CDOT R6 office



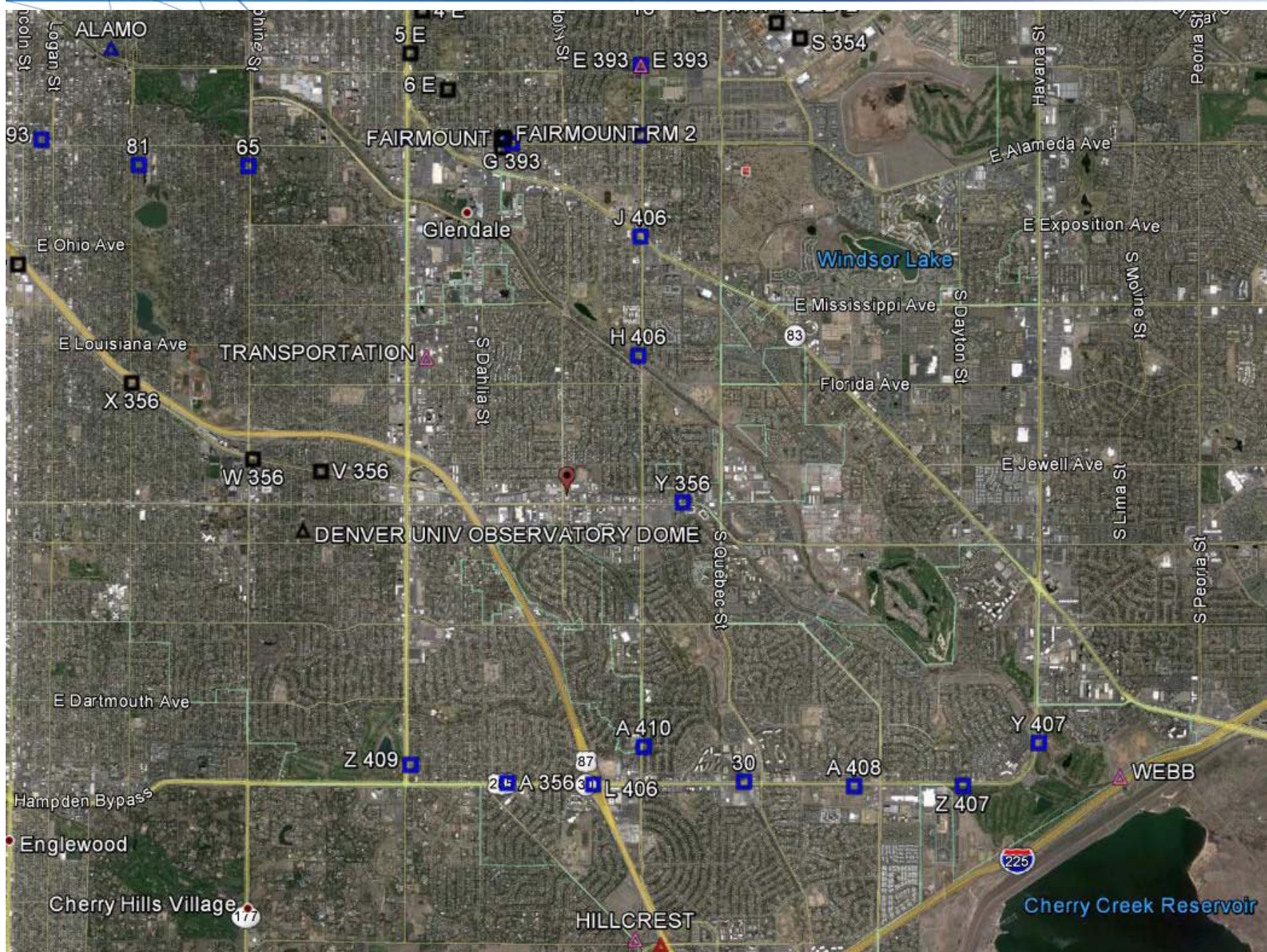
Triangles – Horizontal Control
Squares – Vertical Control

Blue – First Order
Red – Second Order



National Oceanic and Atmospheric Administration

National Geodetic Survey



National Geodetic Survey

Search

Search Google Parcel Search (APN)

2000 S. Holly Street denver, co Search

ex: pizza near NYC

Get Directions History

2000 S Holly St, Denver,
CO 80222, USA

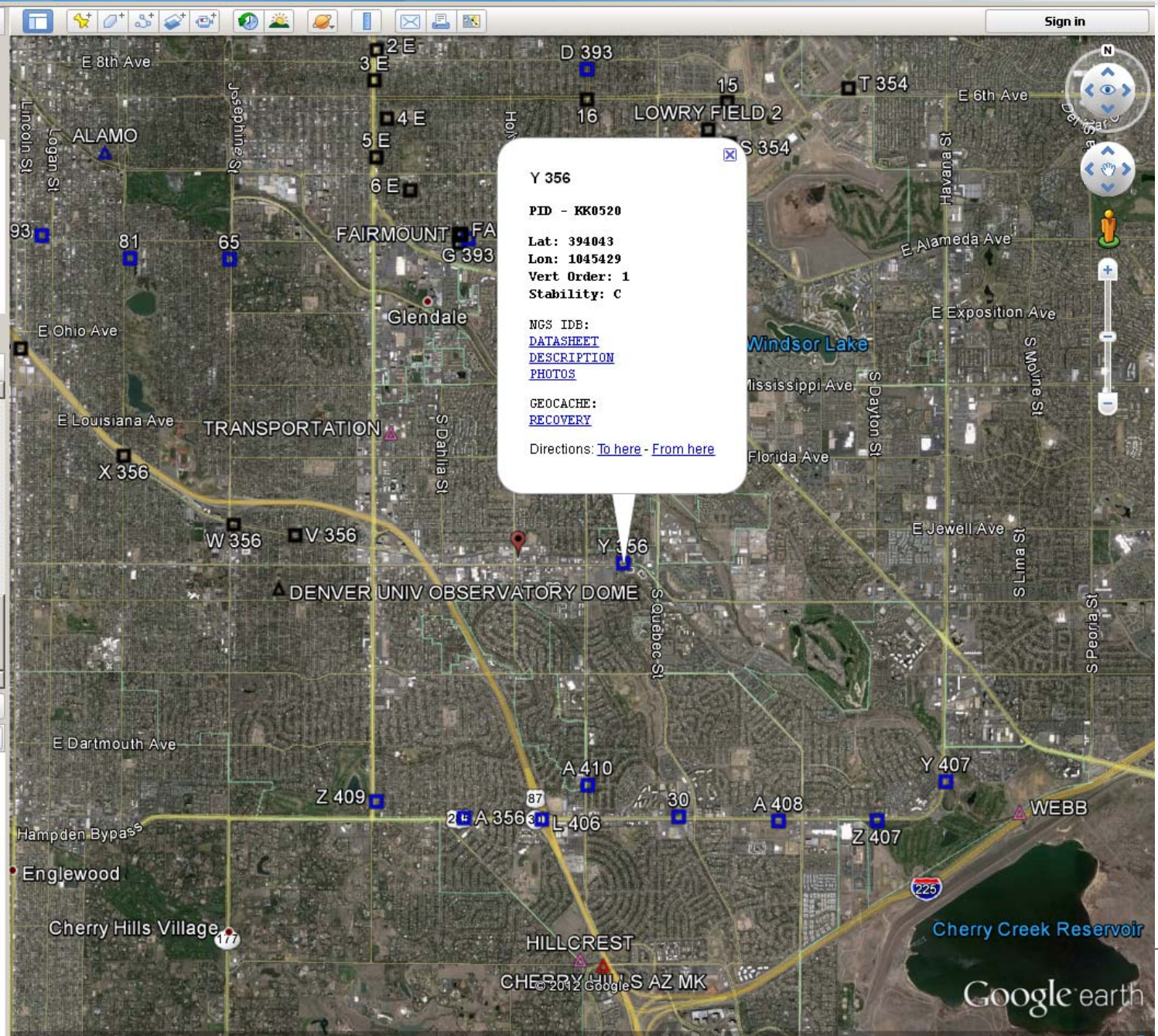
Places

- ☐ CO_GEOMAG.kml
- ☐ OPUS_DB.kml
- ☒ CO_JEFFERSON_X-0-0.kml
- ☒ CO_ADAMS_X-0-0.kml
- ☒ Buffalo_Feeding_Area.kmz
- ☐ Geoid and Gravity Images f...
- ☐ Terrain Corrected Bougu...
- ☐ GEOID96
- ☐ DEFLEC96 N/S Deflections
- ☐ DEFLEC96 E/W Deflections
- ☐ Topography used in GEO...
- ☐ G96SSS Geoid Undulations
- ☒ Temporary Places
- ☒ CO_PUEBLO_X-0-0.kml
- ☒ CO_DENVER_X-0-0.kml

Layers

Earth Gallery >>

- ☒ Primary Database
- ☐ Earth Pro (US)
- ☒ Borders and Labels
- ☐ Places
- ☒ Photos
- ☒ Roads
- ☐ 3D Buildings
- ☐ Ocean
- ☐ Weather
- ☐ Gallery
- ☐ Global Awareness
- ☐ More
- ☒ Terrain



The NGS Data Sheet

See file [dsdata.txt](#) for more information about the datasheet.

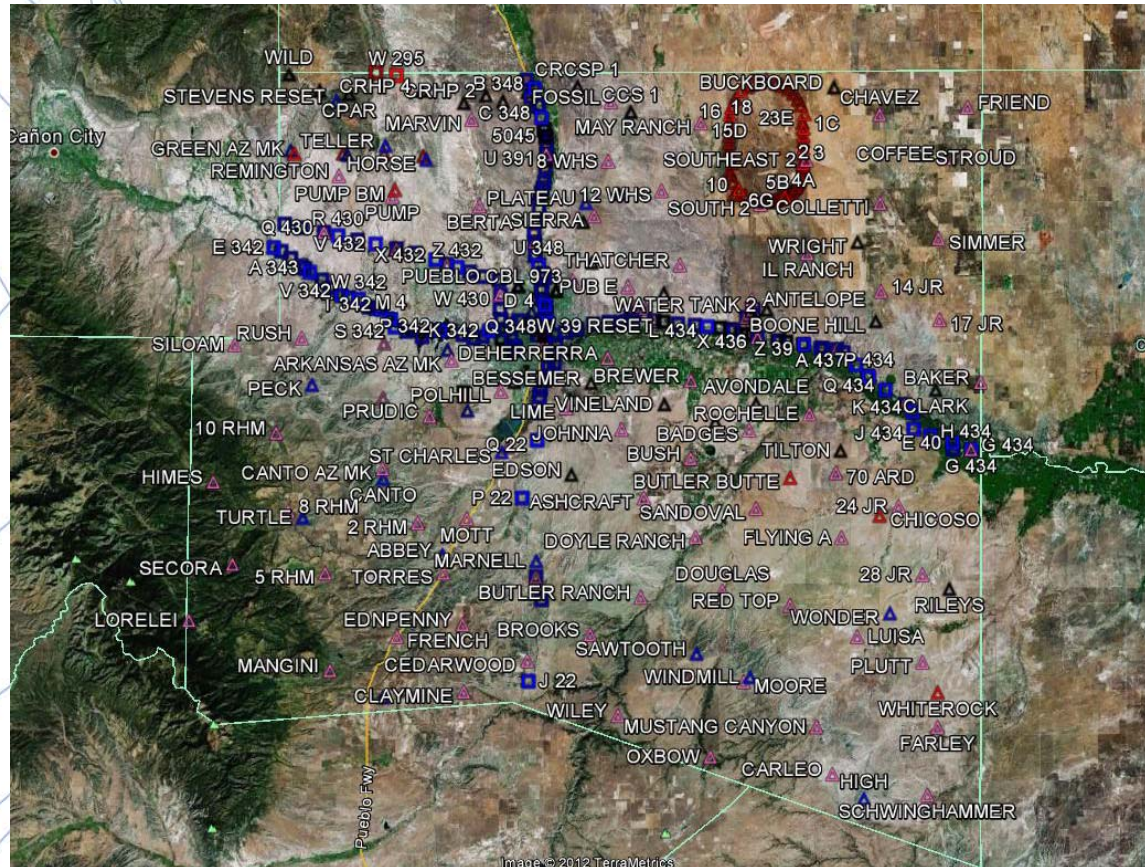
```

DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.87.6.1
1      National Geodetic Survey, Retrieval Date = APRIL 30, 2012
KK0520 *****
KK0520 DESIGNATION - Y 356
KK0520 PID - KK0520
KK0520 STATE/COUNTY- CO/DENVER
KK0520 USGS QUAD - ENGLEWOOD (1997)
KK0520
KK0520 *CURRENT SURVEY CONTROL
KK0520
KK0520* NAD 83 (1986)- 39 40 43. (N) 104 54 29. (W) SCALED
KK0520* NAVD 88 - 1665.429 (meters) 5464.00 (feet) ADJUSTED
KK0520
KK0520 GEOID HEIGHT- -17.30 (meters) GEOID09
KK0520 DYNAMIC HT - 1663.809 (meters) 5458.68 (feet) COMP
KK0520 MODELED GRAV- 979,595.3 (mgal) NAVD 88
KK0520
KK0520 VERT ORDER - FIRST CLASS II
KK0520
KK0520.The horizontal coordinates were scaled from a topographic map and have
KK0520.an estimated accuracy of +/- 6 seconds.
KK0520.
KK0520.The orthometric height was determined by differential leveling and
KK0520.adjusted in June 1991.
KK0520
KK0520.The geoid height was determined by GEOID09.
KK0520
KK0520.The dynamic height is computed by dividing the NAVD 88
KK0520.geopotential number by the normal gravity value computed on the
KK0520.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
KK0520.degrees latitude (g = 980.6199 gals.).
KK0520
KK0520.The modeled gravity was interpolated from observed gravity values.
KK0520
KK0520; North East Units Estimated Accuracy
KK0520;SPC CO C - 509,810. 965,190. MT (+/- 180 meters Scaled)
KK0520
KK0520 SUPERSEDED SURVEY CONTROL
KK0520
KK0520 NGVD 29 (??/??/??) 1664.509 (m) 5460.98 (f) ADJUSTED 1 2
KK0520
KK0520.Superseded values are not recommended for survey control.
KK0520.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
KK0520.See file dsdata.txt to determine how the superseded data were derived.
KK0520
KK0520 U.S. NATIONAL GRID SPATIAL ADDRESS: 13SED078920(NAD 83)
KK0520
KK0520 MARKER: DB = BENCH MARK DISK
KK0520_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
KK0520_SP SET: SET IN TOP OF CONCRETE MONUMENT
KK0520_STAMPING: Y 356 1954
KK0520_MARK LOGO: CGS
KK0520_PROJECTION: FLUSH
KK0520_STABILITY: C = MAY HOLD BUT OF TYPE COMMONLY SUBJECT TO

```

Direct Access to the NGS Datasheet

Geodetic Control Near CDOT R2 office



Triangles – Horizontal Control

Squares – Vertical Control

Blue – First Order

Red – Second Order



National Oceanic and Atmospheric Administration

National Geodetic Survey



▼ Search

Search Google Parcel Search (APN)

905 Erie Avenue pueblo, co

Search

ex: pizza near NYC

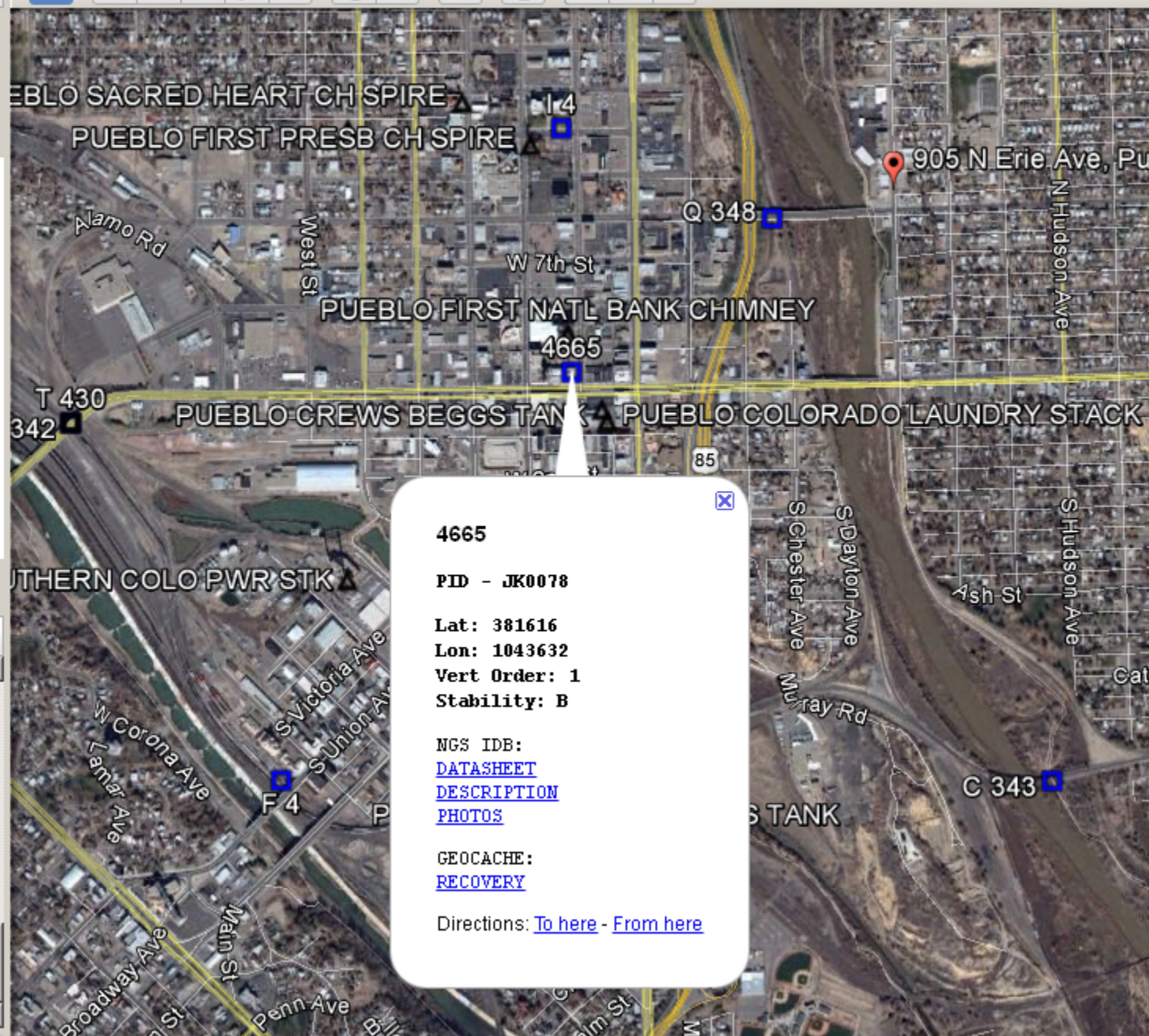
[Get Directions](#) [History](#)

 **905 N Erie Ave, Pueblo, CO 81001, USA**



▼ Places

- ☐ OPUS_DB.kml
- ☒ CO_JEFFERSON_X-0-0.kml
- ☒ CO_ADAMS_X-0-0.kml
- ☒ Buffalo_Feeding_Area.kmz
- ☐ Geoid and Gravity Images f...
- ☐ Terrain Corrected Bougu...
- ☐ GEOID96
- ☐ DEFLEC96 N/S Deflections
- ☐ DEFLEC96 E/W Deflections
- ☐ Topography used in GEO...
- ☐ G96SSS Geoid Undulations
- ☒ Temporary Places
- ☒ CO_PUEBLO_X-0-0.kml



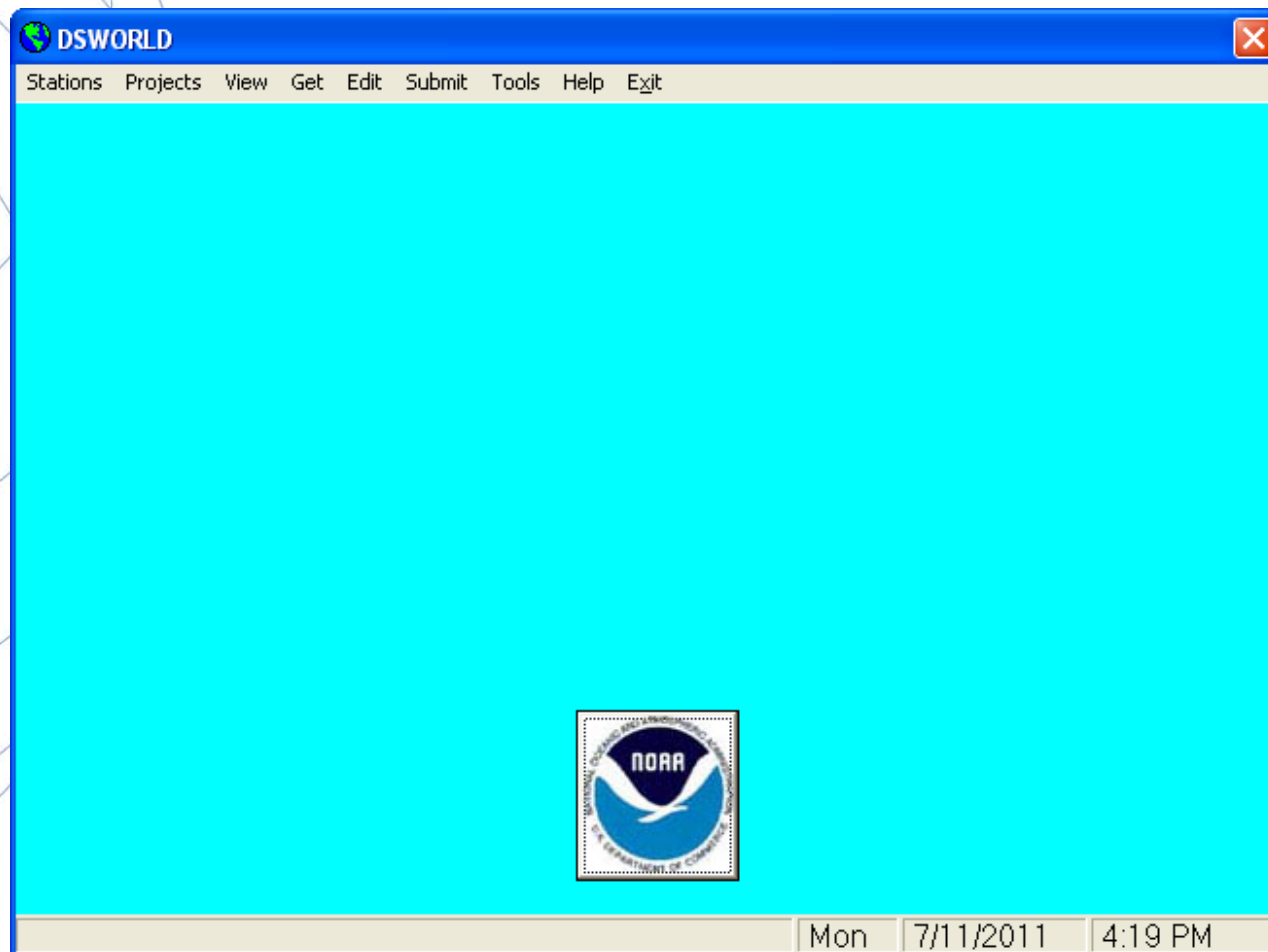
The NGS Data Sheet

See file [dsdata.txt](#) for more information about the datasheet.

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DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.87.6.1
1      National Geodetic Survey,  Retrieval Date = APRIL 30, 2012
JK0078 *****
JK0078 DESIGNATION - 4665
JK0078 PID - JK0078
JK0078 STATE/COUNTY- CO/PUEBLO
JK0078 USGS QUAD - NORTHEAST PUEBLO (1974)
JK0078
JK0078 *CURRENT SURVEY CONTROL
JK0078
JK0078* NAD 83(1986)- 38 16 16. (N) 104 36 32. (W) SCALED
JK0078* NAVD 88 - 1423.789 (meters) 4671.21 (feet) ADJUSTED
JK0078
JK0078 GEOID HEIGHT- -19.20 (meters) GEOID09
JK0078 DYNAMIC HT - 1422.302 (meters) 4666.34 (feet) COMP
JK0078 MODELED GRAV- 979,535.0 (mgal) NAVD 88
JK0078
JK0078 VERT ORDER - FIRST CLASS II
JK0078
JK0078.The horizontal coordinates were scaled from a topographic map and have
JK0078.an estimated accuracy of +/- 6 seconds.
JK0078.
JK0078.The orthometric height was determined by differential leveling and
JK0078.adjusted in June 1991.
JK0078
JK0078.The geoid height was determined by GEOID09.
JK0078
JK0078.The dynamic height is computed by dividing the NAVD 88
JK0078.geopotential number by the normal gravity value computed on the
JK0078.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
JK0078.degrees latitude (g = 980.6199 gals.).
JK0078
JK0078.The modeled gravity was interpolated from observed gravity values.
JK0078
JK0078; North East Units Estimated Accuracy
JK0078:SPC CO S - 483,240. 992,380. MT (+/- 180 meters Scaled)
JK0078
JK0078 SUPERSEDED SURVEY CONTROL
JK0078
JK0078 NGVD 29 (??/??/92) 1422.938 (m) 4668.42 (f) ADJ UNCH 1 2
JK0078
JK0078.Superseded values are not recommended for survey control.
JK0078.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
JK0078.See file dsdata.txt to determine how the superseded data were derived.
JK0078
JK0078 U.S. NATIONAL GRID SPATIAL ADDRESS: 13SEC342359(NAD 83)
JK0078
JK0078_MARKER: DD = SURVEY DISK
JK0078_SETTING: 36 = SET IN A MASSIVE STRUCTURE
JK0078_SP_SET: BUILDING
JK0078_STAMPING: 4668.511
JK0078_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
JK0078_SATELLITE: THE SITE LOCATION WAS REPORTED AS NOT SUITABLE FOR
JK0078_SATELLITE: SATELLITE OBSERVATIONS - June 28, 2009
```

Direct Access to the NGS Datasheet

DSWorld opening screen



Where do you get DS-World?



Download NGS PC Software
National Geodetic Survey

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Download Free Geodetic Software Developed by NGS

| | | | |
|--------------------|--------------|-----------|----------|
| ADJUST & UTILITIES | DSWIN | HTDP | SPCS83 |
| CALIBRAT | DSFILES | INTERORB | TOLADD |
| CARIB97 | DSUPDATE | INV/FWD3D | Translev |
| COMPGB | ENHANCEMENTS | LOOP | USNG |
| COMPVECS | G99SSS | LVL_DH | USGG2003 |
| CORPSCON | GEOID99 | MEXICO97 | USGG2009 |
| CR88B | GEOID03 | MTEN4 | UTMS |
| CR88ER | GEOID06 | NA2VBBK | VDatum |
| DCAR97 | GEOID09 | NADCON | VERTCON |
| DEFLEC99 | Gethv1st | PCVOBS | WinDesc |
| DMEX97 | GPPCGP | PROMPTER | XYZWIN |

If you have questions, refer to the [Software Download FAQ](#).
If you have download problems, contact the [NGS Webmaster](#).

[User-Contributed Software](#) is also available to perform related functions.

Descriptions of Free Geodetic Software Developed by NGS

ADJUST AND UTILITIES
Programs and utilities to perform least squares adjustment on horizontal, vertical angle, and/or GPS observations. Data checking programs are included. [\[Return to top.\]](#)

CALIBRAT (Version 1.0)
This program is used to determine the scale and constant corrections for electronic distance measuring instruments by making measurements over previously determined base lines. The formulas used in the program are found in NOAA Technical Memorandum NOS NGS-10, "Use of Calibration Base Lines." [\[Return to top.\]](#)

CARIB97 (Version 3.1)
Specially designed software to compute geoid heights for the Caribbean Sea. Boundaries of area



National Geodetic Survey

CORS/OPUS



National Oceanic and Atmospheric Administration

CDOT CORS/OPUS Team

- To incorporate CORS and OPUS into the CDOT Survey Manual
- Presented to SAC on Feb 15, 2012
- Proposed Addendum
- Recommendations



CDOT CORS/OPUS Team

DRAFT Proposed Addendum DRAFT

Surveying and mapping work, upon which all planning, studies and engineering designs are based, shall use the established CDOT project datum. Unless otherwise determined and approved by CDOT Region Survey Coordinator, the horizontal datum shall be the most recent realization of the North American Datum of 1983 (NAD83) as defined by the National Geodetic Survey (NGS). The horizontal control may utilize accepted CDOT and NGS ground based monuments (such as former HARN) and CORS (Continuously Operating Reference Stations).

Established Static Procedures (two 20 minute observations and fast static procedures) as written in Chapter 3 of the CDOT Survey Manual can be followed for baselines up to 60 kms. For baselines greater than 60 kms the following should be used unless otherwise determined and approved by the CDOT Region Coordinator:

| Baseline Distance | Number of Satellites | Time (minutes) |
|----------------------------------|----------------------|----------------|
| Greater than 60 km (37.2 miles) | 4 | 180 |
| | 5 | 135 |
| | 6 or more | 95 |



CDOT CORS/OPUS Team

DRAFT

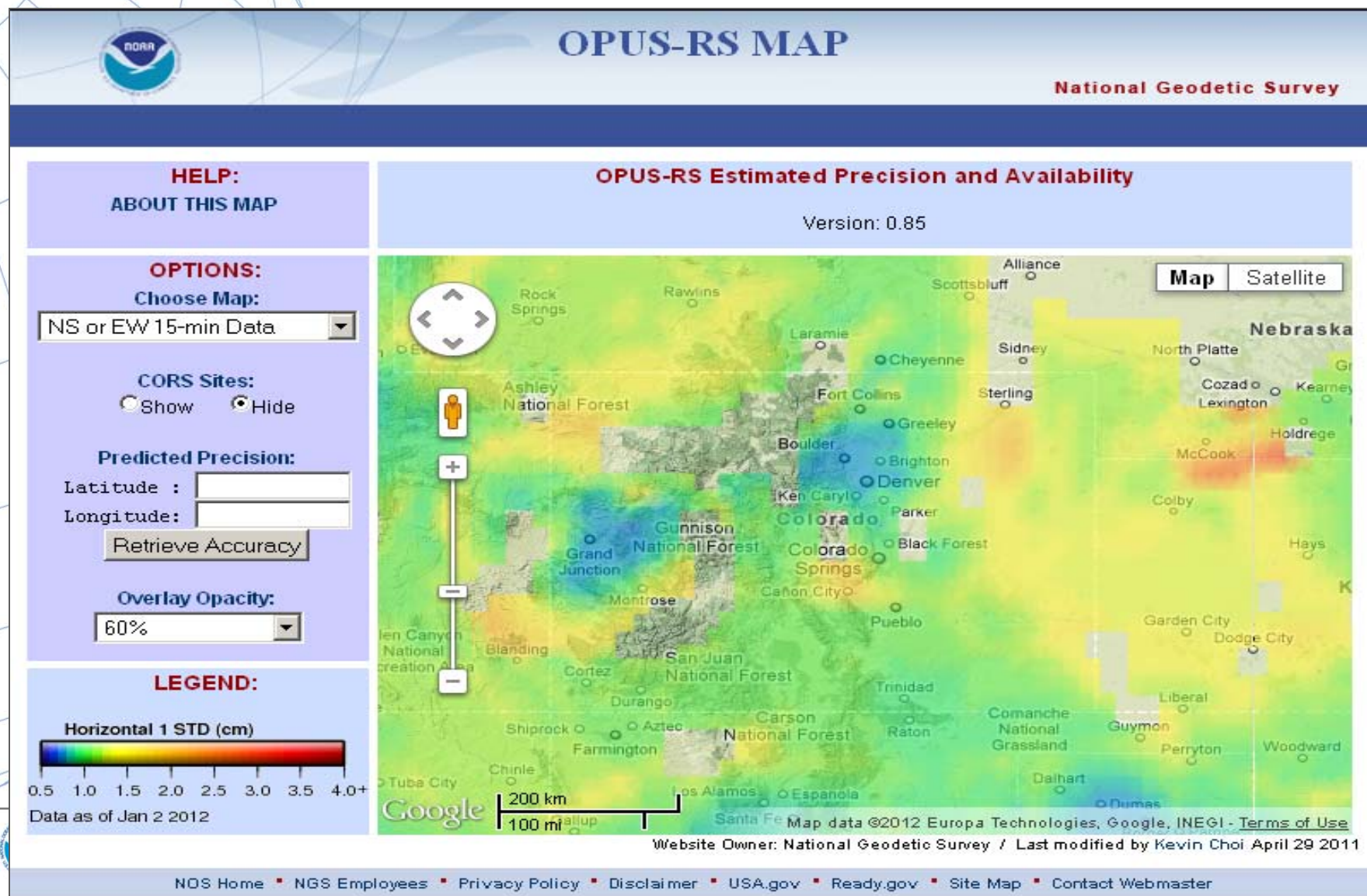
Recommendations

DRAFT

1. OPUS tools are valuable and use of them should be further explored and encouraged where appropriate and incorporated into re-write of Chapter 3.
2. Encourage publishing of control using OPUS-DB especially on NGS vertical marks to prepare the vertical datums for the future.
3. Additional CORS should be added in Colorado
4. Microstation control diagrams be edited to reflect the language in the proposed (approved) Addendum
5. Training to Support these Changes



OPUS-RS Coverage in Colorado



CDOT Comparison Between HARN, CORS and OPUS Region 3 Data

Comparison of Static Solution with HARN Stations to Static Solution with CORS Stations Coordinates are State Plane Colorado Central Zone Coordinates

| <u>Solution</u> | <u>Station</u> | <u>Northing</u> | <u>Easting</u> | <u>Delta N</u> | <u>Delta E</u> | <u>Vector</u> | <u>Remarks</u> |
|------------------|----------------|-----------------|----------------|---------------------|---------------------|-------------------|----------------------------|
| Static Survey | KOEPSSELL | 485019.8310 | 692784.1960 | | | | Held Fixed NGS Coordinates |
| Static (CORS) | KOEPSSELL | 485019.8280 | 692784.1940 | 0.003m (0.010 ft) | 0.002m (0.007 ft) | 0.004m (0.012 ft) | Static Solution from CORS |
| Static Survey | 72.30E | 484813.4910 | 692714.6750 | | | | |
| Static (CORS) | 72.30E | 484813.4880 | 692714.6740 | 0.003m (0.010 ft) | 0.001m (0.003 ft) | 0.003m (0.010 ft) | |
| Static Survey | 72.30E | 484813.4910 | 692714.6750 | | | | |
| OPUS-RS Solution | 72.30E | 484813.4960 | 692714.6800 | -0.005m (-0.016 ft) | -0.005m (-0.016 ft) | 0.007m (0.023 ft) | |
| Static Survey | 72.45E | 485172.0020 | 692900.1110 | | | | |
| Static (CORS) | 72.45E | 485171.9980 | 692900.1090 | 0.004m (0.013 ft) | 0.002m (0.007 ft) | 0.004m (0.015 ft) | |
| Static Survey | 72.30W | 485091.9840 | 692644.0670 | | | | |
| Static (CORS) | 72.30W | 485091.9790 | 692644.0650 | 0.005m (0.016 ft) | 0.002m (0.007 ft) | 0.005m (0.018 ft) | |
| Static Survey | 72.45W | 485367.7120 | 692756.3640 | | | | |
| Static (CORS) | 72.45W | 485367.7060 | 692756.3630 | 0.006m (0.020 ft) | 0.001m (0.003 ft) | 0.006m (0.020 ft) | |

| | <u>Sta to Sta</u> | <u>Dist m</u> | <u>Dist ft (mi)</u> |
|---------------|---------------------|---------------|------------------------|
| Static Survey | 72.30W to MCCARY | 9614.917m | 31544.9 ft (5.97 mi) |
| | 72.30W to FABER | 8901.729m | 29205.1 ft (5.53 mi) |
| | 72.30W to KOEPSSELL | 157.613m | 517.1 ft (0.10 mi) |
| Static (CORS) | 72.30W to GSC1 | 65708.007m | 215577.0 ft (40.83 mi) |
| | 72.30W to MC07 | 17084.257m | 56050.6 ft (10.62 mi) |
| | 72.30W to MC08 | 23088.460m | 75749.4 ft (14.35 mi) |



CDOT Comparison Between HARN, CORS and OPUS Region 2 Data

Comparison of Static Solution with HARN Stations to Static Solution with CORS Stations Coordinates are State Plane Colorado Central Zone Coordinates

Project control is located in Sections 23 and 24, T 19 S, R 69 W, Fremont County CO.

| <u>Solution</u> | <u>Station</u> | <u>Northing</u> | <u>Easting</u> | <u>Delta N</u> | <u>Delta E</u> | <u>Vector</u> | <u>Remarks</u> |
|------------------|----------------|-----------------|----------------|---------------------|---------------------|-------------------|------------------------------|
| Static Survey | 32 | 366101.7765 | 952018.7728 | | | | Held 2 Fixed NGS Coordinates |
| Static (CORS) | 32 | 366101.7753 | 952018.7777 | 0.001m (0.004 ft) | -0.005m (-0.016 ft) | 0.005m (0.017 ft) | Static Solution from CORS |
| Static Survey | 32 | 366101.7765 | 952018.7728 | | | | Held 2 Fixed NGS Coordinates |
| OPUS-RS Solution | 32 | 366101.7580 | 952018.7610 | 0.019m (0.061 ft) | 0.012m (0.039 ft) | 0.022m (0.072 ft) | |
| Static Survey | 5 | 366251.8198 | 951640.9798 | | | | Held 2 Fixed NGS Coordinates |
| Static (CORS) | 5 | 366251.8207 | 951640.9834 | -0.001m (-0.003 ft) | -0.004m (-0.012 ft) | 0.004m (0.012 ft) | Static Solution from CORS |
| Static Survey | 5 | 366251.8198 | 951640.9798 | | | | Held 2 Fixed NGS Coordinates |
| OPUS-RS Solution | 5 | 366251.8090 | 951640.9670 | 0.011m (0.035 ft) | 0.013m (0.042 ft) | 0.017m (0.055 ft) | |

| | <u>Sta to Sta</u> | <u>Dist m</u> | <u>Dist ft (mi)</u> |
|---------------|-------------------|---------------|------------------------|
| Static Survey | 32 to Newlin | 7105.128m | 23310.7 ft (4.41 mi) |
| | 32 to J 430 | 5666.111m | 18589.6 ft (3.52 mi) |
| | 32 to N 349 | 5716.130m | 18753.7 ft (3.55 mi) |
| Static (CORS) | 32 to P037 | 5130.693m | 16832.9 ft (3.19 mi) |
| | 32 to AMC2 | 66407.779m | 217872.9 ft (41.26 mi) |
| | 32 to PUB6 | 64222.000m | 210701.7 ft (39.91 mi) |
| Static Survey | 5 to Newlin | 7084.640m | 23243.5 ft (4.40 mi) |
| | 5 to J 430 | 5915.033m | 19406.2 ft (3.68 mi) |
| | 5 to N 349 | 5352.681m | 17561.3 ft (3.33 mi) |
| Static (CORS) | 5 to P037 | 4787.821m | 15708.0 ft (2.98 mi) |
| | 5 to AMC2 | 66571.061m | 218408.6 ft (41.37 mi) |
| | 5 to PUB6 | 64619.013m | 212004.2 ft (40.15 mi) |

National Geodetic Survey

CORS/OPUS



National Oceanic and Atmospheric Administration

CBLs

STATE OF COLORADO CONTENTS

| BASE LINE DESIGNATION | STATE | COUNTY | QUAD |
|------------------------------------|----------|------------|---------|
| ALAMOSA CBL (2005 REMEASURED) | COLORADO | ALAMOSA | N371053 |
| CHERRY CREEK CBL (UNUSABLE) | COLORADO | ARAPAHOE | N391044 |
| CORTEZ CBL (2004 REMEASURED) | COLORADO | MONTEZUMA | N371083 |
| CRAIG CBL (2004 REMEASURED) | COLORADO | MOFFAT | N401074 |
| DURANGO CBL (2004 MEASURED) | COLORADO | LA PLATA | N371073 |
| EL PASO CBL (2004 MEASURED) | COLORADO | EL PASO | N381044 |
| FORT CARSON CBL (2005 REMEASURED) | COLORADO | EL PASO | N381044 |
| HIGHLINE CBL (2004 REMEASURED) | COLORADO | ADAMS | N391044 |
| KELIM CBL (2004 REMEASURED) | COLORADO | WELD | N401043 |
| LAMAR CBL (2004 REMEASURED) | COLORADO | PROWERS | N381023 |
| LIMON CBL (2004 REMEASURED) | COLORADO | LINCOLN | N391033 |
| MEEKER CBL (2005 REMEASURED) | COLORADO | RIO BLANCO | N401073 |
| MESA (2005 VERIFIED) | COLORADO | MESA | N391083 |
| MONTROSE CBL (2005 REMEASURED) | COLORADO | MONTROSE | N381074 |
| NEW CASTLE CBL (2004 VERIFIED) | COLORADO | GARFIELD | N391074 |
| PINON CANYON CBL (2005 REMEASURED) | COLORADO | LAS ANIMAS | N371041 |
| PUEBLO 2 CBL (2005 VERIFIED) | COLORADO | PUEBLO | N381042 |
| STERLING CBL (2004 VERIFIED) | COLORADO | LOGAN | N401031 |





BETA
This is a BETA Release Site

LOCUS Leveling Online Calculations User Service

National Geodetic Survey

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[Tools](#)

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About LOCUS

The Leveling Online Calculations User Service (LOCUS) is a Web utility developed by the National Geodetic Survey (NGS). The purpose of LOCUS is to simplify the office processing and adjustment of geodetic leveling, including, as a long-term goal, the submission of leveling projects to NGS for publication. LOCUS runs the same programs that NGS uses in-house to process and adjust submitted projects.

LOCUS version 1.0 will be limited to:

1. Correction of observations for systematic errors, and
2. A minimally constrained [free] least-squares adjustment. The option for a fully constrained adjustment exists but will not be supported by analysis tools and documentation until later versions.

There is an option to select one of several datums; NAVD 88 is the default.

A correctly formatted **NGS Bluebook** vertical observation (*.hgz) file must be submitted (the vertical observation format is described in **Chapter 6** of the NGS Bluebook). The *.hgz file must first be checked to be error-free by the NGS program **Translev** (v4.16.07 or later). The NGS program **WinDesc** must also be used to provide positions of all marks and the Permanent Identifiers (PIDs) of published bench marks into the Translev program.

If more than one published bench mark is included in the *.hgz file, users will see the list of all PIDs available to constrain, and they may choose to do a partially or fully constrained adjustment. However, the tools to analyze the results of a constrained adjustment will not be implemented in the first version of LOCUS. Naturally, the adjusted orthometric heights of new marks will vary according to which constraints are held. Thus, results obtained using LOCUS and adjusted with user-supplied constraints may differ somewhat from results adjusted using constraints determined by NGS for publication.

To the extent possible, corrections for systematic errors are made before the adjustment. Refer to **NOAA Technical Memorandum NOS NGS 34, "Corrections Applied By The National Geodetic Survey To Precise Leveling Observations"** and to the **LOCUS Equipment & Corrections** page for more

LOCUS menu

[Upload data file](#)

[About LOCUS](#)

[Description of Output Files](#)

[Corrections](#)

[Sample file](#)

[Help](#)

[Contact LOCUS](#)

LOCUS

Leveling OnLine Calculations User Service

- Provides a means to process and adjust level data
 - Has been done at NGS Headquarters
- Requires *.hgz file from Translev
 - Error free
- Requires Description file from WinDesc
- You pick stations to constrain
- Helps expedite entire process
- Beta Version – Needs to be tested
- Data is not submitted to NGS (at this time)



NGS Real Time Positioning Components

GOAL:

To Ensure the Proper Geodetic
Basis
for Accurate Real Time Positioning
Aligned To The NSRS



NGS - RT Program Components

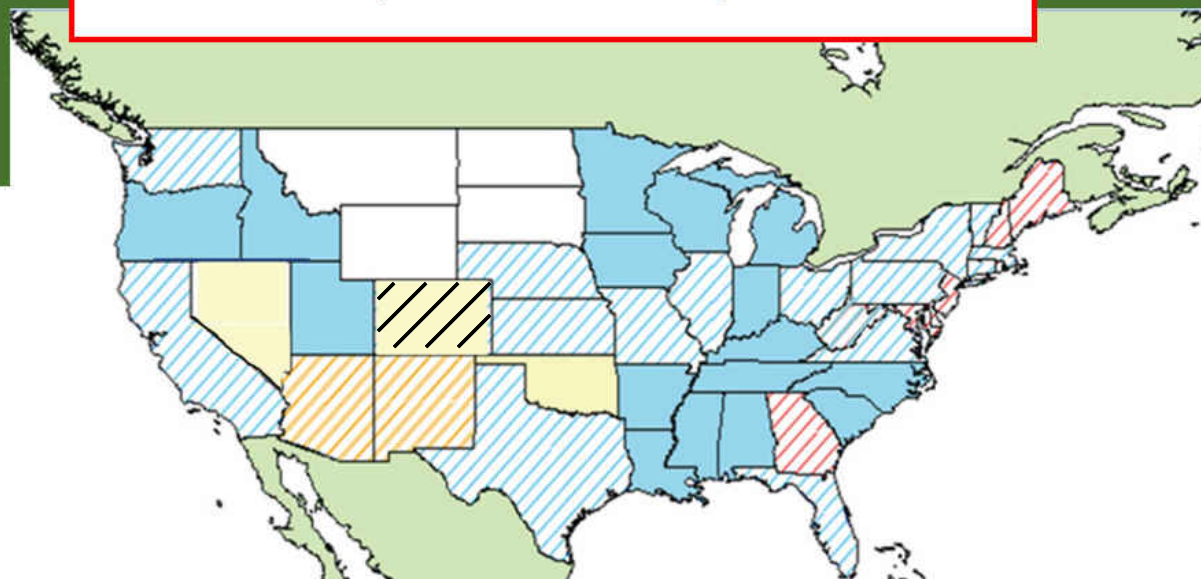
- I. NGS Streams Raw Data From The Backbone CORS
- II. Provide Outreach and Education
- III. Develop and Publish Guidelines Describing Best Practices.
- IV. Research Scientific Research Affecting Accurate Real-Time Positioning. [satellite orbits, refraction, multipath, antenna calibration, and crustal motion.]



≥200 RTN WORLDWIDE
≥107 RTN USA
≥35 DOT

MAJOR RTN IN THE USA (JAN 2011)

- ACADEMIC/SCIENTIFIC
- SPATIAL REFERENCE CENTERS
- VARIOUS DOTS + MACHINE GUIDANCE
- COUNTY
- CITY
- GEODETIC SURVEYS (NC, SC)
- MANUFACTURERS
- VENDOR NETWORKS
- AGRICULTURE
- MA & PA NETWORKS



- Public and Private Statewide
- Public Statewide – Planned or Operating
- Private Statewide
- Public and Private Municipal – No Statewide
- Private Municipal - No Statewide

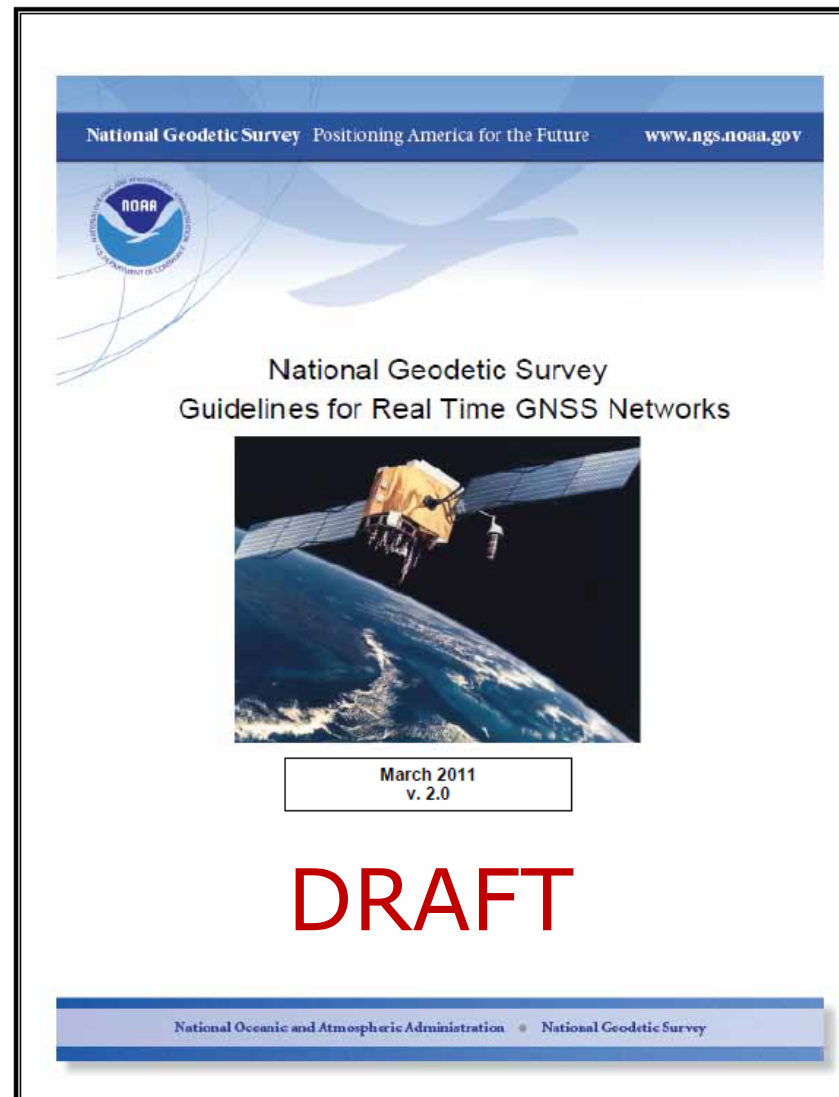
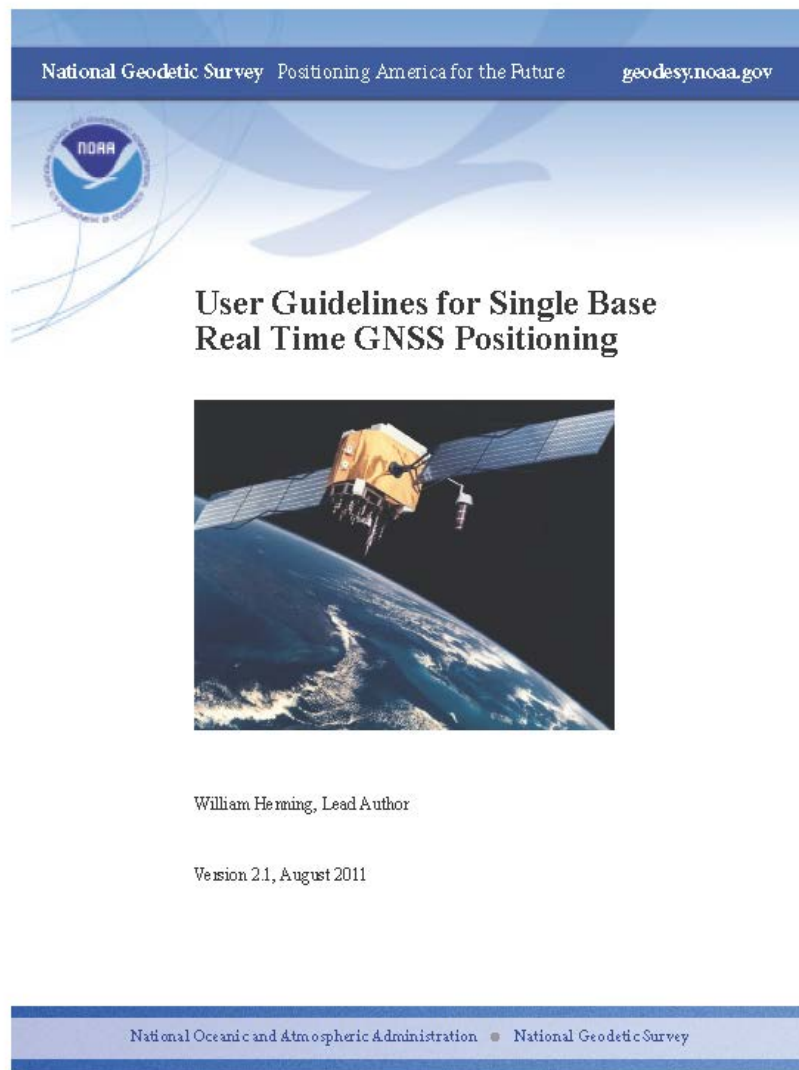
W. Henning 9/2009



Outreach, Cooperative Efforts & Leadership



+ PUBLIC & PRIVATE RTN ADMINISTRATORS SPANNING MORE THAN 35 STATES



Summary Table

RT Single-Base Guidelines

ACCURACY CLASS SUMMARY TABLE

| | CLASS RT1 | CLASS RT2 | CLASS RT3 | CLASS RT4 |
|-----------------------------|---|---|---|--|
| ACCURACY (TO BASE) | 0.015 HORIZONTAL, 0.025 VERTICAL | 0.025 HORIZONTAL, 0.04 VERTICAL | 0.05 HORIZONTAL, 0.06 VERTICAL | 0.15 HORIZONTAL, 0.25 VERTICAL |
| REDUNDANCY | ≥ 2 LOCATIONS, 4-HOUR DIFFERENTIAL | ≥ 2 LOCATIONS, 4-HOUR DIFFERENTIAL | NONE | NONE |
| BASE STATIONS | ≥ 2, IN CALIBRATION PROJECT CONTROL | RECOMMEND 2 IN CALIBRATION | ≥ 1, IN CALIBRATION | ≥ 1, IN CALIBRATION RECOMMENDED |
| PDOP | ≤ 2.0 | ≤ 3.0 | ≤ 4.0 | ≤ 6.0 |
| RMS | ≤ 0.01 M | ≤ 0.015 M | ≤ 0.03 M | ≤ 0.05 M |
| COLLECTION INTERVAL | 1 SECOND FOR 3-MINUTES | 5 SECONDS FOR 1-MINUTE | 1 SECOND FOR 15 SECONDS | 1 SECOND FOR 10 SECONDS |
| SATELLITES | ≥ 7 | ≥ 6 | ≥ 5 | ≥ 5 |
| BASELINE DISTANCE | ≤ 10 KM | ≤ 15 KM | ≤ 20 KM | ANY WITH FIXED SOLUTION |
| TYPICAL APPLICATIONS | PROJECT CONTROL CONSTRUCTION CONTROL POINTS CHECK ON TRAVERSE, LEVELS SCIENTIFIC STUDIES PAVING STAKE OUT | DENSIFICATION CONTROL TOPOGRAPHIC CONTROL PHOTOPPOINTS UTILITY STAKE OUT | TOPOGRAPHY CROSS SECTIONS AGRICULTURE ROAD GRADING SITE GRADING | SITE GRADING WETLANDS GIS POPULATION MAPPING ENVIRONMENTAL |



NGS Guidelines Real Time GNSS Networks

- Site Considerations
- Planning and Design
- Administration
- Obtaining Station Coordinates
Consistent with NAD83 and ITRS
- User Best Methods



Obtaining Station Coordinates Consistent with NAD83 and ITRS

1. Include a subnetwork of the RTN into the National CORS network. This would be three stations if RTN has less than 30 stations, 10% of RTN with greater than 30 stations. NGS will not distribute/broadcast RTN reference station data.
2. Align all RTN reference stations coordinates to the CORS network at 2-cm horizontal and 4-cm vertical
3. For each reference station in the RTN, use the Online Positioning User Service (OPUS) at <http://www.ngs.noaa.gov/OPUS/> to test for the continued consistency of its adopted positional coordinates and velocity on a daily basis, and revise the station's adopted coordinates and/or velocity if the tests reveal a need to do so.



Best methods from the Guidelines: The 7 “C’S” of NOAA’s NGS

The Control is at the Pole

- Check Equipment
- Communication
- Conditions
- Calibration (or not)
- Coordinates
- Collection
- Confidence



Expediting The Guidelines

The NGS Encourages RTN Users and Administrators to become Cooperative Partners to Provide Input that will Enable Valuable Documents to be Drafted that will Benefit the Public Welfare.

- Establishing Reference Stations
- Adjusting Networks
- Accuracy Expectations Vs. Obtained
- Baseline Distances
- Error Modeling
- Communication Issues



Real Time Networks (RTN) Considerations

- How Are They Established?
- How Are Their Coordinates Computed? Are They Consistent?
- How Is The Network Adjusted?
- How Does The RTN Align To The NSRS?
- Can Users Use Any Manufacturers' Equipment In The RTN?
- Do Overlapping Networks Give The Same Coordinates?
- What Are The Field Accuracies?



Real-Time Considerations

- Passive / Active
- Datums & Adjustment Epochs
- Geoid + Ellipsoid / Calibrate
- Single Base / RTN
- GNSS / GPS
- Grid / Ground



Some RT Field Considerations

- Multipath
- Position Dilution of Precision (PDOP)
- Baseline Root Mean Square (RMS)
- Number of satellites
- Elevation mask (or cut-off angle)
- Base accuracy (datum level, local level)
- Base security
- Redundancy, redundancy, redundancy
- Part(s) Per Million Error (ppm) – iono, tropo models, orbit errors
- Space weather- sunspot numbers, solar maximum
- Geoid quality
- Site calibrations (a.k.a. Localizations)
- Bubble adjustment
- Latency, update rate
- Fixed and float solutions
- Accuracy versus Precision
- Signal to Noise Ratio (S/N or C/N0)
- Carrier phase
- Code phase
- VHF/UHF radio communication
- CDMA/SIM/Cellular TCP/IP communication
- WGS 84 versus NAD 83, local datums,
- GPS, GLONASS, Galileo, Compass Constellations



Metadata

The RT Practitioner must record items not recorded in the Field. For instance:

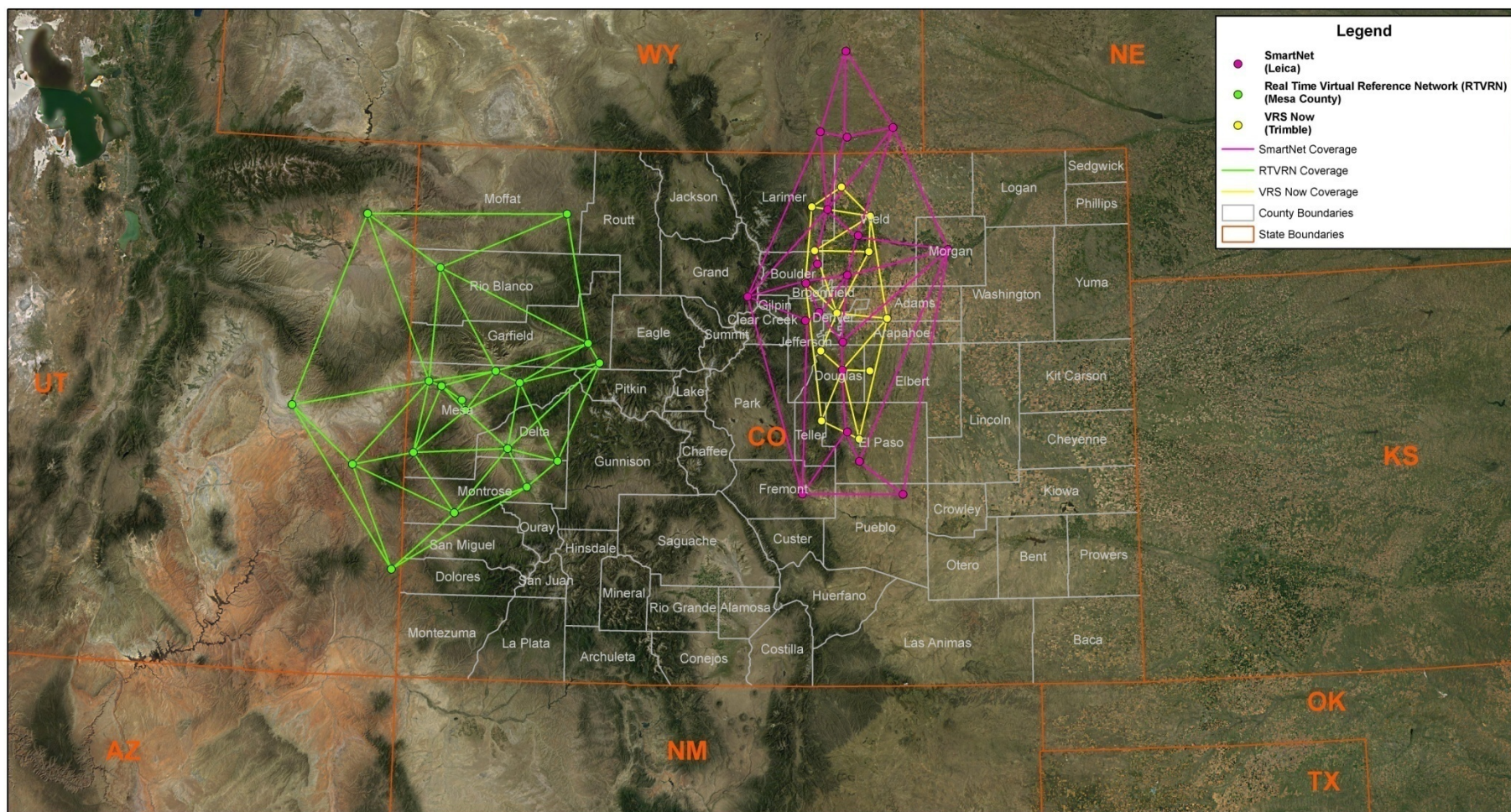
- ✓ What is the Source of the Data?
- ✓ What is the Datum/Adjustment Epoch?
- ✓ What are the Field Conditions?
- ✓ What Equipment was used, especially what Antenna?
- ✓ What firmware was in the receiver and collector?
- ✓ What redundancy, if any, was used?





Real Time Global Navigation Satellite System (GNSS) Reference Networks for the State of Colorado

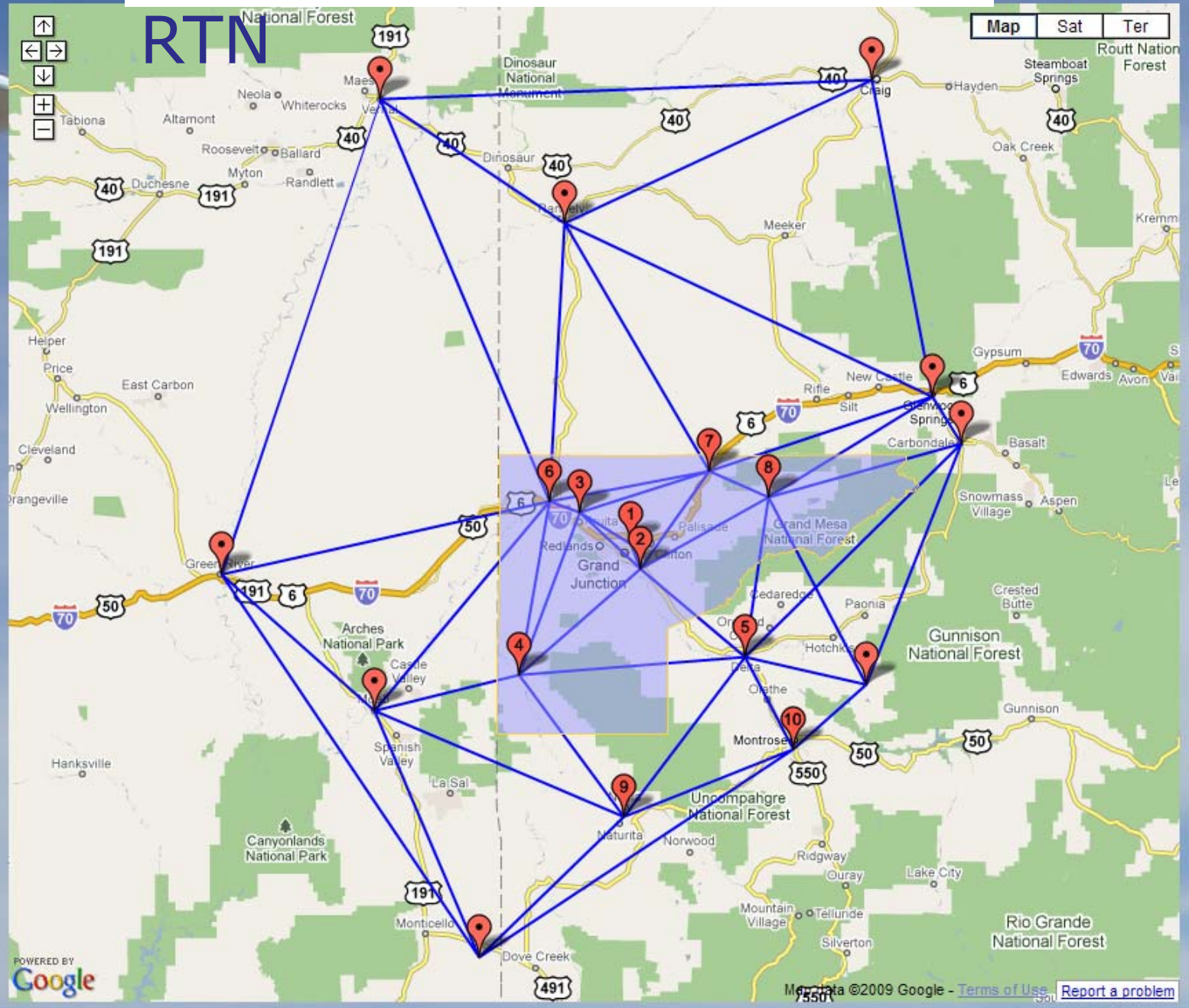
Map Units: Meters
Coordinate System: NAD 83, UTM Zone 13N
50 25 0 50 100 150
Kilometers



National Oceanic and Atmospheric Administration

Mesa County, Colorado

RTN





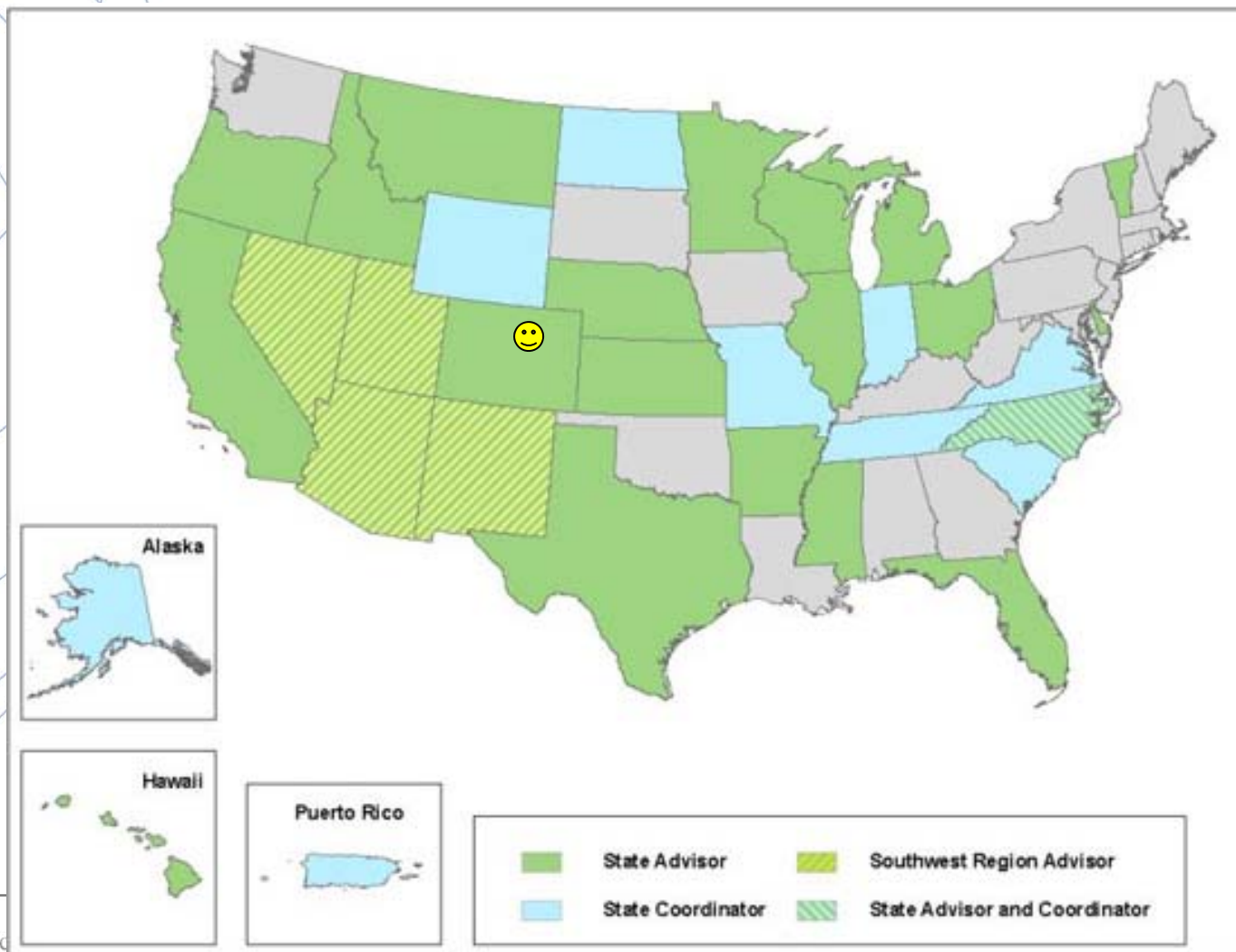


CSRN GPS DAY

- CSRN- Colorado Spatial Reference Network (Chapter of the PLSC)
- MAY 12, 2012 Saturday
- 10:00 – 2:00
- Utah Park Aurora, CO (1800 S. Peoria St)
- Free Food, Vendors, Boy and Girl Scouts

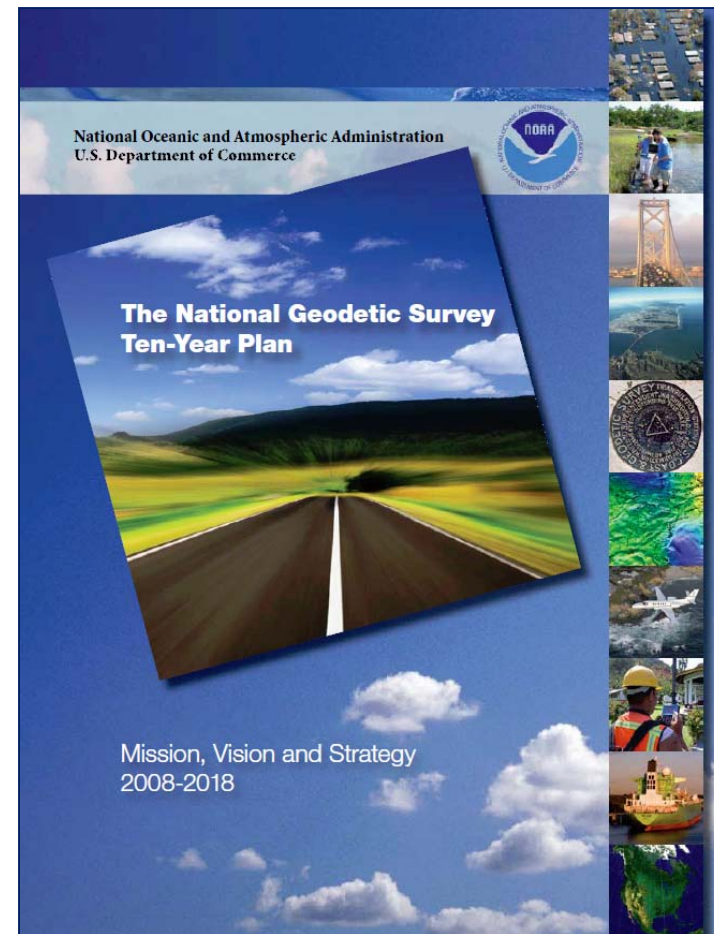


Advisor Status In Your State



National Geodetic Survey Ten-Year Plan

- Official NGS policy as of January 2008
- Replace NAVD 88 with a GPS/geoid datum
- Replace NAD 83 with a geocentric GPS based datum



NGS 10-Year Plan (excerpts)

Vision 1# Summary:
By 2020?, NGS has defined a **new geometric datum** (classically called “horizontal”) **to replace NAD 83** with its many systematic errors. The primary means of accessing this new datum is GNSS technology.

Vision #2 Summary:
By 2020?, a new **geopotential datum** (for orthometric and dynamic heights) is defined and realized through the combination of **GNSS technology and gravity field modeling.**

Note: Vision #2 can not happen without Vision #1.



NGS 10-Year Plan (more excerpts)

“NGS redefines the national horizontal datum to remove gross disagreements with the ITRF.”

“The primary means of accessing this new datum is GNSS technology. While passive control continues to be used as a secondary method to access the NSRS, such control will be “tied to”, not a “part of”, the NSRS.”

“Furthermore, NGS will provide simple transformation tools between historic and current datums and reference frames used by NGS, in four dimensions, wherever practical and possible.”

“In order to support users of NAVD 88, NGS will provide transformation tools between the new datum and NAVD 88 based predominantly on the few thousand measurements of GPS derived ellipsoid heights on NAVD 88 benchmarks.”

Underlining added for emphasis



Why a New Datum(s)?

- NAD 83
 - non-geocentric, i.e. inconsistent with GNSS positioning
 - NAD 83 coordinates of the Continuously Operating Reference Station (CORS) network inconsistent with passive marks
 - Lack of velocities, i.e. NAD 83 does not report station motion for passive marks



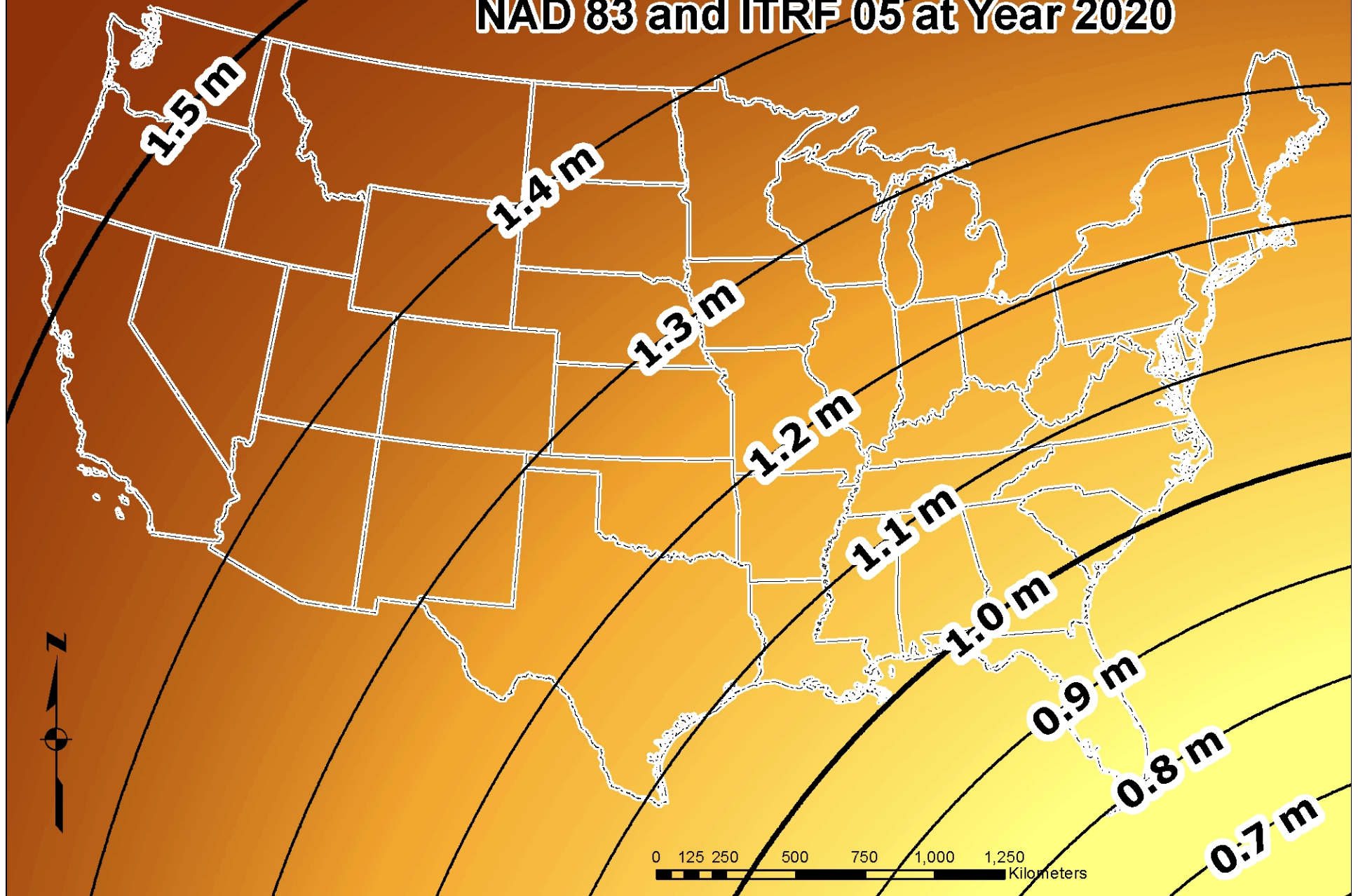
Why a New Datum(s)?

○ NAVD 88

- cross-country build up of errors (“tilt” or “slope”) from geodetic leveling
- Passive marks inconveniently located and vulnerable to disturbance and destruction
- A 0.5 m bias in the NAVD 88 reference surface from the geoid surface best approximating global mean sea level
- Subsidence, uplift, freeze/thaw, and other crustal motions invalidate heights of passive marks, and can make it difficult to detect such motions.
- Passive marks without adequate geophysical models make it difficult to reliably detect sea level change
- Changes to Earth’s gravity field cause changes in orthometric heights, but NAVD 88 does not allow/account for those changes (because it is based on a static gravity model)
- The gravity model and modeling techniques used to determine NAVD 88 are not consistent with those currently used for geoid modeling



Horizontal Position Difference Between NAD 83 and ITRF 05 at Year 2020



New Datums

“NGS redefines the national horizontal datum to remove gross disagreements with the ITRF.”

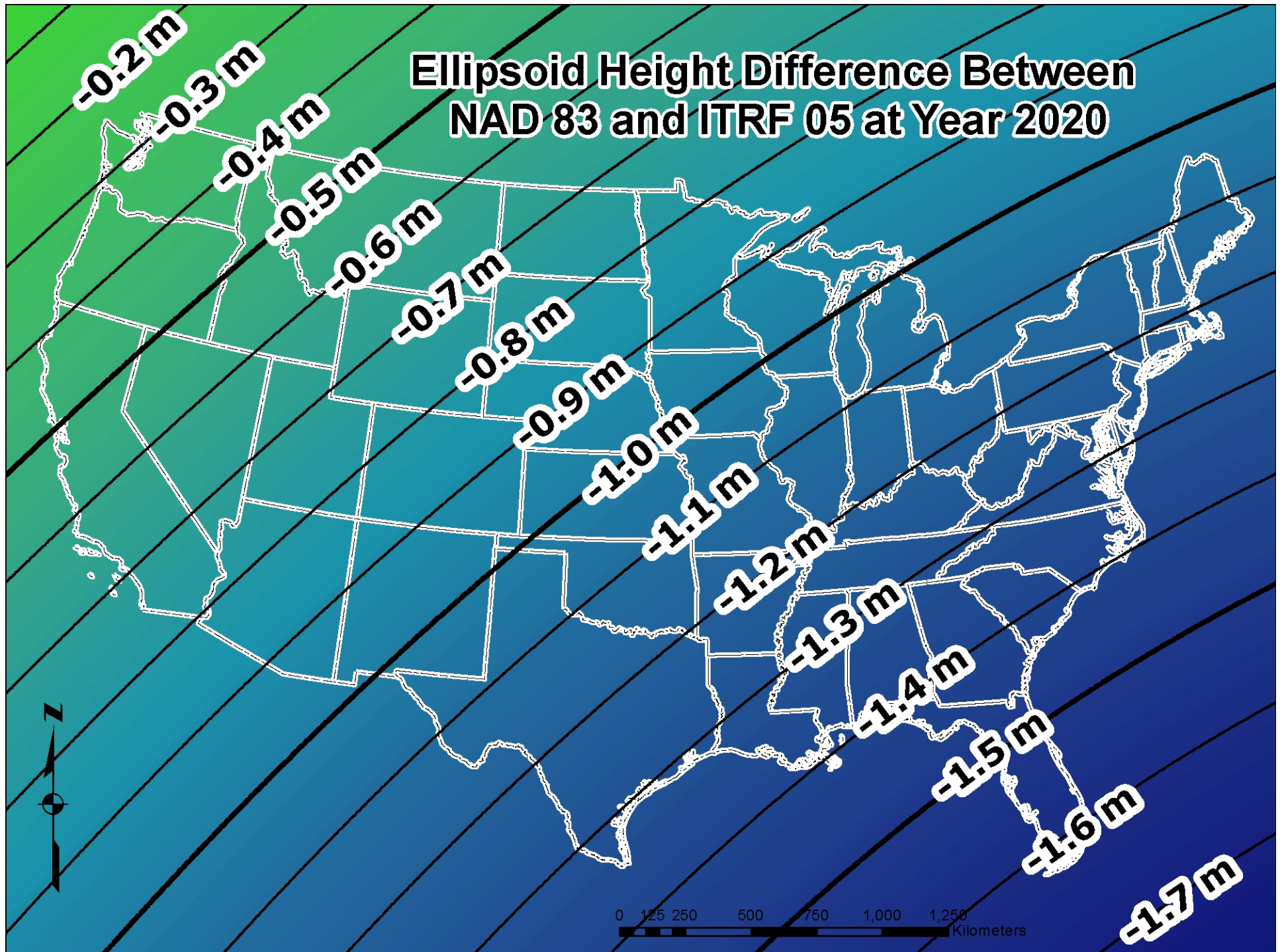
In other words, ellipsoid heights will change.

“By 2020(?), a new geopotential datum (for orthometric and dynamic heights) is defined and realized through the combination of GNSS technology and gravity field modeling.”

In other words, orthometric heights will NOT be based on leveling data and they too will change.




Ellipsoid Height Difference Between NAD 83 and ITRF 05 at Year 2020



<http://www.ngs.noaa.gov/>


www.geodesy.noaa.gov



National Geodetic Survey

Positioning America for the Future

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Announcements

February 16, 2012

NGS Releases Beta LOCUS for Testing
NGS has released a Beta version of the **Leveling Online Computations User Service**, LOCUS, for a 90-day comment period. Through the end of March 2012, NGS is requesting our stakeholders and constituents to test their leveling projects with LOCUS and provide feedback to us at...[more](#)

NGS Announces New Photo Submission Guidelines:
http://geodesy.noaa.gov/web/surveys/photo_submissions/

NGS Releases Final Report for Floodplain Mapping Pilot Project
As NGS moves closer to 2022 and replacing the **North American Datum of 1983** (NAD 83) and the **North American Vertical Datum of 1988** (NAVD 88), NGS is interacting closely with agencies that use the datums to assist in the transition...[more](#)

Notice: Planned Updates to NGS Datasheet Format
In response to stakeholder and NGS staff concerns, NGS has developed several modifications to the format of the **NGS datasheet**—the primary method for accessing the passive control network of the National Spatial Reference System (NSRS)...[more](#)

Trial Version of the New NOAA Shoreline Data Explorer Available:
http://beta.ngs.noaa.gov/shoreline_raster

2010 Federal Geospatial Summit Proceedings on Improvements to the National Spatial Reference System available:
<http://www.ngs.noaa.gov/2010Summit/proceedings.shtml>

A 2009 independent study shows the benefits to the U.S. economy from NOAA's positioning products and services are in the billions of dollars.
Click [here](#) for a one page overview of the study
Click [here](#) for a copy of the full report

In The News


02/16/2012 - NGS Presents at Geodesy Meeting in Austria
The National Geodetic Survey recently represented the United States at the joint meeting of two International Association of Geodesy working groups in Vienna, Austria. The meeting focused on how absolute gravimeter comparisons are conducted...[more](#)

Most Popular


- Contact Us
- CORS
- Survey Mark Datasheets
- Geodetic Tool Kit
- NA2011
- OPUS
- Publications
- Geodetic Advisors
- Storm Imagery
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Upcoming Events

NRC Highlights Importance of NGS Products...



Federal Geodetic Control Subcommittee of the fgdc



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More information...

NGS Home Page: <http://www.geodesy.noaa.gov>

[geodesy.noaa.gov](http://www.geodesy.noaa.gov)

CORS Webpage: <http://www.ngs.noaa.gov/CORS/>

CORS newsletter

OPUS Webpage: <http://www.ngs.noaa.gov/OPUS/>

Find Your Advisor:

www.ngs.noaa.gov/ADVISORS/AdvisorsIndex.shtml

This presentation will be uploaded to:

http://www.ngs.noaa.gov/web/science_edu/presentations_archive/



FAQs on the various webpages

Next Steps/Priorities NGS-CDOT

- OPUS-DB (Begin implementing)
- CORS (Begin Implementing)
- OPUS – CDOT Survey Manual
- Heights -Study



Thank You

pamela.fromhertz@noaa.gov
240-988-6363



Questions? Comments?

Multi-Year CORS Solution

National Adjustment of 2011

New NGS Datasheet Format



Data Sheet

for more information about the datasheet.

SIDB , PROGRAM = datasheet95, VERSION = 7.87.4
 National Geodetic Survey, Retrieval Date = AUGUST 19, 2011

 ID - This is a Height Modernization Survey Station.
 This is a Primary Airport Control Station.
 DESIGNATION - AZC A
 - AC6803
 STATE/COUNTY- AZ/MOHAVE
 QUAD - LOST SPRING MTN EAST (1988)

*CURRENT SURVEY CONTROL

| | 36 57 59.55377(N) | 113 00 32.22917(W) | ADJUSTED |
|-----------|-------------------|--------------------|----------|
| 83(2007)- | 36 57 59.55377(N) | 113 00 32.22917(W) | ADJUSTED |
| 88 - | 1485.56 (meters) | 4873.9 (feet) | GPS OBS |

DATE - 2007.00
 - -1,994,789.496 (meters) COMP
 - -4,697,388.731 (meters) COMP
 - 3,815,306.819 (meters) COMP
 AGE CORR- 3.37 (seconds) DEFLEC09
 P HEIGHT- 1462.787 (meters) (02/10/07) ADJUSTED
 D HEIGHT- -22.80 (meters) GEOID09

--- Accuracy Estimates (at 95% Confidence Level in cm) ---
 PID Designation North East Ellip
 DRK AC6803 AZC A 0.74 0.61 1.37

mark is at Colorado City Municipal Airport (AZC)

horizontal coordinates were established by GPS observations
 adjusted by the National Geodetic Survey in February 2007.

datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
 National Readjustment for more information.

horizontal coordinates are valid at the epoch date displayed above.
 epoch date for horizontal control is a decimal equivalence
 Year/Month/Day.

orthometric height was determined by GPS observations and a
 resolution geoid model.

derived orthometric heights for airport stations designated as
 or SACS are published to 2 decimal places. This maintains
 meter relative accuracy between the PACS and SACS. It does
 indicate centimeter accuracy relative to other marks which are
 of the NAVD 88 network.

AC6803
 AC6803.The X, Y, and Z were computed from the position and the ellipsoidal ht.
 AC6803

The NGS Data Sheet

See file [dsdata.txt](#) for more information about the datasheet.

DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 8.00
 1 National Geodetic Survey, Retrieval Date = JANUARY 1, 2012

 AC6803 HT_MOD - This is a Height Modernization Survey Station.
 AC6803 PACS - This is a Primary Airport Control Station.
 AC6803 DESIGNATION - AZC A
 AC6803 PID - AC6803
 AC6803 STATE/COUNTY- AZ/MOHAVE
 AC6803 COUNTRY - USA
 AC6803 USGS QUAD - LOST SPRING MTN EAST (1988)
 AC6803
 AC6803 *CURRENT SURVEY CONTROL
 AC6803
 AC6803 NAD 83(2007) POSITION- 36 57 59.55377(N) 113 00 32.22917(W) ADJUSTED
 AC6803 NAD 83(2007) ELLIP HT- 1462.787 (meters) (02/10/07) ADJUSTED
 AC6803 NAD 83(2007) EPOCH - 2007.00
 AC6803 NAVD 88 ORTHO HEIGHT - 1485.56 (meters) 4873.9 (feet) GPS OBS
 AC6803 NAVD 88 EPOCH - 2006.81 (feet) (meters) (feet) GPS OBS
 AC6803
 AC6803 NOTE: NAVD 88 ortho height was determined from prior model GEOID03.
 AC6803 GEOID03 HEIGHT - -22.75 (meters)
 AC6803 GEOID09 HEIGHT - -22.80 (meters)
 AC6803 NAD 83(2007) X - -1,994,789.496 (meters) COMP
 AC6803 NAD 83(2007) Y - -4,697,388.731 (meters) COMP
 AC6803 NAD 83(2007) Z - 3,815,306.819 (meters) COMP
 AC6803 LAPLACE CORR - 3.37 (seconds) DEFLEC09
 AC6803
 AC6803 FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)
 AC6803 Type Horiz Ellip Dist(km)
 AC6803
 AC6803 NETWORK ACCURACY 0.86 1.37
 AC6803 MEDIAN LOCAL ACCURACY AND DIST (11 points) 0.67 1.22 1.64
 AC6803
 AC6803 NOTE: Individual local accuracy values and other accuracy information
 AC6803 are available [here](#).
 AC6803
 AC6803 This mark is at Colorado City Municipal Airport (AZC)
 AC6803
 AC6803 The horizontal coordinates were established by GPS observations
 AC6803 and adjusted by the National Geodetic Survey in February 2007.
 AC6803
 AC6803 The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
 AC6803 See [National Readjustment](#) for more information.
 AC6803 The horizontal coordinates are valid at the epoch date displayed above.
 AC6803 The epoch date for horizontal control is a decimal equivalence
 AC6803 of Year/Month/Day.
 AC6803
 AC6803 The orthometric height was determined by GPS observations and a
 AC6803 high-resolution geoid model.
 AC6803
 AC6803 GPS derived orthometric heights for airport stations designated as

