Modernization of the National Spatial Reference System

Rhode Island Society of Professional Land Surveyors
Providence, RI
November 18, 2011

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www.aot.state.vt.us/geodetic/Advisor/advisorpresent.htm

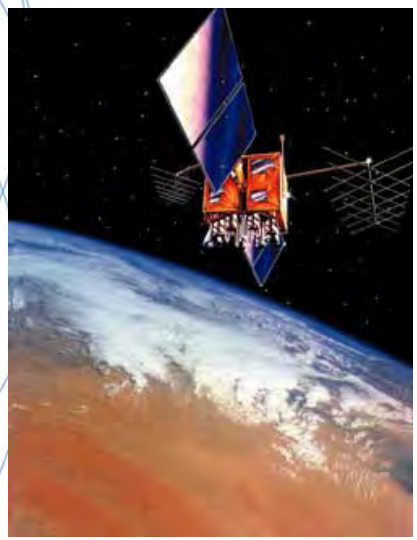
Mission and Vision of NGS

- To define, maintain and provide access to the National Spatial Reference System to meet our nation's economic, social, and environmental needs

- "Maintain the NSRS" means "NGS must *track all of the temporal changes* to the defining points of the NSRS in such a way as to always maintain the accuracy in the NSRS definition."

- Vision - Modernize the Geopotential ("Vertical") and Geometric ("Horizontal") datums

GLOBAL POSITIONING SYSTEM

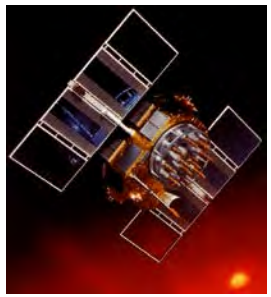


- 1978 1st NAVSTAR Satellite Launched (October 22, 1978)
- 1995 Fully Operational
- 2000 Selective Availability turned off (May 1, 2000)
- 2005 Additional Band L2C
- 2010 Additional Frequency L5 added (May 28, 2010)
- 2020? 10-50 cm real-time accuracy?

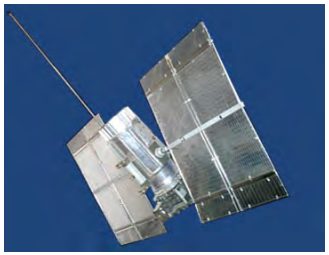
The Global Navigation Satellite Systems (GNSS) Constellations

- Three positioning and navigation systems
  - Navstar/GPS – US (Currently 31)
  - GLONASS – Russia (Currently 24)
    - December 5 (3 satellites lost at launch)
    - December ? (First GLONASS-M launch)
  - GALILEO – EU (Currently 2)
  - BEIDOU (Compass) – China (Complete by 2020?)

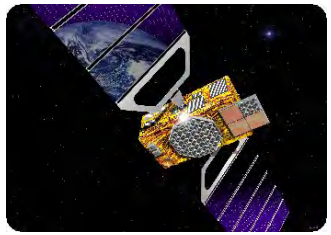
- All satellites available for positioning purposes.



US - GPS



Russia - GLONASS

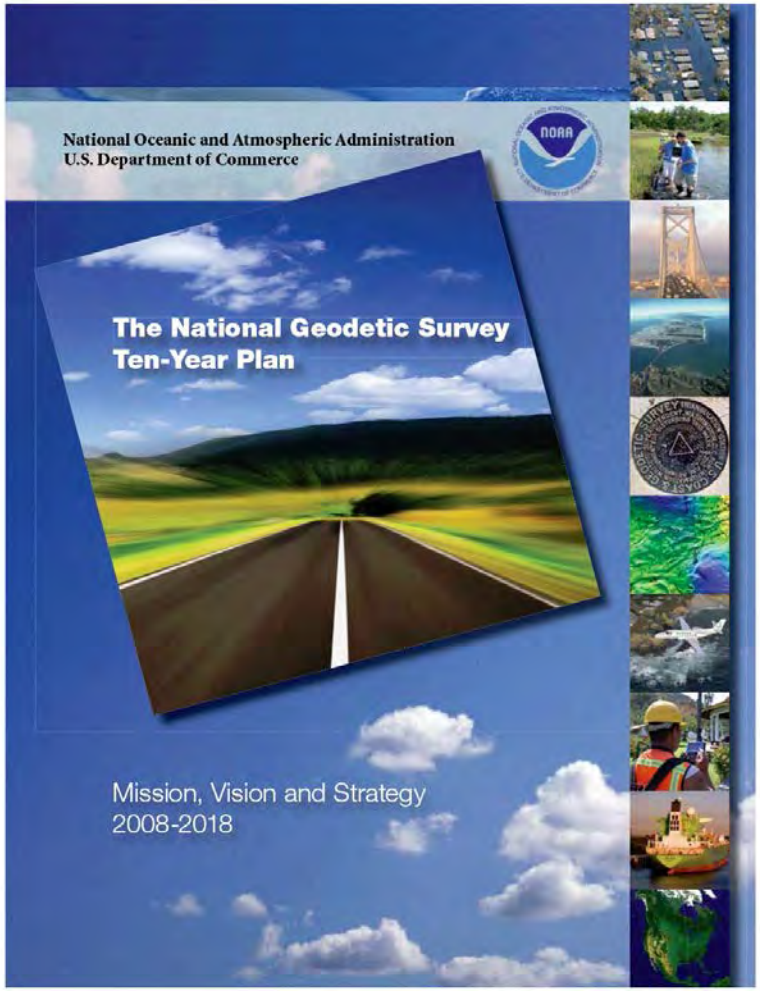


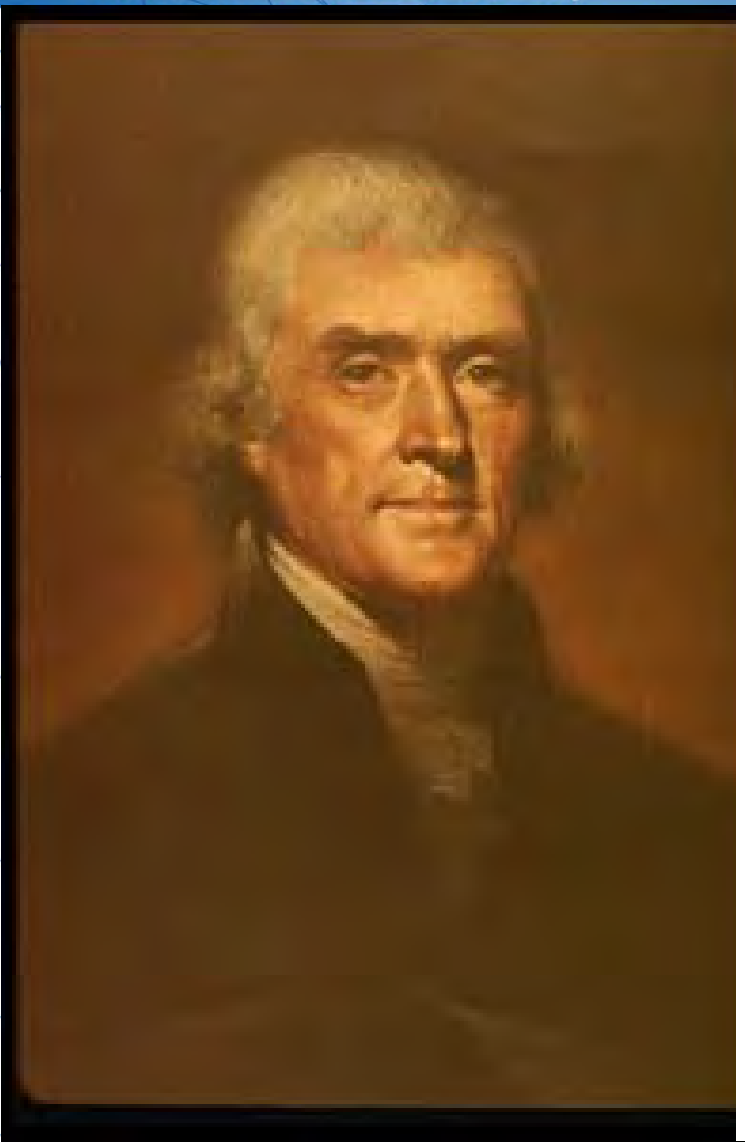
EU - Galileo

The National Geodetic Survey 10 year plan
Mission, Vision and Strategy
2008 – 2018

http://www.ngs.noaa.gov/INFO/NGS10yearplan.pdf

- *Official NGS policy as of Jan 9, 2008*
  - *Modernized agency*
  - *Attention to accuracy*
  - *Attention to time-changes*
  - *Improved products and services*
  - *Integration with other fed missions*
- *2018 Targets:*
  - *NAD 83 and NAVD 88 re-defined*
  - *Cm-accuracy access to all coordinates*
  - *Customer-focused agency*
  - *Global scientific leadership*





NINTH CONGRESS OF THE UNITED STATES.

At the Second Session.

Begun and held at the city of Washington, in the territory of Columbia, on Monday the first of December, one thousand eight hundred and six.

AN ACT *to provide for surveying the coasts of the United States*

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That the president of the United States shall be, and he is hereby authorized and requested, to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shore of the United States; and also the respective courses and distances between the principal capes, or head lands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid.

SEC. 2. And be it further enacted, that it shall be lawful for the president of the United States, to cause such examinations and observations to be made, with regard to St. George's bank, and any other bank or shoal, and the soundings and currents beyond the distances aforesaid in the gulph stream, as in his opinion may be especially subservient to the commercial interests of the United States.

SEC. 3. And be it further enacted, that the president of the United States shall be, and he is hereby authorized and requested, for any of the purposes aforesaid, to cause proper and intelligent persons to be employed, and also such of the public vessels in actual service, as he may judge expedient, and to give such instructions for regulating their conduct as to him may appear proper, according to the tenor of this act.

SEC. 4. And be it further enacted, That for carrying this act into effect there shall be, and hereby is appropriated a sum not exceeding fifty thousand dollars, to be paid out of any monies in the treasury, not otherwise appropriated.

Nath. Macon Speaker of the House of Representatives

Geo. Clinton Vice President of the United States, and President of the Senate.

February 10. 1807

Approved

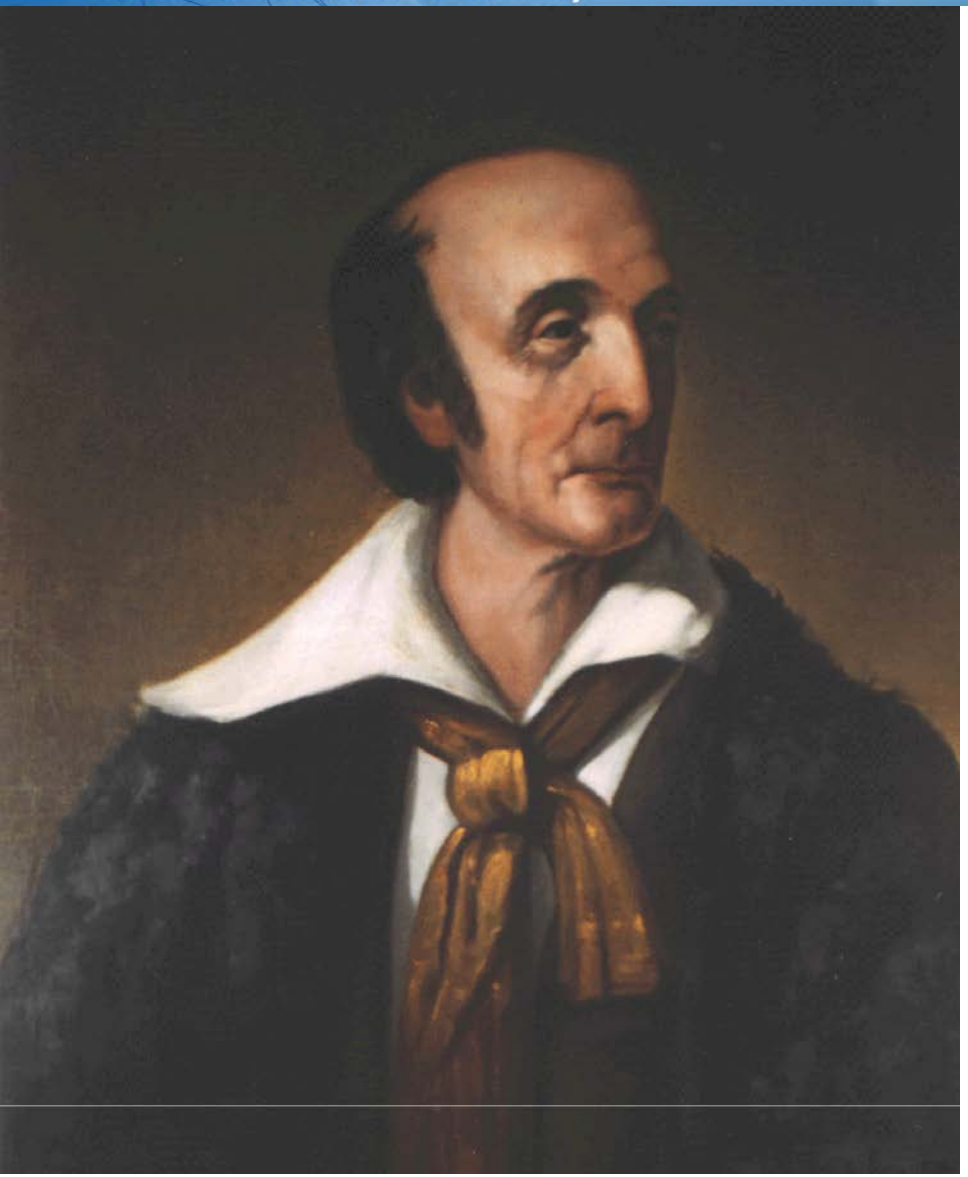
Th: Jefferson

I certify that this act did originate in the House of Representatives.

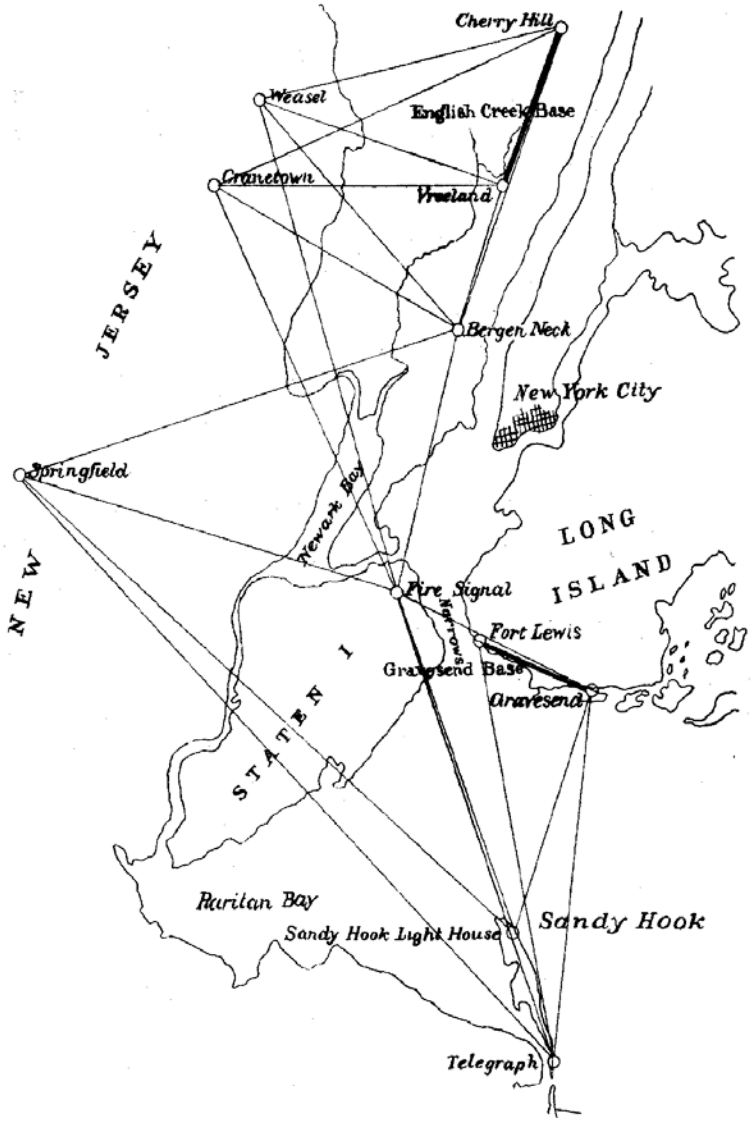
John Beckley Clerk

1807

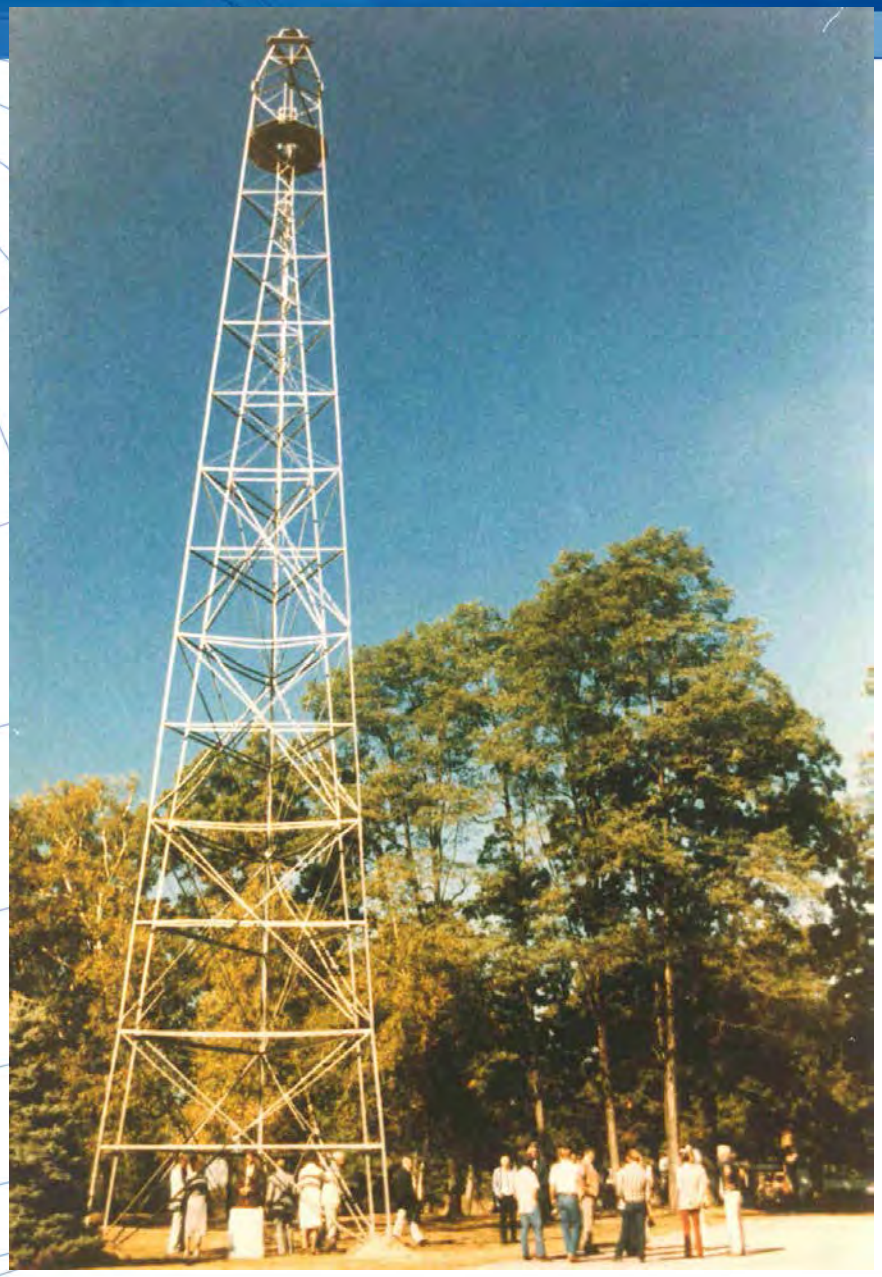
President Thomas Jefferson signs legislation establishing the Survey of the Coast



Ferdinand Hassler (1770-1843)



Hassler's First Field Work, 1816–1817

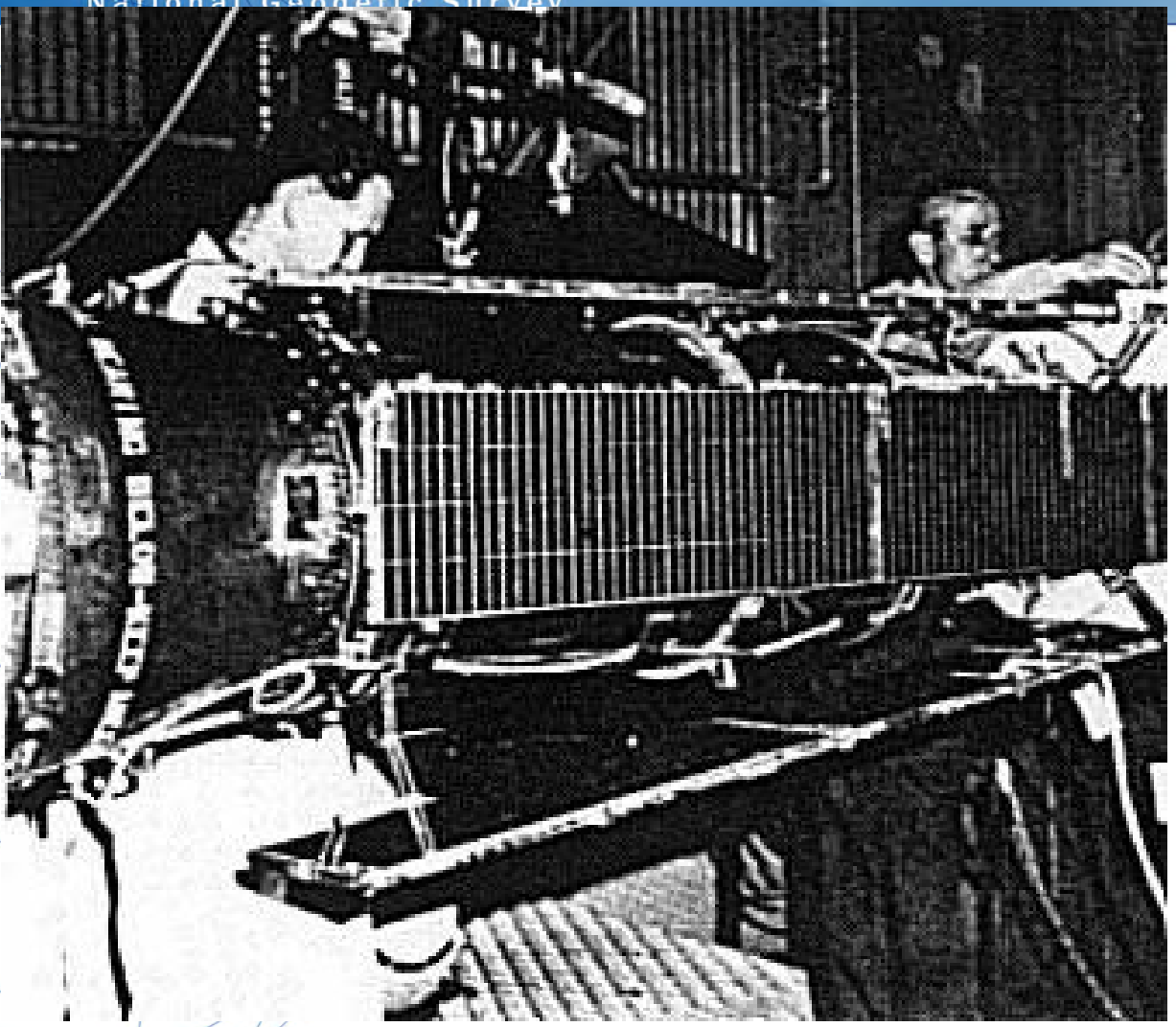


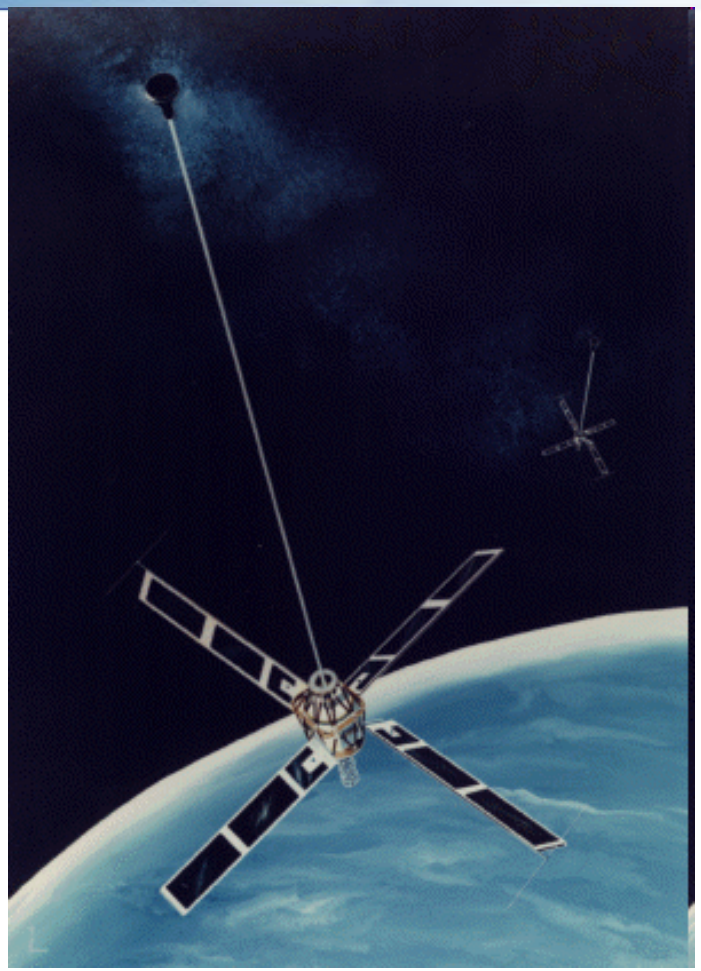
1984
An End of an Era

Global Satellite Triangulation Network
1964-1973

ECHO / PAGEOS Balloon Satellite
type of satellite photographed by BC-4

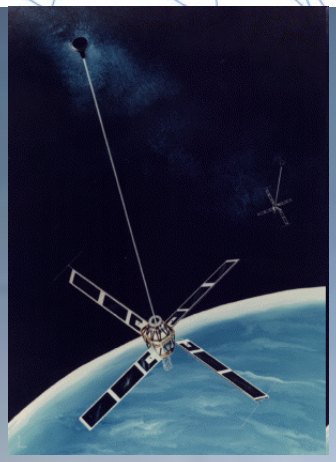
BC-4 camera photograph
stars in circular pattern
satellite is a series of dots in straight line.





US Navy Transit Satellite
1964 (Military), 1967 (Civilian)

DOPPLER and VLBI



File Edit View Go Bookmarks Tools Help

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

Go

NGS Geodetic Tool Kit

on-line interactive computation of geodetic values

See the text version of an article about the NGS Geodetic Toolkit that appeared in the *Professional Surveyor* magazine, May 2003 Volume 23, Number 4

(**See all the Professional Surveyor Articles about the NGS Geodetic Toolkit**)

To learn more about a particular online program, click on its link for a description:

DEFLEC99
DYNAMIC_HT
G99SSS
GEOID99
GEOID03
USGG2003
HTDP
IGLD85
Inverse/Forward/Invers3D/Forwrd3D
LVL_DH
Magnetic Declination
NADCON
NAVD 88 Modelled Gravity
Online Adjustment User Services
Online Adjustment Utilities User Services
OPUS
State Plane Coordinates
Surface Gravity Prediction
Tidal and Orthometric Elevations
U.S. National Grid
Universal Transverse Mercator Coordinates
VERTCON
XYZ Coordinate Conversion

OR... Know what you want to do?
Select a function from this list:

SELECT A TOOLKIT SHORTCUT

The NSRS has evolved

1 Million Monuments
(Separate Horizontal and Vertical Systems)

→ 70,000 Passive Marks
(3-Dimensional)

Passive Marks
(Limited Knowledge of Stability)

→ 1,400 GPS CORS
(Time Dependent System Possible; 4-Dimensional)

GPS CORS → GNSS CORS

GEODETIC DATUMS

HORIZONTAL

2 D (Latitude and Longitude) (e.g. NAD 27, NAD 83 (1986))

VERTICAL

1 D (Orthometric Height) (e.g. NGVD 29, NAVD 88, Local Tidal)

GEOMETRIC

3 D (Latitude, Longitude and Ellipsoid Height)
Fixed and Stable - Coordinates seldom change
(e.g. NAD 83 (1996), NAD 83 (2007), NAD 83 (CORS96))

also

4 D (Latitude, Longitude, Ellipsoid Height, Velocities) Coordinates change with time
(e.g. ITRF00, ITRF08)

ACRONYMS Я US

What is a Datum?

- "A set of constants specifying the coordinate system used for geodetic control, i.e., for calculating the coordinates of points on the Earth."
- "The datum, as defined in (1), together with the coordinate system and the set of all points and lines whose coordinates, lengths, and directions have been determined by measurement or calculation."
- NGS has used the first definition for NAD83

These differing definitions require caution when using the word "datum." The first definition makes datum synonymous with the selection of a reference coordinate system (origin and orientation). The second definition makes datum synonymous with a list of coordinates of the control points. When the first definition is used, the published coordinates of control points can change when better measurements allow better determinations. With the second definition, a change in coordinates should result in a new datum. NGS has used the first definition for NAD 1983.

Why change datums

- NAD27 based on old observations and old system
- NAD83(86) based on old observations and new system
- NAD83(92) based on new and old observations and same system
- NAD83(96) based on better observations and same system
- NAD83(NSRS2007) based on new observations and same system. Removed regional distortions and made consistent with CORS
- NAD83(2011) based on new observations and same system. Kept consistent with CORS

Horizontal Datums/Coordinates…What do we (you) use in Vermont?

- NAD 83 (Lat-Lon) SPC
  - Which one???
    - NAD 83 (1986)
    - NAD 83 (1992)
    - NAD 83 (1996)
    - NAD 83 CORS96(2002)
    - NAD 83 (NSRS2007)
- NAD 27
- WGS 84
  - WGS 84 (1987)
  - WGS 84 (G730)
  - WGS 84 (G873)
  - WGS 84 (G1150)
- ITRF00 (epoch 97)
- IGS08

COORDINATE CHANGES

ADJUSTMENT	YEARS	LOCAL ACCURACY	NETWORK ACCURACY
NAD 27	1927 – 1986	1:100,000	10 m
NAD 83 (1986)	1986 – 1990	1:100,000	1 m
NAD 83 (1992) (HARN)	1990 – 1997	1:10,000,000	0.1 m
CORS	1994 --------	0.01/0.02 m	0.02/0.04 m
NAD 83 (1996) (FBN/CBN)	1997 – 2004	0.05/0.05 m	0.05/0.05 m
NAD 83 (NSRS 2007)	2007 - 2011	0.01/0.02 m	0.02/0.04 m
NAD 83 (2011) epoch 2001.0	2011 - -------		

NAD 83 National (RE) adjustments 2007 and 2011

- NOT a new datum. A readjustment within the original NAD 83 framework
- GPS only – Classical (triangulation) will not be included
- National CORS used as control
- Each state will comprise a separate block
- Coordinates adjusted and published for both NAD83 (NSRS 2007) and ITRF
- Adjustment in NAD 83 – Transformation to ITRF
- All data submitted to NSRS will be included
- Network and Local Accuracies computed
- No changes to NAD 83 State Plane Coordinate System parameters

2007 NAD 83 National Readjustment

3065 Projects complete

- **Free Adjustment**
- **Residual Plot**
- **Outliers Rejected**
- **Connectivity to A/B Order Network Verified**
- **67,708 total stations**
- **751 stations in VT**

NEW STANDARDS FOR GEODETIC CONTROL

TWO ACCURACY STANDARDS

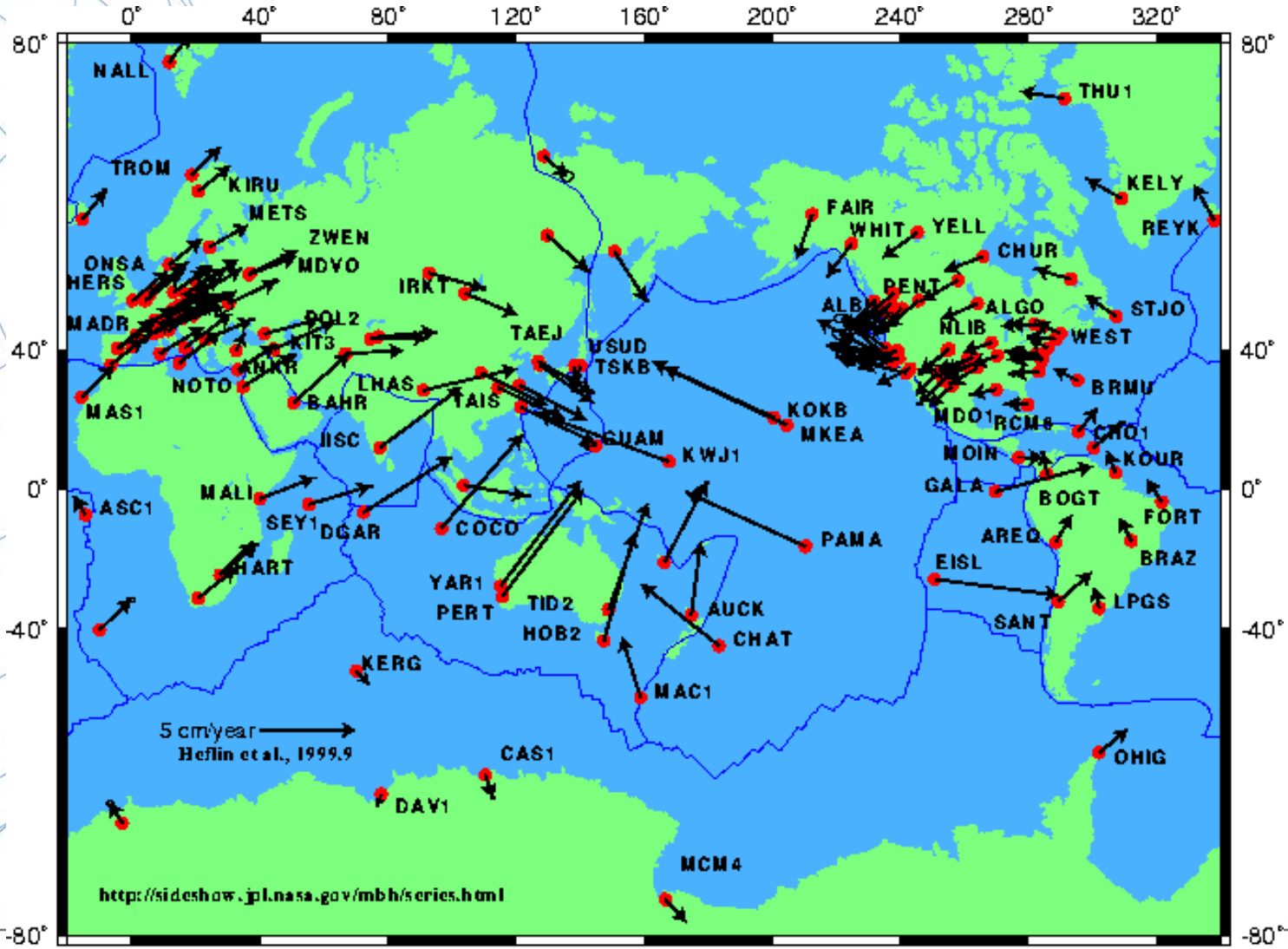
local accuracy ---------- adjacent points
network accuracy ---------- relative to CORS

Numeric quantities, units in cm (or mm)
Both are relative accuracy measures
Do not use distance dependent expression
Horizontal accuracies are radius of 2-D 95% error circle
Ellipsoidal/Orthometric heights are 1-D (linear) 95% error

Problems with NAD 83 and NAVD 88

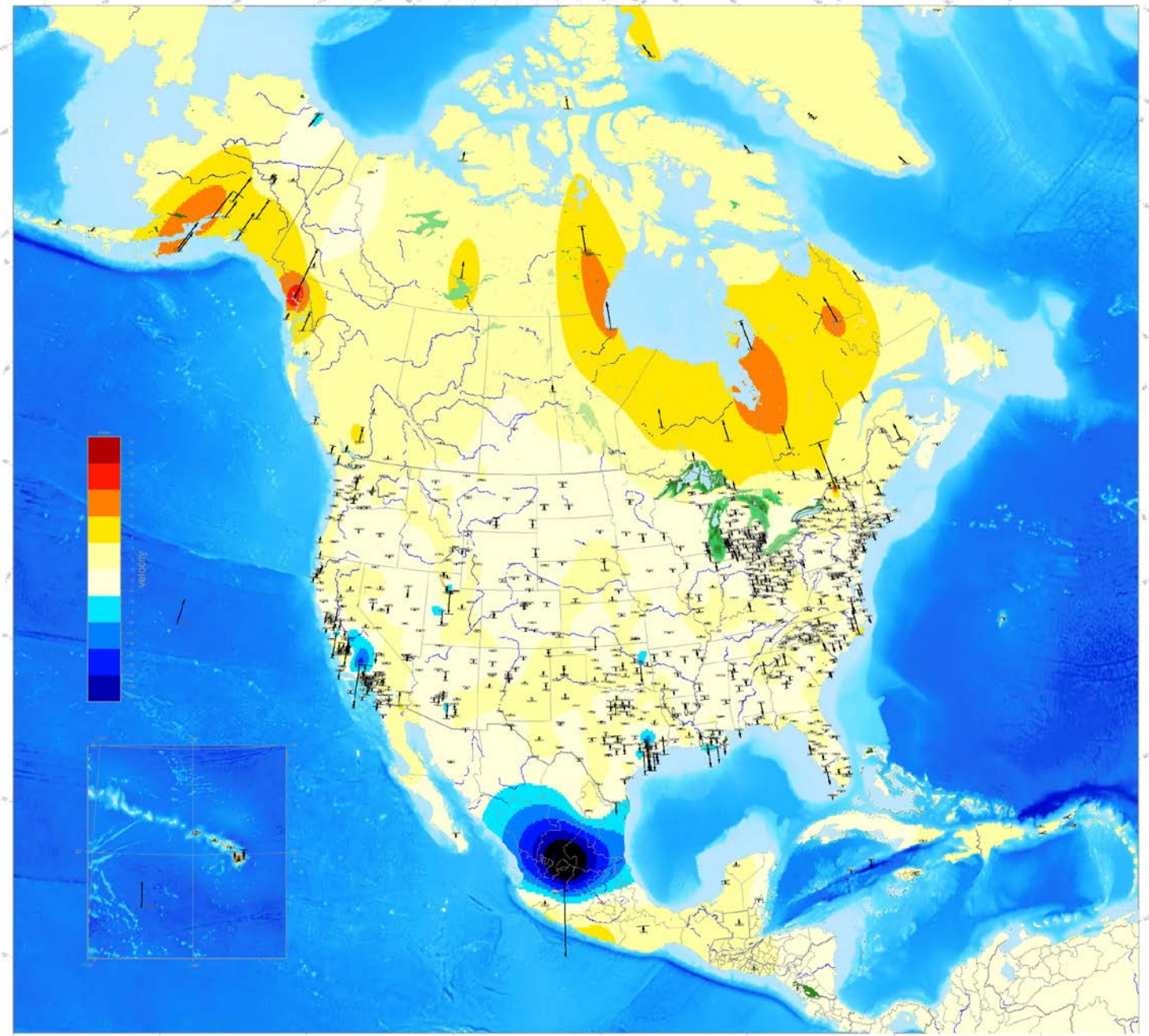
- **NAD 83** is not as geocentric as it could be (approx. 2 m)
  - Surveyors don't see this - **Yet**
- **NAD 83** is not well defined with positional velocities
- **NAVD 88** is realized by passive control (bench marks) most of which have not been releveled in at least 40 years.
- **NAVD 88** does not account for local vertical velocities (subsidence and uplift)
  - Post glacial isostatic readjustment
  - Subsurface fluid withdrawal
  - Sediment loading
  - Sea level rise
    - **Newport – 2.6 mm/yr (0.008 ft/yr) Since 1930 (0.85 ft in 100 years)**
    - **Providence– 2.0 mm/yr (.006 ft/yr) Since 1938 (0.64 ft in 100 years)**

Tectonic Motions



HORIZONTAL VELOCITIES

VERTICAL VELOCITIES



International Earth Rotation and Reference System Service (IERS)

(http://www.iers.org)

The International Terrestrial Reference System **(ITRS)** constitutes a set of prescriptions and conventions together with the modeling required to define origin, scale, orientation and time evolution

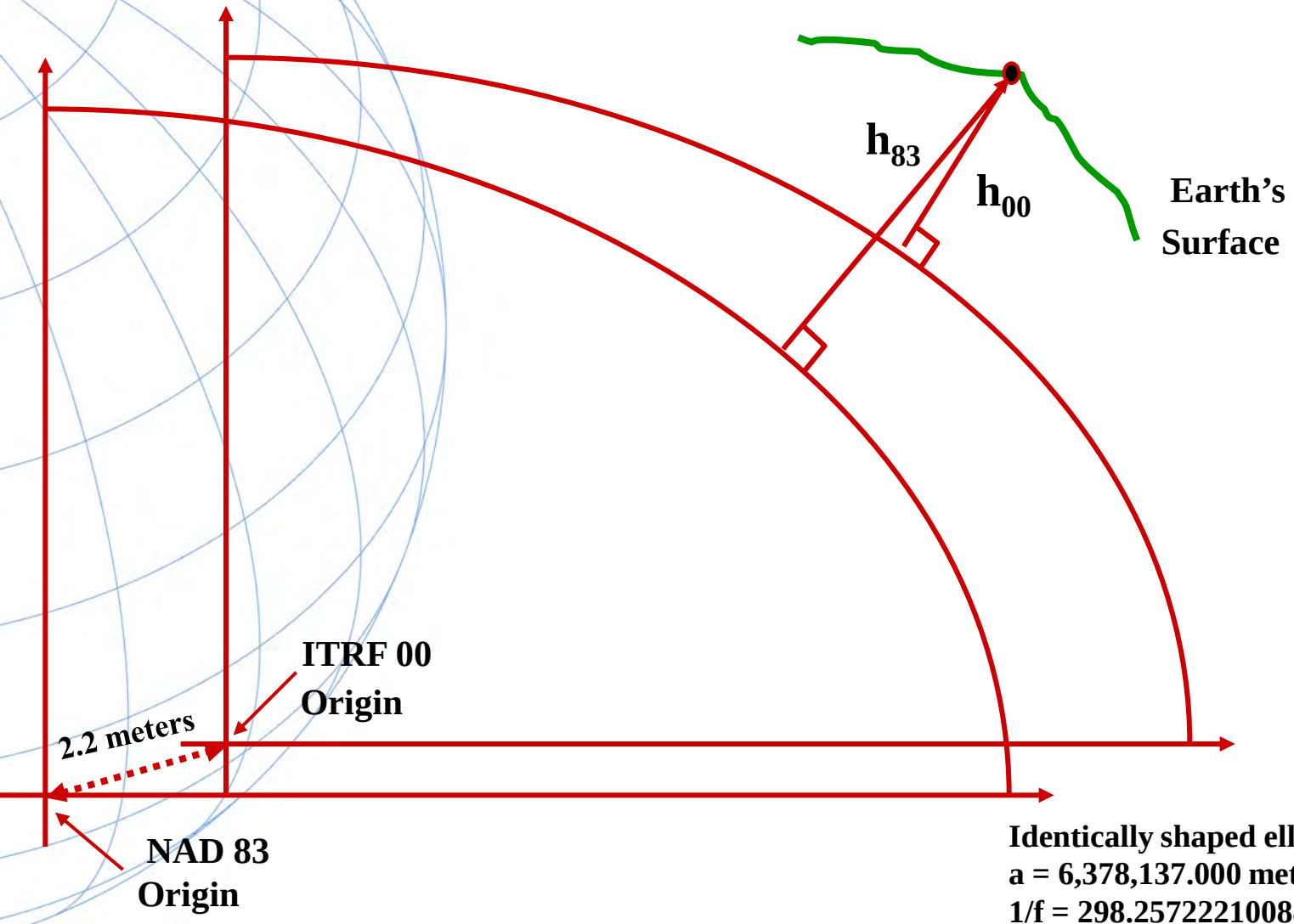
ITRS is realized by the International Terrestrial Reference Frame (**ITRF**) based upon estimated coordinates and velocities of a set of stations observed by Very Long Baseline Interferometry (**VLBI**), Satellite Laser Ranging (**SLR**), Global Positioning System and GLONASS (**GNSS**), and Doppler Orbitography and Radio- positioning Integrated by Satellite (**DORIS**).

ITRF89, ITRF90, ITRF91, ITRF92, ITRF93, ITRF94, ITRF95, ITRF96, ITRF97, ITRF2000, ITRF2005, ITRF2008

International Terrestrial Reference Frame

4 Global Independent Positioning Technologies

Simplified Concept of NAD 83 vs. ITRF00



Identically shaped ellipsoids (GRS-80)
a = 6,378,137.000 meters (semi-major axis)
1/f = 298.25722210088 (flattening)

History of vertical datums in the USA

- **Pre-National Geodetic Vertical Datum of 1929 (NGVD 29)**
  - The first geodetic leveling project in the United States was surveyed by the Coast Survey from 1856 to 1857.
  - Transcontinental leveling commenced from Hagerstown, MD in 1877.
  - General Adjustments of leveling data yielded datums in 1900, 1903, 1907, and 1912. (Sometimes referenced as the Sandy Hook Datum)
  - NGS does not offer a utility which transforms from these older datums into newer ones (though some users still work in them!)

History of vertical datums in the USA

- **NGVD 29**
  - National Geodetic Vertical Datum of 1929
  - Original name: “Sea Level Datum of 1929”
  - “Zero height” held fixed at 26 tide gauges
    - Not all on the same tidal datum epoch (~ 19 yrs)
  - Did not account for Local Mean Sea Level variations from the geoid
    - Thus, not truly a “geoid based” datum


NGVD29
The National Geodetic Vertical Datum of 1929 is referenced to 26 tide gauges in the US and Canada
Prince Rupert
Fort Stephens
San Francisco
San Diego
Galveston
Biloxi
Pensacola
Fernandina Beach
Brunswick
St. Augustine
Cedar Keys
Father's Point
Halifax
Yarmouth
Portland
Boston
Perth Amboy
Annapolis
Norfolk
Old Point Comfort
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Image NASA
Image © 2008 TerraMetrics
Google

History of vertical datums in the USA

- **NAVD 88**
  - North American Vertical Datum of 1988
  - One height held fixed at “Father Point” (Rimouski, Canada)
  - …height chosen was to minimize 1929/1988 differences on USGS topo maps in the eastern U.S.
  - Thus, the “zero height surface” of NAVD 88 wasn’t chosen for its closeness to the geoid (but it was close…few decimeters)

History of vertical datums in the USA

- **NAVD 88** (continued)
  - Use of one fixed height removed local sea level variation problem of NGVD 29
  - Use of one fixed height did open the possibility of unconstrained cross-continent error build up
  - But the H=0 surface of NAVD 88 was supposed to be parallel to the geoid…(close again)


NAVD88
The North American Vertical Datum of 1988 is referenced to a single tide gauge in Canada
Prince Rupert
Vancover
Anacortes
Seattle
Fort Stephens
San Francisco
San Pedro
San Diego
Galveston
Biloxi
Pensacola
Fernandina Beach
Brunswick
St. Augustine
Cedar Keys
Old Point Comfort
Norfolk
Baltimore
Annapolis
Atlantic City
Perth Amboy
Boston
Portland
Yarmouth
Halifax
Father's Point
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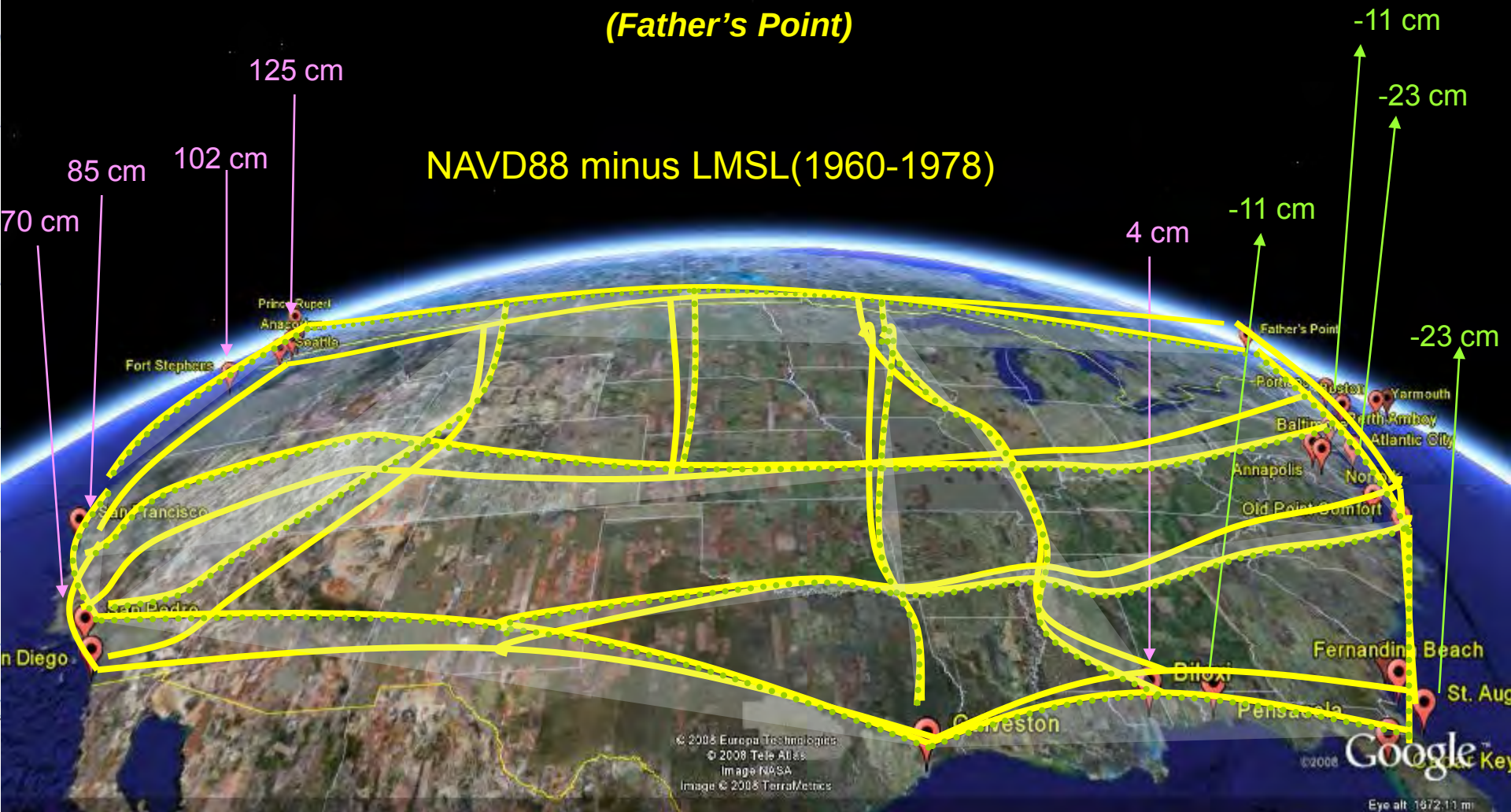
Image NASA
Image © 2008 TerraMetrics
Google

NAVD 88

Referenced to 21 Tide Gages

(Father's Point)



Problems using traditional leveling (to define a National Vertical Datum)

- Leveling the country can not be done again
  - Too costly in time and money
- Leveling yields cross-country error build-up; problems in the mountains
- Leveling requires leaving behind passive marks
  - Bulldozers and crustal motion do their worst

Why isn't NAVD 88 good enough anymore

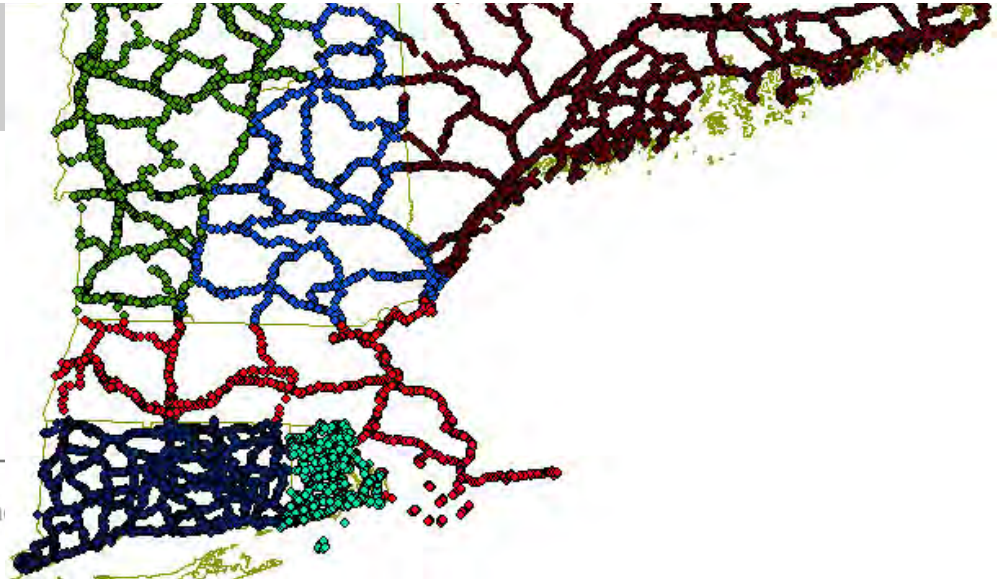
- **NAVD 88 suffers from <u>use of bench marks</u> that:**
  - Are almost never re-checked for movement
  - Disappear by the thousands every year
  - Are not funded for replacement
  - Are not necessarily in convenient places
  - Don't exist in most of Alaska
  - Weren't adopted in Canada
  - Were determined by leveling from a single point, allowing cross-country error build up

Why isn't NAVD 88 good enough anymore?

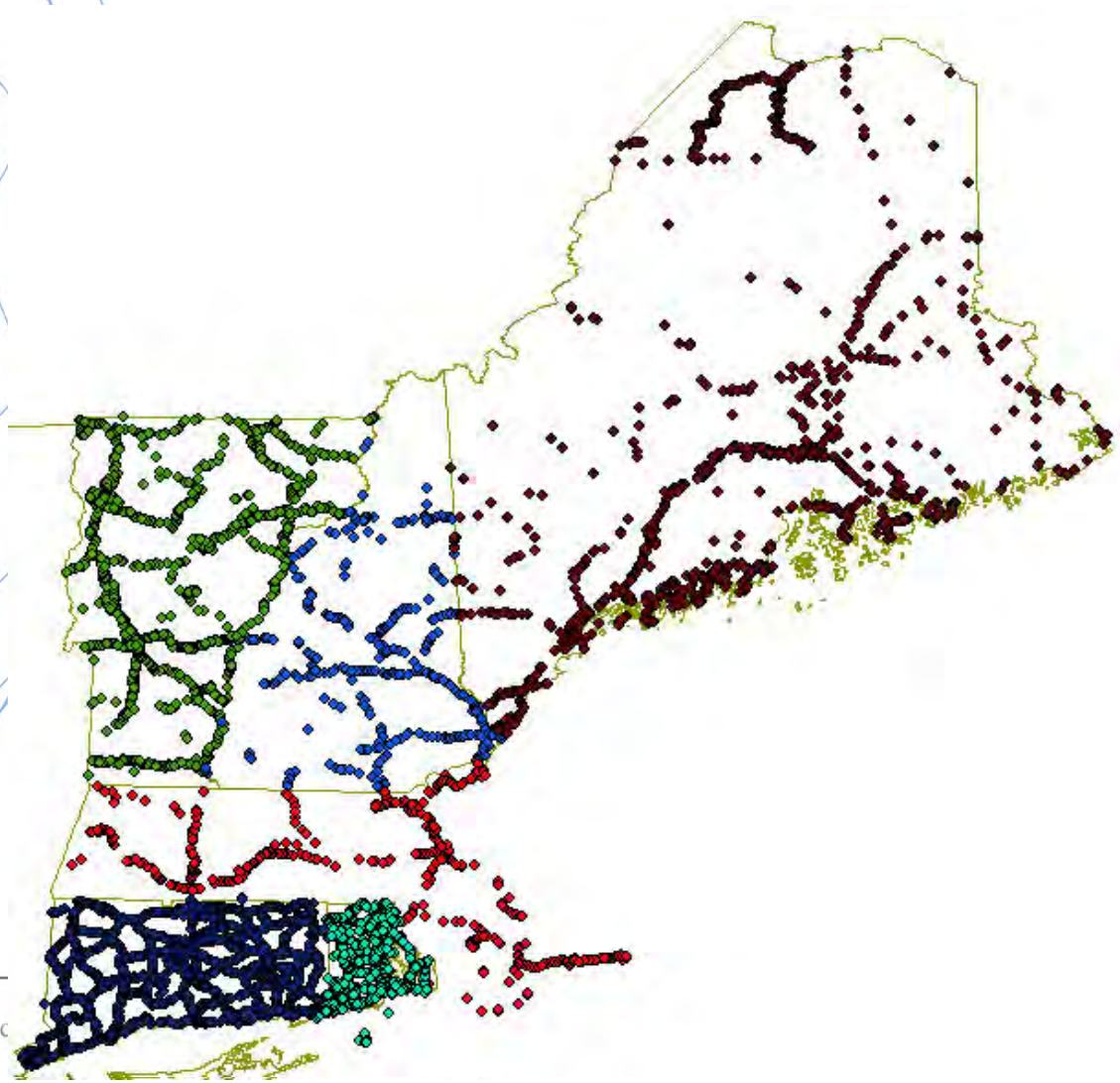
- **NAVD 88 suffers from:**
- A zero height surface that:
  - Has been proven to be ~50 cm biased from the latest, best geoid models (GRACE satellite)
  - Has been proven to be ~ 1 meter tilted across CONUS (again, based on the independently computed geoid from the GRACE satellite)

NGSIDB BM Status (1st, 2nd order)

	CT	MA	ME	NH	RI	VT
In NGSIDB	2599	1125	5401	1092	1380	2158



NE Vertical Control



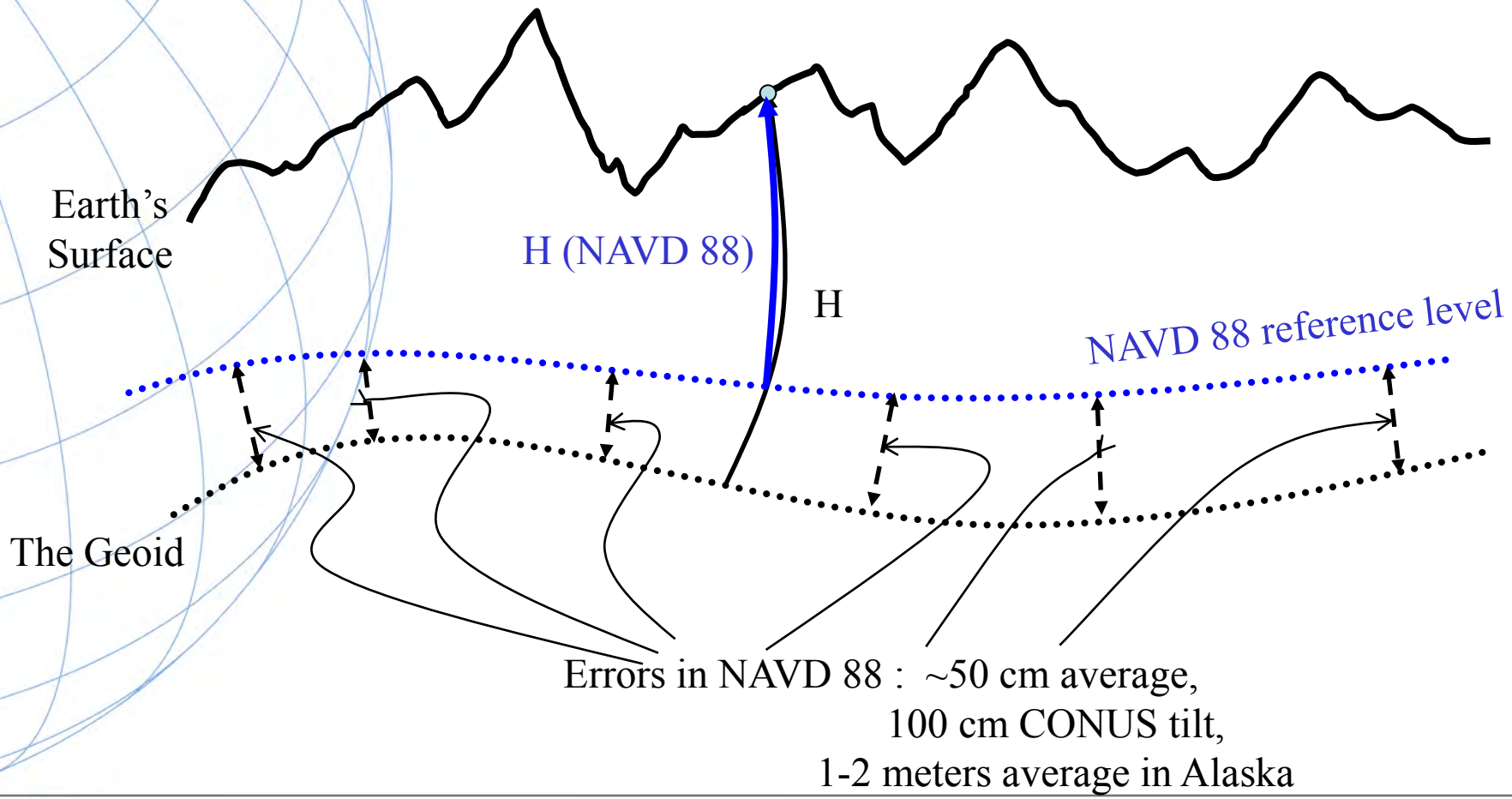
Height-Mod means More Marks

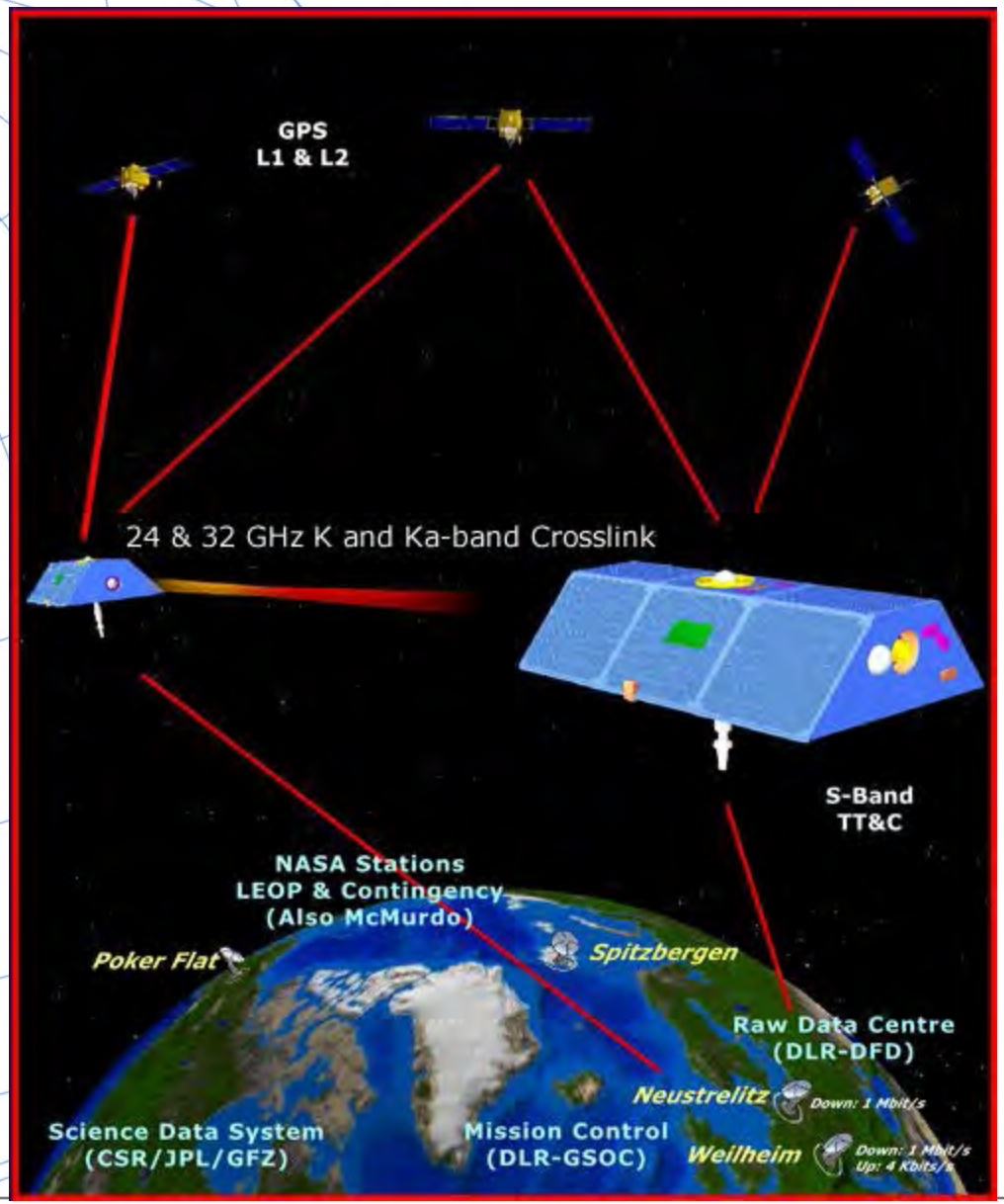
Height Modernization Bottom line

1. Using GNSS is cheaper, easier than leveling

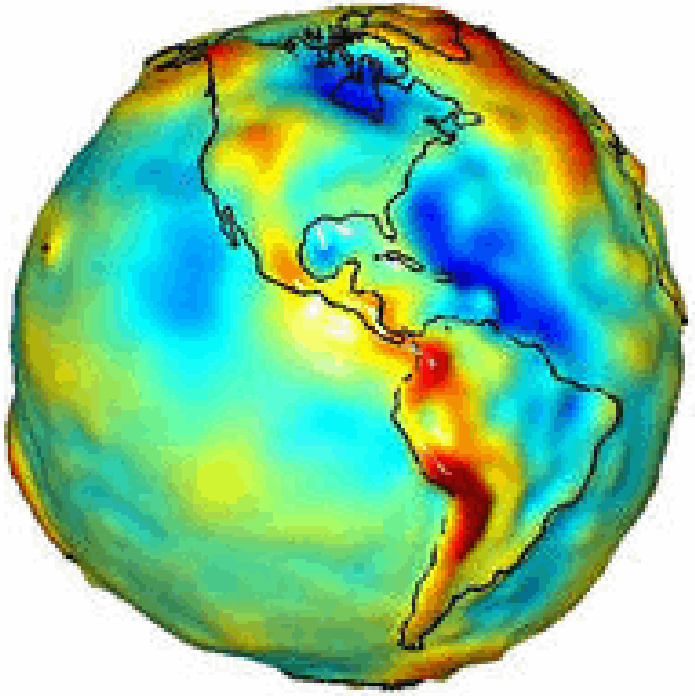
2. To use GNSS we need a good geoid model

Why isn't NAVD 88 good enough anymore?



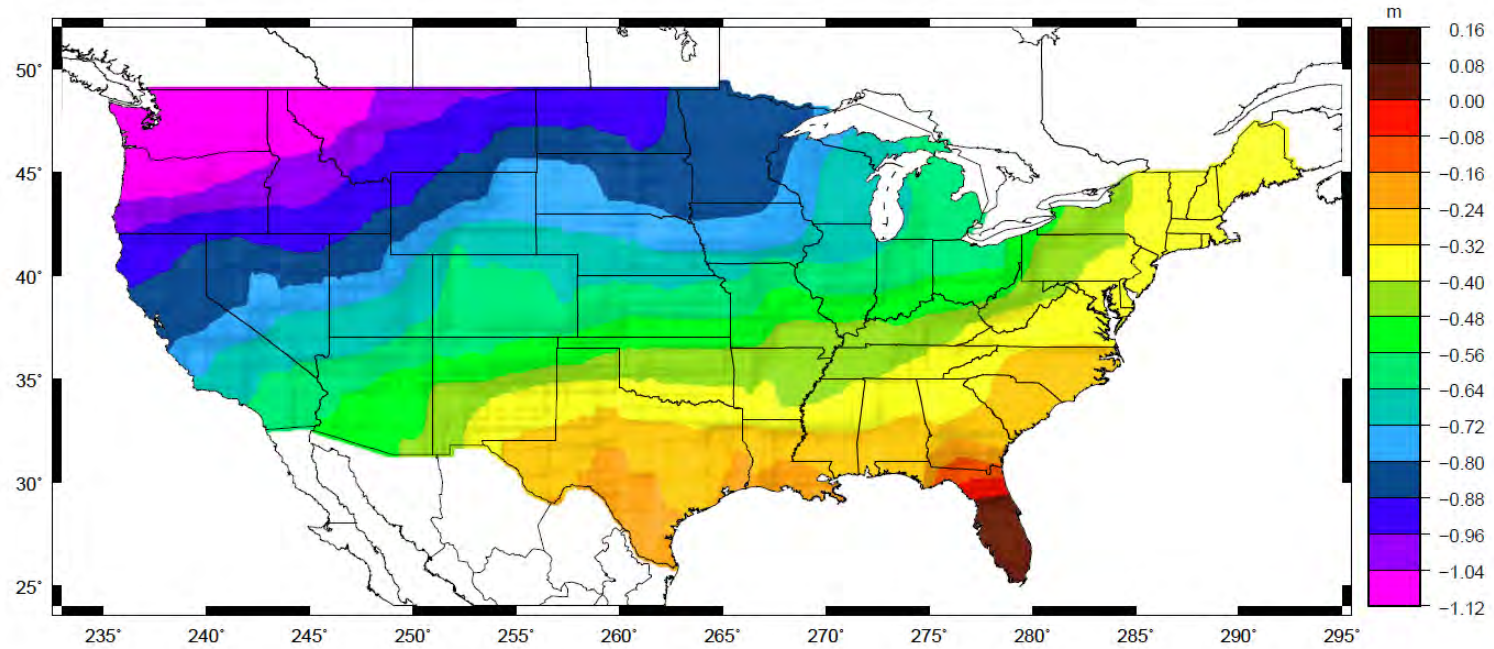


GRACE – Gravity Recovery and Climate Experiment



Why isn't NAVD 88 good enough anymore?

- **Approximate level of geoid mismatch known to exist in the NAVD 88 zero**

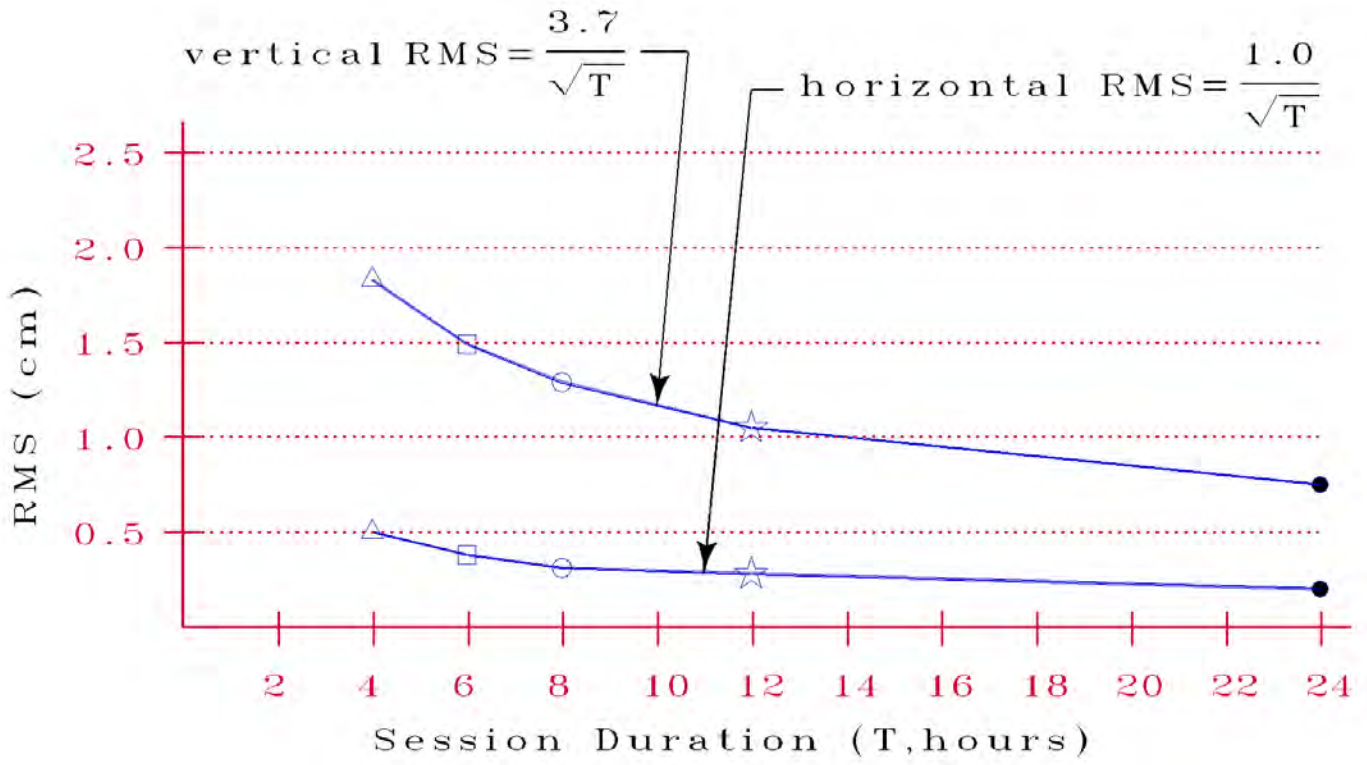


How accurate is a GPS-derived Orthometric Height?

- Relative (local) accuracy in ellipsoid heights between adjacent points can be better than 2 cm, at 95% confidence level
- Network accuracy (relative to NSRS) in ellipsoid heights can be better than 5 cm, at 95% confidence level
- Accuracy of orthometric height is dependent on accuracy of the geoid model – Currently NGS is improving the geoid model with more data, i.e. Gravity and GPS observations on leveled bench marks from Height Mod projects
- Geoid09 can have an uncertainty in the 2-5 cm range.

Positioning Error vs. Duration of the Observing Session

Dual-frequency GPS carrier-phase observations



National CORS Accuracy

Vertical Precision Using Dual-Frequency

GPS Carrier Phase Observations 95% Confidence Level

OPUS-RS MAP

National Geodetic Survey

HELP:
ABOUT THIS MAP

OPUS-RS Estimated Precision and Availability

Version: 0.85

OPTIONS:

Choose Map:
NS or EW 15-min Data

CORS Sites:
Show Hide

Predicted Precision:
Latitude : 19.85717322380
Longitude: -147.36328125
Retrieve Accuracy

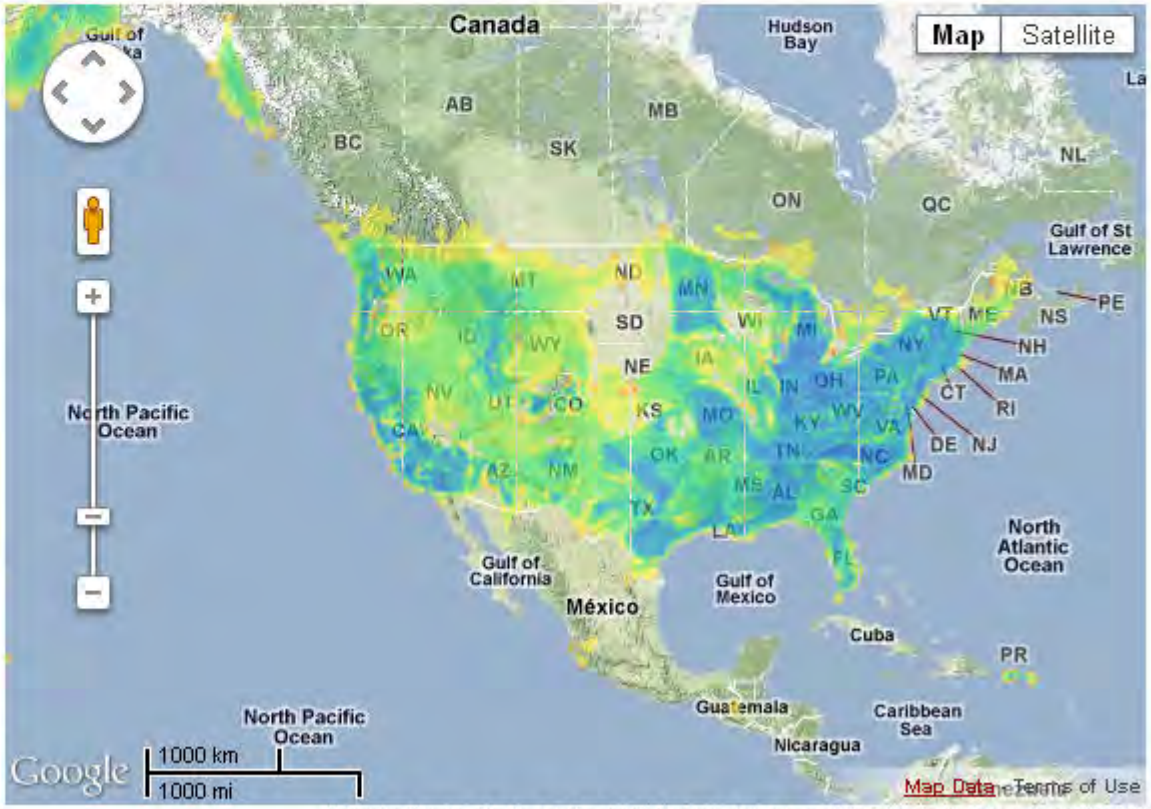
Overlay Opacity:
60%

LEGEND:

Horizontal 1 STD (cm)

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0+

Data as of Nov 7 2011



Website Owner: National Geodetic Survey / Last modified by Kevin Choi April 29 2011

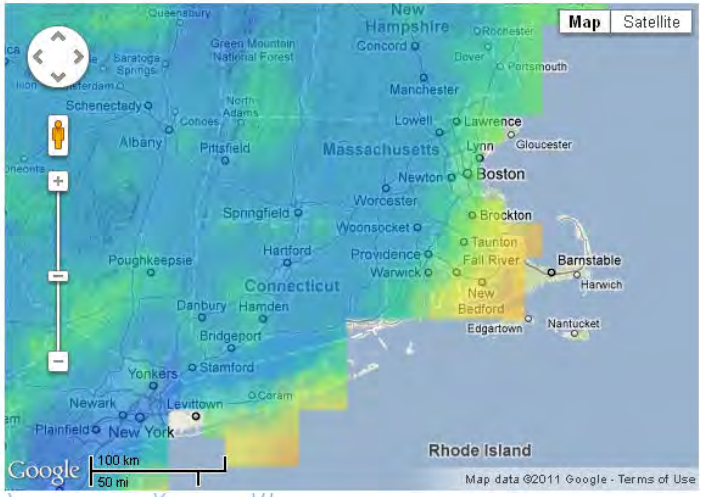
HELP:
ABOUT THIS MAP

OPUS-RS Estimated Precision and Availability

Version: 0.85

OPTIONS:
Choose Map:
NS or EW 15-min Data
CORS Sites:
Show Hide
Predicted Precision:
Latitude : 19.85717322380
Longitude: -147.36328125
Retrieve Accuracy
Overlay Opacity:
60%

LEGEND:
Horizontal 1 STD (cm)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0+
Data as of Nov 7 2011



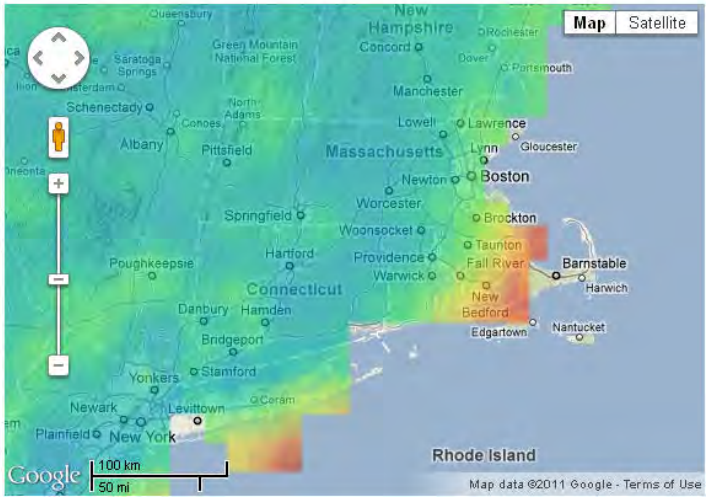
HELP:
ABOUT THIS MAP

OPUS-RS Estimated Precision and Availability

Version: 0.85

OPTIONS:
Choose Map:
Ellipsoid Height 15-min Data
CORS Sites:
Show Hide
Predicted Precision:
Latitude : 19.85717322380
Longitude: -147.36328125
Retrieve Accuracy
Overlay Opacity:
60%

LEGEND:
Ellipsoid Height 1 STD (cm)
1 2 3 4 5 6 7 8+
Data as of Nov 7 2011



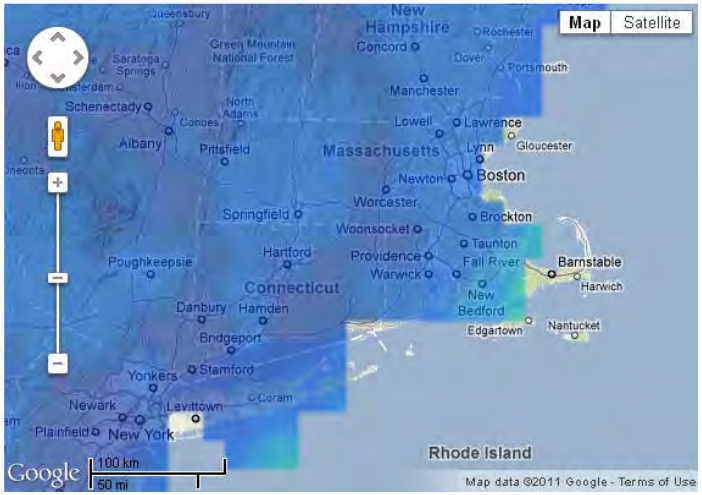
HELP:
ABOUT THIS MAP

OPUS-RS Estimated Precision and Availability

Version: 0.85

OPTIONS:
Choose Map:
NS or EW 1-hour Data
CORS Sites:
Show Hide
Predicted Precision:
Latitude : 19.85717322380
Longitude: -147.36328125
Retrieve Accuracy
Overlay Opacity:
60%

LEGEND:
Horizontal 1 STD (cm)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0+
Data as of Nov 7 2011



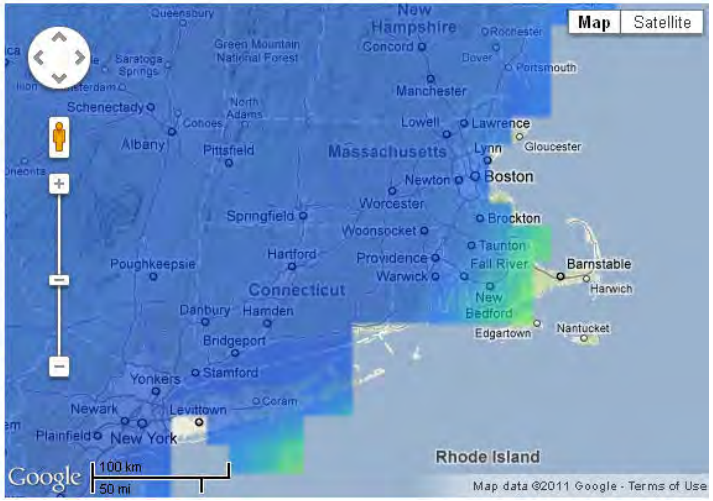
HELP:
ABOUT THIS MAP

OPUS-RS Estimated Precision and Availability

Version: 0.85

OPTIONS:
Choose Map:
Ellipsoid Height 1-hour Data
CORS Sites:
Show Hide
Predicted Precision:
Latitude : 19.85717322380
Longitude: -147.36328125
Retrieve Accuracy
Overlay Opacity:
60%

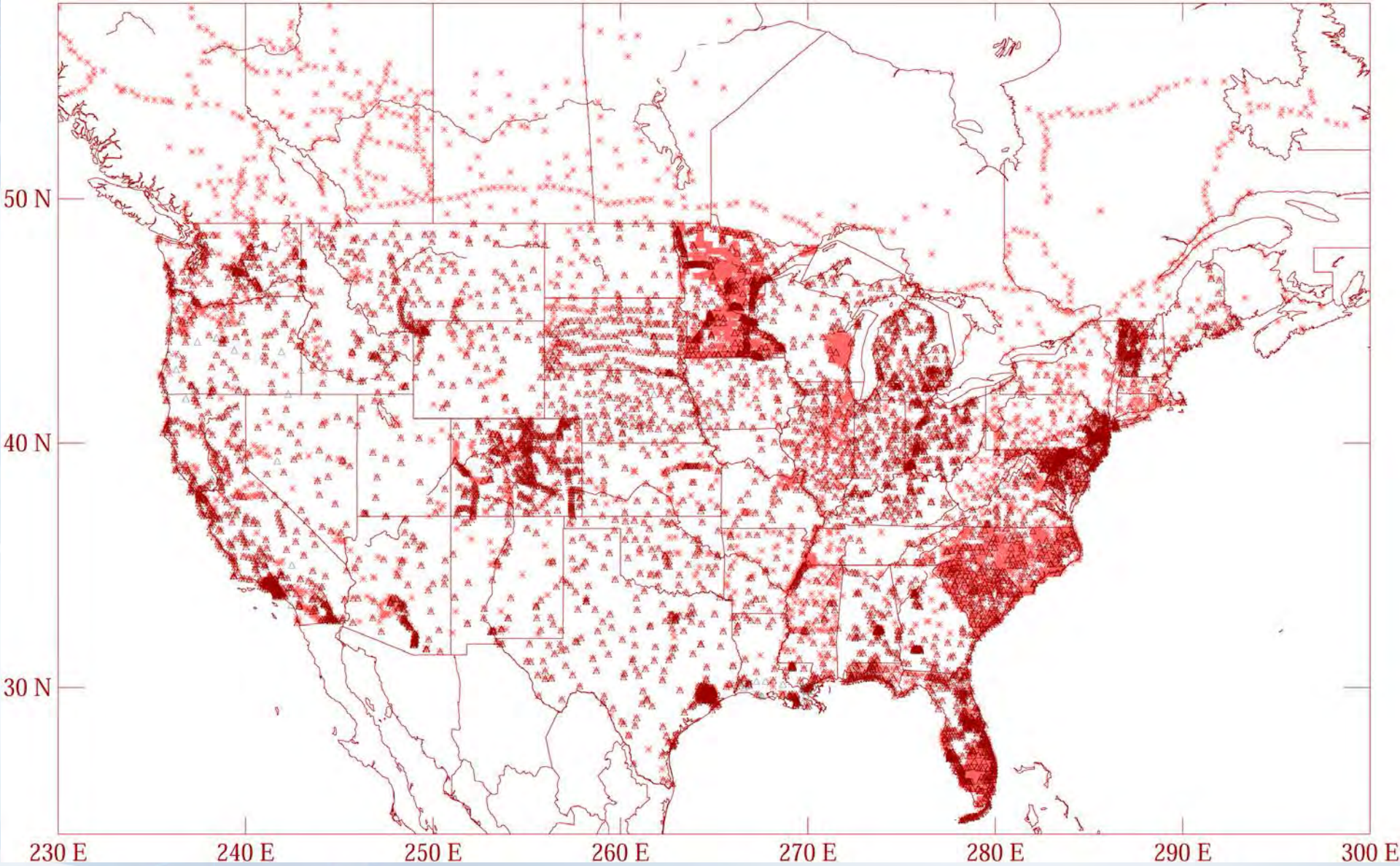
LEGEND:
Ellipsoid Height 1 STD (cm)
1 2 3 4 5 6 7 8+
Data as of Nov 7 2011



Types and Uses of Geoid Height Models

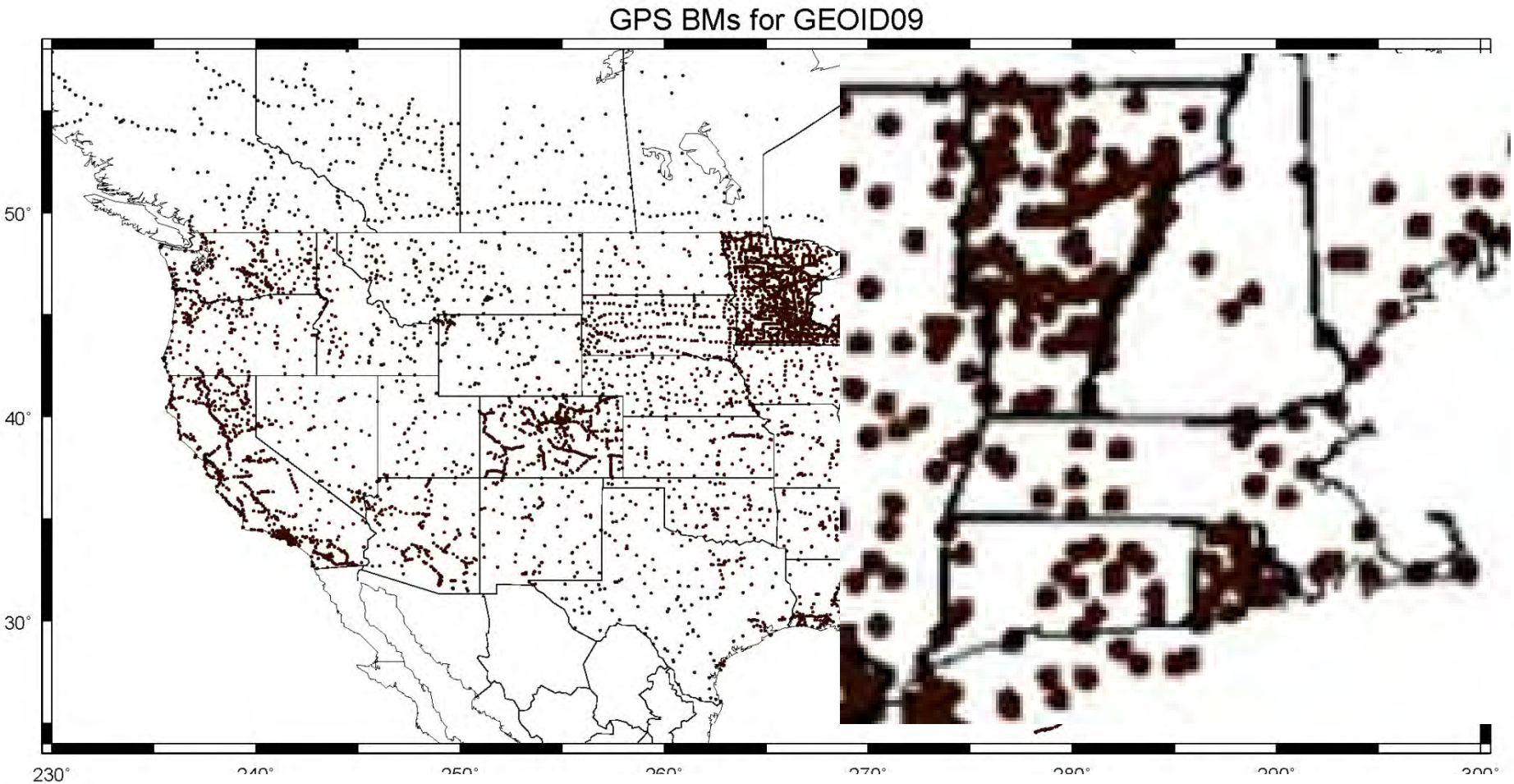
- Gravimetric (or Gravity) Geoid Height Models
  - Defined by gravity data crossing the geoid
  - Refined by terrain models (DEM's)
  - Scientific and engineering applications

- Composite (or Hybrid) Geoid Height Models
  - Gravimetric geoid defines most regions
  - Warped to fit available GPSBM control data
  - Defined by legislated ellipsoid (NAD 83) and local vertical datum (NAVD 88, PRVD02, etc.)
  - May be statutory for some surveying & mapping applications



GGPSBM1999: 6,169 total 0 Canada STDEV 9.2 cm (2σ)

GGPSBM2003: 14,185 total 579 Canada STDEV 4.8 cm (2 σ)



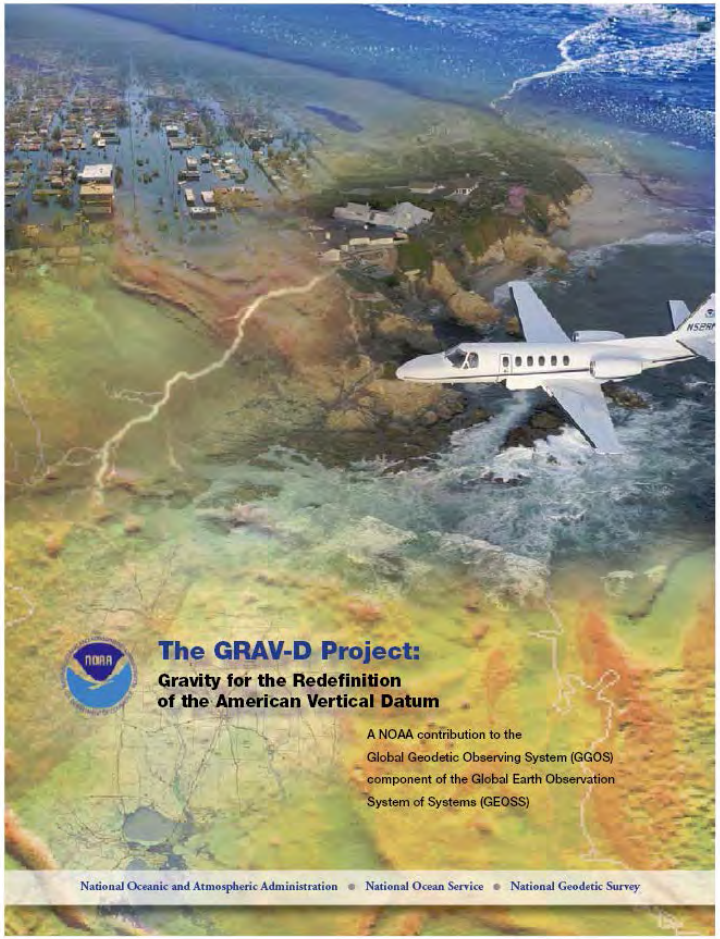
GGPSBM2009: 18,398 STDEV 2.8 cm (2σ)

Transition to the Future – GRAV-D

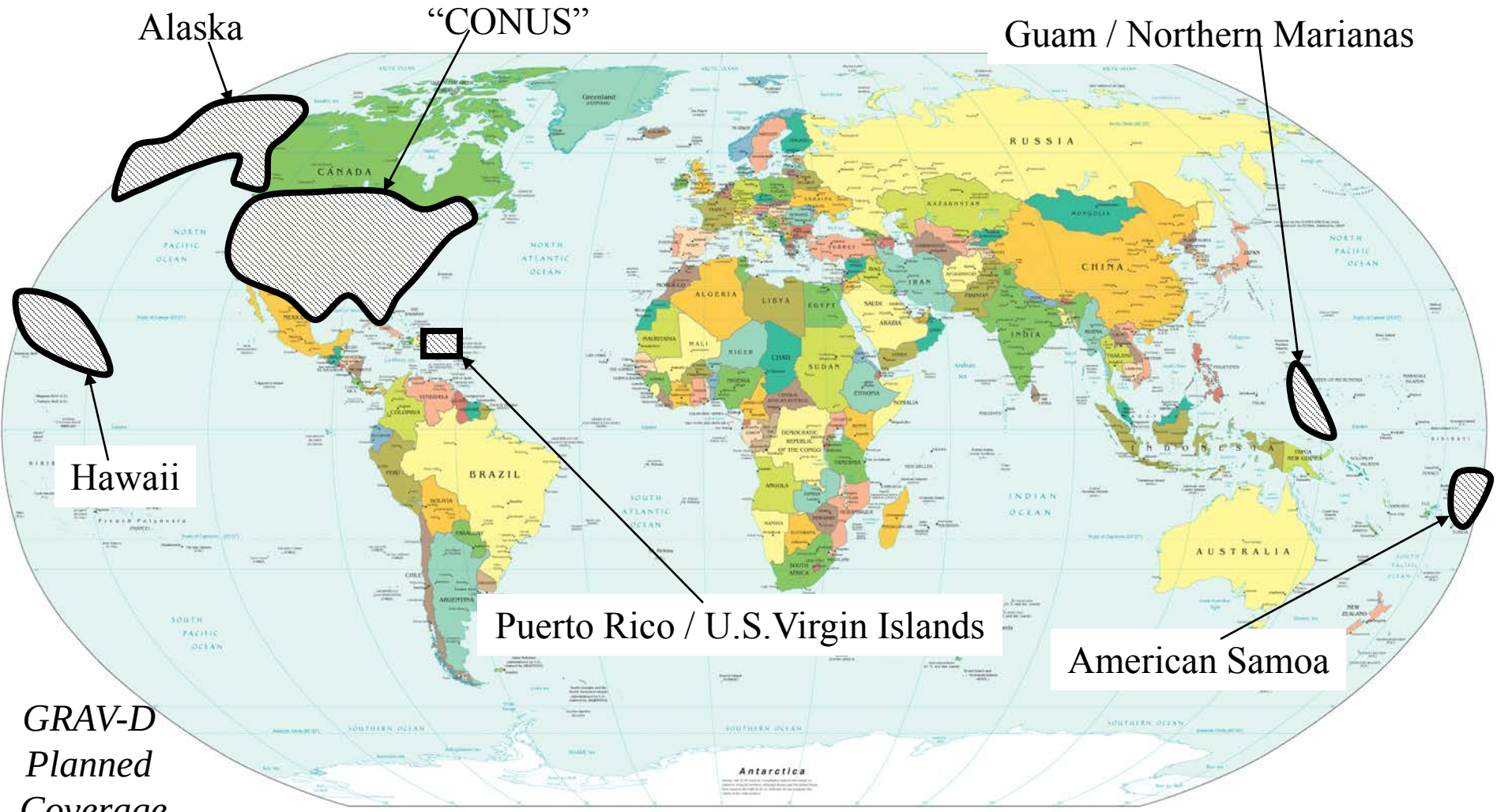
Gravity for the Redefinition of the American Vertical Datum

- Official NGS policy as of Nov 14, 2007
  - – $38.5M over 10 years
- Airborne Gravity Snapshot
- Absolute Gravity Tracking
- Re-define the Vertical Datum of the USA by 2018

  (2022 more likely due to funding issues)



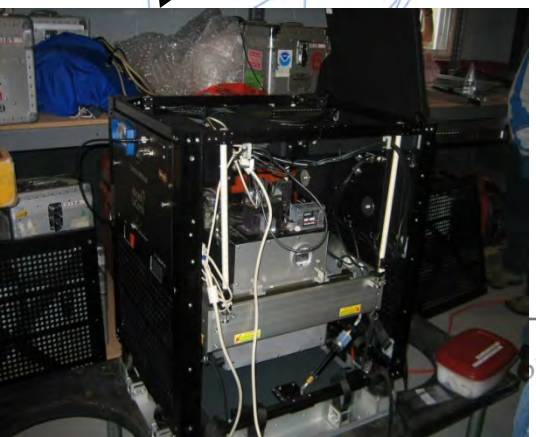
What is GRAV-D?



GRAV-D Planned Coverage

Gravity Survey Plan

- National Scale Part 1
  - Predominantly through airborne gravity
  - With Absolute Gravity for ties and checks
  - Relative Gravity for expanding local regions where airborne shows significant mismatch with existing terrestrial



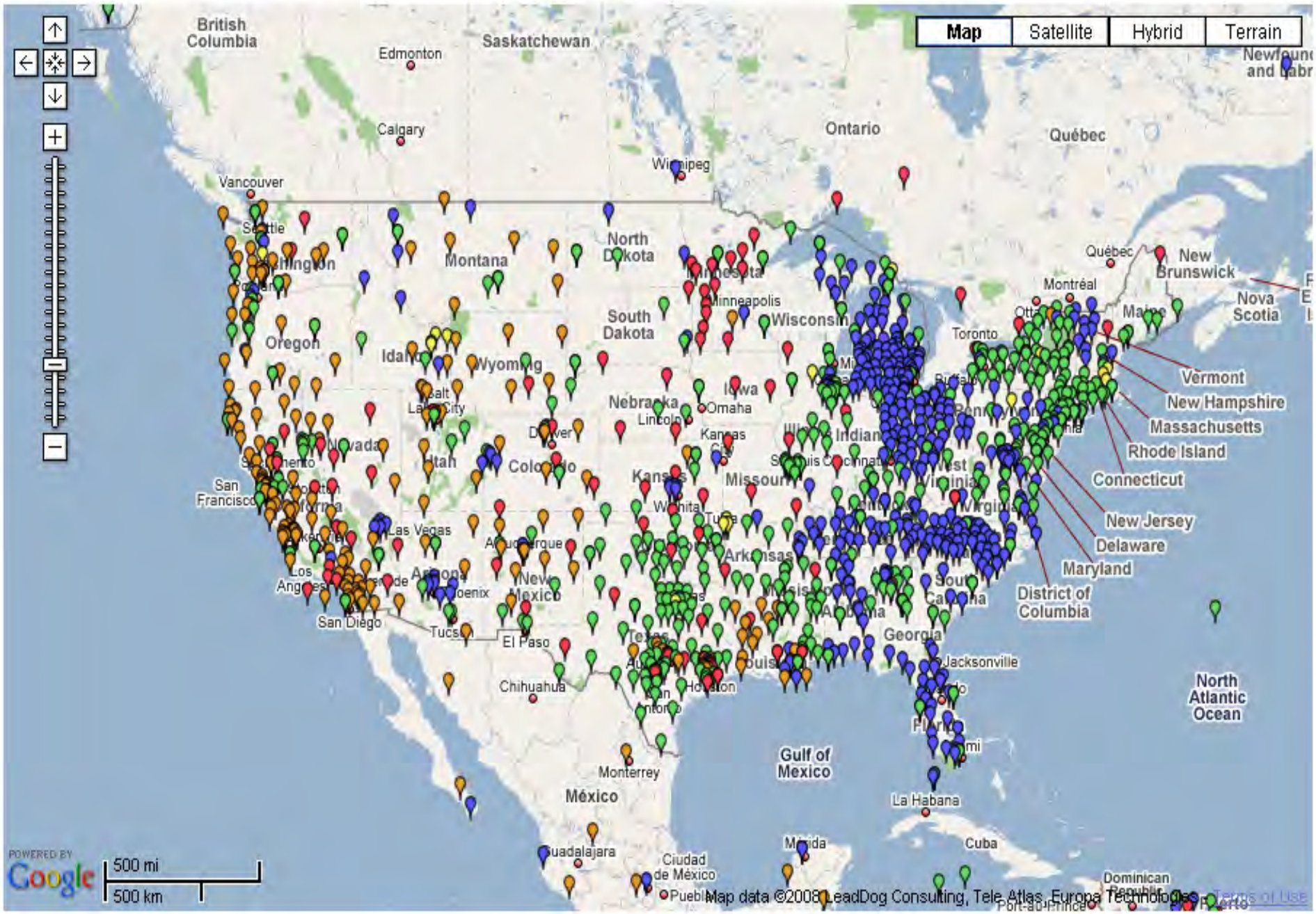
What is GRAV-D?

- **GRAV-D will mean:**
  - As the H=0 surface, the geoid will be tracked over time to keep the datum up to date
  - The reliance on passive marks will dwindle to:
    - Secondary access to the datum
    - Minimal NGS involvement
      - Maintenance/checking in the hands of users
    - Use at your own risk

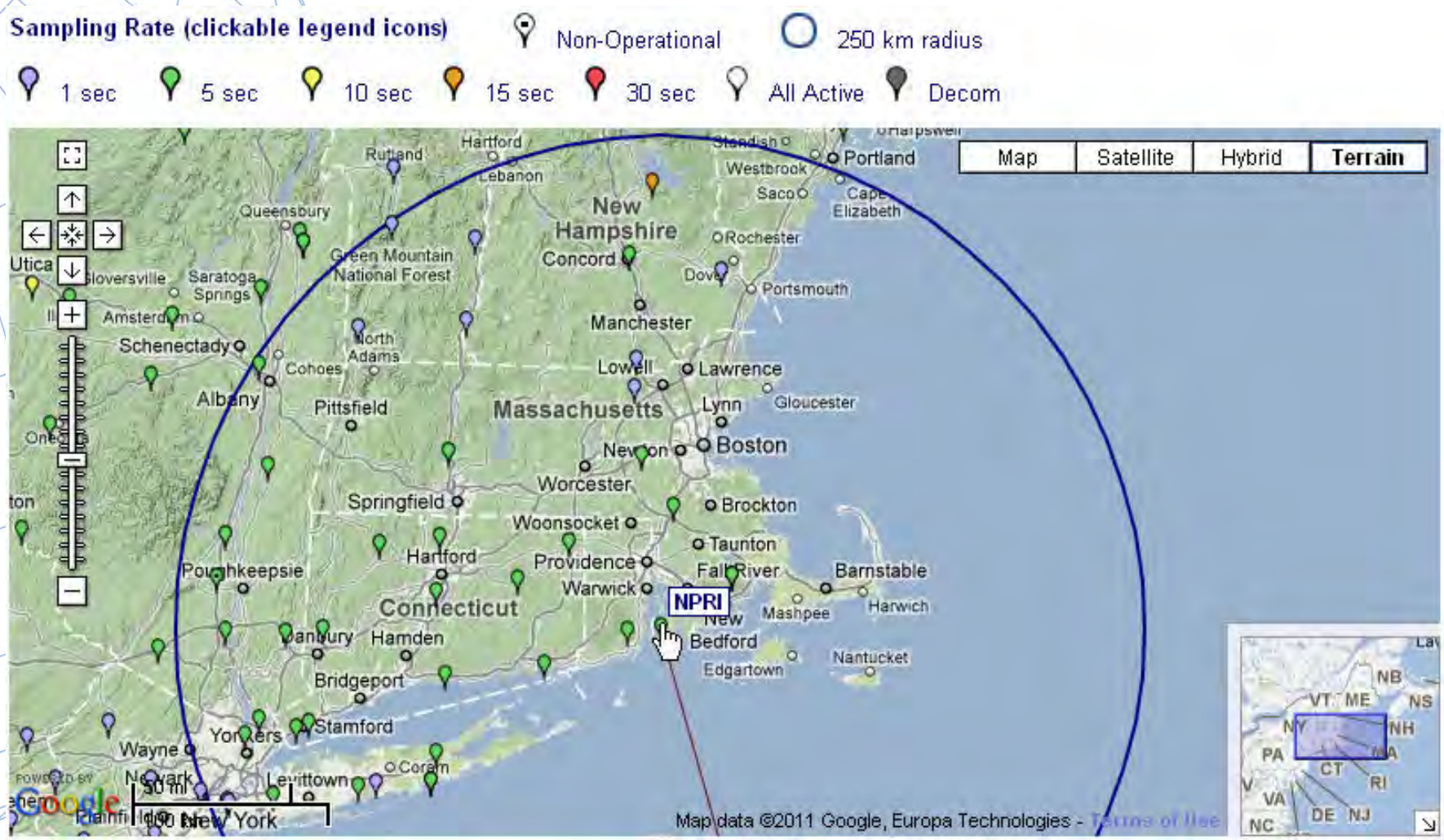
CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS)

1690+ Installed and Operated by various Federal-State-local Agencies

NOAA/National Geodetic Survey
NOAA/OAR Global Systems Division
U.S. Coast Guard - DGPS/NDGPS
Corps of Engineers - DGPS
FAA - WAAS/LAAS
State DOTs
County and City
Academia
Private Companies


1 sec
5 sec
10 sec
15 sec
30 sec
All
Decommissioned
Map
Satellite
Hybrid
Terrain
British Columbia
Saskatchewan
Edmonton
Calgary
Ontario
Québec
Winnipeg
Vancouver
Seattle
Montana
North Dakota
Minneapolis
Wisconsin
South Dakota
Oregon
Wyoming
Nebraska
Omaha
Lincoln
Iowa
Toronto
Montréal
New Brunswick
Nova Scotia
Maine
Vermont
New Hampshire
Massachusetts
Rhode Island
Connecticut
New Jersey
Delaware
Maryland
District of Columbia
Utah
Colorado
Kansas
Missouri
Arkansas
Georgia
Jacksonville
San Francisco
Las Vegas
Los Angeles
San Diego
Arizona
Phoenix
New Mexico
Tucson
El Paso
Texas
Chihuahua
Monterrey
México
Gulf of Mexico
La Habana
Cuba
North Atlantic Ocean
Guadalajara
Ciudad de México
Mérida
Dominican Republic
Port-au-Prince
POWERED BY Google
500 mi
500 km
Map data ©2008 LeadDog Consulting, Tele Atlas, Europa Technologies
Terms of Use

REGIONAL CORS NETWORK



IGS 08
U OF RI COOP (URIL), RHODE ISLAND

Created on 31Aug2011 at 09:59:48.

Antenna Reference Point(ARP): U OF RI COOP CORS ARP
PID = DE6262

IGS08 POSITION (EPOCH 2005.0)
Computed in Aug 2011 using data through gpswk 1631.

X =	1516051.922 m	latitude =	41 29 20.19043 N
Y =	-4538296.763 m	longitude =	071 31 39.78646 W
Z =	4203281.774 m	ellipsoid height =	44.430 m

IGS08 VELOCITY
Predicted with HTDP_3.1.2 Aug 2011.

VX =	-0.0155 m/yr	northward =	0.0059 m/yr
VY =	-0.0010 m/yr	eastward =	-0.0150 m/yr
VZ =	0.0044 m/yr	upward =	-0.0001 m/yr

NAD_83 (2011) POSITION (EPOCH 2010.0)
Transformed from IGS08 (epoch 2005.0) position in Aug 2011.

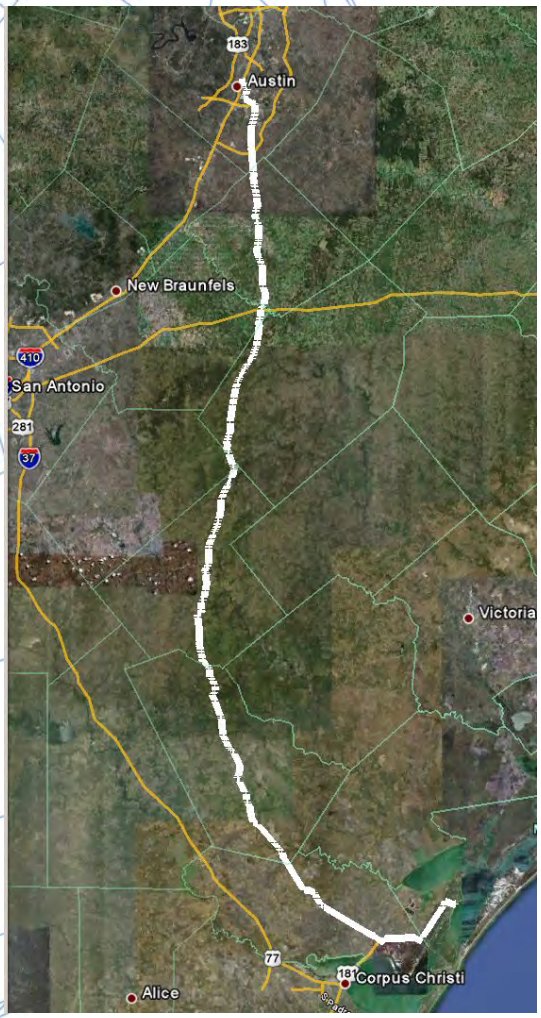
X =	1516052.617 m	latitude =	41 29 20.15772 N
Y =	-4538298.216 m	longitude =	071 31 39.77789 W
Z =	4203281.839 m	ellipsoid height =	45.671 m

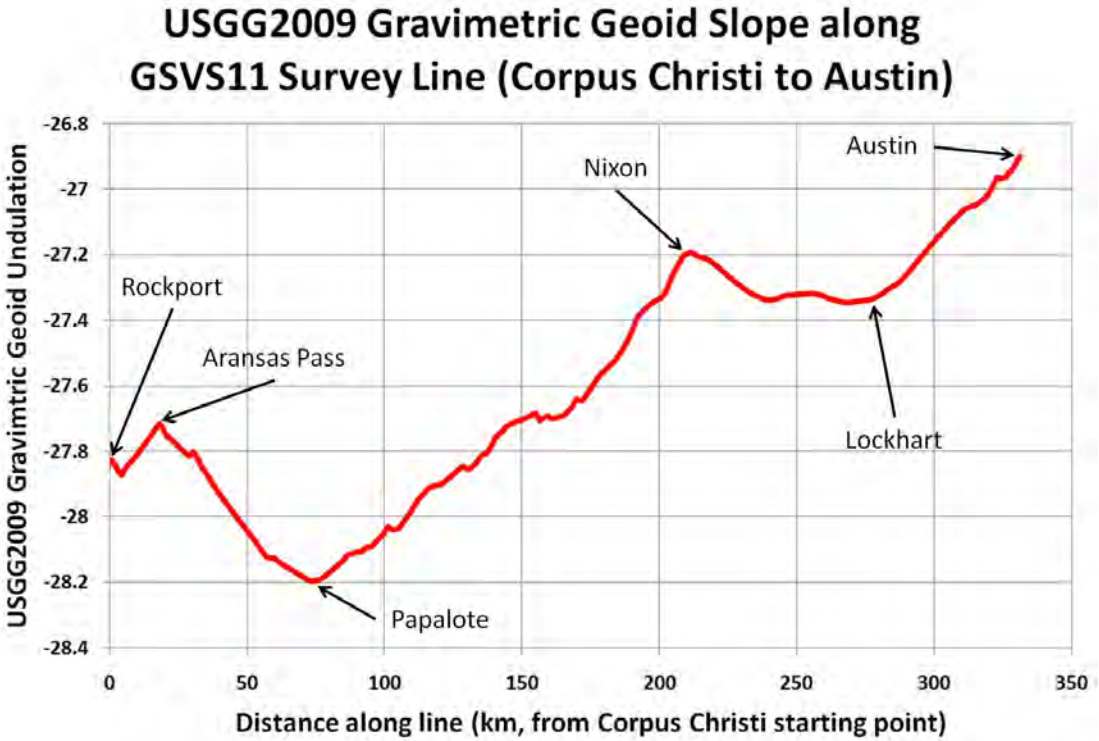
NAD_83 (2011) VELOCITY
Transformed from IGS08 velocity in Aug 2011.

VX =	0.0017 m/yr	northward =	-0.0011 m/yr
VY =	0.0006 m/yr	eastward =	0.0018 m/yr
VZ =	-0.0015 m/yr	upward =	-0.0010 m/yr

IGS08 – NAD 83(2011)
ΔHoriz = 1.029 m
ΔEHt = 1.241 m

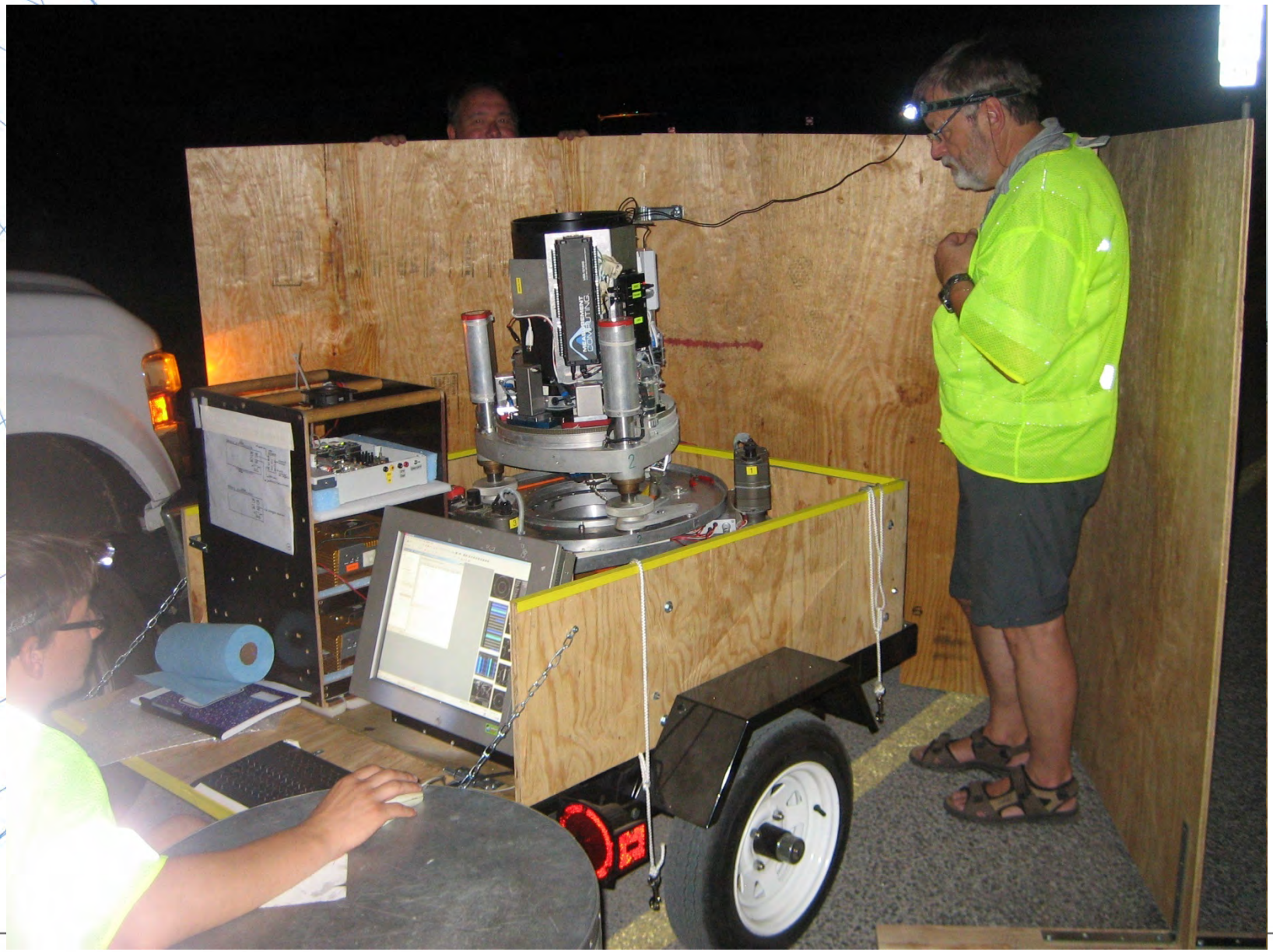
Geoid Slope Validation Survey of 2011 (GSVS11)





GSVS11 Components

- Differential Leveling
- Campaign GPS
- RTN-based GPS
- Absolute Gravity
- Gravity Gradients
- Deflections of the Vertical
- Airborne LIDAR
- Airborne Imagery



Accessing the New Vertical Datum

- **Primary access** (NGS mission)
  - Users with geodetic quality GNSS receivers will continue to use OPUS suite of tools
  - Ellipsoid heights computed, and then a gravimetric geoid removed to provide orthometric heights in the new datum
  - No passive marks needed
  - But, could be used to position a passive mark

- **Secondary access** (Use at own risk)
  - Passive marks that have been tied to the new vertical datum
  - NGS will provide a “data sharing” service for these points, but their accuracy (due to either the quality of the survey or the age of the data) will not be a responsibility of NGS

Continuously Operating Reference Station

Accessing the New Vertical Datum

- **NAVD 88 conversion to new datum**
  - A conversion will be provided between NAVD 88 and the new datum
    - Only where recent GNSS ellipsoid heights exist to provide modern heights in the new datum

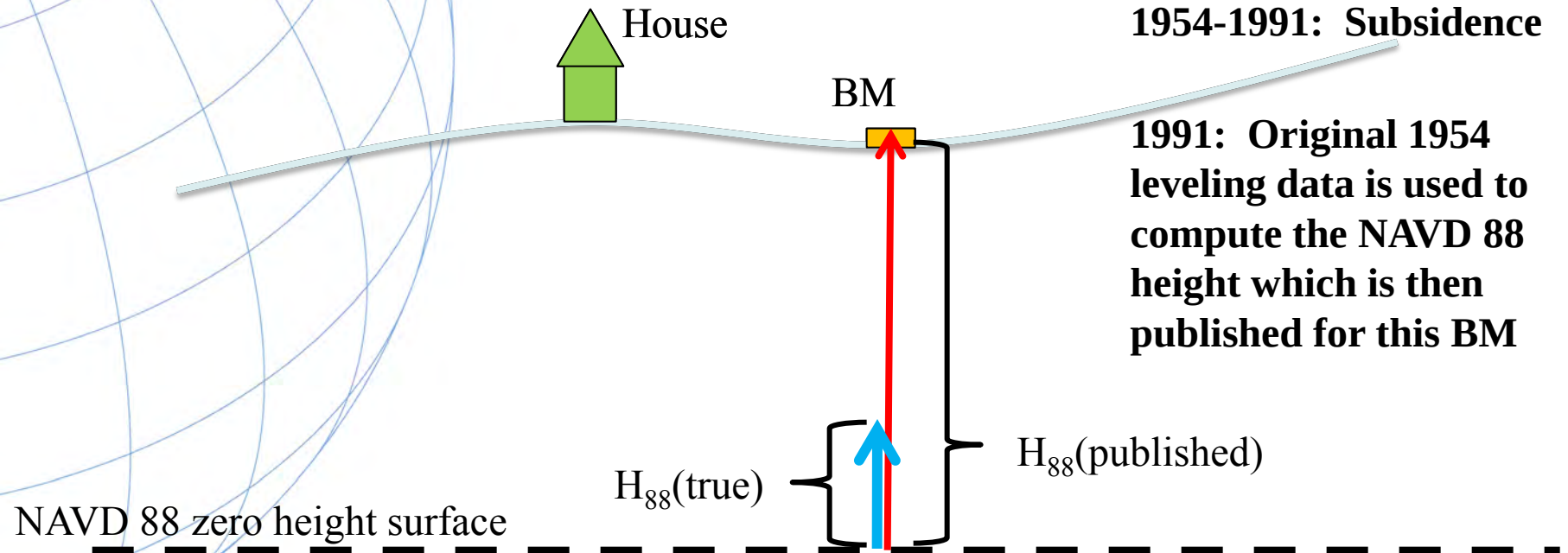
How will I access the new vertical datum?

Example 1: Flood insurance survey

1954: Leveling performed to bench mark

1954-1991: Subsidence

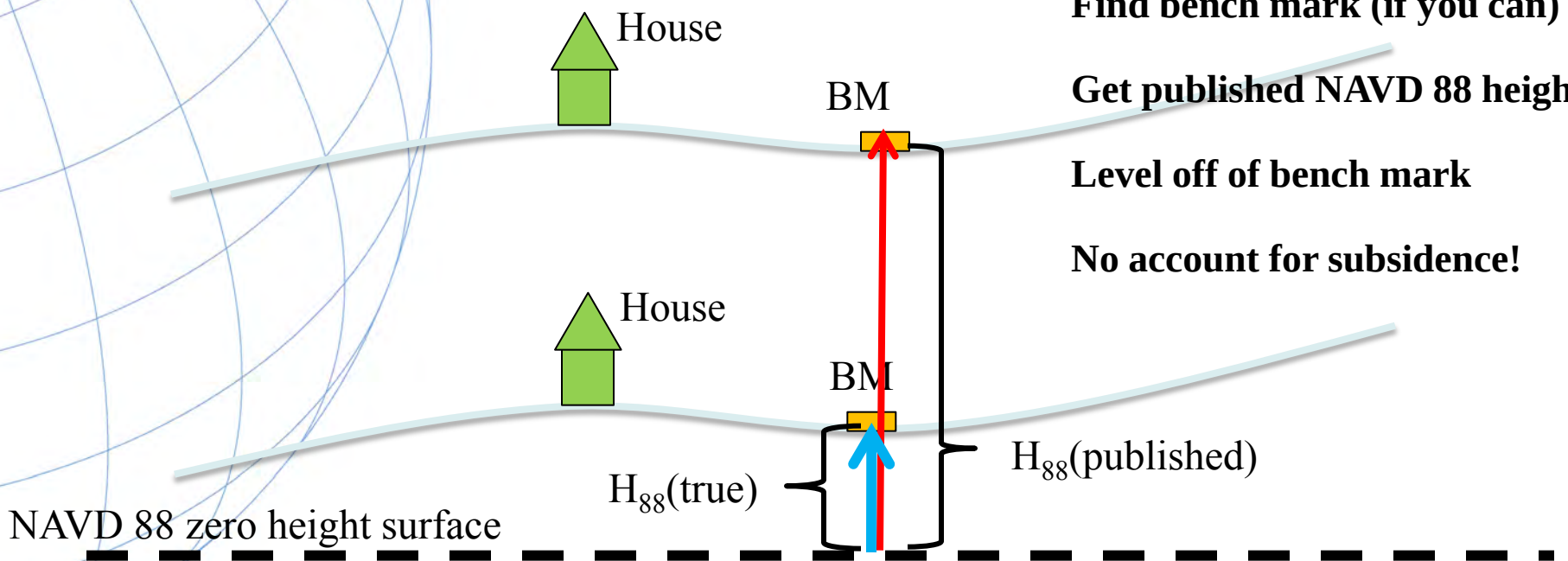
1991: Original 1954 leveling data is used to compute the NAVD 88 height which is then published for this BM



Clearly the true height relative to the NAVD 88 zero surface is not the published NAVD 88 height

How will I access the new vertical datum?

Example 1: Flood insurance survey



Using <u>Existing</u> Techniques:

Find bench mark (if you can)

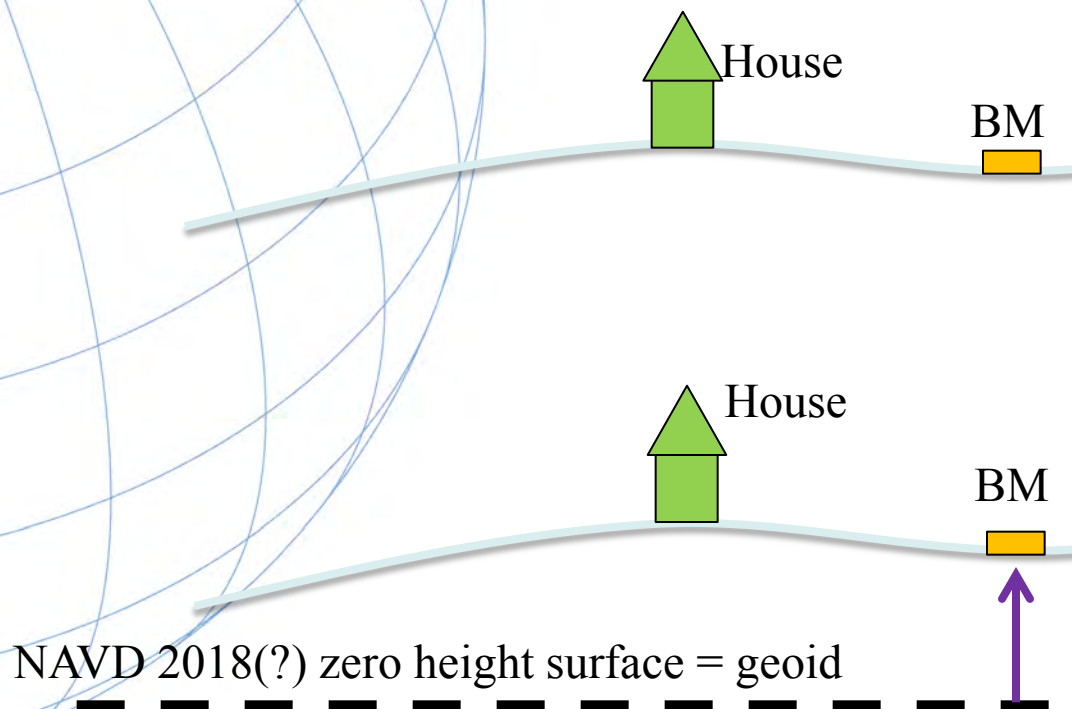
Get published NAVD 88 height

Level off of bench mark

No account for subsidence!

How will I access the new vertical datum?

Example 1: Flood insurance survey



Using <u>Future</u> Techniques:

Find bench mark if you wish, or set a new one of your choosing

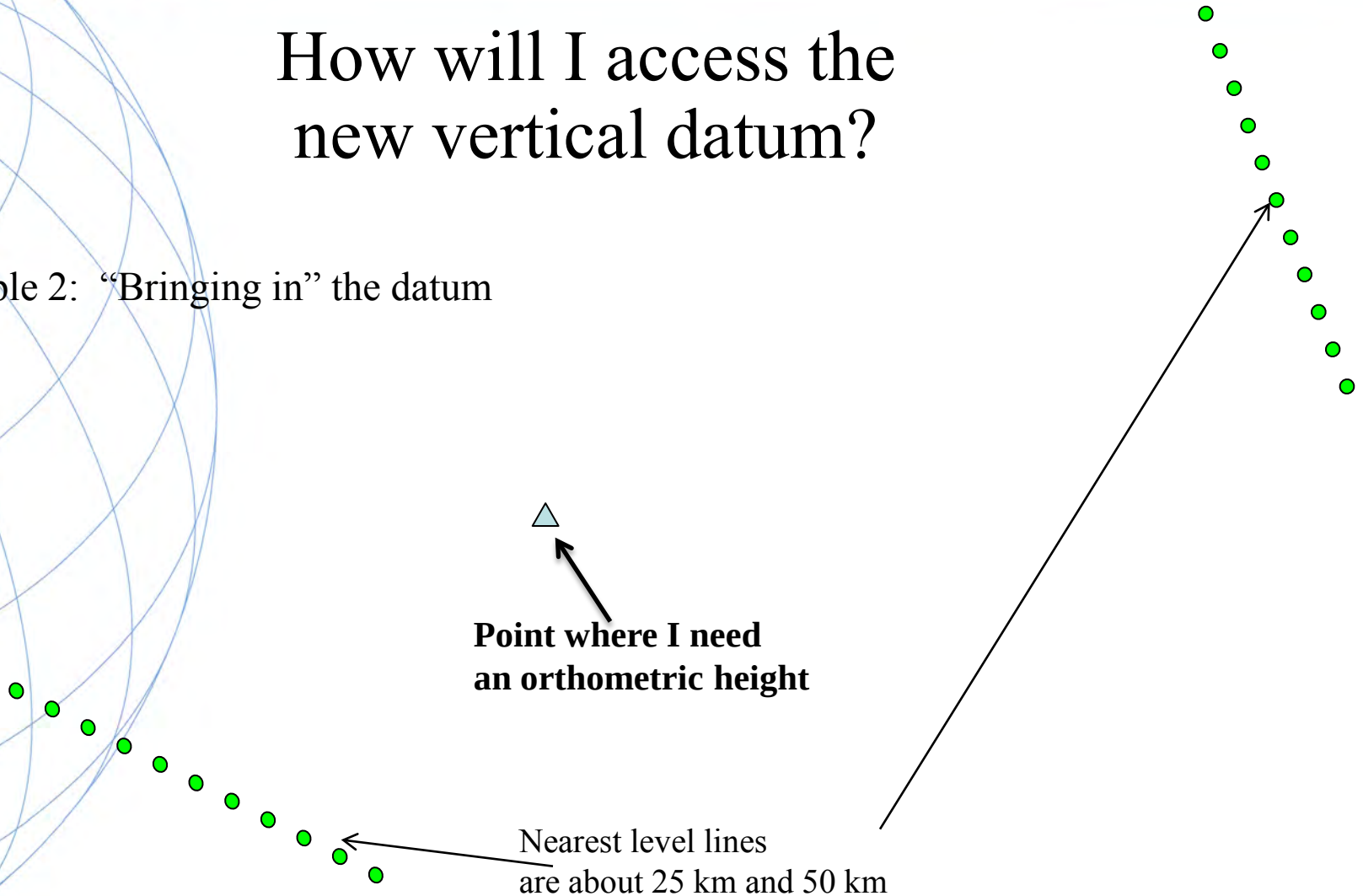
Use GNSS/OPUS to get an orthometric height in the new datum

Level off of bench mark as needed

Subsidence is accounted for by CORS and a geoid that are monitored constantly!

How will I access the new vertical datum?

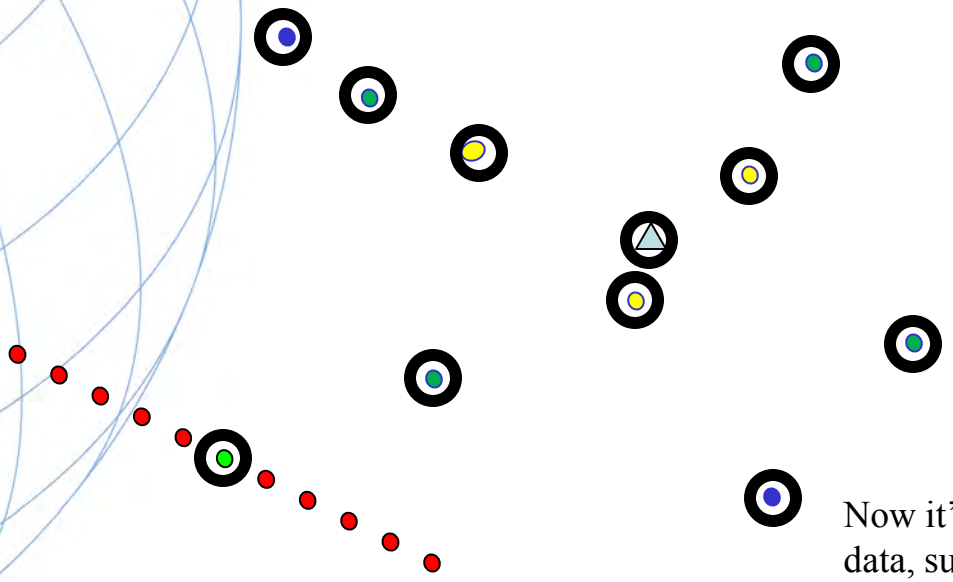
Example 2: "Bringing in" the datum

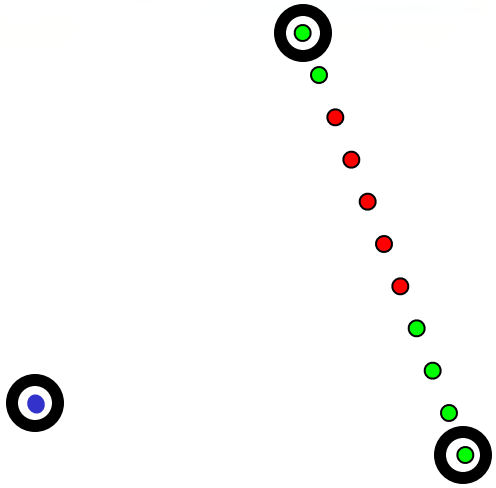


How will I access the new vertical datum?

Example 2: "Bringing in" the datum

Choice 2: Height Mod survey





Create passive marks around area of interest

Using progressive GNSS surveys (NGS 59 Guidelines), transfer orthometric heights to primary, secondary and local marks

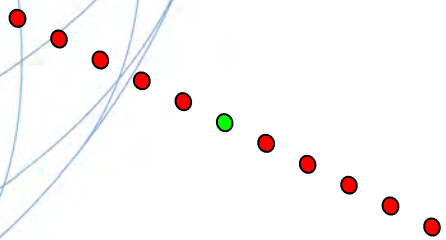
Now it's time to bluebook the data, submit to NGS, wait for it to be loaded into the IDB….

…and all this assumes the published heights are correct to begin with…

How will I access the new vertical datum?

Example 2: "Bringing in" the datum

Choice 3: Once GRAV-D is complete

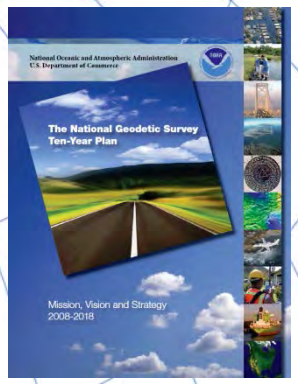


Set up GNSS receiver over mark

Submit data to OPUS and receive orthometric height

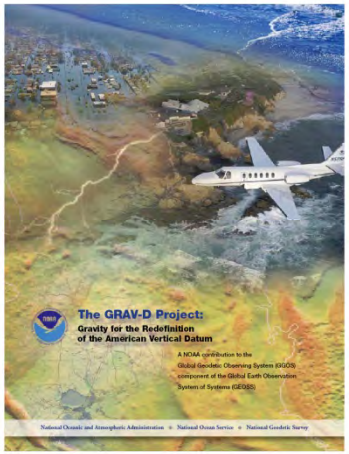
Feeling generous? Share results with others using the NGS online data-base (no bluebooking involved). If not, take your height and walk away.

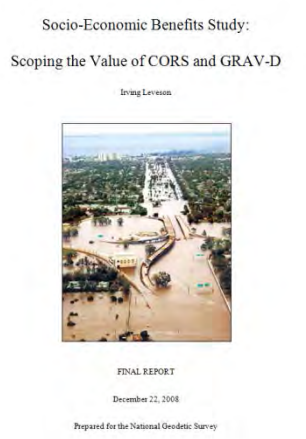
Additional Information



The NGS 10 year plan (2008-2018)
http://www.geodesy.noaa.gov/INFO/NGS10yearplan.pdf

The GRAV-D Project
http://www.geodesy.noaa.gov/GRAV-D





Socio-Economic Benefits of CORS and GRAV-D
http://www.geodesy.noaa.gov/PUBS_LIB/Socio-EconomicBenefitsofCORSandGRAV-D.pdf

Ten-Year Milestones (2018)

1) NGS will compute a pole-to-equator, Alaska-to-Newfoundland geoid model, preferably in conjunction with Mexico and Canada as well as other interested governments, with an accuracy of 1 cm in as many locations as possible

2) NGS redefines the vertical datum based on GNSS and a gravimetric geoid

3) NGS redefines the national horizontal datum to remove disagreements with the ITRF

Predicted Positional Changes in 2022 Vicinity of Providence, RI.

(Computed for station NORTH CENTRAL CBL 0 ZERO, pid LW1765)

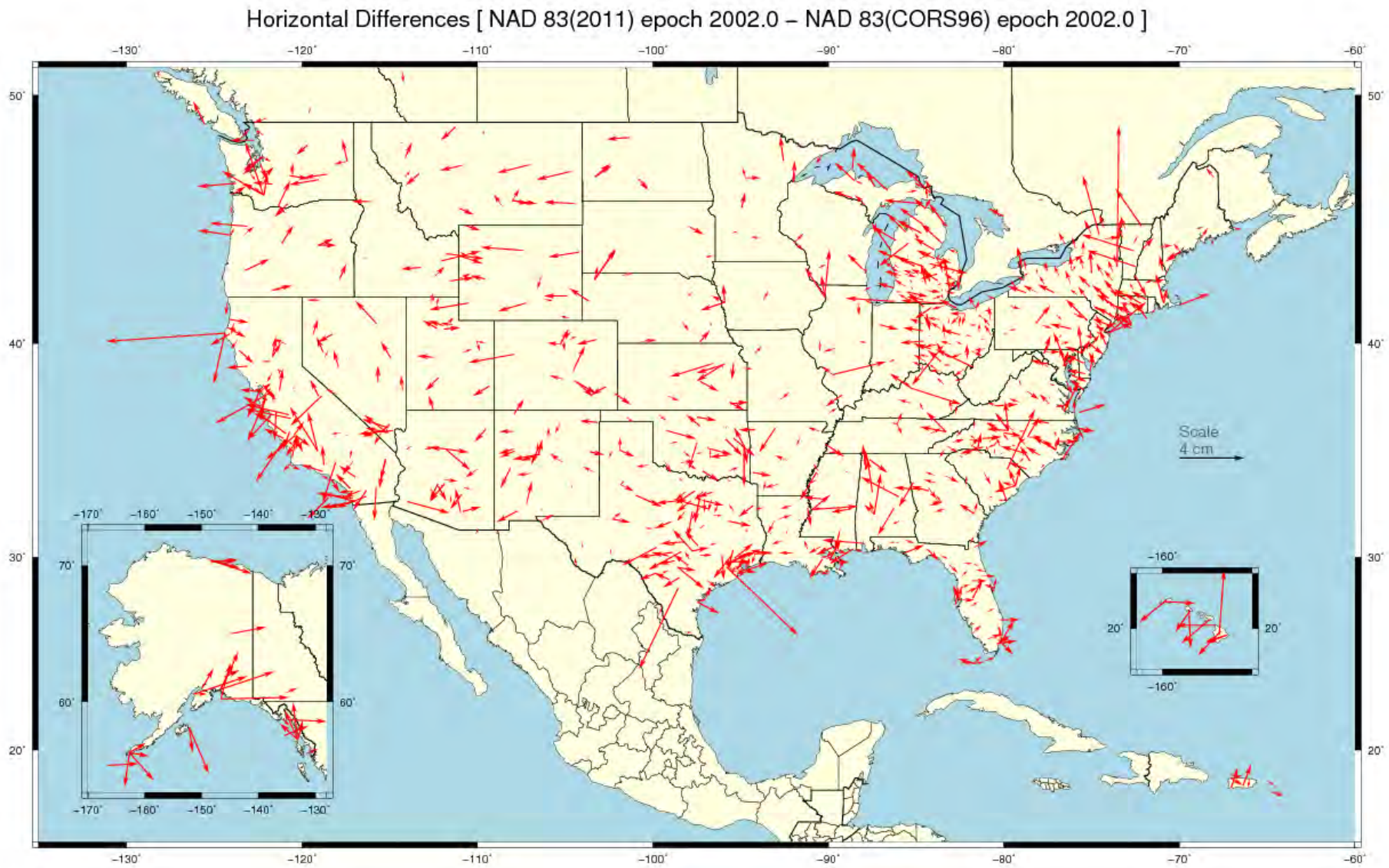
HORIZONTAL = 1.19 m (3.9 ft)
ELLIPSOID HEIGHT = - 1.24 m (- 4.1 ft)
Predicted with HTDP

ORTHOMETRIC HEIGHT = - 0.38 m (- 1.3 ft)
Predicted with HTDP and USGG2009

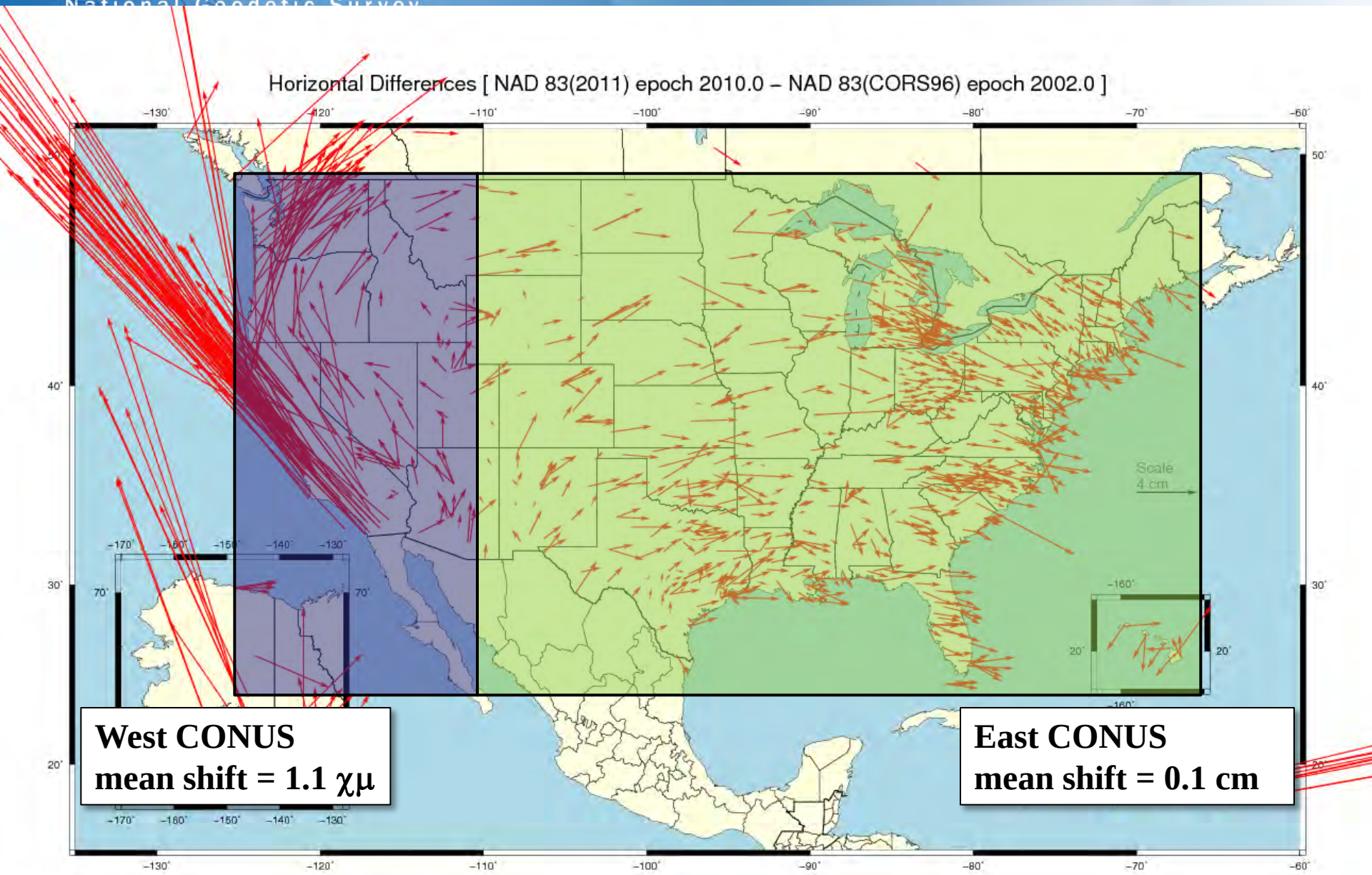
HTDP
"Coping with Tectonic Motion"
R. Snay & C. Pearson
American Surveyor Magazine, December 2010
www.Ameriserv.com

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 *B*est *A*vailable *M*ethods**
  - ***Needed because CORS network is foundation of NSRS***

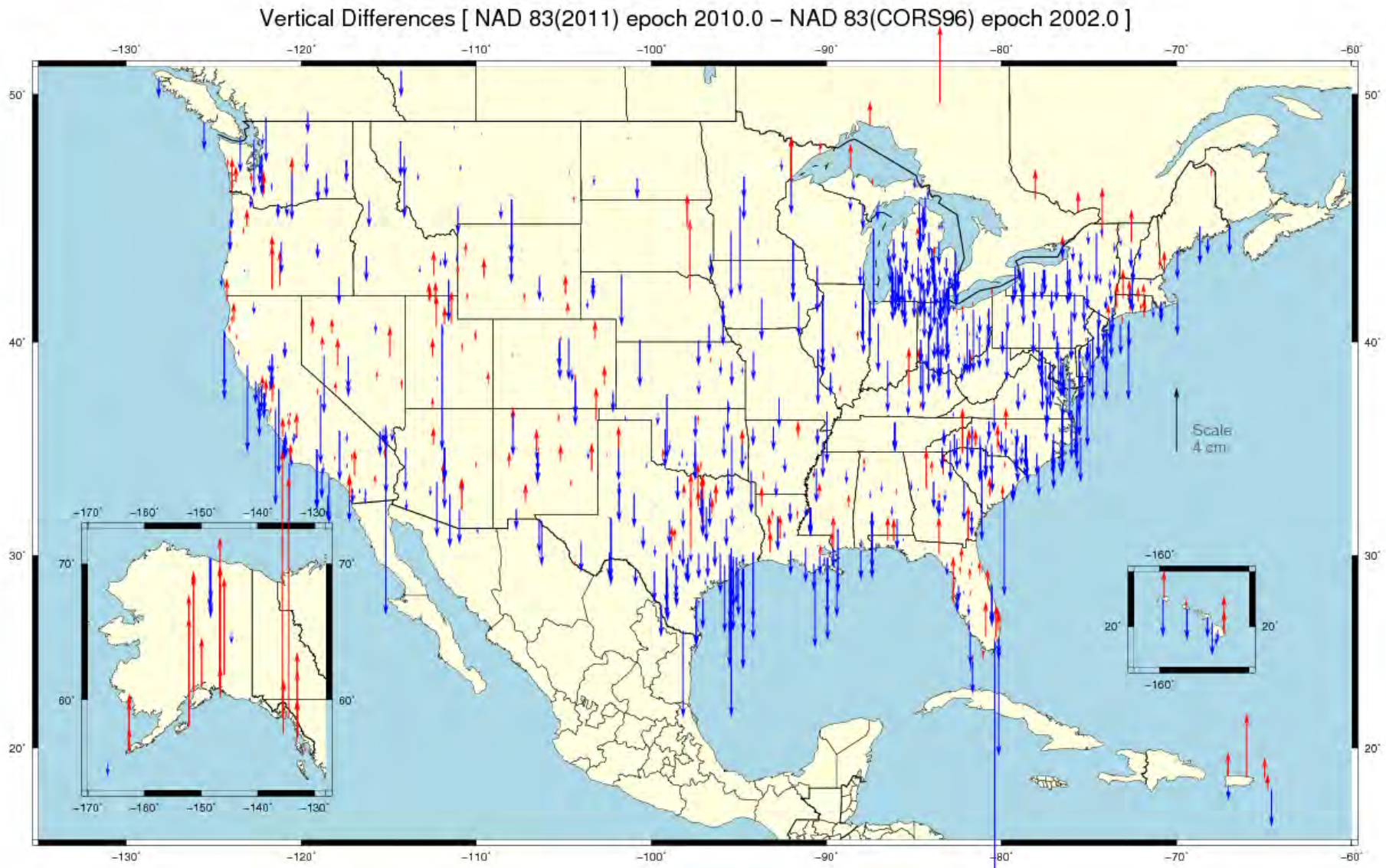


Mean horizontal shift = 0.2 cm (2 cm) at epoch 2002.0



Mean horizontal shift = 2.0 cm (8 cm) from 2002.0→2010.0

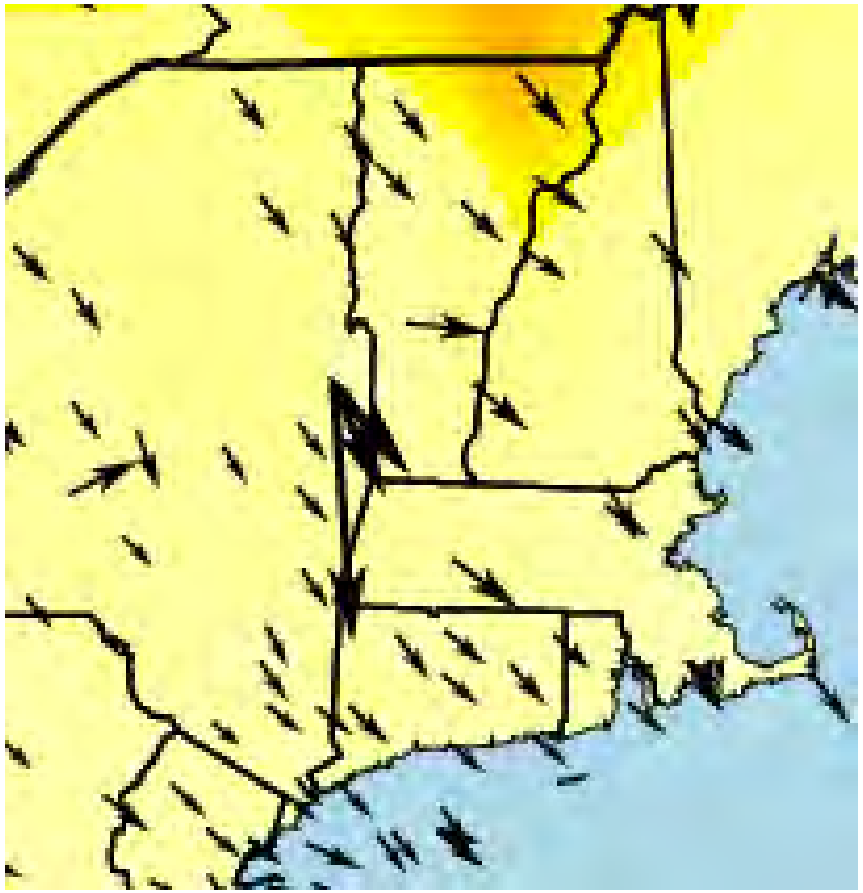
2011 Apr 27 07:59:11

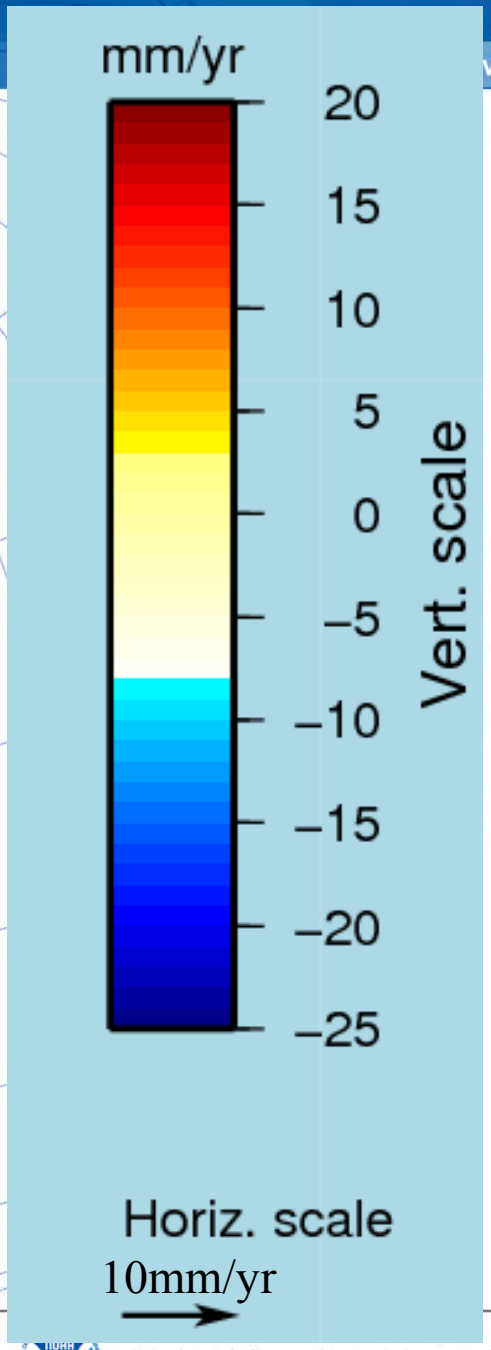


Mean vertical shift = -0.8 cm (2 cm) from 2002.0→2010.0

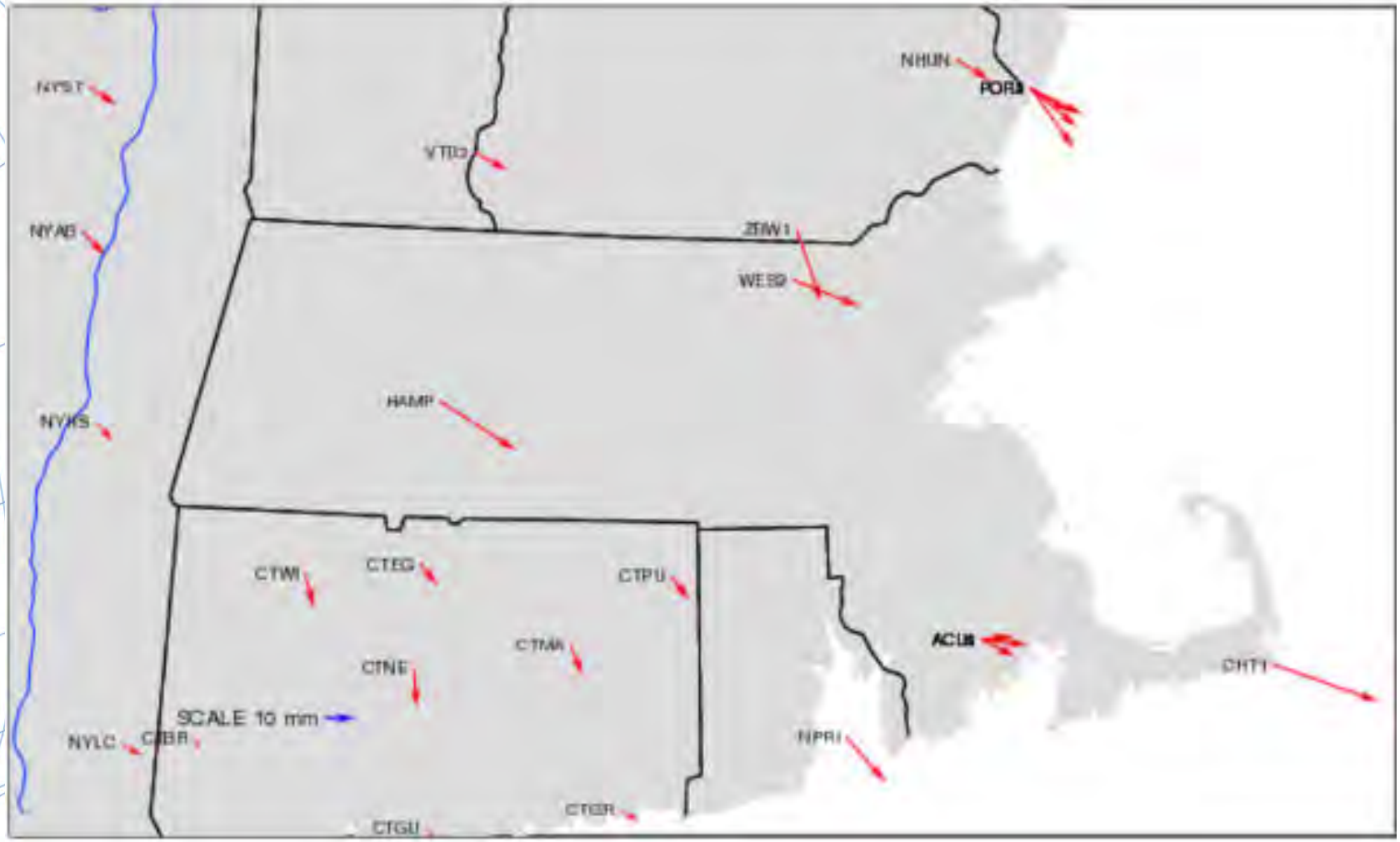
Mean vertical shift = +0.7 cm (2 cm) at epoch 2002.0

NAD 83 (2011) Velocity

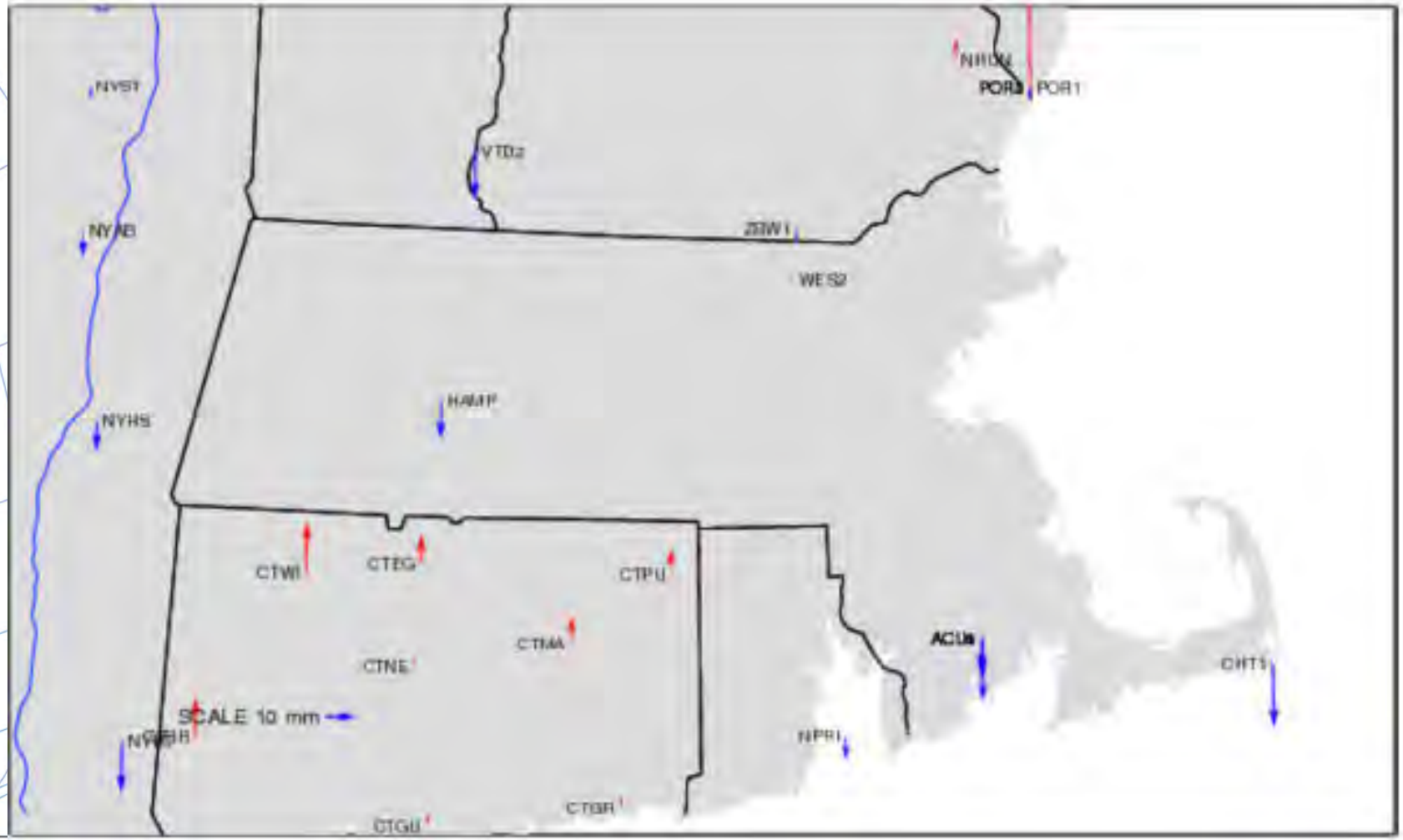




MA Horizontal POSITIONS NAD 83(2011) 2010.00 minus NAD 83(CORS96) 2002.00



MA Vertical POSITIONS NAD 83(2011) 2010.00 minus NAD 83(CORS96) 2002.00



Introducing…
NAD 83(2011) epoch 2010.00

- **Multi-Year CORS Solution (MYCS)**
  - Reprocessed all CORS GPS data Jan 1994-Apr 2011
  - 2264 CORS & global stations
  - NAD 83 computed by *transformation* from IGS08
- **National Adjustment of 2011 (NA2011)**
  - New adjustment of GNSS passive control
  - GNSS vectors tied (and constrained) to CO 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)**

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

Transformation & Tectonic Complications

- NAD 83(2011) transformation tools?
  - NAD 83(2011) ←→ (NSRS2007/CORS96) ←→ (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

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 American tectonic plate
    - Includes California, Alaska, Puerto Rico, and US Virgin Islands
- **NAD 83(PA11) epoch 2010.00**
  - Frame fixed to Pacific tectonic plate (Hawaii and American Samoa)
- **NAD 83(MA11) epoch 2010.00**
  - Frame fixed to Mariana tectonic plate (Guam and CNMI)

When will it all be done?

- Multi-Year CORS Solution
  - Beta results released in May 2011
  - Official release of coordinates August 2011
  - OPUS (Online Positioning User Service)
    - Will provide solutions referenced both to previous (CORS96) and new (MYCS) coordinates
    - Dual solutions will be available until NA2011 complete
- National Adjustment of 2011
  - Goal: Complete by end of CY 2011/early 2012
  - Deadline for submitted projects: Aug 31, 2011

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

More information…

National Geodetic Survey

geodesy.noaa.gov

Positioning America for the Future

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August 19, 2011

In The News

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

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

National Geodetic Survey Announces National Adjustment of 2011 Project
As part of the National Geodetic Survey's (NGS) continuing efforts to improve the National Spatial Reference System (NSRS), on May 27, NGS was pleased to announce the National Adjustment of 2011 (NA2011) project...**more**

08/11/2011 - NOAA Gravity Survey to Begin in the Great Lakes
The National Geodetic Survey's Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project is working with Fugro Airborne Surveys to begin an airborne gravity survey in the eastern Great Lakes...**more**

Most Popular

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- Survey Mark Datasheets
- Geodetic Tool Kit
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- Publications
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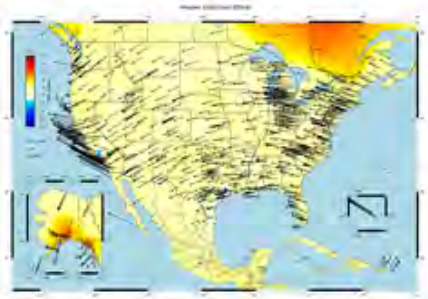
- Storm Imagery
- UFCORS

Upcoming Events

NRC Highlights Importance of NGS Products...

Federal Geodetic Control Subcommittee of the fgdc

NGS Public News Subscription



Summary of the Reanalysis of GPS Data and Release of Revised CORS Positions and Velocities

Beta results, subject to change

CORS Home

The National Geodetic Survey (NGS) operates the Continuously Operating Reference Station (CORS) Network that provides Global Navigation Satellite System (GNSS) data in RINEX format, and associated positions and velocities (coordinates) for each site. Currently NGS provides these coordinates in ITRF00 epoch 1997.00, and in NAD 83(CORS96) epoch 2002.00. NGS has completed a full reanalysis of all data from CORS and a set of global sites with the goal to compute a fully consistent set of coordinates, GPS satellite orbits and Earth Orientation Parameters (EOP). This initial Multi-Year CORS (MYCS1) effort is the first of a series reprocessing projects that will occur periodically in the coming years.

Part 1: Why Reprocess?

1) Mixed coordinates from an earlier solution (1994-2002) that used only 3-8 ITRF reference frame sites to align to the global frame

2) Mixed horizontal velocities: modeled from HTDP vs. computed

3) Mixed vertical velocities, which for many of the NAD 83(COR96) epoch 2002.00 stations are assigned a value of 0 mm/yr

4) NGS's current global frame is ITRF00 epoch 1997.00; projecting positions 13 years to the present is unrealistic

5) NGS's current plate-fixed frame is NAD 83(CORS96) epoch 2002.00; projecting positions 8 years to the present is also questionable

National Adjustment of 2011 (NA2011) Project

Frequently Asked Questions (FAQs)

Last updated June 13, 2011

List of abbreviations used in these Frequently Asked Questions:

CNMI	Commonwealth of the Northern Mariana Islands
CONUS	Conterminous United States
CORS	Continuously Operating Reference Stations
FGDC	Federal Geographic Data Committee
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HTDP	Horizontal Time-Dependent Positioning (NGS software)
IGS	International GNSS Service
MYCS	Multi-Year CORS Solution
NA2011	National Adjustment of 2011
NAD 27	North American Datum of 1927
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NADCON	North American Datum CONversion (NGS software)
NGS	National Geodetic Survey

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
  - Implemented by end of calendar year 2011
  - 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
AC6803|-----------------------------------------------------------------------|
AC6803| PID    Reference Object                    Distance      Geod. Az   |
AC6803|                                                          dddmmss.s  |
AC6803| AE3181 AZC CL END RWY 20                   68.963 METERS 15655      |
AC6803|-----------------------------------------------------------------------|
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|---------------------------------------------------------------------|
AC6803| PID    Reference Object                    Distance      Geod. Az   |
AC6803|                                                          dddmmss.s  |
AC6803| AE3181 AZC CL END RWY 20                   68.963 METERS 15655      |
AC6803|---------------------------------------------------------------------|
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.
```

FLAVORS OF OPUS

OPUS-S
$$ Receivers
2 Hours of data
Results not shared

OPUS-RS
$$ Receivers
15 Minutes of data
Results not shared

OPUS-DB
$$ Receivers
4 Hours of data
Results shared

OPUS-Projects
$$ Receivers
2-4 Hours of data
Multiple Receivers
Network Solution
Results shared or not

LOCUS
Leveling On Line Computing Service
Integration with GPS?
Results shared or not

OPUS – DB

Simple
Shared Data
NGS Archived

SURVEY DATASHEET (Version 1.0)

PID: BBCL97
Designation: USCG RI 2
Stamping: USCG RI 2 2011
Stability: Monument will probably hold position well
Setting: Massive structures (other than listed below)
Description: GENERAL LOCATION - US NAVY BASE NEWPORT, RI

TO REACH FROM GATE 17 OF THE NEWPORT NAVAL BASE, FOLLOW ACCESS ROAD TO PIER 2. DRIVE 0.25 MI WEST ALONG PIER 2 TO THE MARK ON THE RIGHT (NORTH) LOCATED IN THE W SIDE OF A RAISED CONCRETE PAD FOR A MOORING BIT WHICH IS THE 5TH DOUBLE BIT COUNTING FROM THE WEST END OF THE PIER.

THE MARK IS 46.3 FT EAST OF A SINGLE MOORING BIT, 41.3 FT WEST OF AN ELECTRIC TRANSFORMER BOX, AND 2.9 FT SOUTH OF THE NORTH EDGE OF THE PIER.

Observed: 2011-07-19T13:11:00Z
Source: OPUS - page5 1108.09

Close-up View

REF_FRAME:	EPOCH:	SOURCE:	UNITS:	SET PROFILE	DETAILS
NAD_83(2011)	2010.0000	NAVD88 (Computed using GEOID09)	m		

LAT:	41° 31' 49.07514"	± 0.003 m
LON:	-71° 19' 4.79257"	± 0.006 m
ELL HT:	-26.880	± 0.006 m
X:	1531661.122	± 0.005 m
Y:	-4529782.795	± 0.007 m

UTM 19	**SPC** 3800(RI)	
NORTHING:	4600222.313m	49655.583m
EASTING:	306617.198m	115189.298m
CONVERGENCE:	-1.53734509°	0.12067051°
POINT SCALE:	1.00006024	0.99999659

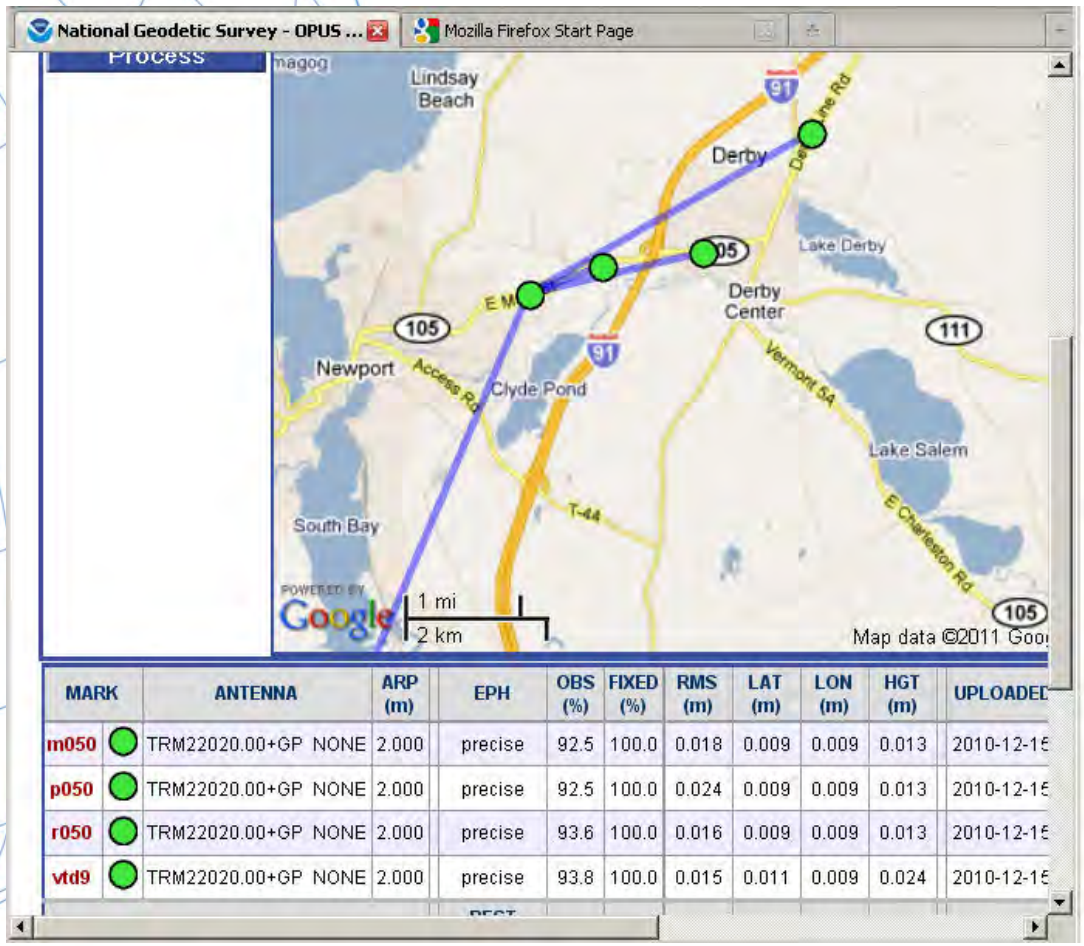
CONTRIBUTED BY

dan.martin
National Geodetic Survey

Horizon View

The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information submitted is accurate and complete.

OPUS Projects



MARK	ANTENNA	ARP (m)	EPH	OBS (%)	FIXED (%)	RMS (m)	LAT (m)	LON (m)	HGT (m)	UPLOADED
m050	TRM22020.00+GP NONE	2.000	precise	92.5	100.0	0.018	0.009	0.009	0.013	2010-12-15
p050	TRM22020.00+GP NONE	2.000	precise	92.5	100.0	0.024	0.009	0.009	0.013	2010-12-15
r050	TRM22020.00+GP NONE	2.000	precise	93.6	100.0	0.016	0.009	0.009	0.013	2010-12-15
vtd9	TRM22020.00+GP NONE	2.000	precise	93.8	100.0	0.015	0.011	0.009	0.024	2010-12-15

MARK	HUB	CONSTRAINT	HE
m050	☑	NONE	EL HGT
p050	☐	NONE	EL HGT
r050	☐	NONE	EL HGT
vtd9	☐	NONE	EL HGT

CORS	HUB	CONSTRAINT	HE
nyet	☑	3-D	EL HGT
nypb	☑	3-D	EL HGT
vcap	☑	3-D	EL HGT
vtuv	☑	3-D	EL HGT

Processing Options	
Output Ref Frame:	NAD_83(CORS96)
Geoid Model:	USGG2009
GNSS:	G (GPS-only)
Tropo Model:	Piece-wise, Linear
Tropo Interval (s):	7200
Elevation Cutoff (deg):	15.0
Constraints:	○ Loose ◉ Normal ○ Tig
Network Design:	◉ USER ○ CORS ○ MS

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Lodging/Transportation
Photos

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Fax: (540) 373-4327
Email Us

To Register for a Webinar:

Follow the 'Register' link on the webpage describing the class content. Click here for webinar Frequently Asked Questions.

To Register for a Classroom-based Session:

Click on this link to take you to the registration form. If you would like to register more than one person from your organization, you can either submit one form per person, or note in the comments section the number of spaces you would like reserved. Include the names of the other attendees and their contact information if possible.

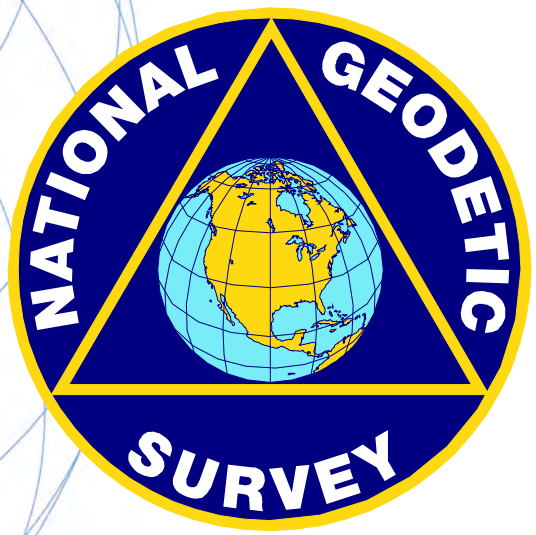
- For classroom-based sessions, we request at least a **3-week notice** if you cannot make a class for which you registered. While we understand that schedules and circumstances change, there are minimum class sizes, and last-minute cancellations can negatively affect other attendees and NGS staff.
- NGS will make every effort to conduct all classes as shown below; however, changes to the schedule may arise due to budget constraints or other considerations. In the event of any changes, those registered for the class will be notified as soon as possible, with at least a 2-week notice.

Unless otherwise noted, classes are free of charge.

For a list of workshops and conferences sponsored or attended by NGS, visit this page.

Date	Name of Class	Status	Trainer(s)	Audience	Classroom / Webinar
11/14/11-11/18/11	Meeting the Requirements of FAA's Advisory Circular 16A (AC-16A)	One open spot, click here to register	Jeff Olsen and Kevin Jordan	Open to all federal, state, local and private organizations	classroom
12/06/11-12/07/11	OPUS-Projects Manager Training	Class full, email for waiting list	Dan Martin, Vermont State Geodetic Advisor	Open to all federal, state, local and private organizations	classroom
03/13/12-03/15/12	Geodetic Digital Leveling Class	Class full, email for waiting list.	Charlie Geoghegan and Malcolm Archer-Shee	Open to all federal, state, local and private organizations	classroom

GOOD COORDINATION BEGINS WITH GOOD COORDINATES



GEOGRAPHY WITHOUT GEODESY IS A FELONY