

Modernization of the National Spatial Reference System

Keeping Pace with Changes in Positioning Technology and User Expectations in a Dynamic World



**Maryland Society of Surveyors
Spring Conference
Linthicum Heights
April 20, 2017**

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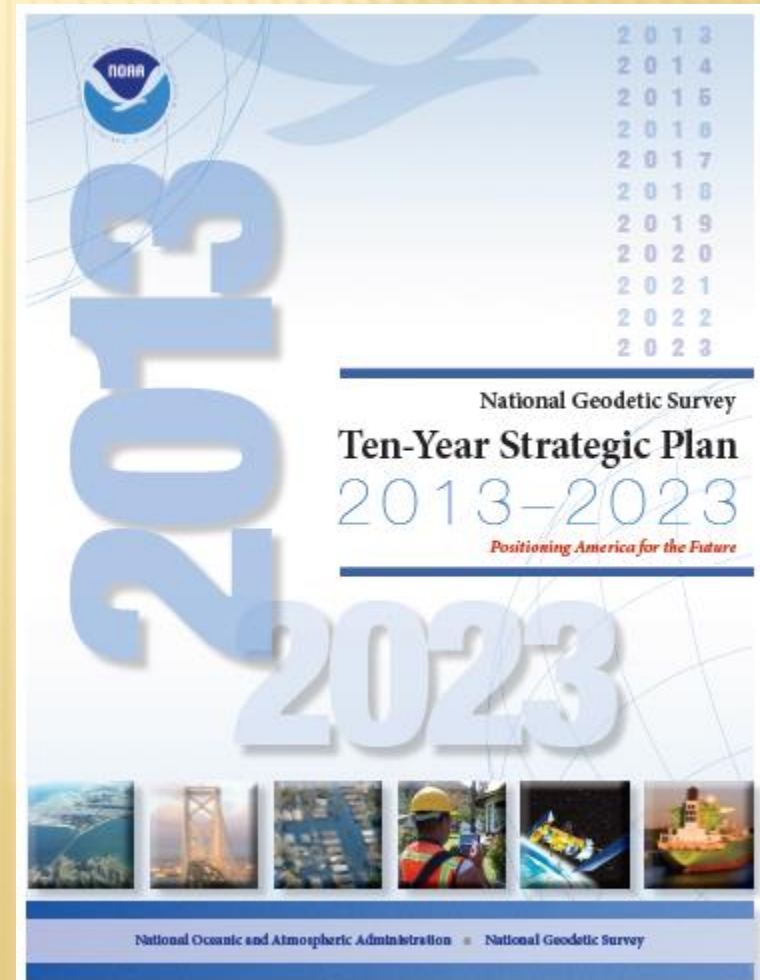
The National Geodetic Survey 10 year plan

Mission, Vision and Strategy

2013 – 2023

http://www.ngs.noaa.gov/web/news/Ten_Year_Plan_2013-2023.pdf

- Official NGS policy as of Jan 31, 2013
 - Updates 2008 plan
 - Modernized and Improve NSRS
 - Attention to accuracy
 - Attention to time-changes
 - Improved products and services
 - Fully vetted by NSPS/AAGS
- 2022 Targets:
 - Replace NAD 83 and NAVD 88
 - Cm-accuracy access to all coordinates



National Spatial Reference System (NSRS)

Consistent National Coordinate System

- Latitude/Northing
- Longitude/Easting
- Height
- Scale
- Gravity
- Orientation

and how these values change with time



NSRS Control Components

- **Networks of geodetic control points**

- Permanently marked passive survey monuments

- **National CORS Network**

- A network of GPS Continuously Operating Reference Stations

NSRS Control Components



NSRS Control Components



Problems with NAD 83 and NAVD 88

NAD 83 is not as geocentric as it could be (approx. 1.5 m for CONUS).

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 30-40 years

NAVD 88 does not easily account for local vertical velocities (subsidence / uplift)

- ❖ Post glacial isostatic readjustment
- ❖ Subsurface fluid/hydrocarbon extraction
- ❖ Sediment loading - Compaction
- ❖ Sea level rise –
 - Ocean City = 5.6 mm/yr (1.8 ft/100 yrs)
 - Baltimore = 3.1 mm/yr (1.0 ft/100 yrs)
 - Solomons Island = 3.7 mm/yr (1.2 ft/100 yrs)

Subsidence in the area of Chesapeake Bay

1973 Report by S. Holdhal and N. Morrison

IGS08 Vertical Velocity at Selected CORS

CORB = - 0.0010

VAGP = - 0.0027

BACO = - 0.0032

GODE = - 0.0011

GAIT = - 0.0004

ANP6 = - 0.0016

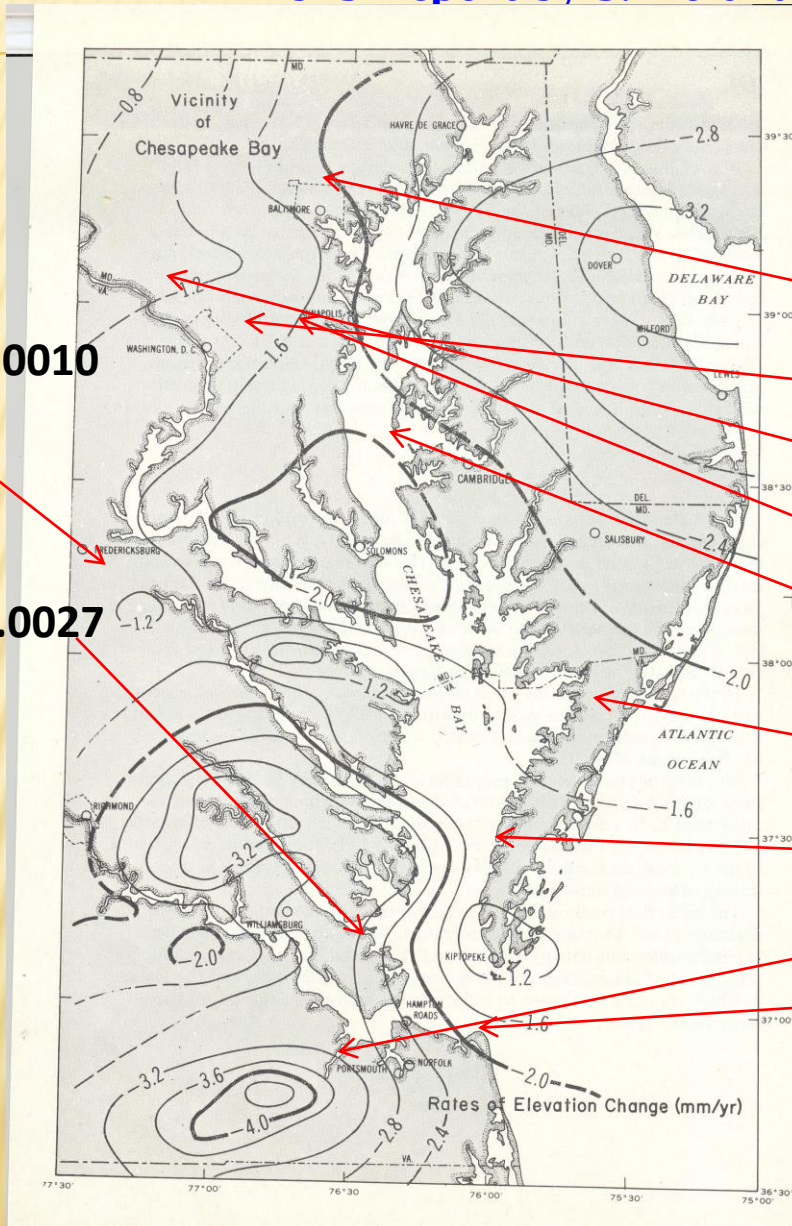
HNPT = - 0.0024

VAWI = - 0.0043

VIMS = - 0.0034

DRV6 = - 0.0033

COVX = - 0.0016



New Reference Frame Names

NAD 83 becomes:

North American Terrestrial Reference Frame (NATR2022)

Caribbean Terrestrial Reference Frame (CTRF2022)

Mariana Terrestrial Reference Frame (MTRF2022)

Pacific Terrestrial Reference Frame (PTRF2022)

NAVD 88 becomes:

North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

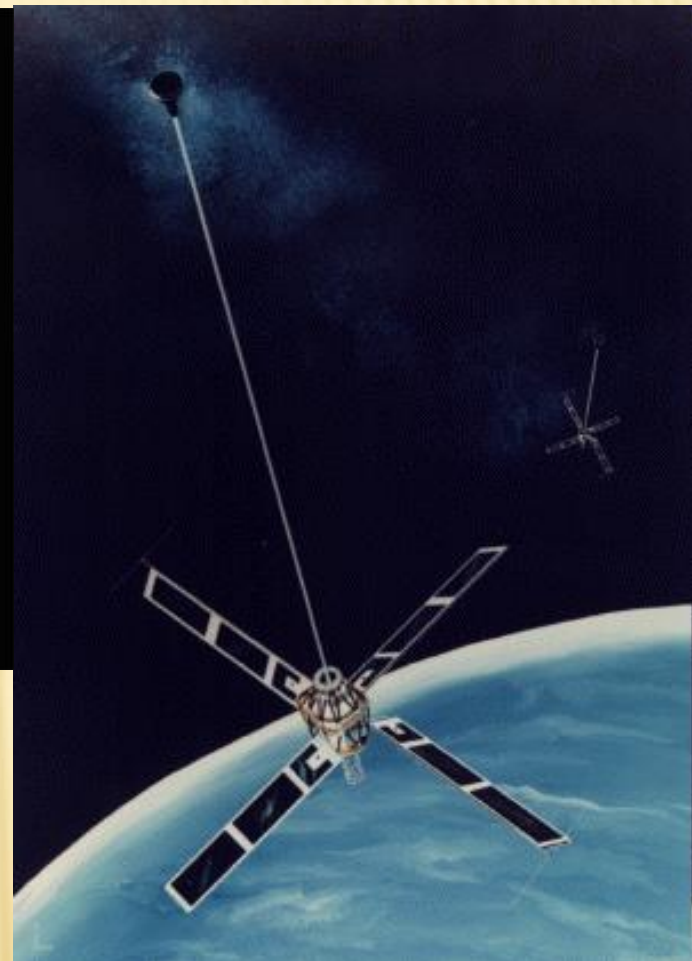
Realized by GEOID2022

Electronic technology 1950s - 1970



A Game Changer





U.S. NAVY NAVSAT TRANSIT SATELLITE “Doppler”

Prototype Launched (Failed) 1959

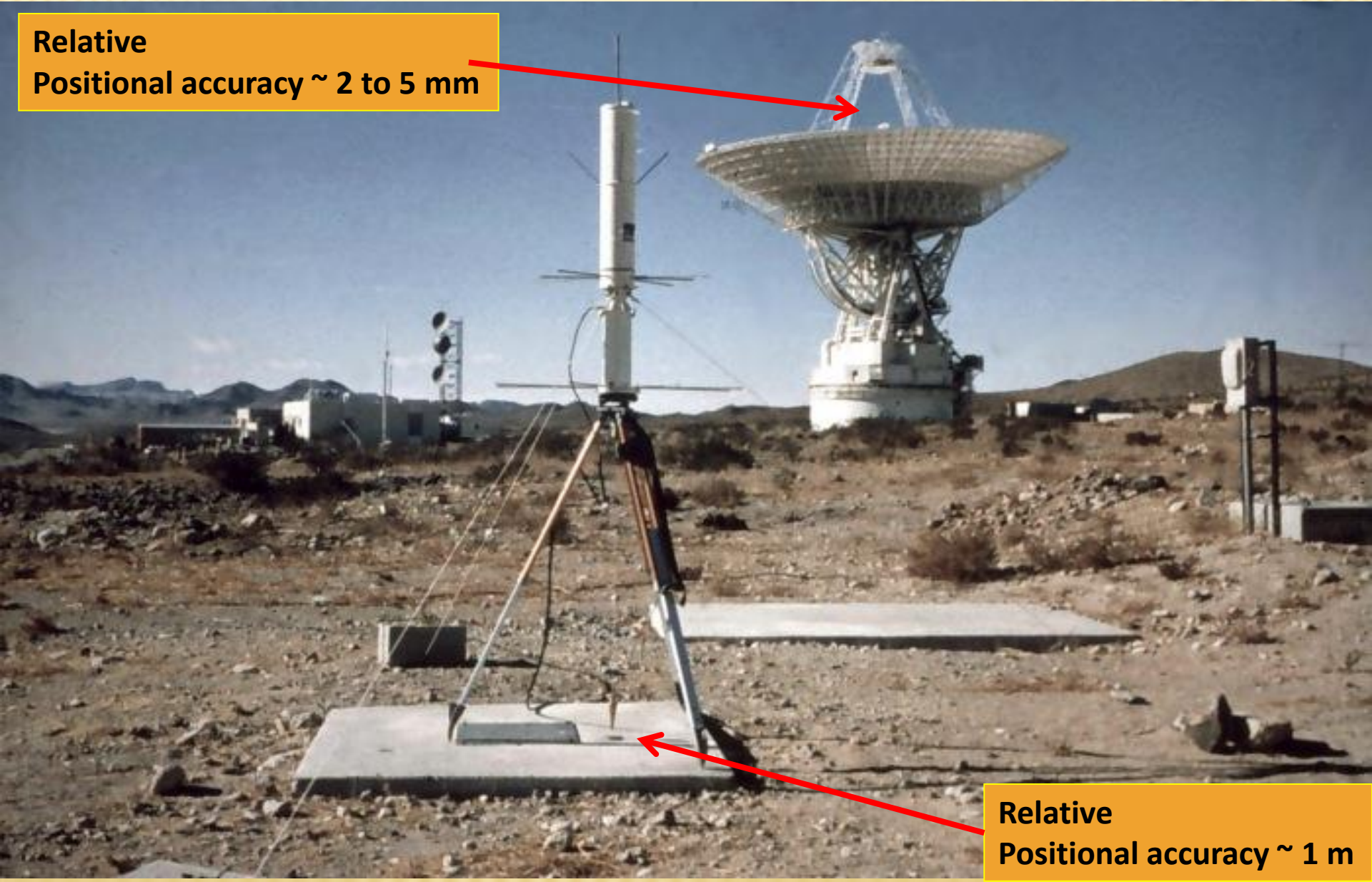
First Successful Test 1960

Operational 1964 (Military)

Civilian Access 1967

Transit Geociever and VLBI

Relative
Positional accuracy ~ 2 to 5 mm



Relative
Positional accuracy ~ 1 m

Macrometer V-1000 GPS Receiver

1982 ~ appox. \$250,000 each



Global Positioning System



GPS Block I



GPS Block II

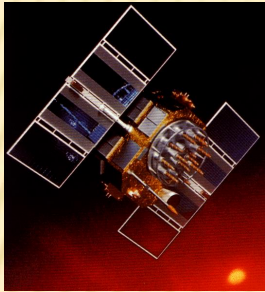


GPS Block III

- **February 22, 1978 - 1st NAVSTAR Satellite launched**
- **July 17, 1995 - System Fully Operational**
- **May 1, 2000 - Selective Availability turned off**
- **September 26, 2005 - L2C band added**
- **May 28, 2010 - First L5 Satellite added**
(12 L5 SVs launched)
- **May 3, 2017 – First Block III scheduled for launch?**
- **2020? - 10-50 cm real-time accuracy! Maybe Sooner!**

NO GROUND CONTROL!

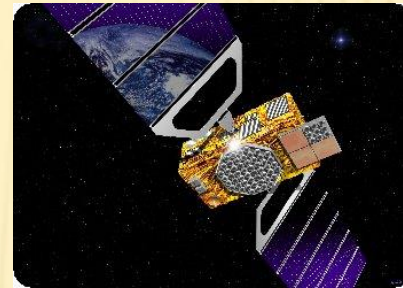
Global Navigation Satellite System



US - GPS



Russia - GLONASS



EU - Galileo



China – BeiDou

Four positioning and navigation systems

- **NAVSTAR/GPS – US (Currently 31)**
- **GLONASS – Russia (Currently 24)**
- **GALILEO – EU (Currently 18)**
- **BEIDOU – China (30+ by 2020?)**

Early NAD 83 Network Problems

NOT “GPSABLE”

POOR STATION ACCESSIBILITY

IRREGULARLY SPACED

POSITIONAL ACCURACY

**HIGH PRECISION GPS NETWORK (HPGN)
HIGH ACCURACY REFERENCE NETWORK (HARN)
1989 - 1997**

“GPSABLE”

Clear Horizons for Satellite Signal Acquisition

EASY ACCESSIBILITY

Few Special Vehicle or Property Entrance Requirements

REGULARLY SPACED

Always within 20-100 Km

HIGH ACCURACY

A-Order (5 mm + 1:10,000,000) (3 5.5 hr sessions)

B-Order (8mm + 1:1,000,000) (2 5.5 hr sessions)

Maryland Observed – 1991

Published as NAD 83 (1991)

FEDERAL & COOPERATIVE BASE NETWORKS (FBN/CBN)

1997 -2004

More State Partnerships

**Remove Distortions in Some Early HARNs
(3-10 CM)**

Ensure Connections CORS

**Improve Ellipsoid Height Accuracy
(Not greater than 2 cm)**

Maryland Observed – 2000

NAD 83 (2007)

First national adjustment of all GPS-derived positions for passive stations in the NSRS

Approx. 68,000 stations with GPS observations dating to mid-1980s

Constrained to CORS network who's positions were considered to be perfect (!)

Can be considered to be identical to NAD 83 (CORS96) – Same as positions from OPUS at that time

Average shift from NAD 83 (1991) to NAD 83 (2007) in MD ~ 0.03 m

NAD 83 (2011)

During 2009-2010 NGS completes multi-year solution of 2000+ CORS

Data from January 1994 to April 2011

Replaced relative GPS antenna calibrations with absolute calibrations

More consistent national set of coordinates Maine to Guam

National adjustment of 81,000+ passive stations to fit new CORS coordinates

Average shift from NAD 83 (2007) to NAD 83 (2011) in MD ~ 0.03 m

International Gold Standard

International Earth Rotation and Reference System Service (IERS)



**Established 1987
Office in Paris, France**

**Produces the International Terrestrial Reference System
And
International Terrestrial Reference Frame**

**First ITRF – 1988
Current ITRF – 2014**

IERS Four Geodetic Services



International GNSS Service



International DORIS Service



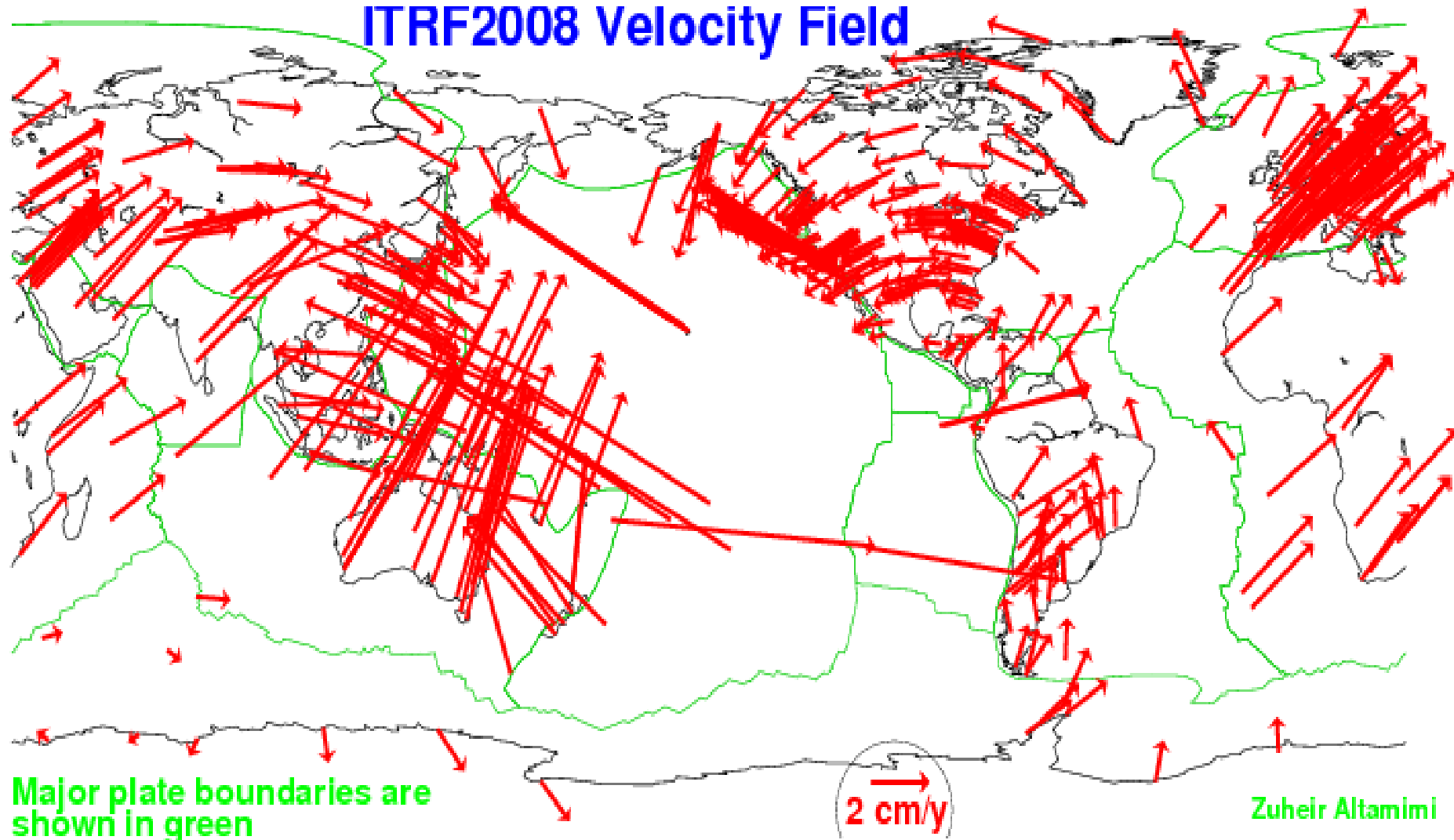
International Laser Ranging Service



International VLBI Service

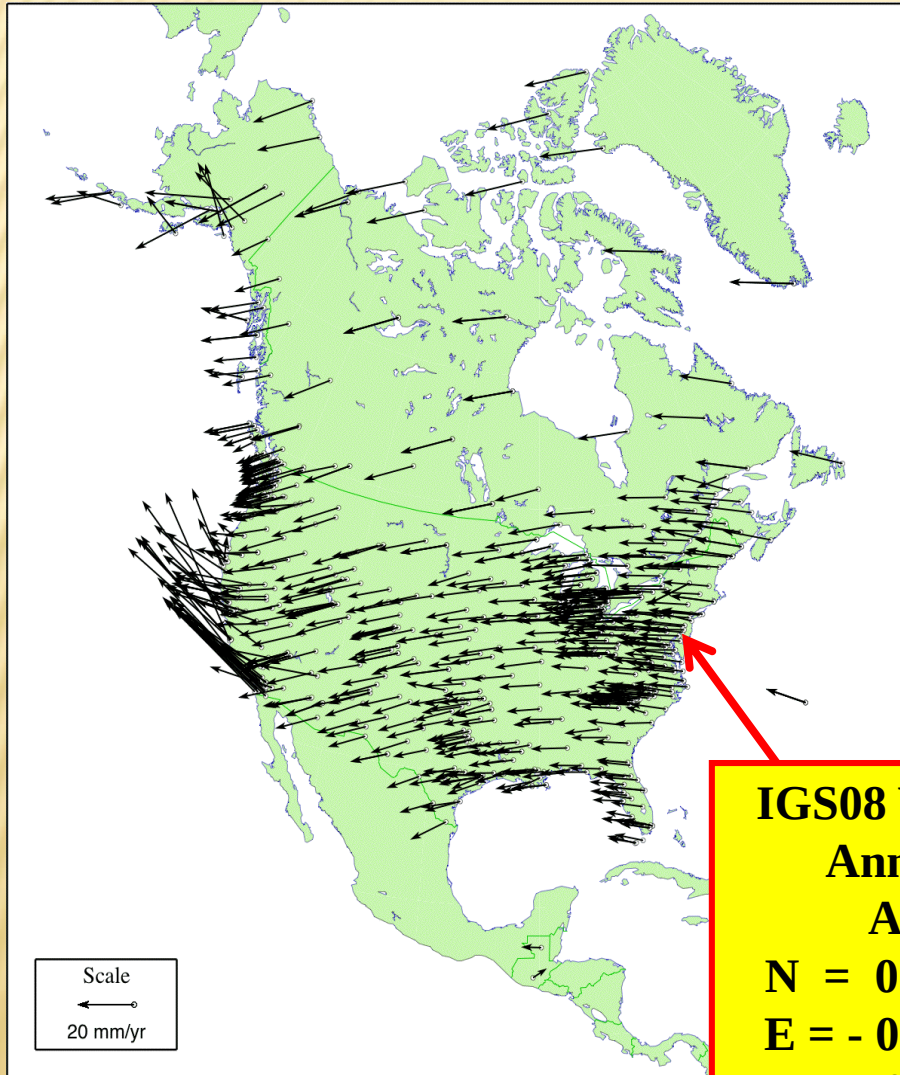
Tectonic Plate Velocities

ITRF2008 Velocity Field

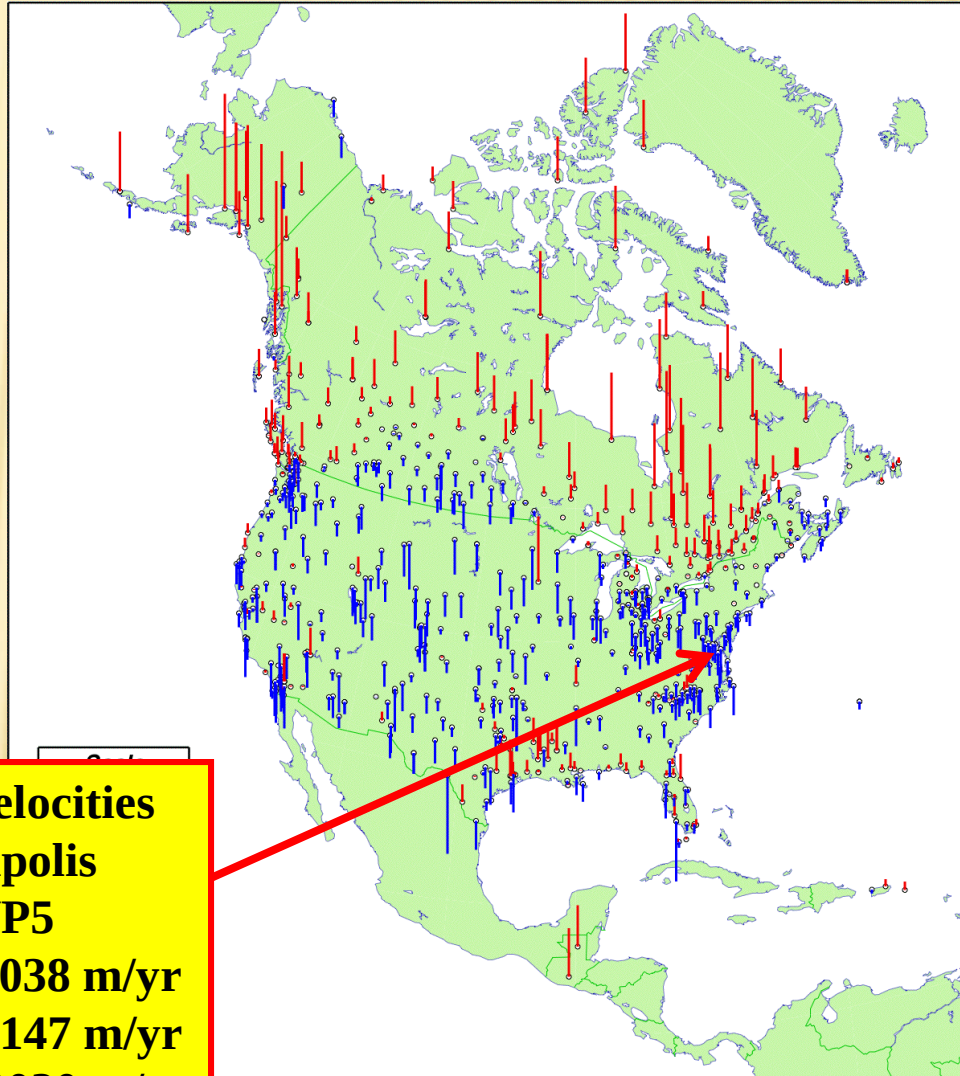


Tectonic Plate Velocities

Horizontal



Vertical



**IGS08 Velocities
Annapolis
ANP5**

N = 0.0038 m/yr

E = - 0.0147 m/yr

U = - 0.0020 m/yr

IGS08 is the GNSS component of the ITRF08

They can be considered to be equivalent

ANNAPOLIS 5 (ANP5), MARYLAND

Antenna Reference Point(ARP): ANNAPOLIS 5 CORS ARP

PID = DJ5210

IGS08 POSITION (EPOCH 2005.0)

Computed in Aug 2011 using data through gpwsk 1631.

X =	1149298.561 m	latitude	=	39 00 37.03416 N
Y =	-4827706.894 m	longitude	=	076 36 33.29391 W
Z =	3993217.347 m	ellipsoid height	=	20.417 m

IGS08 VELOCITY

Computed in Aug 2011 using data through gpwsk 1631.

VX =	-0.0152 m/yr	northward	=	0.0038 m/yr
VY =	0.0005 m/yr	eastward	=	-0.0147 m/yr
VZ =	0.0017 m/yr	upward	=	-0.0020 m/yr

NAD_83 (2011) POSITION (EPOCH 2010.0)

Transformed from IGS08 (epoch 2005.0) position in Aug 2011.

X =	1149299.242 m	latitude	=	39 00 37.00438 N
Y =	-4827708.347 m	longitude	=	076 36 33.28038 W
Z =	3993217.438 m	ellipsoid height	=	21.695 m

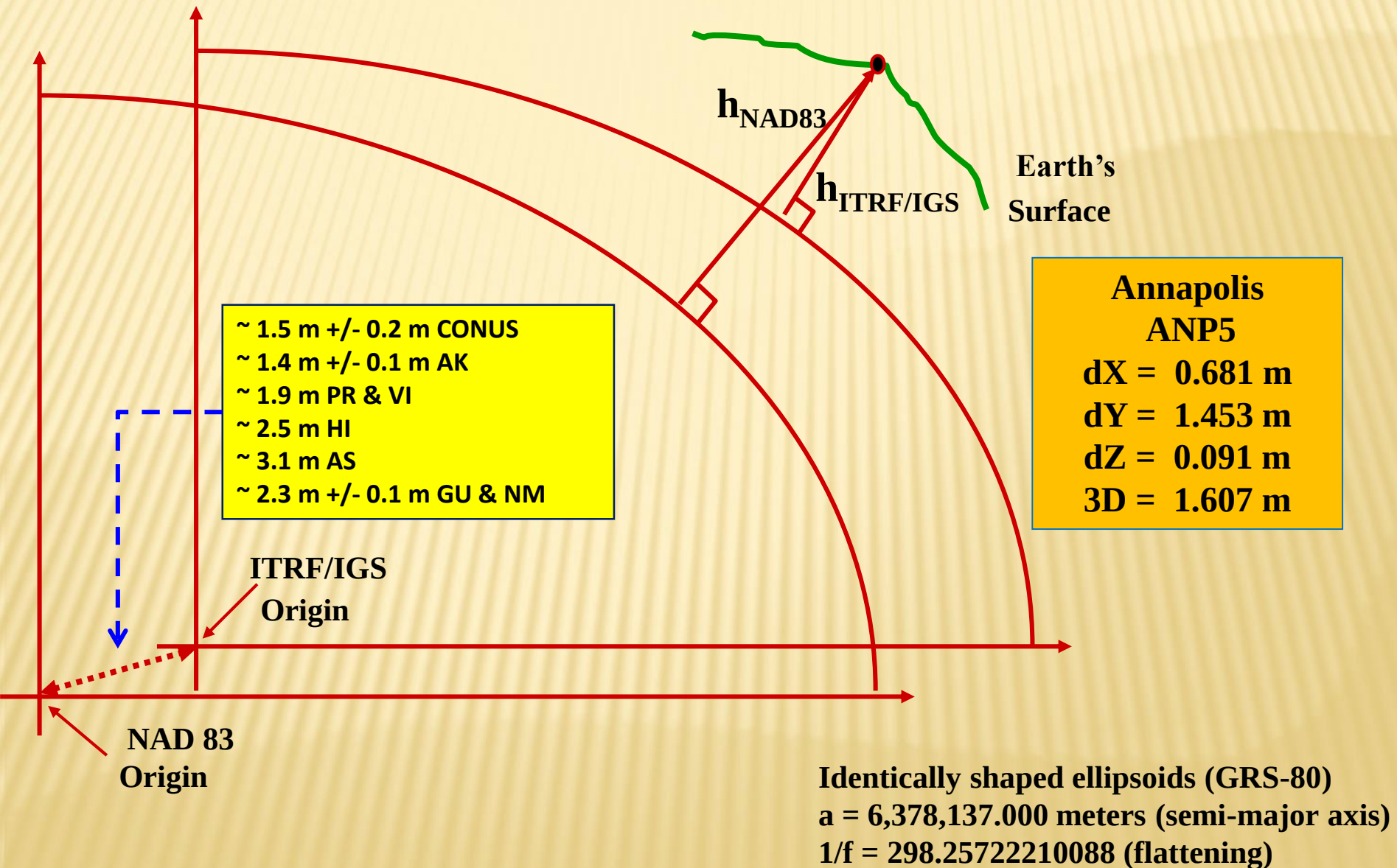
NAD_83 (2011) VELOCITY

Transformed from IGS08 velocity in Aug 2011.

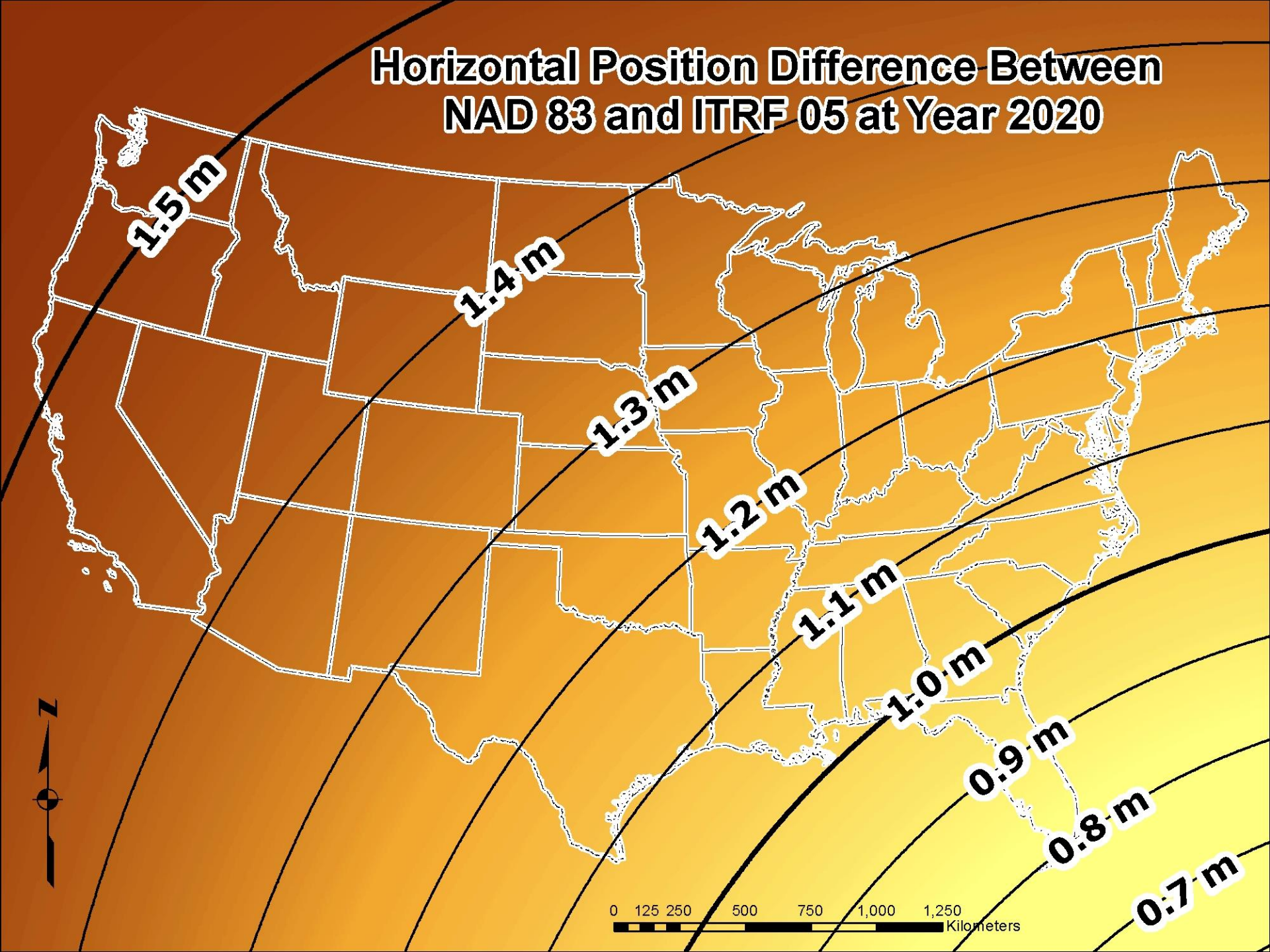
VX =	0.0013 m/yr	northward	=	-0.0011 m/yr
VY =	0.0020 m/yr	eastward	=	0.0017 m/yr
VZ =	-0.0027 m/yr	upward	=	-0.0030 m/yr

IGS08 - NAD 83(2011)
 Δ Horiz = 0.974m/3.20ft
 Δ Eht = 1.278m/4.19ft

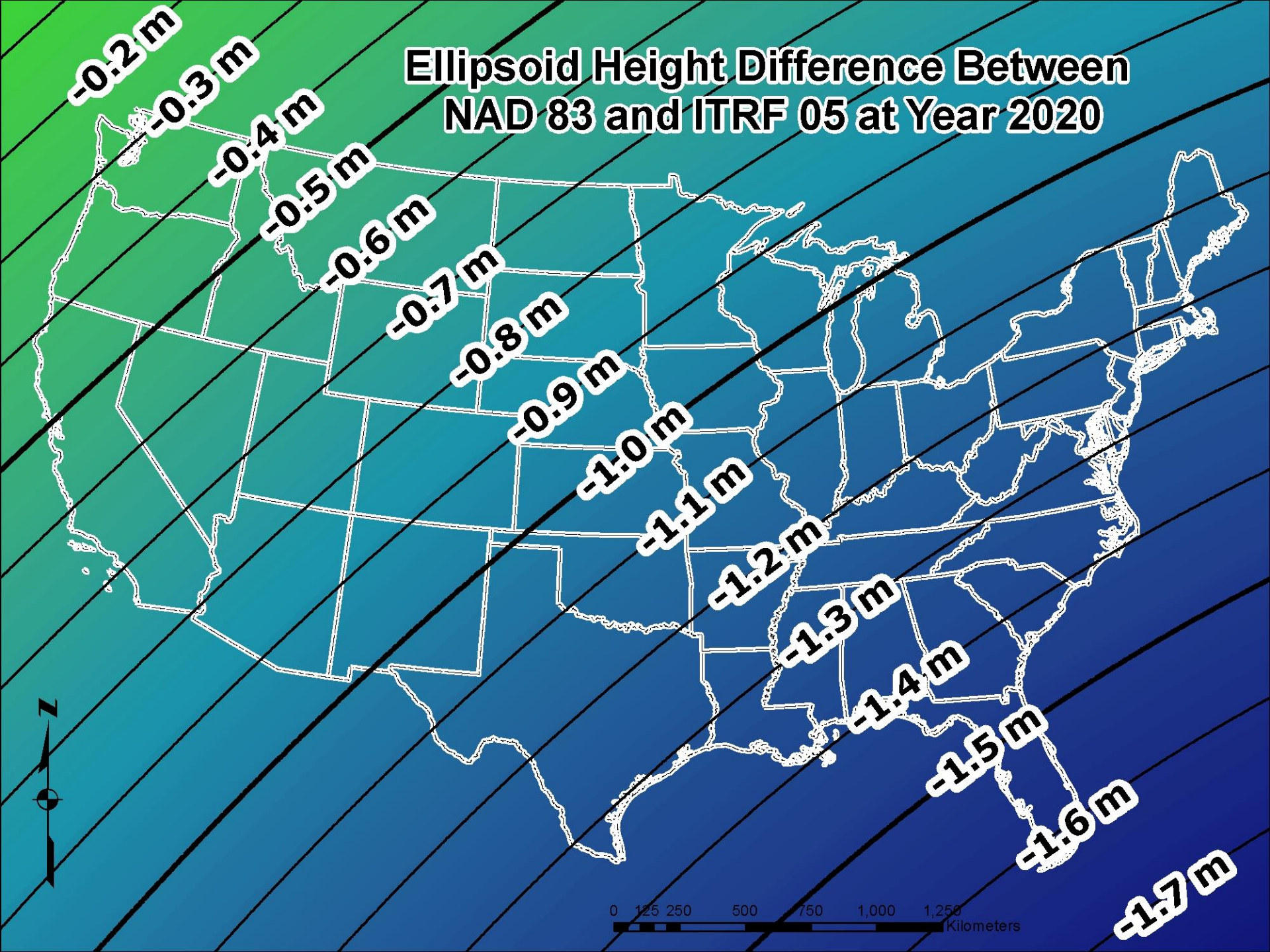
Simplified Concept of NAD 83 vs. ITRF/IGS



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

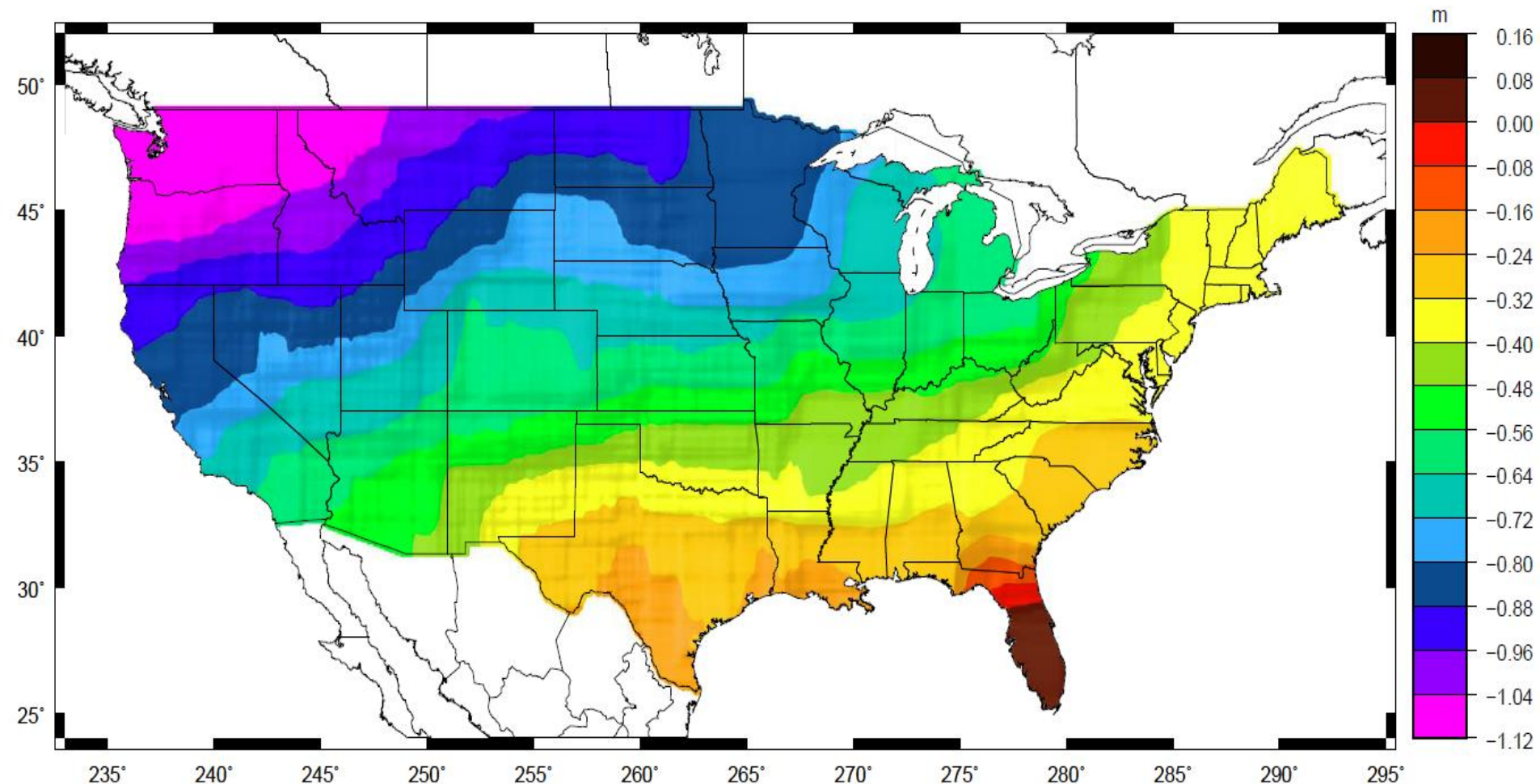


Ellipsoid Height Difference Between NAD 83 and ITRF 05 at Year 2020



Why isn't NAVD 88 good enough anymore?

Approximate level of global geoid mismatch known to exist in the NAVD 88 zero surface:



THE GEOID

An equipotential surface to which gravity is normal and most closely approximates Mean Sea Level over the entire Earth.

So What Do We have??

Types of NGS Geoid Height Models

Gravimetric (or Gravity) Geoid Height Models

(e.g. xGEOID16A&B, USGG2012, USGG2009)

Defined by gravity data crossing the geoid

Refined by terrain models (DEM's)

Scientific and engineering applications

Composite (or Hybrid) Geoid Height Models

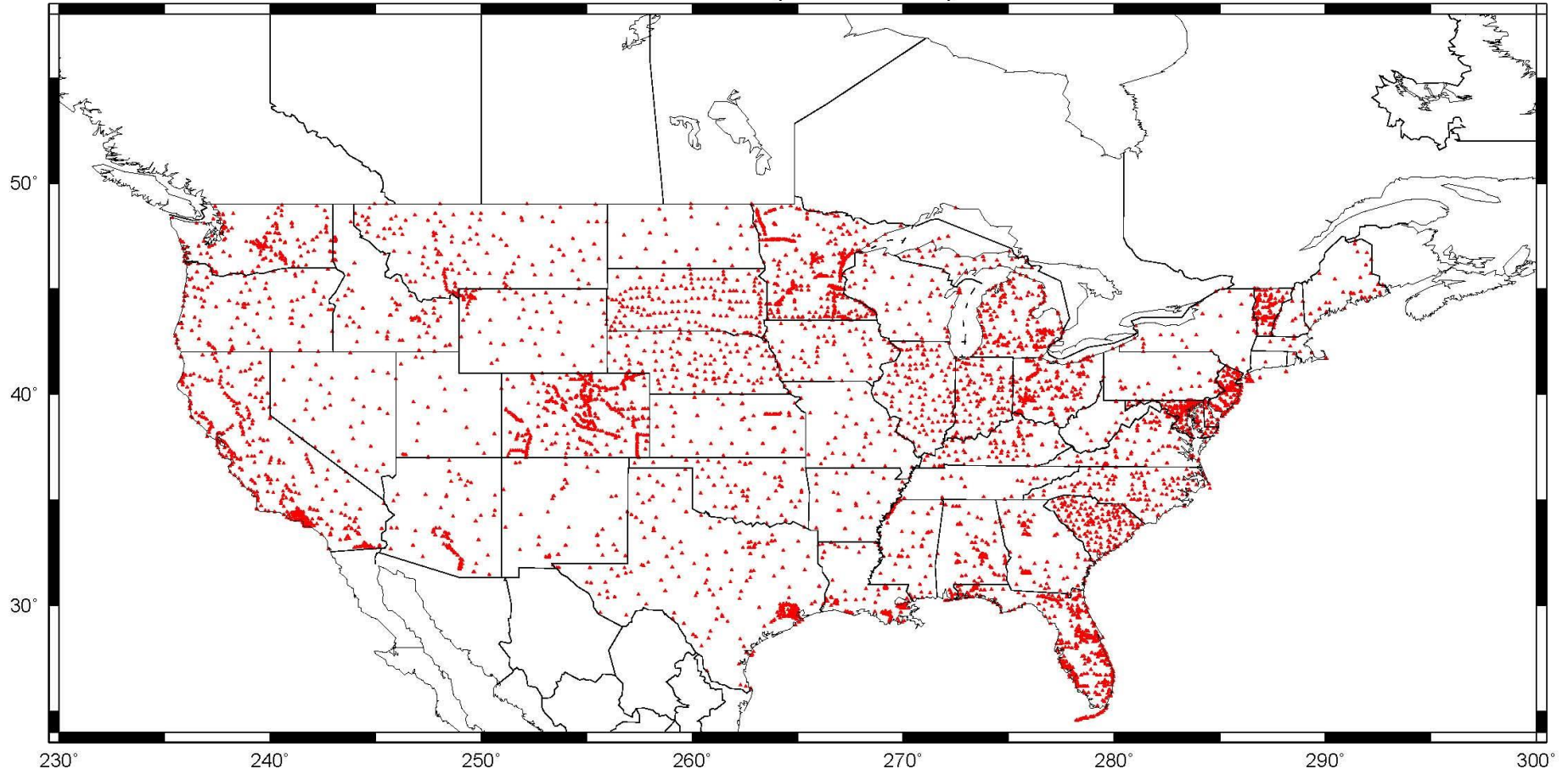
(e.g. GEOID12A/B, GEOID09)

Starts with gravimetric geoid model

Warped to fit available GPS on BM control data

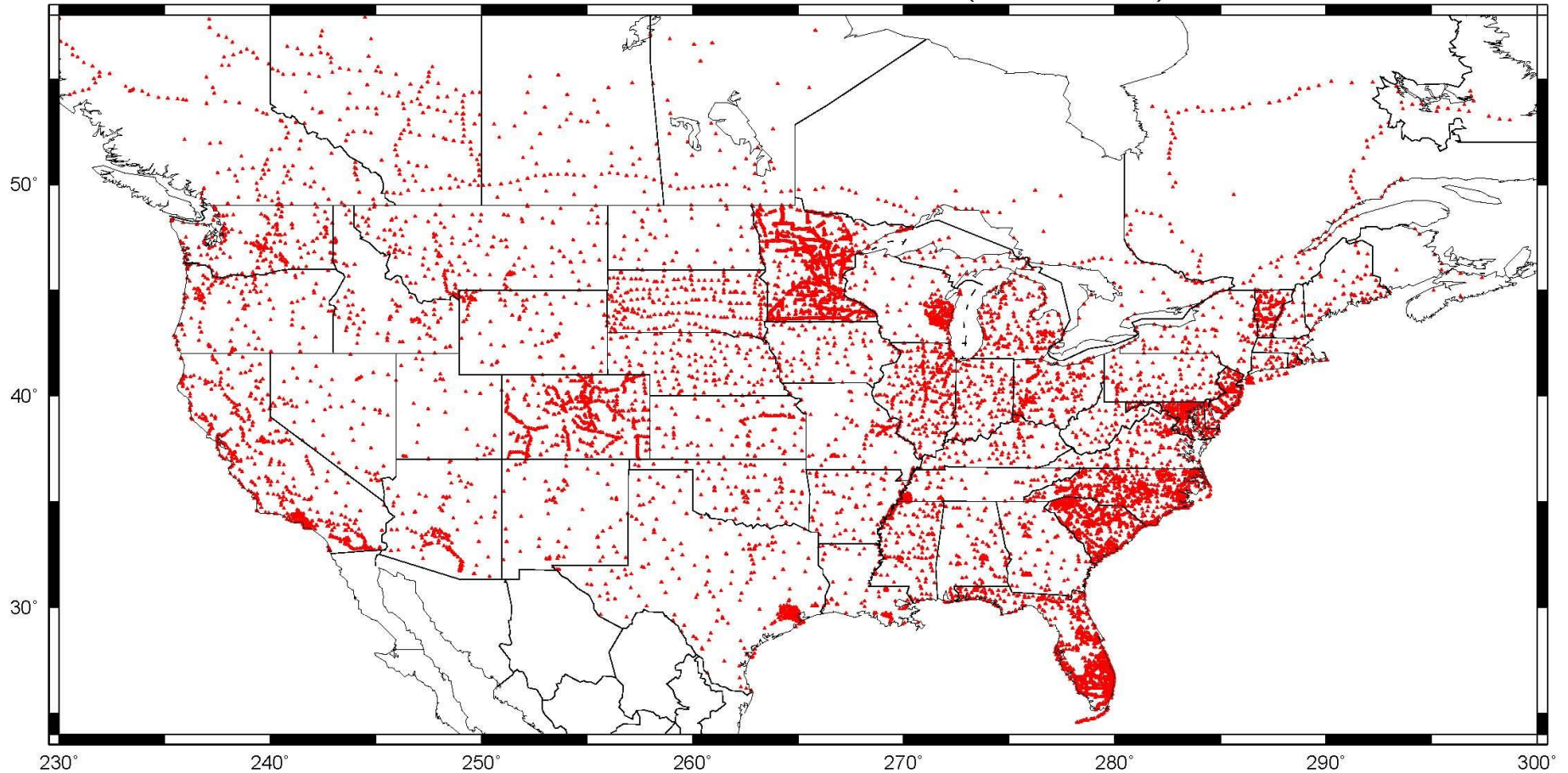
Defined by legislated geometric datum (NAD 83) and local vertical datum (NAVD 88, PRVD02, etc.)

GPS BMs for GEOID99 (6169 Points)



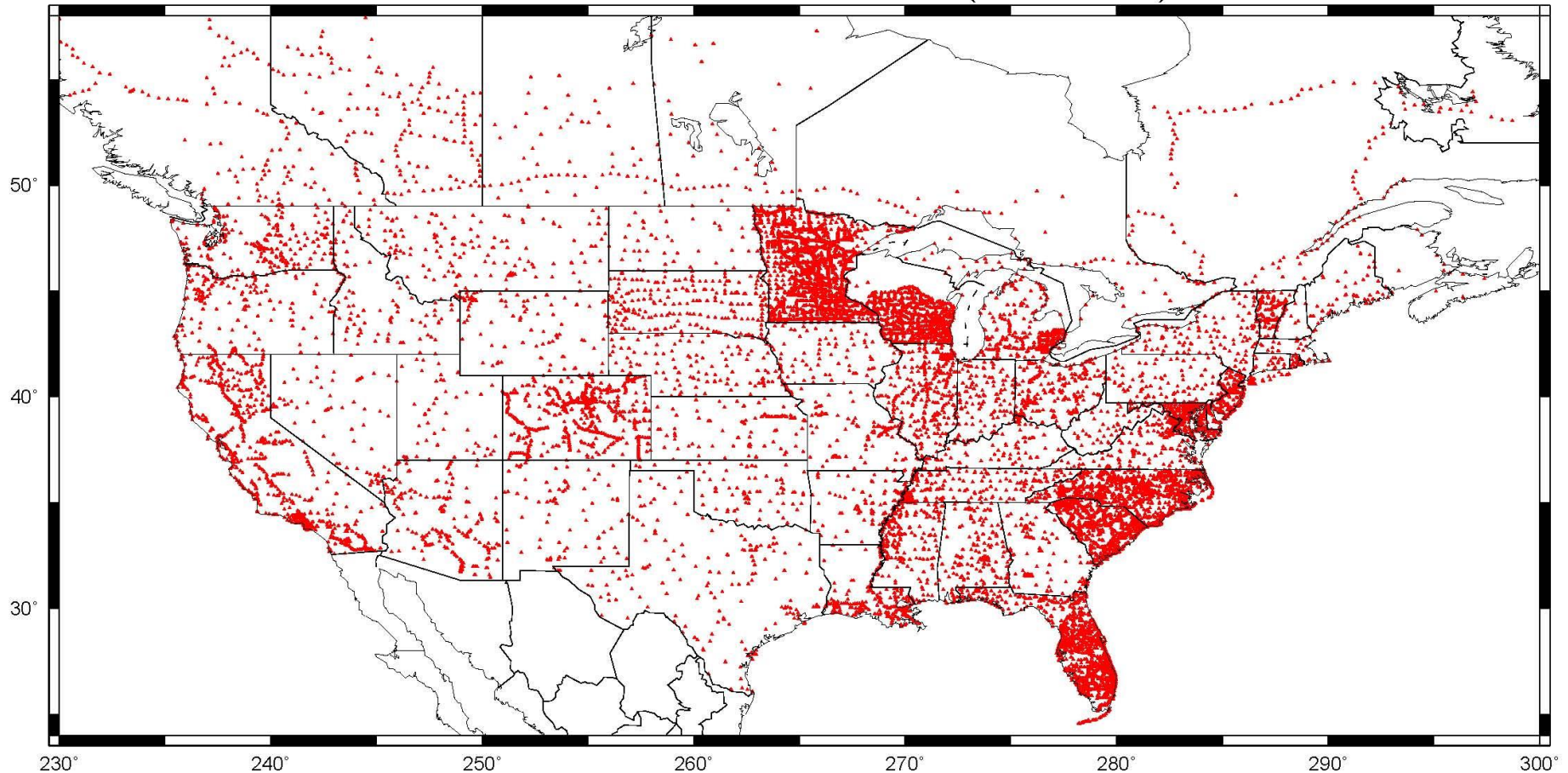
GPSBM1999:	6,169 total	0 Canada	STDEV 9.2 cm (2σ)
GPSBM2003:	14,185 total	579 Canada	STDEV 4.8 cm (2σ)
GPSBM2009:	18,291 total	576 Canada	STDEV 2.8 cm (2σ)

GPS Bench Marks Used for GEOID03 (14185 Points)



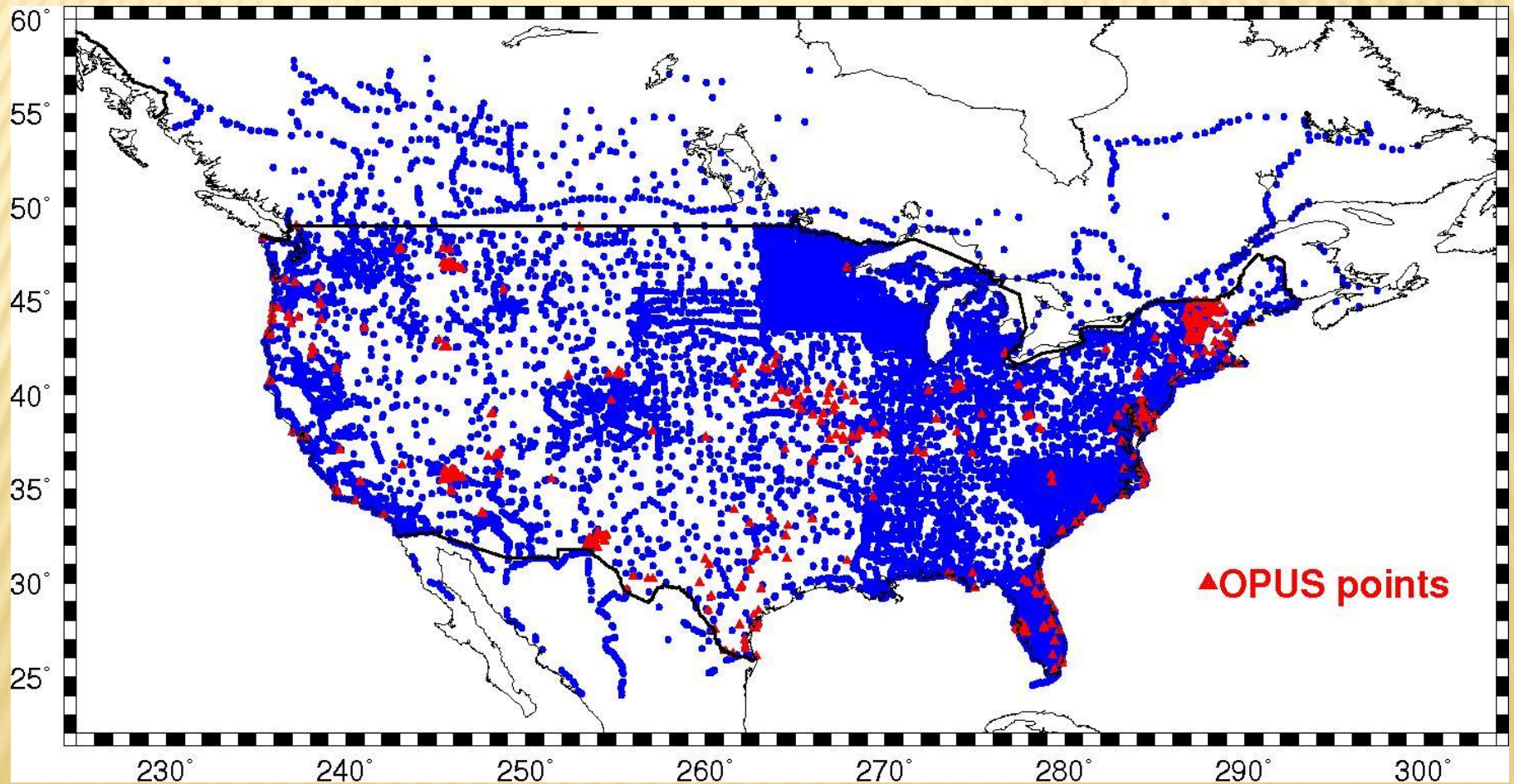
GPSBM1999:	6,169 total	0 Canada	STDEV 9.2 cm (2σ)
GPSBM2003:	14,185 total	579 Canada	STDEV 4.8 cm (2σ)
GPSBM2009:	18,291 total	576 Canada	STDEV 2.8 cm (2σ)

GPS Bench Marks Used for GEOID09 (18972 Points)



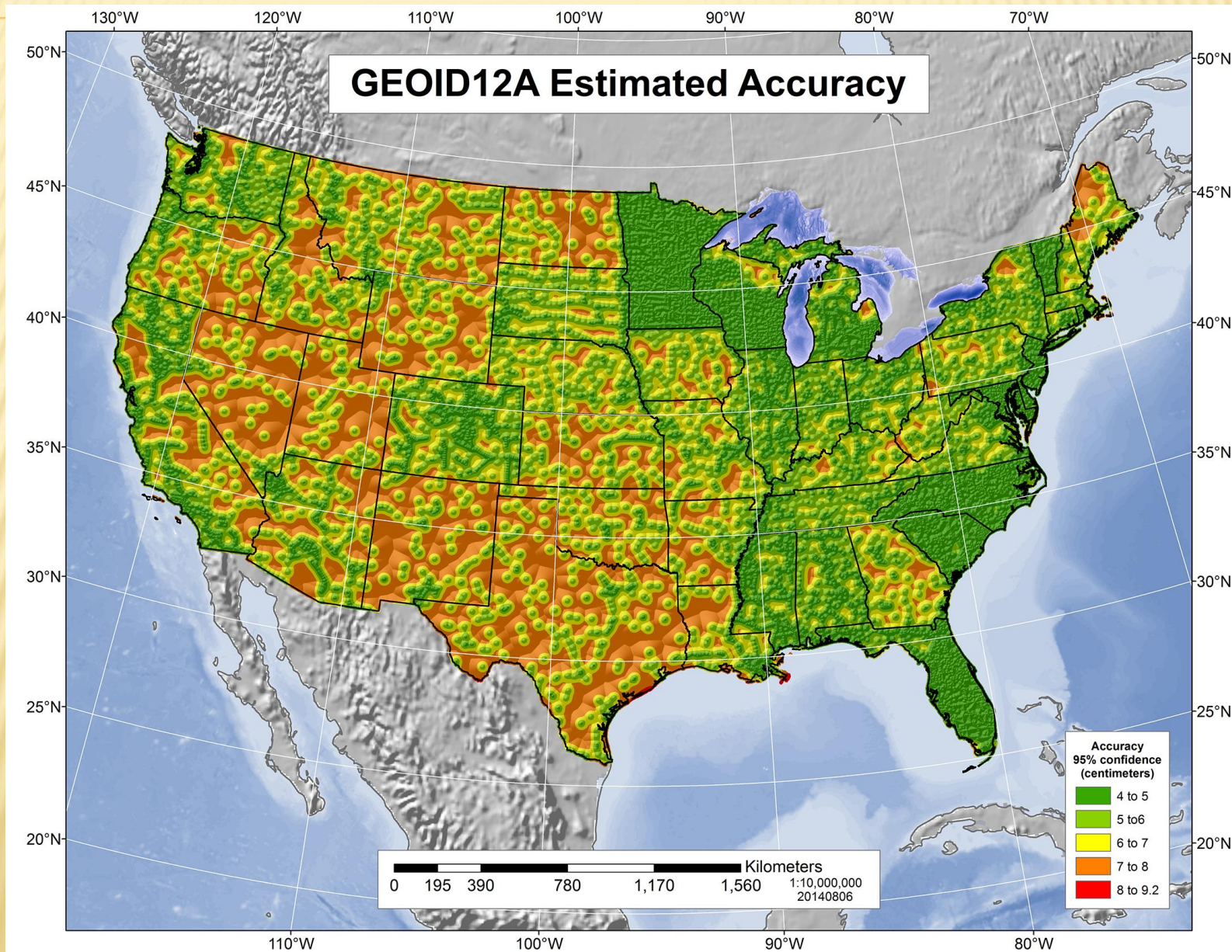
GPSBM1999:	6,169 total	0 Canada	STDEV 9.2 cm (2σ)
GPSBM2003:	14,185 total	579 Canada	STDEV 4.8 cm (2σ)
GPSBM2009:	18,291 total	576 Canada	STDEV 2.8 cm (2σ)

Distribution of GPSBM in GEOID12A/B

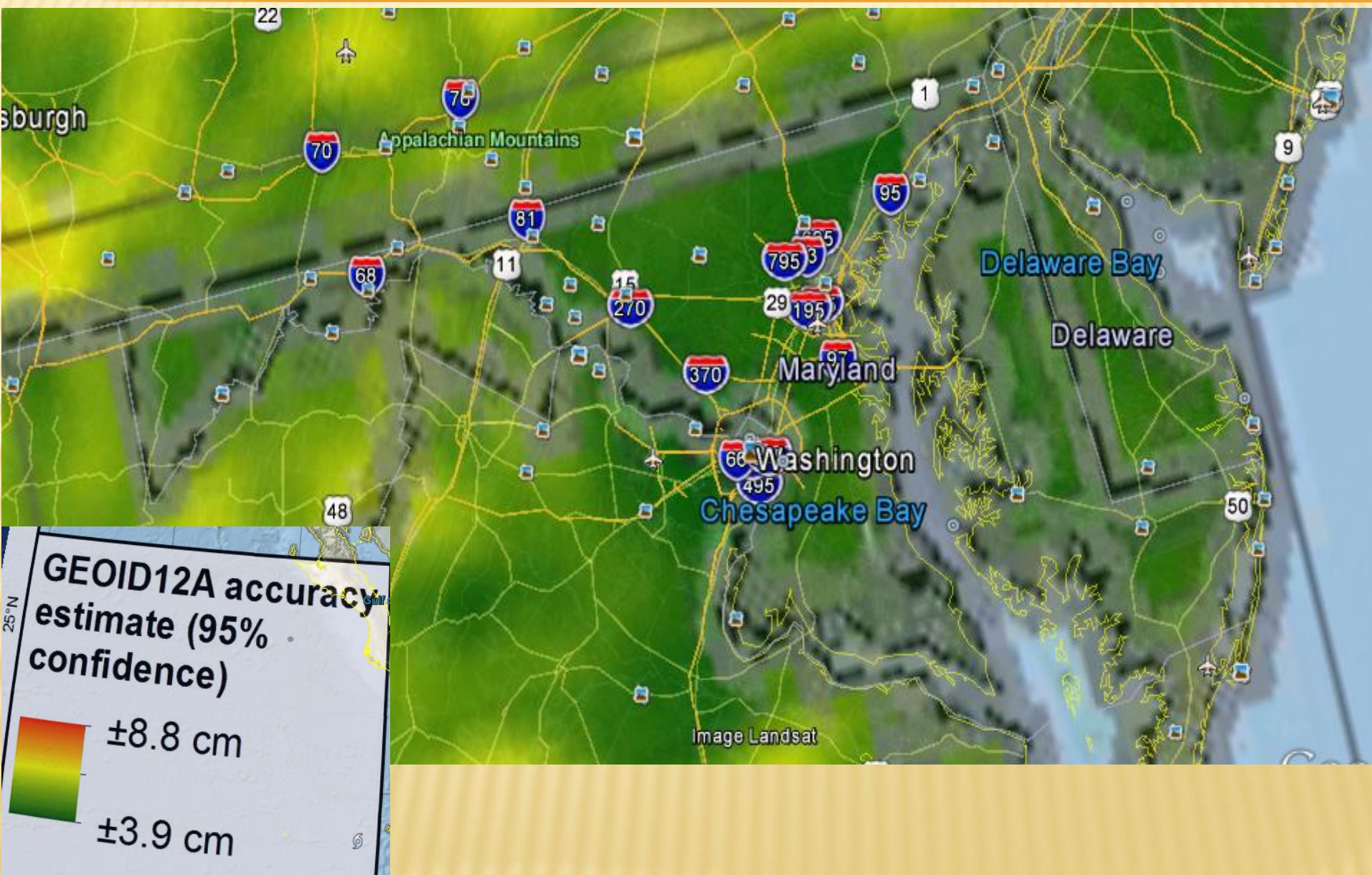


GEOID 12A/B ACCURACY

http://www.ngs.noaa.gov/web/surveys/GPSONBM/maps/GEOID12A_Accuracy.png



GEOID 12A ACCURACY IN MARYLAND

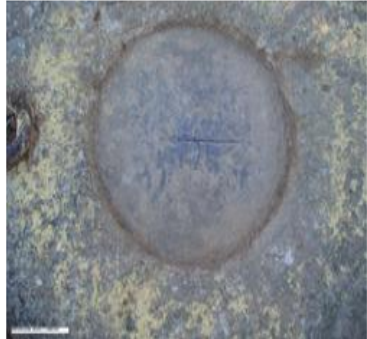
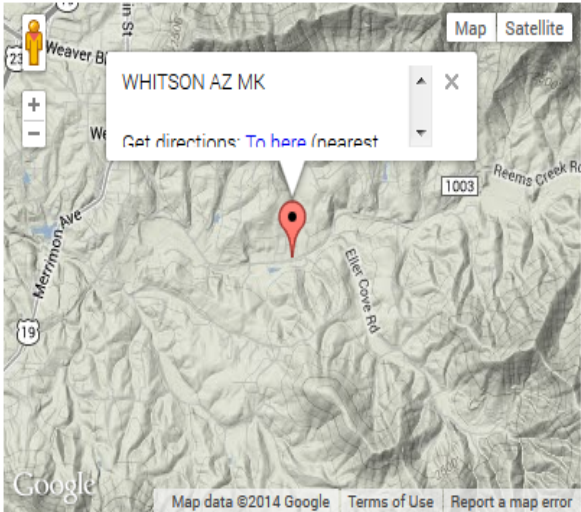


OPUS – DB

Simple Shared Data NGS Archived

- Update scaled NAD 83 positions for most NAVD 88 BMs
- Position NAVD 88 BMs for inclusion in next geoid model
- Helps improve accuracy of future vertical datum transformation tool
- Validate position/height of stations published in NSRS
- Position your new marks
- Position marks of other agencies not already in NSRS:
 - USGS
 - USACE
 - BOR
 - GLO/BLM
 - State DoT

SURVEY DATASHEET (Version 1.0)

PID: AA5693 Designation: WHITSON AZ MK Stamping: WHITSON 1991 Stability: May hold commonly subject to ground movement Setting: Set in top of concrete monument Mark: GC Condition: GC Description: MARK PROJECTS 1 INCH AND IS LOCATED 30.4 FEET SOUTHEAST OF THE NORTHEAST END OF A 15 INCH CORRUGATED METAL PIPE UNDER HAMBURG MOUNTAIN ROAD. Observed: 2007-12-17T14:20:00Z See Also 1991 See Also Original Source: OPUS - page5 1209.04							
Close-up View							
<table border="1"><tr><td>REF_FRAME: NAD_83(2011)</td><td>EPOCH: 2010.0000</td><td>SOURCE: NAVD88 (Computed using GEOID12A)</td><td>UNITS: m</td><td>SET PROFILE</td><td>DETAILS</td></tr></table>		REF_FRAME: NAD_83(2011)	EPOCH: 2010.0000	SOURCE: NAVD88 (Computed using GEOID12A)	UNITS: m	SET PROFILE	DETAILS
REF_FRAME: NAD_83(2011)	EPOCH: 2010.0000	SOURCE: NAVD88 (Computed using GEOID12A)	UNITS: m	SET PROFILE	DETAILS		
LAT: 35° 41' 12.59507" ± 0.006 m LON: -82° 32' 27.21872" ± 0.005 m ELL HT: 600.507 ± 0.008 m X: 673347.145 ± 0.005 m Y: -5142941.718 ± 0.009 m Z: 3700374.662 ± 0.004 m ORTHO HT: 630.402 ± 0.020 m	UTM 17 SPC 3200(NC) NORTHING: 3950308.326m 220570.488m EASTING: 360570.466m 289183.253m CONVERGENCE: -0.89903249° -2.04369875° POINT SCALE: 0.99983956 0.99990134 COMBINED FACTOR: 0.99974533 0.99980711						
CONTRIBUTED BY james.gay North Carolina 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 info

What can you do to improve the next NGS geoid model? / 2022 vertical transformation tool?

OPUS – DB “Shared Solutions”

<http://www.geodesy.noaa.gov/OPUS/about.jsp#sharing>

Share Your OPUS Solution

top ↑

it's simple, **upload to OPUS** using Options 'share my solution' and the following criteria:

Careful field procedures

- verify antenna type, height, and plumb
- fixed-height tripod recommended, brace the legs with sandbags or chain

High-Quality OPUS Solution

- 4+hour GPS data file
- $\geq 70\%$ observations used
- $\geq 70\%$ ambiguities fixed
- ≤ 3 cm RMS
- ≤ 4 cm peak-to-peaks, lat. & lon.
- ≤ 8 cm peak-to-peak, el. hgt.

Permanent mark of public interest

- durable, stable setting, with good satellite visibility
- add description & photos to aid future recovery
see **observer field log** (optional) and preview the **upload form**



Why share? Your data can help maintain local ties to the National Spatial Reference System, and, by linking observations, strengthen the models used to translate between modern and legacy mapping products.

[View shared solutions.](#)

Transition to the Future – GRAV-D

Gravity for the Redefinition of the American Vertical Datum

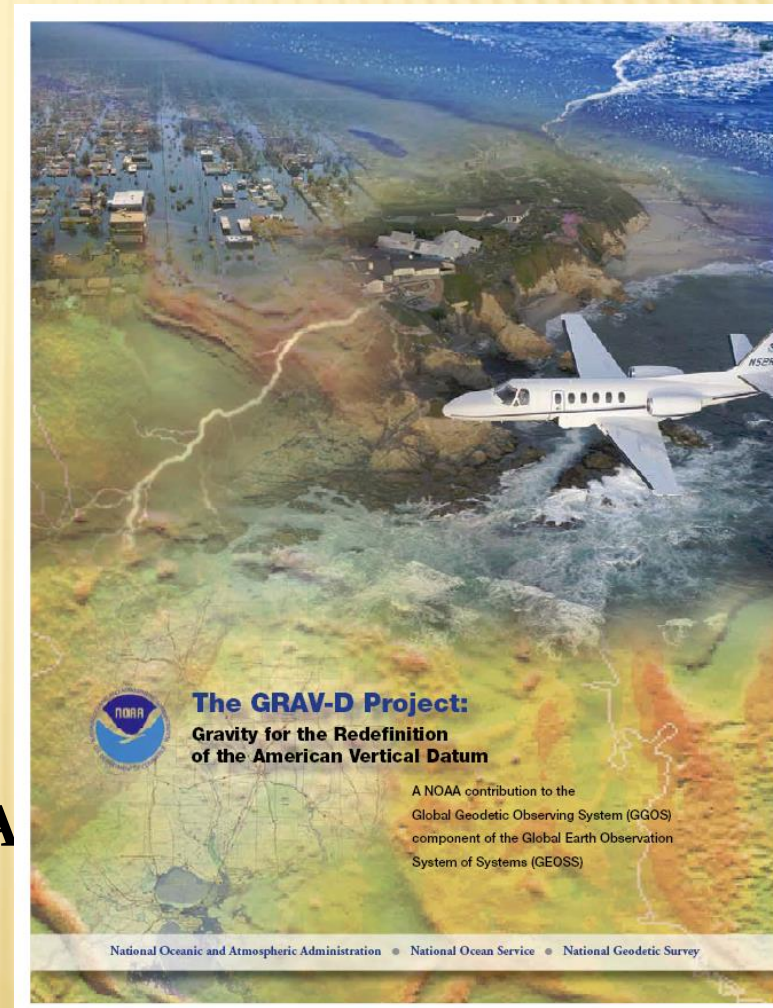
Official NGS policy as of Nov 14, 2007
\$38.5M over 10 years

Airborne Gravity Snapshot

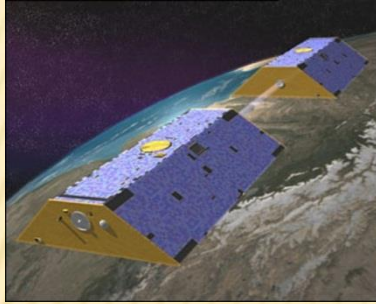
Absolute Gravity Tracking

Re-define the Vertical Datum of the USA
by 2022

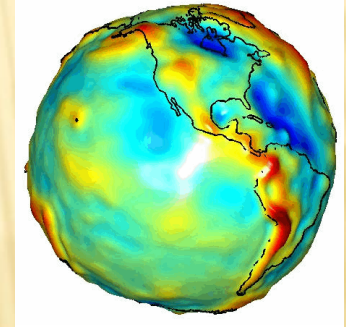
Approximately 58% Complete



Building a Gravity Field



Long Wavelengths
(≥ 250 km)



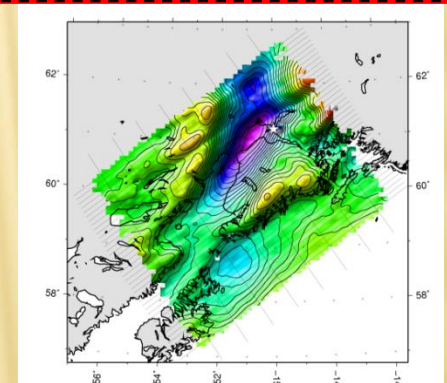
GRACE/GOCE/Satellite Altimetry

+

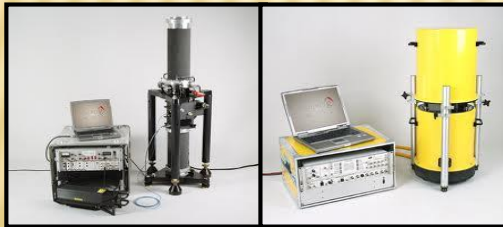


Intermediate Wavelengths
(500 km to 20 km)

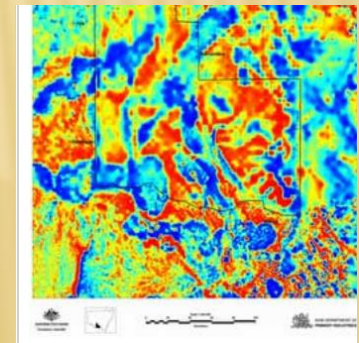
Airborne Measurement



+

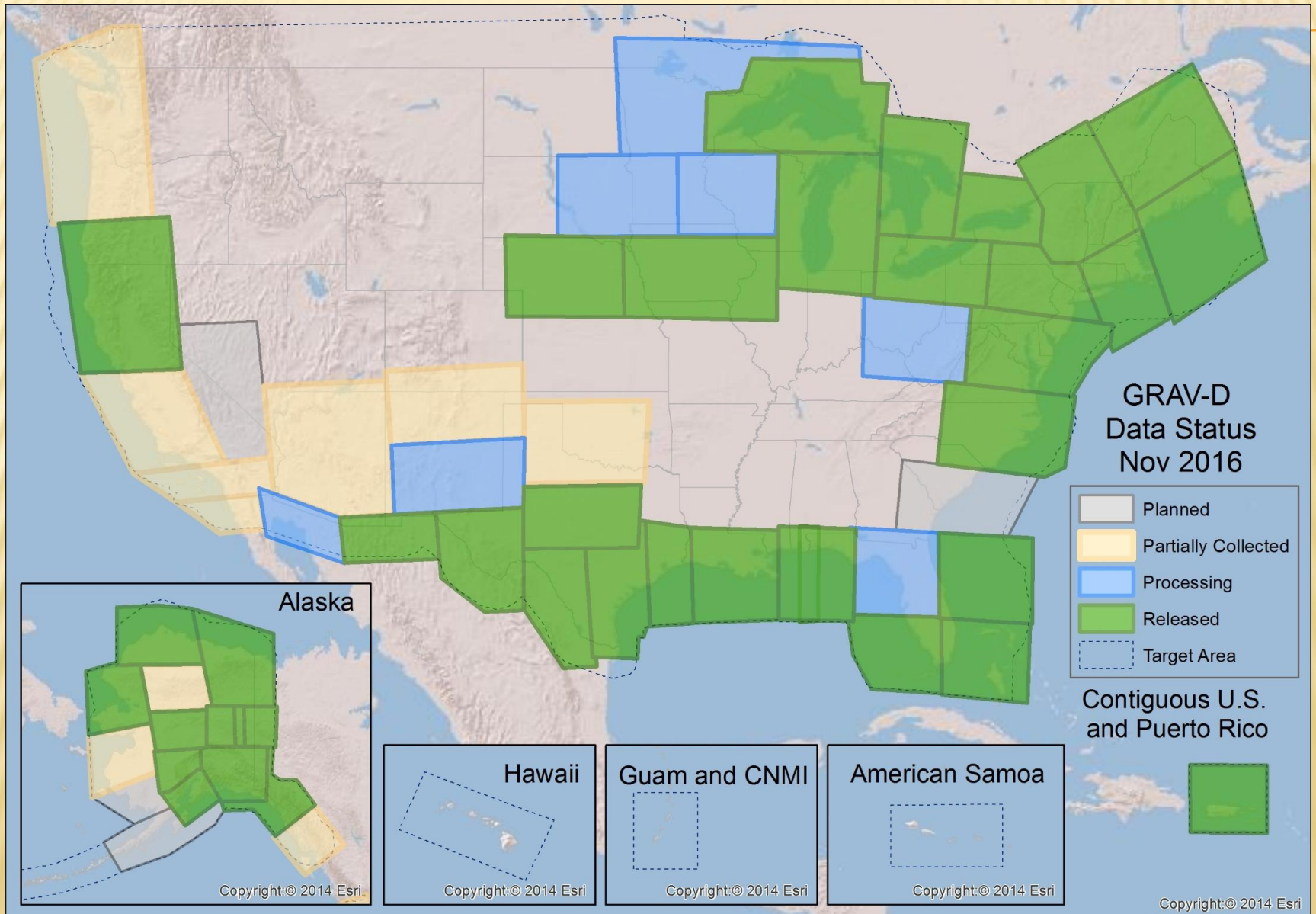


Short Wavelengths
(< 100 km)

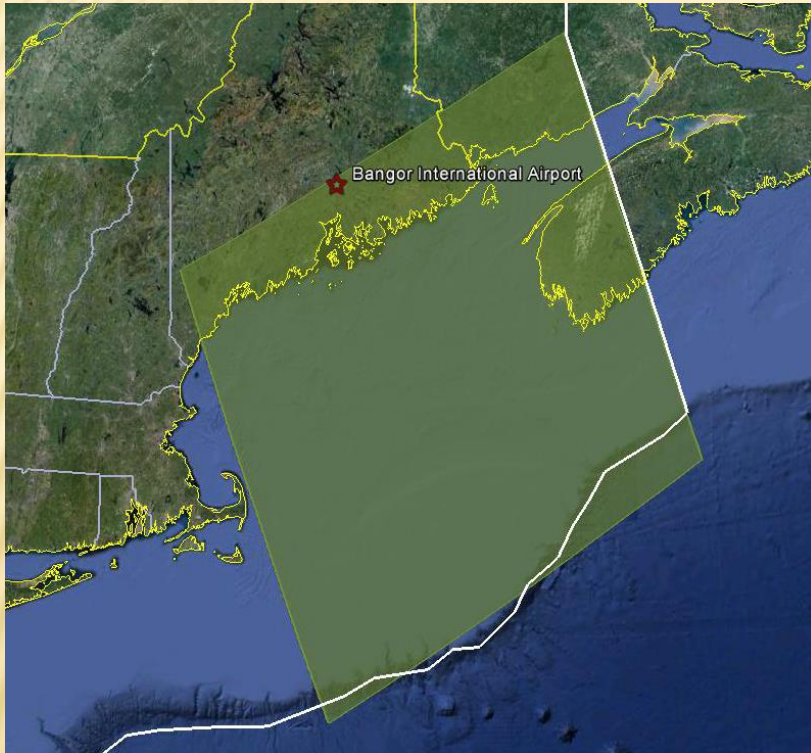


Surface Measurement and
Predicted Gravity from Topography

GRAV-D STATUS 12-31-16: 58.4%

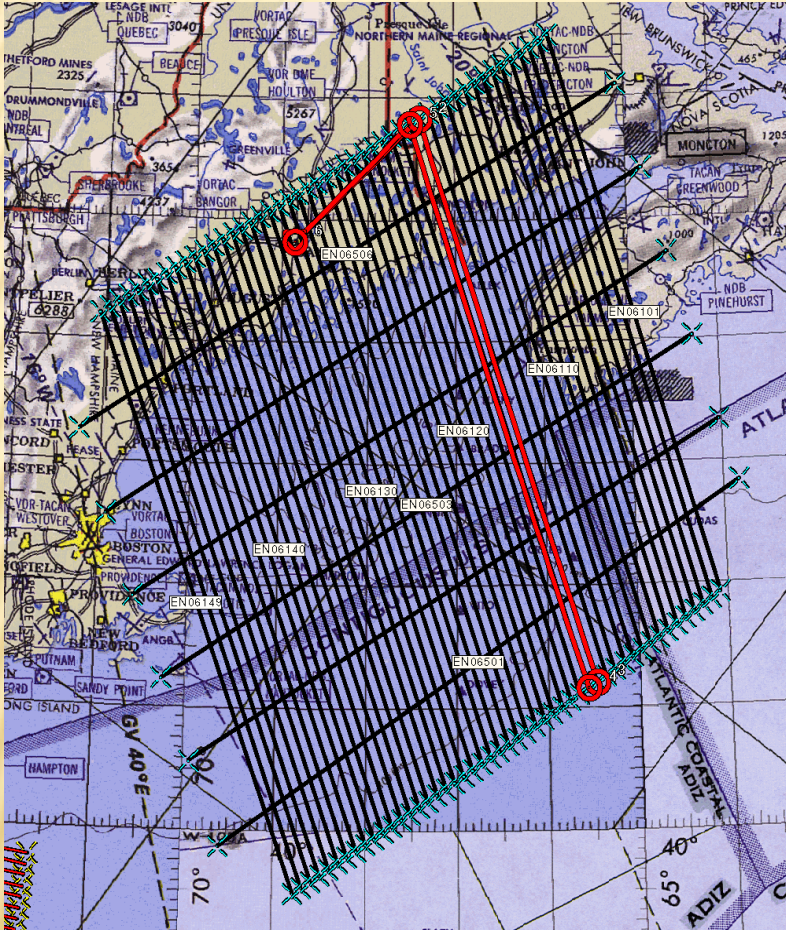


SURVEY AND BLOCK PLANS



- ✗ **Layout rectangular survey 400 x 500 km**
- ✗ **Extends beyond the shelf break**
- ✗ **Block size will reflect the endurance of the aircraft**

SURVEY AND BLOCK PLANS



- ✖ **Data lines spaced 10 km apart**
- ✖ **Cross lines spaced 60-80 km apart**
- ✖ **Flight altitude 20,000 ft**
- ✖ **Nominal speed 220-250 kts**

GRAV-D AIRCRAFT

- ✖ **DOI Bureau of Land Management**
 - + **Pilatus PC-12**
- ✖ **Fugro**
 - + **King Air E-90A**
 - + **Cessna Conquest**
- ✖ **Naval Research Lab**
 - + **King Air RC-12**
- ✖ **NOAA**
 - + **Gulfstream Jet Prop**
 - + **NOAA P-3 Hurricane Hunter**



Pilatus PC-12



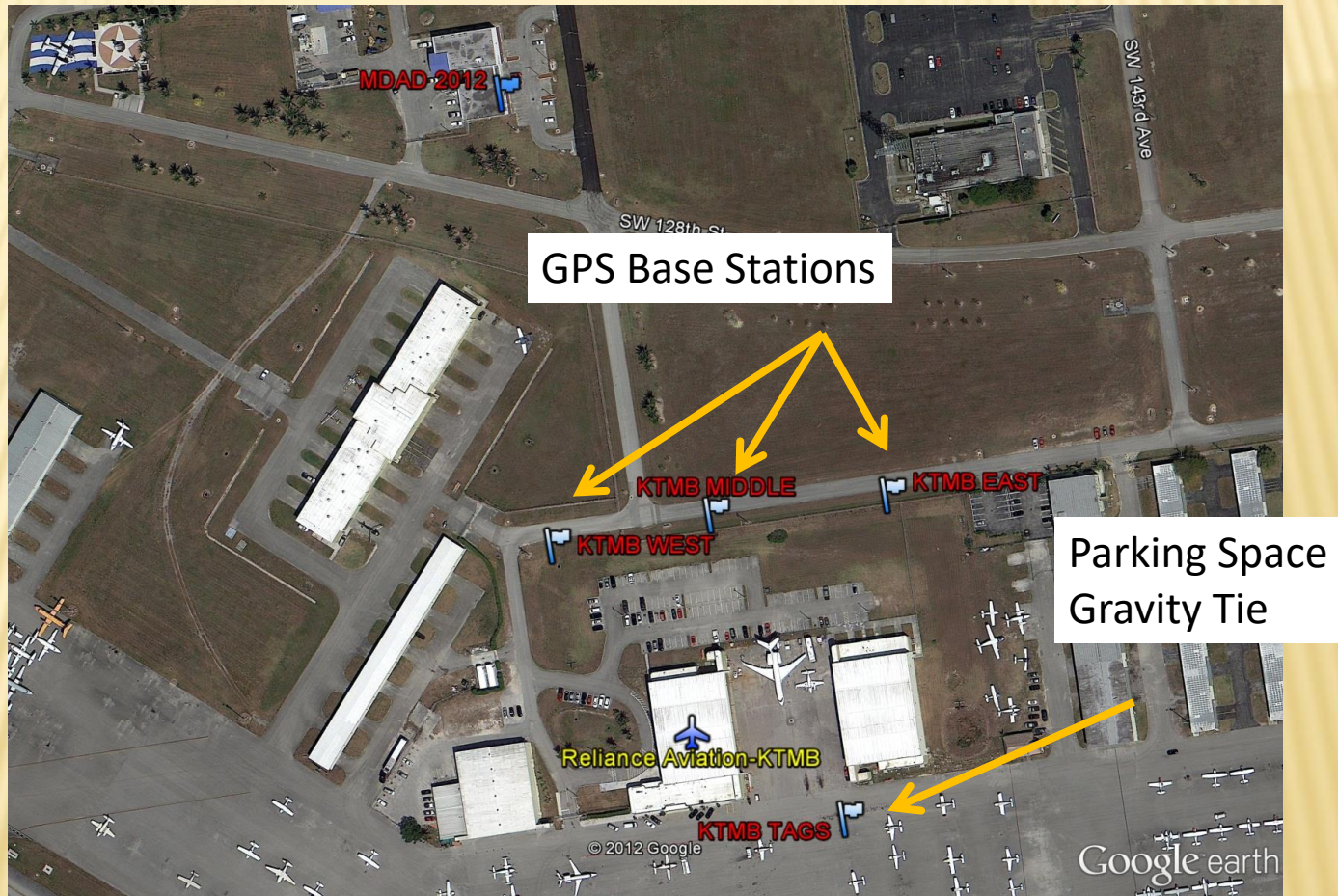
King Air RC-12



King Air E-90A



GRAV-D Reconnaissance Survey



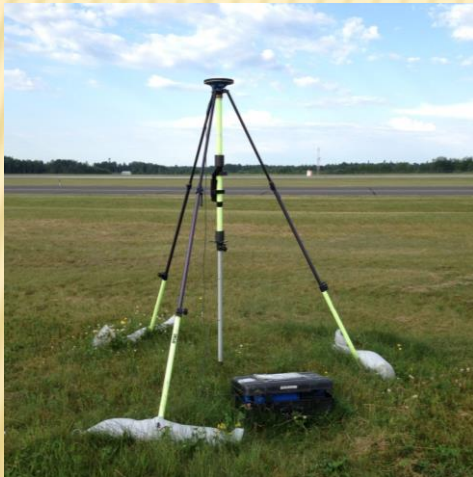
Gravity and GPS Base Stations



Parking spot ID



Micro-G A10 Absolute Gravity measurement



GPS Base Stations



Vertical gravity gradient

GRAV-D Aircraft Instrumentation



**Micro-g LaCoste
TAGS Gravimeter**



**NovAtel SPAN-SE
w/ Honeywell μ IRS IMU**

- **Both instruments include GNSS receivers**
- **SPAN system allows for tightly coupled GPS/IMU solutions**

INSTRUMENT INSTALLATION



- ✗ Instrument suite installed
- ✗ Lever arm survey required
- ✗ Test flight performed

BETA GEOID MODEL COMPUTATION

- ✖ **The gravity data from satellites, airborne, corrected surface data, and terrain predictions will be blended into a gravity field**
- ✖ **As regions are completed, “beta” preliminary geoid models will be created and released to the public for local testing**
- ✖ **Create a gravimetric geoid model that will be the basis of the new vertical datum**

xGEOID16

- + Experimental geoid model released by NGS on July 21, 2016 – xGEOID16A & B**
- + Online tool for accessing it
beta.ngs.noaa.gov/GEOID/xGEOID16/**
- + Includes GRAV-D collected thru December 2015**

Why GRAV-D?

- A relatively small workforce can update the geoid as compared to the large workforce needed to re-level bench marks
- As the $H=0$ surface (W_0), the geoid will be tracked over time to keep the datum up to date. Also known as the equipotential surface
 $W_0 = 62,636,856.0 \text{ m}^2/\text{s}^2$
- A 2 cm target accuracy anywhere that GNSS receivers can be used, kept up to date through monitoring CORS and the geoid, is better than the accuracy and accessibility of NAVD 88 today
- It is far cheaper than leveling
- The geoid can't be bulldozed out of usefulness
- The effect of subsidence/uplift upon the realization will be known (and accounted for) by monitoring CORS and monitoring the geoid

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

How will I access the new vertical datum?

Primary access (NGS mission)

- Users with geodetic quality GNSS receivers will continue to use OPUS suite of tools and other standard processing methods (e.g. RTNs, RTK, Static)
- Ellipsoid heights computed, and then a gravimetric geoid applied to provide orthometric heights in the new datum
- No passive marks needed
- But, could be used to position a passive mark

How will I access the new vertical datum?

Secondary access (Use at your own risk)

- **Passive marks that have been tied to the new vertical datum**
- **NGS will provide a “data sharing” service (e.g. OPUS Shared Solutions) 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**

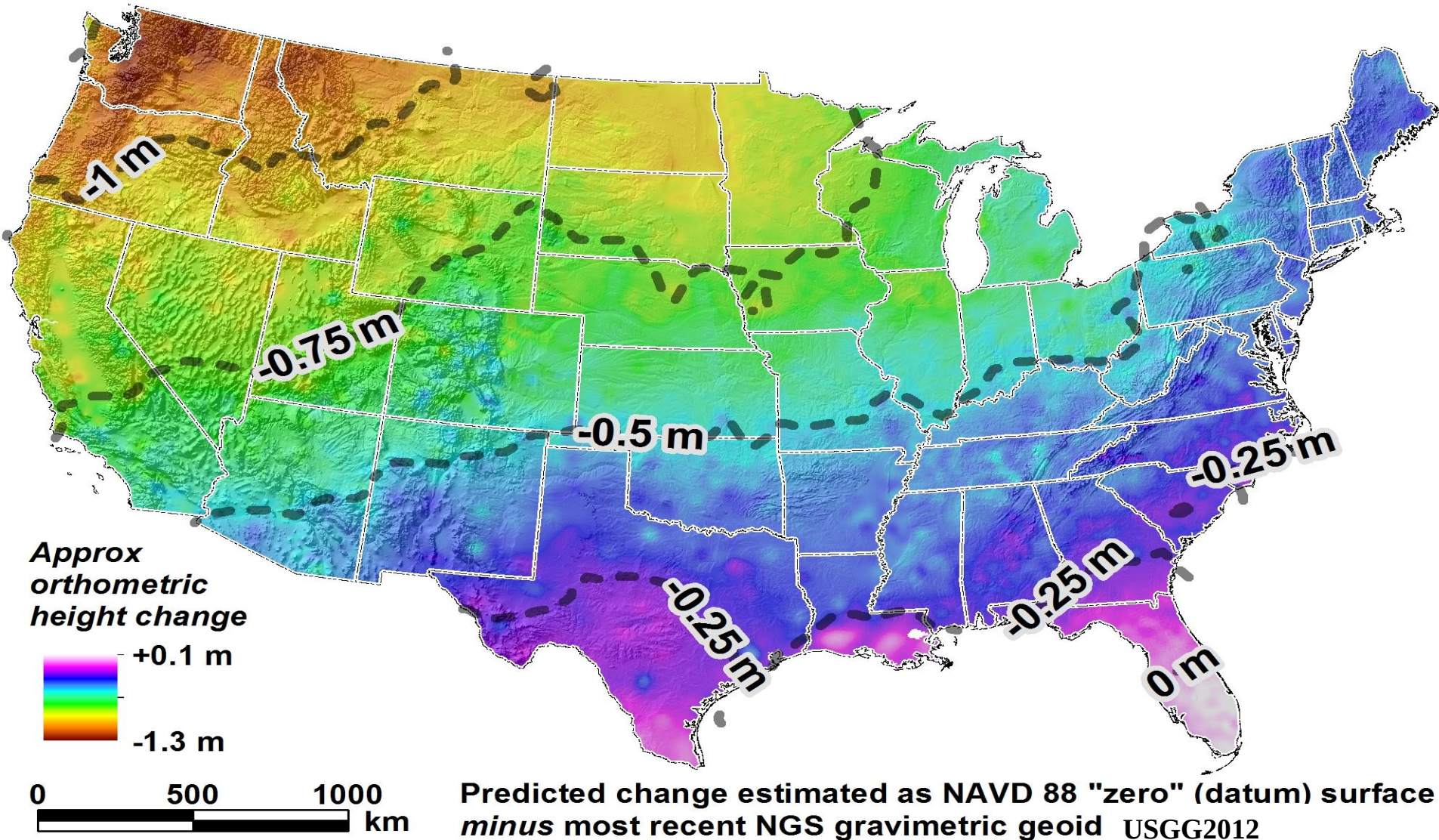
How will I access the new vertical datum?

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 reference system**

Geopotential Datum Changes

Approximate predicted change from NAVD 88 to new vertical datum



Predicted Position & Height Changes in 2022

MARYLAND

Silver Spring

Computed for R 15 (HV1789)

HORIZONTAL = 0.97 m (3.2 ft)

ELLIPSOID HEIGHT = - 1.29 m (- 4.2 ft)

ORTHOMETRIC HEIGHT = - 0.39 m (- 1.3 ft)

Computed with [xGEOID16B](#)

Baltimore

Computed for 857 4680 (TIDAL BASIC)

HORIZONTAL = 0.98 m (3.2 ft)

ELLIPSOID HEIGHT = - 1.28 m (- 4.2 ft)

ORTHOMETRIC HEIGHT = - 0.38 m (- 1.2 ft)

Computed with [xGEOID16B](#)

Predicted Position & Height Changes in 2022

MARYLAND

Ocean City

Computed for J 104 (HU0273)

HORIZONTAL = 0.96 m (3.1 ft)

ELLIPSOID HEIGHT = - 1.32 m (- 4.3 ft)

ORTHOMETRIC HEIGHT = - 0.35 m (- 1.1 ft)

Computed with xGEOID16B

St Marys City

Computed for PARK HALL (AJ8007)

HORIZONTAL = 0.96 m (3.1 ft)

ELLIPSOID HEIGHT = - 1.31 m (- 4.3 ft)

ORTHOMETRIC HEIGHT = - 0.36 m (-1.2 ft)

Computed with xGEOID16B

Predicted Position & Height Changes in 2022

MARYLAND

Near Hagerstown

Computed for HAGERS (JV3211)

HORIZONTAL = 0.99 m (3.2 ft)

ELLIPSOID HEIGHT = - 1.26 m (- 4.1 ft)

ORTHOMETRIC HEIGHT = - 0.39 m (- 1.3 ft)

Computed with xGEOID16B

Near Oakland

Computed for E 167 (JW1142)

HORIZONTAL = 0.99 m (3.2 ft)

ELLIPSOID HEIGHT = - 1.25 m (- 4.1 ft)

ORTHOMETRIC HEIGHT = - 0.33 m (- 1.1 ft)

Computed with xGEOID16B

Predicted 2022 Orthometric Heights From OPUS

Make geoid-based orthometric heights available via
OPUS - **Done**, in extended output

**** Orthometric Heights Above Future Geopotential Datum.**

Prototype orthometric heights are now being made available as a precursor to the completion of GRAV-D and the replacement of NAVD 88 with a new geopotential reference system. The following height reflects the current best estimate of the true orthometric height, based on the existing gravimetric geoid model. This height is subject to change as data and modeling for the gravimetric geoid change throughout the lifetime of the GRAV-D project, or as new realizations of the ITRF are adopted. However, at the completion of GRAV-D, these heights will supersede the NAVD 88 heights

APPROX ORTHO HGT: 5.862 (m) [PROTOTYPE (Computed using USGG2012,GRS80,IGS08)]

METADATA

DATA ABOUT DATA

DATUMS and REALIZATIONS

**NAD 27, NAD 83(1986), NAD83 (199X),
NAD 83 (2007), NAD 83 (2011), Epoch xxxx.xx
NGVD29, NAVD88**

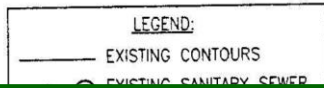
UNITS

Meters, U.S. Survey Feet, International Feet

ACCURACY

0.03 m, 0.1 ft, 1st -, 2nd -, 3rd - Order etc.

EXAMPLES OF BAD METADATA



SUPREME COURT OF THE UNITED STATES

LE0000 STATION RECOVERY (2013)
LE0000
LE0000'RECOVERY NOTE BY INDIVIDUAL CONTRIBUTORS 2013
LE0000'RECOVERED BY XXXX ENGINEERING COMPANY
LE0000'RECOVERED WITH THE FOLLOWING READINGS
LE0000'LAT N03X 50' 55.18204782
LE0000'LONG W09X 20' 43.56815322
LE0000'ELEV 1032.174
LE0000'
LE0000'NAD83 IOWA STATE PLANES, SOUTH ZONE, US FOOT
LE0000'NORTHING X29889.4330'
LE0000'EASTING XX01850.4550'

TOP OF CONCRETE BOUND
EL=73.68 GPS DATUM

Metadata

Coordinates and heights without appropriate metadata has the same value as a boundary line in a GIS

Just A Wild A Guess**

What can you do to get ready for 2022??

Understand the impact of changing positions and heights for your community, company or agency

Watch for upcoming NGS status reports/webinars
www.geodesy.noaa.gov/corbin/calendar.shtml

Consider legislative changes to
Maryland Code, Real Property, Title 33, Chapter 13

NGS plans to publish State Plane Coordinates using the same geometric parameters as NAD 83

Communicate your issues directly to NGS

Scott Lokken – scott.lokken@noaa.gov – Mid Atlantic Regional Advisor

Dru.Smith – dru.smith@noaa.gov – NSRS Modernization Manager

**GOOD COORDINATION BEGINS WITH
GOOD COORDINATES**



**Maryland Society
of Surveyors**

GEOGRAPHY WITHOUT GEODESY IS A FELONY