2022 is Coming – Will You Be Ready? (or NAD83 and NAVD88 Are Going Away)

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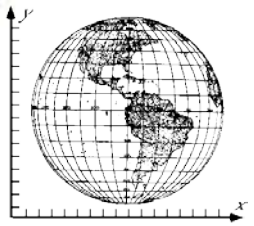
NOAA's National Geodetic Survey

UGIC 2015 snowbird

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Geodetic Survey

Mission: To define, maintain & **provide access** to the ***National Spatial Reference System (NSRS)*** to meet our Nation's economic, social & environmental needs

National Spatial Reference System



- **Latitude**
- **Longitude**
- ***Height***
- Scale
- Gravity
- Orientation

& their time variations

(& National Shoreline, etc.)

- North American Datum 1983 (NAD83)
- North American Vertical Datum 1988 (NAVD88)

NAD 83(2011) epoch 2010.00

DESIGNATION - HENNA
PID - AI5806
STATE/COUNTY- UT/SALT LAKE
COUNTRY - US
USGS QUAD - DRAPER (1975)

*CURRENT SURVEY CONTROL

NAD 83(2011) POSITION-	40 37 21.14423(N) 111 47 57.20194(W)	ADJUSTED
NAD 83(2011) ELLIP HT-	1464.588 (meters) (06/27/12)	ADJUSTED
NAD 83(2011) EPOCH -	2010.00	
NAVD 88 ORTHO HEIGHT -	1481.1 (meters) 4859. (feet)	GPS OBS
NAVD 88 orthometric height was determined with geoid model		GEOID09
GEOID HEIGHT -	-16.46 (meters)	GEOID09
GEOID HEIGHT -	-16.49 (meters)	GEOID12B
NAD 83(2011) X -	-1,800,738.064 (meters)	COMP
NAD 83(2011) Y -	-4,502,343.473 (meters)	COMP
NAD 83(2011) Z -	4,131,651.220 (meters)	COMP
LAPLACE CORR -	20.32 (seconds)	DEFLEC12B

Network accuracy estimates per FGDC Geospatial Positioning Accuracy Standards:

	FGDC (95% conf, cm)		Standard deviation (cm)			CorrNE
	Horiz	Ellip	SD_N	SD_E	SD_h	(unitless)
NETWORK	0.62	1.37	0.28	0.22	0.70	-0.08326909

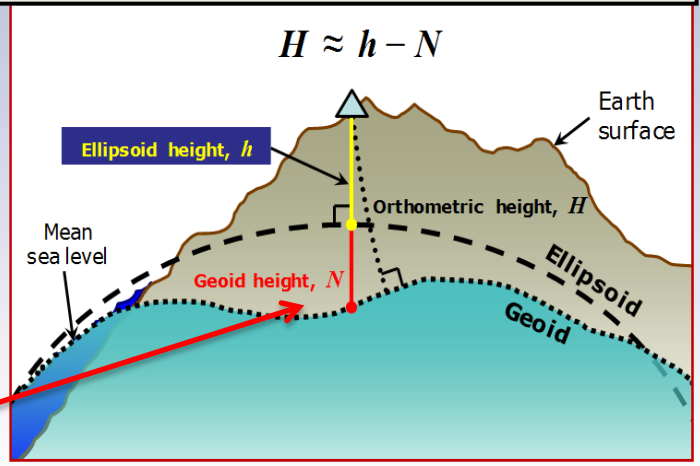
Click here for local accuracies and other accuracy information.

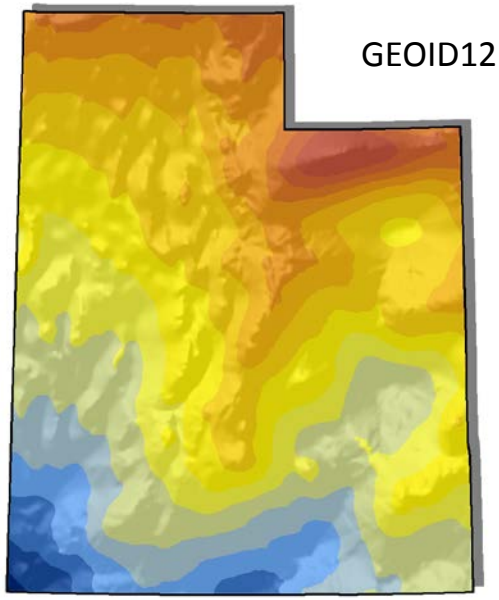
The horizontal coordinates were established by GPS observations and adjusted by the National Geodetic Survey in June 2012.

NAD 83(2011) refers to NAD 83 coordinates where the reference frame has been affixed to the stable North American tectonic plate. See NA2011 for more information.

The horizontal coordinates are valid at the epoch date displayed above which is a decimal equivalence of Year/Month/Day.

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



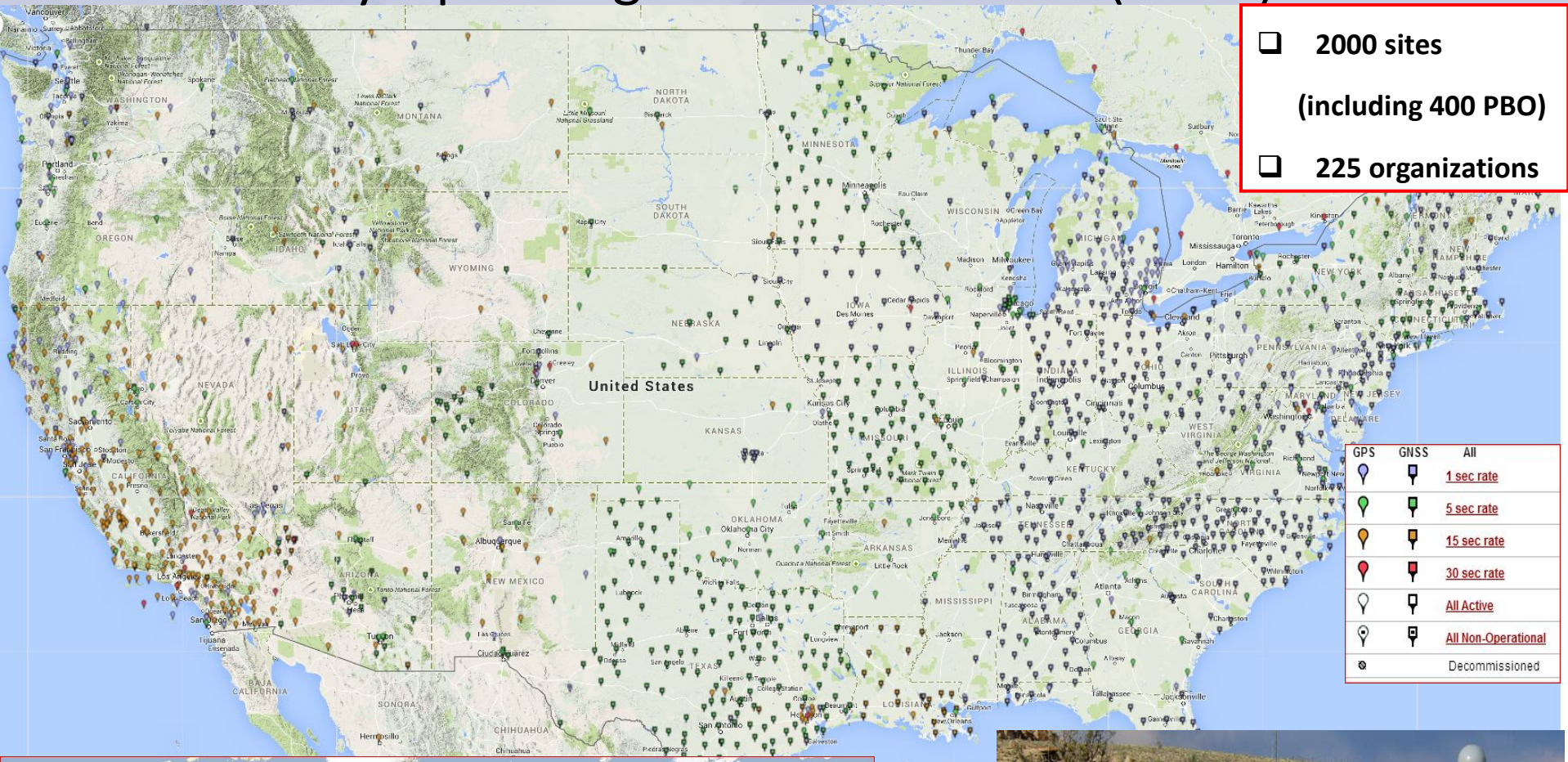


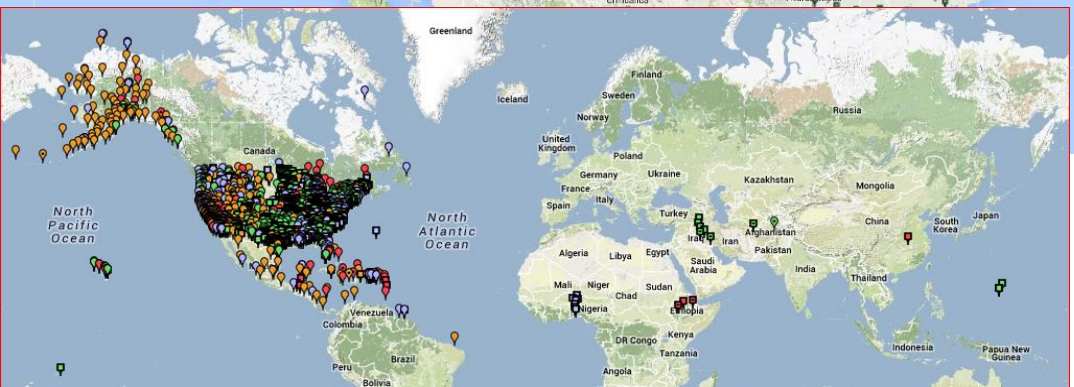
GEOID12B for Utah

Geoid Height (meters)
-13 to -12
-14 to -13
-15 to -14
-16 to -15
-17 to -16
-18 to -17
-19 to -18
-20 to -19
-21 to -20
-22 to -21
-23 to -22
-24 to -23
-25 to -24
-26 to -25

Continuously Operating Reference Station (CORS) Network

- ❑ 2000 sites (including 400 PBO)
- ❑ 225 organizations





CORS Coordinates

IGS08 Position >>>

IGS08 Velocity >>>

NAD83 Position >>>

NAD83 Velocity >>>

```
        Antenna Reference Point(ARP): SCOTTSDALE CORS ARP
        ------------------------------------------------
                          PID = AH3759

 IGS08 POSITION (EPOCH 2005.0)
 Computed in Aug 2011 using data through gpswk 1631.
     X =  -1982826.934 m     latitude    =  33 34 07.39597 N
     Y =  -4936878.021 m     longitude   = 111 52 55.77821 W
     Z =   3506904.128 m     ellipsoid height =  391.322   m

 IGS08 VELOCITY
 Computed in Aug 2011 using data through gpswk 1631.
     VX =  -0.0128 m/yr      northward =  -0.0060 m/yr
     VY =   0.0023 m/yr      eastward  =  -0.0127 m/yr
     VZ =  -0.0055 m/yr      upward    =  -0.0008 m/yr

 NAD_83 (2011) POSITION (EPOCH 2010.0)
 Transformed from IGS08 (epoch 2005.0) position in Aug 2011.
     X =  -1982826.249 m     latitude    =  33 34 07.38024 N
     Y =  -4936879.362 m     longitude   = 111 52 55.73421 W
     Z =   3506904.203 m     ellipsoid height =  392.188   m

 NAD_83 (2011) VELOCITY
 Transformed from IGS08 velocity in Aug 2011.
     VX =   0.0023 m/yr      northward =   0.0033 m/yr
     VY =   0.0028 m/yr      eastward  =   0.0011 m/yr
     VZ =   0.0017 m/yr      upward    =  -0.0019 m/yr

 L1 Phase Center of the current GPS antenna: SCOTTSDALE CORS L1 PC C
```

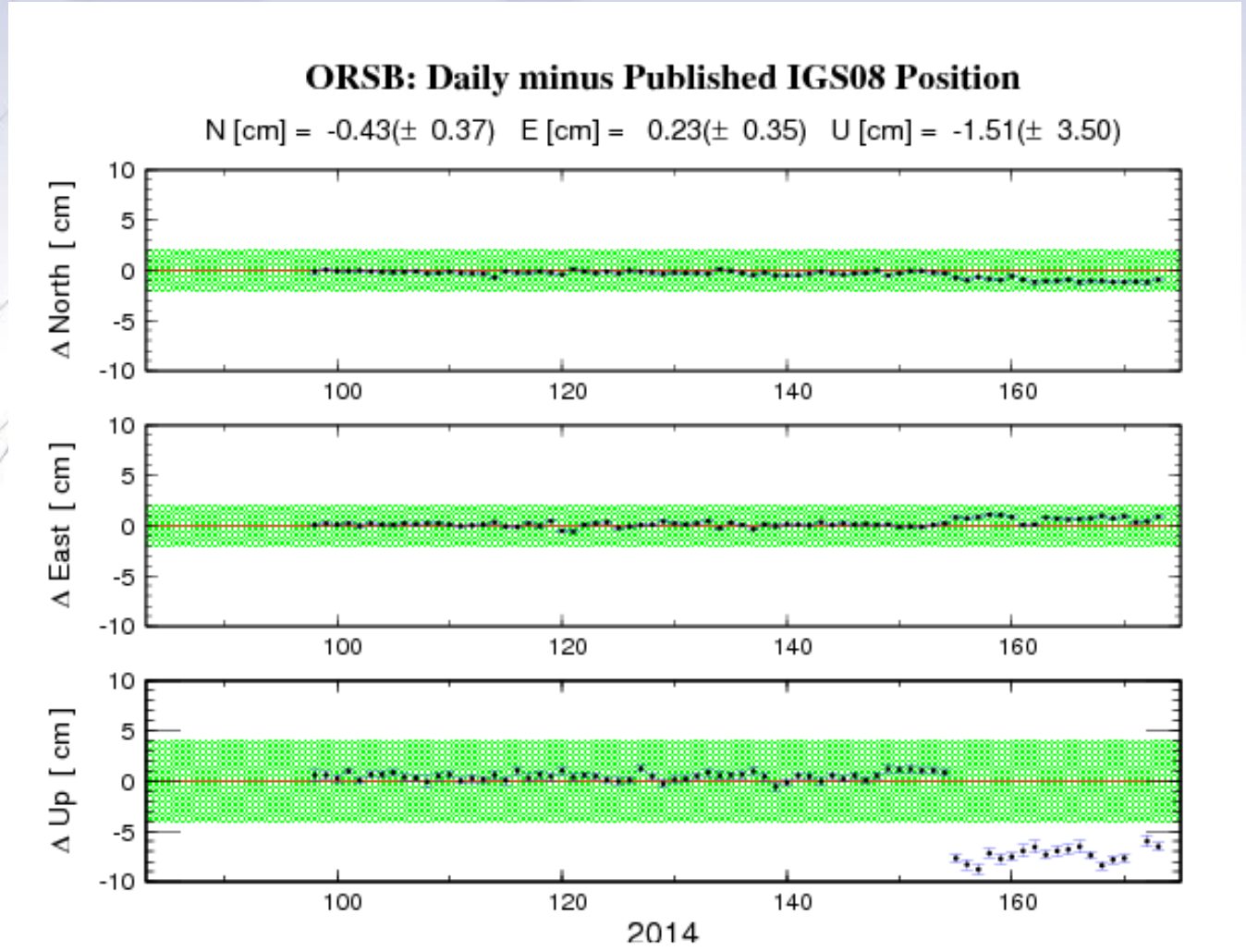
IGS08 = International GNSS Service 2008
(GPS-only realization of ITRF2008)

[replaces ITRF00 (epoch 1997.0)]

NAD83 (2011) epoch 2010.00 = North American Datum 1983
(2011 realization @ January 1, 2010)

[replaces NAD83(CORS96) (epoch 2002.0)]

CORS 90-day Coordinate Plots



National Geodetic Survey ***Ten-Year Strategic Plan***

- By 2022, reduce all definitional & access-related errors in geometric reference frame to 1 cm when using min of GNSS data

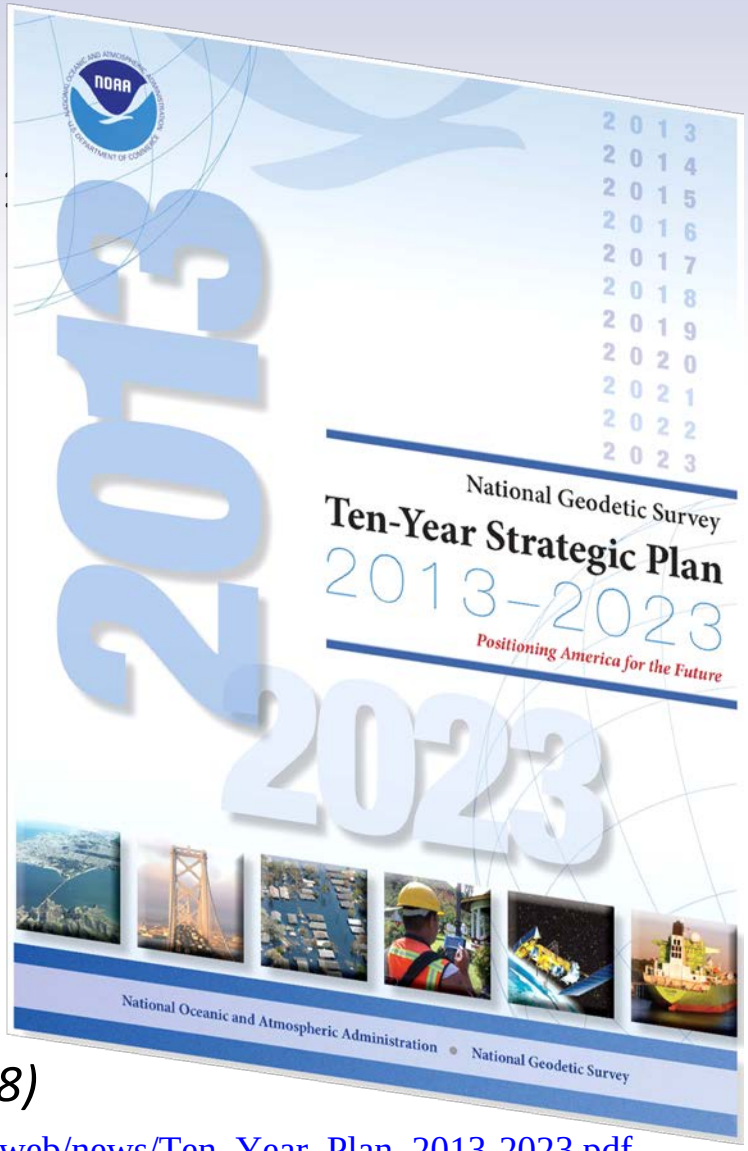
  "**Replace NAD83**"

(NAD83 = North American Datum 1983)

- By 2022, reduce all definitional & access-related errors in orthometric heights in geopotential reference frame to 2 cm when using 15 min of GNSS data

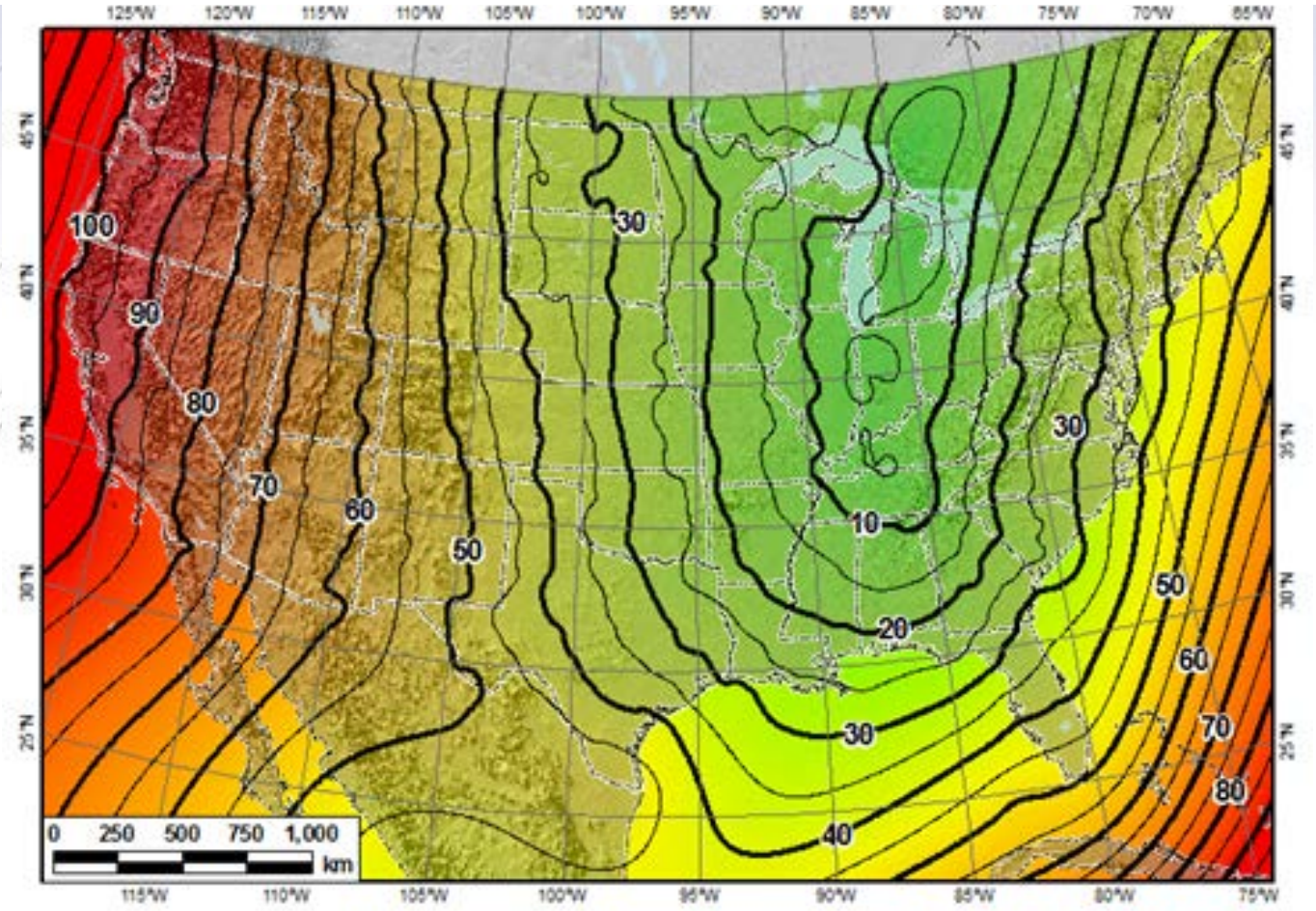
  "**Replace NAVD88**"

(NAVD88 = North American Vertical Datum 1988)



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

Magnitude of Positional Change: NAD27 to NAD83 (meters)

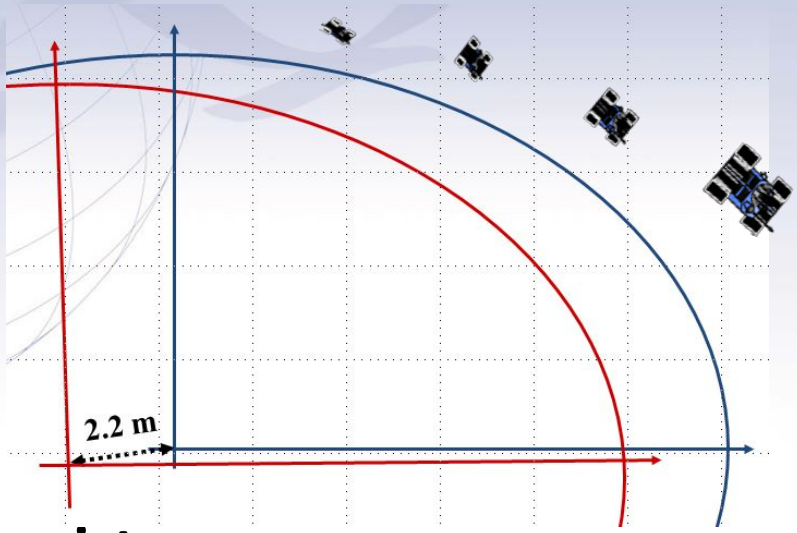


North American Datum 1983 (NAD83) Shortcomings

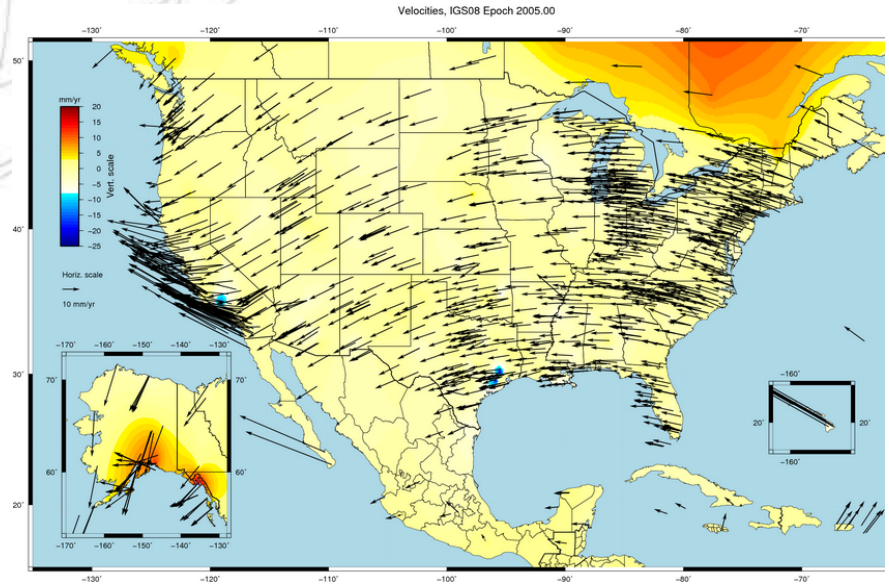
- **2.2 m offset –**

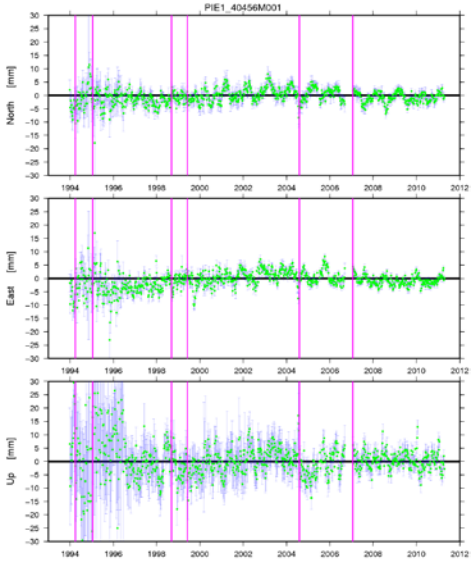
  NAD83 vs.

  International Terrestrial Reference Frame (ITRF)



- **CORS & passive network inconsistency**

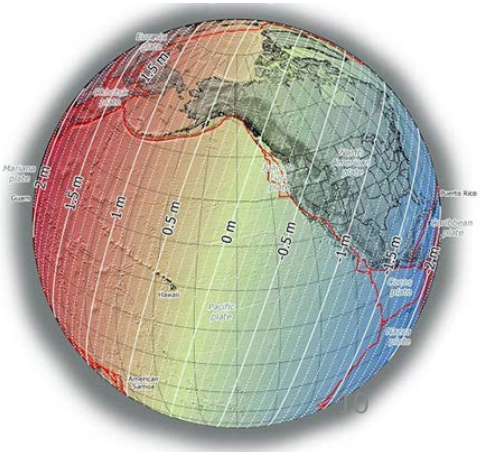




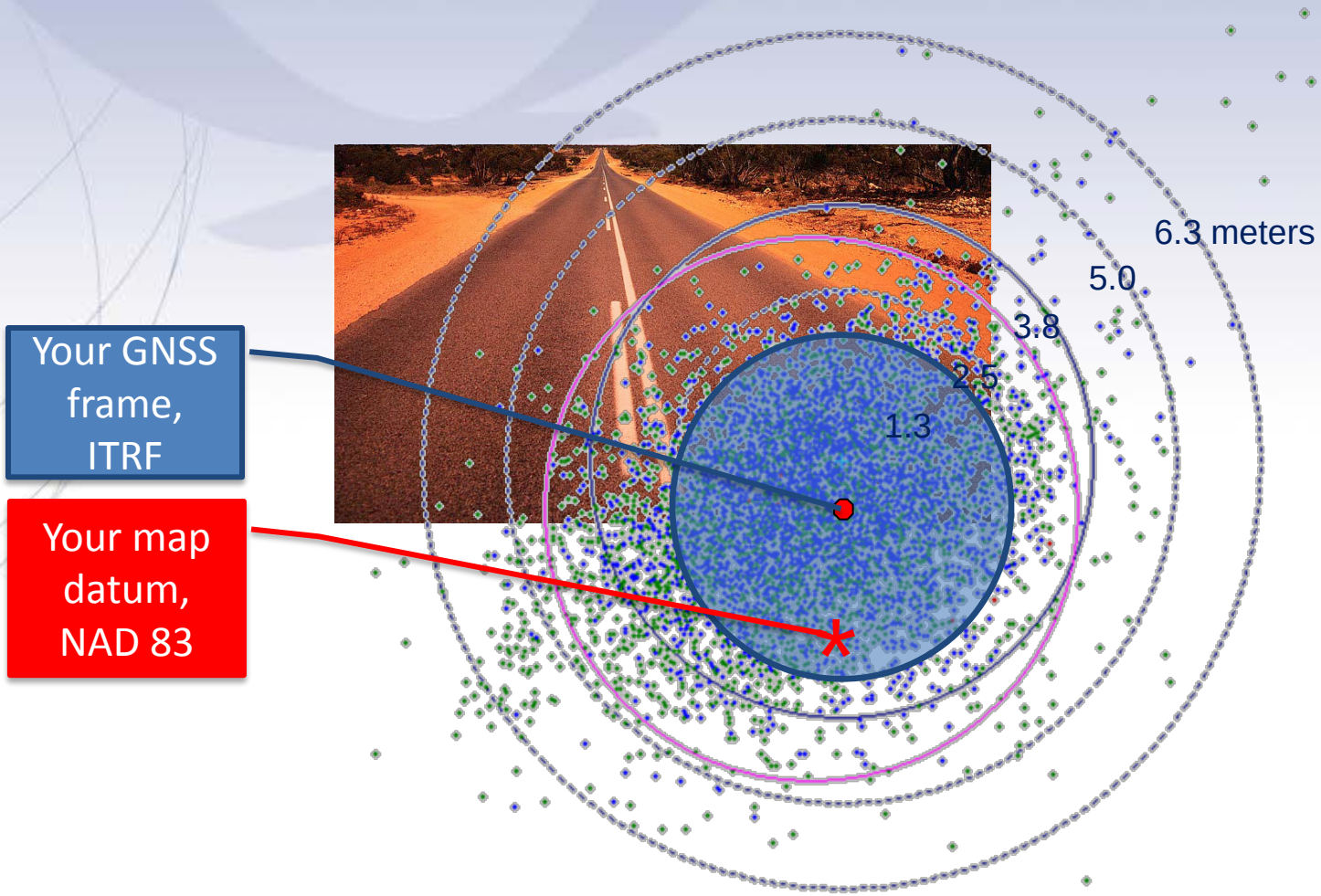
VS.

Needed Repairs: NAD 83

- NAD83 frame ≠ GPS navigation frame
- NAD83 frame ≠ WAAS navigation frame
- NAD83 frame ≠ satellite orbits frame
- NAD83 frame ≠ satellite product frame
- NAD83 frame ≠ international geodetic frame
  - International flights take off & land on different datums
  - Many geodetic tools assume ITRF as default



Map how you navigate



As GNSS un-augmented user range error improves over time …

Future Geometric (3-D) Reference Frame

- **replace NAD83 with new geometric reference frame – by 2022**
- **CORS-based, accessed via GNSS observations**
- **coordinates & velocities in ITRF & new US reference frame**

  (NAD83 replacement: plate-fixed or "ITRF-like"?)
- **passive control tied to new reference frame (not a component of)**
- **transformation tools will relate NAD83 to new US reference frame**

Approximate Horizontal Change

Mariana Plate
(Meters)

High: 1.4 m

Low: 1 m

North American Plate
(Meters)

High: 2 m

Low: 0 m

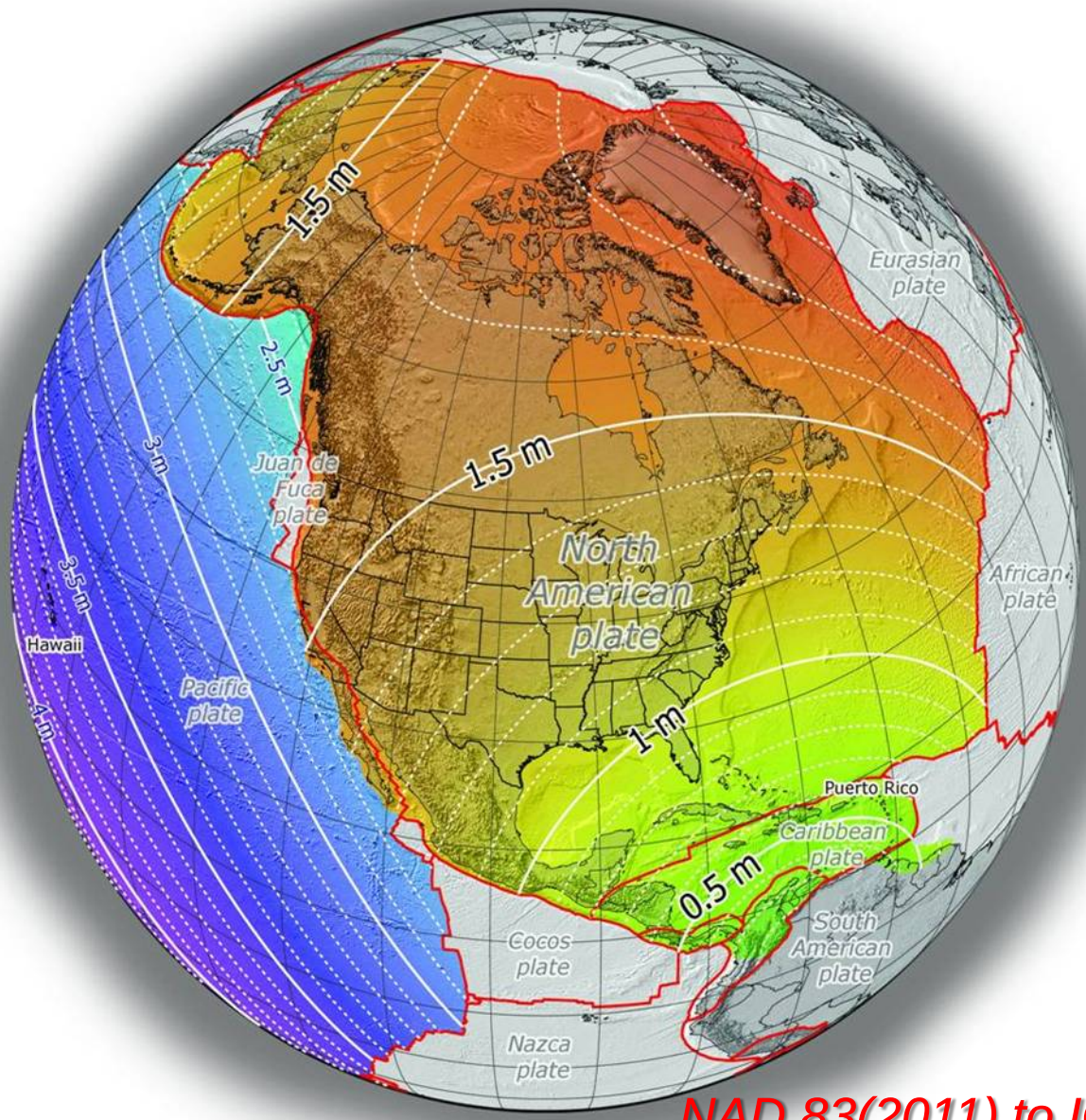
Pacific Plate
(Meters)

High: 4.3 m

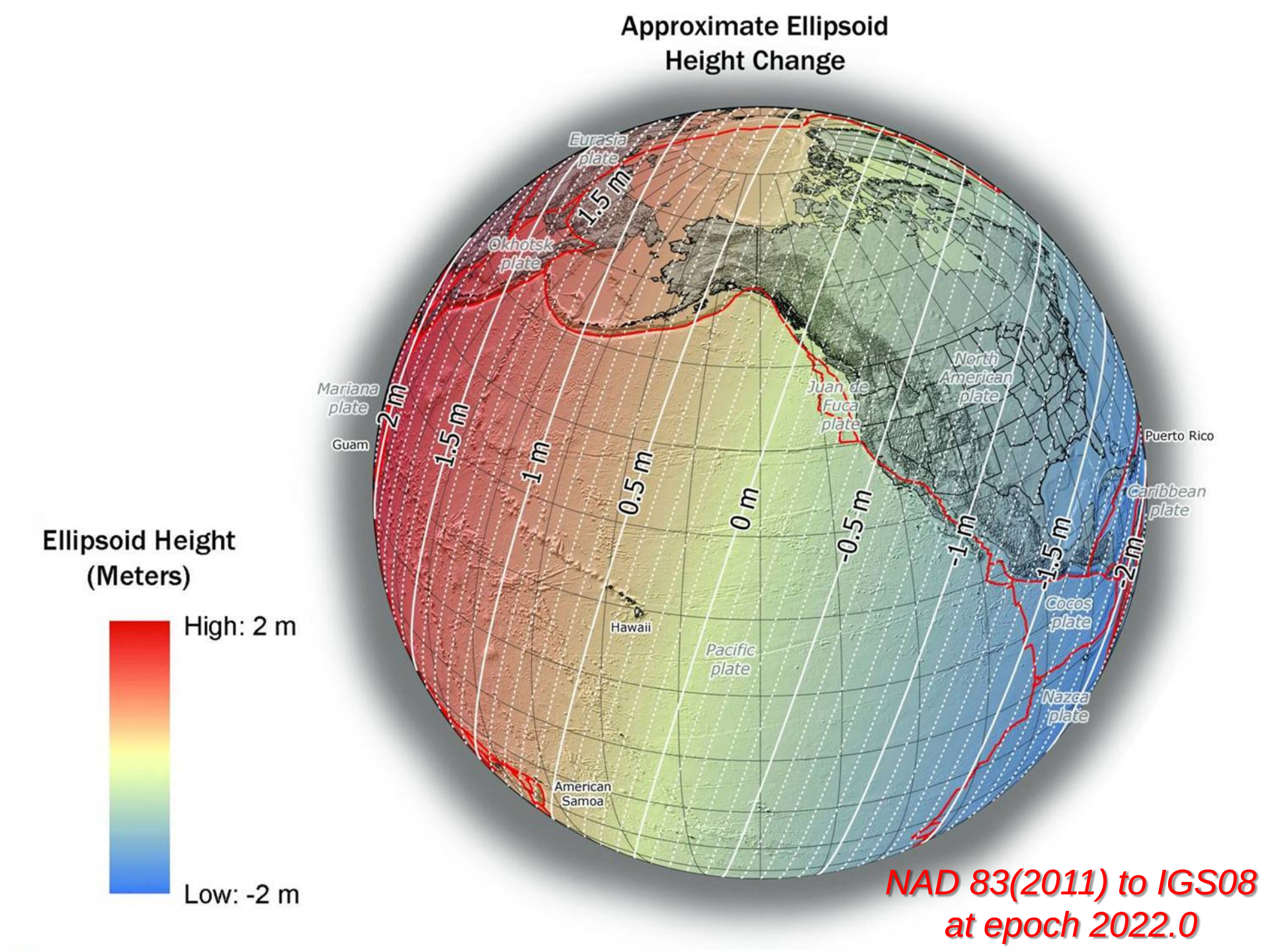
Low: 2.3 m

Tectonic Plate Boundaries

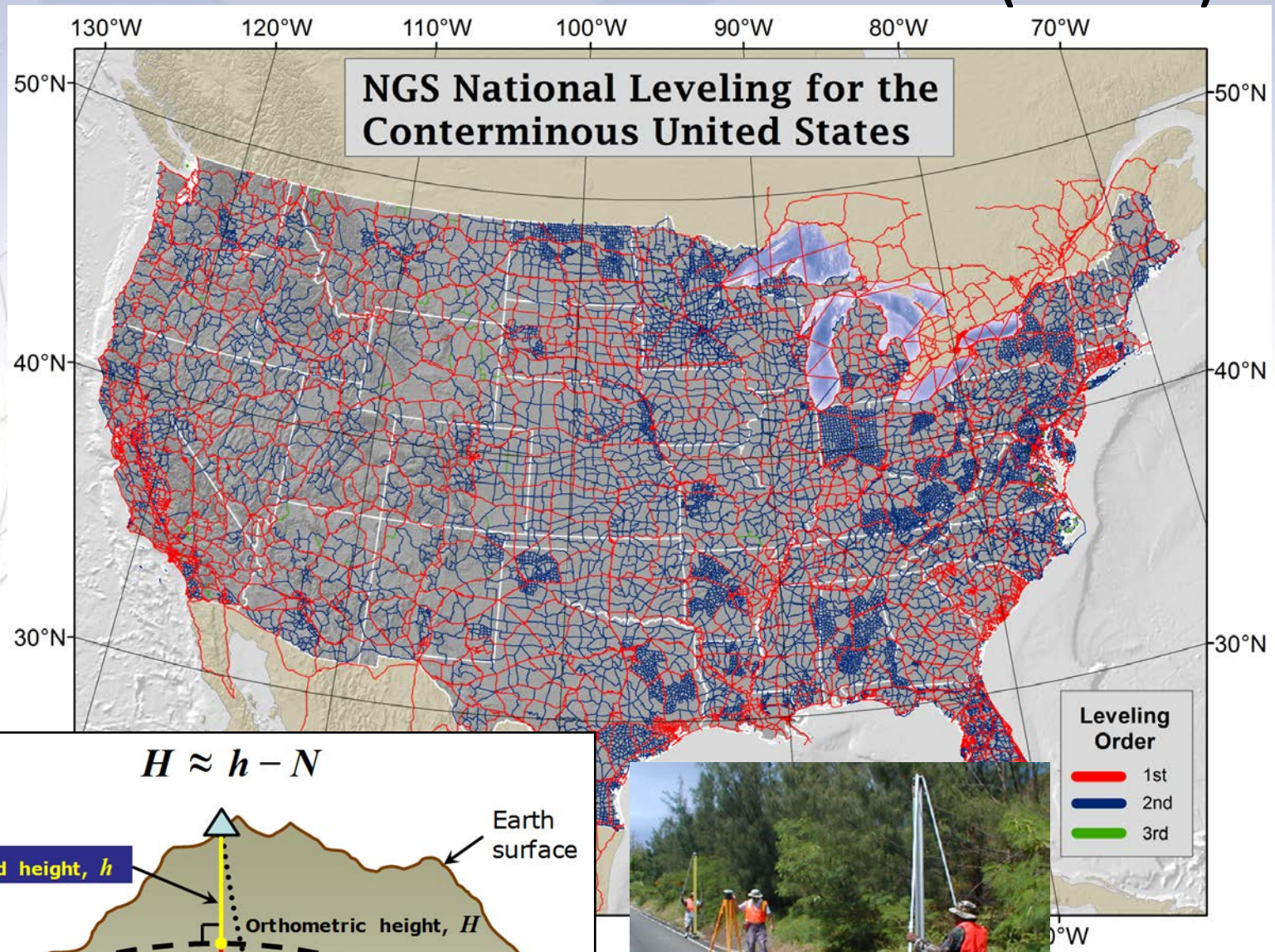
Approximate Horizontal Change
North American Plate

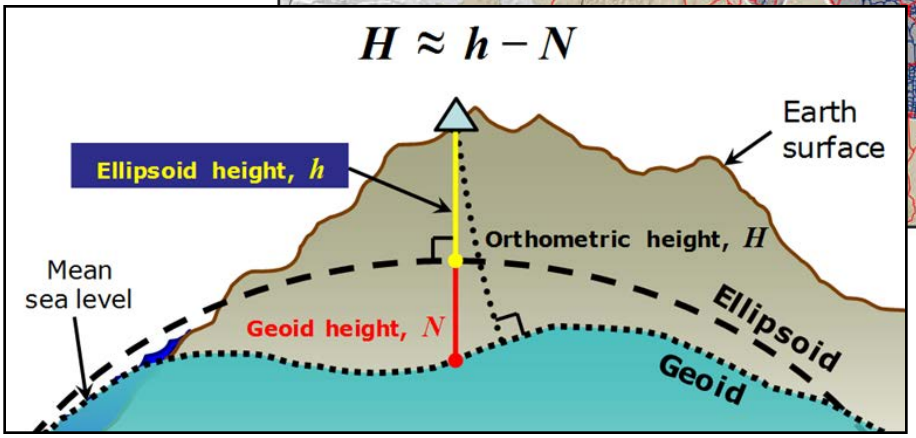


NAD 83(2011) to IGS08
at epoch 2022.0

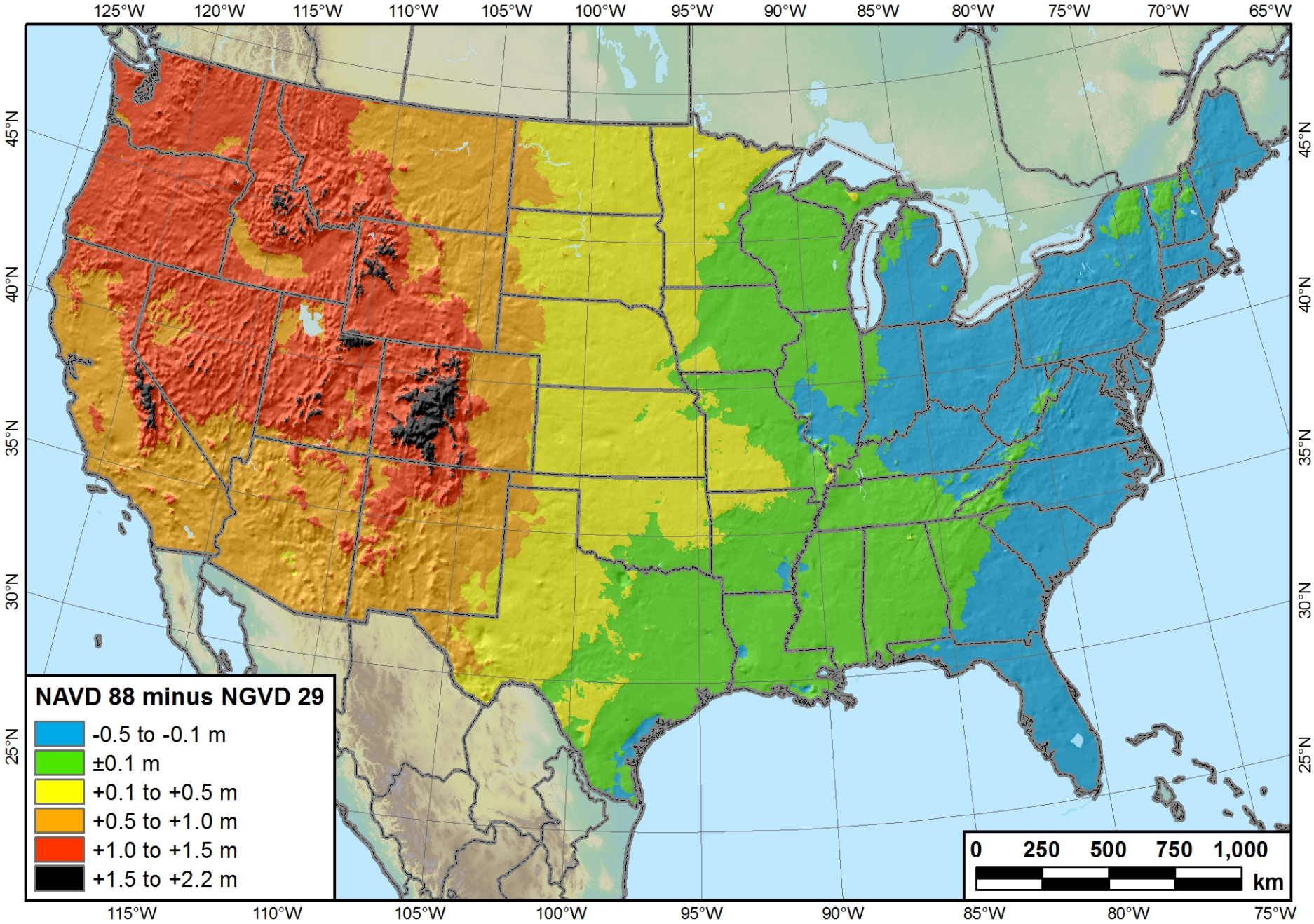

Approximate Ellipsoid Height Change
Eurasia plate
Okhotsk plate
Mariana plate
Guam
North American plate
Juan de Fuca plate
Puerto Rico
Caribbean plate
Cocos plate
Nazca plate
Hawaii
Pacific plate
American Samoa
2 m
1.5 m
1 m
0.5 m
0 m
-0.5 m
-1 m
-1.5 m
-2 m
Ellipsoid Height (Meters)
High: 2 m
Low: -2 m
NAD 83(2011) to IGS08 at epoch 2022.0

NORTH AMERICAL VERTICAL DATUM 1988 (NAVD88)



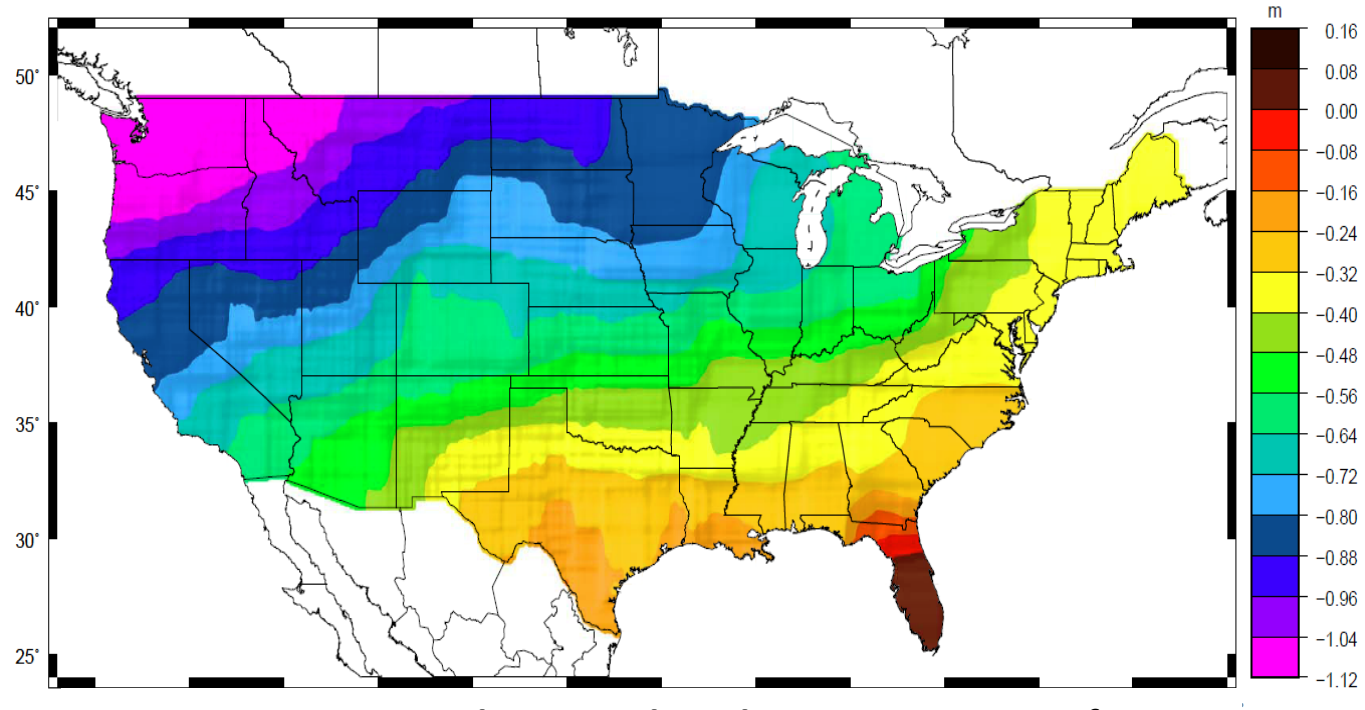


Vertical change from NGVD 29 to NAVD 88 (meters)



North American Vertical Datum 1988 (NAVD88) Shortcomings

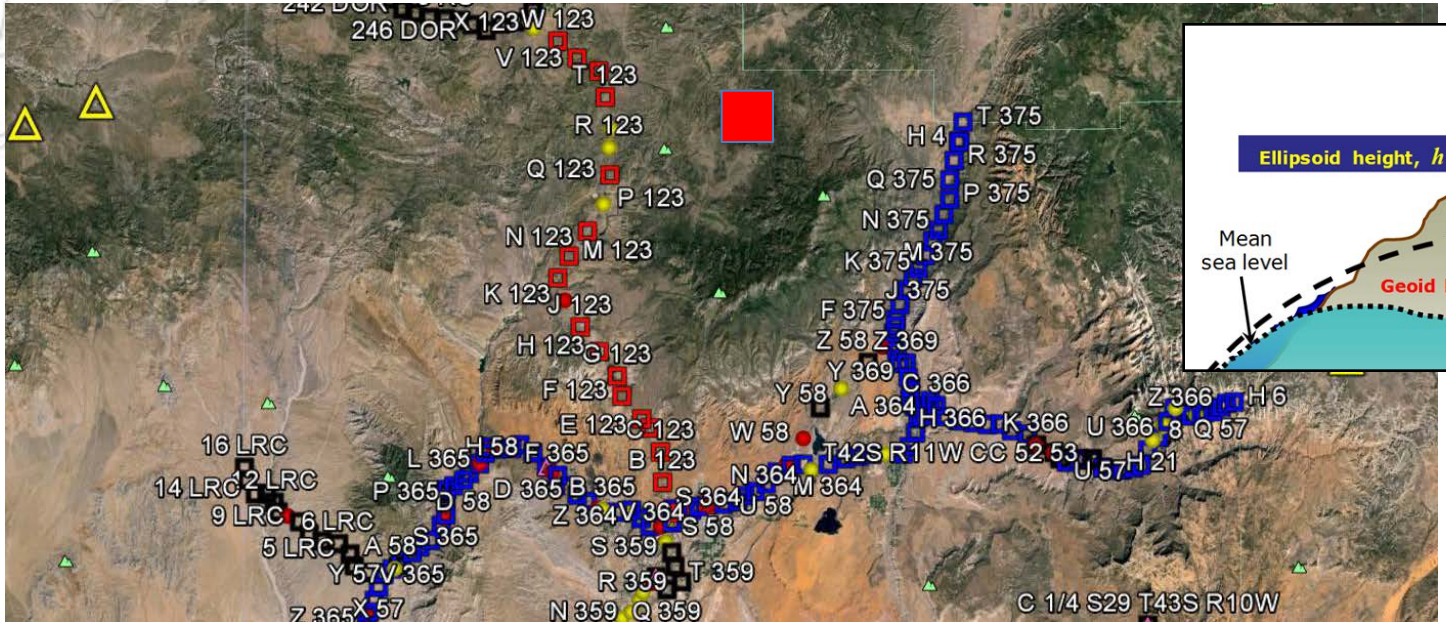
- **Cross-country errors (1-m tilt)**
- **0.5 m bias in reference surface vs. global mean sea level geoid**
- **Subsidence, uplift, freeze/thaw invalidate BM elevations**
- **LIMITED AVAILABILITY / ACCESS**

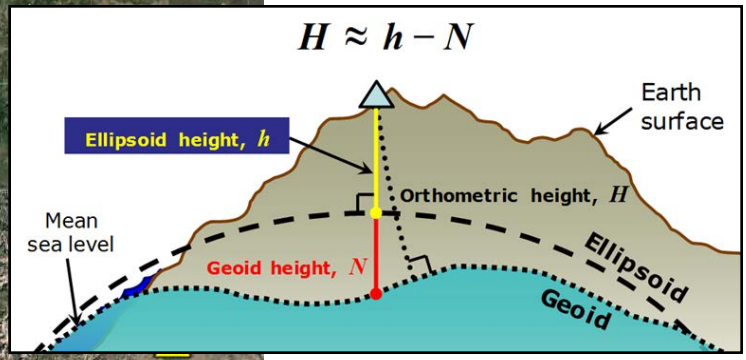


Approximate Geoid Mismatch in the NAVD88 H=0 surface

Future Geopotential (Vertical) Reference Frame

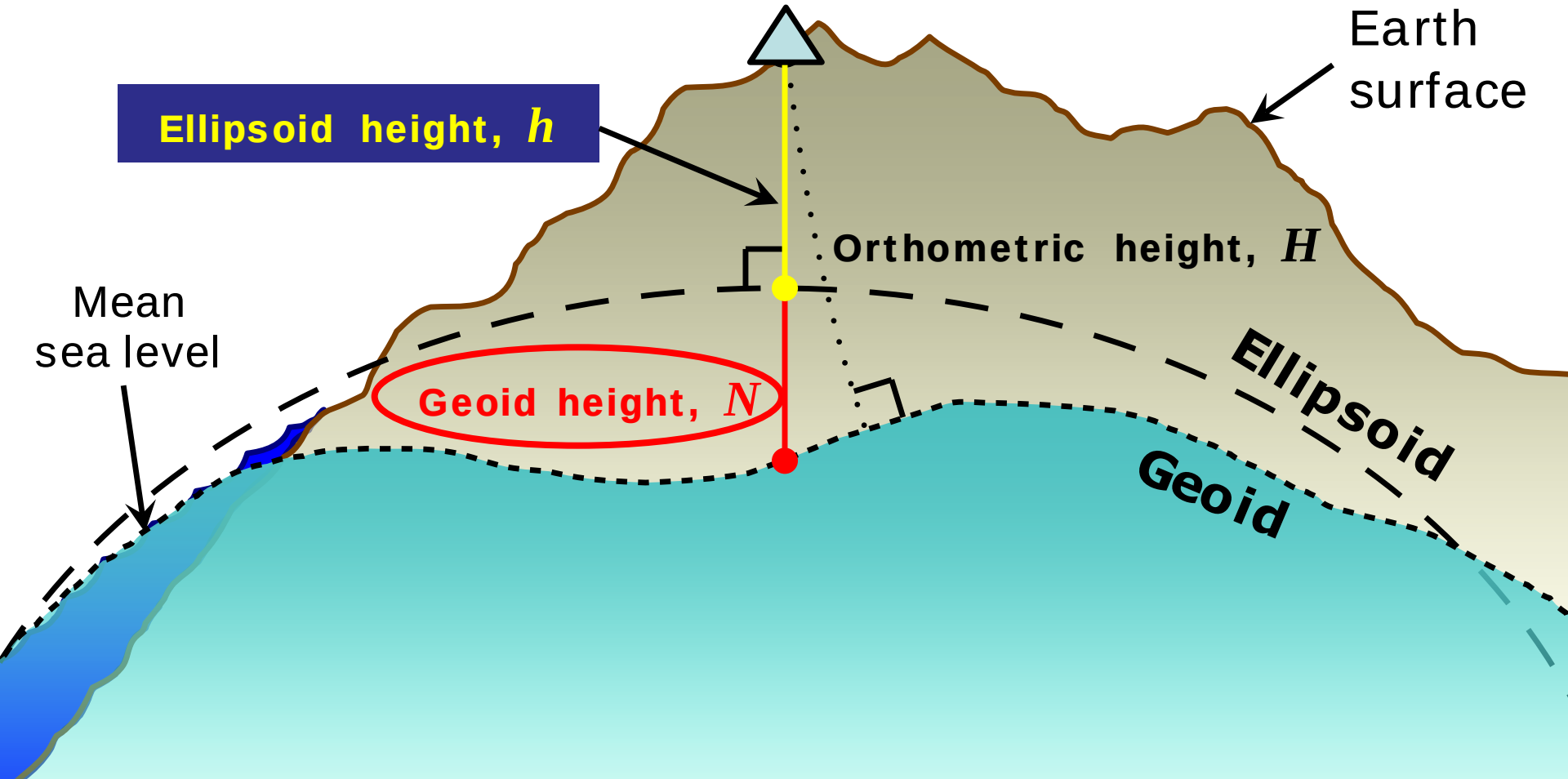
- **replace NAVD88 – by 2022**
- **accessed by GNSS & gravimetric geoid**
- **monitor time-varying nature of gravity field**
- **most accurate continental gravimetric geoid model, ever**



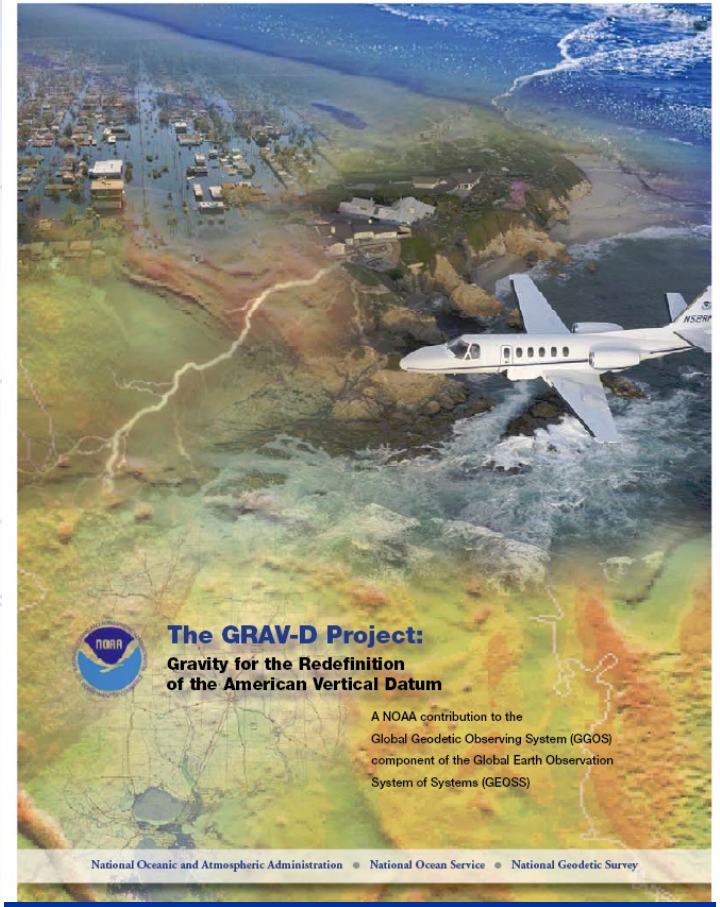


The Relationship of Heights

$$H \approx h - N$$



Gravity for the Redefinition of the American Vertical Datum (GRAV-D)

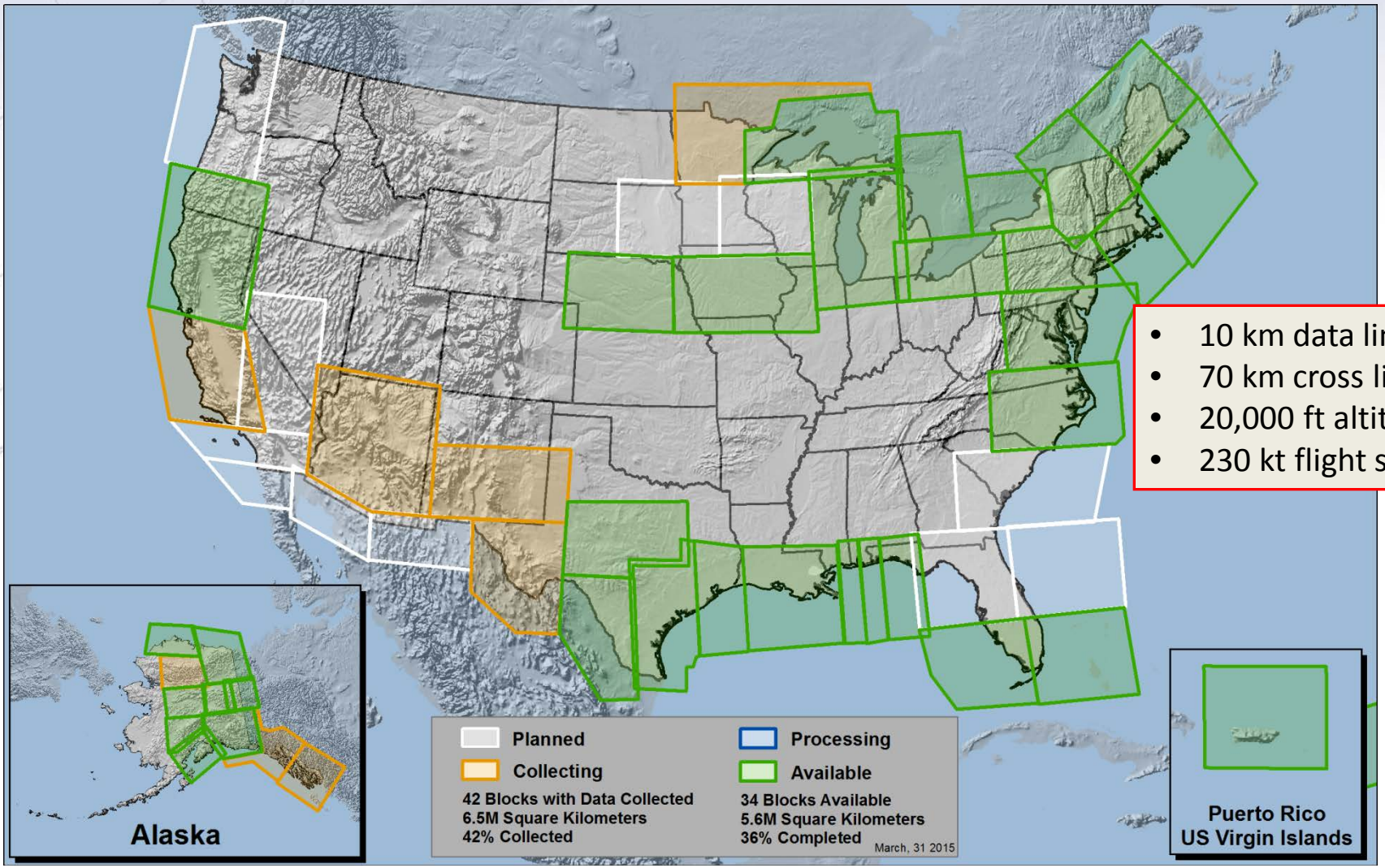


Gravity *and* ***Heights*** *are inseparably connected*

- Replace the national vertical datum (NAVD88) by 2022 with a ***1 cm accurate gravimetric geoid***
- Orthometric heights accessed via GNSS ***accurate to 2 cm***
- Thrusts of project:
  - Airborne gravity survey of entire country and its holdings
  - Long-term geoid change monitoring
  - Partnership surveys

Gravity for the Redefinition of the American Vertical Datum (GRAV-D)

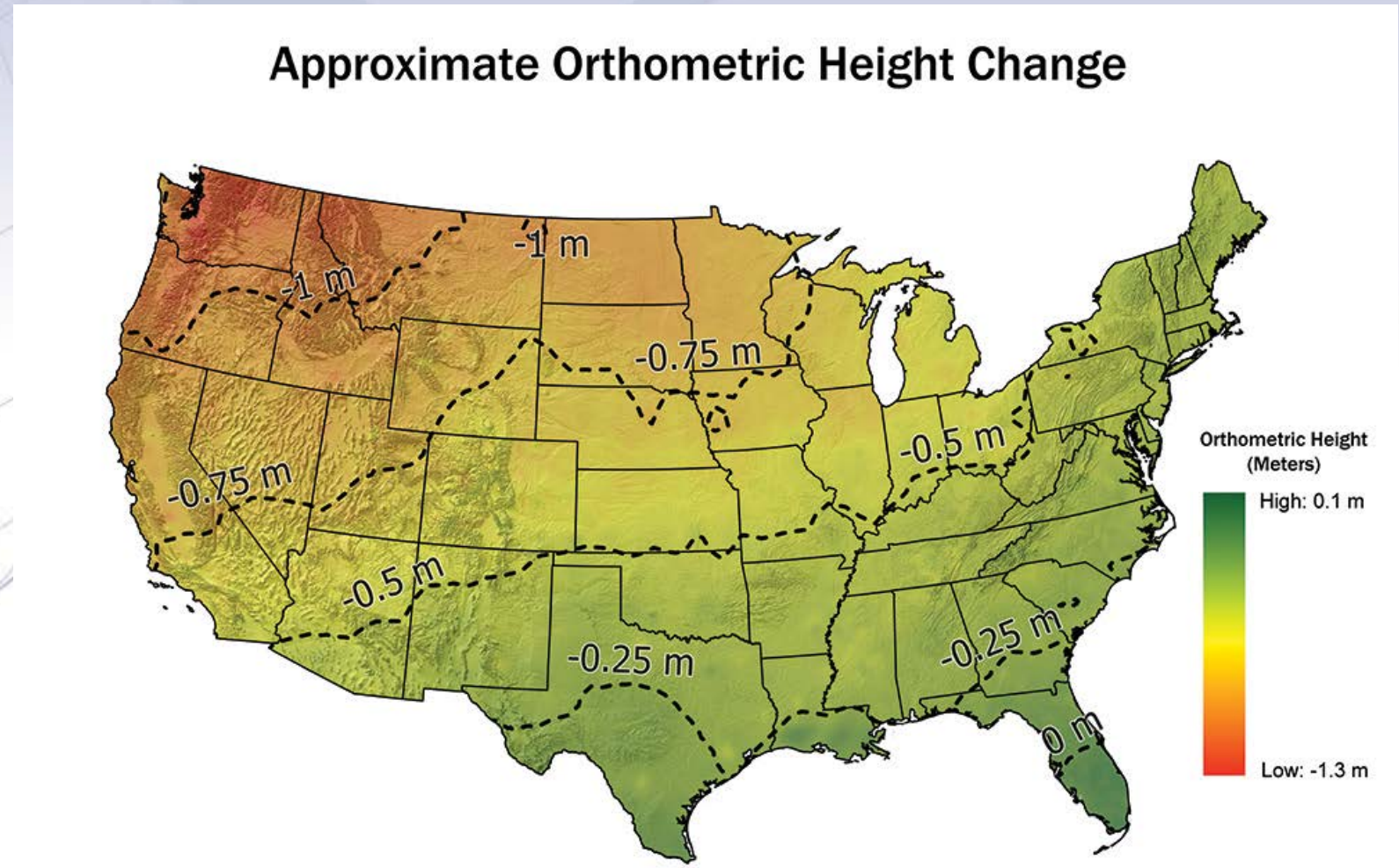
http://www.geodesy.noaa.gov/GRAV-D/



- 10 km data lines
- 70 km cross lines
- 20,000 ft altitude
- 230 kt flight speed

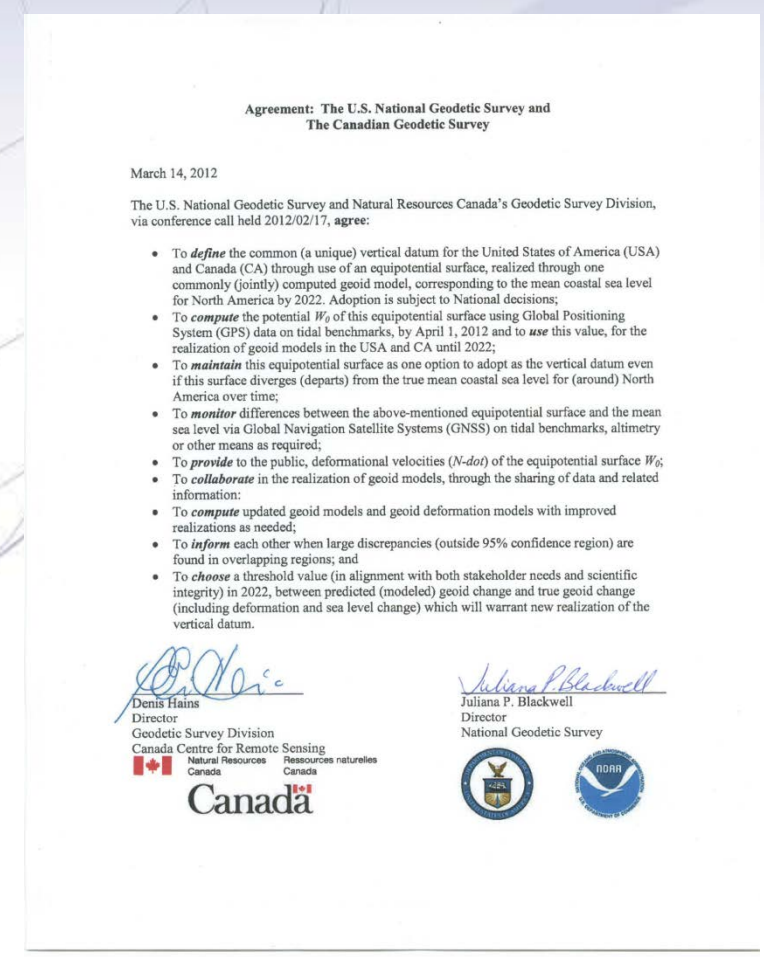
Extent of 2022 gravimetric geoid model used for new geopotential reference frame

How will the new datums affect you?



The new vertical (geopotential) datum will change heights on average 50 cm with a 1m tilt towards the Pacific Northwest.

Agreement on W_0 Value – between Canada & United States



Agreement: The U.S. National Geodetic Survey and The Canadian Geodetic Survey

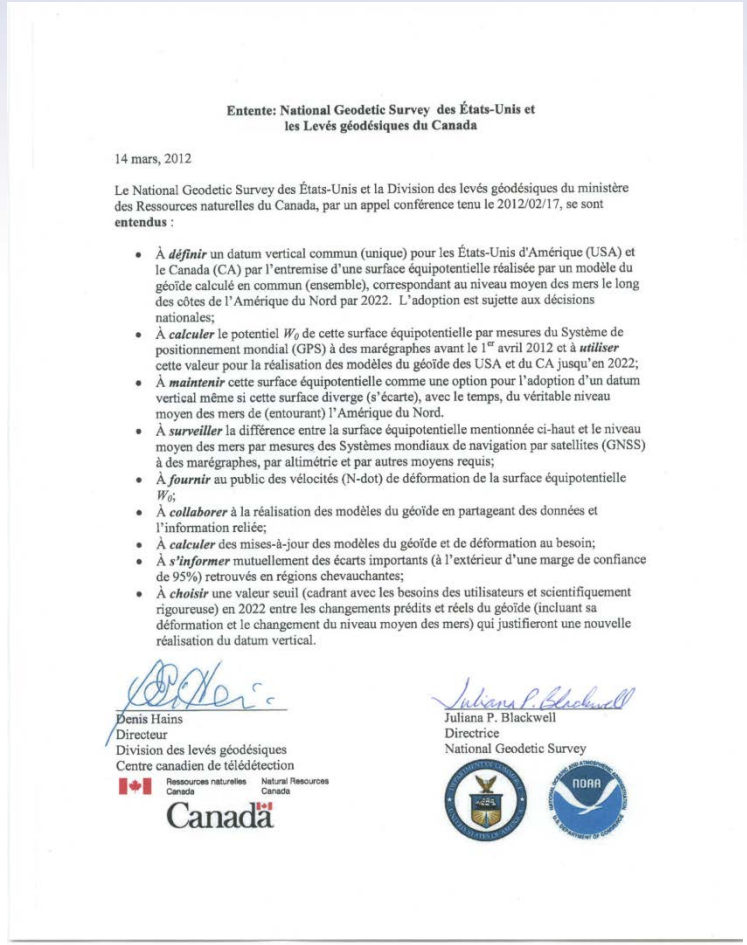
March 14, 2012

The U.S. National Geodetic Survey and Natural Resources Canada's Geodetic Survey Division, via conference call held 2012/02/17, **agree**:

- To ***define*** the common (a unique) vertical datum for the United States of America (USA) and Canada (CA) through use of an equipotential surface, realized through one commonly (jointly) computed geoid model, corresponding to the mean coastal sea level for North America by 2022. Adoption is subject to National decisions;
- To ***compute*** the potential W_0 of this equipotential surface using Global Positioning System (GPS) data on tidal benchmarks, by April 1, 2012 and to ***use*** this value, for the realization of geoid models in the USA and CA until 2022;
- To ***maintain*** this equipotential surface as one option to adopt as the vertical datum even if this surface diverges (departs) from the true mean coastal sea level for (around) North America over time;
- To ***monitor*** differences between the above-mentioned equipotential surface and the mean sea level via Global Navigation Satellite Systems (GNSS) on tidal benchmarks, altimetry or other means as required;
- To ***provide*** to the public, deformational velocities (*N-dot*) of the equipotential surface W_0;
- To ***collaborate*** in the realization of geoid models, through the sharing of data and related information:
- To ***compute*** updated geoid models and geoid deformation models with improved realizations as needed;
- To ***inform*** each other when large discrepancies (outside 95% confidence region) are found in overlapping regions; and
- To ***choose*** a threshold value (in alignment with both stakeholder needs and scientific integrity) in 2022, between predicted (modeled) geoid change and true geoid change (including deformation and sea level change) which will warrant new realization of the vertical datum.

Denis Hains
Director
Geodetic Survey Division
Canada Centre for Remote Sensing
Natural Resources Canada / Ressources naturelles Canada
Canada

Juliana P. Blackwell
Director
National Geodetic Survey



Entente: National Geodetic Survey des États-Unis et les Levés géodésiques du Canada

14 mars, 2012

Le National Geodetic Survey des États-Unis et la Division des levés géodésiques du ministère des Ressources naturelles du Canada, par un appel conférence tenu le 2012/02/17, se sont **entendus** :

- À ***définir*** un datum vertical commun (unique) pour les États-Unis d'Amérique (USA) et le Canada (CA) par l'entremise d'une surface équipotentielle réalisée par un modèle du géoïde calculé en commun (ensemble), correspondant au niveau moyen des mers le long des côtes de l'Amérique du Nord par 2022. L'adoption est sujette aux décisions nationales;
- À ***calculer*** le potentiel W_0 de cette surface équipotentielle par mesures du Système de positionnement mondial (GPS) à des marégraphes avant le 1er avril 2012 et à ***utiliser*** cette valeur pour la réalisation des modèles du géoïde des USA et du CA jusqu'en 2022;
- À ***maintenir*** cette surface équipotentielle comme une option pour l'adoption d'un datum vertical même si cette surface diverge (s'écarte), avec le temps, du véritable niveau moyen des mers de (entourant) l'Amérique du Nord.
- À ***surveiller*** la différence entre la surface équipotentielle mentionnée ci-haut et le niveau moyen des mers par mesures des Systèmes mondiaux de navigation par satellites (GNSS) à des marégraphes, par altimétrie et par autres moyens requis;
- À ***fournir*** au public des vélocités (N-dot) de déformation de la surface équipotentielle W_0;
- À ***collaborer*** à la réalisation des modèles du géoïde en partageant des données et l'information reliée;
- À ***calculer*** des mises-à-jour des modèles du géoïde et de déformation au besoin;
- À ***s'informer*** mutuellement des écarts importants (à l'extérieur d'une marge de confiance de 95%) retrouvés en régions chevauchantes;
- À ***choisir*** une valeur seuil (cadrant avec les besoins des utilisateurs et scientifiquement rigoureuse) en 2022 entre les changements prédits et réels du géoïde (incluant sa déformation et le changement du niveau moyen des mers) qui justifieront une nouvelle réalisation du datum vertical.

Denis Hains
Directeur
Division des levés géodésiques
Centre canadien de télédétection
Ressources naturelles Canada / Natural Resources Canada
Canada

Juliana P. Blackwell
Directrice
National Geodetic Survey

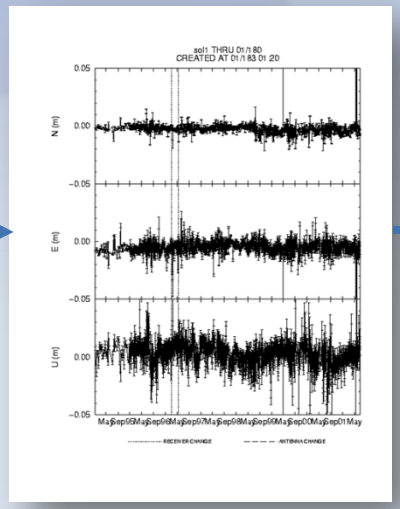
Monitoring Sea-Level Change

Observing Systems

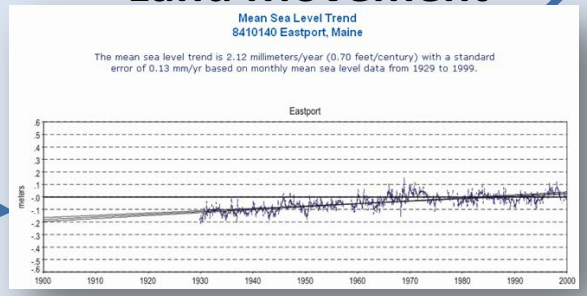
CORS

NWLON

Local Predictions

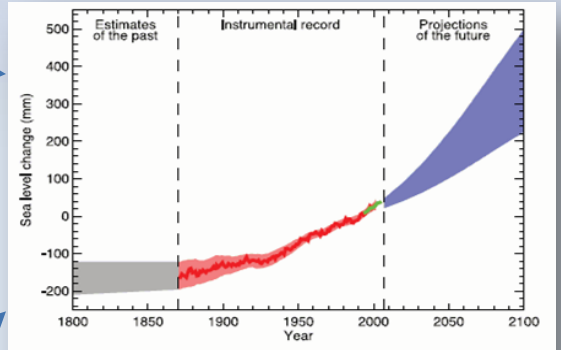


Vertical & Horizontal Land Movement



Local Relative Sea Level Trends

Global Predictions



FAQ 5.1, Figure 1. *Time series of global mean sea level (deviation from the 1980-1999 mean) in the past and as projected for the future. For the period before 1870, global measurements of sea level are not available. The grey shading shows the uncertainty in the estimated long-term rate of sea level change (Section 6.4.3). The red line is a reconstruction of global mean sea level from tide gauges (Section 5.5.2.1), and the red shading denotes the range of variations from a smooth curve. The green line shows global mean sea level observed from satellite altimetry. The blue shading represents the range of model projections for the SRES A1B scenario for the 21st century, relative to the 1980 to 1999 mean, and has been calculated independently from the observations. Beyond 2100, the projections are increasingly dependent on the emissions scenario (see Chapter 10 for a discussion of sea level rise projections for other scenarios considered in this report). Over many centuries or millennia, sea level could rise by several metres (Section 10.7.4).*

Global Mean Sea Level Trend

OPUS Extended Output - Estimate of New Datum (2022) Orthometric Height

** 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: 1659.685 (m)

[PROTOTYPE (Computed using USGG2012, GRS80, IGS08)]

New Datums: How to Prepare

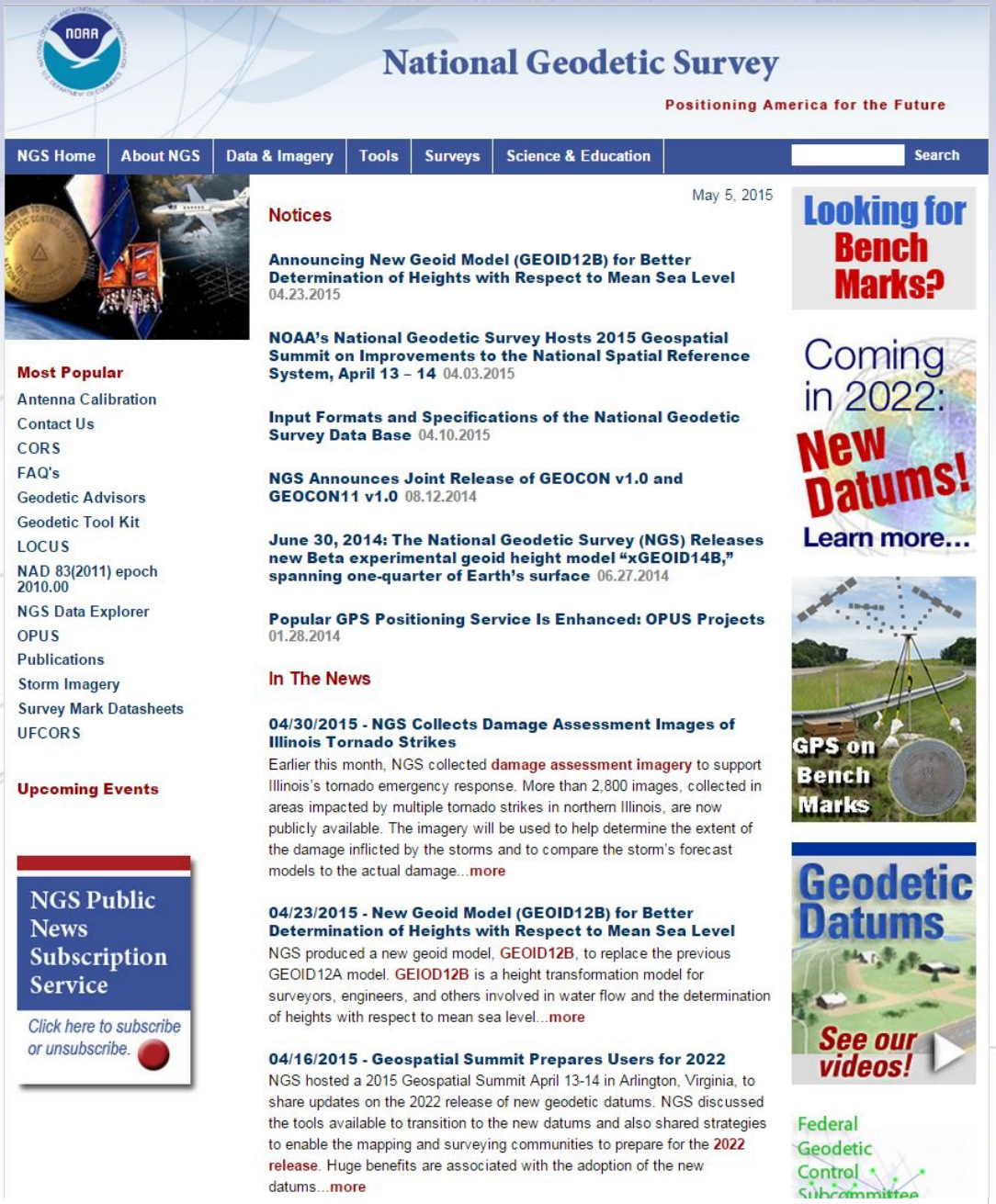
- Move to newest realizations.
  NAD 83(2011) epoch 2010.00
  USGG12 (gravimetric geoid) / GEOID12B (hybrid geoid)

- Obtain precise ellipsoid heights on NAVD 88 bench marks.
  (OPUS-DB, contact NGS Geodetic Advisor)
  Improves hybrid geoid models and provides "hard points" in new vertical datum.
  Follow new NGS Guidelines when released.

- Move from NGVD 29 to NAVD 88.
  Understand the accuracy of VERTCON in your area.

- Move away from passive marks to GNSS.
  Utilize CORS, OPUS, Real-time Networks.

- Require/provide complete metadata for all mapping contracts.
  How were the positions/heights derived? Document it!



NGS homepage: **geodesy.noaa.gov**

- Data access
- Geodetic Toolkit
- Publications
- Height Modernization
- Training opps
- Education resources
- Presentations

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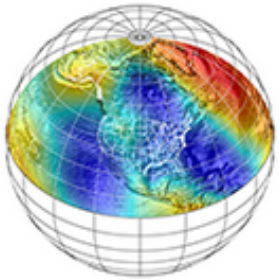
New Datums

National Geodetic Survey

May 6, 2015



Replacing NAVD 88 and NAD 83

NAD 83 and NAVD 88 will be replaced in 2022, and there are many related projects to make sure the transition goes smoothly. Read the **NGS Ten-Year Plan** to learn more and continue to visit this web-page for more information.

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2010 Summit

Why is NGS replacing NAD 83 and NAVD 88?

NAD 83 and NAVD 88, although still the official horizontal and vertical datums of the National Spatial Reference System (NSRS), have been identified as having shortcomings that are best addressed through defining new horizontal and vertical datums.

Specifically, NAD 83 is non-geocentric by about 1.5 meters. Secondly, NAVD 88 is both biased (by about one-half meter) and tilted (about 1 meter coast to coast) relative to the best global geoid models available today. Both of these issues derive from the fact that both datums were defined primary using terrestrial surveying techniques at passive geodetic survey marks. This network of survey marks deteriorate over time (both through unchecked physical movement and simple removal), and resources are not available to

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- Workshops and Conferences
- NGS Online Learning Resources

http://www.geodesy.noaa.gov/web/science_edu/training/

NOS Online Learning Resources cover NGS programs and more.

http://oceanservice.noaa.gov/multimedia/

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Title	Presenter	Author	Co-Author(s)	Date Presented	Location	Group/Forum/Meeting	Keywords/Topics	Abstract	File Information
GRAV-D and the New Datums: Coming Your Way in 2022!	Vicki Childers	Vicki Childers	Theresa Damiani	2014/03/22	Tony Cheng Restaurant, Washington, DC	DC Association of Land Surveyors Spring Banquet	GRAV-D, New Datums	Show Abstract	Download (pptx) (32.68 MB)
NGS Update - Focus on Height Modernization	William Stone	William Stone		2014/03/14	Albuquerque, NM	New Mexico Professional Surveyors 2014 Conference	Height Modernization, geoid model, bench marks, GPSBM, datums, CORS, OPUS, GEOID12A	Show Abstract	Download (ppt) (69.98 MB)
NGS Products and Services Update	Brian Shaw	Brian Shaw		2014/02/25	Penn State Wilkes-Barre campus	Lambda Sigma Honor Society	NGS, Products, Services		Download (ppt) (63.64 MB)
NGS Updates	David Zenk	David Zenk		2014/02/21	Bloomington, MN	Minnesota Society of Professional Surveyors	OPUS, GRAV-D, Leveling, GEOID Slope Validation	Show Abstract	Download (pdf) (3.34 MB)
National Geodetic Survey - Height Modernization Program	William Stone	William Stone		2014/02/21	St. George, UT	Utah Council of Land Surveyors 2014 Conference	geodesy, geoid models, GEOID12A, heights, GPSBMs, new datums, DSWorld, CORS, OPUS, Height Modernization	Show Abstract	Download (ppt) (68.03 MB)
NGS UPDATE	Dave Rigney	Dave Rigney		2014/02/21	Manistee, MI	Michigan Society of Professional Surveyors	Datums Product and Services	Show Abstract	Download (ppt) (17.62 MB)
Vertical Datums, Geoids: What you need to know	Pamela Fromhertz	Pamela Fromhertz		2014/02/20	Denver, CO	DRCOG	GIS, State Capitol Mile HI Marks, datums, geoids, new datums, National Surveyor Week		Download (ppt) (15.86 MB)
Usage of GOCE Data with GRAV-D	Daniel Roman	Daniel Roman	Xiaopeng Li and Simon Holmes	2014/02/20	ESTEC,Noordwijk, The Netherlands	STSE-GOCE+ Height System Unification Final Meeting	ESA, GOCE, World Height System, GRAV-D	Show Abstract	Download (ppt) (4.62 MB)
Datums and Projections	Pamela Fromhertz	Pamela Fromhertz		2014/02/19	Golden, CO	Graduate Student of Geosciences Colorado School of Mines: Reservoir Characterization Project	NGS, NSRS, datums, geoids, new datums, projections, SPCS, UTM, National Surveyor Week		Download (ppt) (17.88 MB)
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Shortly after sending your "subscribe NGS.news" message, you will receive an automated reply from the mailing list service with a subject line similar to: Subscribe NGS.news Confirm 111111 {where 111111 is a random number assigned to your request}. The email will instruct you to confirm your request by replying to the confirmation message.

You will receive one final message welcoming you to the NGS News mailing list. The email will include a help message explaining how to get help and how to unsubscribe from the list.

What's Next for Geodetic Datums?

https://www.youtube.com/playlist?list=PLsyDl_aqUTdFY6eKURmiCBBk-mP4R10Dx

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National Geodetic Survey

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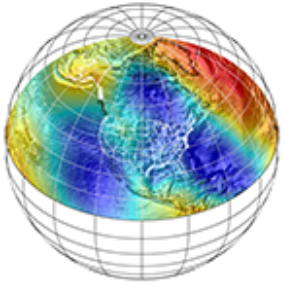

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- Overview
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- Recorded Webinars
- Frequently Asked Questions (FAQ)

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- Sign-up for webinar announcements
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Geodetic Datums

Overview

Each month, a speaker will give a presentation on various topics related to NGS programs, projects, products and services to educate constituents about NGS activities.

Webinars are held on the second Thursday of every month, from 2:00-3:00 p.m. East Coast time. You can register for any presentation on the **"Upcoming Webinars" page**, and you can **sign-up to receive a monthly notice** describing the upcoming presentation.

This webinar series is a continuation of **monthly presentations sponsored by the National Height Modernization Program**, and you can download previous presentations from the Program's online meeting archive.

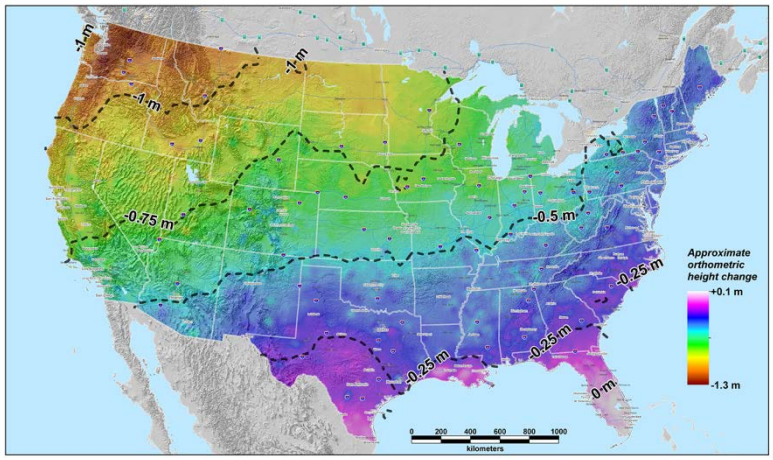
Many additional NGS resources are available online, including:

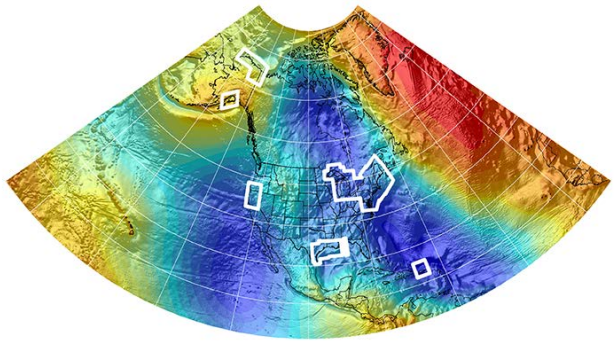
- **Continuously Operating Reference Station (CORS) weekly newsletter archive**
- **Ecosystem and Climate Operations newsletter archive**
- **Educational videos**
- **Height Modernization monthly meeting archive**
- **Online Learning Resources** (e.g. recorded webinars and online training modules)
- **Presentation library**

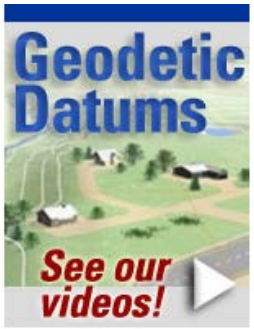
New Datums Are Coming in 2022!

- NOAA's National Geodetic Survey will release new geometric (horizontal) and geopotential (vertical) datums in 2022
- The realization of the new datums will be through GPS/GNSS receivers and will replace the current datums:

  NAD 83(geometric) and NAVD 88 (geopotential)
- Target: 2-centimeter accuracy relative to sea level (orthometric heights) using GPS/GNSS and a geoid (gravity) model from NGS' GRAV-D project.
- NGS will provide the tools to easily transform between the new and old datums.



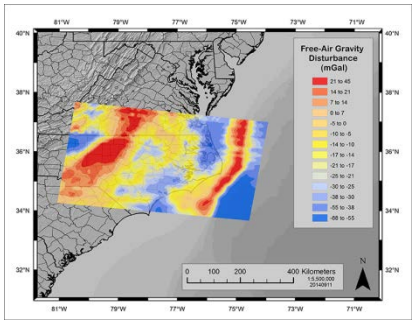




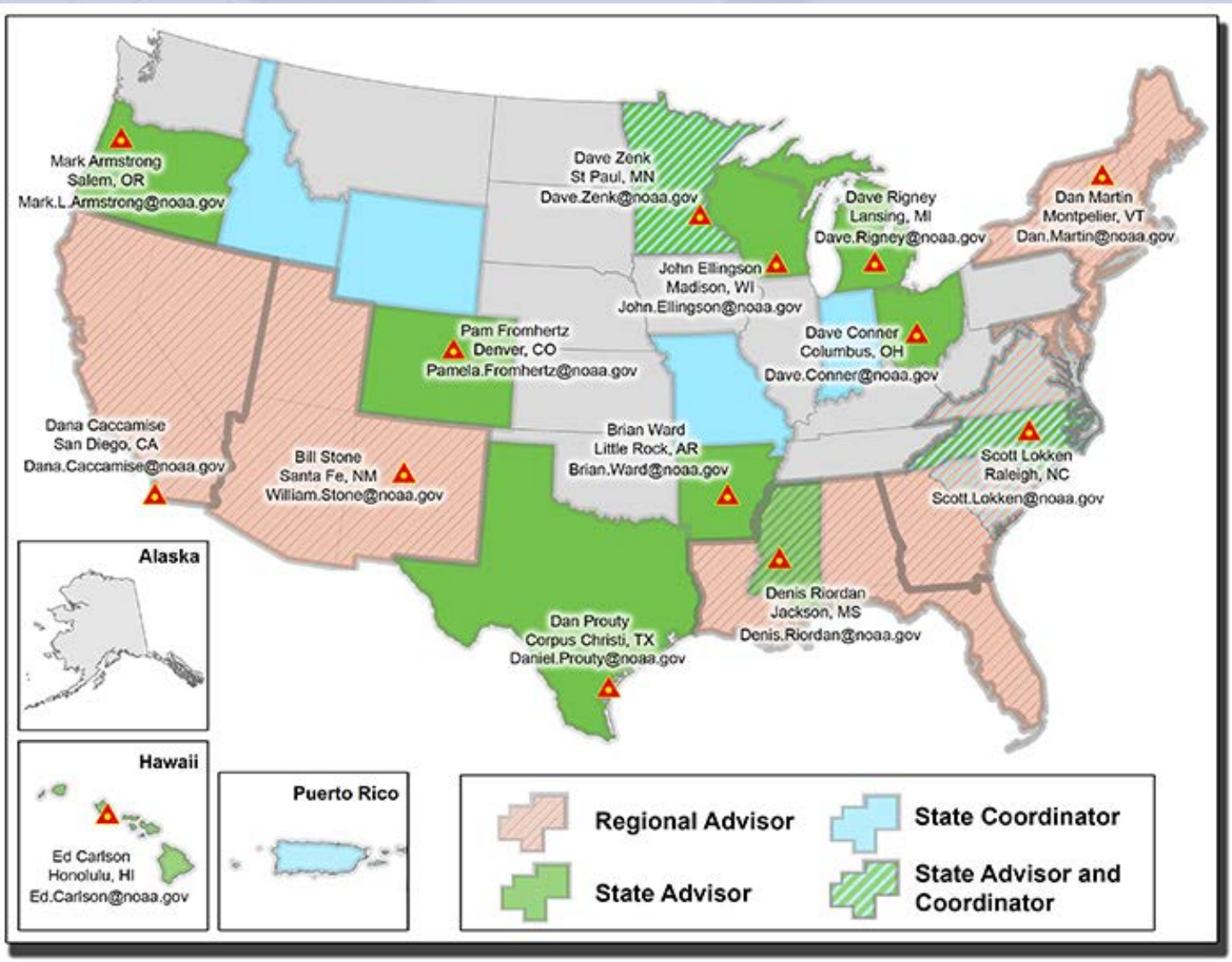
MORE INFO:

April 13-14 DC Area Geospatial Summit:
http://www.geodesy.noaa.gov/2015GeospatialSummit/

New Datums Webpage and Videos:
http://www.geodesy.noaa.gov/datums/newdatums/NewDatums.shtml



National Geodetic Survey - Geodetic Advisors



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