



Overview of New Datums

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NOAA's National Geodetic Survey

New Datums are Coming in 2022!

- Both a new geometric and a new geopotential (vertical) datum will be released in 2022.
- The realization of the new datums will be through GNSS receivers.
- NGS will provide the tools to easily transform between the new and old datums.



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

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 above, 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

Why change datums/Realizations

- NAD27 based on old observations and old datum
- NAD83(86) based on old observations and new datum
- NAD83(95) based on new and old observations and same datum (original HARN)
- NAD83(2001) based on better observations and same datum
- NAD83(NSRS2007) based on new observations and same datum. Removed regional distortions and made consistent with CORS
- NAD83(2011) based on new observations and same datum. Consistent with new Multi Year CORS solution

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 (1995) (HARN)	1990 – 1997	1:10,000,000	0.1 m
CORS	1994 -----	0.01/0.02 m	0.02/0.04 m
NAD 83 (2001) (FBN/CBN)	1997 – 2007	0.05/0.05 m	0.05/0.05 m
NAD 83 (NSRS2007)	2007 - 2012	0.01/0.02 m	0.02/0.04 m
NAD 83 (2011) epoch 2010.0	2012 - -----		0.009/0.015m

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

The NSRS has evolved



**1 Million
Monuments**
(Separate Horizontal
and Vertical Systems) →

**70,000
Passive Marks**
(3-Dimensional)



**Passive
Marks**
(Limited
Knowledge of
Stability) →

**≈ 2,000 GPS
CORS**
(Time Dependent
System Possible;
4-Dimensional)



GPS CORS → GNSS CORS



ITRF2008, IGS08 AND NAD 83(2011)

ITRF2008

For the geodesy, geophysics and surveying communities, the best International Terrestrial Reference Frame is the “gold standard.”

The global community recently adopted an updated expression for the reference frame, the ITRF2008.

International Earth Rotation and Reference System Service (IERS)

[\(http://www.iers.org\)](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

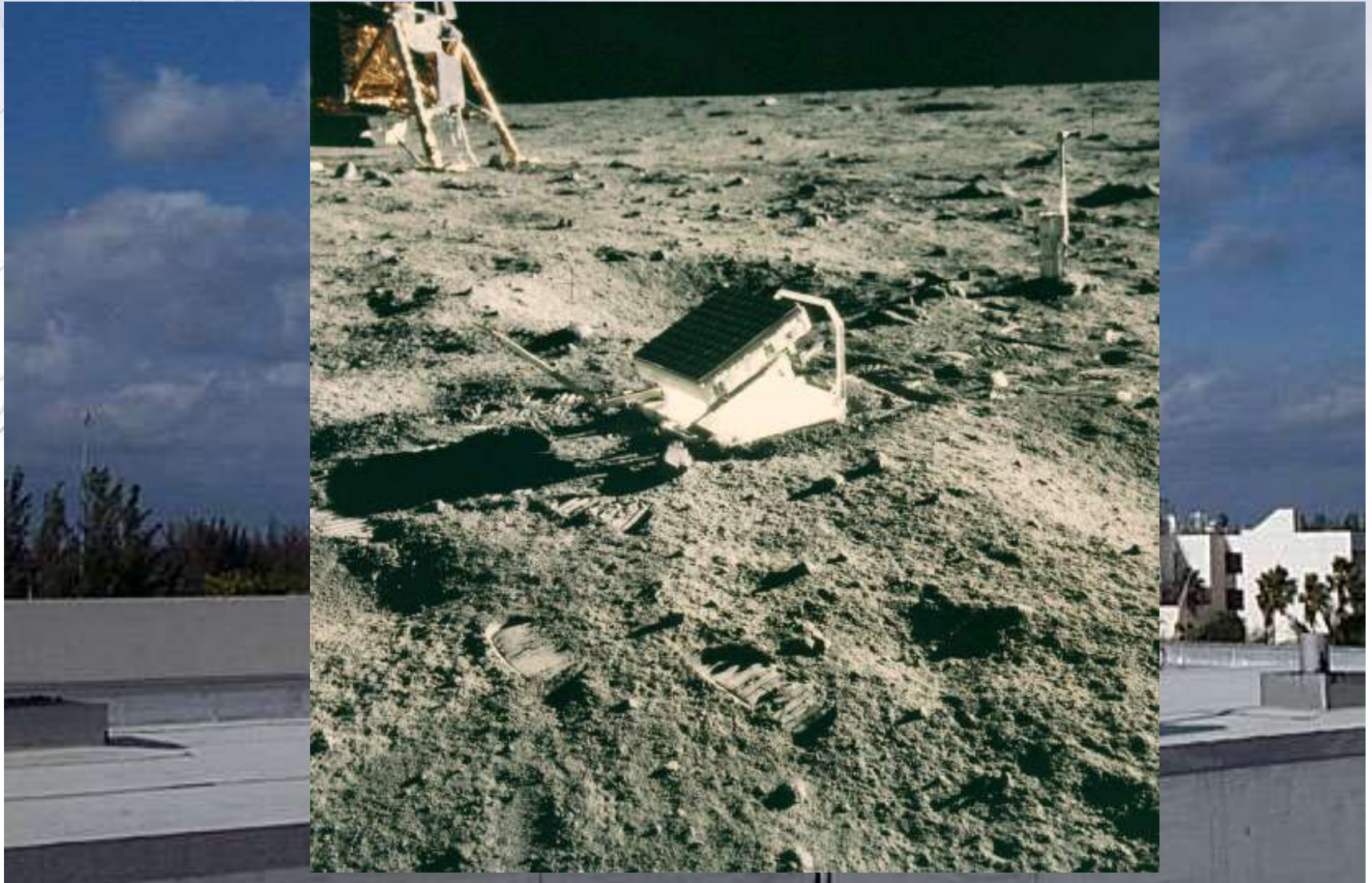
ITRS is realized by the International Terrestrial Reference Frame (**ITRF**) based upon estimated coordinates and velocities of a set of stations observed by:

- 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



Densification

The ITRF2008 is expressed through the coordinates and velocities of marks on the ground plus ancillary data.

Other organizations can take that information, add additional marks, perform their own adjustment and align their results to the ITRF2008 (A.K.A. densifying).

The variants try to be as consistent with the ITRF2008 as possible, but in the most formal sense, they are unique from the ITRF2008. Therefore, they are given unique names.

The IGS08

The IGS has densified reference frame with much larger, global subset of GNSS tracking sites thereby creating a GNSS-only expression of the ITRF2008 called the IGS08. All IGS products have been recreated so as to be consistent with the IGS08 including GNSS ephemerides and antenna models. Information about the IGS08 can be found at the IGS web sites: igs.cb.jpl.nasa.gov. I would suggest starting with IGSMAIL-6354, -6355 and -6356, all dated 2011-03-07.

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. NAD83(1995), NAD83(NSRS2007), NAD83(CORS96), NAD83(2011))

also

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

NGS's Mission and Role

- **NGS Mission:** “To define, maintain, and provide access to the National Spatial Reference System to meet our nation’s economic, social, and environmental needs”
- **OMB Circular A-16 (revised)** names DOC and NOAA as “lead agency” for Geodetic Control:
 - “All NSDI framework data and users' applications data require geodetic control to accurately register spatial data.”
 - “The National Spatial Reference System is the fundamental geodetic control for the United States.”
- **Coast and Geodetic Survey Act** (Public Law 80-373) gives DOC the right to (among numerous other things) “... conduct ... geodetic control surveys ... ”

<http://uscode.house.gov/download/pls/33C17.txt>

NGS's Mission and Role

- NGS has defined the datums of the NSRS as NAD 83 and NAVD 88 (plus others)
- FGCS requires that all civilian federal surveying and mapping use NAD 83 and/or NAVD 88 (plus others)
- “To the extent practicable, legally allowable, and feasible, require that all Federal agencies using or producing (vertical height / coordinate) information undertake an orderly transition to (NAVD 88/NAD 83)”
 - 1989 FGCC Federal Register Notice (54 FR 25318)
 - 1993 FGCS Federal Register Notice (Vol. 58, No. 120)
- These regulations do not apply to DoD nor to state and local surveying, but these groups often do adopt NAD 83 / NAVD 88

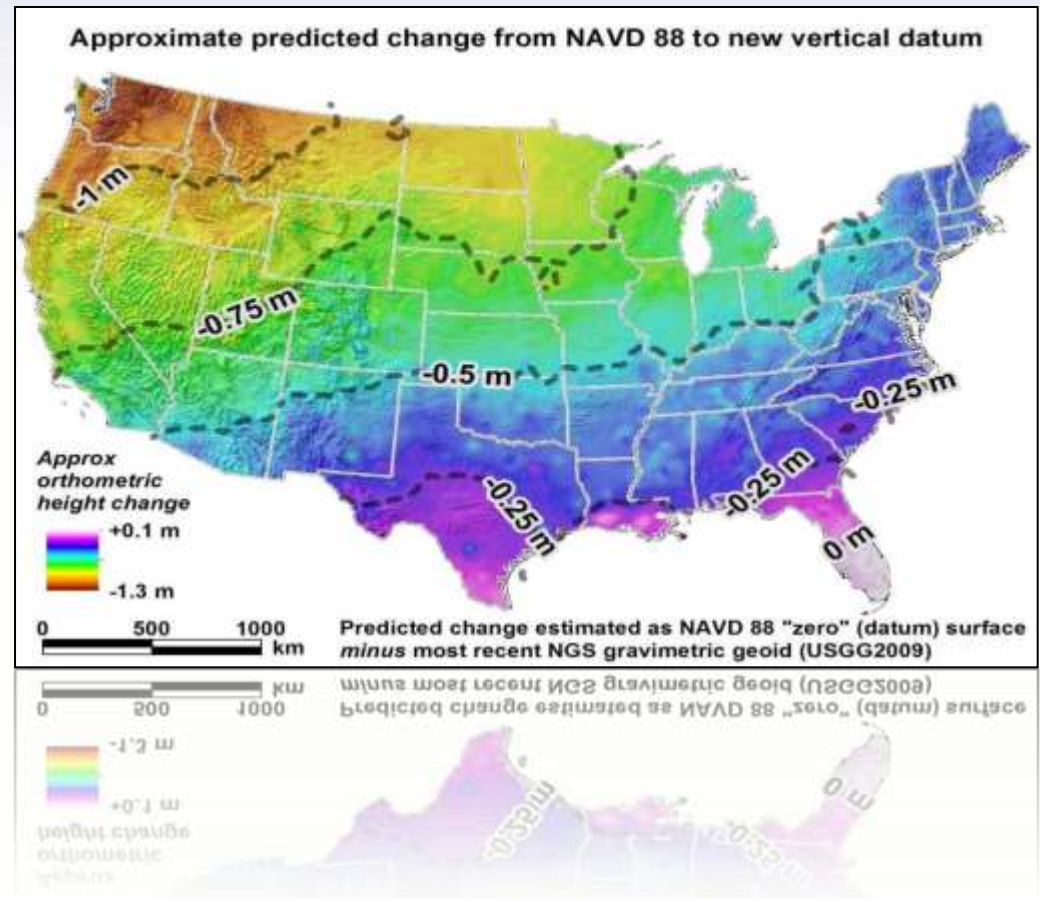
New Datums are Coming in 2022!

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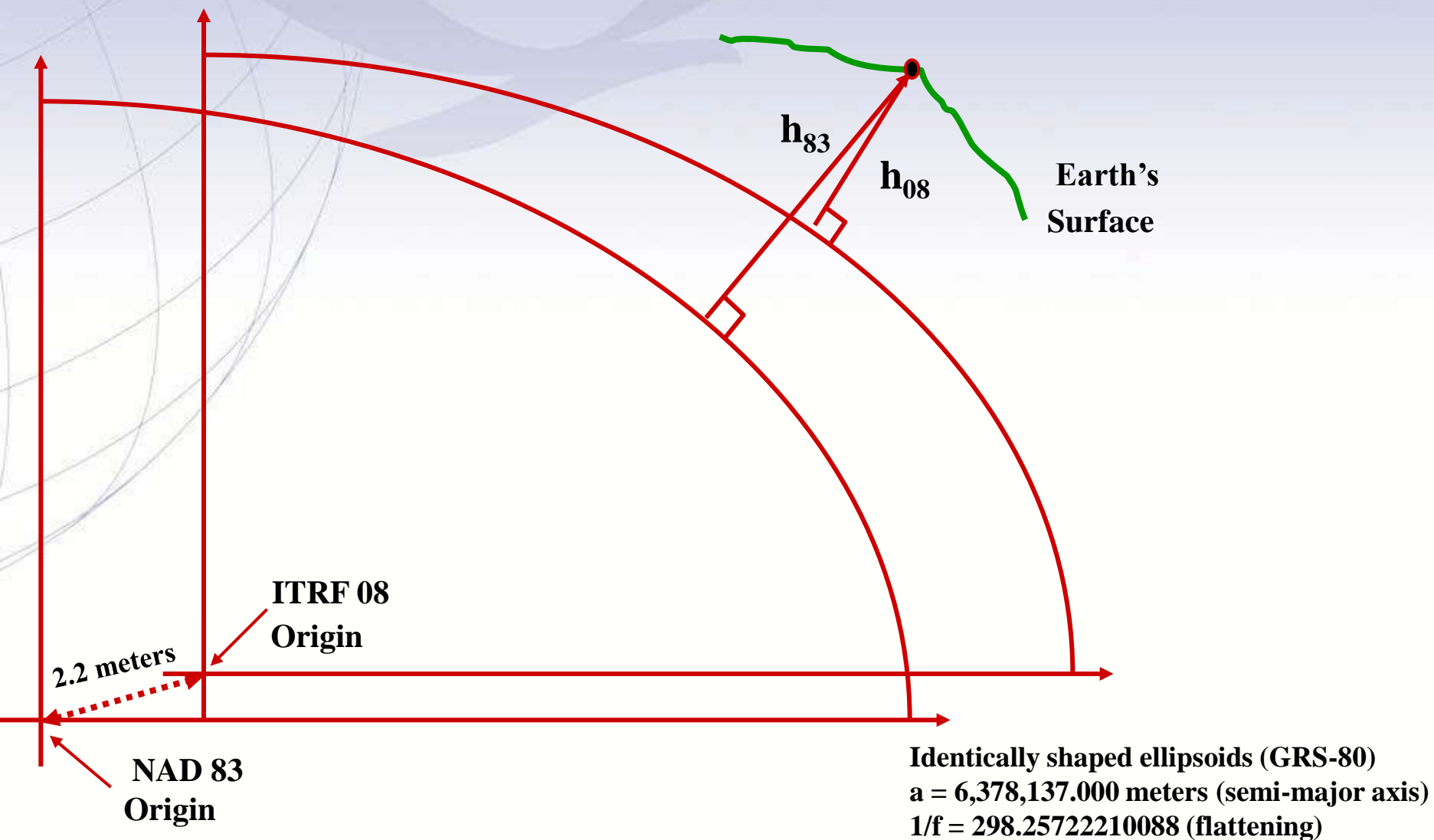


How will the new datums affect you?

- The new geometric datum will change latitude, longitude, and ellipsoid height by between 1 and 2 meters.
- The new vertical (geopotential) datum will change heights on average 50 cm (20"), with a 1 meter (39") tilt towards the Pacific Northwest.



Simplified Concept of NAD 83 vs. ITRF08



Questions: Themes

The questions provided to NGS fall into 3 major categories:

- Datum adoption
 - Speed, legal issues, impacts, transformations
- Datasheets
- State Plane Coordinates

Old vs New Datums

- What's being replaced:

Horizontal

- NAD 83(2011)
- NAD 83(PA11)
- NAD 83(MA11)

Latitude
Longitude
Ellipsoid Height
State Plane Coordinates

Vertical

- NAVD 88
- PRVD 02
- VIVD09
- ASVD02
- NMVD03
- GUV D04
- IGLD 85

Heights

Old vs New Datums

• The old way

Text based datasheets

```
NAD 83(2011) POSITION- 40 03 10.11448(N) 082 58 34.91800(W) ADJUSTED
NAD 83(2011) ELLIP HT- 239.400 (meters) (06/27/12) ADJUSTED
NAD 83(2011) EPOCH - 2010.00
NAVD 88 ORTHO HEIGHT - 273.3 (meters) 897. (feet) GPS OBS
```

Observed changes viewed as
“corrections” not “movement”

SUPERSEDED SURVEY CONTROL

```
NAD 83(2007)- 40 03 10.11456(N) 082 58 34.91884(W) AD(2002.00) 0
ELLIP H (02/10/07) 239.418 (m) GP(2002.00)
ELLIP H (03/08/05) 239.413 (m) GP( ) 4 2
NAD 83(1995)- 40 03 10.11462(N) 082 58 34.91855(W) AD( ) B
ELLIP H (08/20/96) 239.417 (m) GP( ) 4 2
NAD 83(1986)- 40 03 10.12158(N) 082 58 34.92303(W) AD( ) 1
NAD 27 - 40 03 09.89400(N) 082 58 35.26500(W) AD( ) 1
NGVD 29 (09/26/89) 273.5 (m) RAPSUS86 model used GPS OBS
```

Fragile, unchecked passive control



• The new way

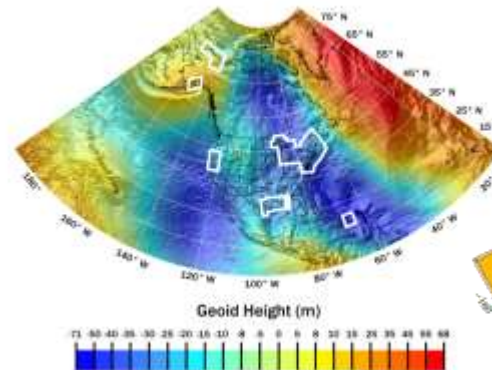
Modern datasheets



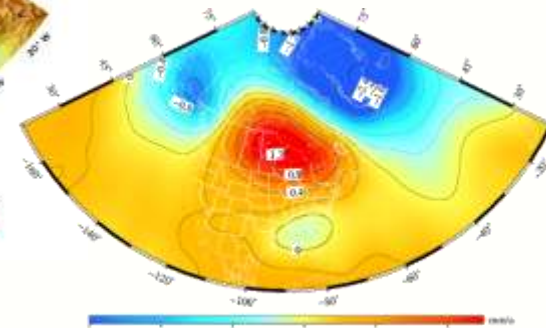
CORS



RTN



Geoid



Temporal Geoid Change

Why isn't NAVD 88 good enough anymore?

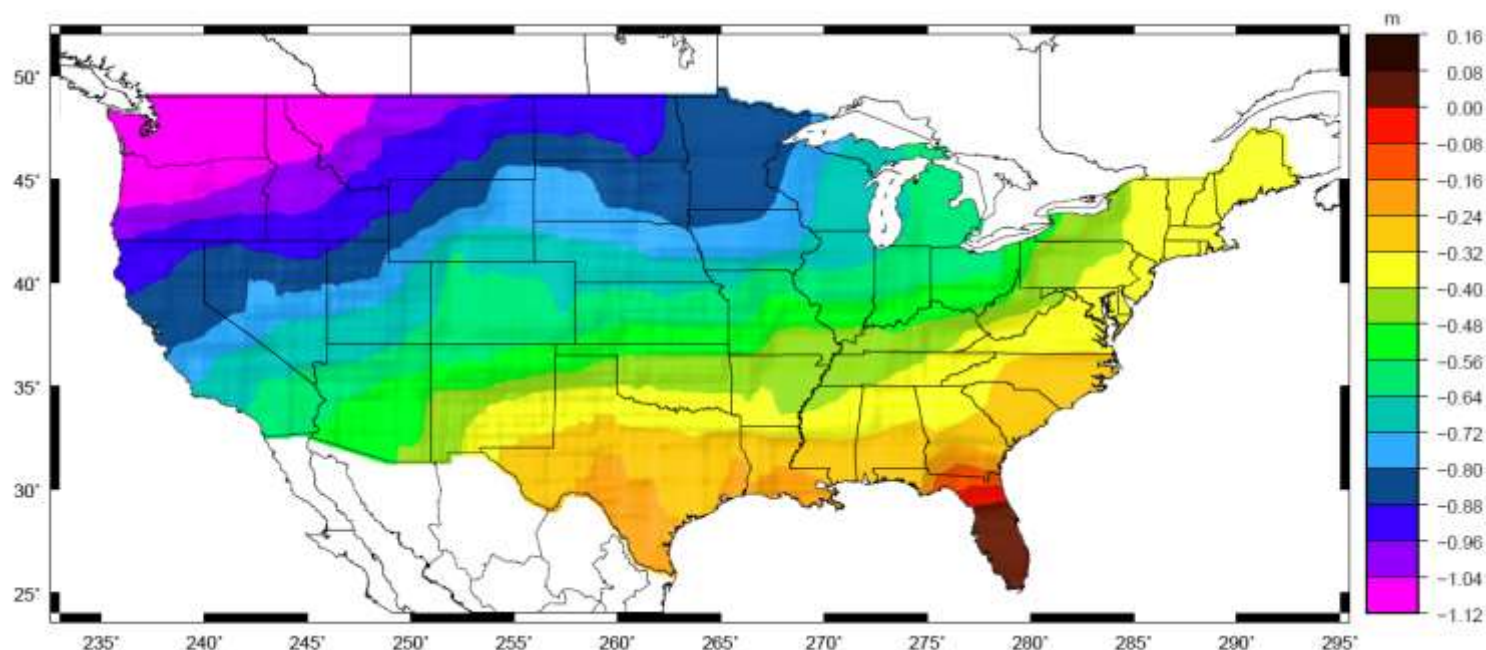
NAVD 88 suffers from use of bench marks that:

- Almost never re-checked for movement
- Unknown numbers disappear every year
- No funding for replacement
- 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?

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



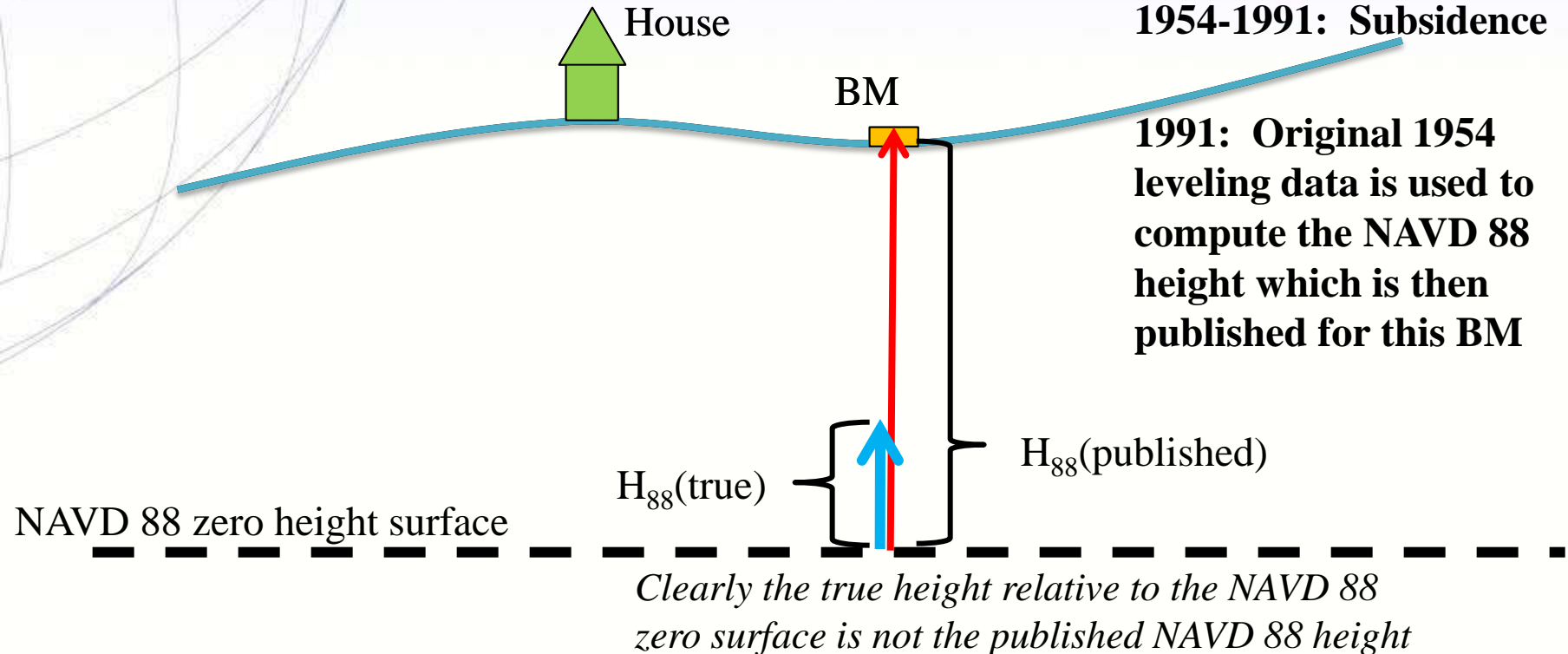
How will I access the new vertical datum?

Example 1: Flood insurance survey

1954: Leveling performed to bench mark

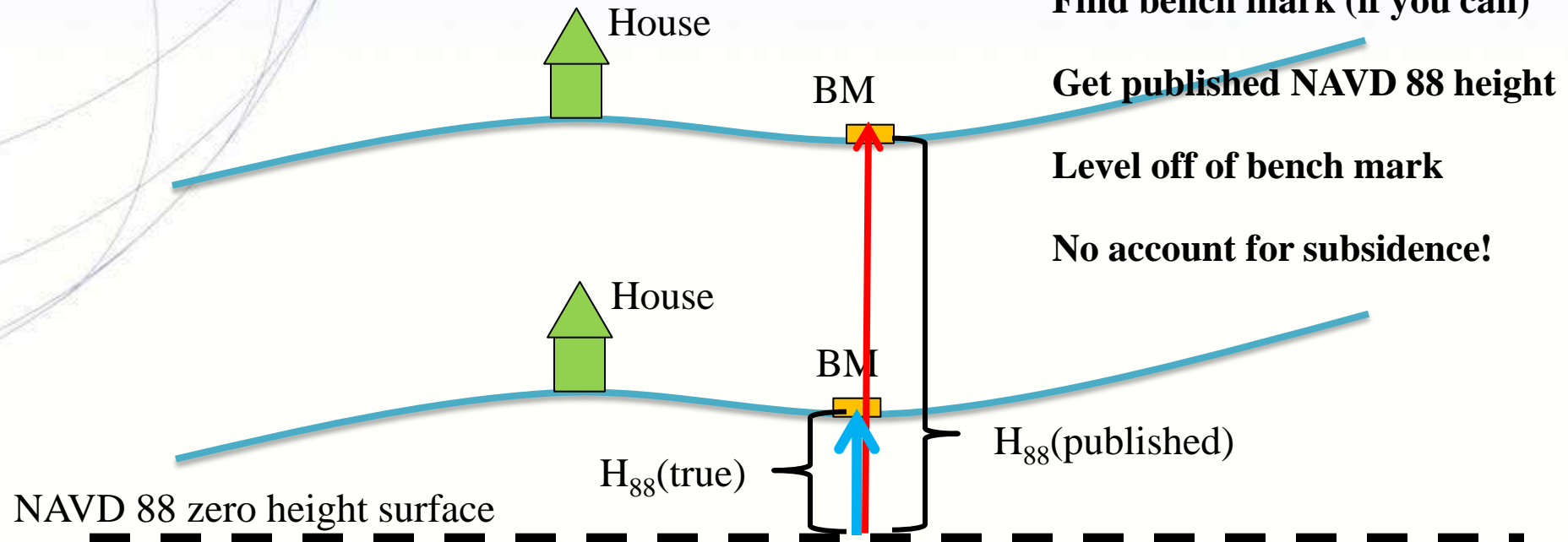
1954-1991: Subsidence

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



How will I access the new vertical datum?

Example 1: Flood insurance survey



How will I access the new vertical datum?

Example 1: Flood insurance survey

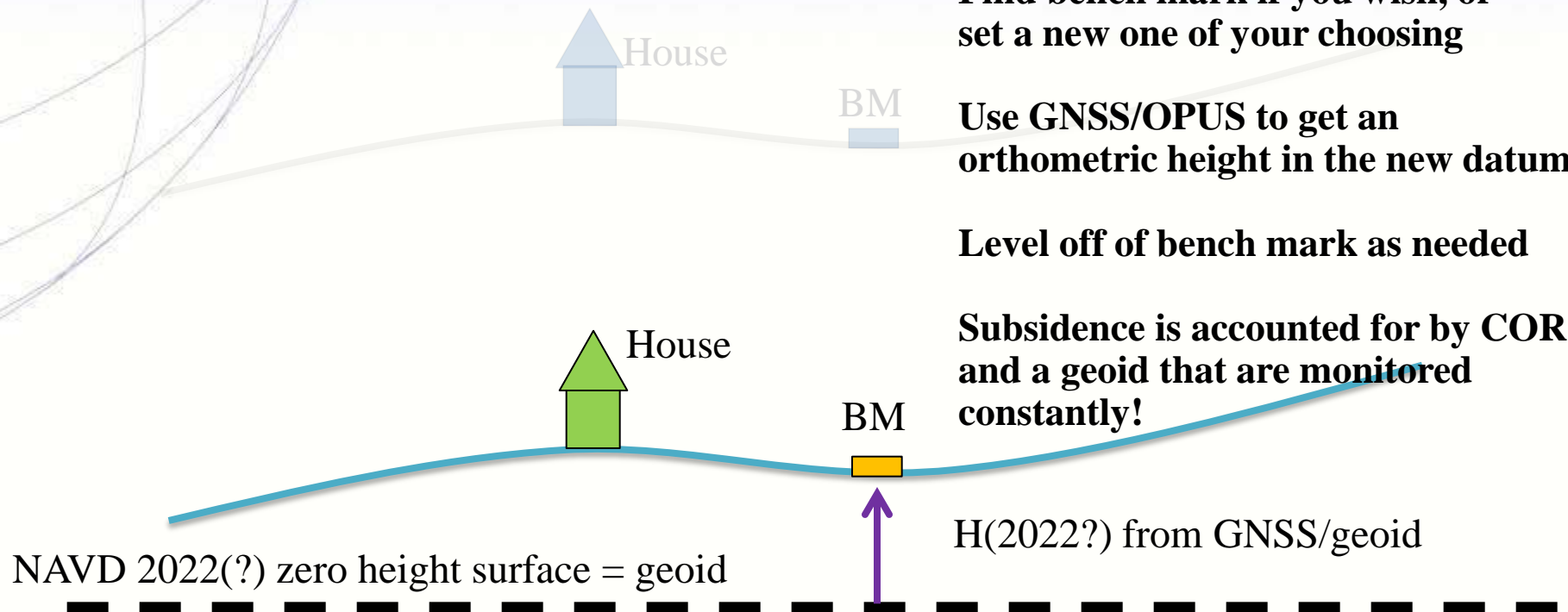
Using Future Techniques:

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!

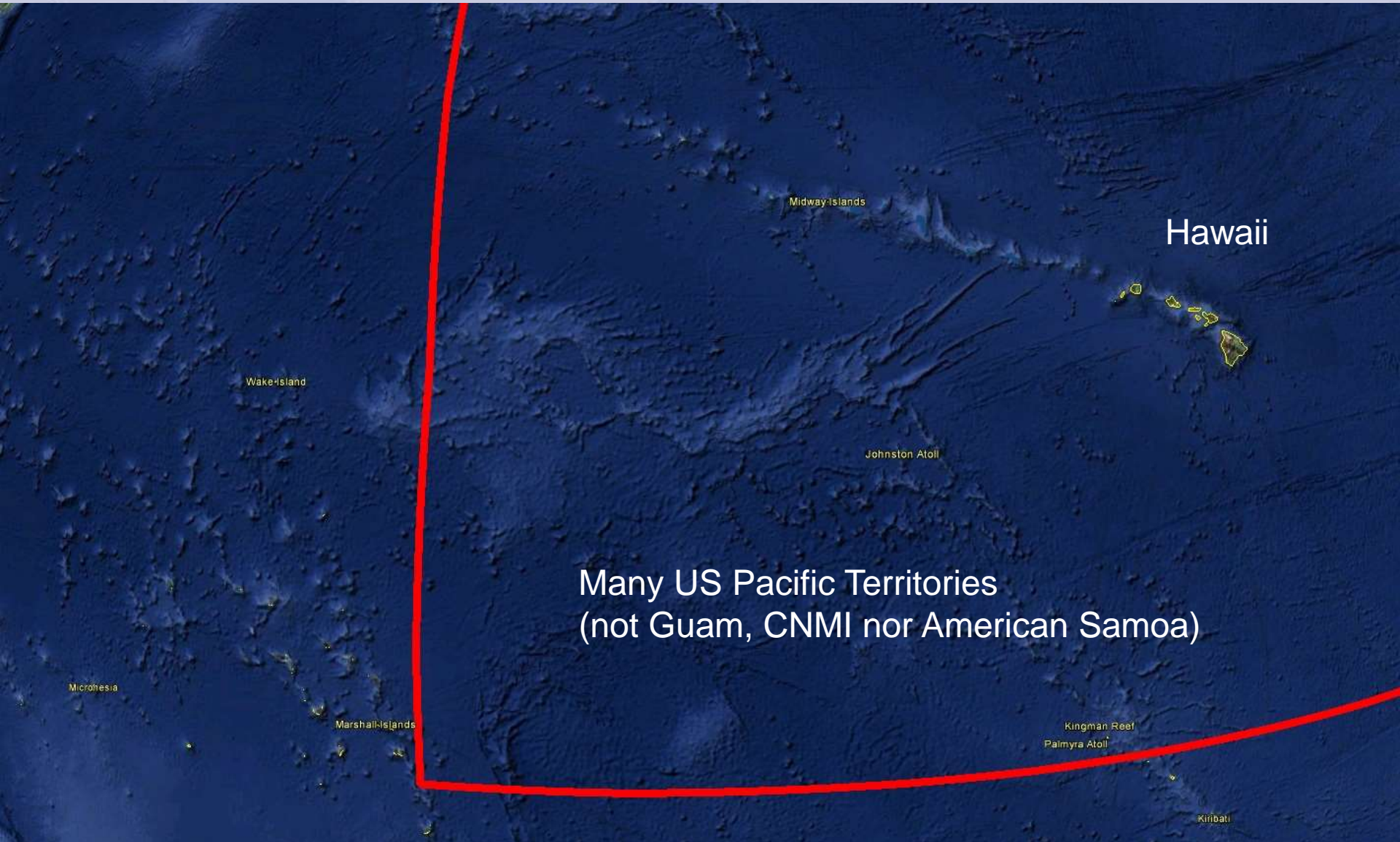


Terminology

- ~~Horizontal Datum~~
 - Geometric Reference Frame
 - Geocentric X,Y,Z
 - Latitude, Longitude, Ellipsoid Height
- ~~Vertical Datum~~
 - Geopotential Reference Frame
 - Geoid undulation
 - Orthometric height
 - Gravity
 - Deflection of the Vertical



Approximate extent of 2022 geoid model used for the “North American” part of the new geopotential reference frame.



Many US Pacific Territories
(not Guam, CNMI nor American Samoa)

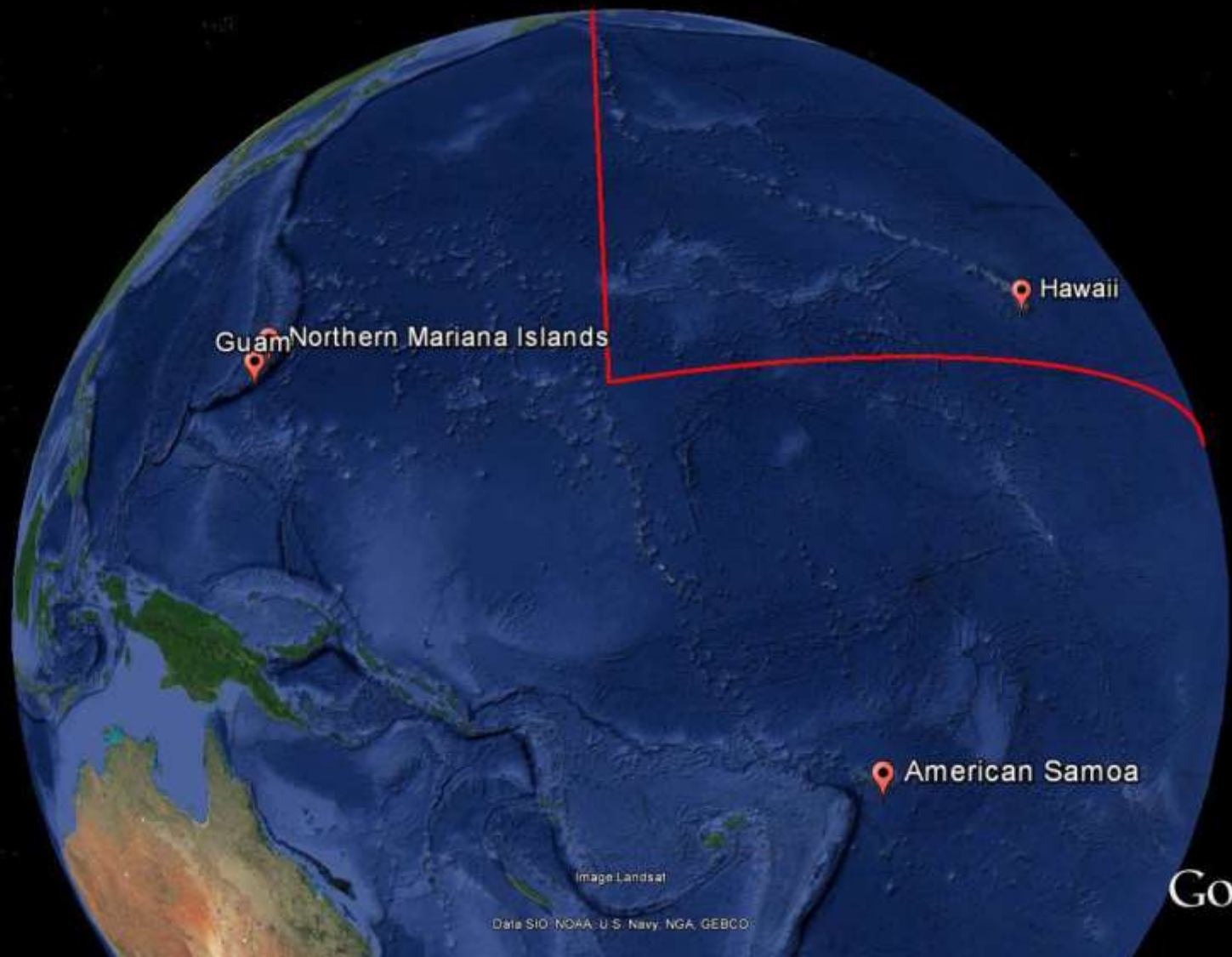


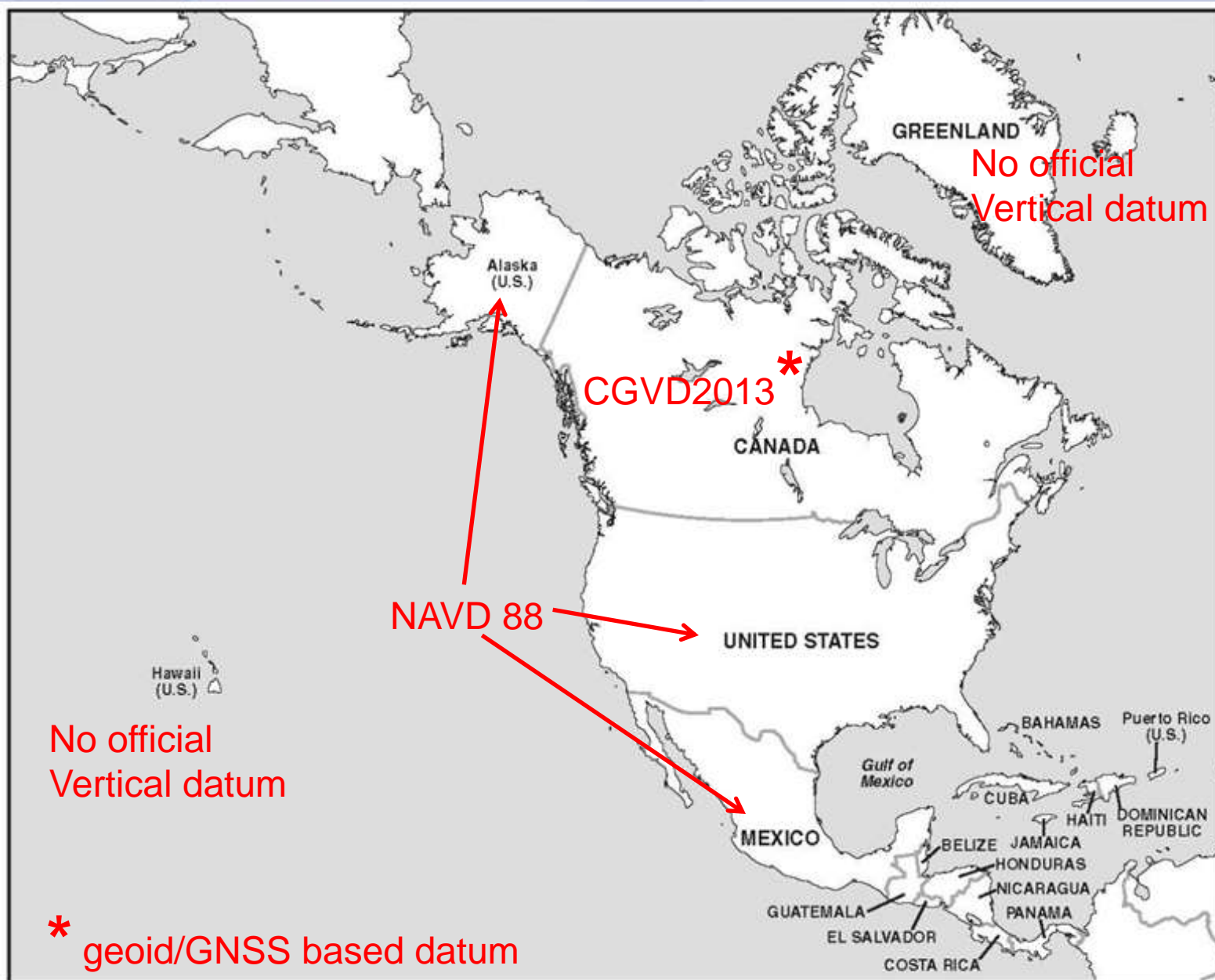
Alaska, including
entire Aleutian
Island Chain

Canada

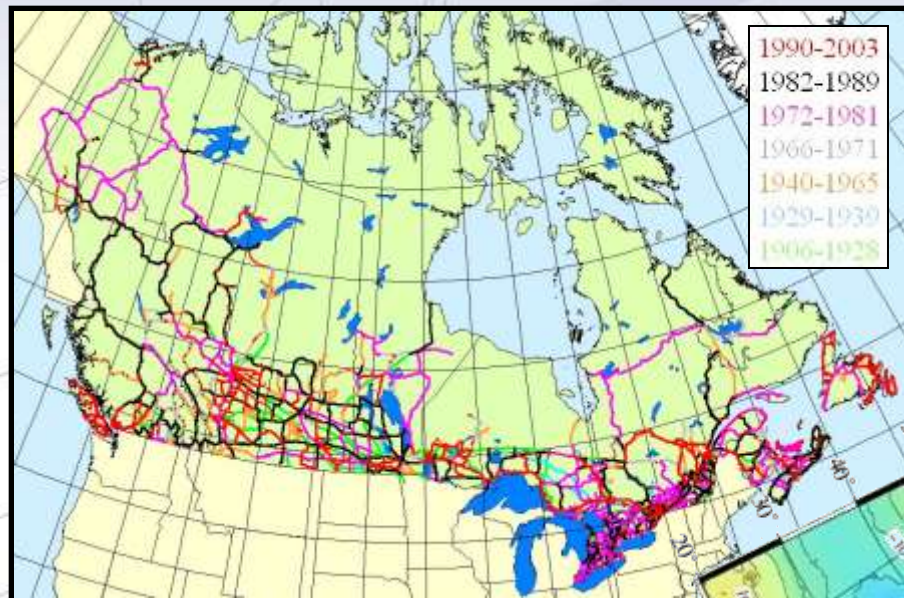
CONUS (USA)







Canada Height Modernization - 2013

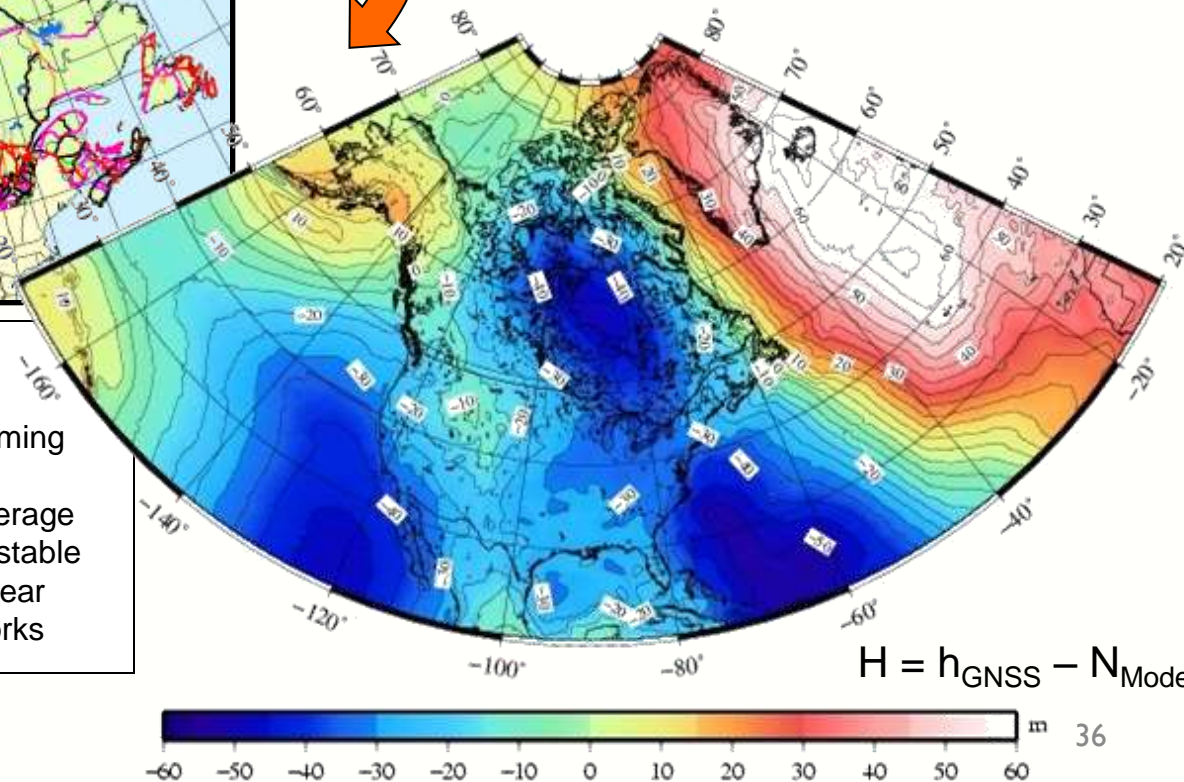


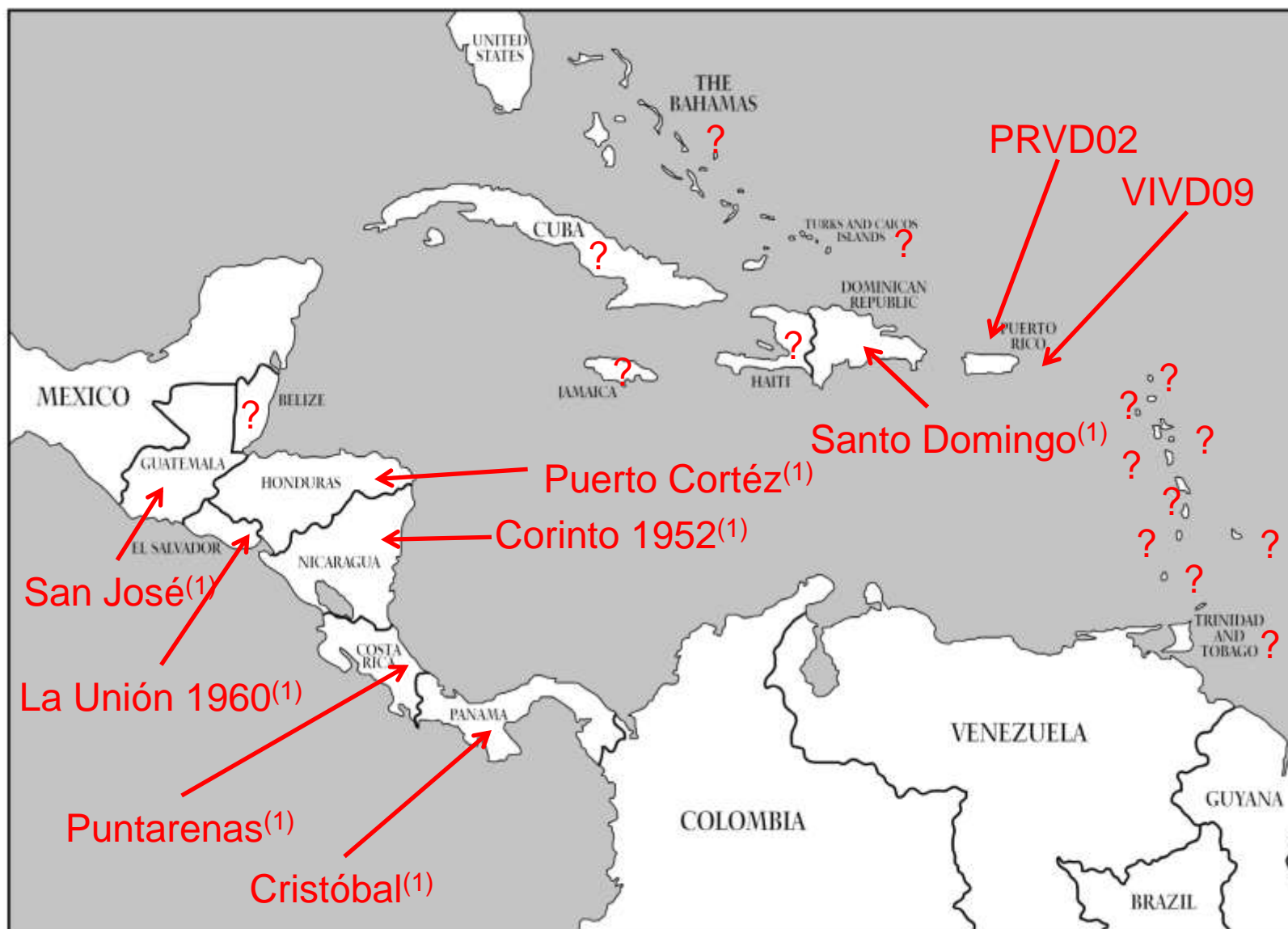
Levelling Networks:

- | | |
|--|---------------------|
| 1. Established over the last 100 years | 1. Time consuming |
| 2. 120,000 km of levelling lines | 2. Expensive |
| 3. Some 80,000 benchmarks | 3. Limited coverage |
| | 4. BMs are unstable |
| | 5. BMs disappear |
| | 6. Local networks |

The geoid model:

- | | |
|---|------------------------------------|
| 1. Entire coverage of the Canadian territory (land, lakes and oceans) | 3. Less expensive for maintenance |
| 2. Compatible with space-based positioning (e.g., GNSS, altimetry) | 4. Fairly stable reference surface |





⁽¹⁾ Información cortesía de David Avalos

Old vs New Datums

- Step 1: Do the best scientific positioning work we can in ITRF
 - Before any discussion of “plate fixed” or “map projections”
 - NGS’s core goal must be the *scientific integrity of positions*
 - **New database**
 - **Replacement of static vector-based GNSS processing**

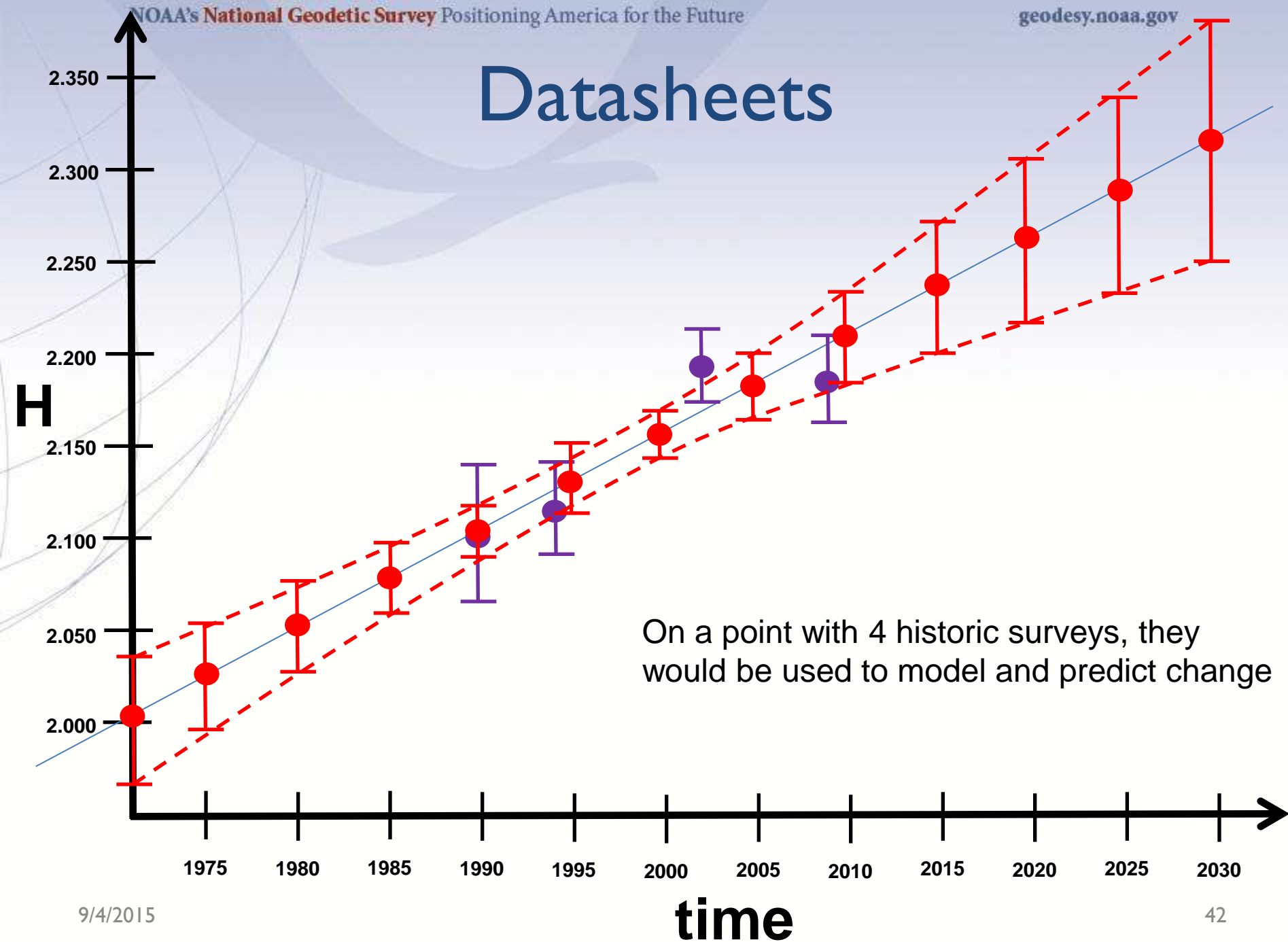
Old vs New Datums

- Step 2: Consider the question of “plate fixed”:
 - Why do users want this?
 - Fixed latitude and longitude?
 - Nothing is “fixed” though
 - Plate is not just rotating; more than 1 plate
 - Who wins? Who defines “fixed”? Must all points maintain zero change?
 - Model and remove all real motion? (aka “HTDP”)
 - If not removing *all* motion, why remove *any* motion?
 - » ITRF minus plate rotation vs just ITRF

Old vs New Datums

- Roll of passive control in the future
 - Control for projects
 - Depending on accuracy needs, new coordinates should be determined rather than relying on published coordinates based on old surveys
 - Monitoring sites for motion
 - Calibrating RTNs

Datasheets



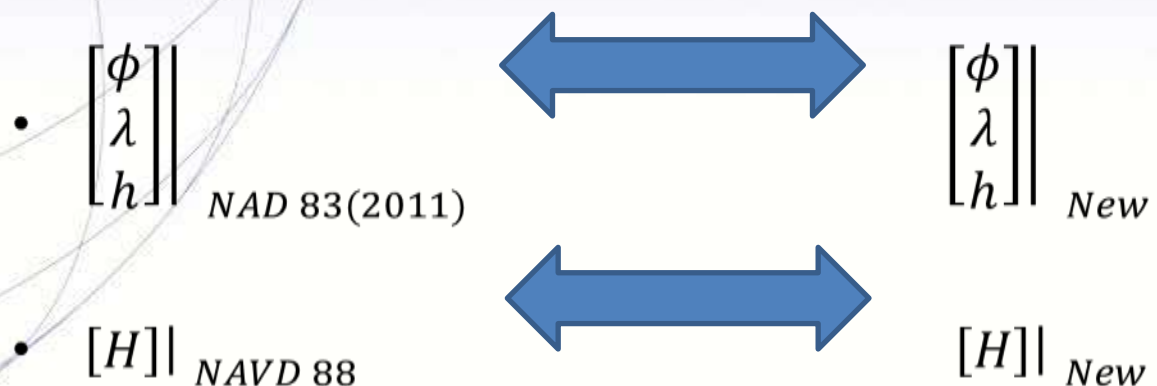
State Plane Coordinates

- Barring user-requested changes, NGS may use existing SPC projections, boundaries and equations, but with new false northings & eastings (to distinguish from NAD 27 and NAD 83)
- User-provided plug-ins (pre-written code) for SPC or other projections may be possible

Tools for Transitioning

Tools: Transformational

- NADCON and VERTCON will be expanded to provide coarse mapping grade transformations:



Geocon/Geocon11



News Item

National Geodetic Survey

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Tuesday, August 12, 2014

NGS Announces Joint Release of GEOCON v1.0 and GEOCON11 v1.0

NGS is pleased to release two related products: **GEOCON v1.0** and **GEOCON11 v1.0**. Each product transforms coordinates between specific realizations of the North American Datum of 1983 (NAD 83).

GEOCON v1.0 allows users to transform latitudes, longitudes, and ellipsoid heights between NAD 83("HARN") and NAD 83(NSRS2007). (NAD 83["HARN"] is an abbreviation for "the most recent pre-NSRS2007 realization of NAD 83 at any given point.") GEOCON also issues information about the quality of the transformation at each point and notifies users in the event of poor quality results.

GEOCON11 v1.0 performs a similar task as GEOCON, but it transforms coordinates between NAD 83(NSRS2007) and NAD 83(2011). Similar to GEOCON, GEOCON11 issues information regarding the quality of the transformations to users.

You may find more information about **GEOCON v1.0** and **GEOCON 11 v1.0**, including operator and user guides, technical reports, and download instructions on the NGS website at: <http://www.ngs.noaa.gov/GEOCON/>. Information on **GEOCON11 v1.0** can be found at the above link or at: <http://www.ngs.noaa.gov/GEOCON11/>.

For more information, contact: **Dru Smith**

Website Owner: National Geodetic Survey / Last modified by NGS.webmaster Aug 12 2014

Adoption and Outreach

Adoption: Legal / Feds

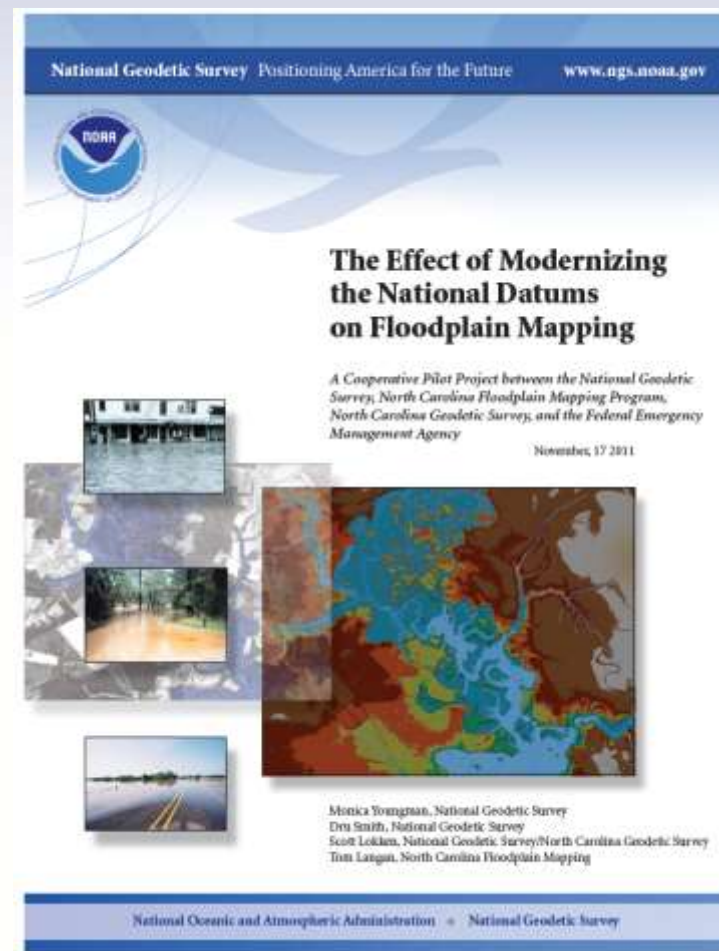
- The datums will be official once the FGCS approves them
- OMB A-16 then requires all federal, civil agencies to transition to the new datums
- Other groups may adopt at their own speed and need

Adoption: Legal / States

- NGS historically provided template acts for each state to help adopt changes
 - NAD 83
 - SPCS
- Has one major drawback: “NAD 83” is now *by-name* mandated in over 40 states.
- Would this be useful again?
 - **Only if “the latest coordinates of the NSRS as defined by the NGS” is the language used**
 - Avoids name-specific issues in the future

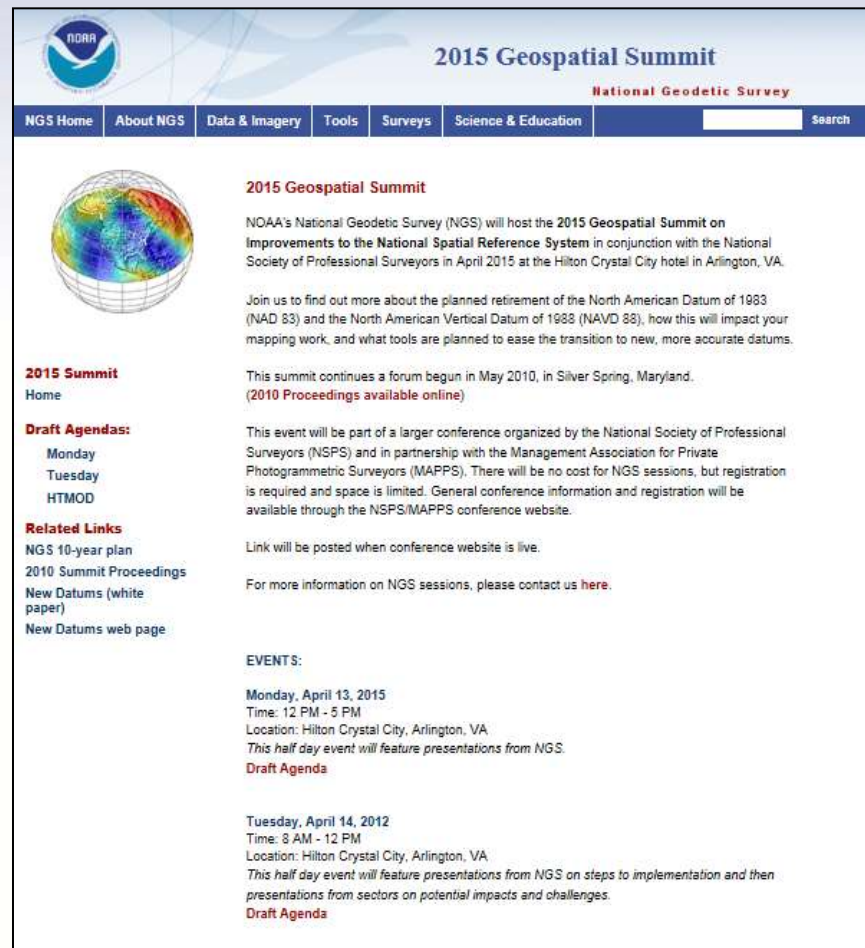
Outreach

- FEMA Pilot Project
 - NGS, NCGS and FEMA partnered in 2011
 - Goal: Evaluate how the NSRS is used at FEMA and how changes will affect FEMA workflow



2015 Geospatial Summit

- April 13-14, 2015, in the Washington, DC Area
- As part of a broader “conference of conferences” with National Society of Professional Surveyors and Management Association for Private Photogrammetric Surveyors (MAPPS)
- Follows the successful 2010 Geospatial Summit. More info at the 2015 Geospatial Summit website.



The screenshot shows the NOAA National Geodetic Survey (NGS) website for the 2015 Geospatial Summit. The header includes the NOAA logo and the title "2015 Geospatial Summit National Geodetic Survey". A navigation bar contains links: NGS Home, About NGS, Data & Imagery, Tools, Surveys, Science & Education, and a search box. The main content area features a globe icon and the following text:

2015 Geospatial Summit

NOAA's National Geodetic Survey (NGS) will host the **2015 Geospatial Summit on Improvements to the National Spatial Reference System** in conjunction with the National Society of Professional Surveyors in April 2015 at the Hilton Crystal City hotel in Arlington, VA.

Join us to find out more about the planned retirement of the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88), how this will impact your mapping work, and what tools are planned to ease the transition to new, more accurate datums.

This summit continues a forum begun in May 2010, in Silver Spring, Maryland. ([2010 Proceedings available online](#))

This event will be part of a larger conference organized by the National Society of Professional Surveyors (NSPS) and in partnership with the Management Association for Private Photogrammetric Surveyors (MAPPS). There will be no cost for NGS sessions, but registration is required and space is limited. General conference information and registration will be available through the NSPS/MAPPS conference website.

Link will be posted when conference website is live.

For more information on NGS sessions, please contact us [here](#).

EVENTS:

Monday, April 13, 2015
Time: 12 PM - 5 PM
Location: Hilton Crystal City, Arlington, VA
This half day event will feature presentations from NGS.
[Draft Agenda](#)

Tuesday, April 14, 2015
Time: 8 AM - 12 PM
Location: Hilton Crystal City, Arlington, VA
This half day event will feature presentations from NGS on steps to implementation and then presentations from sectors on potential impacts and challenges.
[Draft Agenda](#)

2015 Summit Home

Draft Agendas:

- Monday
- Tuesday
- HTMOD

Related Links

- NGS 10-year plan
- 2010 Summit Proceedings
- New Datums (white paper)
- New Datums web page

<http://www.geodesy.noaa.gov/2015GeospatialSummit/>

Summary: Priorities

NGS Priorities, in order:

1. Define datums on solid scientific footing
2. Provide tools for transitioning
3. Work within FGCS to ensure OMB A-16 compliance
4. Work with additional groups to aid in adoption

Questions