Overview of New Datums

A webinar for NGAC and FGDC

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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

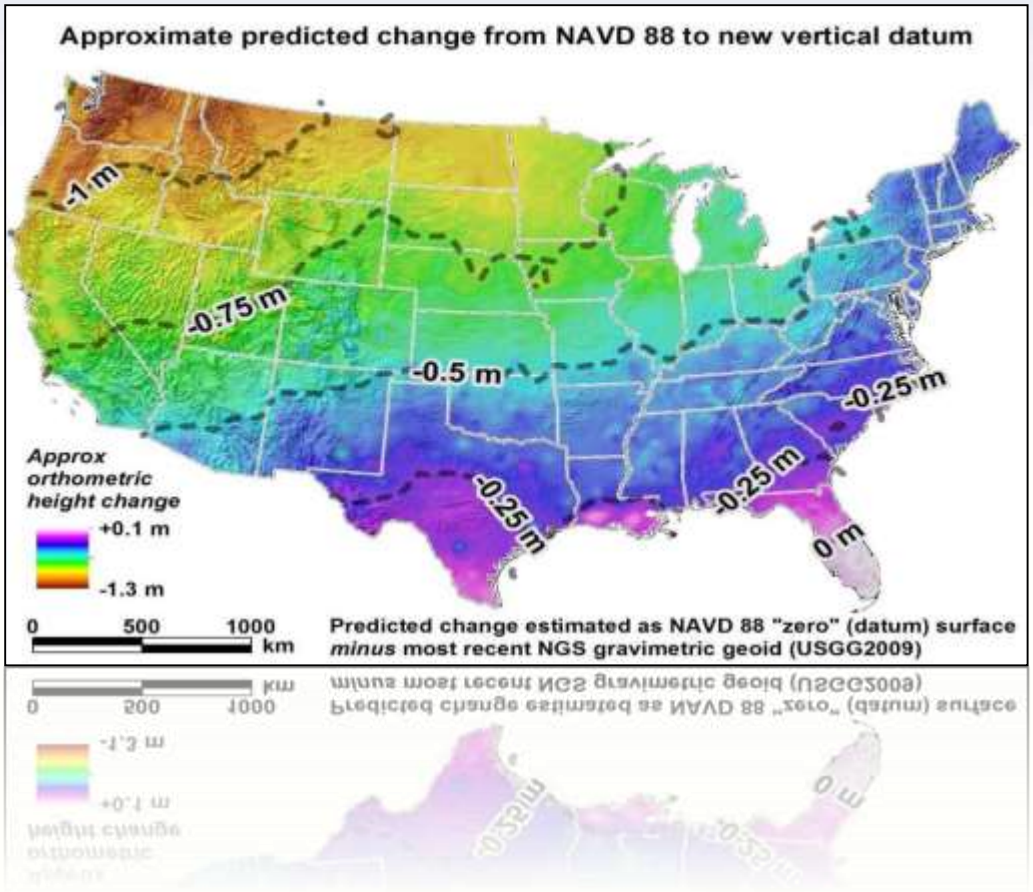
- NGS has defined the datums of the NSRS as NAD 83 and NAVD 88 (plus others)
- FGCS requires that all civilian federal surveying and mapping use NAD 83 and/or NAVD 88 (plus others)
- "To the extent practicable, legally allowable, and feasible, require that all Federal agencies using or producing (vertical 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!

- 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.

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.



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
- GUVD04
- 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)  RAPSU86 model used   GPS OBS
```

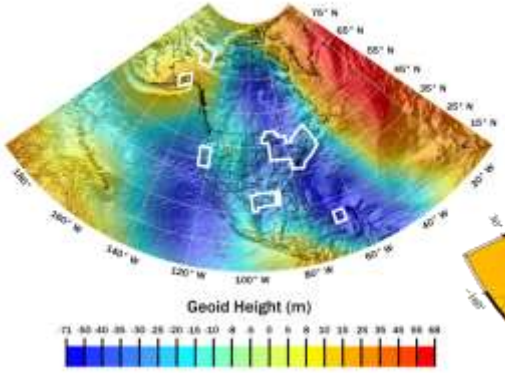
Fragile, unchecked passive control

- The new way

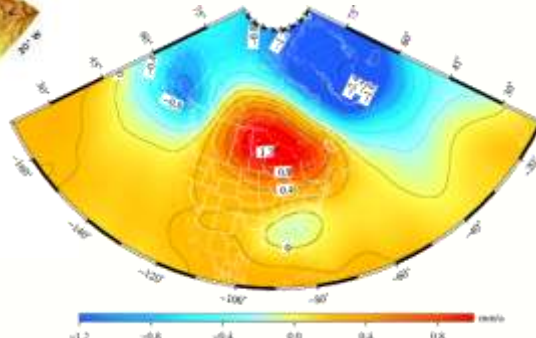
Modern datasheets

CORS

RTN



Geoid



Temporal Geoid Change

Why isn't NAVD 88 good enough anymore?

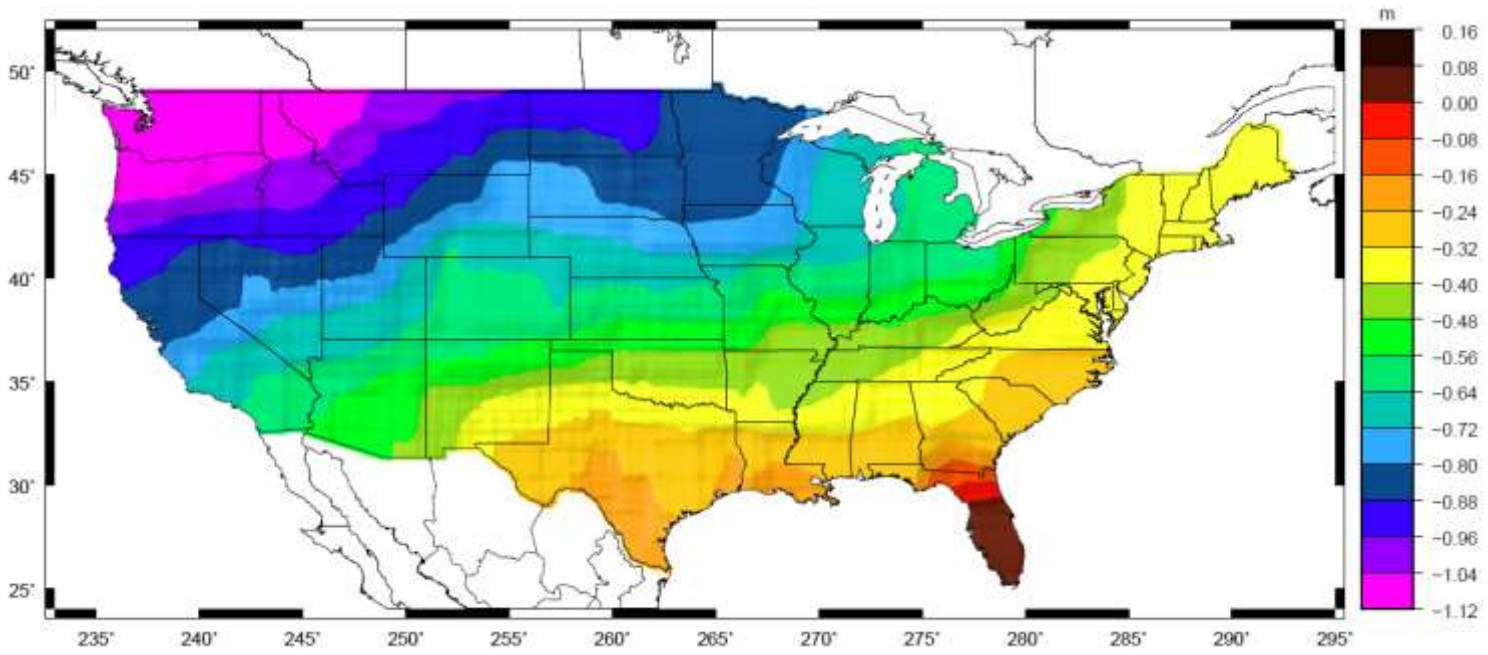
NAVD 88 suffers from <u>use of bench marks</u> that:

- 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?

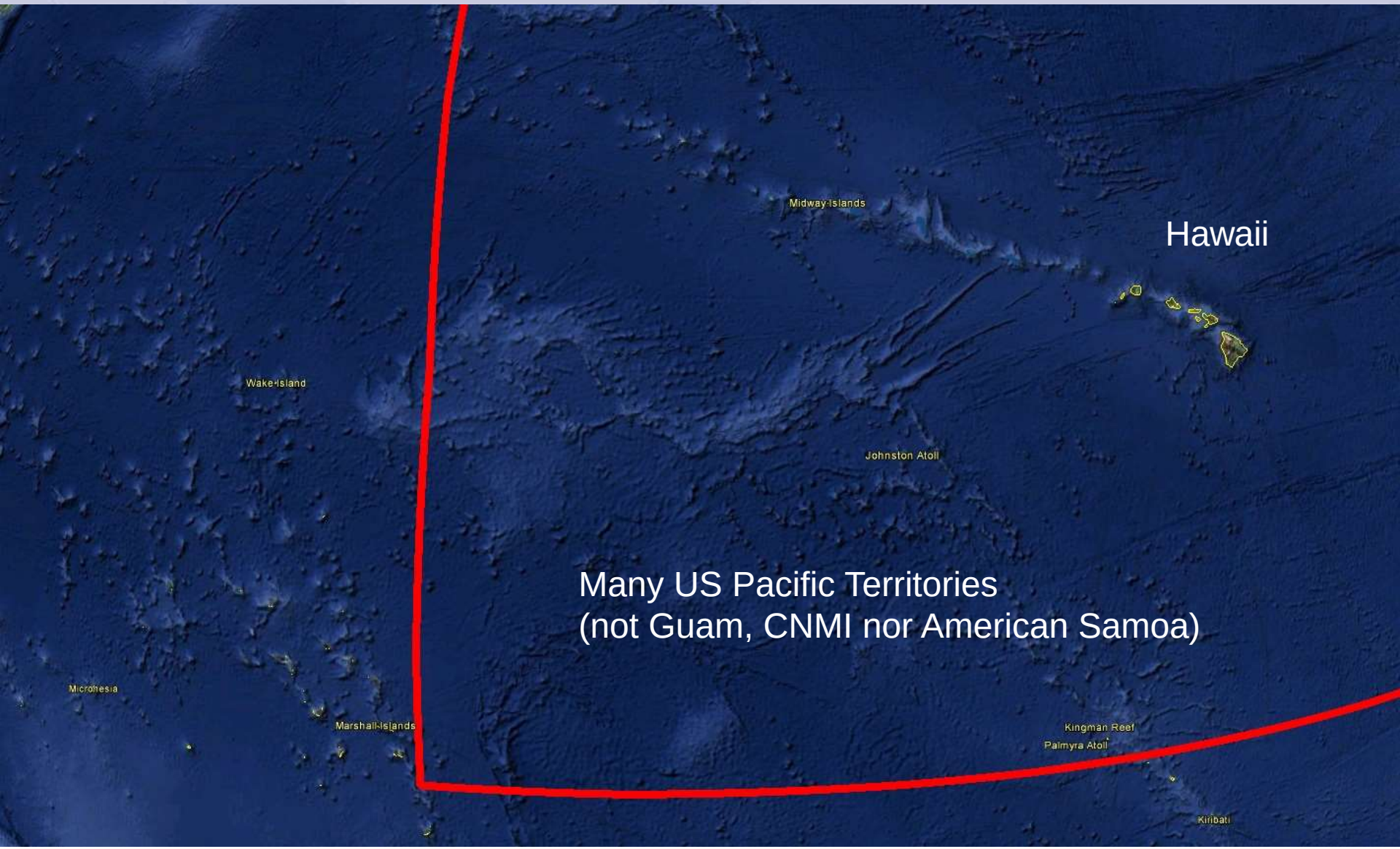
- **Approximate level of geoid mismatch known to exist in the NAVD 88 zero surface:**

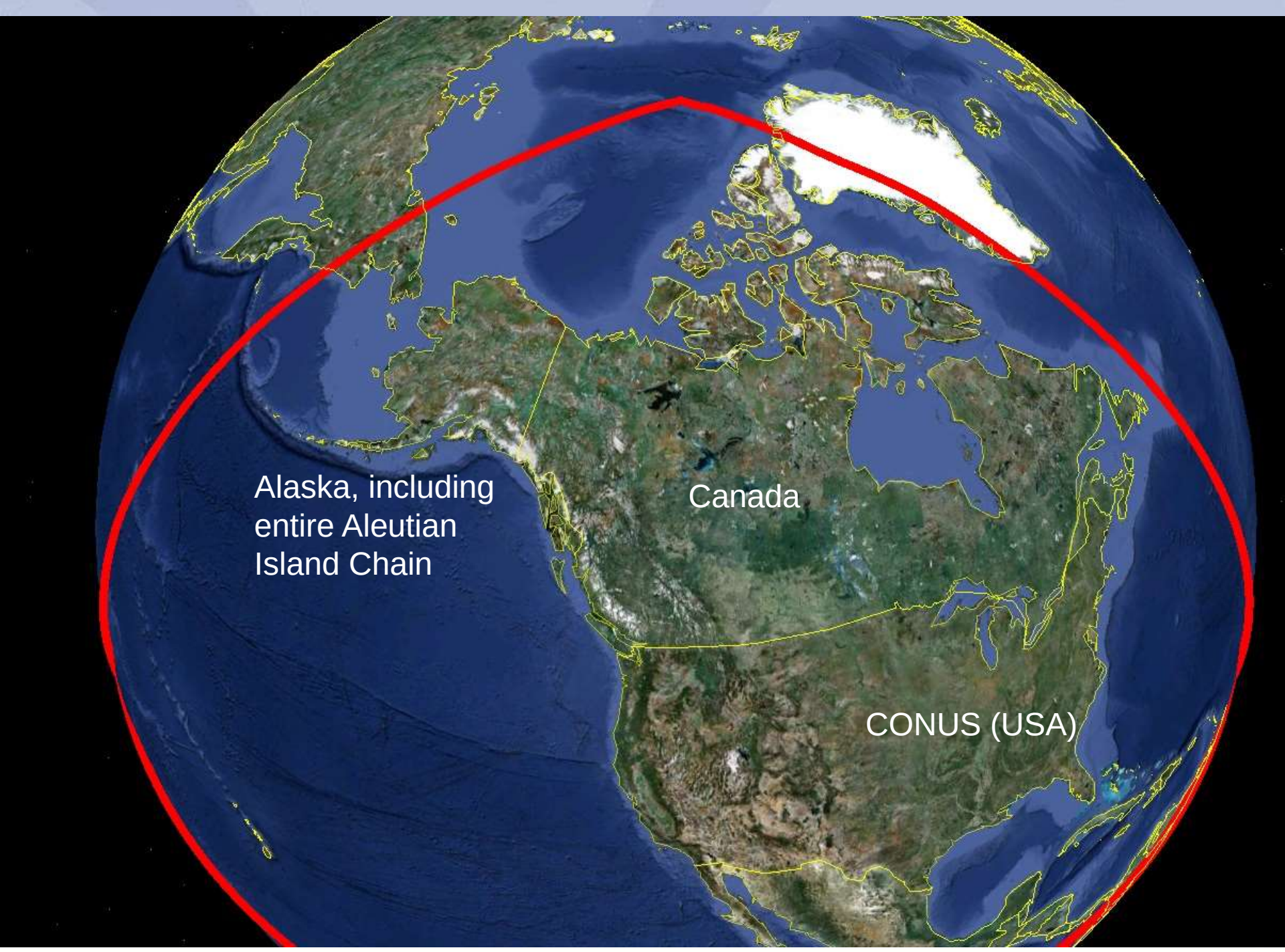


Terminology

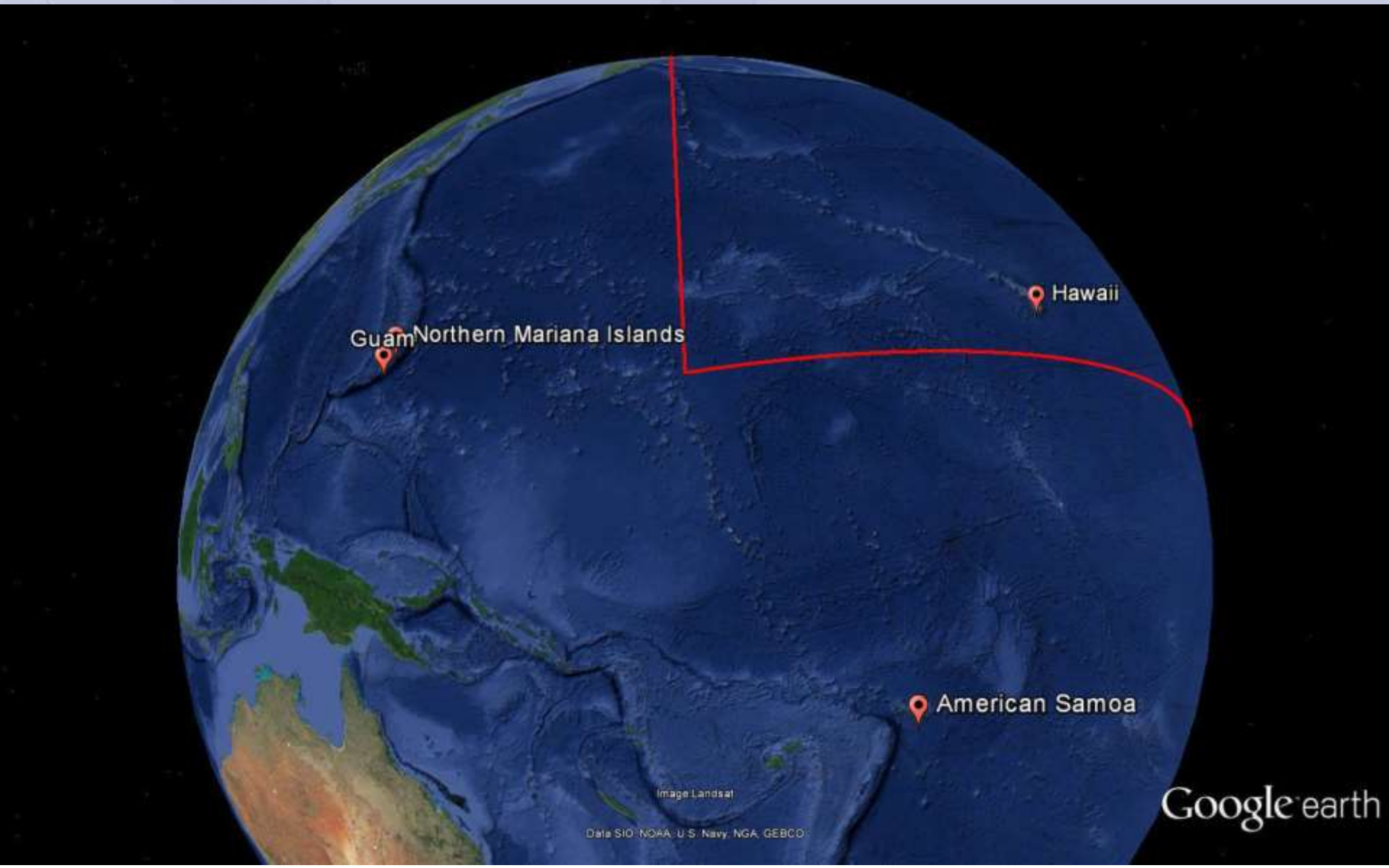
- ~~Horizontal Datum~~
  - Geometric Reference Frame
    - Geocentric X, Y, Z
    - Latitude, Longitude, Ellipsoid Height
- ~~Vertical Datum~~
  - Geopotential Reference Frame
    - Geoid undulation
    - Orthometric height
    - Gravity
    - Deflection of the Vertical

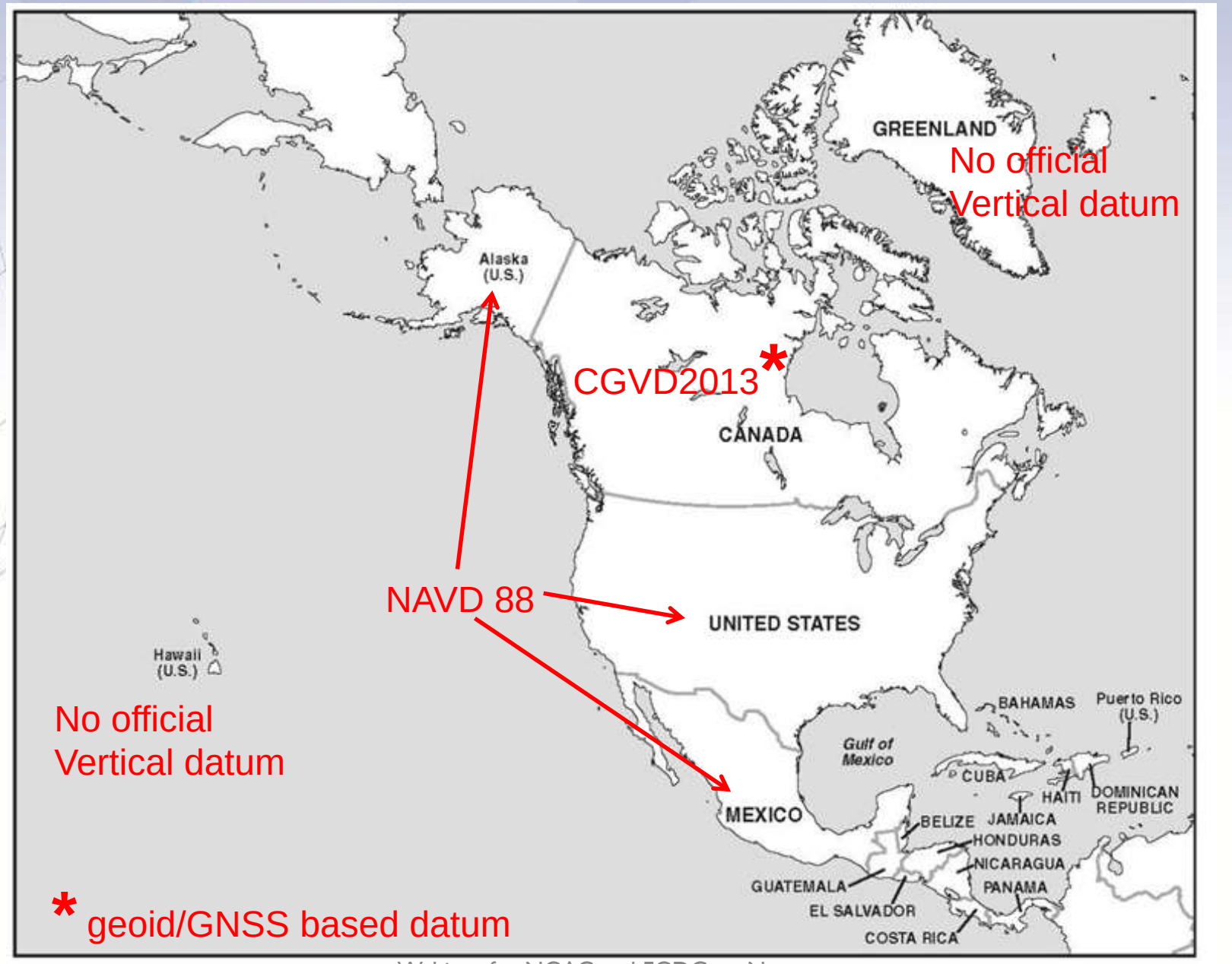
Approximate extent of 2022 geoid model used for the "North American" part of the new geopotential reference frame.


Midway Islands
Hawaii
Wake Island
Johnston Atoll
Many US Pacific Territories
(not Guam, CNMI nor American Samoa)
Micronesia
Marshall Islands
Kingman Reef
Palmyra Atoll
Kiribati

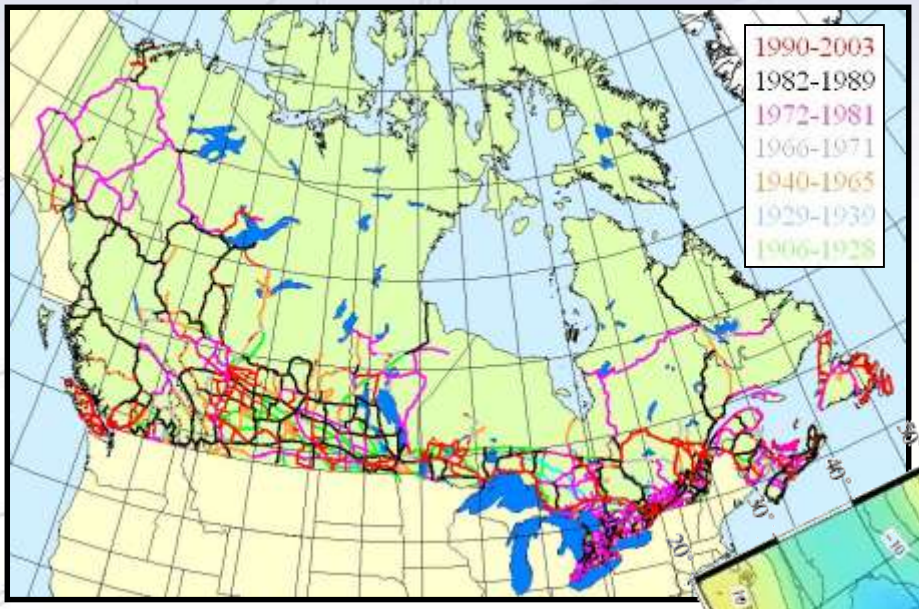

Alaska, including
entire Aleutian
Island Chain
Canada
CONUS (USA)


Bermuda
Mexico
All Caribbean Countries
All Central American Countries


Hawaii
Guam
Northern Mariana Islands
American Samoa
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth

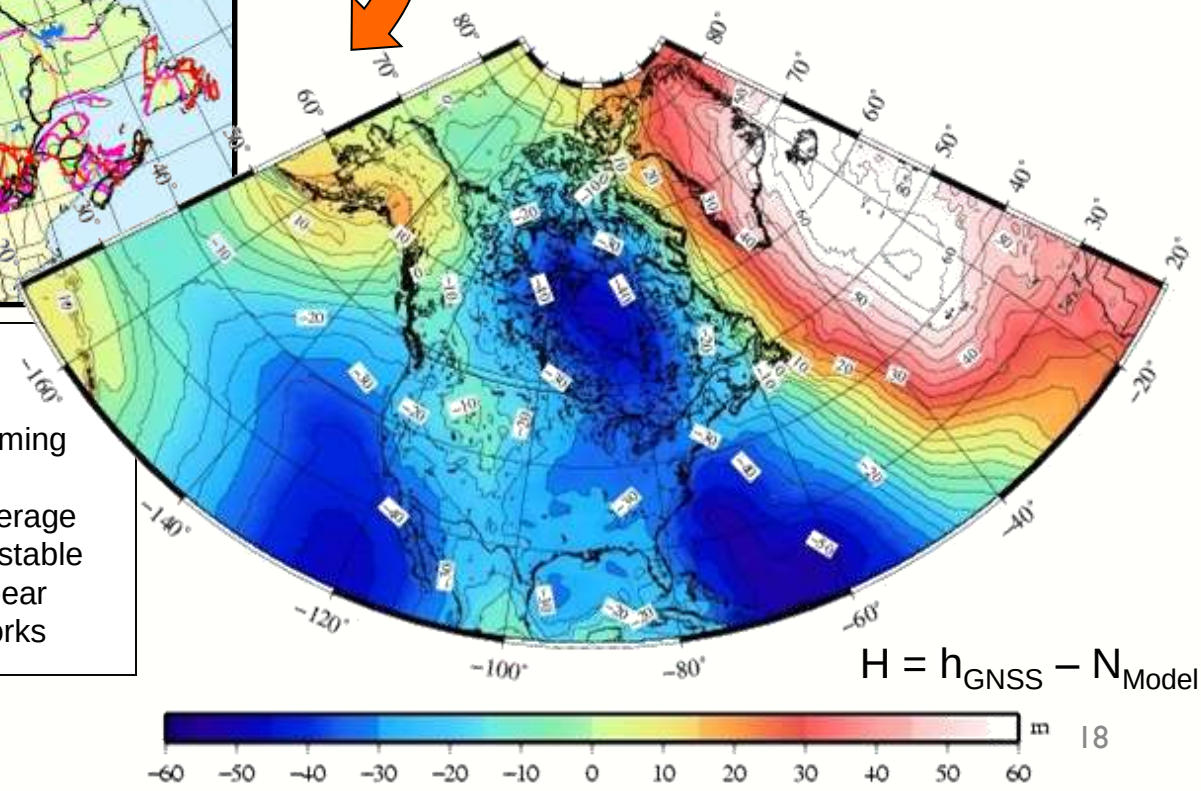

GREENLAND
No official
Vertical datum
Alaska
(U.S.)
CGVD2013*
CANADA
NAVD 88
UNITED STATES
Hawaii
(U.S.)
No official
Vertical datum
BAHAMAS
Puerto Rico
(U.S.)
Gulf of
Mexico
CUBA
HAITI
DOMINICAN
REPUBLIC
MEXICO
BELIZE
JAMAICA
HONDURAS
NICARAGUA
GUATEMALA
PANAMA
EL SALVADOR
COSTA RICA
* geoid/GNSS based datum

Canada Height Modernization - 2013



The geoid model:

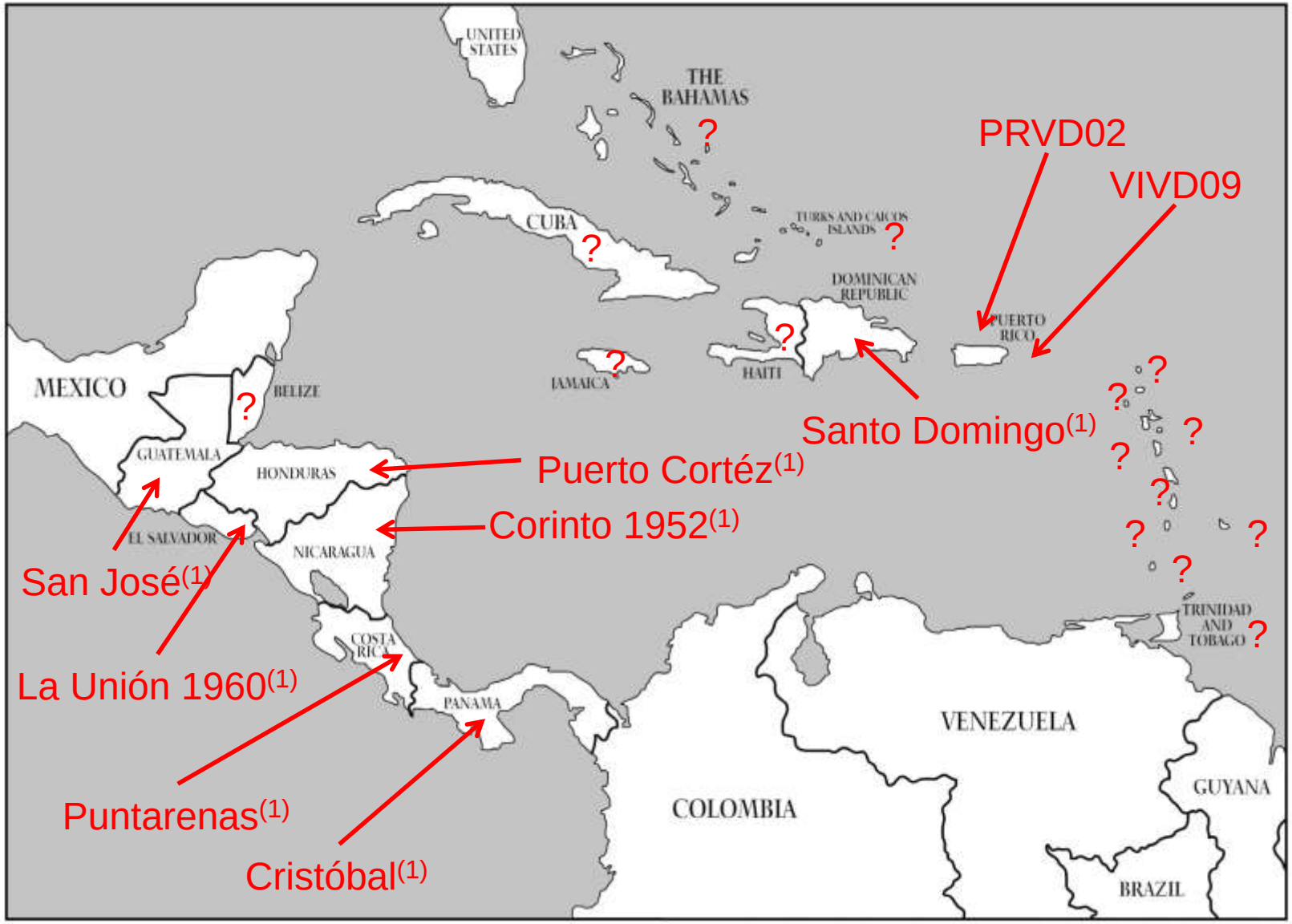
1. Entire coverage of the Canadian territory (land, lakes and oceans)
2. Compatible with space-based positioning (e.g., GNSS, altimetry)
3. Less expensive for maintenance
4. Fairly stable reference surface



Levelling Networks:

1. Established over the last 100 years
2. 120,000 km of levelling lines
3. Some 80,000 benchmarks

1. Time consuming
2. Expensive
3. Limited coverage
4. BMs are unstable
5. BMs disappear
6. Local networks



(1) Información cortesía de David Avalos

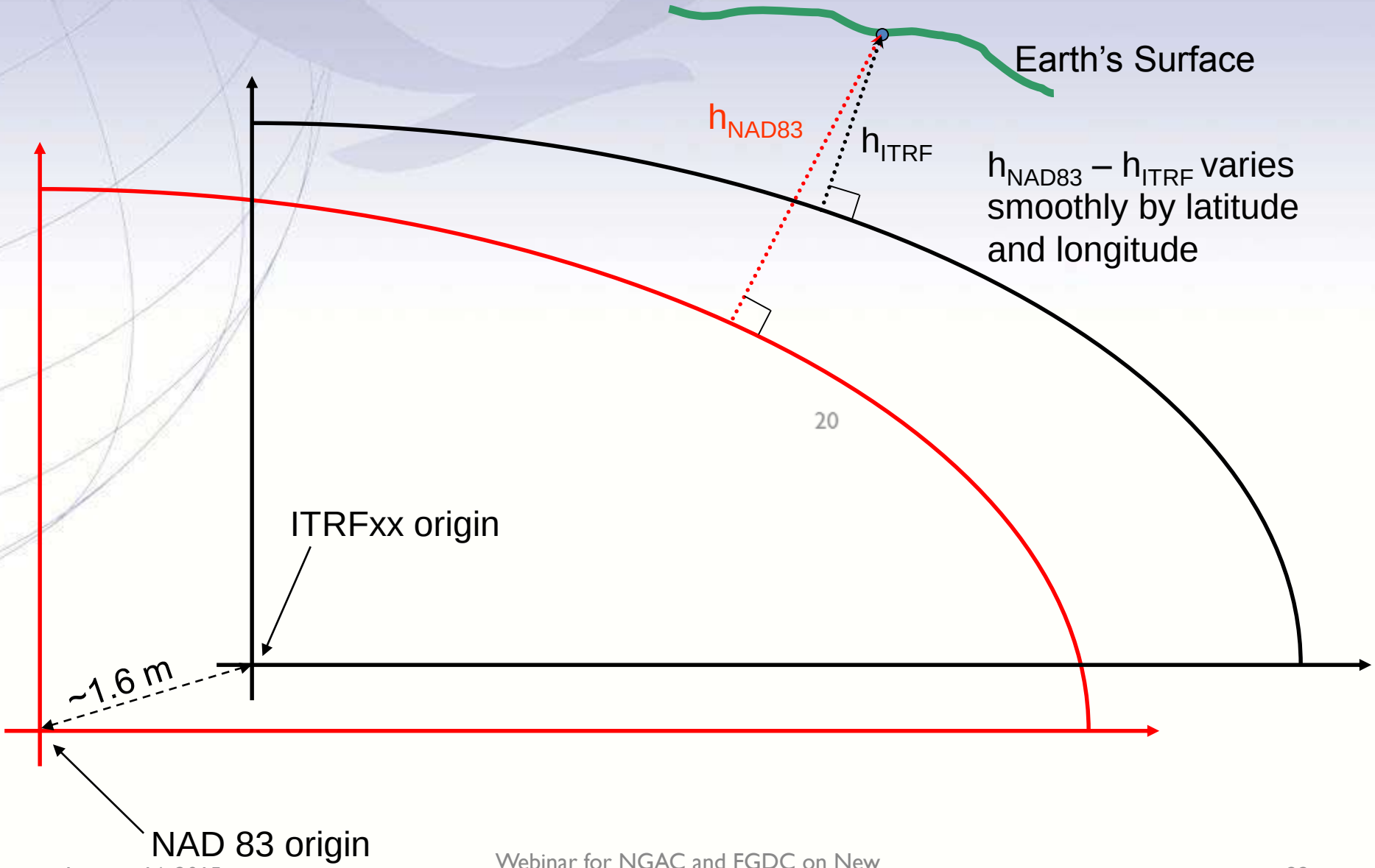
Old vs New Datums

- 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**

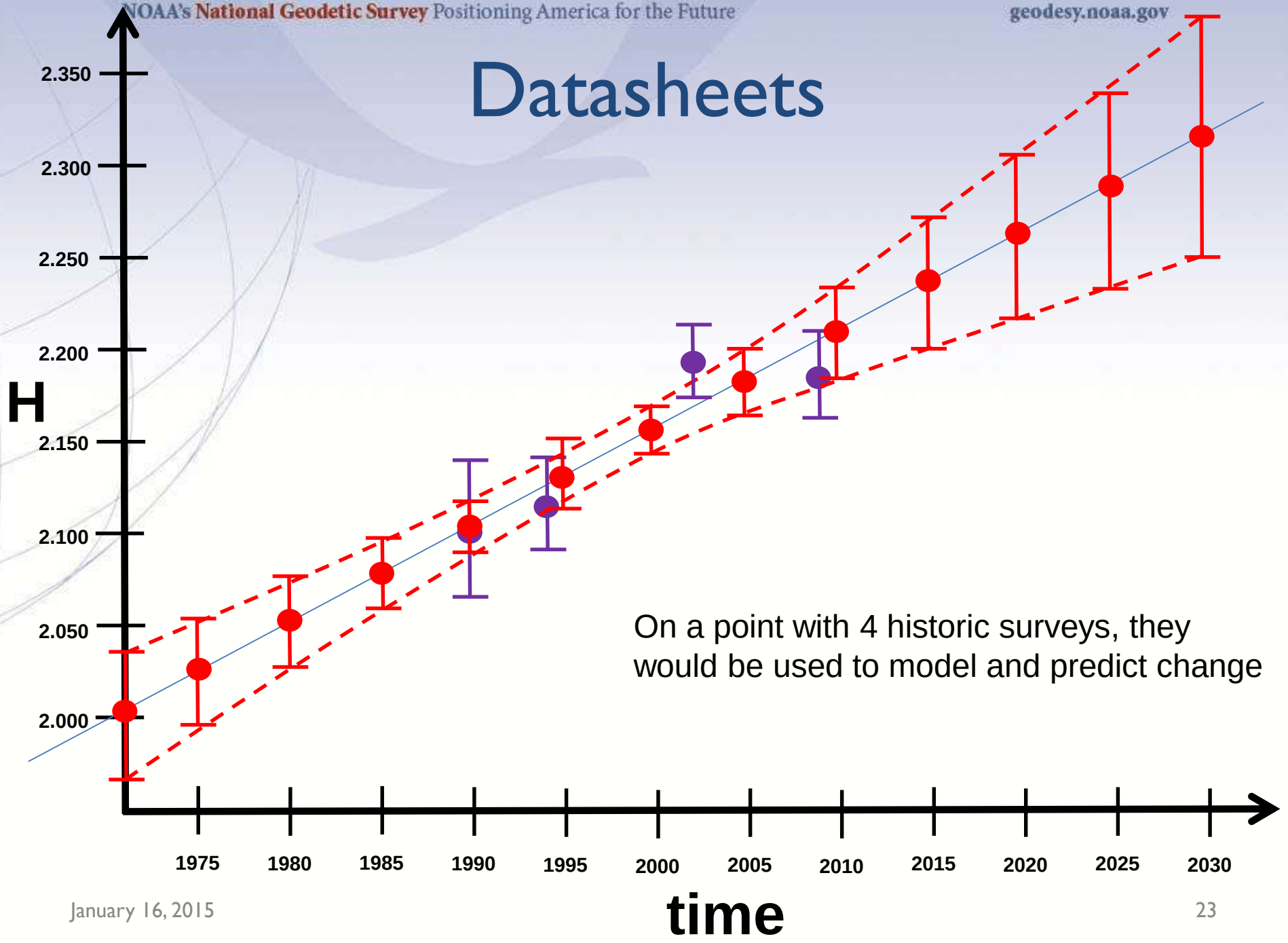
Old vs New Datums

- 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

Simplified Concept of NAD 83 vs. ITRF



Datasheets



On a point with 4 historic surveys, they would be used to model and predict change

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:
- $\left[\begin{matrix}\phi\\ \lambda\\ h\end{matrix}\right]\Big|_{NAD\ 83(2011)}$ ⟷ $\left[\begin{matrix}\phi\\ \lambda\\ h\end{matrix}\right]\Big|_{New}$
- $[H]|_{NAVD\ 88}$ ⟷ $[H]|_{New}$

Adoption and Outreach

Adoption: Legal / Feds

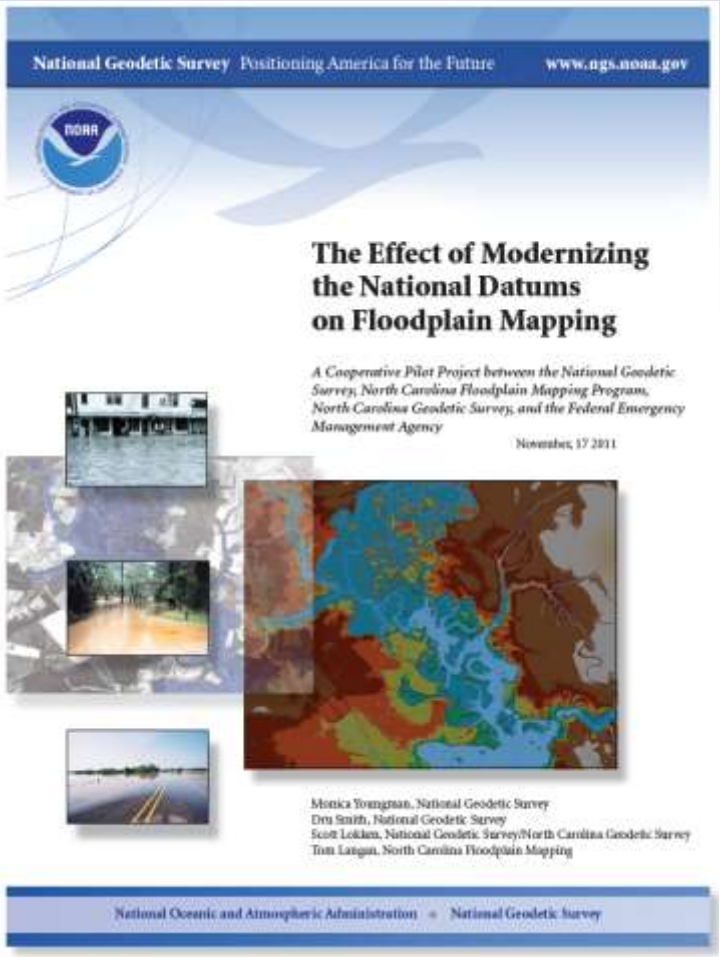
- The datums will be official once the FGCS approves them
- OMB A-16 then requires all federal, civil agencies to transition to the new datums
- Other groups may adopt at their own speed and need

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

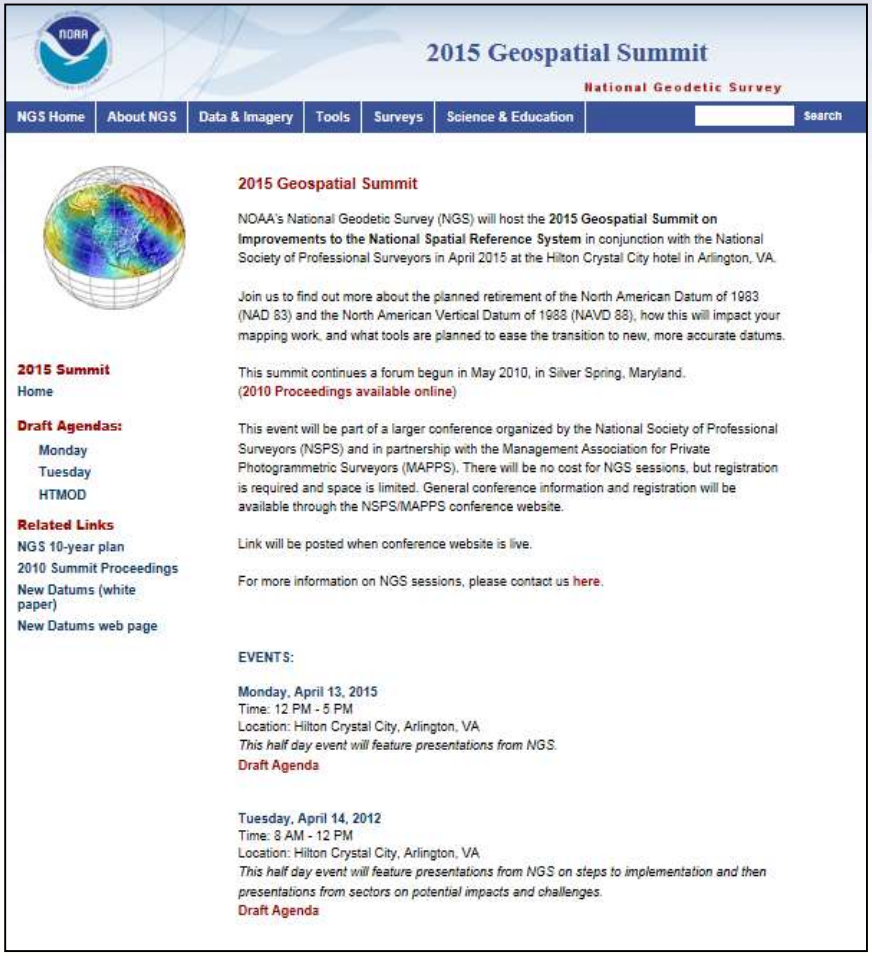


Outreach

- Federal Geospatial Summits
  - 2010: 200 attendees
    - http://geodesy.noaa.gov/2010Summit/
    - "White paper" described why the datums are changing
    - Significant end-user feedback collected
  - Next summit: April 2015

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.



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

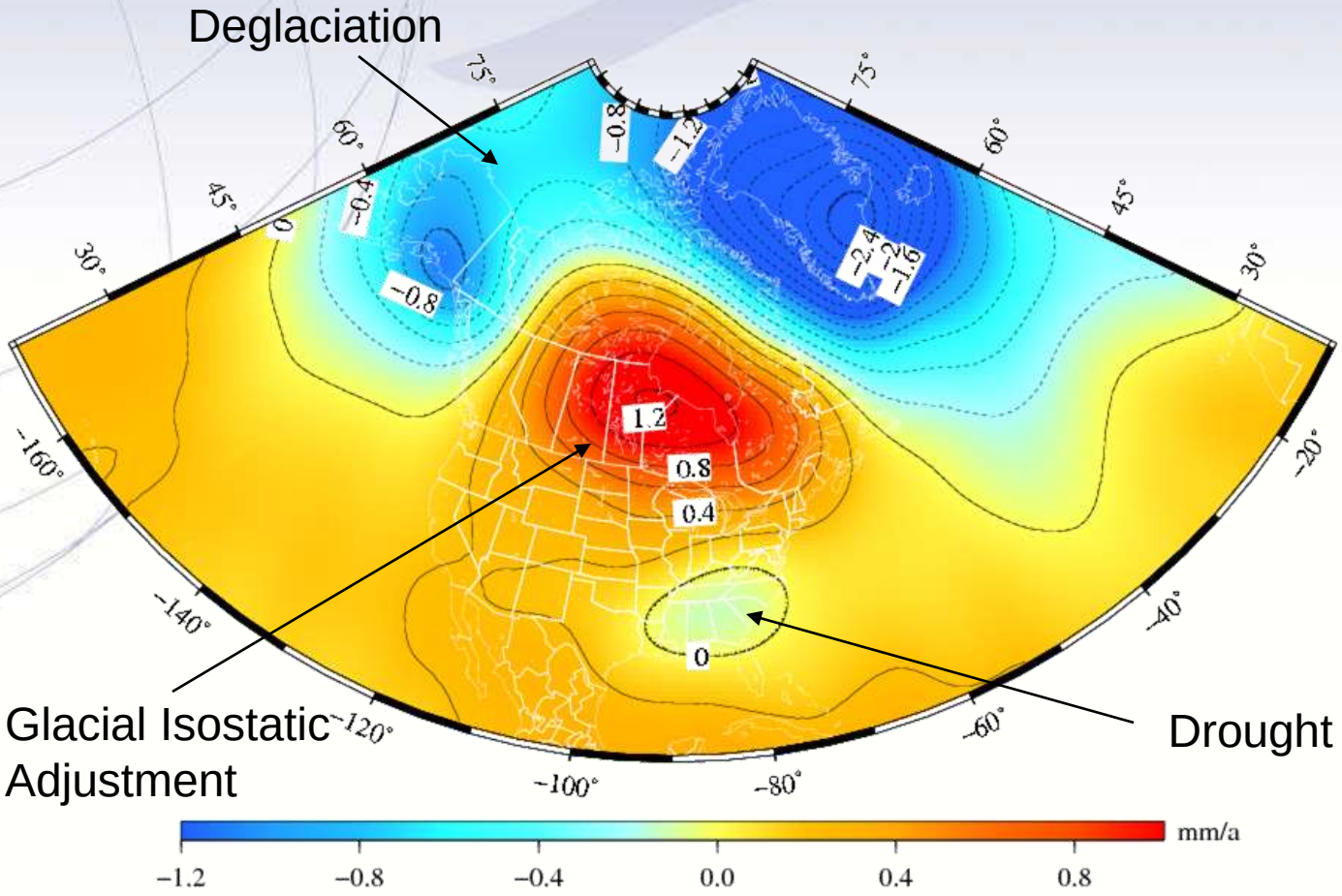
Thank you!

Extra Slides

Expected GRAV-D airborne gravity coverage by 2022

GRAV-D Planned Coverage

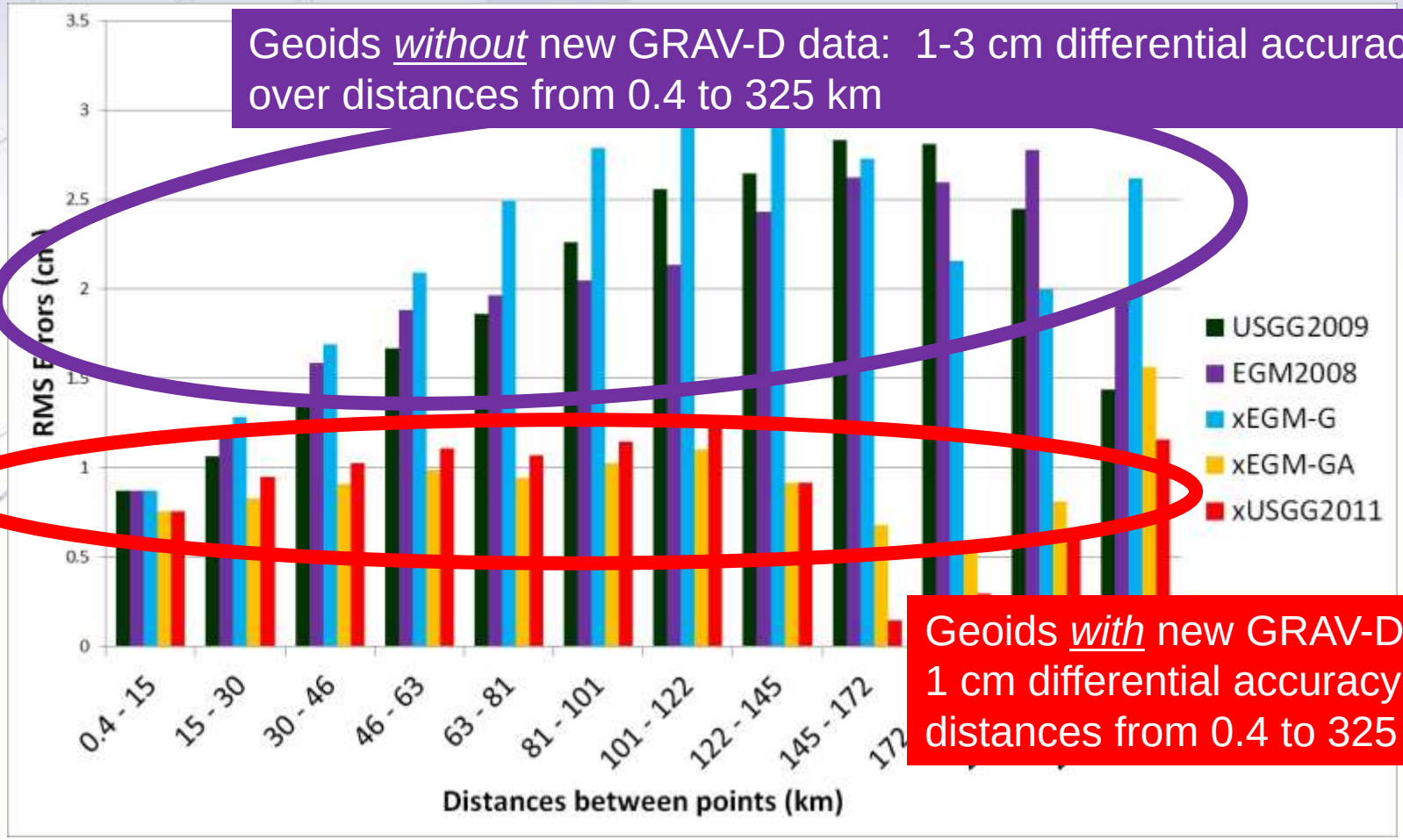
The "secular" geoid change from the monthly GRACE models (2002-2008)



The solution represents the effect due to total mass changes.

The solution uses a 400-km Gaussian filter.

GSVS11: Proving why we need GRAV-D



Old vs New Datums: Origin

- NAD 83 was theoretically "geocentric"
  - Primarily based on pre-GNSS satellite geodesy
    - Doppler, etc
  - Off from ITRF2008 origin by ~ 1.5 meters

- New geometric reference frame will all be "geocentric" to IGS frame circa 2020.00 or so

Old vs New Datums: Access

- Old datums used passive control as the primary access
  - CORS / OPUS helped, but "datasheets" remain the largest download, far and away more than OPUS is used

Old vs New Datums: Access

- New datums
  - Primary access: GNSS + geoid model
  - Secondary access: Passive control
- Fixed:
  - CORS + geoid (coords and velocities both)

Old vs New Datums: Passive Control

- 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

Tools: Improvements

- NADCON, VERTCON, SPCS, UTM, USNG, Vdatum, HTDP, VTDP will be merged into a single tool

- Tool will be web-services based
  - Online browser-based computations
  - GIS-plug-in