



Updates from NGS Part 1: Status of New Datums

Jacob Heck

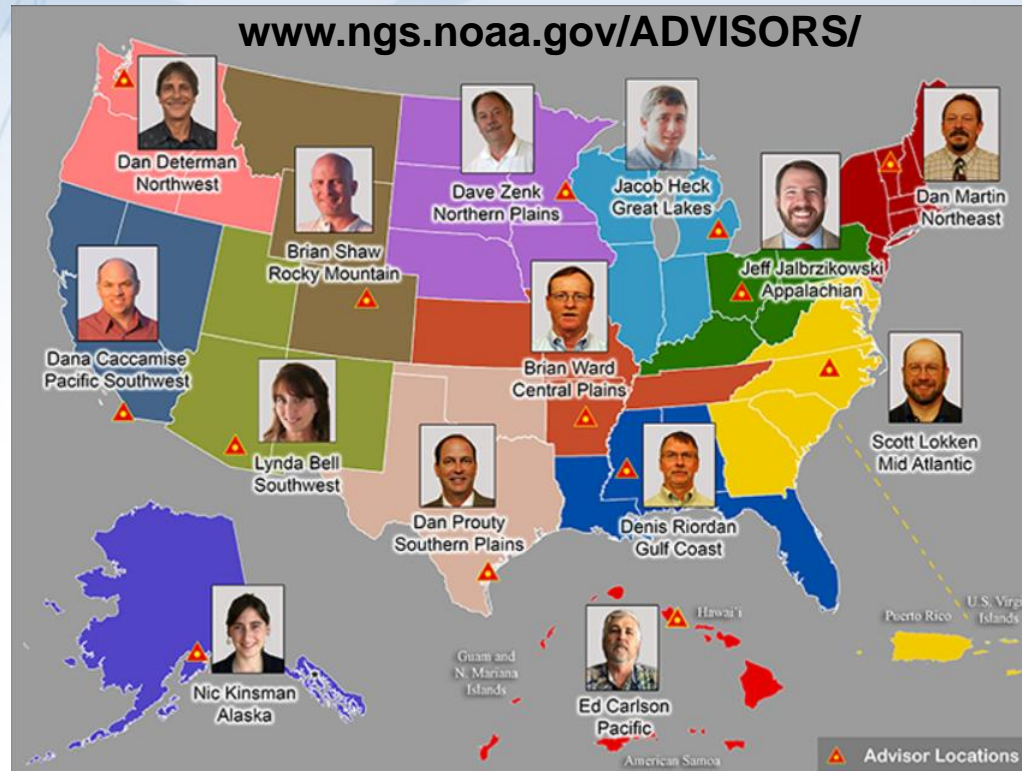
NGS Great Lakes Regional Geodetic Advisor
ISPLS 2023 Convention

My Background

- Great Lakes Regional Geodetic Advisor (IN, IL, WI, MI)
- Previously at NGS Headquarters Geosciences Research Division
- B.S. Surveying Engineering at Michigan Tech
- Ph.D. in Geodetic Science at The Ohio State University
- Professional Surveyor (MI)



Regional Geodetic Advisor Program



Deprecation of the US Survey Foot

- U.S. survey foot was deprecated on December 31, 2022
- But use can continue for SPCS 83 (and SPCS 27)
 - The 40 states that “officially” use U.S. foot for SPCS 83
 - All SPCS 27 zones
 - NGS will support such “legacy” use forever
 - But **NOT** supported for **ANY** zones in SPCS2022

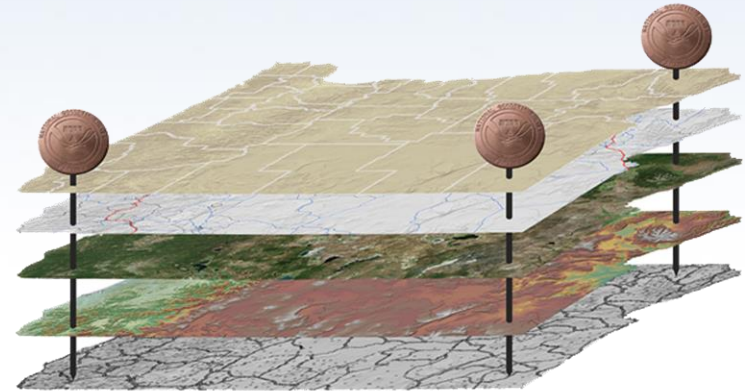
**NGS will always support
U.S. survey foot for SPCS 83 and 27**

The National Spatial Reference System (NSRS)

NGS defines, maintains and provides access to the NSRS to meet our Nation's economic, social & environmental needs

Latitude • Longitude • Elevation
• Gravity • Shoreline Position
+ changes over time

- North American Datum of 1983 (**NAD 83**)
- North American Vertical Datum of 1988 (**NAVD 88**)



Today's NSRS

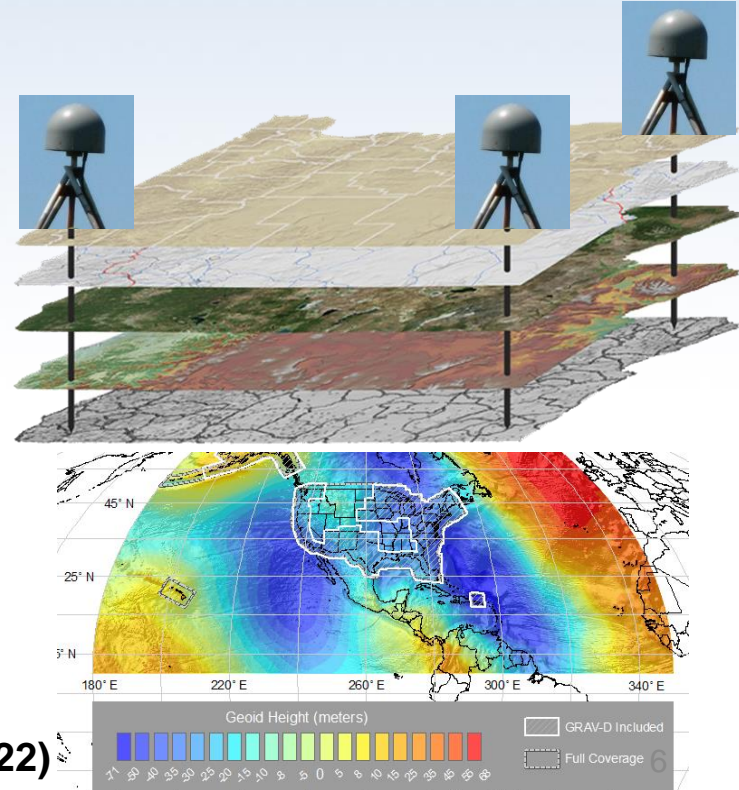
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North American Terrestrial Reference Frame (NATRF 2022)
Caribbean Terrestrial Reference Frame (CATRF 2022)
Pacific Terrestrial Reference Frame (PATRF 2022)
Marianas Terrestrial Reference Frame (MATRF 2022)

North America and Pacific Geopotential Datum (NAPGD2022)



Number of SPCS2022 zones (preliminary)

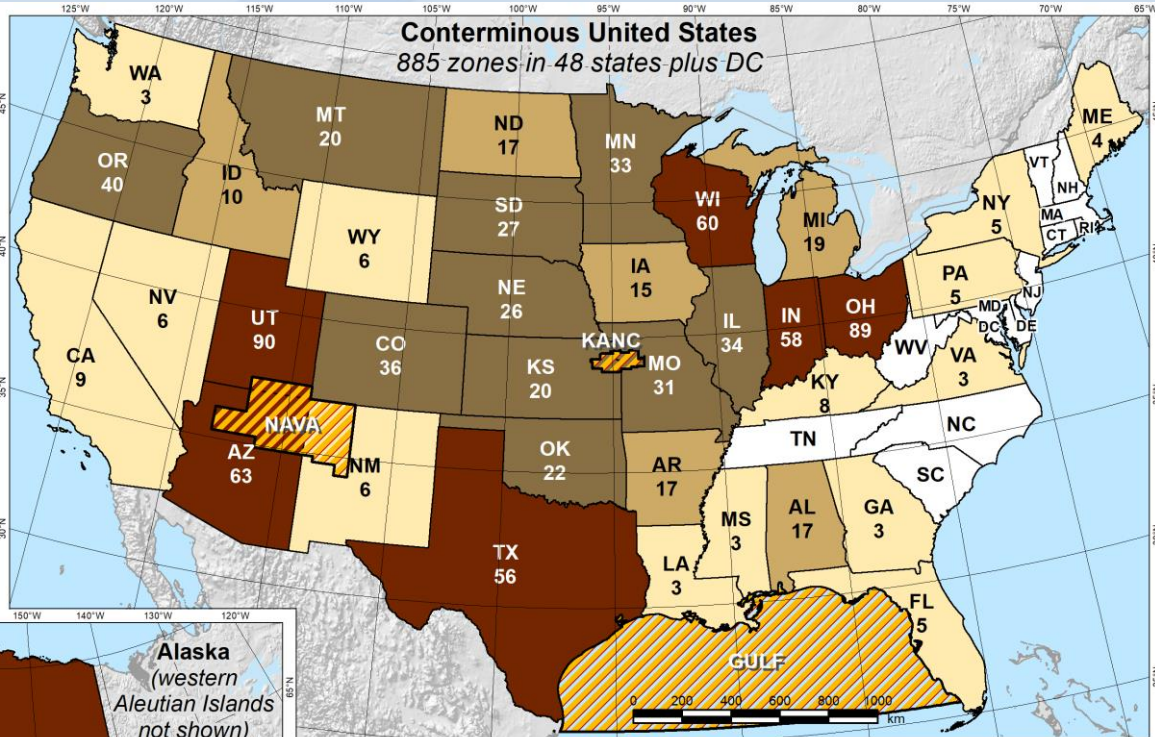
(CONUS,
Alaska,
and Hawaii)

Three island
zones not shown:

*Puerto Rico and
U.S. Virgin
Islands*

American Samoa

*Guam and
Commonwealth of
the Northern
Mariana Islands*

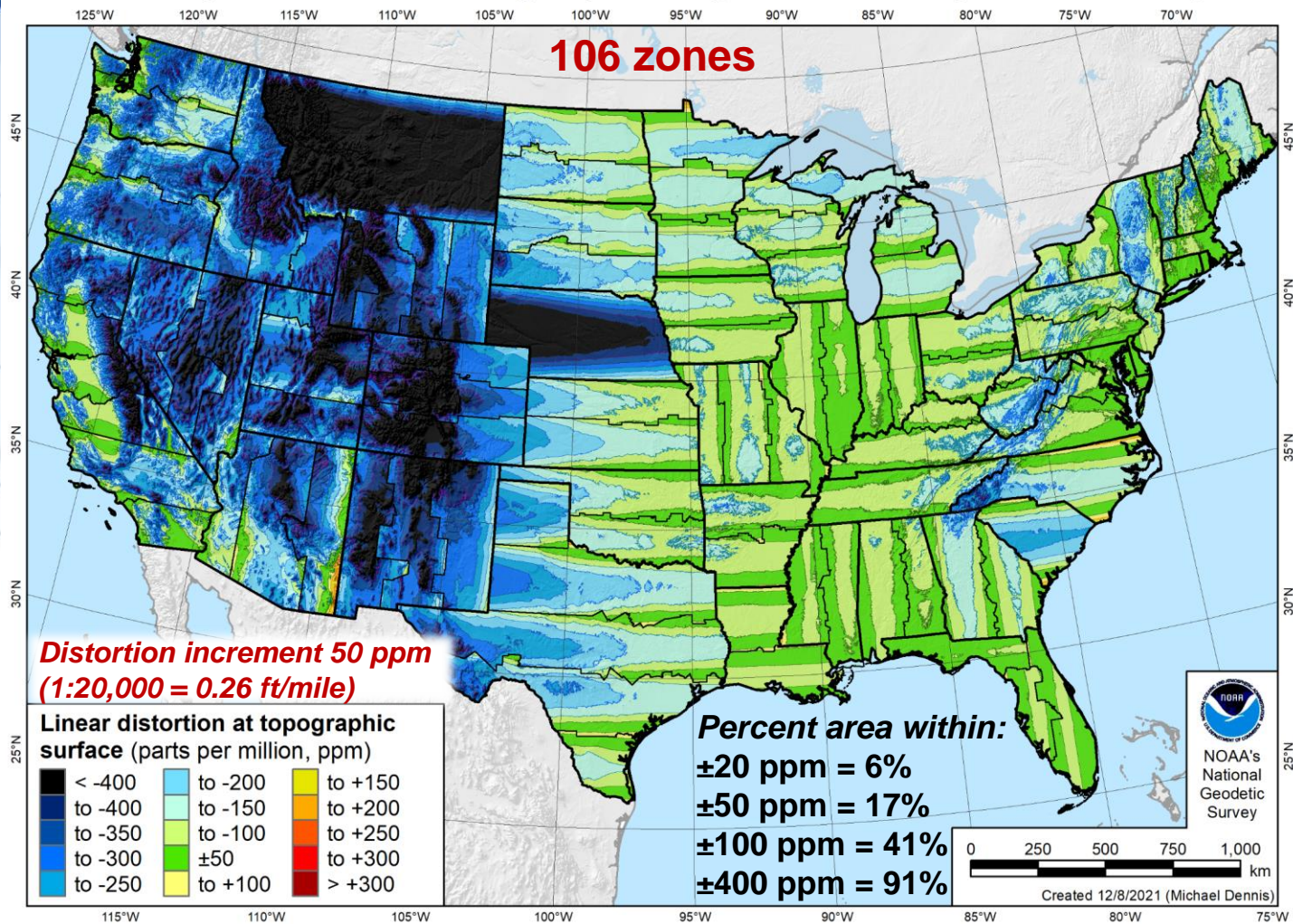


Getting acquainted with SPCS2022

- **Distortion design philosophy**
 - ***Linear distortion*** minimized at topographic surface (***not*** at ellipsoid surface)
 - ***Purpose:*** to reduce difference between projected “grid” and actual “ground” distances
- **Other things:**
 - Zone “layers”
 - Low distortion projections (LDPs)
 - Illinois designs approved by NGS in October 2022
 - Will be implemented with the Modernized (2022) NSRS

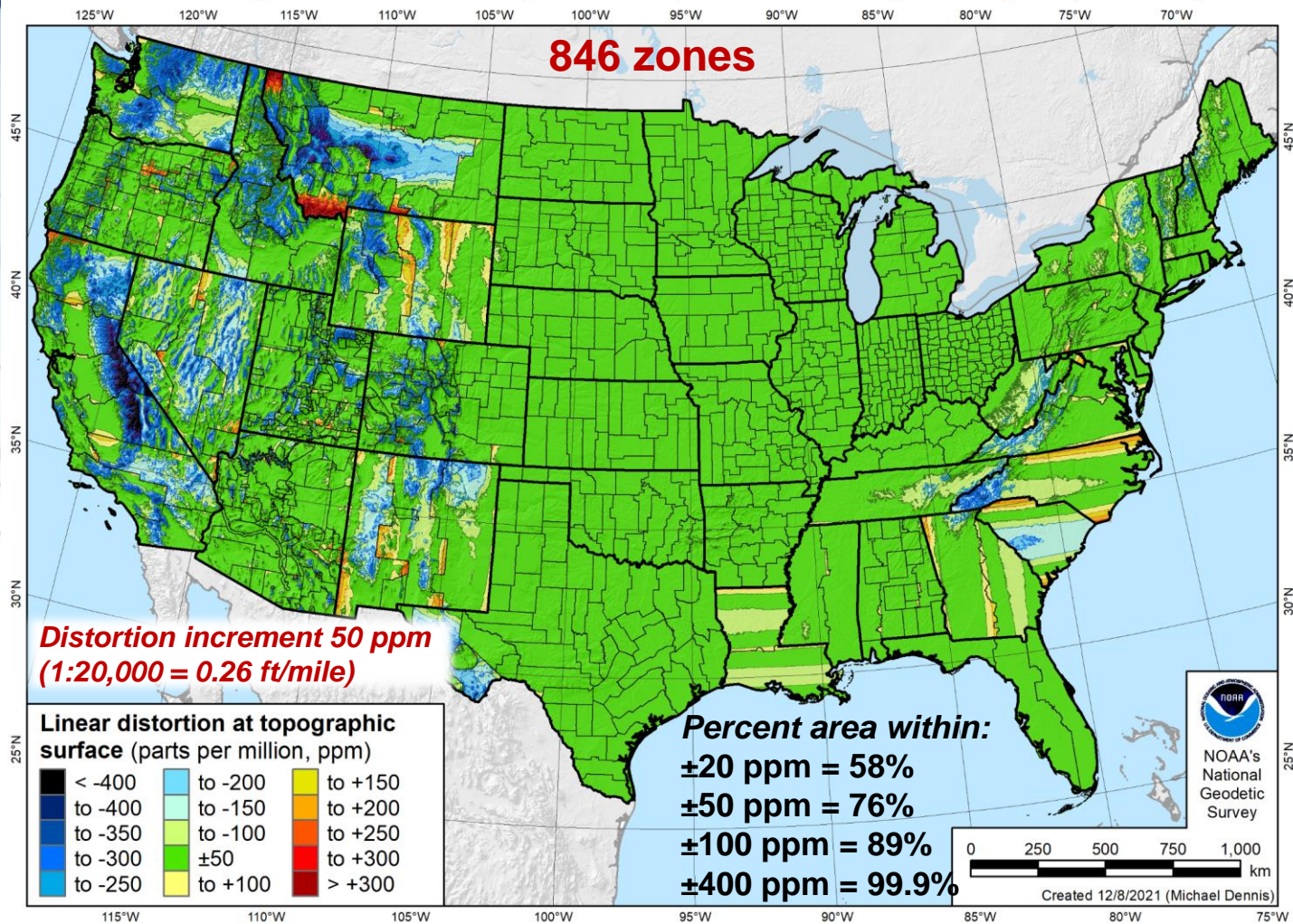
Existing SPCS83 zone designs (CONUS), with 2-zone layer for Kentucky

aa.gov



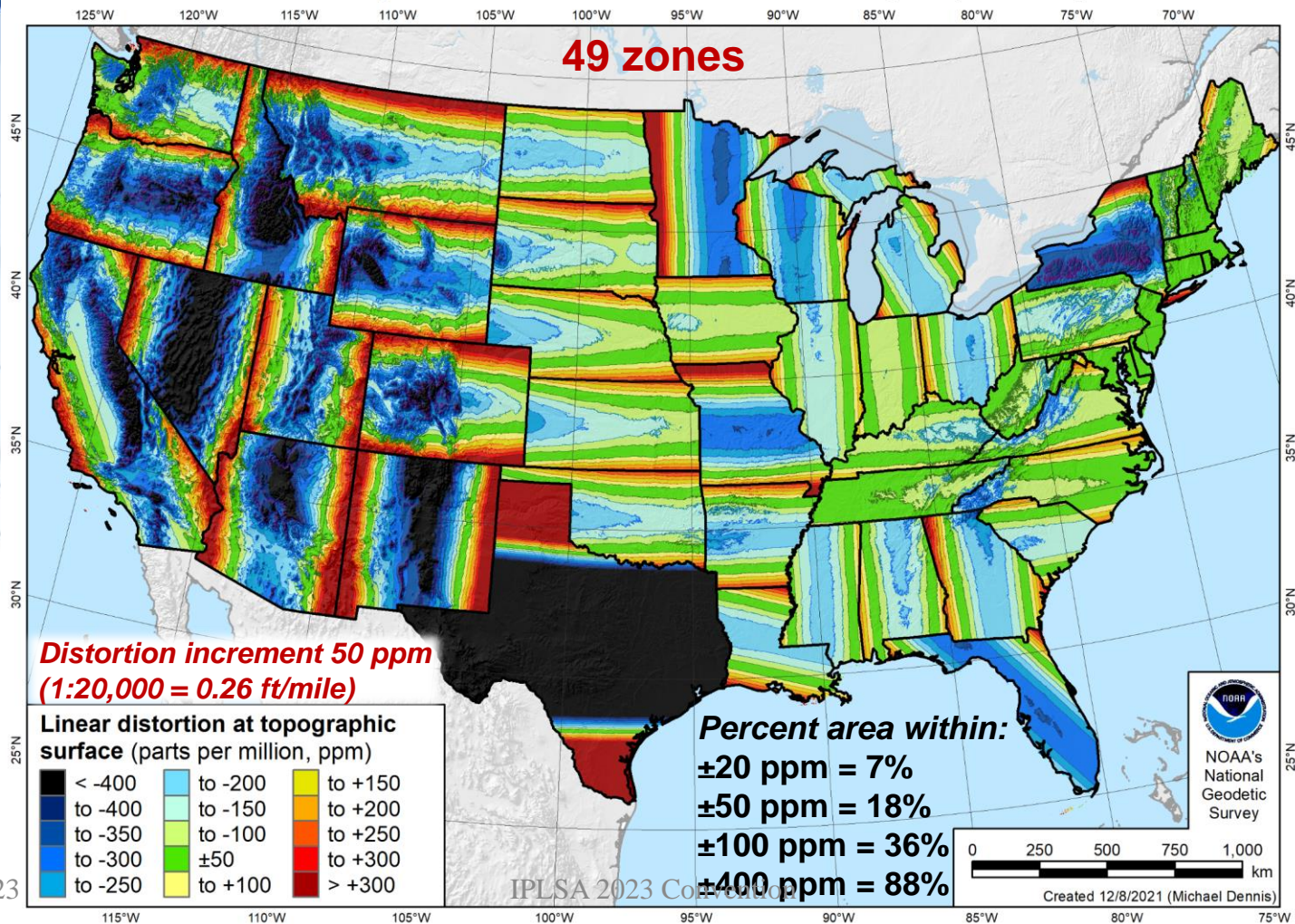
Preliminary SPCS2022 complete and partial coverage designs (CONUS)

aa.gov



Preliminary SPCS2022 statewide zone designs (CONUS)

noaa.gov

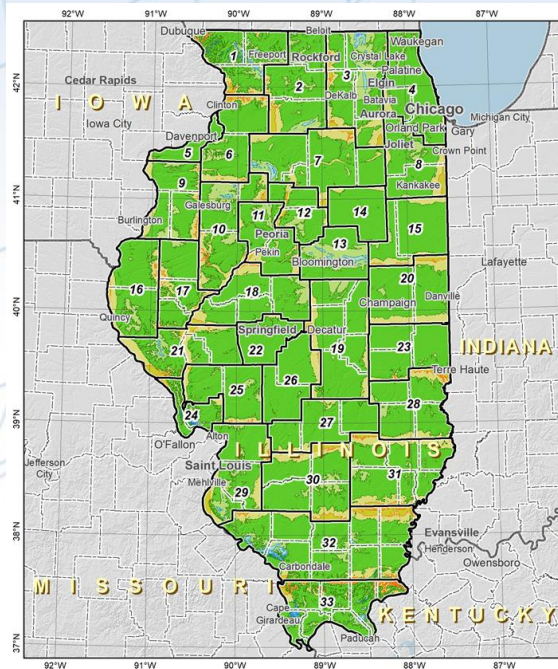


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Illinois SPCS2022 Layers



Preliminary SPCS2022 design Illinois complete coverage layer (33 zones)



North American Terrestrial Reference Frame of 2022

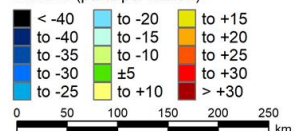
Distortion statistics (ppm)

	Cities	Area
Mean	Min -13	-20
weighted by population	Max +17	+23
	Range 31	43
	Mean +0.1	+0.6

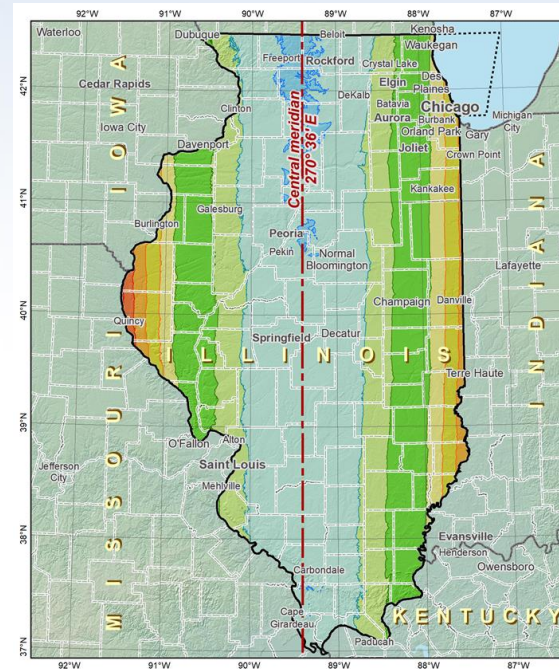
Percent within distortion ranges

Range	Pop	Cities	Area
±5 ppm	85%	78%	74%
±10 ppm	98.9%	97%	96%
±15 ppm	99.95%	99.7%	99.6%
±20 ppm	100%	100%	99.99%
±25 ppm	100%	100%	100%
±30 ppm	100%	100%	100%
±40 ppm	100%	100%	100%
±50 ppm	100%	100%	100%
±75 ppm	100%	100%	100%

Linear distortion at topographic surface (parts per million)



Created 10/29/2022 (Michael Dennis)



Preliminary SPCS2022 statewide zone design: Illinois NGS design



Transverse Mercator projection

North American Terrestrial Reference Frame of 2022

Central meridian: 270° 36' E

Cen merid scale: 0.999 88 (exact)

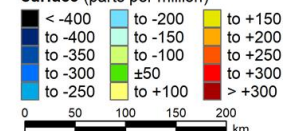
Areas within ±150 ppm distortion (1:6,667 = ±0.79 ft per mile):

- 98% of population
- 96% of all cities and towns
- 95% of entire zone area

Distortion values (ppm)

Entire zone:	Cities and towns:
Min, Max = -164, +261	Min = -158
Range = 425	Max = +225
Mean = -61	Range = 384
Weighted mean = +3	Mean = -50
(weighted by population)	

Linear distortion at topographic surface (parts per million)



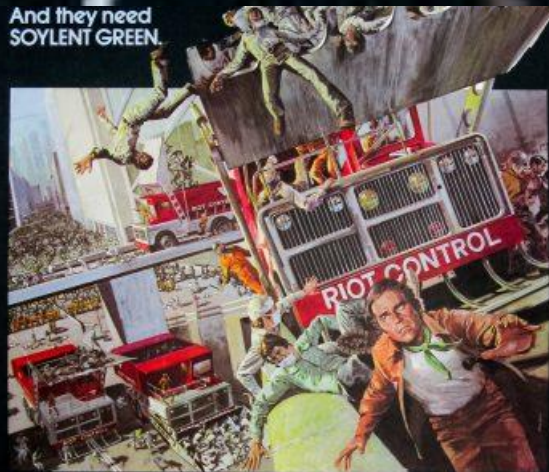
Created 12/23/2019 (Michael Dennis)

What to expect for SPCS2022

- **Coordinates will change by at least 10,000 m**
 - Latitude and longitude change about 1-2 m
 - Rest of change due to projection definition
- **Less difference between “grid” and “ground”**
- **More than one zone layer in most states**
 - Zones will be similar to SPCS 83 in some states
 - Zones will be very different in most states
- **Every state will have a statewide zone layer**

It's the year 2022...

And they need
SOYLENT GREEN.



SOYLENT GREEN

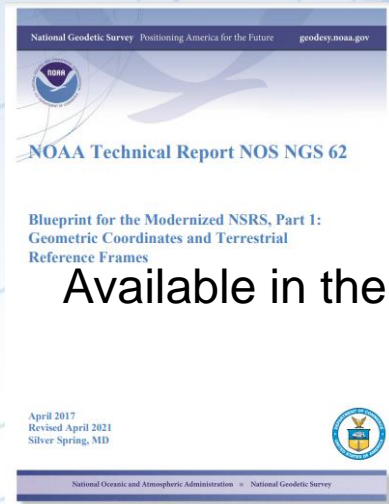
MGM Presents
A Movie
by Richard Fleischer
Starring
CHARLTON HESTON • LEIGH TAYLOR-YOUNG • SOYLENT GREEN
CHUCK CONNORS • JOSEPH COTTEN • BROCK PETERS • PAULA KELLY and EDWARD G. ROBINSON
Screenplay by
STANLEY R. GREENBERG • HARRY HARRISON • ROBERT S. RAY
Produced by
WALTER SELTZER and RUSSELL THACHER
Directed by
RICHARD FLEISCHER
METROCOLOR • PANAVISION

IPLSA 2023 Convention

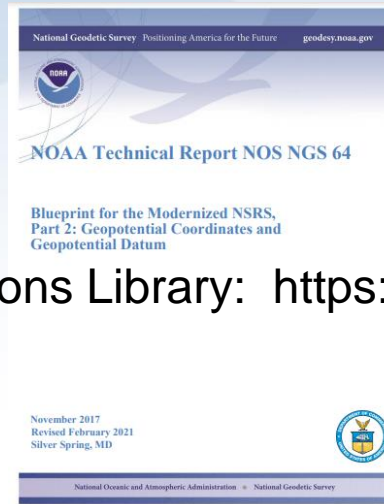
NSRS Modernization: Delay

- Will names change?
 - No, “GEOID2022”, “NATRF2022”, etc. will remain the same
- NGS anticipates the release of all data, and limited tools, by the **middle of 2025**.
 - Some of this may depend on things outside of NGS control (we have already delayed beyond 2022!)
- Work on additional tools will continue in the out-years

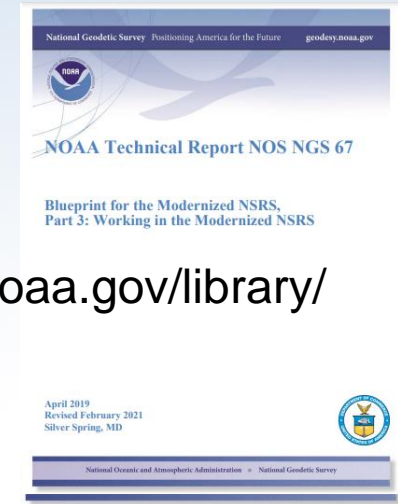
Updated blueprint documents



Geometric:
Sep 2017
Revised April 2021
NOAA TR NOS NGS 62
61 pages



Geopotential:
Nov 2017
Revised Feb 2021
NOAA TR NOS NGS 64
53 pages



**Working in the
Modernized NSRS:**
April 2019
Revised Feb 2021
NOAA TR NOS NGS 67
133 pages

Available in the NGS Publications Library: <https://geodesy.noaa.gov/library/>

A two-track approach to coordinates

Reference Epoch Coordinates

- An estimated “snapshot” of entire network
- Every 5 or 10 years
- Similar to NAD 83(2011) epoch 2010.00

Survey Epoch Coordinates

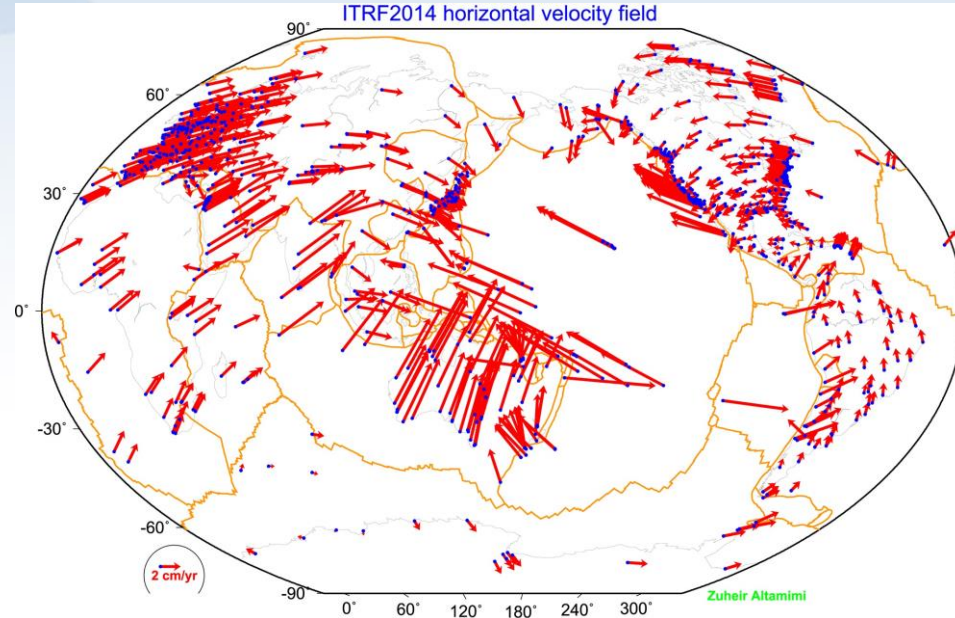
- Time-dependent!
- Reflects coordinates at time of observation
- Multiple SECs can show changes over time

Replacing the NAD 83s

The Old	The New
NAD 83 (2011)	NATRF2022 - The North American Terrestrial Reference Frame of 2022
NAD 83 (2011)	CATRF2022 - The Caribbean Terrestrial Reference Frame of 2022
NAD 83 (PA11)	PATRF2022 - The Pacific Terrestrial Reference Frame of 2022
NAD 83 (MA11)	MATRF2022 - The Mariana Terrestrial Reference Frame of 2022

The IGS Reference Frame

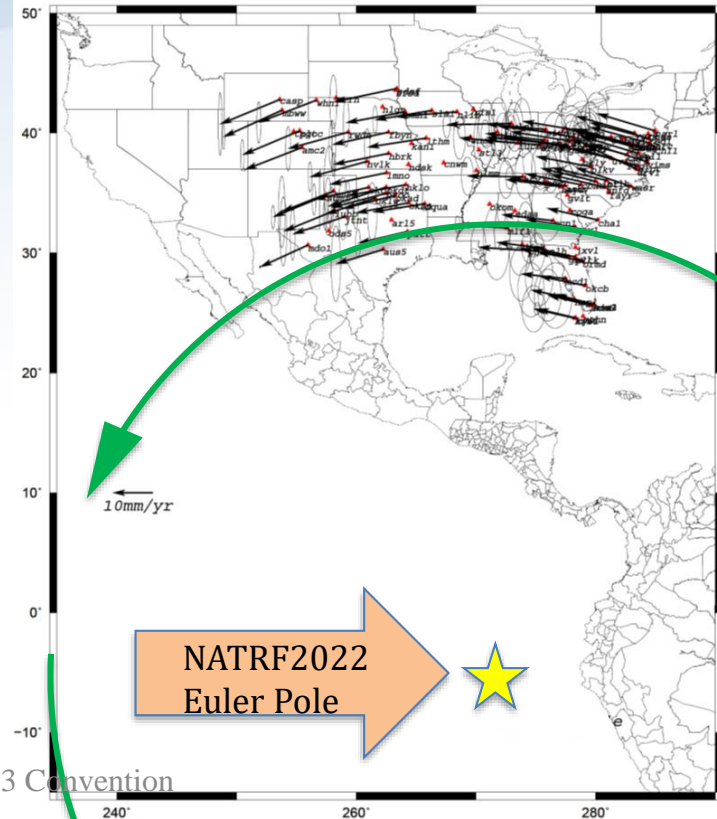
- The ITRF is defined by reference epoch coordinates AND velocities at stations
- The ITRF velocity field very closely resembles absolute plate motion
- The ITRF and IGS frames are both no-net-rotation frames – the sum of the angular velocities is constrained to be zero
- The Modernized (2022) NSRS Reference Frames will tie to ITRF2020



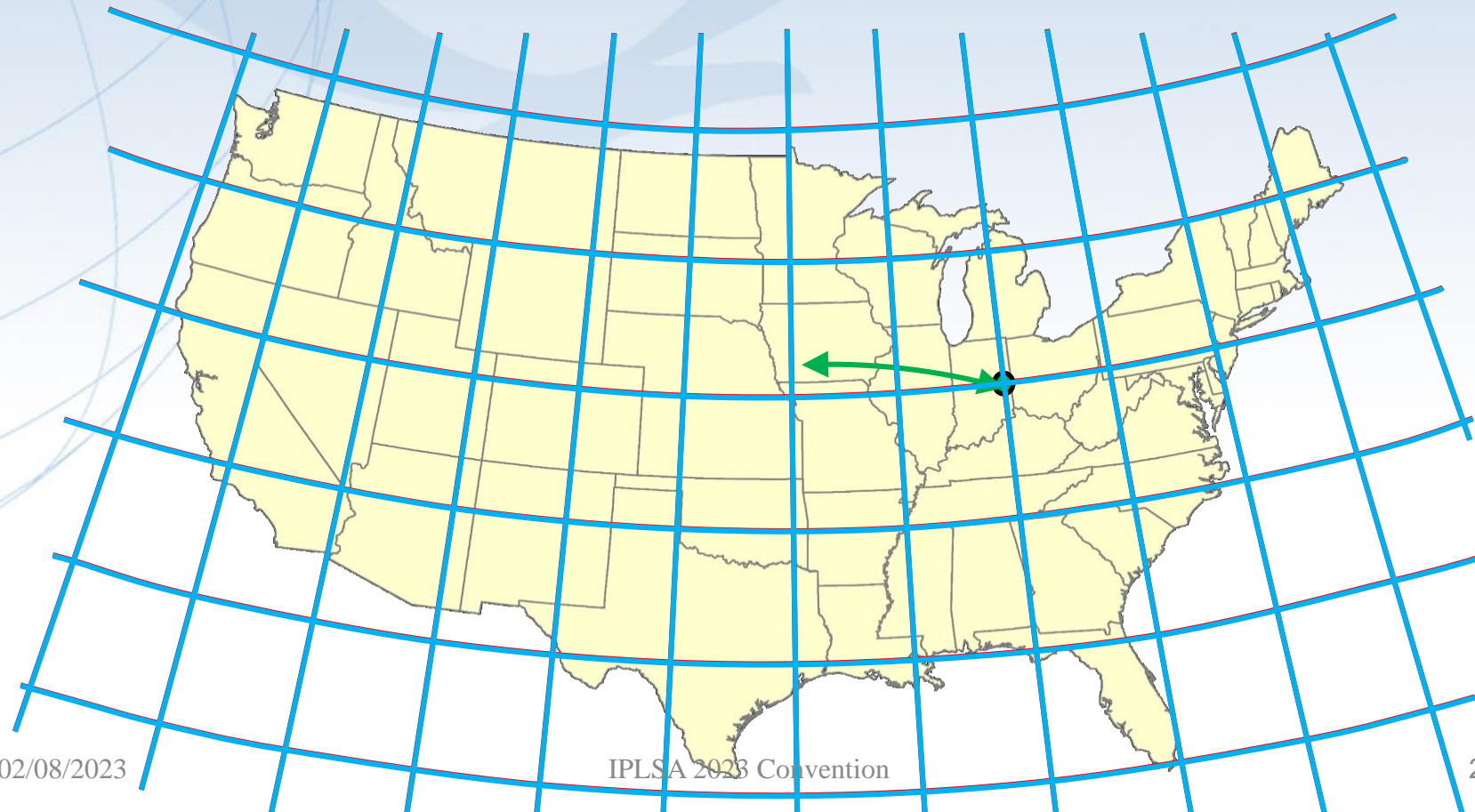
Altamimi et al., 2016, JGR

Euler Poles and “Plate-Fixed”

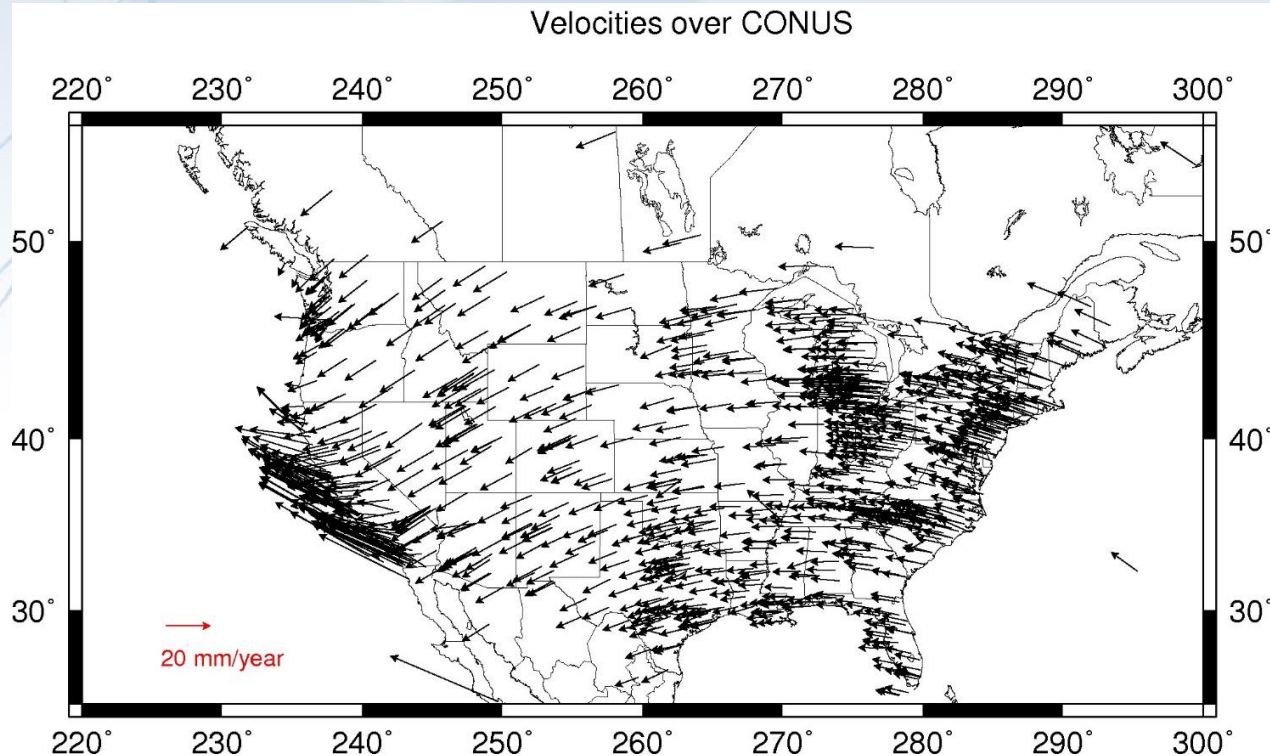
- In the ITRF, many tectonic plates have a *dominant* motion: **rotation**
- **Euler Pole** - point about which a plate rotates (yellow star)
- Euler Pole Parameters (**EPP**) define this rotation
- Residual motion is characterized in an Intra-Frame Deformation Model (**IFDM**)



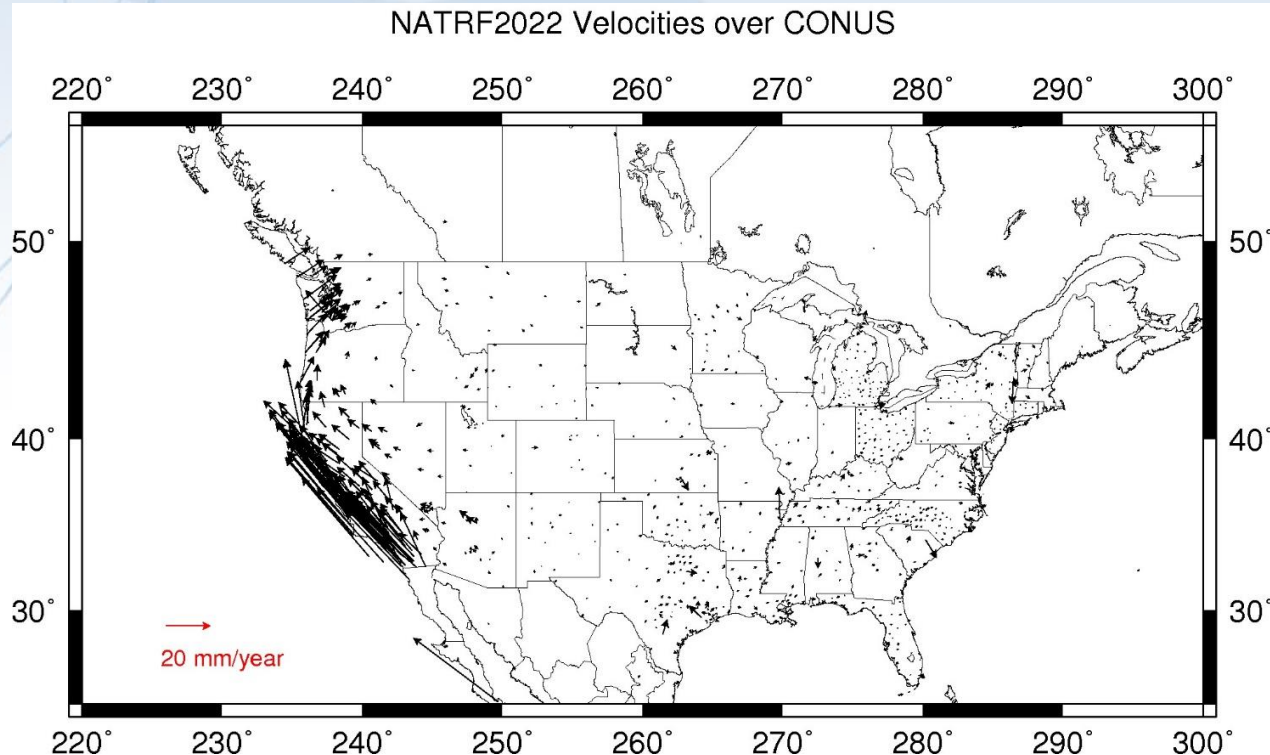
ITRF2020 or NATRF2022



Residual Velocities – ITRF2020/CONUS

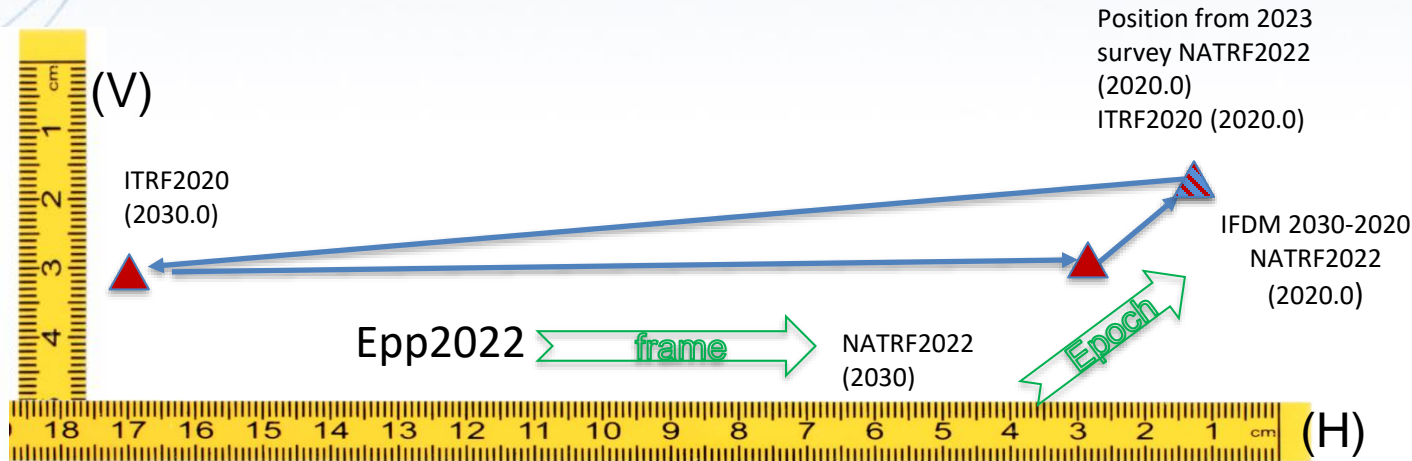


Residual Velocities – NATRF2022/CONUS

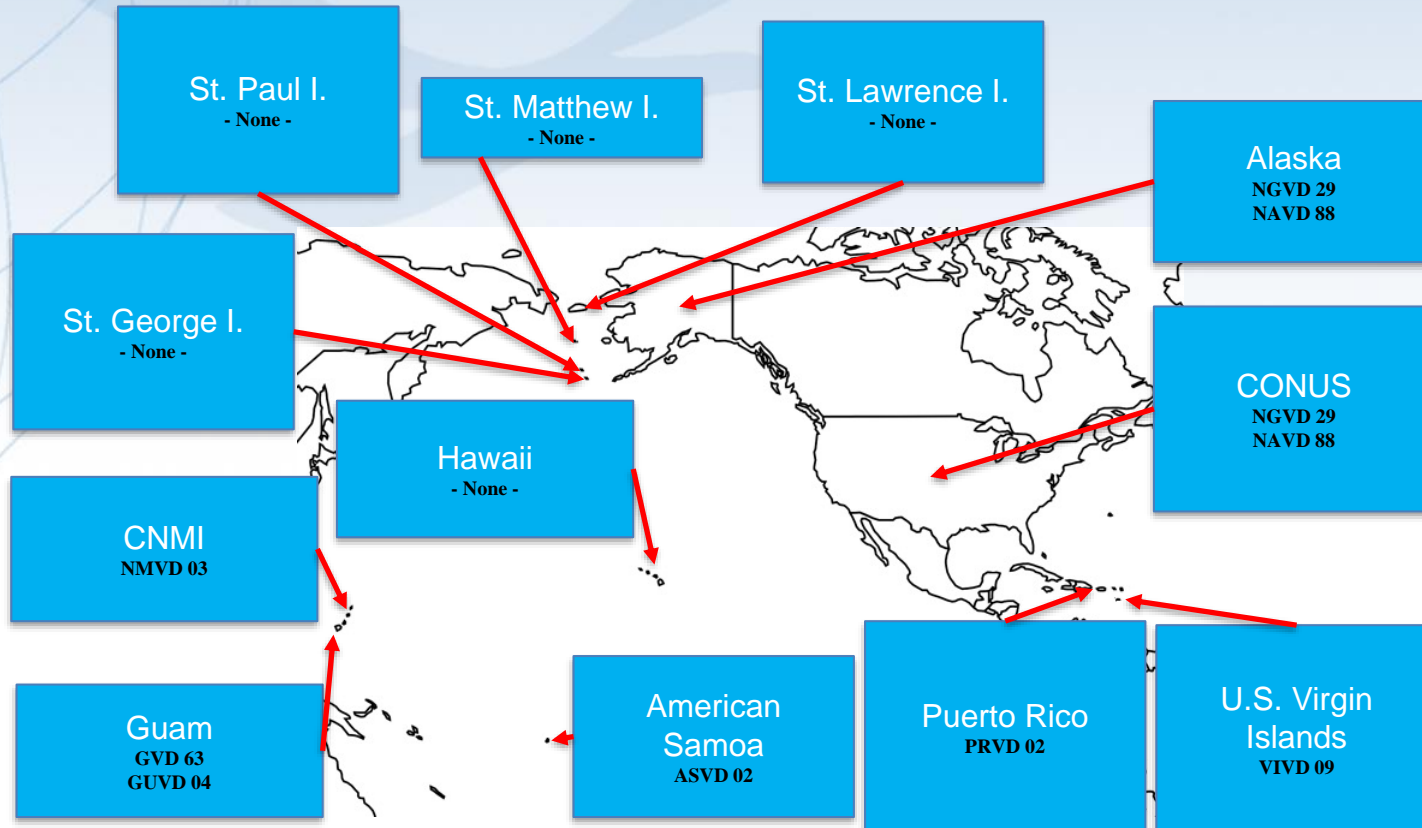


Coordinates, Frames, Epochs, EPP2022 and IFDM2022

1. A survey done Jan 1, 2023 and reported at epoch 2020.0
2. New Survey (same point) done Jan 1, 2030
3. Position of point in NATRF2022(2030)
4. Position of point in NATRF2022(2020)
5. If IFDM = 0, then NATRF2022 (2030) = NATRF2022 (2020)

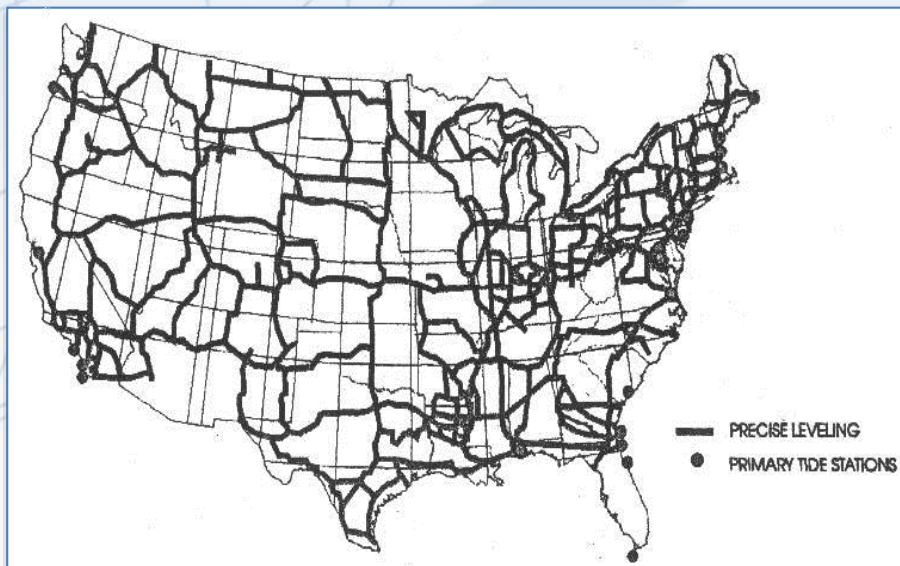


Vertical Datums of the NSRS

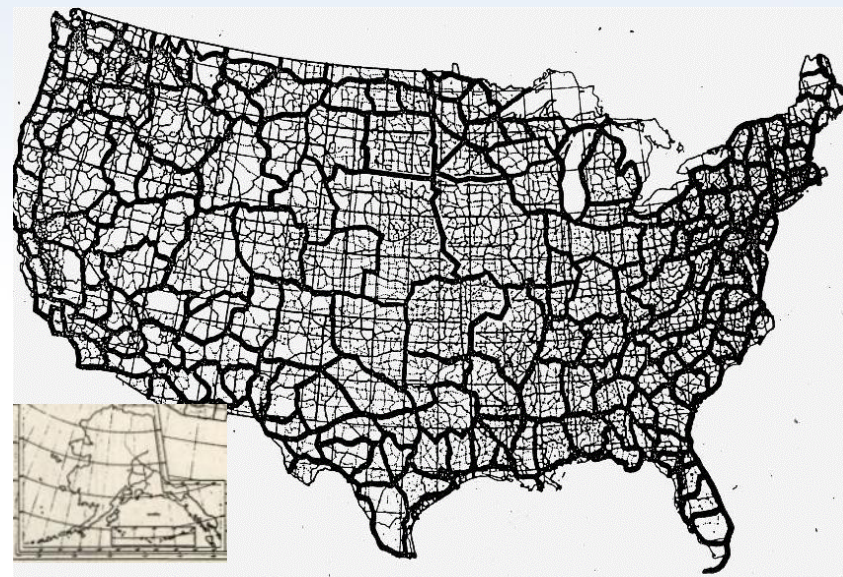


Developing the Previous Vertical Datums

NGVD 29



NAVD 88



Leveling



Replacing NAVD 88

Orthometric
Heights

Normal
Orthometric
Heights

Dynamic
Heights

Gravity

Geoid
Undulations

Deflections of
the Vertical

The Old:

NAVD 88

PRVD 02

VIVD09

ASVD02

NMVD03

GUVD04

IGLD 85

IGSN71

GEOID18

DEFLEC18

The New:

The North American-Pacific **Geopotential Datum** of 2022 (NAPGD2022)

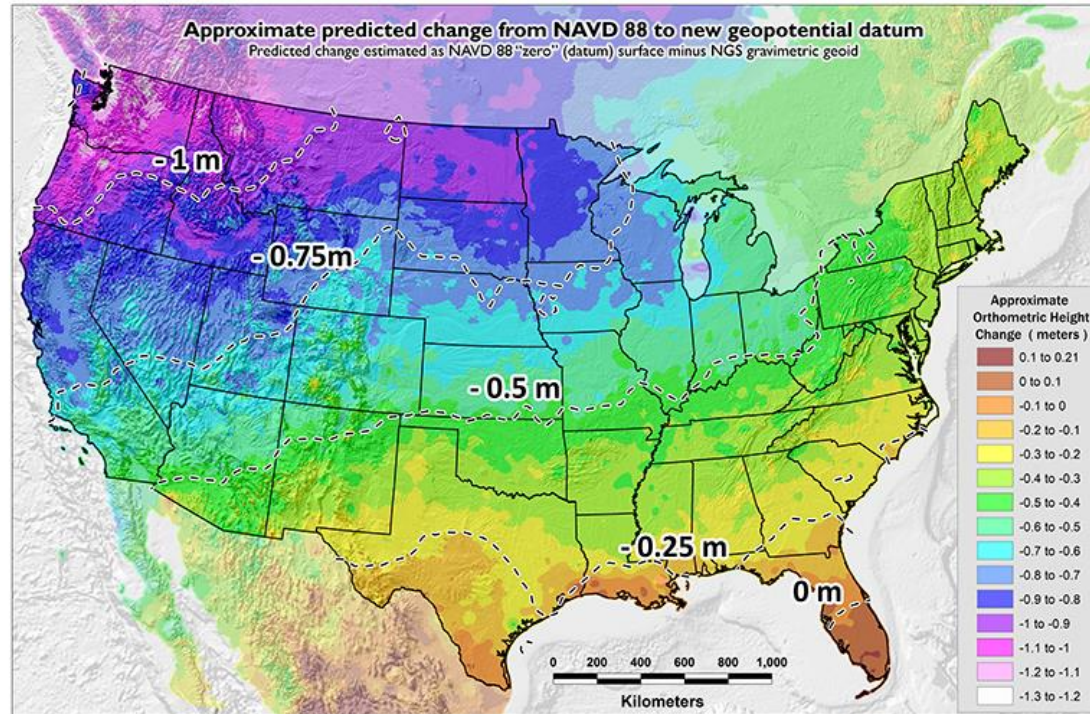
Will include:

- GEOID2022
- DEFLEC2022
- GRAV2022
- DEM2022
- More

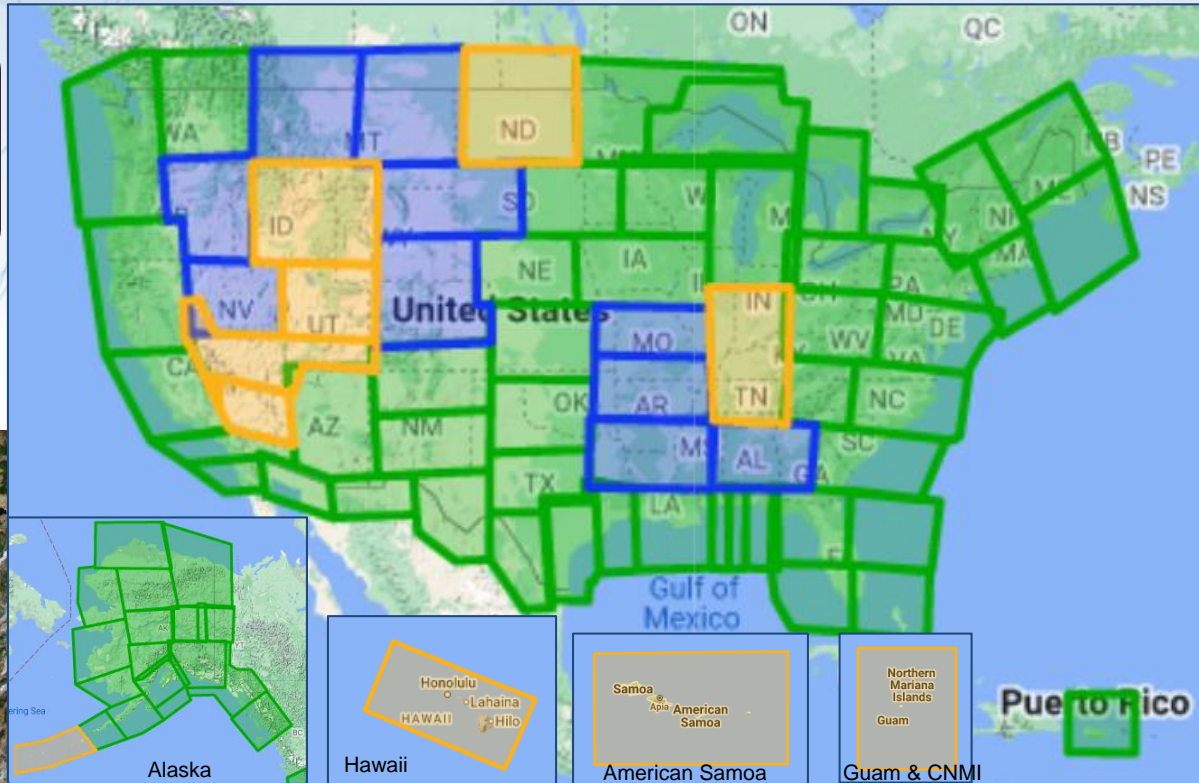
A HUGE component of this effort is GRAV-D:

Gravity for the Redefinition of the American Vertical Datum

NAVD 88 (epoch ?) to NAPGD2022 Epoch 2020.00 (estimate)



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



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



Over 96% complete



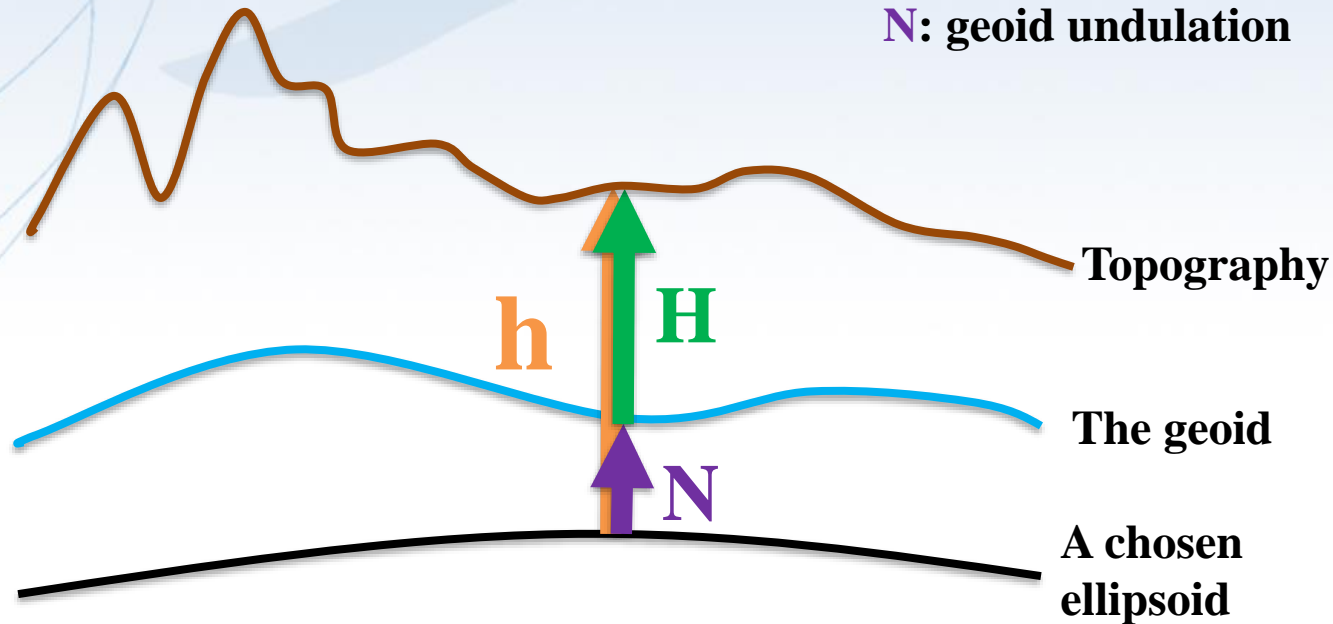
The Geoid, and Heights

$$h = H + N$$

h: ellipsoidal height

H: orthometric height

N: geoid undulation



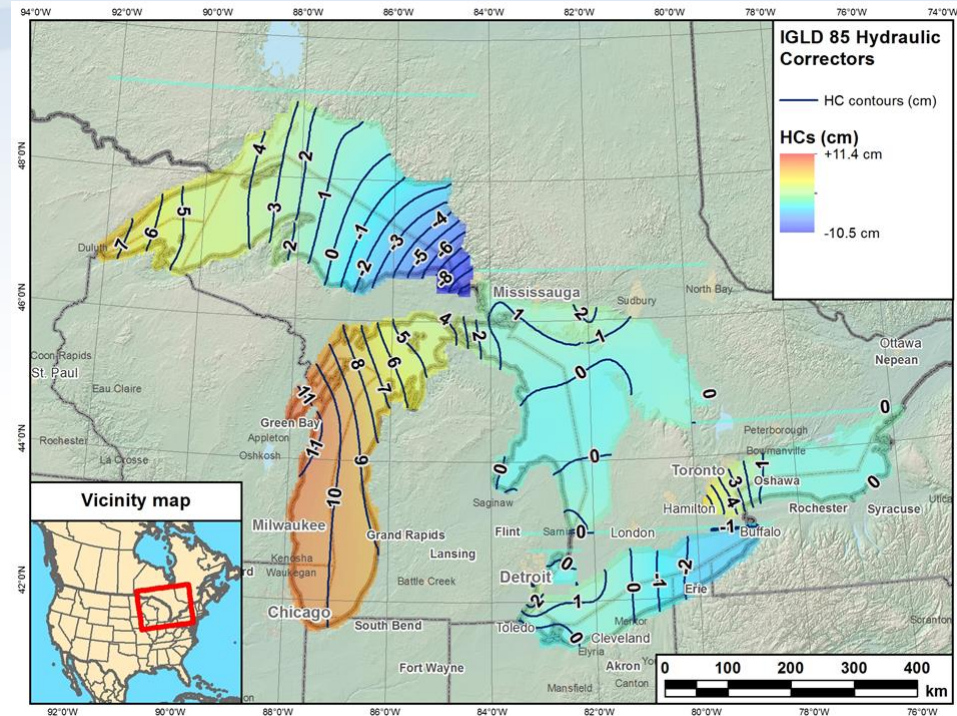
IGLD UPDATE

What is IGLD?

- International Great Lakes Datum (IGLD) is a common height reference system by which water levels can be measured and meaningfully related to each other
- Joint effort between the United States and Canada
- Maintained by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data
- Due primarily to Glacial Isostatic Adjustment, IGLD is updated every 25-35 years
- The next update will be IGLD (2020)

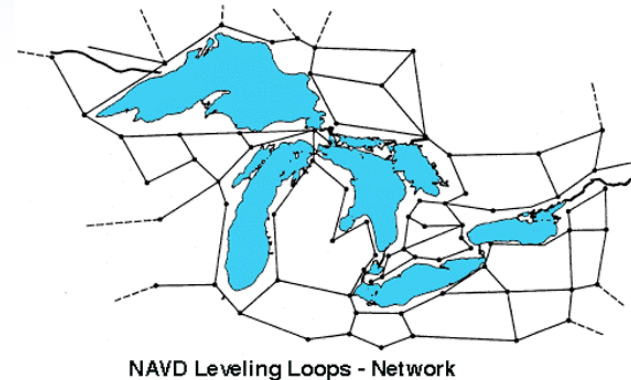
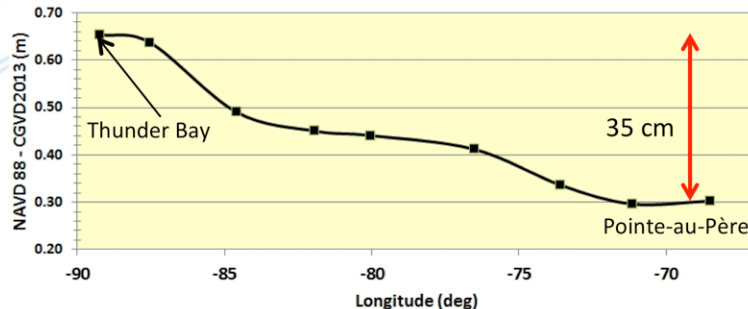
Current IGLD

- IGLD (1985) replaced IGLD (1955) in 1992
- Same reference zero as NAVD 88 (at Pointe au Père, Québec)
- Surface determined by leveling
- Dynamic heights
- Hydraulic correctors



IGLD (1985) Reference Surface

- Reference surface is each lake (equipotential surface) to which heights are referenced
- IGLD 1955 & 1985 used 1000's miles of geodetic leveling to indirectly define the reference surface
 - Very time consuming & cost prohibitive
 - Datum accessible only where leveling exists (benchmarks)
 - Susceptible to accumulation of systematic errors
- Extends the reference zero inland

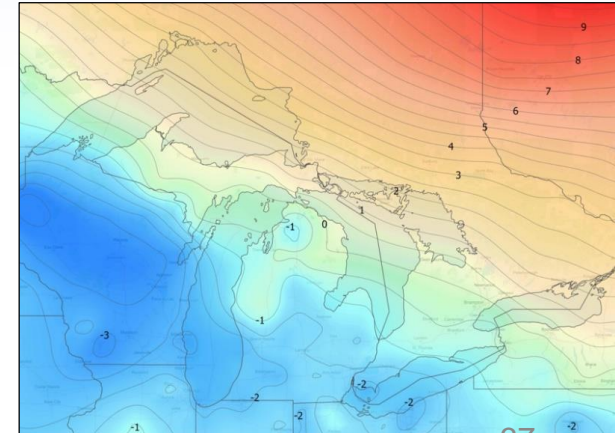
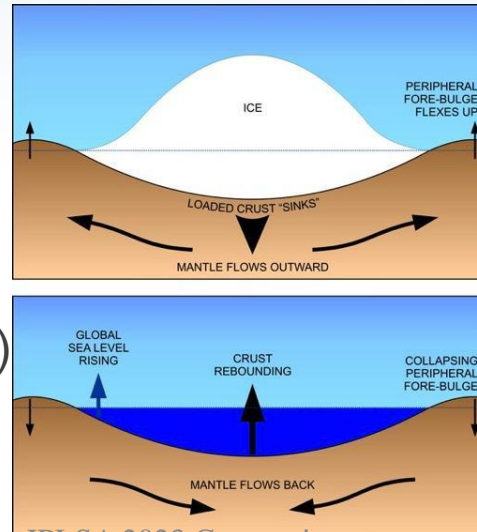


Why a new IGLD?: Glacial Isostatic Adjustment – (GIA)

Process of Glacial Isostatic Adjustment (left) and the resulting tilting of the entire Great Lakes region (right) as determined by high accuracy GPS measurements in units of mm/year. M. Craymer and C. Wisotzkey, 2021.

Entire basin is:

- Uplifting in north
- Subsiding in south
- Overall tilting ~7 mm/year
(21cm or 0.7' over 30 year)
- Need to update IGLD
every 25-30 years



Definition of IGLD (2020)

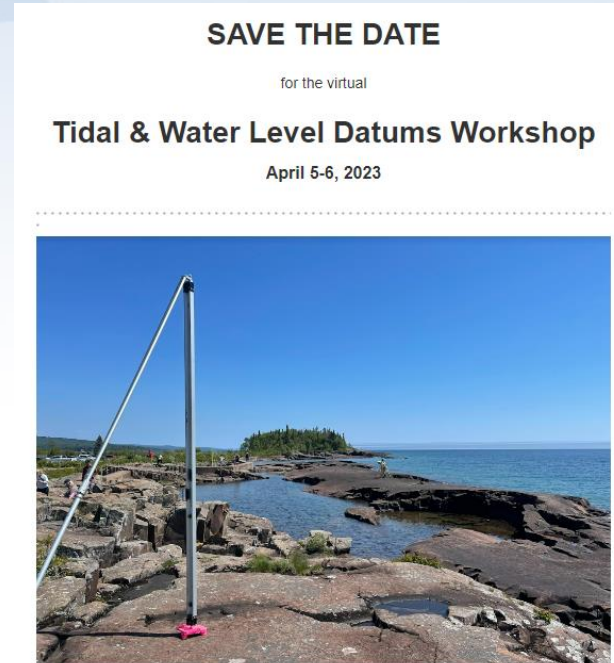
- Reference Zero
 - $W_0 = 62,636,856.00 \text{ m}^2/\text{s}^2$ that the U.S. and Canada have adopted for the new geoid-based North American-Pacific Geopotential Datum of 2022 (NAPGD2022) & Canada has already adopted for the Canadian Geodetic Vertical Datum of 2013 (CGVD2013)
- Realization of the Reference Surface
 - NAPGD2022 geoid model representing the reference zero everywhere over the Great Lakes – St. Lawrence River system, not only where leveling and bench marks exist
- Reference Epoch
 - 2020.0, the central epoch of the 7-year water level observation period of 2017–2023
- Dynamic Height
 - IGLD (2020) will use dynamic heights derived from GNSS occupations
 - The dynamic height represents the difference in potential above the reference surface and is the same at all points on a level surface

Status of IGLD Update

- GNSS field campaign took place in 2022 – data processing continues
- Seasonal gauging continues
- Hydraulic corrector working group is investigating the need for HCs in IGLD (2020)
- IGLD (2020) is planned for release about one year after the release of the NAPGD2022 vertical datum (around 2026)

Save the Date! Water Level Datum Workshop

- NOAA, the Canadian Hydrographic Service (CHS), and the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data would like to invite you to a virtual workshop on Tidal and Water Level Datums. Participants will have the opportunity to learn more about the datums and impacts on the coastal, navigation and shipping communities and industries.
- **April 5:** *National Tidal Datum Epoch (NTDE)*
- **April 6:** *International Great Lakes Datum (IGLD) and the Low Water Datum (LWD)*
- The workshop will feature presentations and discussions from NOAA's Center for Operational Oceanographic Products and Services, the National Geodetic Survey, and the Office of Coast Survey, as well as U.S. Army Corps of Engineers, CHS, Natural Resources Canada, Environment and Climate Change Canada, and others.





Updates from NGS Part 2: Updates to Online Tools

Jacob Heck

NGS Great Lakes Regional Geodetic Advisor
IPLSA 2023 Convention



OPUS Projects

National Geodetic Survey

NGS Home About NGS Data & Imagery Tools Surveys Science & Education Search



OPUS Projects gives users web-based access to simple management and processing tools for projects involving multiple sites and multiple occupations. The advantages of OPUS Projects are:

- Data uploading through OPUS.
- Customizable data processing via the PAGES software suite.
- Visualization and management aids.

What is OPUS projects?

- One page class description.
- What is OPUS Projects.
- User Manual.
- Manager training videos.

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shared solutions

support / feedback

The NOAA CORS Network (NCN) and OPUS reference system in September 2019. While the reference system is still offered through the BETA OPUS tools, IGS08 reference system will end. NGS strongly encourages you to complete existing projects or convert them to the ITRF2014 reference system by the end of the year. Until that time, a one-time option to convert an existing IGS08 project to the ITRF2014 will be offered the first time the project is accessed.

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Create a new project.

Create **RESTRICTED** to trained project managers who have completed OPUS Projects training, you can create a new project. All others, see the Project Tracking web site to request a required

Configure, edit, and process individual network sessions.

Session **Project Identifier:**
Session Key
Your Email:
Privacy Act Statement

Manage, edit, process, and publish the project.

Manage **Project Identifier:**
Manager Key

for the Future

www.ngs.noaa.gov

geodesy.noaa.gov

beta.ngs.noaa.gov



BETA

This is a BETA Release Site

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If you're interested in submitting your project's request to the NGS Integrated Database (IDB) and have not done so, please visit the Project Tracking web site to request a required

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Manage, edit, process, and publish the project.

Manage **Project Identifier:**



DEV

Internal Development Area

OPUS Projects

National Geodetic Survey

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OPUS menu

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support / feedback

CORS and OPUS converted to the ITRF2014 reference system in September 2019. From that point forward, all new projects will be created in the ITRF2014 reference system. **more**

The IGS08 reference system will be supported through the end of 2019 here, in **BETA OPUS** and in **BETA OPUS-Projects**. The **OPUS team** can copy your project to **BETA OPUS-Projects** on request; however, OPUS support for the IGS08 reference system will end. NGS strongly encourages you to complete existing projects or convert them to the ITRF2014 reference system by the end of the year. Until that time, a one-time option to convert an existing IGS08 project to the ITRF2014 will be offered the first time the project is accessed.

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NGS Products and Services

- Not just OPUS
- All exist in three environments:
 - **Development** (DEV) - internal testing and development
 - same as when you hear a company talk about an “Alpha” product
 - **Beta** - continued internal testing, open for public testing
 - key features have already been vetted/tested
 - **Production** - final product, open to public use
 - this is what you see first when navigating our website

NGS Coordinate Conversion and Transformation Tool (NCAT)

- Converts between types of coordinates
- Transforms between datums
- Works with vertical and horizontal datums in the NSRS

The screenshot shows the NGS Coordinate Conversion and Transformation Tool (NCAT) web interface. The header includes the NOAA logo and the text "NGS Coordinate Conversion and Transformation Tool (NCAT)" and "National Geodetic Survey". Below the header is a navigation bar with links: "NGS Home", "About NGS", "Data & Imagery", "Tools", "Surveys", "Science & Education", and a search bar. The main content area has tabs for "Single Point Conversion", "Multipoint Conversion", "Web services", "Downloads", "Tutorial & FAQs", and "About NCAT". The "Single Point Conversion" tab is active. It contains a "Convert/Transform from:" section with radio buttons for "Horizontal" (selected), "Horizontal+height", and "XYZ". Below this is a "Select the type of horizontal coordinate:" section with radio buttons for "Geodetic lat-long" (selected), "SPC", "UTM", and "USNG". A map of Wisconsin is shown on the left, with a blue pin indicating a location near Lake Superior. To the right of the map are input fields for "Lat" and "Lon" in decimal degrees, degrees-minutes-seconds, or by dragging a map marker. Below the map is a "Submit" button. On the right side, there are dropdown menus for "Input reference frame (historically called 'horizontal datum')", "Output reference frame (historically called 'horizontal datum')", and "SPC zone". At the bottom, there is a section for "Converted Coordinate" with a "Reference Frame:" label.

Transitioning Data into the Modernized NSRS

Most accurate,
Most costly,
Most complex

Resurvey



Readjust

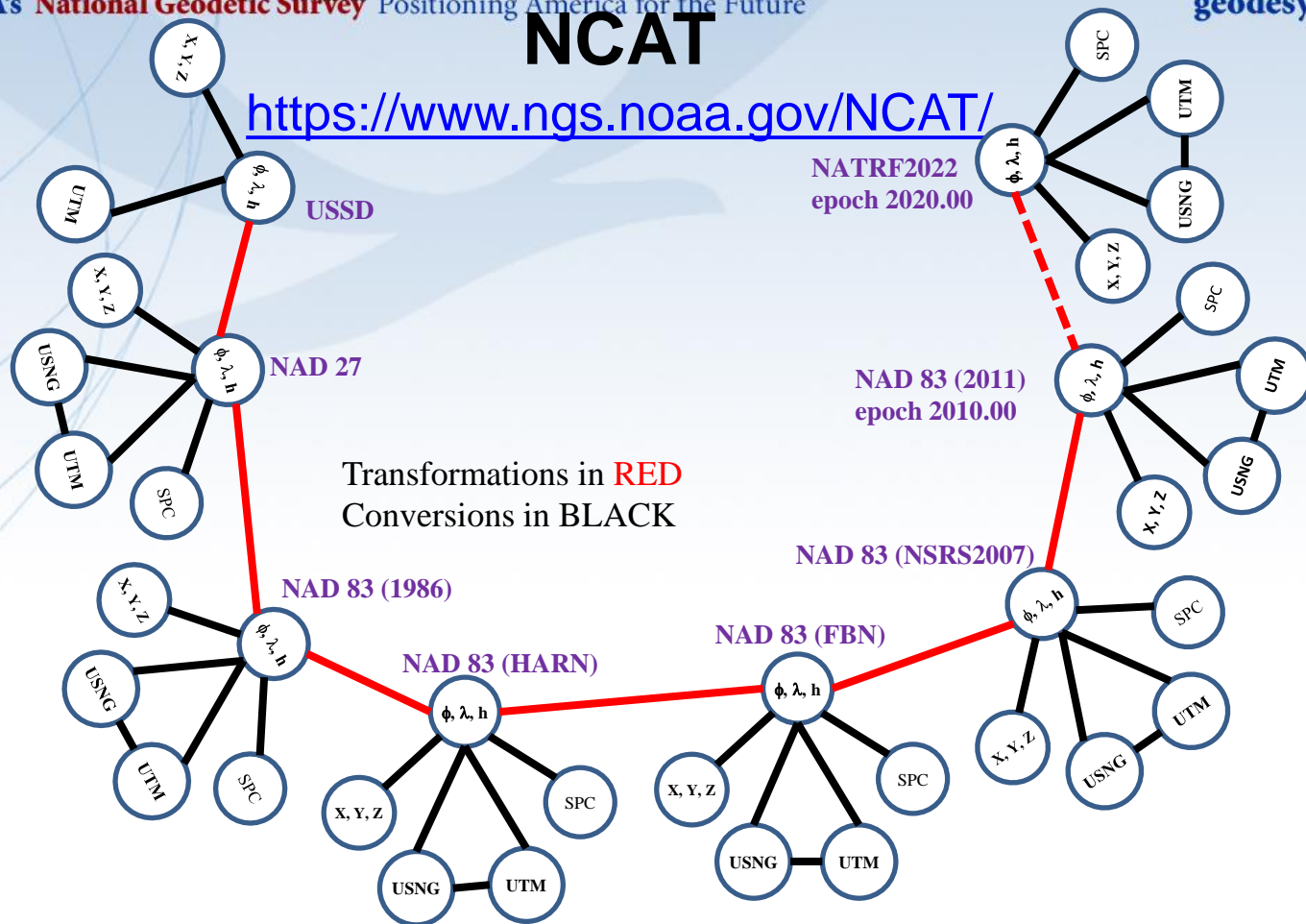


Transform

Least accurate,
Least costly,
Least complex

NCAT

<https://www.ngs.noaa.gov/NCAT/>



OPUS-PROJECTS UPDATES

What is OPUS?

- OPUS-S (static processing, 2-48 hours)
- OPUS-RS (rapid-static, 15 minutes – 2 hours)
- Sharing database of solutions
- OPUS Projects
 - campaign style survey-processing, adjustments, publication



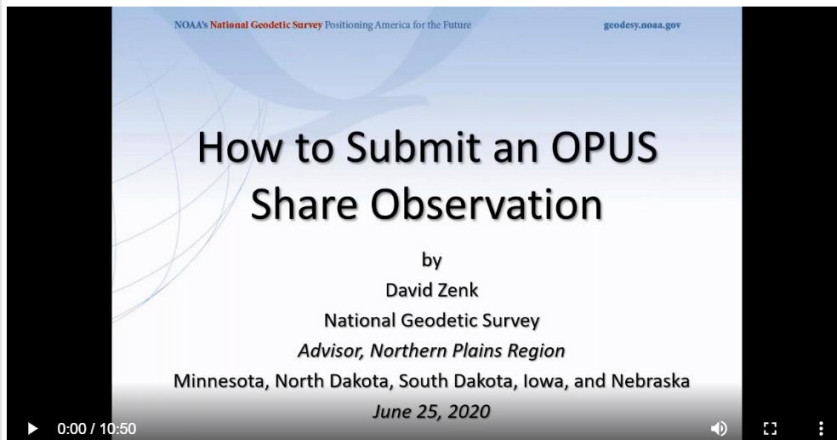
The screenshot shows the OPUS: Online Positioning User Service website. The header includes the NOAA logo and the text "OPUS: Online Positioning User Service" and "National Geodetic Survey". A navigation bar contains links: "NGS Home", "About NGS", "Data & Imagery", "Tools", "Surveys", "Science & Education", and a search bar. A sidebar on the left has a photo of a surveying station and a menu with links: "home / upload", "about OPUS", "projects", "shared solutions", "planned improvements", "support / feedback", and "OPUS Today". The main content area features a warning about the ITRF2020 update on 11/27, a section for uploading data files with a "Choose File" button and a note about dual-frequency GPS observations, a dropdown menu for antenna selection, a text input for antenna height, an email address field, and buttons for "Options", "Upload to Rapid-Static", and "Upload to Static". A "sample solutions" link is also present.

Share GPS observations through OPUS

- Upload 4+hour GPS observation file
- Provide antenna type, antenna height, and email address
- Click “Options” & Select “Yes, Share”
- Identify the Mark by PID
- Write a “To Reach” description
- Attach 2 photos: Close up & Horizon
- Respond to confirmation email

How to Submit an OPUS Share Observation Tutorial

The purpose of this tutorial is to explain the steps needed to submit an OPUS Share observation in the context of supporting the GPS on Bench Marks campaign.



geodesy.noaa.gov/corbin/class_description/opus-share-tutorial/

Why use OPUS-Projects?

- Supports both static GPS and RTK GNSS surveys
- Organizes data for multiple occupations on more than one mark
 - Campaign-style surveys for control
- Performs least squares adjustments of control survey networks
 - Estimate relative accuracy between marks
- Constrains NAVD 88 bench marks – check/establish NAVD 88 heights
- Ensures survey is tied to the NSRS
 - CORS data and published coordinates/heights
 - Official models (HTDP, GEOID18)
- Submits survey to NGS for review, loading in database, and publication on datasheets
 - Establishment of geodetic control
 - NGS will use data for making models (e.g., future transformation model for the new datums)

OPUS-Project 4.0

- Currently on Production
- What does this version add?
 - Allows you to submit campaign style GPS survey to NGS for inclusion in the IDB (Integrated DataBase)
 - Upload GPS data to OPUS-S
 - Upload photos and mark descriptions ← (must be created using WinDesc)
 - Process simultaneous/overlapping sessions
 - Run network adjustment (using GPSCOM and ADJUST)
 - Click the “Submit” button to send to NGS!

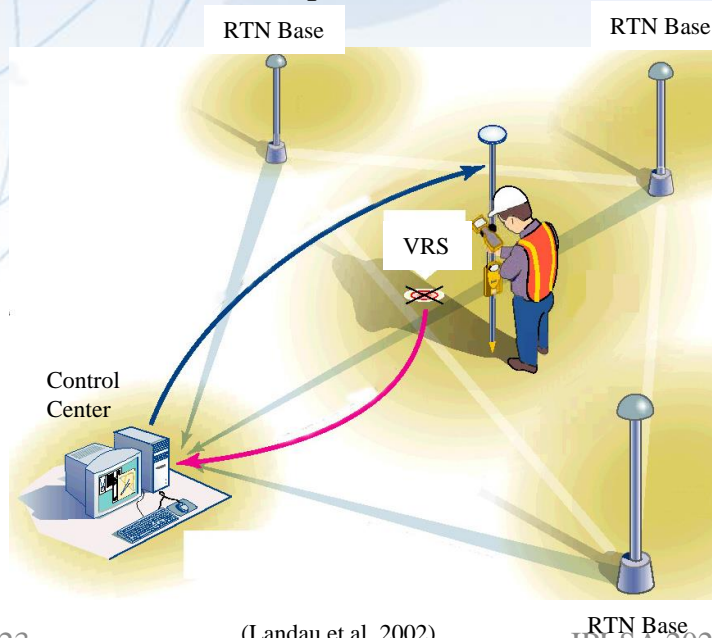
OPUS-Projects 5

- Available on BETA at: <https://beta.ngs.noaa.gov/OP-bluebook/OpusProjects.shtml>
- Continues to support static GPS baseline processing and network adjustments
- Continues to prepares all files according to FGCS Bluebook for submission to NGS for loading in the NGS Integrated Database and publication on Datasheets
- Supports GVX → uploading of previously processed GNSS vectors
 - Single-base RTK vectors
 - Network RTK vectors
 - Vectors post-processed in other software
- Automatically “weights” uploaded vectors in a network least squares adjustment

Real-Time Networks

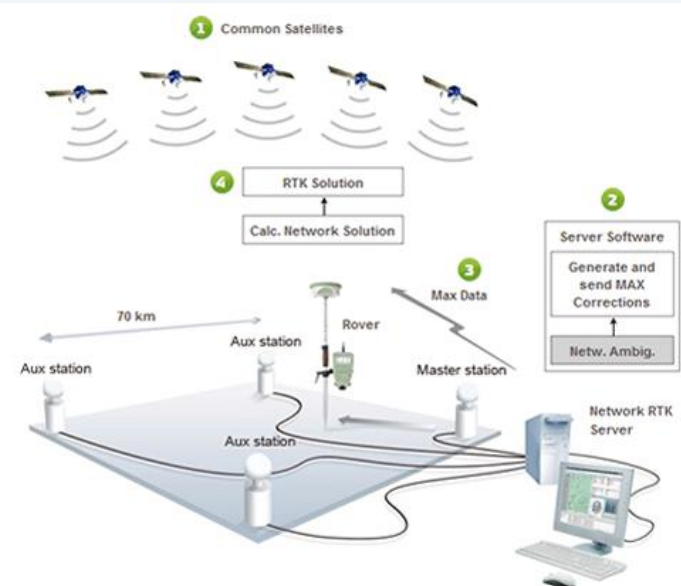
Virtual Reference Stations (VRS)

- Vector “tails” referenced to virtual base station
- Base station position is variable

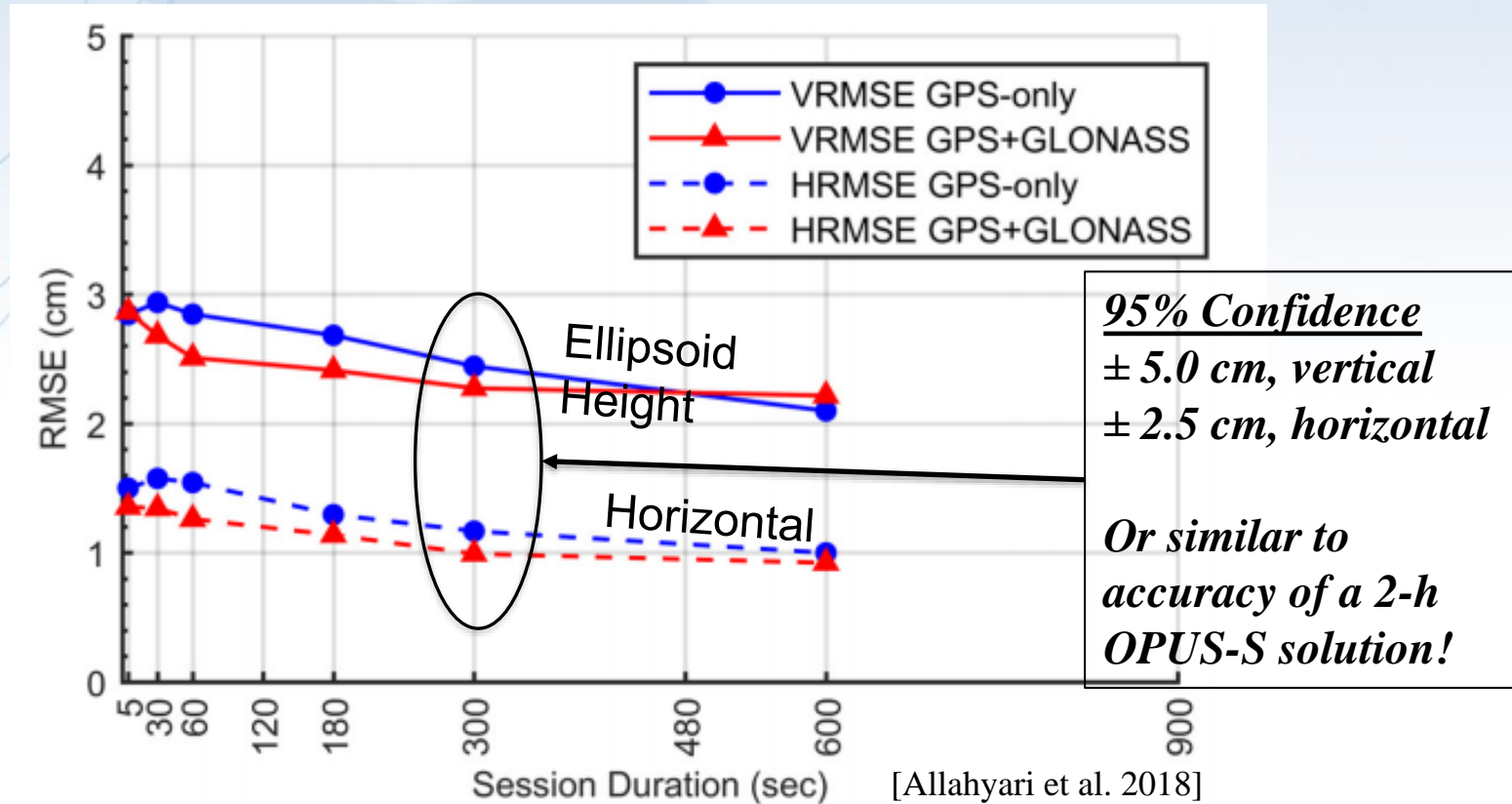


Master-Auxiliary Concept (MAC)

- Vector “tails” connected to physical base station
- Base station position is fixed



Empirical Evaluation of the Accuracy of RTNs

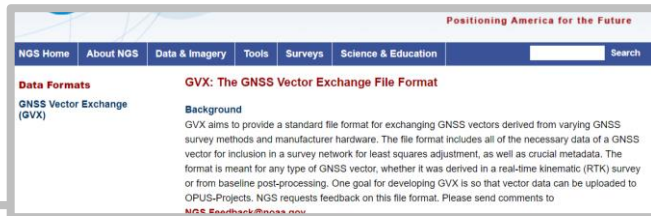


GNSS Vector eXchange (GVX)

[Hyperlink to GVX Info Page](#)

- Detailed documentation, Schema, and Example File available
- Any major search engine: “ngs gv x file format”
- Open standard for anyone to use or integrate

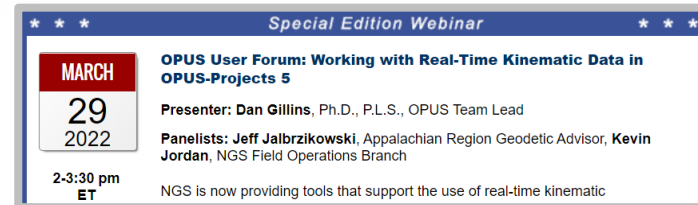
GVX is sort of like RINEX for RTK/RTN data



GVX: The GNSS Vector Exchange File Format and its Application in OPUS-Projects

Daniel Gillins, Ira Sellars, Mark Schenewerk and Weibing Wang (USA)

FIG Working Week 2020
Smart surveyors for land and water management
Amsterdam, the Netherlands, 10–14 May 2020



GVX \approx RINEX for RTK/RTN data

RINEX

Uncorrected Observations

- That's why we post-process them

Static Observations

- One observation per file

Proprietary Format \rightarrow Open Standard

- Export RINEX using your COTS software

Metadata

- Antenna, Rx, HI, Point Name, Start Time, SVs at each epoch

Based on ASCII Text File Format

- Longtime industry standard
 - Way too many to list!

GVX

Corrected/Processed Positions

- *And* the Vectors used to create them

RTN, RTK, PP Static, even PPK

- Many observations, any mix of above

Proprietary Format \rightarrow Open Standard

- Export GVX using your COTS software

Metadata - same as RINEX, *plus*...

- Project Info, Solution Types, PDOP, Mount Points, Correlation Matrices, QC data

Based on XML File Format

- Longtime industry standard
 - e.g. LandXML, JXL, MAXML, KML/KMZ

Status of GVX Exporters

...that we know of.

Available Now

- Trimble Business Center (TBC) v5.60 - released Nov 2021
- Topcon MAGNET Software v7.2 - released Nov 2021
- Leica Infinity 4.0.0 - released May 2022



Developers who have expressed interest to us

- iGage
- Carlson
- Emlid

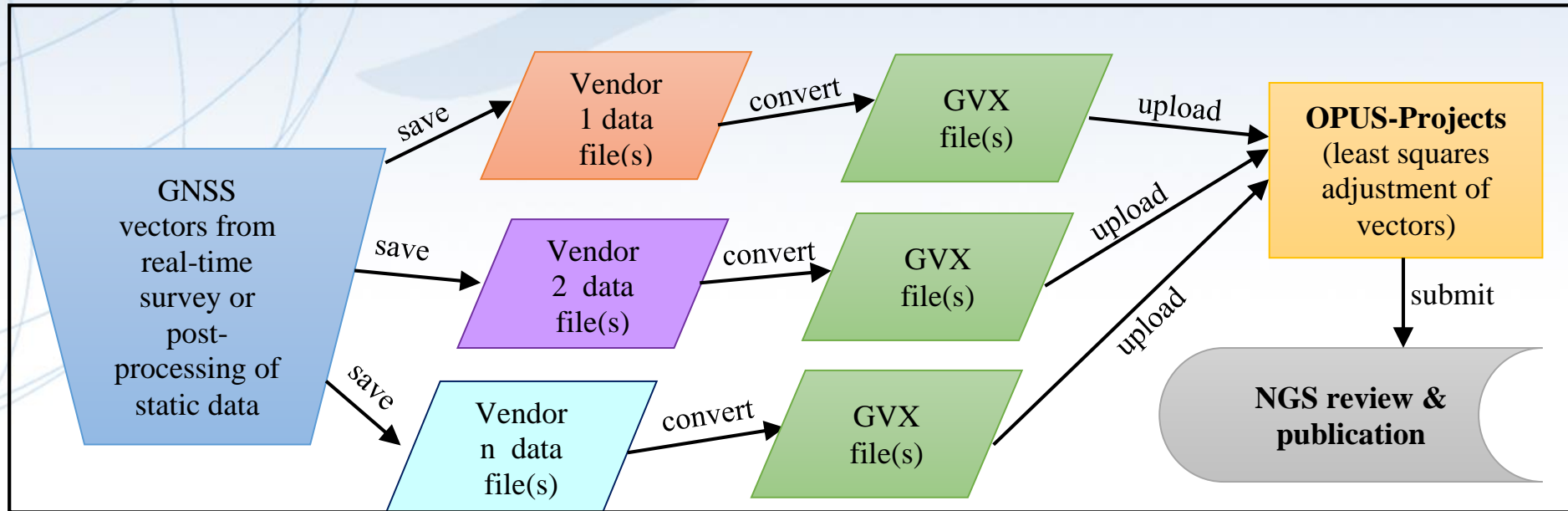


Available, but not fully functional

- JAVAD J-field - onboard Triumph-LS device



GVX Flow Chart



Steps for Submitting a Survey to NGS

1. Submit a [survey project proposal](#) and obtain a project tracking ID
2. Create descriptions for marks in WinDesc. [Tutorial video](#) available
3. Upload all static data via Beta OPUS-S
4. **Upload GVX file(s)**
5. Upload description files from WinDesc
6. Perform session baseline processing
7. Run all 5 network adjustments
8. Upload 3 photos per mark (close-up of mark, horizon photo, and downward from eye-level)
9. Upload observation logs (as a single PDF), and a project report
10. Submit to NGS (*button not enabled on Beta*)

*All but step 4 is currently explained
in the [OPUS-Projects User Guide!](#)*

Equipment Setup

- When using VRS, store points as vectors

Remote Access

☰ Rover options

Survey type: RTK

Broadcast format: VRS (CMR)

Antenna

Type: R10-2 Internal

Antenna height: 2.000m

Serial number: ?

Measured to: Bottom of quick release

Part number: 90912-xx

Store points as: Vectors

Elevation mask: 10°

PDOP mask: 6.0

Esc Enter

Future Directions

- Perform Beta Testing and respond to feedback from users
 - Provide your feedback! NGS.Feedback@noaa.gov
- Finish OPUS-Projects 5 development and enable “submit” button
- Update OPUS-Projects User Guide materials to include GVX workflow
- Draft new guidelines for surveying with RTK/RTN to replace NGS-58/59

```

DE9524 *****
DE9524 DESIGNATION - SP 0109
DE9524 PID - DE9524
DE9524 STATE/COUNTY- IL/SANGAMON
DE9524 COUNTRY - US
DE9524 USGS QUAD - SPRINGFIELD WEST (2018)
DE9524
DE9524 *CURRENT SURVEY CONTROL
DE9524
DE9524* NAD 83(2011) POSITION- 39 49 41.85939(N) 089 39 02.64176(W) ADJUSTED
DE9524* NAD 83(2011) ELLIP HT- 147.185 (meters) (06/27/12) ADJUSTED
DE9524* NAD 83(2011) EPOCH - 2010.00
DE9524* NAVD 88 ORTHO HEIGHT - 179.776 (meters) 589.82 (feet) ADJUSTED
DE9524
DE9524 GEOID HEIGHT - -32.579 (meters) GEOID18
DE9524 NAD 83(2011) X - 29,900.259 (meters) COMP
DE9524 NAD 83(2011) Y - -4,904,962.342 (meters) COMP
DE9524 NAD 83(2011) Z - 4,063,456.865 (meters) COMP
DE9524 LAPLACE CORR - 1.42 (seconds) DEFLEC18
DE9524 DYNAMIC HEIGHT - 179.677 (meters) 589.49 (feet) COMP
DE9524 MODELED GRAVITY - 980,077.1 (mgal) NAVD 88
DE9524
DE9524 VERT ORDER - SECOND CLASS I
DE9524
DE9524 Network accuracy estimates per FGDC Geospatial Positioning Accuracy
DE9524 Standards:
DE9524 FGDC (95% conf, cm) Standard deviation (cm) CorrNE
DE9524 Horiz Ellip SD_N SD_E SD_h (unitless)
DE9524 -----
DE9524 NETWORK 0.59 1.37 0.27 0.20 0.70 -0.03058419
DE9524 -----
DE9524 Click here for local accuracies and other accuracy information.
DE9524
DE9524
DE9524 The horizontal coordinates were established by GPS observations
DE9524 and adjusted by the National Geodetic Survey in June 2012.
DE9524
DE9524 NAD 83(2011) refers to NAD 83 coordinates where the reference frame has
DE9524 been affixed to the stable North American tectonic plate. See
DE9524 NA2011 for more information.
DE9524
DE9524 The horizontal coordinates are valid at the epoch date displayed above
DE9524 which is a decimal equivalence of Year/Month/Day.
DE9524
DE9524 The orthometric height was determined by differential leveling and
DE9524 adjusted by the NATIONAL GEODETTIC SURVEY
DE9524 in September 2015.
DE9524
DE9524 Significant digits in the geoid height do not necessarily reflect accuracy.
DE9524 GEOID18 height accuracy estimate available here.
DE9524
DE9524 09/08/2023
DE9524 02/08/2023 - Photos may exist for this station.
DE9524
DE9524 The X, Y, and Z were computed from the position and the ellipsoidal ht.

```

Datasheets

- Datasheets are the current way to access the NSRS
- Give information about passive marks, including coordinates

Beta Passive Marks page

- Easier to read
- Includes geospatial information
- A preview of the future data delivery system

NOAA BETA This is a BETA Release Site National Geodetic Survey Positioning America for the Future

NGS Home About NGS Data & Imagery Tools Surveys Science & Education Search

Passive Mark Page

*****Note: This page does not work with Internet Explorer.**

This is a Beta product. NGS is interested in your feedback concerning its function and usability as well as how users would like to interact with NGS datasheet information in the future. Email us at ngs.feedback@noaa.gov

The information provided on this page may be out of date with the current published datasheet. Whenever there are differences the datasheet will be the authoritative source. Visit the [Datasheet](#)


Enter PID:

Enter a PID above to continue.

[NOS Home](#) • [NGS Employees](#) • [Privacy Policy](#) • [Disclaimer](#) • [USA.gov](#) • [Ready.gov](#) • [Site Map](#) • [Contact Webmaster](#)

<https://beta.ngs.noaa.gov/datasheets/passive-marks/index.html>

Beta Passive Marks page



BETA
This is a BETA Release Site

National Geodetic Survey
Positioning America for the Future

NGS Home About NGS Data & Imagery Tools Surveys Science & Education Search

Passive Mark Page

***Note: This page does not work with Internet Explorer.

This is a Beta product. NGS is interested in your feedback concerning its function and usability as well as how users would like to interact with NGS datasheet information in the future. Email us at ngs.feedback@noaa.gov

The information provided on this page may be out of date with the current published datasheet. Whenever there are differences the datasheet will be the authoritative source. Visit the [Datasheet](#)

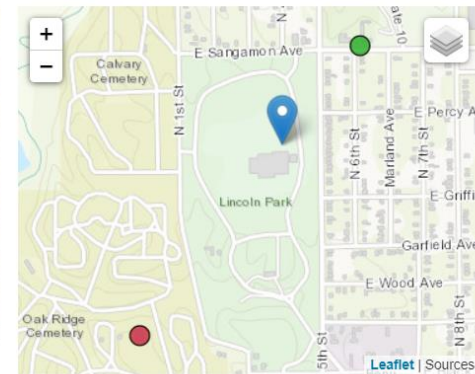
Enter PID: DE9524 [Get Data](#) [Recover this mark](#) [Go to Datasheet](#)

Designation: ①	SP 0109
Setting: ①	7 = SET IN TOP OF CONCRETE MONUMENT
Last Recovery Date/Condition/By: ①	08/06/2020 - Recovered in good condition - ILLINOIS DEPARTMENT OF TRANSPORTATION

PID: ①	DE9524	State, County: ①	IL, SANGAMON
Stability: ①	C	Country: ①	US
GNSS Useable: ①	Y	Latitude: ①	N 39° 49' 41.85939"
Orthometric Ht. (m): ①	179.776	Longitude: ①	W 089° 39' 02.64176"
Vertical Datum: ①	NAVD 88	Ellipsoid Ht.: ①	147.185

Order/Class:	2/1
Geoid Ht (m): ①	-32.579
Geoid Model: ①	GEOID18
GNSS Ortho Ht. (m): ①	179.76

Position Source: ①	ADJUSTED
Network Accuracy Hz (cm): ①	0.59
Network Accuracy Ellip (cm): ①	1.37
Ortho Ht. Residual (cm): ①	-1.2



Nearby Marks ①

[Hide](#)

PID	Designation	Position Source	Vertical Source	Condition
DP8505	ELLER	HD_HELD1	ADJUSTED	MONUMENTED
KB1487	SPRINGFIELD LINCOLN MONUMENT	ADJUSTED		GOOD

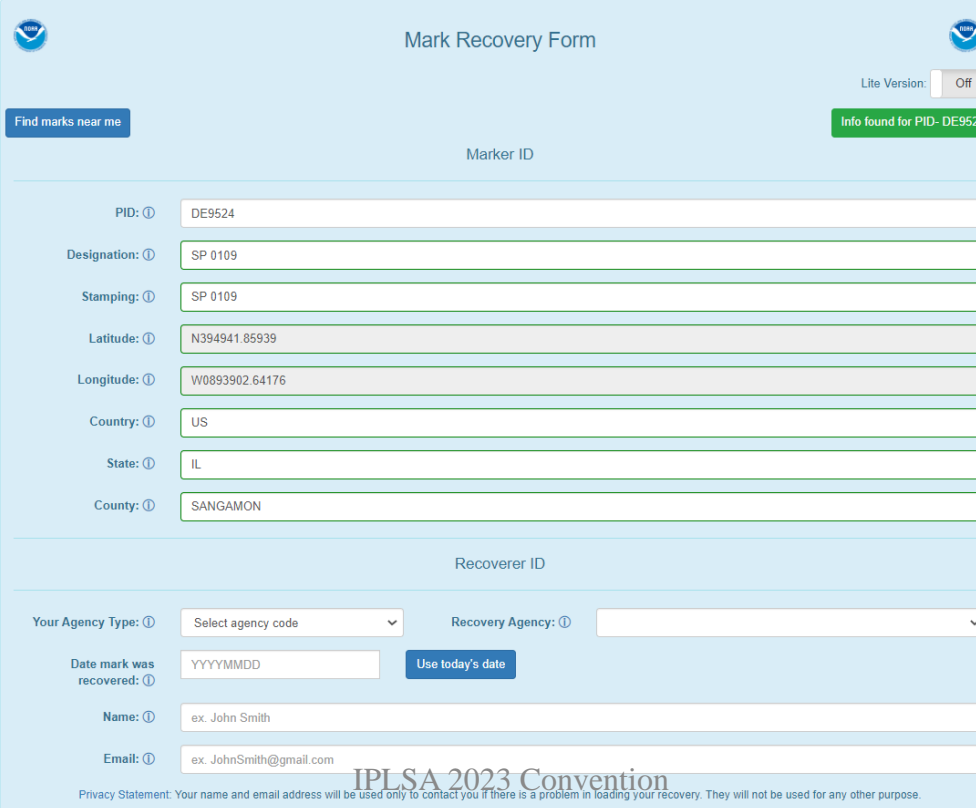
02/08/2023

IPLSA 2023 Convention

67

Easy to use mark recovery tool

https://geodesy.noaa.gov/cgi-bin/mark_recovery_form.prl



The screenshot shows the NOAA Mark Recovery Form interface. At the top, there are NOAA logos and the title "Mark Recovery Form". A "Lite Version" toggle is set to "Off". A blue button "Find marks near me" is on the left, and a green button "Info found for PID- DE9524" is on the right. The form is divided into two main sections: "Marker ID" and "Recoverer ID".

Marker ID Section:

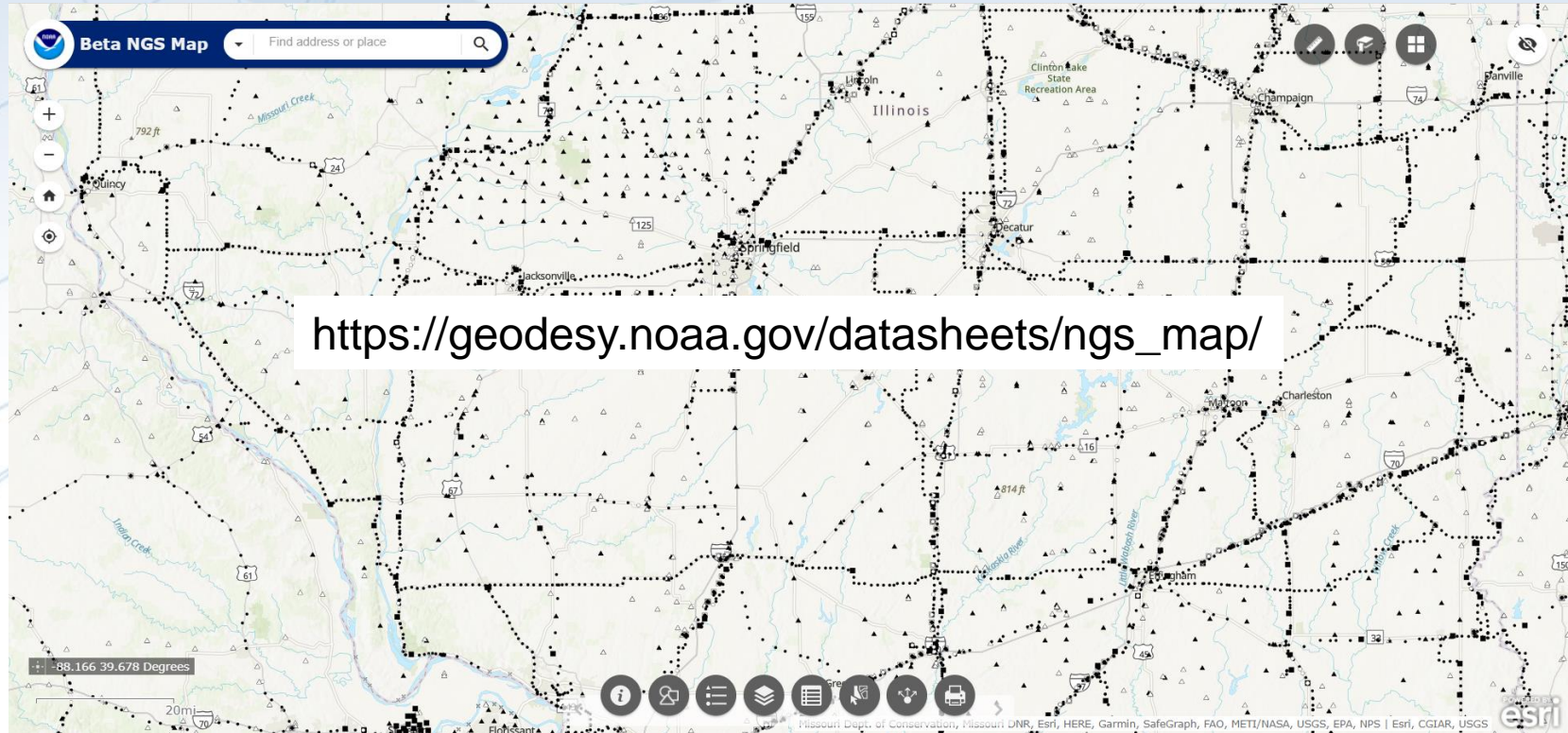
- PID: ① DE9524
- Designation: ① SP 0109
- Stamping: ① SP 0109
- Latitude: ① N394941.85939
- Longitude: ① W0893902.64176
- Country: ① US
- State: ① IL
- County: ① SANGAMON

Recoverer ID Section:

- Your Agency Type: ① Select agency code (dropdown)
- Recovery Agency: ① (dropdown)
- Date mark was recovered: ① YYYYMMDD (text input) with a "Use today's date" button
- Name: ① ex. John Smith (text input)
- Email: ① ex. JohnSmith@gmail.com (text input)

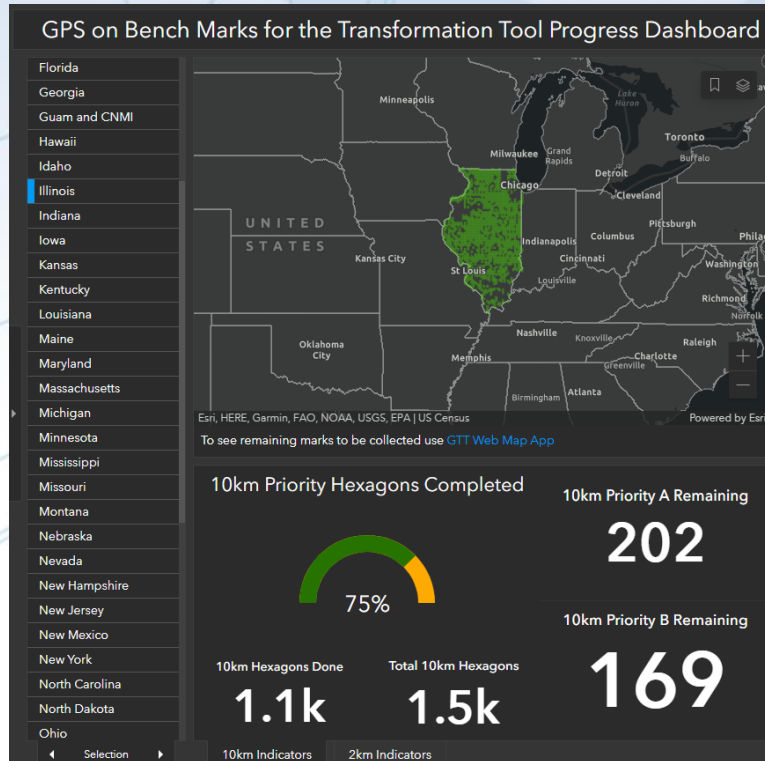
At the bottom, there is a "Privacy Statement" link and a copyright notice for 2023.

NGS Map



GPS ON BENCH MARKS

GPS on Bench Marks



- Priority Map:

<https://noaa.maps.arcgis.com/apps/webappviewer/index.html?id=6093dd81e9e94f7a9062e2fe5fb2f7f5>

<https://geodesy.noaa.gov/GPSonBM/>

GPS on Bench Marks - What & Why?

GPS on Bench Marks is about preparing the country and our communities to take full advantage of the benefits of the Modernized NSRS, by collecting new GPS observations on bench marks with published NAVD 88 heights.

Primary GPSONBM Campaign Benefits:

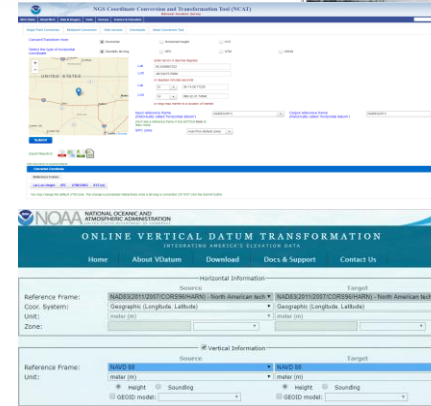
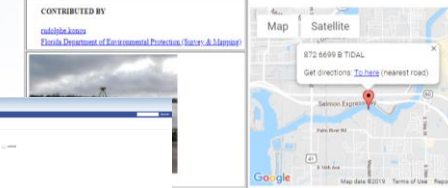
- 2020.0 Reference Epoch Coordinates (REC's)
- Data for NAVD 88 – NAPGD2022 Transformation Tools
- Build time series of observations in areas of motion

Added benefits:

- Evaluate gravimetric geoid models
- Check your RTN results
- Update and maintain passive control marks
- Identify marks suspected of movement



LAT: 27° 58' 53.86278" ± 0.004 m LON: -82° 23' 13.02224" ± 0.006 m ELL HT: -22.150 ± 0.032 m N: 74742.489 ± 0.008 m Y: -138868.082 ± 0.020 m Z: 297448.245 ± 0.007 m ORTHO HT: 3.054 ± 0.002 m	UTM 17 APC 902FL 93° NORTHING: 3082250.756m 405542.903m EASTING: 385713.231m 162081.011m CONVERGENCE: -0.6897150° -0.1886027° POINT SCALE: 0.99992524 0.99992522 COMBINED FACTOR: 0.99993258 0.99996224
--	---

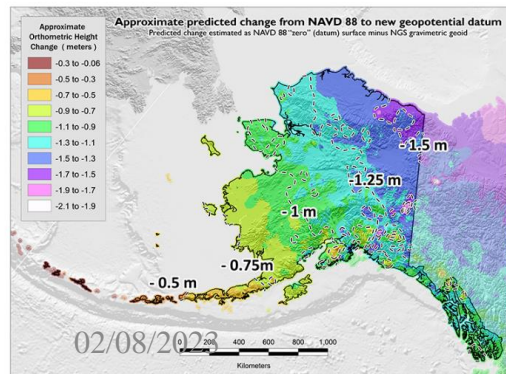


GPSonBM Measurements Connect Current and Future Datums

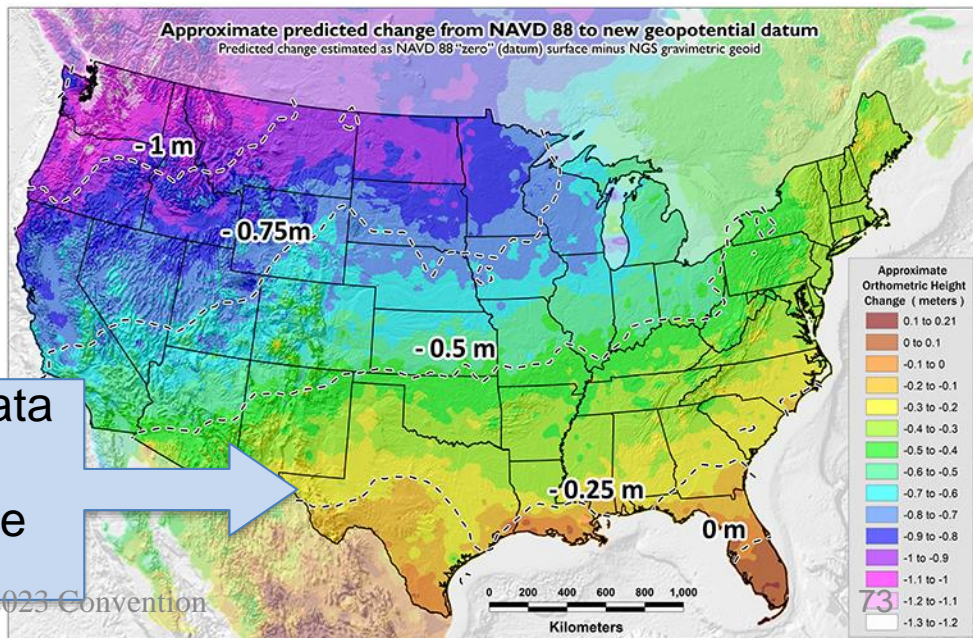
The relationship between the old and new datums vary by location. GPSonBM data is used to measure that relationship. The accuracy of the transformations in any particular place will be directly related to the density of GPSonBM data available in that area.

In moving from NAVD 88 to NAPGD2022, there will be a Shift: A one-time 0 to 2 meter jump in orthometric heights



-From fixing biases and/or tilts in NAVD 88



GPSonBM data is used to measure the Shift



Data Contribution Routes

	 <p>via OPUS option “<u>share</u> my solution”</p> <p>share my solution <input type="button" value="Yes, share"/></p>	 <p>via OPUS option “project ID”</p> <p>project identifier <input type="text"/></p>
WHAT DATA?	<p>minimal</p> <p>one receiver, one 4+ hour observation</p>	<p>more; many receivers, redundant sessions, network adjusted by project manager</p>
USE, in transformation tool	<p>Will be used in modeling, existing BMs only (with published ortho heights)</p>	<p>Will be used in modeling, all marks, as projects publish new NGS datasheets with ortho heights</p>
USE, in current generation datasheets	<p>for all marks, results appear as ‘shared solutions’ = not published geodetic control <i>for existing BM datasheets only, updates “SCALED”>“HD_HELD2” coordinates</i></p>	<p>for all marks, results appear as NGS datasheets = published geodetic control</p>
USE, in next generation datasheets	<p>will be published with 2020.00 RECs in the modernized NSRS</p>	

FAQ's #1

Q: What is the deadline to submit GPSONBM for the Transformation Tool?

A: **September 30, 2023**— so that observations can be used to create 2020.0 Reference Epoch Coordinates (See Blueprint 3 -Working in the Modernized NSRS)

Q: Can we submit previous observations?

A: Yes! Observations made within the past 3 years may be submitted if you have the required metadata and pictures.

Q: What do we do if we can't find the priority mark or if it not observable with GPS?

A: 1) Submit a Mark Recovery with the new Mark Recovery Form.

2) Find and observe an secondary mark listed in the hexagon layer on the web map.

The image shows two overlapping screenshots. The top one is the 'Mark Recovery Form' with fields for PID, Designation, Wavelength, Latitude, Longitude, Country, State, and County. The bottom one is a pop-up window titled 'ALL_lowRes_hexFile: UM-299' showing details for a hexagon mark: Hexagon ID (UM-299), Priority (4), Primary PID (HV7797), and Secondary PIDs (HV7795, HV7794, HV1140). A link for 'All Datasheets' is also present.

Mark Recovery Form	
Marker ID	
PID	010000
Designation	UM-299
Wavelength	CM-000
Latitude	NAD83 (2011)
Longitude	NAD83 (2011)
Country	US
State	IL
County	Cook
Recovery ID	
Your Agency Type	
Recovery Agency	

ALL_lowRes_hexFile: UM-299	
Hexagon ID	UM-299
Priority	4
Primary PID	HV7797
Secondary PIDs	HV7795, HV7794, HV1140
All Datasheets	More info

FAQ's #2

Q: Can we submit offset observations for marks that are not GPS-able?

A: Not for now, unless you follow the NGS [Mark Reset Procedures](#). In the future, OPUS 6.0 will enable you to process and adjust GPS, leveling, and total station observations together, and submit them to NGS.

Q: Can we submit less than 4 hours of data?

A: Yes, but only by using OPUS Projects to Bluebook the data.

Q: Can we submit RTK observations?

A: YES! The recently released BETA version of OPUS Projects 5.1 enables processing of Hybrid Survey Networks that include both static and real-time observations uploaded in the new GVX vector exchange file format.

Required Metadata for GVXonBM

- WinDesc Files → *1 each* of .dsc, .des, .err, .dis, .nbr
 - Yes, for the foreseeable future you will need to download, install, and learn how to use WinDesc
- 3 photos per mark → uploaded to Marks Pages
 1. close-up
 2. downward from eye-level
 3. horizon/setup
- Project Report (PDF)
- Observation Logs (single PDF)



Resources

- [Survey Project Proposal Page](#)
- [WinDesc Tutorial Video](#)
- [OPUS Projects User Guide \(HTML version\)](#)
- [OPUS Projects User Guide \(PDF version\)](#)
- [Requirements for Using OPUS-Projects 5 in the 2023 GPSonBM Campaign](#)

Save the Date! NGS day at FIG 2023

NGS will present a full day's worth of content at the 2023 FIG Working Week in Orlando, FL on May 31, 2023

<https://fig.net/fig2023/>

<https://geodesy.noaa.gov/datums/newdatums/fig-2023.shtml>

FIG 2023 Working Week



Save the Date: NGS @ FIG - May 31, 2023

NGS will be presenting a full-day's worth of content on NSRS Modernization during the **FIG Working Week 2023** meeting taking place at the end of May 2023 in Orlando, Florida. For the first time in over 20 years, this annual gathering of the **International Federation of Surveyors** will be taking place in the United States, hosted by the **National Society of Professional Surveyors** (NSPS).

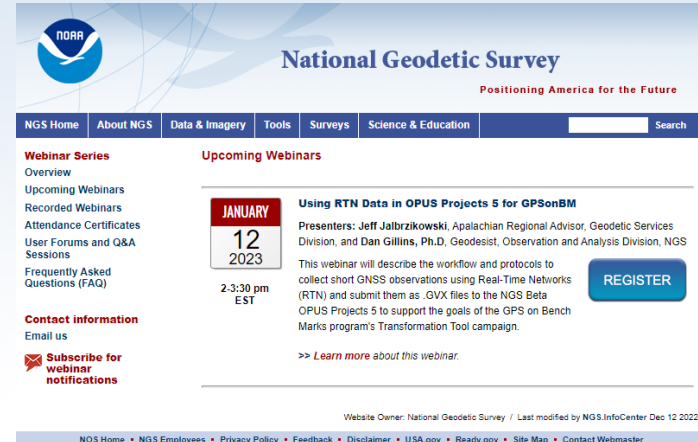
The International Federation of Surveyors (FIG) is a United Nations and World Bank recognized non-governmental international professional organization. FIG was founded in 1878 and represents national associations of surveying, cadastre, valuation, national mapping professionals, geospatial experts and quantity surveyors working in both the public and private sectors, in the scientific, research and academic community, as well as from technology innovators and industry from more than 120 countries around the world.

We encourage you to attend the entire event and be sure to join us on the Wednesday after Memorial Day, May 31, 2023 for an NSRS Modernization update.

REGISTER

NGS Webinar Series

- Monthly webinars highlight geodesy and coastal mapping programs, products, and research
- Each webinar features an NGS employee delving into a topic of interest, and generally includes a moderated question and answer session
- Registration is free and video recordings are made available for later viewing
- Certificates of attendance are available



The screenshot shows the NGS website with the following content:

- Logo:** NOAA National Geodetic Survey, Positioning America for the Future
- Navigation Bar:** NGS Home, About NGS, Data & Imagery, Tools, Surveys, Science & Education, Search
- Webinar Series Section:**
 - Overview
 - Upcoming Webinars
 - Recorded Webinars
 - Attendance Certificates
 - User Forums and Q&A Sessions
 - Frequently Asked Questions (FAQ)
- Contact information:** Email us
- Subscribe for webinar notifications:** (with envelope icon)
- Upcoming Webinars Section:**
 - Calendar:** JANUARY 12 2023, 2-3:30 pm EST
 - Title:** Using RTN Data in OPUS Projects 5 for GPSONBM
 - Presenters:** Jeff Jalbrzikowski, Appalachian Regional Advisor, Geodetic Services Division, and Dan Gillins, Ph.D, Geodesist, Observation and Analysis Division, NGS
 - Description:** This webinar will describe the workflow and protocols to collect short GNSS observations using Real-Time Networks (RTN) and submit them as .GVX files to the NGS Beta OPUS Projects 5 to support the goals of the GPS on Bench Marks program's Transformation Tool campaign.
 - Register Button:** REGISTER
 - Link:** >> Learn more about this webinar
- Footer:** Website Owner: National Geodetic Survey / Last modified by NGS.InfoCenter Dec 12 2022
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Learn more about GPS on Bench Marks

NOAA's National Geodetic Survey (NGS) provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, and shoreline information impact a wide range of important activities.



Process GPS
Data (OPUS)



NGS Data
Explorer



Looking for
Bench Marks



Conversion &
Transformation
(NCAT)



NOAA CORS
Network



New Datums

Popular Links

New Visitor

Storm Imagery

State Plane Coordinates

Stay Informed: Subscribe



News Bulletins

Deprecation of the US Survey Foot

- U.S. survey foot was deprecated on December 31, 2022
- But use can continue for SPCS 83 (and SPCS 27)
 - The 40 states that “officially” use U.S. foot for SPCS 83
 - All SPCS 27 zones
 - NGS will support such “legacy” use forever
 - But **NOT** supported for **ANY** zones in SPCS2022

**NGS will always support
U.S. survey foot for SPCS 83 and 27**

NSRS Modernization: Delay

- Will names change?
 - No, “GEOID2022”, “NATRF2022”, etc. will remain the same
- NGS anticipates the release of all data, and limited tools, by the **middle of 2025**.
 - Some of this may depend on things outside of NGS control (we have already delayed beyond 2022!)
- Work on additional tools will continue in the out-years



Thank You!

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For more information, visit <https://geodesy.noaa.gov>

NEW TYPES OF COORDINATES



NOAA Technical Report NOS NGS 67

Blueprint for the Modernized NSRS, Part 3: Working in the Modernized NSRS

April 2019
Revised February 2021
Silver Spring, MD



Coordinate: One of a set of N numbers designating the location of a point in N-dimensional space. Specific to the modernized NSRS, five types of coordinates will be supported.

New Types of Coordinates

NGS anticipates that 5 types of coordinates will be used in the NSRS. They are:

Reported
OPUS
Reference Epoch
Survey Epoch
Active

“Part of the NSRS”

- Only coordinates computed by NGS and stored in the NSRS database are “*part of the NSRS*”
 - *Reference Epoch*
 - *Survey Epoch*
 - *Active*
- OPUS Coordinates can be “*tied to the NSRS*”

Passive Control

- Any geodetic control point that is not active control. Common examples include a metal disk set in concrete or stone, or a stainless steel rod driven into the ground.



Active Control

- A geodetic control point at a station occupied by equipment intended for and capable of continuously collecting geodetic quality data for multiple years and with active defined by or adopted by NGS.
- CORS



Shift and Drift

When transitioning off of NAD 83, your coordinates will experience shift and drift

- Shift: A one-time jump somewhere in the 0 to 4 meter range (latitude, longitude, ellipsoid height)
- Drift: Coordinates are now time-dependent. The shift will take you to 2020.00. Working at any other epoch means you must account for the drift (velocity, as well as any other motions over time) of your coordinates

New Types of Coordinates

- **Reported**
 - *“Coordinates directly reported to NGS without the data necessary for NGS to replicate or evaluate them. These coordinates are neither ‘part of the NSRS’ nor ‘tied to the NSRS.’”*
 - Scaled from a map
 - Transformed using NCAT or VDatum
 - Smartphone
 - Reported directly from an RTK rover without data files

Reported Coordinates



Buyer Beware!

- **Reported** coordinates might be very wrong!
 - Reported in NAD 27 or NAD 83 or WGS 84
 - Systematic Error: 2–100 meters
 - Scaled off of a USGS topographic map
 - Random Error: ± 600 meters
 - Smartphone
 - Random Error: ± 10 –50 meters
- NGS **will show you** reported coordinates
 - But their function is to get you “in the neighborhood” of a mark, not to use as geodetic control!

New Types of Coordinates

- **OPUS**

- *“Coordinates computed by OPUS that have not been evaluated by anyone at NGS. As these coordinates are not computed by NGS they are not considered “part of the NSRS.” However, if NGS-provided OPUS recommendations are followed, they may be ‘tied to the NSRS.’”*
 - User-computed values, such as they might get today from either OPUS-S or OPUS Projects
 - “OPUS” coordinates are the **only** coordinates a user will get directly from OPUS
 - NGS will *not* evaluate your OPUS coordinates!

New Types of Coordinates

- **OPUS** coordinates may also come with the label “**tied to the NSRS**”
 - **Only** if a user restricts their computations to OPUS-recommended constraints
 - Users who deviate from OPUS-recommended constraints can still perform computations and will get OPUS coordinates, but they will not be “tied to the NSRS”, nor have any NSRS label at all.
 - In neither case will OPUS coordinates be considered “**part of the NSRS**” however.

Survey
data

OPUS

data
processing

Did you follow
OPUS
recommendations?

yes

no

If you choose to deviate from the
OPUS recommendations:

1. OPUS will warn you when you do so
2. You will receive an explanation why your coordinates are not tied to the NSRS

OPUS Coordinates that
are
"tied to the NSRS"

OPUS Coordinates that are
"not tied to the NSRS"

Do you want to "share" your
results with the world?

yes

no

Unique, public
URL for this
survey which you
can share with
anyone

Your results are
shown to you on
screen or via email
only

New Types of Coordinates

Reference epoch coordinates (RECs)

- *“Coordinates estimated by NGS for one of the official reference epochs. As these coordinates are computed by NGS they are considered ‘part of the NSRS’”*
- These will be computed by NGS every 5 or 10 years
 - On a schedule 2–3 years past the reference epoch

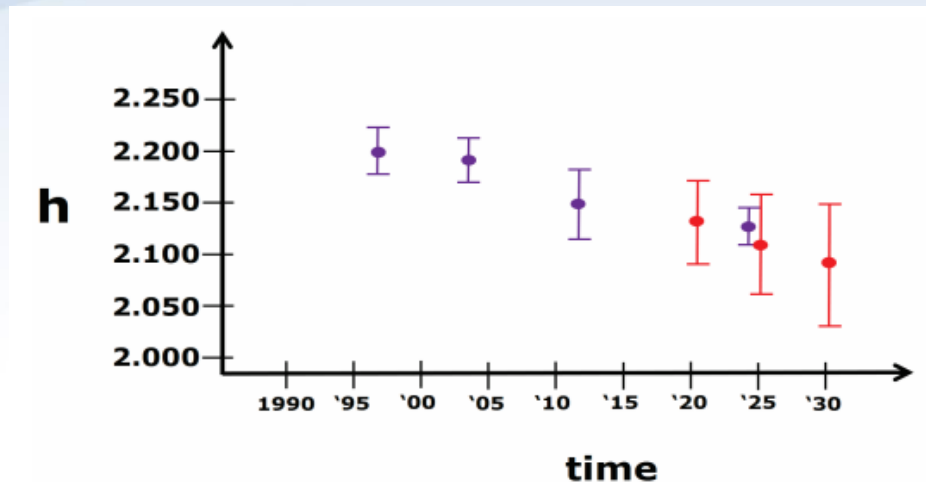
New Types of Coordinates

Survey epoch coordinates (SECs)

- *“Coordinates computed by NGS for one survey epoch. As these coordinates are computed by NGS they are considered ‘part of the NSRS.’”*
 - These represent the best estimates NGS has of the time-dependent coordinates at any mark
 - Adjusting multiple surveys in timespans called “adjustment windows”, to a single epoch within that window.
 - Initial plan: 4 weeks for GNSS; 1 year for leveling

More on SECs and RECs

- At passive control
- SECs: adjusted to a midpoint epoch near the survey
 - (4 weeks for GNSS; 1 year for leveling)
- RECs: adjusted to a ref. epoch (2020.00, etc.)
- REC adjustments will include Some **age-limited** span of data
 - If that age-limit were 10 years prior and 2 years post R.E., Then 2020.00 RECs come from data spanning 2010.00 to 2021.99999

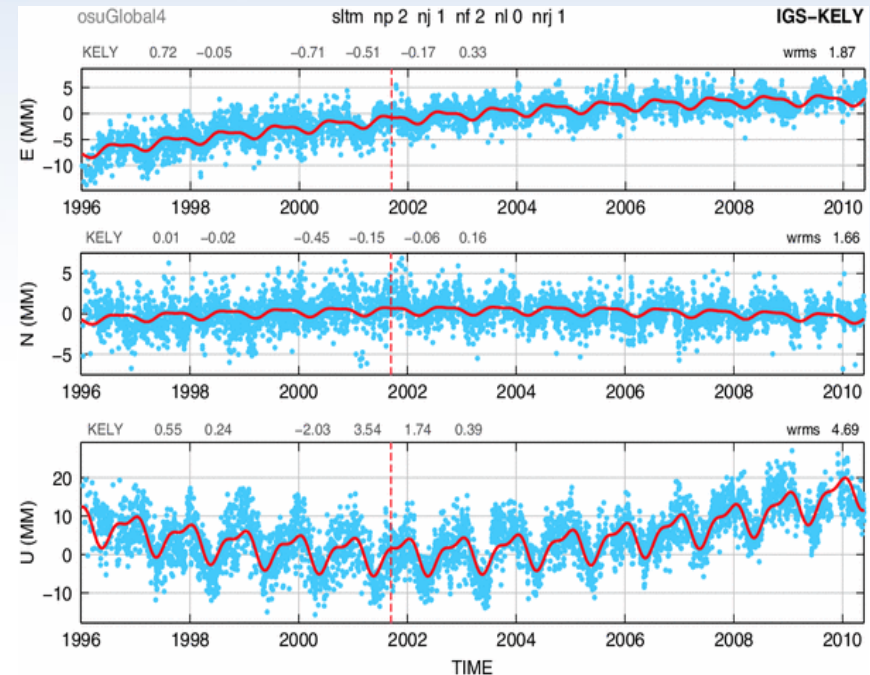
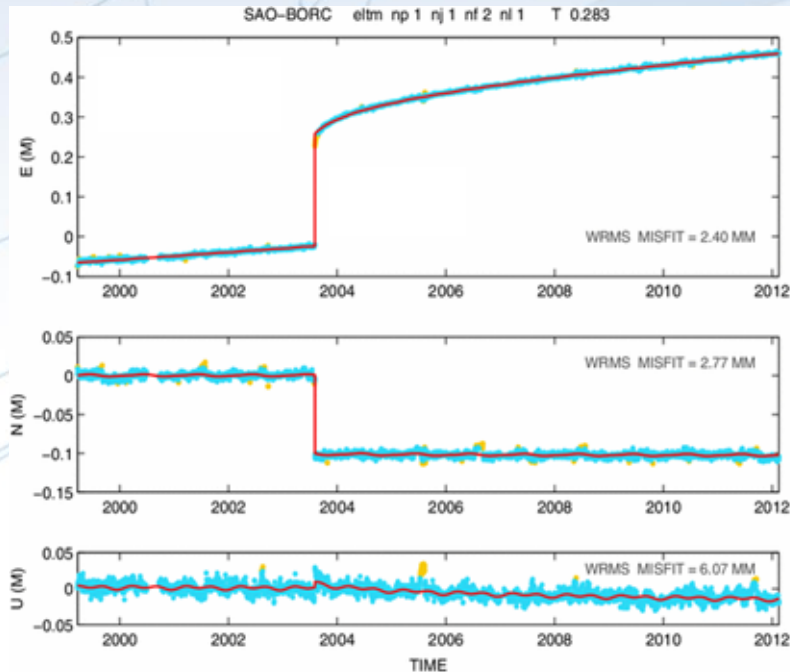


New Types of Coordinates

Active coordinates (ACs)

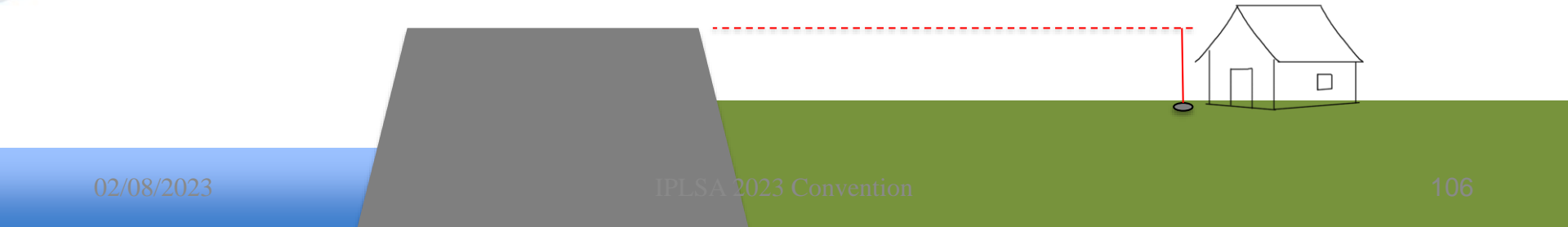
- Coordinate functions in time, generated by NGS, and not associated with a specific epoch. As these coordinates are computed by NGS (or adopted by NGS) they are considered “part of the NSRS.”
- Which will be generated by a “fit” to regularly computed coordinates

Examples of How Non-Linear CORS Coordinate Functions Might Look



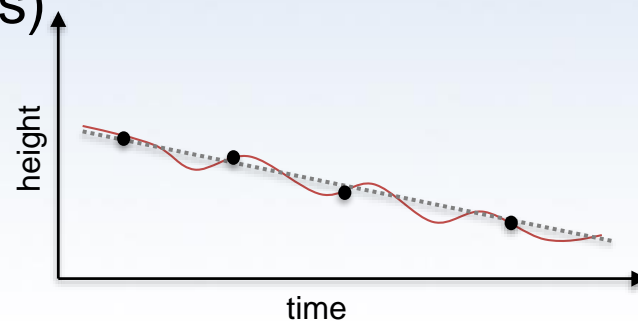
Published Coordinates

- **RECs** 'stable' at project scales (5-10 years)



Published Coordinates

- **RECs** 'stable' at project scales (5-10 years)
- **SECs** reflective of narrow window in time
- **ACs** or ***Coordinate Function*** at CORS



Coordinates

- Five types:
 - **Active:** Continuous functions at a CORS
 - **Survey Epoch:** “Time dependent coordinates”
 - **Reference Epoch:** “Estimated at 2020, 2025, 2030, ...”
 - **OPUS:** Computed by you, and as accurate or inaccurate as the choices you make
 - *Tied to the NSRS if you follow OPUS recommendations*
 - **Reported:** Good for finding a point somewhere on Earth.
 - *Not to be used as geodetic control*