Work Towards a Geometric and Vertical Reference Frame by 2022

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Outline

- NGS Personnel Changes
- SRSD Personnel Changes
- 2022 Reference Frames
  - Reference Frames≈Datums
  - Geometric
    - CORS Updates
    - OPUS Updates
  - Vertical (Geopotential)
    - GSVS 11/14/16
    - GRAV-D
    - xGEOID14/15
- Outreach Efforts
- Summary and Outlook

NGS Personnel Changes

- HQ
  - Dru Smith now NSRS Implementation Manager (e.g., 2022 datums)
  - Neil Weston is now Chief Geodesist
  - Brett Howe is serving as acting Deputy Director
- Other Divisions
  - Vicki Childers is now the Chief, OAD
  - Gerry Mader has retired as Chief, GRD
  - Steve Hilla is filling in as acting Chief, GRD
  - Ross Mackay is filling in as acting Chief, GSD

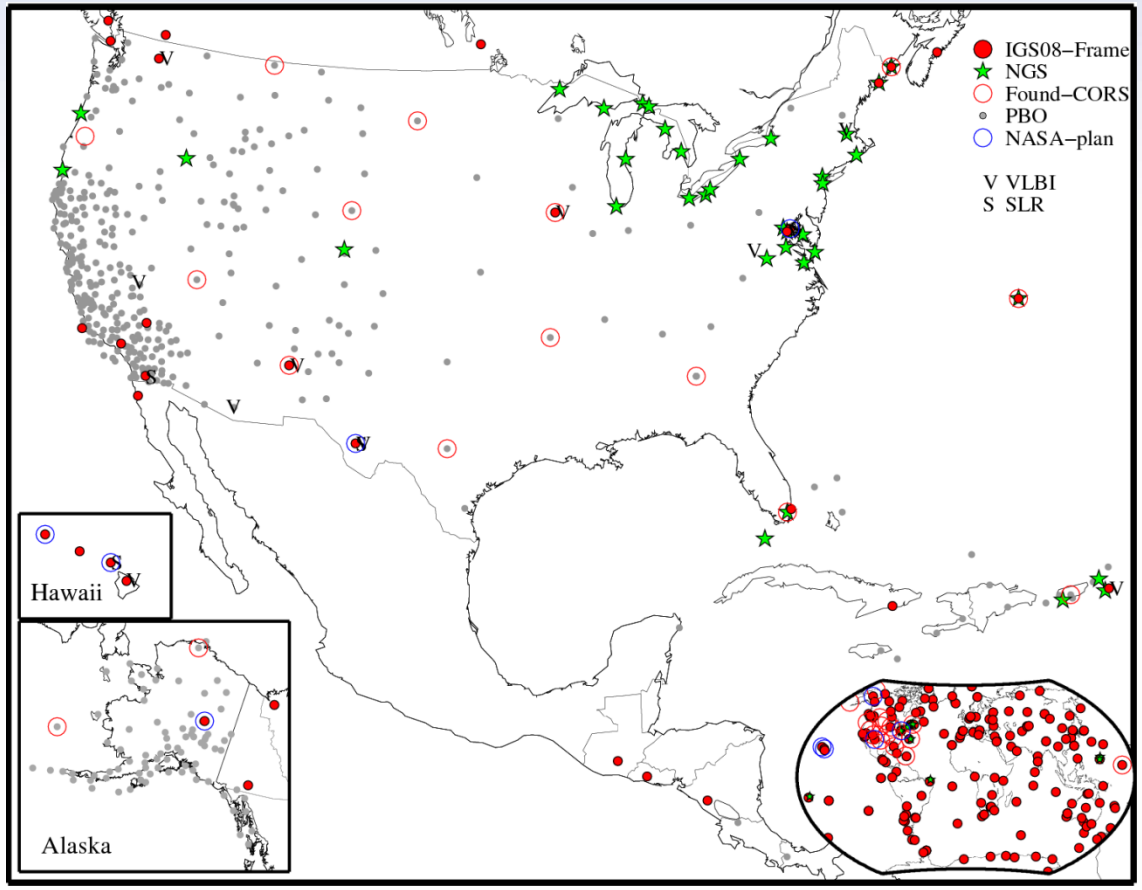
Personnel Changes in SRSD

- GSA Branch
  - Bang Le is new RTN Liaison
  - Dave Hatcher and Weibing Wang are OPUS Analysts
  - They replace Cindy Craig and Bob Siclari
- CORS Branch
  - Kevin Choi is Branch Chief and will soon divest ACC duties
  - Sungpil Yoon and Jarir Saleh are Orbiteers
  - Fran Coloma and Lijuan Sun are CORS Analysts

2022 Geometric Reference Frame

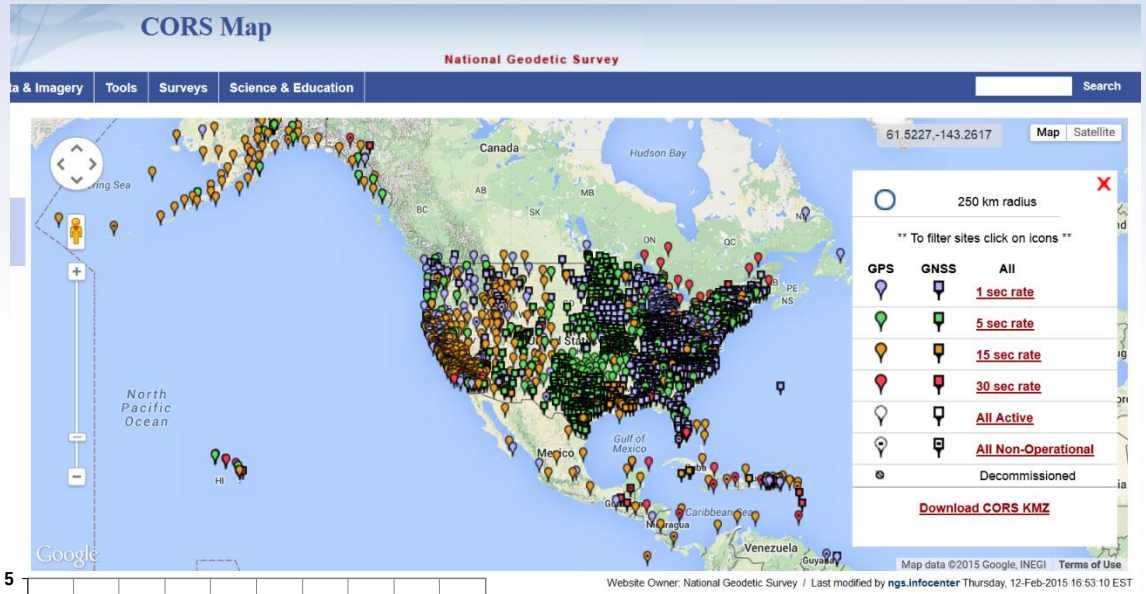
- Will be fit from global to local
- Foundation CORS will be the U.S. subset of IGS global sites
- These will adjust the CORS Sites
  - Collected/archived at ~ 2000 sites
  - Even when a site is dropped, it must be maintained in the list
- CORS Sites can then adjust RTN's
- Akin to Helmert Blocking scheme

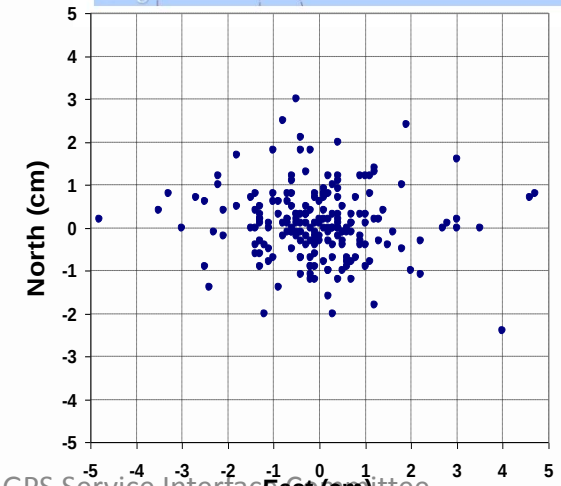
Possible Foundation CORS



2022 Geometric Reference Frame

- The archived CORS data are used in OPUS tools
  - Currently, OPUS output is only Shared (e.g., OPUS Database)
  - Official coordinates remain those in the NGSIDB
- RTN Validator tool in DEV
  - Difference between OPUS solution and reported coordinates
  - Expedited upload – as frequent as wanted



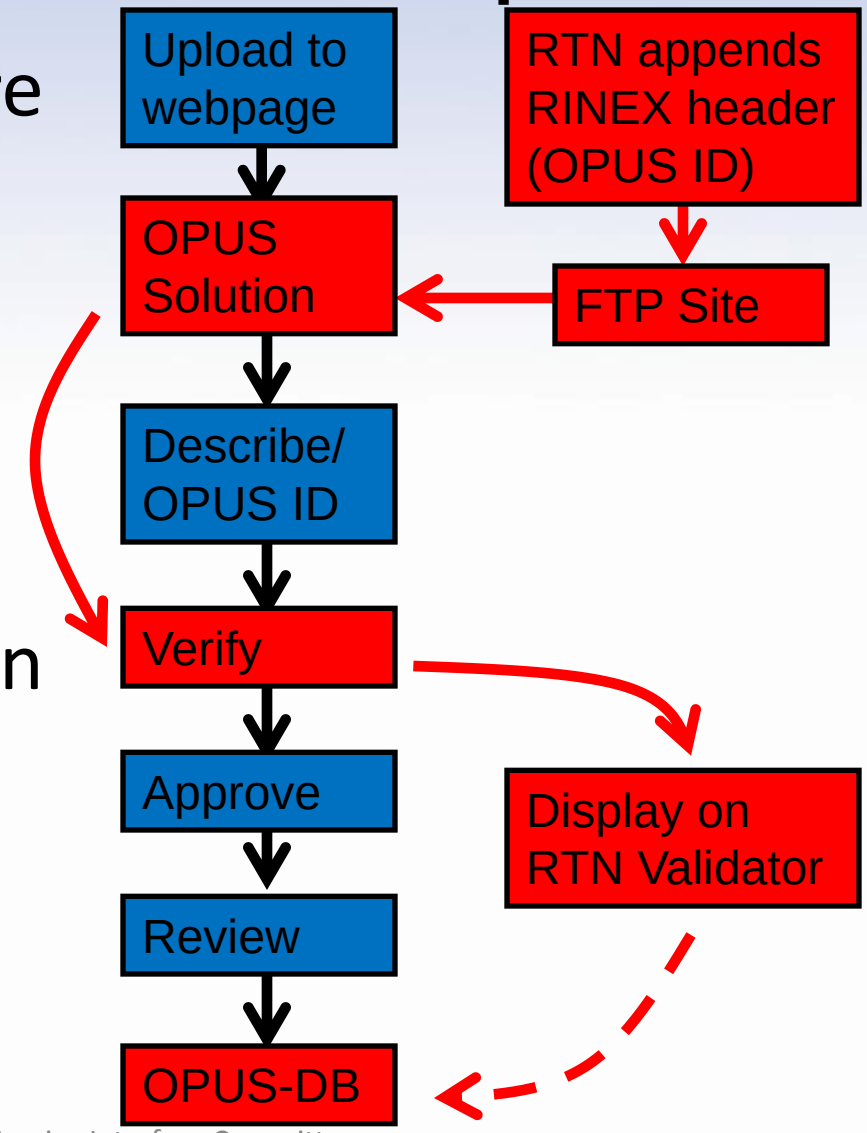


QA test of OPUS-S with
2-hour data sets at 200 CORS:
Compare output to CORS coord.

Mean: <0.1 cm
N-S RMS: 0.8 cm
E-W RMS: 1.4 cm

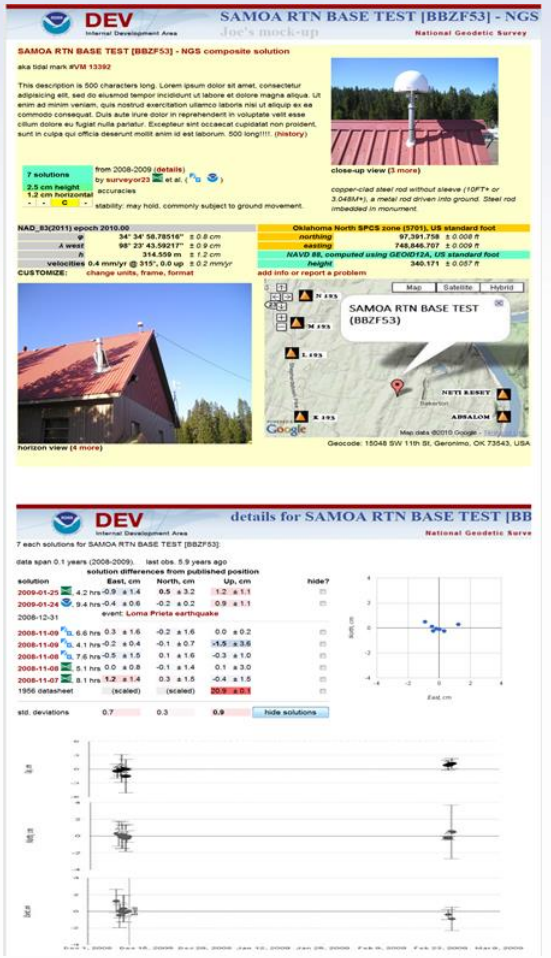
Validate RTNs with a modified OPUS process

- Major steps in OPUS are shown in left column
- Some steps can be skipped for RTN case
- Site is well established
- Operator would have an ID and appropriate header info
- Expedited upload avoids most QC checks



RTN Validator Tool for Base Station

- On a periodic (e.g., daily) basis, data are FTP'd and processed
- Top section has similar elements as in OPUS-DB
- Middle section shows available solutions
- Bottom shows a time series for X-Y-Z or lat-lon-ht
- Offset and trends are clear



RTN Validation for Users

- To evaluate the base station, the RTN operator would make that sheet available and/or publish to OPUS-DB
- Additionally, occupy established GPS bench marks listed in either the NGSIDB or OPUS-DB
  - Any systematic features observed between the established solutions and those from roving on the RTN would indicate a potential bias/offset
  - Should be located within 20 km intervals

CORS Updates

- Repro2 – better late than never
  - Reprocessing 1 (or repro1) happened as a part of IGS08/MYCS
  - After Kevin Choi turns over his IGS ACC duties (December)
  - Will reprocess all CORS data (cleaning, stacking, etc.)
  - Will bring in newer CORS sites (since 2008) and update velocities
  - Will define transformation to IGS2014
  - For CORS site coordinates, orbits, and derived positions
  - There will not be a new Realization of NAD 83
    - Since IGS2014 is expected to nearly equal IGS2008

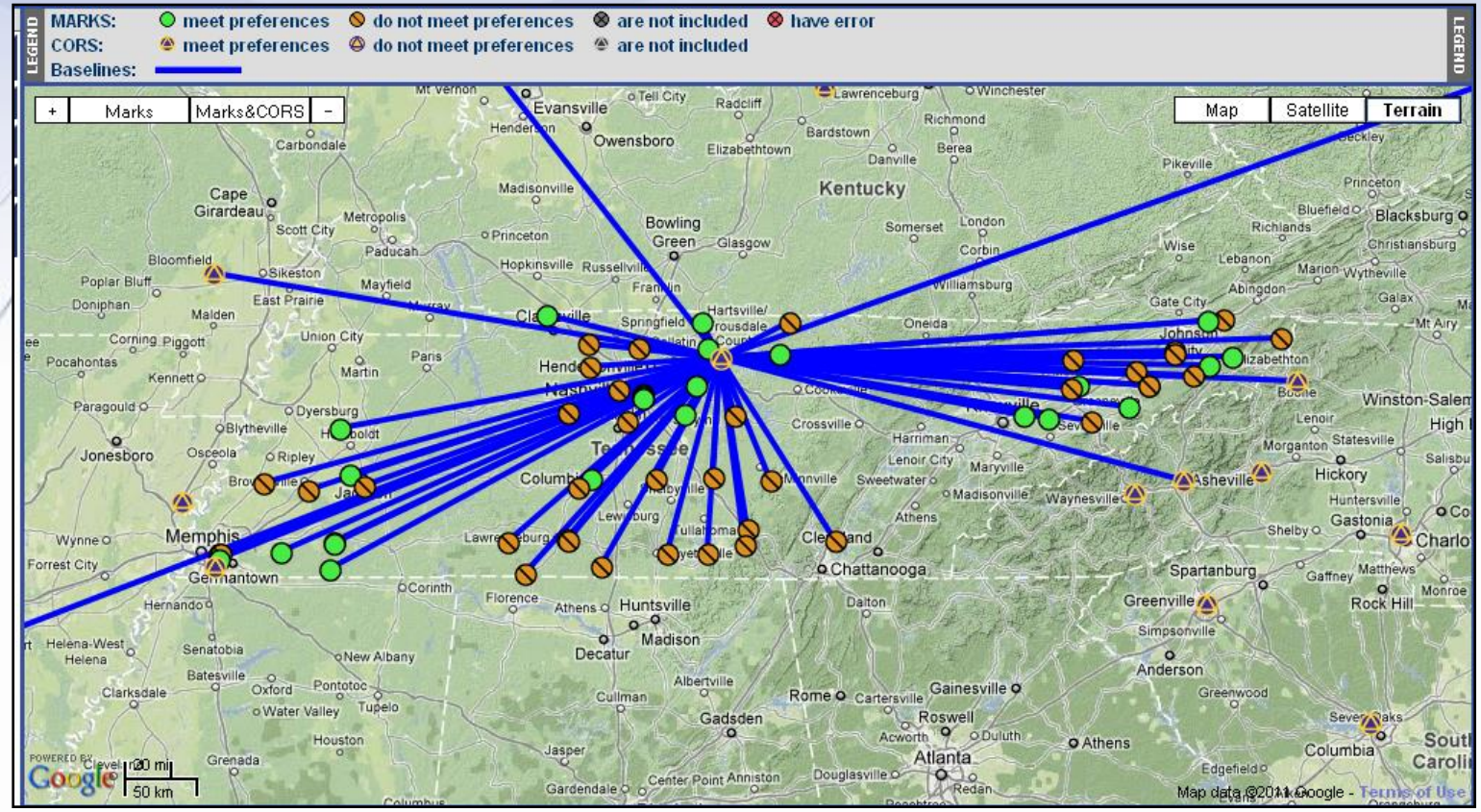
CORS Updates (continued)

- Reference Frame definition
  - Likely adopting most recent IGS model (e.g. 2014 if nothing newer)
  - Examining plate fixed vs. semi-dynamic vs. dynamic
  - Velocities could be as simple as Euler pole rotation to use of HTDP
- GNSS data collection
  - 40% of CORS sites have GNSS receivers (GLONASS)
  - Started archiving this data in January of this year
  - Not using the GNSS data in OPUSS yet but will eventually (2022 goal)

OPUS

- NOS/NGS 58/59 updates
  - HT MOD surveys still are being bluebooked
  - Goal it so have OPUS Projects (OP) replace this
  - Two separate studies: OSU vs. OSU (Ohio State U. vs. Oregon State U.)
  - Possibly reduction in collection times
  - Still aiming for Fall of 2016
- OPUS Projects
  - Multiple observations on multiple sites on multiple days
  - Uses hub and spoke design to get local control plus national ties

Simple Hub & Spoke Network Design Strategy

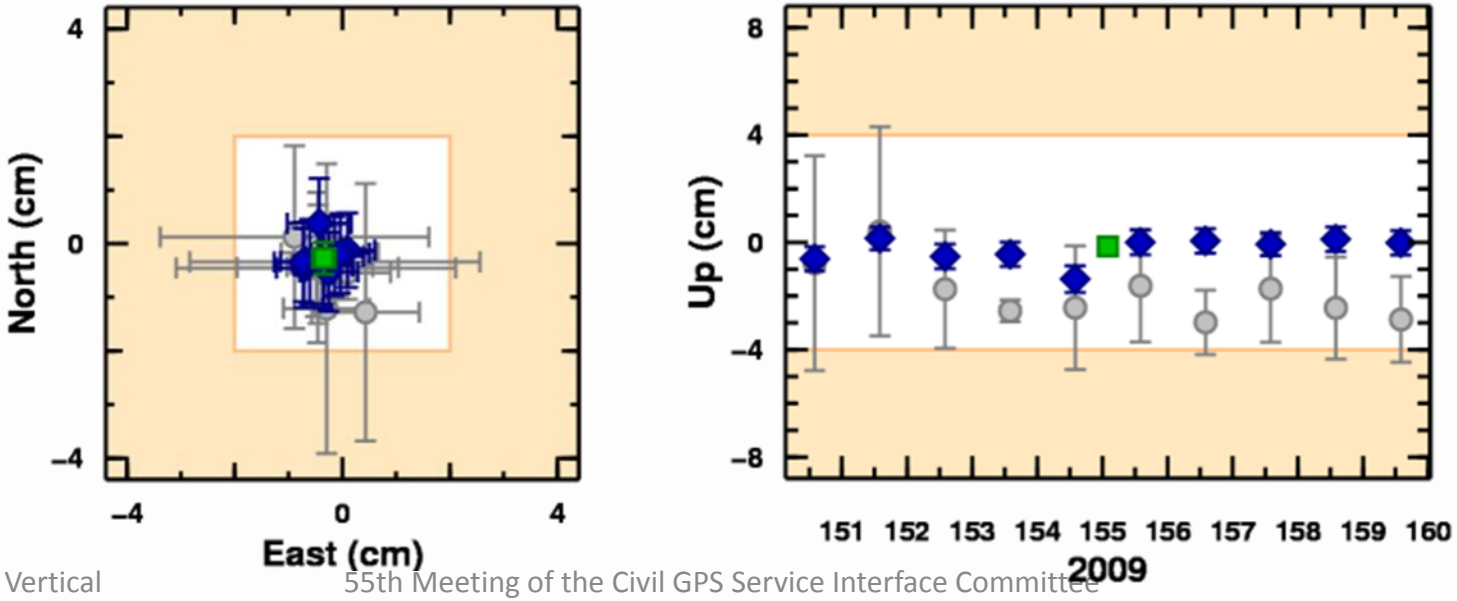


Consider a single hub site when that mark has more than 4 hrs of data:

- Include and tightly constrain CORS, loosely constrain the hub.
- Connection to CORS creates a strong connection to the ITRF.
- Provides a consistent reference for each project mark.

What's in it for me?

- **OPUS solutions** = pretty good, but each treated as independent and assumes "perfect" CORS.
- **Sessions** = simultaneously-observed marks processed together in sessions increases consistency.
- **Adjustments** = interlinking sessions through network adjustments increases accuracy.



A Possible Strategy for Use of RTN's

- Use the RTN Validator Tool to keep RTN coordinates consistent
- During a survey, use RTN stations as supplemental control
- OP permits you to weight the various observations
- Upweight the RTN and CORS and downweight the GNSS sites
- Adjusts the observations locally based on all sites plus RTN's
- Keeps regional and international control from CORS and ITRF

OPUS (continued)

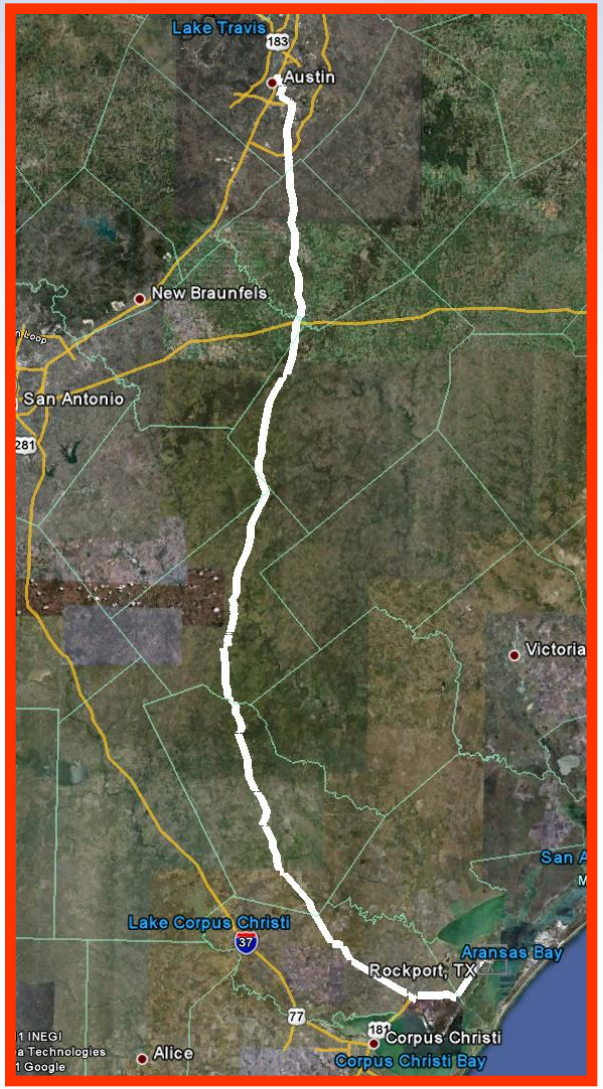
- Currently, OP outputs only to the Project
- OP output to OPUS Database
  - A project is underway to Share into OPUSDB
- OP output to NGSIDB
  - Must resolve Bluebook vs. OP results
  - Can then use OP to process and then load into NGSIDB
- OP output to NSRS DB
  - With a NSRS DB defined, OP would feed it directly (2022 goal)

2022 Vertical Reference Frame

- Defined through a geopotential model (this is a broad term)
- Current models use LSC to fill in between control points
  - Doesn't resolve underlying datum defects (1.2 m trend in NAVD 88)
  - These "hybrid" geoid models are datum conversion tools only
  - Only as reliable as the accuracy and **distribution** of the control points
- Previous studies show data grid > 1' yields significant omission
- Could use a Gravimetric Geoid model (practical method)
  - Geoid model is one arc-minute resolution
  - Converts ellipsoid height to orthometric height (H = h – N)
  - Conversion to other heights/functions of the gravity is difficult

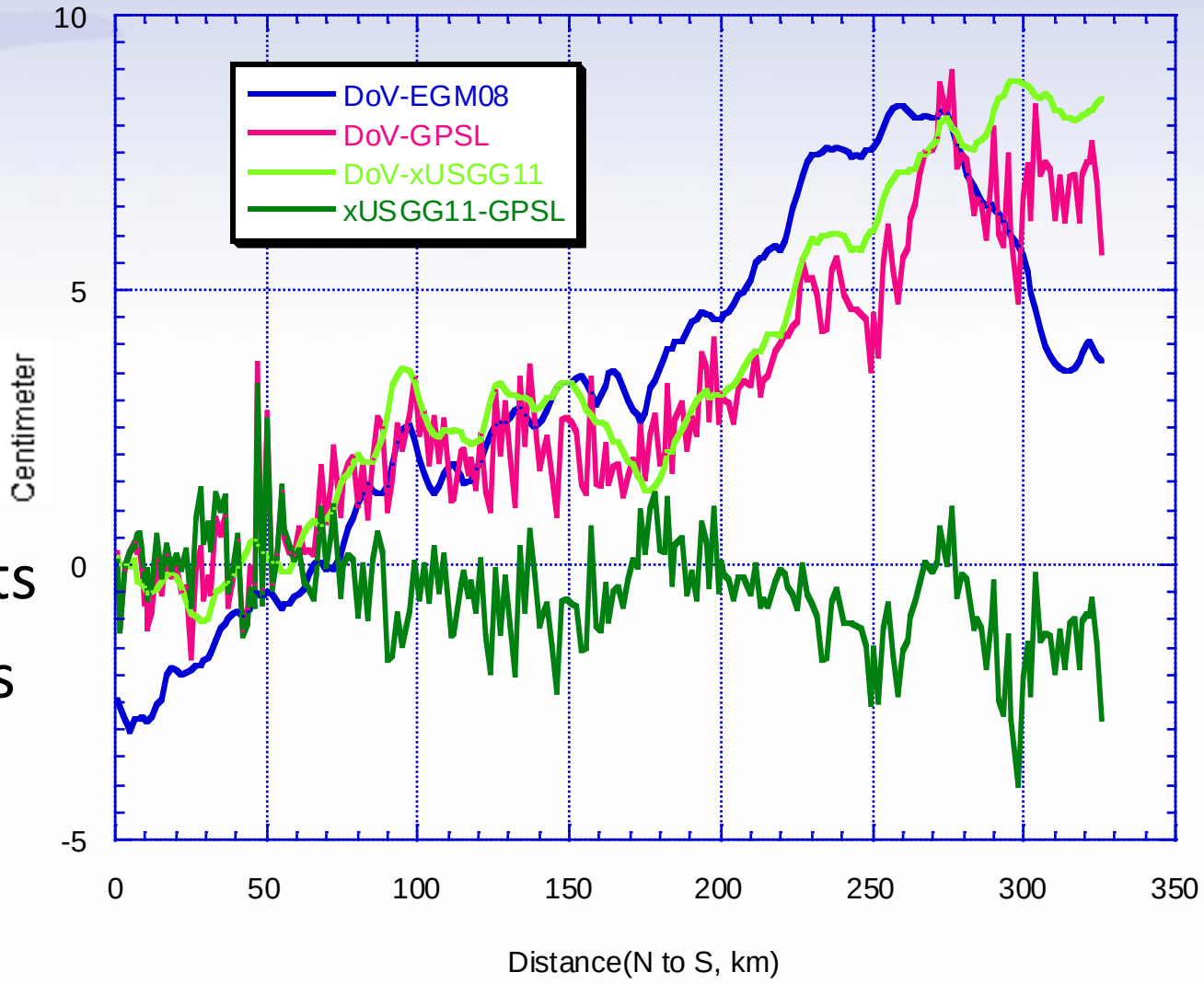
2022 Vertical Reference Frame (continued)

- Use a Geopotential model (desired method)
  - Geopotential yield any function of gravity field
  - Current models limited to degree 2160 => 5'
  - For 1' resolution, require a degree 10,800 model
  - Likely ellipsoid harmonics vs. spherical harmonics
- Geoid Slope Validation Studies (GSVS)
  - GSVS 11 – completed (presented at EGU/elsewhere)
  - GSVS 14 – completed but still being processed
  - GSVS 16 – being planned (recon IP in Colorado)
  - Will be used to check geoid models for vertical RF



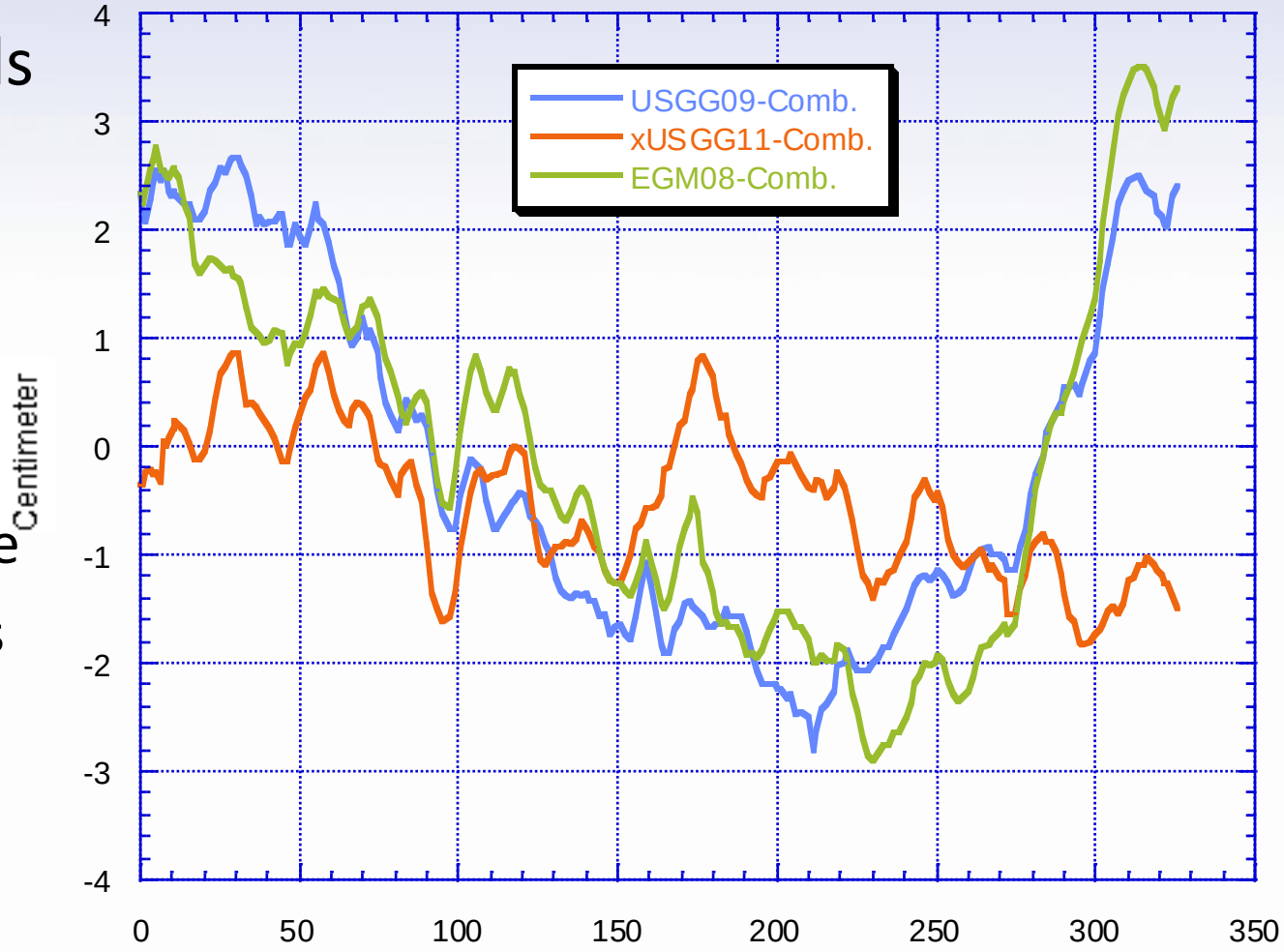
Geoid differences from GSVS 11 observations

- Data collected along the lines:
  - GPS on leveling marks (GPSL)
  - Astrogeodetic DoV's
  - Relative & absolute gravity data
- Gravity data => xUSGG11 geoid
- GPSL => pointwise geoid heights
- DoV => pointwise geoid heights



(geoid model – Comb.) along the line

- Desire is to compare vs. geoids
- Combine the DoV and GPSL
  - Long wavelength => GPSL
  - Short wavelength => DoV
- Now compare against geoids
  - xUSGG11 fits closest to zero line
  - Other models have large trends

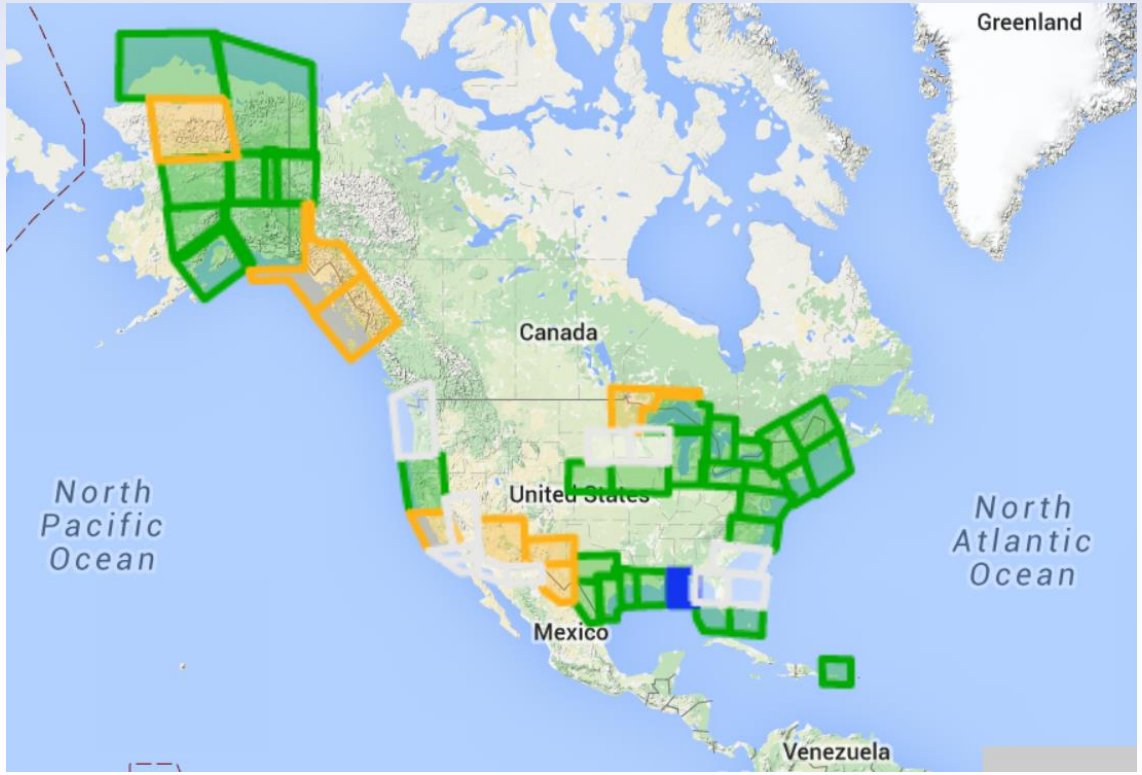


Geoid comparison (model –Comb.)

	GPSL (mm)	USGG09 (mm)	EGM08 (mm)	xUSGG11 (mm)
Mean	-0.0	-0.4	0.1	-0.5
STD	7.6	16.9	17.2	6.7
RMS	7.6	16.9	17.2	8.2
Min.	-22.2	-28.0	-29.1	-18.2
Max.	33.0	26.7	35.1	8.7

2022 Vertical Reference Frame (continued)

- GRAV-D to help define vertical RF
- Bridges spectral band between satellite and surface gravity data
- Satellite controls long wavelength (global to 500 km scales)
- Aerogravity controls intermediate wavelength (40-500 km)
- Terrestrial data and terrain models control short wavelength



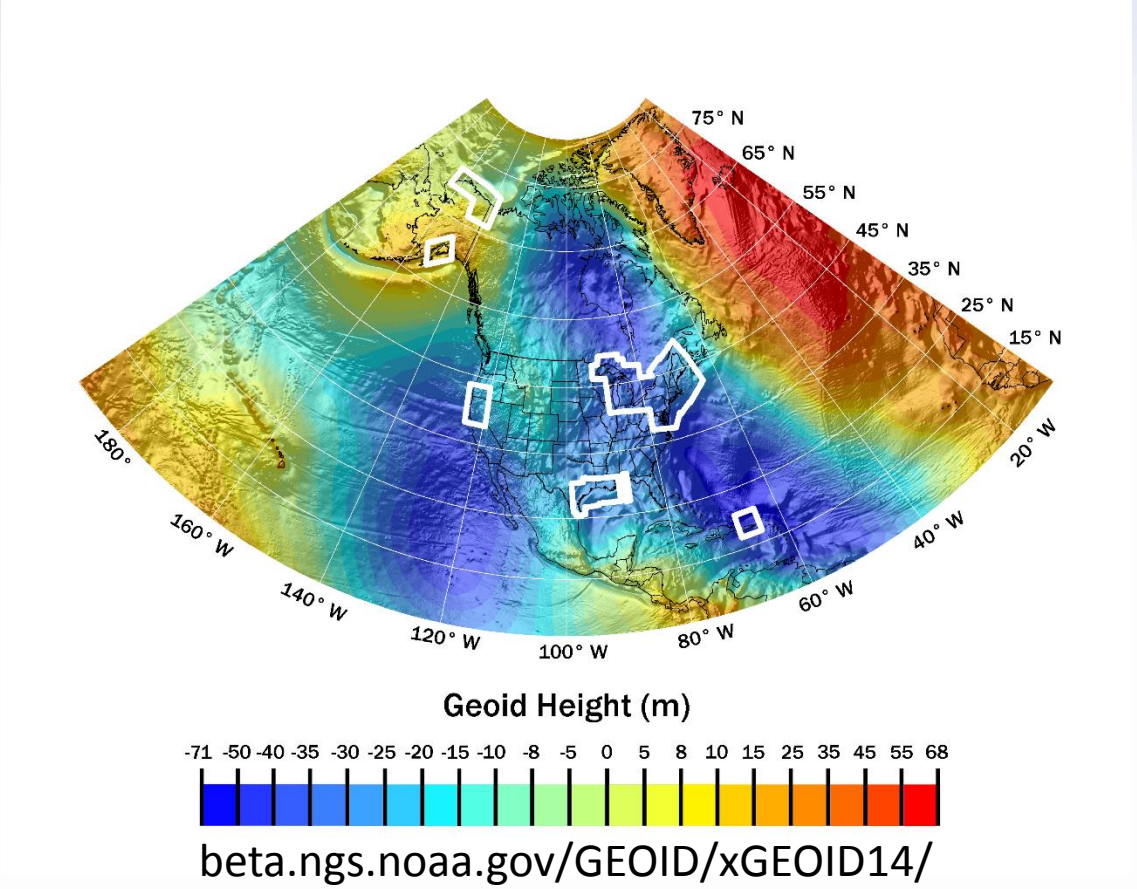
Map Key - Airborne Gravity Data

Green: Available data and metadata Blue: Data being processed

Orange: Data collection underway White: Planned for data collection

xGEOID14 & xGEOID15

- These use available aerogravity
- Also use same techniques as USGG models but updated data
- xGEOID14A has no aerogravity
- xGEOID14B has data available from last year
- xGEOID15B is developed but still on Test/DEV website
- Will release to Beta in September



OUTREACH

- Will continue at future Geospatial Summits and other national and international meetings.
- Continued collaboration with IAG, FIG, and the UN-GGIM
- Continued collaboration with Canada, Mexico, and nations in Caribbean and Central America
- Will work with state surveying groups through NSPS and others to hone message for States to implement new laws

Summary and Outlook

- OPUS Projects (OP) or some derivative thereof will serve as means of determining geometric coordinates in the 2022 Geometric Reference Frame
- GNSS data will be used – not just GPS
- These coordinates will be used in some type of geopotential model to derive orthometric and other heights
- The models will be consistent with other global models and reference systems

Questions?

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