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Volunteering for the future – Geospatial excellence for a better living

A nation of volunteered data: Analysis of the NGS's GPS on Bench Marks project

Kevin Ahlgren*, Jacob Heck, Galen Scott, Brian Shaw;

National Oceanic and Atmospheric Administration's National Geodetic Survey
United States

kevin.ahlgren@noaa.gov
ngs.gpsonbm@noaa.gov

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GPS on Bench Marks:

- Project at NGS ongoing since 2014
- Crowd-sourced survey effort
  - Static GNSS occupations on passive geodetic marks (geodetic users)
  - Mark recovery information (general audience/geocaching)
- Motivated and changed by geodetic priorities:
  - Past: Support hybrid geoid models (e.g. GEOID18)
  - Now: Support transformation between previous and future vertical datums

    NAVD 88 ←→ NAPGD2022

Objectives:

1) for the local surveying community: please consider submitting data to NGS for inclusion in geodetic products

2) for the research community: a wealth of accurate, completely public geodetic data

3) international geodetic agencies: best practices and experiences for crowd-sourced geodetic data

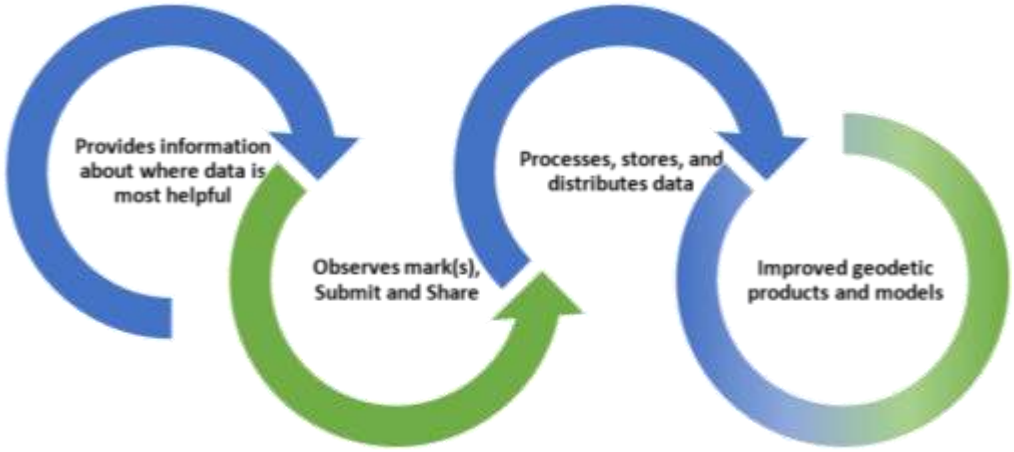

Figure 1: GPS on Bench mark general process and relationship between NGS (in blue) and the geodetic community (in green)

Communication from NGS:

- Where does NGS need additional data? (Where does NGS already have the needed data?)
- Wide spectrum of tools:
  - Web map(s)
  - Online Dashboard(s)
  - Presentations/Webinars
  - Newsletters

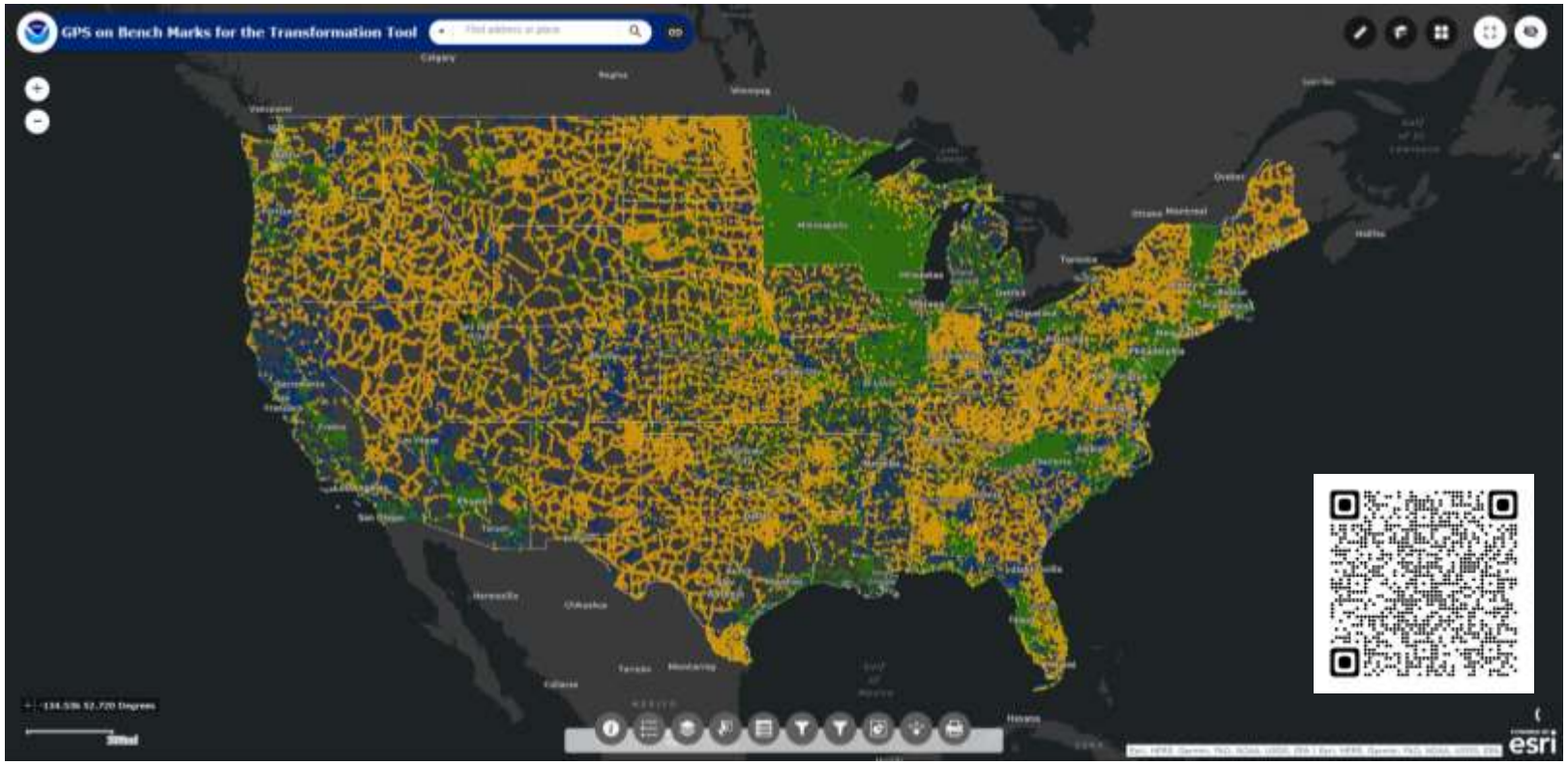

Figure 2: GPS on Bench Marks web map. Green regions are completed 10 km hexagons. Blue and Yellow regions are awaiting additional GPS observations

NGS GPS on Bench Marks Web Map

Efficient Monitoring and Reporting

1) Time: Over 200,000 hours of observation time!
2) Quantity: Nearly 29,800 total occupations
3) Growth in Audience: 100% increase from 204 contributors in 2019 to 424 in 2021.
4) Growth per Contributor: median of 4 per contributor in previous years to 6 per contributor in 2021

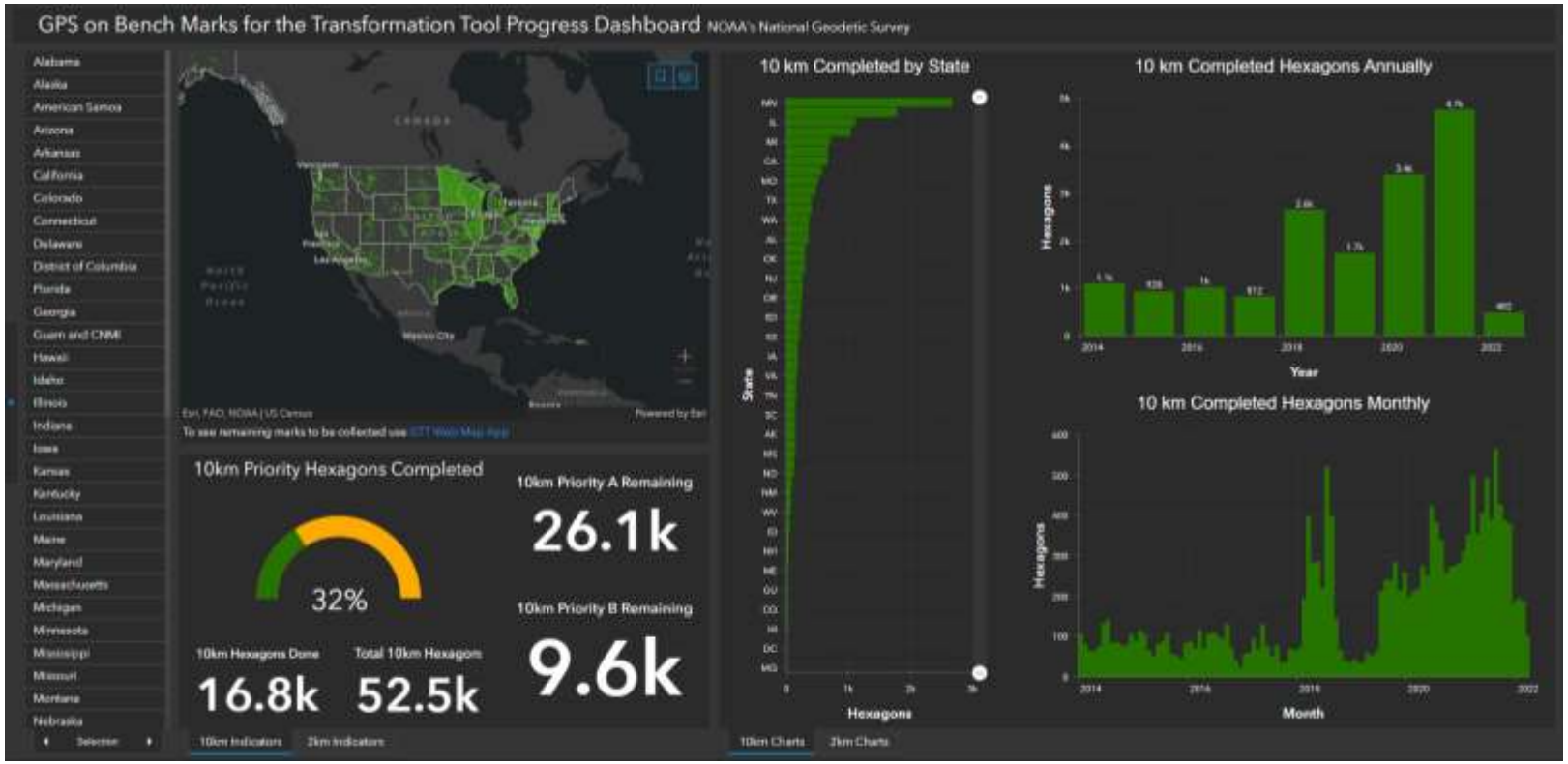

Figure 3: GPS on Bench Marks Progress Dashboard

NGS GPS on Bench Marks Dashboard

Growth for Current Campaign: IDB and OPUS Share

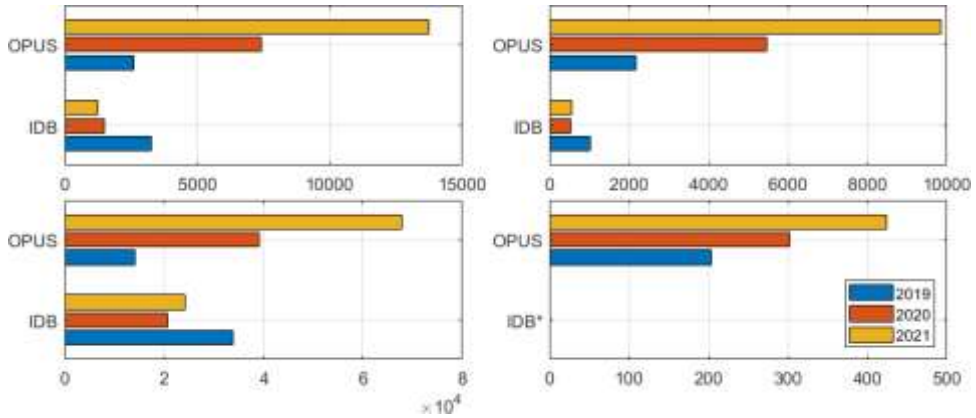

Figure 4: Annual statistics for GPS on Bench Marks from both data sources (OPUS and IDB). Upper-left: total occupations; Upper-right: total unique PIDs; Lower-left: total hours; lower-right: total unique contributors (IDB* is not available presently)

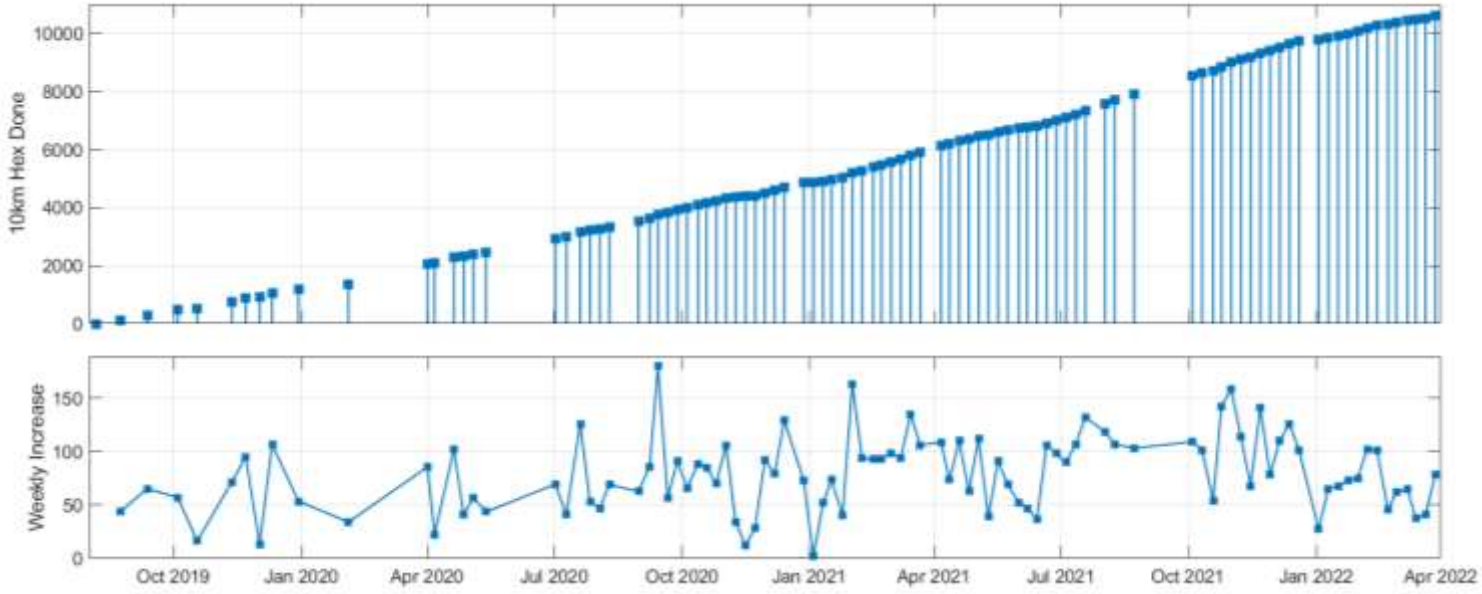

Figure 5: GPS on Bench Marks weekly 10 km hexagons completed. Upper: total 10 km hexagons completed since the start of the campaign in August 2019. Lower: weekly increase in 10 km hexagons completed.

Coverage of OPUS Share in CONUS:

- Vastly different coverage on state-by-state basis
- 58 000+ total submissions
- 15 000+ have 2+ observations

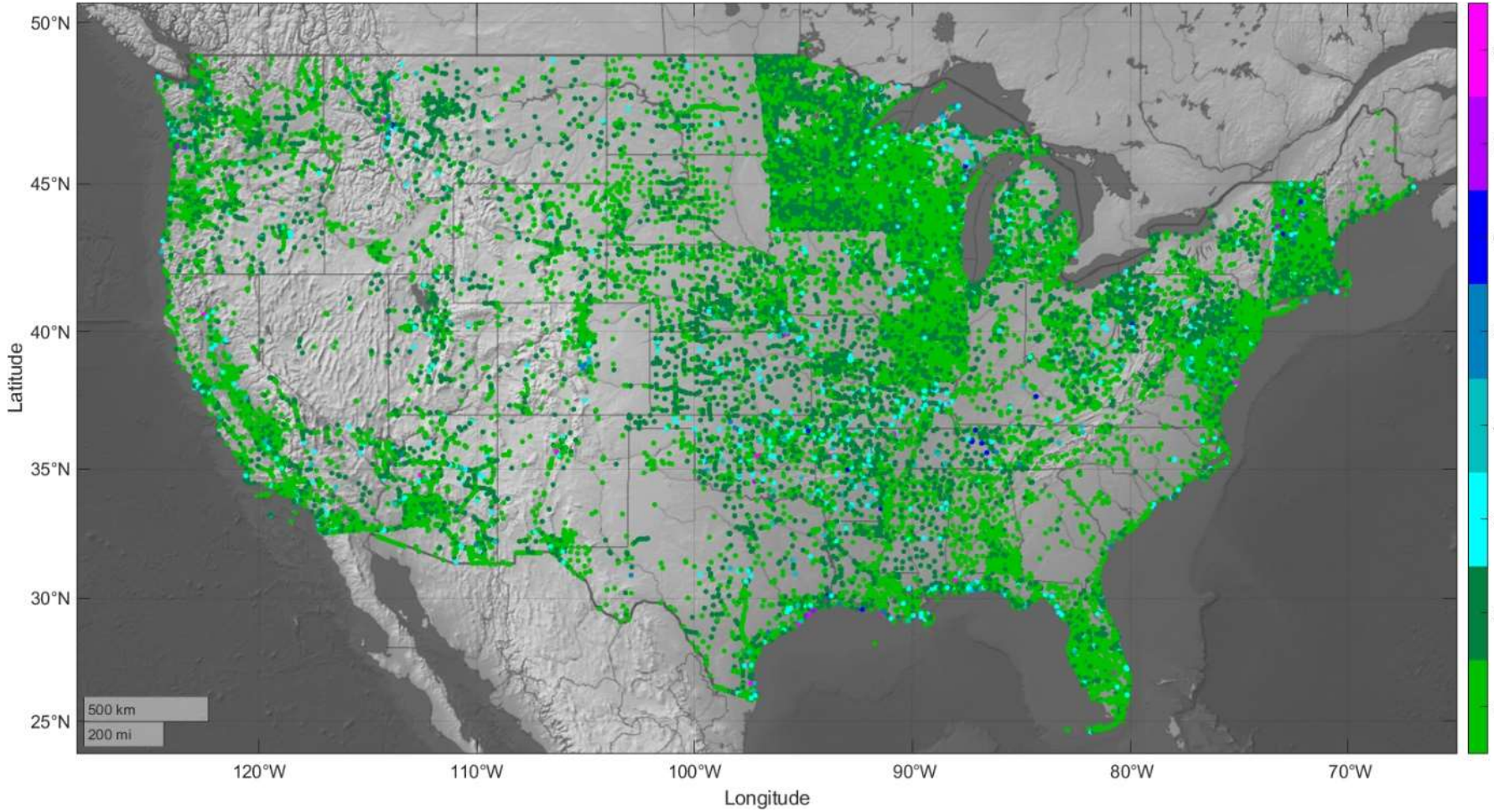

Figure 6: OPUS Share Database coverage and number of occupations throughout CONUS (as of 15 March 2022)

Coverage of OPUS Share in OCONUS

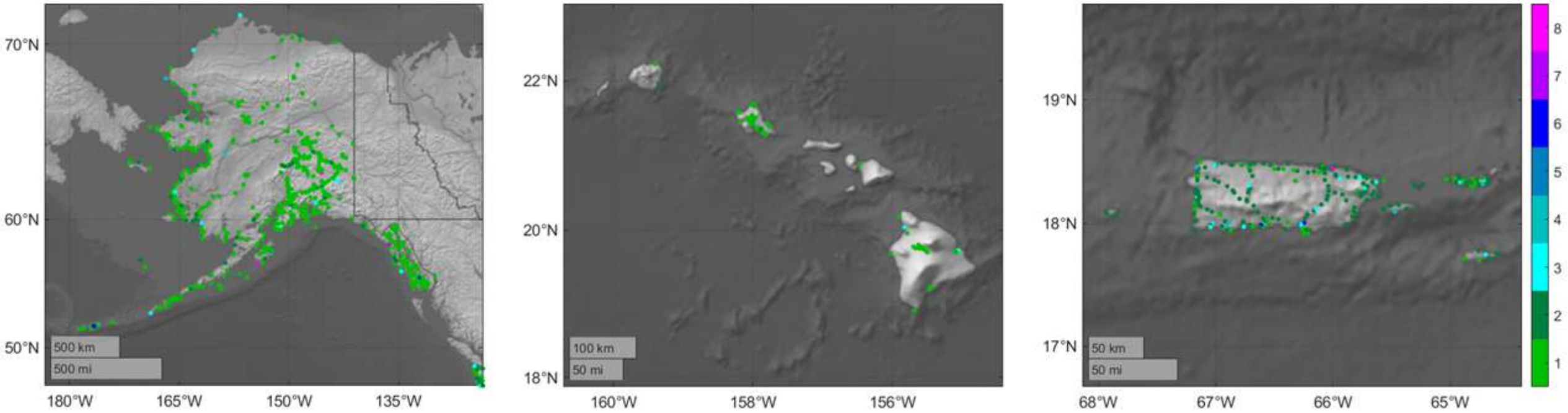

Figure 7: OPUS Share Database coverage for Alaska, Hawaii, and Puerto Rico/U.S. Virgin Islands (left to right, as of 15 March 2022).

NAD83(2011) Comparison:

- Some just noise
- Some real geophysical signal
  - California
  - Great Lakes area
- Some systematic artifacts

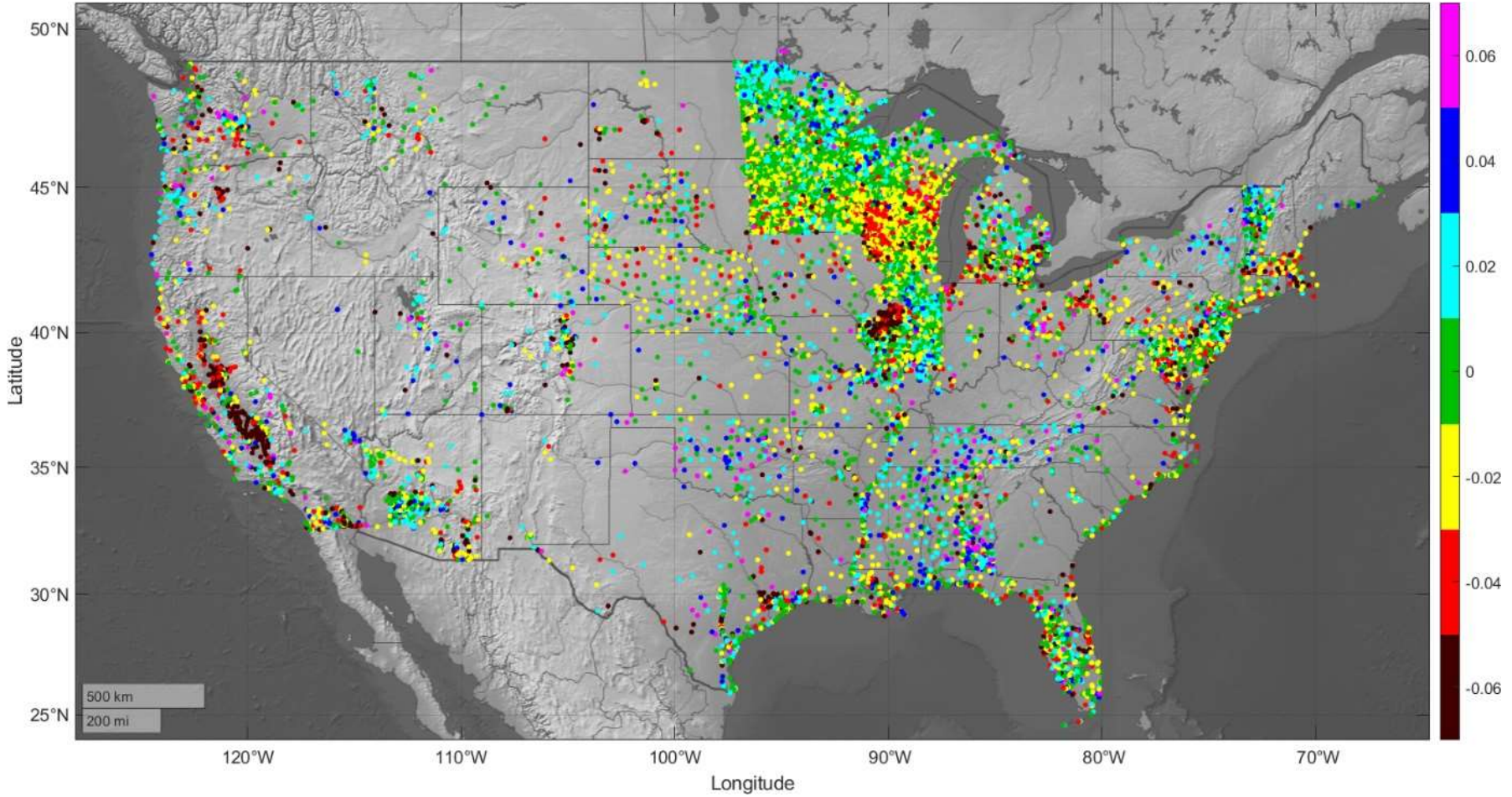

Figure 10: Difference between ellipsoid height in NAD 83(2011) epoch 2010.0 as published on NGS Datasheets and the OPUS Share determined value (units: [m]).

Individual Mark Time Series: TIDAL 11 in Southern Louisiana, USA (PID: AT0685, Grand Isle LA)

OPUS Share Solution(s)

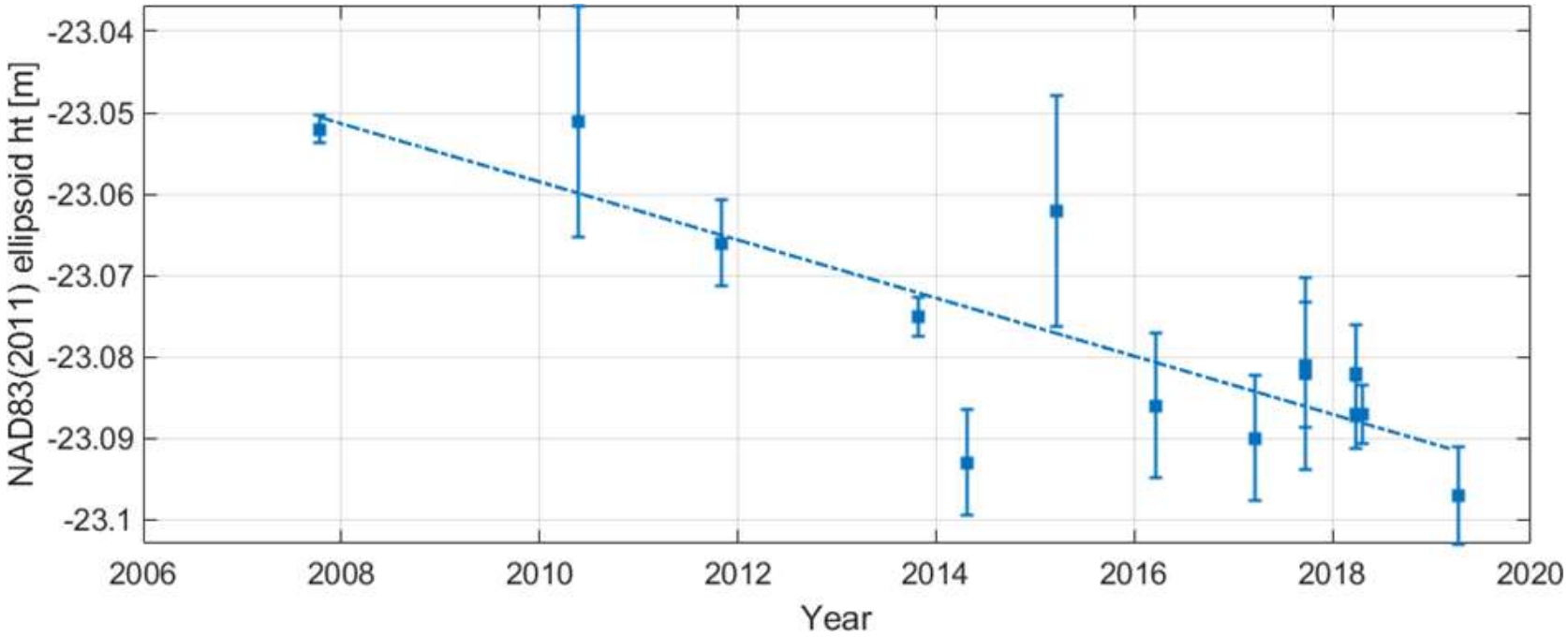

Figure 11: NAD83(2011) ellipsoid height available on OPUS Share solution for tidal bench mark in Grand Isle, Louisiana. The estimated velocity is -3.6 mm/yr. Error bars shown are based on the ellipsoid height peak-to-peak value / 1.6929 (Schwarz, 2006) but are not used in the velocity estimation

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OPUS Share Solution(s)

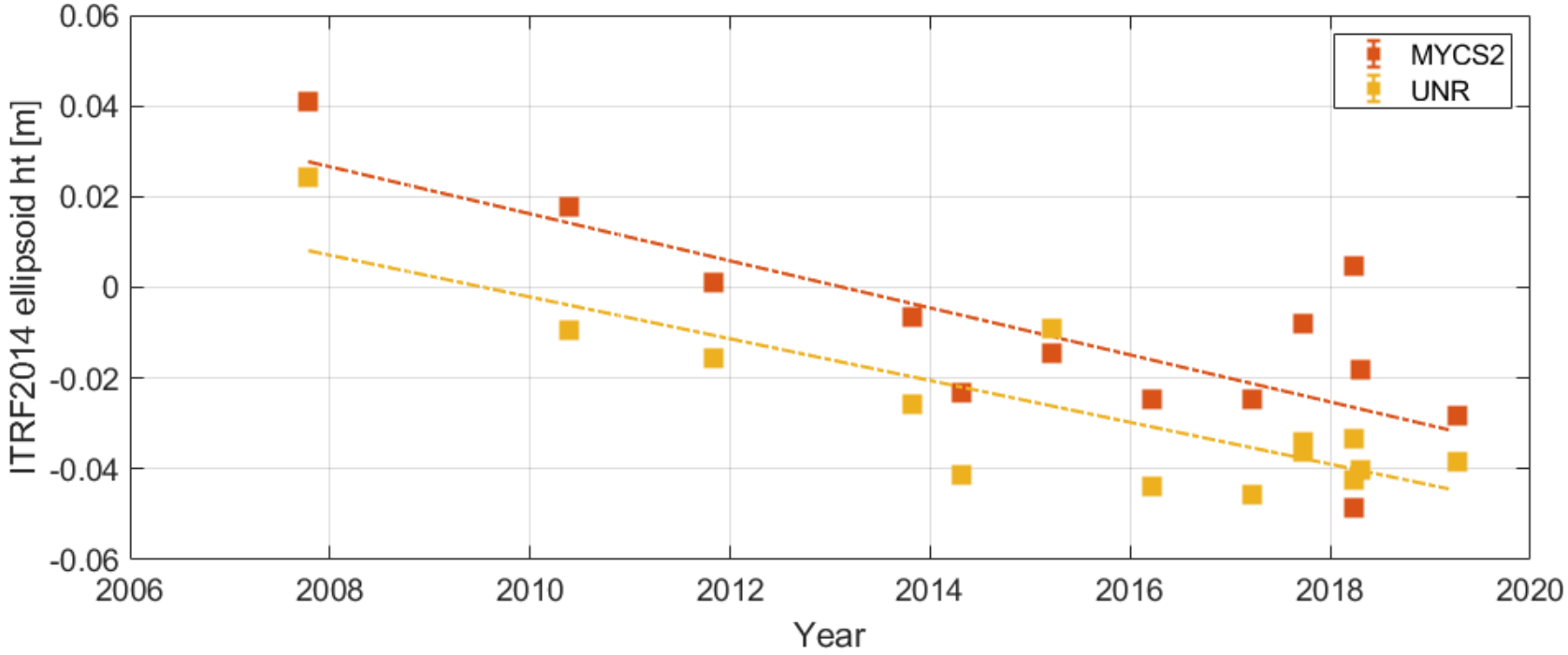

Figure 12: ITRF2014 ellipsoid height (with constant of -24.45 m removed) time series. Full unscaled, variance/covariance used to estimate the individual solution coordinates at survey epoch.

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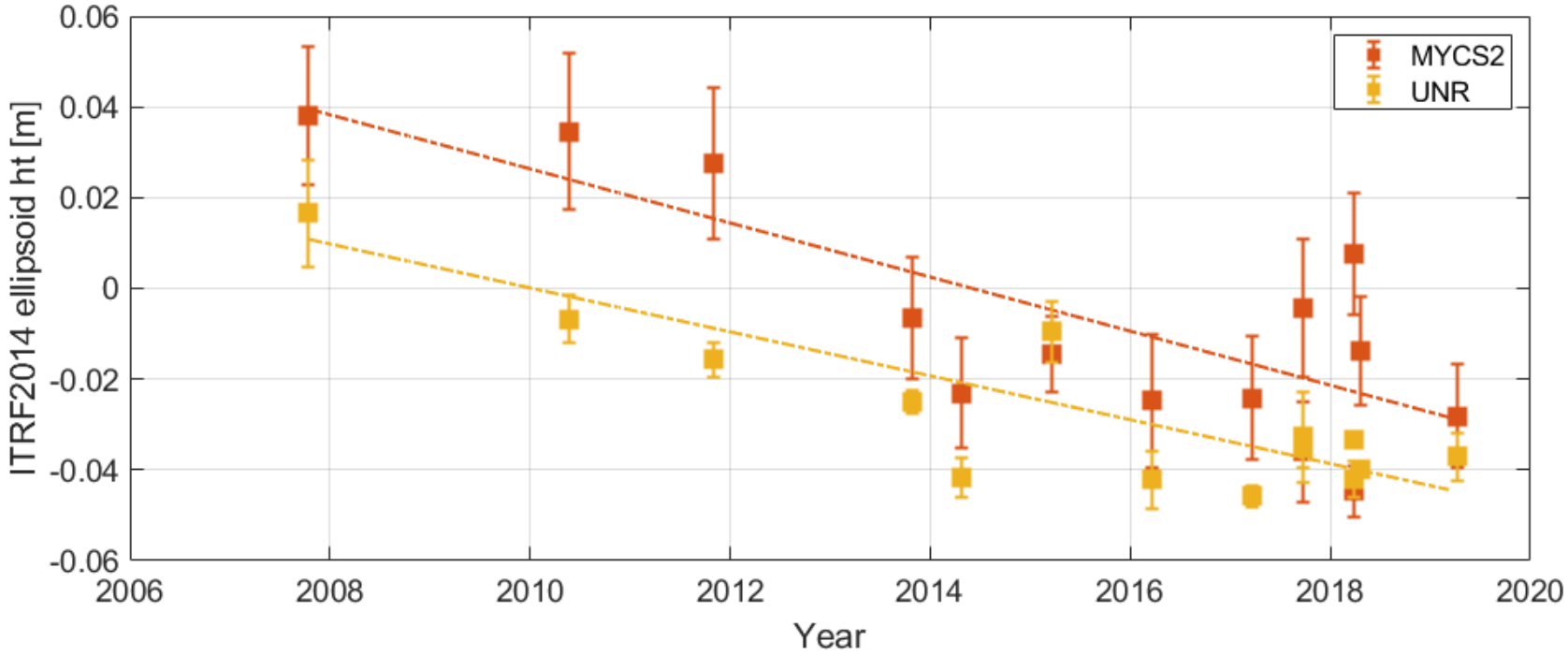

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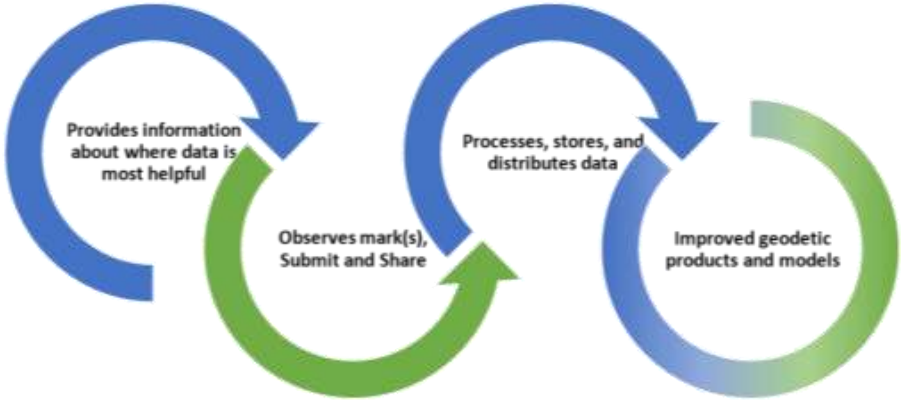
OPUS Share Solution(s)

Table 1: Estimated linear vertical velocities with uncertainty for all solutions (units: mm/yr)

Estimated vertical velocity: [*mm/yr*]	Estimated uncertainty, 1-sigma: [*mm/yr*]	Weighting scheme:	Constraints Solution:	Reference Frame:
-3.6	+/- 0.7	Equally weighted	Original OPUS Share	NAD 83(2011)
-5.2	+/- 1.3	Original variance/covariance	MYCS2	ITRF2014
-4.6	+/- 0.8	Original variance/covariance	UNR	ITRF2014
-6.0	+/- 1.2	Scaled variance/covariance	MYCS2	ITRF2014
-4.8	+/- 0.7	Scaled variance/covariance	UNR	ITRF2014

Conclusions

- GPS on Bench Marks project provides a linkage between NGS and users of the National Spatial Reference System
  - Collaborative & crowd-sourced
  - Highlights geodetic needs throughout the USA
  - Wide-variety of reporting tools (web maps, dashboards, newsletters, etc.)
- Untapped potential for applied geodetic research
  - Fully online and publicly available
  - All available data for a particular location
  - Examples:
    - NAD83(2011) comparison
    - Local time series of vertical mark motion



GPS on Bench marks: