National Geodetic Survey Positioning America for the Future geodesy.noaa.gov

National Geodetic Survey

FY16 NGS Update

Transitioning to the new geometric and geopotential datum/reference frames by 2022

ODOT 2016 Surveyors Conference
Salem, OR – March 8-9, 2016

NOAA's National Geodetic Survey
geodesy.noaa.gov
Mark L. Armstrong, PLS, WRE
Oregon State Geodetic Advisor
mark.l.armstrong@noaa.gov

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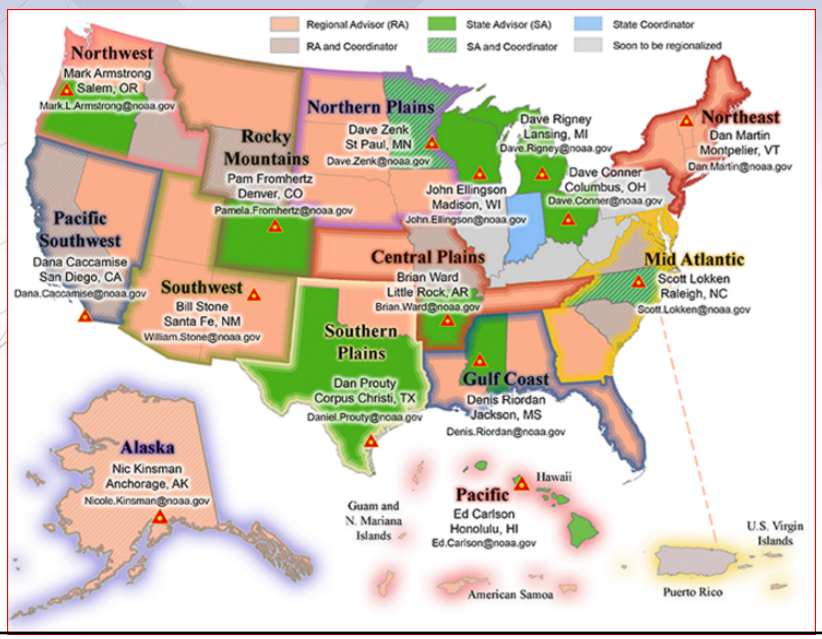
NGS Geodetic Advisor Program Current Status



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NGS Regional Geodetic Advisor Program Status when complete

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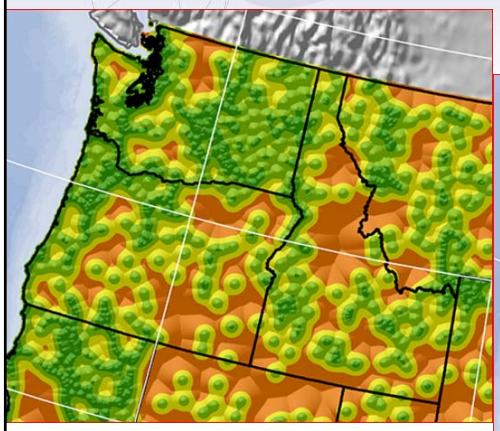
GPS ON BENCH MARKS CAMPAIGN

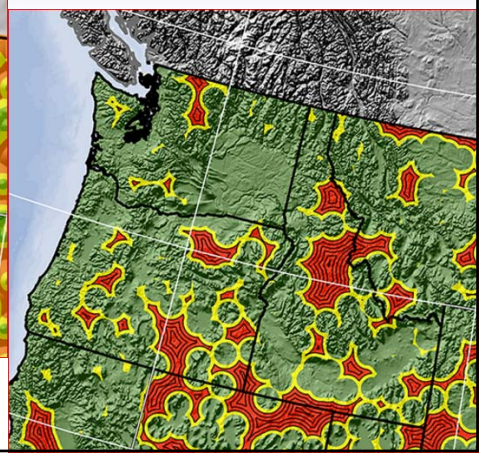
http://www.ngs.noaa.gov/GPSonBM/

Share your solutions with the OPUS Database



GEOID12B ACCURACY

You can help improve the next geoid by helping to fill these gaps



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Quick update on current products and services

- **Hybrid GEOID model**: Maybe two or more years before the next NAVD88 hybrid geoid model. **GEOID12B is the latest.**
- NGS working on annual experimental gravimetric geoid models.

As of Thursday, October 1, 2015

2015 Experimental Geoid Models xGEOID15A and xGEOID15B are available

In 2022, the National Geodetic Survey (NGS) will replace the current North American Vertical Datum of 1988 (NAVD 88) with a new vertical datum based on the geoid: an equipotential surface that best represents mean sea level.

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OPUS Projects Update

The OPUS Projects Team relies on trained OP Managers and academia research to suggest changes and additions to the program!

The most popular requests for additions or changes dictate the priority.

OP was updated on 3/1/16. An adjustment constraint weight fix has been applied. Typically this affected projects lasting a month or more where an undesirable coordinate shift may have occured using NORMAL constraint weighting.

Email the OPUS Projects Team with your suggestions: ngs.opus.projects@noaa.gov

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Ongoing work for future versions of OPUS PROJECTS

- **OPUS Projects to IDB project**: **The re-invention of blue-booking is progressing and may be out in BETA form by the end of Sept. 2016 for users to test.**
- **OPUS Projects "sharing" to the OPUS database project**:
- **ON HOLD for now**. **Do you want it, need it?**
- **A whole new database is 5 years away.**

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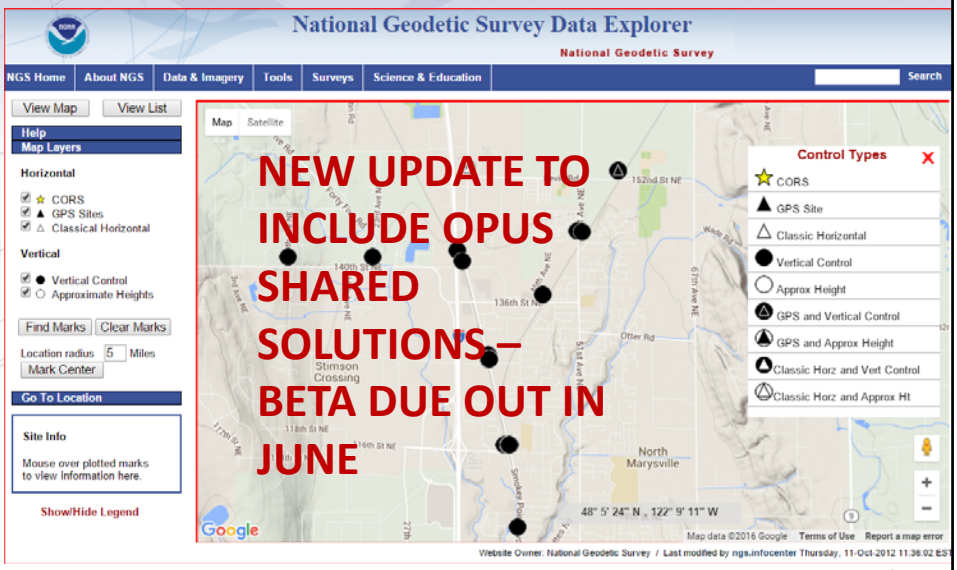
NGS Data Explorer Update



NEW UPDATE TO INCLUDE OPUS SHARED SOLUTIONS – BETA DUE OUT IN JUNE

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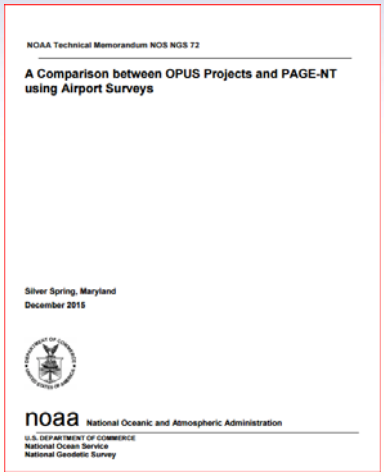
FAA Survey Update

On 12-18-15 NGS released **NOAA Technical Memorandum NOS NGS 72**

The purpose: Determine whether vector processing in **OPUS Projects** is equivalent in performance to that used in **PAGE-NT**.

Results: National Geodetic Survey's opinion is that OPUS Projects can be used to process GPS airport survey data in an equivalent manner to PAGE-NT.


NOAA Technical Memorandum NOS NGS 72

A Comparison between OPUS Projects and PAGE-NT using Airport Surveys

Silver Spring, Maryland
December 2015

noaa National Oceanic and Atmospheric Administration
U.S. DEPARTMENT OF COMMERCE
National Ocean Service
National Geodetic Survey

DOWNLOAD "NOS NGS 72" RIGHT FROM THE NGS HOME PAGE

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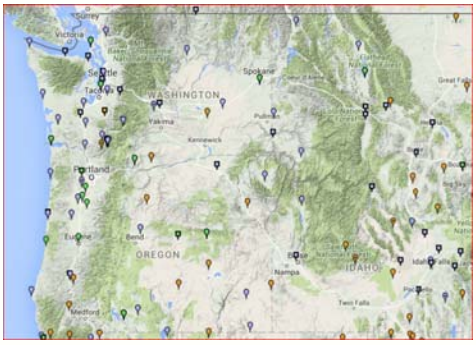
Changes to CORS Products and Services

- **HTDP 3.2.5 has been released** – it now allows for transforming multiple points simultaneously.

http://geodesy.noaa.gov/TOOLS/Htdp/Htdp.shtml

- 7 new CORS in OR in 2015
- Existing active stations (ORGN, WSRN, PBO may be added to the CORS network if they meet criteria.
- Foremost is the 70km spacing rule.



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Changes to CORS NAD 83 Coordinates

NGS will monitor the published NAD 83 coordinates for CORS. Changes to the coordinates may be due to:

a) Seasonal variation.
b) Change in hydrologic or other loading.
c) Change in subsidence or other geophysical phenomena.
d) A receiver firmware upgrade or other related equipment change.

If the long term deviation of the coordinates from the published values appears permanent, NGS will revise the published NAD 83 coordinates for the CORS.

OPUS-net is used to compute coordinates for CORS.

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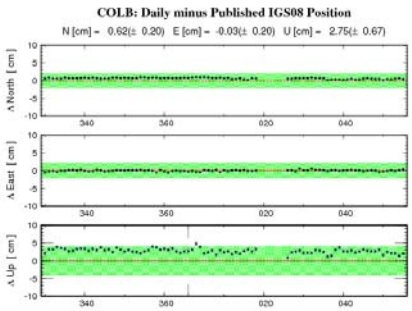
We manage (store, analyze, disseminate) data from over 2000 GNSS stations in the CORS network



90 day time series shown above

April 13, 2015 2015 Geospatial Summit 12

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How YOU can influence and help shape NGS products and services

1. Fill out the NGS webpage popup survey form quarterly. NGS tabulates responses, reviews and focuses on the biggest needs.
2. Your questions may be answered by the product team.
   - NOS NGS OPUS ngs.opus@noaa.gov
   - NOS NGS Opus Database NGS.Opus_db@noaa.gov
   - NOS NGS OPUS Projects ngs.opus.projects@noaa.gov
   - NOS NGS CORS ngs.cors@noaa.gov
   - NOS NGS Absolute Antenna Calibrations ngs.absantcal@noaa.gov

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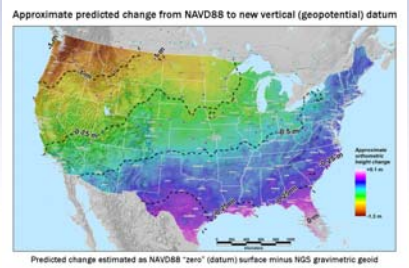
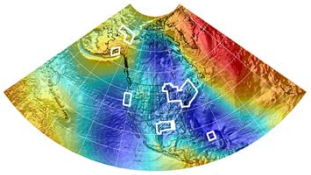
New Datum/Reference Frames Are Coming in ~2022!

- NOAA's National Geodetic Survey will release new geometric (horizontal) and geopotential (vertical) reference frames in ~2022
- Realization of the new frames will be through GPS/GNSS receivers
- Target- 2 cm accuracy: relative to sea level (orthometric heights) using GPS/GNSS and a geoid (gravity) model from NGS' GRAV-D project.
- NGS will provide the tools to transform between the new reference frames and old datums.

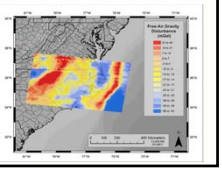




MORE INFO:

Go to the Geospatial Summit webpage:
http://www.geodesy.noaa.gov/2015GeospatialSummit/

New Reference Frame Webpage and Videos:
http://www.geodesy.noaa.gov/datums/newdatums/NewDatums.shtml



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NAD 83 Datum vs New Geometric Global Frame

Live in the present

Access 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(      ) 8
ELLIP H (08/20/96)  239.417  (m)                       GP(      ) 4 2
NAD 83(1986)-  40 03 10.12155(N)    082 58 34.92303(W) AD(      ) 1
NAD 27      -  40 03 09.89400(N)    082 58 35.26500(W) AD(      ) 1
NGVD 29 (09/24/89)  273.5    (m)  RAPSUS6 model used   GPS OBS
```

Reliance on passive marks…
Fragile, unchecked passive control

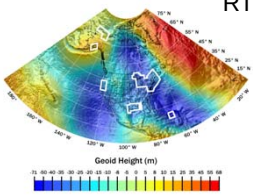
Prepare to access the new way

Modern datasheets

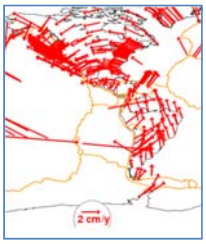
CORS

Work in the NSRS

RTN



Temporal Geoid Change



Global time/velocity changes accounted for

Edited from the 2015 Geospatial Summit 15

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Improvements and advancements are on the way!

- New science yields improved methods and performance which in turn provides:
  - **better service**
  - **better products**
  - **better accuracy**
  - **better repeatability**
  - **better sustainability**
  - **better efficiency**

- **These changes will take time.**
- **May change the way we are used to working.**
- **May require learning new things!**

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The Geometric Frame

- NGS computes all 3D coordinates (LLh) in the current NSRS global frame (ITRF08/IGS08)
- then outputs the current NSRS North American Datum: NAD 83(2011)2010.00
  - This is the way the OPUS products work now.

Current global frame = ITRF08 / IGS08
Next global frame = ITRF14 / IGS14
Future global frame = ITRF20 / IGS20
(there may be others - estimated dates)

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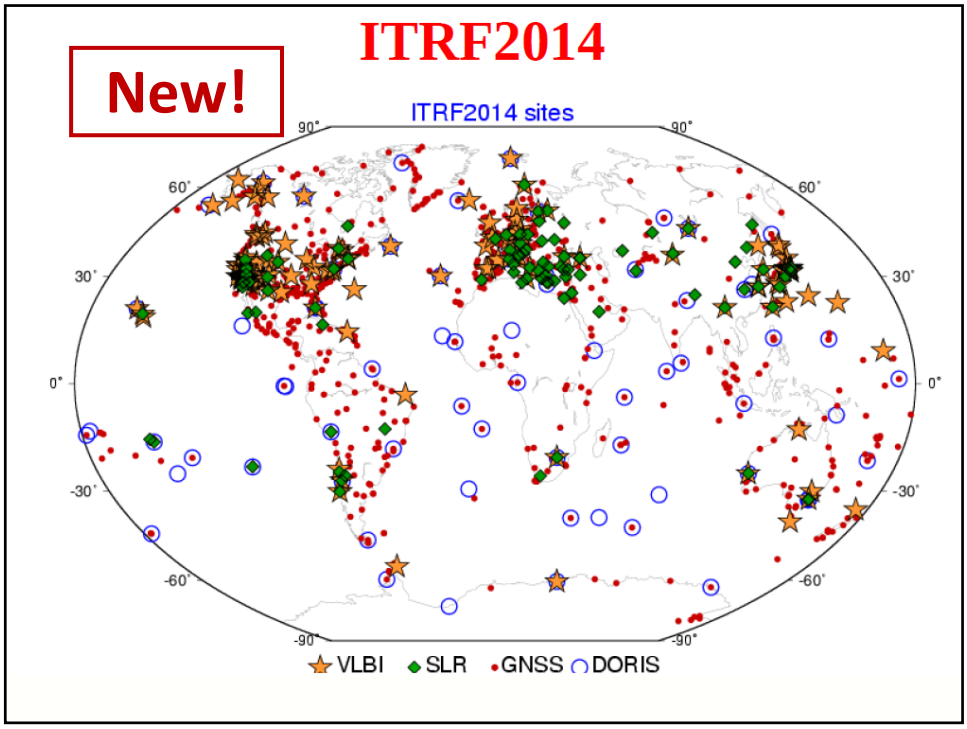
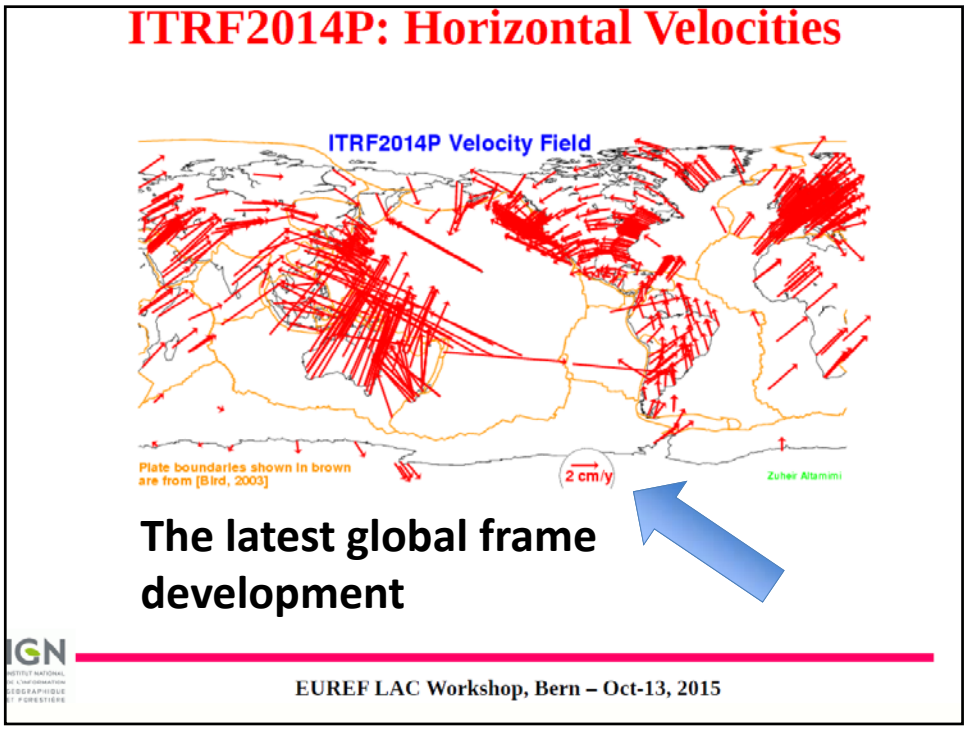
International Terrestrial Reference Frame (ITRF)

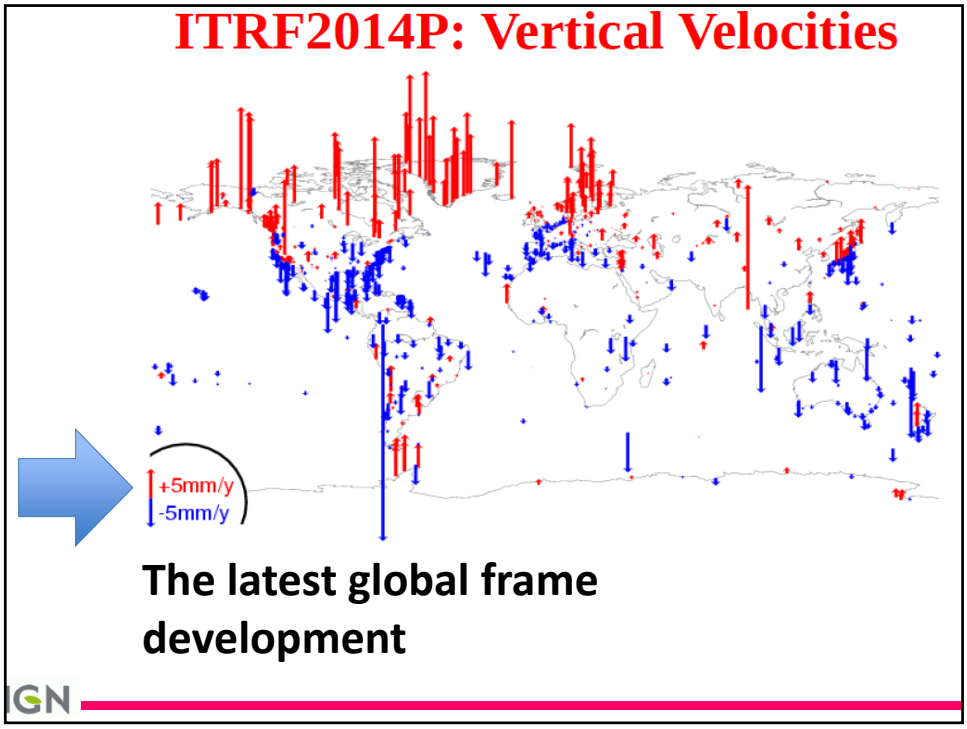
4 Global Independent Positioning Technologies

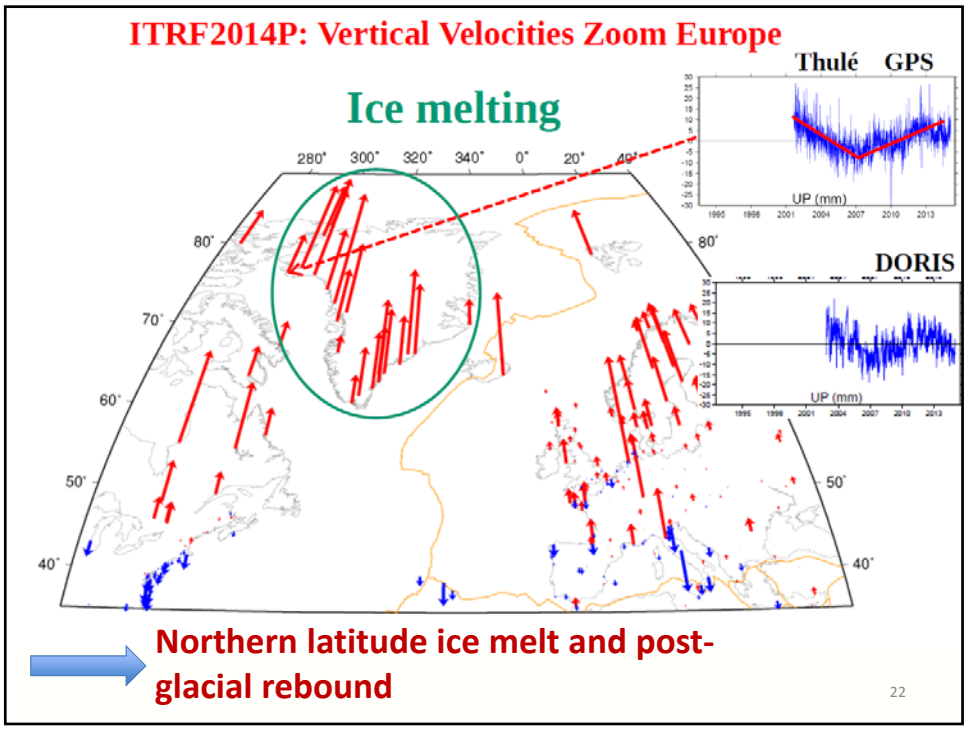
- International Global Navigation Satellite Systems Service (IGS)
- International Laser Ranging Service (ILRS)
- International Very Long Baseline Service (IVS)
- International DORIS Service (IDS)

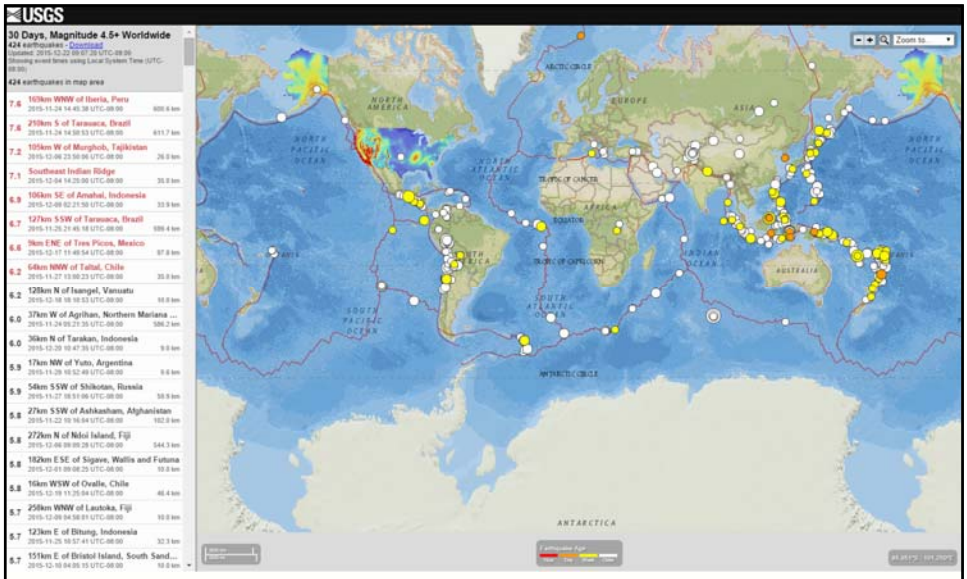
http://itrf.ensg.ign.fr/


ITRF2014
New!
ITRF2014 sites
90°
60°
30°
0°
-30°
-60°
-90°
VLBI
SLR
GNSS
DORIS


ITRF2014P: Horizontal Velocities
ITRF2014P Velocity Field
Plate boundaries shown in brown are from [Bird, 2003]
2 cm/y
Zuheir Altamimi
The latest global frame development
IGN
EUREF LAC Workshop, Bern – Oct-13, 2015


ITRF2014P: Vertical Velocities
+5mm/y
-5mm/y
The latest global frame development
IGN


ITRF2014P: Vertical Velocities Zoom Europe
Ice melting
Thulé GPS
UP (mm)
DORIS
UP (mm)
280° 300° 320° 340° 0° 20° 40°
80° 70° 60° 50° 40°
Northern latitude ice melt and post-glacial rebound
22



Map of 424 earthquakes magnitude 4.5+ in the last 30 days. Quakes may cause a discontinuity in time/velocity model and need to be accounted for.

Courtesy USGS website

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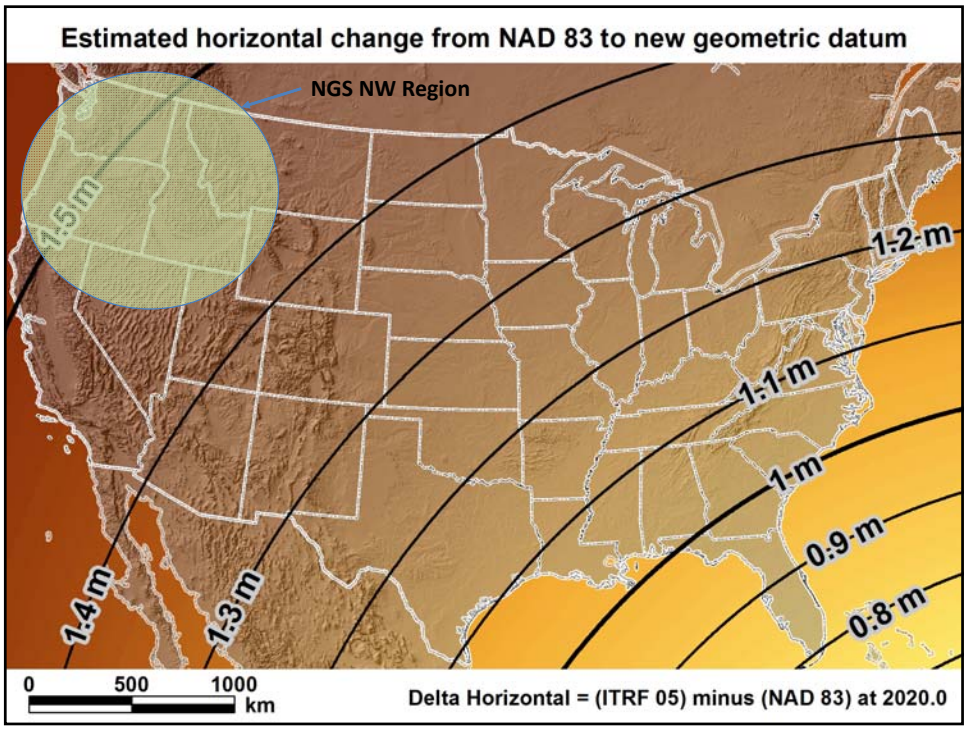
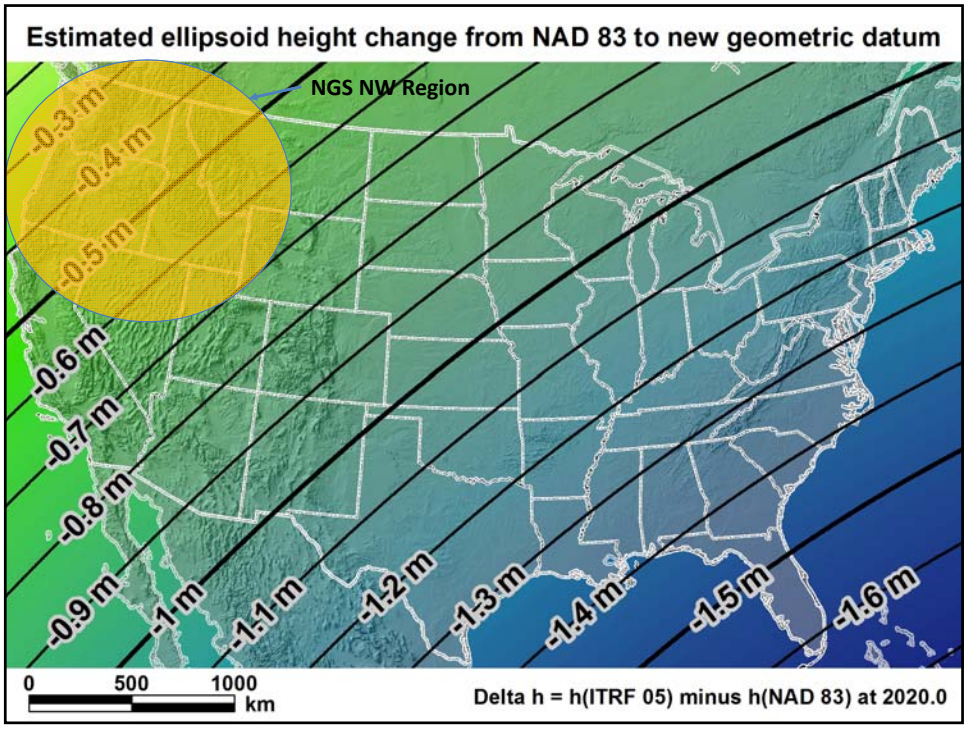
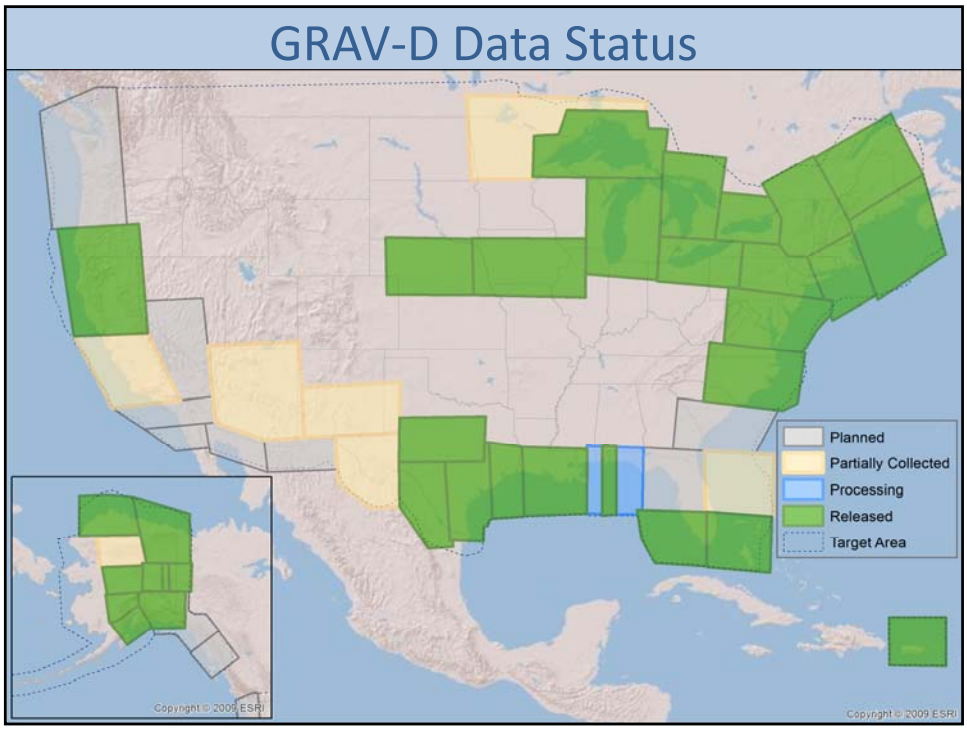



Estimated ellipsoid height change from NAD 83 to new geometric datum
NGS NW Region
-0.3 m
-0.4 m
-0.5 m
-0.6 m
-0.7 m
-0.8 m
-0.9 m
-1 m
-1.1 m
-1.2 m
-1.3 m
-1.4 m
-1.5 m
-1.6 m
0 500 1000 km
Delta h = h(ITRF 05) minus h(NAD 83) at 2020.0


GRAV-D Data Status
Planned
Partially Collected
Processing
Released
Target Area
Copyright © 2009 ESRI
Copyright © 2009 ESRI

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GSVS2011, GSVS2014, GSVS17

- Field ground surveys that provide for external confirmation check on the GRAV-D geoid model.
  - **GSVS2011 located near sea level in TX**
  - **GSVS2014 located mid elevation in IO**
  - **GSVS2017 located high elevation in CO**
    - » **Survey methods include:**
      - Differential Leveling
      - Campaign GPS
      - RTN-based GPS if available
      - Absolute Gravity
      - Gravity Gradients
      - Deflections of the Vertical
      - Airborne LIDAR
      - Airborne Imagery

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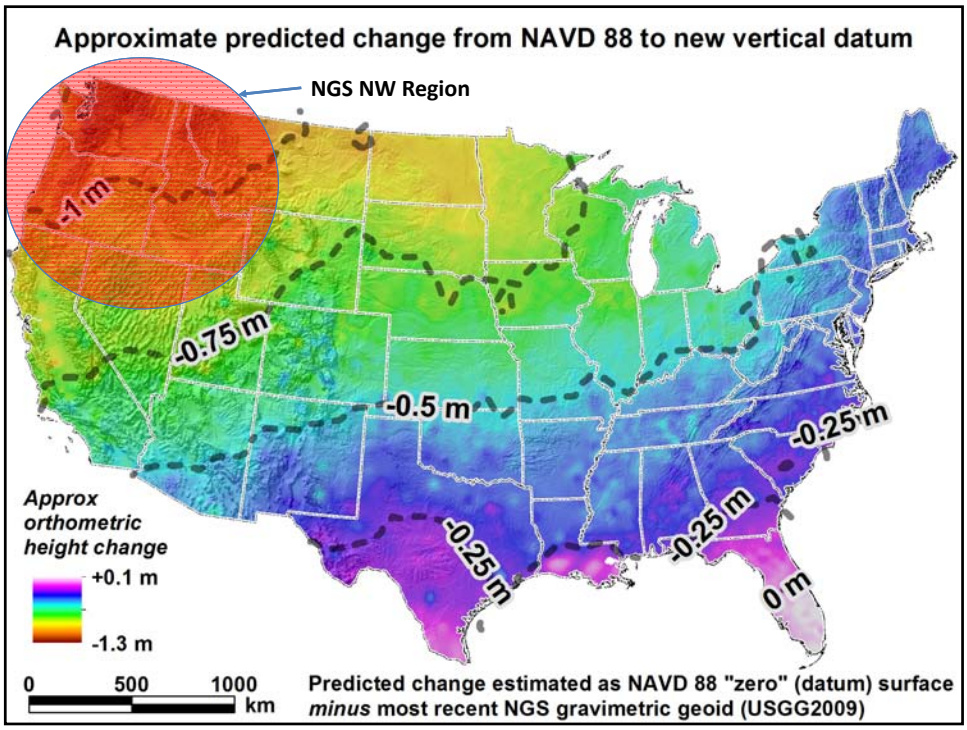

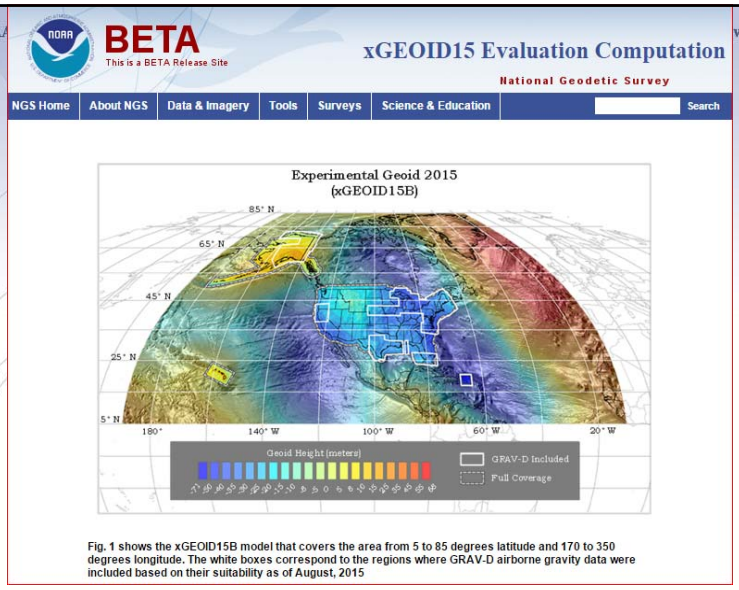

xGEOID15A: All available data and best methods EXCLUDING GRAV-D airborne gravity data.

xGEOID15B: All available data and best methods INCLUDING GRAV-D airborne gravity data.

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Orthometric Heights from OPUS

Make geoid-based orthometric heights available via OPUS (NGS' Online Positioning User Service)

– **Done**, in the OPUS extended output

```
            ** Orthometric Heights Above Future Geopotential Datum.

Prototype orthometric heights are now being made available as a precursor to the completion
of GRAV-D and the replacement of NAVD 88 with a new geopotential reference system.  The
following height reflects the current best estimate of the true orthometric height, based on
the existing gravimetric geoid model.  This height is subject to change as data and modeling
for the gravimetric geoid change throughout the lifetime of the GRAV-D project, or as new
realizations of the ITRF are adopted.  However, at the completion of GRAV-D, these heights will
supersede the NAVD 88 heights

APPROX ORTHO HGT:      5.862 (m) [PROTOTYPE (Computed using USGG2012,GRS80,IGS08)]
```

Questions
Mark L. Armstrong, PLS - Oregon State
Geodetic Advisor
mark.l.armstrong@noaa.gov
Photo by Pat Barott