Update and Refinement of the North American Datum of 1983
NAD 83(2011/PA11/MA11) epoch 2010.00

The 2011 national adjustment of passive control and its impact on NGS products and services...

...and on your work

CGSIC
Nashville, TN
September 17, 2012

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The Plan

- The National Spatial Reference System (NSRS)
  - A (very) brief history of NAD 83
  - The latest realization: NAD 83(2011) epoch 2010.00

- National adjustment of passive control

- Related and dependant NGS products & services
  - The Multi-Year CORS Solution (MYCS)
  - Online Positioning User Service (OPUS)
  - New hybrid geoid model (GEOID12A)
  - New process for Bluebooking GPS project
  - New NAD 83 coordinate transformations
  - New NGS Datasheet format

- What about orthometric heights (aka “elevations”)?
The Basics

• When will it be done?
  – Publication completed on **June 30, 2012**
    • *Intent: Simultaneous with release of GEOID12A*

• How many stations? **80,872**

• How much did the coordinates change?
  – Median: **1.9 cm horiz, 2.1 cm ellipsoid ht**

• How accurate are the results?
  – Median: **0.9 cm horiz, 1.5 cm ellipsoid ht**
    (at 95% confidence level)
A (very) brief history of NAD 83

• Original realization completed in 1986
  – Consisted (almost) entirely of classical (optical) observations

• “High Precision Geodetic Network” (HPGN) and “High Accuracy Reference Network” (HARN) realizations
  – Based on GPS, but classical stations included in adjustments

• National Re-Adjustment of 2007
  – NAD 83(CORS96) and (NSRS2007)
  – Simultaneous nationwide adjustment (GPS only)

• New realization: NAD 83(2011) epoch 2010.00
Introducing...

NAD 83(2011) epoch 2010.00

• **Multi-Year CORS Solution (MYCS)**
  – Continuously Operating Reference Stations
  – Reprocessed all CORS GPS data Jan 1994-Apr 2011
  – 2264 U.S. & global stations
  – NAD 83 computed by transformation from IGS08

• **2011 national adjustment of passive control**
  – New adjustment of GPS passive control
  – GPS vectors tied (and constrained) to CORS NAD 83(2011) epoch 2010.00
  – Over 80,000 stations and 400,000 GPS vectors

• **Realization SAME for CORS and passive marks**

• **This is NOT a new datum! (still NAD 83)**
Why a new NAD 83 realization?

- Multi-Year CORS Solution
  - Previous NAD 83 CORS realization needed many improvements
  - Consistent coordinates and velocities from global solution
  - Aligned with most recent realization of global frame
  - Major processing, modeling, and metadata improvements
    - Including new absolute phase center antenna calibrations

- National adjustment of passive control
  - Optimally align passive control with “active” CORS control
    - Because CORS provide the geometric foundation of the NSRS
  - Incorporate new data, compute accuracies on all stations
  - Better results in tectonically active areas

- Bottom line
  - Must meet needs of users for highly accurate and consistent coordinates (and velocities) using Best Available Methods
Approach

• Used a Helmert blocking strategy for CONUS
  – Over 80,000 points (> 240,000 unknowns)
  – Over 400,000 GPS vectors (> 1.2 million observations)
• Individual projects weighted to account for variable error
  – Horiz and vertical std deviation scale factors computed for all projects
• Outlier detection (for rejecting vectors)
  – Used threshold 4 cm horizontal, 5 cm up
• Challenges:
  – Mixing old and new observations (e.g., pre-1994)
  – CORS complications
  – Horizontal and vertical tectonic motions
  – No-check stations
  – Duplicate stations, duplicate vectors
What’s in a name?

That which we call a datum
By any other name would smell as sweet...

• NAD 83(2011) epoch 2010.00
  – “2011” is datum tag → year adjustment complete
  – “2010.00” is “epoch date” (January 1, 2010)
    • Date associated with coordinates of control station
  – Frame fixed to North America tectonic plate
    • Includes California, Alaska, Puerto Rico, and US Virgin Islands

• NAD 83(PA11) epoch 2010.00
  – Frame fixed to Pacific tectonic plate (Hawaii and American Samoa)

• NAD 83(MA11) epoch 2010.00
  – Frame fixed to Mariana tectonic plate (Guam and CNMI)
National adjustment of passive control

- 4267 GPS projects; 80,872 stations; 424,711 vectors
  - Observations from April 1983 thru Dec 2011
  - Includes 1195 CORS with Multi-Year CORS Solution coordinates

- CONUS and Caribbean adjusted together (79,364 stations)
  - Both referenced to North America tectonic plate
  - Split into Primary (62,024 stations) and Secondary (17,340 stations)

- AK adjusted separate from CONUS and Caribbean (968 stations)
  - No useable ties to CONUS
  - Also referenced to North America tectonic plate

- Pacific region also adjusted separately (540 stations)
  - Referenced to different tectonic plates
    - Hawaii, American Samoa, Marshall Is., etc. → Pacific plate (363 stations)
    - Guam, Northern Mariana Islands, Palau → Mariana plate (177 stations)
  - Pacific not included in 2007 national adjustment
NAD 83(2011/PA11/MA11) epoch 2010.00
National adjustment of passive control
Total of 80,872 stations in 5 networks

Passive & non-CORS active
- 79,677 stations

CORS constrained (1195 total)
- Computed (973)
- Modeled (222)

GNSS vectors (424,711 total)
- Enabled (403,112 = 94.9%)
- Rejected (21,599 = 5.1%)
NA2011 CONUS GNSS vectors (total 426,977)

- 2006-2011 (6 yrs) 99,823 = 23.4%
- 2002-2005 (4 yrs) 99,214 = 23.2%
- 1998-2001 (4 yrs) 73,440 = 17.2%
- 1994-1997 (4 yrs) 72,184 = 16.9%
- 1990-1993 (4 yrs) 69,513 = 16.3%
- 1983-1989 (7 yrs) 12,803 = 3.0%

1983-2005 (23 years) 327,154 vectors (76.6%)
NAD 83(2011) epoch 2010.00
Passive & non-CORS active
△ 78,135 stations
CORS constrained (1113 total)
☆ Computed (911)
☆ Modeled (202)
GNSS vectors (420,023 total)
— Enabled (398,792 = 94.9%)
— Rejected (21,231 = 5.1%)
NAD 83(2011/PA11/MA11) epoch 2010.00

Passive control results summary

• Station network accuracies (95% confidence)
  – Overall median: 0.9 cm horiz, 1.5 cm height (78,709)
    • 90% < 2.3 cm horizontal and 4.8 cm ellipsoid height
    • 2163 no-check stations excluded
  – Median accuracies by network
    • CONUS Primary: 0.7 cm horiz, 1.2 cm height (61,049)
    • CONUS Secondary: 1.6 cm horiz, 3.4 cm height (16,441)
    • Alaska: 3.2 cm horiz, 5.7 cm height (814)
    • Pacific (PA11): 2.2 cm horiz, 5.0 cm height (282)
    • Pacific (MA11): 1.8 cm horiz, 3.8 cm height (123)
Change in horizontal NAD 83 CORS coordinates
NAD 83(CORS96) epoch 2002.00 $\rightarrow$ NAD 83(2011) epoch 2010.00

Avg shifts (cm): $\Delta N = 2.0 \ (\pm 6.4)$; $\Delta E = 0.2 \ (\pm 5.9)$; $\Delta U = -0.9 \ (\pm 2.0)$

- Large shifts in western U.S. due to crustal deformation
- Apparent rotation in "stable" U.S. likely due to errors in NUVEL-1A (used in HTDP)
Horizontal coordinate change in CONUS
NAD 83(NSRS2007) to NAD 83(2011) epoch 2010.00

Horizontal coordinate change
79,061 CONUS stations

- 0 to 2 cm (44,847 = 56.7%)
- 2 to 4 cm (29,001 = 36.7%)
- 4 to 6 cm (2655 = 3.3%)
- 6 to 10 cm (1633 = 2.1%)
- 10 to 20 cm (866 = 1.1%)
- >20 cm (59 = 0.1%)
Related Tasks, Products & Deliverables

• OPUS (Online Positioning User Service)
  – Solutions now NAD 83(2011/PA11/MA11) epoch 2010.00
• New hybrid geoid model (GEOID12A)
  – NAD 83(2011) ellipsoid heights on leveled NAVD 88 BMs
• New process for Bluebooking GPS projects
  – Currently under development
  – New version of “ADJUST” program
  – Includes new GIS tools as part of adjustment process
• New NAD 83 coordinate transformation tools
  – HARN ↔ NSRS2007 ↔ 2011
  – Tools created but still needs to be implement
New NGS Datasheet Format

• New Datasheet version
  – Changed location, length, and text for many fields
  – Added new fields, deleted fields, augmented existing fields
  – Production release in May 2012

• Summary of content changes
  – Added country (e.g., USA) where control station located
  – Hyperlinked vertical datum designation to datum web page
  – Ortho height epoch date, if applicable (e.g., subsidence areas)
  – Note for geoid model used on Ht Mod stations if not current geoid
  – Network and (median) local accuracies
    • Horizontal and ellipsoid height accuracy at 95% confidence (per FGDC)
    • Includes link to detailed accuracy info, list of all local accuracies
BJ0831 HT_MOD - This is a Louisiana Height Modernization Survey Station.
BJ0831 FBN - This is a Federal Base Network Control Station.

BJ0831 DESIGNATION - G 293
BJ0831 PID - BJ0831
BJ0831 STATE/COUNTY - LA/IBERVILLE
BJ0831 USGS QUAD - BAYOU SORREL (1992)

*CURRENT SURVEY CONTROL

BJ0831 NAD 83(2007) - 30 07 51.21248(N) 091 19 20.37359(W) ADJUSTED

BJ0831 NAVD 88 - 6.81 (meters) 22.3 (feet) GPS OBS(2006.81)

**This station is located in a suspected subsidence area (see below).

BJ0831 EPOCH DATE - 2002.00
BJ0831 X - -127,406.838 (meters) COMP
BJ0831 Y - -5,519,499.719 (meters) COMP
BJ0831 Z - 3,182,921.288 (meters) COMP
BJ0831 LAPLACE CORR - 0.80 (seconds) DEFLEC09
BJ0831 ELLIP HEIGHT - -20.072 (meters) (02/10/07) ADJUSTED
BJ0831 GEOID HEIGHT - -26.88 (meters) GEOID09

Accuracy Estimates (at 95% Confidence Level in cm) -------

Type PID Designation North East Ellip

NETWORK BJ0831 G 293 0.47 0.59 1.43

The horizontal coordinates were established by GPS observations
and adjusted by the National Geodetic Survey in February 2007.

The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
See www.ngs.noaa.gov/NationalReadjustment for more information.

The horizontal coordinates are valid at the epoch date displayed above
which is a decimal equivalence of Year/Month/Day.
**Announcing…**

**A New NGS Datasheet Format**

**PROGRAM = datasheet95, VERSION = 7.89.3.1**

Updated National Geodetic Survey, Retrieval Date = SEPTEMBER 11, 2012

**BJ0831**

- **HT_MOD** - This is a Height Modernization Survey Station.
- **FBN** - This is a Federal Base Network Control Station.
- **DESIGNATION** - G 293
- **PID** - BJ0831
- **STATE/COUNTY** - LA/IBERVILLE
- **COUNTRY** - US
- **USGS QUAD** - BAYOU SORREL (1992)

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**BJ0831**

*CURRENT SURVEY CONTROL*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Note</th>
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<tbody>
<tr>
<td><strong>NAD 83(2011) POSITION</strong></td>
<td>30 07 51.21287(N) 091 19 20.37290(W)</td>
<td>ADJUSTED</td>
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<td><strong>NAD 83(2011) ELLIP HT</strong></td>
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<td>(06/27/12) ADJUSTED</td>
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<td><strong>NAD 83(2011) EPOCH</strong></td>
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<td><strong>NAVD 88 ORTHO HEIGHT</strong></td>
<td>6.81 (meters) 22.3 (feet)</td>
<td>GPS OBS</td>
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<td><strong>NAVD 88 EPOCH</strong></td>
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</table>

**NOTE:** This station is located in a suspected subsidence area (see below).

**Navd 88 orthometric height was determined with geoid model:**

- **GEOID HEIGHT** - 26.93 (meters)
- **GEOID HEIGHT** - 26.83 (meters)
- **NAD 83(2011) X** - 127,406.819 (meters)
- **NAD 83(2011) Y** - 5,519,499.702 (meters)
- **NAD 83(2011) Z** - 3,182,921.292 (meters)
- **LAPLACE CORR** - 0.80 (seconds)

**FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm):**

<table>
<thead>
<tr>
<th>Type</th>
<th>Horiz</th>
<th>Ellip</th>
<th>Dist(km)</th>
</tr>
</thead>
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<tr>
<td>NETWORK</td>
<td>0.48</td>
<td>2.69</td>
<td></td>
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<tr>
<td>MEDIAN LOCAL ACCURACY AND DIST (094 points)</td>
<td>0.63</td>
<td>3.28</td>
<td>53.96</td>
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</table>

**NOTE:** Click [here](#) for information on individual local accuracy values and other accuracy information.
Announcing…

A New NGS Datasheet Format

SERVER: NGSBASE DATABASE: NGSIDB
National Geodetic Survey, Retrieval Date = SEPTEMBER 11, 2012

BJ0831 ACCURACIES - Complete network and local accuracy information.
BJ0831 HT_MOD - This is a Louisiana Height Modernization Survey Station.
BJ0831 FBN - This is a Federal Base Network Control Station.
BJ0831 DESIGNATION - G 293
BJ0831 PID - BJ0831

BJ0831 Statistical Information, in cm, for point BJ0831 follows.

BJ0831 Note that Horz and Ellip values are the official 95%
BJ0831 FGDC accuracy standards. The values of StdN, StdE and Stdh are the
BJ0831 standard deviations (one sigma) of the coordinates (NETWORK) or
BJ0831 of the difference in the coordinates (LOCAL) in Latitude, Longitude
BJ0831 and Ellipsoid Height. The value CorrNE is the correlation
BJ0831 coefficient between the latitude and longitude components of either
BJ0831 the coordinate (NETWORK) or coordinate difference (LOCAL).

<table>
<thead>
<tr>
<th>Type/PID</th>
<th>Horz</th>
<th>Ellip</th>
<th>Dist(km)</th>
<th>StdN</th>
<th>StdE</th>
<th>Stdh</th>
<th>CorrNE</th>
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<td>0.13</td>
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BJ0831 LOCAL:

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<th>PID</th>
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<th>Ellip</th>
<th>Dist(km)</th>
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<th>StdE</th>
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<th>CorrNE</th>
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<td>0.16</td>
<td>0.29</td>
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<td>0.17</td>
<td>0.27</td>
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<td>0.17</td>
<td>0.31</td>
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</tbody>
</table>
Announcing…

A New NGS Datasheet Format

BJ0831

The ellipsoidal height was determined by GPS observations and is referenced to NAD 83.

BJ0831

The geoid height was determined by GEOID09.

BJ0831

<table>
<thead>
<tr>
<th></th>
<th>North</th>
<th>East</th>
<th>Units</th>
<th>Scale Factor</th>
<th>Converg.</th>
</tr>
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<tbody>
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<td>180,775.280</td>
<td>1,001,060.584</td>
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<td>0.99992831</td>
<td>+0 00 19.8</td>
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<td>SPC LA S</td>
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<td>sFT</td>
<td>0.99992831</td>
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<td>UTM 15</td>
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<td>MT</td>
<td>0.99992222</td>
<td>+0 50 32.4</td>
</tr>
</tbody>
</table>

BJ0831

Elev Factor x Scale Factor = Combined Factor

BJ0831

SPC LA S

1.00000315 x 0.99992831 = 0.99993146

BJ0831

UTM 15

1.00000315 x 0.99992222 = 0.99992537

BJ0831

SUPERSEDED SURVEY CONTROL

BJ0831

ELLIP H (06/20/00) -20.090 (m) GP( ) 3 1

BJ0831

NAD 83(1992) - 30 07 51.23112 (N) 091 19 20.37006 (W) AD( ) 1

BJ0831

NAD 83(1992) - 30 07 51.21235 (N) 091 19 20.37230 (W) AD( ) B

BJ0831

ELLIP H (09/10/92) -20.004 (m) GP( ) 4 1

BJ0831

NAVD 88 (08/12/94) 6.97 (m) 22.9 (f) LEVELING 3

BJ0831

NAVD 88 (02/14/94) 6.971 (m) 22.87 (f) ADJUSTED 1 1

BJ0831

NAVD 88 (09/10/92) 7.1 (m) 23. (f) GPS OBS

BJ0831

NGVD 29 (??/??/??) 7.003 (m) 22.98 (f) ADJUSTED 1 1

BJ0831

Superseded values are not recommended for survey control.

BJ0831

NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

BJ0831. See_file_dndata.txt to determine how the superseded data were derived.

BJ0831

U.S. NATIONAL GRID SPATIAL ADDRESS: 15RXP6160634477(NAD 83)

BJ0831

MARKER: DV = VERTICAL CONTROL DISK

SETTING: 36 = SET IN A MASSIVE STRUCTURE

SP_SET: RIVER LOCK

STAMPING: G 293 1976

MARK LOGO: NGS
The ellipsoidal height was determined by GPS observations and is referenced to NAD 83.

The following values were computed from the NAD 83(2011) position.

<table>
<thead>
<tr>
<th></th>
<th>North</th>
<th>East</th>
<th>Units</th>
<th>Scale Factor</th>
<th>Converg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC LA S</td>
<td>180,775.292</td>
<td>1,001,060.603</td>
<td>MT</td>
<td>0.99992831</td>
<td>+0 00 19.8</td>
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<tr>
<td>SPC LA S</td>
<td>593,093.60</td>
<td>3,284,313.00</td>
<td>sFT</td>
<td>0.99992831</td>
<td>+0 00 19.8</td>
</tr>
<tr>
<td>UTM 15</td>
<td>3,334,477.332</td>
<td>661,606.568</td>
<td>MT</td>
<td>0.99992222</td>
<td>+0 50 32.4</td>
</tr>
</tbody>
</table>

Elev Factor x Scale Factor = Combined Factor

SPC LA S
- 1.000000315 x 0.99992831 = 0.99993146

SPC LA S
- 1.000000315 x 0.99992222 = 0.99992537

SUPERSEDED SURVEY CONTROL

NAD 83(2007) - 30 07 51.21248(N) 091 19 20.37359(W) AD( ) 0

ELLIP H (02/10/07) -20.072 (m) GP( )

ELLIP H (06/20/00) -20.090 (m) GP( ) 3 1

NAD 83(1992) - 30 07 51.23112(N) 091 19 20.37006(W) AD( ) 1

NAD 83(1992) - 30 07 51.21235(N) 091 19 20.37230(W) AD( ) B

ELLIP H (09/10/92) -20.004 (m) GP( ) 4 1

NAVD 88 (08/12/94) 6.97 (m) 22.9 (f) LEVELING 3

NAVD 88 (02/14/94) 6.971 (m) 22.87 (f) ADJUSTED 1 1

NAVD 88 (09/10/92) 7.1 (m) GEOID90 model used GPS OBS

NGVD 29 (??/??/??) 7.003 (m) 22.98 (f) ADJUSTED 1 1

Superseded values are not recommended for survey control.

NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

See file dsdata.txt to determine how the superseded data were derived.

U.S. NATIONAL GRID SPATIAL ADDRESS: 15RXP6160634477(NAD 83)

MARKER: DV = VERTICAL CONTROL DISK

SETTING: 36 = SET IN A MASSIVE STRUCTURE

SP_SET: RIVER LOCK
Recap: The fundamental questions

• When was it done?
  – Publication completed on **June 30, 2012**
    • Intent: *Simultaneous with release of GEOID12A*

• How many control stations? **80,872**

• How much did the coordinates change?
  – Median: **1.9 cm horiz, 2.1 cm vertical**

• How accurate are the results?
  – Median: **0.9 cm horiz, 1.5 cm vertical**
    (at 95% confidence level)

• How do I make use of the results?
  – Key is **metadata**: Know and identify what you have
  – Be consistent (i.e., don’t mix realizations)
  – Understand your software (e.g., relationship to “WGS 84”)
    • Latest WGS 84 is G1674 (week of Feb 5, 2012), epoch 2005.00
Announcements

 NOTICE: NGS Update, September 4, 2012

GEOID12A Model Nearly Finalized
The National Geodetic Survey has modified the GEOID12A model on the NGS Beta website. After further analysis of the existing control data, we have modified several additional control points in Alabama, as well as a few points in Wisconsin. Click here for more information. NGS expects these points to be the final changes, however the GEOID12A model will continue to be posted on the NGS Beta website for any final comments until around September 10, 2012, after which we expect the model to be released for production.

 NOTICE: NGS Update, August 17, 2012

Revision of GPS Project Adjustment and Submission Process
NOAA's National Geodetic Survey (NGS) is revising the adjustment and submission process (i.e., "Bluebooking") for GPS projects. NGS asks users to wait until the revision is complete before submitting new projects using the NAD 83(2011/PA11/MA11) epoch 2010.00 realization and geoid model GEOID12A. We estimate the revision will be finalized by September 30, 2012. Please check the NGS website for updates and additional information.

The National Geodetic Survey Improves the National Spatial Reference System with Simultaneous Major Product Releases
In the first week of July, NOAA’s National Geodetic Survey (NGS) released the NAD 83(2011/PA11/MA11) epoch 2010.00 realization as part of an ongoing effort to produce new, high-quality spatial reference systems for use throughout the United States. The release included new national horizontal and vertical datums, new 3D coordinates for the geoid and the Earth's center of mass, new coordinates for the North American Datum of 1983 (NAD 83), and new first-order geodetic control points. The release also included new national height systems, new orthometric heights for the geoid and the Earth's center of mass, new heights for the NAD 83, and new orthometric height data for the central United States. These products are available for download at the NGS website.
Basic Concepts on Modeling

- Start with a gravimetric geoid (USGG2012)
- Use control data to fit to local datums
  - Appropriate versions of NAD 83
  - Respective local Vertical Datum (if one exists)
- Use LSC to determine correlated signal
- For complex areas (e.g., CONUS), use MMLSC
- Apply grid of correlated signal to USGG2012
- Results in GEOID12 with high frequency nature from USGG2012 but fit to local control
Hybrid Geoid Height Models (e.g., GEOID12), Gravimetric Geoid Height Models (e.g., USGG2012) and Conversion Surfaces using GPS on BM data

- **Gravimetric Geoid** systematic misfit to BM’s but best fits “true” heights
- **Hybrid Geoid** “converted” to fit local BM’s, so best fits NAVD 88 heights
- **Conversion Surface** model of systematic misfit derived from BM’s in IDB

-0.737 M in Salt Lake – 2009 model
## Control Data for GEOID12 Modeling

<table>
<thead>
<tr>
<th>Region</th>
<th>Reference Frame</th>
<th>Vertical Datum</th>
<th># GPSBM used (# Rejected)</th>
<th>#OPUSDB used (# Rejected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONUS</td>
<td>NAD 83 (2011)</td>
<td>NAVD 88</td>
<td>* 24,003 (868)</td>
<td>478 (258)</td>
</tr>
<tr>
<td>- VTDP Region</td>
<td>NAD 83 (2011)</td>
<td>NAVD 88/VTDP</td>
<td>357 (153)</td>
<td>1 (17)</td>
</tr>
<tr>
<td>Alaska</td>
<td>NAD 83 (2011)</td>
<td>NAVD 88</td>
<td>** 105 (4)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>NAD 83 (2011)</td>
<td>PRVD 02</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>U.S. Virgin Islands</td>
<td>NAD 83 (2011)</td>
<td>VIVD 09</td>
<td>21 (3)</td>
<td>0</td>
</tr>
<tr>
<td>Hawaii</td>
<td>NAD 83 (PA11)</td>
<td>Geoid ($W_0$)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>American Samoa</td>
<td>NAD 83 (PA11)</td>
<td>ASVD 02</td>
<td>19 (3)</td>
<td>0</td>
</tr>
<tr>
<td>Guam</td>
<td>NAD 83 (MA11)</td>
<td>GUVD 04</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>CNMI</td>
<td>NAD 83 (MA11)</td>
<td>NMVD 03</td>
<td>55</td>
<td>0</td>
</tr>
</tbody>
</table>

* Supplemented by 574 (5 rejected) in Canada and 674 (70 rejected) in Mexico
** Supplemented by 88 (2 rejected) in Canada

Ellipsoid Height Changes (NA2011-NA2007)
Distribution of OPUSDBBM12
Distribution of OPUSDBBM12
An additional 6,000 points?
GEOID12 Error Map for Southwest

Triangles show locations of GPSBM2012 & OPUSDBBM12 control points.

Error increases based on the size of the gap.

Dense coverage yields < 1 cm.

Errors will be provided with GEOID12 hts. %
So ... What Went Wrong?

• Erroneous Data
  – VTDP exclusion region – what’s in/out? (MS, LA)
  – Transposed numbers (AL)
  – Recent adjustment and superseding data (WI)
  – Miscoded error flags (Canada)
  – Judgment call – keep or reject? (OK)

• Miscommunication/Misunderstanding
  – No-check GPS: NGSIDB vs. OPUS-DB (TX)
  – Hybrid to use minimal number of points (LA)
What Went Wrong: A Picture’s Worth a 1000 Words
What Went Right?

• Big changes in Alexandria, LA & Meridian, MS were reported shortly after GEOID12’s release
• These were quickly checked and GEOID12 was found to be consistent with the control data
• The control data (GPSBM2012) were then re-checked and a number of errors detected
• Notices went up quickly & GEOID12 pulled
• A new SOP was developed for a more public vetting of the final product (Beta release)
There are Valid Big Changes

Ignore changes outside CONUS

VTDP region does see 50 cm change

Can see the effect of 3″-5’ RTM in the mountains

200-400 km features are due to GOCE in USGG2012
Coming Soon: Error Maps ...

GEOID03 made using a Cholesky Decomposition

Rigorous LSC was used in GEOID12A

This ensured we had a var-cov matrix to estimate errors on a regular grid

This means errors can be provided with geoid heights

Mean=4.28
STD=1.53
Max=6.32
Min=0.00
One of the main factors affecting errors is distance to control.

This plot will provide the distance to the closest point.

This provides an estimate of interpolation error impact.

Minimum Distance to Control Data

Mean=60
STD=78
Max=1050
Min=0.006
# of points =5,673,708
Summary

- GEOID12 is complete for all regions
- It converts between NAD 83 (**11) and the local vertical datum (NAVD 88 in CONUS)
- Modeling is much the same as before (MMLSC)
- Incorporation of data in Mexico and OPUSDBBm12 is new and has had an impact
- Error maps will be available to provide estimated errors along with geoid heights
Near Term Goals

- DEFLEC12A (made from GEOID12A)
- USDOV2012 (made from USGG2012)
- Error and interpolation grids
  - Online interpolation geodetic tool
  - OPUS results
- Updates to FAQ and Technical Details
- Paper, likely on GEOID09, USGG2012, GEOID12 & GEOID12A
Questions?

NAD 83(2011/PA11/MA11) epoch 2010.00