USGG2009 & GEOID09: New geoid height models for surveying/GIS

ACSM-MARLS-UCLS-WFPS Conference 2009

20 FEB 2009 Salt Lake City, UT

Work Shop Outline

- Gravimetric Geoid Development
  - 60 minute presentation
  - 30 minute break and Q&A period
- **Hybrid Geoid Development**
  - 60 minute presentation
  - 30 minute break and Q&A period
- Summary and Outlook
  - 30 minute presentation
  - 30 minute break and Q&A period

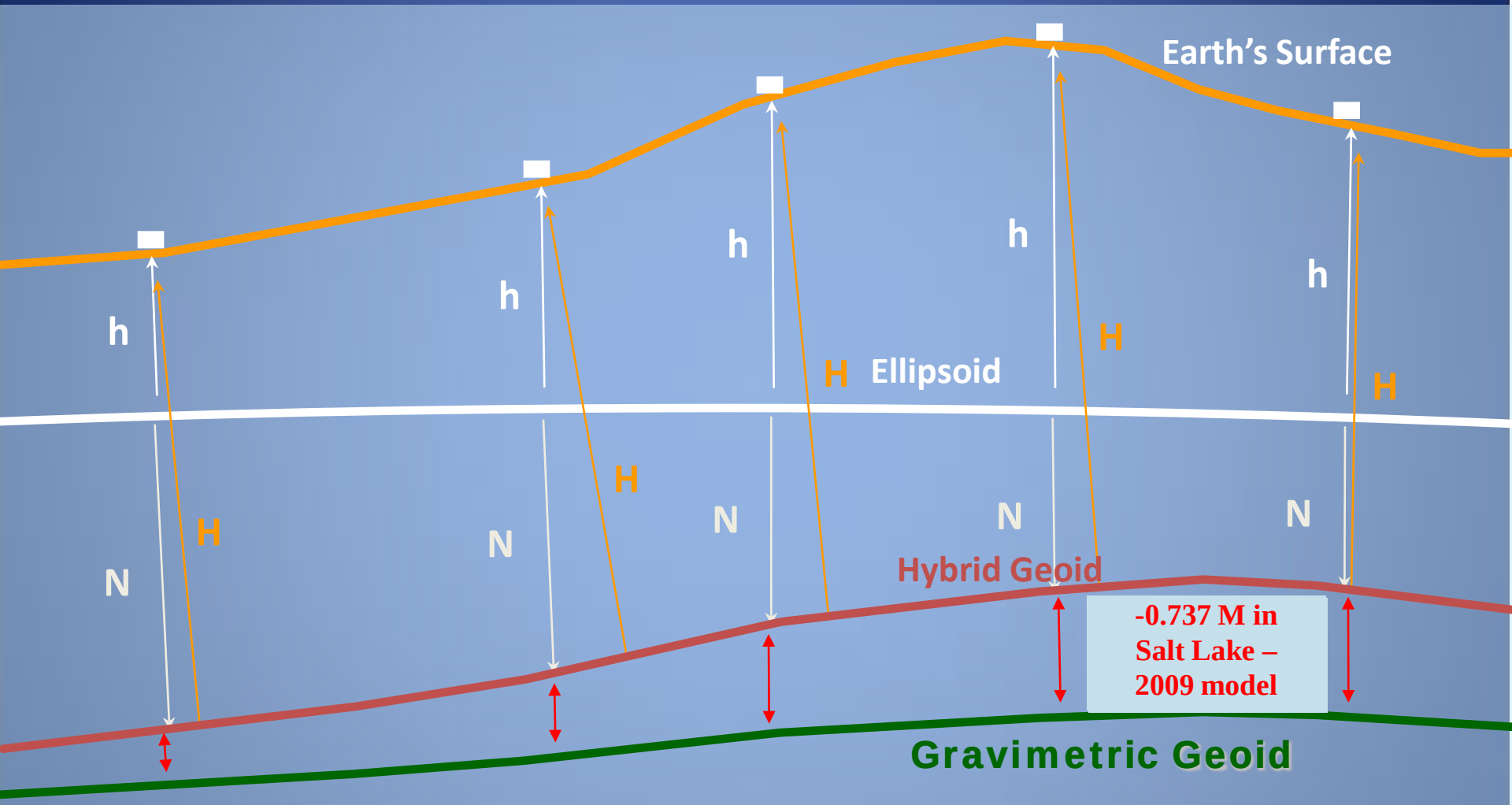
Hybrid Geoid Development

- Background
- Hybrid Geoid Methodology
- NRA 2007 versus NAD 83 (NSRS2007)
- GPS on BM
- The Beta GEOID09 Model
- Final GEOID09

Background

- Hybrid geoid height models (GEOIDxx) are most useful for direct conversion between NAD 83 and NAVD 88
- They are developed from an underlying gravimetric geoid height model and GPSBM's
- The GPSBM's represent the *current* ellipsoidal and orthometric heights in the NGSIDB
- As the values in the NGSIDB are updated, so must the geoid height models

Hybrid Geoid Height Models (e.g., GEOID09), Gravimetric Geoid Height Models (e.g., USGG2009) and Conversion Surfaces using GPS on BM data

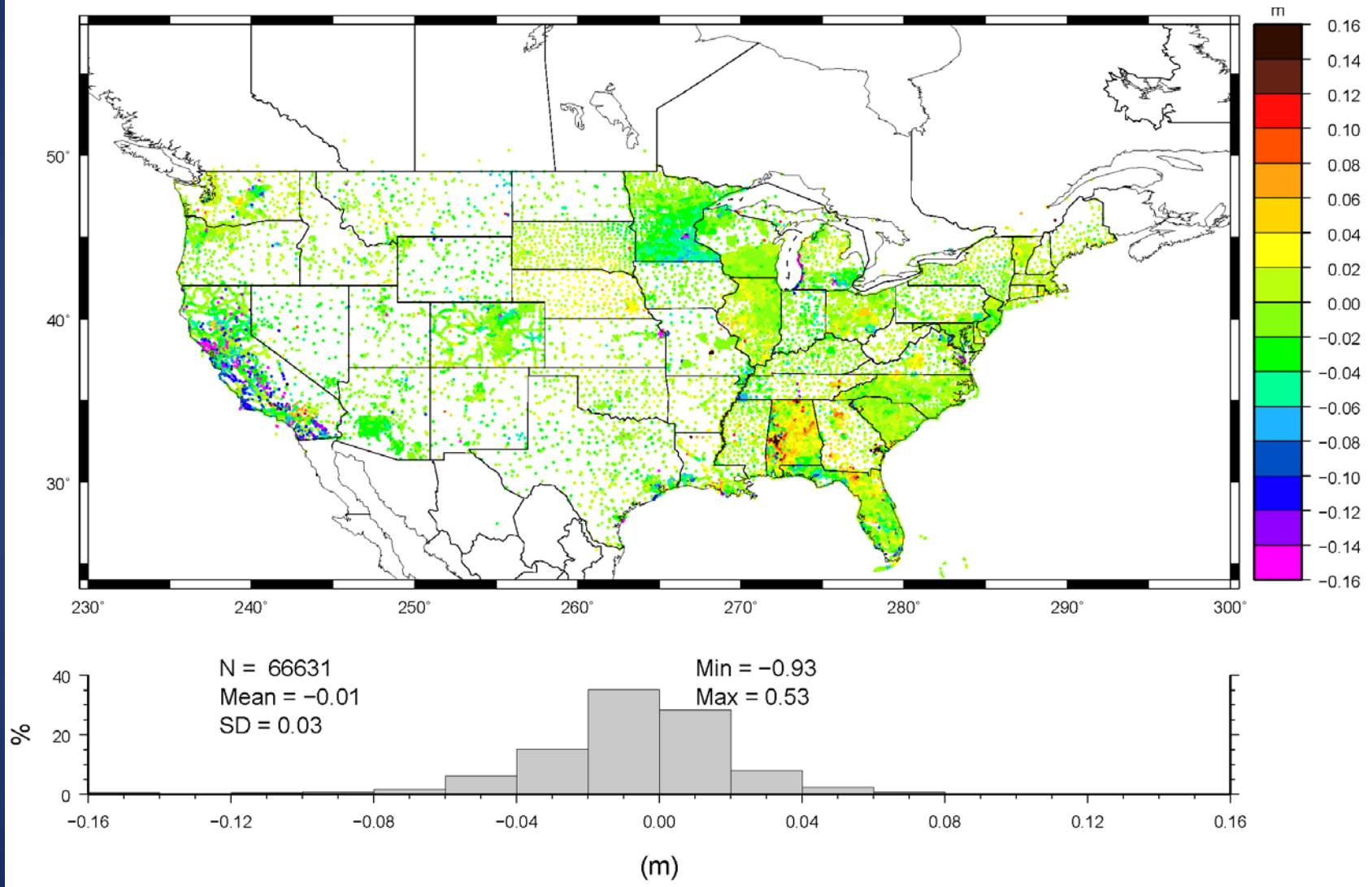


- Gravimetric Geoid systematic misfit to BM's but best fits "true" heights
- Hybrid Geoid "converted" to fit local BM's, so best fits NAVD 88 heights
- Conversion Surface model of systematic misfit derived from BM's in IDB

NRA2007 Development Timeline

- NRA2007 was processed and the NAD 83 (NSRS2007) reference frame developed
- After NRA2007 started, any projects were adjusted into older HARN's (group A)
- Then the NRA2007 values posted in NAD 83 (NSRS2007) with height errors (group B)
- Subsequent projects were adjusted into NAD 83 (NSRS2007) without errors (group C)

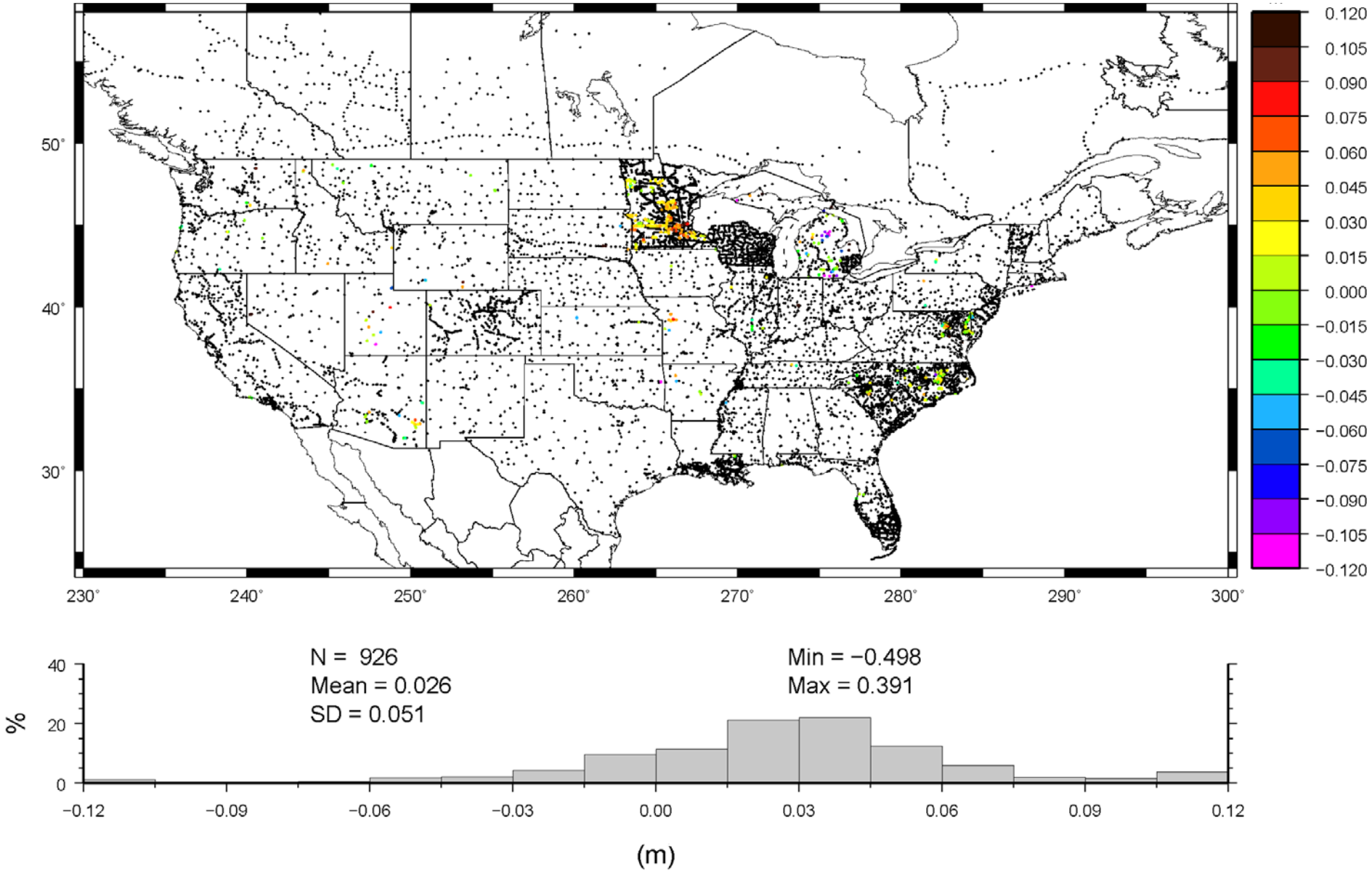
Vertical Shift due the National Readjustment of 2007

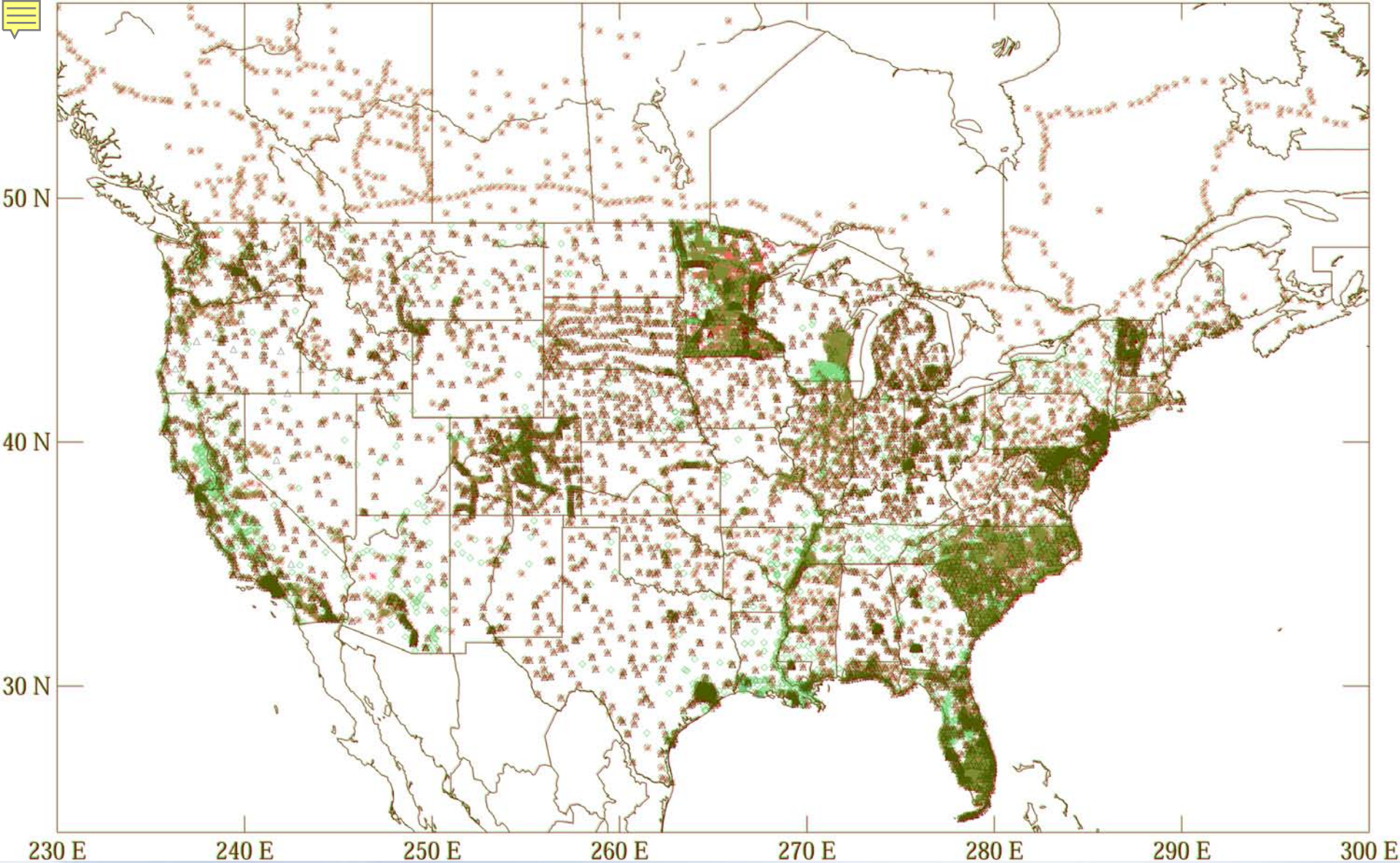


Consequences for Extracting GPSBM2009

- A delay has been instituted in development of the final GEOID09 models (around April/May)
- This permits readjustment of projects adjusted to the HARN's (i.e., group A) and adjustment of projects in the pipeline
- It also permits continued (spirited) debate on what data should or should not be included
- Current guidance is posted on website
- Essentially test new data against Beta-GEOID09, which was developed using groups B & C
- Models will be created wherever a local vertical datum has been established (NAVD 88, PRVD 02, GUVD 04, NMVD 03, and ASVD 04)

(Beta) GPSBM 2009 for CONUS





GGPSBM1999: 6,169 total 0 Canada STDEV 9.2 cm (2σ)

GGPSBM2003: 14,185 total 579 Canada STDEV 4.8 cm (2 σ)

GPSBM2007: 18,609 total 579 Canada STDEV 5.8 cm (2 σ)

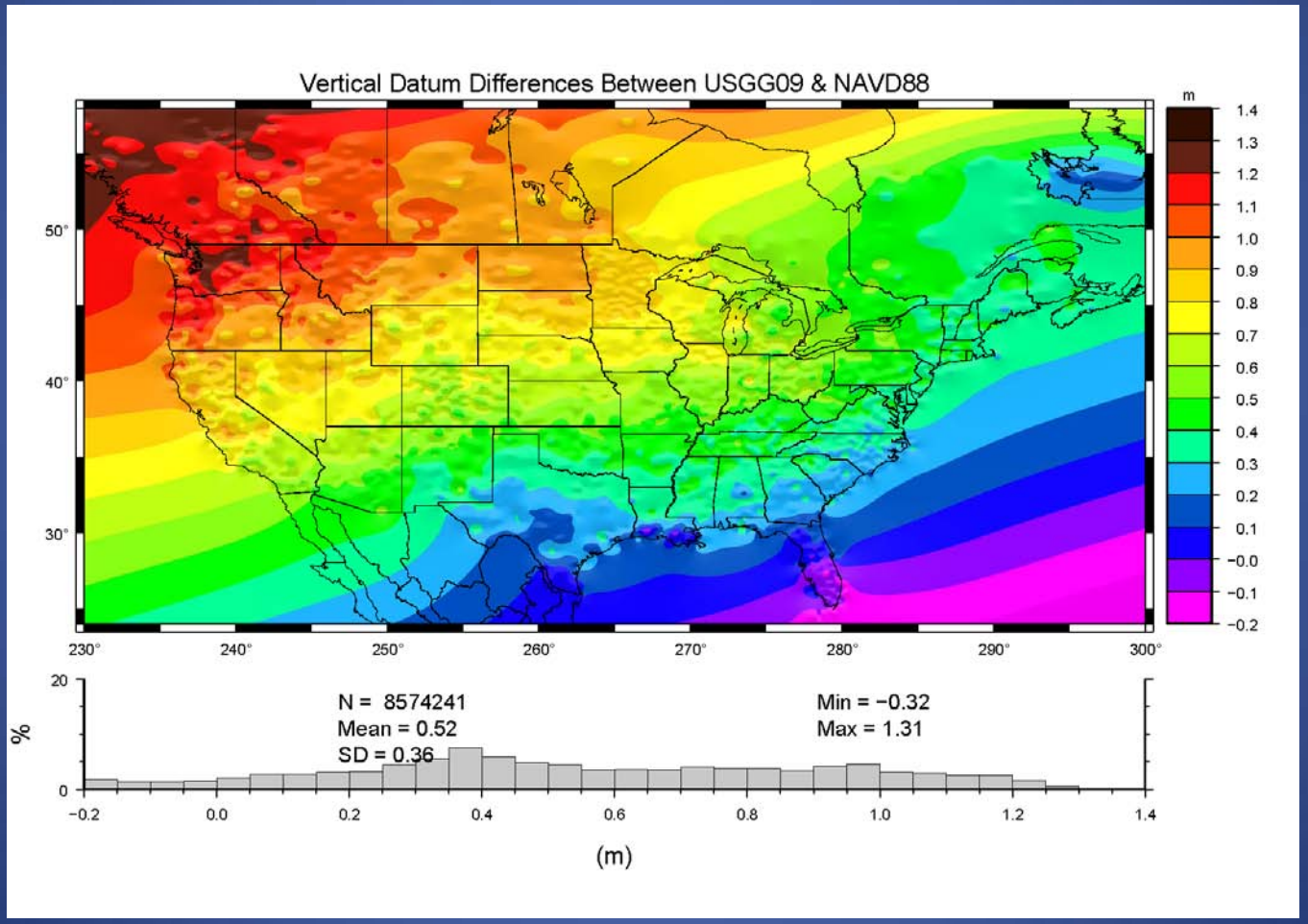
Comparison Between GPSBM2009, USGG2009, and GEOID09

ST	No. Pts.	σ_h cm	USGG2009		GEOID09	
			Ave.	SD	Ave.	SD
	53	1.3	-40.0	5.5	0.1	2.3
AZ	153	0.8	-62.0	7.4	0.0	1.6
AR	58	1.2	-49.2	3.2	0.0	0.8
CA	557	2.7	-83.2	12.2	0.0	2.3
CO	459	1.1	-69.2	8.1	0.0	2.8
CT	8	1.7	-41.3	4.0	-0.1	1.6
DE	20	2.5	-40.3	4.2	0.2	2.5
DC	16	0.6	-44.6	2.0	-0.2	2.0
FL	1413	1.6	-5.8	7.7	0.0	1.5
GA	95	1.2	-33.9	6.4	0.0	1.0
ID	87	1.4	-101.7	7.9	0.0	1.5
IL	266	1.1	-68.7	8.3	0.1	1.2
IN	113	1.1	-60.7	6.3	-0.1	2.0
IA	73	1.0	-77.4	4.9	0.0	0.8
KS	94	1.0	-65.9	5.3	0.0	1.2
KY	97	1.6	-50.2	4.1	-0.1	1.7
LA	343	1.0	-22.2	8.9	0.0	0.6
ME	57	0.9	-39.8	4.6	0.0	0.9
MD	186	0.8	-43.2	2.9	0.0	1.9
MA	30	1.1	-40.7	3.5	0.0	1.1
MI	199	2.0	-64.5	7.2	0.1	1.7
MN	2943	0.4	-87.3	3.6	0.0	1.0
MS	104	1.7	-44.8	4.3	0.0	1.6
MO	96	0.9	-58.7	5.3	0.0	1.1
MT	150	2.2	-101.3	8.7	0.0	1.7

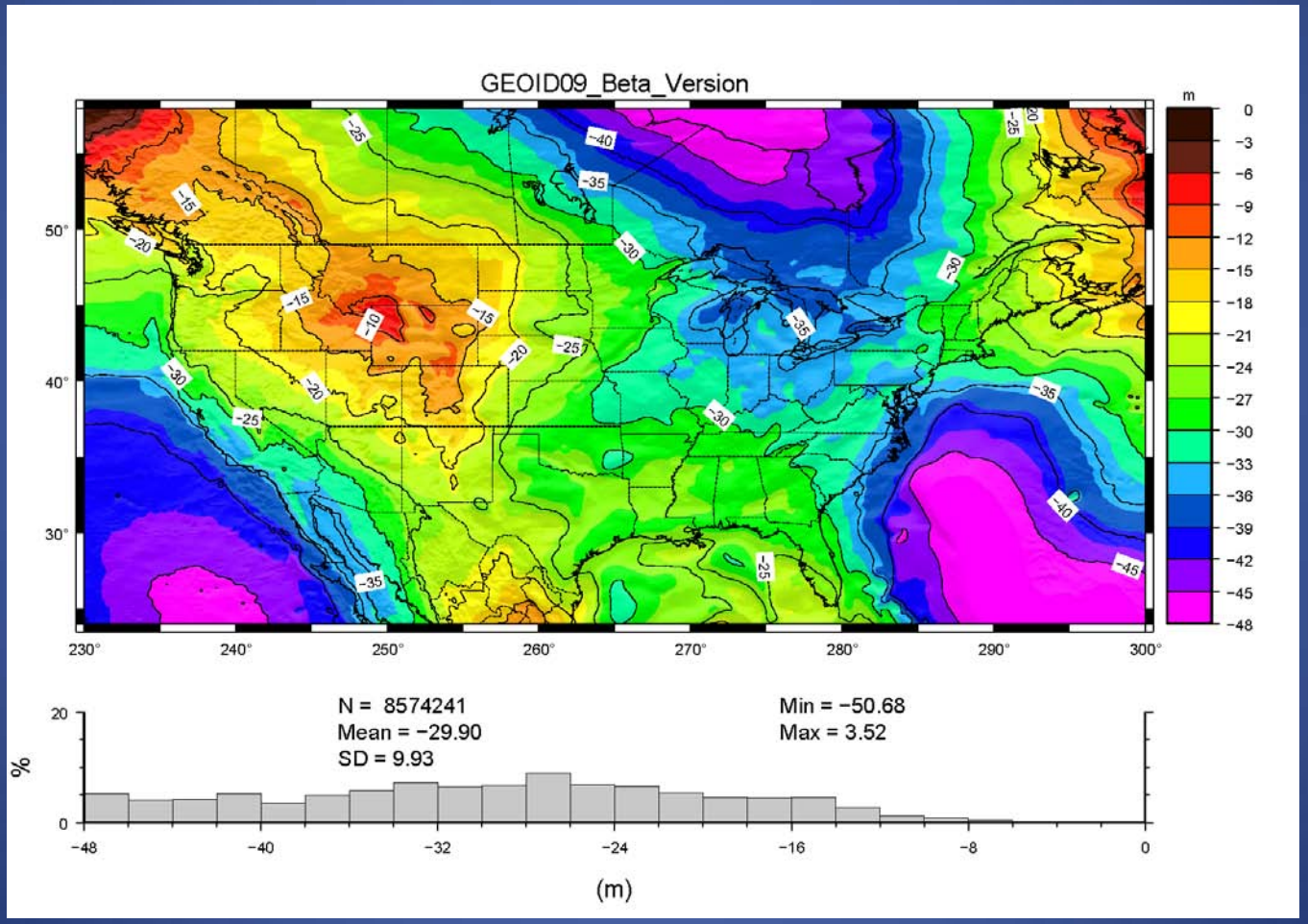
ST	No. Pts.	σ_h cm	USGG2009		GEOID09	
			Ave.	SD	Ave.	SD
NE	119	0.6	-75.8	4.4	-0.1	0.8
NV	64	1.0	-82.8	8.0	0.1	1.4
NH	13	1.5	-41.6	2.9	-0.2	1.3
NJ	198	0.4	-42.9	2.7	0.0	1.1
NM	89	1.0	-51.3	8.9	0.0	1.4
NY	105	1.2	-46.4	6.9	0.0	1.4
NC	1231	0.8	-35.8	5.2	0.0	1.7
ND	41	0.7	-97.7	3.4	0.2	0.8
OH	191	1.4	-60.4	5.0	0.0	2.0
OK	71	1.4	-51.8	5.4	0.0	1.0
OR	163	0.9	-108.7	8.5	0.0	1.4
PA	80	0.7	-49.8	4.1	0.0	1.1
RI	15	0.9	-42.9	1.7	0.0	1.4
SC	663	1.0	-38.1	6.2	0.0	1.1
SD	172	1.1	-84.7	5.9	0.1	0.9
TN	248	1.1	-49.9	3.7	0.0	1.9
TX	188	1.4	-36.8	8.1	0.0	2.4
UT	37	0.8	-79.8	9.1	0.1	2.1
VT	279	1.0	-42.1	4.3	0.0	1.3
VA	190	1.0	-41.6	4.5	0.0	1.8
WA	183	1.3	-116.4	8.2	0.0	1.9
WV	41	1.2	-51.3	4.8	0.1	1.9
WI	551	0.3	-73.3	3.4	0.0	0.7
WY	89	2.2	-84.1	9.3	0.0	2.6
all	12961	1.2	-58.5	6.3	0.0	1.5

Units in cm

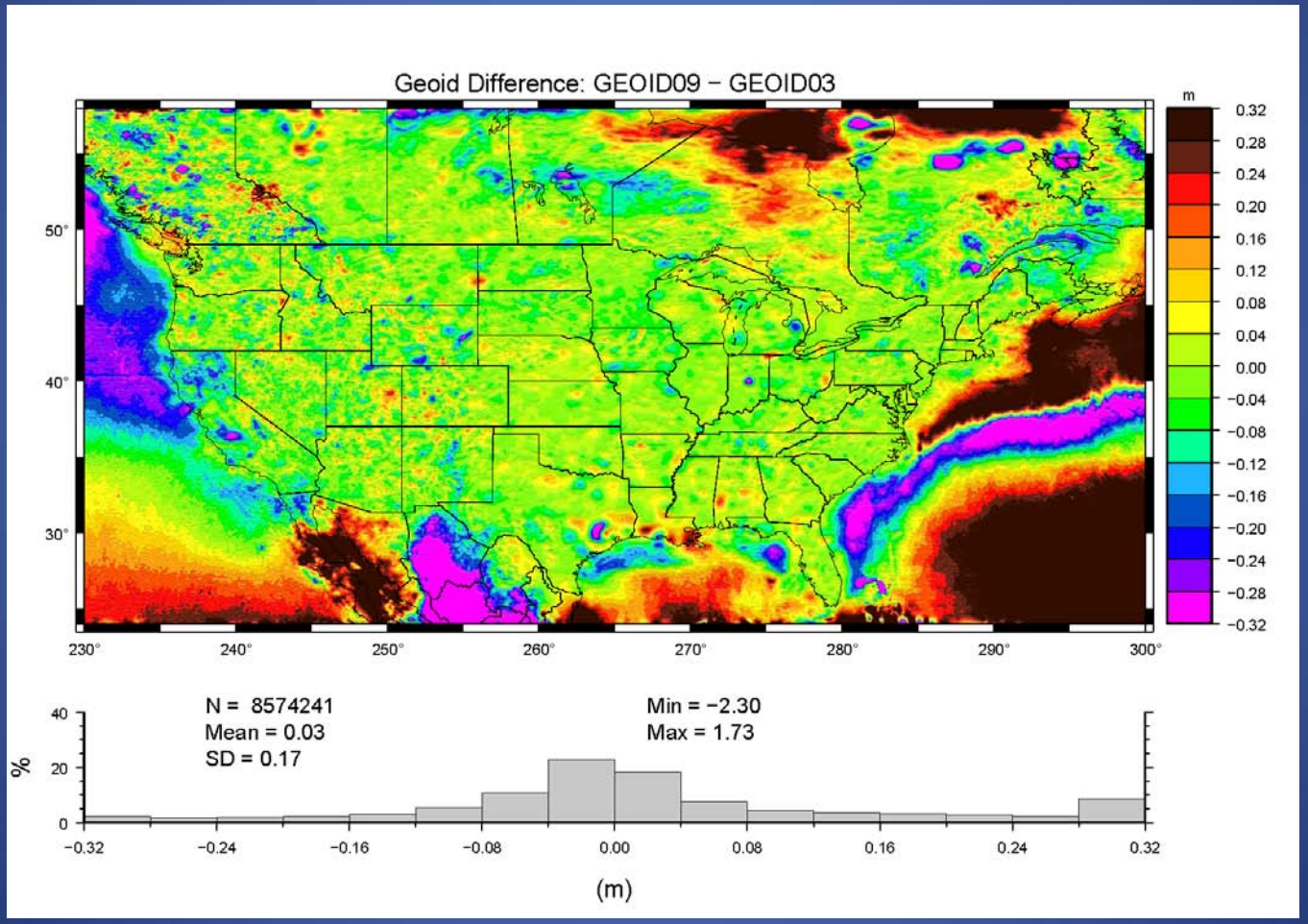
Conversion Surface for Beta-GEOID09



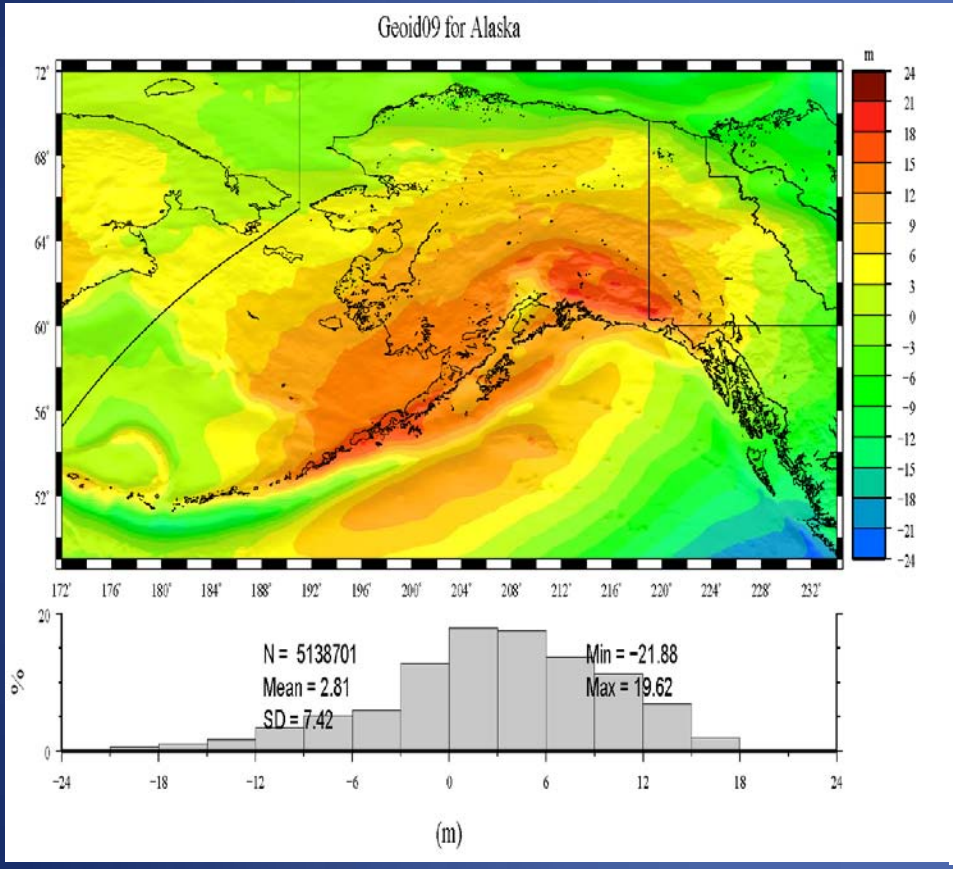
GEOID09 (Beta)

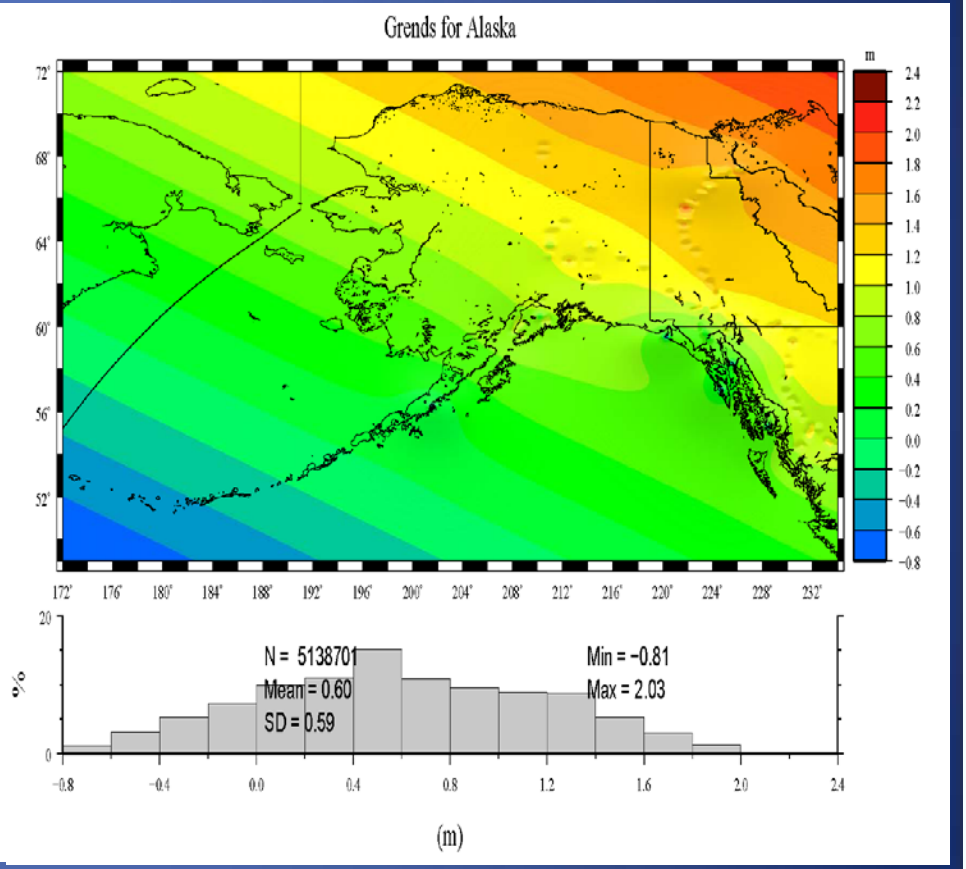


GEOID09-GEOID03 Differences

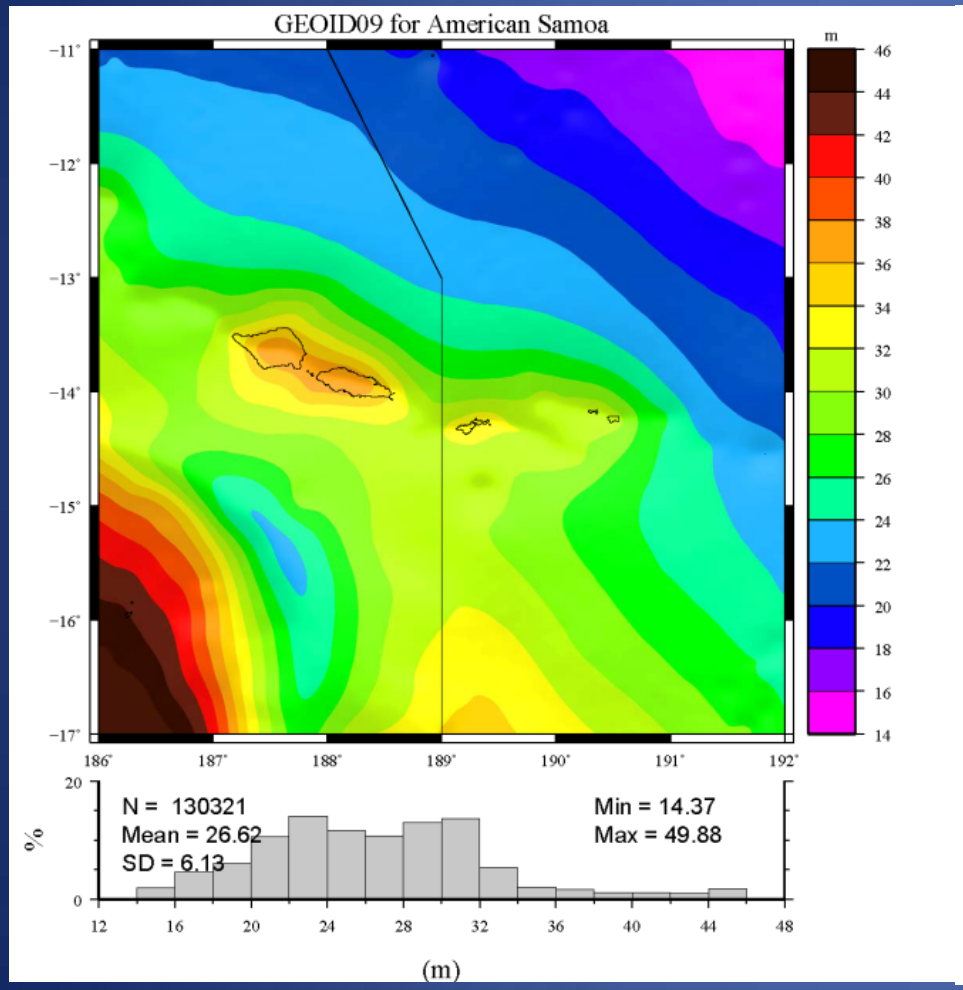


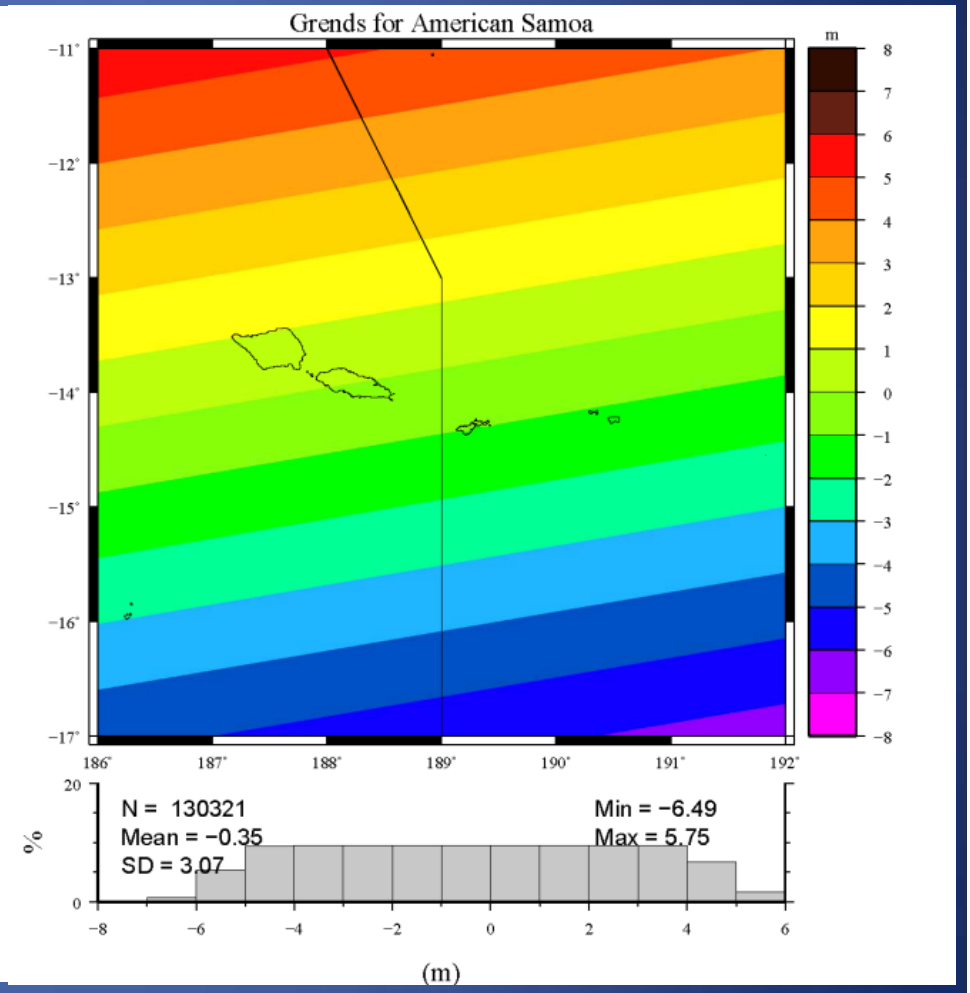
Alaska


Geoid09 for Alaska
m
N = 5138701
Mean = 2.81
SD = 7.42
Min = −21.88
Max = 19.62
%
(m)

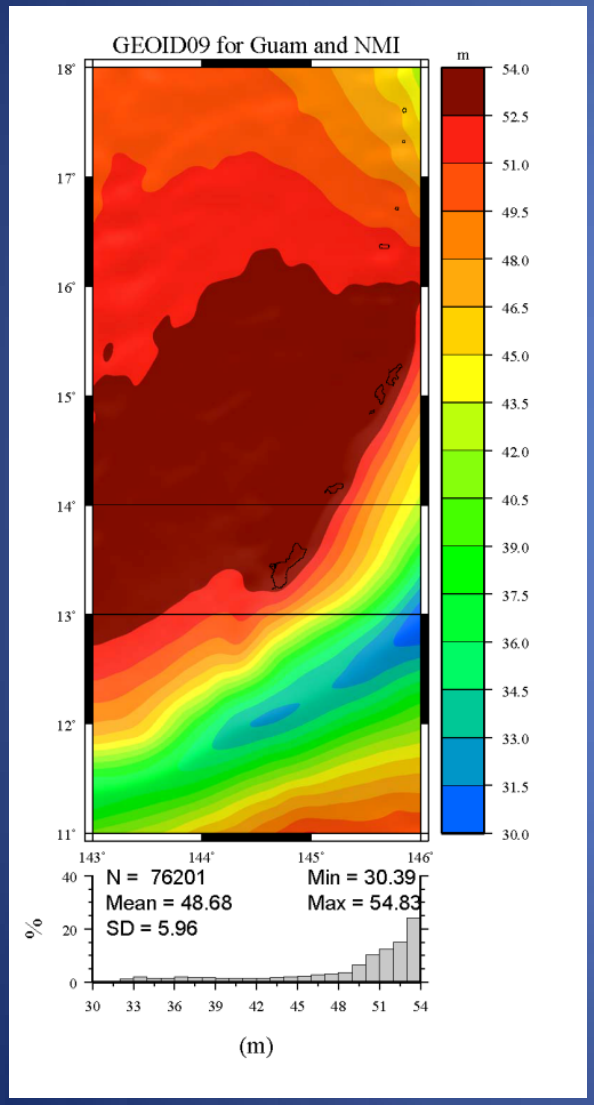

Grends for Alaska
m
N = 5138701
Mean = 0.60
SD = 0.59
Min = −0.81
Max = 2.03
%
(m)

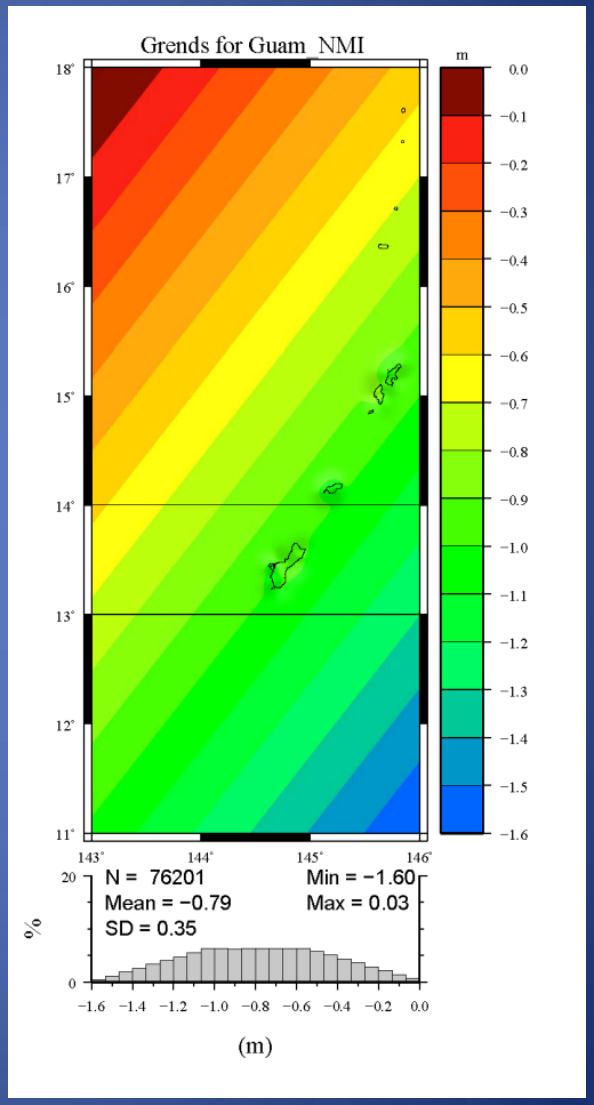
American Samoa



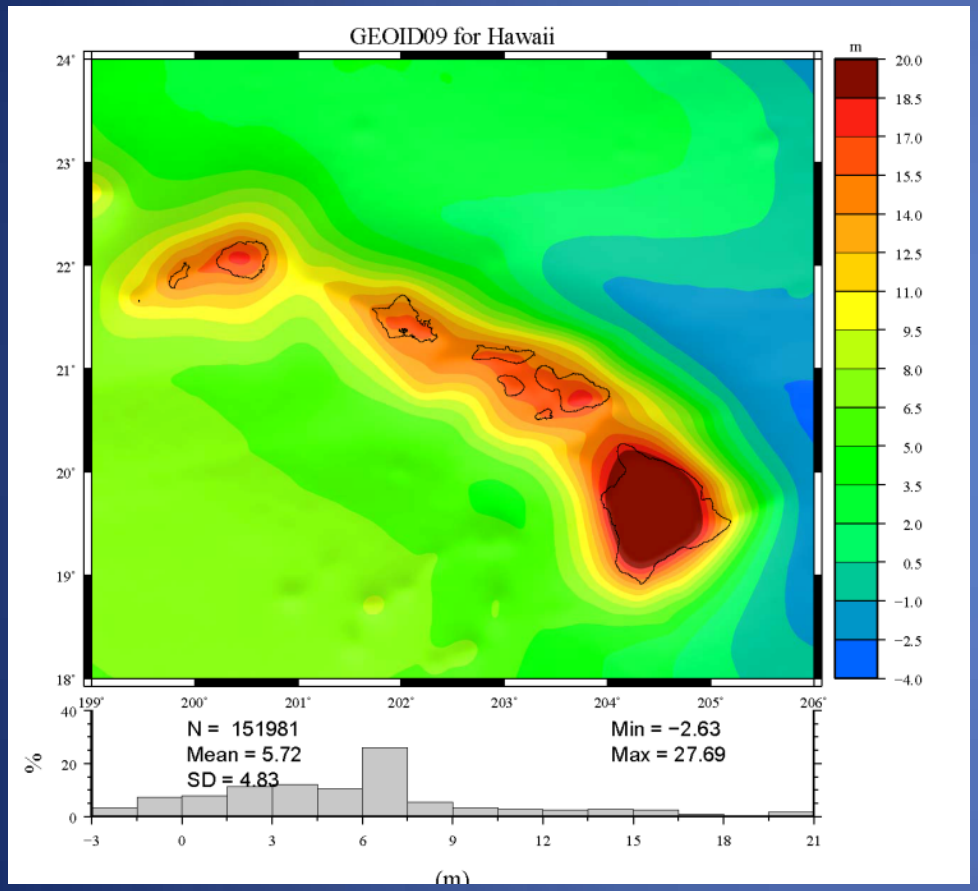


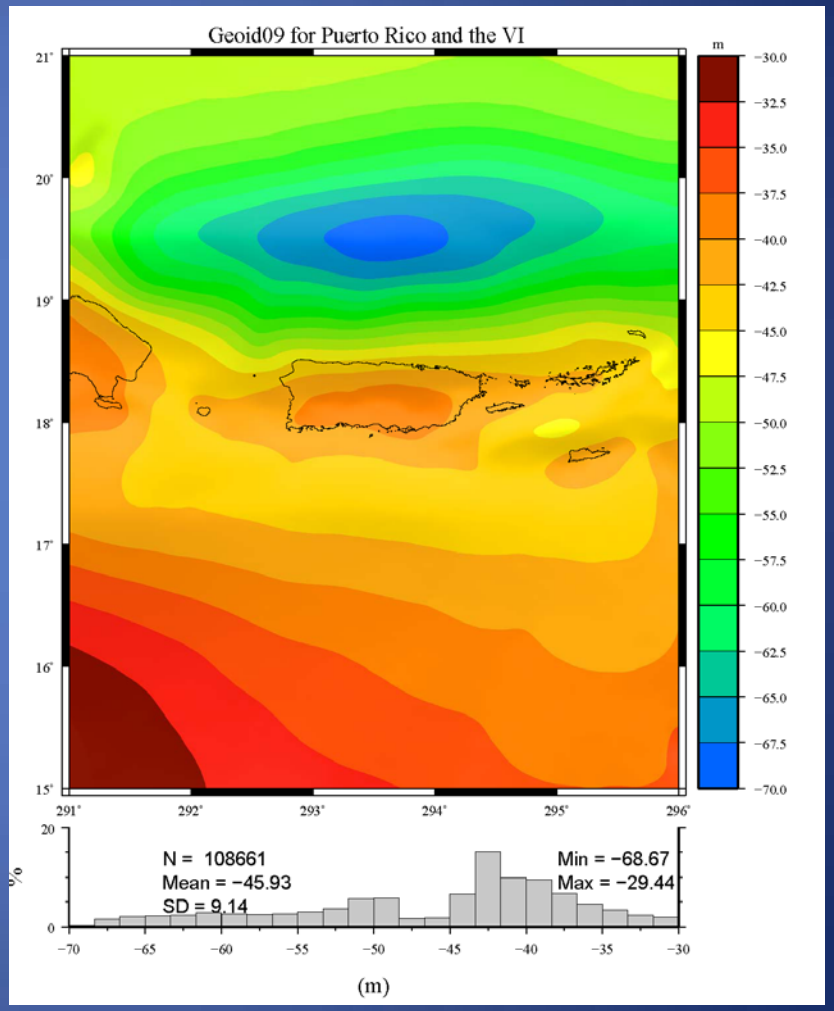
Guam and the CNMI





Hawaii and Puerto Rico/USVI





Final GEOID09 Models

- About April, the group A (adjusted to HARN's) should be readjusted into NAD 83 (NSRS2007)
- Error estimates should be available for all data
- Inputs will have been received for addition and deletions to the Beta-GPSBM2009 set
- A separate file will be posted on the website showing the current, and eventually final, data
- Models for all regions should be done in May

Special Note Regarding Puerto Rico and the U.S. Virgin Islands

- Originally, a new gravimetric geoid based vertical datum was planned for the USVI
- However, a decision was recently made to adopt a Virgin Islands Vertical Datum 2009 (VIVID09)
- VIVD09 will be based on the TBM's
- Hence, no delay is expected in the production of final models for PR/VI
- Airborne data as a part of GRAV-D will be used to assess the quality of the datum after the fact

Summary for GEOID09

- Significant changes result from underlying gravimetric geoid (USGG2009) and GPSBM's
- New regions have been added tied to their respective vertical datums
- Largely the same techniques have been used (MMLSC)
- This last includes multiple correlation lengths to preclude the loss of fidelity that happened from GEOID99 and GEOID03 in select western states
- Use of the ellipsoid height errors are instrumental in quantifying the model development
- In the future, they will be necessary for potential error propagation
- Models should be available for production in May