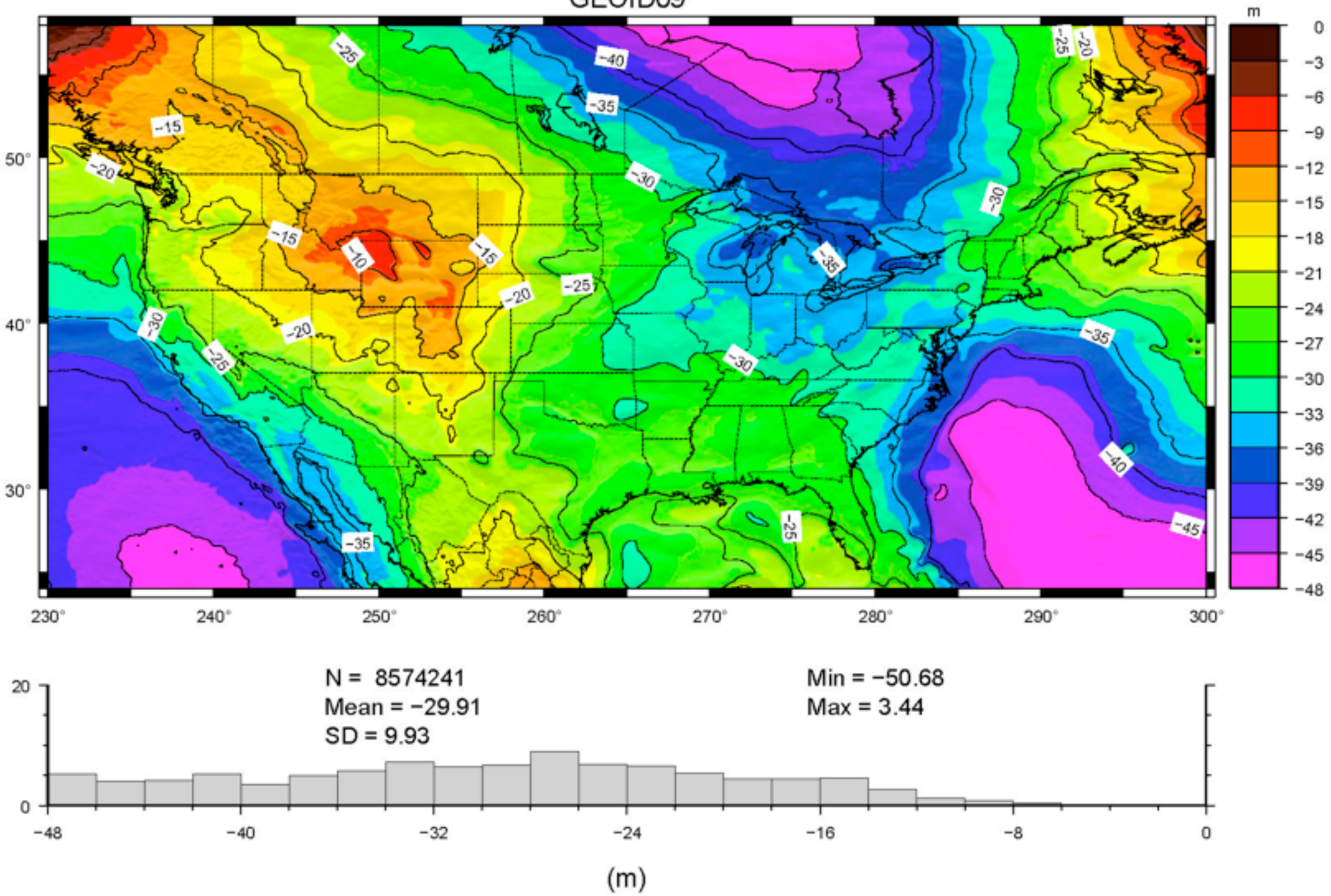
Class 19: The Geoid

GISC-3325 - 2010

GEOID09


m
0
-3
-6
-9
-12
-15
-18
-21
-24
-27
-30
-33
-36
-39
-42
-45
-48
50°
40°
30°
230°
240°
250°
260°
270°
280°
290°
300°
-25
-40
-35
-30
-15
-20
-10
-45

N = 8574241
Mean = −29.91
SD = 9.93
Min = −50.68
Max = 3.44
20
0
−48
−40
−32
−24
−16
−8
0
(m)

The National Geodetic Survey (NGS) has been developing gravimetric geoid models for nearly two decades starting with GEOID90 (Milbert, 1991; Smith and Milbert, 1999; Smith and Roman, 2001; Roman et al 2004). Since 1996, these models have been combined with GPS/leveling information to create hybrid geoid height models. These models use the control data available in the NGS database at the time of their creation. The control data consist of bench marks where both the GPS-derived NAD 83 ellipsoidal height and leveled NAVD 88 orthometric height are known, and are called "GPSBM" data. The difference between these two heights provides an estimate of the separation between NAD 83 and NAVD 88 at that location.

Since these points are insufficient in coverage to develop a model of the NAD 83-NAVD 88 separation across the country, the gravimetric geoid model is used as a base and the control data used to warp the gravimetric geoid to fit between the two datums. This takes place by removing an interpolated gravimetric geoid height (N) from the GPSBM-derived geoid height (ellipsoidal height (h) - orthometric height (H)):

$$\text{residual} = (h - H) - N$$

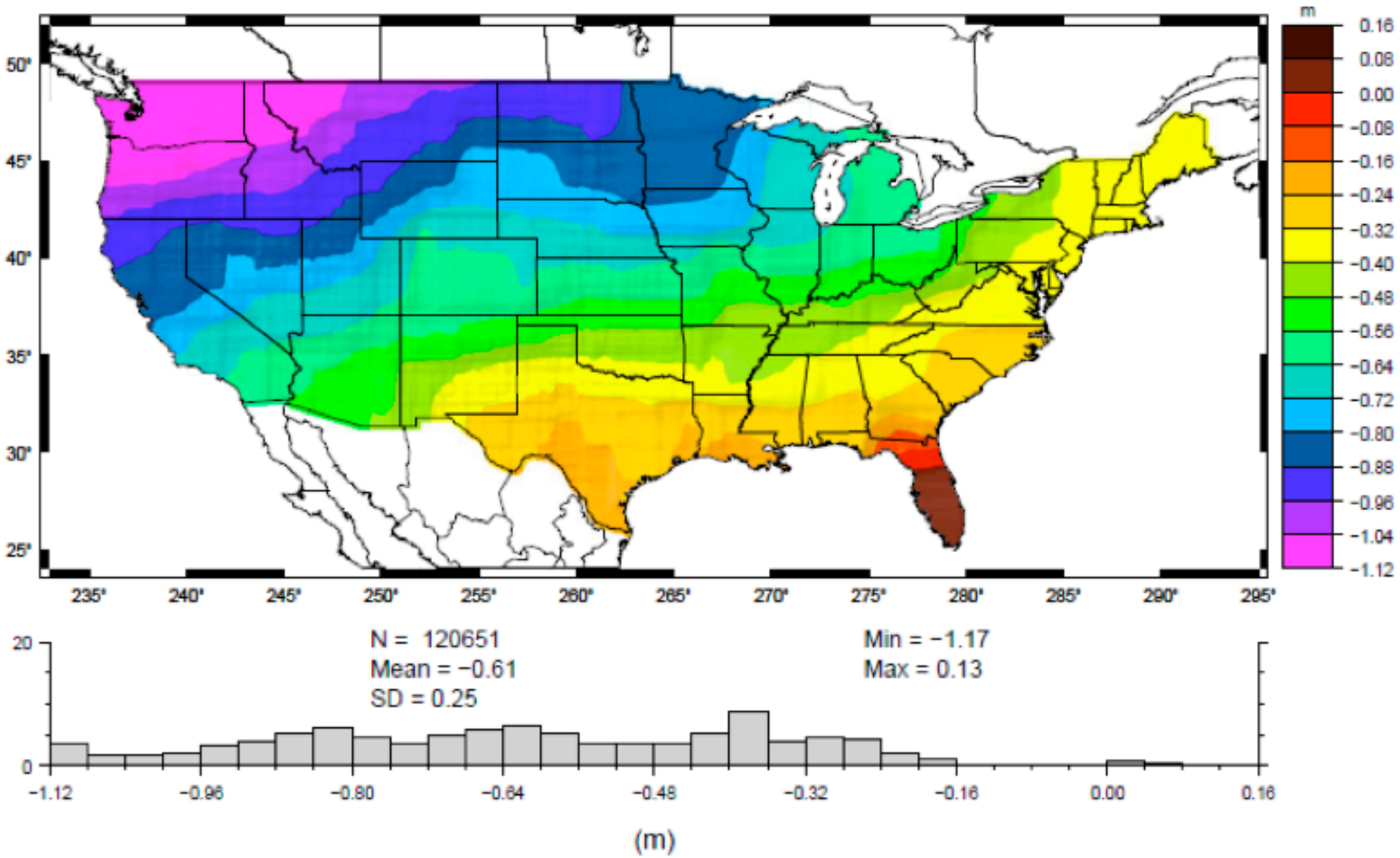
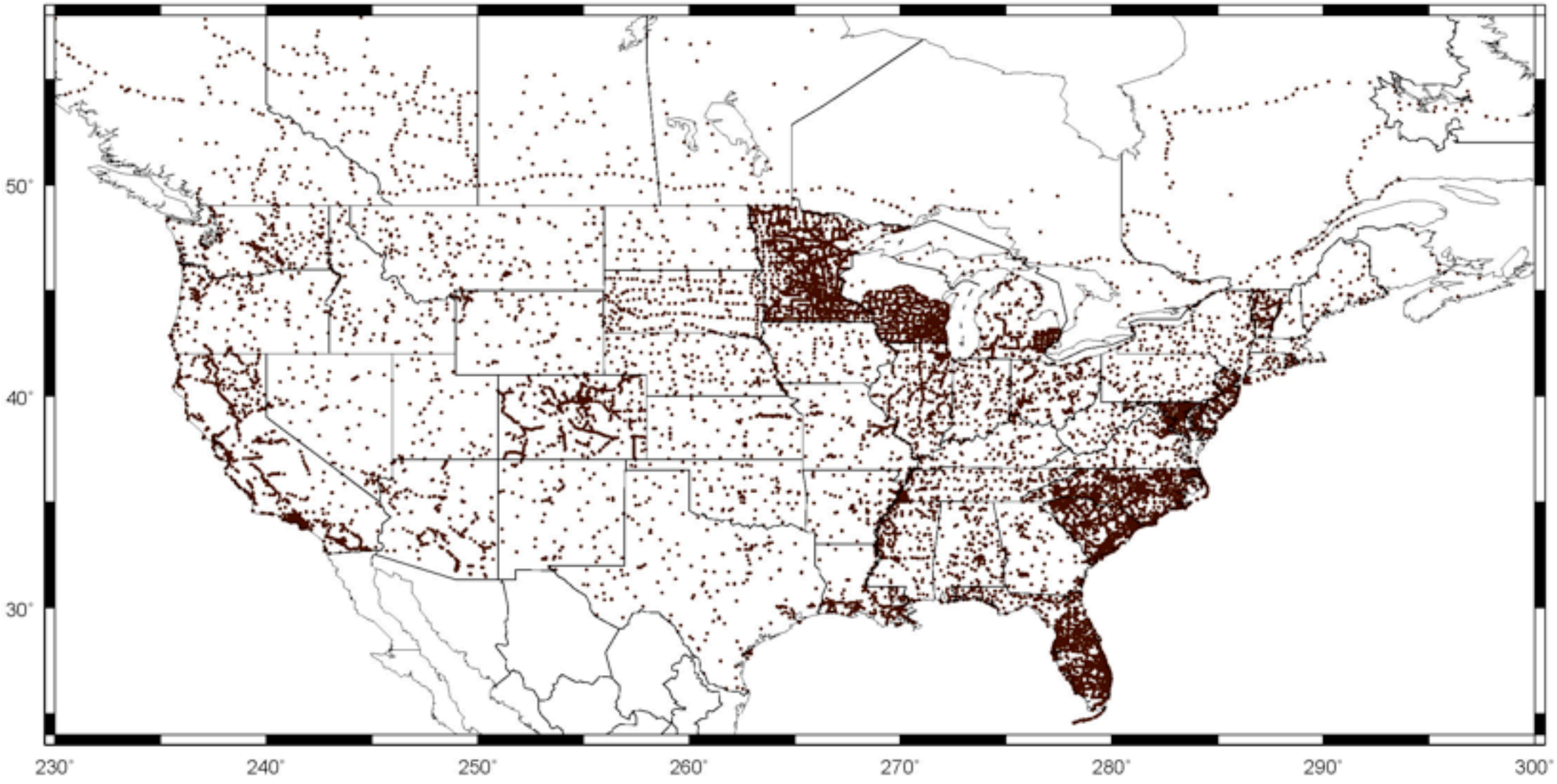
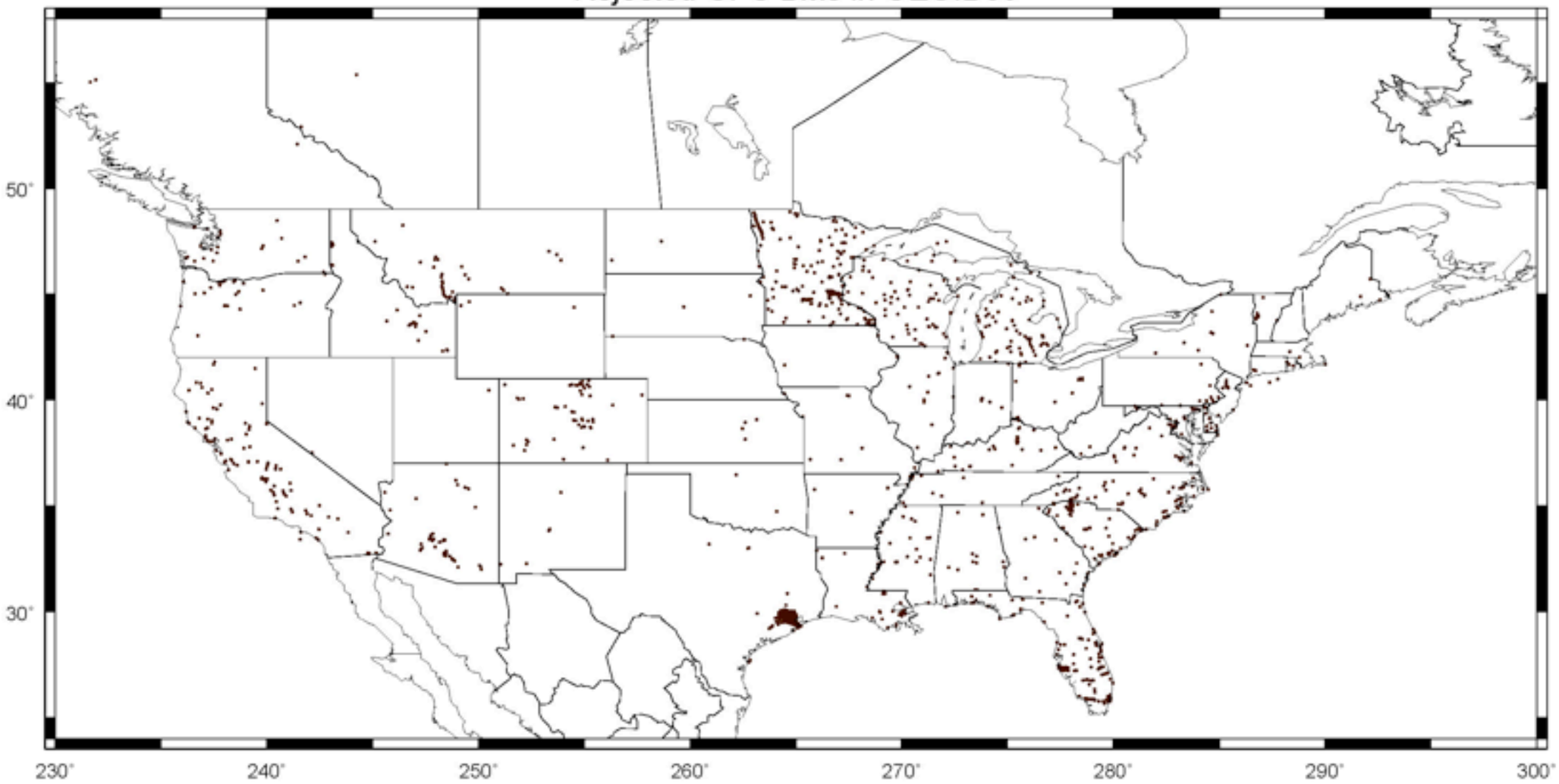


Figure 1: The long wavelength errors of NAVD 88 as determined from comparison to GRACE gravity field data.

GPS BMs for GEOID09



Rejected GPS BMs in GEOID09



Thursday, March 25, 2010

J 1037	30040803880N093475243184W	-24205	3216	H	88	00TXBK1760	1.23	1.13	-.03851719	2.88			BP
HGCSD 26	29472725298N095351150280W	-145	27308	H	88	00TXAW5604	0.11	0.12	-.00032385	0.38	S		BP
ADDICKS 1795 CORS L1 PHS CTR	29472747141N095351104249W	4124	31568	H	88	00TXAA9862	0.10	0.08	.07305092	0.41	S		BP
LBB B3	33391908290N101492787318W	966666	991750	H	88	00TXAB6602	0.11	0.08	.09165896	1.29			BP
HGCSD OFFICE POLE ARP	29321900956N095090801627W	-15861	11098	H	88	11TXAB7501				0.00		N	BP
ADDICKS 1795 CORS ARP	29472747165N095351104299W	4097	31498	H	88	00TXAJ6426	0.03	0.03	.04015739	0.07		N	BP
JCAD	30034224191N094135997698W	-16829	10643	H	88	00TXAJ8220	0.45	0.48	.23520740	1.10			BP
AFW B	32583294064N097184889272W	174076	201790	H	88	00TXCS3405	0.32	0.30	.05722020	0.62			BS
AFW D	32591657721N097185886948W	182565	210260	H	88	00TXCS3406	0.31	0.29	.06013878	0.60			BS
REALITOS NORTH BASE	27280313569N098295681250W	104218	129710	H	88	00TXAJ1515	0.79	1.23	.31963559	2.55			BS
A 285	31402959352N098080721127W	353149	379851	A	88	00TXCA0068	0.84	0.77	.35923322	1.23			NP
X 1419	31103445610N099190879304W	530005	553597	A	88	00TXCA0807	0.67	0.68	.63001871	0.81			NP
J 1473	31412526910N098490484339W	432507	458373	A	88	00TXCA0917	0.20	0.20	.12429720	1.67			NP
ARP MAF	31561984611N102120938434W	844802	869143	A	88	00TXCC0029	0.79	0.70	-.13063266	1.58			NP
V 285 RESET	31065780116N098113537637W	337581	363244	A	88	00TXCA0144	1.01	0.80	.31193889	1.47			NP
N 1099	29220599773N100551479782W	279648	302372	A	88	00TXAZ0115	0.79	1.04	-.16474614	1.60			NP
L 1099	29221141830N100550637580W	279507	302228	A	88	00TXAZ0113	0.54	0.81	-.22215700	1.51			NP
B 1148	29534147228N095034878960W	-13454	13920	A	88	00TXAW0400	14.25	12.14	-.11920046	14.06	hS		NP
DAVIS RM 1	29441189569N095013944271W	-20397	6856	A	88	00TXAW0956	0.61	0.52	.04342296	2.59	S		NP
E 1212	29342762707N095463145529W	3160	30434	A	88	00TXAW4733	6.90	6.24	.08440419	10.71	h		NP
C 1212	29344443787N095461658005W	1819	29142	A	88	00TXAW4731	4.88	4.40	.14097438	6.16	h		NP
TORY HILL RESET	29455831276N095042343491W	-20845	6458	A	88	00TXAW0941	4.05	3.55	.09894814	4.06	S		NP
877 1510 TIDAL 44	29171786976N094472458102W	-22204	4378	A	88	00TXAW0591	0.35	0.25	.29693447	0.72			NP
E 1302	31384185285N097050722609W	119728	146538	A	88	00TXBZ1079	0.73	0.67	.06708061	1.46			NP
T 478	32421396000N096130398649W	133943	159187	A	88	00TXCS0306	1.22	0.85	.55582657	1.37			NP
ARP ADS	32575694759N096500871698W	169175	195723	A	88	00TXCS1308	0.41	0.39	.10220031	0.72			NP
U 1470	34104029355N102392215782W	1131477	1155866	A	88	00TXEO0543	0.76	0.84	-.06342248	1.49			NP
C 281	33111075472N099061186433W	353943	383464	A	88	00TXDO0454	0.56	0.75	-.15326980	1.09		N	NP
P 156	33012331006N094581535354W	91144	117914	A	88	00TXDM0277	0.68	0.93	.18594883	1.22			NP
M 1085	28312332688N099493759902W	157583	181242	A	88	00TXAO0410	0.50	0.55	.13470420	1.47			NP
D 1124	35413706902N101233749578W	901982	928957	A	88	00TXFL0805	0.81	0.73	.01385538	1.39			NP
CHINA RESET	30024541190N094205532295W	-15080	12438	A	88	00TXBL0195	0.26	0.24	-.02916795	0.76			NP

Ortho Datum Code

Code	Explanation
H 88	North American Vertical Datum of 1988

Reject Code

Rejection is based on three tests. The first test is to evaluate the given ellipsoid height errors and determine outliers. Points outside of the 95% confidence level (two sigma) after 4 iterations are rejected and assigned 'h'. Points are then compared to a gravimetric geoid to form residuals. Points with abnormally large residual values are dropped as having a bad orthometric height 'H'.

h	Ellipsoid height error
H	Orthometric height error
D	Duplicate
Blank	Indicates no rejection.

Ellipsoid Order & Class (OC) Codes

The OC codes are used to classify each ellipsoid height value observed and adjusted at horizontal control points. The first character indicates order while the second indicates class in accordance with the following draft standards for classifying ellipsoid height determinations:

OC Code	Classification	b = maximum height difference accuracy
00	NRA2007 absolute accuracy determined instead	
11	First Order, Class I	0.5
12	First Order, Class II	0.7
21	Second Order, Class I	1.0
22	Second Order, Class II	1.3
31	Third Order, Class I	2.0
32	Third Order, Class II	3.0
41	Fourth Order, Class I	6.0
42	Fourth Order, Class II	15.0
51	Fifth Order, Class I	30.0
52	Fifth Order, Class II	60.0

The ellipsoid height difference accuracy (b) is computed from a minimally constrained, correctly weighted, least squares adjustment by the formula:

$$b = s / \sqrt{d}$$

where: d = horizontal distance in kilometers between control points

s = propagated standard deviation of ellipsoid height difference in millimeters between control points obtained from the least squares adjustment

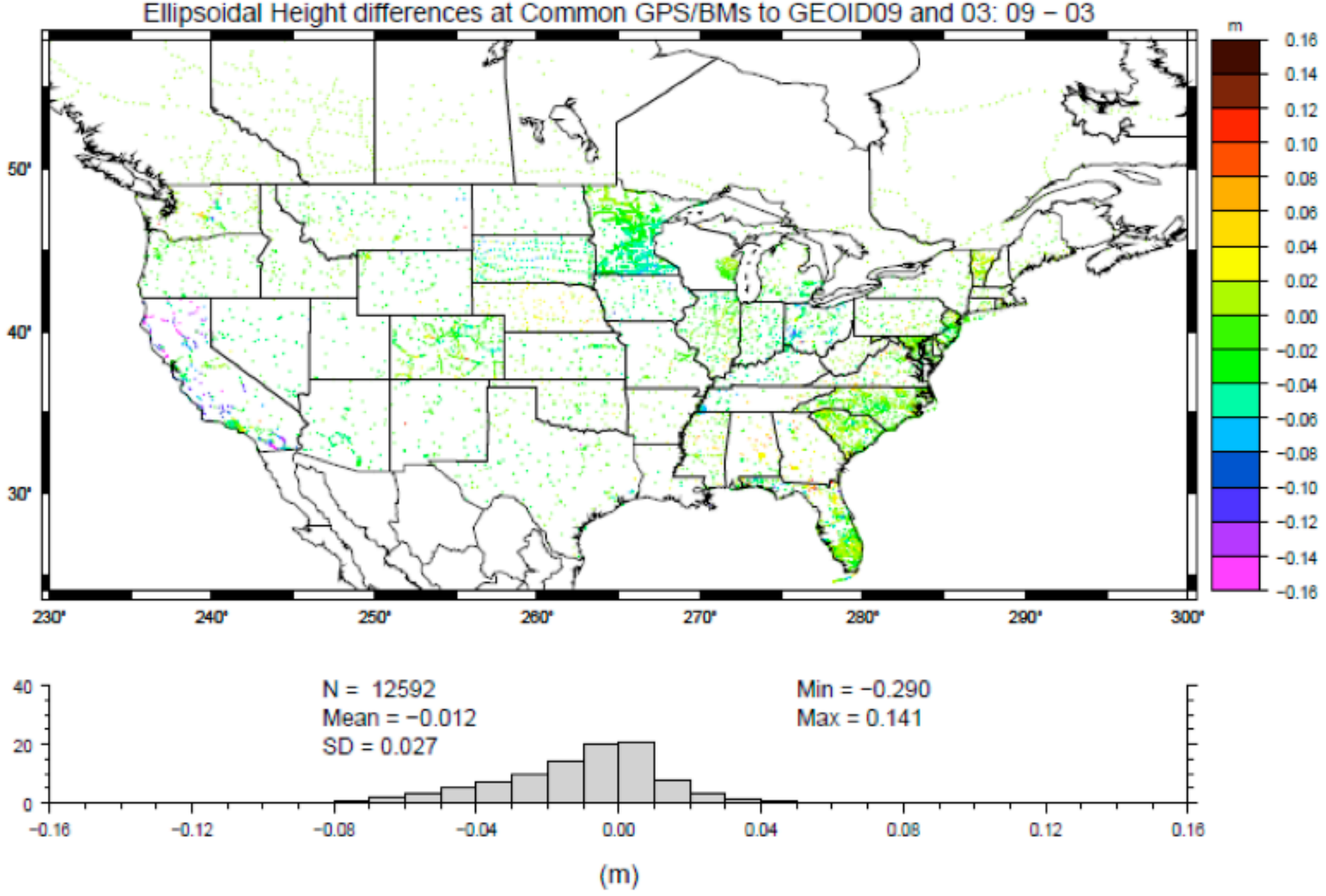


Figure 2: Differences in the ellipsoidal heights at GPSBMs common to GEOID03 and GEOID09.

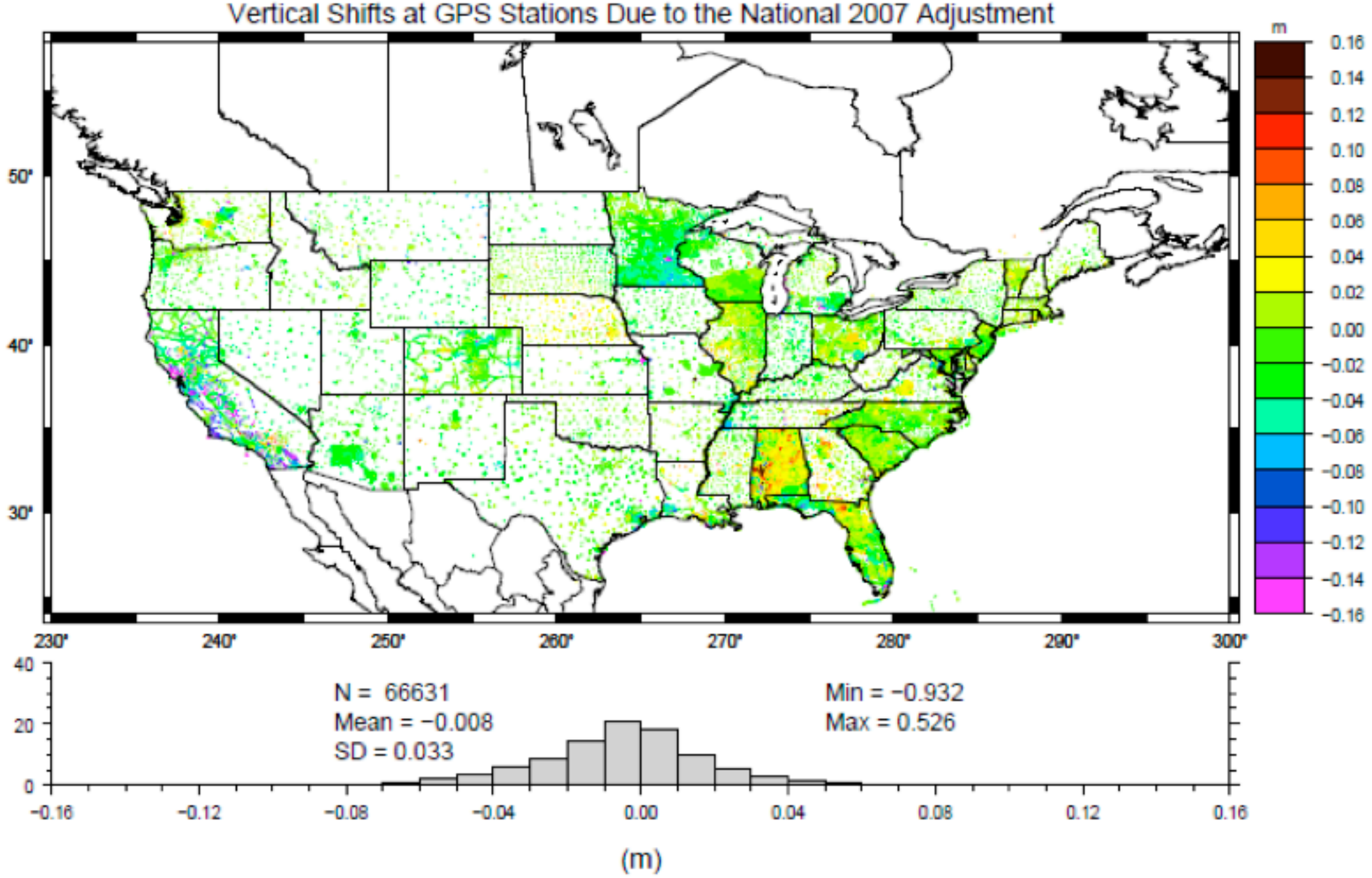


Figure 5: Vertical shifts at all GPS stations due to the NSRS2007. Those points given in Figure 4 represent a subset of this group.

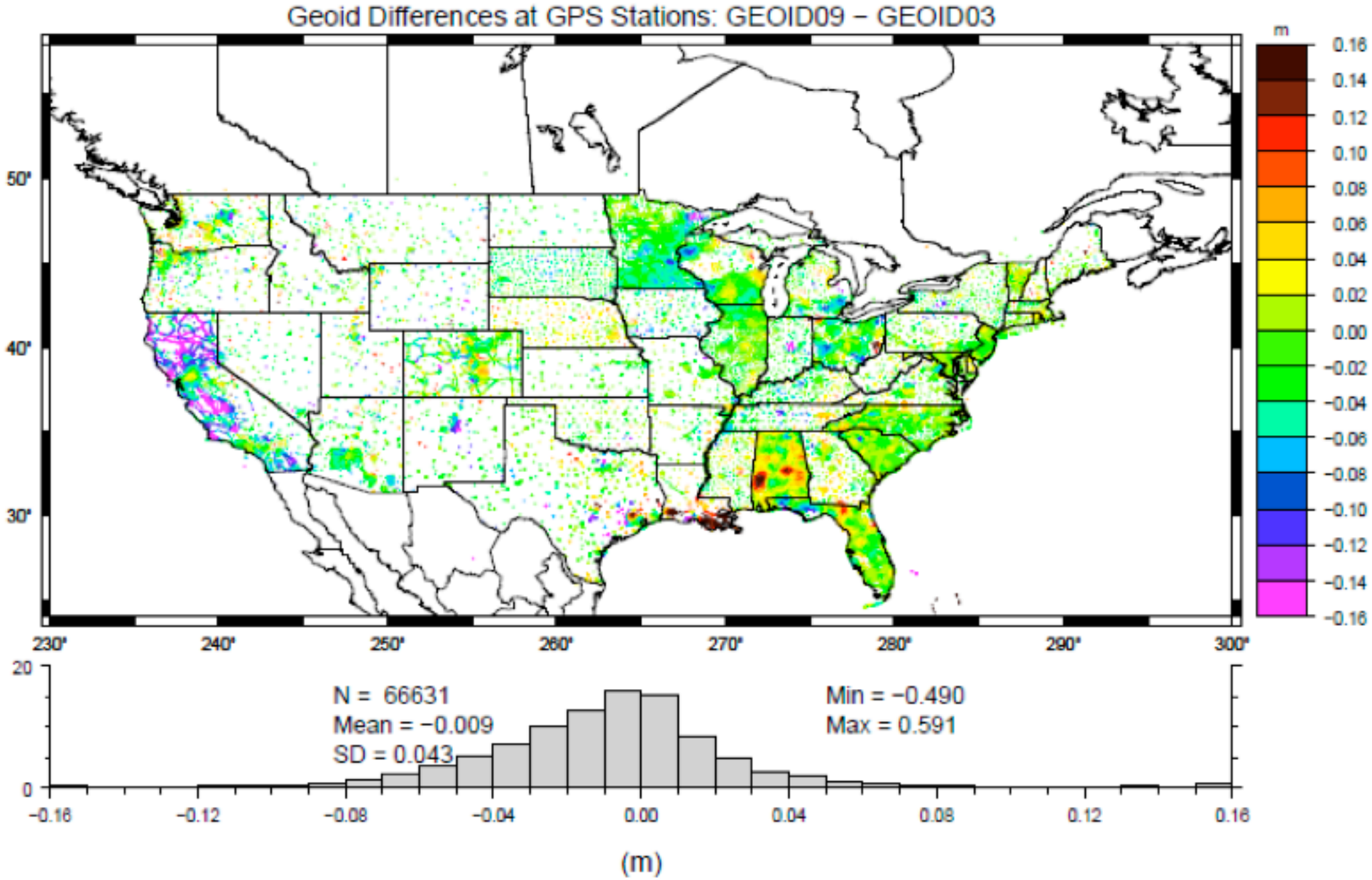


Figure 9: Geoid differences between GEOID09 and GEOID03 at GPSBM lcoations

In GEOID99, only a single Gaussian function at 400 km correlation length was utilized. For GEODI03, two functions were used with correlation lengths of 650 km and 60 km. For the western states such as Arizona, the function with the 60 km correlation length did not work because of the spacing of the GPSBM's. This left only the 650 km correlation length to model the remaining signal. This caused signal between 400 km and 650 km to be neglected, resulting in a slight degradation for those regions from GEOID99 to GEOID03.

To mitigate this in GEOID09, multiple models were used. The GPSBM spacing will determine which of the functions will actually apply for each region. Incrementing from 30 km to 60km to 90 km to 120 km creates thresholds that can better capture the correlated signal present in the GPSBM residuals. For example, the GPSBM station spacing may be insufficient for the function with a 60 km correlation length but it is sufficient for the function with the 90 km correlation length. This prevents a jump to longer wavelength function and neglecting correlated signal.