

# Digging For Datums

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## A Common Problem

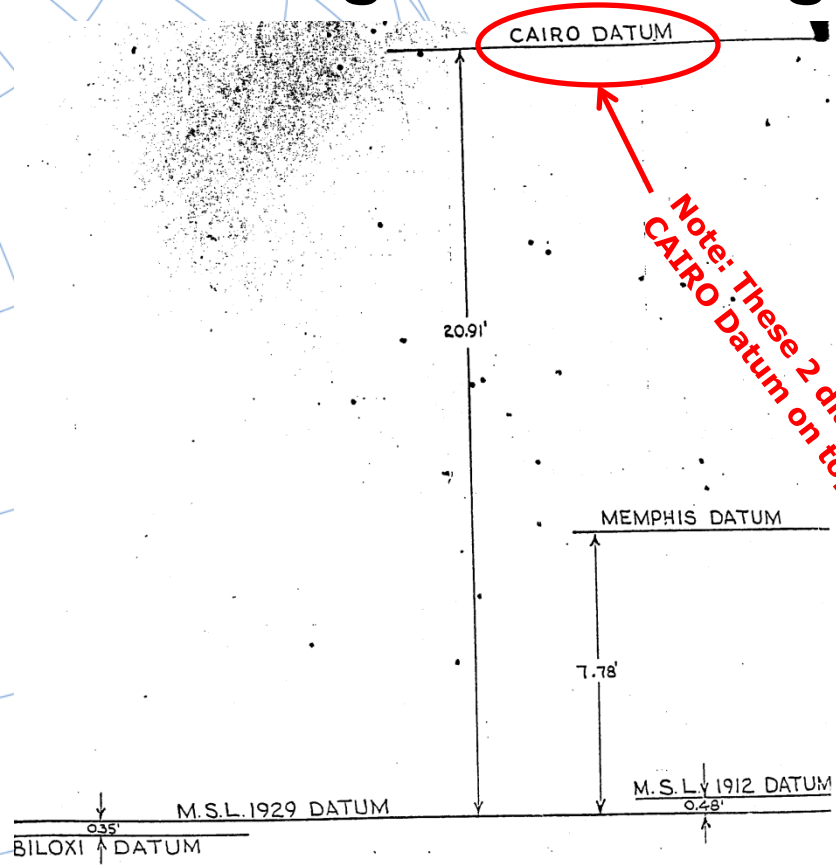
- “I need to convert my elevations from NADV88 to NGVD29, what’s the separation between them?”
- “I need to convert my elevations from NADV88 to 1912, what’s the separation between them?”
- “I need to convert my elevations from NADV88 to my project datum, what’s the separation between them?”



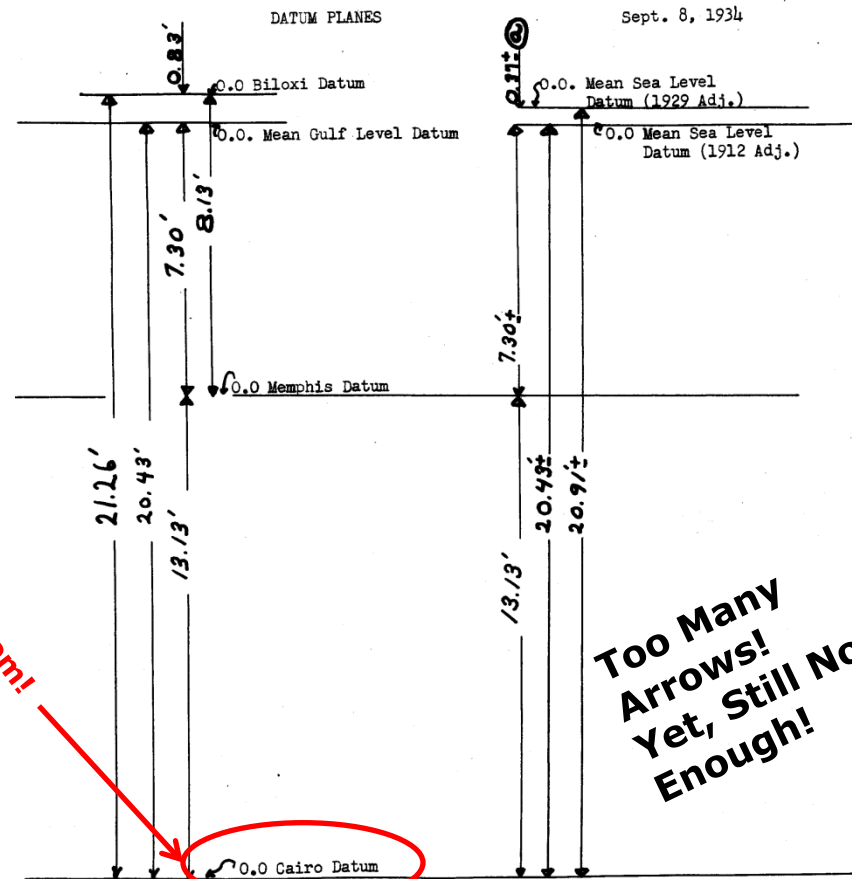
## Operation: “Enduring Confusion”

- A major contributor to the flooding in New Orleans was conflicting and confusing datum conversions along the levees.
- Many datums existed – all are near sea level – so many elevations approximate “zero” – some are negative!
- It would be really easy to add rather than subtract when converting between datums.
- Mistakes did occur, with tragic and expensive results.

# Existing Datum Diagrams



Note: 710.30 MSL. 1929 DATUM = 0.00 MINNEAPOLIS DATUM  
 694.10 MSL. 1929 DATUM = 0.00 ST PAUL DATUM  
 0.00 MSL 1912 DATUM = 0.00 MEAN GULF DATUM



*Note: These 2 diagrams show CAIRO Datum on top and at bottom!*

**Too Many Arrows! Yet, Still Not Enough!**

(a) The difference between Mean Sea Level (1912 Adj.) and Biloxi, Mean Gulf Level, Memphis, and Cairo datums is a variable because the Mean Sea Level (1912 Adj.) elevations are adjusted into U.S. Level Net while elevations given on the other datums have not been adjusted into the U.S. Level Net. This is also true of the Mean Sea Level (1929 Adj.) elevations.



# Would This Approach Reduce Confusion?

To Convert Elevations in Column A to those in Columns B through G, **SUBTRACT** the amount shown at the intersection of the columns.

However, to Convert Elevations in Column B through G to that shown in Column A, **ADD** the amount shown at the intersection of the columns.

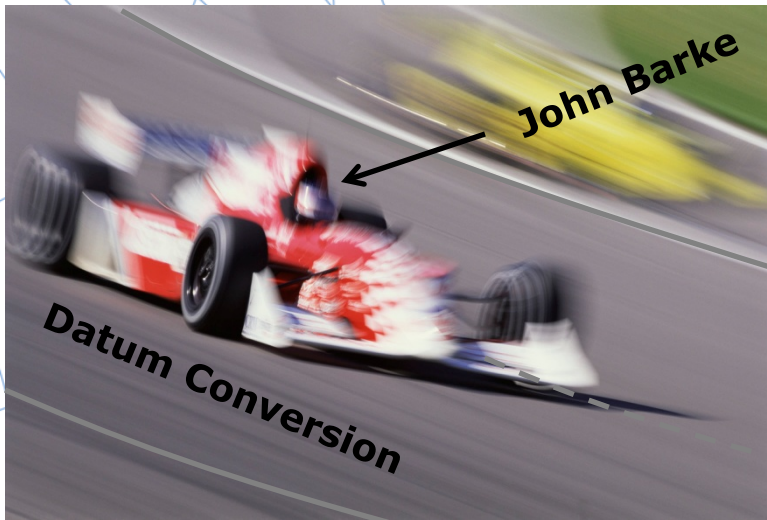
Watch your algebraic signs!

A	B	C	D	E	F	G
	NAVD88	NGVD29	1912	MEMPHIS	MEAN GULF	BILOXI
NAVD88	---	0.046 m	-0.101 m	-2.323 m	-0.098 m	
NGVD29	-0.046 m	---	-0.147 m	-2.369 m	-0.144 m	
1912	0.101 m	0.147 m	----	-2.222 m	0.003 m	
MEMPHIS	2.323 m	2.369 m	2.222 m	---	2.225 m	
MEAN GULF	0.098 m	0.144 m	-0.003 m	-2.225 m	---	-0.253 m
BILOXI					0.253 m	---

Remember, you will need a chart like this for every location of interest in the state



# Impending Crash



**MNDOT Geodetic Unit said:  
"Dave, we think this looks like an NGS Problem!"**

## First, Do Your Research

- Dig into the published records for all elevations at a given mark.
- Do this on a mark-by-mark basis.
- Include at least 3 or more benchmarks in a vicinity to detect consistency and typographical errors.
- Compute the results.
- Draw a diagram.
- **UNIQUE to EACH LOCATION !!!**

# Elevation Comparisons (meters)

## St. Paul, MN

Station	GSID	NAVD88	NGVD29	"1912"	Memphis	Mean Gulf
MACALESTER MRC	25090	284.151	284.099		286.479	284.254
70 BOLT	66139		214.505	214.649	216.850	214.625
PBM 67	25129	215.740	215.694	215.841	218.063	215.838
65 BOLT	51841	217.517	217.476	217.621	219.849	217.624
PBM 77	7513		215.010	215.155	228.914	226.689

## Red Wing, MN

Station	GSID	NAVD88	NGVD29	"1912"	Memphis	Mean Gulf
PBM 112	9761	209.534	209.497	209.644	211.842	209.617
PBM 118	9764		205.939	206.085	208.279	206.054
PBM 120	9766		205.406	205.552	207.746	205.520





# Elevation Comparisons (meters)

## Winona, MN

Station	GSID	NAVD88	NGVD29	"1912"	Memphis	Mean Gulf
PBM 168	34659	202.946	202.954	203.102	205.262	203.037
PBM 170	71349		198.063	198.212	200.370	198.145
PBM 177	85171		200.473	200.621	202.775	200.550

## Dresbach, MN

Station	GSID	NAVD88	NGVD29	"1912"	Memphis	Mean Gulf
PBM 186	71383		199.894	201.265	203.412	201.187
PBM 182	34662		201.874	202.023	204.171	201.945
8580 F	34484	209.191	209.204			



# Elevation Comparisons (meters)

## Royalton, MN

Station	GSID	NAVD88	NGVD29	"1912"	Memphis	Mean Gulf
298-2	19997	332.574	332.418	332.514		
PBM 301-2 BOLT	20233	338.962	338.802	338.902		
302-2	20004	340.806	340.646	340.746		

## Walker, MN

Station	GSID	NAVD88	NGVD29	"1912"	Memphis	Mean Gulf
WALKER CAP	40268	403.814	403.570	403.737		
WYE PBM MRC	4400	406.947	406.666	406.844		
WYE BOLT	51952	405.731		405.629		



# Analyze Differences

Mississippi River Commission  
book states 2.225 meter offset

Station	GSID	NAVD88	diff	NGVD29	diff	"1912"	diff	Memphis	diff	Mean Gulf
MACALESTER MRC	25090	284.151	0.052	284.099				286.479	2.225	284.254
70 BOLT	66139			214.505	-0.144	214.649	-2.201	216.85	2.225	214.625
PBM 67	25129	215.74	0.046	215.694	-0.147	215.841	-2.222	218.063	2.225	215.838
65 BOLT	51841	217.517	0.041	217.476	-0.145	217.621	-2.228	219.849	2.225	217.624
PBM 77	7513			215.01	-0.145	215.155	-13.759	228.914	2.225	226.689

"diff" columns should be consistent



# Analyze Differences

## PBM 67

Elevation	diff	Datum
215.694		NGVD29
	0.046	
215.74		NAVD88
	0.098	
215.838		Mean Gulf
	0.003	
215.841		"1912"
	2.222	
218.063		Memphis

**Sort by Elevation -  
Smallest to Largest**

# Datum Diagrams



## St. Paul, MN (PBM 67)

Elevation above datum  
= Depth to datum



NGVD29	_____	215.694
	0.046 m	
NAVD88	_____	215.740
	0.098 m	
Mean Gulf	_____	215.838
	0.003 m	
1912	_____	215.841
	2.222 m	
Memphis	_____	218.063

## Red Wing, MN (PBM 112)

Elevation above datum  
= Depth to datum



NGVD29	_____	209.497
	0.037 m	
NAVD88	_____	209.534
	0.083 m	
Mean Gulf	_____	209.617
	0.027 m	
1912	_____	209.644
	2.198 m	
Memphis	_____	211.842

# Datum Diagrams

## Winona, MN (PBM 168)

Elevation above datum  
= Depth to datum

NAVD88	—————	202.946
	0.008 m	
NGVD29	—————	202.954
	0.083 m	
Mean Gulf	—————	203.037
	0.065 m	
1912	—————	203.102
	2.160 m	
Memphis	—————	205.262

## Dresbach, MN (PBM 182)

Elevation above datum  
= Depth to datum

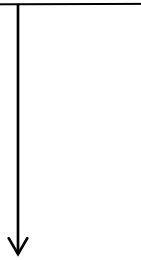
NAVD88	—————	201.861
	0.013 m	
NGVD29	—————	201.874
	0.071 m	
Mean Gulf	—————	201.945
	0.078 m	
1912	—————	202.023
	2.148 m	
Memphis	—————	204.171



# Datum Diagrams

## Royalton, MN (PBM 301-2 BOLT)

Elevation above datum  
= Depth to datum



NGVD29	_____	332.418
	0.096 m	
1912	_____	332.514
	0.060 m	
NAVD88	_____	332.574

## Walker, MN (WYE PBM MRC)

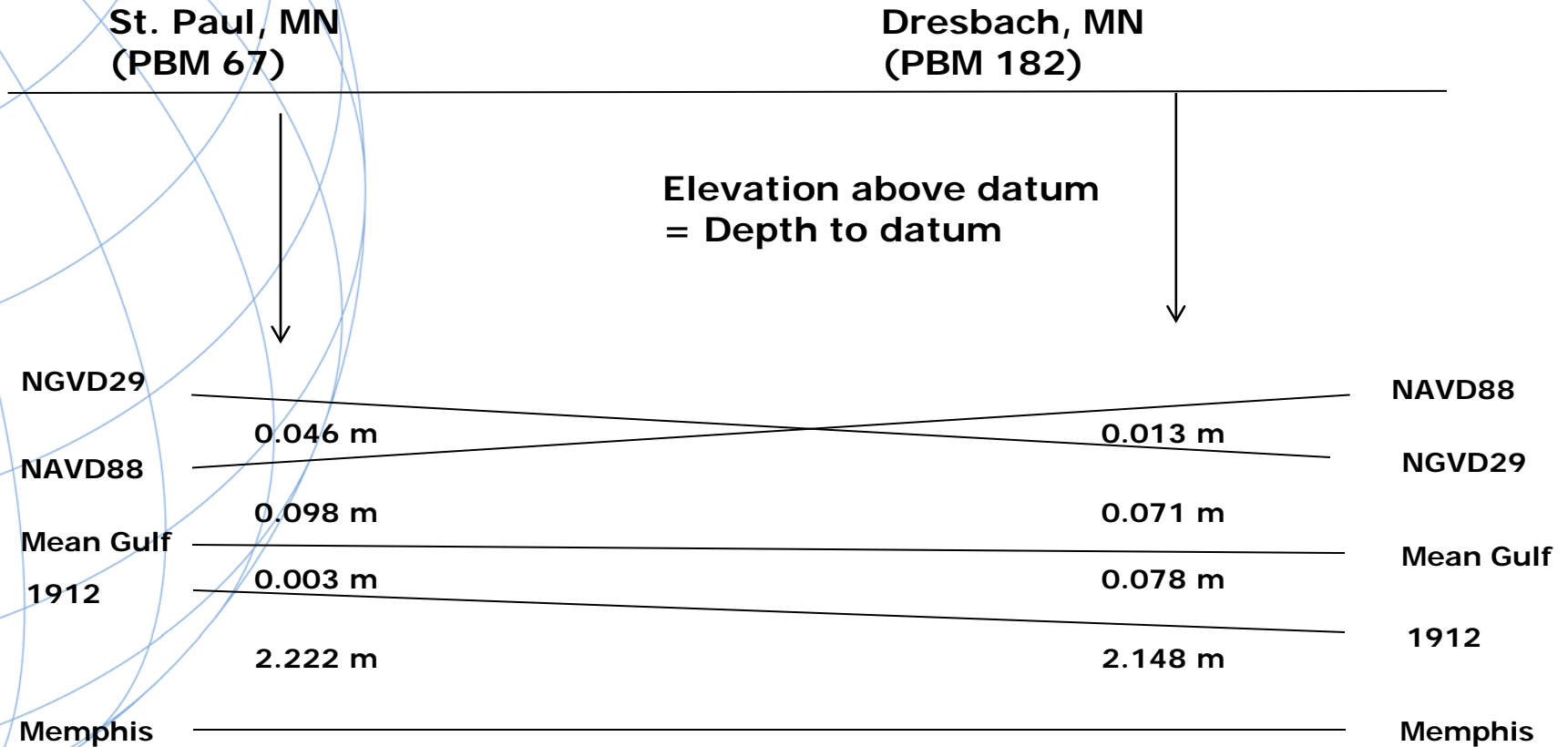
Elevation above datum  
= Depth to datum



NGVD29	_____	406.666
	0.178 m	
1912	_____	406.844
	0.103 m	
NAVD88	_____	406.947



# Draw a DATUM PROFILE

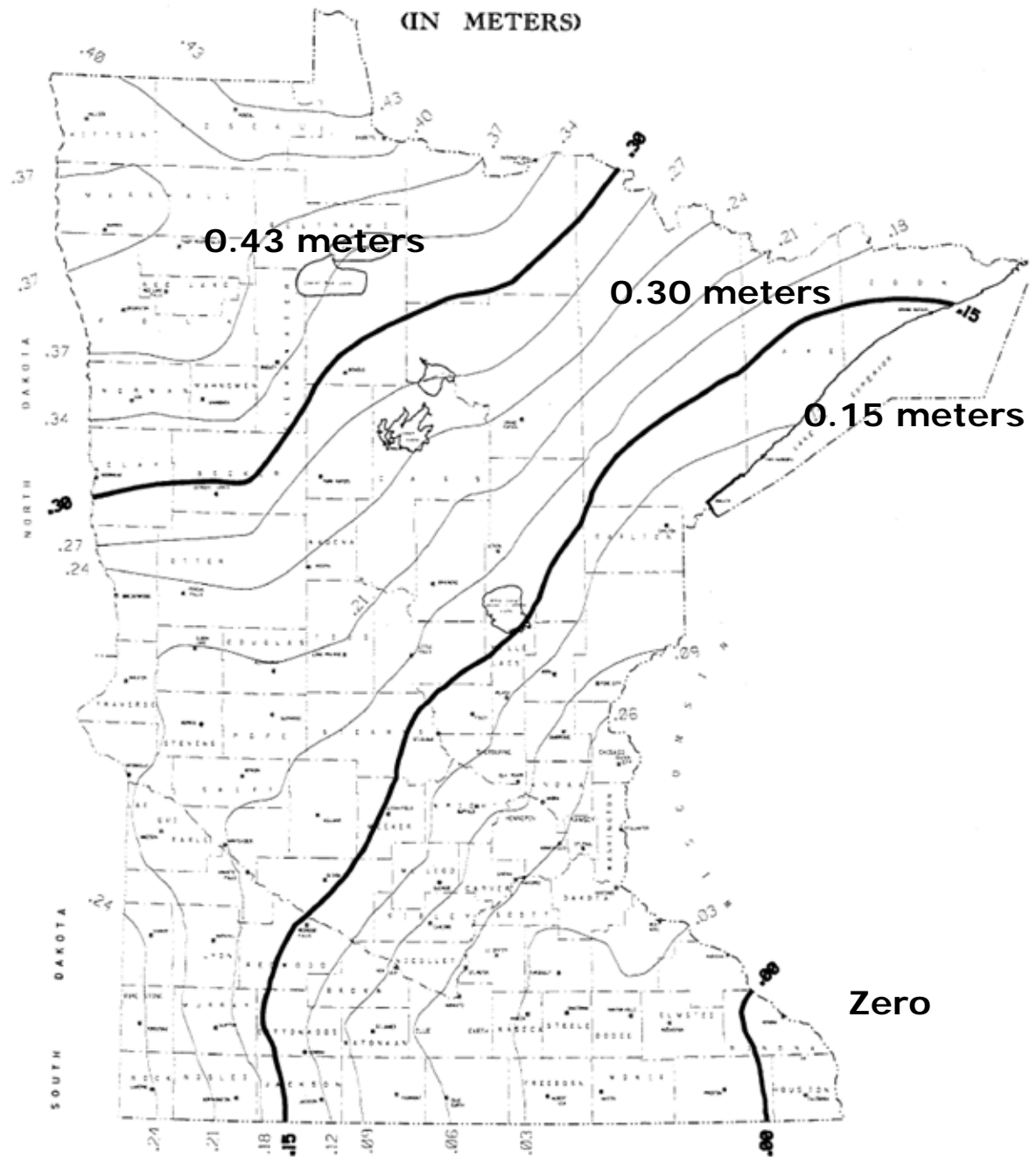




# NAVD88 to NGVD29 Shifts

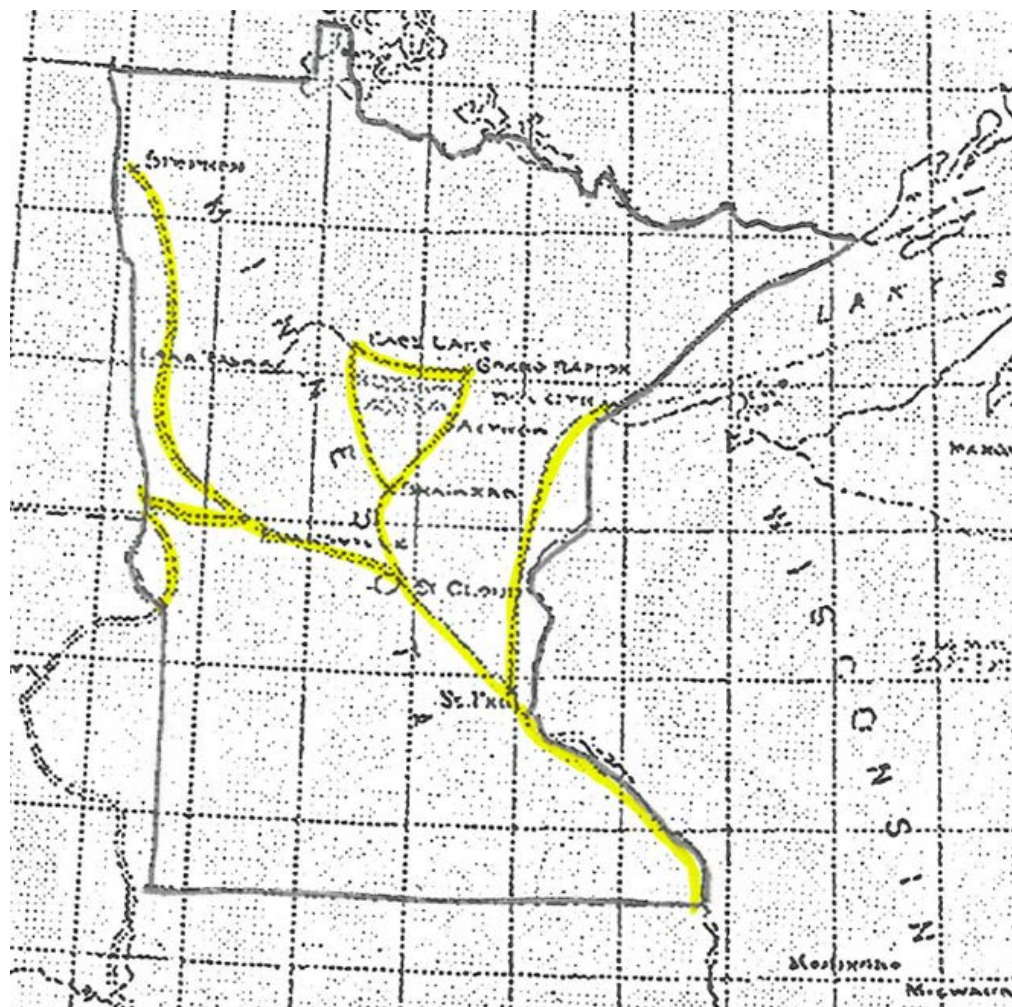
Chapter 2 of  
MNDOT Surveying  
and Mapping  
Manual.

NAVD 88 MINUS NGVD 29 ADJUSTED ELEVATIONS  
NOVEMBER, 1991  
(IN METERS)



# Extent of 1912 Datum In MN (as of 1914)

Subsequent leveling extended the 1912 Datum beyond these limits, but I don't have a set of records to show how far.



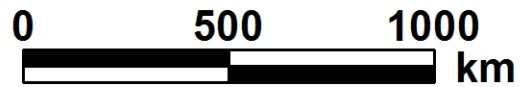
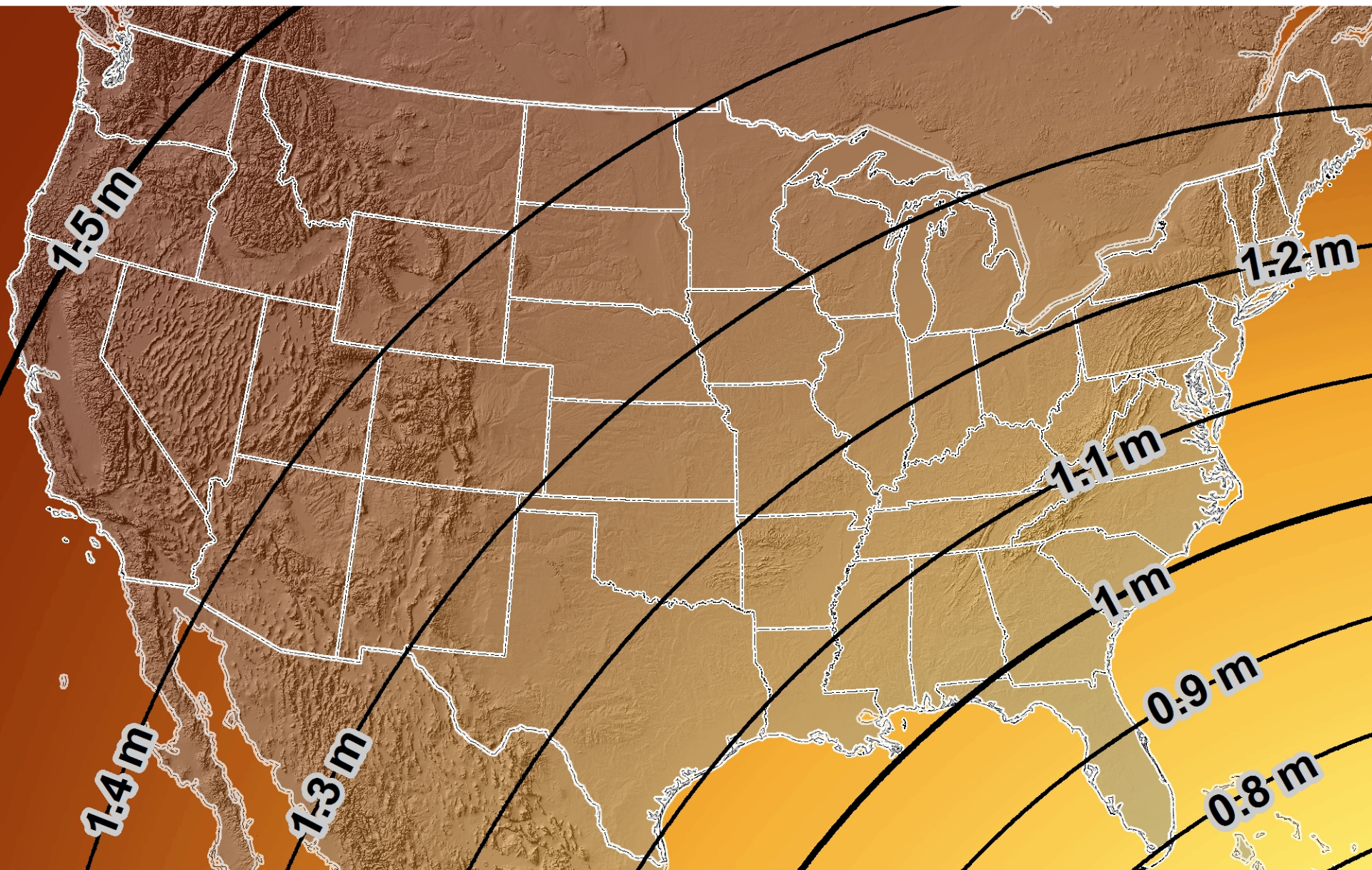
## Conclusion

- Datums do not exist everywhere
- We note that the DATUMS are not parallel.
- Nor do they converge/diverge uniformly.
- This is caused by:
  - underlying undetected errors in the leveling
  - underlying undetected errors in the adjustment
  - by the choice of constraints used in the adjustments.
- There is NO single “Correct” conversion between datums!
- However, there are many correct conversions.

## Future Datum

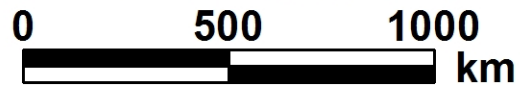
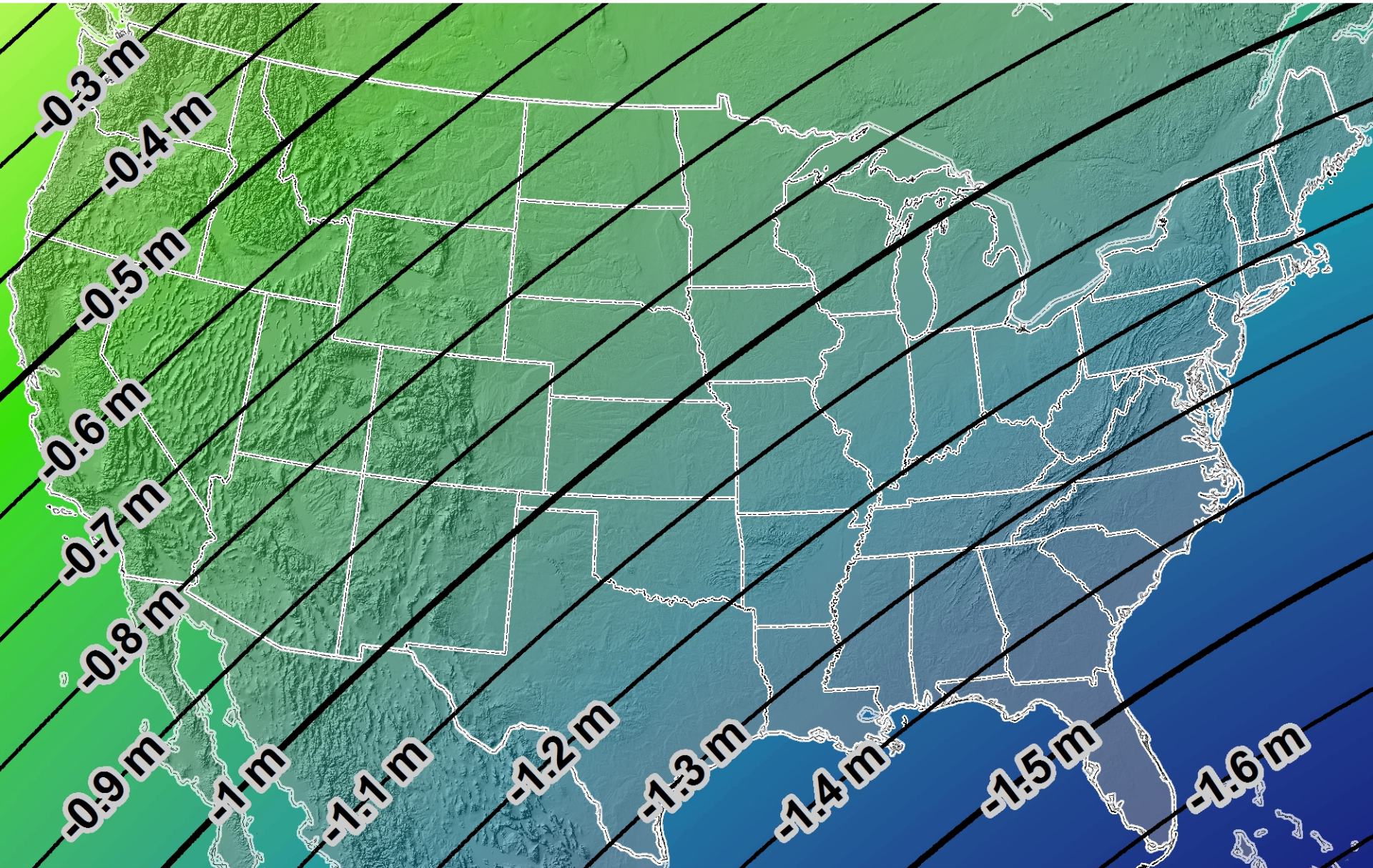
- NGS is planning to release an all-new 3D datum
- Timeline not definite.
- Consider 10 years away.

# Estimated horizontal change from NAD 83 to new geometric datum



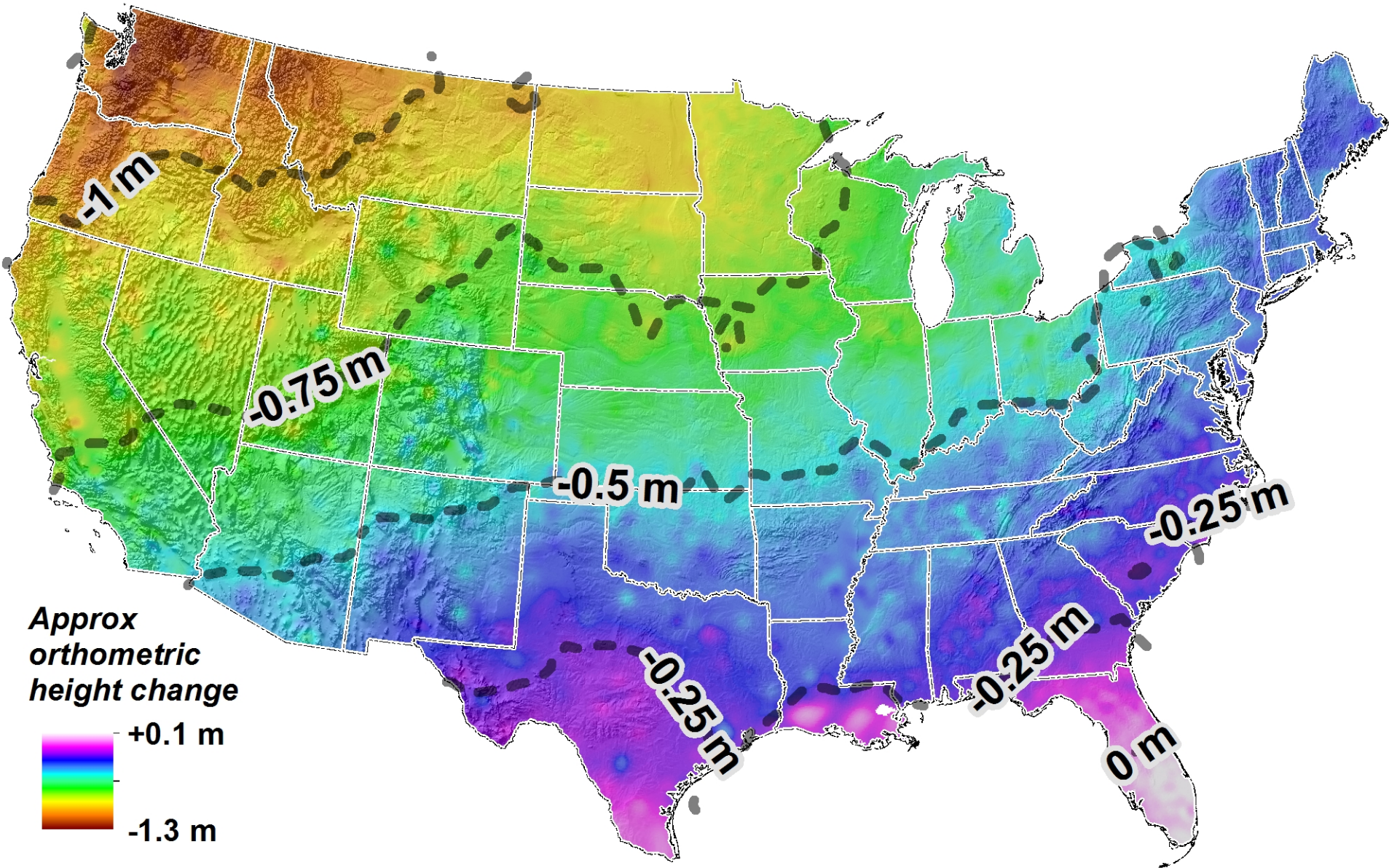
Delta Horizontal = (ITRF 05) minus (NAD 83) at 2020.0

# Estimated ellipsoid height change from NAD 83 to new geometric datum

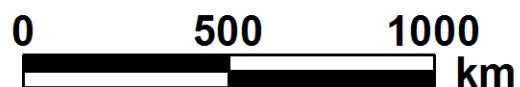
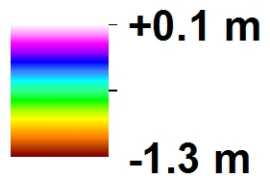


Delta h =  $h(\text{ITRF 05}) - h(\text{NAD 83})$  at 2020.0

# Approximate predicted change from NAVD 88 to new vertical datum



Approx  
orthometric  
height change



Predicted change estimated as NAVD 88 "zero" (datum) surface *minus* most recent NGS gravimetric geoid (USGG2009)