

Presented at the FIG Working Week 2016,  
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# Physical Heights from GNSS-Derived Geometric Coordinates and a Geophysical Model (8174)

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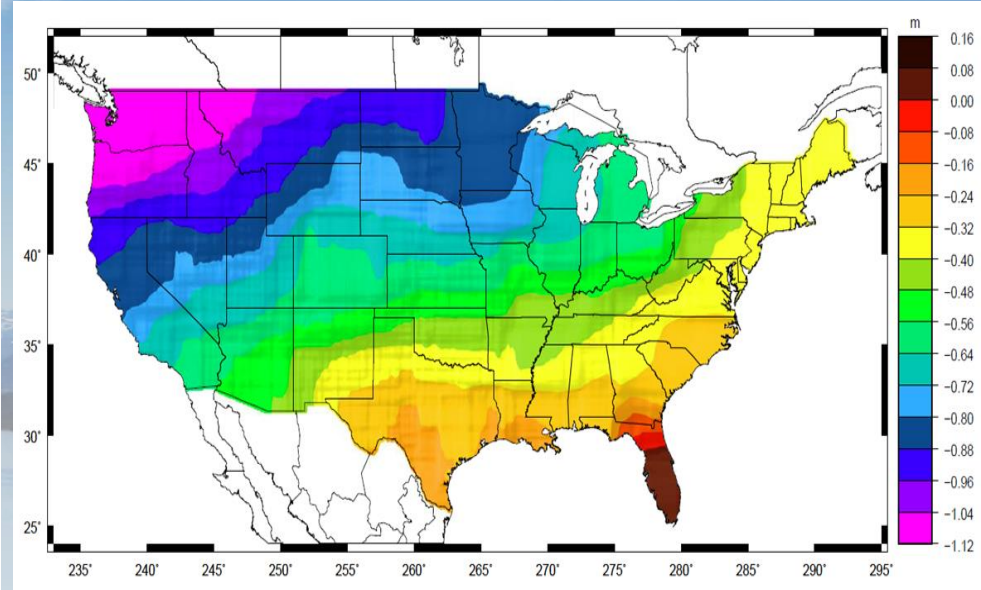
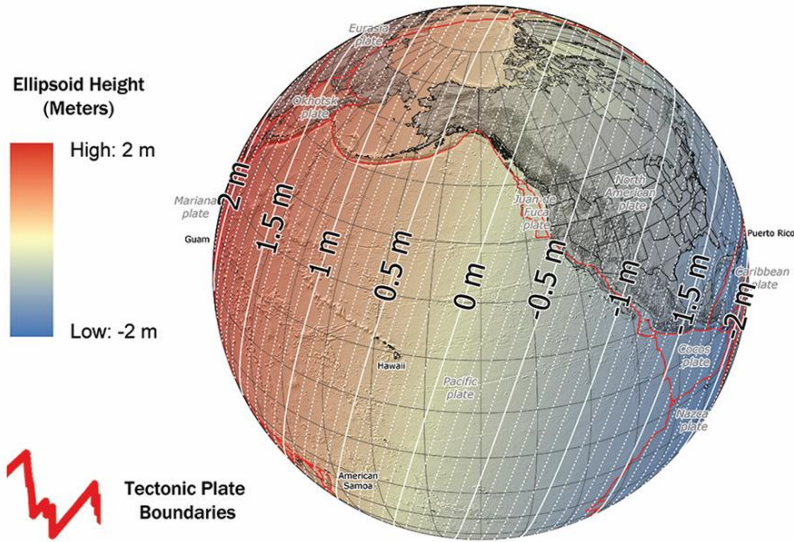


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# Datum Defects of NAD 83 and NAVD 88

## Approximate Ellipsoid Height Change



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# What will a future geometric frame look like?

- With only 15 minutes of GNSS data to have cm-level accuracy
- A more geocentric frame – consistent with others (ITRF/WSG84)
- Will likely retain CORS (i.e., not PPP)
- Better velocities for all stations (Reprocessing)
- Agreeable datum for regional use (U.S., Canada, Mexico, etc.)
- More consistent tie for engineering and scientific applications
- Realized using Online Positioning User Service (OPUS) suite
- Passive bench marks serve as secondary access and for backup



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# Implementation

- Foundation CORS tied to IGS solutions
- Reprocessing yields consistent CORS coordinates
- Bench Marks are then adjusted to fit CORS control
- GNSS/OPUS coordinates supersede bench mark values
- Velocities applied to revert back to datum epoch (2022.0)
- Effectively provides “fixed” plate & state plane coordinates
- Permits use for RTK positioning at current epoch



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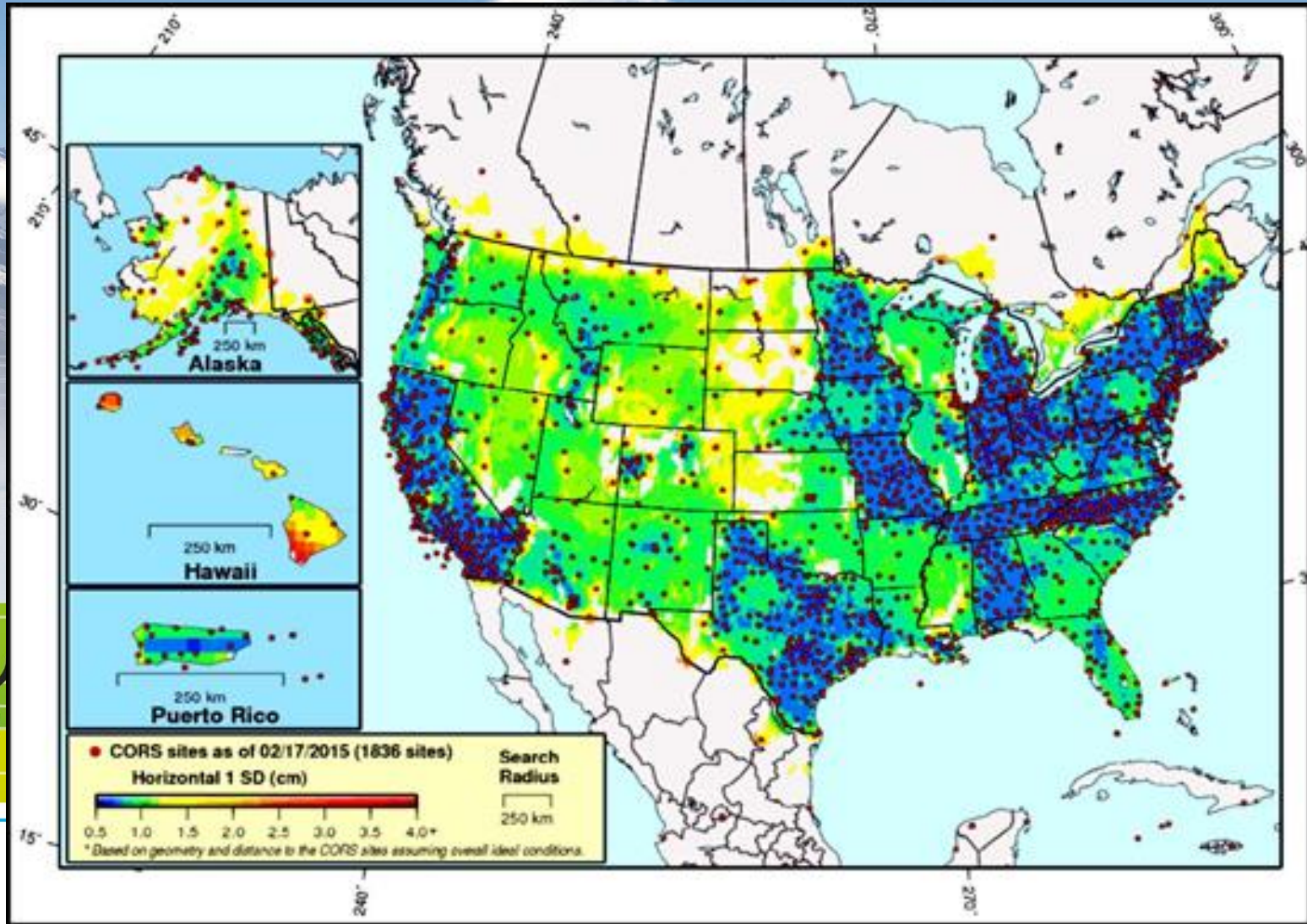
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# OPUS-RS Quality Directly Depends on CORS Spacing



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# What will a future geopotential frame look like?

- Scientific basis that can be modeled & updated
  - geoid change, MSL rise, local effects
- More consistency in heights across the region
- Better ties between geoid (MSL), TBM's (LMSL) & MODT
  - $\text{Geoid (MSL)} = \text{LMSL} - \text{MODT}$
- Better basis for comparisons with SIRGAS



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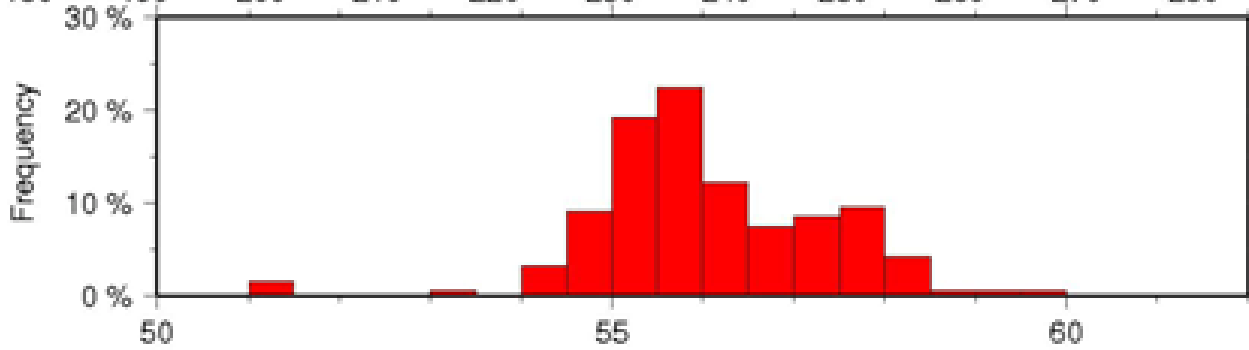
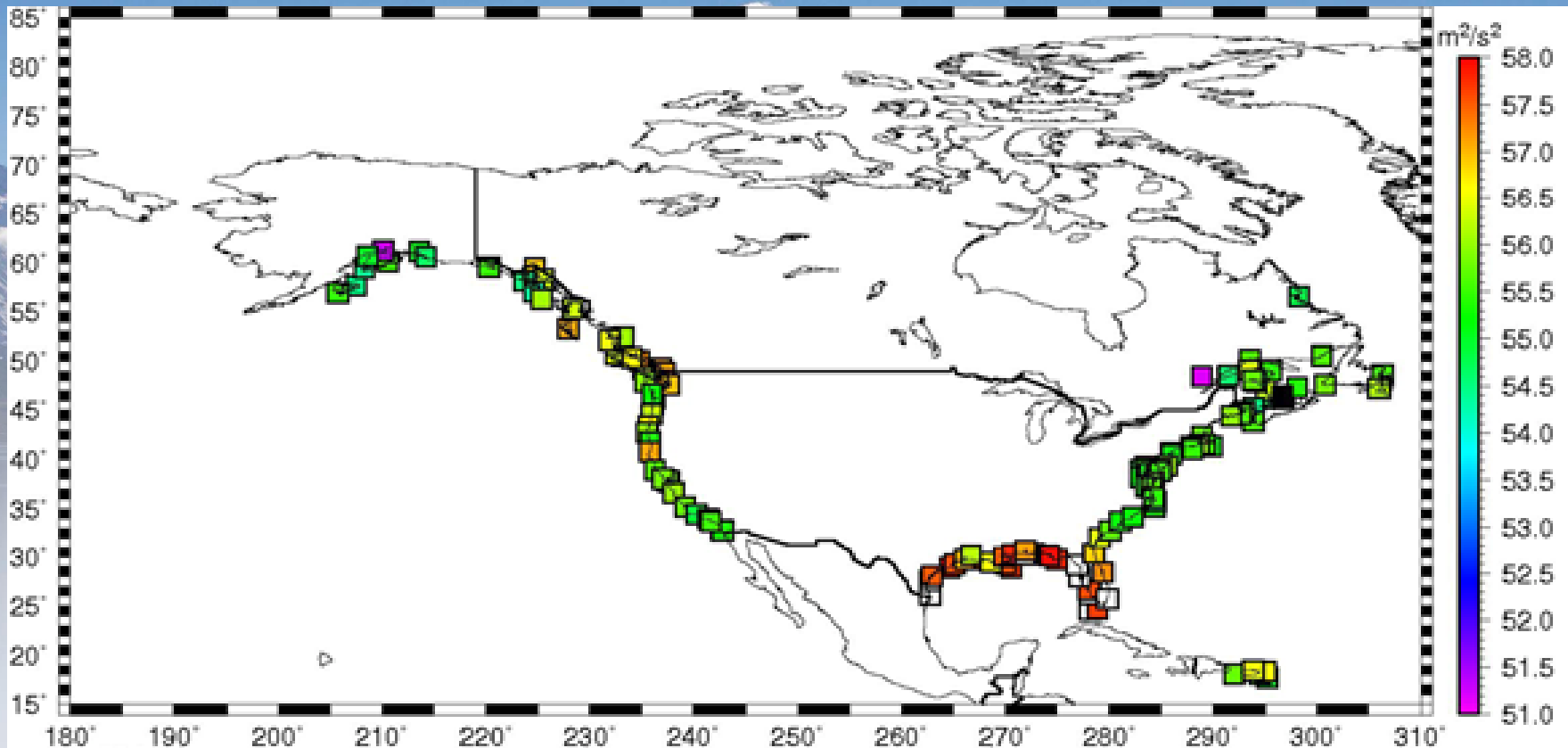
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# Which geopotential to pick for datum level or $W_0$ ?



#pts=188  
Mean=56.00  
STD=1.429

W0-62,636,800 at TGs - SST ( $m^2/s^2$ )



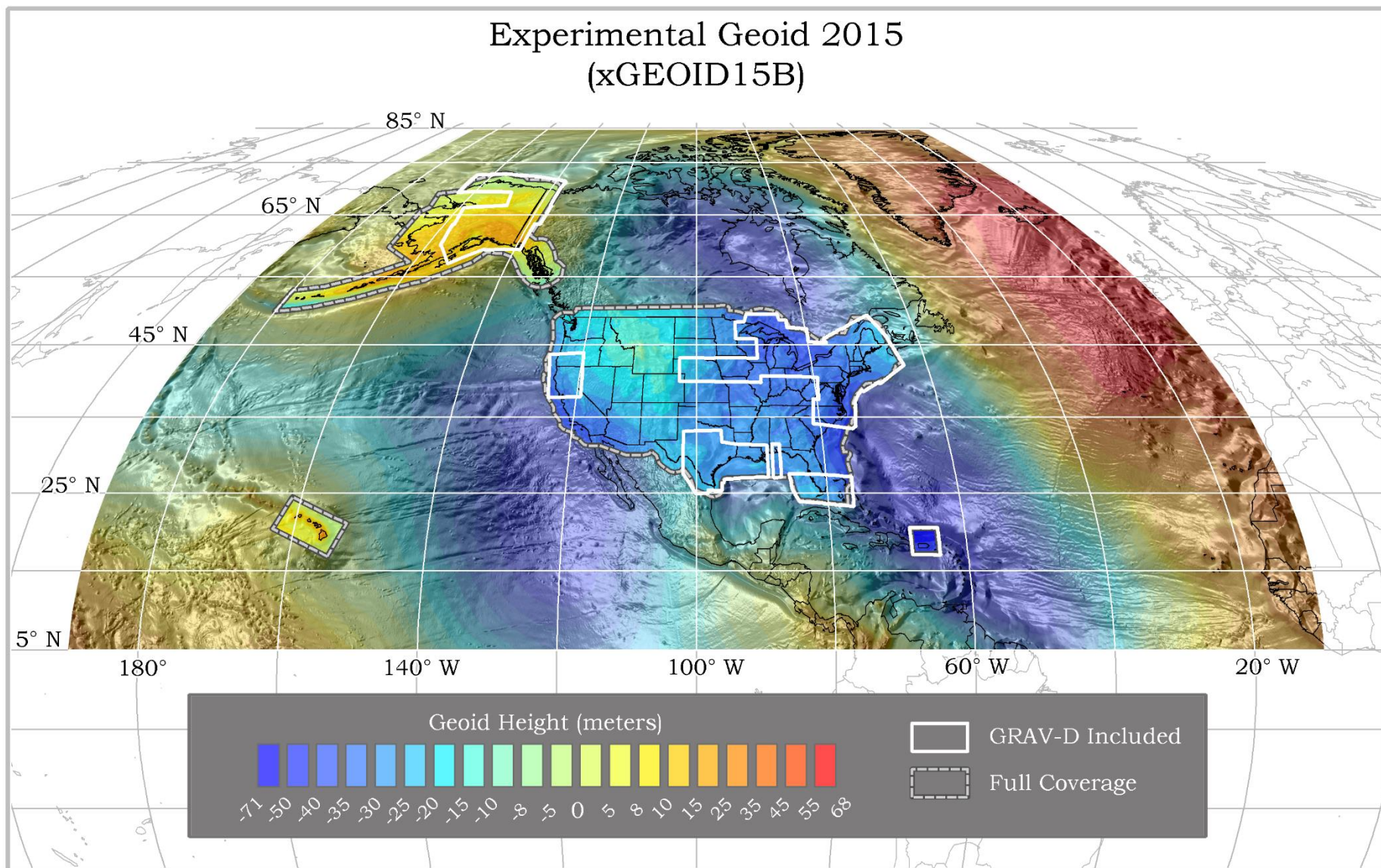
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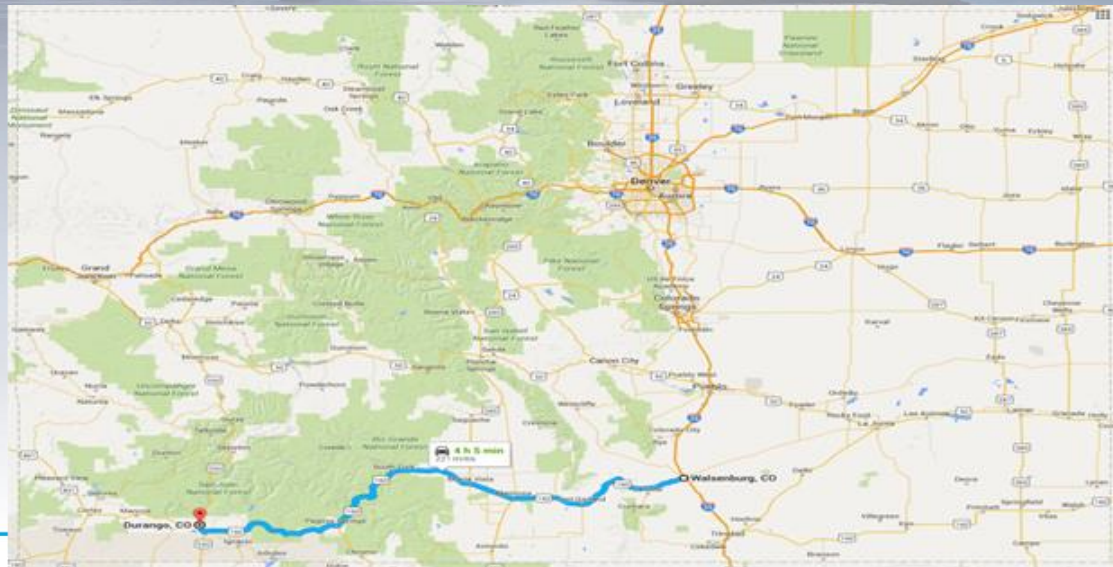
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# Coverage of primary future geopotential model





# Geoid Slope Validation Studies 2014 and 2017



- Survey Techniques
  - BM's installed ~1.5km
  - Leveling (double run)
  - Abs./Rel. Gravity
  - Vertical Gravity Gradient
  - Long-session GPS
  - Deflection of Vertical
- GSVS 11 – sub-cm
- GSVS 14 – prel. 2 cm
- GSVS17 – in planning

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# International Great Lakes Datum (IGLD) Replacement

- Current model (IGLD 85) based on NAVD 88 geopotential
- Update should be based on common geopotential model
- Each Lake would have it's own geopotential surface
- Likely some effects from currents, etc. (water topography)
- Ideal solution is a geopotential model at one arcminute
- Acceptable solution is a geoid height model combined with a gravity model at same resolution
- Current geopotential models only 5's => omission errors



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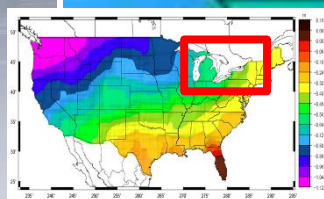
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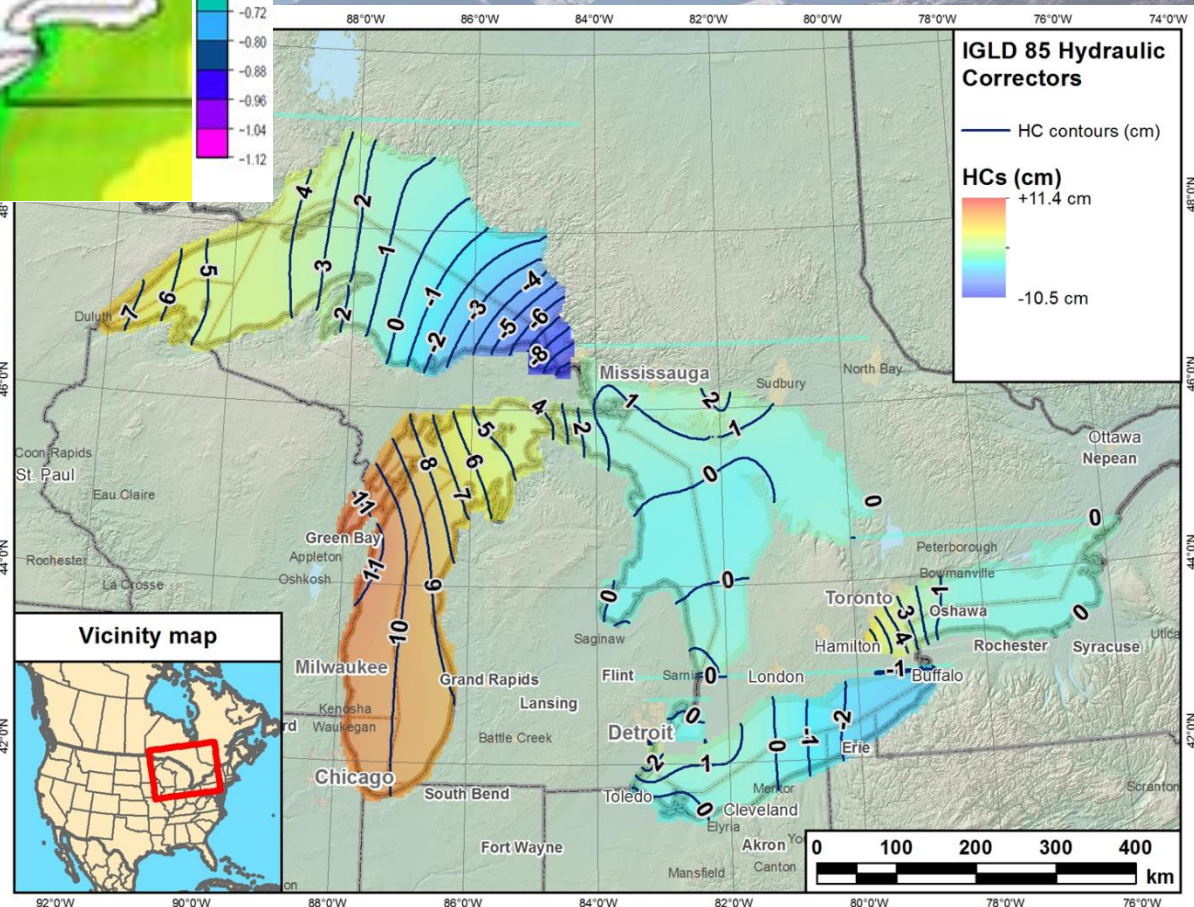


# Why update? Same reason as for NAVD 88.



# FIG V

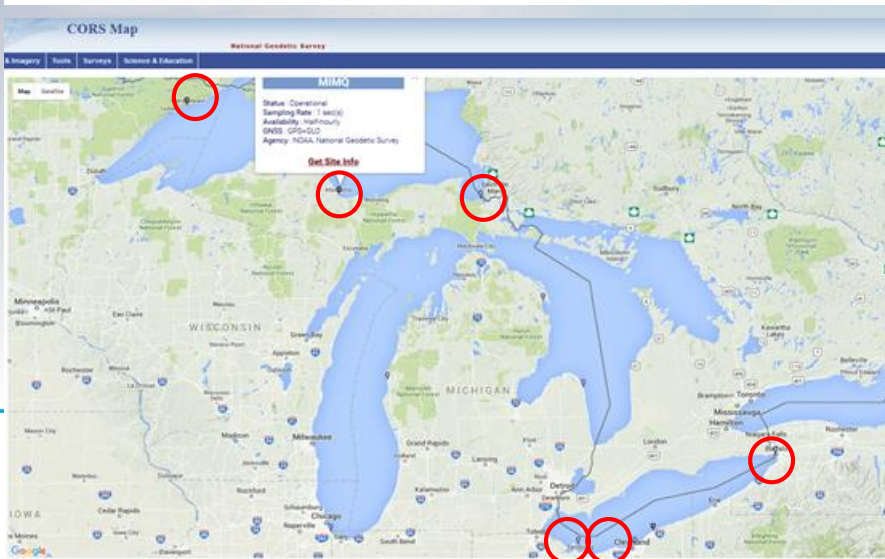
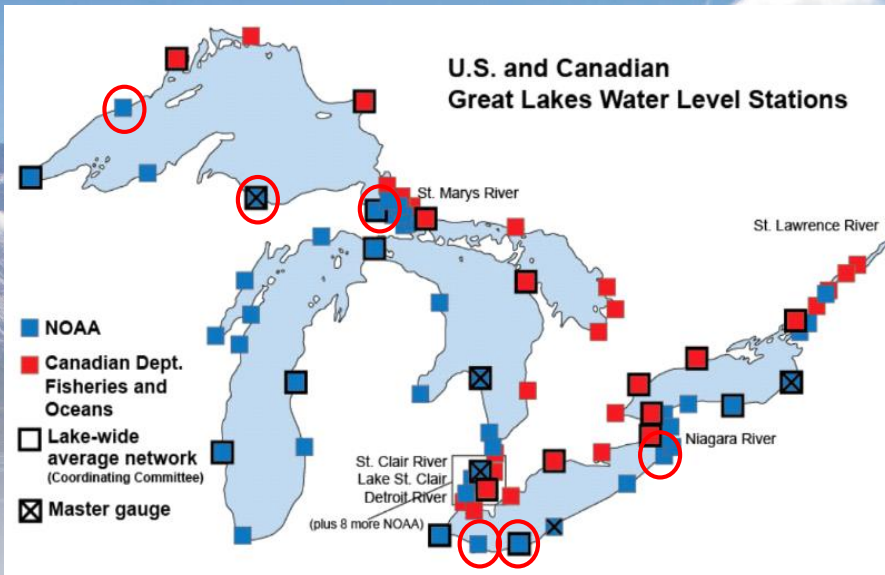
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# Collocated CORS and WLS Stations



- Great Lakes WLS in IGLD 85
  - U.S. side has 53 active stations
  - CO-OPS visits annually to survey
  - NGS GPS campaign 5 yr. cycle
  - Looking to use OP vice BB
- Great Lakes CORS stations
  - Master WLS on each Lake
  - Lake Erie: Buffalo, Cleveland, Marblehead
  - Superior: Point Iroquois, Marquette, Grand Marais
- NGS surveys fix TBM positions to sub-cm relative accuracy
- CO-OPS survey makes mm-level ties between TBM & WLS

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# Comparisons on Lakes Erie and Superior

Site	WLS ID	CORS ID	CORS ARP (IGS08)			ARP to WL (m)	WL HAE (m)
			Latitude (degrees N)	Longitude (degrees E)	HAE (m)		
Buffalo	9063020	BFNY	42.87755697	281.10955496	145.462	-7.610	137.852
Cleveland	9063063	OHCD	41.54074488	278.36485371	144.582	-5.932	138.650
Marblehead	9063079	OHHM	41.54368360	277.26854509	142.866	-5.357	137.509
Pt. Iroquois	9099004	PTIR	46.48458324	275.36915966	151.362	-5.399	145.963
Marquette	9099018	MIMQ	46.54554809	272.62130392	155.102	-7.337	147.765
Grand Marais	9099090	GDMA	47.74855226	269.65874853	157.364	-5.498	151.867

Site	IGLD 85 ht	Dynamic Heights (m) from Geopotential Numbers ( $W_i$ )			
		EGM2008	EIGEN6c4	xGEOID15A_REF	xGEOID15B_REF
Buffalo	174.197	173.653	173.635	173.652	173.648
Cleveland	174.158	173.582	173.570	173.564	173.586
Marblehead	174.144	173.541	173.544	173.571	173.566
Pt. Iroquois	183.580	182.901	182.897	182.911	182.906
Marquette	183.614	182.916	182.932	182.941	182.931
Grand Marais	183.613	182.890	182.891	182.908	182.919

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# Summary

- Existing datums are treated separately
  - They both have meter-level defects
- Future datum will be combine geometric and geopotential
  - Consistent with global models but regional in nature
- GNSS-derived positions from OPUS at cm-level
- Coordinates used in geopotential/geoid model for heights
  - Orthometric heights for terrestrial and dynamic for Lakes
- Close ties between physical heights and ocean surface
- Regional usage of datum by multiple countries



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# Questions?

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