



IGLD (2020): Updating the common height reference system for the Great Lakes

Jacob M. Heck, Ph.D.

NOAA's National Geodetic Survey

Vertical Control - Water Levels Subcommittee of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data



Mapping the Great Lakes Webinar Series

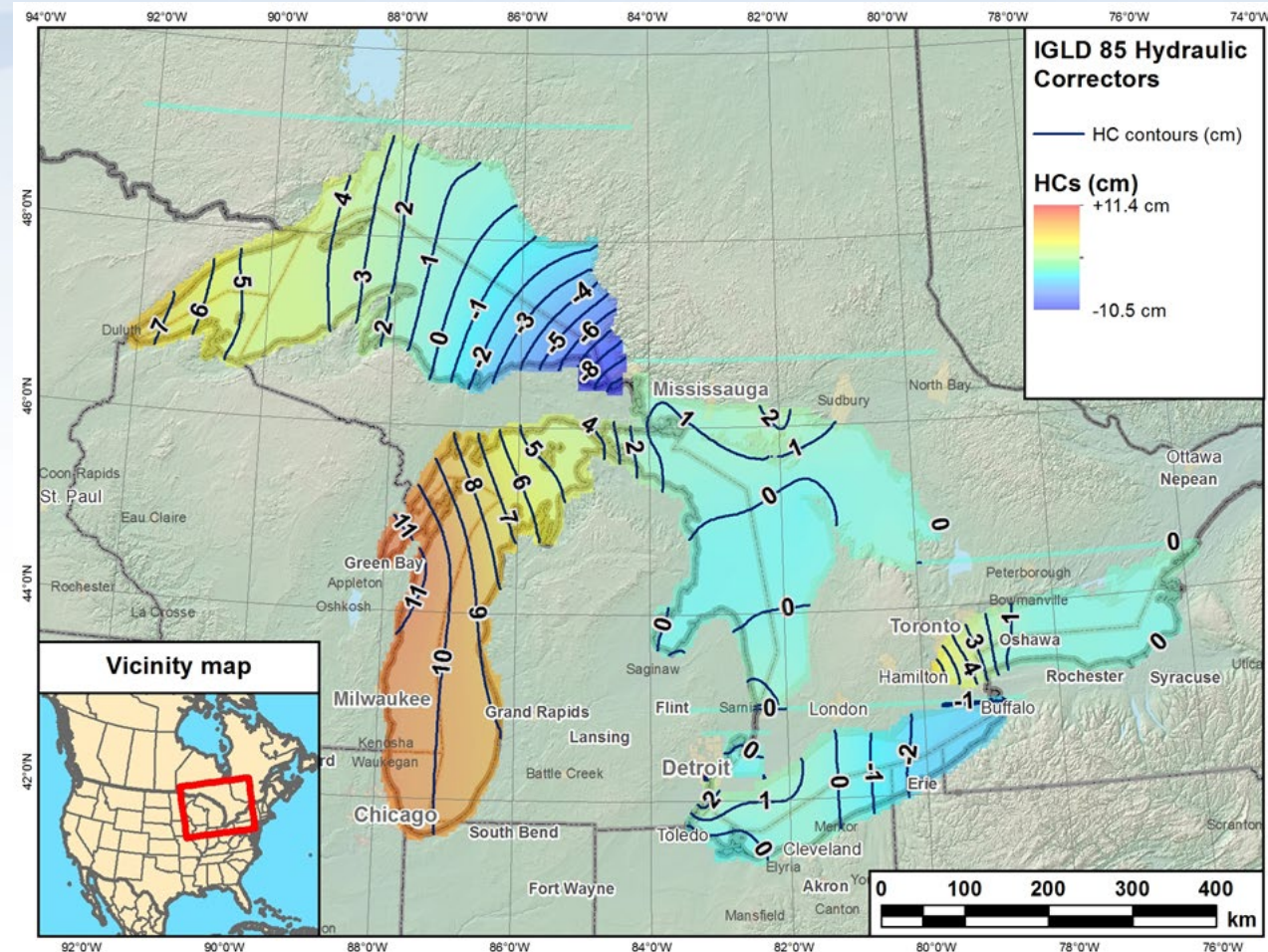
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What is IGLD?

- International Great Lakes Datum (IGLD) is a common height reference system by which water levels can be measured and meaningfully related to each other
- Joint effort between the United States and Canada
- Maintained by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data
- Due primarily to Glacial Isostatic Adjustment, IGLD is updated every 25-35 years
- The next update will be IGLD (2020)

Current IGLD

- IGLD (1985) replaced IGLD (1955) in 1992
- Same reference zero as NAVD 88 (at Pointe au Père, Québec)
- Surface determined by leveling
- Dynamic heights
- Hydraulic correctors



IGLD (1985) Reference Surface

- Reference surface is each lake (equipotential surface) to which orthometric or MSL heights are referenced
- IGLD 1955 & 1985 used 1000's miles of geodetic leveling to indirectly define the reference surface
 - Very time consuming & cost prohibitive
 - Datum accessible only where leveling exists (benchmarks)
 - Susceptible to accumulation of systematic errors
- Extends the reference zero inland

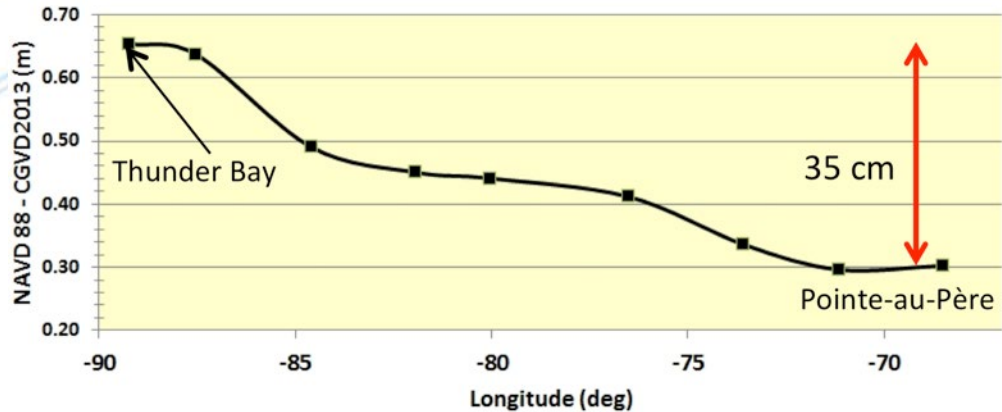


Figure 2: NAVD Leveling Loops - Network

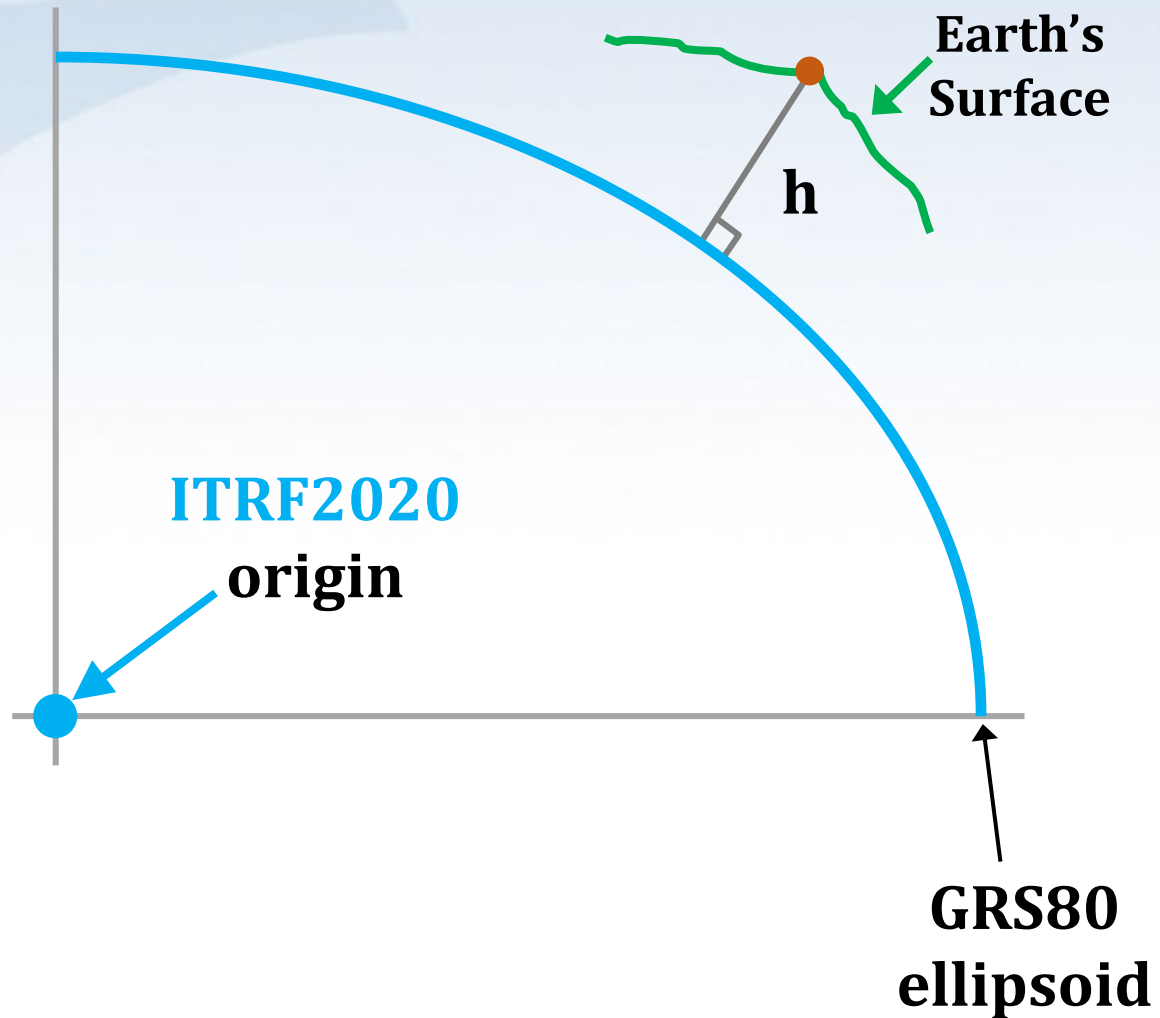


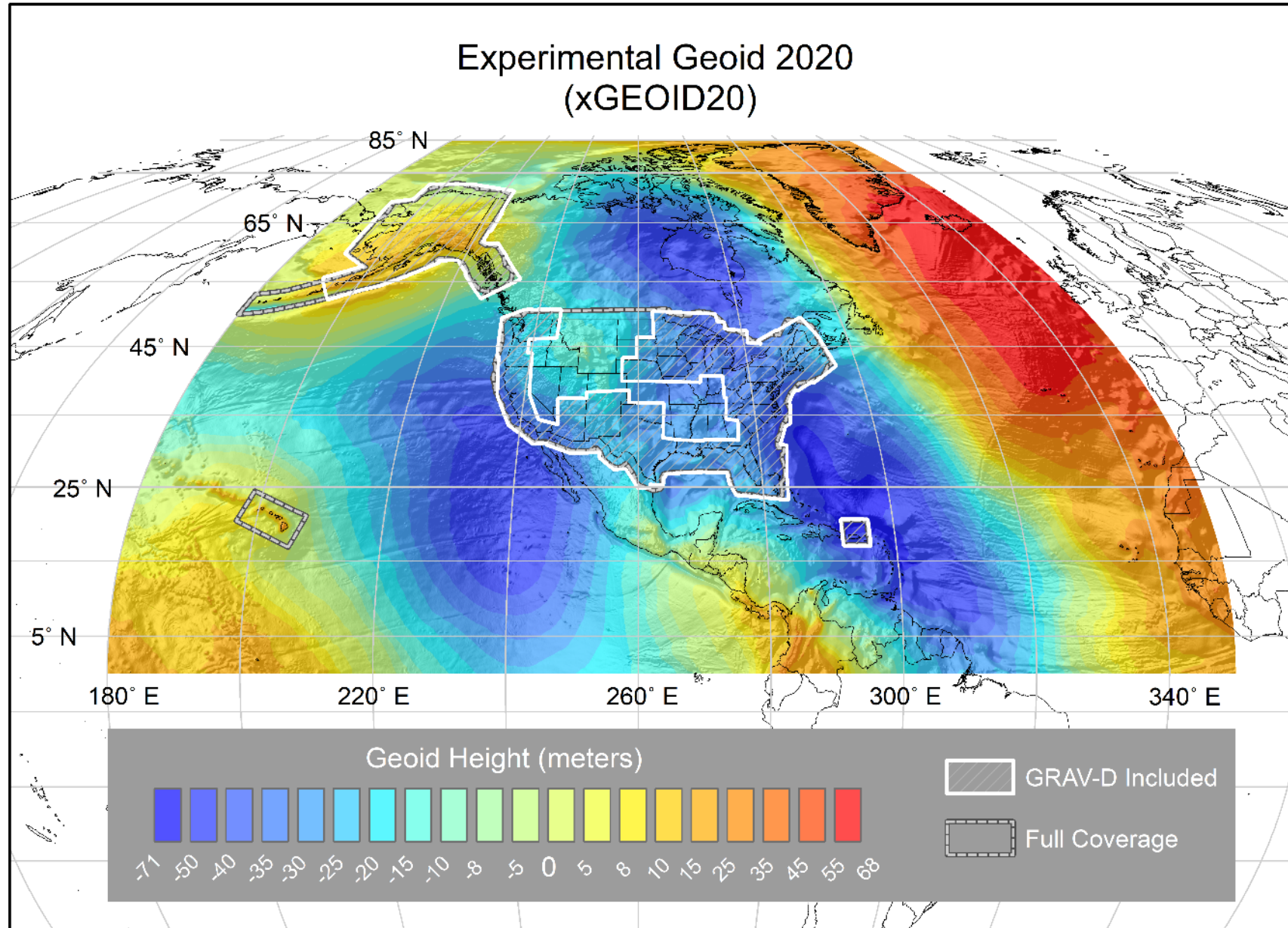
Definition of IGLD (2020)

- Reference Zero
 - $W_0 = 62,636,856.00 \text{ m}^2/\text{s}^2$ that the U.S. and Canada have adopted for the new geoid-based North American-Pacific Geopotential Datum of 2022 (NAPGD2022)
- Realization of the Reference Surface
 - Geoid model that represents the reference zero everywhere over the Great Lakes – St. Lawrence River system and not only where leveling and bench marks exist
- Reference Epoch
 - 2020.0, the central epoch of the 7-year water level observation period of 2017–2023
- Dynamic Height
 - IGLD (2020) will use dynamic heights derived from GNSS occupations
 - The dynamic height represents the difference in potential above the reference surface and is the same at all points on a level surface



ITRF2020





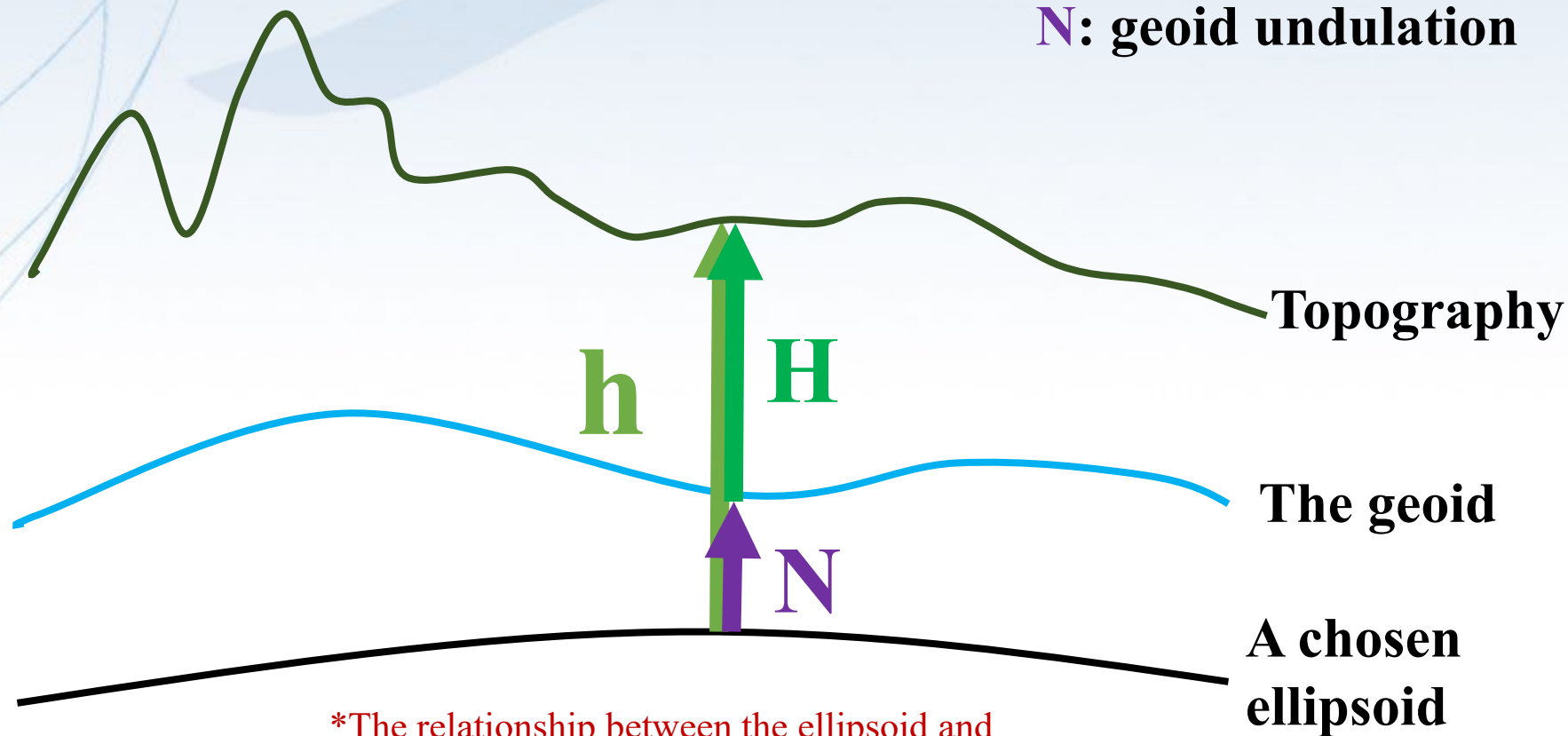
The Geoid, and Heights

$$h = H + N$$

h: ellipsoidal height

H: orthometric height

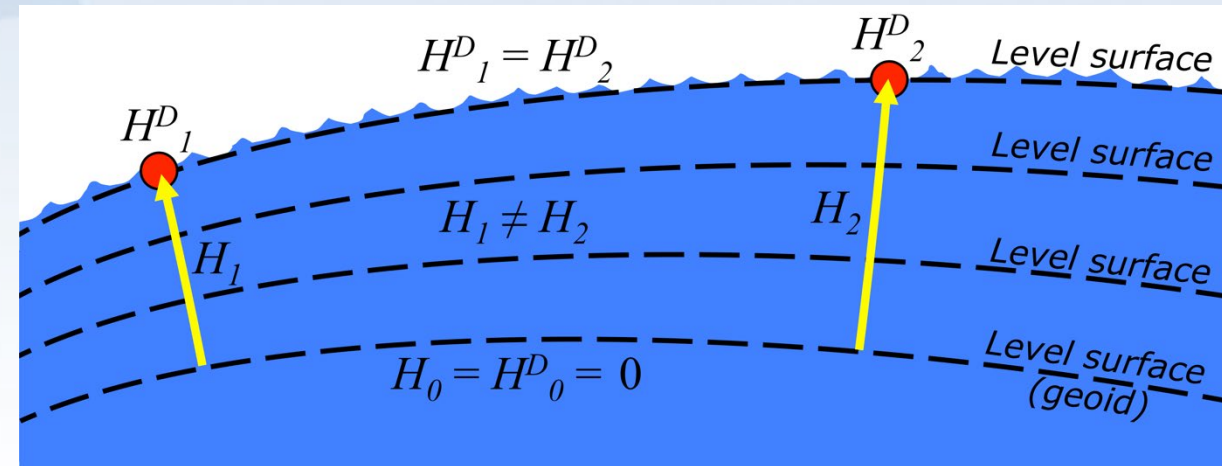
N: geoid undulation



*The relationship between the ellipsoid and the geoid may be swapped in some locations

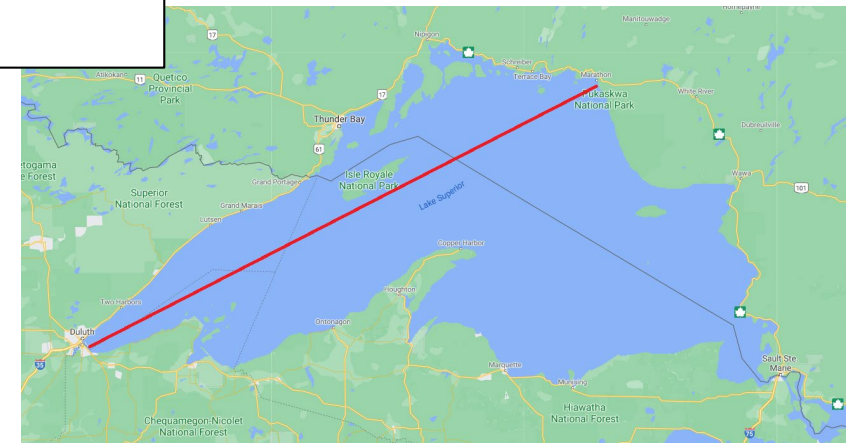
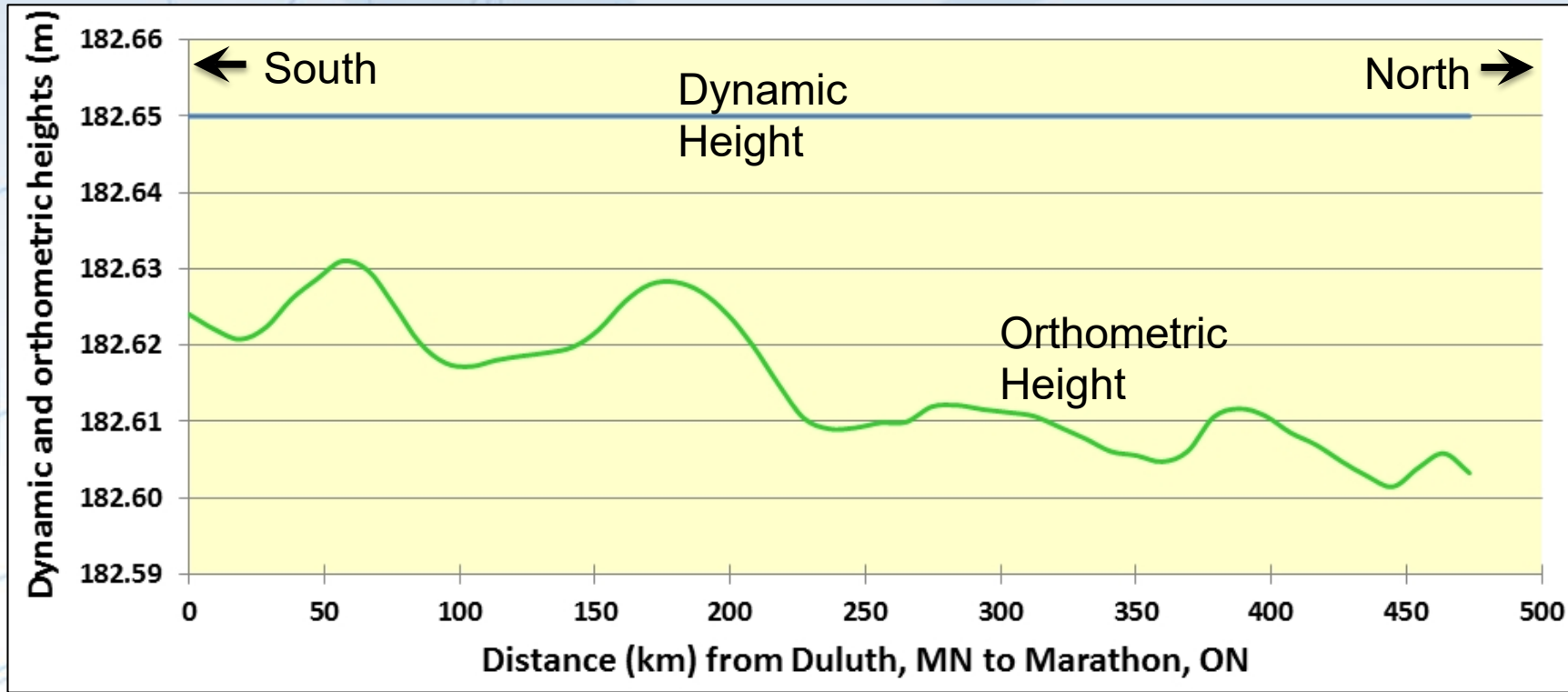
Determining Heights in IGLD (2020)

- $H = h - N$
- $H^D = \frac{\bar{g}*(h-N)}{\gamma_{45}}$
- h determined from GNSS
- \bar{g} determined from surface gravity model and Helmert height reduction formula
- γ_{45} is normal gravity at 45 degrees (constant)
- N determined from the NAPGD2022 geoid model



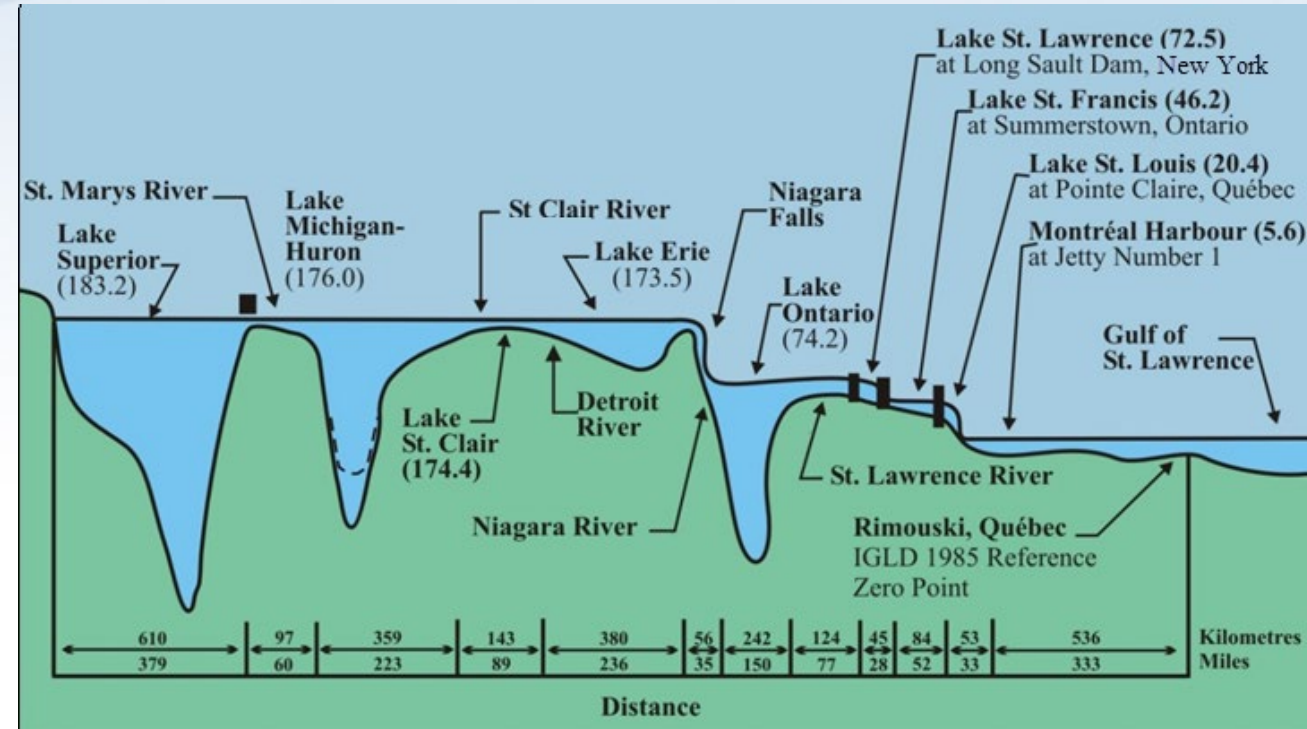
Dynamic heights, H^D , and orthometric heights, H .

Dynamic vs. Orthometric Heights



Low Water Datum

- LWD or chart datum identifies a surface so low that the water level will seldom fall below it
- Different LWD surfaces are used for different lakes & rivers
- Depths on navigation charts & for navigation improvements refer to LWD

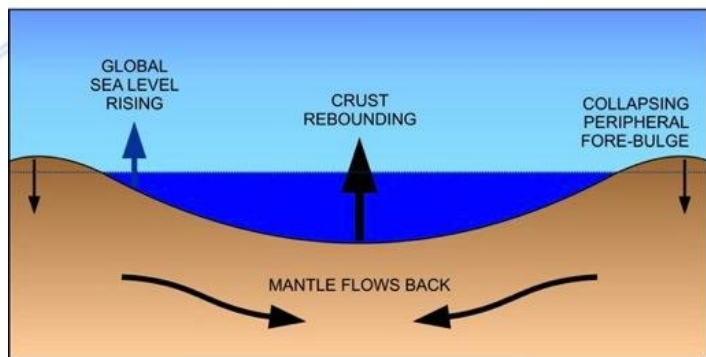
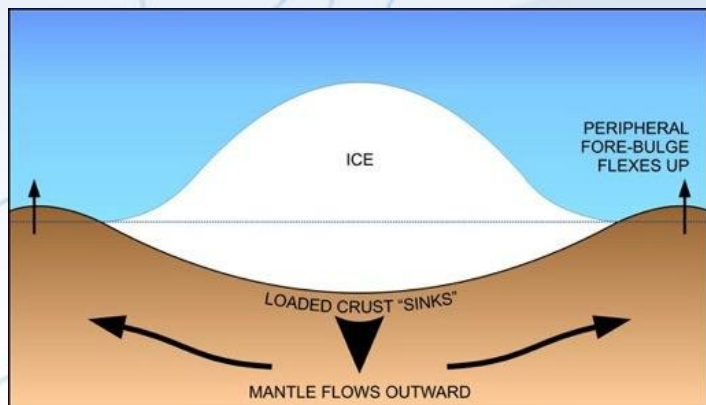


Low Water Datum

- LWD originally determined in 1933 and has not been reviewed since
- The same LWD surface has been referenced to the different IGLD datums through a translation of the old LWD surface
- Can reference the same LWD to IGLD (2020) but...
- Re-evaluation of LWD is recommended due to
 - Historically high and low water levels since 1933
 - Changes to hydraulic and hydrologic conditions

Why a new IGLD?

Glacial Isostatic Adjustment – (GIA)

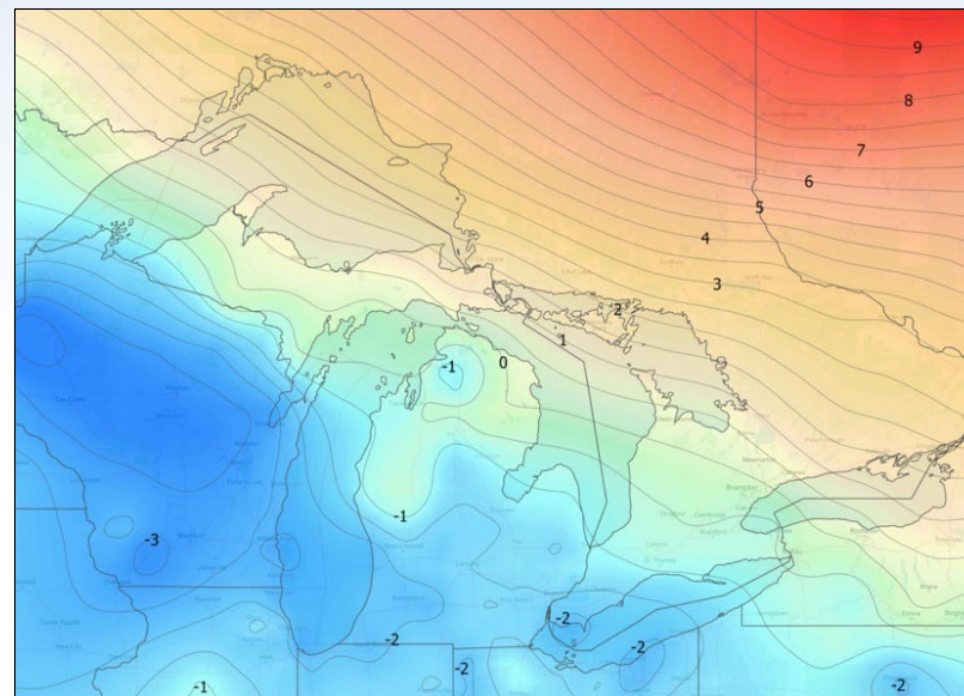


Process of glacial isostatic adjustment

Uplifting in north
Subsiding in south

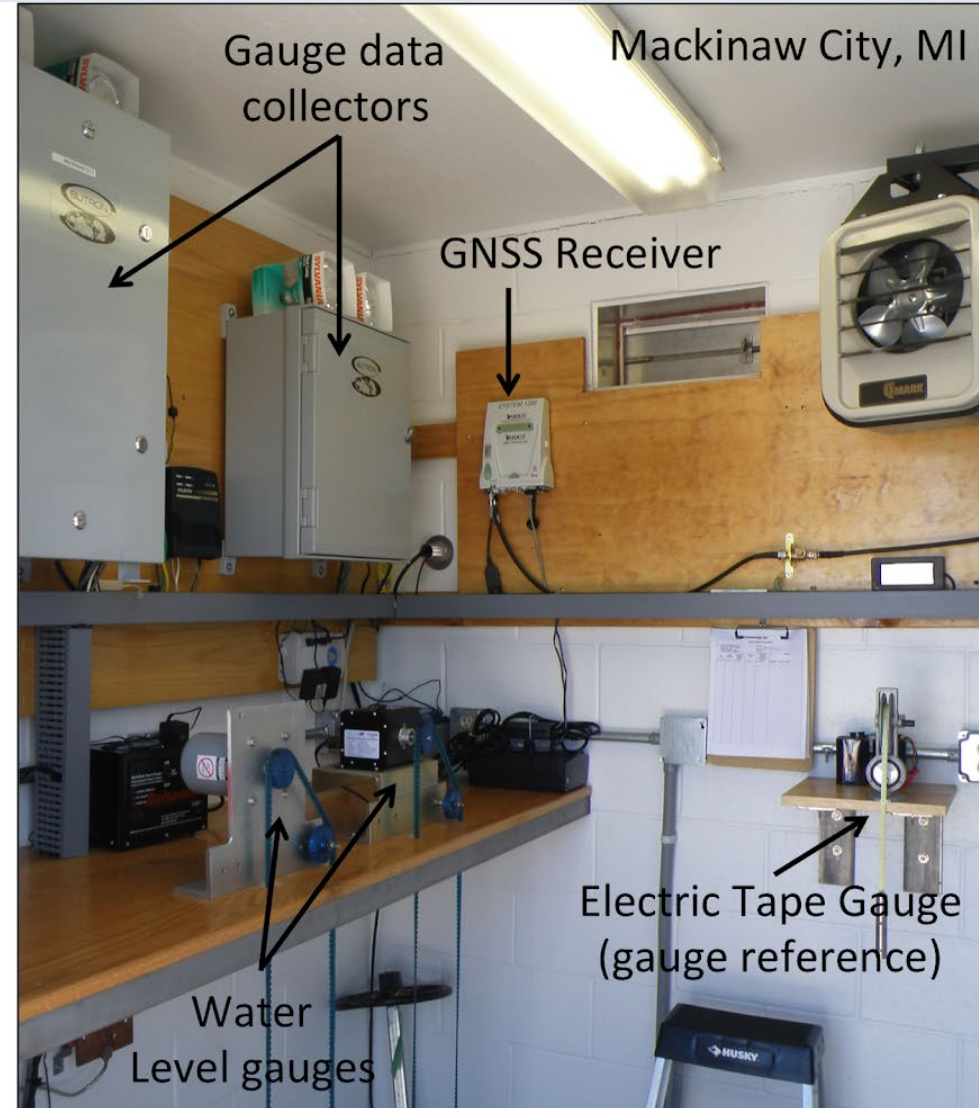
Overall tilting ~7 mm/year
(21cm or 0.7' over 30 year)

Need to update IGLD every
25-30 years

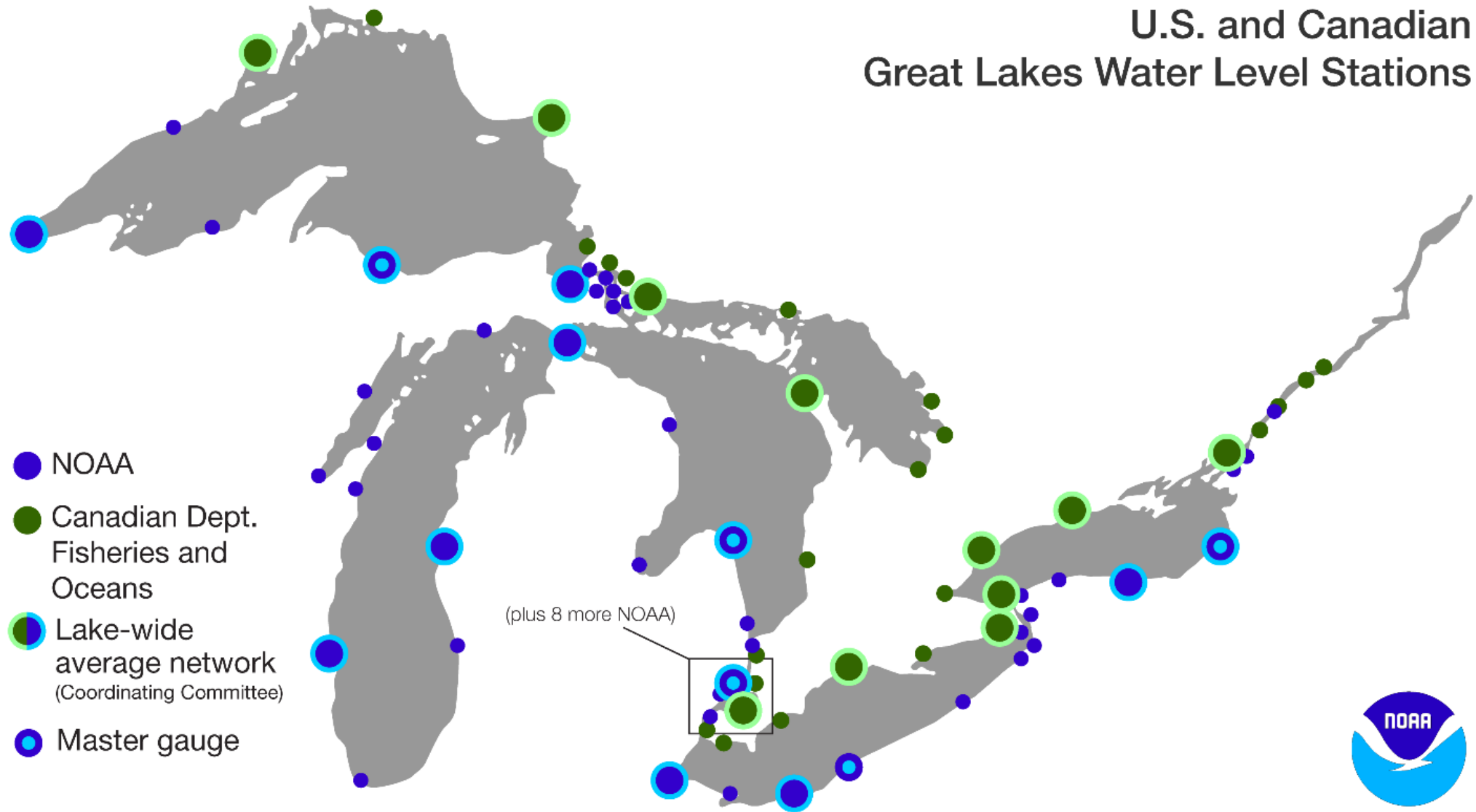


Contour map of vertical velocities in mm/yr

Typical CORS/CACS



U.S. and Canadian Great Lakes Water Level Stations



Typical GNSS Setups



Status

- GNSS field campaign originally scheduled for 2020 is now postponed until 2022.
- Seasonal gauging continues.
- Hydraulic corrector working group set up to investigate the need for HCs in IGLD (2020).
- IGLD (2020) is planned for release after NAPGD2022 is released.

Thank you

Jacob M. Heck, Ph.D.

jacob.heck@noaa.gov

Great Lakes Regional Geodetic Advisor
National Geodetic Survey
National Oceanic and Atmospheric Administration

<http://www.greatlakescc.org>