

The International Great Lakes Datum: Foundational Infrastructure for Monitoring Lake Levels

 COORDINATING COMMITTEE 



Jacob Heck & Jeff Jalbrzikowski
NOAA/National Geodetic Survey
On behalf of the



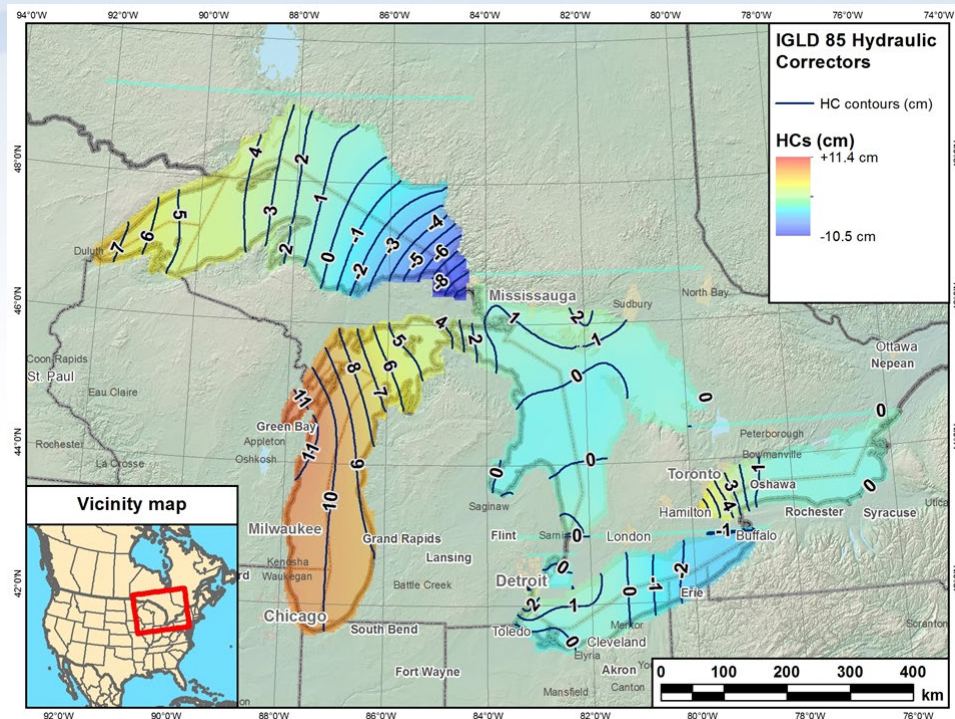
Vertical Control-Water Levels Subcommittee of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data

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)

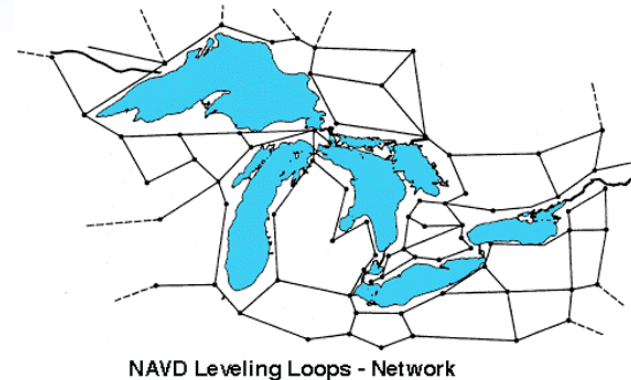
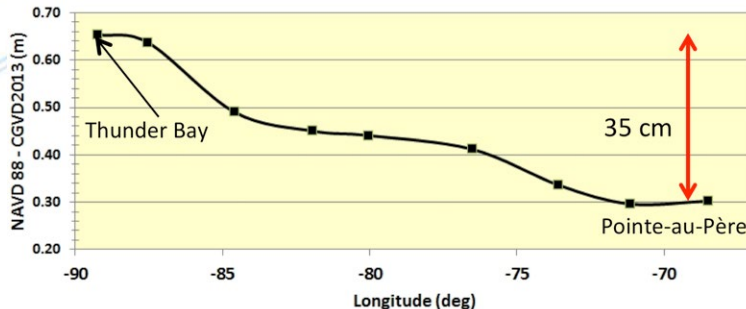
Current IGLD

- 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



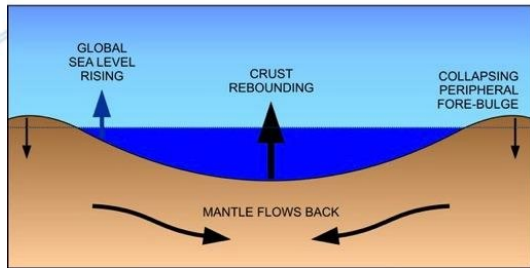
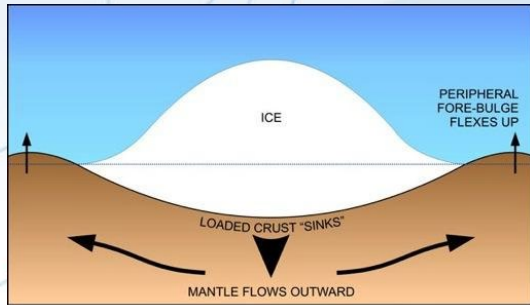
IGLD (1985) Reference Surface

- Reference surface is each lake (equipotential surface) to which 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



Why a new IGLD?

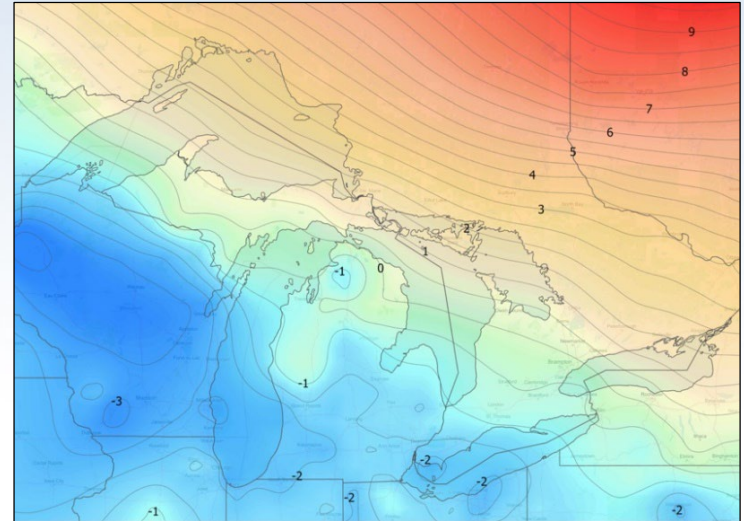
Glacial Isostatic Adjustment – (GIA)



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

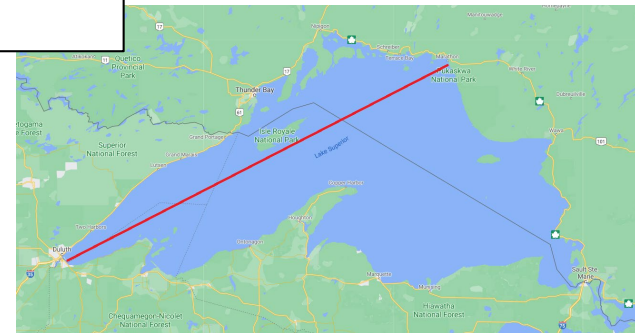
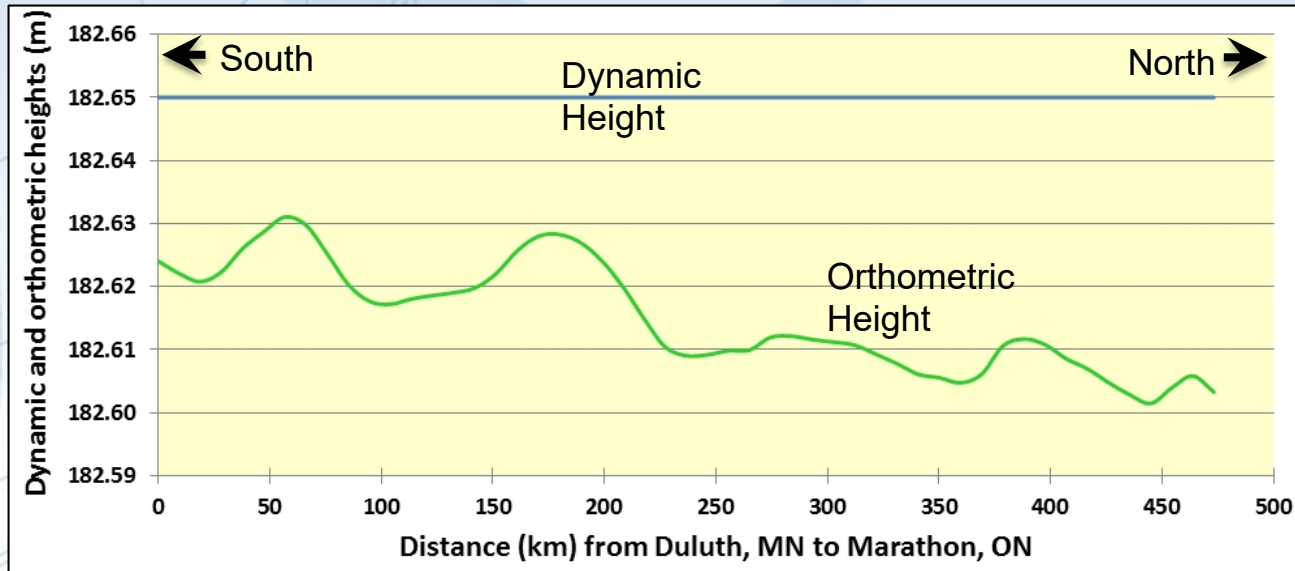


Process of Glacial Isostatic Adjustment (left) and the resulting tilting of the entire Great Lakes region (right) as determined by high accuracy GPS measurements in units of mm/year. M. Craymer and C. Wisotzkey, 2021.

Definition of IGLD (2020)

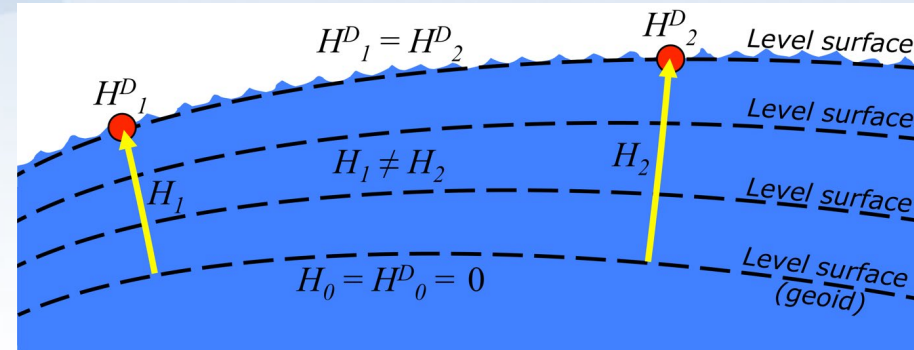
- Reference Zero
 - $W_0 = 62,636,856.00 \text{ m}^2/\text{s}^2$ that the U.S. and Canada have adopted for the new geoid-based North American-Pacific Geopotential Datum of 2022 (NAPGD2022) & Canada has already adopted for the Canadian Geodetic Vertical Datum of 2013 (CGVD2013)
- Realization of the Reference Surface
 - NAPGD2022 geoid model representing the reference zero everywhere over the Great Lakes – St. Lawrence River system, 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

Dynamic vs. Orthometric Heights



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 .

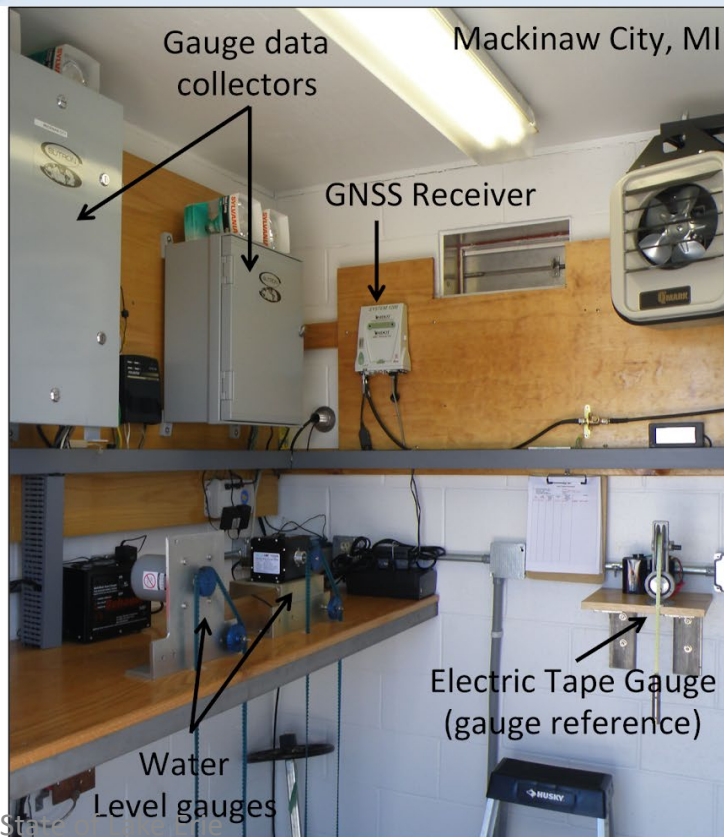
Key Activity – GNSS Surveys

- Need to determine heights of water level stations in the new geoid-based IGLD (2020)
- GNSS survey campaign will be required at all water level stations in **2020** → **2021** → **2022**
 - Permanent, seasonal, Seaway & hydro stations
- Using standardized binational guidelines
- Campaigns at permanent gauges
 - 1997, 2005, 2010, 2015, **2022** & 2027
 - Used to improve vertical velocity model

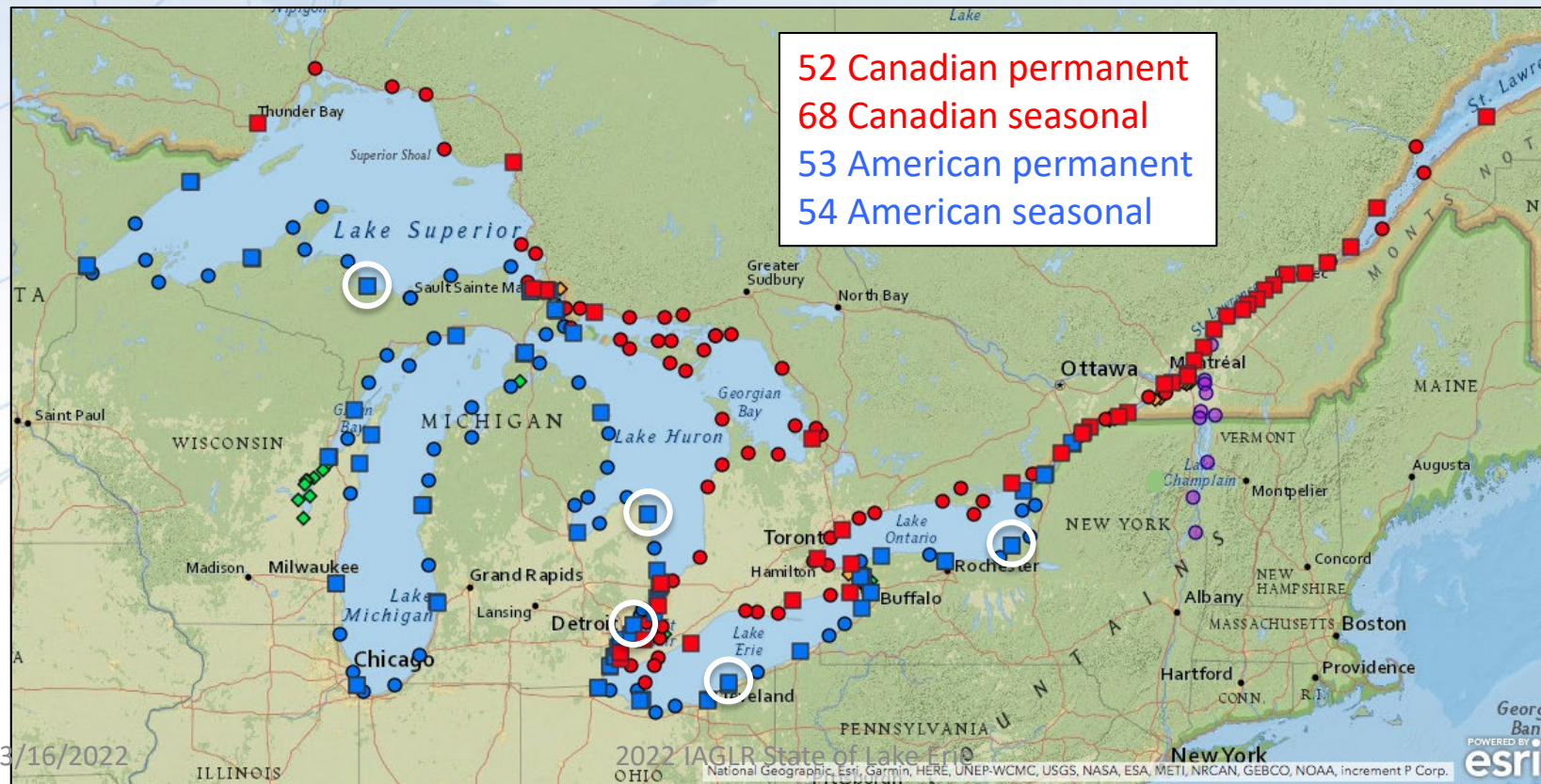


Typical GNSS Setup

Typical CORS/CACS



Water Level Gauges



Lake Erie Gauges



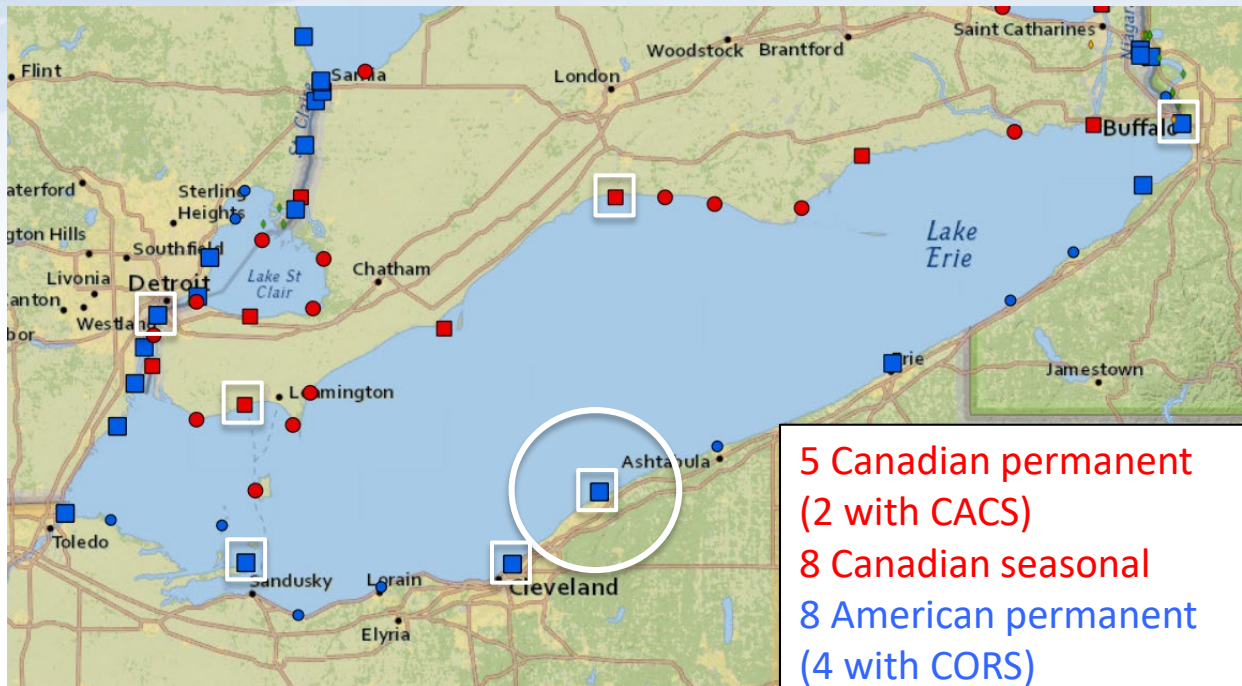
Home / Stations / 9063053 Fairport, OH ☆ Favorite Stations ▾

Station Info ▾ Tides/Water Levels ▾ Meteorological Obs. Phys. Occ

Fairport, OH - Station ID: 9063053

Station Info Today's Tides Photos Sensor Information Obs

Established:	May 04, 1935
Time Meridian:	75° W
Present Installation:	Aug 18, 1996
Date Removed:	N/A
Water Level Max (ref IGLD 1985):	575.10 ft. Jul 02, 2019
Water Level Min (ref IGLD 1985):	568.80 ft. Jan 30, 2008
Latitude	41° 45.6 N
Longitude	81° 16.9 W
NOAA Chart#:	14837
Met Site Elevation:	N/A



5 Canadian permanent (2 with CACS)
 8 Canadian seasonal
 8 American permanent (4 with CORS)
 7 American seasonal

Status of IGLD Update

- GNSS field campaign planned for 2022 – no plans to postpone again
- Seasonal gauging continues
- Hydraulic corrector working group set up to investigate the need for HCs in IGLD (2020)
- IGLD (2020) is planned for release about one year after the release of the NAPGD2022 vertical datum

IGLD Resources

- Great Lakes Coordinating Committee website

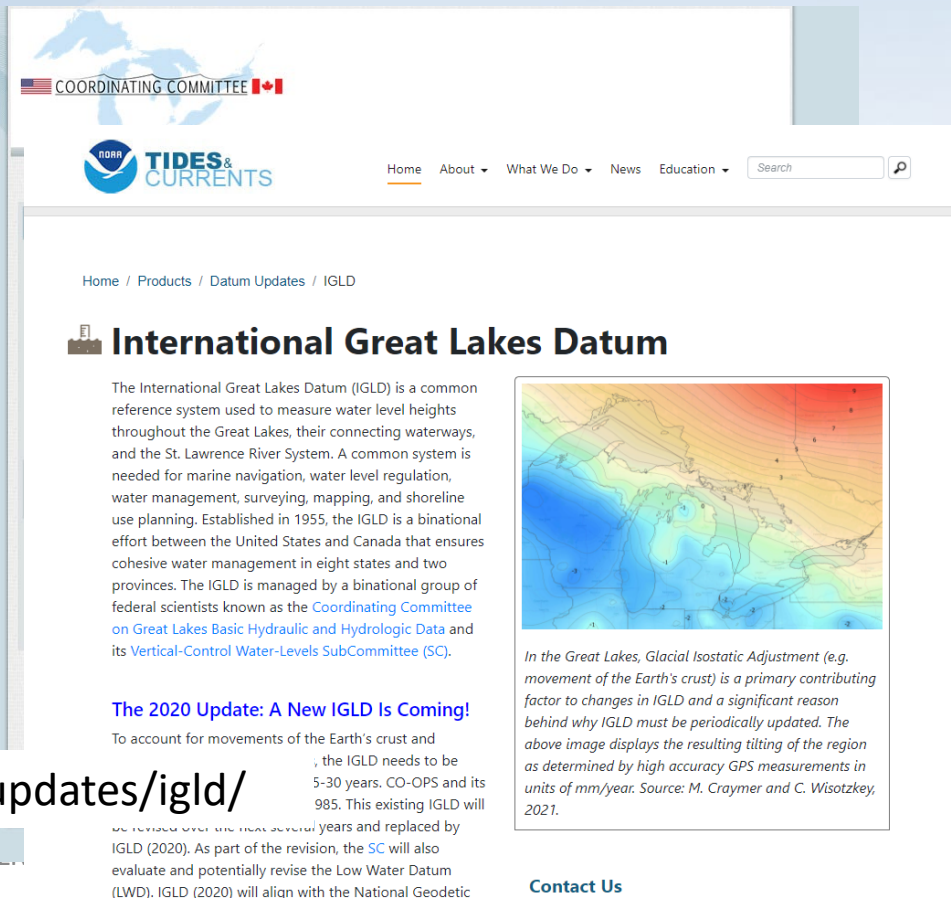
<http://www.greatlakescc.org>

- NOAA Center for Operational Oceanographic Products and Services (CO-OPS) website

<https://tidesandcurrents.noaa.gov/datum-updates/igld/>

3/16/2022

2022-03-16



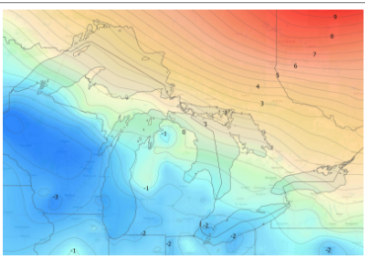
The screenshot shows the NOAA Tides & Currents website. At the top, there is a navigation bar with links for Home, About, What We Do, News, and Education, along with a search box. The main content area features a breadcrumb trail: Home / Products / Datum Updates / IGLD. The title of the page is "International Great Lakes Datum". The text explains that the IGLD is a common reference system used for water level measurements in the Great Lakes region. It mentions that the IGLD is a binational effort between the United States and Canada, managed by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data and its Vertical-Control Water-Levels Subcommittee (SC). A section titled "The 2020 Update: A New IGLD Is Coming!" states that the IGLD needs to be updated every 5-30 years. The current IGLD (1985) will be replaced by IGLD (2020) over the next several years. The update will align with the National Geodetic Vertical Datum of 1988 (NGVD 88) and the Low Water Datum (LWD). IGLD (2020) will align with the National Geodetic Vertical Datum of 1988 (NGVD 88).

International Great Lakes Datum

The International Great Lakes Datum (IGLD) is a common reference system used to measure water level heights throughout the Great Lakes, their connecting waterways, and the St. Lawrence River System. A common system is needed for marine navigation, water level regulation, water management, surveying, mapping, and shoreline use planning. Established in 1955, the IGLD is a binational effort between the United States and Canada that ensures cohesive water management in eight states and two provinces. The IGLD is managed by a binational group of federal scientists known as the [Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data](#) and its [Vertical-Control Water-Levels Subcommittee \(SC\)](#).

The 2020 Update: A New IGLD Is Coming!

To account for movements of the Earth's crust and sea level rise, the IGLD needs to be updated every 5-30 years. CO-OPS and its partners are currently working on the IGLD (2020). This existing IGLD will be replaced over the next several years and replaced by IGLD (2020). As part of the revision, the SC will also evaluate and potentially revise the Low Water Datum (LWD). IGLD (2020) will align with the National Geodetic Vertical Datum of 1988 (NGVD 88).



In the Great Lakes, Glacial Isostatic Adjustment (e.g. movement of the Earth's crust) is a primary contributing factor to changes in IGLD and a significant reason behind why IGLD must be periodically updated. The above image displays the resulting tilting of the region as determined by high accuracy GPS measurements in units of mm/year. Source: M. Craymer and C. Wisotzkey, 2021.

Contact Us

NGS Resources

- July 15, 2021 webinar: **[Vertical Datums: An Overview & Planned Updates](https://geodesy.noaa.gov/web/science_edu/webinar_series/2021-webinars.shtml)**
- **https://geodesy.noaa.gov/web/science_edu/webinar_series/2021-webinars.shtml**
- **New Datums: <https://geodesy.noaa.gov/datums/newdatums/>**

The screenshot shows the NOAA National Geodetic Survey website. At the top, the NOAA logo and the text "National Geodetic Survey Positioning America for the Future" are visible. Below this is a navigation menu with links for "NGS Home", "About NGS", "Data & Imagery", "Tools", "Surveys", "Science & Education", and a search bar. The main content area features a large banner for "Webinar Certificates" with the text: "Earn certificates for viewing recorded NGS webinars about geodesy, remote sensing and more." To the right of this text is an icon of a certificate with a ribbon and a seal. Below the banner is a section titled "Learn more about Webinar Certificates" with a paragraph of text: "NOAA's National Geodetic Survey (NGS) provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, and shoreline information impact a wide range of important activities." Below this text are six icons representing different services: "Process GPS Data (OPUS)", "NGS Data Explorer", "Looking for Bench Marks", "Conversion & Transformation (NCAT)", "NOAA CORS Network", and "New Datums". At the bottom of the page, there are sections for "Popular Links" (with a "New Visitor" indicator) and "Stay Informed: Subscribe" with a red envelope icon.

<https://geodesy.noaa.gov/>

National Geodetic Survey
Positioning America for the Future

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NOAA's National Geodetic Survey (NGS) provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, and shoreline information impact a wide range of important activities.

Process GPS Data (OPUS) NGS Data Explorer Looking for Bench Marks

Conversion & Transformation (NCAT) NOAA CORS Network New Datums

Popular Links New Visitor

Stay Informed: Subscribe

Thank You!

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For more information, visit <http://www.greatlakescc.org>

Extra slides



Coordinating Committee on Great Lakes
Basic Hydraulic & Hydrologic Data



Updating the International Great Lakes Datum (IGLD)



Prepared by the
Vertical Control – Water Levels Subcommittee
on behalf of the
Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data

http://www.greatlakescc.org/wp36/wp-content/uploads/2017/09/IGLD_Update_20170929_220dpi.pdf

September 2017

America for the Fu

National Geodetic Survey Positioning America for the Future

geodesy.noaa.gov



NOAA Technical Report NOS NGS 64

Blueprint for the Modernized NSRS, Part 2: Geopotential Coordinates and Geopotential Datum

https://geodesy.noaa.gov/library/pdfs/NOAA_TR_NOS_NGS_0064.pdf

November 2017

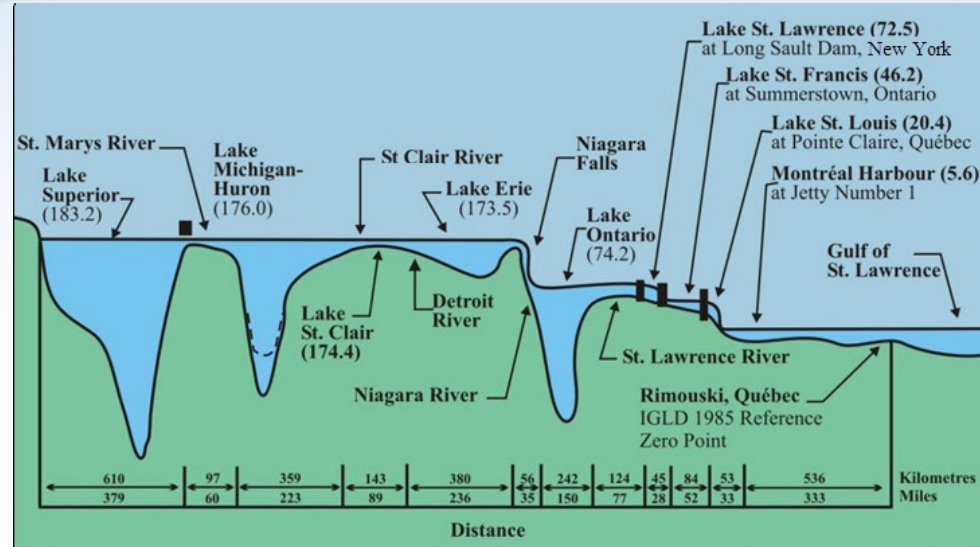


National Oceanic and Atmospheric Administration • National Geodetic Survey

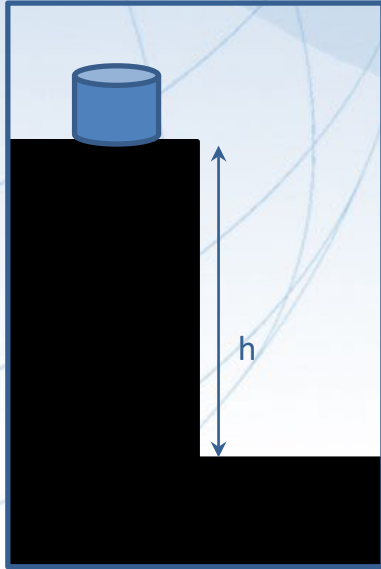
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Low Water Datum

- 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

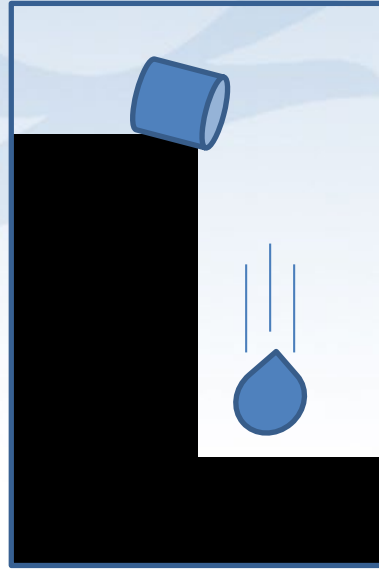


Understanding “Geo-Potential”



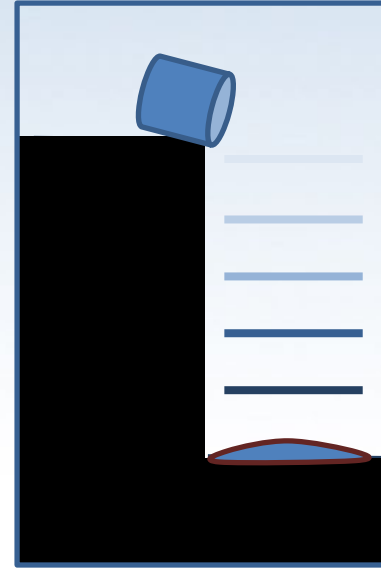
The resting water has “potential” energy just by being high up on this cliff.

Energy = mgh



That potential energy can turn into real (kinetic) energy by falling.

Energy = $\frac{1}{2} mv^2 (= mgh)$



Think of the Earth as creating a “gravity field” that masses experience. I’ve drawn potential “field lines”

Potential = gh

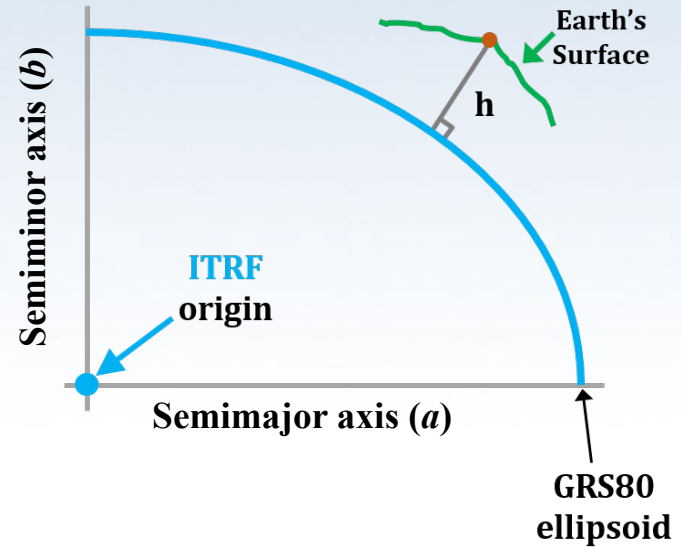
Gravity x Height is “Geopotential”. This is what water “feels”.



ITRF2020

Ellipsoidal height h

- Accessible through GNSS
- Height above simple mathematical surface (ellipsoid)
- Geometric coordinate (has nothing to do with water flow)



$$\text{Flattening } f = \frac{a-b}{a}$$

Geoid Height N and Orthometric Height H

- Separation of ellipsoid and geoid
- Modeled

