International Great Lakes Datum: Possible Impacts and What You Need to Know

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COORDINATING COMMITTEE
COMITÉ DE COORDINATION

Overview of 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
- Official vertical datum used for water level measurements and navigation charts throughout the Great Lakes, their connecting channels and the upper St. Lawrence River
- Maintained by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data, a binational committee with representatives from the Governments of Canada and the United States
- IGLD is updated every 25-35 years due to Glacial Isostatic Adjustment (GIA)
- The next update will be IGLD (2020), expected for release around 2026

Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data

- Formed in 1953
- Ad hoc group of federal experts
- Four subcommittees
  - Hydraulics
  - Hydrology
  - Coordinated Regulation and Routing Model
  - **Vertical Control - Water Levels**
    - Update and revise IGLD
    - Standardize water level data processing

Environment and Climate Change Canada

Environnement et Changement climatique Canada

NOAA – National Oceanic and Atmospheric Administration – U.S. Department of Commerce

Fisheries and Oceans Canada

Pêches et Océans Canada

USGS science for a changing world

Natural Resources Canada

Ressources naturelles Canada

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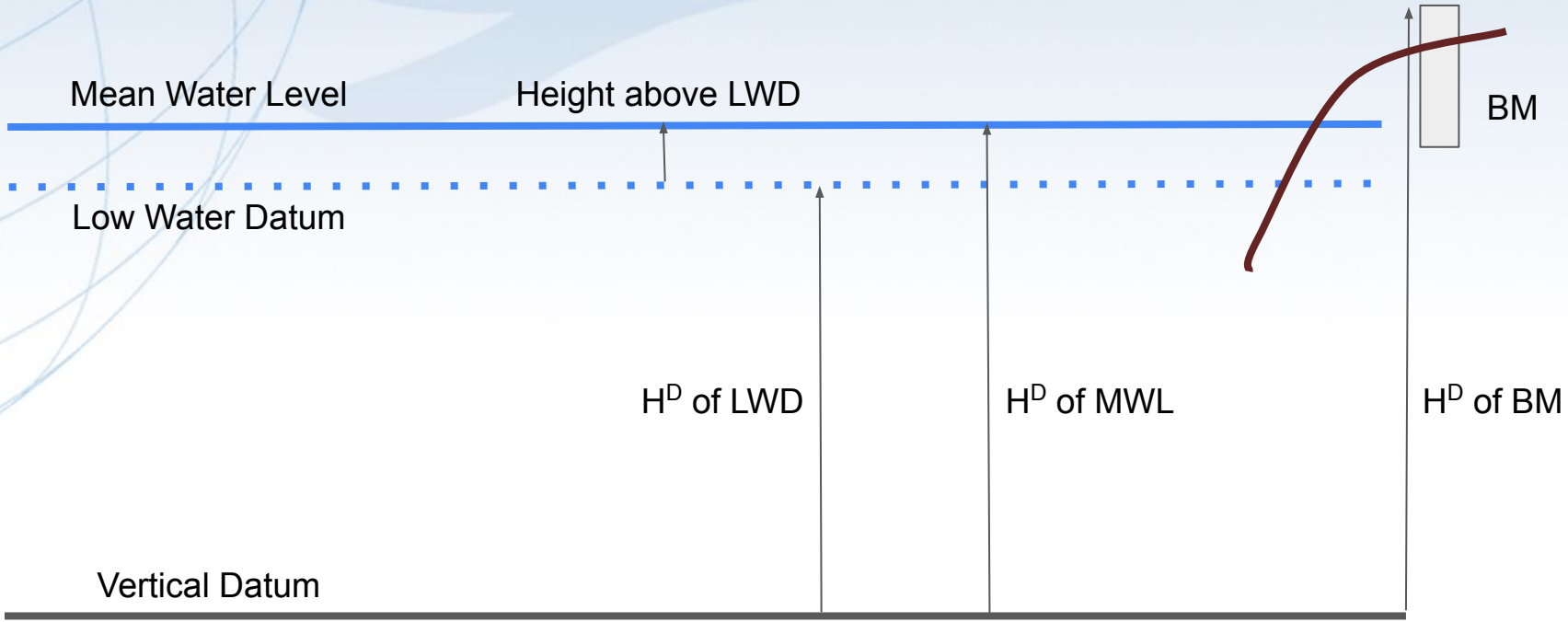
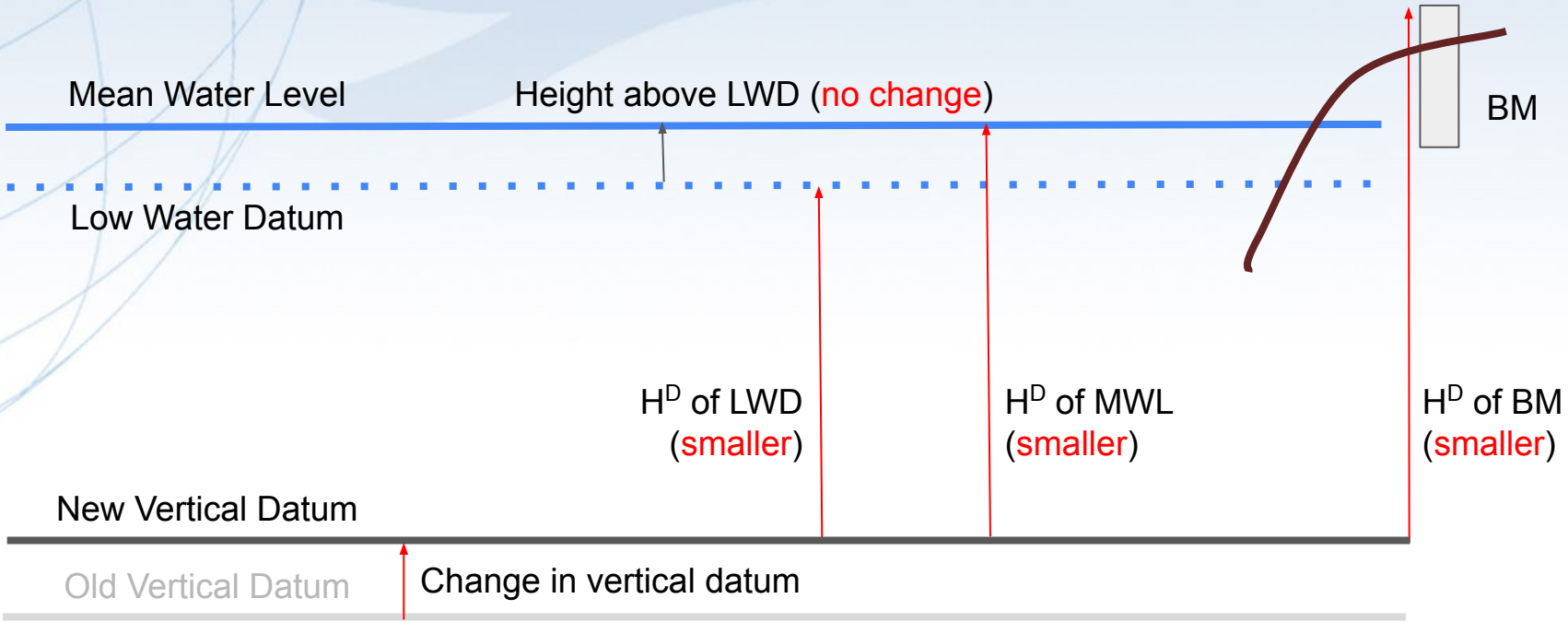
Change of Vertical Datum



Change of Vertical Datum



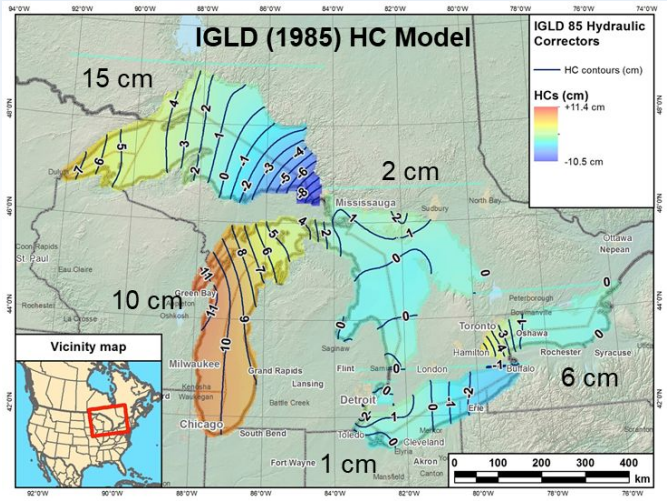
Current IGLD

- IGLD (1985) replaced IGLD (1955) in 1992
- Same reference zero as NAVD 88 (tide gauge at Pointe au Père, Québec)
- Surface determined from leveling
  - Very time consuming & cost prohibitive
  - Datum accessible only where leveling exists (bench marks)
  - Susceptible to accumulation of systematic errors
- Uses dynamic heights
- Hydraulic correctors applied to water levels of the lakes

Figure 2: NAVD Leveling Loops - Network

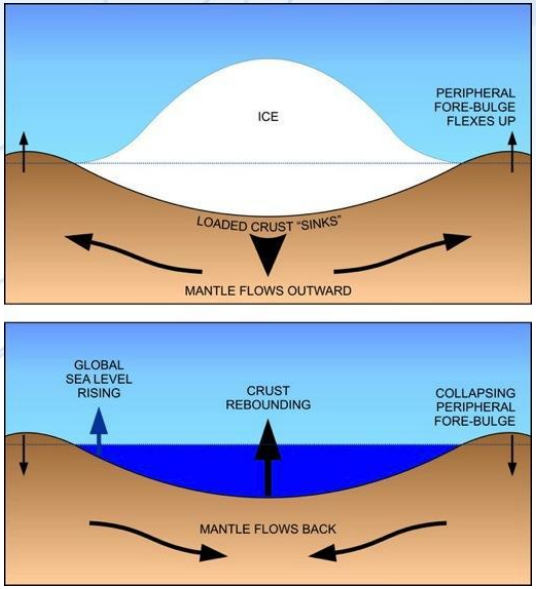
Hydraulic Correctors

- Dynamic heights should be the same at all gauges on a level lake
- In reality this is not the case because of
  - Currents, river discharge, temperature/density variations, prevailing winds, outlet drawdown
  - Creates a lake surface "topography"
- Hydraulic correctors (HCs) adjust the dynamic height at each gauge to agree with a single "master" gauge on each lake
- Used only for heights of water levels



Why a new IGLD?

Glacial Isostatic Adjustment – (GIA)

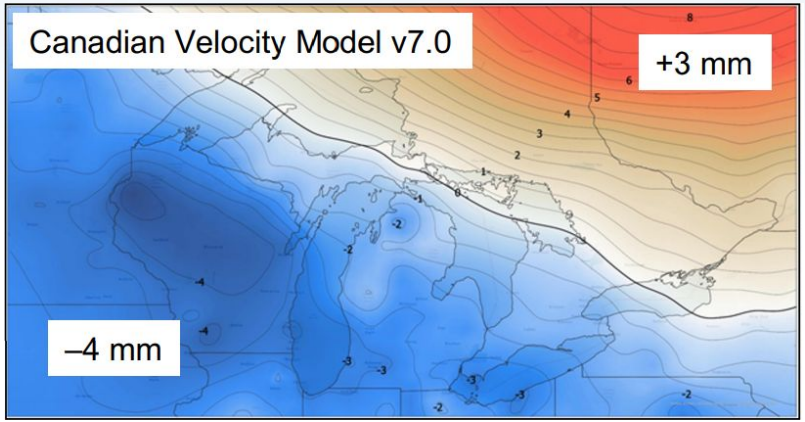


Process of glacial isostatic adjustment

Uplifting in north
Subsiding in south

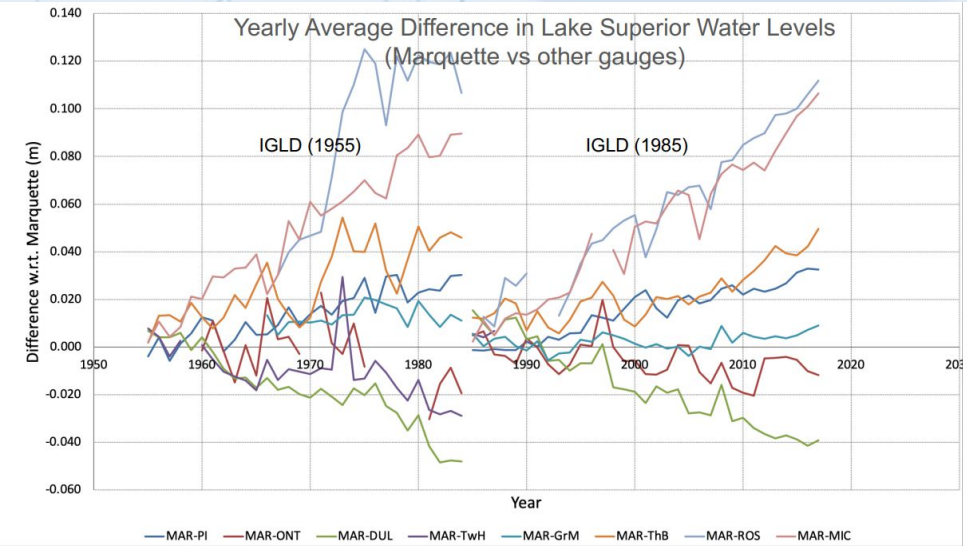
Overall tilting ~7 mm/year (21cm or 0.7' over 30 year)

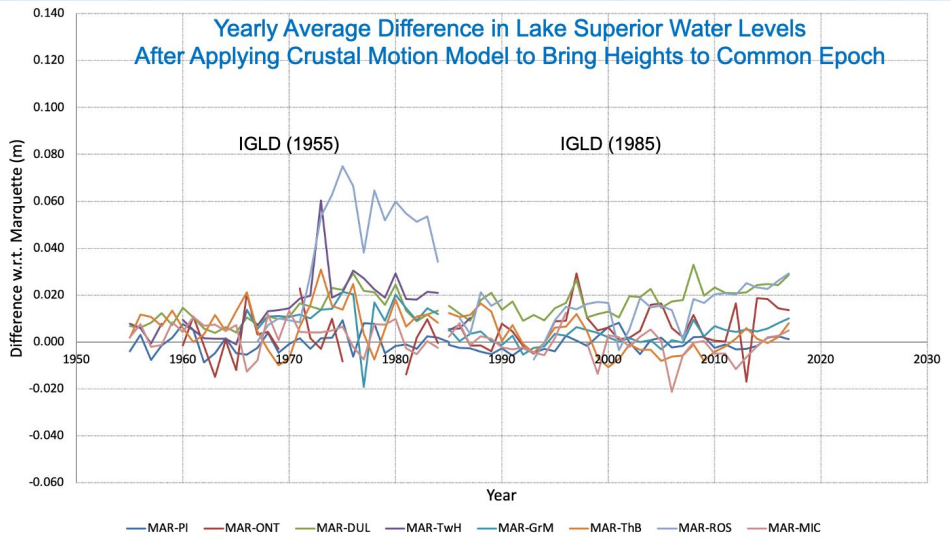
Need to update IGLD every 25-30 years



Contour map of vertical velocities in mm/yr

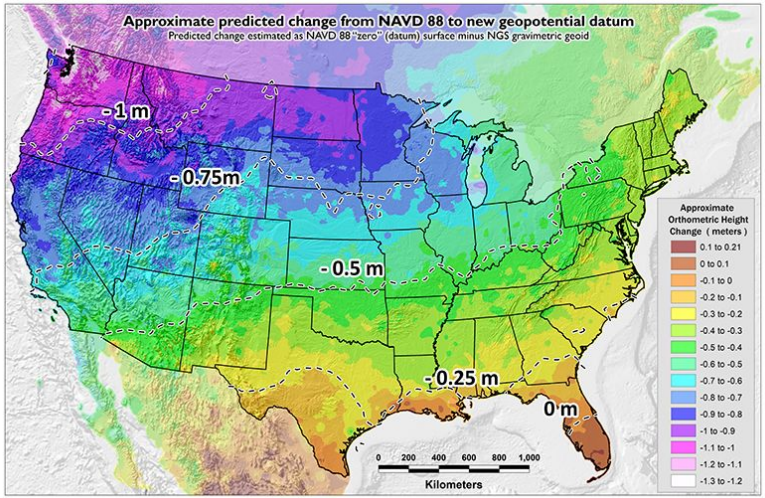
Effect of GIA Tilting on Water Levels





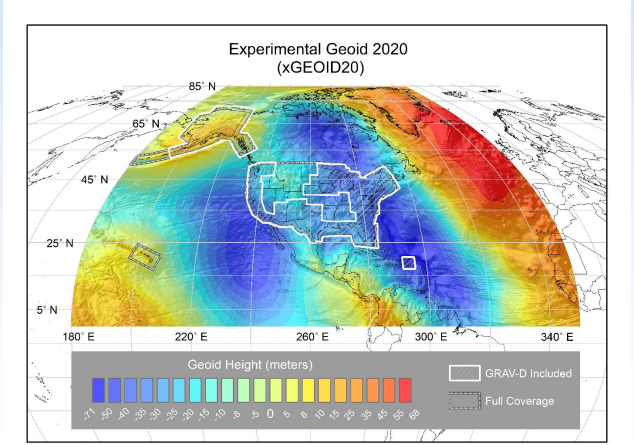
North American-Pacific Geopotential Datum of 2022

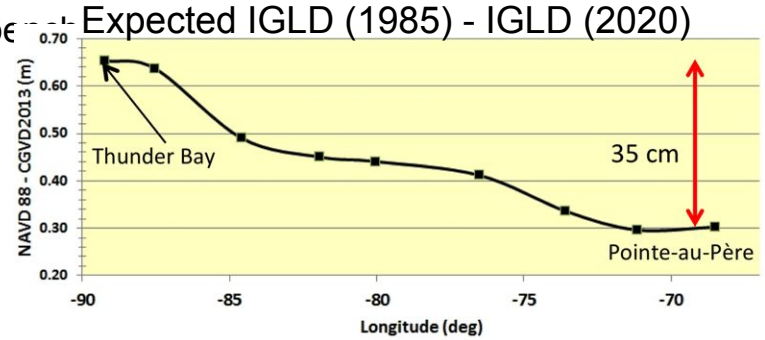
- NAVD 88 is being replaced by NAPGD2022
- Based on a geoid model
  - Geoid defined by gravity data
  - Not dependent on expensive leveling
  - Defined everywhere
  - Height determined via GNSS (more efficient) and references to the NATRF2022 ellipsoid
  - Local leveling will still be needed
- Time-dependent
  - Coordinates will keep up with physical changes
- Compatible with CGVD2013
  - Using identical reference zero
  - Canada expected to adopt the new geoid model
  - Will harmonize national vertical datums for IJC's International Watersheds Initiative
- IGLD (2020) will be based on NAPGD2022



IGLD (2020) Defining Attributes

- Reference Zero
  - A geopotential value representing mean sea level around the coast of North America
  - Same value as geoid-based North American-Pacific Geopotential Datum of 2022 (NAPGD2022) and the geoid-based Canadian Geodetic Vertical Datum of 2013 (CGVD2013)
- Reference Surface
  - NAPGD2022 geoid model representing the reference zero
  - Defined everywhere over the Great Lakes – St. Lawrence River system, not only where leveling and benchmarks exist
- Reference Epoch
  - 2020.0 is the reference epoch for the heights
  - Same as the central epoch of the 7-year water level observation period of 2017–2023

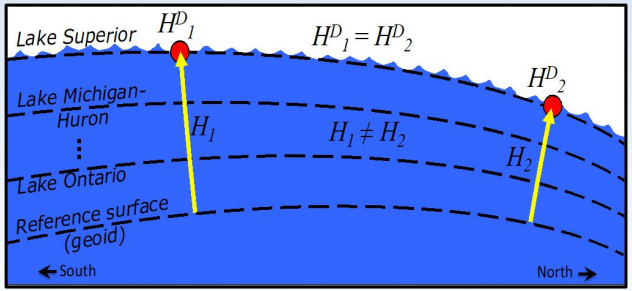




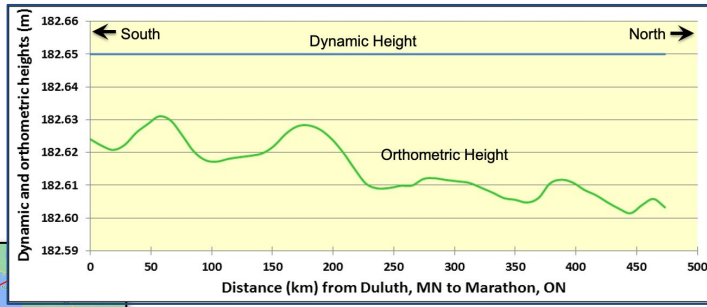
IGLD (2020) Attribute: Dynamic Heights

- Orthometric heights (H)
  - Typical heights used in most applications
  - Physical distance above reference surface (geoid)
  - Not constant along a level surface (like a lake) because equipotential convergence as you go north
  - Geopotential numbers scaled by local gravity

- Dynamic heights (H^D)
  - Geopotential numbers scaled by a constant gravity value
  - Constant along a level (lake) surface by definition
  - Enables the measurement of hydraulic head for water level management
  - Used by all IGLD realizations



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



Determining Heights in IGLD (2020)

- Previous IGLDs were determined by levelling
  - Over time, many benchmarks likely moved or were damaged
  - Levelling network is outdated
  - Re-levelling the whole network is too costly and time consuming
- Levelling network will be readjusted in NAPGD2022/IGLD (2020) but…
- No plans to maintain the existing levelling network or its benchmarks
- Primary access will be via GNSS, not levelling from benchmarks (BMs)

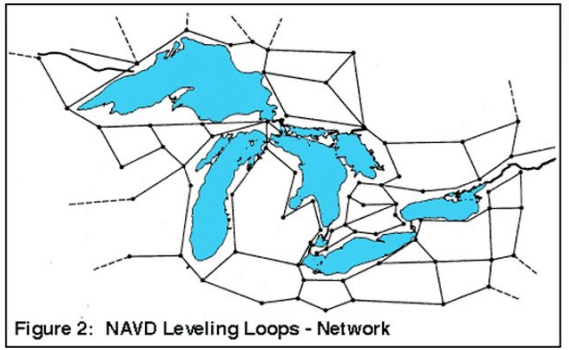


Figure 2: NAVD Leveling Loops - Network

Determining Heights via GNSS

$$h \rightarrow H \rightarrow H^D$$

h = ellipsoidal height obtained from GNSS

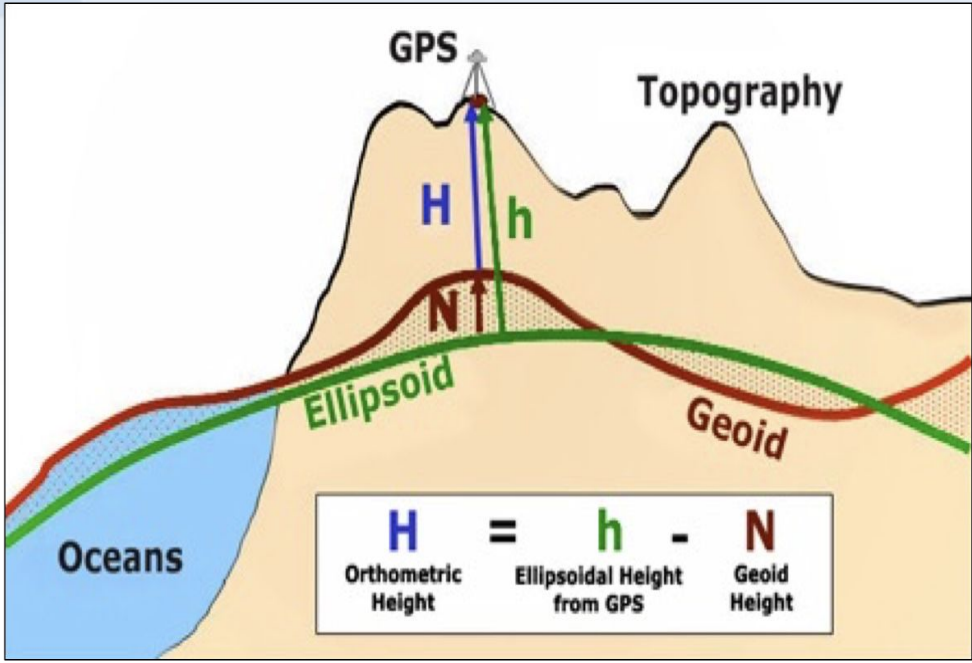
N = geoid height obtained from geoid model (provided by CGS & NGS)

H = orthometric height

H^D = dynamic height obtained from H using gravity model (provided by NGS/CGS)

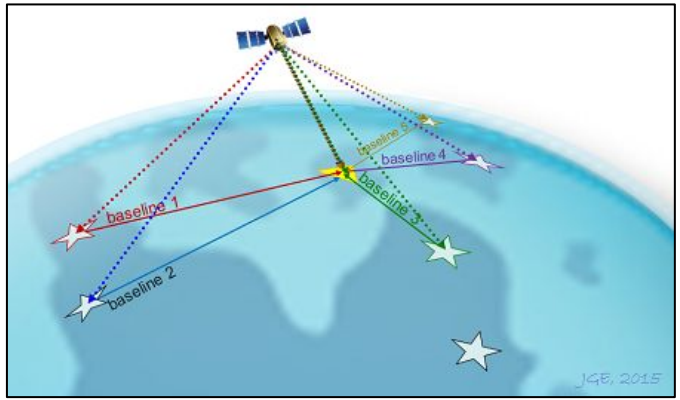
h & N must be referenced to the same reference ellipsoid (NATRF2022)

Online conversion tools provided by CGS & NGS



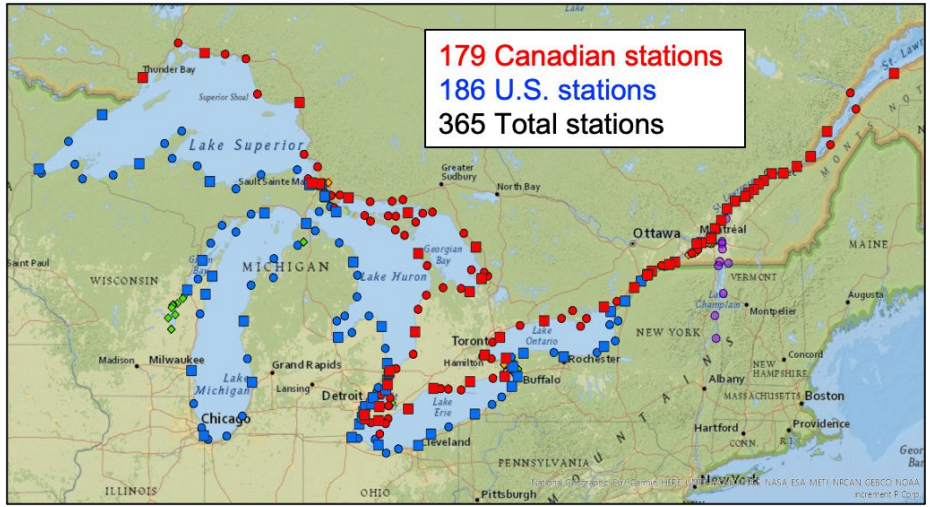
GNSS Processing Tools

- Free online GNSS processing services
  - NRCan's CSRS-PPP (precise point positioning service) — used world-wide - reference defined by precise orbits
  - NGS's OPUS traditional baseline processing service — uses data from nearby permanent GNSS stations (CORS) to tie to geometric reference frame (NAD83, NATRF2022 or ITRF?)
  - Online tools to be provided by NRCan & NGS for converting from GNSS ellipsoidal heights to IGLD (2020) dynamic heights
- Receiver manufacturers' software



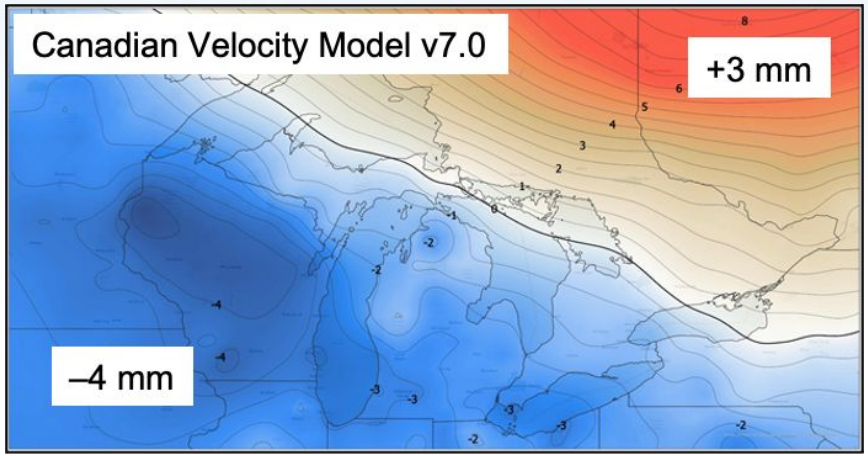
Moving Water Level Gauges to IGLD (2020)

- Need to determine IGLD (2020) heights for all water level gauges
- Previous GPS surveys at CHS & NOAA permanent gauges in 1997, 2005, 2010, 2015
- 2022 GNSS survey conducted by members of the Coordinating Committee led by CGS and NGS
- Occupied GNSS BMs at most gauges on the Great Lakes, their interconnecting channels, St. Lawrence River, Richelieu River, and Lake Champlain
  - Permanent gauges (CHS, ECCC, NOAA, USACE, USGS, Seaway, NYPA, OPG)
  - Seasonal gauges for determination of hydraulic correctors
  - Two 24-hr occupations on each BM for highest accuracy
- Presently processing data



"Dynamic" Nature of IGLD (2020)

- IGLD (2020) & NAPGD2022 are time-dependent (dynamic) datums
- Heights are changing in time due to regional & local crustal motions
- A deformation model will be used to propagate heights to a common epoch
- Estimated from a long history of GNSS positions of CACS & CORS stations
- Used to account for crustal motion by propagating coordinates to a common reference epoch (i.e., 2020.0)
- Deformation models (interpolation grids) Will be provided by CGS & NGS
- Expected to be also incorporated into commercial software (e.g., ArcGIS)



Transformations from Older Datums

Transformation grids will be provided by CGS & NGS to enable moving large data sets from older datums to IGLD (2020)

- Need heights at common points in old and new datums
- Will use a common (binational) grid format based on international standards

Accuracy of transformations depends on:

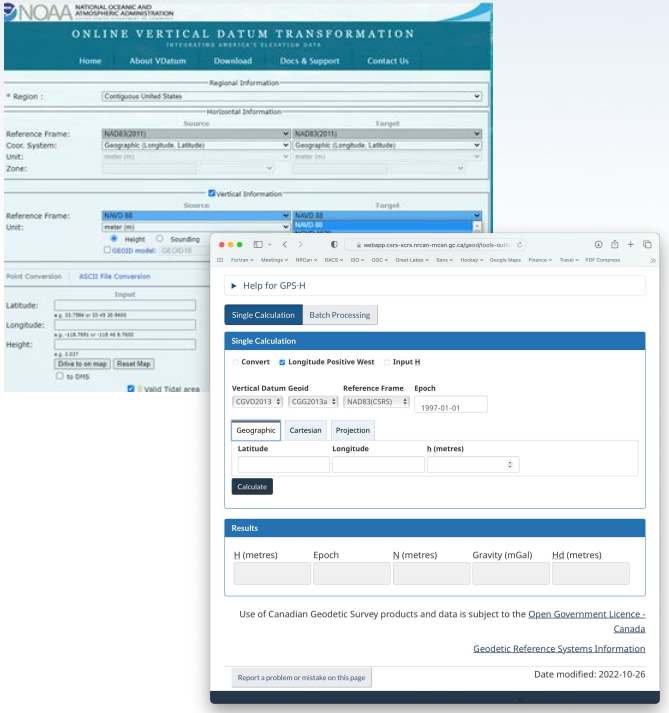
- Accuracy of heights in older datums — can't improve accuracy
- Spatial coverage of stations for better modelling of distortions in older datums

CGS/NGS Transformation Tools

Grids for NATRF/NAPGD2022 & IGLD (2020) will be provided by NOAA & NRCan

GPS-H (Canada) & VDatum (US) Software

- GNSS ellipsoidal heights to orthometric & dynamic heights
- Transform heights between datums
- Supports batch processing of stations
- Desktop applications available
- REST APIs available



Commercial GIS Tools

Transformation grids are expected to be implemented in many GIS software.
CGS & NGS are working with software developers to ensure they have what they need

Geospatial Software Developers Summit

- Hosted by CGS & NGS, Nov 30 – Dec 1, 2022
- 19 federal & provincial government participants
- 17 participants from 13 software companies
- Commercial & open source software represented
- Most developers committed to having transformation tools ready by 2025
- Alpha & Beta products to be provided by CGS & NGS to help developers prepare

Impacts of Updating IGLD

Updating water levels to a new IGLD will have significant impacts on many operations, products and services in the Great Lakes region

- Economic viability and safety of commercial and recreational navigation, including charts, ports/harbors and dredging of navigation channels
- Water level regulation and forecasting
- Coastal zone management and planning, including flood & erosion prediction and response, and coastal structure design, construction & maintenance
- Coastal habitat restoration under the Great Lakes Restoration Initiative (GLRI)
- More details provided in IGLD Update Plan on CC website

The Coordinating Committee is conducting outreach efforts like this one to inform and get feedback from stakeholders

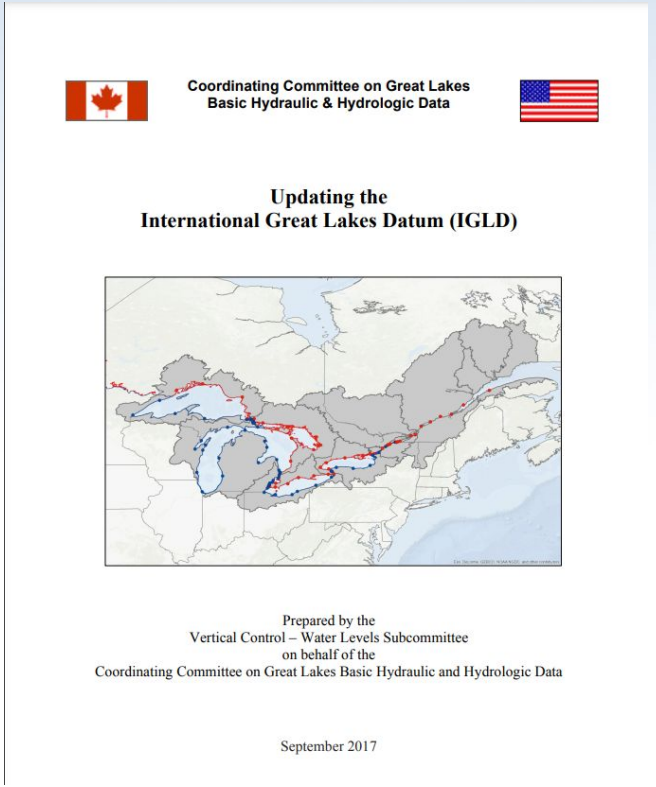
Status of IGLD Update

- GNSS field campaign took place in 2022 – data processing continues (used for realizing IGLD (2020)) at the water level gauges
- Seasonal gauging continues
- Hydraulic corrector working group is investigating the role of HCs in IGLD (2020)
- IGLD (2020) is planned for release about one year after the release of the NAPGD2022 vertical datum (around 2026)

Resources

IGLD
https://www.greatlakescc.org/en/international-great-lakes-datum-update/
Email: info@GreatLakesCC.org

NATRF2022 & NAPGD2022
https://geodesy.noaa.gov/datums/newdatums/index.shtml


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

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Questions?

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