



Advances in Computational Methods to Deliver the International Great Lakes Datum (2020) Update: Seasonal and Permanent Gauging

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

US Hydro Virtual Conference, September 13-16, 2021

Speaker Introductions



Khaleel Arfeen - Physical Scientist,
TCWLSci Unit, CHS



Sierra Davis - Oceanographer,
Datums Team, NOAA CO-OPS



International Great Lakes Datum (IGLD)

- IGLD is the official vertical datum reference for water level measurements and navigation products through the Great Lakes, their connecting channels and the St. Lawrence system
- Required for the unified, internationally coordinated collection, compilation and use of data for hydraulics, hydrology and water level management:
 - **Marine navigation and transportation**
 - **Regulation of lake & river flow through connecting waterways**
 - Nautical chart updates (CHS, NOAA)
 - Lake level forecasting
 - Coastal zone activities



Updating IGLD (1985) to IGLD (2020)

- Responsibility of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data (CC)
- Need to update every 25-30 years to account for movement of Earth's crust (GIA) - Overdue!
- IGLD (2020) will use geoid-based North American - Pacific Geopotential Datum of 2022 (NAPGD2022)

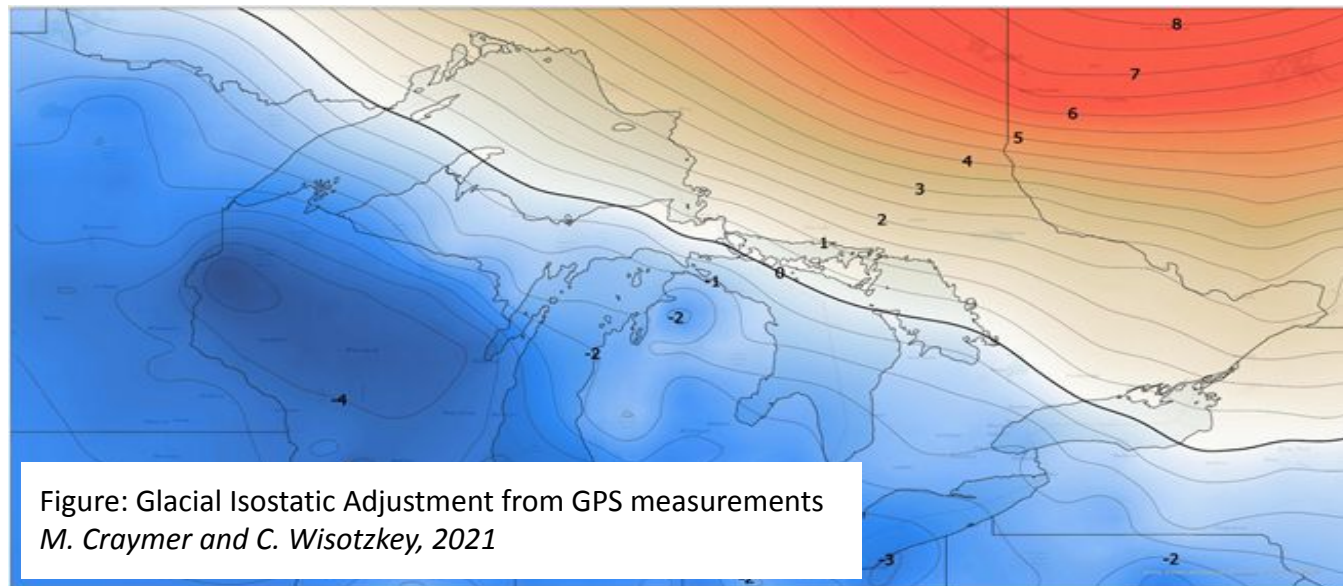
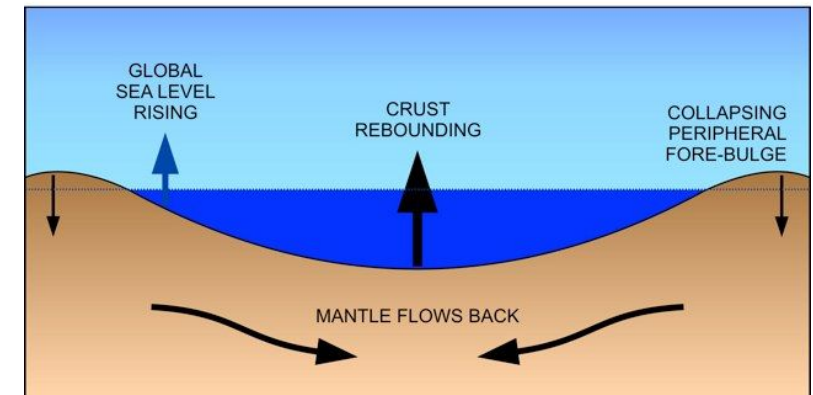
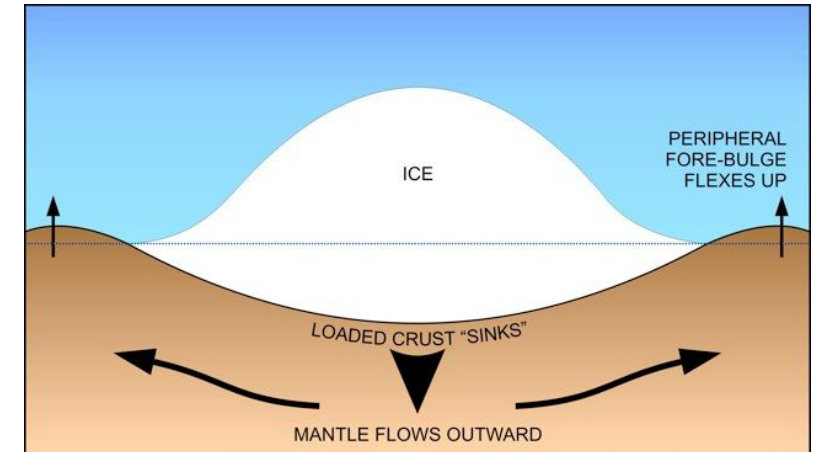


Figure: Glacial Isostatic Adjustment from GPS measurements
M. Craymer and C. Wisotzkey, 2021



The general process of GIA. Top: Heavy ice loads Earth's surface. Bottom: Once the ice is removed, some areas rebound, while others collapse.

Introduction to Permanent and Seasonal Stations

Permanent Stations

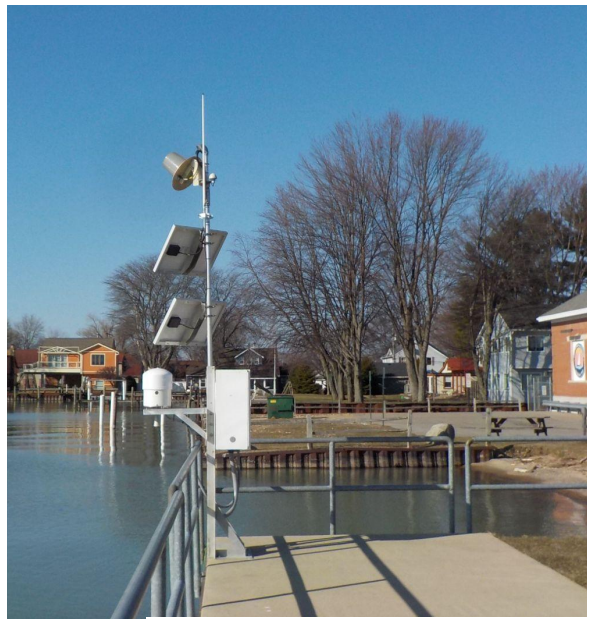
- Permanent structure
- Collects data year round
- Most have been around for decades and are quite stable
- Sensors: encoders, pressure



13320 Toronto, ON

Seasonal Stations

- Fixed to existing infrastructure
- Collects data during summer months
- First used in IGLD (1955) absent in IGLD (1985) computation
- Reintroduced for IGLD (2020)
- Sensor: microwave radar



9034057 New Baltimore, MI (left), 11250 Killarney, ON (right)



Locations of Permanent and Seasonal Stations










Selection of Permanent/Seasonal Stations

Permanent Gauging – support daily operational mission

- Located where year-round water levels measurements are critical for operations
- Few permanent gauges installed in recent years
- Canada: 58
- United States: 53

Seasonal Gauging – The United States and Canada considered 140 potential locations

- Canada: 66 
- United States: 54  **National Ocean Service**
National Oceanic and Atmospheric Administration
U.S. Department of Commerce  **Great Lakes RESTORATION**   **Sea Grant**
- Factors considered for selecting seasonal gauging locations:
 - Datum transformation and lake surface topography
 - Ports and coastal infrastructure
 - Storm preparedness
 - Proximity to bench mark locations
 - Spatial analysis (geographic distribution across Great Lakes region)



IGLD (2020) Seasonal Stations By Year

2014



Use of Water Level Stations

Permanent Gauging:

Essential for Day-to-Day Operations and Long-Term Monitoring



Photo: Chamber of Marine Commerce

Marine Navigation:

- Safe and efficient marine commerce
- Recreational safety
- Storm warnings and real-time water level data availability

Water Level Regulation and Policy:

- Hydro-electric power
- US-Canadian treaty agreements
- Official vertical datum – IGLD



Coastal Management:

- Storm surge warnings
- Water level forecasting
- Restoration projects
- Dredging

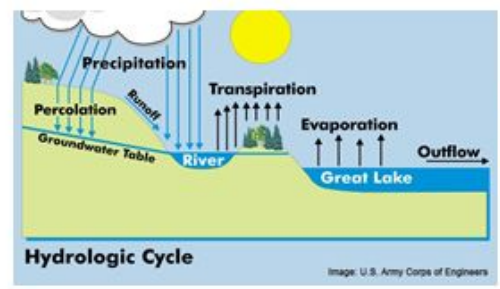
Long-Term / Time Series Analysis Studies:

- Extensive water level time series used to compute Low Water Datum (chart datum)
- Crustal motion (GNSS equipped stations)
- Water level variability (long-term, annual, seasonal, monthly)



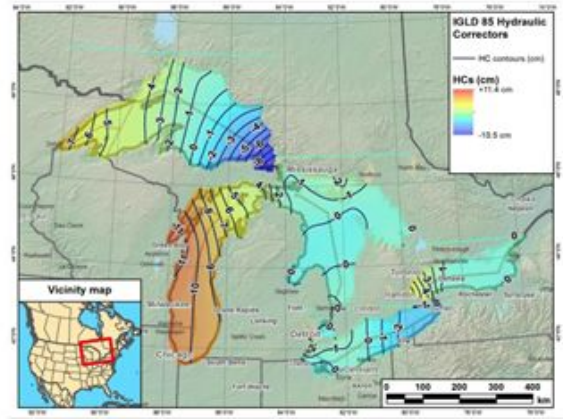
Seasonal Gauging:

Supports Permanent Station Network by Filling Data Gaps



Lake topography changes: river discharge, prevailing winds, temperature variations

Refine and/or Validate Numerical Models



Data from both station types will be used to compute IGLD (2020)

Permanent Gauging Stations

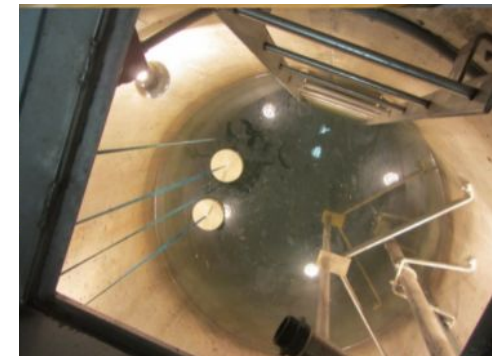
- The permanent water level network consists of 53 sites in the U.S. and 58 sites in Canada
- Permanent gauge sites are housed in a brick structure built upon solid foundation
 - Thermostatic controlled heat lamps inside the gauge house further prevents freezing
- Encoder located inside stilling well as the high accuracy WL sensor
- Backup/redundant sensors
- Other sensors present at the gauge house may include:
 - Data logger
 - Meteorological & oceanographic
 - High accuracy GNSS
 - Communications: satellite (GOES), internet, radio
 - Data transmission every 6 mins (US) or 3 mins (CAN)



Mackinaw City, MI 9075080



Encoder Displays



Stilling well

Seasonal Gauging Stations

- The seasonal water level network varies in count and location in recent years
 - US has been collecting data since 2014
 - Canada has been collecting data since 2018
- Seasonal Gauges lack dedicated structure and affixed to existing infrastructure
 - Considerations for operational accessibility, public tampering, weather
- Primarily use MWWL sensors as high-accuracy WL sensor
 - Typically no redundant sensors at seasonal locations
- Other sensors present at seasonal locations may include:
 - Data logger: Sutron
 - Communications: satellite (GOES), cell modem
 - Data transmission every 6 mins (US) or 3 mins (CAN)
 - Solar panel and battery



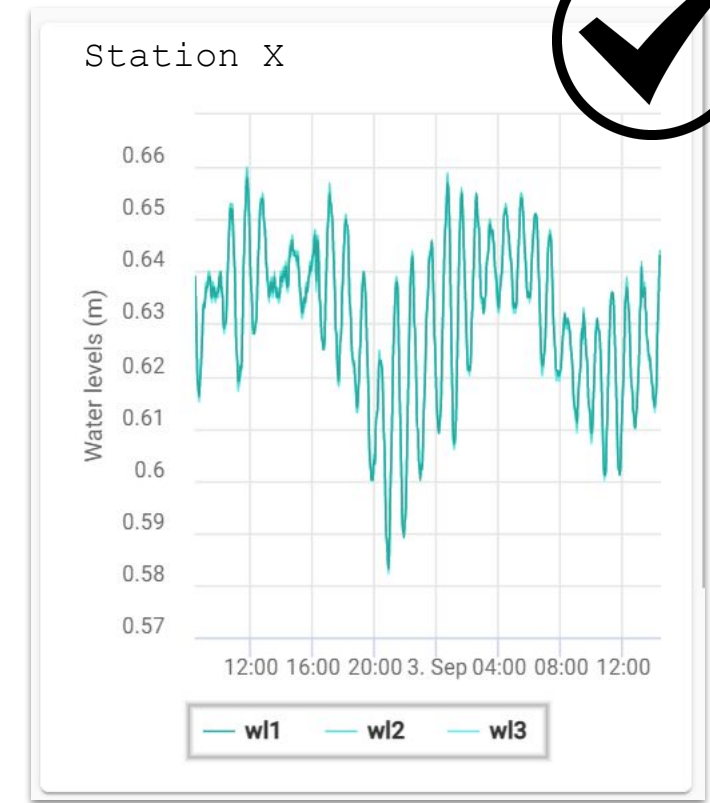
MWWL Sensor



Satellite Antenna

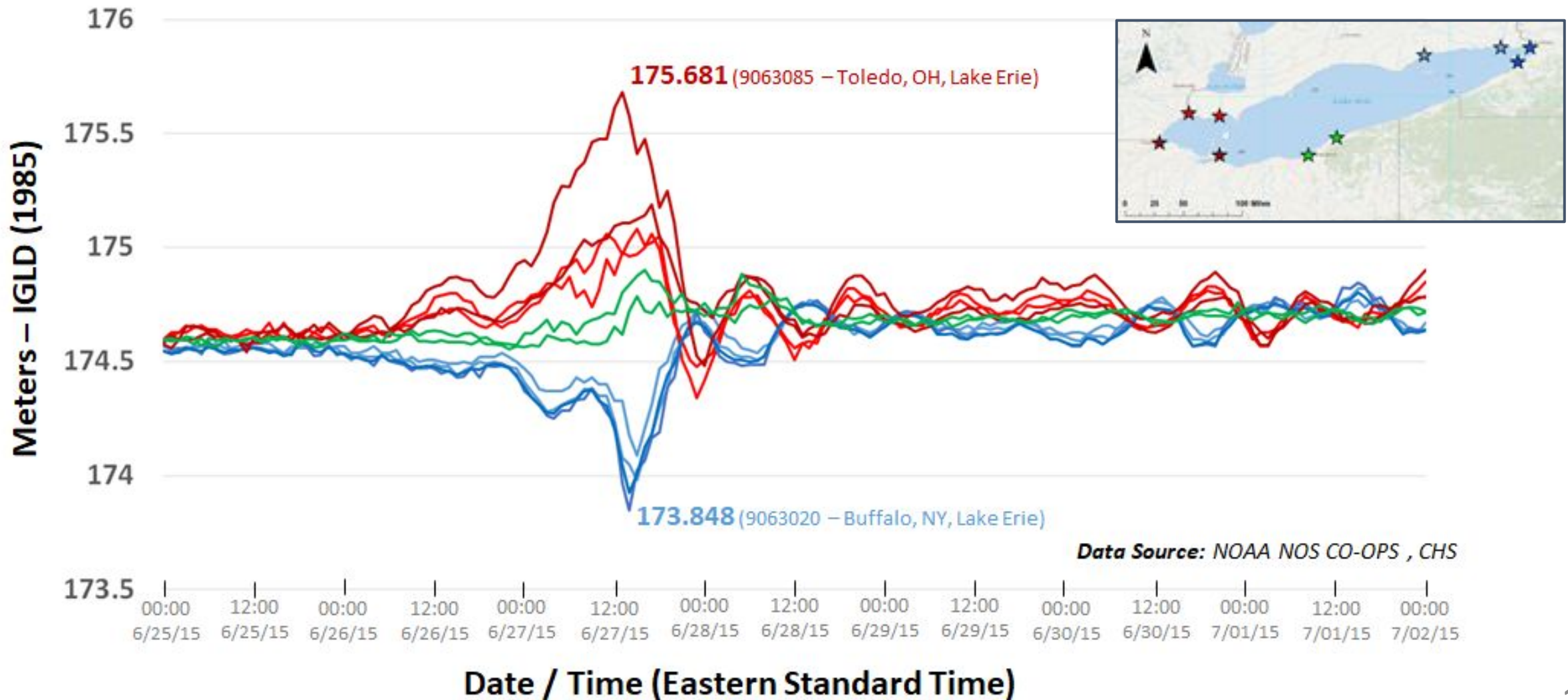
Water Level Data Quality Control & Product Generation

- Data quality control checks:
 - Daily monitoring of data
 - Automated checks & expert review
 - Outlier identification and removal
 - Flat data identification and mitigation
 - Ex. Well Icing, Sensor Malfunction
 - Datum and sensor offset value check
 - Primary sensor vs. redundant sensor
 - Offset should remain within tolerance (0.003m)
- No predictions or transfers from neighboring stations
 - No mathematical filling of data gaps (observed data only)
- Product Generation:
 - Hourly heights, daily means, and monthly averages
 - Hydrographic operations: 3- and 6-minute datasets





Lake Erie June 2015: Seiche Event





Data Collection Status and Next Steps

- Water level data collection
 - IGLD (2020) permanent gauge data collection period: 2017-2023
 - IGLD (2020) seasonal gauging data collection period: 2014-2024
 - Investigating significance of Hydraulic Correctors (lake topography)
- Binational coordination Of:
 - Permanent and seasonal gauge WL processing
 - IGLD 2020 datum computation
 - CHS and CO-OPS beginning analysis of water level data in fall of 2021



Further Information



www.greatlakescc.org