CLIMATE CHANGE AND THE GREAT LAKES WATER BALANCE

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Summary

- Great Lakes and St. Lawrence Governors and Premiers is preparing a third Cumulative Impact Assessment for 2016-2021.
- This project provides more detailed and updated large lake statistical water balance model data to project the future of water availability in the Great Lakes.

3 research goals accomplished:

1. **Reducing Uncertainty in the Great Lakes Water Balance**
   - Refine the use of the L2SWBM by looking at various historical periods, hydrological processes modeling and integration adjustments
2. **Looking for signals of climate change in the historical record**
   - 5 statistical analyses through which to view the historical record
3. **Laying the foundation for more informed policy for the future**
   - Informing the next Cumulative Impact Assessment with improved scientific data and plausible future climate scenarios

Methods: Statistical Analysis

The Large Lake Statistical Water Balance Model (L2SWBM) updates include improved outflow component modeling to ensure that changes in inter-lake flow are reflected in the overall water budget, among other updates.

We used this improved recreation of the historical water balance record to look for signals of climate change that may have already occurred. Using statistical analyses including:

- Linear regression
- Fixed change point
- Model auto-detected change point
- "Hockey-stick" plots

We compare with IPCC standard definitions of climate change.

We find a linear regression to oversimplify results, indicating a simple increasing or decreasing trend where more nuanced interpretations are more appropriate. Using a fixed change point, we use a standard reference period of 35 years as recommended by the IPCC to compare "historical" data to a "modern" period of data to assess whether a regime-shift has occurred. The presence of a change point suggests that it may not be appropriate to represent all the data in a historical record with a single summary statistic, such as a mean or trend.

We also use the model to auto-detect a change point in the re-created data, with constraints that limit the model from using the first and last five years of data, to limit "end' effects. Scan the QR code to learn more about methodology and see more plots generated by this model.

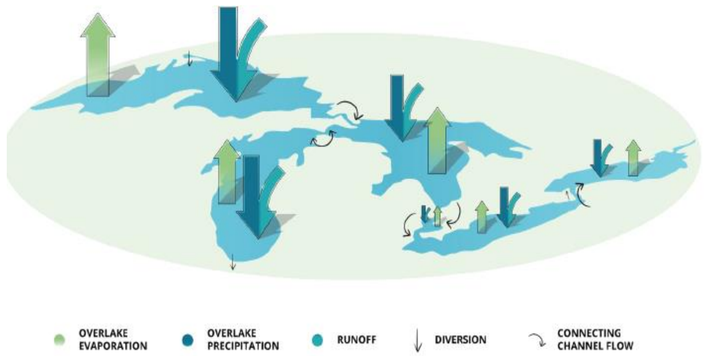
Future Work

Updated L2SWBM output is used by USACE, ECCC, and other federal agencies working to understand where to invest in nature based coastal resilience efforts. This information can inform the next phase of coastal resilience planning with greater investments in nature- based solutions and restoring native coastal wetland habitats. **Scan the QR Code to learn more about the relationship between water levels and coastal wetlands, and for ongoing wetland projects around the Lake Michigan and Lake Superior shorelines**

Water Balance Formula

$$\Delta S = P + I - Q - E + \mathcal{E}$$

Total Water Storage = Precipitation + Inflow – Discharge – Evaporation + Error



Goal 1: Reduced Uncertainty in Past Data

Historical Precipitation Data over Lake Michigan-Huron Basin

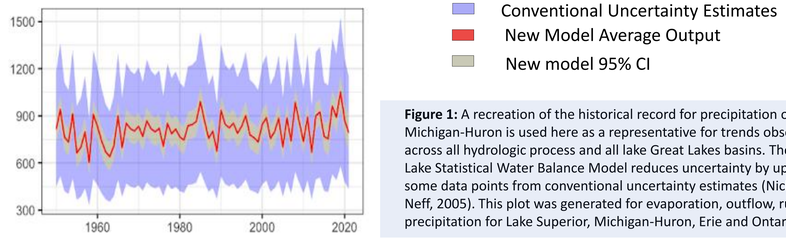


Figure 1: A recreation of the historical record for precipitation over Lake Michigan-Huron is used here as a representative for trends observed across all hydrologic process and all lake Great Lakes basins. The Large Lake Statistical Water Balance Model reduces uncertainty by up to 45% in some data points from conventional uncertainty estimates (Nicholas and Neff, 2005). This plot was generated for evaporation, outflow, runoff, and precipitation for Lake Superior, Michigan-Huron, Erie and Ontario.

Goal 2: Identify Signs of Climate Change

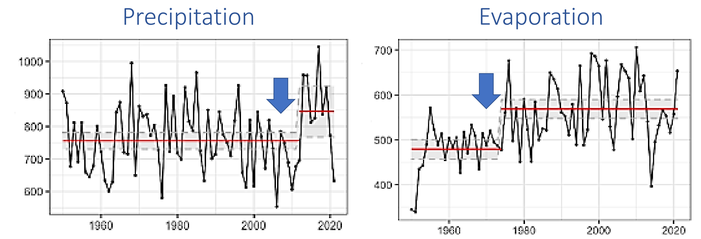
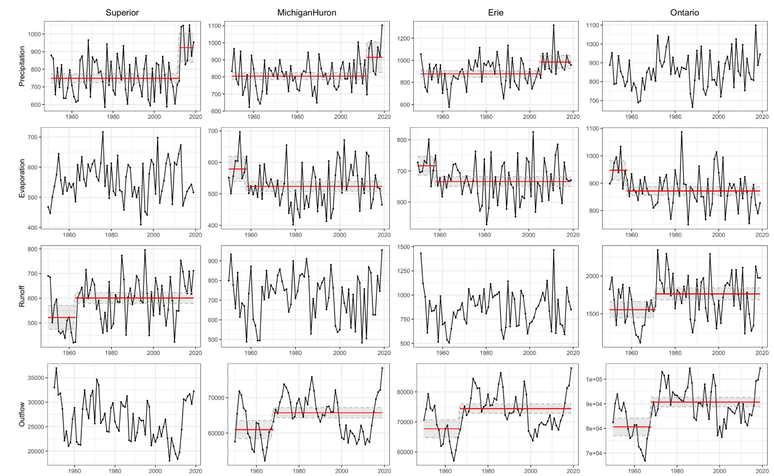


Figure 2: Output from the L2SWBM of precipitation and evaporation over Lake Superior from 1950-2021 fitted with an average line (red) in each period, split by a model detected change point . This is a standard method to detect climate change. In the long term, both precipitation and evaporation are increasing in Lake Superior and their effects will likely offset each other resulting in no change in the water balance.

Goal 3: Better Science, Better Policy



The plot above shows model output data fitted with an average line (red) for a model-detected change point. Note that change points of precipitation were spotted at around 2010 for the 3 most upstream lake basins. For evaporation, a change point was detected before 1960. Note how outflow values follow similar patterns for the 3 most downstream lakes.

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