Quantification of Temperature and Precipitation Variability over the Great Lakes

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Introduction

The U.S. Army Corps of Engineers (US-ACE) and Environment Canada (EC) currently provide six months of internationally coordinated monthly water level forecasts for each lake. The UC-ACE forecast relies on a combination of a physical model (NOAA – GLERL's Advanced Hydrologic Prediction System [AHPS]) and statistical models, with an emphasis on climate outlooks (provided by NOAA's Climate Prediction Center [CPC]) for the region. Input of forecasted temperature and precipitation (T and P, respectively) is the key starting point for the Great Lakes net basin supply and lake level forecasts. Several steps in the forecasting procedure can be modified to minimize subjectivity, increase efficiency, and reduce the margin of uncertainty in the forecasts.

US-ACE forecasts contain uncertainty from various sources: 1) possible climate and weather forecast model error used by the CPC, 2) CPC forecaster interpretation, 3) uncertainty from qualitative analysis performed by GLERL or US-ACE forecaster, and 4) model uncertainty from AHPS. The uncertainties inherited from steps 2 and 3 could be minimized with the use of an objective blend of T and P forecasts (from statistical and physical models).

Experiment

- An experimental forecast method is created that identifies the best correlated climate index for each month, each lake.
- The lagged climate index (by at least 3 months) or a forecasted climate index is used to forecast temperature for each month, each lake.
- This experimental method is compared with three month forecasts that are currently made by GLERL (AHPS), the GFDL climate model, and the CPC (detailed in Table 1).
- A statistical root mean squared error is performed for the experimental method, AHPS, and GFDL (compared to just using climatology).
- A non-statistical analysis is performed to compare with CPC outlooks.

Forecast Method	Description	Reference
Experimental (Exp)	Monthly linear model as a function of the best correlated climate index (MEI, PDO, or AMO)	Bolinger et al.
AHPS	Forecasted T and P using CPC to weight historical observations	Croley (2000)
GFDL	High resolution coupled climate model	http://nomads.gfdl.noaa.gov Jia et al. (2014)
CPC	Tercile probability distribution based on a suite of models and forecaster discretion	http://www.cpc.ncep.noaa.gov

Table 1.

Current Procedures

- Begins with a visual analysis of CPC outlooks for temperature and precipitation, focusing on the Great Lakes Basin.
- GLERL – AHPS uses CPC forecast information to weight historical regimes (Croley 2000), generating a probability distribution of six months of forecasted temperature and precipitation for each lake basin.
- AHPS forecasted lake levels and CPC outlooks are used operationally by US – ACE forecasters in the development of the official coordinated lake level forecasts.

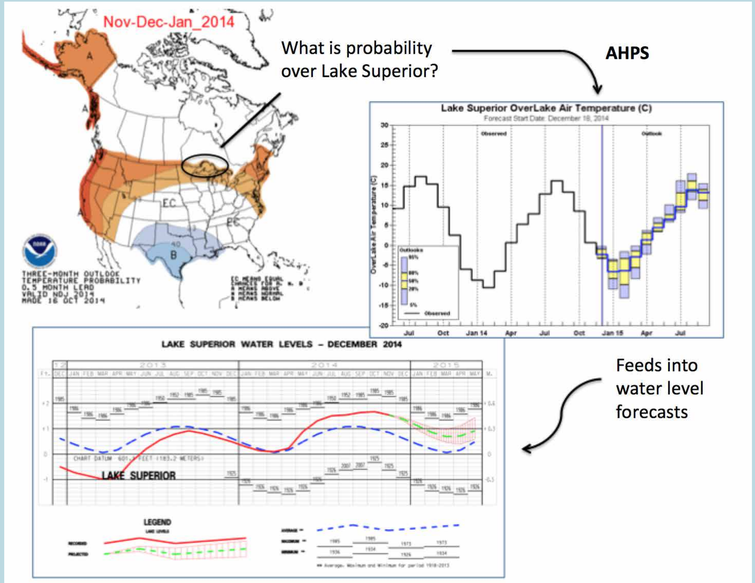

Table 2 gives the root mean squared errors for each forecast method, given the data shown in the figures. There is no clear best method throughout the Great Lakes. Usually, the "best" method is not significantly better than all other methods.

MODEL	Superior	Michigan	Huron	Erie	Ontario
Climatology	2.40	2.03	2.57	1.85	1.86
Exp.	2.37	2.05	2.40	1.84	1.83
AHPS	2.36	2.14	2.10	1.99	1.92
GFDL	2.36	2.49	2.62	2.39	2.03

Table 2. Root Mean Square Error For 3-Month Temperature Forecasts

Table 3 shows how many times the correct tercile (near, above, or below normal) was chosen for each method, compared to CPC's one month pick. In general, the experimental method picks right most often, but this is partly due to how conservative of a model it is. All of the methods perform better than randomly predicting (expected to be right for 33% of the forecasts).

MODEL	Superior	Michigan	Huron	Erie	Ontario
CPC (1 month)	19	19	20	20	21
Exp.	19	26	23	24	22
AHPS	16	24	18	22	20
GFDL	22	18	16	22	17

Table 3. Correct Tercile for 3-Month Temperature Forecasts

CONCLUSION

The main "take home" message from this study is that the AHPS method, currently used operationally as input for water level forecasts, can be replaced with other methods. These alternative methods may not necessarily perform better, but they don't do worse, and they would allow for increased efficiency and decreased subjectivity for the forecasters at GLERL and US-ACE.

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Results

The five graphs below show the three month forecasted monthly temperature for every lake basin. Those that fall in the gray window denote a near normal forecast, with red (blue) denoting an above (below) normal forecast.