Anticipated future lake levels on Superior, Michigan and Huron due to climate change

This information is based on hydrologic model responses to inputs from Canadian and British global circulation models (GCMs) and from a Great Lakes regional circulation model called CHARM: Coupled Hydrosphere-Atmosphere Research Model at the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory (NOAA-GLERL) in Ann Arbor, Mich.

Hydrologic models at NOAA-GLERL simulate the natural responses of Great Lakes water levels and flows to runoff, precipitation, evaporation, inflows and outflows. The hydrologic models have been run with input from GCMs for the atmosphere under assumed global warming conditions. The regional model; CHARM has been run to project climate over the Great Lakes Basin in time periods centered at 1989, 2030, and 2095.

Some preliminary indications

Modeling with the use of early transient GCMs and the Canadian Centre for Climate Modeling and Analysis' CGCM1 model indicate a possible major lowering of lake levels and a reduction of water supplies to the upper Great Lakes in two or three decades. Present low water levels provide a taste of this possible future.

Water levels predicted from the dryer climate of the CGCM1 model for the upper Great Lakes have greater variability than the variability experienced between 1961 and 1990 which included record high water levels on Lake Superior and both record high and low water levels on Lakes Michigan and Huron.

The CGCM1 model does not include any representation of the Great Lakes nor interactions between the lakes and the atmosphere. The British Hadley Climate Centre's HadCM2 model does include a crude representation of the Great Lakes but does not include interactions between the lakes and the atmosphere. The CHARM model includes interactions between the Great Lakes and the atmosphere.

Water levels predicted from the wetter climate of the HadCM2 model for the upper Great Lakes do not have greater variability than the variability experienced between 1961 and 1990 and indicate the possibility of higher-than-record water levels in the future.

Climate change is expected to change the shape of the annual water level cycle which has highest water levels in the summer and lowest water levels in the winter.

The following tables show predicted changes from the average lake levels that occurred during a Base Case period of 1961 to 1990. The predicted changes are for 20 year periods centered on the years 2030 and 2090.

Table 1. Predicted Response of Lake Superior to Climate Change (Global Warming).

Model	Year	Change in Water Level

		feet	meters
HadCM2	2030	-0.03	0*
CGCM1	2030	-0.7	-0.2
HadCM2	2090	+0.4	+0.1
CGCM1	2090	-1.4	-0.4

*zeros represent non-zero values less than 0.05 m.

Results obtained by using input from four earlier transient GCMs (GFTR2, HCTR2, MOTR2, and CCTR2) indicated water levels on lakes Huron and Michigan may be lower in 2020 by 1.3, 1.6, 4.6 and 3.0 feet ((0.4, 0.5, 1.4, and 0.9 meters), respectively.

Table 2. Predicted Response of Lakes Michigan and Huron to Climate Change (Global Warming).

Model	Year	Change in Water Level	
		feet	meters
HadCM2	2030	+0.2	+0.1
CGCM1	2030	-2.4	-0.7
HadCM2	2090	+1.1	+0.3
CGCM1	2090	-4.5	-1.4

*zeros represent non-zero values less than 0.05 m.

Results obtained by using input from four earlier transient GCMs (GFTR2, HCTR2, MOTR2, and CCTR2) indicated water levels on lakes Huron and Michigan may be lower in 2020 by 1.3, 1.6, 4.6 and 3.0 feet ((0.4, 0.5, 1.4, and 0.9 meters), respectively.

Sources of information for Tables 1 and 2 a) *Preparing for a Changing Climate, Great Lakes Overview*. Peter J. Sousounis and Jeanne M. Bisanz. October 2000. A report of the Great Lakes Regional Assessment Group for the U.S. Global Change Research Program. AOSS Department, University of Michigan, Ann Arbor, Michigan 48109-2143, b) Supplemental information from Brent M. Lofgren, NOAA Great Lakes Environmental Research Laboratory. March 2002.

Explanation for the predictions of water level changes that are based on models

Hydrologic models used at NOAA-GLERL simulate the natural responses of the Great Lakes to runoff, precipitation, evaporation, inflows and outflows. The hydrologic models have been run with input from global circulation models (GCMs) for the atmosphere under assumed global warming conditions. The hydrologic modeling was done as recently as 2000 at the National

Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory (NOAA-GLERL) in Ann Arbor, Michigan. Results from improved models are expected in 2003.

About the models

The CGCM1 model was run at the Canadian Centre for Climate Modeling and Analysis. The HadCM2 model was run at the Hadley Centre in Great Britain. The CGCM1 and HadCM2 models are the most recent GCMs used to estimate Great Lakes water level responses to global warming expected over this 21st century. The CGCM1 model lacks any representation of the Great Lakes. The HadCM2 model has a very crude spatial representation of the Great Lakes that allows for some feedback from the lakes to the atmosphere. Reasons for different results from CGCM1 and HadCM2 models are not known.

All of the recent model runs have used transient GCM models. Transient models incorporate full dynamical ocean models (with their thermal capacity) coupled to a model atmosphere with a gradual rise in greenhouse gases and gradual changes in atmospheric temperatures and precipitation. Transient models create a delay in warming, compared to results from earlier equilibrium models which showed results from a doubling of carbon dioxide in the atmosphere (for example). Results from a more recent HadCM3 model run have not yet been used to estimate Great Lakes water level responses. It is anticipated that this work will also be done at NOAA-GLERL.

How to use the model predictions of lake level change

Example: What do the models predict the water levels will be on Lakes Michigan and Huron in 2030?

Table 2 shows that water levels could be 0.2 feet higher, or 2.4 feet lower, than 1.6 feet above Low Water Datum (Chart Datum). The Base Case period was 1961 to 1990 and contained the lowest water levels of the century in the 1960s and the highest water levels of the century in the 1980s, according to the U.S. Army Corps of Engineers' Monthly Bulletin of Lake Levels for the Great Lakes. The lower of the two levels predicted for 2030 would be: 1.6 – 2.4 = 0.8 feet below Low Water Datum (LWD).

According to the U.S. Army Corps of Engineers' Monthly Bulletin of Lake Levels for the Great Lakes, the record low monthly mean lake level during the recreational boating season was 10 inches (0.8 feet) below LWD and it occurred in May, June and September of 1964. July and August levels were only an inch higher. That level is where one model predicts the 20-year average lake level will be in 2030.

Another way to use this information: think of the 1961 to 1990 range of lake levels repeating in 2020 to 2040, but at levels 2.4 feet lower. If this were to occur, a new record low boating season water level would be somewhere around 0.8 + 2.4 feet = 3.2 feet below LWD. For comparison, the level of lakes Michigan and Huron from mid-June through mid-December varied slightly from LWD to 0.1 feet (2 inches) above LWD. What would commercial shipping and recreational boating be like if water levels become three feet lower?

Other sources to check

More information on the potential lake level changes for all of the Great Lakes as predicted by hydrologic response models and GCMs can be found in the Journal of Great Lakes Research in an article titled: *Evaluation of Climate Impacts on Great Lakes Water Resources* by Brent M. Lofgren, Frank H. Quinn, Anne H. Clites, and Raymond A. Assel. The paper includes results for a period centered in 2050.

Early results from CHARM modeling are presented in a short paper titled: *Simulation of Possible Future Effects of Greenhouse Warming on Great Lakes Water Supply Using a Regional Climate Model* by Brent Lofgren to the American Meteorological Society's 17th Conference on Hydrology.

For new developments in modeling estimated impacts of climate change on Great Lakes water levels, periodically check NOAA-GLERL.

For new developments in research on climate change, check NOAA climate change.