Fluctuations in Great Lakes Water Levels

Briefing Notes

for WRM classes on January 7 and 12

The Great Lakes contain 20 per cent of the world's fresh surface water and supply a variety of needs for more than 45 million people in the Great Lakes region. They cover parts of Canada and the United States (US) and support $5 trillion regional economies in both countries (U.S. Department of Commerce 2011). They contribute to quality of life in the Great Lakes region.

Warming temperatures and more extreme precipitation patterns are compounding effects on ecological systems that have already been changed since European settlement. Climate change projections suggest continued changes in the Great Lakes region, including higher risk of more intense drought and flooding, and changes in various factors that influence Great Lakes water levels. Current lake levels are available at http://w3.lre.usace.army.mil/hh/GreatLakesWaterLevels/GLWL-CurrentMonth-Meters.pdf

History

- Geological times: evidence of raised beaches
- Paleo data derived from submerged tree stumps and ancient beach ridges; Baedke and Thompson 2000, Wilcox et al., 2007) show natural cycles of wet periods and dry periods occurring most often in six- to eight-year time periods, but they also show wet and dry periods lasting 10 to 15 years in duration.
- Historic range of variability in Great Lakes water levels can be observed in monthly, seasonal and long term fluctuations. Great Lakes water levels have been recorded using reference gauges since as early as 1800.
- Current daily and monthly data can be followed at

Discussion

The International Upper Great Lakes Study Board is using lake level projection data to inform and redefine water level regulations for Lake Superior (International Upper Great Lakes Study 2012). Their adaptive management approach may be a model that can be applied locally by coastal communities, using available online data and tools, as they consider planning scenarios under extreme high and low water levels along with other climate threats.

Great Lakes coastal communities are beginning to plan for essential services like commercial shipping, energy, water and sewer, as well as access to recreational facilities at parks, beaches, marinas and harbours. Rising summer temperatures, more intense storm events and longer periods of drought are forcing communities to consider future climate impacts as they make what used to be routine planning and infrastructure investment decisions.

Planners and policy-makers need to know how future climate will impact their local area and infrastructure or resources they manage. They need to understand and quantify the present changes and what is vulnerable, or at risk, in the future.

Climate impacts and threats include:

- Annual average temperatures are increasing in the Great Lakes region: 1.3° C increase between 1968 and 2002. Lake Superior has been increasing by 1° C per decade.

- An additional increase of 1-3°C increase is projected by 2050 (U.S. Global Change Research Program 2009).
- The duration of Great Lakes ice cover has decreased as air and water temperatures rise. Overall there has been a 71 per cent reduction in the extent of Great Lakes ice cover between 1973 and 2010. Lake Superior has experienced the most pronounced decline (Wang et al. 2011).
- Heavy precipitation events are becoming heavier. Between 1958 and 2007, the heaviest 1% of rain events increased by 31% in the Midwest resulting in more flooding, runoff, and sediment and nutrient loading impacts (U.S. Global Change Research Program 2009).

One of the challenges in planning for possible changes in Great Lakes water levels is that these levels are naturally variable. The entire historic extent of high and low water levels should be considered when defining the potential range of variation that coastal communities could experience in the future (International Upper Great Lakes Study 2012). How will climate change influence this historic range of variation? Scientists across the Great lakes basin and beyond are working to understand how changing climate patterns could affect the probability of future water levels to rise above and drop below historic extremes.

Future Lake Level Projections

Water level projections are calculated using three key factors based on water inputs and outputs (see Figure 1):

- Evaporation off the lakes and evapotranspiration from the land (evapotranspiration = evaporation from plants + evaporation from soil and other land surfaces)
- Precipitation onto the land and lakes
- Runoff from the land and rivers into the lakes.

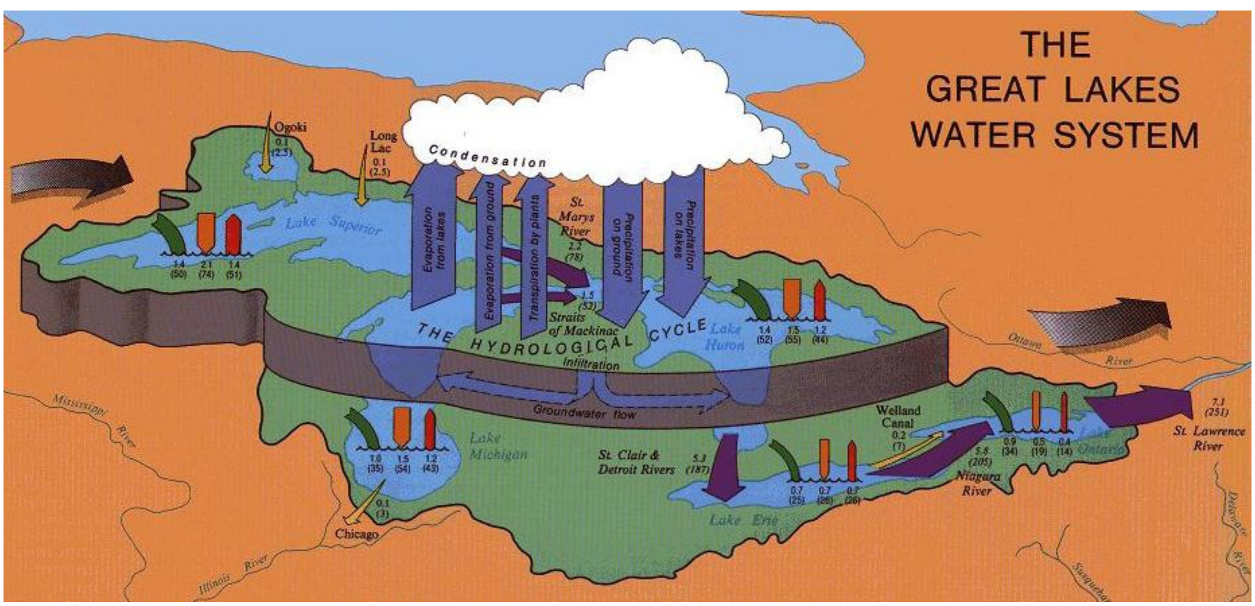

Figure 1 The Great Lakes water budget. Precipitation, evaporation and runoff are shown for each Great Lake using orange, red, and green arrows respectively (U.S. EPA 2012). Large blue arrows represent basin-wide evaporation and precipitation. Some groundwater flows into and out of the lakes directly, while most is assumed to be captured as runoff to streams, wetlands and other lakes.

Other factors used for estimating future lake levels:

- Glacial isostatic adjustment (I..e. glacial rebound). The Great Lakes Basin is still rebounding after regional glaciers retreated about 10,000 year ago. The southwestern end of the basin is falling relative to the center of where the past glacier existed. This makes water levels in Chicago and Duluth for example, appear to be rising. At the same time, water levels in the northern areas of the basin e.g., Georgian Bay and the northern shores of Lake Superior, appear to be dropping. The rebound process accounts for about 30 cm of water level change (rising or dropping) in a person's lifetime (International Upper Great Lakes Study 2009).
- Climate change: Annual average air and water temperatures are rising and future climate models project continued warming, which contributes to higher rates of evaporation and water expansion. Projected future precipitation amounts, rates, and annual variability in timing of wetter and drier periods vary by model.
- Changes in inputs/outputs from water diversion volumes.

Future basin-wide precipitation inputs and outputs are uncertain, hence future lake level projections are also uncertain (Lofgren et al. 2011, Holman et al. 2012). Some sources of uncertainty can be addressed. For example, there is limited direct measurement of over-lake evaporation and precipitation (especially in Canada). A Great Lakes evaporation monitoring network will require continued investment from agencies in the United States and Canada.

Given the need to plan in spite of uncertainty, the database of historic water level records, archived by NOAA's National Ocean Service, offers a meaningful guide and provides critical context for any water level projection: www.glerl.noaa.gov/data/now/wlevels/levels.html

Coastal community decision makers should consider that presently, it may make more sense to invest in framing how the high and low water levels described in the historical record can impact local assets, rather than basing plans on results from the newest models. Identifying actions that protect assets under a range of future conditions is a way to early adaptation in the face of this uncertainty.

Footnote

World Lakes are in Hot Water

Another site that may be of interest is: http://www.cbc.ca/player/play/2681038441