Lake Superior: A Warming to be Concerned with?

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Introduction:
To understand the complex interactions among climate, the knowledge of hydrologic variability between different systems is key. Understanding how ecosystems interact is essential to assessing risk associated with climatic changes. Temperature is a major driving force in natural systems. With global air temperatures likely to increase anywhere between 1.4 and 5.8 °C, what impacts will this have on Lake Superior? For example, if the water temperature rises in Lake Superior, dissolved oxygen concentrations will decrease and with this decrease of dissolved oxygen, it will affect what species of fish can survive. If certain populations of fish are not stable under the new conditions, what implications will this have on the food web? Besides the biological implications that are likely to occur with an increase in temperature, the physical conditions will change as well. Ice cover will decrease, wind speeds are likely to increase, and the summer stratification patterns will be altered. All of these changes are driven by the change of temperature. Although this warming might be harmful to our ecosystem, some might argue that all changes are not negative. An increase in the summer tourist season may be seen as well as in increase in the duration of the shipping season, which potentially bring more economic growth to the Lake Superior watershed.

Importance of Ice Cover:
Since Lake Superior is deeper than the rest of the Great Lakes, it is more susceptible to ice breakup due to winds, upwelling, and wave action. Ice Cover plays an important role in many aspects of its environment, mainly with the amount of light that is reflected from its surface.

Thermal Mixing:
Thermal mixing is an important phenomenon that is necessary for oligotrophic lakes. Since the temperature of the lake is increasing, the length between these two turn over events (or mixing events) is also increasing. In the last century, it has actually increased by 25 days. Mixing is responsible for the exchange of oxygen, distribution of nutrients, and plays an important role in primary productivity. Figure two shows stratification period is getting longer and longer, and as a result, the time between mixing events has increased.

Possible Effects of Increasing Air and Water Temperatures:

- Evaporation
- Precipitation
- Longer duration between thermal mixing
- Suitable habitats for non-indigenous species
- Net long wave radiation (approximately 1-10%)
- Wind speed (nearly 5% per decade since 1985)

Potential decreases in:
- Ice coverage (12-23% over the last century)
- Periods of ice cover (ice free days increasing at 1.5 days/decade)
- Run-off
- Dissolved oxygen
- Cold water fish populations
- Water levels

References:


Figure 1: Ice Cover distribution patterns; the columns represent early-winter (left), mid-winter (center), and late-winter (right). The rows represent differences in annual temperature conditions for severe-cold (top), typical-winters (center), and mild-winters (bottom). (Assel 2005)

Figure 2: Mean summer stratified season temperatures for Lake Superior, air (crosses) and surface water (stars) as observed by buoys. (Desai 2009)

Figure 3: Raw Sault St. Marys (SSM) data summer (July-Sept.) means, and SSM open Lake proxy data (Austin 2008)

Figure 4: Duration of closed navigation days for Bayfield harbor. Faint solid line is 5-year average, and solid black line is linear trend line. (Howk 2009)

But what happens if Lake Superior’s temperature increases:
- Longer shipping season
- Shallower depths of water due to evaporation, so ships will have to take more trips to carry the same amount of cargo
- In Bayfield, WI since 1975, the ice season has begun an average of 11.7 days later per decade as well as ending 3 days earlier per decade (Howk 2009)

Longer shipping seasons seem great for the economy but one must also be careful as the winter months have historically been spent for maintenance of locks, dams, and other annual repairs. But without an ice over event, when will this “shut down” period occur?