The Mississippi River in a Changing Climate

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What is Climate?

Senior climatologist and author David Phillips explains that "climate is what we expect but weather is what we get". According to Environment Canada, climate normals are often used to classify a region's climate and make decisions for a wide variety of purposes involving basic habitability, agriculture and natural vegetation, energy use, transportation, tourism, and research in many environmental fields. Normals are also used as a reference for seasonal monitoring of climate temperature and precipitation for basic public interest, and for monitoring drought or forest fires risk. Real-time values, such as daily temperature, are often compared to a location's "climate normal" to determine how unusual or how great the departure from "average" they are.

Climate also has a large influence on how local ecosystems have evolved and how we interact with them.

Watershed Facts

The Mississippi River drains an area of 3765 square kilometers at its confluence with the Ottawa River east of Arnprior. Its area is split like this:
66% forested
19% agriculture
14% open water and wetland
1% settlement

The average annual temperature across the watershed ranges from 4°C in the west to 6°C in the east. On average the watershed receives 900 mm/year of precipitation (77% rain and 23% snow). Of this, 331 mm contributes to surface water and 555 mm is lost to evapotranspiration.

How has our climate influenced the Mississippi River?

Decades of stream flow records at Appleton dating back to 1918 show how the river has responded to climatic conditions and weather events over that time.

Figure 1 shows average annual stream flows have increased marginally over this period with the exception of a period between 1957 and 1965 which reflects a period of exceptionally low precipitation. While this indicates a relatively stable stream flow regime, examination of seasonal stream flow patterns provide insight into seasonal changes occurring over the past 93 years.

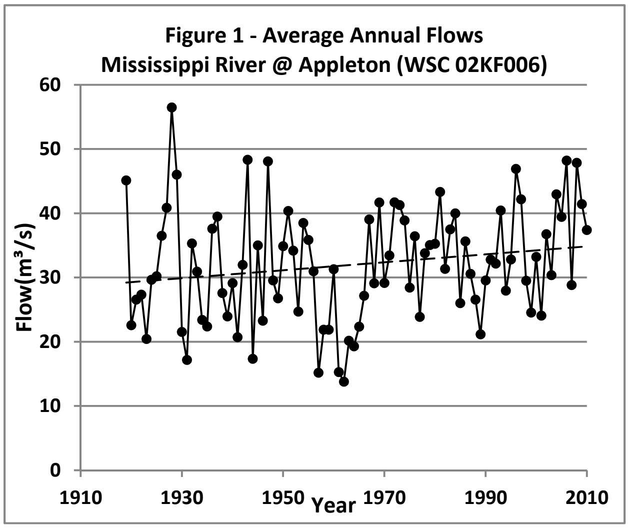
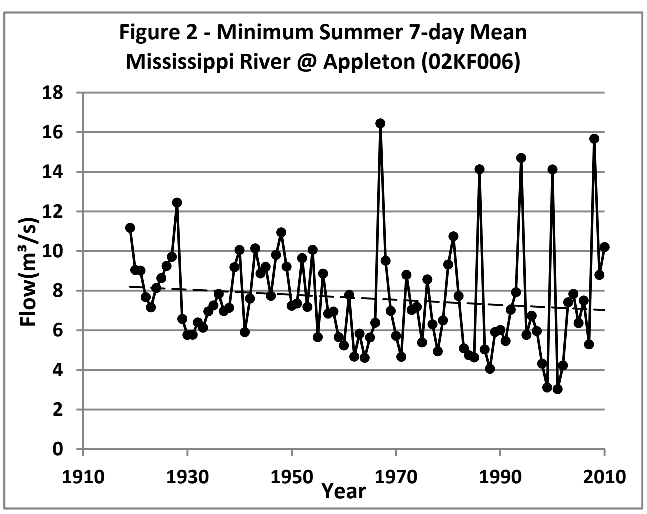
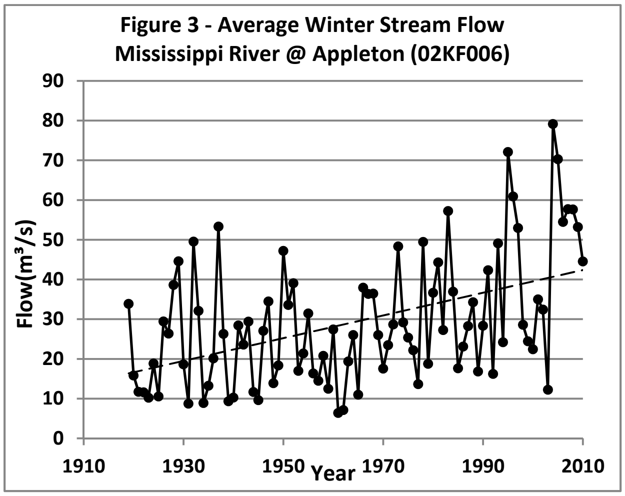


Figure 2 describes minimum summer stream flows, expressed as a 7 day mean. This chart indicates that minimum summer stream flows tend to be lower over the past 30 years with greater variability from year to year. As mentioned previously, 1957 to 1965 was a period of exceptionally low precipitation. This is reflected in the low summer stream flows during this period. After 1970 low summer stream flows continue to persist and become more pronounced despite a return to more normal precipitation levels.



Conversely, **Figure 3** provides an indication of average stream flows over the winter period (January through February). As shown, the average winter stream flow in the period after 1970 has increased substantially and exhibits greater variability from year to year.

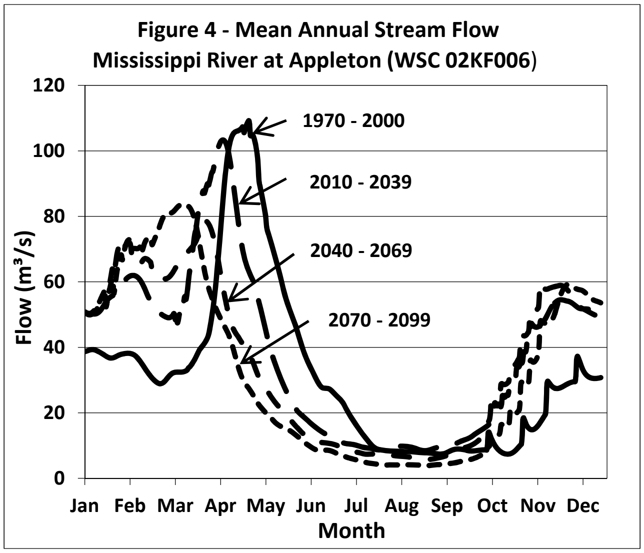


Changes of the magnitude observed in the seasonal stream flow patterns can be attributed to either large scale changes in land use or changes in climatic conditions. Since 1970, changes in land use across the Mississippi River watershed have been relatively minor and cannot account for the shifts in runoff characteristics which are being observed.

In 2007, Natural Resources Canada published "From Impacts to Adaptation: Canada in a Changing Climate 2007" which reports that the average annual temperature in Ontario has increased by as much as 1.4°C since 1948. This trend is projected to continue, with the most pronounced temperature increases occurring in winter. Projected impacts on water resources across the Great Lakes Basin are consistent with observed changes in the Mississippi River stream flows.

MVC conducted an investigation, in collaboration with Queens University and the University of Guelph, to assess the impact which projected changes in climate would have on the flow regime of the Mississippi River. Three consecutive 30 year periods were modeled (2010 – 2039, 2040 – 2069 and 2070 – 2099) and compared to observed stream flow conditions between 1970 and 2000.

Figure 4 shows the average annual stream flow hydrograph for the Mississippi River at Appleton for the four periods modeled.



As can be seen from Figure 4, future stream flow patterns will continue to shift resulting in a 25% – 30% reduction in spring freshet flows occurring 6 – 7 weeks earlier. Stream flows in the late fall will continue to increase by approximately 70% while through the summer stream flows will tend to be approximately 40% lower and persist for a greater length of time.

Note: these represent the average yearly hydrograph for each period modeled and are based on the output from a single climate model and future emission scenario. Within each 30 year period there will continue to be considerable variability from year to year.

Further details can be obtained from http://www.mvc.on.ca/conservation-education/climate-change/80-current-projects.

Watershed Implications

Water Levels

The reservoir system on the Mississippi River was developed in the early 1900's to use historic runoff characteristics of the watershed and store spring snowmelt runoff then releasing water over the summer during periods of low flow. During extended dry weather periods most of the stream flow in the Mississippi River is supplied from this stored water. With projected shifts in future runoff patterns, the length of time in which stream flows may require augmentation will exceed the capacity of the reservoir system if it is to provide the same level of augmentation as in the past. This will ultimately result in lower water levels throughout the watershed. These average or expected conditions will not be consistent and are expected to be highly variable from year to year due to a greater frequency in high intensity rainfall events.

Fisheries

Dr. John Casselman from Queens University also studied the effects of water temperature on fish communities in the Mississippi River watershed and across the Great Lakes Basin. Casselman reports that the average summer surface water temperature in the Mississippi River increased by approximately 1°C between 1970 to 2000, and that it is apparent a relatively small increase in temperature is associated with a substantial increase in recruitment of warm-water species and a reduction in recruitment of cold-water species. The analysis of Mississippi River watershed data provides additional confirmation that fish community structure and dynamics are changing in association with climate warming. His research has concluded that an increase in average surface water temperature of 3°C will result in a 14.7 fold increase in the recruitment of warm water fish species with a corresponding decrease in cold species of 20.1 fold.

What this means

The analysis completed to date provides some insight into the scope of impacts which projected changes in climate will have on our watershed ecosystem along with the challenges and opportunities which this will present. Considerably more work is required to further understand how our ecosystems will respond to changes in climate, however, the scientific community is clear that our climate has and will continue to change for some time. While we may not be able to prevent changes in climate from occurring, we will have to find effective ways to adapt to the changes which the climate will have on our daily lives.