Buffalo's Lost Lake Effect

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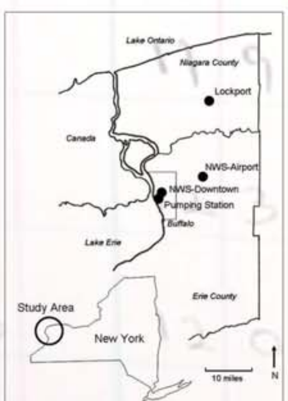
Introduction

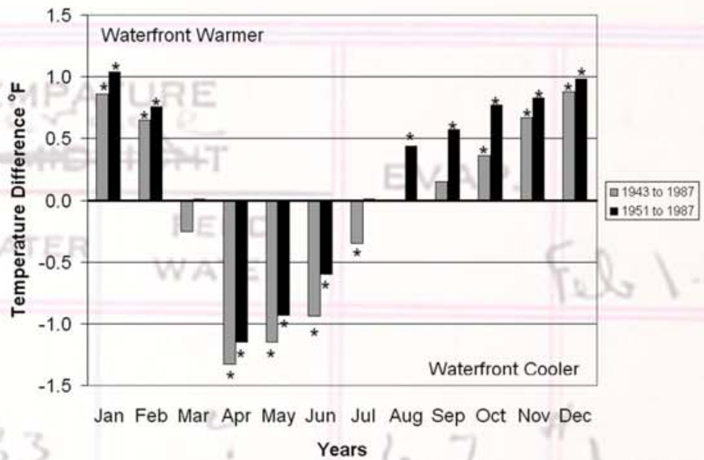
Due to specific heat capacity differences, large bodies of water such as Lake Erie take longer to warm or cool in relation to neighboring land, thus moderating air temperatures near the lake shore by cooling surface air temperatures in summer and warming temperatures in winter - a condition termed the "lake effect". A lake breeze is characterized as localized onshore winds generated by lake/land temperature differences (actually a circulatory pattern with a lakeward return flow at higher altitude). These onshore winds moderate surface air temperatures inland, penetrating about 40 km inland. However, surface air modifies rapidly and reaches near-inland values after traveling only a few kilometers. In other words, while lake breeze penetration may extend considerable distances onshore, the temperature moderating effects are often confined to a lesser distance from the shoreline. Similarly, it may be argued that prevailing synoptic winds blowing off of the lake modify surface air temperatures only a few kilometers inland.

Today (post 1942) the official weather data for Buffalo, New York are collected by the National Weather Service (NWS) at the Buffalo Niagara International Airport (42.94°N and 78.73°W). This site is located 14 km inland from Lake Erie. Prior to 1943 weather data was collected in downtown Buffalo, near the Lake Erie waterfront. Air temperature data from a waterfront location were recently found in the log books of the Colonel Ward Pumping Station, located at the confluence of Lake Erie and the Niagara River. The availability of the post-1942 pumping station temperature data may serve as a proxy for the original NWS downtown location, allowing for a comparison of waterfront and inland (airport) station temperatures.

Objectives of this paper are: 1) to compare surface air temperature data from Buffalo's current inland weather station with that recorded at the waterfront Colonel Ward Pumping Station in order to determine if the lake effect climatology has been "lost" from the post-1942 temperature record; and 2) to determine if the seasonal and annual temperature means of the airport weather station have been impacted by its move inland.



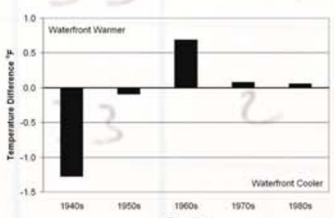
Temperature differences were calculated for each month by subtracting the monthly average temperature as recorded at the airport inland station from those values at the waterfront pumping station (Difference °F = Waterfront °F - Inland °F). The difference in temperatures between the two locations is defined here as the "lost lake effect." A negative difference indicates that the waterfront is cooler than the inland (NWS airport) site. A positive difference indicates that the waterfront is warmer than the inland site. No differences between the two stations indicates either the absence of a lake effect at both station or its extension inland to the airport station.



Average Monthly Time Series

A comparison of average monthly temperatures between the waterfront and inland sites clearly shows a classic lake breeze along Buffalo's waterfront - warmer waterfront air temperatures in the fall and winter and cooler waterfront temperatures in the spring and early summer, as compared to the inland location. Two data sets are presented: 1943 to 1987 (45 years), and 1951 to 1987 (36 years). The latter data set does not include the uncharacteristically cool period of the 1940's. The lost lake effect was statistically significant at the 90% confidence level for the months with an asterisk.

Decadal Series

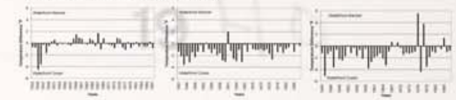


While lake effect may be seen as a zero-sum phenomenon at the annual scale, with cooler summers canceling out warmer winters, this is not always the case, and there are decadal trends apparent in the data. The 1940s exhibit the coolest net lake effect of -1.27°F (most distinct in July to October when compared with other decades), while the 1960s appear to exhibit the warmest and most pronounced net lake effect of 0.69°F. Implications for the inland weather station is that the 1940s air temperature record is warmer than if the station had remained at the waterfront, and the 1960s air temperature record is cooler than if it had remained at the waterfront. The 1950s, 1970s, and 1980s appear to exhibit a net lake effect hovering around zero. In other words, the lost lake effect had a minimal impact on the annual mean temperature record during these three decades.

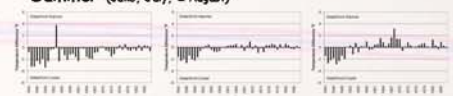
Monthly Plots

Winter (December, January, & February)

Spring (March, April, & May)



Summer (June, July, & August)



Fall (September, October, & November)

Conclusion

Differences in average monthly temperatures between the waterfront Colonel Ward Pumping Station and the inland NWS location at the Buffalo Niagara International Airport support our claim that the move of the NWS to the current airport location has resulted in the loss of the lake effect in Buffalo's post-1942 climate record.

The character and magnitude of the lost lake effect can be described as one with winter months that would have averaged 0.80°F to 0.93°F warmer than the current Buffalo record. Spring and early summer temperatures would have averaged -0.75°F to -0.89°F cooler than the current Buffalo record, with the month of April experiencing the greatest cooling (-1.15°F to -1.33°F). The autumn months would have averaged 0.52°F to 0.77°F warmer than the current Buffalo record, peaking in the early winter month of December (0.88°F and 0.98°F). March and July (and August and September to a lesser degree) appear as transition months having the least impact on the post-1942 climate record.

Within the 1943 to 1987 study period, the impact of the lost lake effect on the annual mean temperature record appears minimal (-0.04°F) as temperature gains in one season are lost in another, although this difference is dependent on the decades studied. The 1950s, 1970s, and 1980s show minimal annual temperature difference (<0.20°F) between the waterfront and inland sites, and thus the move of the NWS inland would have had a minimal impact on the annual climate record during that period. However, the 1940s lake effect would have resulted in an average annual cooling of -1.27°F, while the 1960s lake effect would have resulted in an average annual warming of 0.69°F.