Atmospheric Temperature Changes in the Western Lake Erie Climate Division

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Background

Globally, temperatures are increasing as an effect of climate change. According to ongoing analysis at NASA's Goddard Institute for Space Studies, Earth's average global temperatures have increased by approximately 0.8° Celsius, with two thirds of the warming occurring after 1975 (GISS, 2019; Lenssen et al., 2019). While this information applies on a global scale, the trend can also be observed on a local scale.

The Western Lake Erie climate division also exhibits a warming trend. Using combined data from three National Oceanic and Atmospheric Administration (NOAA) U.S. climate divisions in the western Lake Erie area (displayed below in Figure 1), these trends are examined in the following section (Vose et al., 2014). The use of data sourced from NOAA allows for high confidence in the analyses of these data.

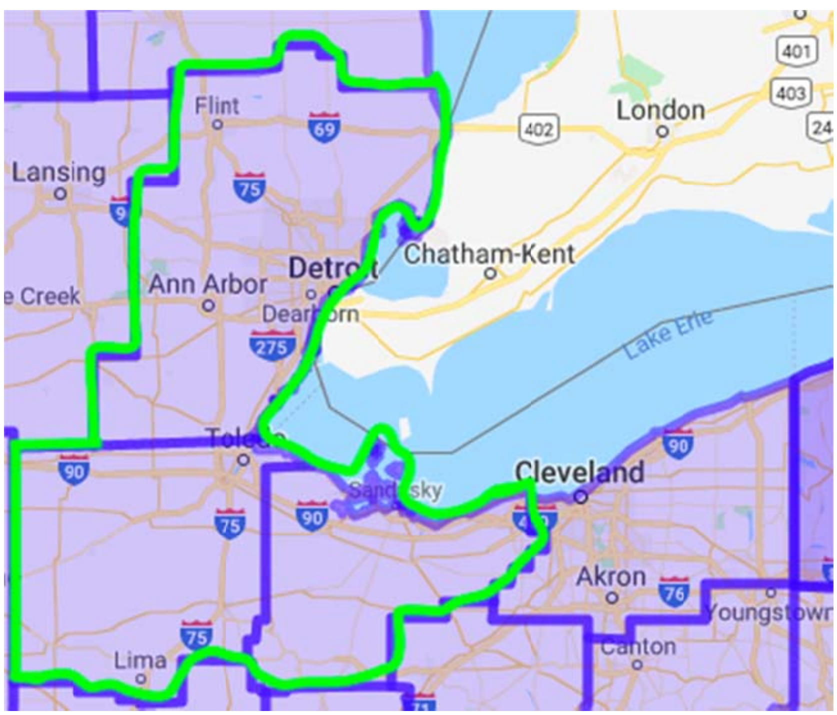

Figure 1: The green outline shows the area of the three NOAA Climate Divisions used for analysis of temperature trends in the western Lake Erie area.

The trend of increasing temperatures have had and will continue to have various impacts on the region. These impacts include changes in local ecosystems and amplified extremes in regional temperature, amongst others (Wuebbles et al., 2019). Because of this, it is important to consider and monitor the changes in atmospheric temperatures.

Trends

An overall increase in annual average atmospheric temperature has been observed in the Western Lake Erie climate division since 1951. This trend is demonstrated below in Figure 2 showing annual average temperature data from 1951 to 2018. The time series of the annual average atmospheric temperatures in the region trends upwards, as shown by the linear trendline, while also exhibiting inter-annual variability.

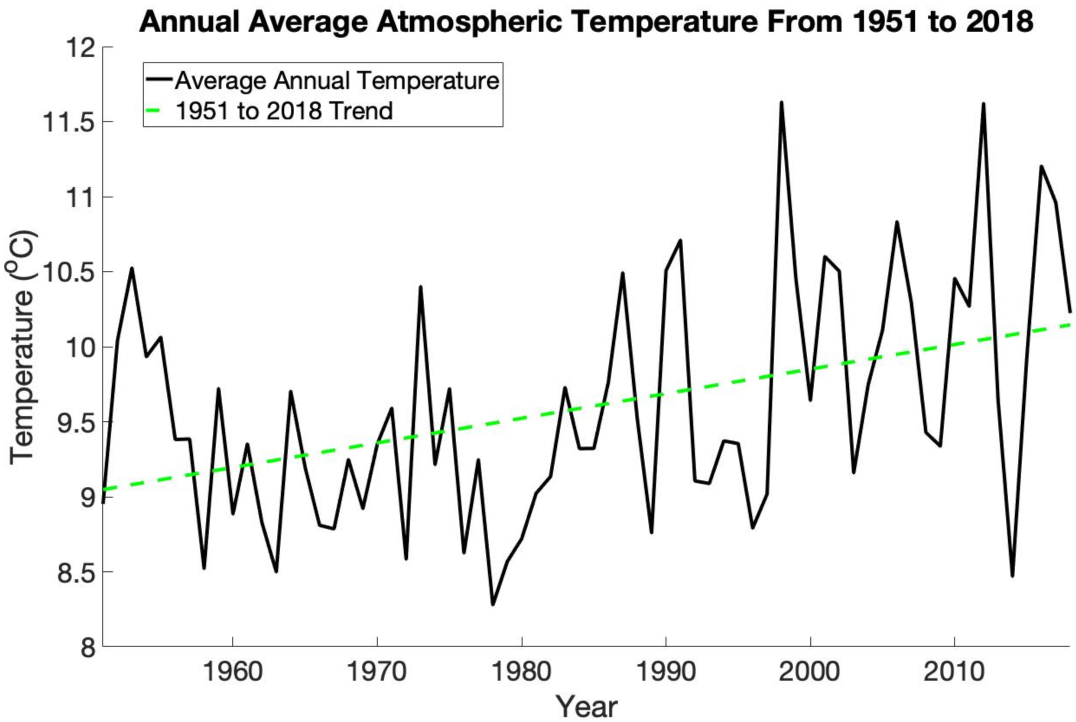

Figure 2: Annual average atmospheric temperature (black solid) in the Western Lake Erie climate division from 1951 to 2018, shown here with the trendline (green dashed) for the same time period.

Looking solely at the annual increase in average atmospheric temperature does not tell the whole story, making it important to examine seasonal trends. The annual trend is broken down seasonally in the following figure. Each season exhibits an increase in temperature since 1951 with winter showing the greatest increase and summer showing the smallest increase (Figure 3). It is interesting to note that the increase in average winter temperature is well above the annual average, while the increase in summer temperature is well below the annual average.

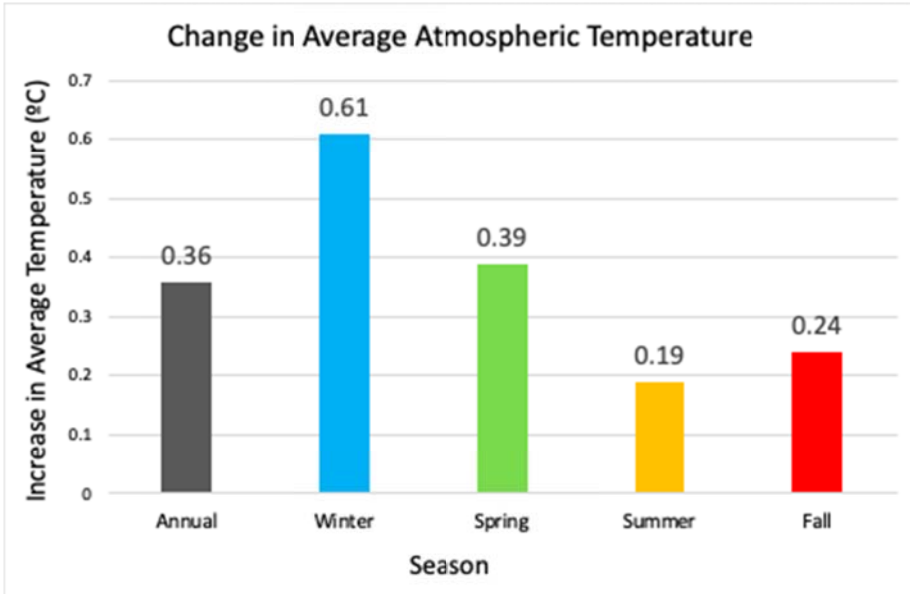

Figure 3: Change in annual average and seasonal atmospheric temperature in °C in the Western Lake Erie climate division. Calculated as the difference between the 1951-1980 averages and the 1951-2017 averages.

It is important to recognize that these values are for annual average temperatures. While the overall trend is upward, it is still possible to have extreme cold or hot days or periods that appear to be outside of this trend. Figure 4 shows the ten-year running average of annual average temperatures from 1951 to 2018, with the individual annual averages represented with black circles.

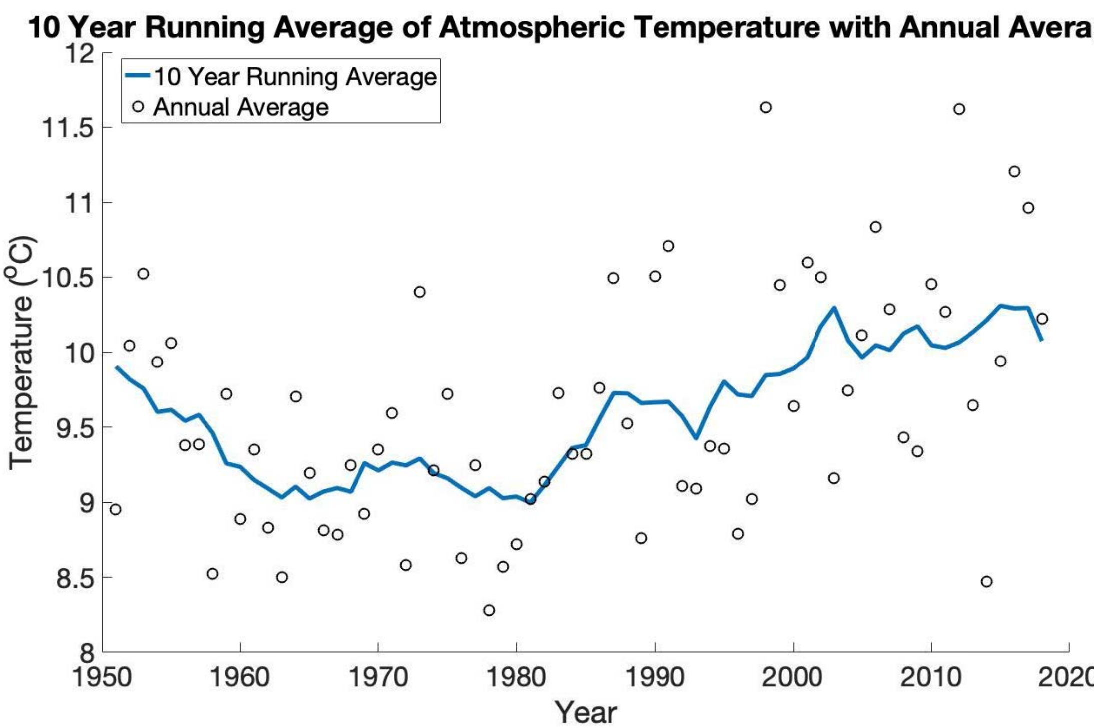

Figure 4: Comparison of ten-year running average (blue solid) with annual averages (black circles) to demonstrate variability of temperature.

There is a period of a few years after 1950 that is anomalously warm, which can be attributed to to natural variability. Due to a few anomalously warm years, the ten-year running average temperature during this period appears similar to ten-year running average temperatures of recent years. However, it is important to note that extremes in recent years are much higher than in any past period.

To analyze trends in days with high heat in the Western Lake Erie climate division, days per year above two temperature thresholds (32°C and 35°C) are shown in Figure 5 below. These thresholds were chosen because at these temperatures, regardless of relative humidity, the National Oceanic and Atmospheric Administration advises extreme caution with regard to heat related disorders (National Weather Service Heat Index). Extreme heat is generally observed more at a local, rather than regional scale, so Toledo, OH was chosen to represent a local look at historical extreme heat.

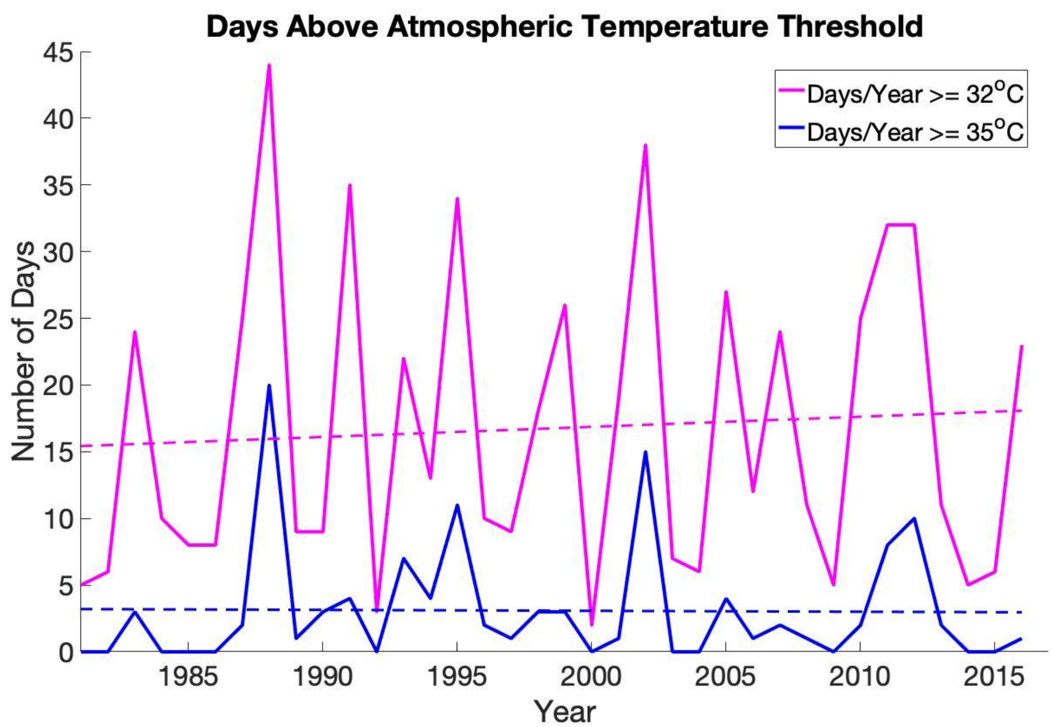

Figure 5: Days above 32°C (pink) and 35°C (blue) over time between 1981 and 2016 in Toledo, OH. The solid lines represent the number of days per year at or above the given thresholds while the dashed lines represent linear trendlines.

The figure above does not show any significant trend for either heat threshold between 1981 and 2016. Despite this lack of trend, it is important to note that there are multiple instances of high numbers of high heat days in a year. These days can be health hazards and the possibility of several high heat days needs to be considered.

Management Next Steps and Future Research Needs

In the future, atmospheric temperature changes in the Western Lake Erie climate division should continue to be monitored. This will allow for continued analysis of regional trends and planning for future impacts. Monitoring both annual and seasonal trends in atmospheric temperature along with extreme heat days will allow for better understanding of regional changes, and more informed decision making and planning.

Increases in atmospheric temperature impact a range of sectors in the Western Lake Erie climate division. As temperatures rise, competing species will migrate into the region potentially causing wildlife populations better adapted to cold temperatures to decline (Jump et al., 2009). Increases in evaporation rates will also result from higher atmospheric temperatures, which contributes to lower lake levels (Deacu et al., 2012). The combined effects of increased atmospheric temperatures, lake water temperatures, and precipitation can also exacerbate harmful algal bloom (HAB) formation (Reutter et al., 2011; Mackey, 2012; Ficke et al., 2007). More runoff from storms leads to higher nutrient loadings to Lake Erie (Michalak et al., 2012). Warmer surface water temperatures, that are influenced by warmer atmospheric temperatures, can lead to higher stratification (less vertical mixing) in the lake, which allows these nutrients to stay in the warm surface waters and contribute to the formation of algal blooms (Shuter et al., 2009; Magnuson et al., 1997). All of these impacts are important considerations for the management of the Western Lake Erie climate division.

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