Precipitation Changes in the Western Lake Erie Climate Division

Erin Maher, Great Lakes Integrated Sciences + Assessments, University of Michigan, eemaher@umich.edu
Kimberly Channell, Great Lakes Integrated Sciences + Assessments, University of Michigan, kimchann@umich.edu

Background

Changes in precipitation patterns have been observed in the Great Lakes basin as a result of the region's overall changing climate. In the Western Lake Erie climate division, there has been an overall increase in annual precipitation since 1951. Using combined data from three National Oceanic and Atmospheric Administration (NOAA) U.S. climate divisions in the Western Lake Erie area (displayed in Figure 1), these trends are examined below (Vose et al., 2014). Both liquid precipitation and snowfall (calculated as snow-water equivalent) are accounted for in the data below. The use of data sourced from NOAA allows for high confidence in the analyses of these data.

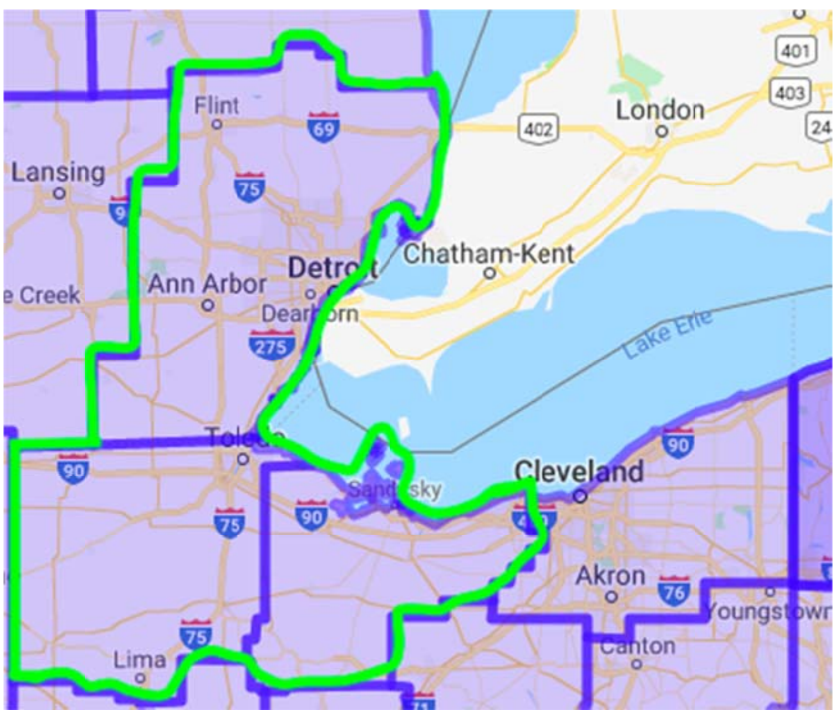

Figure 1: The green outline shows the area of the three NOAA Climate Divisions used for analysis of precipitation trends in the Western Lake Erie climate division.

Changing trends in precipitation have had and will continue to have various impacts on the region. These impacts include increased runoff (possibly containing phosphorus or other chemicals) and flooding, amongst others (Wuebbles et al., 2019). Because of this, it is important to consider and monitor the changes in precipitation.

Trends

An overall increase in annual precipitation totals has been observed in the Western Lake Erie climate division since 1951. Looking solely at the annual increase in total precipitation does not tell the whole story, making it important to examine seasonal trends. The annual trend is broken down seasonally in Figure 2. Each season exhibits an increase in precipitation since 1951, with fall showing the greatest increase and spring showing the smallest increase. It is interesting to note that the percent increase in fall precipitation is well above the annual average, while the percent increase in spring precipitation is well below the annual average.

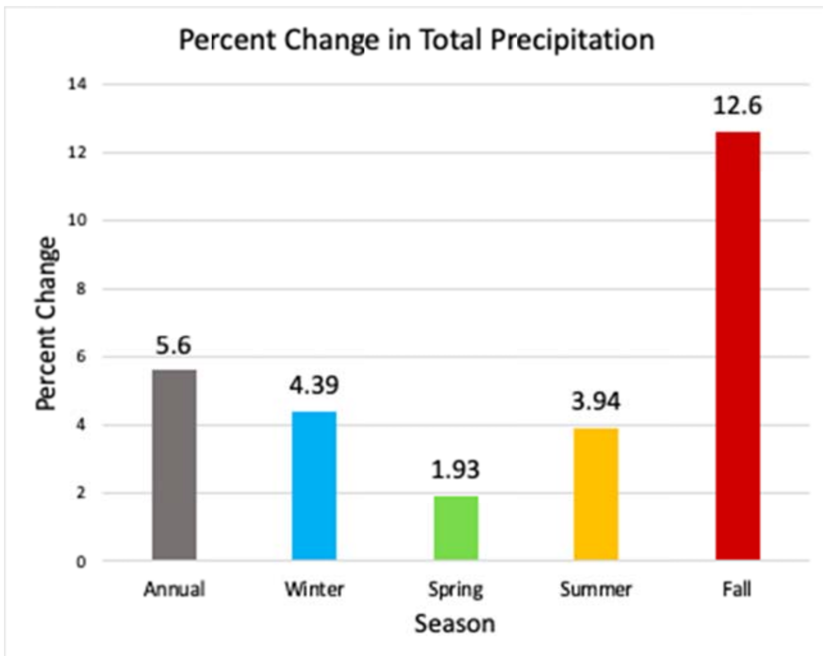

Figure 2: Changes in total average and seasonal precipitation, shown by percentages, in the Western Lake Erie climate division. Calculated as the difference between the 1951-1980 average and the 1951-2017 average, divided by the 1951-1980 average.

It is important to recognize that these values are for average annual or seasonal precipitation. While the overall trend is upward, it is still possible to have extreme precipitation events that appear to be outside of this trend. Extreme precipitation events can include extreme lack of precipitation (drought) or extreme excess of precipitation. Individual seasons exhibit variations in precipitation totals over periods of time. Figure 3 demonstrates this variability, showing the ten-year running averages of seasonal precipitation from 1951 to 2018.

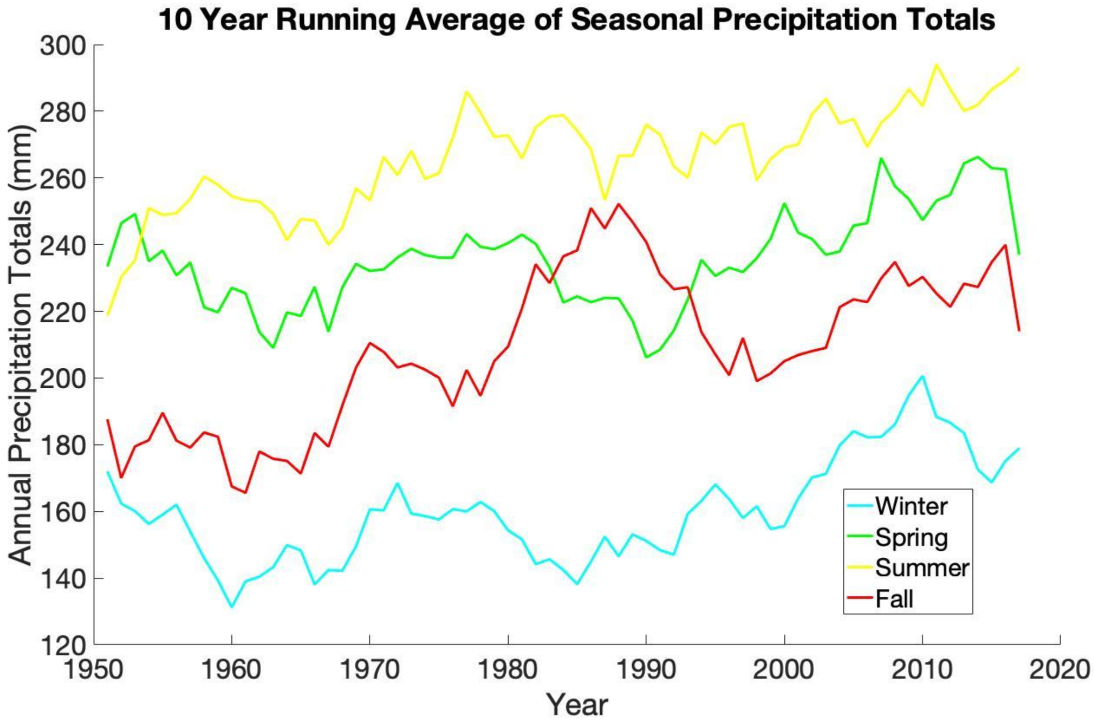

Figure 3: Ten year running average of individual seasonal precipitation totals plotted together for comparison and demonstration of variability. Each color represents a different season, corresponding with those used in Figure 2.

While the variability is evident, it is also clear that the overall trends are consistent with the data presented in Figure 2. The greatest increase seen in both figures is that of the total precipitation in the fall.

Variability and extremes are also important to consider on an annual time scale. Figure 4 shows the ten-year running average of annual precipitation totals from 1950 to 2018, with individual annual totals represented by black circles that demonstrate annual variability. While the general trend is positive, there are years that have anomalously high or low precipitation.

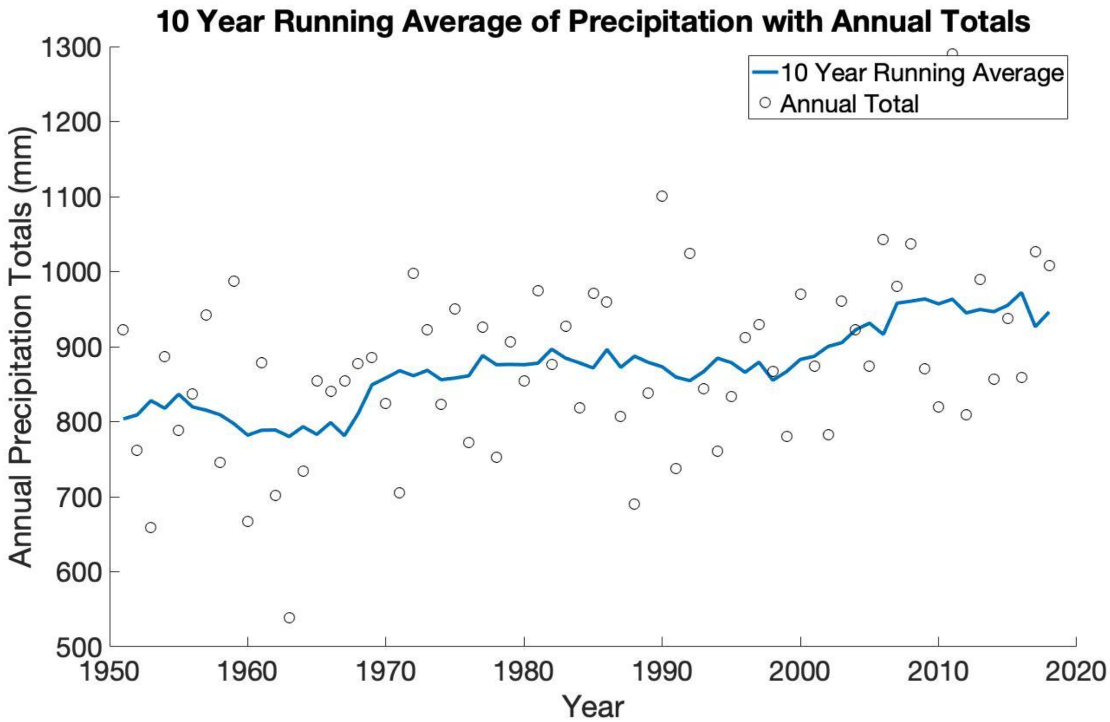

Figure 4: Comparison of ten-year running average (blue solid) with annual averages (black circles) to demonstrate variability of precipitation.

Along with an overall increase in total annual precipitation, there has been an increase in the frequency of extreme precipitation events. These events bring high amounts of precipitation in relatively short periods of time. To analyze trends in days with extreme precipitation, days per year above two total precipitation thresholds (i.e., 25 mm and 40 mm) are shown in Figure 5 below. Heavy precipitation is generally observed more at a local, rather than regional scale, so Toledo, OH was chosen to represent a local look at historical heavy precipitation.

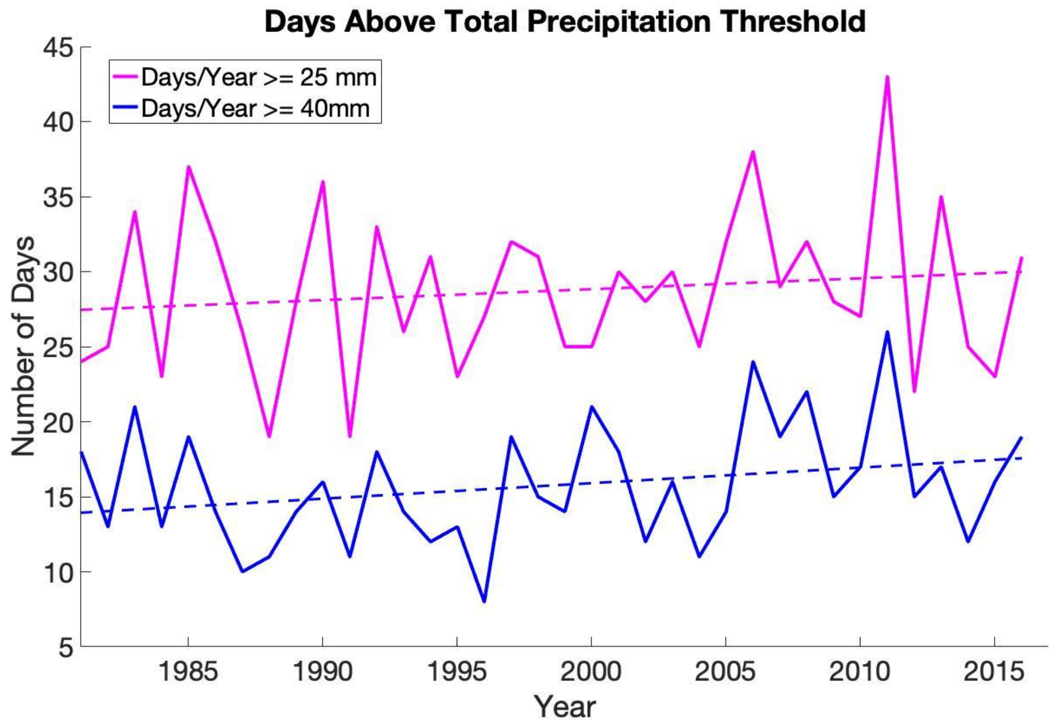

Figure 5: Days above 25 mm (pink) and 40 mm (blue) over time between 1981 and 2016 in Toledo, OH. The solid lines represent the number of days per year at or above the given thresholds while the dashed lines represent linear trendlines.

Aside from slight overall increase in high precipitation days, there is variability in the number of days over 25 mm and 40 mm yearly. This shows that different years can have anomalously high or low numbers of high precipitation days. These days can be hazardous and the possibility of several days with precipitation above these thresholds needs to be considered.

Management Next Steps and Future Research Needs

In the future, total precipitation 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 total precipitation, along with heavy precipitation days, will allow for better understanding of the changes, and more informed decision making and planning.

Increases in extreme precipitation events impact a range of sectors in the Western Lake Erie climate division. Higher volumes of precipitation can lead to flooding and erosion of coastal areas (Winters et al., 2015). Soil moisture, surface waters, and groundwater supplies could be affected by more frequent summer drought (Wuebbles et al., 2006; Hayhoe et al., 2007; Karl et al., 2009). In addition, runoff has increased in the Lake Erie Watershed, leading to the deposition of excess nutrients from agricultural lands, such as phosphorus and nitrogen, into the lake (Michalak et al., 2013). 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 loading in Lake Erie. Warmer surface water temperatures, that are influenced by warmer atmospheric temperatures, lead to higher stratification (less vertical mixing) in the lake, which allows these nutrients to stay in the warm surface waters and help form algal blooms (Shuter et al., 2009). All of these impacts are important considerations for the management of the Western Lake Erie climate division.

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