Climate Change in the Corn Belt

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Temperature change, or global warming, is what people most commonly associate with climate change. Average temperature in the United States has increased by 1.3° F to 1.9° F since record keeping began in 1895. Most of this increase has occurred since 1970 (Melillo et al. 2014). However, average annual global and US temperatures over time mask geographical variations across continents and within regions. The map below (Figure 1) shows US temperature changes over the last two decades compared to 1901-1960 averages.

The Project

The Sustainable Corn Project is a USDA-funded transdisciplinary partnership among 11 institutions creating new science and educational opportunities. The project seeks to increase resilience and adaptability of midwestern agriculture by identifying farmer practices and policies that increase sustainability while meeting crop demand. ***sustainablecorn.org***

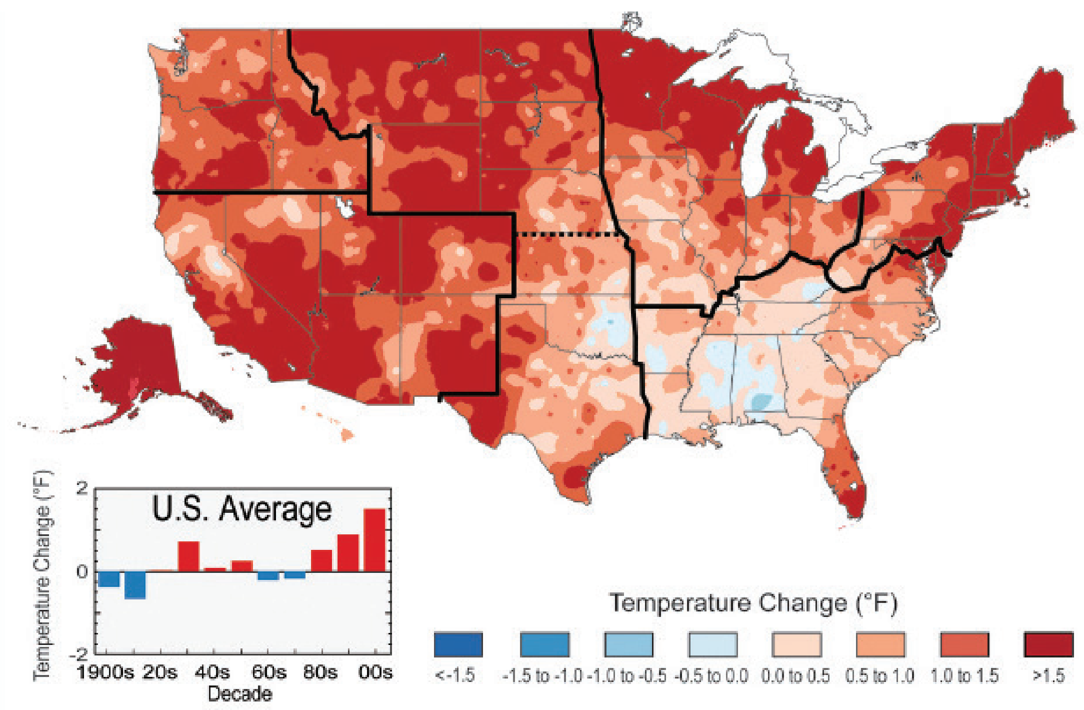

FIGURE 1 | Observed US Temperature Change | The colors on the map show temperature changes over the past 22 years (1991-2012) compared to the 1901-1960 average for the contiguous U.S., and to the 19-51-1980 average for Alaska and Hawaii. The bars on the graph show the average temperature changes for the U.S. by decade for the 1901-2012 (relative to the 1901-1960 average). The far right bar (2000s decade) includes 2011 and 2012. The period from 2001-2012 was warmer than any previous decade in every region.

Melillo, JM, TC Richmond, GW Yohe, Eds., 2014 Highlights of Climate Change Impacts in the United Sttes: The Third national Climate Assessment. US Global Change Research Program. Washington, DC. http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate#intro-section-2

Most of the region's warming has been in the cool half of the year

Midwestern United States temperatures have been quite different in terms of summer warming patterns compared to the rest of the country. The Southeastern US extending up into the lower Midwest is one of the only land areas on Earth that hasn't warmed appreciably over the past century. Some call this region a "warming hole."

Figure 2 shows the change in mean temperature annually; Figure 3 shows temperature change during the growing season, April through September; and Figure 4 shows the cool season, October through March. These graphs reveal that across the corn belt almost all of the warming has happened during the cool part of the year. The summer seasons do not reveal a warming trend; if anything just a slight cooling. If a farmer in the Midwest says, "Our summers haven't gotten any hotter from what I've been able to see" – he or she is correct!

The warming winter months have an effect on agriculture. This includes a shift in growing season frost dates and a northward extension of vegetation hardiness zones. There are also increased possibilities of overwintering effects that influence pest pressure and plant diseases.

Summer humidity has increased across most of the region

Climate change affects humidity as well as temperature. The Midwest experiences summertime humidity and it's getting more and more humid. Figures 5-7 are graphs of what meteorologists call dew point, a measure of the amount of moisture in the air. Most of the Midwest has experienced an increase in moisture content of the air throughout the summer which may have implications for the spread of crop disease.

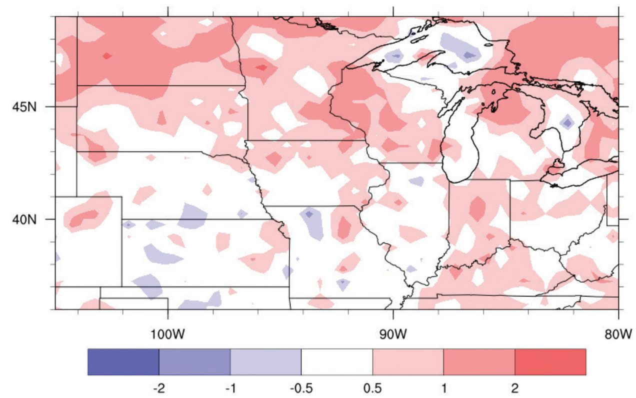

FIGURE 2 | Change in annual mean temperature. Average for 1981-2010 versus 1951-1980, ˚F | University of Delaware Precipitation and Air Temperature gridded analysis, v3.01

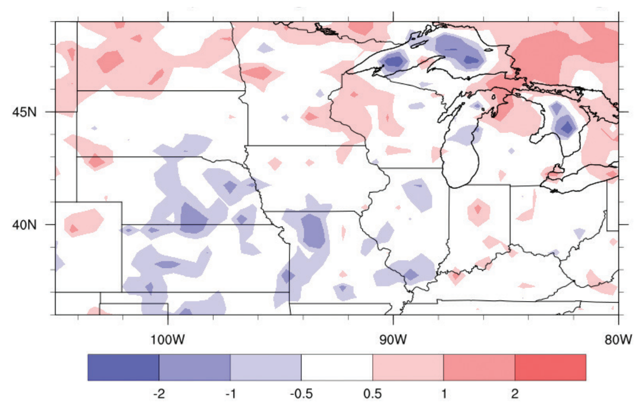

FIGURE 3 | Warm season temperature change. Average for 1981-2010 versus 1951-1980, ˚F | University of Delaware Precipitation and Air Temperature gridded analysis, v3.01

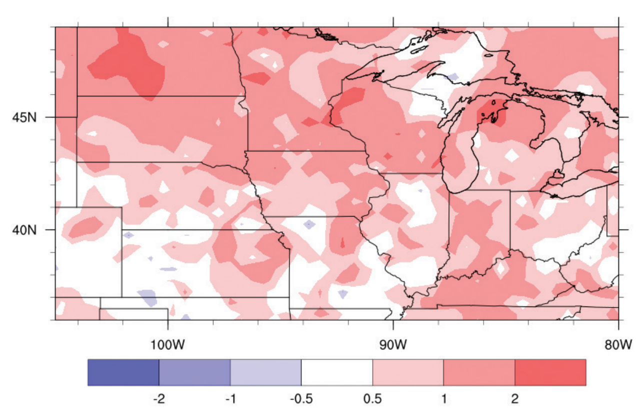

FIGURE 4 | Cool season temperature change. Average for 1981-2010 versus 1951-1980, ˚F | University of Delaware Precipitation and Air Temperature gridded analysis, v3.01

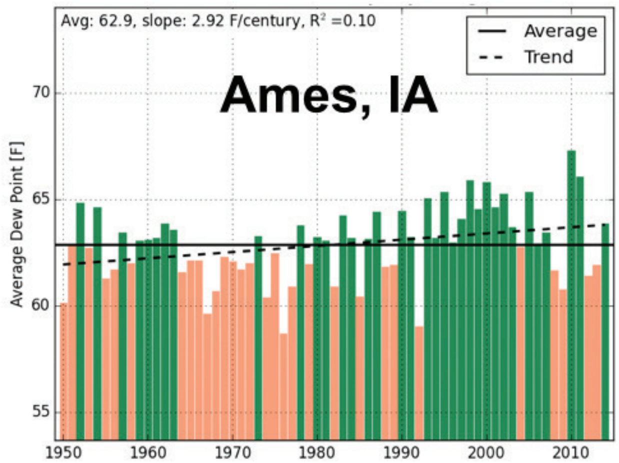

FIGURE 6 | Ames, Iowa. Average dew point for June-July-August of each year, 1950-2014. Green bars show years that are above the mean. | D. Herzmann, Iowa Environmental Mesonet.

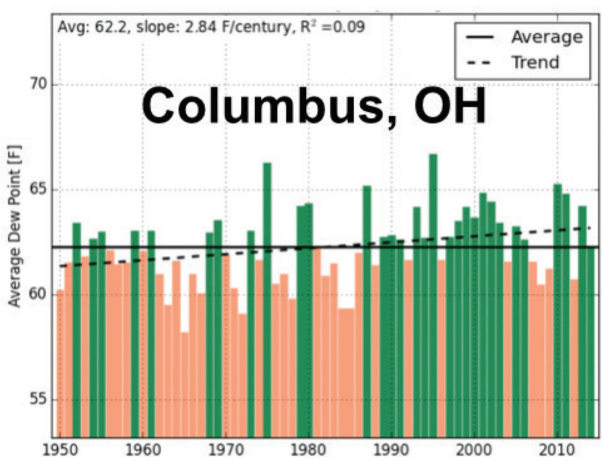

FIGURE 7 | Columbus, Ohio. Average dew point for June-July-August of each year, 1950-2014. Green bars show years that are above the mean. | D. Herzmann, Iowa Environmental Mesonet.

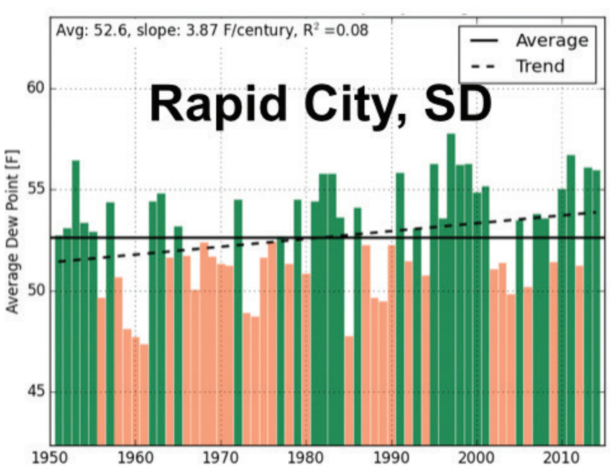

FIGURE 5 | Rapid City, South Dakota. Average dew point for June-July-August of each year, 1950-2014. Green bars show years that are above the mean. | D. Herzmann, Iowa Environmental Mesonet.

Mean precipitation has increased slightly, with regional and seasonal variations

Rainfall levels have also been changing. The average annual rainfall for most of the Midwest has increased, usually by one to two inches per year. This is a slight increase – 5-10% of the average rainfall – over almost the entire region. When comparing the seasonal distribution of rainfall of the past three decades to the three decades prior, most of the rainfall increase has come during the fall. There is a region from Central Missouri through Iowa that has also seen a spring and summertime increase in rainfall. Overall, the Midwest has seen an increase in rainfall in the warmer months but not much of a change in the winter.

Heavy rainfall happens more often

The most dramatic difference is the change in heavy rainfall. Do you remember when hundred-year floods were more than a few years apart? For example, Ames, Iowa has experienced a number of floods over the past few decades that are really out of the normal occurrence range. Over the last fifty years, the Midwest has seen a substantial increase in the number of days with rainfall over four inches, despite the fact that the average annual rainfall hasn't gone up much. One of the clearest trends in the United States observational record is an increasing frequency and intensity of heavy precipitation events (Figure 13). Over the last century there was a 50% increase in the frequency of days with precipitation over 101.6 millimeters (4 inches) in the upper Midwestern US; this trend is statistically significant.

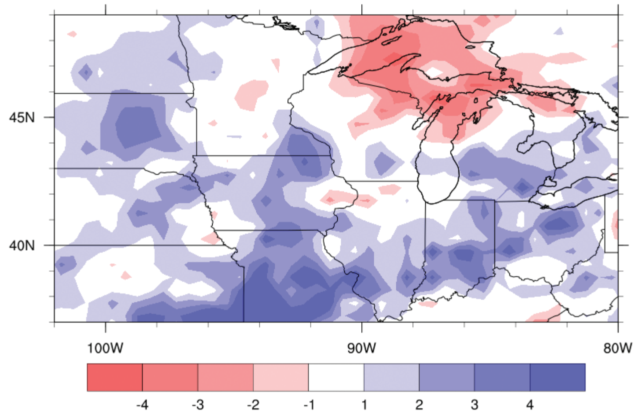

FIGURE 8 | Change in annual mean precipitation. Observed change for 1981-2010 versus 1951-1980, inches. | University of Delaware Precipitation and Air Temperature gridded analysis, v3.01

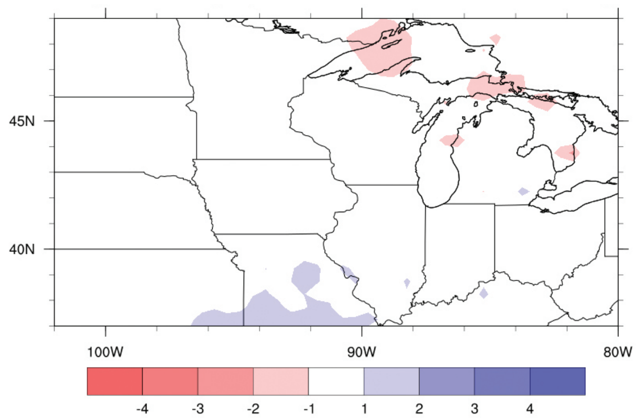

FIGURE 9 | Change in winter mean precipitation. Observed change for 1981-2010 versus 1951-1980, inches. | University of Delaware Precipitation and Air Temperature gridded analysis, v3.01

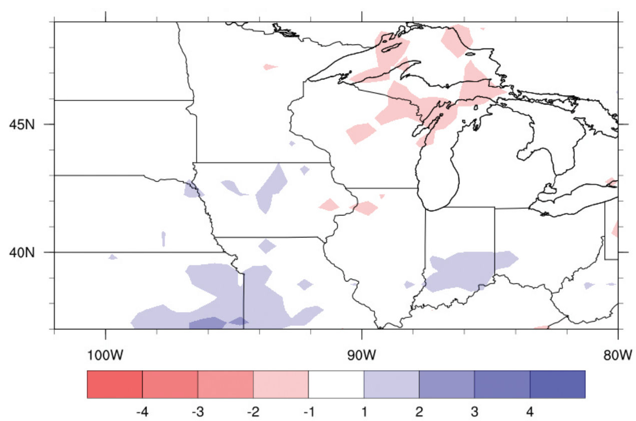

FIGURE 10 | Change in spring mean precipitation. Observed change for 1981-2010 versus 1951-1980, inches. | University of Delaware Precipitation and Air Temperature gridded analysis, v3.01

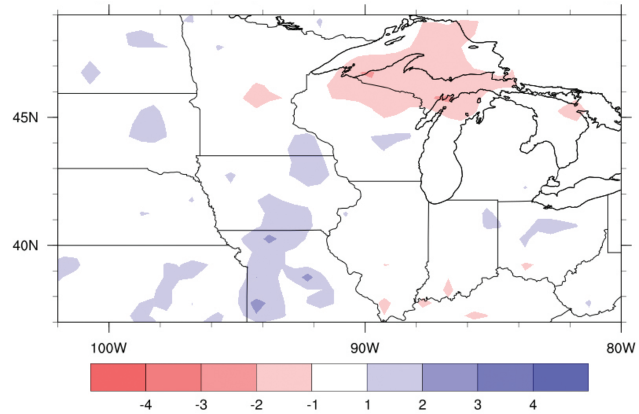

FIGURE 11 | Change in summer mean precipitation. Observed change for 1981-2010 versus 1951-1980, inches. | University of Delaware Precipitation and Air Temperature gridded analysis, v3.01

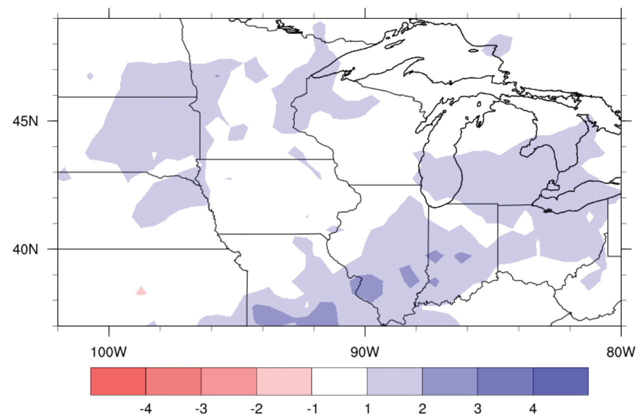

FIGURE 12 | Change in fall mean precipitation. Observed change for 1981-2010 versus 1951-1980, inches. | University of Delaware Precipitation and Air Temperature gridded analysis, v3.01

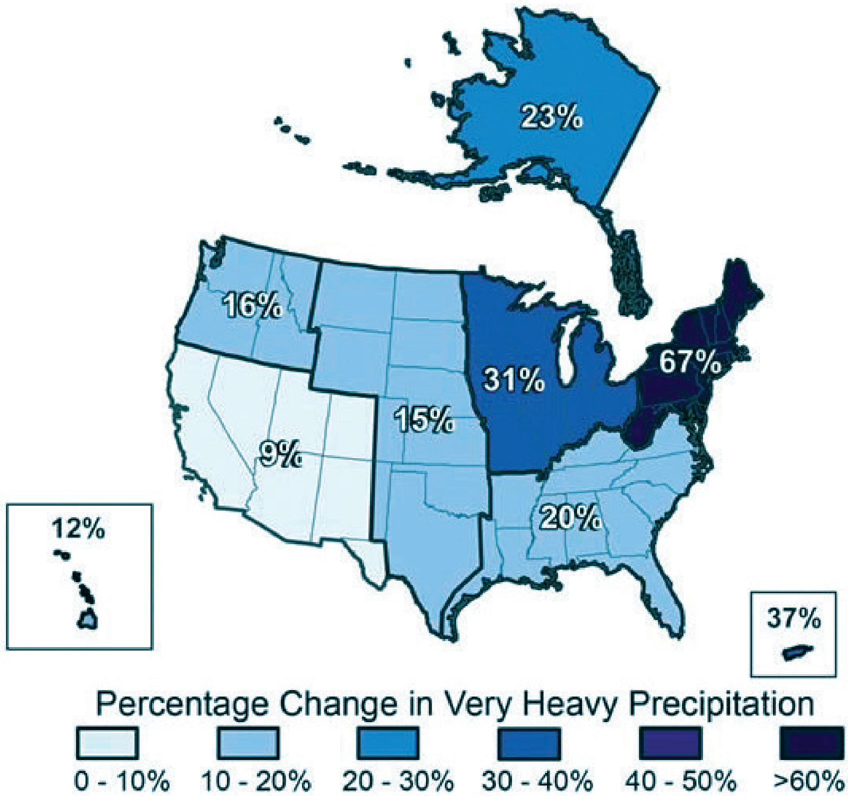

FIGURE 13 | Increase in Amounts of Very Heavy Precipitation (1958-2007). Karl, T. R., J. M. Melillo, and T. C. Peterson, (eds.), 2009: Global Climate Change Impacts in the United States. Cambridge University Press, 2009, 196pp.

Heavy rainfall has become noticeably more frequent

In all of six states in Figure 14 on page 6, heavy rainfall – daily precipitation that's two to four inches per day – has become more frequent.

The region is also experiencing some geographical variations in heavy rainfall events. South Dakota, which is historically relatively dry, now has more four-inch-per-day rainfalls than Ohio. South Dakota's four-inch rainfalls actually go off the top of the chart. Although not shown, it's about a factor of three increase. Nebraska has seen around a 50% increase, and there are increases in Illinois and Iowa. Indiana has seen around a 30% increase. Ohio bucks the trend a little bit, but the sample size is smallest there – they have the fewest events which can make the statistics a little unstable. There has been a dramatic increase in heavy rainfall in places that are historically and climatologically somewhat dry.

Downscaled climate predictions

Looking at the current changes in climate leads one to question what the future change will be. Climate changes must be watched over the next few decades, especially the increase in heavy rainfall. One challenge is that global climate models are too coarse to represent the kinds of thunderstorms and smaller-scale systems that are important to rainfall patterns in the Corn Belt.

We have used a finer-scale climate model to add details to the coarse global model results. This procedure, which climatologist call "downscaling," is the culmination of work over the past few years as part of the USDA-NIFA Climate and Corn-based Cropping System CAP project (also known as the Sustainable Corn Project). The next few figures show a number of results from these downscaled climate models. The finest runs take five months of continuous computing time on 72 processors, so this is an intensive and time-consuming set of calculations.

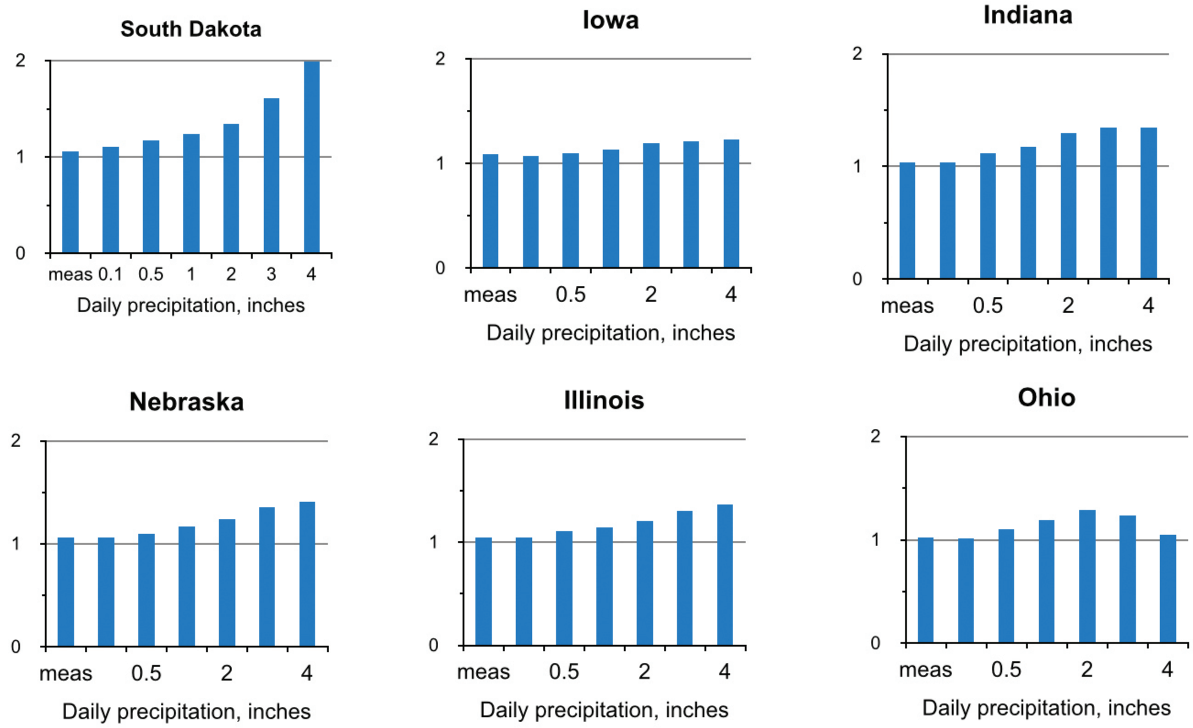

FIGURE 14 | Ratio of mean frequency in 1981-2010 versus mean frequency in 1951-1980 for each daily threshold. NWS Cooperative Observer network.

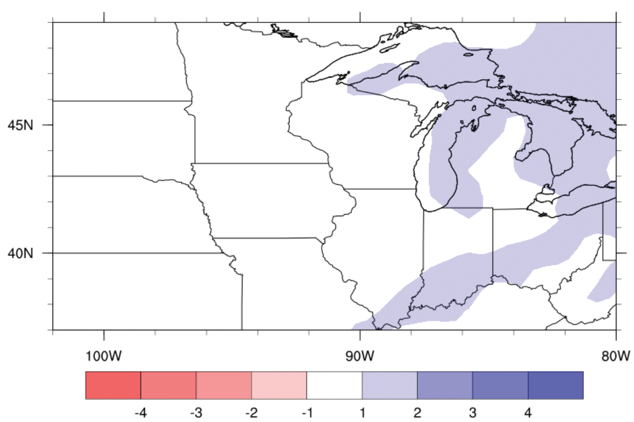

FIGURE 15 | Change in winter precipitation for 2041-2070 versus present, inches

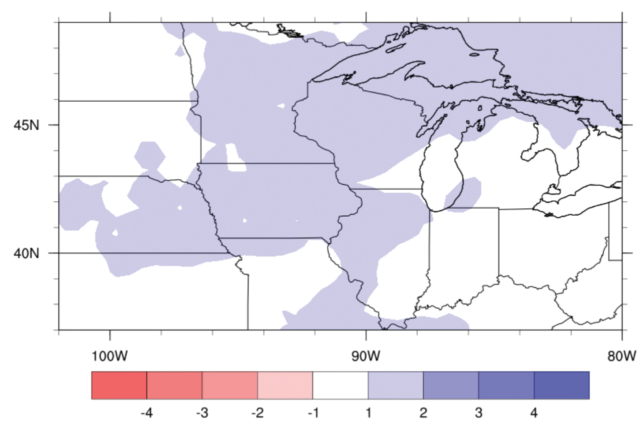

FIGURE 16 | Change in spring precipitation for 2041-2070 versus present, inches

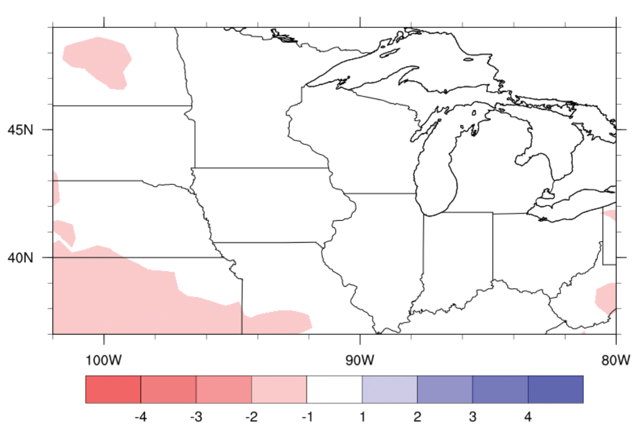

FIGURE 17 | Change in summer precipitation for 2041-2070 versus present, inches

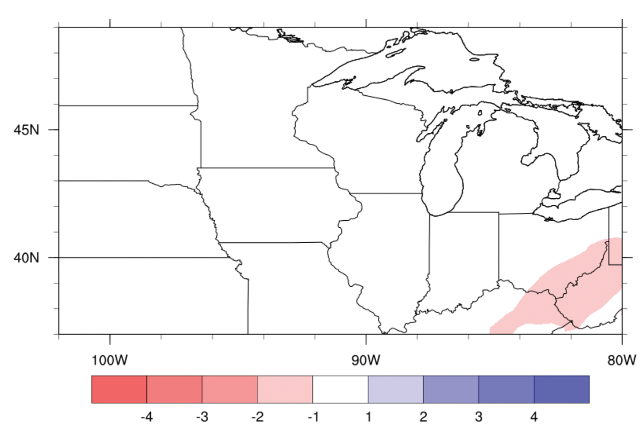

FIGURE 18 | Change in fall precipitation for 2041-2070 versus present, inches

Mean precipitation is predicted to increase slightly, mostly in winter and spring

Based on these calculations, over the next 30 years the average precipitation is predicted to increase slightly, mostly in the winter and the spring. This is because the air is projected to warm, which can then hold more moisture. The model does not show much projected change in the summer and fall.

This is different from global climate models which tend to predict that the Midwest will see a decrease of rainfall in the summertime. However, when using a finer-scale model that can represent thunderstorms better, the projection to decrease doesn't seem likely.

Heavy summer precipitation is projected to increase

The next projection is the change in heavy precipitation. Instead of a single simulation, the finer "downscaling" model calculations used to add details to the global models are done in several different ways. This lets us account for details such as how clouds are represented, variations in the grid spacing in the model, and the input data source. Figure 19 shows that regardless of the details of how we do the downscaling, heavy rainfall is always predicted to increase. Rainfall of more than 2 inches per day is predicted to happen about 20-40% more often, while rainfall more than 4 inches per day is predicted to happen about twice as often.

To summarize, over the past sixty years the Midwest has seen a slight warming, mostly in the cooler half of the year, which has allowed the hardiness zones to go northward. There was also a 5-10% increase in average yearly precipitation, which is a couple inches increase for most states.

The biggest change in terms of both the observations and the predictions is the increase in heavy rainfall. Heavy rainfall has increased significantly more than the annual or the seasonal totals. In fact, a consensus has evolved that a change in average precipitation isn't a useful predictor of the change in extreme precipitation. There can be more frequent heavy rainfalls even if the average rainfall stays the same or declines slightly. This trend of increased heavy rainfall is predicted to continue and to strengthen in the future 30 years.

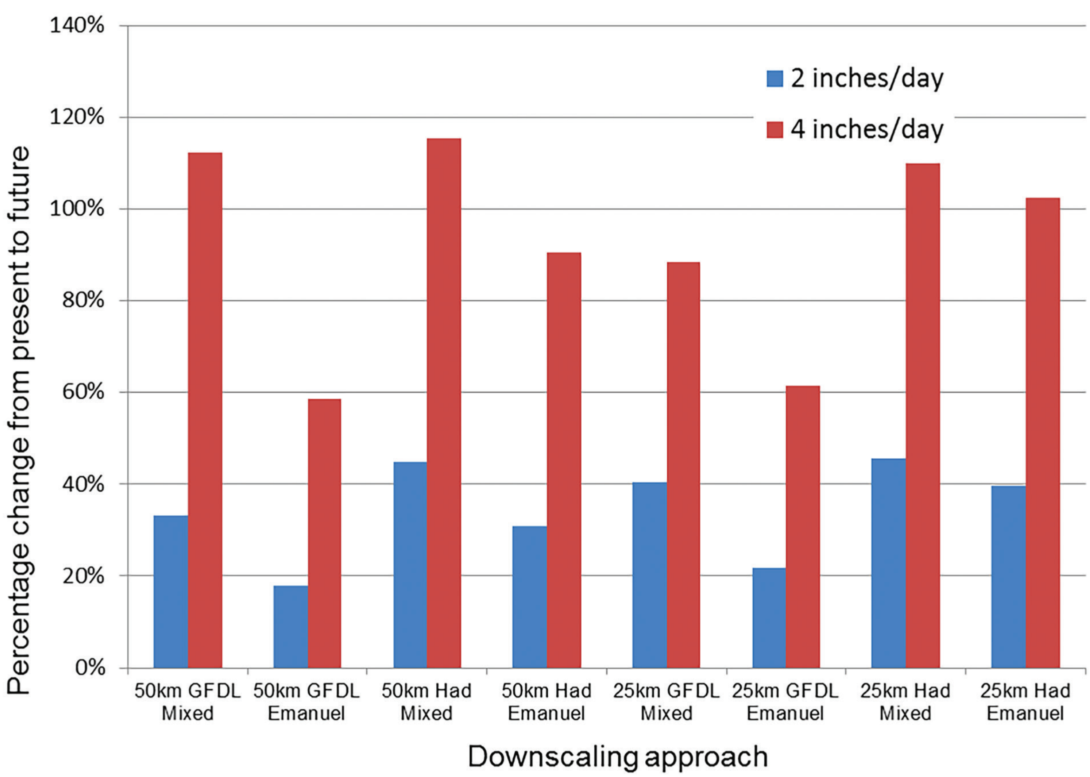

FIGURE 19 | Predicted change in occurrence of heavy one-day precipitation for the central U.S. in 2041-2070 compared to 1971-2000.

What does this mean for the Midwest?

It is evident that there is growing weather variability in the Midwest. The weather is changing and farmers must adapt. The increase in summer humidity may lead to increased disease pressure, and the winter warming may lead to overwintering of pests. More and more heavy frequent rainfall is the new normal, and farmers need to be prepared. Drainage water management and cover crops can help in coping with heavy rainfall, preventing erosion, and controlling nutrient runoff. Water storage solutions are needed since rain is falling heavier but less frequently.

About Author

Raymond Arritt's research encompasses mesoscale meteorology, regional climate, and aerobiology in the Departments of Agronomy and Geological and Atmospheric Sciences at Iowa State University, Ames, Iowa. He is a co-Principal Investigator in the USDA-NIFA Climate and Corn-based Cropping Systems CAP project. His current work focuses on analysis and prediction of precipitation systems, especially summertime precipitation over the central United States. 2009, 196pp.

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