# Climate change and drought in Minnesota and the Midwest

## Key Takeaways:

- As climate change progresses in the future, precipitation in Minnesota will become increasingly unstable and intense.
- Future Minnesotans will likely see longer dry periods and more flash droughts, with heavier rain events in between.
- Transitions between very wet and very dry periods are likely to happen more quickly in the future.

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# Historical Trends

On average, since record-keeping began in 1895, Minnesota has gotten warmer and wetter. Since 1990, total annual precipitation in Minnesota has been above the long-term average (1895-2020; Runkle, et al. 2022). The magnitude of wet extremes has also increased more than the magnitude of dry extremes (Ford et al., 2021). In addition to extreme dry and wet events becoming more severe, the annual standardized precipitation index (SPI), a common measure of meteorological drought, has become more variable. This means that **rainfall in most of the Midwest varies more widely within a given year than it used to** (Ford et al., 2021). In addition, the transitions between dry and wet periods have accelerated, meaning the **weather "flips" from wet extremes to dry extremes more rapidly and frequently than it used to**.

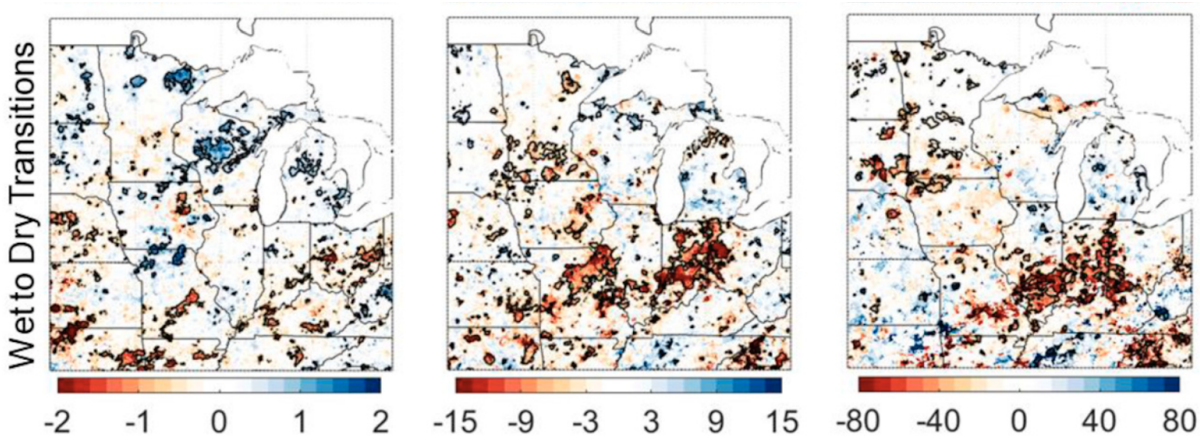


***Figure 1:*** *These maps show how the transitions between wet and dry periods have changed over time (1951-present). Red areas show where the transition between wet and dry periods has accelerated. Blue colors indicate regions where the transition between wet and dry periods has decelerated. The change is measured in days per decade, i.e., by how many days have the transitions accelerated/decelerated for each decade that we've been measuring? Areas outlined in black show statistically significant trends. Maps are shown for the (left) 30-day Standardized Precipitation Index (SPI), (center) 90-day SPI, and (right) 180-day SPI. Source: Ford et al., 2021.*

# Projected Future Trends

## Longer consecutive dry days and heavier rain

As climate change continues, precipitation in the Midwest and Minnesota is projected to become increasingly irregular. Minnesota's climate is getting warmer and wetter, and this trend is expected to continue, but it will not get wetter uniformly throughout the year. Rather, we expect more frequent and intense heavy rain events, with long dry periods in between. In other words, "**When it rains, it pours.**"

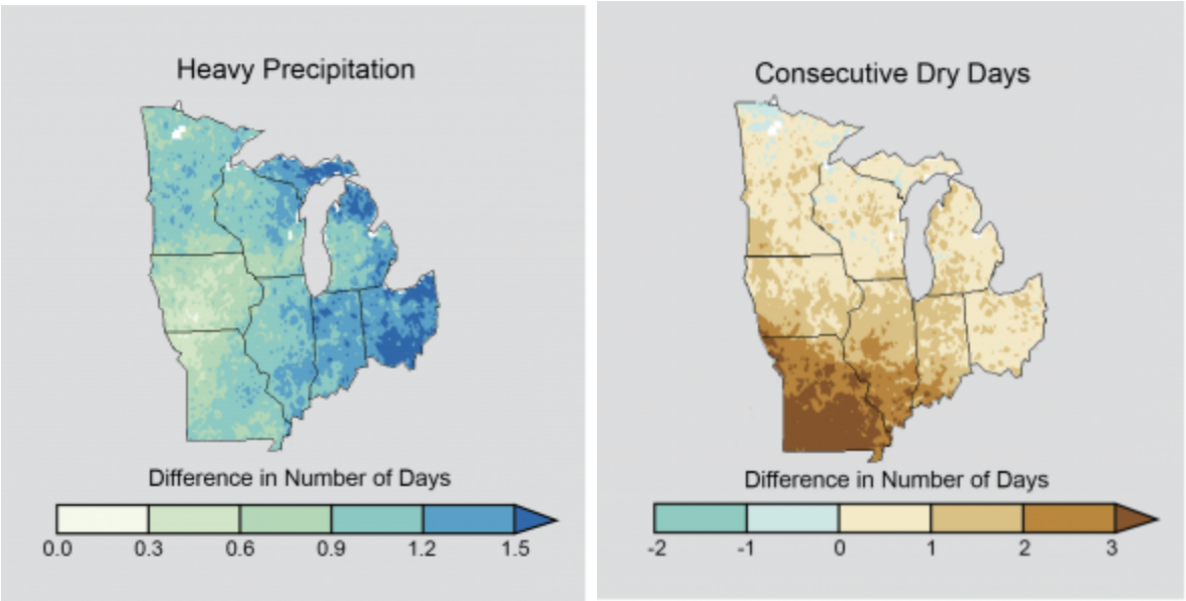


***Figure 2**: Projected changes to (left) heavy precipitation and (right) consecutive dry days in the U.S. Midwest for the middle of the 21st Century assuming continued emissions (A2 scenario, similar to RCP8.5 in CMIP5 and SSP5 in CMIP6). Figure source: [climatechange.gov](climatechange.gov)*

The length of consecutive dry days (CDD) is projected to increase more in the Midwest than in any region in the United States, up to 25% by 2100 (Akinsanola et al., 2020). This means that if we historically expected a dry period to last 8 days, we might expect it to last 10 days in the end of this century. We also expect a decrease in overall summer precipitation and a decrease in light rain events, but an increase in moderate and heavy rain events (Akinsanola et al., 2020).

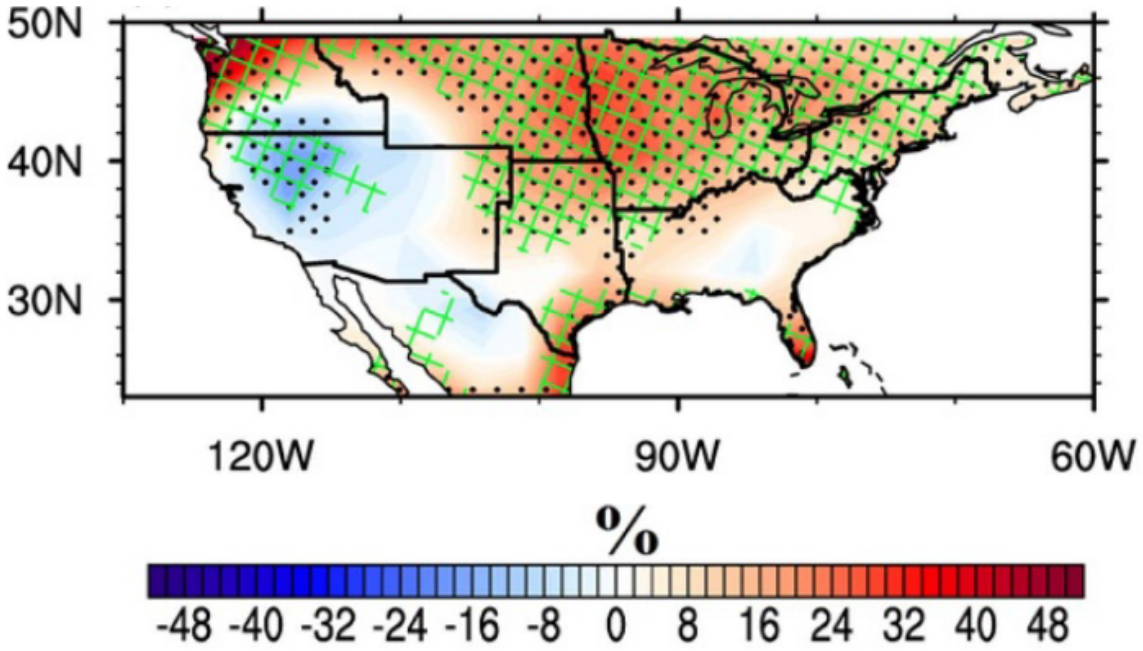


***Figure 3:*** *Projected change to consecutive dry days length by the end of the 21st Century, assuming continuously increasing emissions. Green Xs mean the trend is statistically significant, and black dots mean that all of the models tested in this study agreed on the direction of the trend. (Akinsanola et al., 2020). In Minnesota, the trend is strongly positive and statistically significant, and all models agree that it is positive.*

## Variability with seasons and amplified extremes

Projected changes to rainfall depend on the season in question. On average, we expect that springtime will become wetter, followed by a drier summer (Chen et al., 2023). In addition, these springtime wet extremes and summertime dry extremes may become ***more*** **intense and** ***more*** **frequent** than in the past (Chen & Ford, 2023). Transitions between extremes are also expected to accelerate and happen more frequently, especially from a wet spring to dry summer and from a dry fall to a wet winter (Chen & Ford, 2023). **Put simply, rainfall in Minnesota is expected to become increasingly unstable and intense**.

# Implications and Impacts of Changing Drought Conditions

These projected changes in precipitation tell us that future Minnesotans cannot rely on regular rainfall as much as their predecessors. Increasingly dry summers and increasingly long Consecutive Dry Days increase the likelihood of drought. Faster transitions between wet periods and dry periods imply that flash droughts might become more common. There are also important implications for agriculture, forest and water resource management, and the built environment. For farmers, wet springs can lead to flooded fields and delayed planting, while hot dry summers increase evapotranspiration rates and indicate a need for adaptive management such as irrigation. In addition, increasing variability on a monthly timescale poses management challenges for planting, nutrient application, and harvesting. In Minnesota's cities and towns, meanwhile, springtime flooding can overburden stormwater systems and seasonal-scale variability poses challenges for water resources planners.

**Flash drought** - "the rapid onset or intensification of drought" (Source: drought.gov)

Water resource managers in the future may need to consider water storage and transportation to help carry residents through increasingly long and intense dry spells. Forest and land managers will need to be proactive in tree species selection and planting, and may need to adapt management practices in ways that prioritize resilience to drought. For example, reducing stand density is one strategy to reduce competition for soil moisture among trees in a stand. The changing seasonal timing, severity, intensity, and flashiness of droughts may also put pressures on forests and tree species that lead to greater susceptibility to pests and pathogens.

As climate change progresses,
the stable precipitation that Minnesotans take for granted
could become a thing of the past.

Historically, Minnesota has benefitted from a stable climate with predictable seasonal cycles. The state is famous for its frigid winters, but its warm summers with

regular rainfall have enabled its thriving agriculture sector. As the state's climate continues to warm, this stability will become less and less common, with more frequent, intense, and variable wet and dry extremes. Unless emissions are reduced rapidly and drastically, future Minnesotans will likely face a climate with longer dry periods, more flash droughts, and heavier rain events in between.

## References


Akinsanola, A. A., Kooperman, G. J., Reed, K. A., Pendergrass, A. G., & Hannah, W. M. (2020). Projected changes in seasonal precipitation extremes over the United States in CMIP6 simulations. *Environmental Research Letters*, *15*(10), 104078. https://doi.org/10.1088/1748-9326/abb397

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