Climate Change - Impact on Midwestern Agriculture

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Eugene Takle
Professor of Atmospheric Science and
Professor of Agricultural Meteorology
515-294-9871
gstakle@iastate.edu

Don Hofstrand
Emeritus Professor
Iowa State University
641-423-0844
dhof@iastate.edu

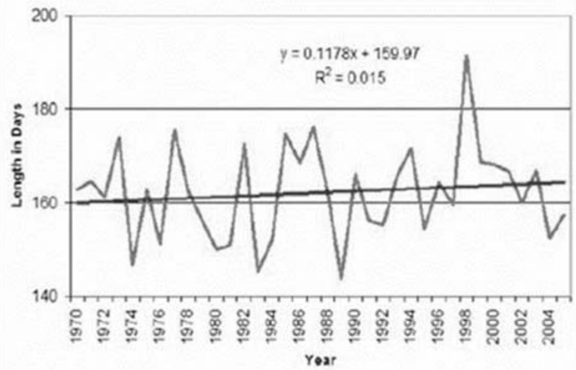
In previous articles we discussed the science of climate change and how agriculture is affecting it. However, in the short term (next 50 years) we can do little to mitigate the effects of climate change. Changes during this period have already been set in motion by past greenhouse gas emissions. Limiting greenhouse gas emissions in the future will only affect climate change in the long-term (beyond 50 years). So we must learn to adapt to the changes in climate that will occur over the next 50 years. In this article we discuss some of the ways that climate change may affect Midwest agriculture. A better understanding of these climate changes will help us harden agriculture to adverse changes and find new opportunities that might emerge from favorable changes.

The study of global climate change discussed briefly in previous articles is an important first step in understanding Midwest climate because the atmosphere links our region with changes going on elsewhere such as tropical sea-surface temperature changes and shrinking Northern Hemisphere ice masses. However,farmers and agribusinesses are affected by local and regional - not just global- climate change. So, what changes can we expect here in the Midwest? How confidently can we make such statements? Below is a list of changes likely to occur in the Midwest as gleaned from the most recent report of the International Panel on Climate Change 2007 4th Assessment Report and from the US Climate Change Science Program Synthesis and Assessment Report of 2008. In each case we give the level of confidence (high or medium) of the scientific consensus. In some cases we have combined more than one indicator to provide factors relevant to agriculture.

Temperature-related changes:

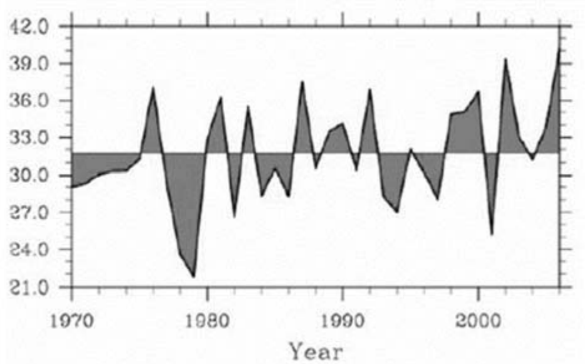
- Longer frost-free period (Figure 1) (high)
- Higher average winter temperatures, both daily maximum (Figure 2) and daily minimum (Figure 3) (high)
- Fewer extreme cold temperatures in winter (high)
- Fewer extreme high temperatures in summer in short term but more in long term (medium)
- Higher nighttime temperatures both summer and winter (high)
- More freeze-thaw cycles (high)
- Increased temperature variability (high)

Figure 1. Trend in length of the frost-free season in Iowa (statewide average)



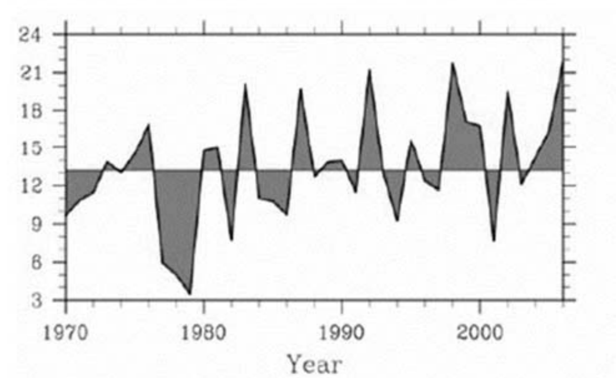
Source: D. Herzmann, Iowa Environmental Mesonet

Figure 2. Trend in average winter (Dec-Jan-Feb) daily maximum temperature (statewide average).



Source: D. Herzmann, Iowa Environmental Mesonet

Figure 3. Trend in winter (Dec-Jan-Feb) average daily minimum temperature (statewide average).



Source: D. Herzmann, Iowa Environmental Mesonet

Most plant processes are accelerated under higher (except extreme) temperature. So, even though the frost-free period will be longer, the growing season required by the plant may be shortened. Nighttime temperatures have risen more than daytime temperatures over the last 30 years. This trend is likely to continue. Although it seems counter-intuitive, summer daytime maximum temperatures in Iowa have gone down in the last 30 years. We rarely have extended periods of 100+ °F temperatures. This is in part due to more precipitation and likely slightly more cloudiness.

Over-wintering of pests may be more of a problem in the future. It is already happening in the Rocky Mountains where the pine-bark beetle is expanding its range northward and to higher elevations due to fewer extreme cold events.

More freeze-thaw cycles might be better for breaking down hard-pan soils and allowing more winter recharge of soil moisture. They may be detrimental to animal health, however, and certainly will create more challenges for road maintenance.

Higher day-to-day and year-to-year variability in temperatures (2007: warm March followed by widespread freeze in early April; 2008: cold March-May) can damage agricultural and fruit crops as happened in 2007, or delay spring planting and crop growth as happened in 2008.

Precipitation-related changes:

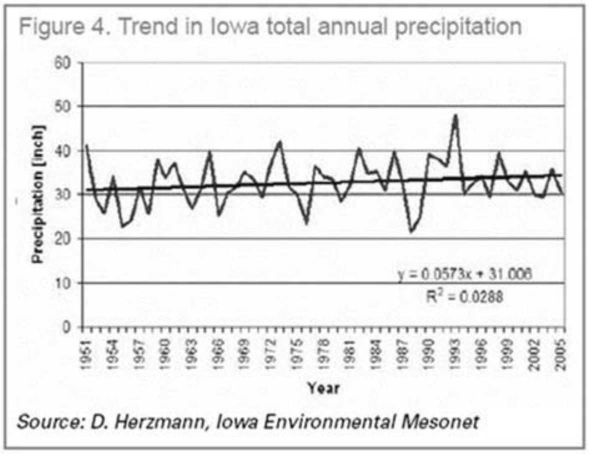


Figure 4. Trend in Iowa total annual precipitation

Source: D. Herzmann, Iowa Environmental Mesonet

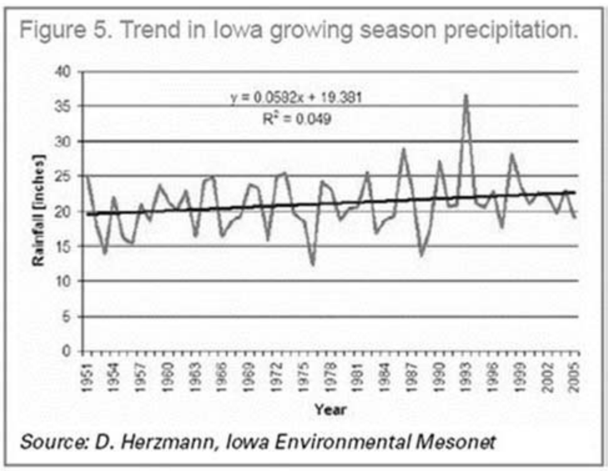


Figure 5. Trend in Iowa growing season precipitation.

Source: D. Herzmann, Iowa Environmental Mesonet

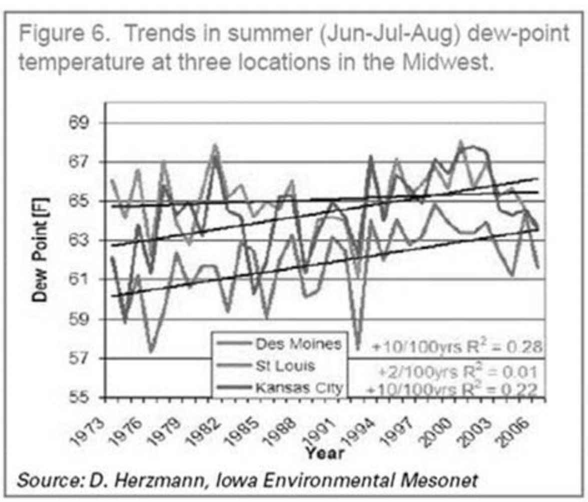


Figure 6. Trends in summer (Jun-Jul-Aug) dew-point temperature at three locations in the Midwest.

Source: D. Herzmann, Iowa Environmental Mesonet

- More (~10%) precipitation annually (Figure 4) and during the growing season (Figure 5) (medium)
- Most of the increase will come in the first half of the year (wetter springs, drier or little change in summers) (high)
- More water-logging of soils (medium)
- More variability of summer precipitation (high)
  - More intense rain events and hence more runoff (high)
  - Higher episodic stream flow (medium)
  - Longer periods without rain (medium)
- Higher absolute humidity (Figure 6) (high)
- Stronger storm systems (medium)
- Snowfall increases (late winter) in short term but decreases in long run (medium)
- More winter soil moisture recharge (medium)

Precipitation is much more difficult for climate models to simulate. So we have less confidence in the predictions of changes in precipitation due to climate change (more "mediums" and fewer "highs" in the confidence levels). A complicating issue of assessing changes in precipitation in the Midwest is that we are located close to regions of high precipitation gradients. That is, annual precipitation is much less in western Iowa than eastern Iowa and less in northern Iowa than southern Iowa. In Illinois, there is less in the north than the south, but east-west differences are small. So if precipitation patterns shift eastward, for instance, in a future climate, Iowa will be more affected than Illinois, but both will be affected by a northward shift of higher rainfall.

Other changes:

- Reduced wind speeds (high)
- Reduced solar radiation (medium)
- Increased tropospheric (atmospheric layer next to the earth) ozone (high)
- Accelerated loss of soil carbon (high)
- Faster plant growth and development to maturity (high)
- Weeds and vines grow more rapidly under elevated atmospheric CO_2 (high)
- Weeds migrate northward and are less sensitive to herbicides (high)
- Plants have increased water-use efficiency (high)
- Combinations of conditions and pathogens more favorable for development of toxins (medium)

Reduced wind speeds can affect pollination and dispersion of pests and pathogens and, of course, influence wind power generation. At ISU we are examining the impact of climate change on wind speeds.

Increased precipitation in our region likely would be accompanied by more cloudiness and hence less solar radiation, particularly in spring. This likely would slow early-season crop growth.

Higher temperatures promote conditions that allow for the generation of tropospheric (atmospheric layer next to the earth) ozone from automobile exhaust. Ozone near the ground now likely accounts for a small reduction in yield, but may rise to as much as 30% over the next century.

Higher temperatures and more soil moisture accelerate the microbial action in soil. This leads to a faster breakdown of plant materials to form carbon dioxide out of soil carbon, increasing the loss of soil carbon.

Plant biological processes also are accelerated, which may be good or bad. A shortened pollination period for corn, for instance, might increase its vulnerability to drought – even short period droughts.

Many weeds, particularly C3 weeds 1/, respond more quickly to elevated CO_2than crops. Herbicides are, in some cases, less effective on weeds grown under these conditions.

Crops grown under high CO_2 environments do not require stomatal (minute pores in the epidermis of a leaf or stem through which gases and water vapor pass)openings as wide as those grown under lower CO_2. A positive side effect of this is that plants tend to conserve water better and thereby increase their water-use efficiency.

A plant that is stressed, by whatever cause, is more vulnerable to succumb to other biotic (living) or abiotic (non-living) stresses. For example, if humidity levels increase, corn encountering drought during the grain-filling phase may be more vulnerable to mycotoxin or aflatoxin growth. We are only beginning to understand how such combinations of stress factors interact to challenge the flourishing of agricultural crops.