What We (also) Need to Know is How the Weather is Changing

Michael C. MacCracken
Climate Institute
Washington DC 20006

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Introduction

Ongoing anthropogenic emissions of carbon dioxide and other greenhouse gases are creating long-lasting changes in atmospheric composition, and these changes are altering the long-term energy balance of the planet. Thus, it is said that the climate is changing: the decadal-average temperatures of the atmosphere, oceans, and land surface are increasing; the cryosphere is shrinking; sea level is rising; ranges of species are shifting; and more.

The climate, however, is a mathematical construct that is only roughly connected to the most important societal and ecological impacts being caused by society’s use of fossil fuels.

Changes in the statistics of the weather (the higher moments of climate statistics)—that is, the changing mix of instantaneous conditions—are what people and the biota experience and what causes many of the impacts.

Climate models derive their projections of changes in the climate from simulation of changes in the weather. More detailed consideration of the model-simulated weather is needed so that the characteristics of the weather can be provided to those who can enhance their resilience, who can adapt to the changes, and who are likely to suffer the consequences.

Changes that Matter

Changes in the climate are made up of changes in the weather. The changes in the weather (the higher moments of climate statistics) that matter most include changes in:

- the intensities, frequency, and duration of extremes in temperature and precipitation;
- the locations where extremes (or favorable conditions) occur; and
- the timing and sequencing of the weather.

Examples of the types of weather events for which such information is needed include:

- path, speed, and reference temperatures of major storms;
- the intensity, location, and duration of blocking events;
- the intensity and cycling of oscillations such as ENSO;
- locations and timing of likely tornadic activities;
- the strength and intensities of the summertime cold fronts that trigger thunderstorms;
- the duration and heat index of heat waves; and
- changes in the return frequency of extreme storms.
Example 1: Russian 2010 fires

The summer of 2010 was exceptionally hot and dry (figure from Climate Central). A critical question is whether such conditions will become more frequent and/or persist for longer each year. For the European heat wave of 2003, projections indicate that it could go from a roughly one in 500-year occurrence to a 1 in every 2-3 year occurrence over the next 50-100 years. Determining whether a similar shift might occur for the Russian event requires detailed analysis of the model simulations rather than looking at changes in the multi-decadal average.

Annual-average anomaly: Although July was exceptionally warm, the annual anomaly (see map on following page) does not indicate that it was exceptionally warm in that region, making clear that relatively fine scale time and space resolution is required to pick up important variability.
Precipitation Anomalies July 2010
(with respect to a 1961-1990 base period)
National Climatic Data Center/NESDIS/NOAA

Temperature Anomalies Jan-Dec 2010
(with respect to a 1971-2000 base period)
National Climatic Data Center/NESDIS/NOAA
**Significance for the future:** Air does not naturally sink (as was occurring over Russia)—it is pushed down by air rising elsewhere, normally driven by latent heat release from precipitation released as air rises (as was occurring Pakistan-India especially strongly as moist Indian Ocean air pushed northward against the Himalayas). Given geography and orography, it is difficult to see how moisture will flow into Russia in summer, suggesting drought and heat are likely for the future.

**Example 2: Changing Conditions in Minnesota**

*WWF Climate Witness story from 2007:* “My name is Joe Schaedler…. I have lived my whole life in the vicinity of Minneapolis, Minnesota…. Minnesota is considered a part of “The Great White North”, where extremely cold and snowy weather drives residents to stay indoors as much as possible for about a third of the year…. In the late 1990s, this traditional pattern underwent significant changes…. Winter weather used to always come in November at the latest, but for four of the last eight winters, we did not see a day with over an inch of snowfall until the month of December. In the winter of 2004-2005 snow did not fall until late January. Not only is the snow coming later, but the end of the snowy season is coming earlier as well. The historical heavy snowfalls of March are being replaced more and more with rain and melting snow….

“[The] lack of constant winter snow cover threatens Minnesota’s agricultural areas because the snow normally acts as a security blanket for the soil beneath when temperatures dip below freezing. When the snow is absent and the temperatures are low, the exposed soil becomes much more susceptible to damage. The continued trend of soil damaging winter conditions is degrading the quality of Minnesota’s farmland. This is further exacerbated by the emergence of drought conditions during the growing season here in the last couple of years. Altogether, the changes to Minnesota’s climate and the associated loss of our winter snow present a dangerous problem for the agriculture industry.”
More frequent summertime drought in the Southeast, similar to conditions in 2007, seems likely as the cold fronts from Canada weaken and warming aloft by increased CO₂ both tend to make thunderstorms less likely. If hurricanes become less likely, but more powerful, the region will become one with greater extremes.

**Significance of Arctic warming for the future of conditions in North America**

**Fall/Winter:** As the Arctic sea thins and is melted back, the additional heat gained during the warm season due to the lower albedo is injected into the atmosphere, making the overlying atmosphere significantly warmer from fall into winter. Being less dense, the cold air masses over North America are less able to keep warm, moist Gulf coast air from pushing northward, even into the upper Great Plains, where it is causing significant wintertime warming. Depending on variations in the global circulation (e.g., due to ENSO variability), the warm, moist air can occasionally reach up into the northern Great Plains, leading to the unusually heavy snows and even wintertime tornadoes.

**Spring/Summer:** With the Arctic and northern Canada warming earlier in the year and the ground not as cold, the cold fronts will not be as strong, and again the moist Gulf coast air will push further into the central to northern Great Plains. But it is the summertime cold fronts that are needed to trigger thunderstorms in the Southeast and along the coastal plain of the Atlantic. With weaker cold fronts, moist Gulf and Atlantic air pushes northwestward, so thunderstorms are plentiful in the Ohio River basin to the northwest of the Appalachians, while the states along the Atlantic swelter in high humidity but have no trigger for mid-summer thunderstorms.

**Recommendations**

1. Augment existing analyses with characterizations of changes in air mass types, origins, and characteristics to provide those experiencing and studying impacts to consider how changes in the weather will affect them.

2. Broaden the set of those who are able to consider the significance of changes in the weather by putting online 10-day sequences of the monthly/seasonal weather for selected decades from high-resolution model runs (e.g., post on weatherunderground.com the set of 10-day calculations for Novembers in the 1990s, 2020s, 2050s, 2080s, etc.)

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