Extreme Weather, Atmospheric Circulation, and Global Warming

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A belief commonly held is that global warming will produce more extreme weather. While this thinking serves as convenient fuel for sensationalist headlines linking what only a decade ago would have been viewed as the normal vagaries of weather to some approaching climatic apocalypse, it is not based on sound science. On the contrary, should the predicted global warming actually occur, both theory and data show that our future climate may very well consist of *fewer* extreme weather events worldwide.

In this chapter, I shall present some examples of observed trends in extreme weather events and provide a context for hypothesizing about future conditions, beginning with some background on atmospheric circulation since this is fundamentally linked with variations in temperature, precipitation, and all other weather conditions.

Atmospheric circulation

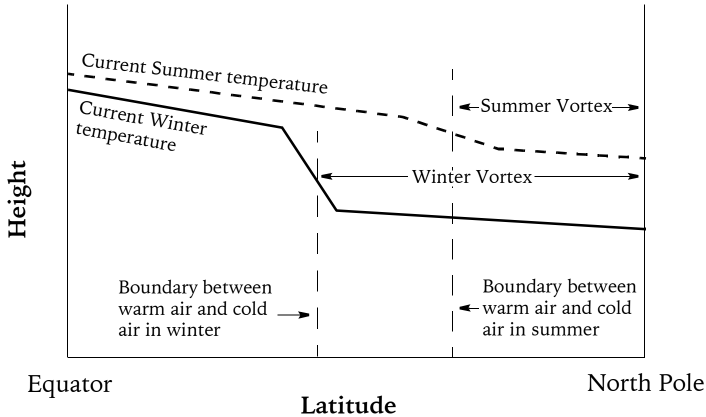
The general term "atmospheric circulation" encompasses large-scale winds around the globe and includes features like the jet stream, fronts, and low and high pressure systems (cyclones and anticyclones). Changes in the weather and climate on a daily, seasonal, and year-to-year basis are driven by changes in atmospheric circulation.

The jet stream is a good example of a key circulation feature. We can think of the jet stream as a narrow river of fast-moving air that meanders around the poles at an elevation of about 10,000 meters. In the northern hemisphere, the jet stream essentially marks the boundary between the cold polar air to its north and the warm tropical air to its south. The jet stream is at the top of a zone of strong wind speeds that extends all the way to the ground; this is referred to as the *circumpolar vortex*. At the surface, this vortex is related to the position of the cold and warm fronts and cyclones that are responsible for most of the precipitation in the middle and high latitudes.

On any given day, the jet stream is located in the region of the strongest temperature change on a line from the equator to the North Pole (figure 1). Over the course of the year, tropical temperatures are relatively steady while temperatures in high latitudes vary greatly because of differences in the position of the sun and the length of the day. The jet stream is strongest in winter, therefore, because the colder polar climates generate a large equator-to-pole temperature gradient. Furthermore, in winter, the extensive polar air mass covers more of the hemisphere, causing the jet stream to shift farther south. And, because the jet stream is responsible for the formation of cyclones, winter has more and stronger cyclones that tend to track through the southern parts of the mid-latitudes (the mean latitude of cyclone formation over North America is about 38°N in winter and about 47°N in summer). By contrast, in summer the polar regions warm substantially so the summer jet stream is weaker, positioned farther north, and generates fewer surface cyclones. The circumpolar vortex (and the jet stream) strengthens and expands southward in winter and weakens and contracts poleward in summer.

Since circulation drives surface weather, an understanding of atmospheric circulation and how it varies provides an useful indicator of regional, hemispheric or global weather and climate

Figure 1 The circumpolar vortex is located in the region of maximum temperature change between the equator and the pole. In response to seasonal changes in solar radiation, the vortex is most expanded and strongest in winter and weaker and more contracted in summer.



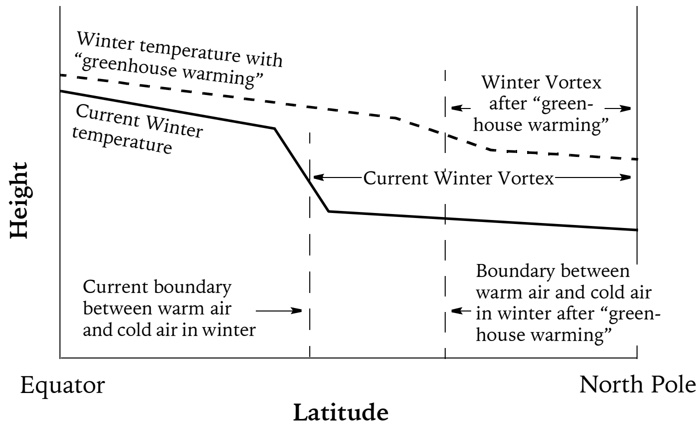
conditions. Circulation theory is one of the primary components of general circulatory models (GCMs), mathematical models used to project future climates based on conditions changing over time (e.g., the introduction of more greenhouse gases—carbon dioxide, methane, and other trace gases—into the air). The future projections from these models were primarily responsible for the 1992 Rio Climate Treaty.

While individual GCMs have different characteristics and produce widely varying results, they agree in predicting that most of the warming will occur in the high latitudes in the winter. If these projections are correct, the circumpolar vortex should take on a configuration more like the present summer-time configuration. Thus, we should expect the winter vortex to be weaker and more contracted (figure 2). This weaker winter jet stream should generate fewer and less intense surface low-pressure systems (Beersma *et al.* 1997; Zhang and Wang 1997).

Vortex trends

Several studies have examined the annual variation in the position of the circumpolar vortex (Davis and Benkovic 1992; Burnett 1993). In these studies, a specific contour is selected for each month to be representative of the core of strongest winds

Figure 2 General Circulation Models predict more warming over the poles than over the tropics. This should decrease the pole-to-equator temperature gradient and cause the circumpolar vortex to contract, resulting in a more summer-like circulation pattern year-round.

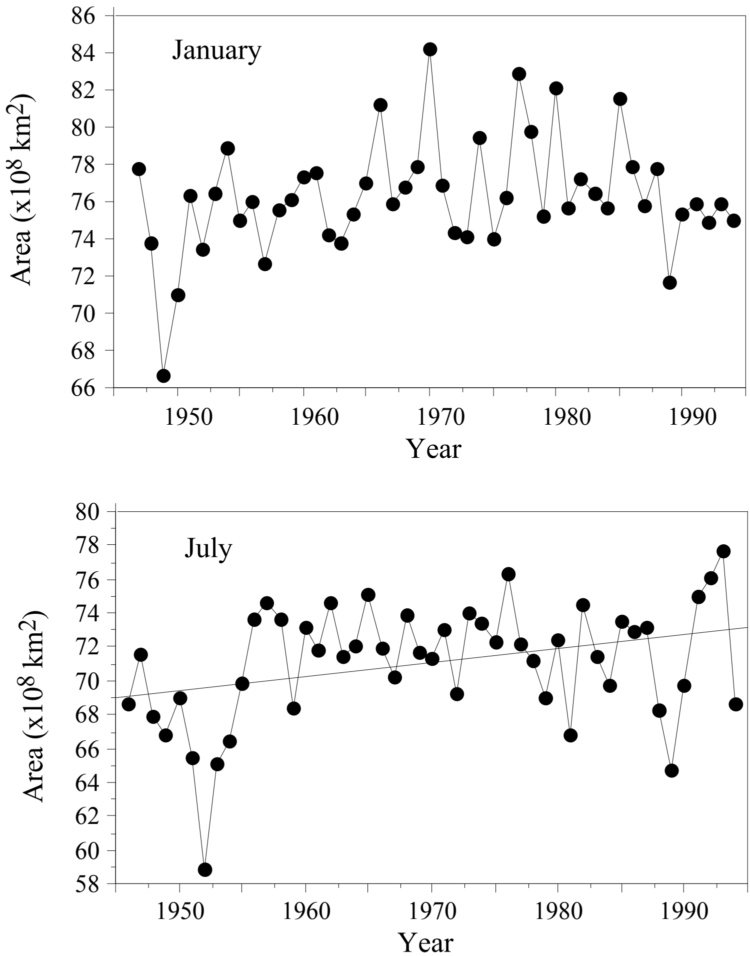


at the centre of the circumpolar vortex (Davis *et al.* 1997). By keeping track of the latitude of this key contour, information is obtained on the size and shape of the circumpolar vortex over time and space. The latest results indicate that there is no contraction evident in the vortex (figure 3). In fact, the circumpolar vortex shows statistically significant *expansion* in July from 1947 to 1994 and no trend in January.

Recall that the vortex should contract under our global warming scenario. In fact, no statistically significant contraction is found in any month. These results suggest (1) that the GCMs are wrong or (2) that the planet simply is not warming as much as, or in the way that, some climatologists expect it to.

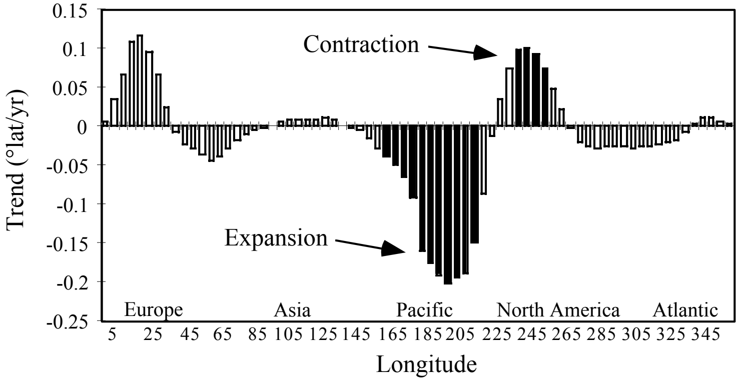
A closer examination of the January vortex trends shows that, while expansion is occurring in many locations, the most prominent expansion is occurring over the central and eastern Pacific Ocean (figure 4). There is, however, a significant vortex contraction over western North America, which could bring more warm, moist oceanic air into Alaska and northwestern Canada in winter. So, in short, while some regions are contracting as predicted by climate-change projections, overall expansion is the dominant trend for the vortex. Figure 4 illustrates the danger of extrapolat-

Figure 3 Average area of the circumpolar vortex in January and July. A statistically significant vortex expansion is evident in July, while there is no trend in January, when the vortex should be contracting. This is in contradiction to global warming projections.



ing local or regional climate changes like those occurring over northwestern North America to the global climate.

Figure 4 When the January vortex record is broken down by region, areas of statistically significant expansion and contraction (solid bars) are evident. This type of pattern should produce more warm winter air masses in Alaska.

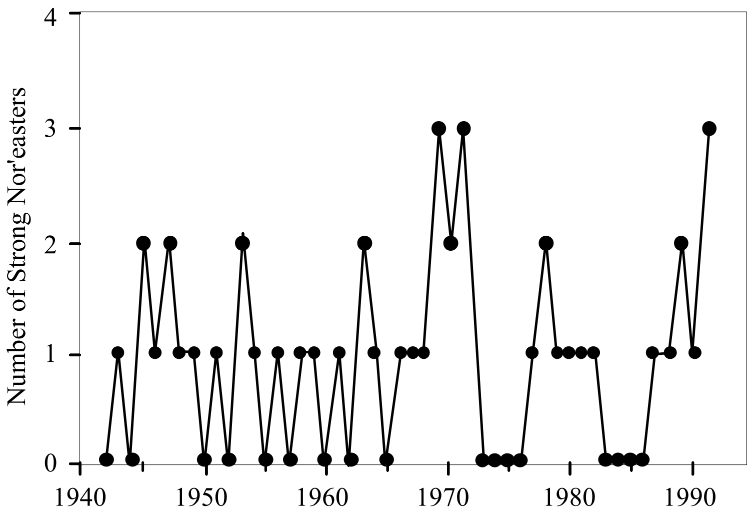


Extreme events

The study of atmospheric circulation can also be used to examine links between global warming and extreme events. Over the past several years, global warming has been blamed for nearly every manner of weather anomaly, including flooding, drought, heat waves, and even, most illogically, for events such as stronger blizzards and cold air outbreaks. In the remainder of this chapter, I shall scrutinize examples of these extreme climatic events and their connection (or lack thereof) to global warming.

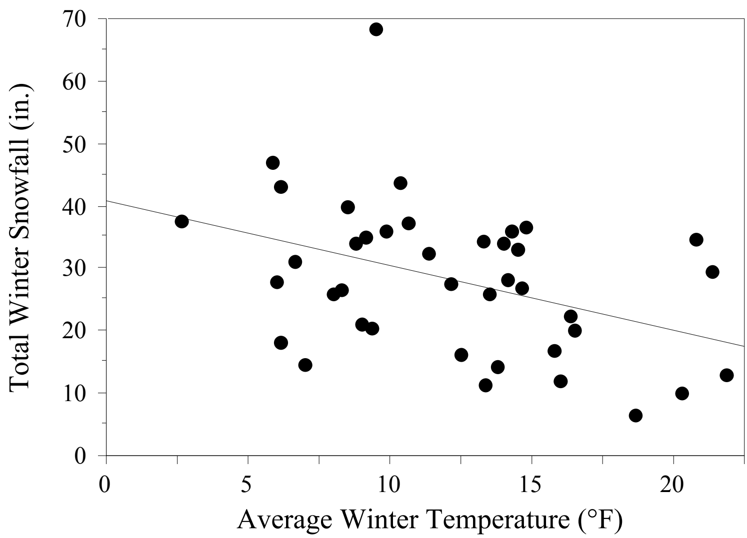
The winter of 1995/96 was noteworthy for the number of heavy snowstorms in the eastern United States. Many locations in the mid-Atlantic region from New York to North Carolina (e.g. Maryland) set all-time seasonal snowfall records. Prominent climate-modeller James Hansen implied that more intense blizzards should be expected as global warming sets in, since our future atmosphere should be moister (*Newsweek*, Jan. 22, 1996). Hansen also insisted that some places will be drier, and in the Intergovernmental Panel on Climate Change 1995 Report (h 1996), the Panel not only agreed with Hansen on both points but also added that in some places precipitation will stay about the same.

Figure 5 Annual frequencies of strong nor'easters along the mid-Atlantic coast. There has been a tendency to more strong coastal storms since the late 1960s.



The theory behind heavier snowstorms is that a moister atmosphere will precipitate more. Yet this logic lacks a circulation-based understanding of snowstorms on the American east coast. In addition to sufficient moisture, eastern blizzards require a deep layer of below-freezing air over the region and a coastal cyclone tracking northward. There is conflicting evidence about temperature trends in the polar regions where these Arctic air masses originate. While some researchers claim there is no consistent warming trend (Przybylak 1997), others have found global warming hidden in the coldest air masses, which are either becoming warmer or less common (Kalkstein *et al.* 1990). In any case, there is no logical reason to expect these polar air masses to become colder from global warming. Coastal cyclones, the second major precondition for an east-coast blizzard, form or intensify along the region of strong temperature change between the cold air mass over land and the warmer air residing over the ocean. If the cold air masses are warming, these coastal storms should become *less* common. Interestingly, they have not (figure 5). Nevertheless, this trend toward stronger winter coastal storms has been linked

Figure 6 The relationship between average winter snowfall and temperature in Grand Forks, North Dakota is negative, indicating that warm winters there have less snow than cold winters.



by implication to global warming, even though logic dictates they should be getting weaker (IPCC 1995). Of the three ingredients needed for East Coast blizzards, the lack of sufficient moisture from the Atlantic is rarely a limiting factor.

The flooding of the Red River in Canada and North Dakota provided top story in 1997 about an extreme event warning us of the dangers of global warming. The devastation caused by the flood—occurring in timely fashion on Earth Day—was used by the Clinton Administration to promote their environmental agenda. Yet, the intuitive logic linking extreme floods to global warming is scientifically unsound. Most of the flooding was caused by spring snow melt, which was exceptionally problematic this year because of record winter snowfall in the area. The relationship between mean winter temperature and average snowfall is negative—in other words, in North Dakota, warm winters have less snow than cold winters (figure 6). So why did they get all that snow in the first place, if winters are supposed to be warming so much?

Perhaps the most common perception of our future world under the shroud of global warming is that of widespread drought and famine. Yet, there is a voluminous literature indicating that the increased concentrations of carbon dioxide in the atmosphere will enhance plant growth (*e.g.*, Idso and Idso 1994; Wittwer 1995). The honest answer to the question of future precipitation is that no one really has any idea in what direction—let alone of what magnitude—the change in global precipitation will be. Over the United States, where a relatively dense network of raingauges is maintained, there has been no trend in the frequency of severe or extreme drought but rather an increase in wet conditions (figure 7). If warming brought about by human activity is indeed a component of this signal, then more atmospheric moisture added to warmer winters and enhanced plant growth, hardly sounds like the recipe for apocalypse.

Conclusion

Many people anxious for political solutions to their personal environmental agendas have used purported signals of global warming as calls for immediate action. This is often successful since the impulse of the non-scientific person is to blame just about any anomalous weather event on mankind's industrial productivity. Yet, most of these projections fail under the scrutiny of scientific evidence. And, if sound science is not the fundamental basis for policy decisions on global-climate change, then these decisions have no sound basis.

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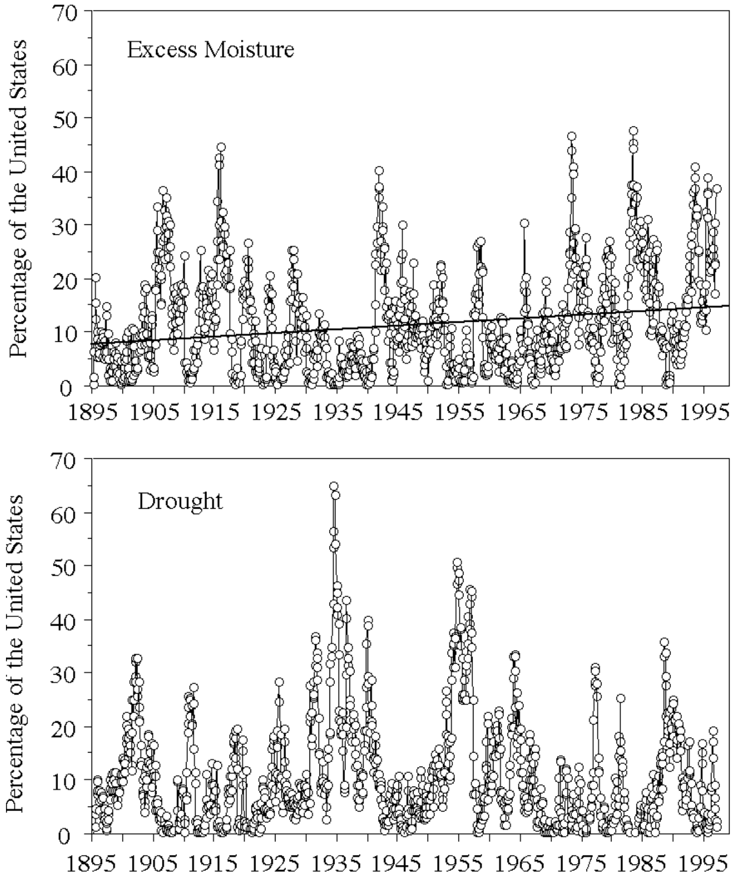
Figure 7 Percentage of United States experiencing severe or extreme wet conditions (top) and severe or extreme drought conditions (bottom). While there is an upward trend in wetness there is no change in drought frequency since 1895.



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