Torrents, Droughts, and Twisters – Oh My!

Student Background

Not all kinds of extreme weather have the same relationship with our atmosphere's increasing burden of greenhouse gases. Below is a summary of what scientists already know and what they're working to nail down, including some conclusions from recent reports by the Intergovernmental Panel on Climate Change.

Carbon Dioxide: Observations collected atop Hawaii's Mauna Loa since the late 1950s, and at many other locations around the world, confirm that the amount of carbon dioxide in Earth's atmosphere is increasing every year. Now about 390 parts per million (ppm), the concentration has risen by more than 30% since preindustrial times and continues to grow by around 1 to 3 ppm per year. Each year's increase is influenced by economic activity (less CO2 is added when a recession is underway) as well as by natural and human-induced factors, including processes such as El Niño and La Niña, that affect the total amount of vegetation consuming CO2 through growth or releasing it through fire in a given year. Other greenhouse gases, such as methane (CH4) and nitrous oxide (N2O) are also increasing.

Tornadoes: A unique blend of large-scale weather conditions is required to support the long-lived supercell thunderstorms that produce the most dangerous tornadoes. Although the number of observed U.S. tornadoes has more than doubled since the 1950s, as more spotters and chasers watch the skies, there has been no significant trend in the strongest twisters (EF3 or greater).
Recent work suggests that the instability fueling supercells may increase across much of the eastern U.S. this century, but the wind shear that supports tornadic storms may not. The upshot could be more severe weather (high wind gusts, heavy rain) without any increase in tornadoes. To see how these and other ingredients will come together, scientists are now embedding small-scale weather models that simulate thunderstorms in large-scale climate models that depict global warming.

Hurricanes: Over the last decade, researchers have vigorously debated the effect of increased greenhouse gases on recent and future trends in tropical cyclones, including North Atlantic hurricanes. Hurricanes draw energy from warm water, and sea surface temperatures (SSTs) have risen across many hurricane-prone areas in recent decades, with greenhouse gases likely a factor. Also, the number and power of the strongest Atlantic hurricanes has grown since the 1970s in line with SSTs. But hurricane records are limited for the period before satellites and hurricane-hunter flights, complicating the research.
Moreover, future changes in wind shear may partially counteract the nourishing effect of warming oceans on hurricanes in some areas, including the North Atlantic.
According to a 2010 paper by an all-star group of hurricane researchers, scientific knowledge of the physics of hurricanes and com-puter modeling studies agree that Earth as a whole will shift during this century toward fewer but stronger tropical cyclones. Their impact on society will depend largely on which hurricanes strike land (a function of short-term weather) and how much population and construction occurs in coastal areas.

Global Temperature: The carbon dioxide emitted by fossil fuels mixes throughout Earth's atmosphere, and its effect is most noticeable on temperatures averaged worldwide. A wide range of studies since the 1990s have confirmed that the bulk of global warming over the last few decades, as well as its regional characteristics, or "fingerprint"—such as greater warming observed at higher latitudes—can be attributed to human-produced greenhouse gases.

Drought: Warmer temperatures not only allow more evaporation from bodies of water (see "Intense rain or snow"), they also help draw moisture from already-dry soils. All else being equal, this would help strengthen the effects of drought on areas that are parched. In line with this concept, the global spread of drought has increased with global temperatures in the second half of the 20th Century.
As with precipitation, there are large regional variations in this picture. It can be difficult to untangle the combined effects of heat and drought and determine how much climate change might have played a role in each one. Large-scale ocean patterns, such as El Niño/La Niña and the Pacific Decadal Oscillation, play a major role in shaping drought, and it's not yet clear how climate change will affect these.

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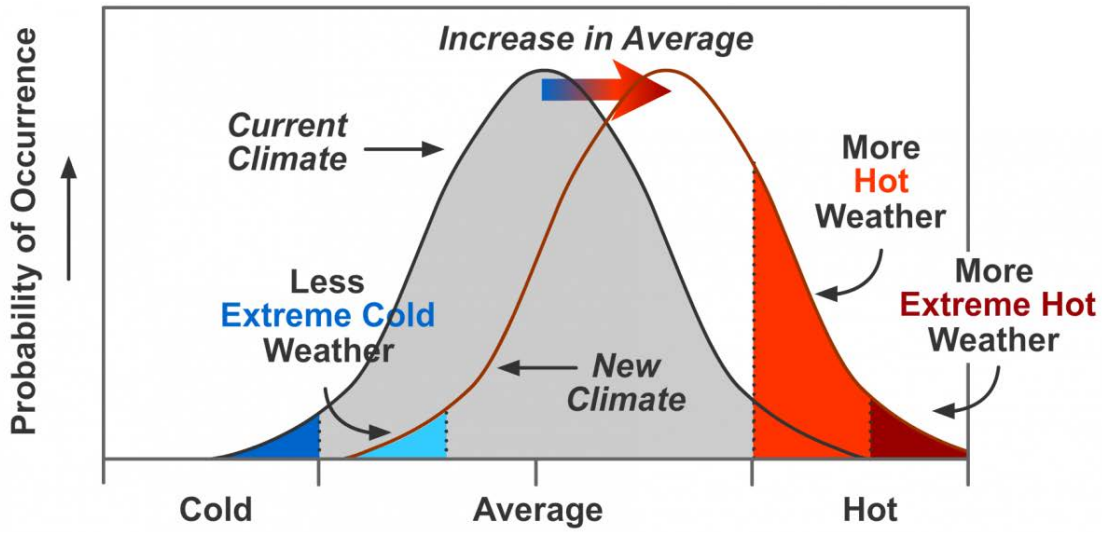
Extreme heat: Even a small rise in average temperature can substantially boost the odds of extreme heat—and reduce the odds of extreme cold—by pushing the ends of the temperature spectrum beyond certain thresholds, as shown in the graphic on page 3.

When scientists attempt to link a particular heat wave to human factors, the results have been mixed, partly due to the regions examined and how the question is posed. One major study found it is very likely that human influence at least doubled the odds of an event like the catastrophic 2003 heat wave in Europe. Another group found that recent trends did not explain the 2010 heat wave in western Russia, though they added that such events should become more likely later this century as greenhouse gases accumulate.

Intense rain and snow: Warmer temperatures allow for more evaporation from oceans and lakes. The added moisture in the air could help intensify rain and snow where it's falling. Since the 1970s, many regions—including the United States—have seen more precipitation clustered into the heaviest rain and snow events.

Analysts have noted that this global picture is consistent with what one would expect from climate change. However, not all regions follow these trends, and regional-scale attribution is challenging because precipitation is difficult to measure (for reasons given in the IPCC excerpt below) and it can vary greatly over small distances. Moreover, the impact of heavier rain and snow on flooding depends in part on how cities and waterways are structured. A recent study found that England's flooding of 2000 was made at least 20% more likely by human influence.

Extreme weather is typically rare. But climate change is increasing the odds of more extreme weather events taking place as the graph below shows in a warming world.



Source: Environmental Protection Agency (EPA)

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