BULLETIN

Arctic Matters: How a Warming Arctic May Bring More Extreme Weather

SPRING 2019 / BY JENNIFER H. SHAKUN

In this bulletin, we delve into an active area of climate research that is investigating how warming may affect atmospheric circulation and lead to more extreme weather. In recent years, major flooding events, heat waves, and droughts, have prompted researchers to examine the conditions that produced those extreme events and ask whether climate change might be playing a role. Meanwhile, a number of Climate Smart Land Network (CSLN) members have noted that extreme and/or persistent weather is creating challenges for forestry operations (e.g. extended wet periods that require equipment to be pulled out of the woods). Here we examine whether those weather patterns are symptomatic of an emerging trend and what to expect in the future.

The Dynamics of Extreme Weather

In a previous bulletin we described how climate change will alter the frequency and intensity of some weather and climate extremes, like record heat, heavy rains, and drought (see *Climate Change and Extreme Weather Part I: Trends & Projections*). Those categories of extremes are related to the physics (i.e. thermodynamics) of climate change—rising average temperatures lead to more record-breaking heat, a warmer atmosphere holds more water vapor leading to heavier rains, and so on. It is relatively straightforward to measure these types of extremes and there is a high degree of confidence regarding how they will change in the future.

But warming can also affect the mechanics (i.e. dynamics) of the climate, including aspects of atmospheric circulation like wind and pressure systems. Dynamics are the key to understanding and predicting weather at the regional level, including future changes in extremes in the mid-latitude regions where most CSLN members own and manage land. These are the kinds of changes that can lead to counterintuitive impacts like warming winters that include deep cold snaps driven by southern incursions of Arctic air (which we discuss below). Changes in atmospheric circulation are more difficult to consistently and accurately measure or model than the thermodynamically-driven changes mentioned earlier (Palmer 2013; Shepherd 2014). Nonetheless, this is an emerging area of research worth watching because, as one researcher put it: “Though the uncertainties are large, changes in atmosphere dynamics have the potential to cause rapid transitions at a regional scale leading to surprises for society” (Coumou et al. 2018).

It’s all about Persistence

The persistence of a weather system can quickly elevate a moderate event to something more extreme. A day of rain is no problem, but multiple days of rainfall become an issue when saturated soils lead to flooding. Likewise, hitting a new record high temperature may just be an interesting statistic, while a long heat wave can have real costs for energy use and human health.

Persistent extremes can happen when weather systems move more slowly or when there is atmospheric blocking that causes a system to stall in a particular location. A persistent low pressure system leads to rain and flooding (such as the record rain with Hurricane Harvey), whereas a persistent high pressure system leads to heat, drought, and wildfire (such as the conditions in California in summer 2018) (Mann 2018). One of the big questions in atmospheric research right now is whether climate change is leading to more persistent weather patterns.

The Arctic Connection

In recent years, there has been a lot of conversation in the media and elsewhere about the idea that change in the Arctic—an area that is warming twice as fast as the rest of the world (Osborne et al. 2018)—is leading to unusual weather in mid-latitude regions like the U.S. This includes the so-called “polar vortex” events, when Arctic air drifts south and causes a deep freeze over parts of the northern U.S. In fact, the polar vortex is nothing new (see side bar), but there has been a vigorous debate among scientists about whether the kind of jet stream activity that leads to these incursions of Arctic air is becoming more likely because of warming-induced changes in the atmosphere.

The jet streams are fast-moving “rivers” of air flowing around the planet that are driven by the temperature difference between the equator and the poles on a spinning globe. They are also the major factor driving our weather at the surface, which is one reason why there has been an explosion of science on this topic over just the last five years or so. Mathematical theory, observations of the atmosphere, and computer models are all being used to understand how accelerated warming in the Arctic might be influencing the path of the jet stream and our mid-latitude weather, including extreme weather in summer (Coumou et al. 2018; Mann 2018) and winter (Screen 2014; Rasmijn et al. 2016; Cohen et al. 2018a; Kretschmer et al. 2018; van Oldenborgh et al. 2018). There are complicated debates going on within the scientific community, but they can be broken down into essentially three questions about the influence of a warming Arctic:

POLAR VORTEX

Colloquially, the term polar vortex has come to mean extreme cold from the influx of Arctic air over the continental U.S. (Lyons et al. 2018). In fact, the term has been around since the mid-1800’s and it is described in scientific papers beginning in the late 1940’s (Waugh 2019). Technically, it’s short for the circumpolar vortex, which is a rotating area of cold air and low pressure, high in the atmosphere above the poles. When it expands in winter it can occasionally send Arctic air south into the U.S., which has happened several times over the last few decades (NWS; Waugh et al. 2017). But winter will still be warmer *on average* going forward, even if we experience more cold snaps from polar vortex events. Changes in the polar vortex are a good example of how warming could actually increase climate variability in certain regions (as we discussed in a previous bulletin).

- ***Can it*** influence the jet stream?
- ***Has it*** done so already?
- ***Will it*** have an effect in the future?
  (Barnes & Screen 2015)

Evidence suggests changes in the Arctic certainly ***can*** have an influence on the jet stream and much of the debate is centered on the question of exactly ***how***. A variety of pathways have been proposed, including a smaller temperature difference between the equator and the poles, a jet stream with a wavier route or larger (i.e. higher amplitude) waves, changes in the location or strength of storm tracks, or weakening of the polar vortex that makes incursions of Arctic air happen more often (Barnes & Screen 2015; Taylor et al. 2017; Cohen et al. 2018b).

Many of these pathways lead to more extreme weather, especially more persistent weather systems that bring prolonged wet or dry periods. For example, the reduced temperature difference between the equator and the poles may slow the westerly wind speed of the jet stream, causing it to become highly wavy and move more slowly from west to east, which would lead to more persistent weather patterns and deeper troughs of cold air from the Arctic (Francis & Vavrus 2012; Francis & Overland 2014; Francis et al. 2017). Other research has suggested that we may increasingly be seeing conditions that cause atmospheric waves to resonate and become amplified (much like resonance increases the intensity or loudness of a sound from a musical instrument), which is also associated with more persistent and extreme weather (Petoukhov et al. 2013a; Palmer 2013; Mann et al. 2017).

There is disagreement about whether there ***has*** already been a discernable effect on the jet stream (at least in a statistical sense). This is because there are different methods being used to detect change, there is a lot of natural variability in the jet stream, and we only have the necessary observational data for the last few decades, which is too short a time period to confidently determine to what degree observed changes are related to human-induced climate change (if at all) (Barnes 2013; Barnes & Screen 2015; Screen & Simmonds 2013; Petoukhov et al. 2013b; Screen et al. 2018).

As for whether the warming Arctic will be a significant factor affecting mid-latitude weather going forward, the scientific consensus seems to lean toward the idea that ***it probably will***, but the jury is still out (Barnes & Screen 2015; Taylor et al. 2017). There are a variety of factors in play and it is unclear whether other forces will outweigh or counteract the influence of the Arctic. Although, some research has suggested that these trends are only just beginning to emerge (Francis & Overland 2014; Mann et al. 2017), so it is likely that the science will continue to rapidly evolve on this issue.

Consequences for Working Forests

Over the last several years, a number of CSLN members have reported issues related to stagnant weather patterns that bring prolonged periods of rain or drought.

FORESTRY OPERATIONS

Persistently wet weather, in particular, has put a significant (and in some cases unprecedented) burden on the transportation and logging sectors in some regions. It is also affecting the number of good operating days and leading managers to plan for less predictability by developing alternative harvest plans and schedules. The ability to take a more nimble approach and "make hay while the sun shines" has become a real advantage in some circumstances. Examples include:

- Taking advantage of drought conditions to conduct summer harvests in areas that were historically winter-only (with the added benefit of evening out harvests throughout the year)
- Developing backup harvest plans
- Increasing logging capacity to cut more wood during a shorter season
- Changing the size of logging jobs to make them easier to complete in a shorter period or easier to harvest piece-meal over multiple years
- Moving logging crews around to drier sites during wet summers

Some of these adaptation approaches have major implications for logging contractors in terms of equipment and personnel. In regions where extreme, persistent weather patterns have been reducing the number of operable days per season, this has become a real challenge for the traditional business model of the logging community. Beyond harvest operations, CSLN members describe a similar notion of preparedness and being "ready to go when conditions are good" in relation to forest fire fighting efforts, especially with longer dry spells and warmer temperatures creating conditions ripe for fire.

FOREST IMPACTS

In a previous bulletin (*Climate Change and Extreme Weather Part II: Forest Impacts*), we described how "extremes play an equal or greater role [than average conditions] in shaping the distribution, survival, productivity, and diversity of plant communities." Much of the predicted forest change will be driven by extreme events, especially when those extremes exacerbate other types of forest stress. CSLN members have already reported instances where persistent extreme weather is compounding other stressors. Examples include heavy rains that saturate soils leading to increased wind throw and forest stands with unexpected signs of decline due to the combination of drought and forest tent caterpillar.

Conclusion

Ultimately, the impact of a warming climate is not as simple as rising temperatures. In a fluid dynamical system like our planet, global change is complicated and will lead to some counterintuitive impacts and surprises. This includes changes in weather patterns that will affect forest health and harvest operations. There is a growing body of scientific research aimed at understanding and predicting regional weather extremes, but the inherent challenge of modeling such complex and (relatively) small-scale phenomena means that there is a lot of uncertainty. It has been suggested that the research community should move toward "a more explicitly probabilistic, risk-based approach" (Shepherd 2014), which would be helpful for decision-makers who are trying to grapple with this uncertainty. We will continue to watch for updates in this regard. In the interim, it will be important to have a robust forest monitoring system in place to track local change, given that these changes will manifest differently from one region to the next.

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