Ecologically-Relevant Changes in Temperature Variability

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The majority of the conversation about global or regional temperature involves discussion about how the average annual or monthly temperature has changed over time. However, for many organisms it is actually the range of temperatures they experience throughout the day (the diurnal temperature cycle or DTC) and throughout the year (the annual temperature cycle or ATC) that is most important in terms of biological processes, phenology, and other ecological interactions. Think, for example, about any forest pest that is a concern in your region - chances are its population is significantly affected by the magnitude of temperature ranges from summer to winter and from night to day. In this bulletin, we will explore this topic further and highlight a recent analysis that sheds new light on global temperature trends during the period 1975-2013.

Temperature Variation

Before we delve into the recent research, let's take a moment to discuss how daily and annual temperature ranges have historically varied across the globe.

Annual

The range of temperatures experienced over a given year, or the annual temperature cycle (ATC), is generally larger in higher latitudes because winters are so much colder in those areas, compared to the tropics. Therefore, ATC increases as you move from the equator to the poles (Figure 1).

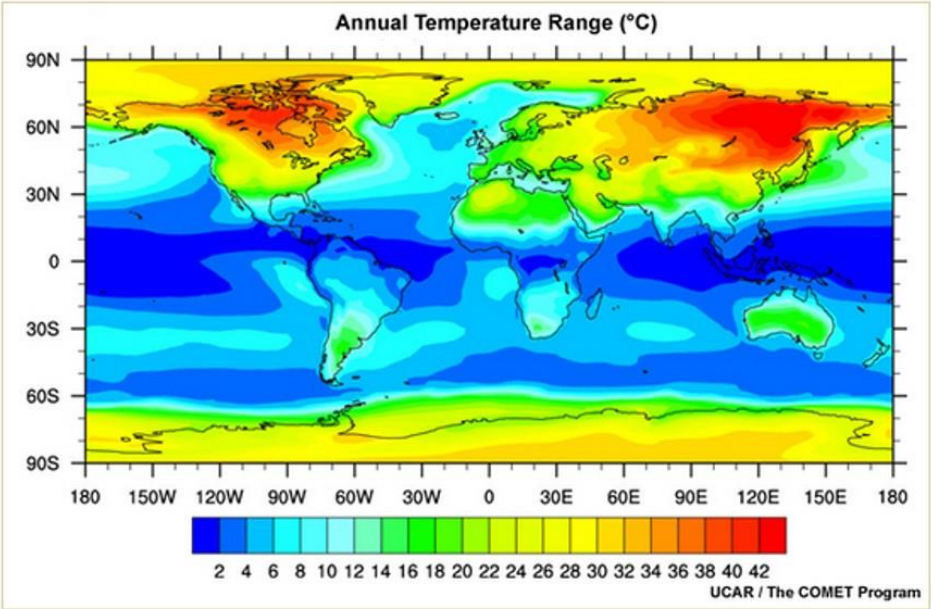

Figure 1: Annual range of monthly surface temperature (°C); data from the Japanese Reanalysis Project (JRA25), 1979-2004.
Source: http://www.goes-r.gov/users/comet/tropical/textbook_2nd_edition/navmenu.php_tab_2_page_6.0.0.htm

Daily

In contrast, the daily temperature cycle (DTC) is typically much larger in tropical regions than in higher latitudes because there is more intense solar heating during the day in the tropics. This means that DTC generally decreases as you move from the equator toward the poles (as you can see in this map—Bonebrake & Deustch 2012, Figure D1). The combination of DTC and ATC gives each latitude a unique temperature cycle profile (Figure 2).

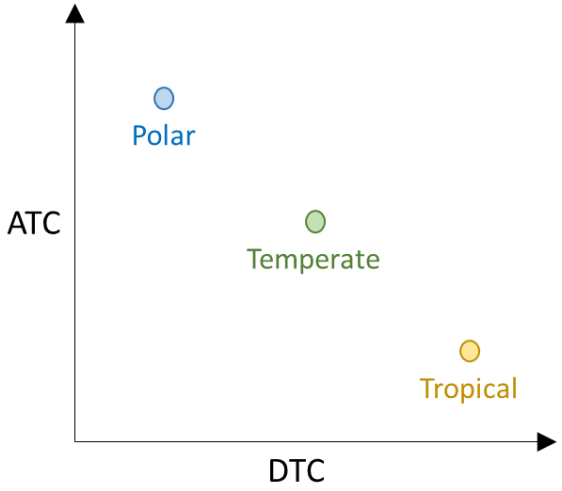

Figure 2: Typical distribution of temperature cycle profiles at different latitudes.

Study Overview

So what did the researchers find out about how these temperature profiles have changes in recent decades?

In a study published in the journal *Nature Climate Change* (Wang & Dillon 2014), researchers estimated the diurnal (i.e., daily) and annual temperature cycles (DTC and ATC) from 1975 to 2013 by analyzing 1.4 billion hourly temperature measurements from over 7,900 weather stations around the globe.

These were the key findings:

1. There has been a global increase in DTC since 1975, and this effect was stronger at higher latitudes.

   Note: See Wang & Dillon 2014, Figure 2:
   - *Figure 2 (b)—showing the change in DTC for polar (grey), temperate (blue), and tropical (red) regions*
   - *Figure 2 (f) showing a map of the difference in DTC from 1975-1980 and 2010-2013*

2. There has been a change in the magnitude of the ATC since 1975, but the direction and magnitude of the change varied by latitude:
   - decreased ATC in polar regions
   - increased ATC in temperate regions
   - no change in tropical areas

   This effect was also stronger at higher latitudes.

3. Altogether, these changes indicate that the temperature cycles of high latitude climates are becoming more like the tropics (a phenomenon the researchers call a 'flattening' of the global temperature profile) (Figure 3).

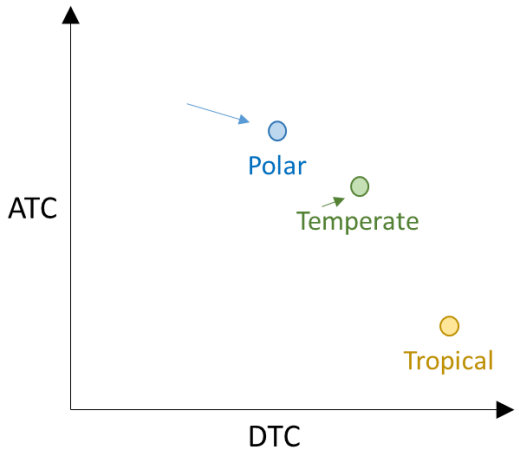

Figure 3: Polar and temperate latitudes shift toward temperature cycle profiles that are more similar to tropical areas.

What's New?

The observation that there has been an increase in the magnitude of the daily temperature cycle, is particularly interesting because it differs from previous research. The last global analysis of daily temperature range was done almost ten years ago and most of the subsequent regional studies have suggested that the daily temperature range has either decreased or remained mostly unchanged (IPCC 2013).

However, this study is data-rich, global in scope, and it employs a new statistical approach. Many of the techniques commonly used for this type of analysis require regularly sampled data, which forces researchers to average their temperature records over a particular time window, such as a monthly average. That may be fine for certain types of research questions, but it can also 'smooth over' changes that may be happening on the timescales that are most relevant to organisms. The type of analysis used here does not require that kind of data selection or aggregation, so they were able to capture more of the biologically-relevant temperature changes.

The Implications

The observed changes in the range of daily and annual temperatures will have important consequences for many species. In particular, short-lived organisms, such as the mountain pine beetle, have already benefited from increased winter temperatures that have allowed

their populations to increase. Organisms adapted to a larger range of temperatures may fare better under conditions where the DTC is increasing, as opposed to more specialized organisms that can only survive or reproduce within a narrow temperature range. Also, in places where the daily and annual temperature ranges are becoming more similar (as they are in the tropics), we may see seasonal organisms that can now persist throughout the year. The most immediate concern for forest managers will be the effect of these changes on the life cycle and population dynamics of various pests and diseases.

Putting Things in Context

The researchers in this study primarily focused on *what* has happened with regard to temperature cycles, rather than *why* those changes may have happened. Other studies suggest that changes in the level of solar radiation reaching earth's surface (resulting from factors such as pollution in the atmosphere and cloud patterns) are a big piece of the DTC puzzle. In fact, clouds have a particularly large influence on daytime temperatures, but cloud patterns are difficult to model, which is why they are an important area of uncertainty that explains why most models do not agree on future projections of DTC (Lobell et al. 2007). At the same time, cloud cover is an example of an atmospheric feedback that is influenced by the backdrop of a warming planet. These kinds of complex interactions illustrate why it is challenging to determine the role global warming will play in influencing existing climate dynamics.

Climate is a broad and dynamic subject, with new research and refinements to our understanding emerging every week. The potential for change in temperature variability is one of questions that will be particularly important because of its ecological implications. This studies raises a number of important questions on this subject and we will be sure to keep you informed as the science evolves.

Sources

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