A Dynamical Perspective on Temperature Variability, Extremes and Their Response to Climate Change

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Earth's atmospheric temperature distribution is often described by its mean, which is directly related to the climate state, and by its variance, which is influenced by shorter time-scale changes such as passing weather systems. Higher order terms describing the temperature variability, such as skewness, are often ignored or neglected. The skewness is a measure of the asymmetry between the positive and negative tails of the distribution, and is therefore closely related to extreme events like heat wave or cold spells. The spatial distribution of skewness has important consequences for weather and climate. For example, it was recently shown that warm (cold) temperature anomalies occur more on the poleward (equatorward) flank of the jet stream, and that this may be a result of horizontal advection by cyclone and anticyclone pairs[1]. Here we take a dynamical approach to further study what controls the spatial structure of the temperature distribution. We isolate warm and cold temperature anomalies in reanalysis data and employ a tracking algorithm to learn about their formation, intensity, frequency, motion, and growth. We perform composites of cold and warm extremes and investigate the thermodynamic budget following these anomalies, to study the processes that control their evolution. Finally, we perform a similar analysis to comprehensive climate change simulations from the IPCC RCP8.5 scenario, to study the expected changes in a warmer climate. While numerous papers have investigated the changes in atmospheric temperature variability as a result of climate change, due to the expected increase in the global mean temperatures and the inevitable increase in the frequency of extreme warm temperatures, not many papers examined the changes in skewness relative to the new climates. For example, we find that over central Europe, while temperature variance is expected to increase in summer, it is actually the cold anomalies that contribute to the increase in variability. On the contrary, in winter, it is the warm anomalies that intensify relative to the mew climate. In the SH, a clear poleward shift of both temperature variance and skewness is found. These changes in skewness and variance might have tremendous influence on agriculture, animals as well as humans, as they adapt to new mean climate state but also experience new relative changes.

Key words: temperature variability, extreme events, climate change, atmospheric dynamics

References

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