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Editorial

Editorial "The Impacts of Climate Change on Atmospheric Circulations"

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Understanding the atmospheric general circulation is, in a way, analogous to cleaning a large home. Just when you think you are about done cleaning one room, you carry a stray object from another room back to where it goes, only to find a collection of items belonging to the first room. In the end, cleaning one room becomes impossible without at least partially cleaning one or more other rooms in the home. In my own work dealing with the width of the tropics, it is not enough to understand the basic theory of the tropical tropospheric Hadley circulation; it is necessary also to understand midlatitude dynamics—particularly the production, propagation, and dissipation of Rossby waves. Of course, neither of these phenomena can be completely understood without a good grasp of the behavior of the tropical and extratropical tropopause, which in turn requires a basic understanding of stratospheric dynamics and thermodynamics.

Many of the open problems in atmospheric dynamics thus lie at the intersection of the individual flow scales and regimes. This Special Issue of *Atmosphere* invited contributions that captured our current understanding of these connections, or pushed the envelope of our understanding of such interplay between dynamical components. Unsurprisingly, then, the submissions themselves draw a circuit through the atmosphere, from the tropical stratosphere, through the Arctic, to the midlatitude troposphere.

Fu et al. [1] examine two influential modes of stratospheric variability—the quasi-biennial oscillation (QBO) and sudden stratospheric warmings (SSWs) in the Last Glacial Maximum (LGM)—using the well-suited Whole Atmosphere Community Climate Model version 6 (WACCM6). Both the QBO and SSWs have the potential to influence the troposphere, and both are driven by waves emanating from the troposphere. Furthermore, while gravity wave drag must be parameterized, in simulations of the LGM it decreased along with the resolved wave forcing, lengthening the QBO period relative to its present-day timescale. Meanwhile, SSWs in the LGM simulations appeared to be more concentrated near the end of the active winter season, though the final warming date did not appear to change.

These SSWs were more closely examined by Overland et al. [2], who used the National Center for Environmental Prediction/National Center for Atmospheric Research reanalysis to examine the split and displacement of the stratospheric polar vortex (SPV) following an SSW during winter 2018. The resulting European cold winter event was dubbed the "Beast from the East." That said, it did not result simply from cold air advection from the northeast. Instead, the event was the result of an arctic-wide one-two punch of SPV displacements. First, a split over North America that propagated westward to Siberia, and second a weaker SPV event over Europe. Each of these events produced their own distinct pattern of tropospheric cold air advection.

The flipside of such cold air advection to the midlatitudes is warm-air advection to the Arctic. Mewes and Jacobi [3] examined patterns of temperature flux in RCP8.5 warming projections in CMIP5. Self-organizing maps reveal three main classes of meridional temperature flux: a Pacific mode, an Atlantic mode, and a continental mode. While the heat flux locations and their corresponding frequencies do not clearly change in projections of a warmer climate (at least not discernably, given differences between models), the amplitudes of the heat fluxes themselves may decrease. The authors ascribe the weakening to a greater meandering of the jet.

Not only is there evidence for changes in the sinuosity of the jet, but in where the meanders are occurring. Chien et al. [4] use a mixture of long- and short-term reanalyses, paleoclimate simulations, and forced warming experiments to argue that a warmer climate produces more North American winter dipole (NAWD) variability, and less Pacific-North American (PNA) variability. While examination of trends in century-long reanalyses is fraught with difficulty, by connecting the results of the reanalyses to those from paleoclimate and forced warming scenarios, the authors make a strong case for the shifting pattern of variability over North America. The changing variability in turn may be connected to an increasing frequency in extreme events—specifically, droughts in the American Southwest, and cold events in Eastern North America.

East Asia likewise is experiencing shifts in its surface temperature and hydroclimate. Li et al. [5] also relate this to changes in the jet, as indicated by a set of jet indices proposed in previous work, and then modified by the authors to suit the regional seasonal jet structure over East Asia. Such modifications to indices may be a way for more researchers to connect changes in the global jet with regional-scale impacts around the globe.

The combination of the paper shows our improved understanding on the atmospheric general circulation, yet more questions than answers seem to be in our understanding under the continued warming climate.

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