Sea-surface temperature patterns a key source of uncertainty in future atmospheric circulation changes

Abstract: While the global impacts of anthropogenic climate change are well established, there remains substantial uncertainty in climate projections at the regional scale, which are critical for long-term planning for climate adaptation. Uncertainty in regional climate change arises primarily from uncertain changes in the large-scale atmospheric circulation, which redistributes heat and moisture around the globe. In this talk, I will present the results of two projects that both emphasize the key role of sea-surface temperature (SST) patterns in the uncertainty in future atmospheric circulation changes.

First, I will present evidence that differences in Indo-Pacific SST patterns between global climate models (GCMs) are a leading cause of inter-model differences in atmospheric circulation throughout much of the globe. Complicating matters further, none of the GCMs are able to reproduce the observed pattern of Indo-Pacific SST trends over the period 1979-2020, in particular the lack of warming in the East Pacific and Southern Ocean and the enhanced warming in the West Pacific and Indian Ocean. Due to the large impact of tropical SSTs on the atmospheric circulation, these systematic model biases in SST trends potentially result in systematic model biases in regional climate trends throughout the globe.

Second, I will present evidence that the large-scale circulation response to midlatitude SST anomalies is greatly enhanced (compared to modern GCMs) if the model resolution is increased to resolve weather fronts. In particular, I will show that a regionally refined model with a resolution of 14 km over the North Atlantic has a factor of three larger response of the winter North Atlantic Oscillation (NAO) to Gulf Stream SST anomalies compared to a lower resolution model. These results suggest that the influence of midlatitude SST anomalies on the atmospheric circulation could be substantially larger than previously thought, with implications for both multi-year predictability and long-term trends.