Atmospheric Response to SST anomalies. Background-state dependence, teleconnections and local effects in winter and summer

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One potential source for seasonal predictability is via the influence of sea-surface temperatures on the atmospheric circulation. However, the atmospheric response to SST anomalies is notoriously difficult to simulate and may be sensitive to model details and biases, particularly in midlatitudes. Studies have suggested that the response is particularly sensitive to a model's background wind field and its variability. The dependence on such factors has meant that it is difficult to know what responses, if any, are robust, and whether the system itself is sensitive or whether models themselves are failing. Our goal in this work is to better understand the geographical and seasonal dependence of the atmospheric response to SST anomalies, with particular attention to the role of the background state.

We examine the response of an idealized atmospheric model to SST anomalies using two slightly different configurations of continents and topography. These configurations give rise to different background wind fields and variability within the same season, and therefore give a measure of how robust a response is to small changes in the background-state. We study the atmospheric response to small-scale SST anomalies in 31 different locations across the northern hemisphere, including regions suggested by previous studies as being useful for seasonal prediction, such as the tropical Pacific and the Caribbean.

In northern-hemisphere winter we find that many of the midlatitude SST anomalies considered do not produce responses that are common across our model configurations, confirming that this problem is very sensitive to the background state. Tropical-to-midlatitude teleconnections are similarly sensitive, despite local responses in the tropics being much more robust. In addition, midlatitude responses involving a significant amount of vertical advection of anomalous temperature produce larger-scale responses, consistent with recent studies of atmospheric responses near strong western-boundary currents.

Both model configurations are ‘high-top’, and use prescribed annually-averaged zonally-symmetric ozone. The latter leads to a somewhat unrealistic stratospheric circulation. To investigate the role played by the stratosphere, we also compare responses in a selection of winter cases with a more realistic ozone prescription.

In northern-hemisphere summer, we find that the responses to midlatitude SST anomalies are generally on a much smaller spatial scale than those in DJF. Responses in the tropics are much less dependent on season, although teleconnections between the tropical Pacific and the North Atlantic are not found in JJA as robustly as they are in DJF. Given insight from our model results, we do find some summer periods in reanalysis data where there is a strong association between the tropical Pacific and the summer North-Atlantic Oscillation. We discuss the reasons for these effects and the implications for Northern Hemisphere seasonal prediction in summer.

Key words: seasonal prediction, atmospheric responses, teleconnections, idealized models