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The European summer circulation response to tropical and extratropical North Atlantic sea surface temperatures

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Recent years have seen considerable advances in the understanding of drivers of climate at seasonal lead times in the extratropics and skilful seasonal forecasts are now possible. However, skill in seasonal forecasts in the Northern Hemisphere extratropics is mostly limited to winter. Drivers of summer circulation anomalies over the North Atlantic-European (NAE) sector are poorly understood. Here, we investigate the role of concurrent North Atlantic sea surface temperatures (SSTs) in driving summer atmospheric circulation changes in the NAE sector. We are interested in drivers of circulation variability at interannual time scales, since these are most relevant to seasonal prediction. Using observations and a reanalysis we show that the summer North Atlantic Oscillation (SNAO), the leading mode of observed summer mean sea level pressure variability in the NAE sector, is correlated with a distinct SST tripole pattern in the North Atlantic, with a predominantly cool (warm) North Atlantic associated with positive (negative) SNAO. An atmospheric general circulation model (AGCM) is used to test whether there are robust atmospheric circulation responses over the NAE sector to this SST tripole pattern. We perform a series of simulations to determine the response to whole North Atlantic SSTs, extratropical North Atlantic SSTs and tropical North Atlantic SSTs. We find that there is no significant NAE circulation response to whole North Atlantic SSTs, but this masks contrasting responses to tropical North Atlantic SSTs and extratropical North Atlantic SSTs. The responses to these domains project onto opposite phases of the summer East Atlantic (SEA) pattern, the second dominant mode of observed summer mean sea level pressure variability in the NAE sector. The tropical to extratropical teleconnection appears to be due to Rossby wave propagation from SST anomalies, and in turn precipitation anomalies, in the Caribbean region. We identify key biases in the model, which cause it to simulate the SEA pattern as the dominant mode of variability in the NAE region (instead of the SNAO), and show that a response to the SST tripole pattern that projects onto the SEA pattern is consistent with these biases. Efforts to eradicate these biases, perhaps achieved by higher resolution simulations, would allow for an improved understanding of the true response to North Atlantic SST patterns.