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The role of ocean-atmosphere interaction in shaping climate change in the North Atlantic sector

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Here, we present an analysis of North Atlantic ocean-atmosphere interaction in a warming climate, based on a long-term coupled general circulation model experiment forced by the RCP 8.5 (Representative Concentration Pathways 8.5) scenario. In addition to globally strongly increased SSTs as a direct response to the radiative forcing, the model run shows a distinct change of the local sea surface temperature (SST hereafter) pattern in the Gulf Stream region. This includes changes of the SST gradients in the region of the Gulf Stream SST front, likely as a response of the wind-driven part of the oceanic surface circulation. As a consequence of a massive slow-down of the Atlantic Meridional Overturning Circulation the northern North Atlantic furthermore shows a much weaker warming than the other oceans.

The feedback of these changes on the atmosphere was studied in a set of sensitivity experiments based on the SST climatology of the coupled runs. The set consists of four runs: a control experiment based on the historical run, a run using the full SST from coupled RCP 8.5 run and two runs, where where we deconstructed the SST signal into a homogenous mean warming part and a local SST pattern change. In the region of the precipitation maximum in the historical run the future scenario shows an increase of absolute SSTs, but a a significant decrease in local precipitation. We show evidence that the local response in that region is connected to the (with respect to the historical run) weakened SST gradients rather than to the absolute SST. Consistently, the model shows enhanced precipitation north of this region, where the SST gradients are enhanced. The warming causes a decreased low-level convergence and upward motion in the region with reduced SST gradient. However, the signal restricts to the low and mid-troposphere and does not reach the higher model levels. There is little evidence for a large-scale response to the SST pattern changes in the Gulf Stream region; instead, the large-scale signal is mainly controlled by the warmer background state. In a warmer climate the same change in the SST gradient has a stronger effect on precipitation and an enhanced North Atlantic storm track is found in the model.