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Impacts of a weakened AMOC on the European climate

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Previous studies have shown that the response of the Atlantic Meridional Overturning Circulation (AMOC) to increasing greenhouse gas forcing is a key driver of inter-model uncertainties. While all models project an AMOC decline, the inter-model spread in the decline rate drives very different climate change impacts, including temperature, precipitation, and large-scale atmospheric circulation patterns. Here we investigate the impacts of a weakened AMOC by performing idealized climate model experiments using EC-Earth3, a state-of-the-art GCM participating in CMIP6. We compare results from a control experiment run under preindustrial forcing, with an experiment in which we force a weakened AMOC by applying a virtual salinity flux in the North Atlantic/Arctic basin. Here we analyze previously unexplored aspects of the climate response to a weakened AMOC, focusing on impacts on wintertime daily timescales in the Euro-Atlantic region.

We find that a weakened AMOC forces an overall drier climate over most of Europe; however, some regions especially in northwestern Europe experience an increase in the number of very wet days. We investigate drivers of precipitation changes by performing a moisture budget and analyzing the association with changes in weather regimes at daily timescales. We find that an increase in the occurrence of the NAO+ days (going from a frequency of ~26% of occurrence to above 42%) together with an enhanced and more central jet, favors drier conditions over southern Europe and wetter conditions over northwestern Europe. Further, enhanced but drier storms cause dryness over Europe while thermodynamic processes per se, namely the Clausius-Clapeyron constraint on temperature, play a second role. Finally, we explore these relationships in additional experiments in which we keep the AMOC constant in a forced 4xCO2 experiment by applying a reversed virtual salinity flux, which allows us to separate the effects of 4xCO2 forcing from the weakened AMOC on climate change impacts. Our results have broader implications for understanding the role of the AMOC response on future climate change, allowing us to separate the impacts of the AMOC from those of the CO2 increase.