Sources of EC-Earth bias in the Tropical Atlantic

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Abstract

The substantial warm SST bias in the eastern Tropical Atlantic reported in most CMIP5 climate simulations with various models, in particular along the coast of Namibia and Angola, remains an issue in more recent and CMIP6-ready versions of climate models such as EC-Earth. This warm bias prevents climate models from producing accurate seasonal forecasts or climate simulations in the Tropics and even globally. We perform an ensemble of experiments with the EC-Earth3.1 climate model in order to investigate the causes and mechanisms responsible for the emergence and persistence of this bias. The fully-developed bias is studied in a historical experiment that has reached quasi-equilibrium, while retrospective prediction experiments are used to study the development/growth from an observed initial state. We further perfrom prediction experiments at both low and high resolution in order to assess the possible dependence of the bias to horizontal resolution. We also analyze standalone experiments with the ocean and atmosphere components of EC-Earth in order to separate the respective role played by the ocean and the atmosphere in the development of the bias. We find that EC-Earth3.1 exhibits a bias similar in pattern, but weaker in magnitude, to that reported in CMIP5 models. Increased horizontal resolution only leads to a small reduction of the bias. The warm SST bias is found to be the result of excessive solar penetration in the mixed layer, linked to the non representation of the spatial and temporal variability of the biological productivity in the ocean component of EC-Earth. The warm SST bias is further linked to deficient turbulent vertical mixing of cold water to the mixed layer. Our study points at a need for better representation of solar penetration and turbulent mixing in the ocean models in order to eliminate the Tropical Atlantic biases.