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Remote Impact of Extratropical Thermal Bias on Tropical Biases in the Norwegian Earth System Model

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One of large biases exhibited by most state-of-the-art coupled general circulation models (CGCMs) is warm sea surface temperature (SST) in the tropical ocean. Due to the warm SST bias, CGCMs fails to represent the location of intertropical convergence zone (ITCZ) realistically. Other common bias is warm SST over the Southern Ocean partly because of less reproduction of stratocumulus over the Southern Ocean. Some previous studies show that the ITCZ position is affected by the extratropical thermal condition. In this study, we explore a connection between the extratropical warm SST bias and tropical biases in the Norwegian Earth System Model (NorESM).

The control simulation of NorESM has the common tropical biases and warm bias over the Southern Ocean. NorESM overestimates the downward shortwave radiation flux over the Southern Ocean and underestimates the low-level cloud formation (in particular, between 40S and 30S). The more incoming shortwave radiation is consistent with the warm SST bias over the Southern Ocean. We conduct a sensitivity experiment in which the incoming shortwave radiation at the top of atmosphere is reduced artificially only between 30S and 60S. The reduced shortwave radiation cools the SST in the Southern Ocean. Interestingly, the annual-mean rainfall over the tropics is reduced (amplified) to the south (north) of the equator. Especially, the double-ITCZ over the tropical Pacific Ocean is diminished in the sensitivity experiment. Moreover, warm SST biases in the tropical ocean are also reduced. Over the tropical Atlantic, the reduction of biases is more remarkable in MAM and JJA: westerly bias over the equatorial Atlantic is reduced and SST is cooler compared to control simulation. Consequently, the rainfall increases (decreases) in the north (south) of the equator, that is, the sensitivity experiment shows more realistic climatological state. This result indicates that a part of tropical biases in NorESM is associated with the warm SST bias in the Southern Ocean.