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Examination of Arabian Sea SST biases in the HiGEM high resolution coupled climate model and the CMIP3 multi-model dataset

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The Arabian Sea region undergoes a pronounced seasonal cycle relating to upwelling, mixing and monsoon dynamics. Any variations in high temperatures of the region may affect the availability of moisture supply to the Indian summer monsoon. Seasonal analysis has been performed for various ocean and atmosphere data from a present day control run in the Indian Ocean region of the HiGEM High Resolution Global Environment Model. When compared with observed and reanalysis datasets such as HadISST, SODA reanalysis and ARGO floats for SST and ocean potential temperature, we find a significant cold bias of around 2°C in HiGEM boreal winter SST. This bias persists through springtime in the northern Arabian Sea, potentially to the detriment of the subsequent Indian summer monsoon which is deficient in this model. Meridional cross-sections of ocean potential temperature and salinity along 65°E also reveal the existence of a deeper mixed layer extending to 300m with highly saline water in the same area. Near-surface winds in HiGEM reveal very strong northeasterly wind biases during boreal winter, which may be the result of a strong north-south air temperature gradient. Compared to estimates from CRU and ERA40, a large cold bias of more than 8°C is observed in HiGEM surface air temperature over northern India during the same season. We suspect that the cold SST bias in the northern Arabian Sea is due to coupling with the strong wind and evaporation biases in HiGEM. Seasonal analysis of modelled latent heat flux in comparison with NOCS (National Oceanographic Centre Southampton) data also suggests that the evaporation rate in HiGEM is too strong over the northern Arabian Sea during winter.

Similar analysis was also carried out for the 20th century simulations from the CMIP3 multi-model dataset. Most of the models show a similar cold bias in the Arabian Sea SST and in northern Indian air temperature during boreal winter. However the mixed layer depth biases show wide variations in each model due to different air-sea interaction processes. Models with stronger north-to-northeasterly wind biases over the Arabian Sea also show a large bias in the northern Arabian Sea winter SST. A further related error in the region consists of excessive winter precipitation over the west equatorial Indian Ocean (WEIO) in HiGEM and many of the CMIP3 models, related to anomalous low-level convergence into the region. We explore connections with the Arabian Sea biases further north with the hypothesis that precipitation biases in the WEIO region, combined with surface temperature biases over northern India during boreal winter, may act to the detriment of accurate mean state simulation of the Arabian Sea. Further study is needed on this topic to determine the impact on the subsequent Indian summer monsoon.