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Variable-resolution global atmospheric models are sensitive to driving SST in ENSO/IOD-Australian rainfall teleconnections

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We have investigated the sensitivity of a global climate model to driving sea surface temperatures (SST) in simulating Australian rainfall characteristics, including the El Niño-Southern Oscillation (ENSO)- and Indian Ocean Dipole (IOD)-related rainfall variability. We employed the Conformal Cubic Atmospheric Model (CCAM), a global atmospheric model characterized by variable resolution, CCAM was forced by two SST datasets with different spatiotemporal resolutions: the 0.25° daily Optimum Interpolation Sea Surface Temperature (CCAM_OISST) version 2.1 and the 2° monthly Extended Reconstruction SSTs Version 5 (CCAM_ERSST5). A benchmarking framework was employed to appraise model performance, revealing strong agreement between the simulations and the Australian Gridded Climate Data (AGCD) in climatological rainfall spatial patterns, seasonality, and annual trends. It is noted that both simulations tend to overestimate rainfall amount, with CCAM_OISST exhibiting a larger bias.

Moreover, CCAM's performance in capturing ENSO and IOD correlations with rainfall was assessed during Austral spring (SON) using a novel hit rate metric. The findings underscore that only CCAM_OISST effectively reproduces observed SON ENSO- and IOD-rainfall correlations, achieving hit rates of 86.6% and 87.5%, respectively, in contrast to 52.7% and 41.8% for CCAM_ERSST5. Noteworthy disparities in sea surface temperatures were observed along the Australian coastline between OISST and ERSST5 (the so-called “Coastal Effect”). These disparities may be attributed to spatial interpolation errors arising from the differences in resolution between the model and driving SST. An additional experiment within CCAM, masking OISST with ERSST within a 5° proximity to the Australian continent, underscores the pronounced impact of the “Coastal Effect” on IOD-Australian rainfall simulations. Conversely, its influence on ENSO-Australian rainfall was constrained. Therefore, realistic local SSTs are important if model simulations are to reproduce realistic IOD-rainfall responses over Australia. Additionally, even though an SST product with a longer time span is preferred in simulating IOD-related variability, circumspection is warranted in the analysis of the impact of IOD on Australian rainfall when utilizing climate model output with a substantial discrepancy in spatial resolutions between the model and the driving SST. After showing CCAM’s ability to simulate ENSO- and IOD-rainfall, our future research will involve pacemaker experiments to isolate remaining climate modes and investigate their independent impact on Australian rainfall.