

The double ITCZ bias in GCMs: Causes and implications for future rainfall projections

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Coupled ocean-atmospheric climate models (GCMs) simulate a double intertropical convergence zone (ITCZ) that is denoted by two zonal bands of annual precipitation in the equatorial central Pacific Ocean which is not present in observations. This spurious double ITCZ affects latent heating in the tropics, and thereby tropical and subtropical weather and climate through atmospheric teleconnections and Hadley circulation. Despite improvements in climate modeling, the double ITCZ bias remains an issue along with a cold sea surface temperature (SST) bias in the eastern equatorial Pacific. The potential relationship between the double ITCZ bias and model trends over the tropical Pacific limits confidence in future climate projections. Using 24 Coupled Model Intercomparison Project Phase 5 (CMIP5) historical runs during 1861-2005, we construct a double ITCZ index to explore its relationship to and implications for mean state and long-term trends. Identical ensemble numbers are chosen from each model run to avoid any changes in simulations due to change in model physics or initial state. Despite the presence of common double ITCZ bias over the tropical Pacific, models show a considerable variation in double ITCZ indices. Our results suggest that equatorial cold tongue SST bias has a critical role in the maintenance of the double ITCZ in these models. Despite strong SST-convection relationship over tropical Pacific in all models, double ITCZ bias is sensitive to background SST. We show that a strong double ITCZ bias limits the amplitude of precipitation trends over the eastern equatorial Pacific, without impacting SST trends directly. We also present a set of AGCM experiments to test our hypothesis for the inter-model spread in precipitation trend. Our analysis can improve our understanding of the role of double ITCZ biases and distant biases in the atmospheric energy budget in climate models, but also will be useful for improving climate projections.

Key words: CMIP5, double ITCZ, climate model biases, climate projection, tropical Pacific