EGU23-6017, updated on 15 Apr 2024
https://doi.org/10.5194/egusphere-egu23-6017
EGU General Assembly 2023

Possible causes of model biases in simulating Tropical-Arctic teleconnections in CMIP6

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The central role of tropical sea surface temperature (SST) variability in modulating Northern Hemisphere (NH) extratropical climate has long been known. However, the prevailing pathways of teleconnections in observations and the ability of climate models to replicate these observed linkages remain elusive. Here, we apply maximum covariance analysis between atmospheric circulation and tropical SST to reveal two co-existing tropical-extratropical teleconnections albeit with distinctive spatiotemporal characteristics. The first mode, resembling the Pacific-North American (PNA) pattern, favors a Tropical-Arctic in-phase (warm-Pacific-warm-Arctic) teleconnection in boreal spring and winter. The second mode, predominant in summer and autumn, is manifested as an elongated Rossby-wave train emanating from the tropical eastern Pacific that features an out-of-phase relationship (cold-Pacific-warm-Arctic) between tropical Pacific SST and temperature variability over the Arctic. This Pacific-Arctic teleconnection (PARC) mode partially explains the observed summertime warming around the Arctic. The reliability of climate models to replicate these leading teleconnections is of primary interest in this study to improve decadal prediction on regional climate. While climate models participating in CMIP6 appear to successfully simulate the PNA mode and its temporal characteristics, the majority of models' skill in reproducing the PARC mode is obstructed by apparent biases in simulating low-frequency SST and rainfall variability over the tropical eastern Pacific and the summer climatological mean flow over the North Pacific. Considering the contribution of the PARC mode in shaping low frequency climate variations over the recent decades from the tropics to the Arctic, improving models' capability to capture the PARC mode is essential to reduce uncertainties associated with decadal prediction and climate change projection over the NH.