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Interactions between mean state biases and synoptic-scale rainfall during tropical-extratropical cloud band events over South America simulated by Two Global Climate Models: BAM-1.2 and HadGEM3

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Abstract

Tropical-extratropical cloud band events are typical of the subtropical South American climate, occurring mainly during the rainy season (November-March) and producing more than 60% of the rainy season precipitation. Given their importance to the precipitation climatology over South America, it is fundamental that climate and weather forecast models correctly represent these events. Using an objective detection algorithm, we evaluate the cloud band simulations from two global models over South America: Brazilian Global Atmospheric Model version 1.2 (BAM-1.2) and Hadley Centre Global Environment Model in the Global Coupled configuration 3.1 (HadGEM3-GC3.1) in two spatial resolution, n96 and n216, considering both atmospheric-only and fully coupled configurations. The observational cloud band baseline is identified in the satellite-derived NOAA CDR OLR dataset. Precipitation and circulation characteristics for the observed cloud bands are drawn from ERA5 reanalysis data. All simulations represent the main location and frequency of the cloud bands during the rainy season and their associated circulation features well. Nonetheless, all simulations have biases in the simulated cloud band precipitation that contribute to more than 50% of the rainy season precipitation bias in some regions. Compared to observations, cloud bands simulated by BAM-1.2 are more persistent while those in HadGEM3-GC3.1 have weaker activity during the onset of the rainy season (Nov-Dec). In both cases, these biases are traced back to biases in westerly's climatology over midlatitudes and subtropics. Stronger zonal winds over the mid-latitude South Pacific change the simulated maximum Rossby wave number, supporting the propagation of longer and slower RWs towards subtropical South America. In BAM-1.2, the westerly wind bias increases the duration of the cloud band events. In the HadGEM3-GC3.1 simulations, it limits the RWs that reach subtropical South America, reducing the number of cloud band events. Additionally, HadGEM3-GC3.1 models simulate weaker basic state upper-level westerlies over subtropical South America in ND, which affects the wind shear and hinders the propagation of synoptic-scale RWs into lower latitudes. In all models, the issues with the simulated cloud band events arise from the interaction of small biases in the basic state mid-latitude zonal winds at upper-levels with those in the synoptic-scale regional circulation and highlight the importance of adopting a process-based framework when evaluating the dynamical components of climate models.

.Keywords

Tropical-Extratropical cloud bands, upper-level circulation