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From surface wave to cloud: An atmosphere physical process in improving the too cold tongue bias and precipitation in a climate model

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The coupled atmospheric-ocean general circulation models (AOGCMs) without flux correction still show defects in simulating sea surface temperature (SST) and precipitation, with too cold tongue and obvious double-ITCZ biases in the tropical Pacific. We make an effort to improve SST too cold tongue bias and the north-south asymmetry of zonal-averaged precipitation distribution in the Community Climate System Model version3 (CCSM3) by incorporating the non-breaking wave-induced vertical mixing. The oceanic thermocline depth deepens in the central and eastern tropical Pacific under the wave mixing effect. SST warming characterized as a conspicuous maximum in the central and eastern equatorial Pacific contributes to moisture increasing in atmosphere through evaporation process. The non-uniform SST brings out distinct horizontal gradient in air pressure across the tropics, which result in an abnormal wind convergence in the central Pacific. As a result, an enhanced Walker circulation and Hadley cell are driven by wind gradient and more latent heat. The subsidence branch of the Walker circulation in the eastern Pacific suppress the formation of clouds, so that more shortwave radiation is absorbed by the ocean. However, in the central to western Pacific, the updraft of the Walker circulation with abundant water vapor provides favorable conditions for cloud formation in middle and high troposphere. A positive feedback between water vapor and cloud fraction warms the SST by less longwave radiation releasing. The warm anomalies in the central and eastern Pacific restrict the westward expansion of cold tongue. Furthermore, the intensive updraft of Hadley circulation with high humidity increases rainfall in the low-latitudes of the northern hemisphere.