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Observed and simulated patterns of tropical Indo-Pacific climate change over the past six decades: Evidence of the Walker circulation slowdown

H. Tokinaga (1), S.-P. Xie (1), C. Deser (2), Y. Kosaka (1), Y.M. Okumura (3), A. Timmermann (1), S. McGregor (4), H. Kubota (5), and T. Ogata (1)

(1) IPRC, University of Hawaii, Honolulu, United States, (2) NCAR, Boulder, United States, (3) Institute for Geophysics, The University of Texas at Austin, Austin, United States, (4) Climate Change Research Centre, University of New South Wales, Sydney, Australia, (5) Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan

A strong linkage between changes in the Walker circulation and tropical sea surface temperature (SST) is evident in recent satellite observations. For instance, a strengthening of the Walker circulation is accompanied by intensified zonal SST and sea level height gradients. On the other hand, climate models predict that the Walker circulation slows down in response to global warming through hydrological cycle changes. We investigate these mechanisms for the Walker circulation changes over the last six decades by synthesizing a wide variety of climate data sets and model simulations. Our bias-corrected surface wind data set displays westerly trends over the western tropical Pacific and easterly trends over the tropical Indian Ocean, indicative of a slowdown of the Walker circulation. This pattern of wind change is consistent with that of observed SLP change showing positive trends over the Maritime Continent and negative trends over the central equatorial Pacific. Suppressed moisture convergence over the Maritime Continent is largely due to surface wind changes, contributing to observed decreases in marine cloudiness and land precipitation there.

An ocean general circulation model (GCM) forced with the bias-corrected wind stress simulates a reduction in zonal thermal contrast in the tropical Indo-Pacific, consistent with observed changes in ocean mixed layer temperature. Whereas results from major SST reconstructions show large uncertainty in zonal gradient in the tropical Indo-Pacific, both bucket-sampled SSTs and nighttime marine air temperatures show a weakening of the zonal gradient consistent with the subsurface temperature changes. All these findings from observations and model simulations provide robust evidence for ocean–atmosphere coupling associated with the reduction in the Walker circulation over the last six decades. We also discuss atmospheric GCM experiments forced with various SST reconstructions.