How oceans shape rainfall patterns in a changing climate

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Sea surface temperature (SST) is of first-order importance in shaping spatio-temporal variations in tropical rainfall. Satellite observations were instrumental in establishing this relationship. Satellite cloud images revealed in the late 1960s that the Pacific intertropical convergence zone (ITCZ) is displaced north of the equator except for a brief period of March-April when a symmetric double ITCZ appears. Such observations spurred research concluding that ocean-atmosphere interactions are the key to the development of the north-south asymmetry of the ITCZ. El Nino/the Southern Oscillation (ENSO) is another example that SST changes cause major shifts in tropical convection.

Global-mean temperature has been increasing for the past century and is project to continue to increase in response to increased greenhouse gas (GHG) concentrations. How rainfall patterns will change under global warming is of great socio-economic importance. Unlike temperature, precipitation change is likely to be highly variable from one region to another. Our recent analysis of climate model simulations indicates that to first order, tropical rainfall change is determined by spatial patterns of SST warming. Rainfall is likely to increase if local SST warming exceeds the tropical mean, and vice versa. In particular, the equatorial maximum in SST warming over the Pacific anchors a band of pronounced rainfall increase. The gross moist instability of the atmosphere follows closely SST warming patterns as equatorial wave adjustments flatten upper tropospheric warming. The comparison with atmospheric simulations in response to a spatially uniform SST warming illustrates the importance of SST patterns for rainfall change, an effect overlooked in current discussion of regional precipitation response to global warming. Implications for global and regional response of tropical cyclones will be discussed.

References

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