

<sup>PB:</sup>~~Large-Scale Clustering of Tropical Precipitation and its Implications for the Radiation~~  
~~Budget across Timescales~~ Large-Scale Clustering of Tropical  
Precipitation in Interannual Variability and in a  
Warming Climate: Mechanisms and Implications for the  
Radiation Budget

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## Abstract

The spatial organization of deep convection in tropical regions is posited to play an important role in determining characteristics of the tropical climate such as the humidity distribution and cloudiness and may therefore be an important control on climate feedbacks. This study analyzes one aspect of convective organization, the clustering of heavy precipitation on large scales, in both interannual variability and under warming in future climate projections. Both observations and global climate models indicate that large-scale clustering is sensitive to the SST gradient in the Pacific, being largest during El Niño events. Under future warming, models project an increase in clustering with a large intermodel spread. The increase is associated with a narrowing of the intertropical convergence zone, while the model spread is partially explained by differences in projections of the SST gradient in the Pacific. Both observations and models indicate large-scale clustering influences the cloud and humidity distributions, albeit with some differences. However, the intermodel spread in changes in clustering with warming is not related to the intermodel spread in projections of tropical-mean relative humidity or low cloudiness in regions of descent, precluding attempts to provide an observational constraint on feedbacks or climate sensitivity. Nevertheless, the tendency for a meridional contraction of precipitation explains about 45% of the variance in projected drying, highlighting the narrowing of the ITCZ as an important aspect of large-scale convective organization in a warmer climate.

## Plain Language Summary

The spatial distribution of rainfall in the tropics is expected to change in a warming climate, with potentially important impacts on how much radiation is absorbed by water vapor and reflected by clouds. This study shows that heavy rainfall tends to move towards the equator and to the Pacific Ocean in projections with global climate models, resulting in an overall increase in the "clustering" of rainfall on the large scale. Further, the results show a shift in rainfall to the equator with global warming is associated with a drying of the tropical atmosphere, which may have an influence on how much the planet warms for a given  $CO_2$  change. However, similar observed shifts in rainfall in the current climate are not found to have the same effect on humidity and clouds as for changes with warming, suggesting caution should be exercised when using relationships derived from observations to predict future changes.

## References