

# **Future changes in monsoon precipitation by high-resolution MRI-AGCM ensemble simulations with multi-SSTs and multi-physics**

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This study investigates future changes in precipitation over monsoon regions around the world based on ensemble simulations by high-resolution global atmospheric models (MRI-AGCMs). Time-slice experiments using a 20-km mesh AGCM were performed for the present-day (1984-2003) and the future (2080-2099). For the future climate simulations, four different sea surface temperature (SST) change patterns derived from the Couple Model Intercomparison Project phase 5 (CMIP5) multi-models were applied to the 20-km mesh AGCM. To assess dependence of the projections on model physics, we also conducted twelve-member ensemble projections combining the four different SST and three different cumulus schemes (Yoshimura (YS), Arakawa-Schubert (AS), and Kain-Fritsch (KF)) using 60-km mesh AGCMs.

In the present-day simulations, the models successfully reproduce the observed annual cycle of global-scale precipitation patterns as well as regional monsoon precipitation. The models' skills outperform those of CMIP5 atmosphere-ocean general circulation models (AOGCMs) and AGCMs. The models also realistically simulate precipitation extremes, although the model incorporating the AS scheme underestimates the magnitude of extreme precipitation.

In future projections, precipitation changes on the global scale is similar to that of the CMIP5 multi-AOGCM mean, but there is some difference between them over the northwestern Pacific where ocean-atmosphere coupling is strong. Monsoon precipitation over land is projected to generally increase in most regions except for North America. The change rates are largely affected by SST patterns for the North America and Australia-Maritime continent monsoons, while the rates are mostly affected by the choice of cumulus schemes for other monsoons. As for precipitation extremes, they are projected to increase in all land monsoon regions, and the change rates strongly depend on the choice of cumulus schemes.

Key words: future change, precipitation, monsoon, high-resolution