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Bias teleconnections: atmospheric variability associated with biases in remote regions

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Atmospheric spatial and temporal variability are closely related with the former being relatively well assessed compared to the latter. New opportunities for understanding the spatio-temporal variability spectrum are offered by coupled high-resolution climate models. However, the models still suffer from significant systematic errors (biases) calling for an approach that assesses circulation variability in relation to biases. Furthermore, biases in simulated variability are often of remote origin; for example, biases in the Atlantic sea-surface temperature in boreal winter may be responsible for changes in simulated variability over Asia.

We present a novel framework for the multivariate, multi-scale variability evaluation in relation to remote biases. Centennial simulations are carried out using a general circulation model PLASIM and a perfect-model framework. Biases in simulated circulation originate from regional errors in the surface forcing by prescribed sea surface temperature (SST). A reference simulation is forced with the monthly SST from ERA-20C reanalyses from January 1900 to December 2010. Sensitivity simulations are forced with the same SST with addition of regional perturbations that mimic the errors in the surface forcing of the atmosphere and lead to systematic errors in the simulated mean state and temporal variance. The erroneous SST is respectively located in tropical basins of Indian ocean, Western Pacific, Central Pacific, Eastern Pacific, and Atlantic, and in extra-tropical areas of North Pacific and North Atlantic.

The bias is the time-averaged difference between the reference and sensitivity simulations. Using the normal-mode function decomposition, the amplitude and phase of the bias can be related to deficiencies in spatial and temporal variance of the two main dynamical regimes: quasi-geostrophic regime and unbalanced circulation. The results show that biases are mainly established in the zonal-mean state and at planetary scales of balanced flow. In boreal winter, the biases at scales with zonal wavenumber $k>0$ are typically manifested in the barotropic Rossby wave train across the Northern Hemisphere. The structure of tropical biases is that of unbalanced flow, projecting predominantly on the Kelvin wave and the vertical baroclinic structure. The effects of biases on spatio-temporal variability are further investigated in spectral space.