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Present-day climate simulation and future projection by the global climate model MRI-CGCM3 and the earth system model MRI-ESM1

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A new global climate model MRI-CGCM3 is developed at Meteorological Research Institute (MRI). The model is overall renewal from the former MRI's climate model MRI-CGCM2 series. MRI-CGCM3 is composed of atmosphere-land, aerosol, and ocean-ice models, which is a subset of the MRI's earth system model MRI-ESM1. The atmospheric component MRI-AGCM3 is interactively coupled with the aerosol model MASINGAR mk-2 to represent direct and indirect effects of aerosols with a new cloud microphysics scheme. MRI-ESM1 includes an ozone chemistry model MRI-CCM2 and carbon cycle processes for land and ocean in addition to the components of MRI-CGCM3. It is expected that the simulated climate is close to each other between MRI-CGCM3 and MRI-ESM1 in many aspects (e.g., mean climate, climate variability, and climate sensitivity).Basic experiments for pre-industrial control, historical, and future projections with RCPs are performed with MRI-CGCM3 and MRI-ESM1.
The simulated present-day mean climate in the historical experiment is evaluated by comparison with the observations including reanalysis. The model reproduces overall mean climate including seasonal variation in various aspects in the atmosphere and the oceans. Variability in the simulated climate is also evaluated, and found to be realistic including El Niño and Southern Oscillation and the Arctic and Antarctic oscillations. However, some important issues are identified. The simulated SST has biases with generally cold in the Northern Hemisphere and warm in the Southern Hemisphere, and the simulated sea ice excessively expands in the North Atlantic in winter. There appears so-called 'double ITCZ' in the tropical Pacific particularly in the austral summer.
The climate sensitivity of MRI-CGCM3 is estimated to be 2.11 K with Gregory's method. In the future projections, the global mean surface air temperature increase at the end of 21st Century relative to the pre-industrial control is 1.4 K, 2.1 K, 2.4 K, and 4.0 K for the RCP2.6, RCP4.5, RCP6.0, and RCP8.5 experiments in MRI-CGCM3, and 3.4 K for the RCP8.5 experiment in MRI-ESM1.The simulated atmospheric CO_2 concentration at the end of 20th Century in MRI-ESM1 is about 350 ppm, which is 20 ppm lower than that of observation, although the simulated present-day mean climate is almost the same as that of MRI-CGCM3. The projected atmospheric CO_2 concentration at the end of 21st Century is about 800 ppm, which is 130 ppm lower than that prescribed in the RCP8.5 experiment with MRI-CGCM3.It is implied that cause of the lower atmospheric CO_2 concentration is a higher sensitivity of the net CO_2 flux at the land carbon cycle process to atmospheric CO_2 concentration. Projections of precipitation and sea ice will be also compared among the experiments.