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Development and evaluation of an Earth System Model with surface gravity waves

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The critical role of oceanic surface waves in climate system is attracting more and more attention. We set up an Earth System Model, which is named as the First Institute of Oceanography-Earth System Model (FIO-ESM), composed of a coupled physical climate model and a coupled carbon cycle model. A surface wave model is introduced through including the nonbreaking wave-induced vertical mixing, which can improve the performance of climate model especially in the simulation of upper ocean mixed layer depth in the southern ocean, into the ocean general circulation model. The FIO-ESM is employed to conduct Coupled Model Intercomparison Project Phase 5 (CMIP5) experiments. The historical simulation of FIO-ESM's physical climate model for 1850–2005 shows that the simulated patterns of surface air temperature (SAT), rainfall, and El Ni∼no-Southern Oscillation (ENSO) match those of the observations. Future projections under the four scenarios of RCP2.6, RCP4.5, RCP6.0, and RCP8.5 are also conducted and the global averaged SAT in 2100 would be 0.007C, 1.10C, 1.85C, and 3.92C higher than that in 2005, respectively. The historical simulation and future projection under RCP8.5 with global carbon cycle show the SAT and atmospheric CO_2 concentration are well reproduced in the historical period and the global averaged SAT would increase by 3.90C in 2100, which is quite similar to the physical climate model's result. Further analysis shows surface wave makes projected SAT in RCP2.6 about 2C cooler in the Arctic area and 2C warmer in the southern ocean.