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Model Description and Evaluation of FIO Earth System Model (FIO-ESM) version 2.0

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The First Institute of Oceanography Earth System Model (FIO-ESM) version 2.0 was developed and participated in the Climate Model Intercomparison Project phase 6 (CMIP6). In comparison with FIO-ESM v1.0, all component models of FIO-ESM v2.0 are updated, and their resolutions are fined. In addition to the non-breaking surface wave-induced mixing (Bv), which has also been included in FIO-ESM v1.0, there are three more distinctive physical processes in FIO-ESM v2.0, including the effect of surface wave Stokes drifts on air-sea momentum and heat fluxes, the effect of wave-induced sea spray on air-sea heat fluxes and the effect of sea surface temperature (SST) diurnal cycle on air-sea heat and gas fluxes. The FIO-ESM v2.0 has conducted the CMIP6 Diagnostic, Evaluation and Characterization of Klima (DECK), historical and future scenario experiments. The results of pre-industrial run show the stability of the climate model. The historical simulation of FIO-ESM v2.0 for 1850-2014 is evaluated, including the surface air temperature (SAT), precipitation, SST, Atlantic Meridional Overturning Circulation (AMOC), El Niño-Southern Oscillation (ENSO), etc. The climate changes with respect to SAT and SST global warming and decreasing AMOC are well reproduced by FIO-ESM v2.0. The correlation coefficient of the global annual mean SAT anomaly can reach 0.92 with observations. In particular, the large warm SST bias at the east coast of tropical Pacific from FIO-ESM v1.0, which is a common challenge for all climate models, is dramatically reduced in FIO-ESM v2.0 and the ENSO period within the range of 2-7 years is well reproduced with the largest variation of SST anomalies occurring in boreal winter, which is consistent with observations.