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Evaluating the Earth Simulator global coupled ice-ocean module of the CCSR/NIES/FRCGC climate model

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The simulations of the Arctic ice-ocean circulation using the high resolution global coupled ice-ocean module of the CCSR-NIES-FRCGC global model with 1/6x1/4 degrees and 48 vertical layers on the 'Earth Simulator' supercomputer was evaluated to determine the model performance, physics soundness, and its sensitivity to different process parameterizations. The coupled ice-ocean module consists of the 3-D s-coordinate ocean model of Tokyo University and the Las Alamos ice model. The coupled module was driven by ECMWF reanalysis forcing with no flux adjustment and restoring to observed temperature and salinity. The model simulations of years 27-38 were examined with and without GM (Gent Williams 1990) parameterization to the north of 45N. The statistical time series of the total oceanic and ice kinetic energy and ice areas suggest that the model is adjusting towards equilibrium without any T/S restoring or flux adjustment. The model climatology (mean over all the model years) was examined and compared with the available observed climatology, such as ice area, temperature and salinity at certain key depths and transects. The mixed layer depth and convection depth shows significant differences between the results with and without the GM scheme, so does the deep water properties, such as the intermediate Atlantic Water in the Arctic Ocean, which suggests that GM parameterization along isopycnal diffusion is important in prevention of deep water properties from numerical diffusions in a climate model. Several important physical features in the Northern Hemisphere, such as the thermohaline in the Arctic Ocean, Atlantic Water, meridional thermohaline overturning, transports at Bering Strait, Fram Strait etc., were exam-

ined to determine physical soundness of the model. An important achievement is that the Atlantic Layer in the Arctic can be reasonably reproduced with no restoring temperature and salinity to observations. Based on the diagnosis, recommendations for further improvement of model parameters, such as ice-ocean drag coefficient, regions to which the GM scheme is applied, and correction of surface freshwater flux deficit, are proposed.