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Validation of a global finite element sea-ice ocean model

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Results from a global Finite Element Sea ice–Ocean Model (FESOM) are evaluated using a wide range of observational datasets. FESOM's ocean component is a primitive-equation, hydrostatic ocean model using isopycnic diffusion and a Gent-McWilliams scheme to parameterize the effects of sub-gridscale turbulence on tracer distribution. Vertical mixing and convection are parameterized as a function of the Richardson number and the Monin-Obukhov length. A finite element dynamic-thermodynamic sea ice–model with elastic-viscous-plastic rheology has been developed and coupled to the ocean component. The model features a prognostic snow layer but neglects internal heat storage. All model components are discretized on a triangular/tetrahedral grid with a continuous, conforming representation of model variables. The coupled model has been run in a global configuration and forced with NCEP daily atmospheric reanalysis data for 1948-2007. Results are analysed with a focus on the Southern Hemisphere. While summer ice extent is underestimated in both hemispheres, winter ice extents are in good agreement with satellite data. Southern Ocean sea ice thickness distribution agrees well with ship-based observations and even quantitatively with data from upwards looking sonars (ULS). Sea ice freezing rates have been validated using repeated salinity profiles from Southern Elephant Seals. Gulf Stream transport is underestimated, but transports of the Kuroshio and the Antarctic Circumpolar Current appear realistic. A comparison of numerical tracer studies to observed CFC distribution indicates that bottom layer ventilation occurs on realistic pathways. Global meridional overturning features a strong Antarctic Bottom Water (AABW) cell, while the formation of North Atlantic Deep Water (NADW) appears to be on the weak side. Besides pure model validation, the study also identifies regions and processes that critically require a locally increased horizontal resolution in order to be represented adequately.