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Improvements and Comparisons of Shortwave Radiation Physics in a Sea Ice Model

Mirong Song (1) and Jiping Liu (2)

(1) Institute of Atmospheric Physics, Beijing, China (songmirong@lasg.iap.ac.cn), (2) Department of Atmospheric and Environmental Sciences, University at Albany, Albany, USA

Shortwave radiation physics in CICE4.0 is improved and evaluated. First, we improved surface albedo parameterization that depends on large-scale variables (named SHCE). The improvements include expanding the spectrum from two to four bands, distinguishing direct and diffuse, considering different albedo for wet and dry snow, and effects of sea ice and snow thickness on albedo, especially incorporating explicit melt pond and its impacts on albedo. Compared to CICE4.0, improved simulations are found in the following aspects: 1) sea ice concentration in the central Arctic is increased, especially in the East Siberia Sea, 2) sea ice thickness gradient from the Canadian Archipelago and Greenland Sea to East Siberia Sea is more like observations, 3) snow and ice albedo is increased in the central Arctic Ocean and closer to the observation. Also, the impacts of different albedo parameterization schemes (SHCE vs. Delta-Eddington which is based on the optical property) on sea ice simulations are examined. The results show that SHCE gives slightly better simulation, as the simulated albedo of Delta-Eddington is much lower than the observations, and sea ice concentration in the East Siberia Sea is less than the observations. Furthermore, the two different albedo scheme show different response to global warming. Second, we improved penetration of solar radiation in snow and sea ice. The improvements include expanding the spectrum bands and distinguishing extinction coefficients as a function of spectral bands and surface properties. Compared to CICE4.0, sea ice is reduced in the Arctic marginal sea ice zone and becomes thinner in the central Arctic Ocean, especially in the East Siberia Sea. This is mainly due to more absorbed shortwave in the inner ice and penetrated radiation into the mixed layer beneath the ice, which increases the basal ice melt.