Session: C25 Poster: W20B

Team MIROC: Sea-ice climatology and trends in twentieth-century simulations by new MIROC coupled models

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Sea ice has a large impact on climatic system and its variability. A good reproducibility of the past state of the sea ice in global climate models will reduce uncertainty in future projection. Here, we present sea-ice simulations for new versions of atmosphere-ocean coupled general circulation models, the Model for Interdisciplinary Research on Climate version 4h (MIROC4h) and version 5 (MIROC5), and assess the reproducibility of the sea ice in hindcast simulations. The sea-ice component of MIROC4h is based on the previous version (version 3; MIROC3), which has contributed to climatic research. MIROC5 employs some improved schemes including subgrid-scale ice thickness distribution. Hindcast simulations of twentieth-century climate by the new models are compared with satellite-based observations and with the results of high and low resolution versions of MIROC3. For the Northern Hemisphere, Arctic sea-ice simulations are improved in both MIROC4h and MIROC5 compared with the previous models. The MIROC5 simulation is in good agreement with observational data, especially in the Arctic Ocean, whereas in MIROC4h, the Arctic sea-ice prediction has been improved from the previous model but is still too small in summer extent and in thickness. The employment of the ice thickness distribution contributes to reproduce the realistic ice thickness in MIROC5. For the Southern Hemisphere, MIROC4h well reproduces the observed ice edge, especially in winter, while MIROC5 underestimates sea-ice extent. Both models indicate decreasing trends in Arctic sea ice in the late twentieth century. A heat budget analysis of the MIROC5 Arctic Ocean suggests that intensification of ice-albedo feedback accelerates the rate of Arctic ice decline.