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Importance of open-water ice growth and ice concentration evolution: a study based on ECHAM6-FESOM

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A newly developed global climate model ECHAM6-FESOM with unstructured mesh and high resolution is used in our study to investigate to what degree the distribution of the new ice volume (i.e. growth in area and thickness) formed on open water affects the ice and ocean properties. To achieve this goal, a reduction factor is used to reduce the ice concentration change when ice formation occurs on open water. Our simulations show a positive feedback among the Arctic sea ice, the AMOC and the sea surface temperature in the Arctic, as the sea ice transport affects the freshwater budget in regions of deep water formation. However, opposite patterns are produced for the Southern Ocean, which arises from the difference in mixed layer depth between the two polar regions. A warming over Europe, Asian and North America, associated with a strengthening of Arctic oscillation, is also simulated in the model. Additionally, a series of sensitivity tests are performed using an idealized 1-D model to further investigate the influence of varying mixed-layer depth and the reduction factor. Most of the 1-D sensitivity experiments show an increase in annual mean ocean temperature and ice thickness, and a decrease in ice concentration. However, thinner ice is simulated in extreme cases of a very small reduction factor applied. In general, the difference in ice thickness, ice concentration and ocean temperature can be even larger as the reduction factor decreases or the depth of mixed-layer increases. In reality, the distribution of new ice on open water relies on many uncertain parameters, for example, wind speed and ocean currents. But knowledge of the detailed processes is currently too crude to be implemented realistically into models. Our sensitivity experiments lead to an important uncertainty which could significantly affect the climate system.