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Understanding influence of ocean waves on Arctic sea ice simulation: A modeling study with an atmosphere-ocean-wave-sea ice coupled model

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Rapid decline of Arctic sea ice has created more open water for ocean wave development and highlighted the importance of wave-ice interactions in the Arctic. Some studies have made contributions to our understanding of the potential role of the prognostic floe size distribution (FSD) on sea ice changes. However, these efforts do not capture the full interactions between atmosphere, ocean, wave, and sea-ice. In this study, a modified joint floe size and thickness distribution (FSTD) is implemented in a newly-developed regional atmosphere-ocean-wave-sea ice coupled model and a series of pan-Arctic simulation is conducted with different physical configurations related to FSD changes, including FSD-fixed, FSD-varied, lateral melting rate, wave-fracturing formulation, and wave attenuation rate. Firstly, atmosphere-ocean-wave-sea ice coupled simulations show that the prognostic FSD leads to reduced ice area due to enhanced ice-ocean heat fluxes, but the feedbacks from the atmosphere and the ocean partially offset the reduced ice area induced by the prognostic FSD. Secondly, lateral melting rate formulations do not change the simulated FSD significantly, but they influence the flux exchanges across atmosphere, ocean, and sea-ice and thus sea ice responses. Thirdly, the changes of FSD are sensitive to the simulated wave parameters associated with different wave-fracturing formulations and wave attenuation rates, and the limited oceanic energy imposes a strong constraint on the response of sea ice to FSD changes. Finally, the results also show that wave-related physical processes can have impacts on sea ice changes with the constant FSD, indicating the indirect influences of ocean waves on sea-ice through the atmosphere and the ocean.