

## Arctic Sea Ice Changes in the DAMIP experiments using the MRI Earth System Model

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Arctic sea ice decreases rapidly with a temperature rise by Arctic amplification which is caused by an increase of the greenhouse gases. According to some studies, the Arctic Ocean is projected to become ice-free Ocean in the nature future. As sea ice melts due to the effect of sensible heat, it has a close relationship with air temperature. Although the historical temperature in the Arctic is well known by the previous observational studies, the historical sea ice variability hasn't still understood sufficiently because of the lack of observations in pre-satellite era. Therefore, the modeling study will greatly contribute to the understanding of the Arctic climate change.

Meteorological Research Institute (MRI) has developed a new version of MRI Earth System Model (MRI-ESM2) for participating in the various Model Intercomparison Project (MIP), especially CMIP6 (Coupled Model Intercomparison Project Phase 6). We conducted the CMIP6 historical experiment (1850-2014) and the DAMIP (Detection and Attribution MIP) experiments by MRI-ESM2. The DAMIP experiments consist of hist-GHG (Well-mixed greenhouse-gas-only historical simulations), hist-aer (Anthropogenic-aerosol-only historical simulations) and hist-nat (Natural-only historical simulations). The DAMIP experiments make it possible to clarify the impacts of anthropogenic and natural forcing on the global warming. And the experiment will be able to estimate how the sea ice variability was influenced by the external anthropogenic and the natural forcing. The decadal to multi-decadal variability of the Arctic sea ice is seen in all experiments, but each experiment indicates some characteristic changes. The hist-GHG experiment shows a strongly decrease in the sea ice extent due to the rapid increase of the greenhouse gases. The hist-aer experiment indicates an expansion in the summer sea ice extent over the period to 1980 when the concentration of sulphate aerosols is peak out, which lead to the global and Arctic cooling. But over the period from 1980 to now, the summer sea ice extent shows a decrease. The hist-nat experiment shows a weakly decrease in the summer sea ice extent over the period from 1880 to 1940, since then the summer sea ice extent remains at the same level. Thus, our simulations show the historical summer Arctic sea ice extent and the contributions of the external anthropogenic and the natural forcing to the sea ice changes.

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