# Abstract

The Arctic Ocean is known as the region where the influence of recent global warming notably appear in the state of climate and characteristic of sea ice. The changes in Arctic sea ice cover suggests that the ice–ocean albedo feedback, which is a key factor of ice retreat in the seasonal ice zone, is also associated with the recent drastic ice retreat in the Arctic. However, most of the previous studies have treated Arctic sea ice cover as the perennial ice zone, therefore few studies have investigated the effect of this feedback. This study considered the effect of ice–ocean albedo feedback on the summer retreat of Arctic sea ice cover, based on the heat budget analysis and the detailed analysis of satellite-derived sea ice data and objective atmospheric data, along with a simple ice–ocean coupled model.

The heat budget analysis using sea ice data from SSM/I shows that the net heat input at the water surface in the active melting season reaches 150–200 W m$^{-2}$ due to the large solar radiation, while that at the ice surface is about 50 W m$^{-2}$. Assuming that the average ice thickness does not change significantly during the active melt season, the seasonal and interannual variations of heat input into the upper ocean through the open water area ($Q_u$) and those of heat required for ice retreat ($Q_m$) quantitatively correspond with

each other. The agreement between $Q_u$ and $Q_m$ is more prominent in the Pacific Sector, where the change into the seasonal ice zone is reported. This implies that the required condition for ice–ocean albedo feedback is satisfied in the Pacific Sector.

The result from a comparison between the ice motion and ice retreat shows that the diverging ice motion in the early melting season (from April to May) has a significant positive correlation with the simultaneous open water fraction and subsequent melting of sea ice for recent decades. This indicates that, in the Arctic Ocean, the effect of ice–ocean albedo feedback triggered by the diverging ice motion has become more prominent after 2000s.

The effect of ice–ocean albedo feedback triggered by the diverging ice motion is also confirmed by a simple ice–ocean coupled model. From the model experiment, it is indicated that the effect of divergent forcing is the most effective when it has occurred at the timing of the onset of melting. The model also reconstructs the temporal variations of summer ice retreat in the 1980s and 2000s, by imposing observed changes in the multi-year ice concentration $A_{my}$ and ice thickness $h_i$. The changes in $A_{my}$ and $h_i$ are both associated with the sensitivity of ice retreat to heat input, and the recent decrease in $A_{my}$ and $h_i$ results in the increase of the effect of ice–ocean albedo feedback.