将来予測における北極域温暖化増幅の季節性と大きさを決める支配的要因

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Dominant factors that determine seasonality and magnitude of Arctic warming amplification in the future projections

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Response of the climate system to imposed perturbations is often formulated in terms of forcing and feedbacks. As the feedback processes interact each other, it is necessary to evaluate their individual contributions by either energy flux diagnostics or process-on/off experiments. During the GRENE project, we primarily have taken the former approach although the hybrid use of the two was also accomplished. The feedback analysis based on the energy flux quantifies the contribution of individual processes to climate change so that the sum of every contributions approximately recovers the actual change. The approach has a benefit of identifying the important processes and the comparison between simulations and observations is in principle possible.

The surface energy flux analysis was applied to the CMIP5 multi-model RCP4.5 simulations, and the energy flux analysis at the surface and individual atmospheric levels (CFRAM-Climate Feedback-Response Analysis Method) was applied to the MIROC5 model RCP4.5 simulation. In both methods, the mechanism of warming (or warming amplification) is distinct between Arctic Ocean, Greenland-Norwegian-Iceland Seas, Greenland, and ice-free Arctic land.

Although the albedo feedback on the ocean due to sea ice melting has the most significant influence in July, when the solar radiation is strong, the actual increase in temperature is considerably suppressed, because most of its energy is absorbed by the ocean or expended on melting snow and ice. However, the energy absorbed by the ocean is released in the period from autumn to winter (with the reduced sea ice cover and exposure of sea surface), and the increase in temperature is confined near the surface because of the strong influence of atmospheric stratification. In addition, the greenhouse effects due to cloud cover causes an increase in temperature in the period from October to January. These factors contribute to the significant increase in temperature.

On the land, the effect of melting (albedo feedback) appears with the highest strength in spring, and becomes small in summer. The amplitude of the temperature increase remains relatively flat throughout the year because, unlike the ocean, there is almost no delay effect in the heat absorption and release on the land. Just like the case of the ocean, however, the temperature increase is affected by the influence of atmospheric stratification and the greenhouse effect of clouds to a large extent in autumn, after October, to winter.

References

Yoshimori, M., A. Abe-Ouchi, M. Watanabe, A. Oka, and T. Ogura (2014): Robust seasonality of Arctic warming processes in two different versions of MIROC GCM. *J. Climate*, **27**(16), 6358-6375.

Yoshimori, M., M. Watanabe, A. Abe-Ouchi, H. Shiogama, and T. Ogura (2014): Relative contribution of feedback processes to Arctic amplification of temperature change in MIROC GCM. *Clim. Dyn.*, **42**(5-6), 1613-1630.

Laîné, A., M. Yoshimori, A. Abe-Ouchi (2015): Surface Arctic amplification factors in CMIP5 Models: Land and oceanic surfaces, seasonality, Part I: Multi-model ensemble mean results. *J. Climate*, in revision.

Yoshimori, M., A. Abe-Ouchi, and A. Laîné (2015): Identification and uncertainty evaluation of the feedback processes that cause amplification of Arctic warming. GRENE News Letter, No. 7, 2-3.

Yoshimori, M. (2014): Arctic amplification. *Saihyo*, **60**, 2-15 [Written in Japanese: 吉森 正和 (2014): 北極温暖化増幅. 細氷, 日本気象学会北海道支部機関紙 **60**, 2-15].