エネルギーフラックスの解析から明らかになった北極温暖化増幅メカニズム

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Mechanism of Arctic amplification revealed from the energy flux analysis

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A 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 process-on/off experiments or energy flux analysis. During the GRENE project, we primarily have taken the latter 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. It does not, however, provide any information on the interaction of feedbacks.

There are three distinct ways of carrying out the energy flux analysis: 1) energy fluxes at the top of the atmosphere, 2) energy fluxes at the surface, and 3) energy fluxes of atmosphere and the surface. As the first method is indirect to interpret the result in terms of regional temperature changes, we chose the second and the third approaches. While the second approach is limited compared to the third approach, it is useful for the multi-model analysis when the available information/data are limited. Here we present the results taking both approaches.

The surface energy flux analysis was applied to the CMIP5 multi-model RCP4.5 simulations, and the whole-column energy flux analysis (CFRAM-Climate Feedback-Response Analysis Method) was applied to the MIROC5 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. Therefore, we summarize the results for these four regions separately with emphasis on the seasonal variations. We also discuss the limitation of the energy-flux based feedback analysis and future perspective for further understanding of the mechanism of Arctic amplification.

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