Towards a deeper understanding of mechanism for amplifying the Arctic warming in the ArCS II project

Masakazu Yoshimori
Atmosphere and Ocean Research Institute, The University of Tokyo

Previous studies including those in the GRENE Arctic Climate Change Research project and the Arctic Challenge for Sustainability (ArCS) project have revealed, to a reasonable extent, which climate feedback processes contribute to the Arctic warming amplification in the future simulations. In the first part of the presentation, we will briefly review what we have learned from these studies. Being diagnosed from the annual mean surface energy balance, the surface albedo feedback contributes most dominantly to the increase in the annual mean surface temperature (Yoshimori et al., 2014a). In particular, it leads to the increased ocean heat content during summer. As the season progresses and the Arctic air becomes colder, the heat stored in the ocean is released to the atmosphere through the sea surface with reduced sea ice cover. Due to the strong stratification in the cold-season atmosphere, cloud greenhouse effect with little sunshine, and nonlinearity of Stefan-Boltzmann law, this anomalous heat release warms the near-surface atmosphere (Yoshimori et al., 2014b, Laîné et al., 2016). It has been shown that the well-known feature of bottom amplification is a result of many processes. The importance of moisture import to the Arctic was also emphasized: the moisture transport contributes to the Arctic warming not only by releasing latent heat but also by enhancing greenhouse effect of water vapor and clouds (Yoshimori et al., 2017). It was also reported that the seasonal respiration of Arctic Ocean – inhale and exhale of anomalous heat in summer and winter, respectively, is a common process in different geological periods in which the dominant forcings are different (Yoshimori and Suzuki, 2019).

Observational support to these understandings remains to be more soundly established, however. One of the obstacles in applying short observational record is that it is difficult to distinguish externally forced response from internal variabilities. In addition, the available reanalysis dataset suffers from the fact that the energy conservation is not strictly satisfied. Furthermore, the entity of individual climatic feedback processes remains obscure and it prevents us from evaluating those processes against short-term record. In the second part of the presentation, we will present our plans on the effort towards a deeper understanding of the Arctic warming amplification mechanism in the new ArCS II project. We pay attention to the atmospheric transport of water vapor and heat into the Arctic, and their contribution to the Arctic warming. Our approach is to link daily meteorological fields to those transport on the climate time scale. Large ensemble data may help distinguish the effect of externally forced response and internal variability. By so doing, we expect to gain insight into the long-term Arctic future projections and possibly to evaluate them. We expect that the usefulness of the project outcome enhances if findings on the Arctic warming are expressed as a function of global mean surface air temperature change. We plan to show some preliminary results in the last part of the presentation.

References

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

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

Laîné, A., M. Yoshimori, and A. Abe-Ouchi (2016): Surface Arctic amplification factors in CMIP5 models: land and oceanic surfaces, seasonality. J. Climate, 29(9), 3297-3316.

Yoshimori, M., A. Abe-Ouchi, and A. Laîné (2017): The role of atmospheric heat transport and regional feedbacks in the Arctic warming at equilibrium. Clim. Dyn., 49(9-10), 3457-3472.

Yoshimori, M. and M. Suzuki (2019): The relevance of mid-Holocene Arctic warming to the future. Clim. Past, 15, 1375-1394.