Feedback analyses on the seasonality of polar amplification driven by changes in the orbital parameters

Kanon Kino[1], Ayako Abe-Ouchi[1,2], Ryouta O'ishi[1], Fuyuki Saito[2] and Masakazu Yoshimori[3]

[1]*The Athosphere and Ocean Research Institute, The University of Tokyo*

[2]*Japan Agency for Marine-Earth Science and Technology*

[3]*Faculty of Environmental Earth Science, Global Institution for Collaborative Research and Education, and Arctic Research Center, Hokkaido University*

Milankovitch theory proposes that summer insolation at high northern latitudes drives the glacial cycles, and a large number of researches indicate the importance of the insolation change (e.g. Abe-Ouchi et al., 2013). However, a main factor of termination 5 (~400,000 years ago), deglaciation accompanied by weak summer insolation change because of the small eccentricity, is under debate.

We investigated the sensitivity of atmospheric GCM coupled to slab ocean and a dynamical vegetation model (MIROC-LPJ; O'ishi and Abe-Ouchi, 2011) to changes in the orbital parameters. We examine 21 idealized orbital parameters that contain past 500,000 years, and realistic orbital parameters during termination 1, 2 and 5 (snapshot for every 2,000 years). We set the atmospheric CO_2 levels at 230 ppm, and the ice-sheet topography for the present day in all the experiments. And then, we applied the feedback analyses proposed by Lu and Cai (2009a) to understand the climate responses to the orbital parameter changes. We also used Ice-sheet model for Integrated Earth system Studies (IcIES; Abe-Ouchi et al., 2013) with the updated parameterization for the past 800,000 years.

These experiments indicate that the polar amplification induced by the insolation change is very similar to the one induced by greenhouse gases. The amplification with the obliquity change is much larger than the precession and the eccentricity changes because of the vegetation-snow-albedo feedback in spring. The result suggests that the obliquity can help the temperature rise even if the summer isolation change is weak, like termination 1 or 5.

We used IcIES with the updated insolation-temperature parameterization (Abe-Ouchi et al., 2007) considering this obliquity effect, and will report the preliminary results.

References

Abe-Ouchi, A., Segawa, T., & Saito, F. (2007). Climatic conditions for modelling the Northern Hemisphere ice sheets throughout the ice age cycle. Climate of the Past, 3, 423–438.

Abe-Ouchi, A., Saito, F., Kawamura, K., Raymo, M. E., Okuno, J., Takahashi, K., & Blatter, H. (2013). Insolation-driven 100,000-year glacial cycles and hysteresis of ice-sheet volume. Nature, 500(7461), 190–193.

Lu, J., & Cai, M. (2009a). Seasonality of polar surface warming amplification in climate simulations. Geophysical Research Letters, 36(16), 1–6.

O'ishi, R., & Abe-Ouchi, A. (2011). Polar amplification in the mid-Holocene derived from dynamical vegetation change with a GCM. Geophysical Research Letters, 38(14), 1–6.