Seasonal climate variations and climate-vegetation feedbacks in the northern high latitude driven by obliquity and precession

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The widely known Milankovitch theory proposes that the summer insolation change at high northern latitudes driven by variations of the orbital parameters is important for the growth and reduction of the large Northern Hemisphere ice sheets over many thousands of years. Several climate modelling studies have been able to reproduce the glacial cycles of the last several hundred thousand years. A quantitative study of the climate feedback processes for determining the summer temperature is important for improving our understanding of this climate system. In this study, we focus on the differences of (1) the seasonal, especially summer, temperature change at high latitudes and of (2) seasonal climate feedback responses induced by changes in the orbital parameters. We also focus on the difference of the vegetation feedback effect, because several recent studies indicate its importance.
An Atmosphere-Ocean-Vegetation GCM (O' ishi and Abe-Ouchi, 2011) with various combinations of realistic orbital parameters (maximum, minimum and present values for each parameter) is used to investigate the summer temperature changes. A seasonal feedback analyses method (Lu and Cai, 2009) is then applied to the results.
Results show that the summer temperature change across the land induced by obliquity changes is much larger than that induced by precession-eccentricity changes, in spite of the similar magnitude of summer insolation changes. It is suggested that a larger obliquity promotes vegetation-snow-albedo feedbacks in spring, especially with a northward shift of the tundra-forest boundary, amplifying the warming at high northern latitudes throughout the year, and a precise consideration of the combinations of the orbital parameters is needed to improve our understanding of glacial cycles.

Keywords: orbital parameter, glacial cycles, climate feedback

