氷期における極域気温増幅：氷床の規模および形状への依存性

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Dependence of Glacial polar amplification on the size and shape of ice sheets

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Larger climate change in the high latitude known as polar amplification is anticipated to occur. Past temperature estimates from polar ice cores and paleoclimate model experiments are used to evaluate the climate sensitivity of General Circulation Models (GCMs) used for future climate projections. For the boundary condition of the Last Glacial Maximum (LGM) experiment of PMIP (Paleoclimate Modelling Intercomparison Project) phase 3, a new set of ice sheet configurations is applied, which is the average of three ice sheet reconstructions derived from different models and methods. Here we compare this new ice sheet boundary condition with the previous boundary conditions for PMIP phase 1 and phase 2, and critically examine the influence of ice sheets on the magnitude of polar amplification. The LGM ice sheets in Northern Hemisphere used in PMIP3 are thinner and flatter than those in PMIP2, which decreases the topography effect of ice sheet and influences on the stationary wave, storm tracks and spatial patterns of the temperature field. On the other hand, in Antarctica, PMIP3 LGM configuration has thicker West Antarctic ice sheet (WAIS) and horizontally more extensive (but little change in height of) East Antarctic ice sheet (EAIS) than the previous reconstructions did. The changes of the ice sheet conditions lead to lower zonal mean temperature in the high southern latitude in PMIP3 than those in PMIP1 and PMIP2. Furthermore, the LGM temperatures at EPICA Dome C and Dome F sites estimated from water isotopic ratios (~9 ˚C lower than late Holocene) are successfully reproduced even though the surface altitude of EAIS inland is approximately the same as today. The above observations indicate that the horizontal extent of EAIS and the height of WAIS have large influences on the zonal mean temperature and even the temperature at domes on EAIS. We also find from our GCM sensitivity experiments that changes in the ice sheets and greenhouse gas contribute to the temperature at the ice coring sites with similar magnitudes. This implies that the magnitude of polar amplification throughout the ice age cycle would depend heavily on the ice sheet history, especially in WAIS, as well as the history of greenhouse gas concentrations. The long-term temperature change that is not explained by the variations of radiative forcing of greenhouse gases, orbital configurations and millennial-scale bipolar seesaw can be largely attributed to the size of WAIS and EAIS for the Antarctic ice coring sites, and to the size of Northern Hemisphere ice sheets for the Greenland ice coring sites.