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The impacts of the North American ice-sheet on glaciation conditions over northern Europe: an atmospheric circulation study with the LMDZ model

Pauline Beghin, Sylvie Charbit, Masa Kageyama, and Christophe Dumas
Laboratoire des Sciences du Climat et de l'Environnement, Gif-sur-Yvette Cedex, France (masa.kageyama@lsce.ipsl.fr)

During the last glacial period (ca. 21 000 years ago), two continental-scale ice sheets covered Canada and northern Europe. It is now widely acknowledged that these past ice sheets exerted a strong influence on climate by causing changes in atmospheric and oceanic circulations. In turn, these changes may have impacted the development of the ice sheets themselves through a combination of different feedback mechanisms. The present study is designed to investigate the potential impact of the North American ice sheet on the surface mass balance (SMB) of the Eurasian ice sheet through simulated changes in the past glacial atmospheric circulation. Using the LMDz5 atmospheric circulation model, we carried out twelve experiments run under constant Last Glacial Maximum (LGM) conditions for insolation, greenhouse gases and ocean. In the all experiments, the Eurasian ice sheet is removed. The twelve experiments differ in the North American ice-sheet topography, ranging from a white and flat (present-day topography) ice sheet to a full-size LGM ice sheet. This experimental design allows to disentangle the albedo and the topographic impacts of the North American ice sheet onto the climate. The results are compared to our baseline experiment where both the North American and the Eurasian ice sheets have been removed. In summer, the sole albedo effect of the American ice sheet modifies the pattern of planetary waves with respect to the no-ice sheet case, causing a cooling of the Eurasian region. By contrast, the atmospheric circulation changes induced by the topography of the North American ice sheet imply summer warming in Northwestern Eurasia. In winter, the Scandinavian and the Barents-Kara regions respond differently to the albedo effect: in response to atmospheric circulation changes, Scandinavia warms up and precipitation is more abundant whereas Barents-Kara area cools down and gets drier. The height increase of the American ice sheet leads to less precipitation and snowfall and to colder temperatures over both Scandinavian and Barents-Kara sectors. The simulated temperature and precipitation fields have then been used to force an ice-sheet model and to compute the resulting surface mass balance over the Fennoscandian region as a function of the American ice-sheet configuration. In response to the summer cooling induced by the American ice-sheet albedo, a highly positive SMB is simulated over the Eurasian ice sheet, leading thus to the growth of the ice sheet. On the contrary, the topography of the American ice sheet leads to more ablation, hence limiting its growth.