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Evolution of the large-scale atmospheric circulation in response to changing ice sheets over the last glacial cycle

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Much effort has been devoted to understanding the circulation and climate of the Last Glacial Maximum (LGM) whereas the long build-up phase to the LGM has received much less attention. We present modelling results of the atmospheric circulation at three stages of the last glacial cycle, the LGM and two earlier stages with smaller ice sheets as well as the interglacial. The paleo-simulations are forced by ice sheet reconstructions consistent with geological evidence and by appropriate insolation and greenhouse gas concentrations. The results suggest that the large-scale features of the atmospheric winter circulation remained qualitatively similar to the interglacial for the larger part of the glacial cycle. The proposed explanation is that the incipient ice sheets were located in areas where their interaction with the mean flow is limited. In North America the cyclonic deflection of the mean flow east of the Rockies yielded a low-level wind largely parallel to the ice sheet topography. Similarly, the influence of the Eurasian ice sheet is found to be weak as the ice sheet was located north of the strongest mean flow.
However, the continental-scale Laurentide ice sheet at the LGM induces a stronger planetary wave response that leads to structural changes in the atmospheric circulation and a zonalisation of the Atlantic jet. A possible explanation for the zonalisation of the jet axis is that the amplified orographic wave is reflected nonlinearly in a subtropical critical layer. Simulations with varying heights of the ice sheet topography give support to this hypothesis as the wave activity flux shows evidence of reflection when the ice sheet is sufficiently high.