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The Holocene climate evolution in the high-latitude Southern Hemisphere simulated by a coupled atmosphere-sea ice-ocean-vegetation model

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The Holocene climate is simulated in a 9,000-year long transient experiment performed with the ECBilt-CLIO-VECODE coupled atmosphere-sea ice-ocean-vegetation model. This experiment is forced with annually varying orbital parameters and atmospheric concentrations of CO_2 and CH_4. Our objective is to study the impact of these long-term forcings on the surface temperature evolution during different seasons over Antarctica and the Southern Ocean. We find in summer a thermal optimum in the mid-Holocene (6 to 3 ka BP), with temperatures locally 3˚C above the preindustrial mean. In autumn the temperatures experienced a long-term increase, particularly during the first few thousand years. The opposite trend was simulated for winter and spring, with relatively a warm Southern Ocean at 9 ka BP in winter (up to 3.5˚C above the preindustrial mean) and a warm continent in spring (+3˚C), followed by a gradual cooling towards the present. These long-term temperature trends can be explained by a combination of 1) a delayed response to orbital forcing, with temperatures lagging insolation by 1 to 2 months due to the thermal inertia of the system, and 2) the long memory of the Southern Ocean. This long memory is related to the storage of the warm late winter-spring anomaly below the shallower summer mixed layer until next winter. Sea ice plays an important role as amplifying factor through the ice-albedo and ice-insulation feedbacks. Our experiments can help to improve our understanding of the Holocene signal in proxies. For instance, the results suggest that, in contrast to recent propositions, teleconnections to the Northern Hemisphere appear not necessary

to explain the Southern Hemisphere Holocene temperature evolution

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