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Past temperature reconstructions from deep ice cores: relevance for future climate change

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Abstract. Ice cores provide unique archives of past climate and environmental changes based only on physical processes. Quantitative temperature reconstructions are essential for the comparison between ice core records and climate models. We give an overview of the methods that have been developed to reconstruct past local temperatures from deep ice cores and highlight several points that are relevant for future climate change.

We first analyse the long term fluctuations of temperature as depicted in the long Antarctic record from EPICA Dome C. The long term imprint of obliquity changes in the EPICA Dome C record is highlighted and compared to simulations conducted with the ECBILT-CLIO intermediate complexity climate model. We discuss the comparison between the current interglacial period and the long interglacial corresponding to marine isotopic stage 11, ~400 kyr BP. Previous studies had focused on the role of precession and the thresholds required to induce glacial inceptions. We suggest that, due to the low eccentricity configuration of MIS 11 and the Holocene, the effect of precession on the incoming solar radiation is damped and that changes in obliquity must be taken into account. The EPICA Dome C alignment of terminations I and VI published in 2004 corresponds to a phasing of the obliquity signals. A conjunction of low obliquity and minimum northern hemisphere summer insolation is not found in the next tens of thousand years, supporting the idea of an unusually long interglacial ahead.

As a second point relevant for future climate change, we discuss the magnitude and rate of change of past temperatures reconstructed from Greenland (NorthGRIP) and Antarctic (Dome C) ice cores. Past episodes of temperatures above the present-day values by up to 5°C are recorded at both locations during the penultimate interglacial period. The rate of polar

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warming simulated by coupled climate models forced by a CO_2 increase of 1% per year is compared to ice-core-based temperature reconstructions. In Antarctica, the CO_2-induced warming lies clearly beyond the natural rhythm of temperature fluctuations. In Greenland, the CO_2-induced warming is as fast or faster than the most rapid temperature shifts of the last ice age. The magnitude of polar temperature change in response to a quadrupling of atmospheric CO_2 is comparable to the magnitude of the polar temperature change from the Last Glacial Maximum to present-day. When forced by prescribed changes in ice sheet reconstructions and CO_2 changes, climate models systematically underestimate the glacial-interglacial polar temperature change.

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