Geophysical Research Abstracts
Vol. 18, EGU2016-6986, 2016
EGU General Assembly 2016

Mean ocean temperature change over the last glacial transition based on atmospheric changes in heavy noble mixing ratios

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On paleo-climatic timescales heavy noble gases (Krypton and Xenon) are passively cycled through the atmosphere-ocean system without seeing any significant sink or source. Since the solubility in water of each gas species is characterized by a specific temperature dependency, mixing ratios in the atmosphere change with changing ocean temperatures. In this study, we use this fact to reconstruct mean global ocean temperatures (MOT) over the course of the last glacial transition based on measurements of trapped air in the WAIS Divide ice core. We analyzed 70 ice samples with a recently developed method which determines the isotopic ratios of N_2, Ar, Kr (and in some cases also of Xe, though with less precision) and the elemental ratios of Kr/N_2, Xe/N_2 and Xe/Kr. We use the isotope ratios to correct the elemental ratios for gravitational enrichment in the firn column. The corrected elemental ratios are then used in a simple box model to reconstruct MOT. The three elemental ratio pairs are first interpreted as independent measures of MOT and then combined to a single "best-estimate" MOT record with an average uncertainty of 0.27°C. We find a clear link to Antarctic temperatures and a LGM-Holocene change in MOT of 2.4°C. This value is in good agreement with results from marine sediment cores (which, however, have an uncertainty of 1°C). Our record provides an unprecedented constrain on ocean heat uptake over the last glacial transition and therefore gives new insights in the mechanisms underlying long term ocean heat fluxes. To our knowledge, this is the first time that MOT has been reconstructed in such great detail.