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Glacial-interglacial changes in Antarctica: High-resolution modelling of water isotopes and temperature-isotope relations

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During the past two decades, several atmospheric and oceanic general circulation models (GCMs) have been enhanced by the capability to explicitly simulate the hydrological cycle of the two stable water isotopes H218O and HDO. For Greenland and Antarctic ice cores, a number of previous studies have demonstrated the possibility of an improved interpretation of observed isotope variability in terms of climate change by such isotope GCM simulations. Here, we report results of the ECHAM5 atmosphere GCM enhanced by explicit water isotope diagnosis (named ECHAM5-wiso hereafter), focussing on Antarctica. Several new climate control simulations with present-day boundary conditions have been performed to evaluate the overall capability of the ECHAM5-wiso model. For Antarctica, an increase of the model grid size from a typical coarse horizontal GCM resolution of 3.8° (T31 spectral mode) to a very fine spatial resolution of 0.75° (T159 spectral mode) results in a substantially better agreement with available present-day observations and ice core data. For both surface temperature and mean water isotope (d18O and dD) values, deviations between the ECHAM5-wiso results are on the order of 10%–15% of the related observed Antarctic values. The same is true for the simulated present-day spatial isotope-temperature relation as well as mean deuterium excess values. Using a new set of high-resolution paleoclimate simulations, we investigate if and how the Antarctic temperature-isotope relation might has changed on a glacial-interglacial time scale. Furthermore, the influence of glacial sea surface temperature changes on the deuterium excess signal in Antarctic precipitation is examined.