Quantifying different climatic controls on d-excess and ^{17}O-excess in Antarctic ice cores with the isotope-enabled Community Atmosphere Model (iCAM)

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Measurements of oxygen and hydrogen isotopes of water in ice cores are widely applied to reconstruct Earth's past climate. The first-order isotope parameters δ^{18}O and δD are primarily governed by equilibrium fractionation and are useful proxies for temperature. The second-order isotope parameter d-excess is sensitive to non-equilibrium fractionation, and can therefore provide information about meteorological conditions at the moisture sources or during the formation of ice and mixed-phase clouds. Recent advances in measurement techniques have allowed measuring the third isotope ratio δ^{17}O precisely enough to determine very small deviations from equilibrium between δ^{18}O and δ^{17}O, which are quantified as the ^{17}O-excess. Even though the d-excess and ^{17}O-excess are both defined as deviations from (approximate) equilibrium, their long-term temporal variability measured in ice cores is different. While the d-excess (in its logarithmic form) increases from the last glacial maximum to present day in all Antarctic ice cores, the ^{17}O-excess does not change much in coastal Antarctic ice cores, suggesting that the two parameters are governed by different processes. Here we quantify the controls on d-excess and ^{17}O-excess in Antarctica with the help of the isotope-enabled Community Atmosphere Model (iCAM) coupled to the isotope-enabled Community Land Model (iCLM), by comparing simulations of present-day climate with simulations of the last-glacial maximum. An important advantage of iCAM is that it allows supersaturation with respect to ice and therefore does not rely on a parameterization of supersaturation as a function of temperature, which is commonly applied in other general circulation models and has been found to be a major source of uncertainty for simulating d-excess and in particular ^{17}O-excess.