Seasonal scale dating of a shallow ice core from Greenland using oxygen isotope matching between data and simulation

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A precise age scale based on annual layer counting is essential for investigating past environmental changes from ice core records. However, the uncertain seasonal cycle (i.e., non-sinusoidal pattern) of oxygen isotope ($\delta^{18}O$) records causes inevitable errors in the dating. Here, we propose a dating method based on matching the $\delta^{18}O$ variations between ice-core records and records simulated by isotope-enabled climate models. We applied this method to a new $\delta^{18}O$ record from an ice core obtained from a dome site in southeast Greenland. The close similarity between the $\delta^{18}O$ records from the ice core and models enabled correlation and the production of a precise age scale, whose accuracy was ±2 months. A missing $\delta^{18}O$ minimum in the 1995/1996 winter is an example of the uncertain $\delta^{18}O$ seasonal cycle, which hampers annual layer counting. Our analysis suggests that the missing $\delta^{18}O$ minimum was likely caused by a combination of warm air temperature, weak moisture transport, and cool ocean temperature. Based on the age scale, the average accumulation rate from 1960 to 2014 was reconstructed as 1.02 m yr^{-1}. The annual accumulation rate increases with a slope of 3.6 (mm $year^{-1}$), which is mainly caused by the increase in the autumn accumulation rate (2.6 mm $year^{-1}$), which is likely linked to the enhanced hydrological cycle caused by the decrease in Arctic sea ice area. On a seasonal time-scale, our reconstructed accumulation suggests that the ERA re-analysis data overestimates the seasonality in this southeast dome region.

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