The SP19 chronology for the South Pole Ice Core – Part 2: gas chronology, age, and smoothing of atmospheric records.

Climate of the Past, 16, 2431-2444.

https://doi.org/10.5194/cp-16-2431-2020

Epifanio JA, Brook EJ, Buizert C, Edwards JS, Sowers TA, Kahle EC, Severinghaus JP, Steig EJ, Winski DA, Osterberg EC, Fudge TJ, Aydin M, Hood E, Kalk M, Kreutz KJ, Ferris DG, and Kennedy JA (2020)

Abstract

A new ice core drilled at the South Pole provides a 54 000-year paleoenvironmental record including the composition of the past atmosphere. This paper describes the SP19 chronology for the South Pole atmospheric gas record and complements a previous paper (Winski et al., 2019) describing the SP19 ice chronology. The gas chronology is based on a discrete methane (CH_4) record with 20- to 190-year resolution. To construct the gas timescale, abrupt changes in atmospheric CH_4 during the glacial period and centennial CH_4 variability during the Holocene were used to synchronize the South Pole gas record with analogous data from the West Antarctic Ice Sheet Divide ice core. Stratigraphic matching based on visual optimization was verified using an automated matching algorithm. The South Pole ice core recovers all expected changes in CH_4 based on previous records. Gas transport in the firn results in smoothing of the atmospheric gas record with a smoothing function spectral width that ranges from 30 to 78 years, equal to 3 % of the gas-age–ice-age difference, or Δage. The new gas chronology, in combination with the

existing ice age scale from Winski et al. (2019), allows a model-independent reconstruction of the gas-age–ice-age difference through the whole record, which will be useful for testing firn densification models.

Plain Language Summary

The SP19 gas chronology for the SPC14 ice core covers the last 52 586 years, complementing the ice chronology presented in Winski et al. (2019). The gas chronology was created using over 2000 high-resolution, discrete CH4 measurements completed at Oregon State University and Pennsylvania State University. The resulting CH4 record was tied to the high-resolution CH4 record of the WAIS Divide ice core using the WD14 chronology. Abrupt changes in CH4 at D-O events as well as distinct variations of 20–30 ppb during the Holocene are used as tie points. The absolute uncertainty of the gas chronology changes through time to a maximum of ±540 years at 35 ka and an uncertainty of ±502 years at the bottom of the core. Key outcomes of this study include a gas age timescale for the SPC14 ice core, the observation of minimal smoothing of the gas record despite the exceptionally deep firn column at the South Pole, an empirical Δage record that can be used to test firn densification models, and the confirmation of centennial variability in atmospheric CH4.

Student Summary

What we know: Ice cores can provide a huge variety of information about past environments and climate. One of the most challenging but important steps in using an ice core is to figure out the age of the ice and the gas bubbles trapped within it. Adding to the challenge, is the fact that the age of the ice itself is usually different than the age of the gas bubbles.
Why it's important: Gas bubbles in ice are particularly exciting to scientists because they preserve ancient samples of the earth's atmosphere, which we can measure to learn about earth's climate in the past.
How the research was done: For an ice core from the South Pole, the age of the ice was measured in 2019, and we are building on those results by measuring the age of the gas bubbles. We did this by measuring a very important gas called methane. We compared the changes in methane at the South Pole with changes in methane from other ice cores in Antarctica to learn the age of the gasses trapped in our ice core.
What the evidence shows: Our results show that the age of the gas bubbles within the South Pole ice core is up to 52,286 years old. This project means that scientists now know the age of all of the gas bubbles in the South Pole ice core which will be very useful in the future.