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Quantifying paleofire emissions for Antarctic ice cores measured from black carbon in Southern Hemisphere lake sediments

Content

Fires are an important ecological agent that has driven terrestrial ecosystem change. Black carbon aerosols emitted from fires and fossil fuel contribute to radiative forcing of climate. Understanding long-term black carbon dynamics is crucial to quantify how humans have modified burning regimes and to disentangle biomass and fossil-fuel burning sources during the Industrial Era of the past 150 years. For example, previous charcoal-based studies from New Zealand lakes and ice core-based studies from Antarctica suggest a strong increase in fire activity in ecosystems where fire was rare after the arrival of the Polynesian Māori (1200-1300 CE) that potentially resulted in increased black carbon aerosols over vast areas of the Southern Hemisphere. Existing black carbon records are limited to remote ice core sites far from potential emission sources. This hamper our ability to spatiotemporally link black carbon records to lake sediment-based paleofire records such as charcoal analyses.

Directly measuring black carbon deposition near fire emission sources using lake sediments may provide an important link between source regions and the observed black carbon deposition on the Antarctic ice sheet. We developed contiguous, high-resolution Holocene black carbon records from an array of eight low-latitude lakes across New Zealand, Tasmania, Patagonia, and Africa using an incandescence-based Single Particle Soot Photometer (SP2)-method for black carbon measurements in lake sediments.

Our records suggest that black carbon in Southern Hemisphere lake sediments is spatially variable over time. Black carbon record from sheltered mountain sites, such as Horseshoe Lake on New Zealand's South Island and Wombat Pool in Tasmania, show striking similarities during the past millennium with previous macroscopic charcoal. Other sites that are more likely to receive long-distance deposition show less similarity between black carbon and charcoal trends. We hypothesize that black carbon in these lakes (e.g., coastal lakes) may include sources from distant regions in addition to black carbon from local fires. Such distal burning emissions are not captured in the charcoal fraction. Lake sediments in New Zealand suggest a significant increase in black carbon deposition with the begin of human fire use after 1200 CE. Black carbon records in other Southern Hemisphere suggest low black carbon deposition in response to wetter climate trends in the Late Holocene preventing regional fire activity. Our black carbon dataset from the Southern Hemisphere may provide quantification of a key emission source for black carbon deposition variability on the Antarctic ice sheet and a direct link between black carbon source emissions and black carbon records in remote polar ice archives. Moreover, we provide new information on past Southern Hemisphere mid-latitude black carbon emissions that can improve climate and fire models, and inform policy decisions.

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