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Fire emission reconstruction in Africa during the last 500 years: A pilot study

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Fire emissions directly affect the global carbon cycle and atmospheric chemistry, yet little is known about past fire variability and the impacts of aerosols produced by biomass burning on the climate system. Tropical savanna fires are the dominant source of carbon from fire emissions and provide more than sixty percent of the global total. The Kilimanjaro ice fields (3º04.6'S; 37º21.2'E, 5893 meters above sea level) are located near the largest savanna system in the world. Glaciers on Kilimanjaro trap and preserve atmospheric aerosols produced by tropical savanna fires. The Kilimanjaro ice cores supply a high-resolution equatorial proxy record that provides a nearly-continuous record of climate parameters (temperature, accumulation, atmospheric chemistry, and aridity) as well as presenting the opportunity for the use of a novel technique to examine the regional fire history. Levoglucosan (1,6-anhydro--D-glucopyranose) is a major component of and a globally present molecular tracer for atmospheric biomass burning. Here, we use triple quadrupole tandem mass spectrometry to quantify past concentrations of levoglucosan, and consequently biomass burning, in the Kilimanjaro ice core.

The investigation of organic atmospheric tracers is expanding the limits of proxy information gleaned from ice cores and provides data for the least understood area of the climate system. Levoglucosan has been measured in Antarctic ice samples, but this work presents the first measurements of levoglucosan on low-latitude ice. Tropical ice cores are located closer to centers of human activity and vegetation than polar cores and therefore are better able to display changes in regional activity such as biomass burning than the polar cores, which provide an integrated global signal. Levoglucosan can be precisely determined due to the lack of other compounds that cause interference with the peak identification in the chromatogram. Initial tests for the presence and levels of levoglucosan were conducted on the Kilimanjaro Northern Ice Field (NIF3) ice core at the Institute for the Dynamics of Environmental Processes-CNR (IDPA-CNR) resulting in concentrations up to 96 pg/mL, demonstrating the repeatability of the results and the applicability of the method to tropical ice. These results allow for the creation of a comprehensive decadal to centennial history of African savanna fires over the past 4000 years using levoglucosan as an atmospheric molecular tracer for biomass burning. We integrate a record of organic compounds with traditional ice core analyses of ionic species and dust to expand the current understanding of the climate system with implications for the global carbon cycle.