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The controversial age of Kilimanjaro's plateau glaciers

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Interpreting climate signals contained in natural archives requires a precise chronology. Radiocarbon analysis can be a powerful tool for dating high-altitude ice cores, especially for the lowermost segments for which ice flow-induced thinning limits the counting of annual layers. Radiocarbon dating has been applied to ice cores containing sufficient organic material, which is a limiting factor to the wider application of this technique. We present a novel radiocarbon dating approach using carbonaceous aerosols enclosed in the ice to help resolve the debate about the age of the Kilimanjaro's plateau glaciers. Paleoclimate reconstructions based on six ice cores drilled in 2000 assigned a basal age of 11'700 years. A recent study claims recurring cycles of waxing and waning controlled primarily by atmospheric moisture and an absence of the ice bodies was suggested for 1200 AD. The Kilimanjaro ice fields are subject to rapid areal shrinkage and thinning and are expected to disappear within several decades. Resolving the controversy of the time frame for the extinction of the Kilimanjaro ice might have wide implications for the understanding of the natural climate variability in the tropics.

A stratigraphic sequence of samples from the exposed vertical ice cliffs at the margins of the Northern Ice Field (NIF) was collected in 2011. A total of 45 horizontal short cores (50 cm length) were extracted from 22 horizons characterized by varying micro-particle concentrations. Additionally, 3 samples were taken from the glacier surface to investigate a potential age offset. All samples were shipped frozen to Paul Scherrer Institute, decontaminated in a cold room by removing the outer layer (0.3 mm) and by rinsing the samples with ultra-pure water. The insoluble carbonaceous particles were filtrated by using freshly preheated quartz fibre filters. Procedural blanks were estimated using artificial ice blocks of frozen ultra-pure water treated as real ice samples and were consistent with previously reported blanks. The combustion of the filters was conducted by means of a thermo-optical OC/EC analyser (Model4L, Sunset Laboratory Inc, USA), using a well-established protocol (Swiss 4S) for OC/EC separation. Analyses of 14C were conducted using the compact radiocarbon AMS system 'MICADAS' equipped with a gas ion source, directly coupled to the Sunset instrument. Conventional 14C ages were calibrated using OxCal v4.2.4 software with the SHCal13 calibration curve.

The results of 14C calibrated ages for the South and North cliffs of the Kilimanjaro NIF span between modern ages on surface to 1200 AD at the bottom. Our 14C analyses results support the hypothesis that the ice on Kilimanjaro's plateau has come and gone repeatedly throughout the Holocene and have an age which differs considerably from the ice core assigned basal age of 11'700 years. It is possible that the cores collected further from the margin of the NIF contained older ice which is not present at the margins. If this is the case, the older ice must be relict, implying one or more long hiatuses, and a non-continuous record. Therefore, further investigations are necessary.