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Rapid emergence of the Sahara as an important source of Greenland dust after the Younger Dryas onset

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The Younger Dryas (YD) abrupt cold event, which followed the warm Allerød period, was characterized by rapid climatic and environmental shifts across the Northern Hemisphere. Despite considerable research, accurately simulating YD climate remains challenging, particularly in the Arctic, due to a limited understanding of the negative radiative forcing induced by changing dust cycles. This dust-induced radiative forcing depends on the transport dynamics of dust from source regions to the Arctic, emphasizing the importance of identifying Arctic dust provenance during abrupt climatic transition from the Allerød to YD period. Here, we present the first high-resolution records of Pb isotopic compositions, mineralogical abundances, and geochemical properties from the Greenland Summit (GRIP and GISP2) ice cores, covering the Allerød–YD transition (12,731–12,967 years before A.D. 2000). Our findings indicate that early-YD dust exhibited more radiogenic Pb isotopic compositions ($^{206}Pb/^{207}Pb$: 1.192 ± 0.011, $^{208}Pb/^{207}Pb$: 2.469 ± 0.014), higher kaolinite-to-chlorite (K/C) ratios (1.1 ± 0.6), and elevated chemical index of alteration (CIA) values (70.1 ± 4.1) compared to late-Allerød dust (1.186 ± 0.014, 2.460 ± 0.015, 0.6 ± 0.3, and 64.2 ± 3.7, respectively), with the differences being statistically significant. By comparing these ice-core records with those from potential dust source areas (e.g., East Asian deserts and the Sahara desert), we find that Asian deserts remained the dominant contributor to Greenland dust throughout the Allerød–YD transition. However, Saharan dust contributions increased following the onset of the YD. This shift in dust provenance likely reflects changes in dust emission rates from source regions and variations in atmospheric circulation patterns that transported dust to Greenland, both of which were influenced by abrupt climate change. Our results are broadly consistent with previous estimates of proportional dust source contributions based on Pb and Sr isotopic compositions in Greenland NEEM ice and provide valuable insights into the relationship between abrupt climate change and dust cycle dynamics.