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Natural variability and recent warming in central Greenland ice cores

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Climate variability of the Arctic region has been investigated by means of temperature reconstructions based on proxies from various climate archives around the Arctic, compiled over the last 2000a in the so called Arctic2k record. However, the representativeness of the Arctic2k reconstruction for central Greenland remains unclear, since only a few ice cores have been included in the reconstruction, and observations from the Greenland Ice Sheet (GIC) report ambiguous warming trends for the end of the 20th and the beginning of the 21st century which are not displayed by Arctic2k. Today, the GIC experiences periods with temperatures close to or above the freezing point at high elevations, area-wide melting and mass loss. In order to assess the recent warming as signature of global climate change, records of past climate changes with appropriate temporal and spatial coverage can serve as a benchmark for naturally driven climate variability. Instrumental records for Greenland are short and geographically sparse, and existing temperature reconstructions from single ice cores are noisy, leading to an inconclusive assessment of the recent warming for Greenland.

Here, we provide a Greenland firn-core stack covering the time span of the last millennium until the first decade of the 21st century in unprecedented quality by re-drilling as well as analyzing 16 existing firn core sites. We find a strong decadal to bi-decadal natural variability in the record, and, while the record exhibits several warming events with trends that show a similar amplitude as the recent one, we find that the recent absolute values of stable oxygen isotope composition are unprecedented for the last 1000 years.

Comparing our Greenland record with the Arctic 2k temperature reconstruction shows that the correlation between the two records changes throughout the last millennium. While in the periods of 1200-1300 and 1400-1650 CE the records correlate positively, between 1300 and 1400 and 1650-1700 CE shorter periods with negative correlation are found. Since then the correlation is characterized by alternation between positive and zero correlation, with a drop towards negative values at the end of the 20th century. Including re-analysis data, we hypothesize that the climate on top of the GIC was decoupled from the surrounding Arctic for the last decades, leading to the

observed mismatch in observations of warming trends.

We suggest that the recently observed Greenland temperatures are a superposition of a strong natural variability with an anthropogenic long-term trend. Our findings illustrate that global warming has reached the interior of the Greenland ice sheet, which will have implications for its surface mass balance and Greenland's future contribution to sea level rise.

Our record complements the Arctic 2k record to a profound view on the Arctic climate variability, where regional compilations may not be representative for specific areas.