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The role of volcanism for abrupt climate change during the last glacial period

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During the last glacial period, abrupt climate events known as Dansgaard-Oeschger (DO) and Heinrich events have been observed in various types of Northern Hemispheric (NH) paleoclimate archives. It has been speculated that volcanism may play a role in the abrupt climate variability of the last glacial period, for example as a trigger of abrupt changes. The investigation of a possible link between abrupt climate events and volcanic eruptions has been hampered by the lack of a global volcanic eruption record from the last glacial period. A recent identification of 80 major bipolar volcanic eruptions in Greenland and Antarctic ice core records within the interval 12-60 ka BP now enables us to investigate this link.

Using high-resolution ice-core records of climate ($\delta^{18}O$), atmospheric circulation changes (calcium) and volcanic eruptions (sulfate and other volcanic proxies) we investigate the timing of abrupt climate events and large volcanic eruptions at decadal resolution. We consider possible links between major volcanic eruptions and DO onsets (NH warming), DO terminations (NH cooling), and Heinrich stadials (strong NH cooling). Heinrich stadials are cold Greenland stadial periods during which Heinrich events occurred; large Hudson Strait iceberg discharge events that are characterized by deposition of significant amounts of ice rafted debris in North Atlantic marine sediments.

Significant links of volcanic and climatic events are tested in a statistical framework under the null hypothesis of random and memoryless volcanic activity. Our analysis shows that while certainly not all abrupt climate change of the last glacial period is associated with volcanism, we find that volcanism may have induced some abrupt Greenland warming events and perhaps several of the extreme North Atlantic cold Heinrich stadials; no significant link is found between volcanism and DO terminations. We speculate that volcanic cooling can drive such transitions when the coupled system of Atlantic Ocean circulation and North Atlantic sea ice is close to a tipping point.