Geophysical Research Abstracts
Vol. 21, EGU2019-8289, 2019
EGU General Assembly 2019

Volcanic synchronization of abrupt climate change in Greenland and Antarctic ice cores during the last glacial period

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The sections of Greenland and Antarctic ice cores covering last glacial period have previously been synchronized primarily by their common records of gas concentrations and cosmogenic isotopes. Here, we apply annual layer counting and matching of volcanic peak patterns to synchronize the onsets and terminations of Greenland Interstadials (GI) in Marine Isotope Stage 3 (MIS3, 25-60 ka). Based on the identification of more than 50 significant bipolar volcanic events throughout MIS3, most abrupt climate events can be synchronized between the two Hemispheres at decadal precision. Layer counting has been performed in the Greenland NGRIP and the Antarctic EDML ice cores using high-resolution records of chemical impurities, dust, and visual grey scale intensity. The time scales obtained from layer counting are not always in agreement with existing ice core chronologies. Volcanic peak patterns have been identified in all available acidity records from the Greenland GRIP, GISP2, NGRIP, and NEEM and the Antarctic EDML (Atlantic sector), EDC (East Antarctic plateau), and WDC (West Antarctica) ice cores. The obtained volcanic synchronizations within Greenland and within Antarctica are in agreement with existing volcanic synchronizations. The bipolar volcanic synchronization is supported by cosmogenic record patterns at several of the major GI onsets and it is in accord with the cosmogenic synchronization at around the geomagnetic Laschamp event (41 ka). The bipolar volcanic synchronization is offset from the NGRIP-WDC methane synchronization by up to 150 years, generally pushing the Antarctic record towards older ages at the GI onsets. The general Antarctic response to a GI onset is a direct warming at the EDC and WDC sites that peaks within a century and a less significant cooling at the EDML site, possibly attributed to a northward shift of the southern hemisphere westerly winds. This pattern is however not consistent among all GI onsets and in particular the weaker GI events show deviating Antarctic response patterns. Several of the sharp Greenland climate transitions in MIS3 are associated with periods of strong volcanism suggesting that volcanism may work as a trigger of abrupt climate change. Other abrupt transitions are not associated with volcanism and many strong volcanic events do not show a response in the climate records. Overall, the bipolar volcanic synchronization gives strong support for the suggested bipolar seesaw mechanism.