Volcanic imprint in the North Atlantic climate variability as recorded by stable water isotopes of Greenland ice cores

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Research Letter

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Abstract

Volcanic eruptions are important drivers of climate variability on both seasonal and multi-decadal time scales as a result of atmosphere-ocean coupling. While the direct response after equatorial eruptions emerges as the positive phase of the North Atlantic Oscillation in the first two years after an eruption, less is known about high latitude northern hemisphere eruptions. In this study we assess the difference between equatorial and high latitude volcanic eruptions through the reconstructed atmospheric circulation and stable water isotope records of Greenland ice cores for the last millennia (1241-1979 CE), where the coupling mechanism behind the long-term response is addressed. The atmospheric circulation is studied through the four main modes of climate variability in the North Atlantic, the Atlantic Ridge, Scandinavian Blocking and the positive and negative phase of the North Atlantic Oscillation. We report a difference in the atmospheric circulation response after high latitude eruptions compared to the response after equatorial eruptions, where the positive phase of the North Atlantic Oscillation and the Atlantic Ridge seem to be more associated with equatorial eruptions while the negative phase of the North Atlantic Oscillation seems to follow high latitude eruptions. This response is present during the first five years and then again in years 8-12 after both equatorial and high latitude eruptions. Such a prolonged response is evidence of an ocean-atmosphere coupling that is initiated through different mechanisms, where we suspect sea ice to play a key role.

Full Text

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Figures

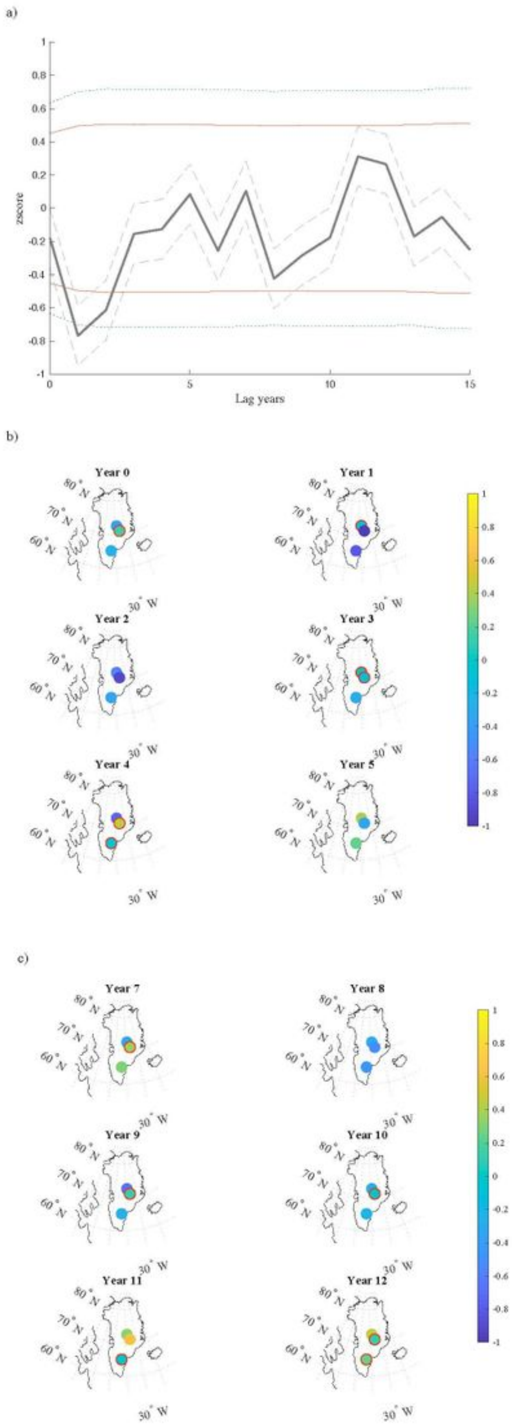
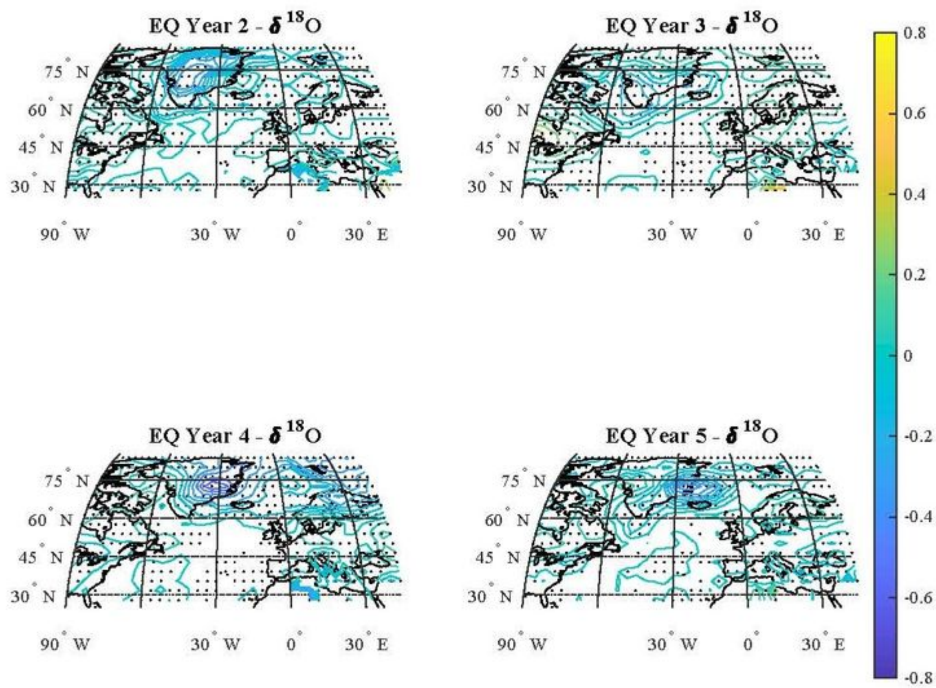


Figure 1

a) The average δ18Oice anomalies of all three ice cores (Dye 3, GRIP and Crete) in a) years 0-15 and for individual sites in b) years 2-5 and c) years 7-12 after a composite of 13 EQ eruptions. Blue color indicates lighter (depleted in 18O) δ18Oice while yellow indicate heavier δ18Oice (enriched in 18O).Red circles indicate insignificant response, compared to the other colored dots that are significant at the 95% confidence level calculated with respect to bootstrapped ice cores. In a) the red line indicate 95%

confidence level (c.l.) and the orange 99% c.l. that is calculated by methods of Monte Carlo (see methods).

a)



b)

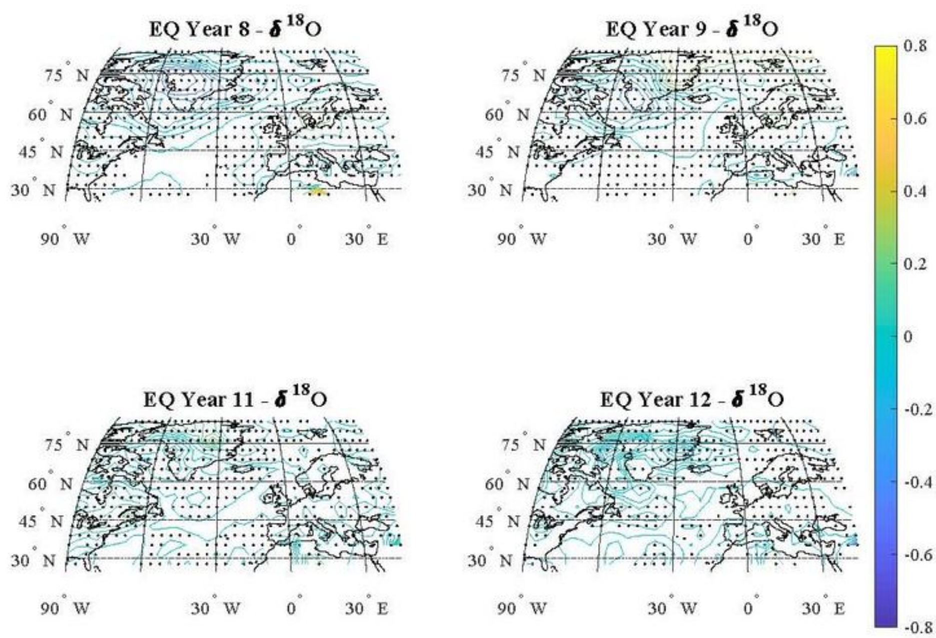


Figure 2

The normalized (mean=0, standard deviation=1) δ18Oreconst response a) 2-5 years and b) 8-12 years after a composite of 8 EQ volcanic eruptions. Blue color indicates lighter (depleted in 18O) δ18Oreconst while yellow indicate heavier δ18Oreconst (enriched in 18O). Black dots are significant at the 95% confidence level calculated with respect to bootstrapped δ18Oreconst.

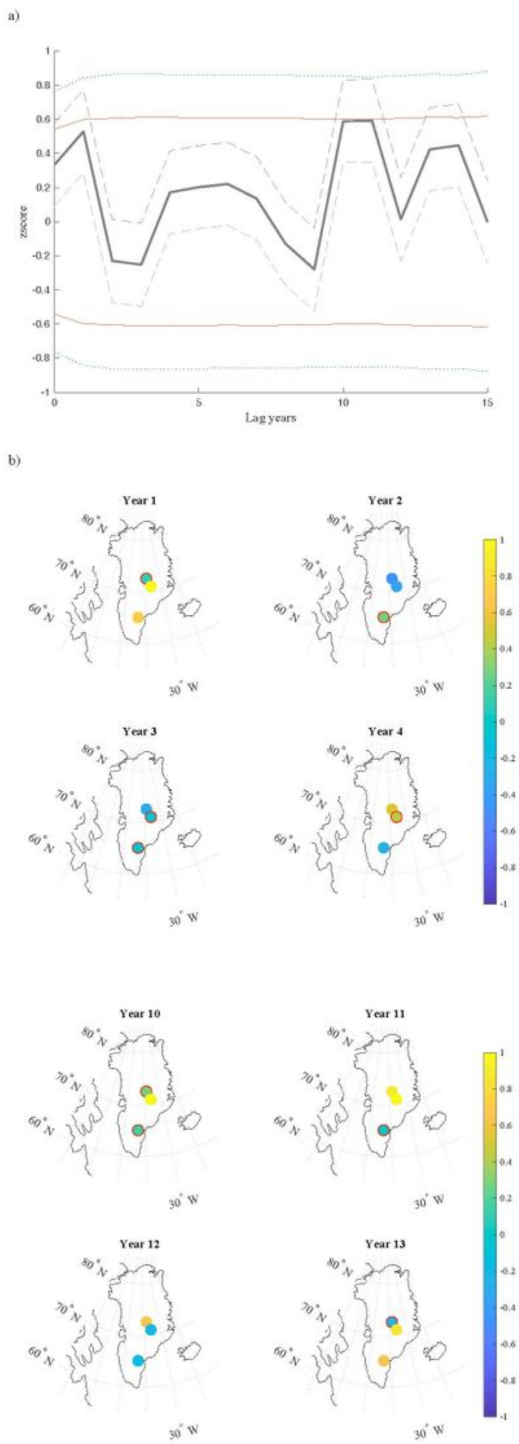


Figure 3

a) The δ18Oice anomalies of all three ice cores (Dye 3, GRIP and Crete) 229 in a) years 0-15 and at individual sites in b) years 1-4 and c) years 10-13. Blue color indicate lighter (depleted in 18O) δ18Oice while yellow indicate heavier δ18Oice (enriched in 18O). Red circles indicate insignificant response, compared to the other colored dots that are significant at the 95% confidence level calculated with respect to bootstrapped ice cores. In a) the red line indicate 95% c.l. and the orange 99% c.l. that is calculated by methods of Monte Carlo (see methods).

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