Time lags between sea surface and air temperatures at the time of the Younger Dryas in palynological records from the Northwest Atlantic

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Abstract

The Younger Dryas (YD) in Bay of Islands, Newfoundland is characterized by major changes in both pollen and dinocyst assemblages, which translate into large drops in air and sea surface temperatures and sea surface salinity. Changes in vegetation are similar with those observed in Newfoundland lakes. Reconstructed air temperature shows a 7ºC drop at the time of the YD, an amplitude comparable to changes recorded in northeastern North America. Changes observed in dinoflagellate cyst assemblages are also like those at nearby sites from the Gulf of St. Lawrence and Laurentian Channel. Sea surface dropped by 7ºC, salinity by 4 psu and sea ice cover duration increased by 7 months. The YD period in eastern North America was traditionally defined by changes in sediments and pollen records. Our records show that the cooling in sea surface and air temperatures started 250 and 110 years before the start of the YD as defined by radiocarbon dates and pollen zones. By having exceptionally high resolution records for both terrestrial and marine conditions in the same core, we can show that there is a 140 years delay between ocean and atmosphere. We speculate that the major lithological and vegetation changes observed in lakes around the time of the YD period in eastern North America might actually represent the full impacts of the cooling, since the cooling trend actually started before the start of the YD period.

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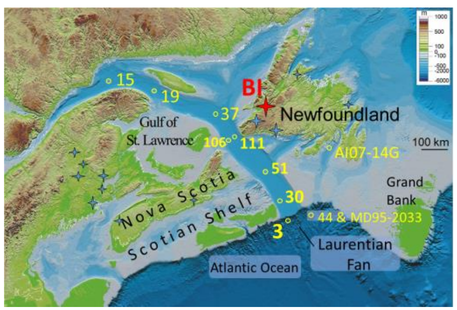
Introduction The Younger Dryas cold event, 12,900-11,700 b2k (Rasmussen et al., 2006) was caused by a slowdown in the AMOC, induced by the catastrophic drainages of large glacial lakes to the North Atlantic (Björck et al., 1996) via the St. Lawrence River valley (Levac et al., 2015). However, it was suggested that changes in atmospheric circulation were involved (Bakke et al. 2009) . We thus used exceptionally high resolution records for both terrestrial and marine conditions in the same core, to assess which of the ocean or atmosphere leads the changes.

Figure 1 Location map showing Bay of Islands (red dot) and nearby sites with YD records (modified from Levac et al. 2015)



Methods
Core MD99-2225 was processed for palynological analysis. Reconstructions of sea surface conditions are based on dinoflagellate cyst records, using the modern analog method (de Vernal et al., 2001). Pollen data was used to reconstruct air temperatures with the modern analogue technique (Overpeck et al., 1985) using C2 software (Juggins, 2010).

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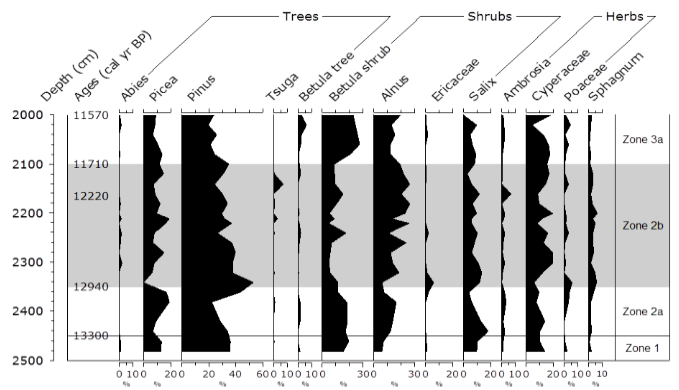
Figure 2 Pollen diagram for core MD99-2225. Percentages are based on the pollen sum (tree, shrub and herb), but excludes spores. The YD period , shown by the grey shading, is defined by ^{14}C dates from pollen diagrams from Eastern Canada (Mayle and Cwynar, 1995; Mayle et al., 1993)



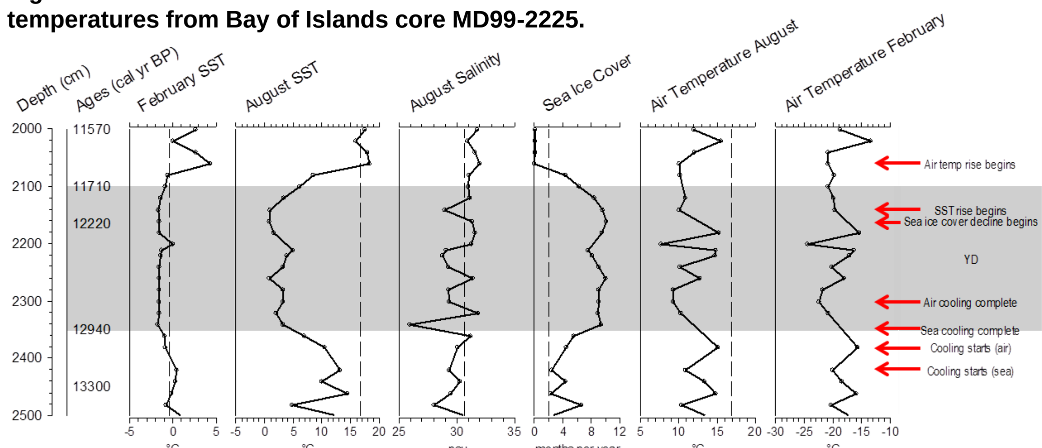
Results

-A major vegetation reversal occurred at the start of the YD, as seen in nearby pollen records.

-Dinoflagellate cyst assemblages (not shown) also show major changes, similar to those at nearby marine sites (Levac et al. 2015).

-Air temperature shows a 7ºC drop at the time of the YD. Sea surface temperature (SST) dropped by 7ºC, salinity by 4 psu and sea ice cover duration increased by 7 months (figure 3).

Figure 3 Reconstructions of sea-surface conditions and air temperatures from Bay of Islands core MD99-2225.



Results (cont.)

-The cooling in sea surface and air temperatures started 250 and 110 years before the start of the YD as defined by ^{14}C date, lithological changes and pollen zones.

-There is a 140 years delay between ocean and atmosphere.

-These results underline the importance of using a variety of proxies to reveal temporal variability such as vegetation lags.

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Conclusions
The YD period in eastern North America was traditionally defined by changes in sediments and pollen records. We speculate that the major lithological and vegetation changes observed in lakes around the time of the YD period in eastern North America might actually represent the full impacts of the cooling, since the cooling trend started before the start of the YD period.