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Provincialism in trends and high frequency changes in the northwest North Atlantic during the Holocene

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Abstract

In the present paper, we report on micropaleontological (dinocysts) and isotopic (^{18}O and ^{13}C in foraminifers) analyses performed in Holocene sediments from fifteen cores raised from the central and northwest North Atlantic. Sea-surface temperature (SST), sea-surface salinity (SSS), thus potential density, and sea-ice cover are reconstructed based on dinocyst assemblages. After proper calibration, oxygen isotope data on the mesopelagic foraminifer *Neogloboquadrina pachyderma* left coiled (Npl) are converted into potential density values deeper in the water column, thus allowing documentation of vertical density gradients and identification of intervals favourable for winter convection to occur with formation of intermediate Labrador Sea Water (LSW). The most important findings from this study include: (1) the existence of an early-mid Holocene thermal optimum with positive anomalies up to 6 °C above present along the main SW–NE axis of the North Atlantic Current, but no significant SST maximum at most sites along eastern Canadian margins; (2) the evidence for larger than present amplitude of annual SSTs during the early Holocene, thus for a stronger seasonality; (3) minimum sea-ice cover from 11 500 to 6000 cal years BP, and a slight increase of sea-ice variability, and average seasonal duration of 0.5 to 1 month per year afterwards; (4) variable SSS during the entire Holocene, suggesting changes in the routing and rates of freshwater–meltwater discharges from the Arctic and eastern Canada; (5) the setting of conditions compatible with LSW production after 8 ka only, and likely a more steady production during the late Holocene; (6) an overall trend for a potential density increase of the Labrador Sea, throughout the Holocene, matching a decreasing trend eastward, thus suggesting a progressive enhancement of the western branch of the Atlantic Meridional Overturning with respect to its northeastern route; and (7) indication of maximum production and fast dispersal of LSW in the entire North Atlantic during recent times only, as suggested by linearly-converging δ^{18}O-values of Npl from all sites, towards its modern relatively homogeneous composition (~ 2.5/2.6‰). The overall picture of the Holocene North Atlantic arising from this study is that of a basin marked by a strong regionalism with large discrepancies in hydrographical trends and high frequency oscillations, at least partly controlled by freshwater–meltwater routes and rates of export from the Arctic.

Keywords: Holocene; North Atlantic; Labrador Sea; dinocysts; oxygen-isotopes; foraminifers; sea ice; temperature; salinity; seasonality

1. Introduction

The present interglacial is the focus of many ongoing paleoclimatic studies aimed at documenting the natural variability of climate at millennial to sub-millennial time scales. High frequency ocean and climate changes at mid- to high latitudes of the North Atlantic and adjacent

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lands during the Holocene have been reported in many publications over the past few years (e.g., O'Brien et al., 1995; Bond et al., 1997; Bianchi and McCave, 1999; Darby et al., 2001; Sarnthein et al., 2003; Solignac et al., 2004). However, the records are heterogeneous depending upon the proxy used to document climate or ocean changes and the location of study sites (cf. Mayewski et al., 2004 for a synthesis). The trends, as well as the amplitude of high frequency oscillations also appear variable from one record to another and the mean periodicity of changes ranges between 400 and 3000 years, suggesting the influence of different forcing mechanisms characterised by distinct time constants (cf. Schulz et al., 2004).

In the North Atlantic and adjacent western European lands, the records of climate changes generally show a cooling trend from an early Holocene optimum often designated as the "Hypsithermal" (Mangerud et al., 1974; about 9–5.7 ka BP). This optimum is, however, not synchronous over high northern latitudes (e.g., Kaufman et al., 2004) and the available Holocene paleotemperature data from the North Atlantic have shown variable amplitudes for the mid-late Holocene cooling trend from site to site (e.g., Marchal et al., 2002; Andersen et al., 2004a,b; Moros et al., 2004; Rimbu et al., 2004). Both the spatial difference in the long-term Holocene trends and the discrepancies seen in the high frequency records from marine sediments suggest regionalism in Holocene climate and ocean changes. They also point to complex ocean dynamics, with internal oscillations playing possibly a determinant role in addition to external forcing (cf. Paul and Schulz, 2002). In this context, it appears relevant to further document the Holocene changes with special focus on the northern North Atlantic because it is a key oceanic region with respect to the general thermohaline circulation (THC) and latitudinal heat fluxes, which

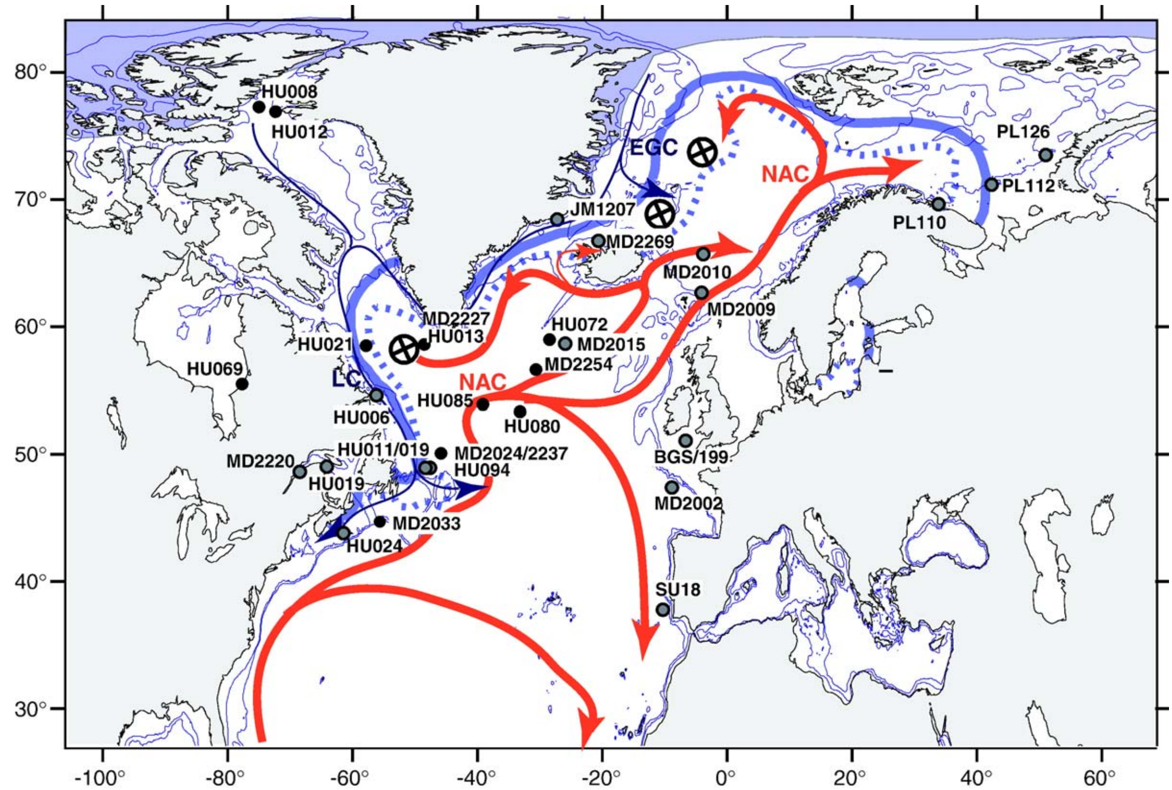

Fig. 1. Map of the northern North Atlantic showing the location of core sites referred to in the text (see Table 1). Black dots correspond to sites where sea-surface reconstructions based on dinocyst assemblages are presented here. The distribution of perennial sea ice corresponds to the area shaded in light blue, and the limits of the mean winter sea-ice and the extreme sea-ice extent are indicated by the thick line and the dashed light blue line, respectively. The isolines correspond to the 200 m and 1000 m isobaths. The arrows illustrate schematically the surface circulation of the North Atlantic (redrafted after Meincke, 2002). The orange arrows correspond to the poleward flow of the North Atlantic Current (NAC) that forms the upper limb of the Atlantic Meridional Overturning. The dark blue arrows correspond to southward flow of Arctic waters through the East Greenland Current (EGC) and the Labrador Current (LC). Circle crosses correspond to centers of vertical convection and deep-water formation. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)