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Simulated Sediment Transport in Modeling of the Ocean Circulation Changes Caused by Southern Meltwater Events

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Introduction

Glacial-to-interglacial climate transitions are characterized by distinct basin–wide sediment accumulation patterns that can reveal ocean circulation changes that occur during these transitions. A combination of an ocean global circulation model (MOM 2) and a large–scale 3–D sediment transport model (SEDLOB=SEDiment transport in Large Ocean Basins) is used to model the global ocean thermohaline conveyor and distribution of the global sediment accumulation rates at present (MOD), at the last glacial maximum (LGM), and a subsequent meltwater event (MWE).

Table 1

Experiment	SST	SSS
MOD	SST from present-day sea surface climatology [Levitus and Boyer, 1994]	SSS from present-day sea surface climatology [Levitus et al., 1994].
LGM	CLIMAP [1981] SST is used everywhere except for the NA to the north of 50°N and east of 40°W, where the data from Schulz [1994], summarized by Sarnthein et al. [1995] and processed by Seidov et al. [1996] replace the CLIMAP data	The present day SSS was increased by 1 psu according to Duplessy et al. [1991]; in the NA, to the north of 10°N, the data set is from Duplessy et al. [1991] and Weinelt et al. [1993], summarized by Sarnthein et al. [1995] and processed by Seidov et al. [1996]
MWE	as for the LGM except for the NA to the north of 50°N and east of 40°W, where SST from Weinelt et al. [1993], summarized in Sarnthein et al. [1995] and processed in Seidov et al. [1996] replace the LGM SST	As in LGM, except for the NA north of 50°N and east of 40°W where SSS from Weinelt et al. [1993], summarized in Sarnthein et al. [1995] and processed in Seidov et al. [1996] replace the LGM surface salinity.

To identify the regions of the world ocean that are most sensitive to changes in glacial and interglacial climate and to compare with geologic record, a realistic present–day eolian dust distribution (Fig. 1) as the sediment input in the sediment transport model was prescribed at the sea surface:

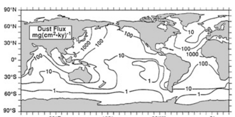


Figure 1: Estimate of the rate of deposition of mineral dust based on consideration of atmospheric transport (reproduced from Rea (1994) after Duce et al. (1991)).

Reference: Seidov, D. and B.J.Haupt, 1999, Last glacial and meltwater interbasin water exchanges and sedimentation in the world ocean: Paleoceanography, v. 14, p. 760-769.

Glacial-to-interglacial changes

The global ocean thermohaline circulation (THC) is believed to be most strongly controlled by the production of North Atlantic Deep Water. Our simulations demonstrate that the THC in the North Atlantic was substantially altered during the LGM and MWE. One indicator for these changes is the northward oceanic heat transport in the Atlantic Ocean (Fig. 2). The LGM heat transport (Fig. 2, blue curve) is twice as weak as those in MOD (Fig. 2, green curve). The collapsed conveyor during meltwater event can be clearly seen by the Southern Ocean heat piracy (Fig. 2, red curve).

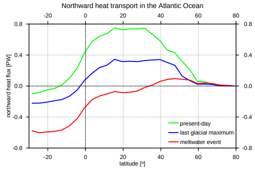


Figure 2: Northward Atlantic heat flux in the Atlantic Ocean (in PW; 1 PW=10^{15} W).

a) MOD-LGM

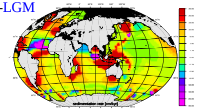
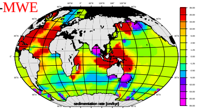
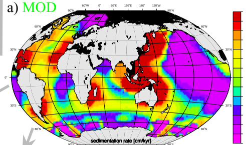


Figure 4: Differences of sedimentation rates between present-day and LGM (a) and prepresent-day and MWE (b). The color bar gives the scale of the thickness (in cm) of sediment accumulated during 1000 years, or sedimentation rates in cm/1000 years.

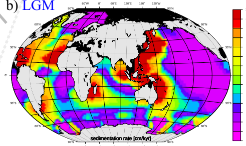
b) MOD-MWE



a) MOD



b) LGM



c) MWE

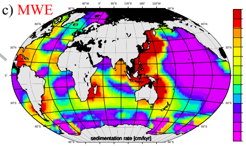


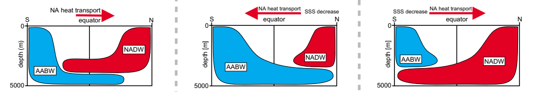
Figure 3: Simulated sedimentation rates for present-day (a), LGM (b), and MWE (c). The color bar gives the scale of the thickness (in cm) of sediment accumulated during 1000 years, or sedimentation rates in cm/1000 years.

The modeled changes of sedimentation deposition rates, linked to changes of the global deep-sea THC help to identify regions of the world ocean that are most sensitive to the glacial and meltwater impacts (Fig. 3). The largest sedi-mentation change is in the key conveyor areas and areas of maximum kinietic energy in the western boundary currents.

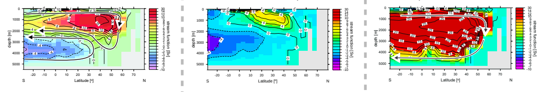
Ocean bi-polar seasaw: Southern versus northern metlwater events

Model simulations demonstrate that meltwater impacts in one hemisphere may lead to strengthening of of the thermohaline conveyor driven by the source in the opposite hemisphere. This leads to significant changes in poleward heat transport and to either deep-sea warming or cooling that could result in a substantial sea level change even without a major ice sheet melting.

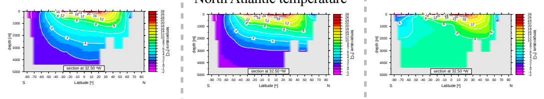
present-day control run | NA meltwater event (1 psu) | SO meltwater event (1 psu)



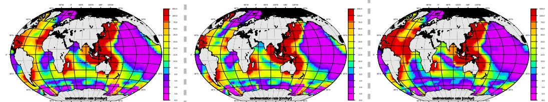
North Atlantic streamfunction (in Sv; 1 Sv=10^6 m^3/s)



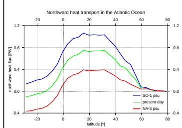
North Atlantic temperature



Sedimentation rates (eolian sediment source: present-day distribution, see Fig. 1)

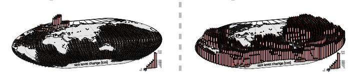


Northward heat flux in the Atlantic Ocean (1 PW=10^{15} W).



Sea level change (in cm) relative to bottom between:

NA-3 psu and control run | SO-1 psu and control run



Reference: Seidov, D., Barron, E.J., and Haupt, B.J., 2001, Meltwater and the global ocean conveyor: Northern versus southern connections: *Global and Planetary Change*, in press.