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Tracing Water and Sediment Transport in Simulations of Present-day, Glacial, and Interglacial Ocean Circulation Regimes

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Overview

Modeling the global ocean thermohaline conveyor at present, at the Last Glacial Maximum, and at a subsequent meltwater event is revisited using a combination of an ocean global circulation model and a sediment transport model. We model changes of sediment deposition rates, linked to the changes of the global deep–ocean thermohaline circulation, provide a better understanding of the glacial–to–interglacial variability of thermohaline currents, and help to identify the regions of the world ocean that are most sensitive to the glacial and meltwater impacts.

Experiments

Surface boundary conditions for the three basic experiments are outlined in **Table 1**. Water transport changes indicate a substantial glacial-to-interglacial variability of the global circulation pattern (**Figure 1**). The surface source of the sediment is assumed to be spatially uniform and the same for all three time slices, and the differences between modern and past eolian sedimentation pattern indicate only changes of the ocean circulation. Therefore we do not yet model a real world sedimentation pattern and our sediment maps do not yet look like any real map of surface sediment accumulation rates. However, one specific feature of terrigenous sediment distribution can easily be seen in the sedimentation maps, namely, the areas of strong impact of the circulation on the sediment drifts (**Figure 2**), which compares well with existing geologic record.

Table 1

Experi-ment	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 , summarized by and processed by , 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 , summarized in Sarnthein et al. [1995] and processed in Seidov et al. [1996] replace the LGM surface salinity.

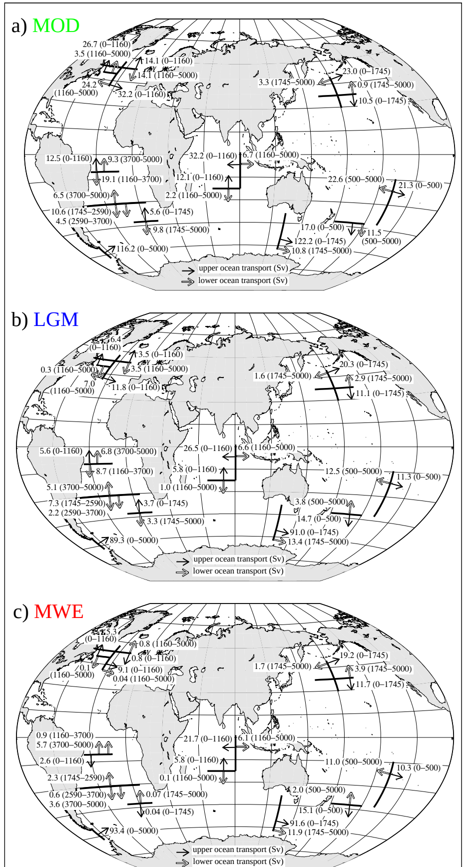

Figure 1. The water transports across the sections in different oceans (in sverdrups; 1 Sv=10 m^3 s^{-1}): (a) MOD, (b) LGM, and (c) MWE. Mostly the transport in the upper and deep ocean are shown; in some cases the transports in three layers are shown to differentiate between the flows in the upper, intermediate–to–deep, and deep–to–abyssal flows in cases when the upper and intermediate waters move essentially different.

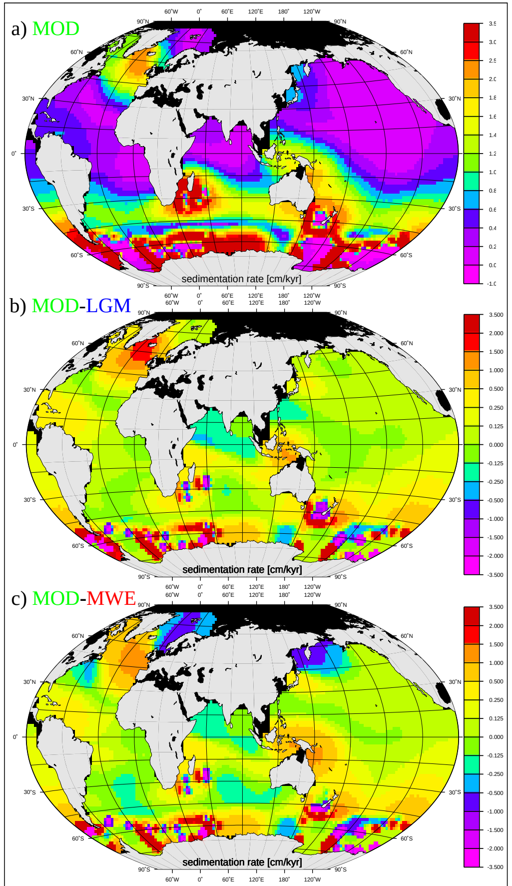

Figure 2. (a) Sedimentation rates in MOD experiment and (b) differences of sedimentation rates between MOD and LGM and (c) between MOD and MWE experiments. The shown sedimentation rates [cm/kyr] are not realistic because of an idealized character of the sea surface eolian sediment source. The goal is to link the changes of sediment drifts to changes of the ocean circulation patterns and interbasin water exchange (see text).

Circulation and Sediment Transport Links

Analysis of velocity maps, water transports and impact of the deep-ocean currents on the sediment drifts shows the links between different ocean basins. In addition to the well–known local changes of the conveyor in the Atlantic Ocean during the last glaciation and subsequent meltwater events, the simulations show the global character of these impacts, detected as far from the North Atlantic as the Indian and the southwestern Pacific Oceans. However, the numerical experiments challenge the idea of a global conveyor–like deep flow strongly connecting the surface waters of northern parts of the North Atlantic and North Pacific Oceans at either glacial or meltwater intervals.

Conclusions

1. Within the limitations of a coarse– resolution model, we demonstrate that the major cooling and meltwater events in the North Atlantic (NA) substantially affected the deep–ocean global conveyor and that changes in the global thermohaline circulation can be traced in simulated eolian sediment deposition rates.

2. Although the conveyor does connect very remote parts of the world ocean, a strong conveyor–like deep–ocean connection of surface waters of the northern NA (NNA) and northern North Pacific (NNP) is not an essential element of the global circulation dynamics.

3. In contrast to the NNA–NNP connection, the midlatitude and tropical western Pacific shows strong sensitivity to cooling and/or freshening in the NA, especially in the southwest Pacific ocean.

References

Seidov, D. and B.J.Haupt: Last glacial and meltwater inter-basin water exchanges and sedimentation in the world ocean, Paleoceanography, 14/6, pp. 760-769, 1999