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

Bernd J. Haupt
Dan Seidov
E-mail: bjhaupt@essc.psu.edu
dseidov@essc.psu.edu
WWW: http://www.essc.psu.edu/~bjhaupt
http://www.essc.psu.edu/~dseidov

PENNSTATE 1855
Earth System Science Center

Introduction

The major unknown in paleoceanographic modeling is whether the changes of circulation can be clearly seen in oceanic sediment, and whether the water mass motion can be effectively traced in ocean models. We present trajectories and sediment patterns obtained using simulation of ocean currents in MOM–2 ocean circulation model. The particles are calculated off–line using velocity and convection depth provided by MOM–2 runs. Sedimentation rates are computed in an off–line sediment transport model. To depict the circulation change only, we use a spatially homogenous inorganic sediment source at the sea surface.

Experiments

We run the model with the specified sea–surface conditions characteristic for different stages of glacial cycle since the last strong glaciation (**Table 1**) Three time slices are chosen as examples of such stages: the Last Glacial Maximum (LGM) of about 18,000 years ago, a subsequent meltwater event (MWE) of about 13,500 years ago, and the present. Lagrangian trajectories help to identfy water paths, whereas comparison of modeled and observed sedimentation patterns reveal the model performance in tracing the circulation stages.

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 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.

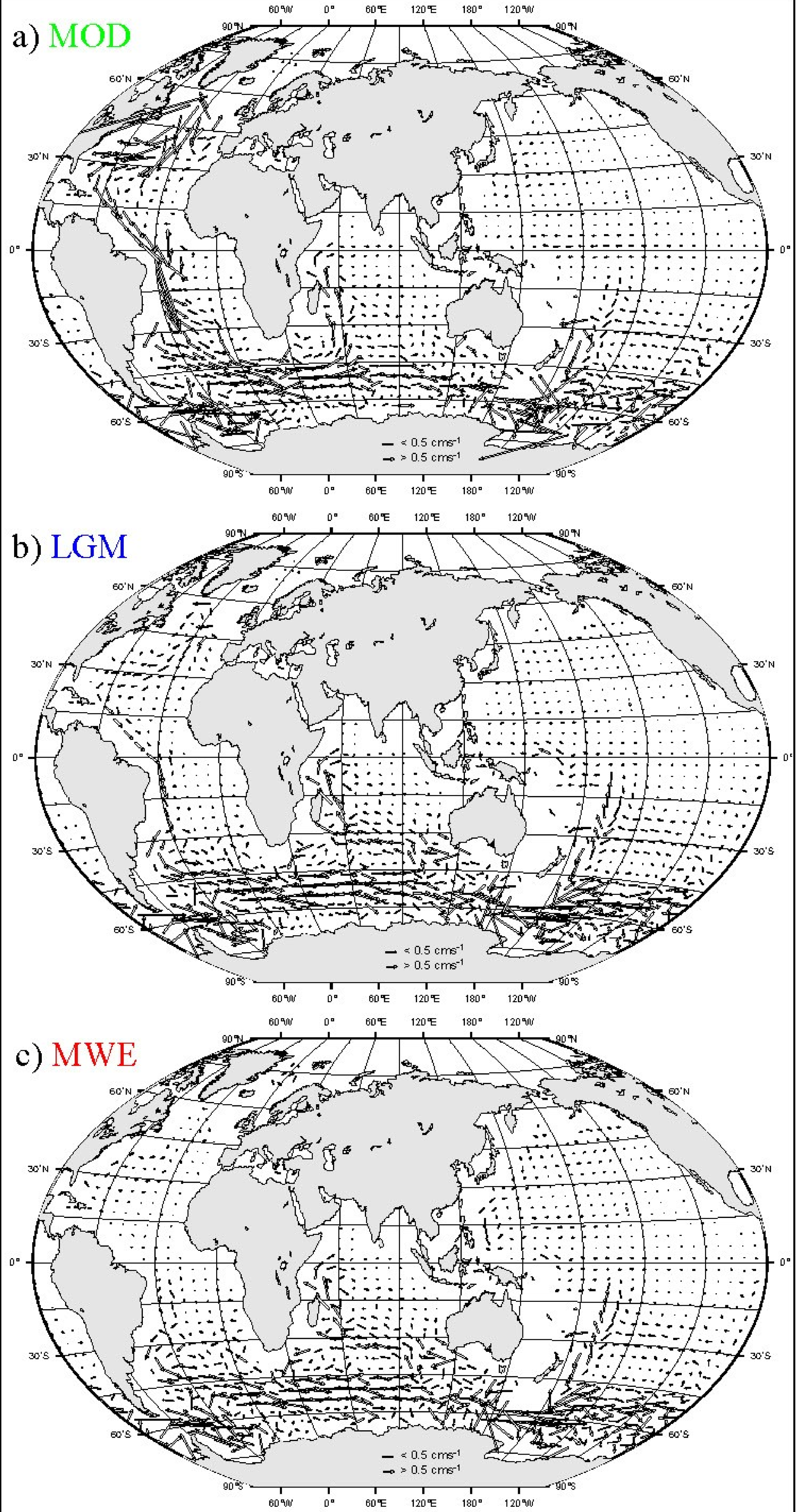

Figure 1. Present–day deep–ocean circulation (a) and its change in two paleocirculation experiments. The present–day circulation conforms to the Stommel–Arons scheme, with major deep–ocean flows shown schematically over the velocity vector map. b) as in a) for LGM, c) as in a) for MWE.

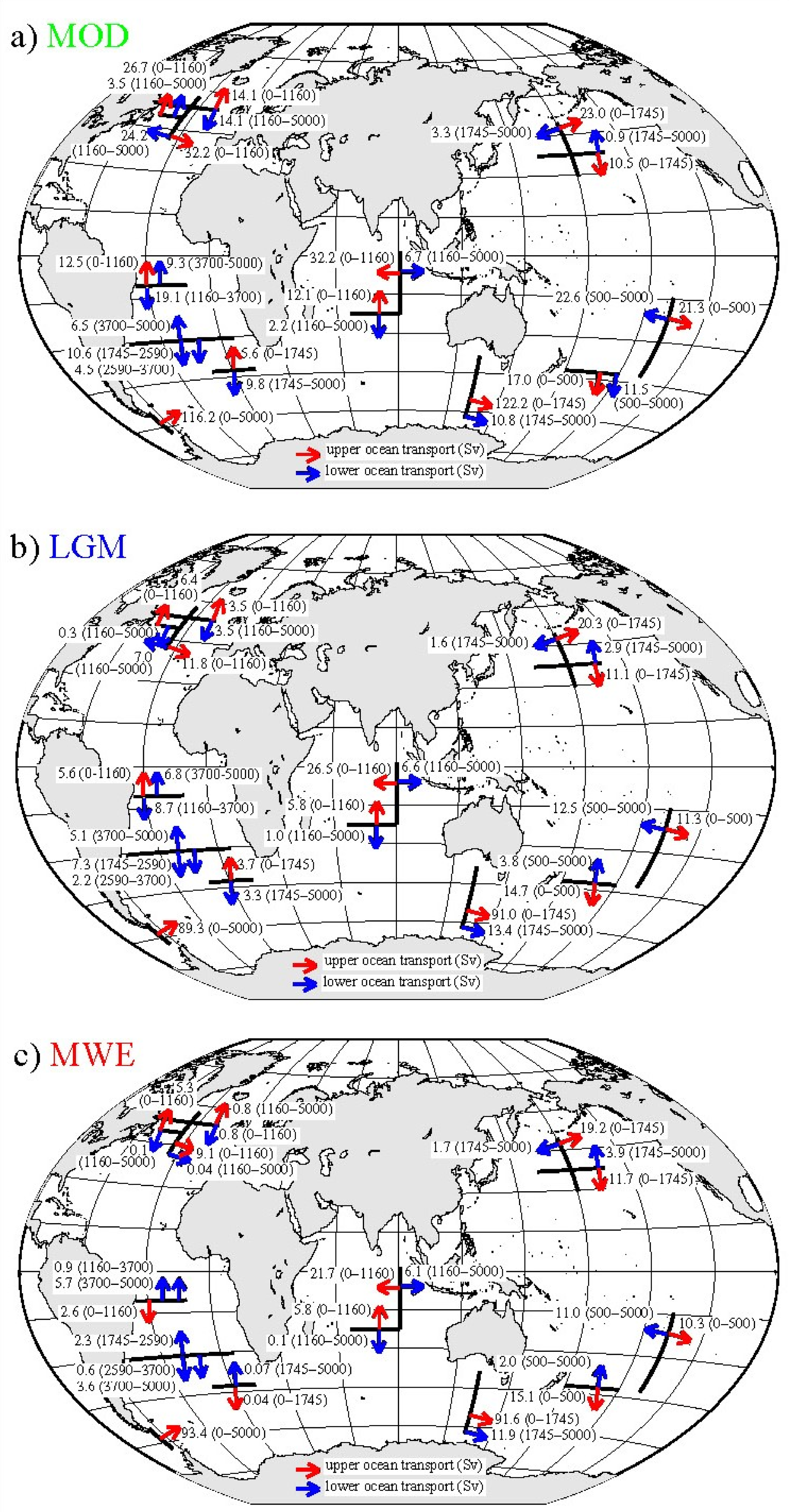

Figure 2. The water transports across the sections in different oceans (in sverdrups; 1 Sv=10 m^3 s^{-1}): (a) MOD, (b) LGM, and (c) MWE. Mostly the transport in the upper and deep ocean are shown; in some cases the transports in three layers are shown to differentiate between the flows in the upper, intermediate–to–deep, and deep–to–abyssal flows in cases when the upper and intermediate waters move essentially different.

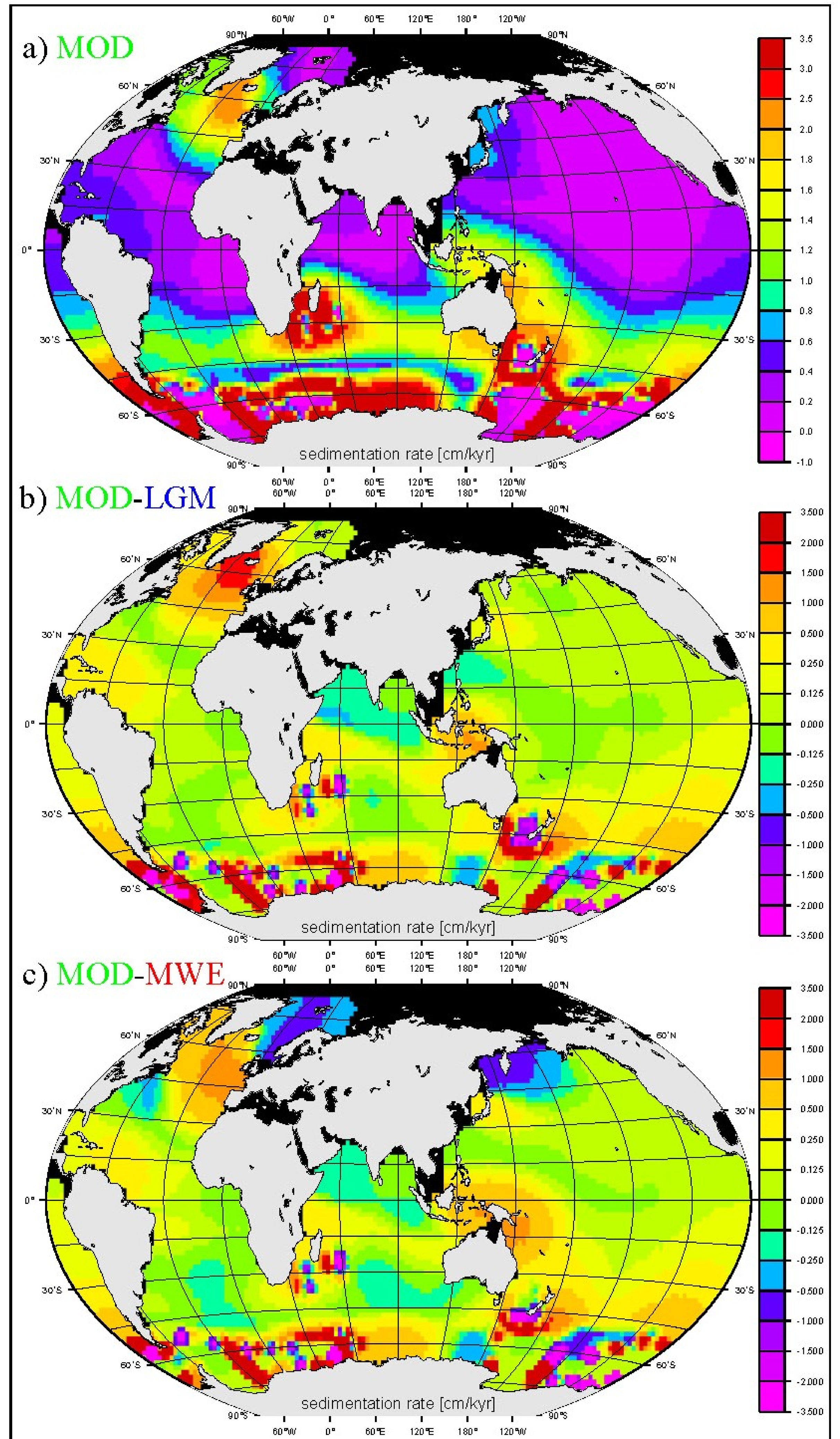

Figure 3. (a) Sedimentation rates in MOD experiment and (b) differences of sedimentation rates between MOD and LGM and (c) between MOD and MWE experiments. The shown sedimentation rates [cm/kyr] are not realistic because of an idealized character of the sea surface eolian sediment source. The goal is to link the changes of sediment drifts to changes of the ocean circulation patterns and interbasin water exchange (see text).

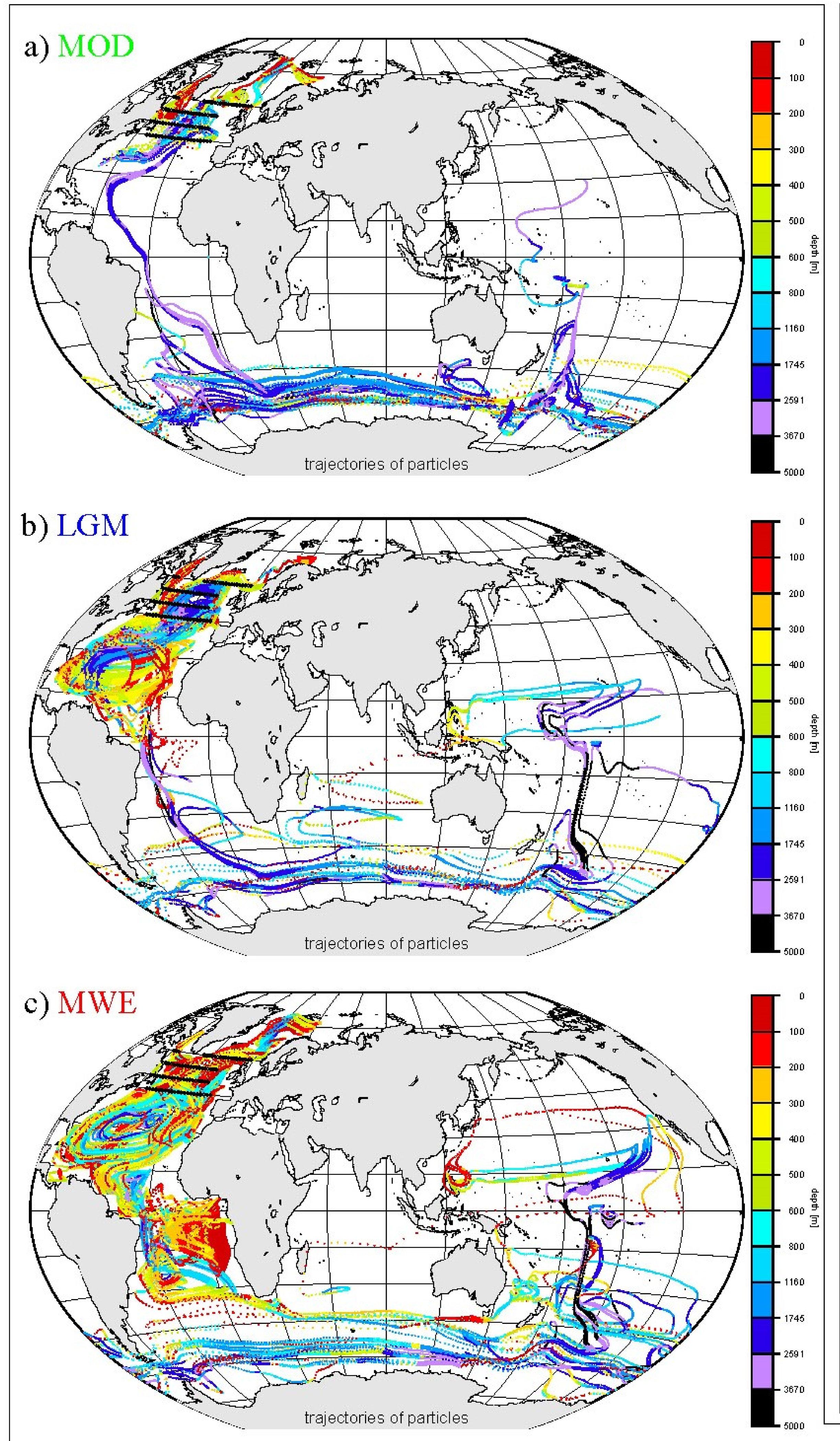

Figure 4. Lagrangian trajectories illustrating the spread of North Atlantic Deep Water in three cases: The present–day run (a), LGM run (b), and MWE run (c). The neutrally–buoyant particles were deployed in the northern North Atlantic. The depth is indicated by colors pallette; as the particle descends or upwells the color of the trajectory changes.

Results

Different sea–surface sources of eolian sediment were used to address the problem of usability of the eolian sediment as an additional tracer. It is shown that the signature of the deep–ocean currents is recognizable in the net inorganic sediment accumulation patterns and is not overwhelmed by sea–surface signal (which is spatially homogeneous in these experiments). Lagrangian particles indicate that northern source of deepwater was at minimum during the deglaciation.

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.