Modeling water volumes and sediment transport in the late Quaternary world ocean

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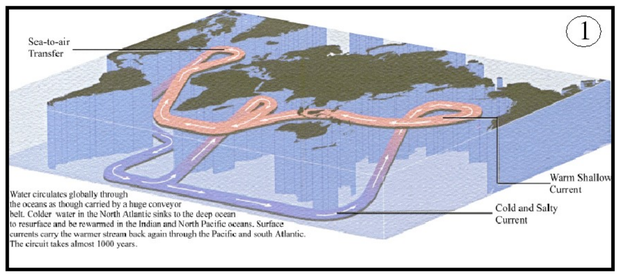
An oceanic general circulation model and a three-dimensional large-scale Lagrangian model are used to simulate the climatically induced complex interactions of the ocean-sediment system for the late Quaternary. Particle trajectories for three different time slices were modeled: the Holocene/Modern state (HM; Figure 2) as control experiment, the Meltwater Event (MWE; 17100 calendar years BP; Figure 3), and the Last Glacial Maximum (LGM, 21600 calendar years BP; Figure 4).

The prognostic sedimentation models SEDLOB (SEDimentation in Large Ocean Basins) and PATLOB (Particle Tracing in Large Ocean Basins) are driven by the output (temperature, salinity, velocity, and convection) of an ocean general circulation model. Special attention is paid to the vertical convection which is an important feature of particle motion in the world ocean producing the global conveyor belt (Figure 1) and governing sedimentation processes.



Modeling the LGM on the 21600 calendar years time slice, the deep water formation in the northern North Atlantic (NNA) is reduced by 30% compared to the modern state but enhanced in the Weddell-Sea and in the Northwest Pacific Basin.

During the meltwater event the deep convection breaks down completely in the NNA and reestablishes itself at the beginning of the HM leading to the known modern circulation regime. In the Northwest Pacific Basin vertical mixing is further intensified during the MWE and breaks down in the HM. In the Weddell-Sea strong deep water formation pertains during the MWE but is reduced in the HM.

Figure 1: Scheme of the threedimensional thermohaline global conveyor.

Figure 2a: HM – Diagram of vertical convection.

Figure 2b: HM – Velocity vectors for the deep ocean at 2500 m water depth.

Figure 2c: HM – Trajectories of particles deployed at the HM in the northern North Atlantic at the sea surface (50 m).Depth is indicated by colors from the color palette; as the particle descends or upwells the color of the trajectory changes.

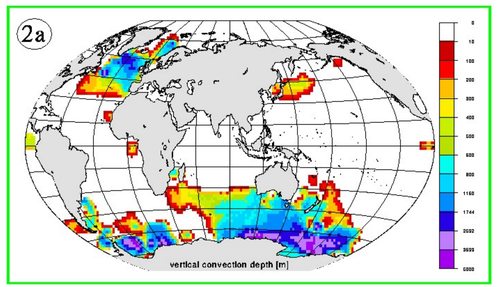
Figure 2d: HM – As Figure 2d. The particles are deployed in the Weddell-Sea at 3500 m.

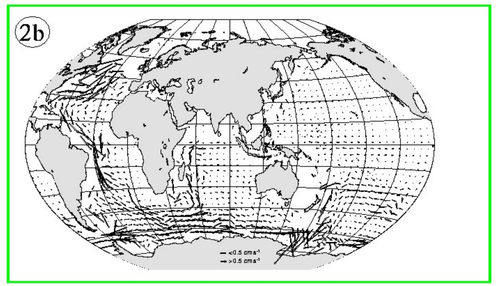
Figure 2e: HM – Pairs of trajectories (one trajectory is shown as a solid and the other as a dashed line) visualizing the deep ocean conveyor. Small rectangles show time elapsed after deployment (upper numbers) and the depth at which the particle is found on the trajectory at that time.

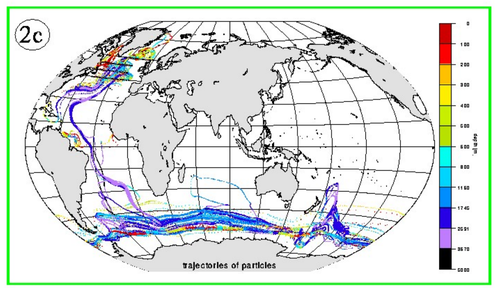
Figure 3a–e: As in Figure 2a–e for MWE.

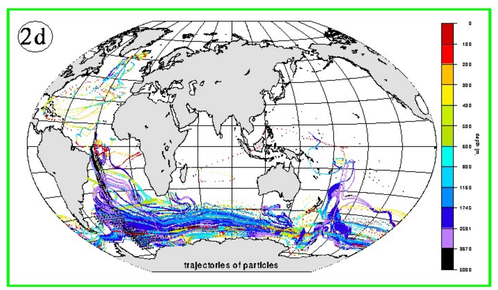
Figure 4a–d: As in Figure 2a–d for LGM.

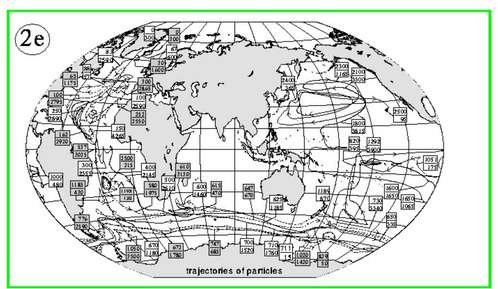
Holocene/Modern



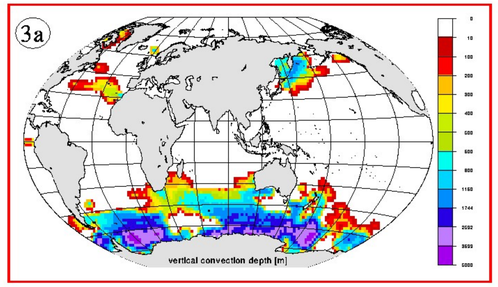


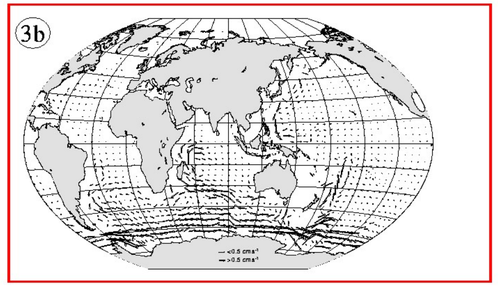


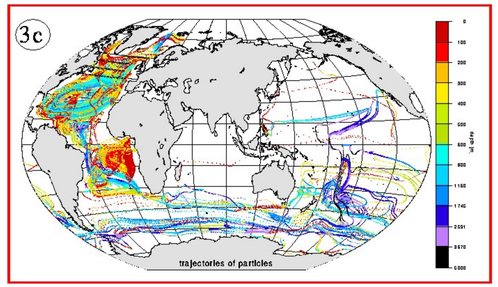


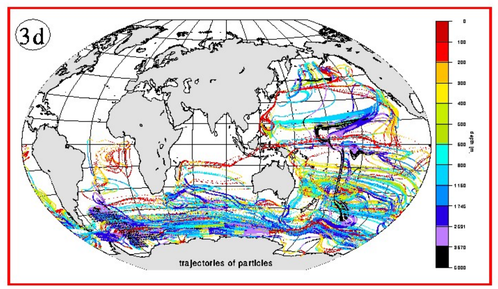


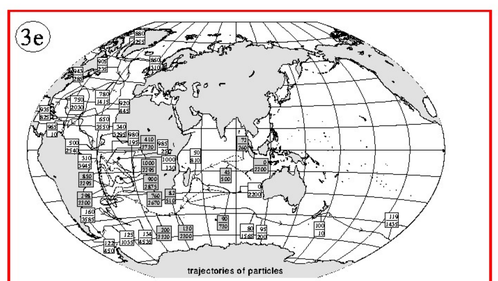
Meltwater Event











Last Glacial Maximum