MODELING LATE PLEISTOCENE OCEAN GLOBAL THERMOHALINE CONVEYOR

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The global ocean thermohaline conveyor at present, at the last glacial maximum, and at a subsequent meltwater event (MWE) is simulated using a combination of a global ocean circulation model and a Lagrangian trajectory tracing technique. The modeled glacial conveyor is somewhat weaker then today, as many previous studies imply. However, the major changes of the deep global ocean conveyor occurred only at the MWE. These changes include a reversal of the Indian–Atlantic branch of the deep conveyor due to a cessation of North Atlantic Deep Water (NADW) production caused by capping of convection by a localized meltwater impact. This response of the meridional overturning supports the idea of hampering the global conveyor operation during Heinrich events. Yet the model results do not support the idea that a global conveyor now or ever directly connected the high–latitudinal North Atlantic and North Pacific. The two oceans are only weakly connected via a series of basin–scale horizontal gyres. The simulated trajectories indicate disconnection of the Atlantic and southern oceans during the MWE because the NADW was not produced at that time. Our results contradict a view of these remote basins as being directly connected by global–scale abyssal and deep–water flow, now or in the past. The trajectories indicate that the deep water that escapes from the Antarctic Circumpolar Current northward into the Pacific Ocean does not penetrate as far northward as might be thought on the basis of the global conveyor paradigm. However, the NADW still controls the global deep–ocean circulation, and there is a system of coherent deep ocean currents that partly justifies the conveyor paradigm and the accompanying terminology. Dramatic change of the northward heat transport during the MWE indicates that this state could not be a stable long–living state of the ocean circulation. It calls for a substantial high–latitudinal cooling right after the meltwater episodes. This implies that instead of a long–term meltwater state, one may expect a transitional behavior with strong oscillations between ice–covered and meltwater covered ocean in the northern North Atlantic.

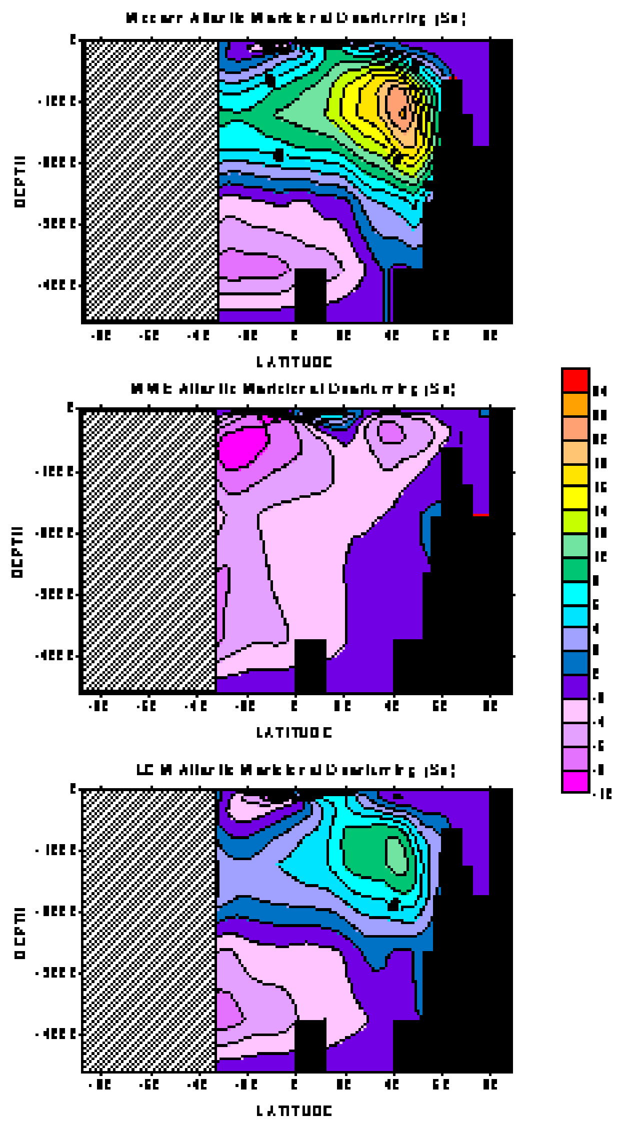

Figure 1. Meridional overturning stream function showing total transport of water in vertical plane in the Atlantic Ocean. From top to bottom: present-day overturning, LGM, and MWE. Transport in Sv (1 Sv=10^6 m^3/s).

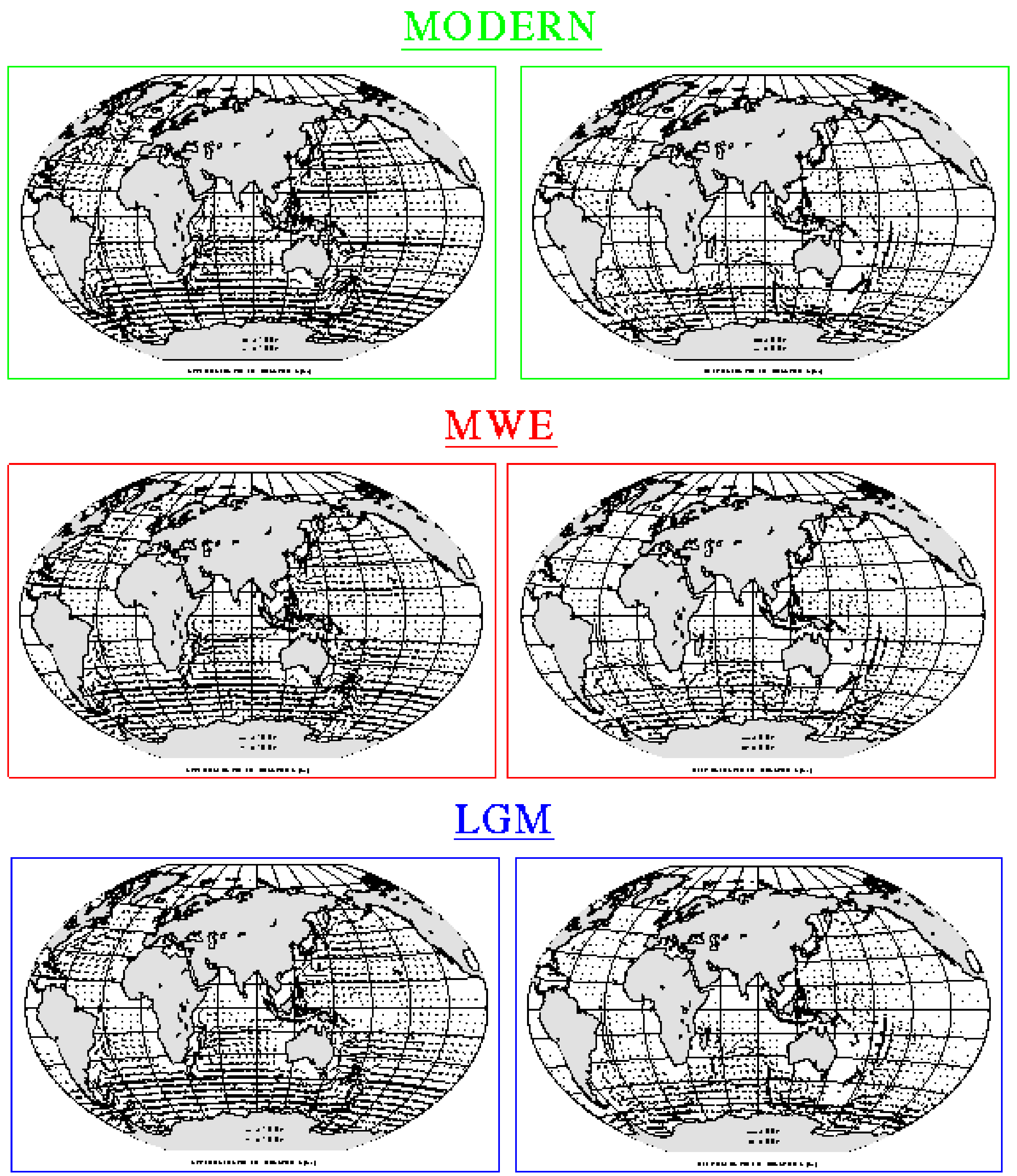

Figure 2. Global thermohaline conveyor. Volume transports across the sides of the grid cells from the top of the ocean to 2 km depth (left) and from 2 km to the bottom (right) are shown in Sv (1 Sv = 10^6 m^3 s^{-1}). Although the LGM conveyor noticeably weakened because of lessened North Atlantic Deep Water production, it still operated and facilitated the global deep ocean tracer transport from the NA to the Pacific. At the MWE the model indicates a complete reversal of the conveyor in the Atlantic–Indian sector, which is not simply a 'conveyor–off' regime but a 'conveyor–reversed' mode.

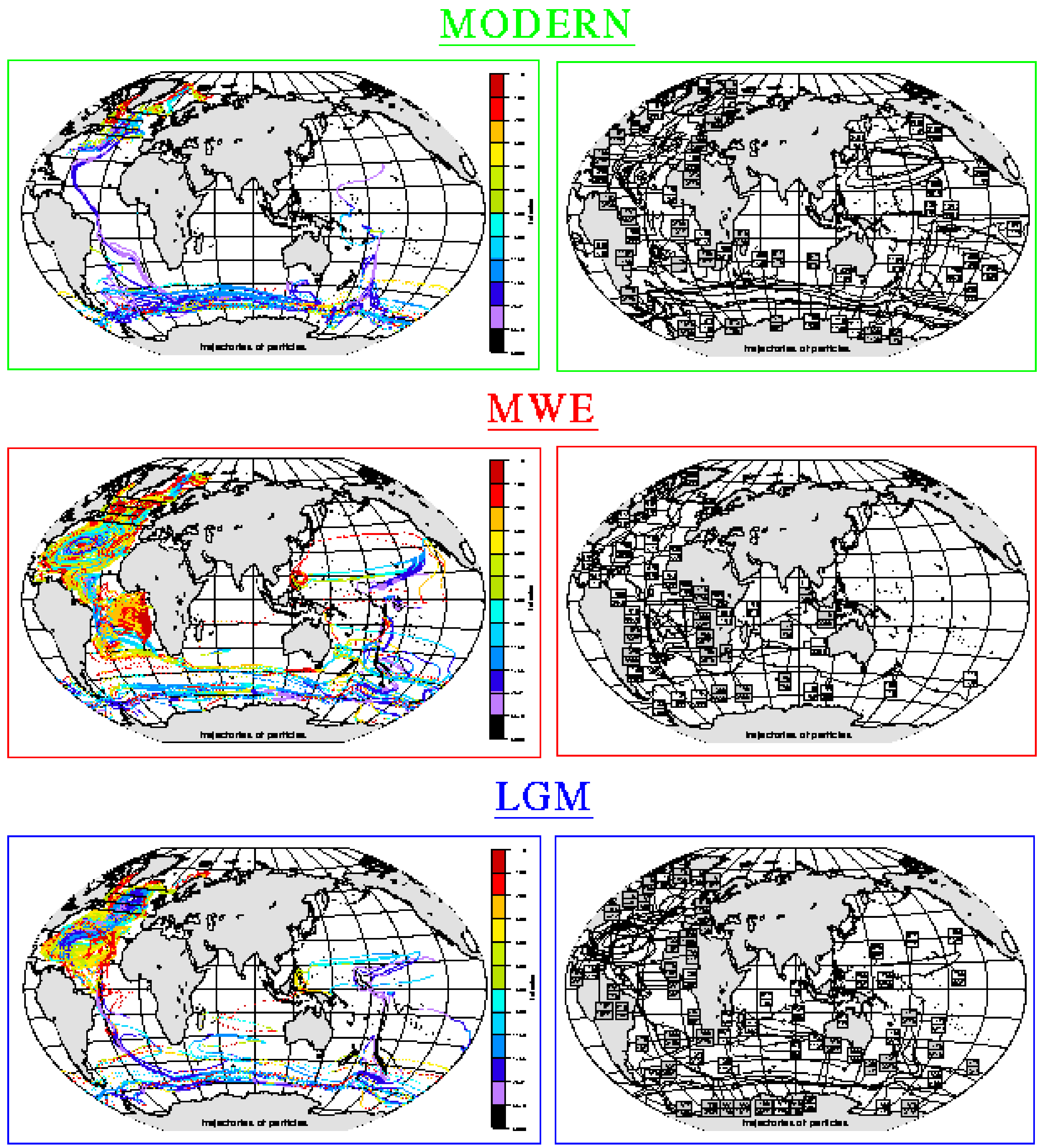

Figure 3. Trajectories of water parcels. Clouds of neutrally-buoyant particles were deployed at different sites to trace the deep ocean conveyor. Left panel shows spaghetti of the trajectories with the depths indicated by color (as a particle descends or upwells the color of its trajectory changes). The right panel depicts pairs of trajectories with elapsed time and depth shown along the paths.

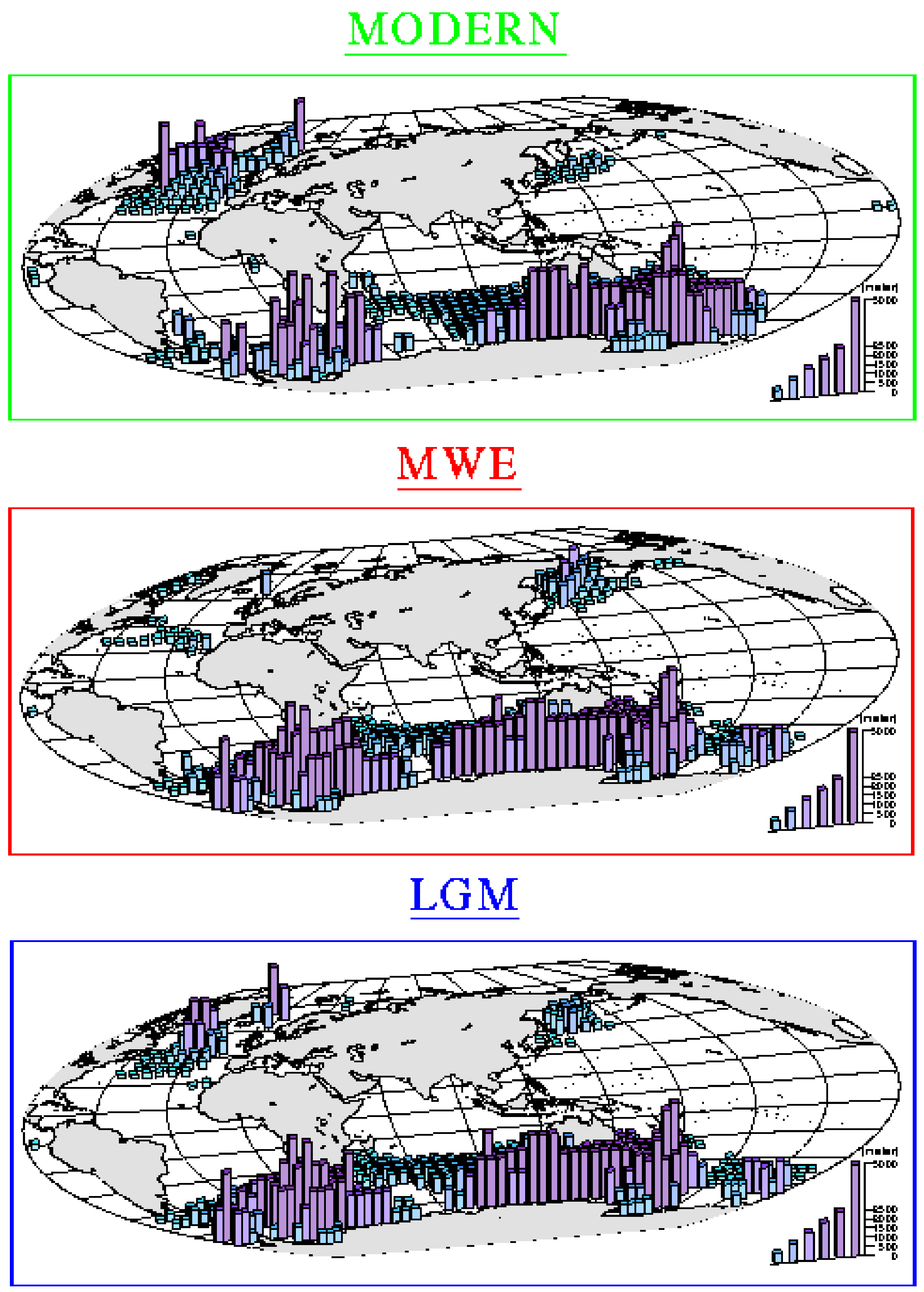

Figure 4. Convection diagrams. The heights of the bars are equal to the convection depth. Present-day, LGM and MWE convection is depicted (from top to bottom). During the LGM convection in the North Atlantic shifted southward, whereas during MWE there were no deep convection in the northern hemisphere.