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Response of large-scale Ocean Circulation to Global Internal Wave Parameterization IDEMIX under Last Glacial Maximum Conditions

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As the most recent glacial period of Earth's history, the Last Glacial Maximum (~21,000 years before the present day, LGM) is an important and one of the most studied paleo times when the ice-sheet coverage was at the maximum extent, and the global average temperature was 6°C cooler than present day (PI). The large volume of ice caused an approximately 130 m drop in sea level and exposure of the continental shelves, shifting the tidal dissipation energy that sinks in the present-day shelf seas to the open ocean during the LGM. Regarding this hypothesis, the LGM ocean is expected to be more turbulent and well-ventilated in the abyssal and possibly have a much stronger overturning circulation in the North Atlantic compared to the present day. However, the paleo records of $\delta^{13}C$ indicate a deoxygenated deep ocean for LGM. In this study, we test the LGM hypothesis on the global circulation and marine biogeochemical processes by implementing a new energetically consistent ocean mixing parameterization: Internal Wave Dissipation, Energy, and Mixing (IDEMIX) in the fully coupled isotope-enabled Community Earth System Model (iCESM1.2). For the scope of this study, we solely focus on baroclinic tidal-induced mixing by parameterizing dissipation from the internal wave breaking in IDEMIX. Our preliminary results illustrate the LGM ocean as more vigorous than the PI ocean only when the IDEMIX is used in the model since the diffusivities are enhanced by almost two orders of magnitude, especially over the rough bathymetry with IDEMIX coupling. Otherwise, no significant difference is observed between the vertical diffusivities of LGM and PI oceans without IDEMIX, despite the divergence in their tidal energy dissipation fields. The increase in the diffusivities with IDEMIX application can be seen not just at the ocean bottom but also along the entire water column near the internal wave generation sites where the tidal energy dissipation is strongest (e.g., the Mid-Atlantic Ridge, the Hawaiian Ridge, or high latitudes in Atlantic). Consistent with the hypothesis, the turbulence near the exposed shelves is boosted in the deep ocean and dispersed across different depth levels from here when the model uses IDEMIX for the LGM simulation. Additionally, the North Atlantic Deep Water (NADW) cell gets weaker and shallower by □ 2 Sv, and the Antarctic Bottom Water (AABW) cell enlarges based on the IDEMIX influence on the LGM ocean.