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The effect of tidally driven mixing on the transient climate response to CO_2 increase

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We investigate the sensitivity of the transient climate change for a global warming scenario to a tidal mixing scheme. The new scheme parameterizes diapycnal diffusivity depending on the location of energy dissipation over rough topography, whereas the standard configuration uses low, horizontally constant diffusivity. We perform experiments with two setups of MPIOM/ECHAM5, one setup with the tidal mixing scheme and the second setup with the standard configuration. The steady-states are obtained by running two experiments with the two setups to equilibrium with pre-industrial CO_2 concentration. The anomaly experiments are obtained by running ensembles of three members for each setup, with CO_2 rate of increase equal to 1% per year. The transient climate sensitivity, defined as the surface air temperature difference between the anomaly and the steady-state climate, is 10% smaller in the tidal run compared to the control run. The tidal transient climate sensitivity is smaller almost everywhere, particularly in the polar regions, indicating that the polar amplification mechanism is sensitive to tidal mixing. Such differences are associated with larger deep-ocean heat uptake in the tidal run. Stronger heat fluxes in the deep ocean in the tidal run remove heat from the upper ocean, which in turn affects the surface climate to produce weaker response to CO_2 doubling. The analysis of the steady-state and anomaly vertical heat balances reveals that the larger tidal deep-ocean heat uptake is due to larger changes in the advective heat fluxes in the tidal deep ocean compared to the control run. Counter-intuitively, the relation between tidal mixing and greater heat storage in the deep ocean is an indirect one, through the influence of tidal mixing on advection.