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Ocean climate response to anomalous surface buoyancy and momentum fluxes

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The aim of the project is to evaluate the response of the global ocean climate to anomalous surface fluxes in terms of ocean heat uptake and circulation changes. All simulations have been performed with the NOAA-GFDL Modular Ocean Model (MOM) version 5. Ocean-only MOM has been integrated toward a near-equilibrium state using as multicentinal initial conditions derivated from a former CORE-I protocol implementation (Griffies et al., 2009). After equilibrium, a restored control simulation has been obtained by a further 70 years of integration while effective total air-sea heat fluxes and freshwater fluxes were stored at daily intervals. A second control simulation has been obtained by the prescription of these storage fluxes. Differences between the restored and prescribed fluxes controls are rather small. Explicit flux sensitivity experiments are proposed by the Flux-Anomaly-Forced Model Intercomparison Project (FAFMIP) in which prescribed surface flux perturbations are applied to the ocean in separated simulations (Gregory et al., 2016). Experiments are 70 years long and branch from piControl conditions. Both wind stress and freshwater anomalies implies nearly-to-zero temperature changes in volume mean temperature. Only the last implies a rather small cooling effect after year 50 of integration. In contrast, anomalous heat flux causes significant volume mean temperature changes. Observed total temperature changes are solely determined by the local addition of heat implying vanishing of the redistribution effect in the entire ocean by inter-basin exchanges and vertical mixing. So far, surface heat anomalies produce the most notable zonal-mean change in ocean temperature. Strong positive temperature change is observed along the top ocean while deepening of temperature anomalies occurs at high latitudes in both hemispheres. Both added and redistributed temperature tracers show maxima in the same area. In most cases, both processes are proportionally inverse. Except for the northern ocean, added temperature tracer is roughly limited to the first 1000 m deep. In contrast, redistributed temperature tracer shows the cooling of subtropical areas and the warming of both the tropical and southern ocean. Maximum at the North Atlantic is possibly due to atmosphere-sea feedbacks, while near-surface tropical and subtropical changes are due to redistribution processes. Heat is mainly taken as a passive tracer in the North Atlantic Ocean and along the entire Southern Ocean. Warming up of mid and low latitudes by redistribution processes is due to the weakening of the Atlantic Meridional Overturning Circulation (AMOC). In turn, changes in AMOC are dominated by surface heat flux changes. The reduction of northward heat transport cools down high latitudes near the surface causing low latitudes to warm up.