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The Ocean's Gravitational Potential Energy Budget in a Coupled Climate Model

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It has been suggested that the ocean's budget of mechanical energy can provide insights into the nature of global ocean circulation and its driving processes. However, the energetics of the physical ocean and realistic ocean and coupled climate models are not well understood, even at steady-state. This study examines, in a unified fashion, the budgets of ocean gravitational potential energy (GPE) and available gravitational potential energy (AGPE) in the control simulation of the coupled atmosphere–ocean general circulation model HadCM3. Only AGPE can be converted into kinetic energy by adiabatic processes. However, not all oceanic processes affect GPE and AGPE in the same way. Diapycnal mixing supplies GPE, but not AGPE, whereas the reverse is true of the combined effect of surface buoyancy forcing and convection. Mixing and buoyancy forcing, thus, play complementary roles in sustaining the large scale circulation. Indeed, surface buoyancy fluxes are the largest globally integrated source of AGPE (+0.72 TW). However, the largest globally integrated source of GPE is resolved advection (+0.57 TW) and the largest sink is through parameterized eddy transports (-0.82 TW). The effect of these adiabatic processes on AGPE is identical to their effect on GPE, except for small perturbations due to numerical leakage exacerbated by nonlinearities in the equation of state.