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Anthropogenic carbon and heat uptake in CMIP5 models: The dominance of the Southern Ocean

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We assess the global ocean anthropogenic CO_2 and heat uptake and storage over the period 1861 to 2005 in a new set of coupled carbon-climate Earth System models conducted for the fifth Coupled Model Intercomparison Project (CMIP5), with a particular focus on the Southern Ocean. Simulations show the Southern Ocean south of 30°S, occupying 30% of global surface ocean area, accounts for $43 \pm 3\%$ (42 ± 5 Pg C) of anthropogenic CO_2 and $75 \pm 22\%$ (23 ± 9 10^{22} J) of heat uptake by the ocean over the historical period. Northward transport out of the Southern Ocean is relatively small, implying storage of 33 ± 6 Pg anthropogenic carbon and 12 ± 7 10^{22} J heat in the region. The CMIP5 models as a class underestimate the global anthropogenic carbon inventory by about 15%, but simulate trends in global ocean heat content over the last fifty years within uncertainties of observation-based estimates. In contrast to forced ocean studies, CMIP5 models suggest global and Southern Ocean CO_2 uptake have been largely unaffected by recent climate change. Uptake and storage of anthropogenic carbon and heat substantially differ on the regional scale confirming that different mechanisms regulate heat and CO_2 uptake. Our results spotlight the crucial Southern Ocean role in the Earth System's response to climate change and as the region where models differ most in representation of both heat and CO_2 uptake.