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Ocean-atmosphere coupling in the eddy-resolving regime

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There is emerging evidence for significantly enhanced coupling of oceanic and atmospheric variability on synoptic to decadal timescales when ocean fronts and eddies are taken into consideration. Recently available satellite observations have revealed fundamentally different air-sea coupling mechanisms on the scale of ocean fronts compared to those on gyre scales. The low-level atmospheric response to frontal scale SST leads to surface wind curl and divergence, which in turn can force vertical motions into the interior of the ocean and atmosphere, and thus a larger scale response. In addition to the coupling of the atmosphere to the ocean mesoscale through surface boundary layer dynamics, the convergence of heat in western boundary currents and their associated recirculation gyres has been demonstrated to be a significant forcing of synoptic and interannual to decadal timescale variability of the mid-latitude atmosphere. We investigate these mechanisms and their role in the global climate system by comparing centennial length simulations using the Community Climate System Model (CCSM) with and without eddy resolving ocean components. As expected, we see strongly enhanced variability in sea surface temperature (SST) and upper ocean heat content in the eddy resolving simulation. Less obvious a priori is that the coupling of the atmosphere to the ocean, as measured by the regression of surface fluxes of heat and moisture on SST or sea surface height, also becomes stronger in the sense that indicates ocean forcing of the atmosphere (positive SST anomalies associated with heat fluxes out of the ocean). The magnitude and geographical distribution of the regression coefficients obtained from the eddy-resolving simulation are corroborated with analysis of high-resolution observations.