Geophysical Research Abstracts, Vol. 7, 05410, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05410

Tropical Pacific ocean adjustment to changes in the hydrological cycle in a coupled ocean-atmosphere model

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As the climate changes, the predicted intensification of the hydrological cycle will modify the net freshwater flux at the ocean surface. Since the freshwater flux maintains salinity structures, changes to the ocean circulation are likely. A modified ocean circulation could further alter the climate, potentially allowing rapid changes, as seen in the past. The relevant feedback mechanisms and timescales are poorly understood in detail, however.

We present an investigation of one half of the above feedback loop, namely the response of the ocean circulation to changes in the freshwater flux. Initiated from the present-day thermohaline structure, a control run of a coupled ocean-atmosphere GCM is compared with a 100-year integration in which the net freshwater flux is prescribed to be zero everywhere. Such an extreme experiment helps to elucidate the general adjustment mechanisms and their timescales. The radiative forcing is constant, and (in this first study) we restrict our attention to the subsequent adjustment of the Tropical Pacific ocean.

By the end of the perturbed experiment, the surface of the Tropical Pacific has warmed relative to the control run by an average of $0.7°$C, most of which is achieved in the first three decades. To explain this surface warming, we note that within the northern subpolar gyre during the first two years, the perturbed experiment mixed layer deepens and the surface temperature rises. Using density as the vertical coordinate, we track the propagation of this warm high-latitude anomaly into the tropics, and we identify two distinct pathways with very different timescales. The warm anomaly moves equatorward at the surface, overcoming a cold low-latitude anomaly associated with the shallower mixed layer within the subtropical gyre, and after a few years the surface temperature has increased everywhere. At the same time, the warm anomaly is subducted and propagates equatorward at depth along an isopycnal surface, being upwelled near the equator a few decades later, where it feeds the mixed layer and reinforces the initial surface temperature rise.