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On the Role of Heat Flux in the Gulf Stream-Sargasso Sea Subtropical Gyre System

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ABSTRACT

In contrast with the traditional view of midlatitude circulation driven by winds in the ocean interior and regulated by friction along the western boundary, it is hypothesized that some control can be attributed to surface cooling acting primarily in a recirculation region off the western boundary current. Several arguments suggests that this mechanism and the generation of eddies are the two major reactions of the midlatitude ocean under the action of the surface winds.

The theory is best described by tracing the journey of a water parcel around the Subtropical Gyre. In the interior, the anticyclonic wind-stress pattern acts to decrease the parcel's potential vorticity (PV). In reaction, the parcel first migrates south, where the planetary vorticity is less, then veers westward and participates in a western boundary jet, where the relative vorticity is less. Instead of calling upon friction within the jet, it is not difficult to conceive that PV restoration can be achieved by diabatic processes beyond the jet. As water parcels await to rejoin the interior circulation, they accumulate and the PV diabatic processes beyond the jet. As water parcels await to rejoin the interior circulation, they accumulate and the PV balance is retained by increased thickness between density surfaces. This forms a high pressure and a recirculation. There, such storage can be imagined to have proceeded until a steady regime has been reached whereby surface cooling triggered by anomalous amounts of warm water is effective in restoring PV and allowing parcels to rejoin the interior circulation.

This scenario is attractive, for it sees the Gulf Stream as an inertial current, whose width is thus set by the deformation radius and not a friction length. It explains why the Gulf Stream transport, augmented by the recirculation, far exceeds the Sverdrup wind-driven transport of the interior. It further gives an explicit dynamical role to the recirculation as a storage area, and it concludes that the recirculation is anticyclonic, a region of minimum potential vorticity and one of intense cooling.

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