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On wind-driven energetics of subtropical gyres

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The flow of energy in the wind-driven circulation is examined in a combined theoretical and numerical study. Based on a multiple scales analysis of the ocean interior, we find the mesoscale field is strongly affected by the ventilated thermocline, but no feed back from the eddies to the large scale is found. We then analyze the western boundary region arguing that the associated currents divide between coastal jets, which conserve mean energy, and open ocean, separated jet extensions where the mesoscale is energized by the mean field. It is the separated jet zone where the primary loss of general circulation energy to the mesoscale occurs. Connections to the `Thickness Weighted Average' form of the primitive equations are made which support the differing roles of the eddies in these regions. These ideas are then tested by an analysis of a regional primitive equation 1/12-degree numerical model of the North Atlantic. The predictions of the theory are generally supported by the numerical results. The one exception is that topographic irregularities in the coastal jet spawn eddies, although they contribute modestly to the energy budget. We therefore conclude the primary sink of wind input into the mean circulation is in the separated jet, and not the interior. The analysis also shows wind forcing is much smaller than the interior energy fluxes. Thus, the general circulation is characterized as recirculating energy in the manner of a Fofonoff gyre.