Abstract View

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Circulation Driven by Winds and Surface Cooling

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ABSTRACT

A three-layer model of ocean circulation in a Northern Hemisphere basin is driven by winds that are anticyclonic in the south and cyclonic in the north. The ocean is also driven by surface cooling, which is parameterized by a vertical velocity through the base of the exposed layer and proportional to the departure of the thickness of the layer from a constant value. The momentum balance is geostrophic except in the Ekman layer at the top. The solution for the layer thickness and the transports is obtained everywhere in the interior. The cffect of cooling is to generate a recirculation region in the northwestern part of the subtropical gyre. A boundary current, appended on the western side to satisfy mass conservation of the top layer, detaches from the coast at 34°N and then moves eastward and finally northward on the eastward side of the subpolar gyre. As a consequence, the recirculation region exhibits a marked north-south asymmetry with the boundary current as the eastward-flowing northern part and a more broadly distributed westward flow on the southern side. Buoyancy forcing increases the transport of the upper-layer boundary current at the point of separation by about 20%. South of the boundary current the middle layer is forced by downwelling (cooling) of upper-layer fluid. In the recirculation region the large variation of the thickness of the middle layer directs the flow eastward and northward so that the circulation appears to be cyclonic. The middle layer is exposed to the wind north of the detached boundary current and forms a small anticyclonic gyre in the subtropical gyre and a cyclonic gyre north of that. The flow in the middle layer is toward the detached boundary current from both the north and the south, suggesting that the subduction process forms an intense boundary current in the middle layer.