Abstract View

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A Three-Layer Model for Wind-Driven Circulation in a Subtropical–Subpolar Basin. Part II: The Supercritical and Hypercritical States

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ABSTRACT

A three-layer model, in which both the second and third layers are allowed to outcrop for strong wind forcing, is studied numerically. A broad range of parameters has been tested to explore possible flow patterns.

There are two possible states with outcropping, depending mainly on a nondimensional forcing parameter. For a moderate the second layer outcrops in the subpolar basin, this is called a supercritical state. For a large the third layer outcrops, the hypercritical state.

Including an active second layer provides a very simple model which reproduces many interesting features including one or two fronts in the upper ocean. For certain parameter settings the model reproduces a loop of boundary currents around the edge of an outcropping zone which resembles the current system in the North Atlantic (i.e., the Gulf Stream, the North Atlantic Current, the Greenland Current, and the Labrador Current). Unlike the quasi-geostrophic models which produce symmetric patterns, the present model always produces highly asymmetric circulation patterns in a subtropical–subpolar basin. Within a certain range of the parameter space, the model reproduces a Gulf Stream-like interior boundary current which branches in the middle of the basin. The southern branch moves southward and forms a C-shape structure when the interfacial friction is very weak. For very strong wind forcing the upper layers separate from the eastern wall and form a warm water pool in the southwestern corner of the basin.

The potential vorticity maps in the second layer clearly show zones of different dynamic balance between potential vorticity advection, interfacial friction, air–sea interaction, and isopycnal mixing.

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