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The role of form drag in the dynamics of the Antarctic Circumpolar Current: a model study

G. Sgubin and S. Pierini

Universita' di Napoli Parthenope, Dipartimento di Scienze per l'Ambiente, Napoli, Italy (giovanni.sgubin@uniparthenope.it, +39 081 5476515)

The circulation driven by the wind in the Southern Ocean is analyzed by means of a three-layer ocean model in a process-oriented approach. The domain covers the ocean for latitudes south of -30°, and steady winds are imposed based on the known climatology. During the spinup process realistic dynamical features emerge, along with the clear evidence of a strong topographic control due to the relevant barotropic component of the motion. However, despite the implementation of several dissipative parameterizations, such as the lateral eddy viscosity through the Laplacian operator (with both a constant coefficient and the Smagorinsky formula) and the bilaplacian operator, and interfacial and bottom friction, the momentum balance cannot be achieved, in agreement with the well known inadequacy of the Sverdrup theory for the Southern Ocean circulation. On the other hand, the implementation of form drag (a process that links topographic variations to ocean mixing) evidences the central role of this effect, since now the equilibrium is eventually established and the circulation reaches the steady state. The obtained circulation patterns are consistent with the structure of the Antarctic Circumpolar Current system as observed through altimeter and in situ measurements. The circumpolar frontal circulation (with related southward upward tilt of isopycnal surfaces and corresponding transport) and the main gyres and countercurrents are correctly reproduced. Future perspectives concerning the modeling of the circulation variability are finally outlined.