Abstract View

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Barotropic Currents over the Continental Shelf

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ABSTRACT

We study below with the aid of linearized equations, but using a quadratic bottom friction law, the barotropic *forced* (aperiodic) response to wind stress or external pressure gradient of various simple continental shelf models. The *frictionless* response to longshore wind stress shows many of the characteristics of the classical “coastal jet” problem but is complicated by depth variations, mainly because of the generation of vorticity over a sloping bottom. Positive vorticity is generated where the depth increases to the left of the wind (in the Northern Hemisphere) and negative vorticity where the depth gradient is opposite. Thus, in a deep gulf separated from the open ocean by a shallow bank (in the Gulf of Maine, for example), a double-gyre circulation tends to be established.

Friction places a definite limit on the maximum velocities which are produced by a storm of given intensity, the limit being more or less independent of depth. For typical shelf conditions the time of establishment of frictionally controlled flow is a few times 10^4 seconds, longer where the establishment of geostrophic balance requires larger influx of water into the shore zone (e.g., in a wide gulf). Outside the shelf break, frictionally controlled flow is never established by any storm of realistic duration. The response remains essentially of the frictionless transient type with a progressive development of a coastal jet that intensifies with time. A realistic, combined model may be obtained by patching a coastal jet over the open ocean to frictionally controlled flow over the shelf. This reveals the further slow change in surface level over the shelf, which, however, does not significantly influence the frictionally controlled flow pattern.

A comparison of the theoretical results with observations in the Gulf of Maine suggests that the observed double-gyre circulation (known to be most intense in May) is a barotropic response to northeasterly wind stress. It is hypothesized that these winds dominate the air-sea momentum exchange early in the season because air blowing off the continent is much warmer than the sea surface and produces only low stresses.

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