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Multiple Steady Solutions of a Model Subpolar Ocean forced by Localized Wind

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Lagrangian ocean floats reveal persistent, depth-integrated recirculations in the Irminger and Labrador Seas that are fast and narrow. Hydrographic profiles suggest these recirculations play a role in the formation and export of deep water. A numerical model of an idealized subpolar North Atlantic shows that a cyclonic, seasonal wind stress applied east of Greenland creates a time-averaged circulation that resembles the float data. This circulation is sensitive to the background gradient of planetary vorticity and multiple steady states exist: the same wind stress can create closed recirculations or open boundary currents. The barotropic vorticity dynamics is governed by the Rossby and Ekman numbers. In the simplest model, a point source of wind stress curl forces an ocean in a periodic channel. Steady solutions of the barotropic vorticity equation for weak forcing resemble the classic beta plume solution with a stream function that diffuses westward. Stronger forcing causes the circulation to elongate and strengthen. The topology, however, does not change. A purely zonal solution is impossible and this is reflected in the numerical channel model. An open question is under what conditions closed recirculations and open boundary currents can exist in the periodic channel as they do in the idealized subpolar model.