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Recirculating flow in the Labrador and Irminger Seas: Impact of bathymetry

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The upper ocean circulation in the Irminger and Labrador Seas is dominated by cyclonic boundary-intensified gyres. The boundary current flows along the coast of Greenland and Labrador and is successively called the East Greenland Current, the West Greenland Current, and the Labrador Current. Lagrangian float data from the late 1990s have provided much insight into the behavior of this circulation system, most notably the existence of four distinct recirculation cells: one in the Irminger Sea and three in the Labrador Sea. The cause of these recirculations has previously been linked to the seasonal cyclonic wind stress pattern in the Irminger Sea which forces a beta-plume around the Labrador Sea. We argue here that small-scale features of the bathymetry are also a leading factor.

Numerical experiments are performed where a boundary current is forced by a cyclonic wind stress east of Greenland, with both idealized and realistic bathymetry. In some cases the boundary current retroflects near the south-west corner of the idealized rectangular domain, and returns to the forcing region. In other cases it loops round the entire domain, depending on the values of the planetary beta effect, forcing strength and bathymetric details. The basic dynamical process is a linear, stratified, topographic beta-plume although nonlinearity seems to be involved in switching between these two circulation modes.

With realistic bathymetry, the boundary current is divided into individual recirculations that resemble those from the float data. The troughs of the recirculation cells are located at Eirik Ridge, Hamilton Bank, and Flemish Cap. The realism of this solution rapidly deteriorates in runs with increasingly smooth bathymetry however, and eventually we recover the idealized boundary current solutions. These results suggest that relatively small bathymetric features can disproportionately influence the large scale

flow.