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The Formation of Non-Zonal Jets over Sloped Topography

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We present the results of an investigation into the effect of a spatially uniform slope in bottom topography in a quasi-geostrophic, doubly periodic, two-layer model. A slope in the meridional direction results in the enhancement of the 'beta' effect, producing zonal jets, familiar from many previous studies. The novel aspect of this investigation is that the bottom slope has arbitrary orientation. Jets continue to form but they are non-zonal and tilted relative to layer-wise potential vorticity gradients. We show that these non-zonal jets follow the barotropic potential vorticity gradient, and we find that eddy energies are larger when the barotropic potential vorticity gradient is aligned with the direction of the shear in the system. The tilted jets are also demonstrated to be weaker barriers to transport than their zonal counterparts using an effective diffusivity diagnostic. These results are shown to be independent of the ratio of layer depths and to carry over to more complicated topographies containing slopes. We also interpret these results in the light of linear Rossby wave theory, showing the extent to which the jet orientation can be explained by the alteration of the linear dispersion relation by the presence of sloped topography, and the extent to which a Rhines scale can explain the separation of such jets. This work is of relevance to the many regions of the oceans where strong non-zonal jets are present, and is a significant step towards understanding the influence of topography on the dynamical properties of jets.