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# Cross-Front Transport Near Topographically-Induced Jet Transitions

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Theories of Southern Ocean circulation and, in particular, its meridional overturning circulation (MOC), largely adopt a zonally-averaged approach to describe the balance between (a) surface wind forcing and its associated Ekman transport and (b) relaxation of isopycnal tilt through eddy fluxes. However, a number of recent studies, in part due to improved observational coverage, have highlighted the importance of zonally-asymmetric dynamics in determining circulation, transport and mixing properties of the Southern Ocean. One aspect of this zonal asymmetry relates to the Southern Ocean's front structure. Both observations from satellite altimetry and output from high resolution ocean general circulation models indicate that Southern Ocean fronts and associated velocity jets undergo rapid transitions downstream of large topographic obstacles. This study considers the impact of these topographical transitions zones on mixing and transport properties of the flow using both idealised numerical models and satellite altimetry data.

A set of doubly-periodic, baroclinically-unstable two- and three-layer quasi-geostrophic simulations with local topographic obstacles are analysed. The simulations are conducted in a large domain that allows many coherent jets to form. The jet structure is influenced by the large-scale planetary potential vorticity (PV) gradient as well as the contribution to the PV gradient from topography. This study focuses on the regime where the number of jets, the jet spacing and the jets' vertical structure vary along the path of the mean periodic flow. Transitions in the number of jets are found to occur rapidly at both the upstream and downstream edges of the topographic obstacle. Both jet merger and the initiation of new jets, or transport barriers, are observed, and the displacement of jet cores due to potential vorticity conservation can give rise to large re-circulation features. Front transitions are typically accompanied by high eddy kinetic energy levels. Passive Lagrangian particles are advected using the velocity fields from the simulations. Analysis of the trajectory data indicates that that particles are more likely to cross transport barriers (as defined by sharp gradients in PV) in the downstream region of the topography.

The second part of this study uses velocity fields derived from seventeen years of satellite altimetry data to advect Lagrangian particles within the Southern Ocean. Particles positions are analysed to determine where exchange across the primary climatological front positions occur. Particles are re-seeded periodically to avoid seasonal and inter-annual variability. Nearly all cross-frontal exchange occurs in isolated locations downstream of major topographical features, such as Kerguelen Island, Campbell Plateau, and Drake Passage. Statistical measures of eddy kinetic energy and eddy length scales are used to the compare the dynamics of the Southern Ocean particle trajectories with those from the quasi-geostrophic simulations.