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Nonlinear Dynamics of Two Western Boundary Currents Colliding at a Gap

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Dynamics and hysteresis of two western boundary currents of Munk thickness LM encounter near a gap is studied using a 1.5 layer reduced-gravity quasi-geostrophic ocean model. When the gap (of width 2a) is narrow, $\gamma \leq 7.3$ (where γ= (a/LM), neither of the flow can penetrate into the western basin due to the viscous force. When $7.3 < \gamma < 9.0$, both flows penetrate into the western basin for small transport, and choke at the gap for large transport. When $9.0 \leq \gamma \leq 9.6$, two WBC flows penetrate for small transport and choke for large transport, and become periodic eddy-shedding for even larger transport, multiple steady states exist and hysteresis behavior show up. When $\gamma > 9.6$, there is no choke state, and multiple states and hysteresis exist between penetrating states and periodic eddy-shedding states. A Hopf bifurcation emerges when the two flows transit from steady penetrating or choke state to periodic eddy-shedding state, and is found to be sensitive to the magnitude of γ and the baroclinic deformation radius. It occurs at lower Reynolds numbers for larger γ or deformation radius. Multiple steady states and hysteresis exist between some certain range parameters. Through vorticity term analysis, we found the time-dependent relative vorticity term varies remarkably and triggers the WBCs to alternately shed eddy into the western basin. The hysteresis is derived from the difference magnitude of the nonlinear inertial between the two different initial states.