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Eddy-mean flow interactions in western boundary current jets

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The Kuroshio Extension System Study (KESS) is a large-scale observational program of the Kuroshio Extension investigating the processes that govern the jet's variability and the relation between the jet and its recirculation gyres. Motivated by the KESS observations we examine the nature and the importance of nonlinear eddy-mean flow interactions in Western Boundary Current (WBC) jet systems.

We use the KESS observations to design the set-up of an idealized quasi-geostrophic numerical model and use it to study the role of eddy-mean flow interactions in a baroclinic, unstable, boundary-forced jet. We find that in this simplified configuration, in a parameter regime relevant to both the Kuroshio Extension and the Gulf Stream, the unstable jet evolves through the shedding of eddies as it flows through the domain until it reaches stability, and the nonlinear eddy fluxes play one of two distinctive roles depending on the downstream location. Upstream of the jet's stabilization point, the eddies act to stabilize the jet through a diffusive-like, down-gradient potential vorticity flux. However downstream of this stabilization, the sense of this eddy flux reverses, and now acts to drive the recirculations through an anti-diffusive, up-gradient flux. These two processes are related, and we also find that the properties of this eddy-driven time-mean circulation occurring downstream can be predicted given the stability properties of the upstream jet that is the source of the eddy variability. These results support the hypothesis that the observed recirculations in the Kuroshio Extension and Gulf Stream are, at least partially, eddy-driven, and provide insight into what

may determine the properties of the observed mean jet and its recirculations as they evolve downstream as a consequence of the nonlinear dynamics.

We next test the relevance of these idealized results to actual oceanic WBC jet systems through analysis of the KESS observations and the output of the 1/10th of a degree resolution (eddy-resolving) Parallel Ocean Program (POP) general circulation model in the Kuroshio Extension region. Work in this direction is on-going, but initial results suggest both that the simplifications of the idealized model are appropriate to the observed oceanic system, and that the observations have several dynamically significant signatures in common with the numerical model's predictions. This leads us to believe that the simplified physics we have studied in our numerical investigations are indeed a useful way to try to understand the important role of the nonlinear eddy-mean flow interactions in the Kuroshio Extension and potentially other WBC jet systems.