Eulerian Statistics for Fluid Trapping and Transport by SSH-Tracked Eddies: Preliminary Results

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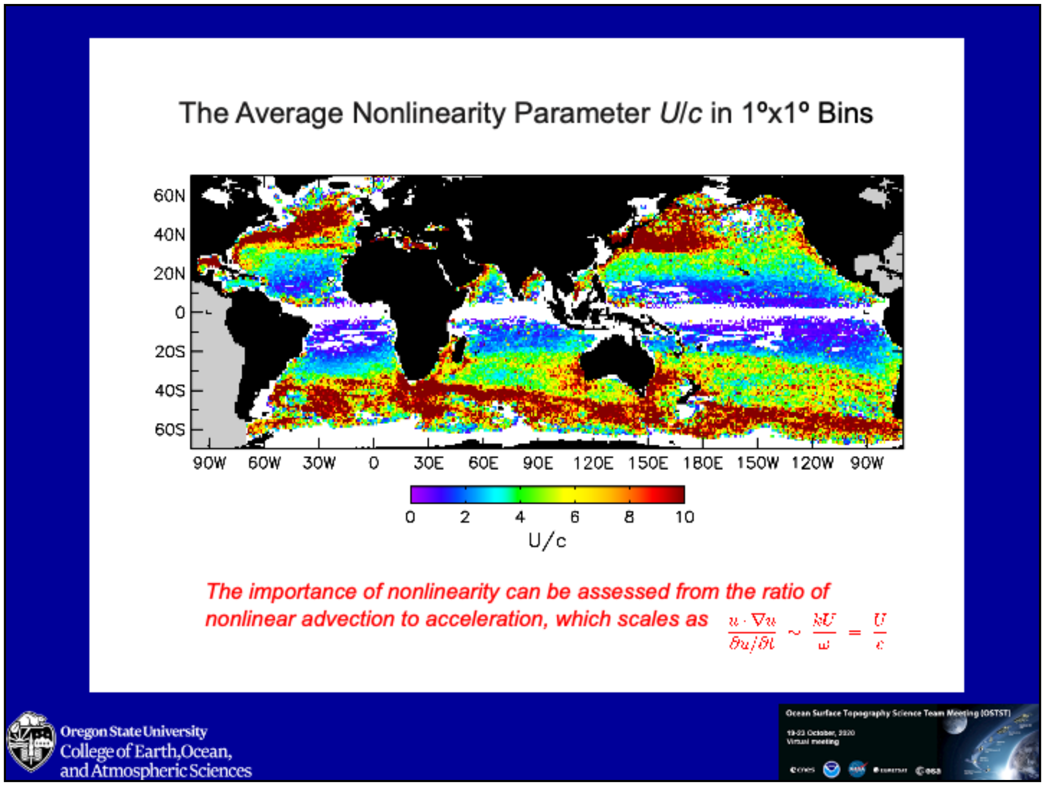
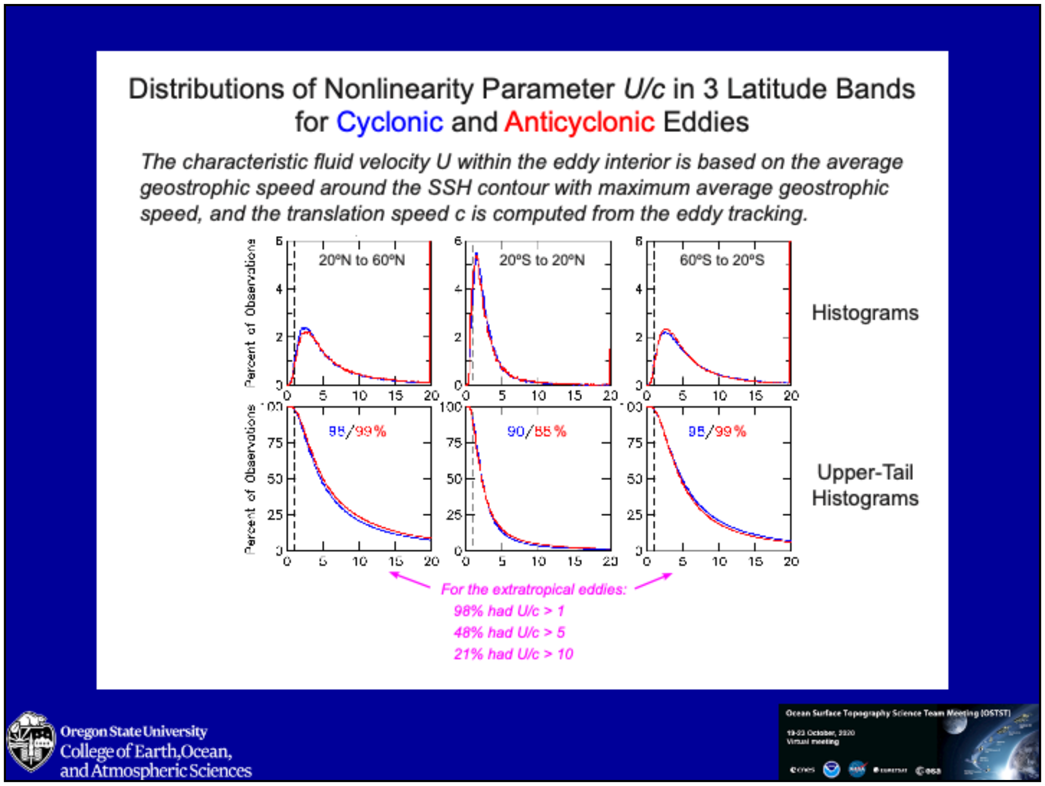
We present a progress report on the development of Eulerian statistics for efficient estimation of fluid trapping and transport by eddies identified and tracked from the global, gridded, multi-decadal, multi-altimeter SSH dataset.

Existing methods for computing Lagrangian transport of fluid by mesoscale eddies primarily depend on explicit computation of Lagrangian trajectories or a large amount of related Lagrangian information, and are computationally intensive. We seek an efficient alternative method for estimating this transport that is based on Eulerian statistics and can be applied conveniently to large datasets such as the global, gridded, multi-decadal, multi-altimeter SSH products available from CLS/DUACS/AVISO.

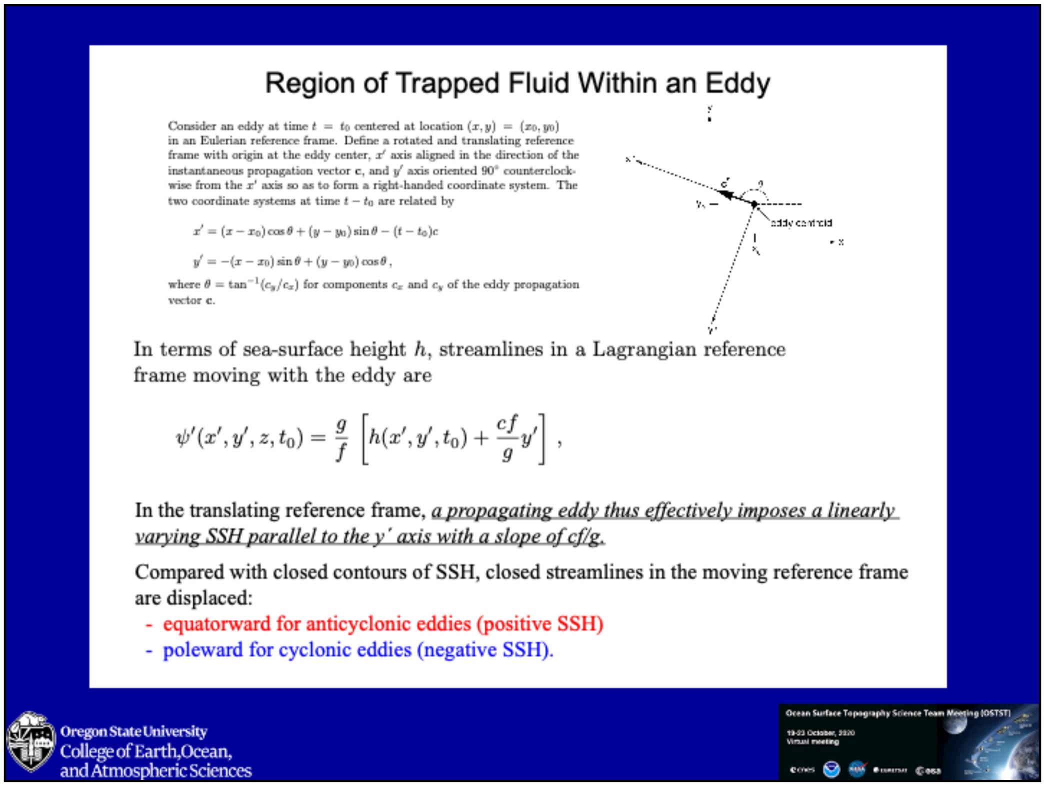
The method makes use of Eulerian estimates of the nonlinearity of SSH-tracked eddies. A progress report on this work is provided here. An anticipated future refinement is the incorporation of other Eulerian statistics that quantify the temporal variability or coherence of the tracked eddy structures, which can have a strong influence on fluid trapping and Lagrangian transport.



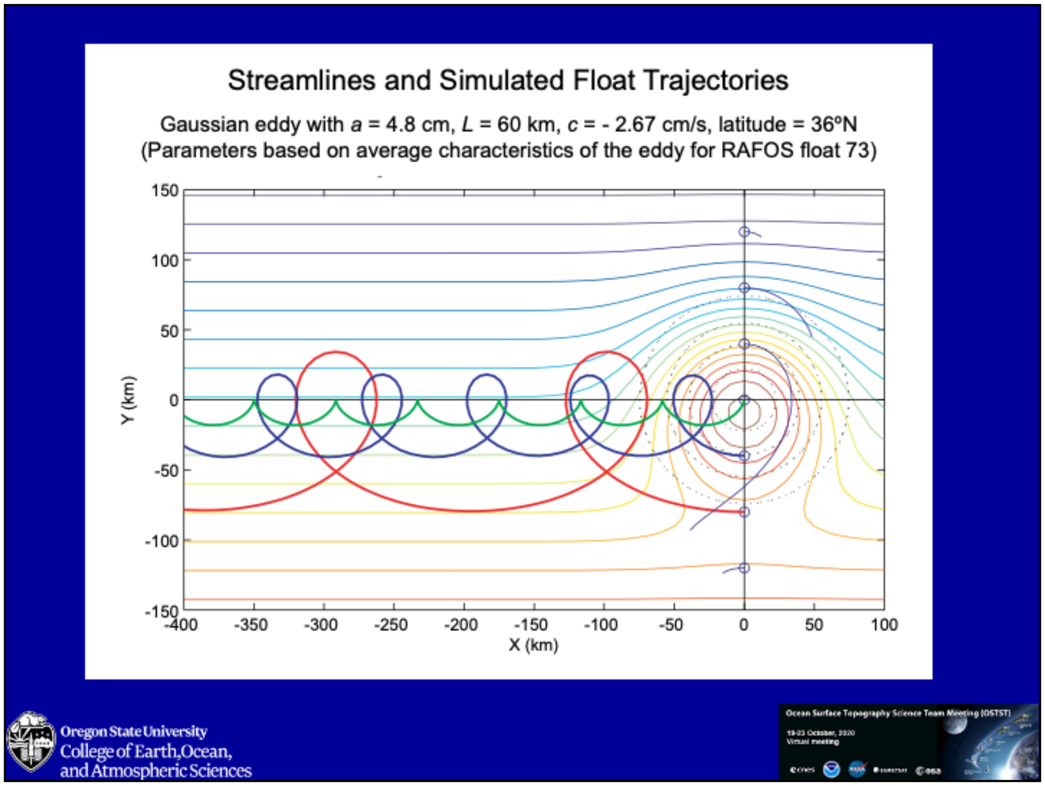
A traditional nonlinearity parameter for nonlinear waves, denoted U/c, can be computed for each of the altimeter-SSH-tracked eddies. The parameter is the ratio of U, the speed of rotational, geostrophic flow around the eddy, to c, the eddy propagation speed. The U/c nonlinearity parameter is a traditional measure of the relative importance of fluid advection and wave propagation for general nonlinear waves, with advection becoming progressively more important as U increases for U/c > 1, and so can be expected to be relevant to the problem of determining the fluid trapping and transport by SSH-tracked eddies.



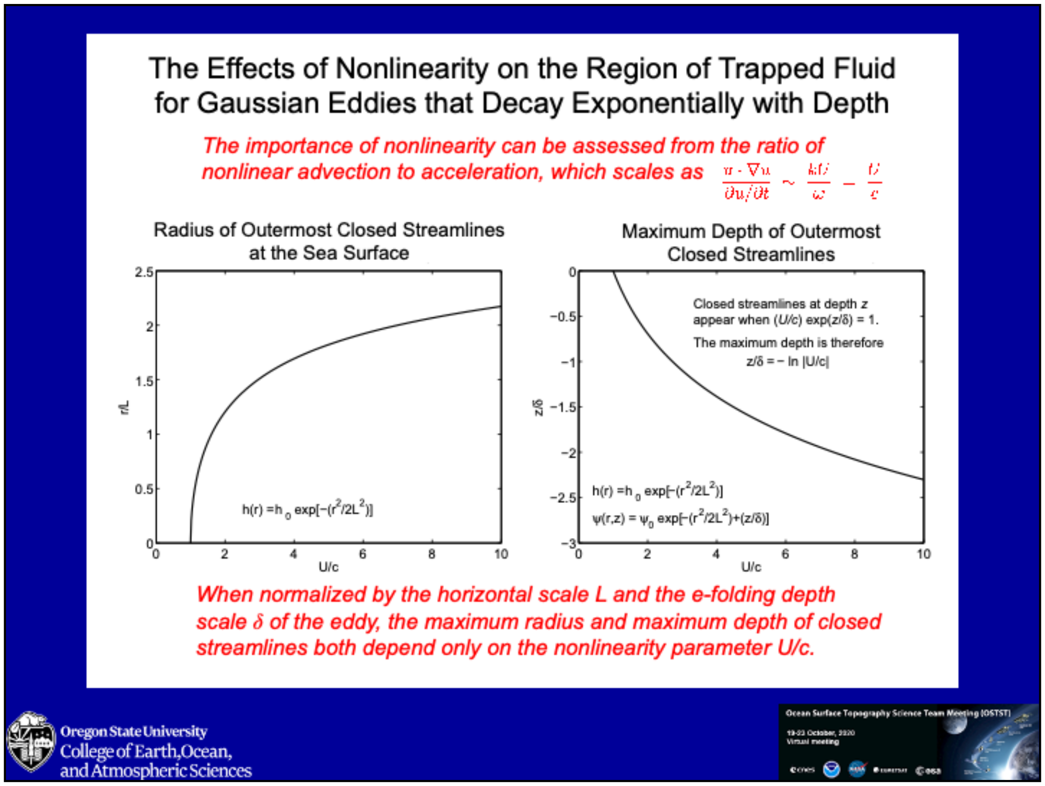
The nonlinearity parameter U/c computed for the SSH-tracked eddies has a pronounced latitude dependence, with larger values at higher latitudes.



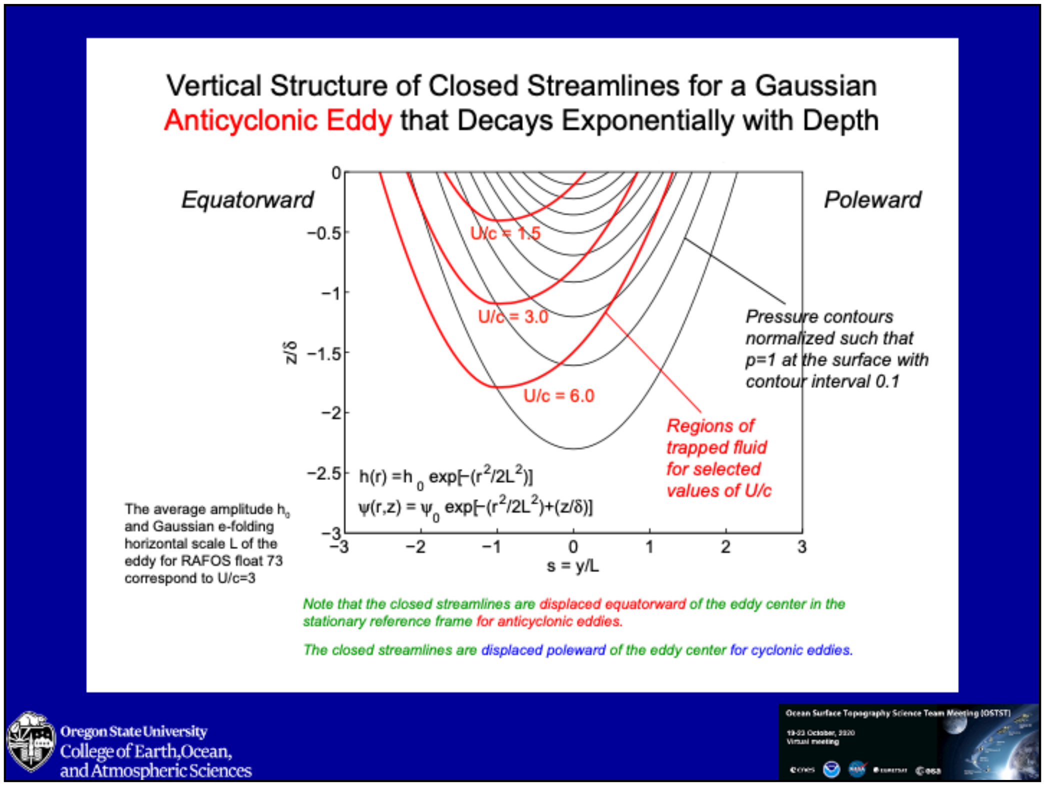
For the case of a perfectly coherent, steadily translating eddy on a resting background state, the region of trapped fluid can be computed exactly by transforming the stream function to a frame of reference moving with the eddy and identifying the region of closed streamlines in the co-moving frame. For a fixed eddy shape, the size of the trapping region is determined by the value of the nonlinearity parameter U/c.



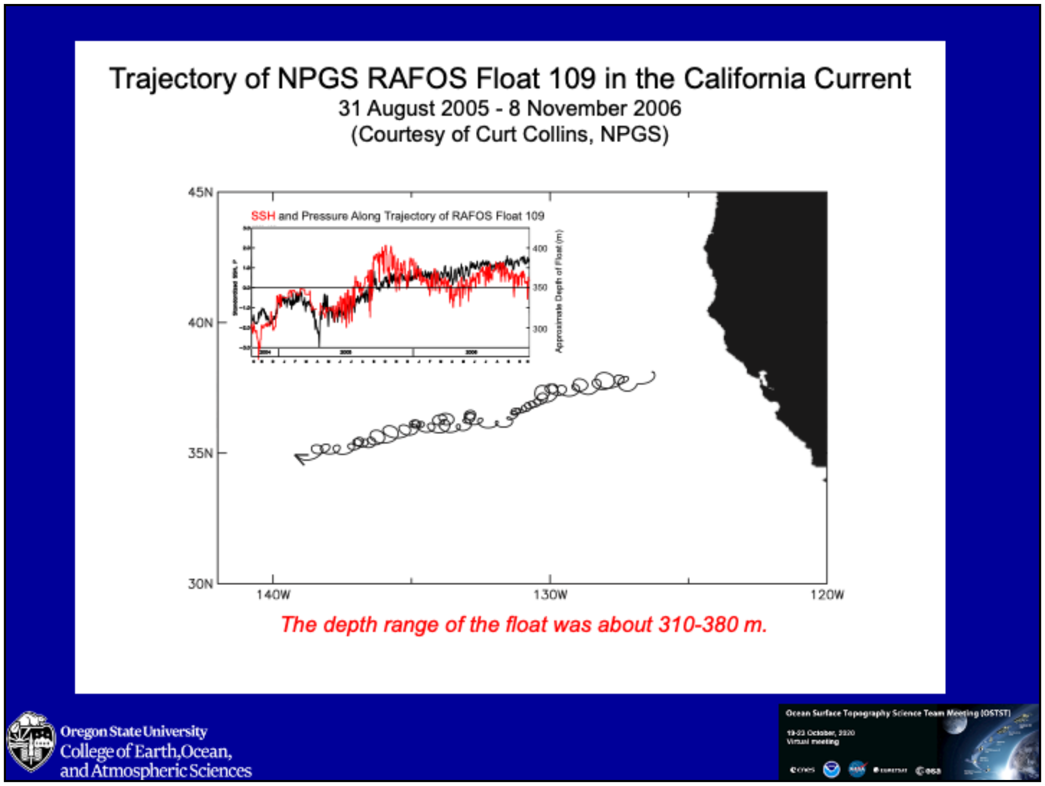
The characteristic structures of fluid trajectories inside and outside of the trapping region of a propagating eddy are shown, for the case of a perfectly coherent, steadily translating eddy on a resting background state.



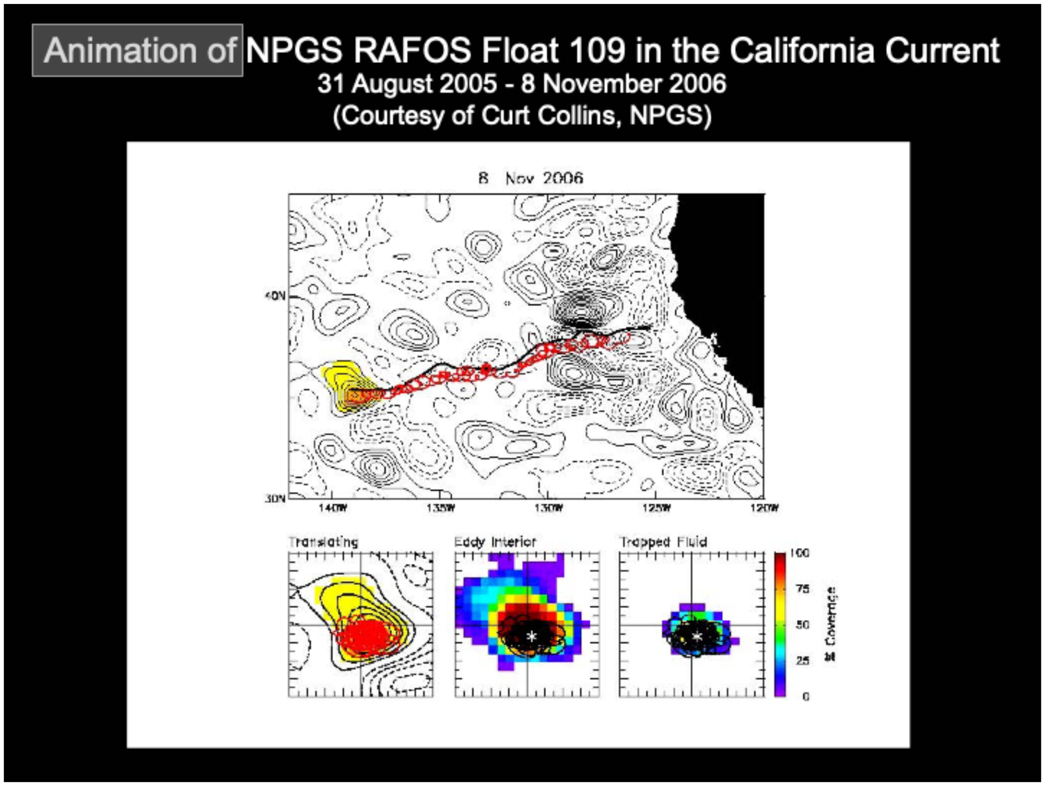
Some basic parameter dependencies of the region of trapped fluid are shown, for the case of a perfectly coherent, steadily translating eddy structure with exponential depth decay.



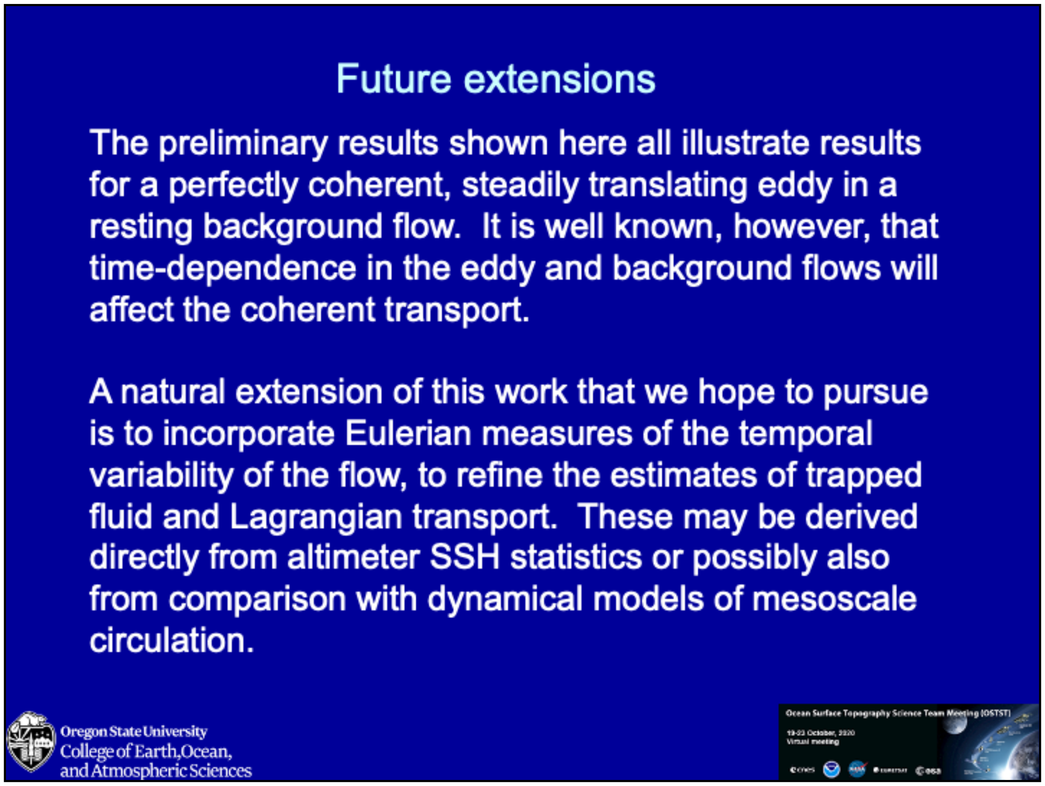
The trapping region will generally decrease with depth, for surface-intensified eddies, as in this analytical example with exponential depth decay.



An example of a RAFOS float (Curt Collins, Naval Postgraduate School) trapped in a mesoscale eddy in the California Current System.



This is the final frame of an animation of the RAFOS trajectory and altimeter SSH that is not included in the presentation file but is available from the authors on request.



A natural basis for the model comparison is the ocean mesoscale regime of the quasi-geostrophic model that was recently identified by Samelson et al. (2019), as summarized briefly in the “Salient Results from OSTST 2017-2020” contribution by the same authors.

Samelson, R. M., D. B. Chelton, and M. G. Schlax, 2019. The ocean mesoscale regime of the reduced-gravity quasi-geostrophic model. J. Phys. Oceanogr., 49, 2469–2498, DOI: 10.1175/JPO-D-18-0260.1; see also links to informal errata and source code at

http://www-poa.coas.oregonstate.edu/~rms/ms/jpo2019omrqg_jpo-d-18-0260.1_errata_eqs_26_27_Fig16.pdf

and

https://github.com/rsamelson/quasigeostrophic_spectral_layer_model/tree/master/qg_1layer_dp.