Transport models based on experimental data from laboratory baroclinic waves

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Abstract

We explore several methods for modeling transport across baroclinic waves in an experimental setting. The waves are generated using a rotating annulus experiment, which creates baroclinic eddies similar to those observed in the mid-latitude atmosphere, driven by a temperature gradient. A particle image velocimetry (PIV) system measures the horizontal velocity components just below the fluid surface, while an infrared camera simultaneously captures the surface temperature. Transport structures within the experiment are visualized using Uranine dye, revealing material curves that are closely associated with the unstable invariant manifolds of hyperbolic trajectories in the flow.

To analyze these transport structures, we propose several transport models based on dynamical systems, where the vector field represents the fluid velocity. The velocity data must be refined before use, as direct experimental measurements are noisy due to limitations in the instruments and procedures. We investigate models that filter the data using empirical orthogonal function (EOF) analysis, as well as a simple kinematic model constructed from key experimental parameters. The results of these different modeling approaches are compared and discussed, summarizing the findings presented in [1].

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References

[1] M. Agaoglou, V. J. García-Garrido, U. Harlander, A. M. Mancho. Building transport models from baroclinic wave experimental data. Physics of Fluids 36, 016611 (2024).