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ABSTRACT

GOALS

Lateral intrusions spend most of their lifetime in a quasi-steady, finite-amplitude state, in which the vertical scale and salinity amplitude do not change. I wish to understand the finite-amplitude dynamics of lateral intrusions well enough to be able to predict their scale and intensity on the basis of large-scale property gradients, and therefore to be able to parameterise the lateral fluxes of heat, salt, and momentum due to lateral intrusive mixing.

OBJECT

The long-term goal of this project is to make predictions of lateral salt, heat, and angular momentum transports in FINITE-AMPLITUDE intrusive mixing. Existing models of intrusive

features are linearized, and therefore cannot predict the amplitude and structure of intrusions which should predominate after several growth periods have elapsed.

Meddy "Sharon" was tracked for two years and surveyed four times by a diverse array of instruments. The high-salinity core of this salt lens was mixed into the background, and the velocity field dissipated, by lateral mixing associated with thermohaline intrusions. We will discover the dynamical mechanisms by which these intrusions operate, and develop models which attempt to predict the structure and rates of transport in finite-amplitude intrusions. It should soon be possible to construct a dynamical picture of intrusive mixing which links the mesoscale changes of the Meddy to the observable microscale vertical mixing and dissipation.

APPROACH

Detailed analysis and space-time mapping of the properties of these intrusions, plus comparison with dynamical theories of intrusive mixing, will give new insights into the dynamics of intrusions, and focus attention on the mechanisms which matter most to the local dynamics. Exploration of these dynamics through simple numerical models and related theoretical calculations will explore the finite-amplitude processes which serve to limit the amplitude and control the lateral fluxes of the intrusions. We especially intend to learn more about the role of frictional coupling between layers in modifying the "triple-diffusive" lateral transports of momentum.

TASKS

The analysis and mapping of the intrusions is essentially complete, and different sections and surveys are being compared to look for azimuthal and temporal variations in intrusion properties. Theoretical work on the slopes demanded by different dynamical driving mechanisms is complete, as is comparisons with observed intrusion slopes. Numerical modelling of intrusions is just beginning: the conceptual model is mapped out, and a search is beginning for the most appropriate numerical methods for the task.

RESULTS

The mapping of intrusion properties and comparison with dynamical theories has revealed that:

(1.) the intrusion vertical wavelength is consistently shorter (longer) in the upper (lower) part of the Meddy. (Figure 1).

(2.) the vertical salinity gradient variance is spatially well-correlated with the lateral salinity gradient, and moves inward with the salinity front as the Meddy is eroded.

(3.) warm, saline intrusions slope down (up) across isopycnals in the upper (lower) part of the Meddy as they extend radially outward. This pattern is consistent with driving by double-diffusive convection, and is inconsistent with the McIntyre (1971) mechanism, except for the unlikely case of Prandtl number less than 1. (Ruddick, 1990 a,b). (Figure 2.)

(4.) the observed slope of these intrusions and the calculated Richarson number of the Meddy are such that the McIntyre (1971) mechanism can not supply energy to the intrusions. (Ruddick, 1990 b)

(5.) A statistically significant correlation has been observed between the intrusion-scale perturbations of salinity (spiciness) and density. This correlation changes sign at precisely the place where the intrusion slope changes sign, indicating that the correlations are real and not instrumental in origin.

(6.) The observed density-spice correlations are consistent with driving of intrusions by double-diffusively induced density perturbations, and are inconsistent with the McIntyre (1971) mechanism. (Ruddick, 1991).

ACCOMP

The observed pattern and magnitude of the intrusion slopes, and the corresponding pattern of correlation between intrusion-scale density and salinity perturbations rule out any possibility of differential diffusion of mass and momentum (the so-called "McIntyre Instability") as a possible driving mechanism for the Meddy intrusions. They completely support the model of thermohaline intrusions driven by double-diffusive vertical fluxes (Ruddick and Hebert, 1987), and tell us that in the upper part of the Meddy diffusive interface transport is dominant. The most exciting aspect of these results is that by observing the magnitude of the slopes and density perturbations which are driving the intrusions, we can estimate the pressure gradient forces involved in the intrusion scale dynamical balances, and learn much about the frictional retarding forces which maintain a steady state at finite amplitude.