Southern Ocean Hydrography and Circulation: Evaluating Mixing and Stirring in the Southern Ocean with Lagrangian Floats

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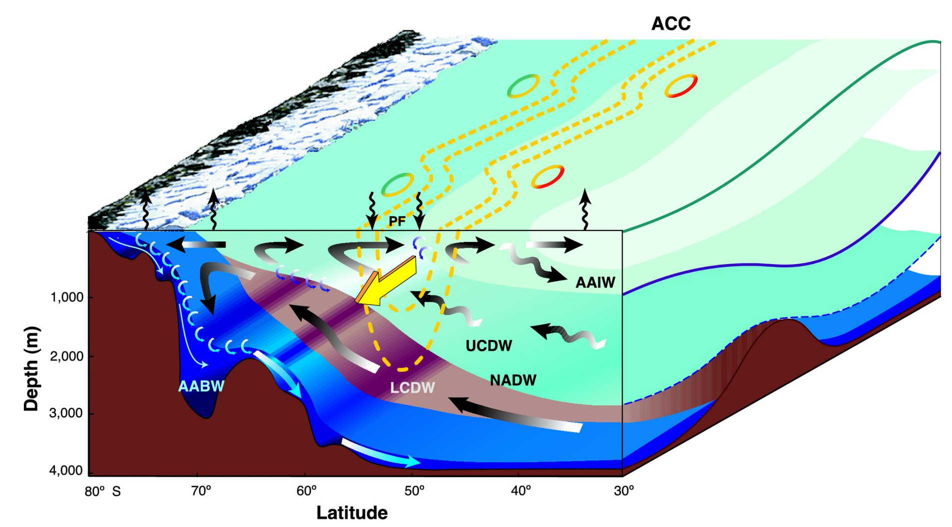
TH81B

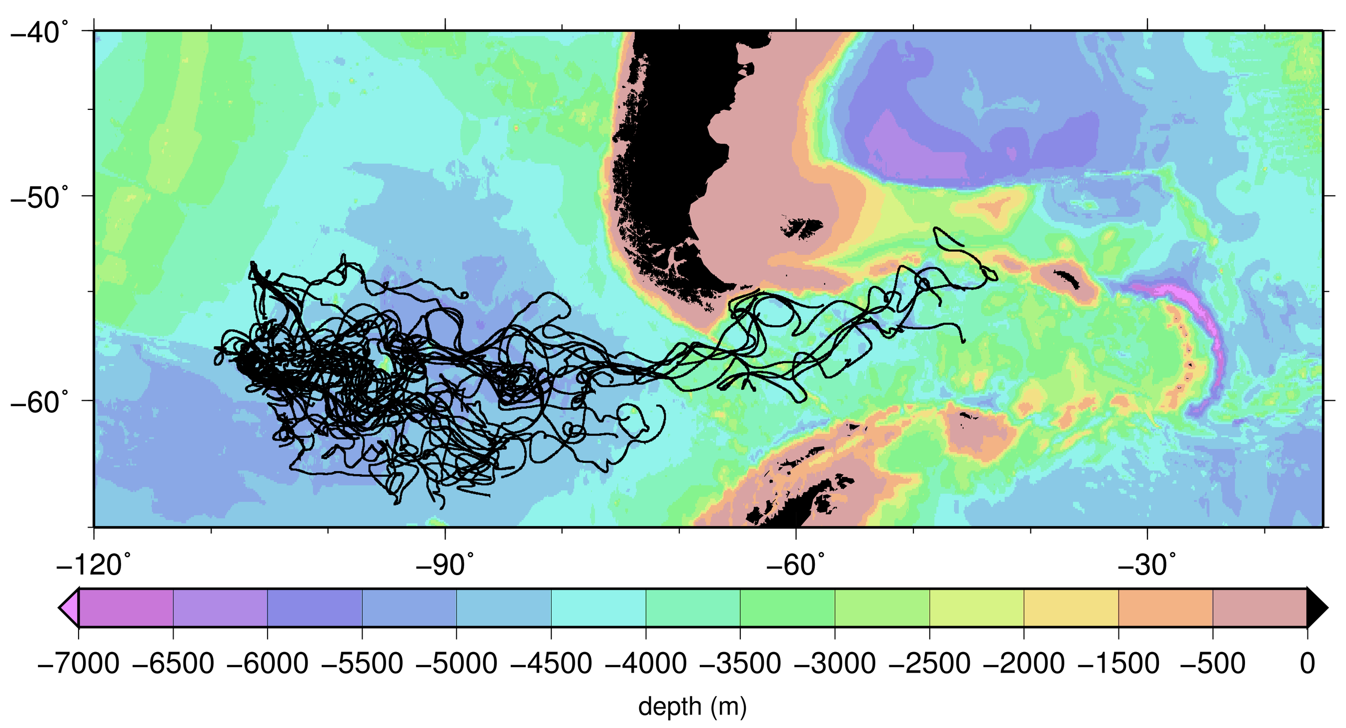
Session C37

1. Introduction

The Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES) deployed over 200 RAFOS floats in order to evaluate processes governing along-isopycnal mixing and stirring. Trajectories from 44 of these floats are now available, along with numerical simulations, Argo floats, surface drifters, and altimetry.



Southern Ocean meridional overturning schematic showing expected upwelling along isopycnals in Antarctic Circumpolar Current region (adapted from Speer et al, 2000).



DIMES questions:

- What is the effective along-isopycnal diffusivity? Are mixing processes diffusive?
- How does mixing vary with depth or position relative to the Antarctic Circumpolar Current jets?
- What methods are most effective for extracting information about mixing?

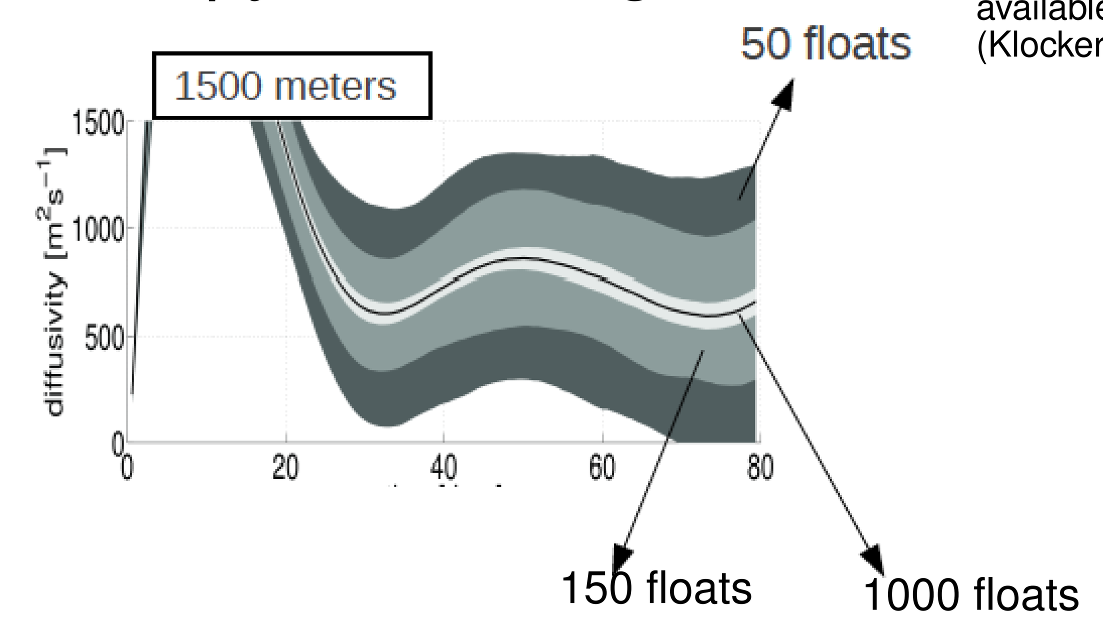
See poster TH80B for DIMES diapycnal findings and poster TH86A for more on DIMES float trajectories.

3. How can we estimate isopycnal mixing?

Isopycnal (or horizontal) diffusivity can be estimated from a variety of methods that in ideal conditions should yield similar results.

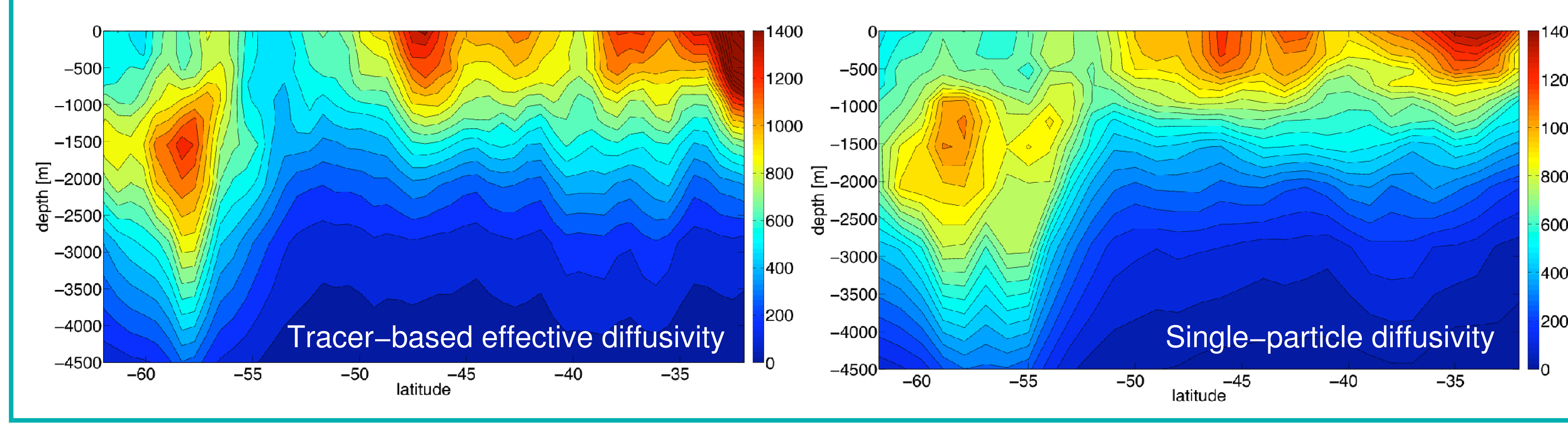
- Single-particle or relative dispersion of Lagrangian floats.
- Eulerian approach: $\kappa = \langle v'T' \rangle / T_y$.
- Tracer-based (Nakamura-style) effective diffusivity.
- Lyapunov exponents.

In practice, diffusivity estimates can have large uncertainties and may differ substantially.

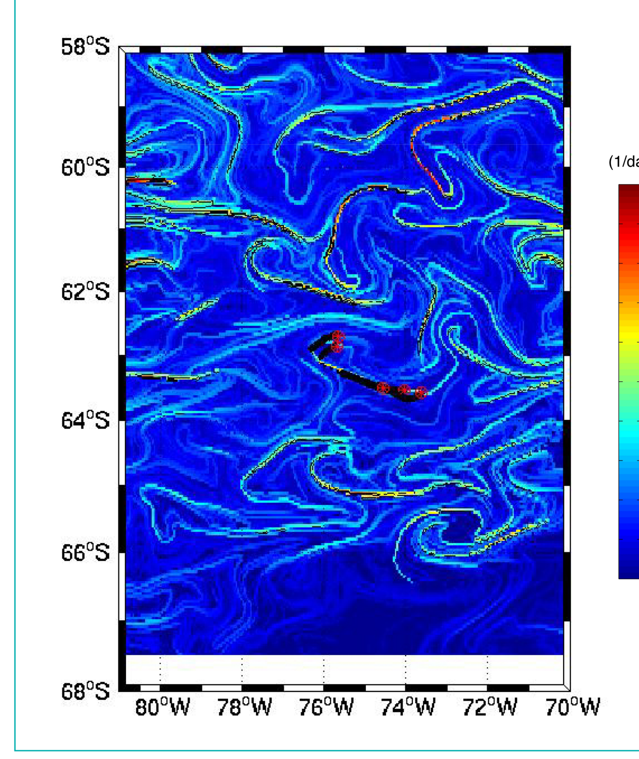


Particle dispersion approaches have large uncertainties unless 1000s of floats are available, possible only in numerical models (Klocker et al, submitted 2011).

Tracer-based effective diffusivity and float-based particle diffusivity estimates agree in idealized numerical-model conditions (Klocker et al, submitted 2011).

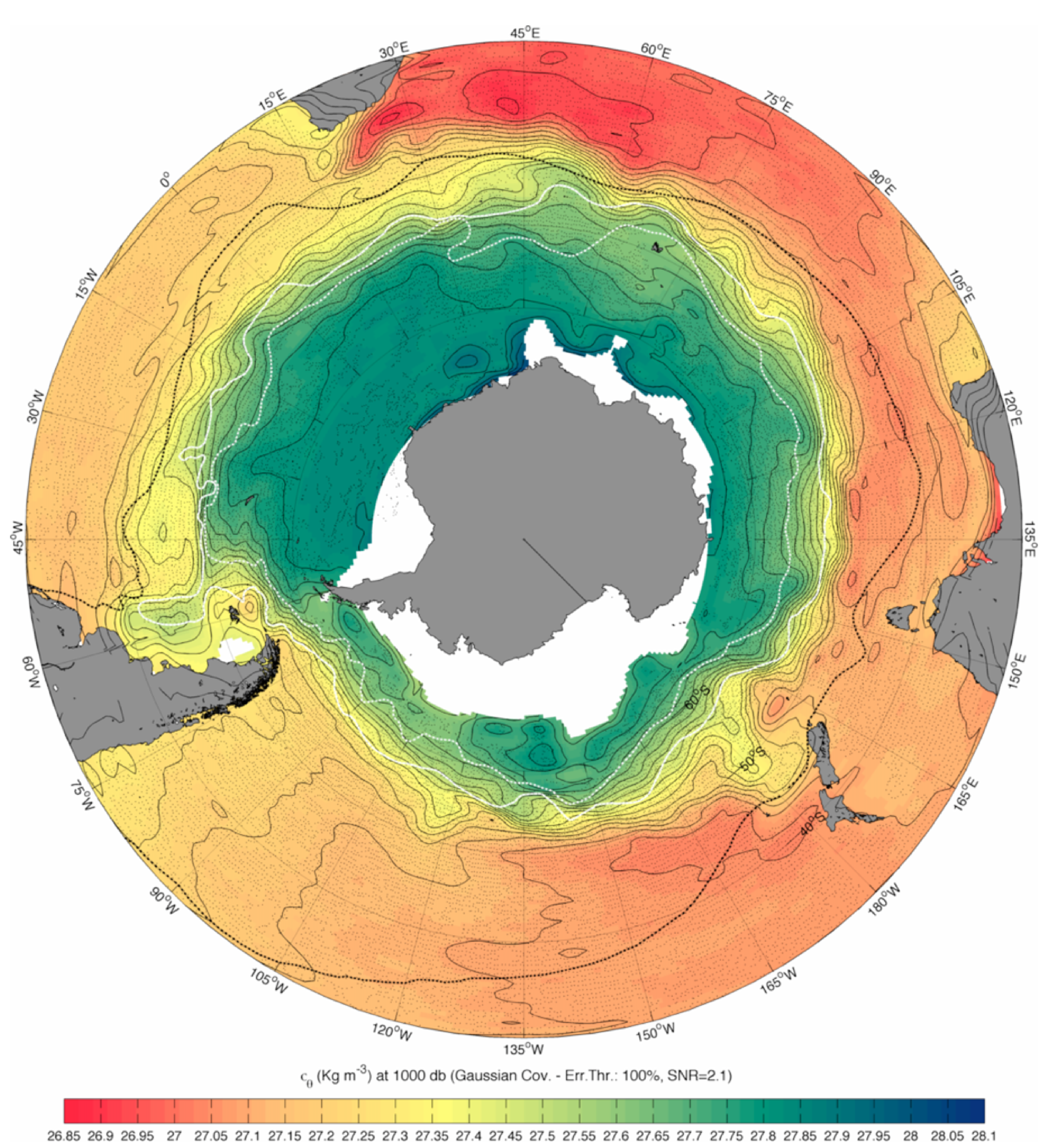


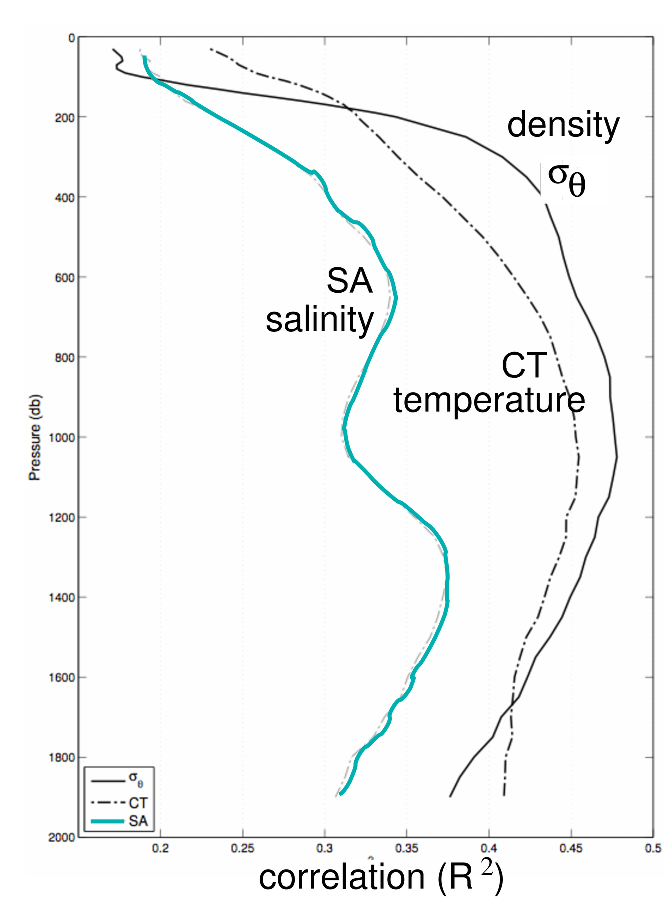
Four-day surface-drifter trajectories (in black) superimposed on the filament structure deduced from Lyapunov analysis of altimetry fields. The drifters follow the targeted filament. Lyapunov exponents provide information on dispersion at 20-100 km scales (Sallée et al, in preparation).



2. Defining the Setting

Argo data and altimetry provide key information about the background circulation in the DIMES region. Argo floats measure vertical temperature, salinity, and density structure, while altimetry provides information about the presence of transient eddies.



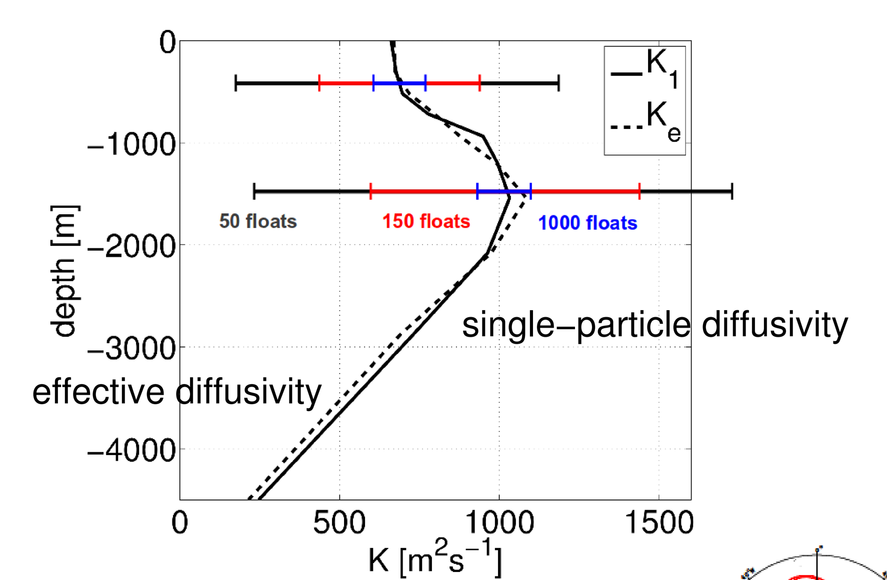


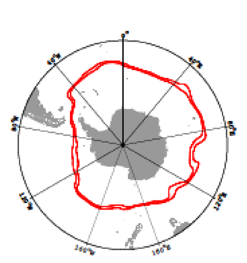
Eddy variability at the surface correlates with subsurface anomalies from Argo. Correlations are strongest at mid-depth, since the upper ocean temperature structure is strongly influenced by transient air-sea exchanges. Argo/altimetry regression coefficients are used to reduce eddy variability in the Argo data (Zajaczkovski and Gille, in preparation).

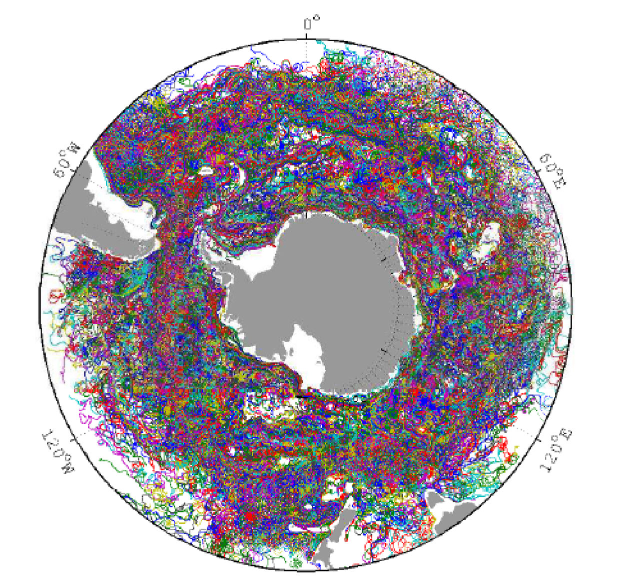
Mean density at 1000 dbar indicates the background flow field, necessary for assessing float dispersion (Zajaczkovski and Gille, in preparation).

4. How does isopycnal mixing vary spatially?

Theory predicts low diffusivities near the surface and high diffusivities at a critical depth where ACC velocity approximately balances the Rossby wave phase speed. This works well for an equivalent barotropic system, with sufficient information (Klocker et al, submitted 2011).

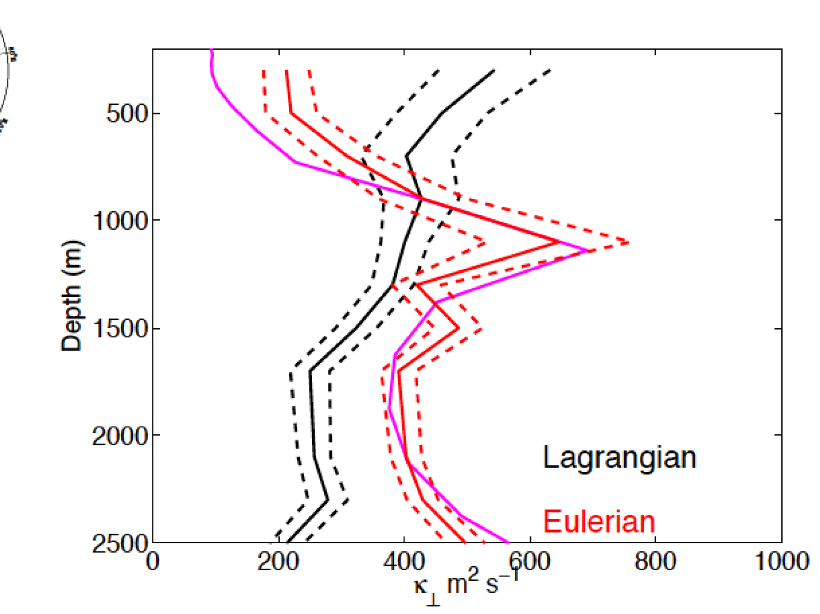






Numerical floats blanket the Southern Ocean when 56,000 are deployed in the 1/10° Parallel Ocean Program (POP) model (Griesel et al, in preparation).

In the POP model, Eulerian diffusivities imply a subsurface diffusivity maximum within the core of the ACC, but Lagrangian diffusivities derived from numerical floats do not. Tests continue to evaluate whether this difference occurs because float coverage is insufficient or because of differences imposed by realistic forcing and bathymetry used in POP (Griesel et al, in preparation).



5. Summary

Additional DIMES floats will surface in the next few months, allowing a more complete analysis effort.

- Numerical studies indicate isopycnal diffusivities with ranges between 200 and 1500 $m^2\ s^{-1}$.
- Diffusivities are hypothesized to vary horizontally and vertically, with large values at a subsurface critical depth below the core of the ACC and also to the north of the ACC.
- DIMES float trajectories will be useful in constraining isopycnal diffusivity estimates, but uncertainties are large with O(100) floats.
- Ancillary information (including Argo float trajectories and altimetry) are critical for defining background flow field and eddy variability.

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More information: http://dimes.ucsd.edu