Preliminary results from DIMES: Dispersion in the ACC

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1. Background

With the enhancement of computer power, our understanding of the climate system has improved greatly. We have come a long way from representing the ocean as a 'slab' that exchanged water with the rest of the Earth system to current generation models which have a 1.25 degree resolution in the ocean. As a result, models have become better at describing processes like the meridional overturning circulation (MOC) of the world ocean, one of the fundamental determinants of the planet's climate.

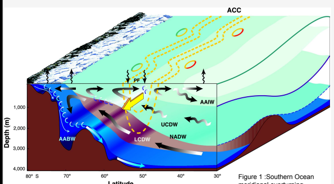


Figure 1 :Southern Ocean meridional overturning schematic (adapted Speer et al., 2000)

One of the components of of the MOC lies in the southern ocean, where the water flows to the continent in the intermediate layers and is returned in the surface (Ekman layer) and as heavy deep water (shown in the left schematic).

The Antarctic Circumpolar current is a highly energetic region which is dominated by a eddies and strong jets (figure on right from 1/12 OCCAM model). These eddies act to homogenize the potential vorticity region while the jets are strong gradients of potential vorticity and act as barriers to mixing. It is this interplay of jets and eddies in the ACC which is responsible for the meridional transport in the intermediate layers of the southern ocean.

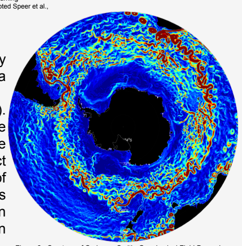


Figure 2 : Courtesy of Carlowen Smith, Geophysical Fluid Dynamics Inst., Florida State University

Open Questions

1. How do eddies and jets cause mixing?
2. How is this mixing influenced by topography or any other factors?
3. Are the current parameterizations sufficient to explain this mixing? (probably not) What will be better ways to represent this mixing?

2. Experiment

The Diapycnal (vertical in density coordinates) and Isopycnal (horizontal in density coordinates) Mixing Experiment in the Southern Ocean (DIMES) is an ongoing CLIVAR process study designed to study mixing in the Antarctic Circumpolar Current, including tracer release, floats, and measurement of small-scale turbulence. The tracer and floats were released along 105W between the polar front and the Subantarctic front to capture the flow structure west of and through Drake Passage. At present data has been received from 50 floats and those trajectories are processed, analyzed and presented here.

3. Trajectories

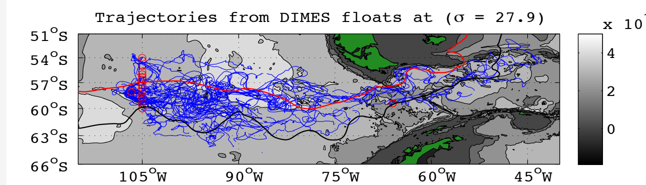


Figure 3 : Trajectories from the 44 floats which have been processed and whose data is used here for the subsequent analysis.

4. Description of Trajectories

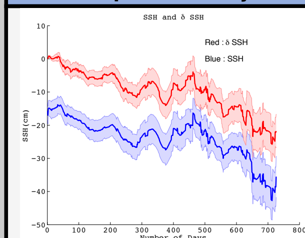


Figure 4(left): The sea surface height (SSH) and change in SSH plotted as a function of time. The floats show significant cross SSH transport and have a tendency to drift southward (to more negative SSH) in SSH coordinates.

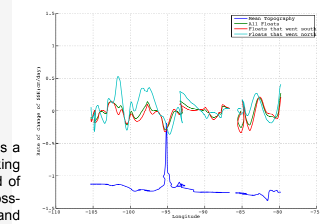


Figure 5(right): The mean rate of change of SSH as a function of longitude. The means are calculate taking all floats, floats that went south in SSH at the end of floats mission and that went north in SSH. The cross-SSH transfer is not uniformly distributed and topography might be a significant contributor. The seamount at 95E seems to have an effect on this cross-SSH motion.

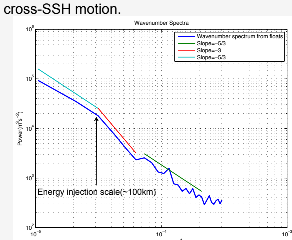
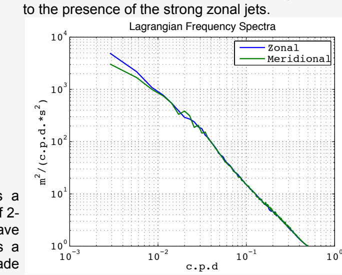


Figure 6(above): The energy spectrum shows a -5/3 and -3 law, which is a clear representation of 2-D turbulence. The energy injection is at low wave numbers (possibly wind ~100km) and there is a forward enstrophy cascade and an inverse cascade of energy.

Figure 7(below): The lag frequency spectrum is anisotropic at lower frequencies. This might be due to the presence of the strong zonal jets.



5. Dispersion Statistics

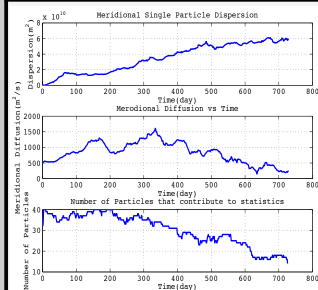
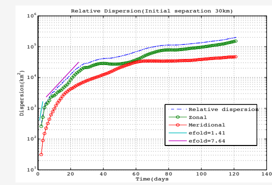


Figure 8(left): Plots of meridional dispersion and diffusivities calculated from single particles. The meridional dispersion predicts diffusivities which are of the right order as compared to other studies. Is the limited data sufficient to provide diffusivity numbers which can be used for climate models? If not, can we use satellite observation and Argos floats along with DIMES results to come up with better diffusivities?



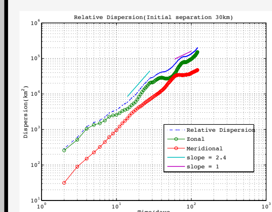
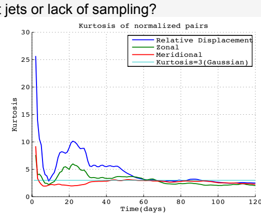


Figure 9(above), 10(left): Plots of relative dispersion in semi-log and log-log plots respectively. The relative dispersion show exponential separation at initial times(<20days) and then seem to settle into a power law.
Does the relative dispersion have a Richardson regime or shear dispersion after 20 days? Is the structure of the zonal dispersion an indication of transient jets or lack of sampling?

Figure 11(right): Plot of kurtosis calculated from probability distribution functions of relative displacement of pairs as a function of time. Strong non-Gaussian behavior of pair separations during the initial days. Anisotropy is also observed in the kurtosis between days 10 and 30. The non-Gaussian kurtosis and anisotropy is an indication of zonal jets in the ACC.



6. Summary

The DIMES floats give us an opportunity to test the current theories about the isopycnal (horizontal) mixing going on in the ACC. The key results obtained are as follows

- **Southward Drift** : Different estimates show that the floats drift southward possibly a signature of the MOC.
- **Anisotropy** :The Lagrangian spectra and the calculation from pair separations show clear indications of anisotropy due to presence of zonal jets.
- **Comparable Diffusivities** : The diffusivity estimates are comparable to studies done with numerical models and altimetry velocities.
- **Flow Regimes** : The flow has different regimes of dispersion at different scales

The work is still in its initial stages and all comments and suggestions are welcome and greatly appreciated. Please feel free to contact the authors about the current or future work via personal communication at the conference or email Dhruv Balwada (db10d@fsu.edu).