Estimating Basin-Averaged Diapycnal Diffusivities

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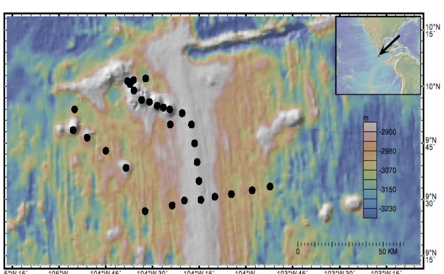
Introduction

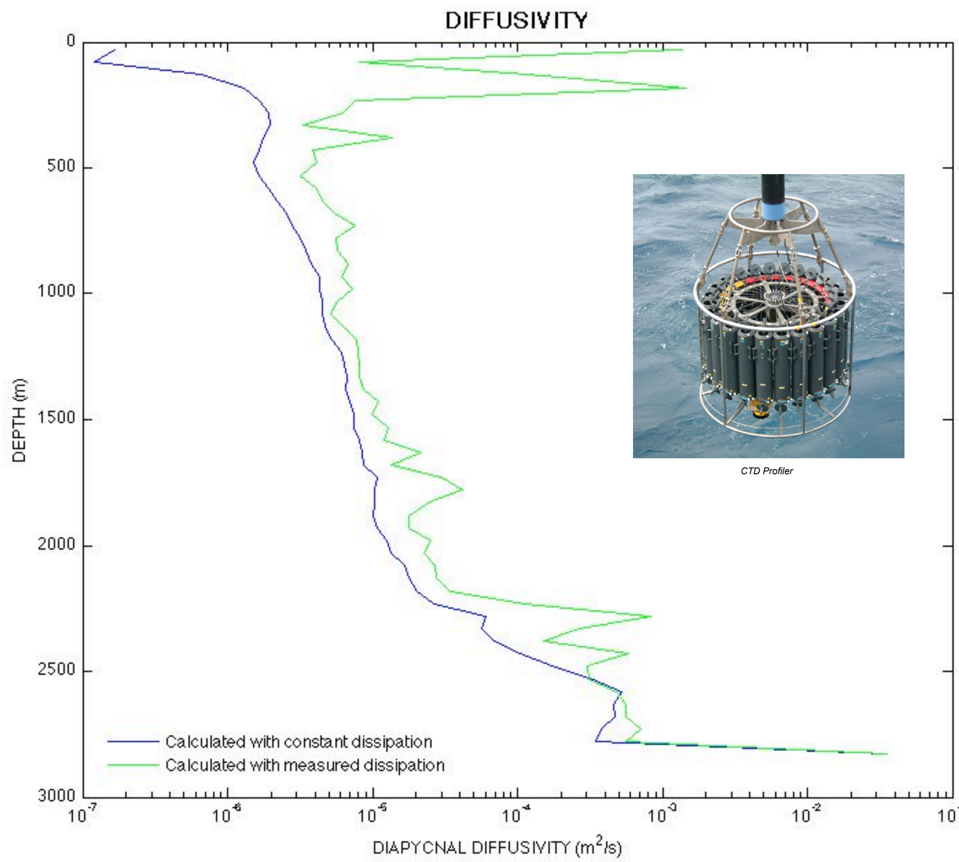
Mixing in the deep ocean plays a large role in global ocean circulation. Buoyancy flux away from the sea surface balances the formation of bottom water at high latitudes. There is a discrepancy between theoretical calculations and measurements of diapycnal diffusivity, a measure of vertical mixing in the ocean; theoretical calculations give basin averages of 10^{-4} m^2/s, while measurements conducted in the thermocline have consistently returned values of 10^{-5} m^2/s, an order of magnitude lower. One recent theory to explain this "missing mixing" argues that enhanced mixing near the seafloor, particularly near the rough topography of mid-ocean ridges, makes up for lower diffusivity in the thermocline. In this project, basin-averaged diapycnal diffusivity profiles are derived in order to explore the rates of mixing at different depth ranges in the ocean. In the project Larval Dispersion over the Deep East Pacific Rise (LADDER), low values of kinetic energy dissipation, another measure of mixing, were observed. Weak regional density stratification, however, leads to low buoyancy frequency and thus intensified mixing in the abyssal ocean. This project aims to compare diffusivity profiles derived using both the measured energy dissipation values, and a constant, low background dissipation in order to determine whether diffusivity profiles derived from buoyancy frequency alone can accurately portray rates of mixing in the deep ocean.



Location of LADDER-3 Stations over the East Pacific Rise, Created using GeoMapApp

Methods

Data for these stations come from the third cruise of LADDER. CTD and Deep Microstructure Profiler measurements were taken at each station. Buoyancy frequency was calculated from CTD salinity, temperature, and pressure measurements, then filtered to remove high frequency signals associated with errors in the calculation. Two profiles of diapycnal diffusivity were derived for each station; one using measured values of kinetic energy dissipation from the DMP data and another using an assumed constant dissipation of 10^{-10} W/kg. Derived diffusivity profiles are then averaged in 50m blocks, and then station profiles are averaged together to create two regionally-averaged profiles. Depths to which the profiles of fewer than six stations extend are excluded from the averages.



CTD Profiler

Results and Discussion

In the above graph, two averaged profiles of diapycnal diffusivity are plotted. The diffusivity profile derived using measured values of dissipation has a value of 10^{-5} m^2/s for the majority of the water column. In the mixed layer above the thermocline, in the top 100m, the dissipation increases to a value close to or above 10^{-3} m^2/s. There is a spike in diffusivity in the thermocline around 250m that is difficult to explain. Near the ocean floor the diffusivity increases to values again around 10^{-3} m^2/s. The profile derived using a constant assumed dissipation matches closely the profile derived using measured dissipation data, especially at depth in the water column, with the constant dissipation profile consistently having slightly lower diffusivity values. Above 500m the two profiles diverge, with the profile calculated using a constant dissipation value dipping to values as low as 10^{-7} m^2/s. The dissipation estimate of 10^{-10} W/kg is not a good estimate for energy dissipation values in the upper layers of the ocean. It is, however, a good estimate for dissipation in the rest of the water column, as evidenced by the similarity of the two profiles, particularly away from the surface. Soon to come is a basin-averaged diffusivity profile from a section of stations extending across the Pacific, calculated using CTD data and an assumed background dissipation.

References

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