Can we infer vertical mixing rates from Argo float's ascent rates? Exploring Apex floats ascent rate variability within the surface mixed layer

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MOTIVATION

Turbulence can be unevenly distributed within the surface layer homogeneized in density from a past turbulent event. The intensity of turbulence in the surface mixed layer can impact biological rates (phytoplankton growth, grazing), and aggreagtion rates impacting on carbon export, and is important to better constrain turbulent fluxes and close biogeochemical tracer budgets.

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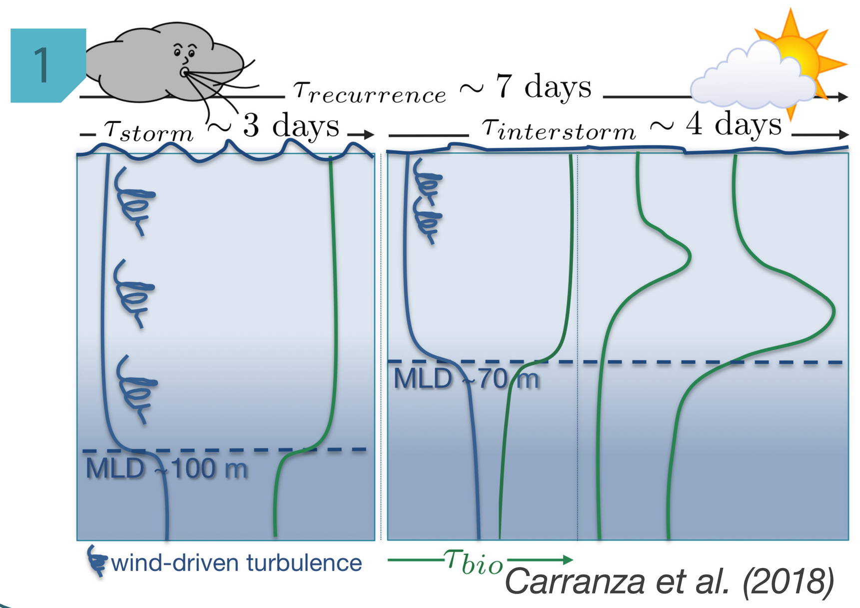


Turbulent fuxes

$$\sim \frac{\partial}{\partial z}\left(K_z \frac{\partial P}{\partial z}\right)$$

K_z (z,t) ? Turbulent diffusivity

Vertical gradients from BGC Argo floats

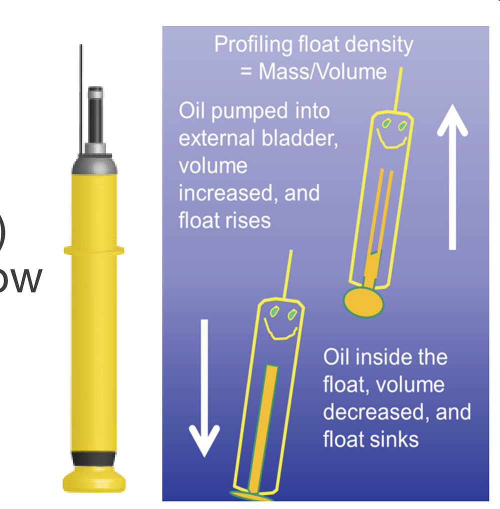
Fine-scale prametrizations are not applicable in the surface mixed where stratifictaion is low.

APPROACH

The Large Eddy Method (LEM) allows to infer turbulence from the largest scales of eddies, and has been sucesfully applied to glider observations. Here, we explore verical ascent rates from a subset of Argo floats deployed by SOCCOM (UW Apex floats carrying SBE41cp CTD sensors) and the feasibility of applying the LEM to infer dissipation rates, with a focus on the surface mixed layer.

Apex float's Ascent Rates

Floats are designed to change their buoyancy by moving oil in/out of an external bladder. The ascent rates inferred from the pressure sensor (w_ctd =dp/dt) can be sensitive to ocean turbulence, but will also show variability induced by the buoyancy engine.
Can we recover vertical velocities from float's ascent rates using filtering techniques? $w = w_{ctd} - w_{steady}$



2A 2B

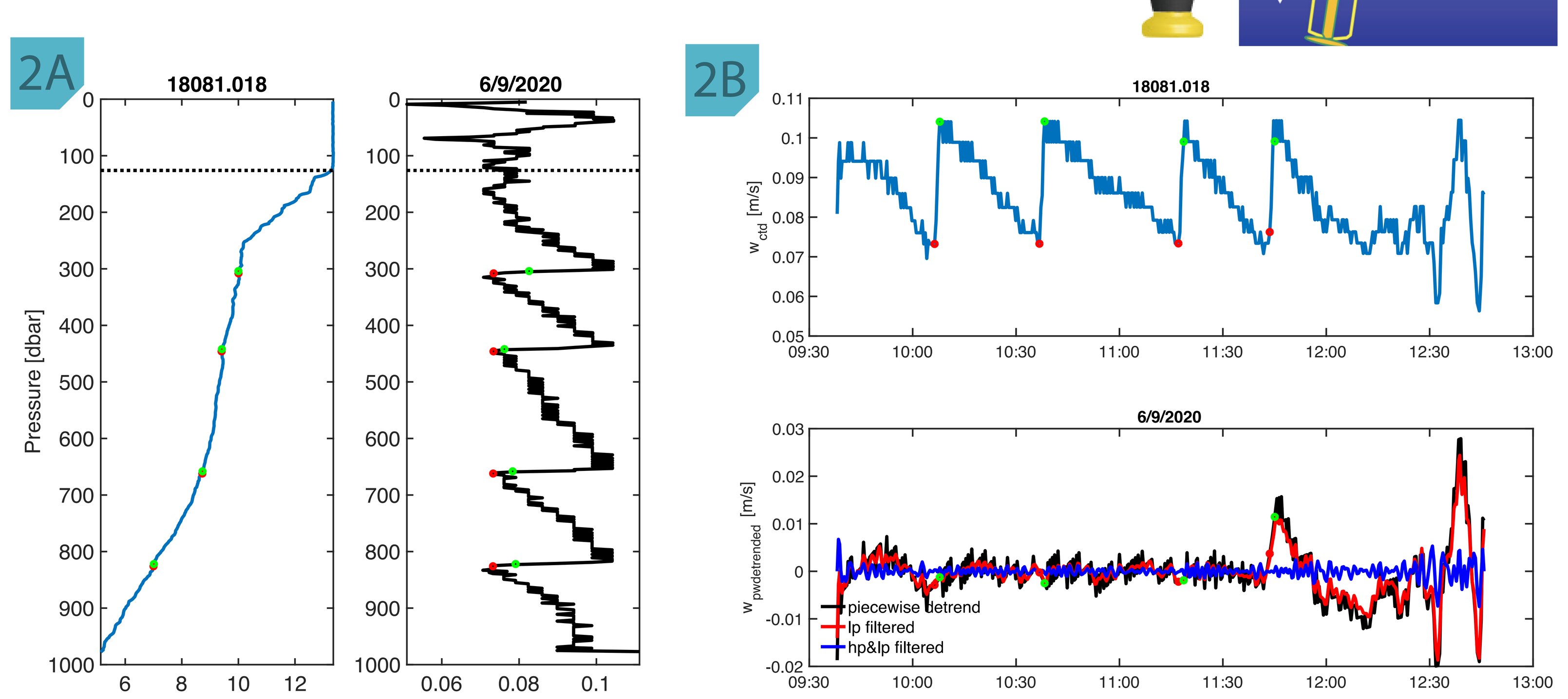


FIGURE 2. (2A) Example profile of ascent rates, w_ctd, for an Apex float (18081, cycle 018) with available engineering data to the surface. Red/green dots indicate pump on/off. (2B) Ascent rates as a function fo time (top), and examples of filtering techniques: piecesewise detrending (black), low-pass to remove pressure sensor noise, high-pass to remove buoyancy pump effects (blue).

REFERENCES

1. Carranza et al. (2018). When mixed layers are not mixed. Storm-driven mixing and bio-optical vertical gradients in mixed layers of the Southern Ocean, JGR Oceans.
2. Beaird et al. (2012). Dissipation of Turbulent Kinetic Energy Inferred from Seagliders. JPO.
3. Cusack et al. (2017). Observation of a Large Lee Wave in the Drake Passage. JPO

Spatio-temporal Patterns

3A 3B

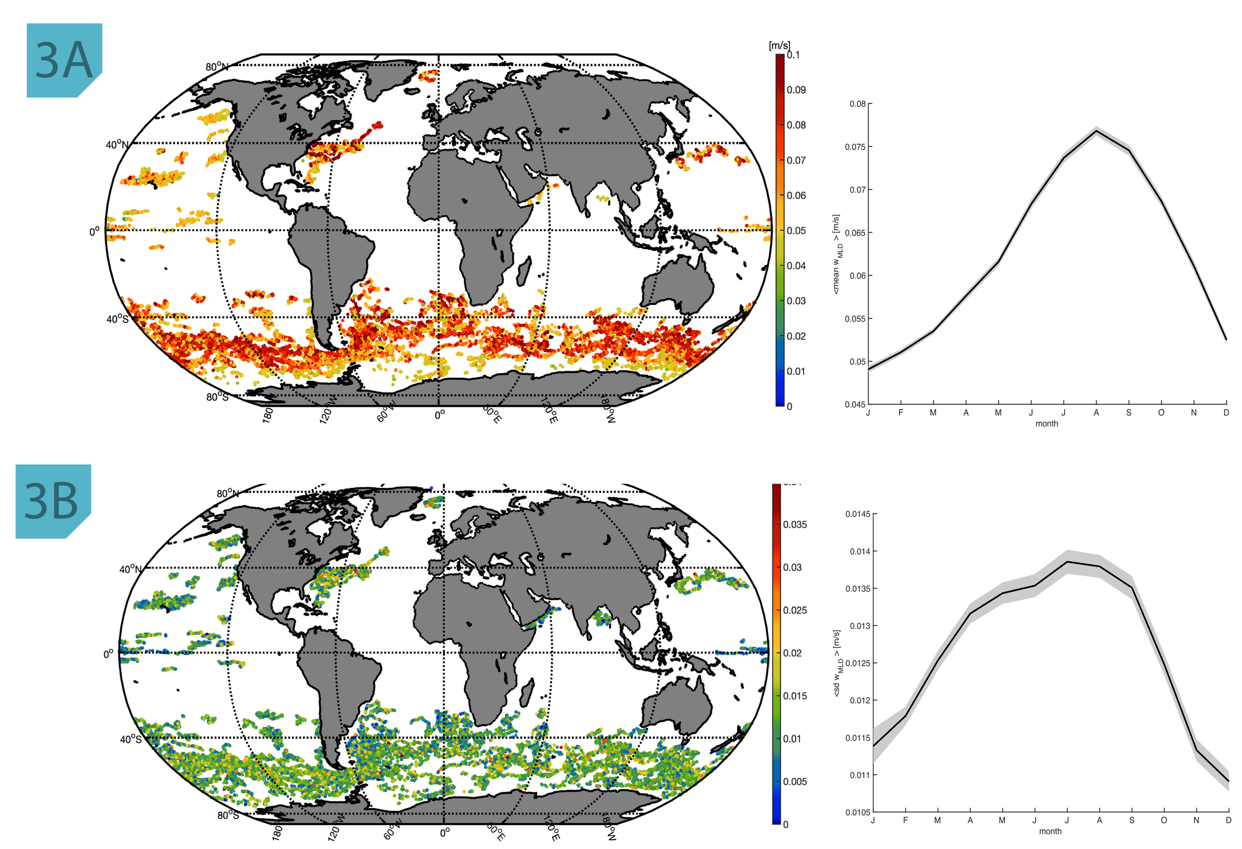


FIGURE 3. Apex floats' ascent rates (3A) Mean surfacing velocities (depth-averaged w_ctd) within the mixed layer (MLD), and seasonality for the Southern Hemisphere (SH). (3B) Standard deviation of w_ctd within the mixed layer (MLD), and SH seasonality (monthly averages)

Wind forcing and mixed-layer depth (MLD)

4A 4B

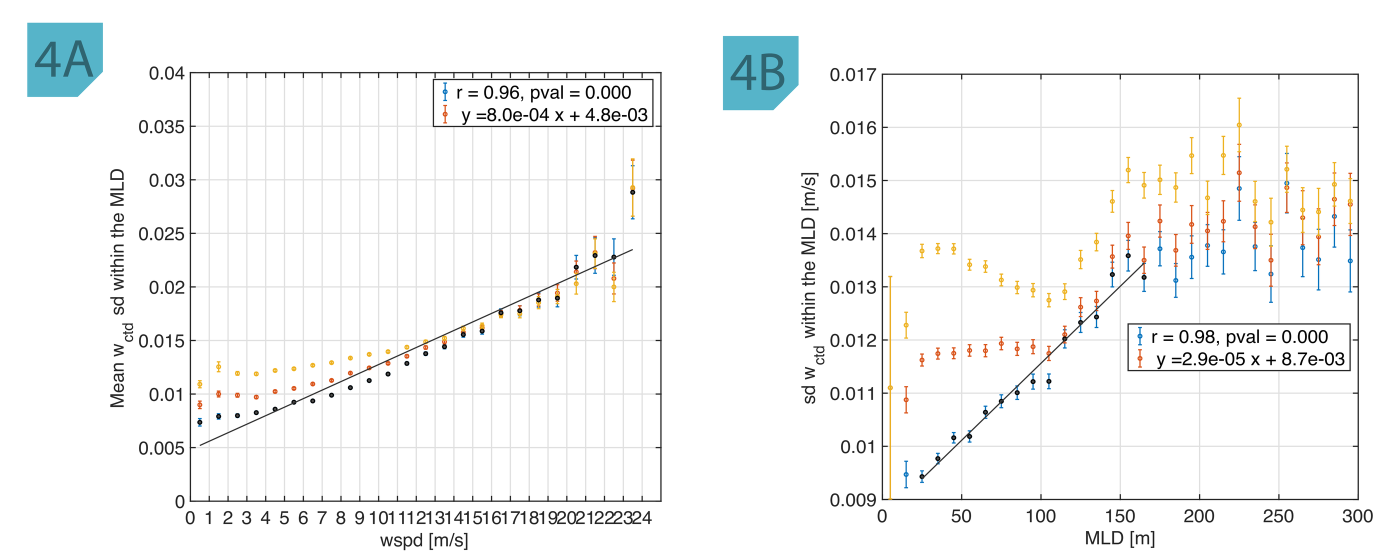
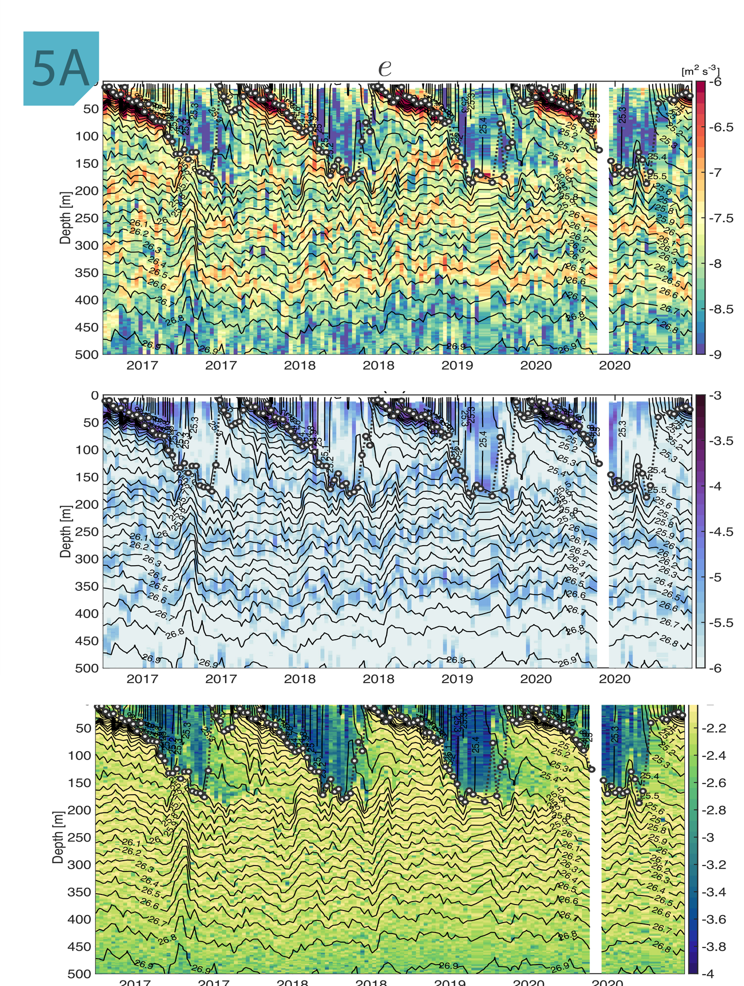


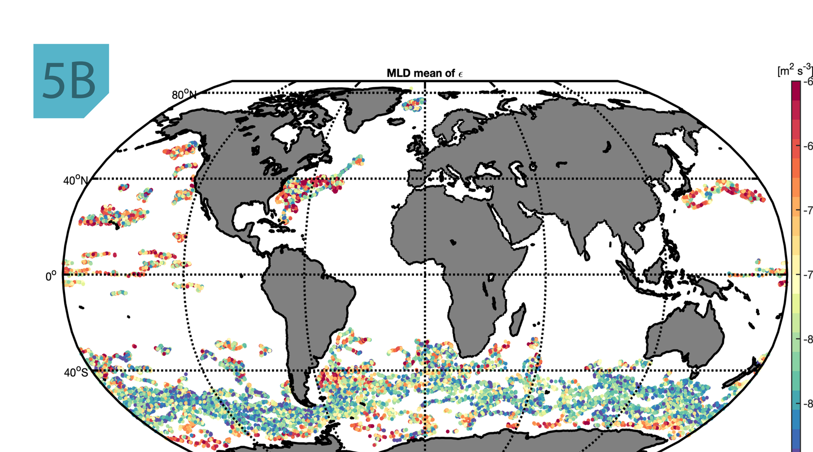
FIGURE 4. Correlation between (4A) standard deviation of w_ctd for the MLD and wind speed (from CCMP, within 25x25km of profile location and 6h of profiling date), (4B) standard deviation of w_ctd for the mixed layer and MLD. MLD based on density threshold of 0.005 (blue), 0.03 (red) and 0.125 (yellow) kg m-3.

Dissipation Rate Estimates (LEM)

5A



5B



Large Eddy Method (LEM):

$$e = c_\epsilon N(w')^2 \qquad c_\epsilon = 1$$

GURE 5. (5A) Dissipation rate estimates (from the LEM, ollowing *Beaird et al. 2012*) for float 9766 in the western oundary current region of the North Atlantic. (5B) veraged e for the surface mixed layer. Float's ascent ates where high-pass and low-pass filtered to remove igh-frequency noise from the pressure sensor (fc=0.01 Hz) and buoyancy pump effects (fc = 0.004Hz).

CONCLUSIONS

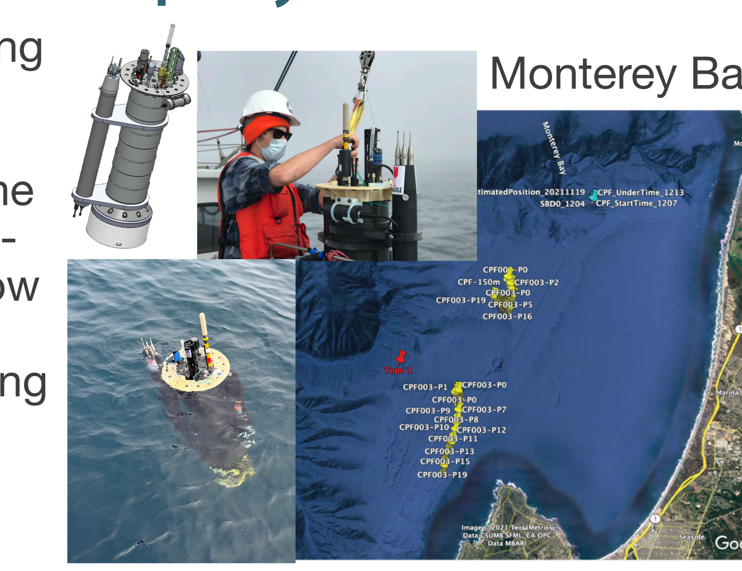
- Argo float's ascent rates within the surface mixed layer show spatial and temporal patterns of variability that suggest an oceanic signal potentially driven by turbulence
- Mean float's ascent rates as well as its variance within the mixed layer are enhanced within the ACC and western boundary currents, in the wintertime and at night (particularly in the Equatorial region, not shown).
- Argo ascent rates within the surface mixed layer are strongly correlated with wind focing in the Southern Ocean, and its variance increases with deep mixed layers

FUTURE PERSPECTIVES

Further investigate buoyancy pump activity within the mixed layer, how to remove effects from the float's buoyancy engine and expand the analysis to core Argo floats.

CPF + MicroRider Deployments

Test deployments of the Coastal Profiling Float (CPF, in development at MBARI) with a turbulence sensor package (MicroRider, RSI) have demonstrated the CPF is an ideal quiet platform for turbulence measurements. CPF+MR will allow to estimate a calibration coefficient required for the LEM to infer vertical mixing rates from the CTD sensor on the float (SBE41cp), and potentially inform LEM applicability on Argo floats.



6A 6B

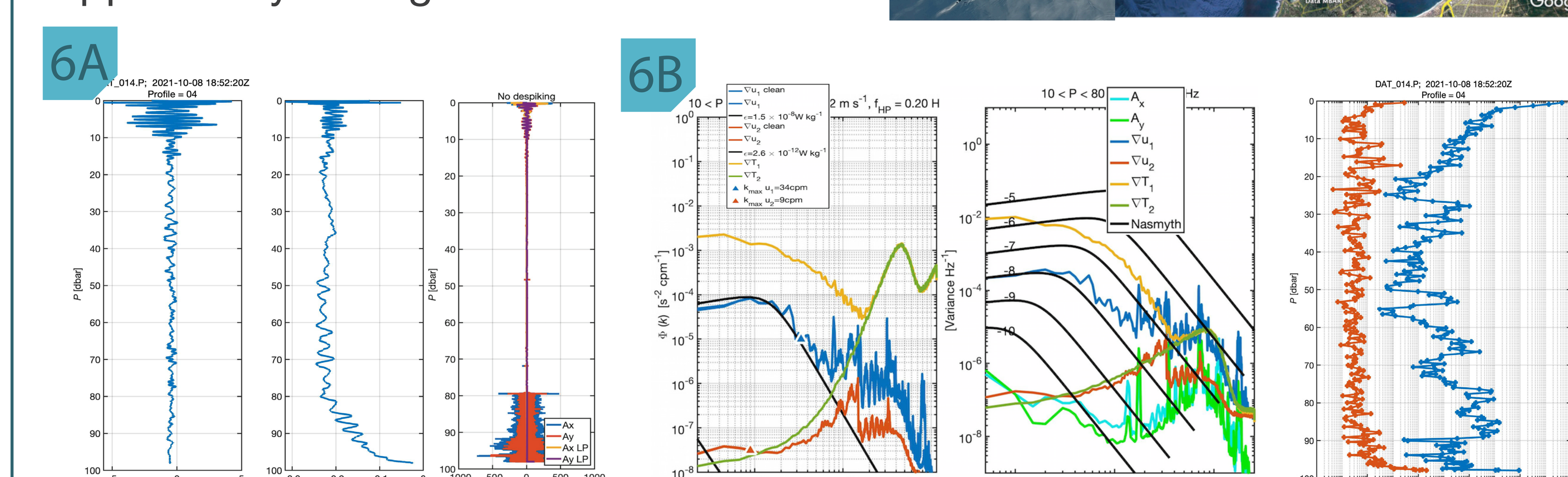


FIGURE 6. Example of (6A) inclinometer, profiling speed, and vibrations profile data from a CPF+MR MicroRider deployment over the shelf in south Monterey Bay. Note that buoyancy engine is turned off at 80 m. (6B) Microstructure shear spectra (between 10-80m), and dissipation rates profile, ϵ_1.

ACKNOWLEDGEMENTS

MBARI Postdoctoral Fellowship and SOCCOM for float data. Tanya Maurer, Josh Plant for assistance retrieving float data. Dana Swift (UW). Joseph Warren and Jared Figurski for assistance with CPF-MR deployments. Rockland Scientific (RSI) Team.

GRC on Ocean Mixing
Mount Holyoke, MA
Jun 5-10, 2022