Past and Future Measurements of Air-sea Interaction, Upper-ocean Mixing, and Ventilation Pathways from High-endurance Autonomous Platforms

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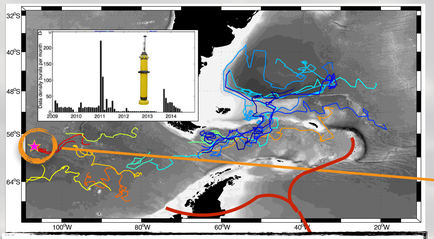
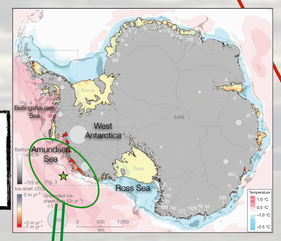
Abstract: Autonomous platform capabilities now allow a wide range of long-term oceanographic experiments to be conducted with little user interference. Gliding and drifting subsurface profilers can reach a substantial fraction of the ocean depth, and autonomous surface craft can provide sustained measurements of atmospheric forcing, with the result that ships need hardly be involved (or, at least, can be freed up for more specialized uses)! Results are described from recent projects using an autonomous Lagrangian approach (horizontally drifting but vertically profiling EM-APEX floats [Sanford et al 2005] carrying CTD and velocity sensors, in addition to other options, including chlorophyll, turbidity, oxygen, microstructure, and acoustic positioning) to study vertical mixing, wind generation of internal waves, and lateral property fluxes.

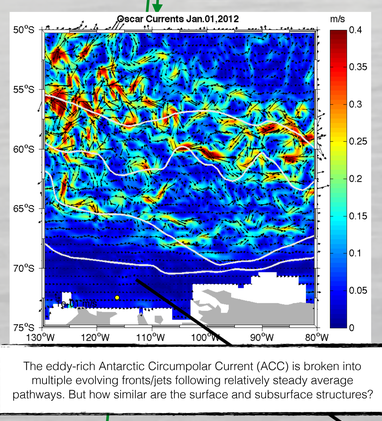
Past



EM-APEX in DIMES, the Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (colored by float).

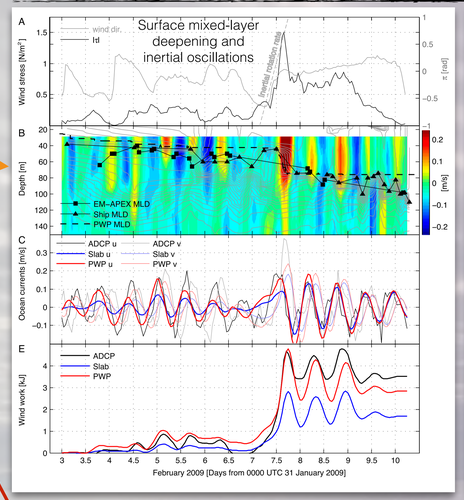


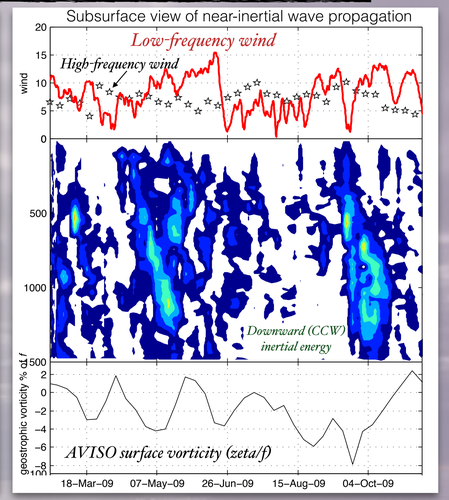
Amundsen Sea, West Antarctica, where Circumpolar Deep Water (CDW) is melting glacial ice.



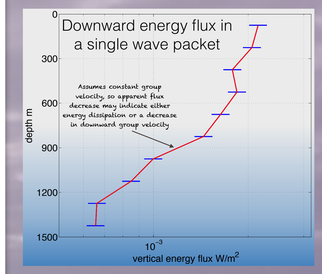
The eddy-rich Antarctic Circumpolar Current (ACC) is broken into multiple evolving fronts/jets following relatively steady average pathways. But how similar are the surface and subsurface structures?

Wind Forcing and Near-Inertial Internal Wave Generation





(1) The role of high-frequency wind components in forcing both surface-layer mixing and near-inertial internal waves emphasizes the continued need for in-situ surface measurement platforms (Kilbourne and Girton 2015).



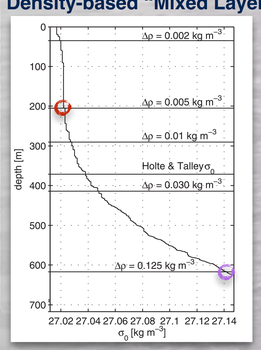
***Near-inertial wind-energy input is enhanced* by:**

- **high-frequency wind products**
- **accurate currents (i.e., not from slab model)**
- **mixed-layer deepening (the acceleration of the initially shallow layer)**

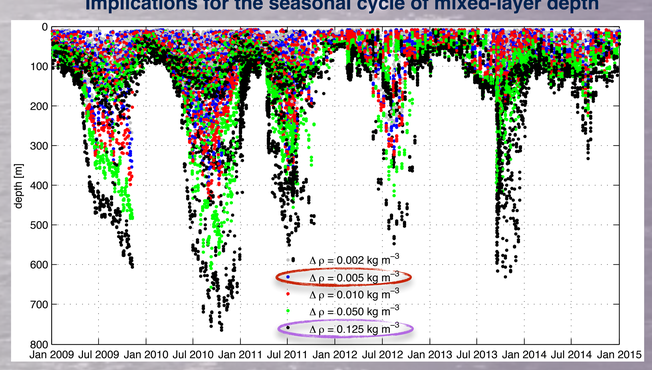
Upper-Ocean Mixing

(2) Layers of active mixing diagnosed from high-resolution density profiles show that, frequently, only a small portion of the "mixed layer" is directly in contact with the surface—a fraction which varies with wind forcing events which may be shorter than the air-sea equilibration time (Kilbourne and Girton 2015a).

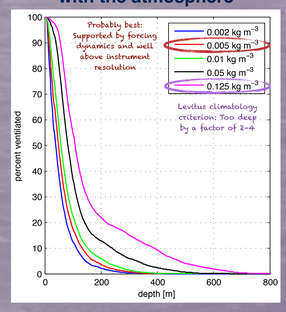
Density-based "Mixed Layer"



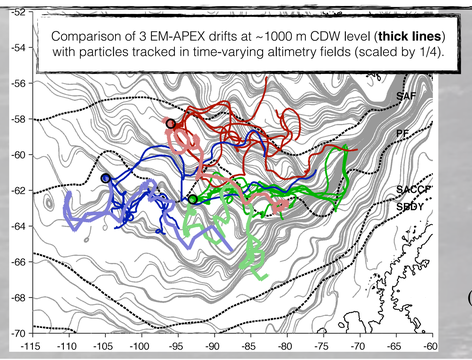
Implications for the seasonal cycle of mixed-layer depth

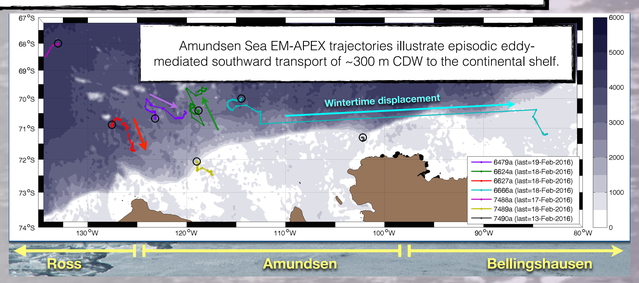


…and fraction of time in contact with the atmosphere

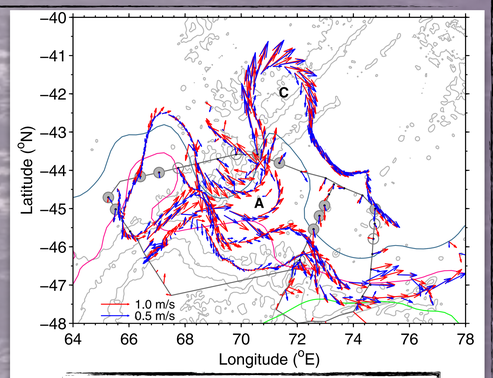


Subsurface Pathways from Isopycnal Drifts and Velocity Profile Measurements





(3) Surface velocity estimates from altimetry are an extremely valuable resource but may deviate substantially from subsurface water pathways–particularly for critical diagnostics like eddy residence time and cross-frontal exchange.



EM-APEX **shallow (200 m)** and **deep (1500 m)** velocities near the Kerguelen Plateau (Phillips and Bindoff 2014).

Future

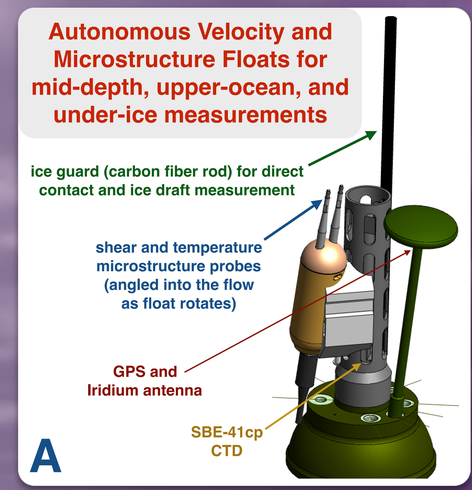
Some directions for new…

(A) vehicles and sensors

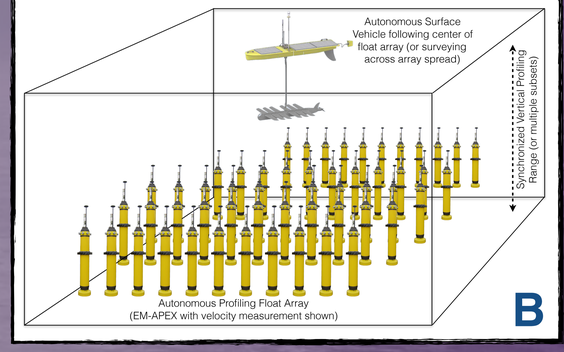
(B) autonomous sampling strategies

(C) long-duration overturning/ ventilation targets

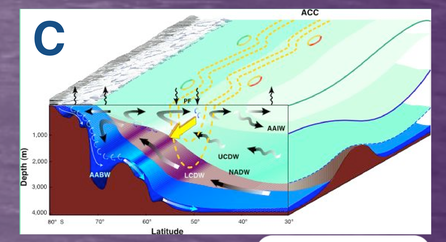
Autonomous Velocity and Microstructure Floats for mid-depth, upper-ocean, and under-ice measurements



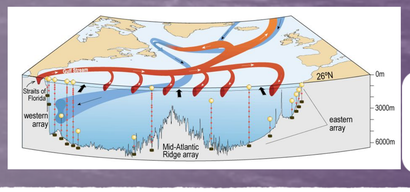
An autonomous array for simultaneous spatial and temporal sampling of *surface forcing* and *subsurface response*. Tuned for a particular dynamical process (at a particular scale).



Cross-frontal shear and watermass ventilation—requires eddy structure, statistics, seasonal cycle.



Antarctic Circumpolar Current



Atlantic Meridional Overturning

Acknowledgments

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