THE ROLE OF MIXED LAYER DEPTH IN REGULATING PRIMARY PRODUCTION AT PALMER DEEP CANYON (WEST ANTARCTIC PENINSULA)

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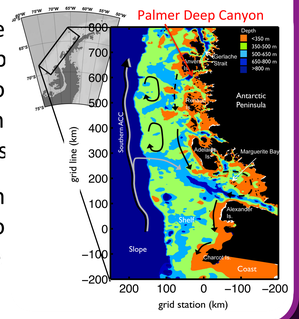
Background

Palmer Deep is considere a biological "hotspot" b providing predictable foo resources and drivin penguin foraging locations

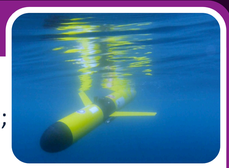
Physical mechanism driving the phytoplankto blooms are not we understood.



Questions

- **Ecologically relevant mixed layer depth (MLD) definition (link water column physics to biological responses)?**
- **Does MLD regulate phytoplankton blooms?**
- **Seasonal/spatial biophysical patterns at Palmer Deep Canyon?**

Gliders

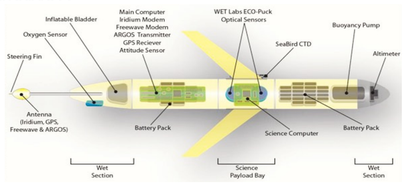


Stats at Palmer Deep Canyon:

- 14 deployments (2007-2015);
- ~ 3 000 Km flown;
- 15 000 water column profiles (up to 100 m);
- Over 2 million individual CTD measurements;
- High spatial resolution (1 profile every ≈ 250 m);

Goals:

1. Map hydrodynamics: focus at the head of canyon;
2. Capture localized regions of high biological activity "hotspots" using chlorophyll as indicator.



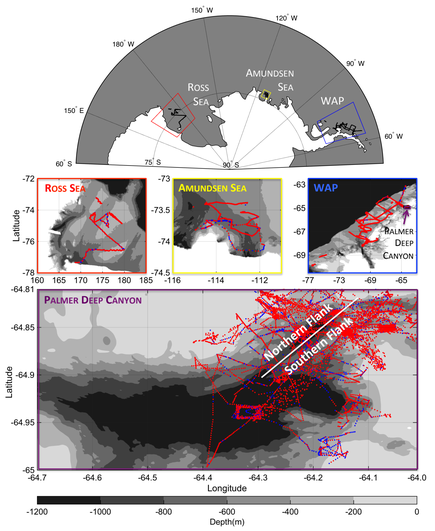
Sensors on gliders:

- Seabird CTD, Wet Labs Fluorescence and Backscatter Eco Pucks.

Glider Dataset

Glider data stats:

	# Profiles	Km flown	# Days
WAP	24 838	8 378	407
Ross Sea	3 476	1 648	67
Amundsen Sea	2 572	682	26



Max(N^2) is ecologically relevant MLD definition across Antarctica

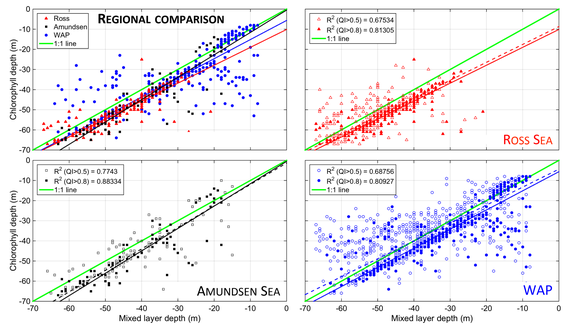
- **Maximum of Buoyancy Frequency (N^2)** was the most ecologically relevant MLD definition:

$$\max(N^2) = \max\left[-\frac{g}{\rho}\frac{\partial\rho}{\partial z}\right]$$

- Quality index (Lorbacher *et al.*, 2006) used to evaluate/filter MLD determined with certainty:

$$QI = 1 - \frac{rmsd(\rho_k - \bar{\rho}_k)|_{(H_1,H_D)}}{rmsd(\rho_k - \bar{\rho}_k)|_{(H_1,1.5\times H_D)}}$$

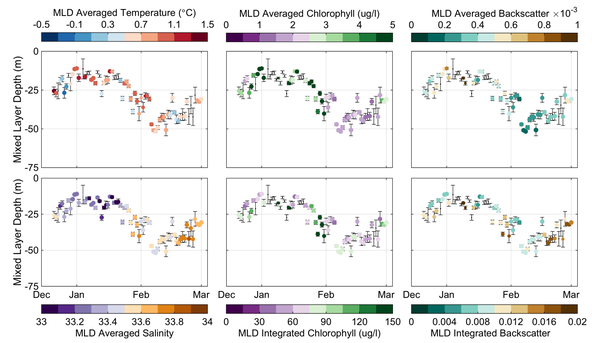
- Chlorophyll depth was adapted from the maximum angle principle (Chu & Fan, 2011).



Higher Chlorophyll in Shallower MLD

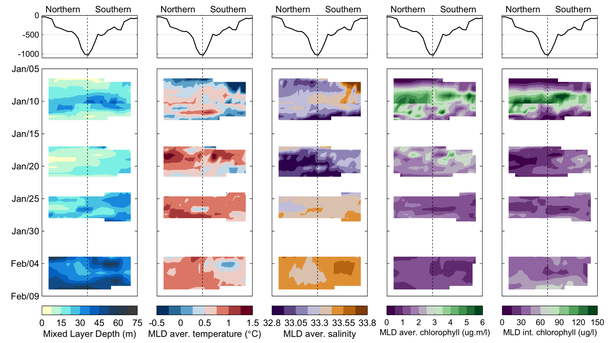
Climatological analysis (6 years of data):

- Bloom condition: starting January, shallower MLD, colder and fresh water with increased chlorophyll;
- Late January, deepening of MLD, warmer and saltier water with lower chlorophyll/backscatter;
- Late February/early March, shoaling of MLD and consequent increase in chlorophyll.

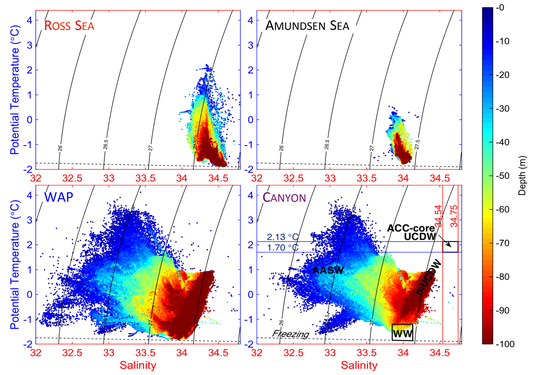


Standard errors shown in bars (MLD) and size of the marker (colored variable)

Temporal/spatial comparison at the head of the canyon:



- 2015 deployment (ru05/ud134): repeated transects across the head of the canyon;
- Temporal signal is the most evident – follows climatology;
- Shallower MLD in Northern region matching warmer and fresher water;
- No major spatial differences in chlorophyll.



- All 3 regions show close 1:1 relationship between MLD and depth of lower boundary of chlorophyll;
- Shallower MLD in WAP/Canyon region – higher ranges in salinity and temperature;
- QI>0.5 (MLD determined with some uncertainty) with similar results to QI>0.8 (MLD determined with certainty) – Filter QI>0.5 for all analyses;
- Different water masses in different regions, yet the same MLD relationship holds, i.e., MLD matches lower boundary of chlorophyll profile.

Conclusions

- Maximum in Buoyancy Frequency (N^2) is an ecologically relevant MLD definition;
- Independently of water masses present, the relationship between MLD and chlorophyll holds across Antarctic waters;
- MLD mostly driven by salinity. Increased influence of temperature on MLD later in the season;
- Shallower MLD results in increased water column chlorophyll (increased light availability?).

Future Work

- Relate MLD freshening and increased stratification with the timing of sea ice melt and retreat;
- Investigate relationship between MLD deepening and mixing with wind forcing.

Acknowledgements

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