Contrasts in turbulent vertical fluxes of nutrients across the permanent Lofoten Basin Eddy in the Nordic Seas

EGU - General Assembly

Session OS1.3 – The ocean surface mixed layer: multi-scale dynamics and ecosystems in a changing climate

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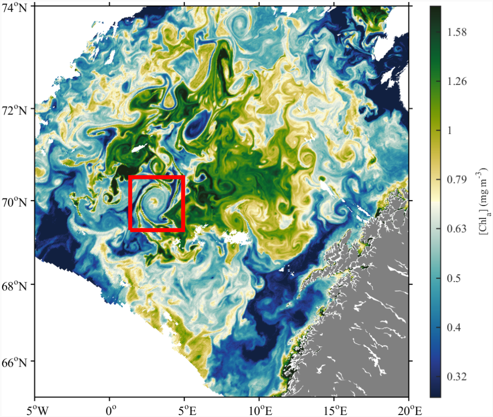
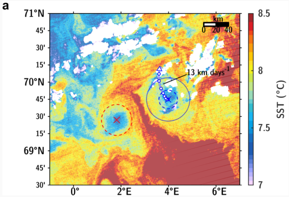
The Lofoten Basin of the Nordic Seas

L2 MODIS at 1 km on July 7, 2005



→ Intense mesoscale activity (10-50 km) in the Lofoten Basin

→ controls heat/salt exchanges between N/S and slope/open-ocean



→ **Permanent anticyclone** (LBE) Yu et al (2017), Fer et al (2018), Bosse et al, Sci Rep (2019)

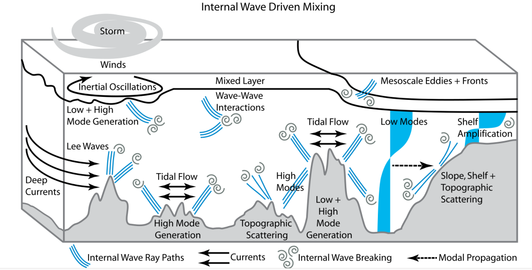
→ Strong interaction between LBE and mesoscale eddies

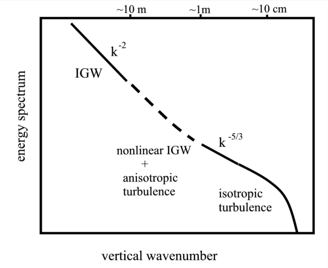
→ LBE traps NIW : enhance mixing at the bottom Fer et al, 2018

⇒ How does the LBE influence turbulence near the surface?

Measuring turbulence: how to and what for?

From McKinnon et al, BAMS (2017)





Energy cascade in the ocean:

Dissipation at centimetric scale, where viscous effects transforms KE into heat.

Measuring turbulence: how to and what for?

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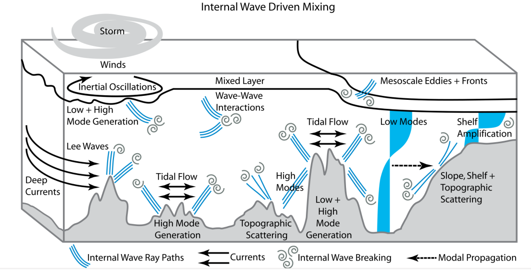
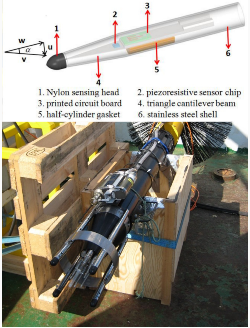
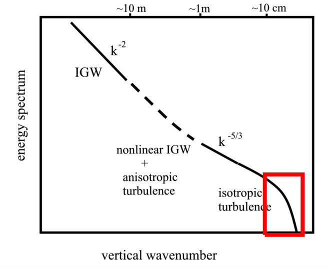


Microstructure Profiler





Energy cascade in the ocean:

Dissipation at centimetric scale, where viscous effects transforms KE into heat.

Oxborn-Cox model:

Measure of dissipation rate ϵ allows to quantify vertical diffusivity: $K_z = \epsilon N^{-2}$.

[The mixing efficiency Γ is classically considered as 0.2

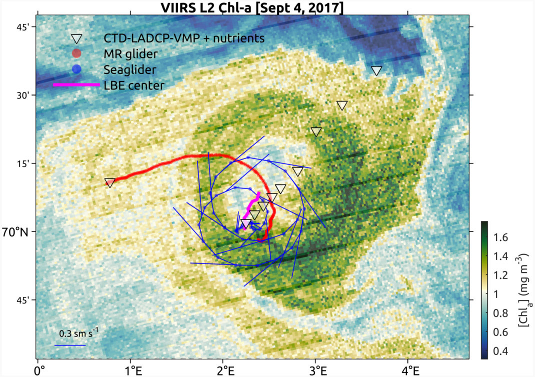
Parametrization by Bouffard and Boegman, DAO (2013) is here used]

Disspiation of energy at microscale

Microstructure turbulence

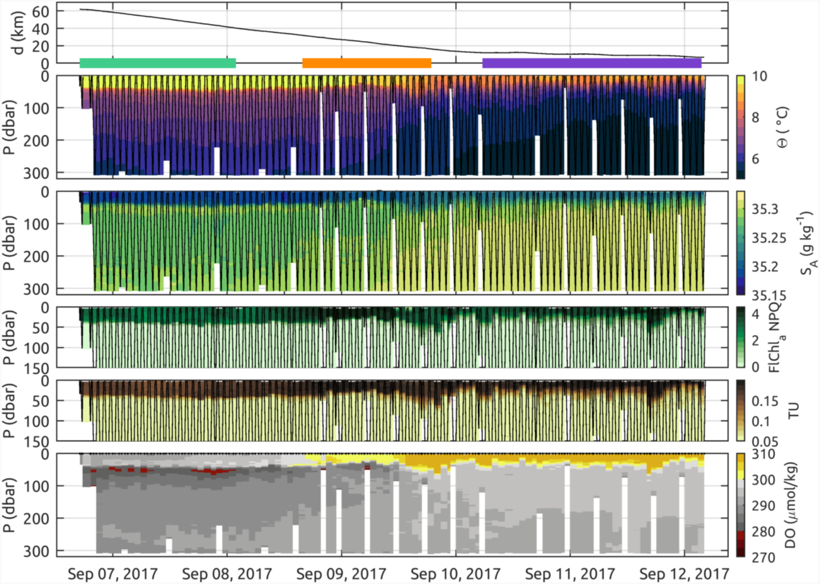
▷ Quantify the role of **small-scale mixing to vertical transfers** (nutrients, heat, ...) and its modulation by mesoscale structures.

Microrider mounted on Slocum glider

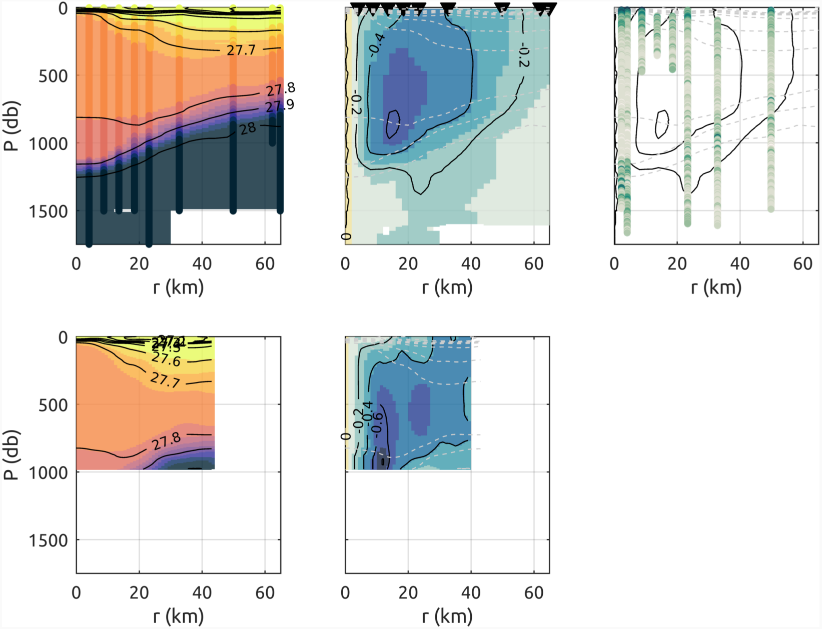


5-day, 212 profiles 0–300m (with Microrider) + CTD/**VMP**/LADCP (¨nutrients)

Slocum glider mission



Dissipation rate of TKE



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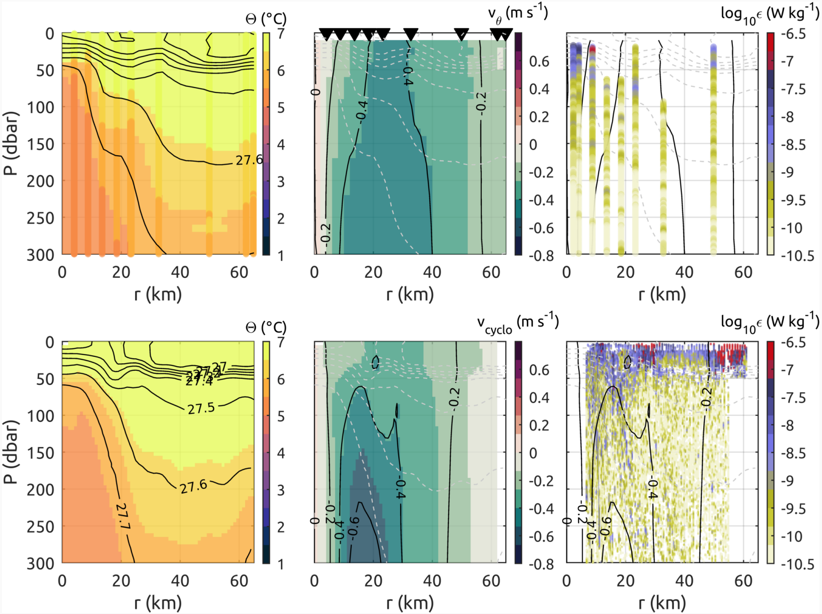
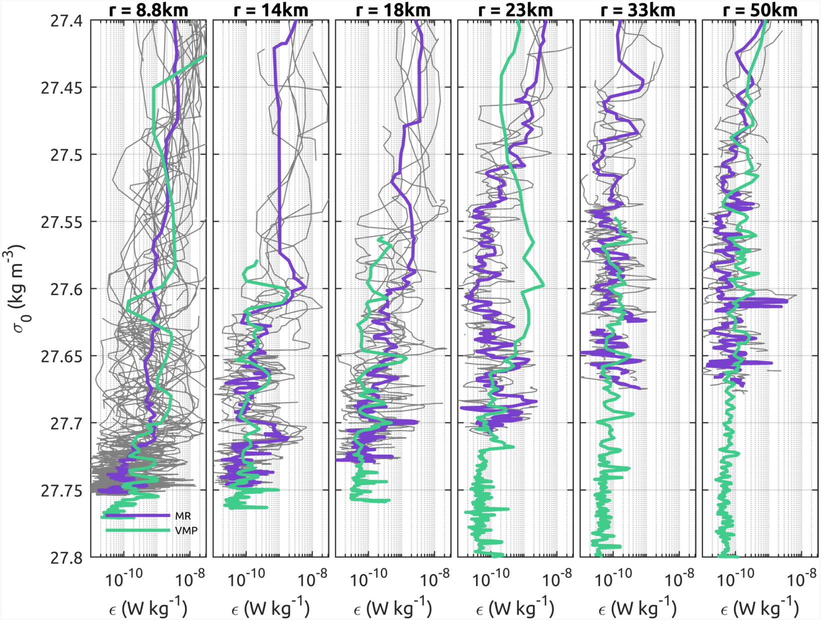
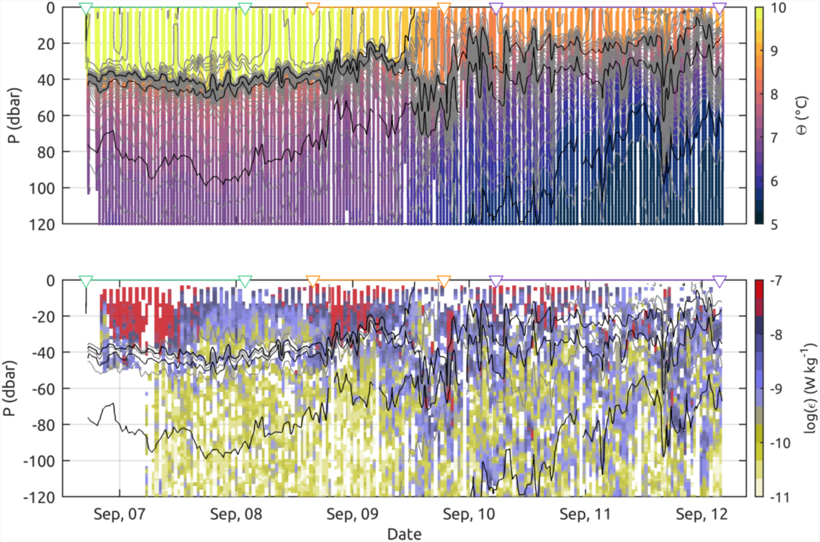


Turbulence : Microrider vs VMP



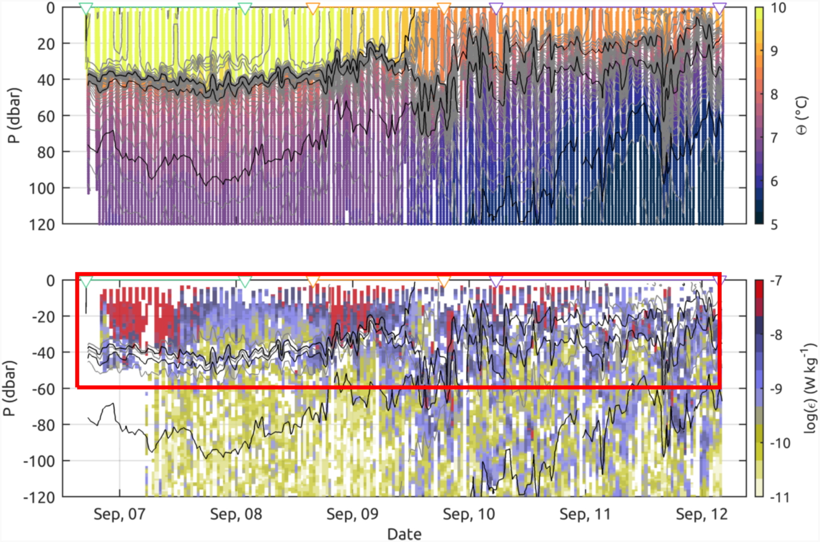
Dissipation rate of TKE (surface zoom)



Important variability of ϵ in the surface layer

Isopycnal outcropping at the rim, large displacements in the core

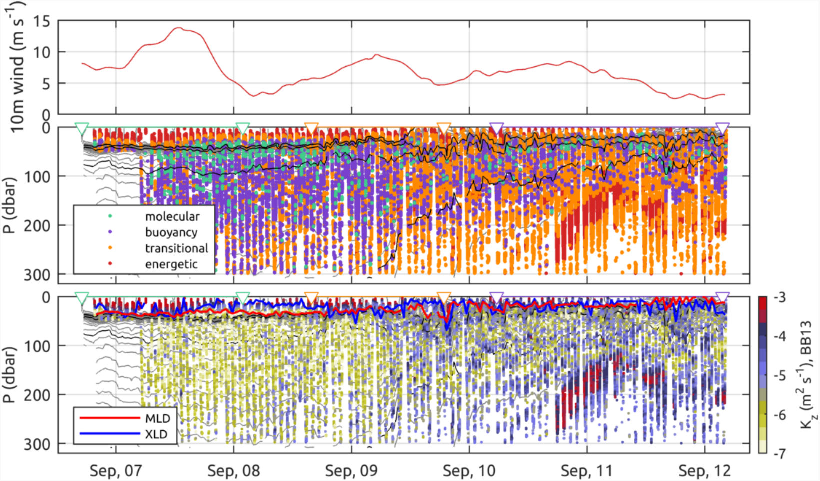
Dissipation rate of TKE (surface zoom)



Important variability of ϵ in the surface layer

Isopycnal outcropping at the rim, large displacements in the core

Vertical diffusivity K_z

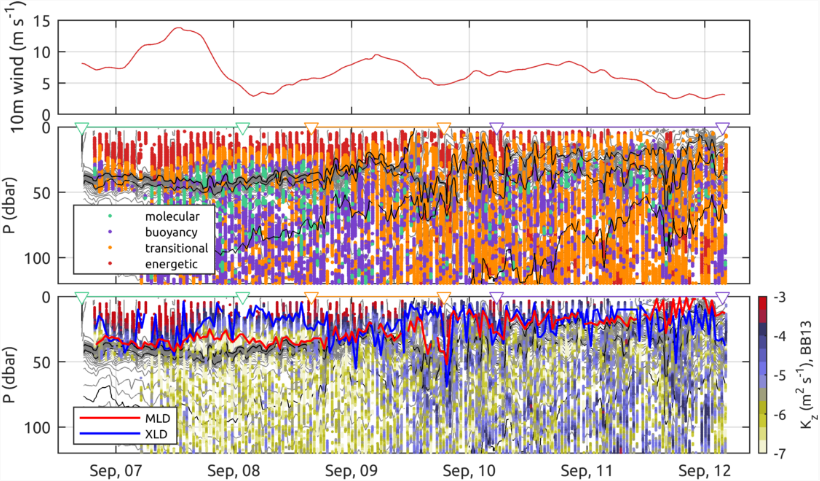


Winds : from $\sim$30kn to calm conditions (wind from ERA5 re-analysis)

Mixing regimes defined from Bouffard and Boegman (2013)

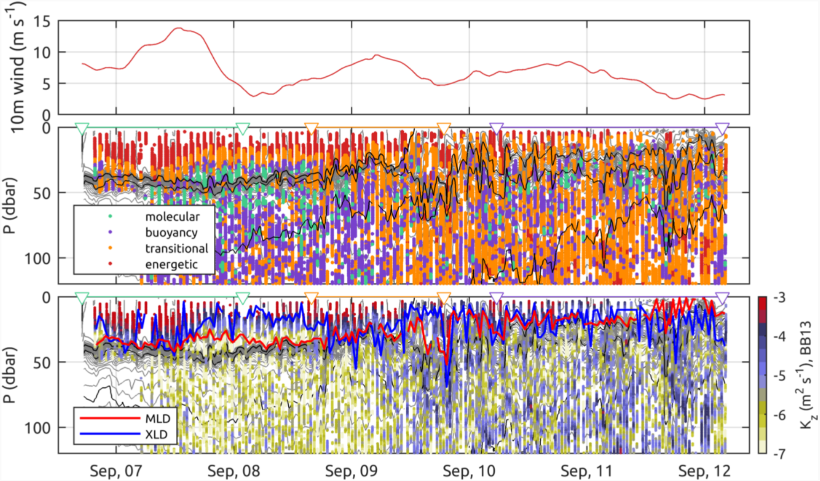
$\rightarrow$ more turbulence below $<$100 m in LBE

Vertical diffusivity K_z (surface zoom)



Mixed layer does not match layer of active mixing under calm conditions. (MLD from 0.03 kg m^{-3} density criterion, XLD where $\epsilon < 3\,.10^{-9}$ W kg^{-1})

Vertical diffusivity K_z (surface zoom)



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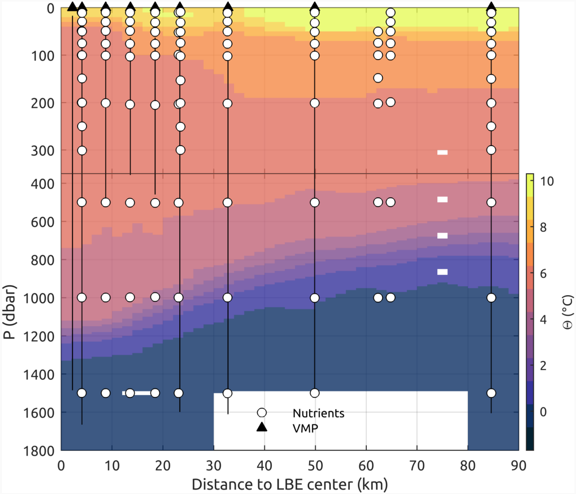
$\boxed{\text{Turbulent vertical fluxes of nutrients: } F = K_z \partial_z C}$

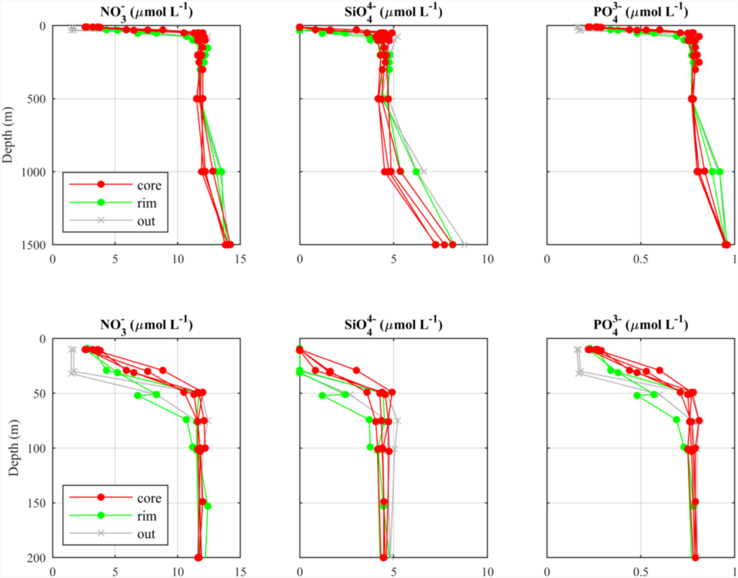
Nutrients sampling across the LBE



→ Nutrients (Nitrate, Phosphate, Silicate) @ stations across the LBE

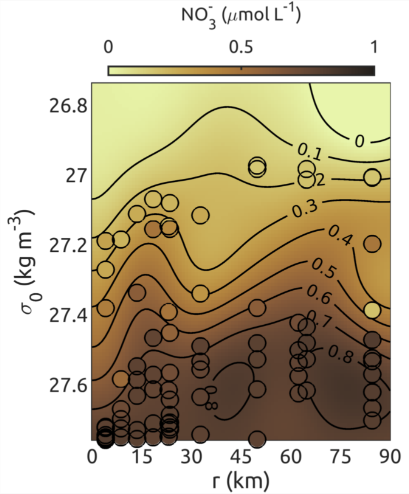
→ Samples every 25m in the top 100m to resolve the nutriclines

Nutrients samples



Lower concentration at depth and shallower nutriclines in the LBE core.

Reconstruction of nutrient distribution

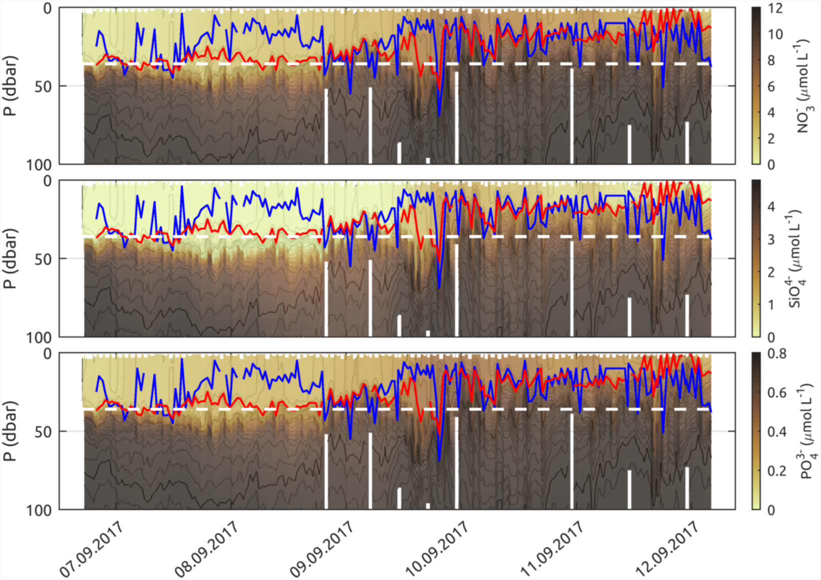


→ Optimal interpolation of nutrients samples on σ levels

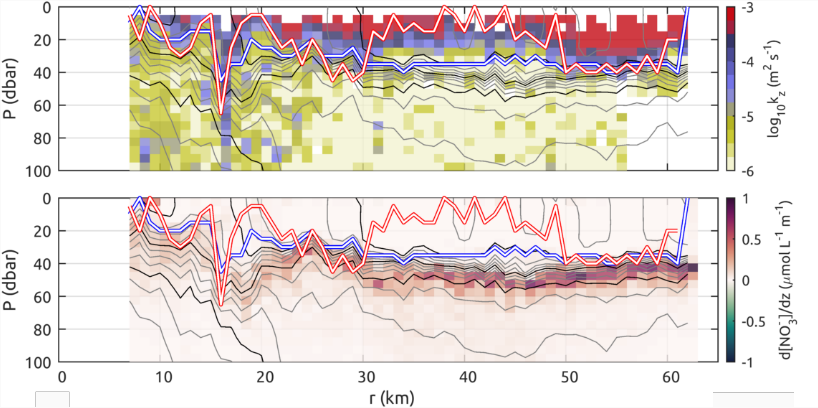
→ [C] = f(σ_0,*r*)

C inferred from σ_0 and *r*

Nutrient distribution



Diffusivity, gradients and fluxes



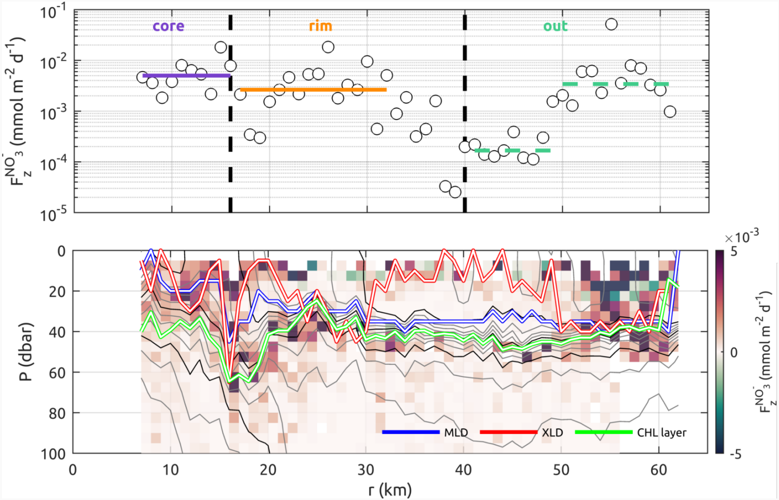
→ Near-surface k_z enhanced during strong winds (r >50km)

→ XLD and MLD different during calm periods, except in LBE

→ k_z varies sharply outside LBE, higher values inside LBE at depth

- Nutriclines sharper outside LBE
- Nutriclines more diffuse and closer to surface in LBE

Turbulent fluxes into the mixed layer



→ Fluxes are of same order of magnitude, but in different layers (closer to surface inside LBE)

⇒ Vertical turbulent nutrient fluxes across the ML (core and rim) = O(10 ×) outside during calm period (wind < 10 m/s)

Conclusion and perspectives

Take home:

- Turbulent nutrients fluxes are **one order of magnitude higher in the LBE** (after a wind event)
- The response of **turbulent mixing to wind is strongly impacted by the mesoscale**

Further analysis:

- Assess other sources of nutrients fluxes in the LBE (vertical velocities, ...) and implications for primary production.
- Ship and L-ADCP to infer source of high dissipation.

Thanks for your attention!
Questions?