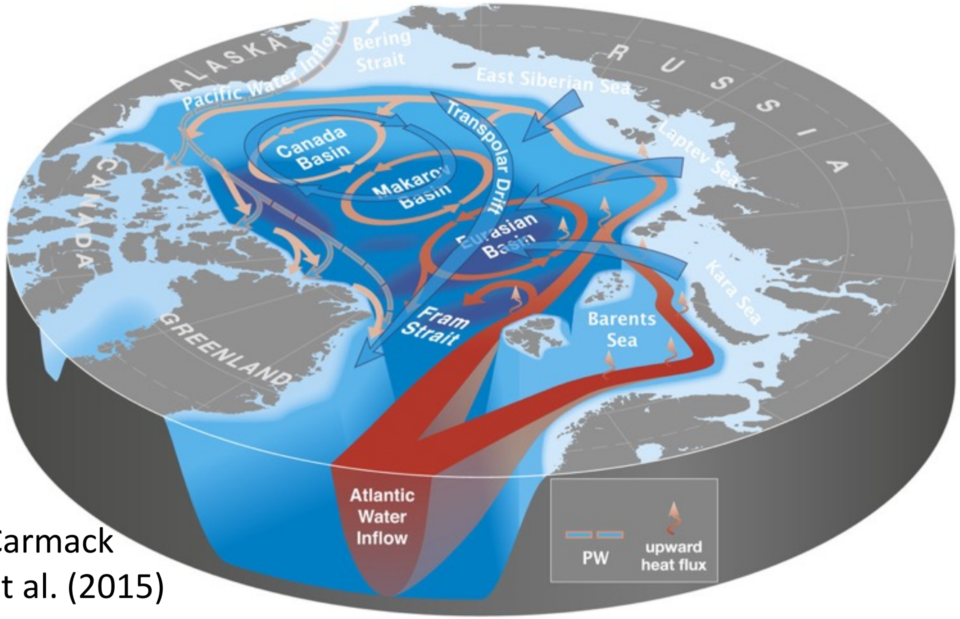
Dissipation measurements near the marginal ice zone northwest of Svalbard using a glider

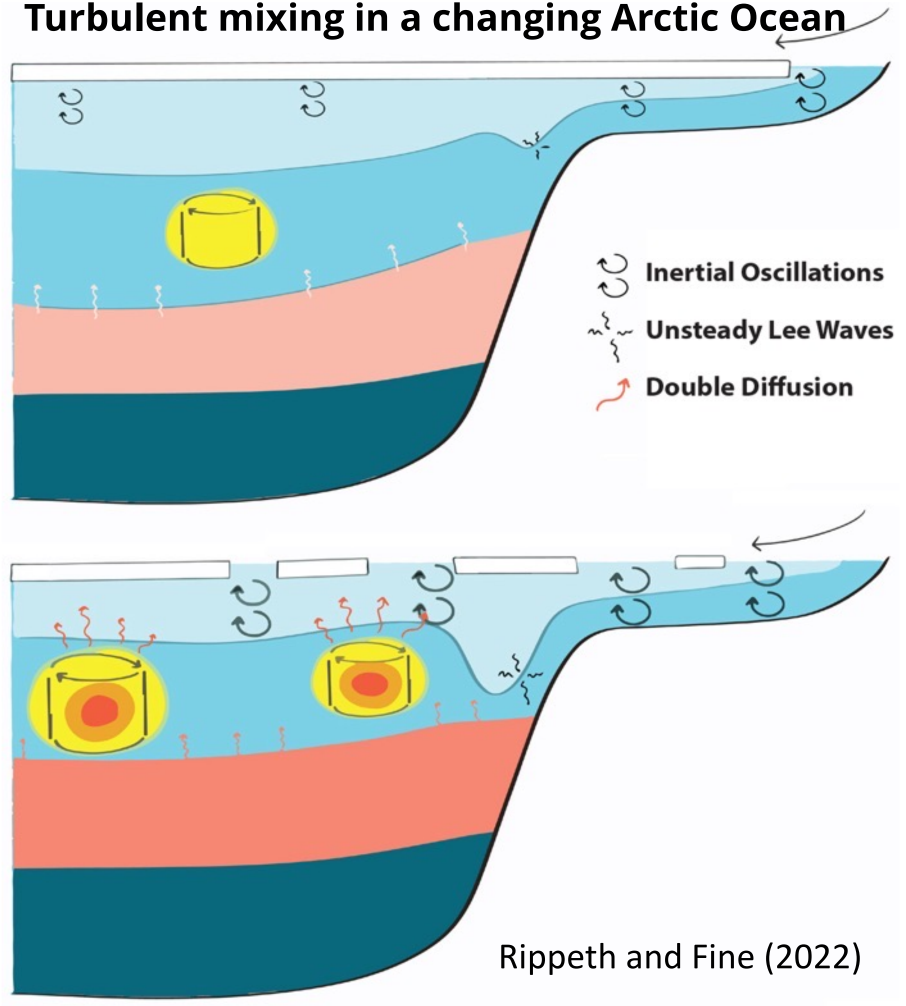
Ilker Fer and Fiona Elliott
University of Bergen, Norway

IUGC, Gothenburg, 10-14 June 2024

Turbulent mixing in a changing Arctic Ocean



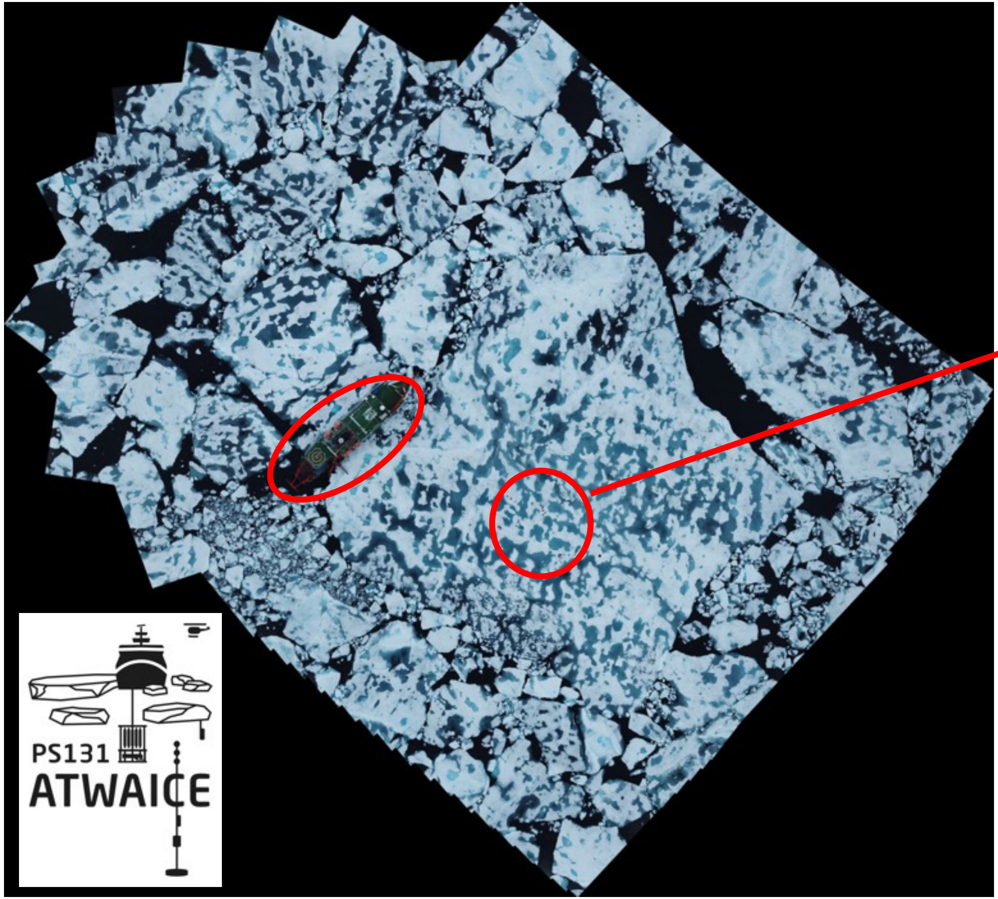
Carmack et al. (2015)



Rippeth and Fine (2022)

- increasing ocean-atmosphere coupling
- changes in stratification
- increasing role of eddies in both the transport of shelf water and mixing
- emerging role of tides and unsteady lee waves

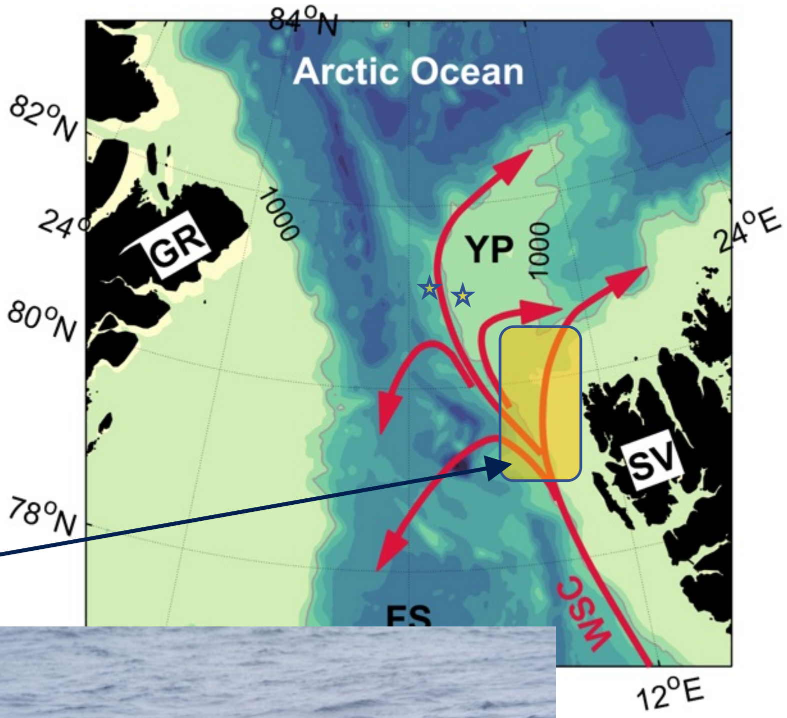
ATWAICE - Atlantic Water pathways to the ice in the Nansen Basin and Fram Strait

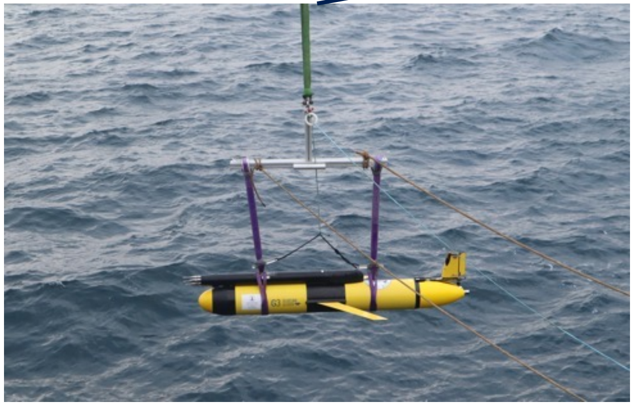


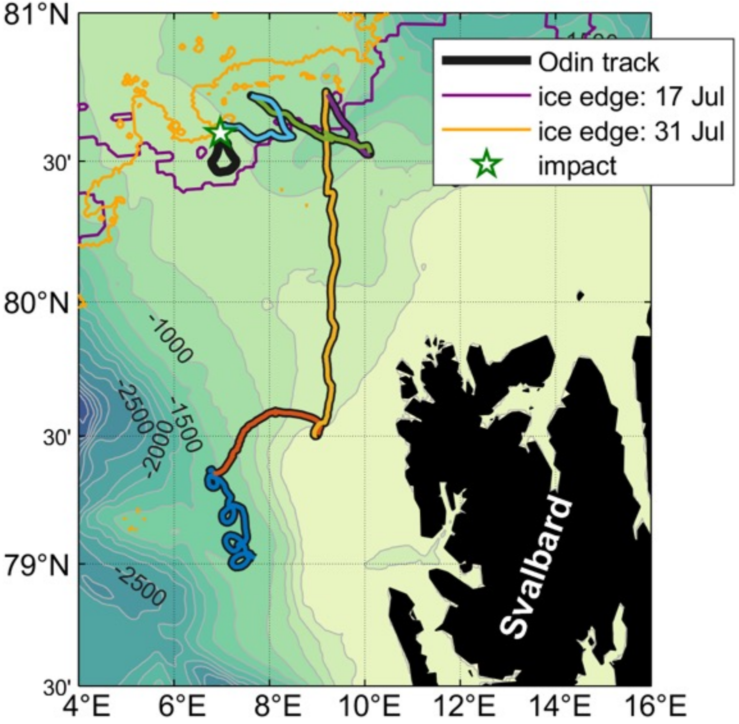
Multidisciplinary field work onboard Polarstern, summer 2022, led by Kanzow and van Appen (AWI)

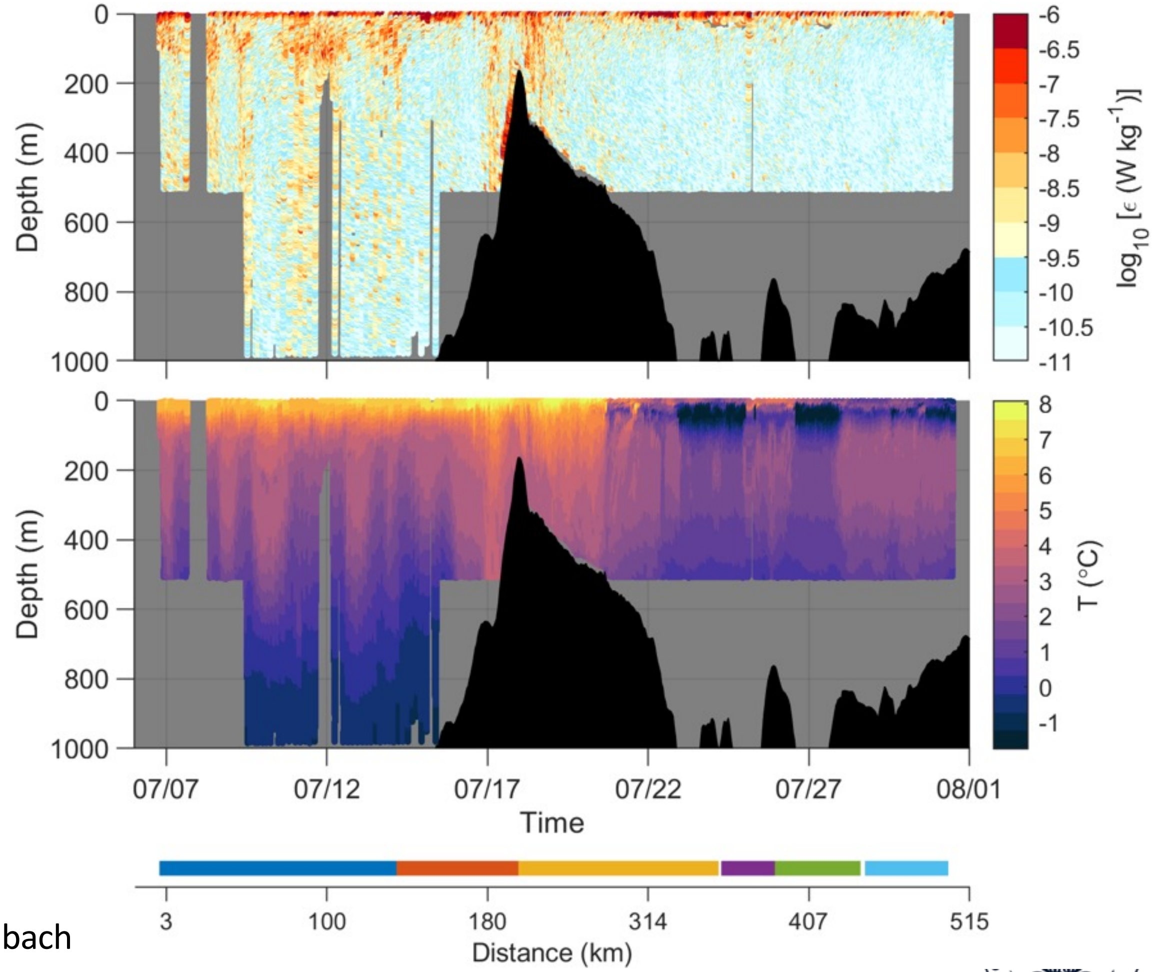
- What are the pathways and processes in the inflow regions of warm AW to the Arctic Ocean that transport heat and nutrients to the sea ice and into the euphotic layer in the MIZ?
- How does the dynamic structure (stratification, mixing rates, submesoscale activity) of the upper ocean change spatially from open ocean across the MIZ to the pack ice?

UIB supported ATWAICE with moorings over Yermak Plateau and glider observations in the upstream, open water areas









Ice edge is from MASIE @ 1km resolution

Thankful for the glider data processing tools provided by Gerd Krahmann and Lucas Merckelbach

Analysing ocean turbulence observations to quantify mixing (**ATOMIX**)

Co-chairs:

Cynthia Bluteau (Canada; velocity point measurements)
Ilker Fer (Norway; **shear probes**)
Yueng-Djern Lenn (UK; velocity profilers)

METHODS article

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Sec. Ocean Observation
Volume 11 - 2024 | https://doi.org/10.3389/fmars.2024.1334327

This article is part of the Research Topic
Best Practices in Ocean Observing
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Best practices recommendations for estimating dissipation rates from shear probes

Rolf Lueck[1*] Ilker Fer[2] Cynthia Bluteau[3] Marcus Dengler[4] Peter Holtermann[5] Ryuichiro Inoue[6,7,8] Arnaud LeBoyer[9] Sarah-Anne Nicholson[10] Kirstin Schulz[11] Craig Stevens[12,13]

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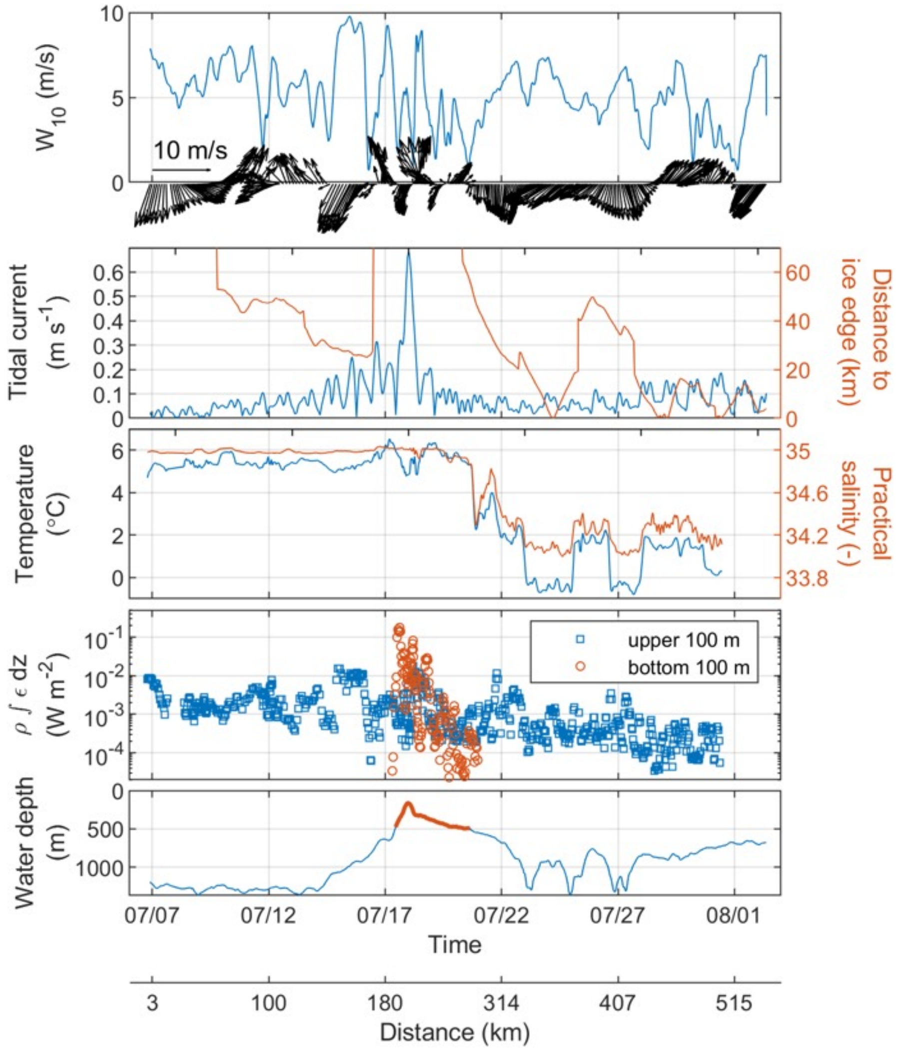
ATOMIX benchmark datasets for dissipation rate measurements using shear probes

Ilker Fer, Marcus Dengler, Peter Holtermann, Arnaud Le Boyer & Rolf Lueck

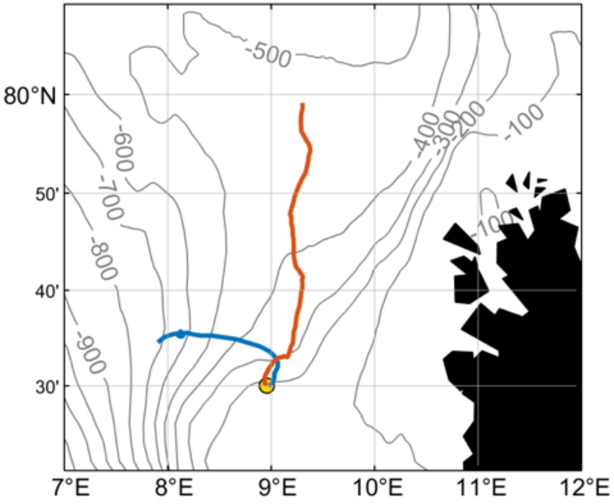
Scientific Data **11**, Article number: 518 (2024) | Cite this article

Overview: Entire mission

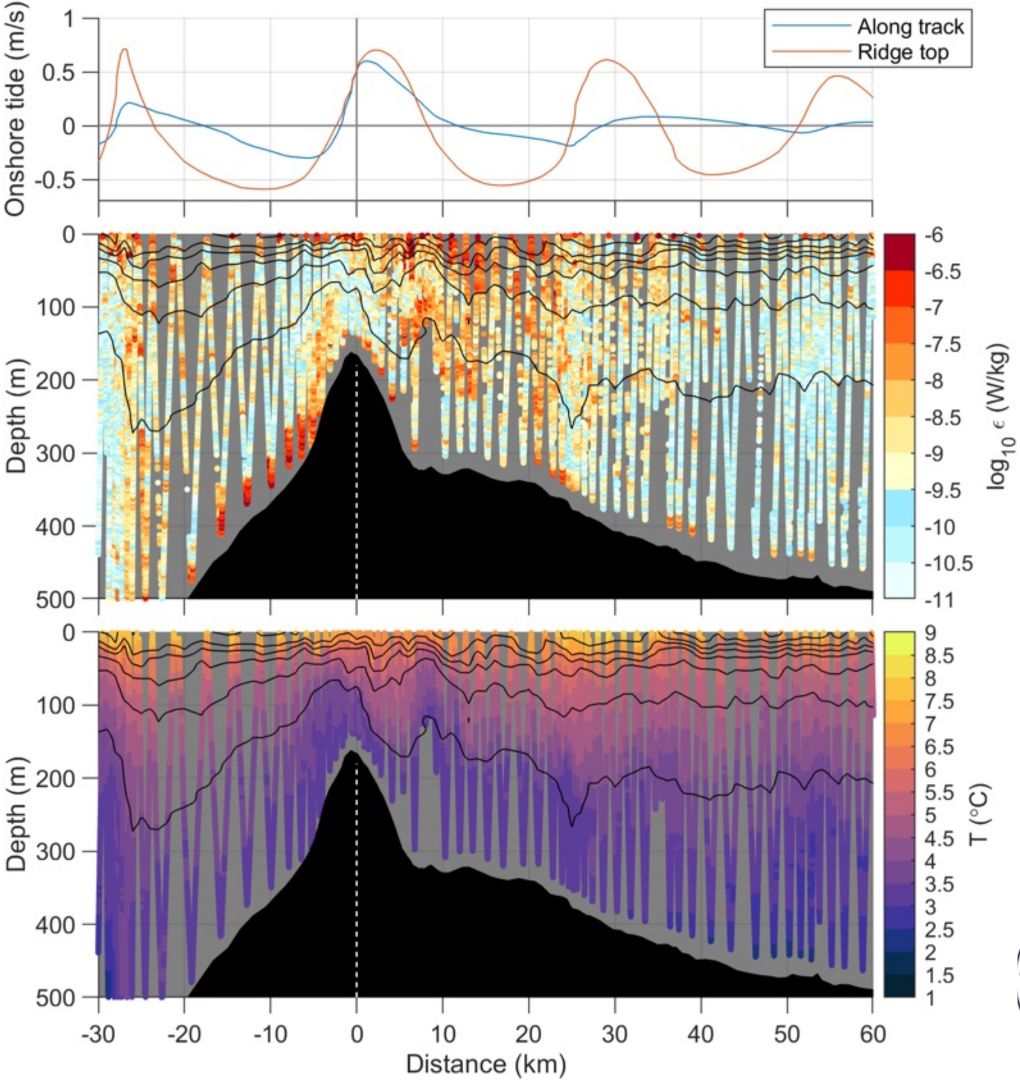
Environmental conditions and depth-averaged measurements

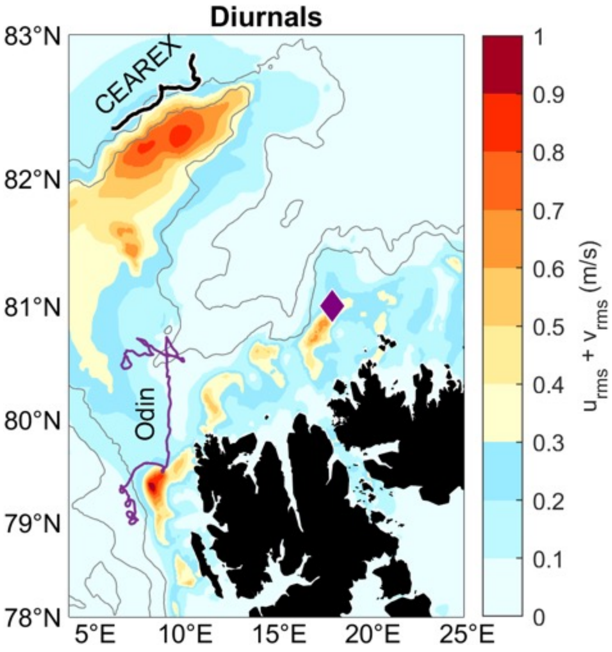


Analysis: Tidally-forced slope

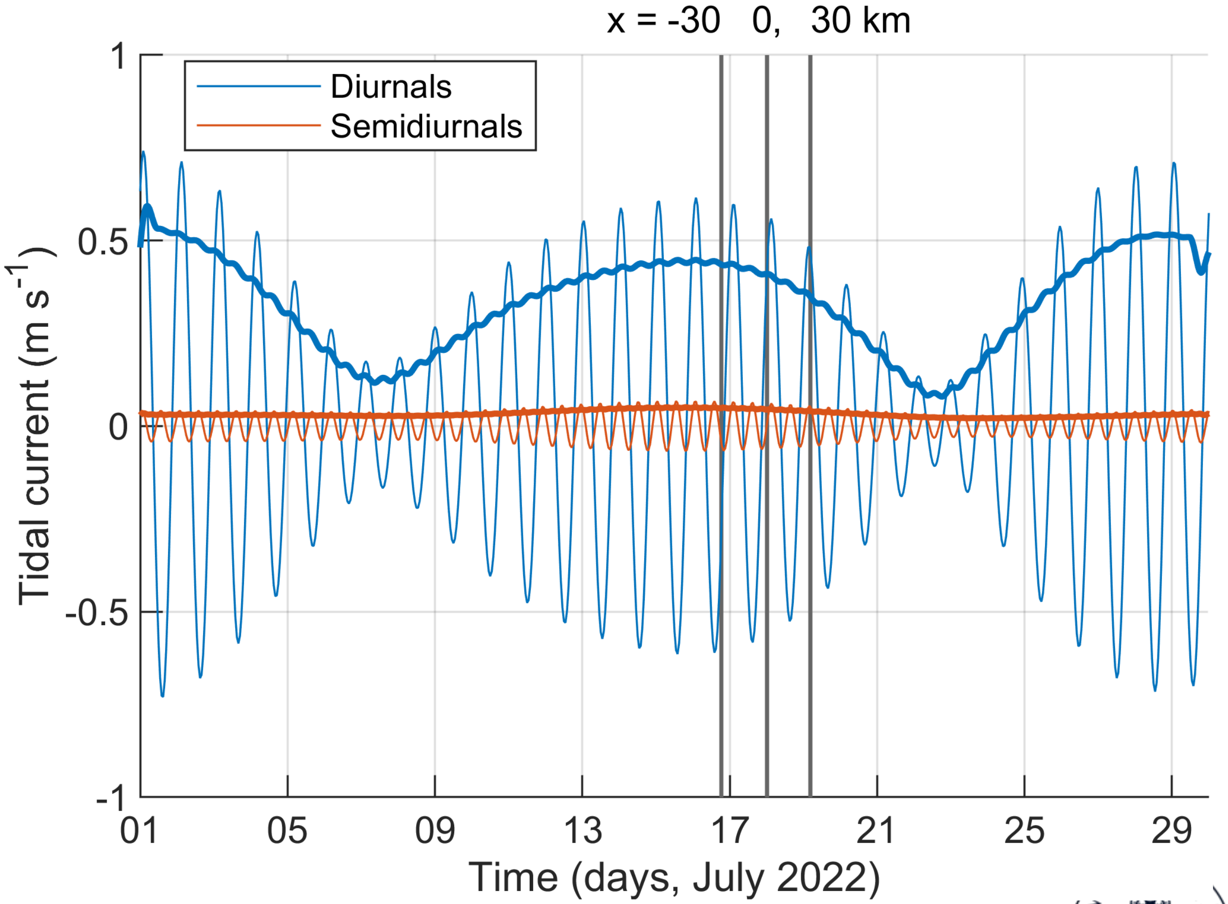


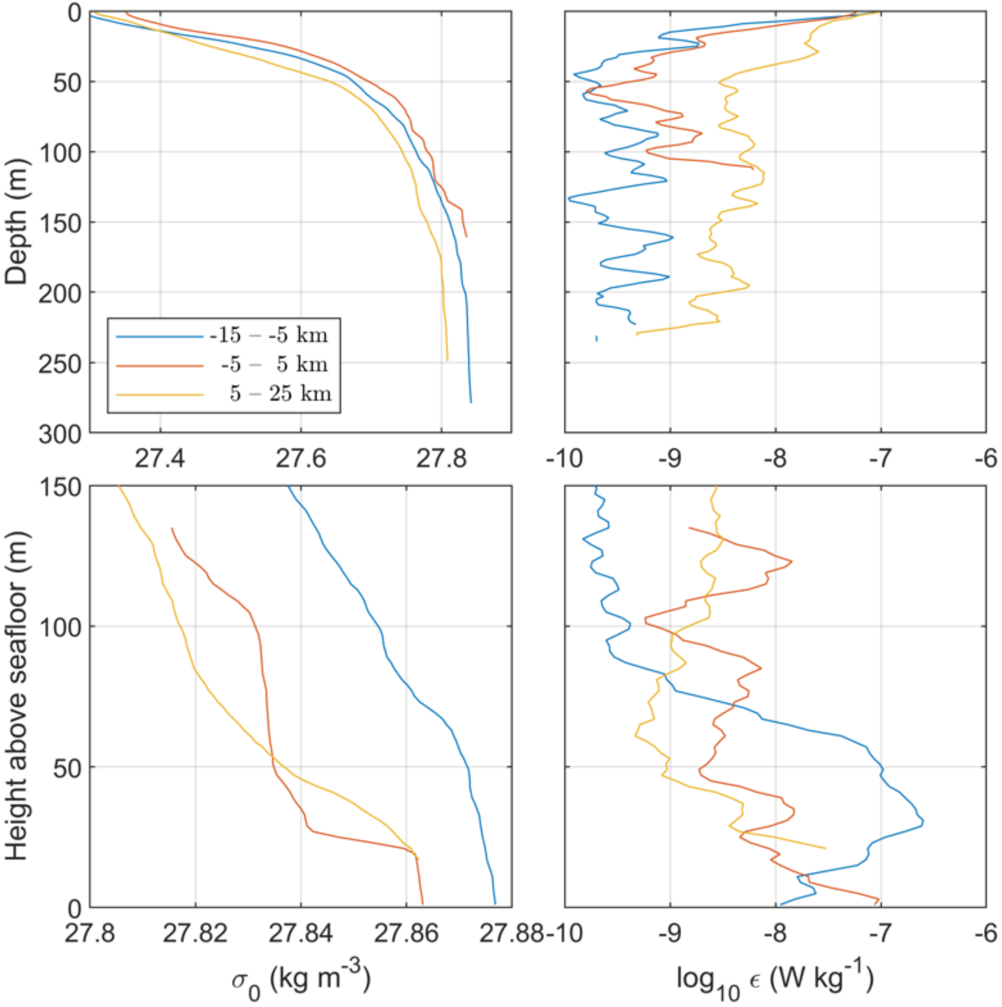
Tidal prediction is from Arc2km-2018 (Howard & Padman 2021)





Tidal prediction from Arc2km-2018
(Howard & Padman 2021)





Inverse Fr based on vertical excursion, Z_ω (Legg and Klymak, 2008),

$$\mathrm{Fr}_{Z_\omega}^{-1} = \frac{|\nabla H| N}{\omega}$$

$\mathrm{Fr}_{Z_\omega}^{-1} > 3$ → hydraulic jumps can occur and nonlinear waves can develop

For diurnal, K_1, frequency wave:

Using near-bottom *N*: $\mathrm{Fr}_{Z_\omega}^{-1} \cong 1$

Using pycnocline *N*: $\mathrm{Fr}_{Z_\omega}^{-1} \cong 4$

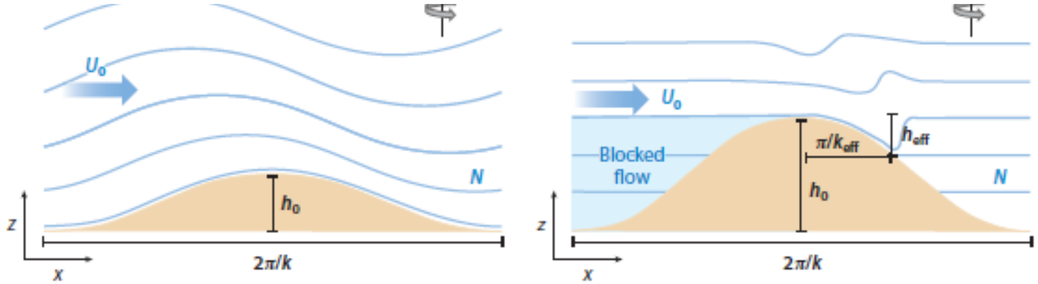
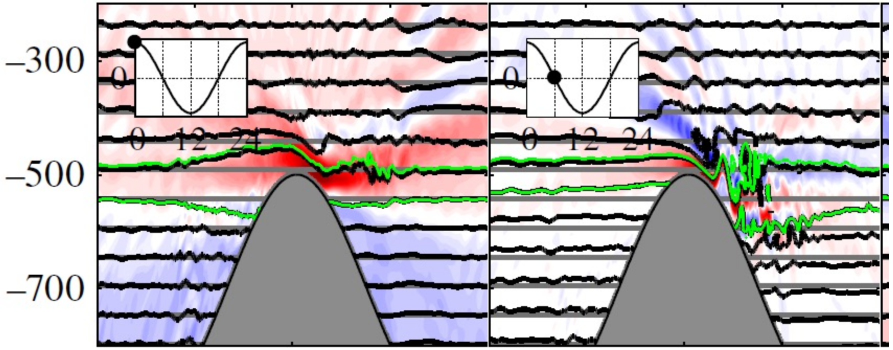


Figure 1

Schematic of lee wave generation, showing key parameters for (*a*) the linear regime (with $Nb_0/U_0 < 1$ and $f < U_0k < N$) and (*b*) the nonlinear regime (with $Nb_0/U_0 > 1$), where N is the buoyancy frequency, f is the Coriolis frequency, b_0 is the height of the topography, k is the topographic wavenumber, and U_0 is the background flow speed. Isopycnals are indicated in blue.

Legg, 2021; see also Klymak et al 2010

Cross-ridge velocity in subinertial tide flow



Musgrave et al., 2016

tidal excursion parameter:

$$\eta = \propto N/\omega_0$$

Quasi-steady lee wave solutions occur for $\eta > 1$

topography aspect ratio:

$$\propto = \text{height/width}$$

Lee wave Froude number:

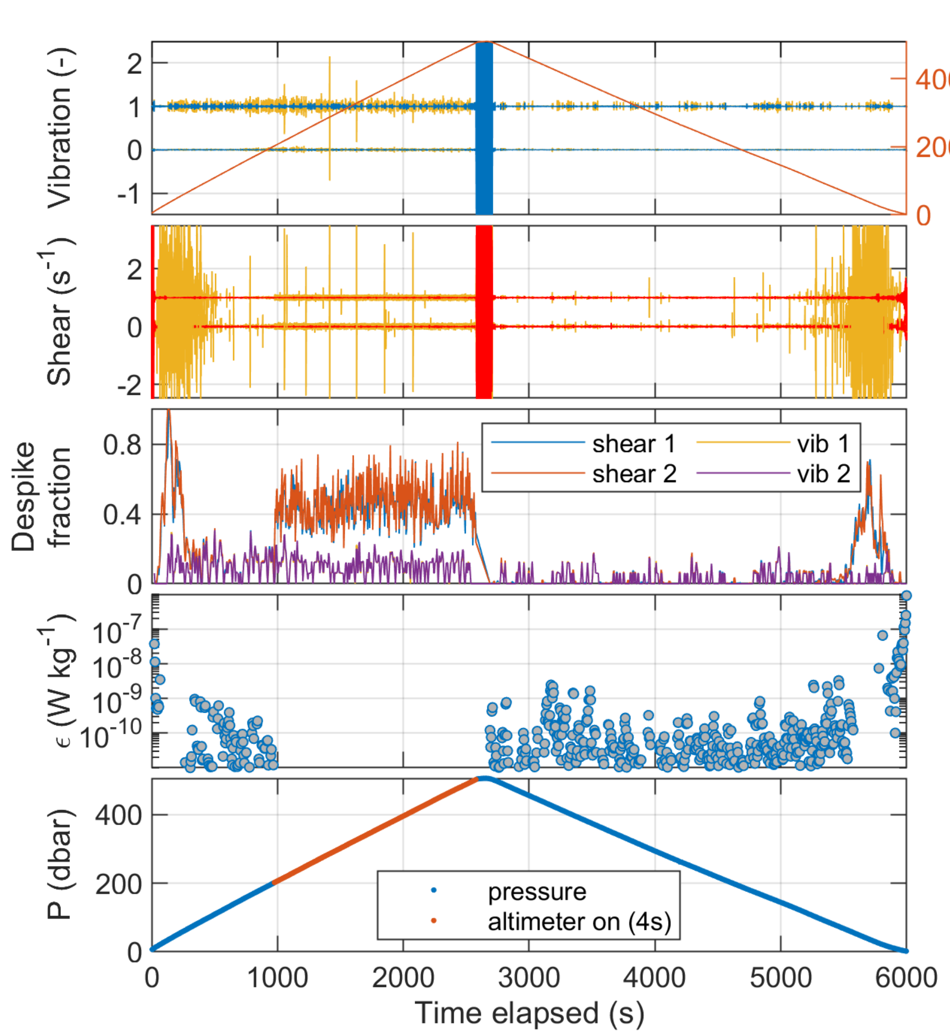
$$\mathrm{Fr_L} = \frac{NU_0}{h_0}$$

$\mathrm{Fr_L} > 1$ → nonlinear & blocking

vertical length scale:

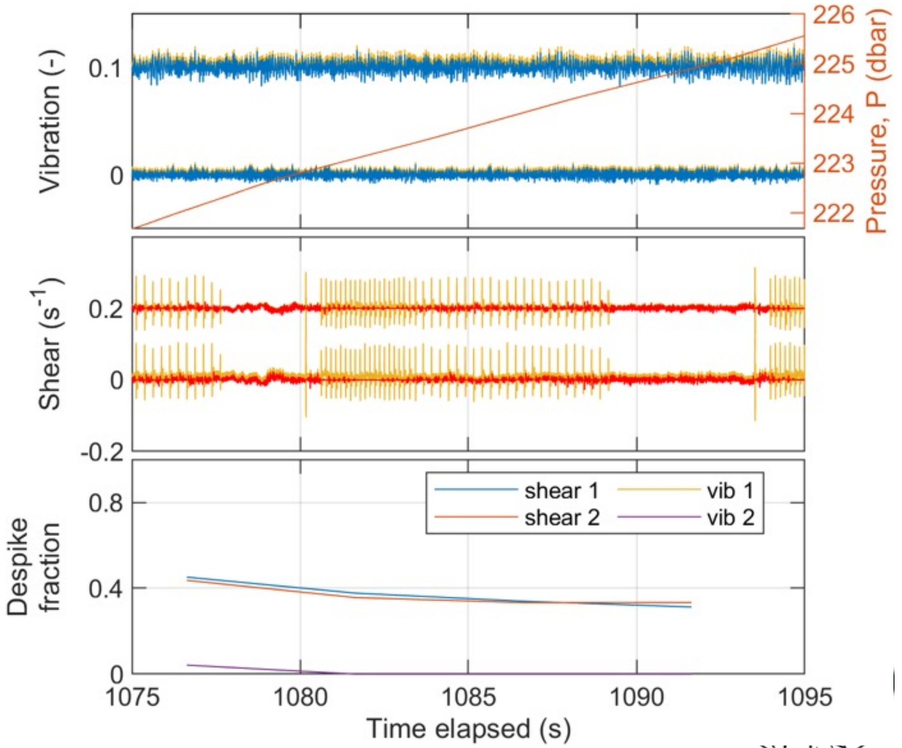
$$1/m = U_0/N$$

$\eta \approx 2$
$\mathrm{Fr_L} \approx 1.5$
$1/m \approx 180$ m

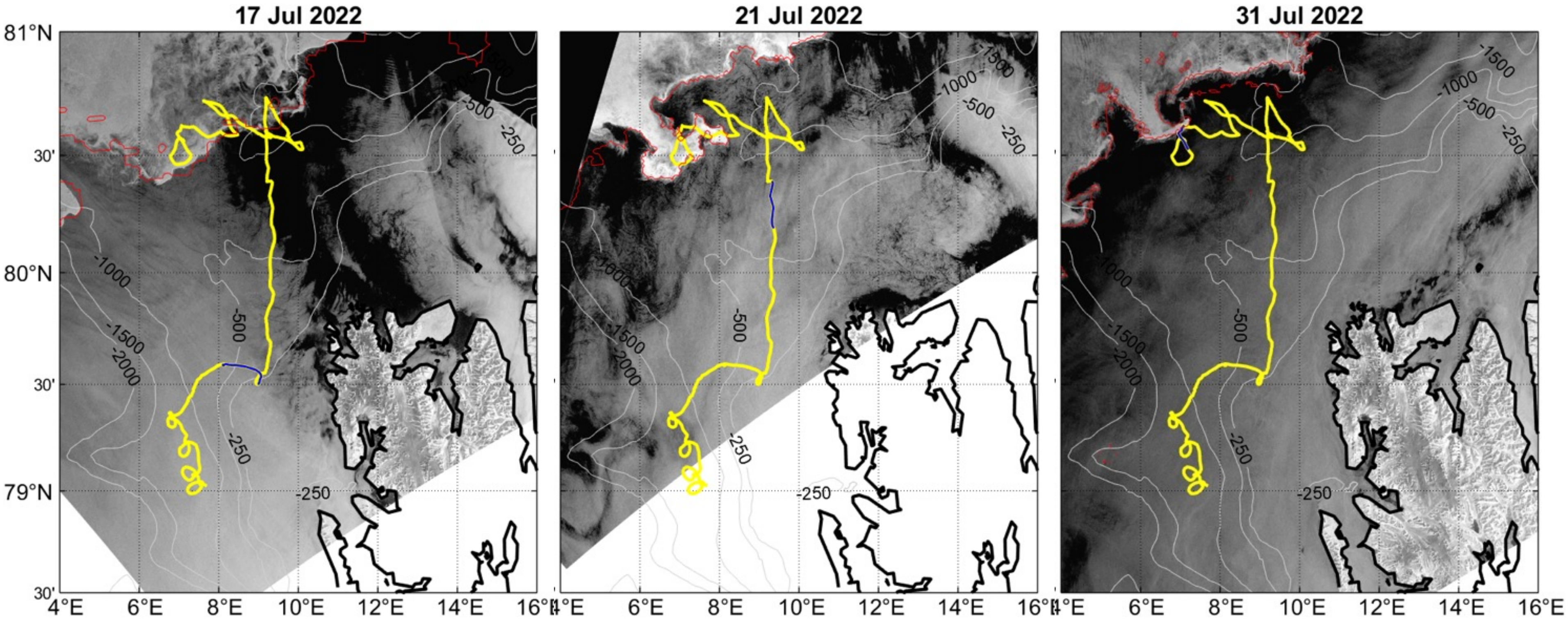


----- Technical note -----

Caution: the use of altimeter on Slocum glider can affect the shear probe data quality.

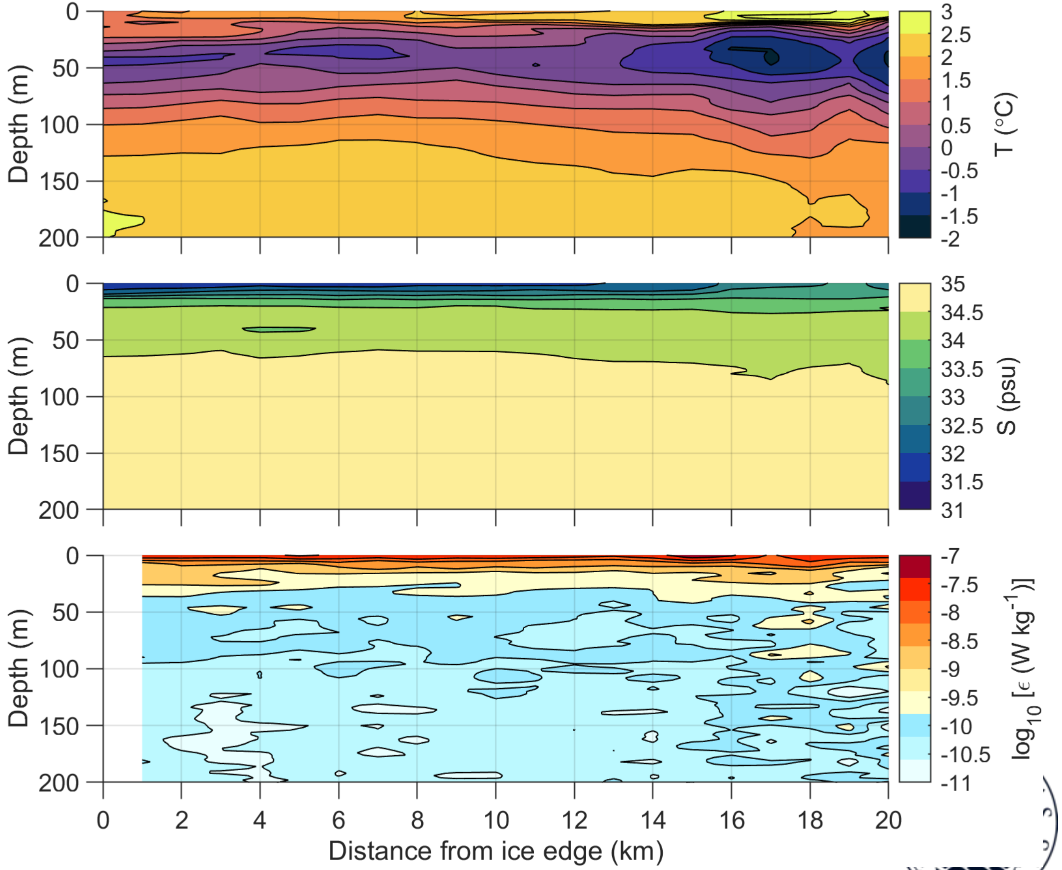


Analysis: Near ice edge

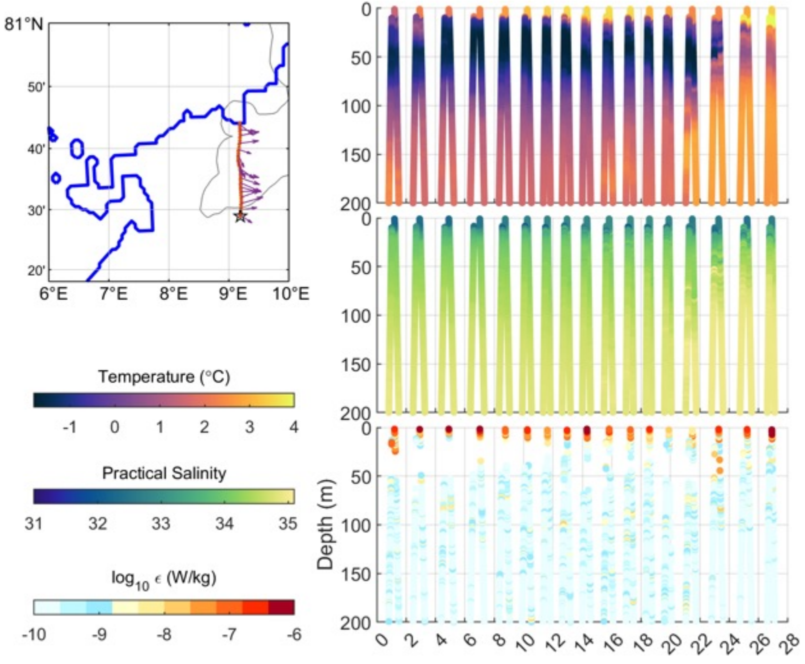


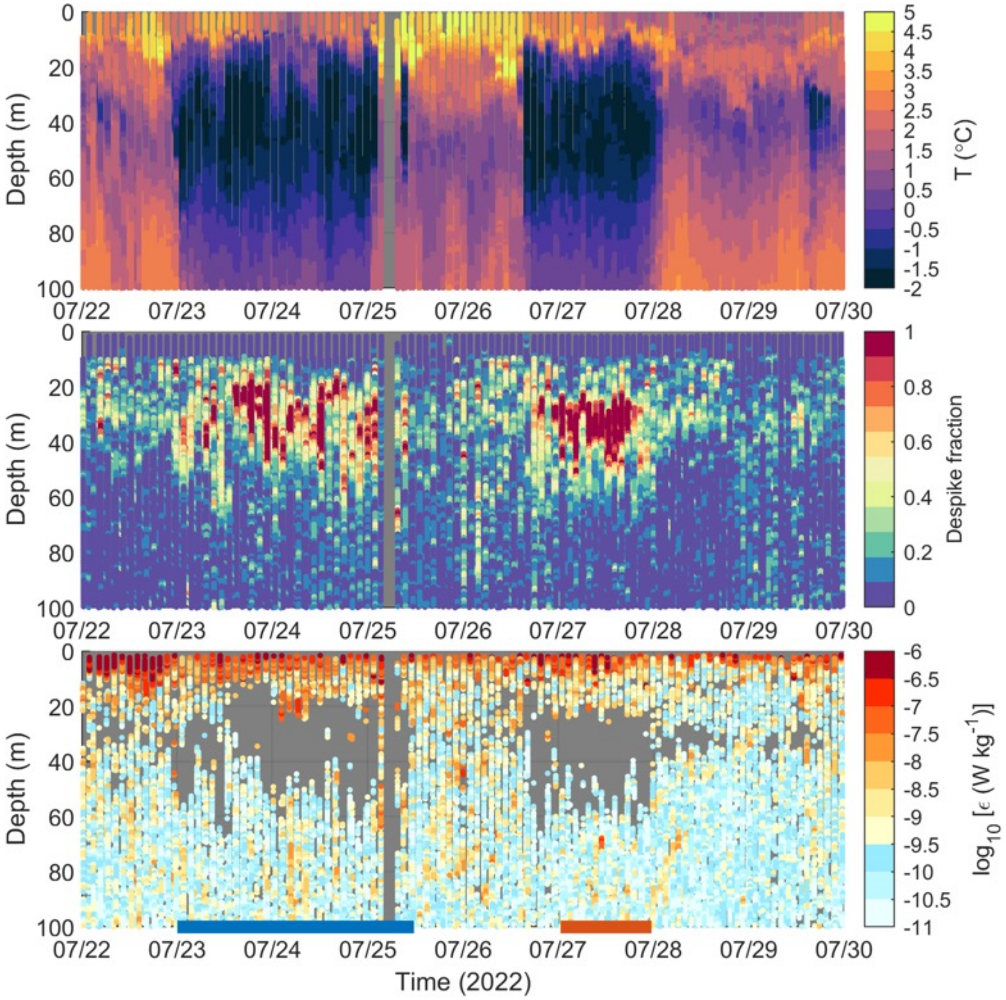
Sentinel 1, SAR images with MASIE ide edge (red)
Glider track (yellow) at the day of image is marked in blue.

5 sections referenced to ice edge gridded and composite averaged:



A section referenced to ice edge

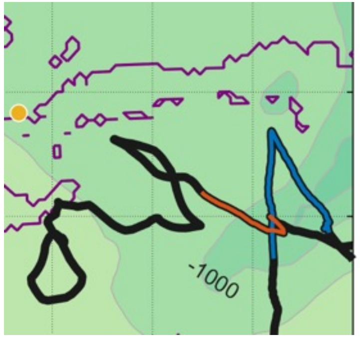


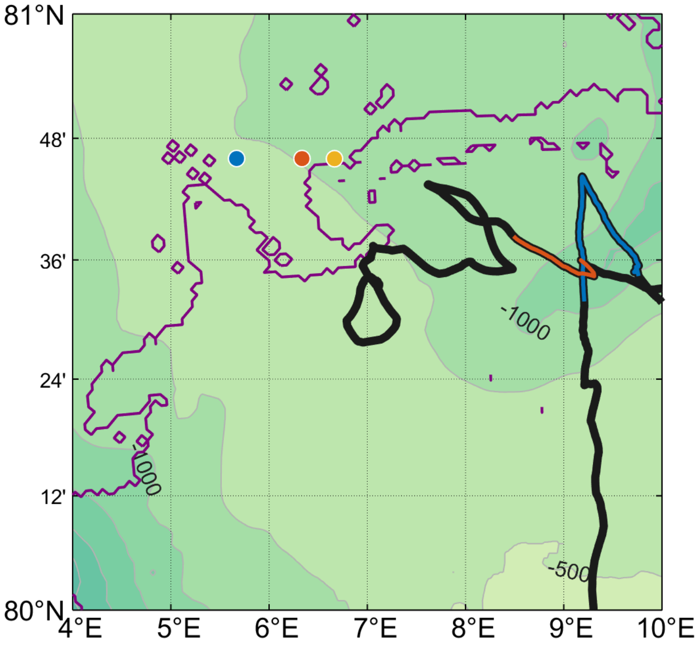


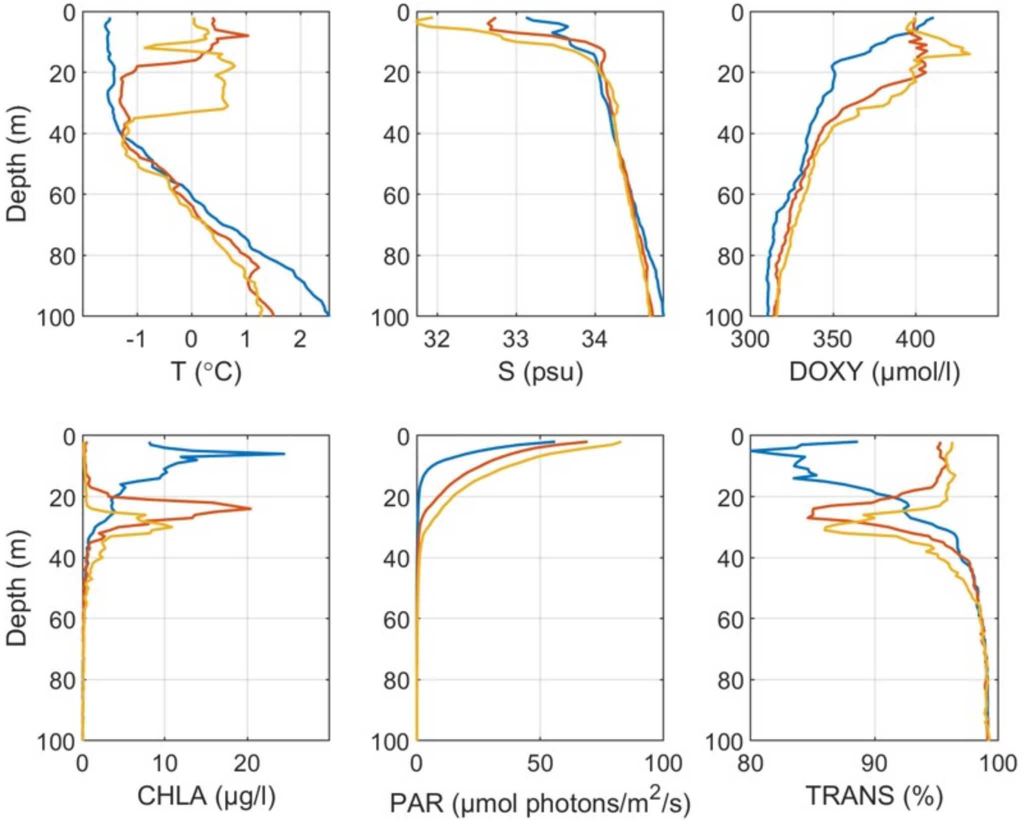
----- Technical note -----

Caution: biology can lead to large loss of shear probe data.

- at 35 m depth at the outer MIZ a layer with the phytoplankton community dominated by the foam algea *Phaeocystis sp*. observed
- High zooplankton biomass (Calanus finmarchicus and glacialis) was found from multi net hauls in the open water station; post bloom conditions.







- The outer MIZ features extensive deep chlorophyll maxima in the upper 30 m
- The transmissivity drops to 80%
- High zooplankton biomass from multinet hauls

Concluding remarks

- along the Arctic Ocean margins, the pathway for the energy from strong tidal currents to turbulence is nonlinear and dominated by breaking unsteady lee waves and critical flow
- the use of altimeter on Slocum glider can affect the shear probe data quality
- phytoplankton community, particularly *Phaeocystis sp* can affect the shear probe data quality
- [not presented:] temperature microstructure can supplement shear probe data and improve the noise level and vertical coverage

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