Observations of turbulence at a near-surface temperature front in the Arctic Ocean

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A. INTRODUCTION.

Fronts in the Arctic are regions of heat exchanges between the edge and the inner part of the basins. Dynamics at the fronts is still poorly understood in the Arctic.

In September, we documented for 24-hour a near-surface temperature front in the Arctic Ocean in the Nansen Basin away from topography, 4-5 km away from the sea ice edge (Figure 1).

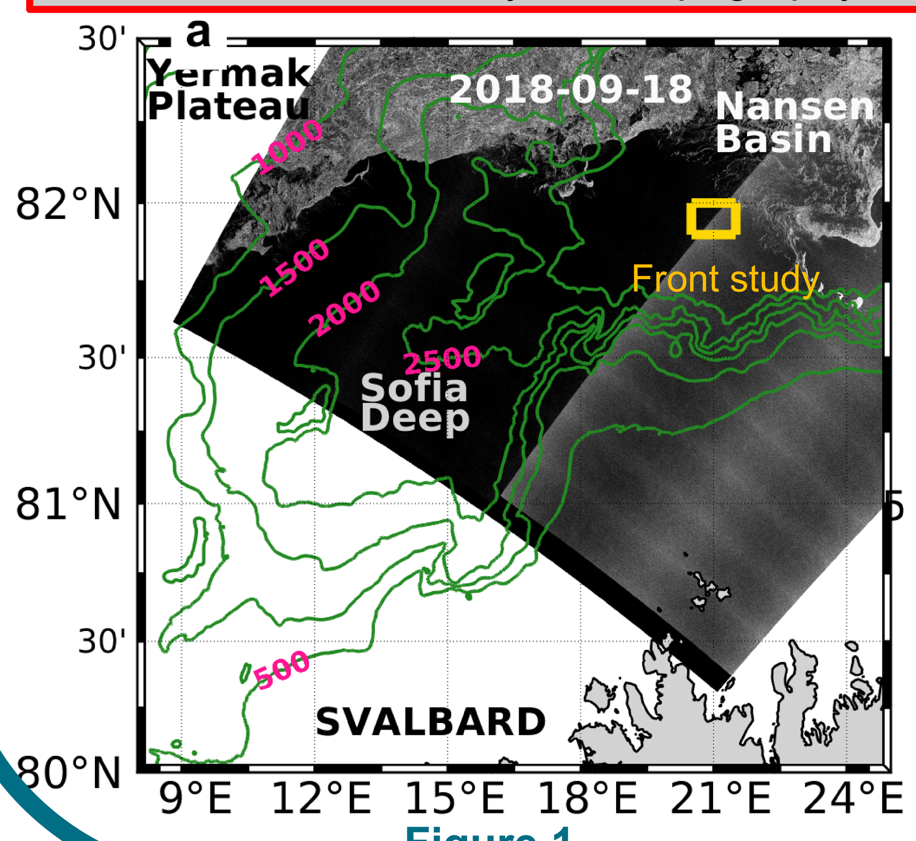


Figure 1

Front was located using the thermosalinograph data.

Across-front sections of Vertical Microstructure Profiler (VMP) were performed.

In parallel, an AUV (automated unmanned vehicle) was deployed away from the ship, that criss-crossed the front and profiled down to 90 m depth.

B. MAPPING OF THE FRONT

The measurement locations have been advected to a common time.

Objective mapping. Decorrelation length scale across: 1km and along: 3km.

During the 24-hour duration of the station, moderate wind was steadily blowing from the northeast.

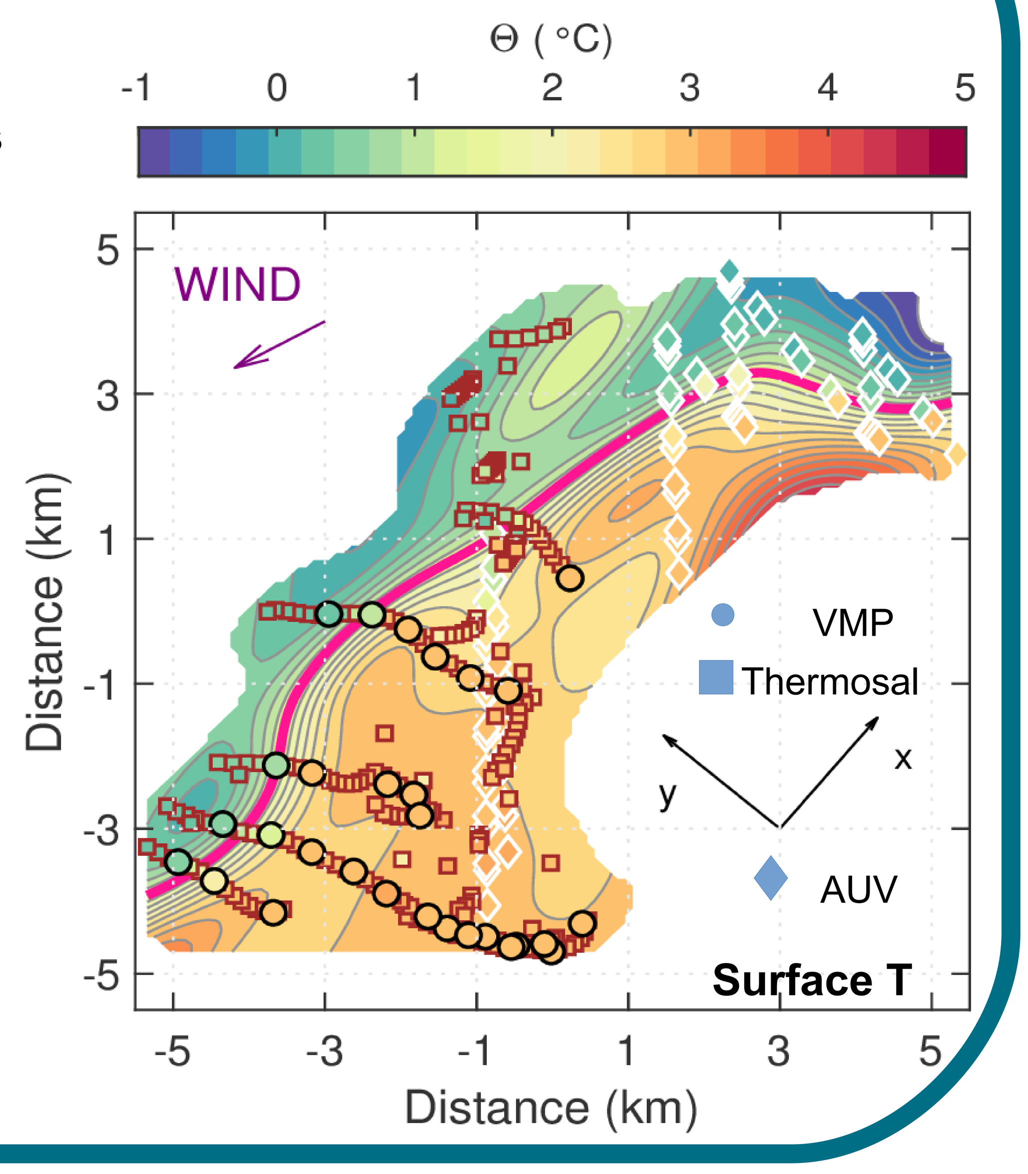
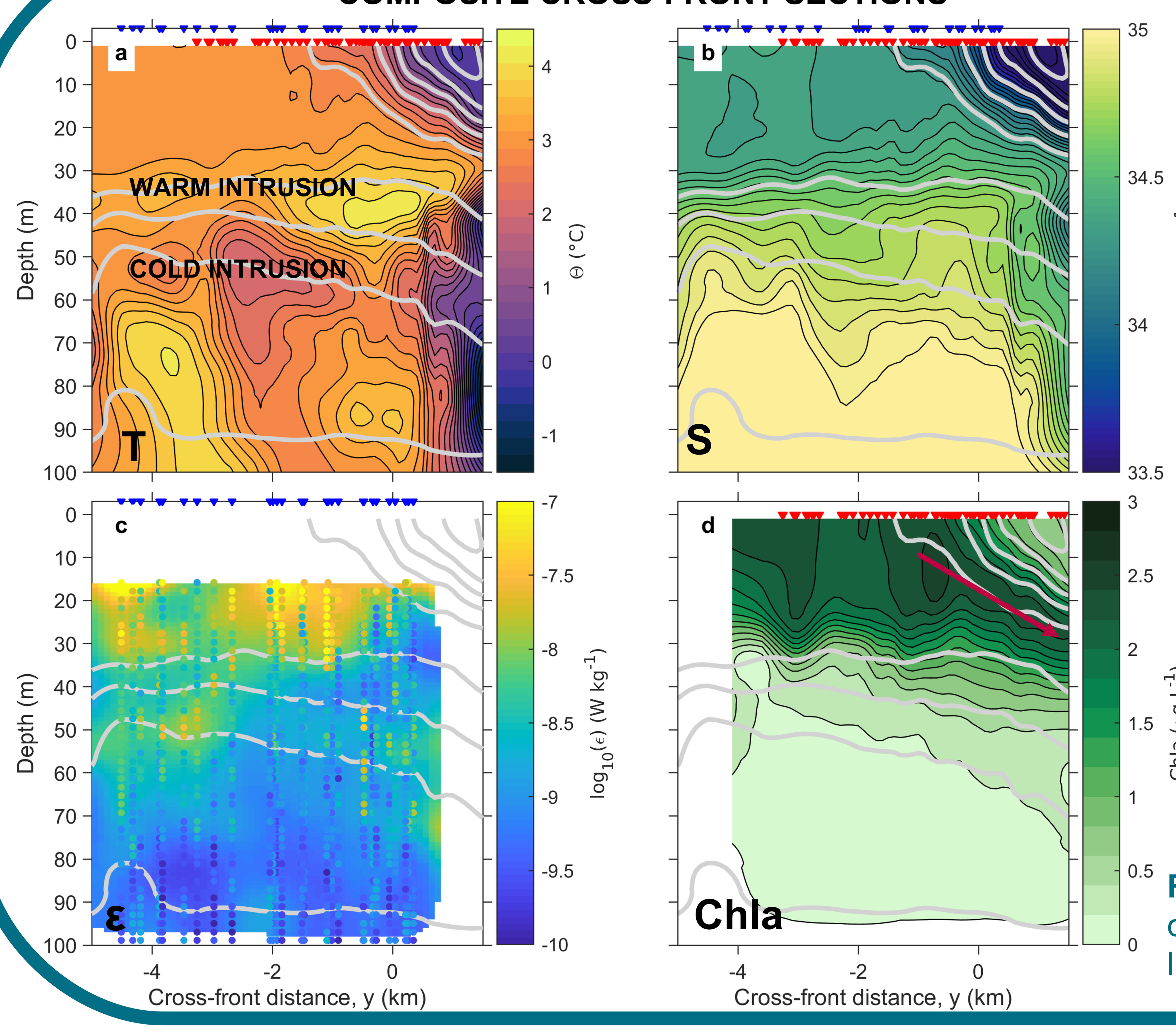


Figure 2
Front: 1.5°C isotherm

C. CROSS-FRONT SECTIONS

COMPOSITE CROSS-FRONT SECTIONS



The surface front is both a temperature and a salinity front. The front is also observed at depth down to 100 m. The front separates the Atlantic Water from Polar waters. A warm layer is noticed at about 35m depth while a cold layer is observed underneath the warm layer (Figure 3)

The deep mixed layer on the warm side is enriched in Chla, and downwells under the cold and fresh surface layer on the cold side. Vertical velocities calculated using the quasi-geostrophic ω equation showed a downwelling of about 5 m.d^{-1} at the front location (Figure 4)

Turbulence is observed around the front, mainly on the warm side, close the surface but also at depth (Figure 3)

Figure 4: Cross-front vertical velocities inferred from the ω-equation. Velocities are negative downward and positive upward. The red line is the 2 μg L −1 Chlorophyll a fluorescence concentration. Gray lines are isopycnals.

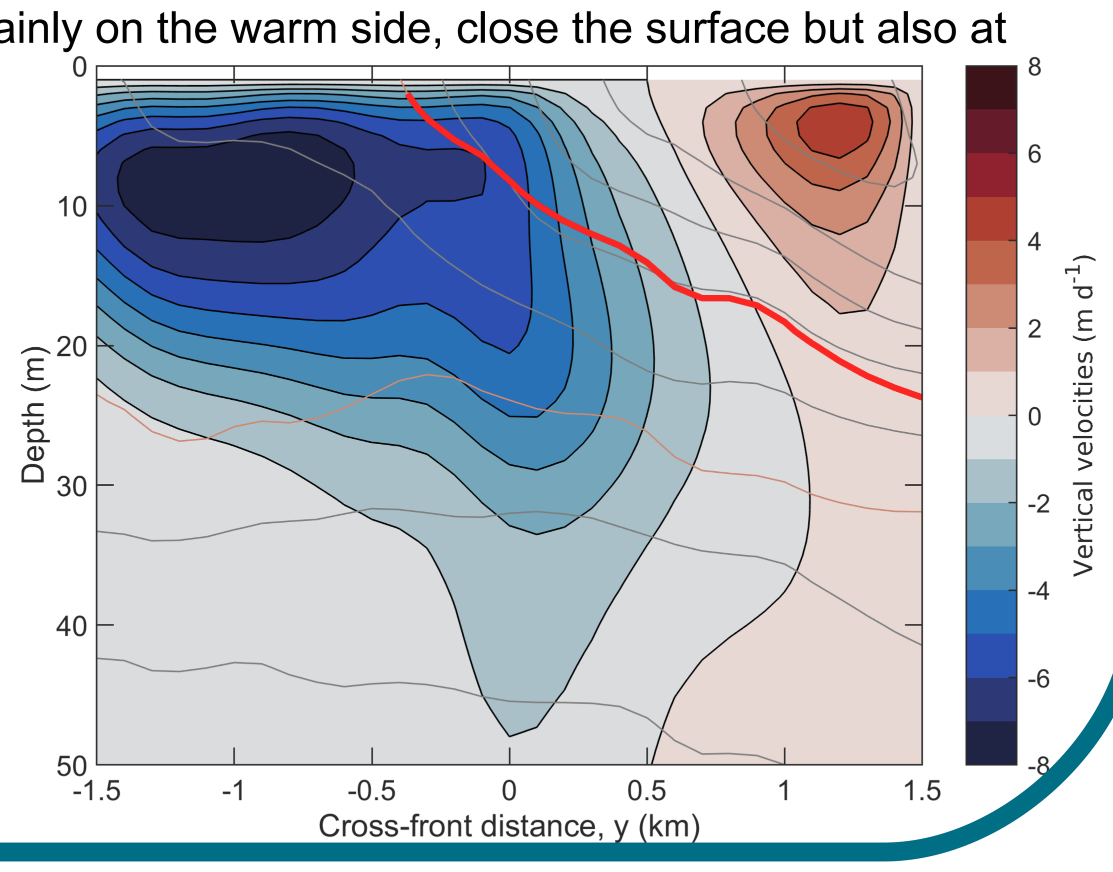
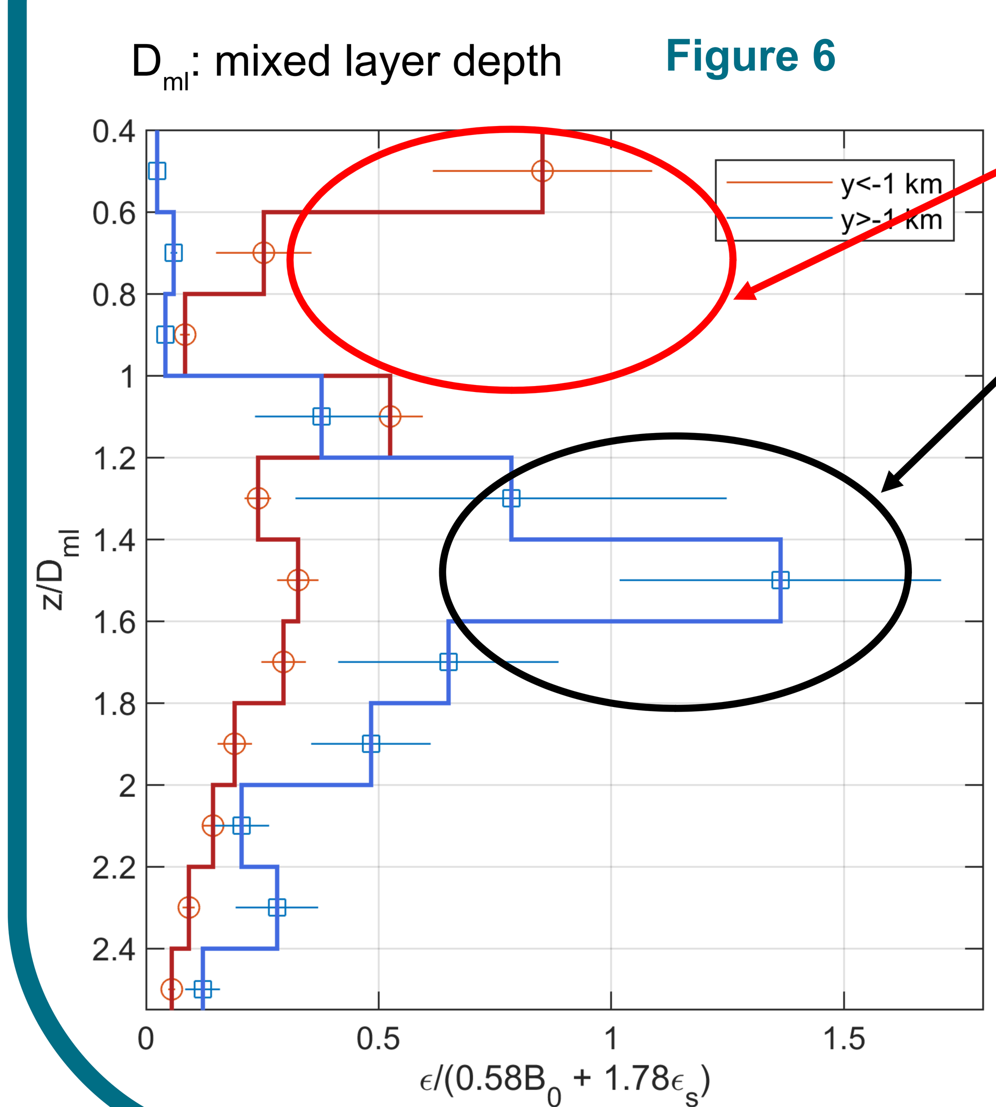


Figure 3: The red/blue triangles are the location of the AUV/VMP profiles respectively. The grey lines are isopycnals (every 0.1 kg m^{-3}).

D. SOURCES OF TURBULENCE

D_{ml}: mixed layer depth

Figure 6



SOURCES OF TURBULENCE

Surface buoyancy fluxes and wind stress

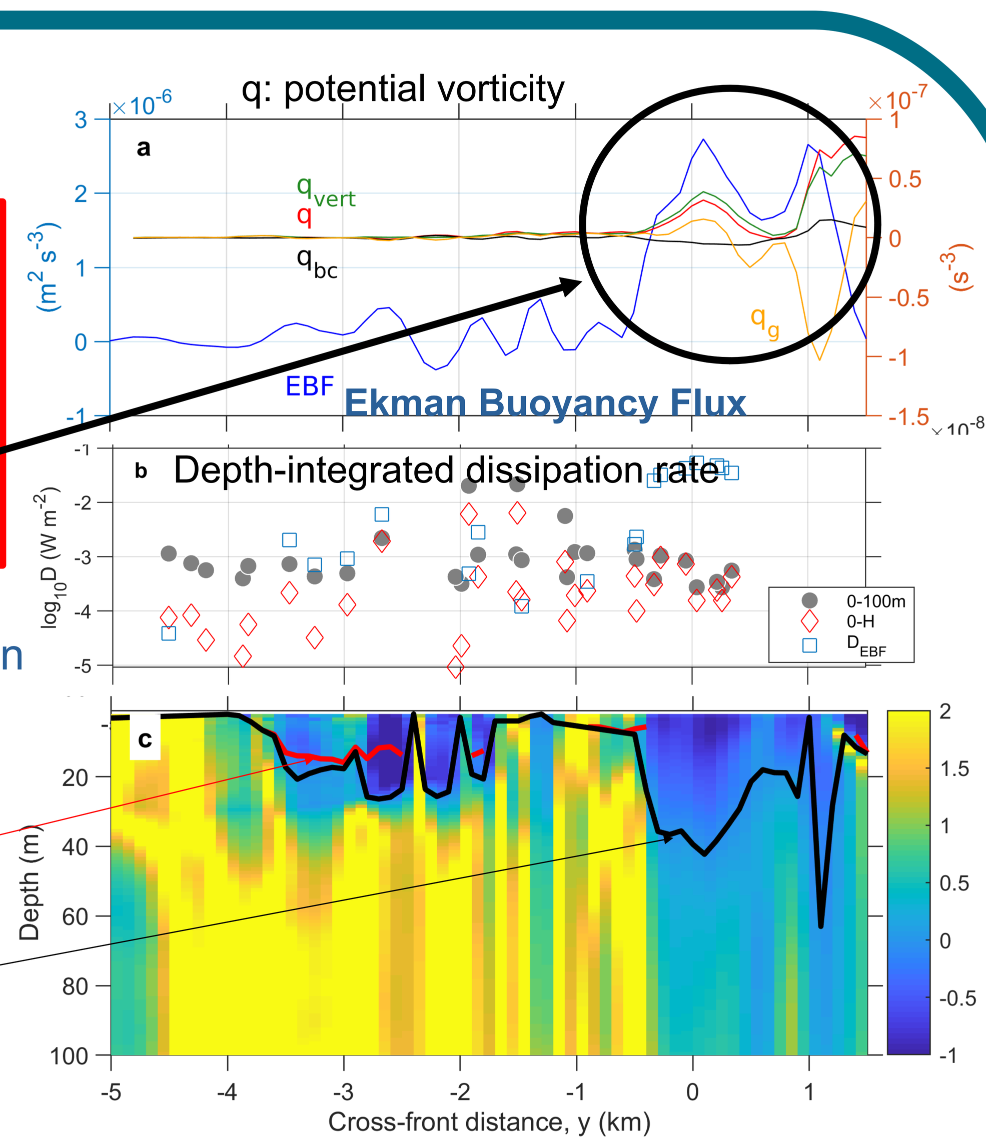
Conditions favorable for forced symmetric instability

D_{EBF}: depth-integrated dissipation rate from forced symmetric instability over H

convective layer depth h

H: low PV layer depth, corresponding to Ri_{bulk}=1

Figure 5



Ekman buoyancy flux decreases the surface potential vorticity at the front (figure 5a), which is a prerequisite for symmetric instability over the layer H, around 30m depth. Explain the increase dissipation rate under the mixed layer (Figure 6 blue profile and Figure 5b)

E. CONCLUSION

- Strong lateral and vertical variability was observed at an **ocean front** close to the **sea ice edge** in the Nansen Basin
- **Surface buoyancy fluxe**s and **wind stress** were the **main sources** of turbulence in the mixed layer
- Conditions were **favorable** for **forced symmetric instability**, which could contribute to **increase turbulence** below the mixed layer

Reference: Koenig Z. et al., (2020) Observations of turbulence at a near-surface temperature front in the Arctic Ocean, *J.Geophys. Res. Oceans* doi: 10.1029/2019JC015526

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