TAL TECH

EVALUATION OF SUBMESOSCALE VARIABILITY CAPTURED BY GLIDER MISSIONS AND HIGH-RESOLUTION NUMERICAL EXPERIMENTS IN THE GULF OF FINLAND, BALTIC SEA

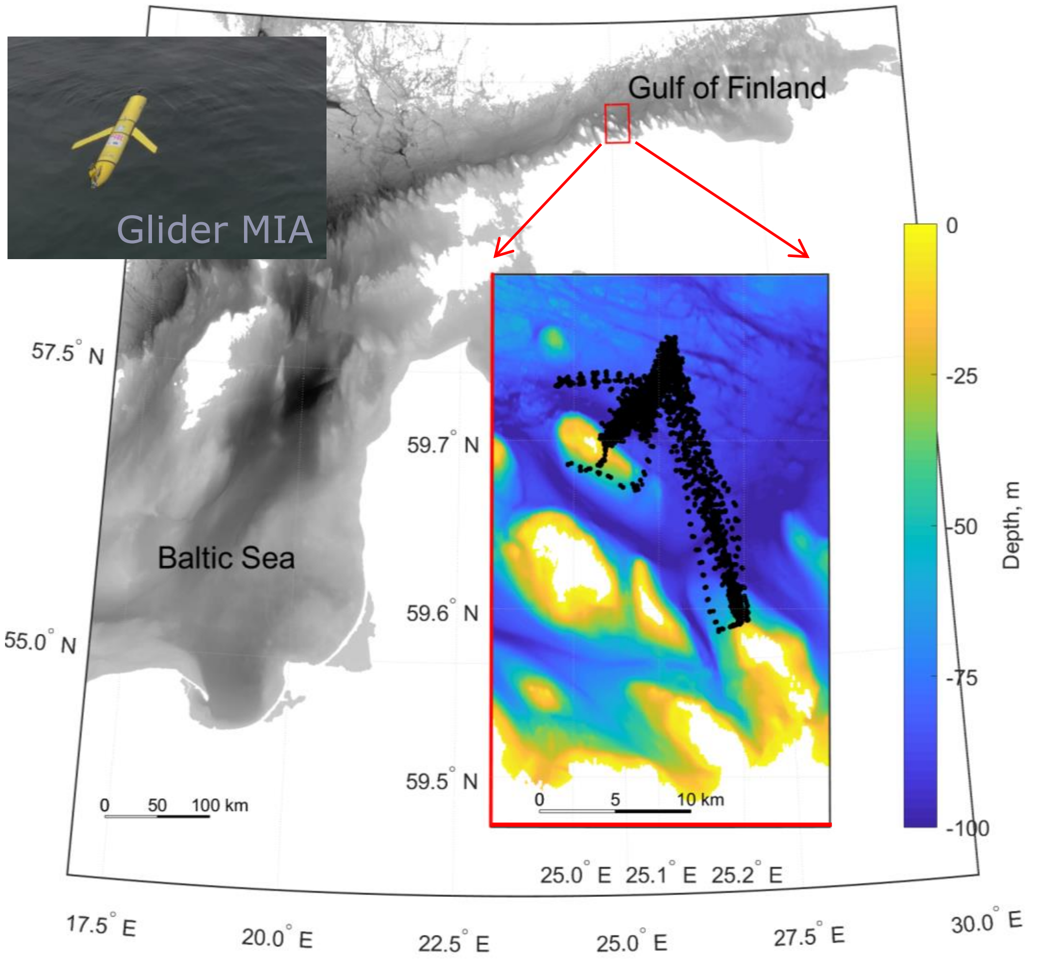
Kai Salm, Germo Väli, Taavi Liblik, Urmas Lips
Department of Marine Systems
Tallinn University of Technology, Estonia

EGU General Assembly 2022

26.05.2022

STUDYING THE SUBMESOSCALE FLOWS IN THE BALTIC SEA

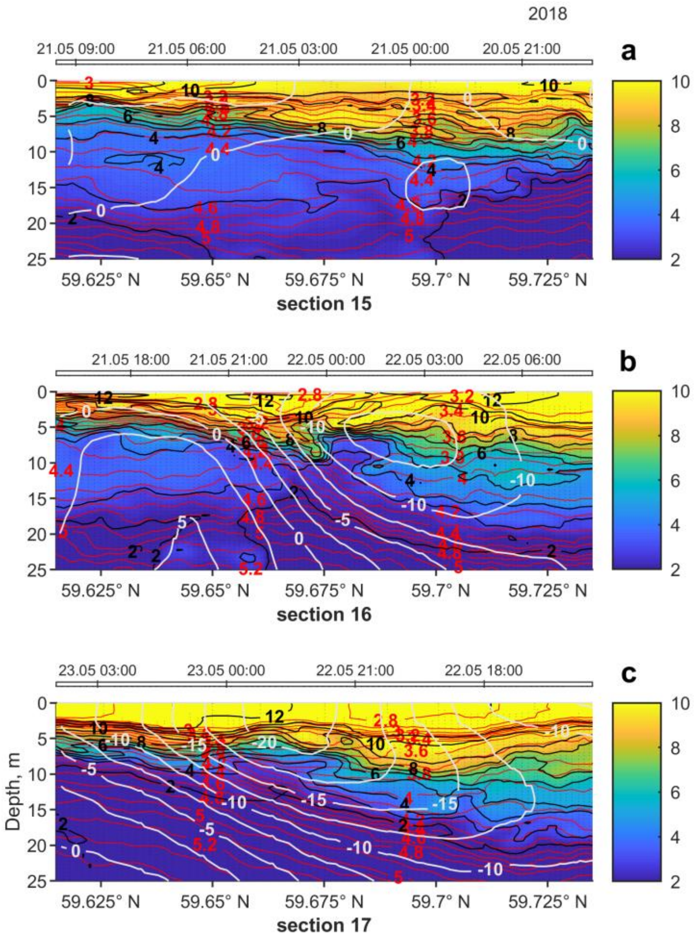
- Intermediate scales (<5 km, a few days)
- Data
  - three month-long glider missions (spring 2018 and 2019, summer 2019)
  - high-resolution numerical experiments
- The aim
  - characterize the submesoscale structures in the simulated area during the glider missions
  - identify the events and/or favorable forcing that permits the smaller-scale features to arise
- Methods
  - statistical parameters, e.g., |Ro|>1
  - spectral analysis



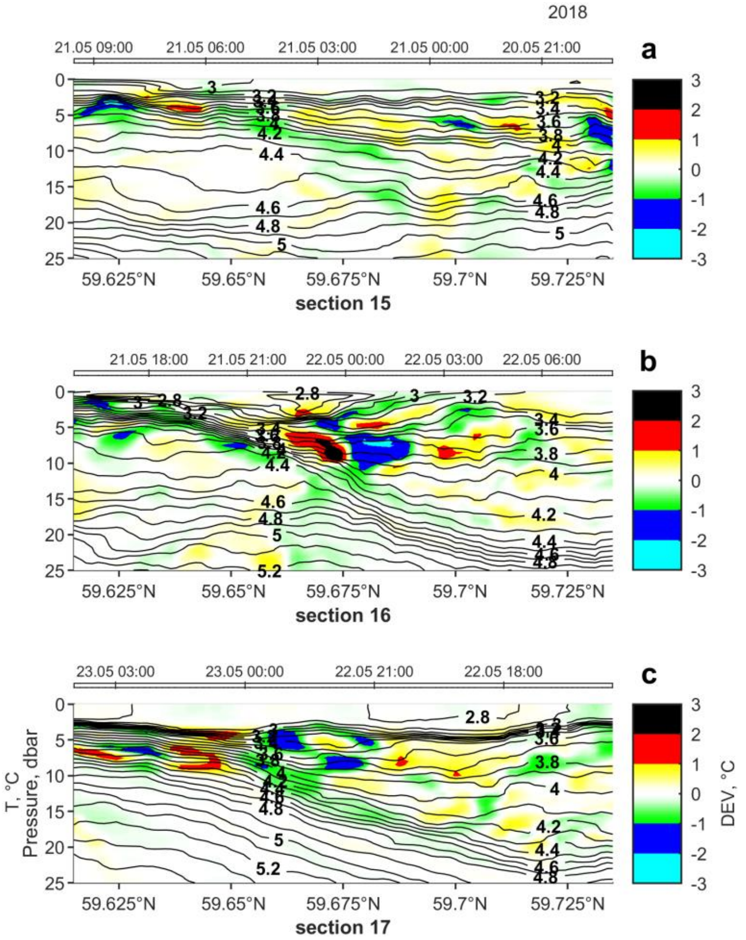
Map of the study area. The overlaid plot shows the bathymetry of the deployment area highlighted by a red rectangle. Black dots indicate the vehicle inflections on the surface.

GLIDER OBSERVATIONS IN 2018 AND 2019

- Repeatedly sampled sections
- Deducing flows by analyzing the tracer variance
- A smaller-scale pattern projected as the intersections of isotherms and isopycnals emerged within the front
- The observed pattern consisted of two motions in opposite directions
- Similar features were mapped in the depth range of the developing thermocline until the cline reached a well-developed stage



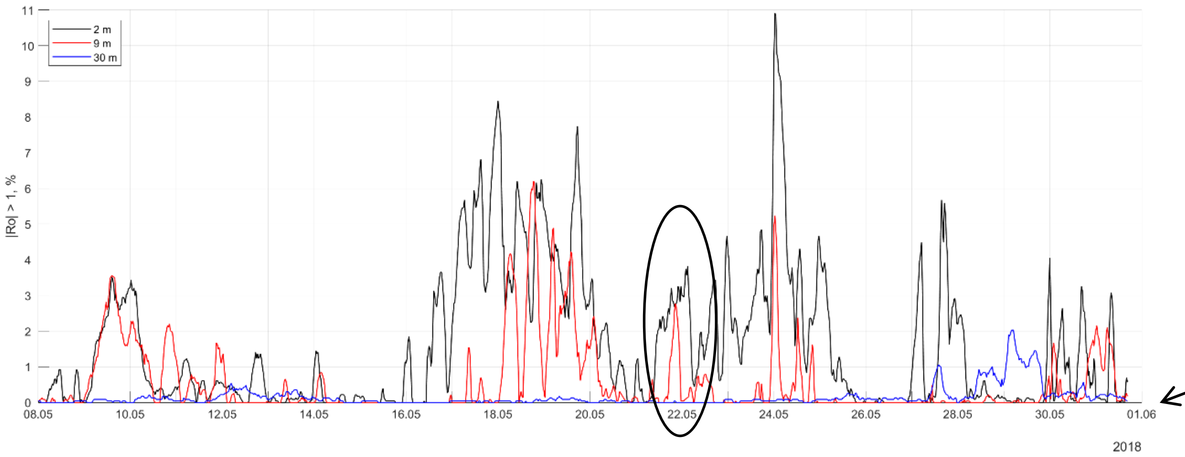
Temperature distribution (0-25 m) in May 2018. Black contours mark temperature, red contours potential density anomaly, and white contours the relative geostrophic velocity.

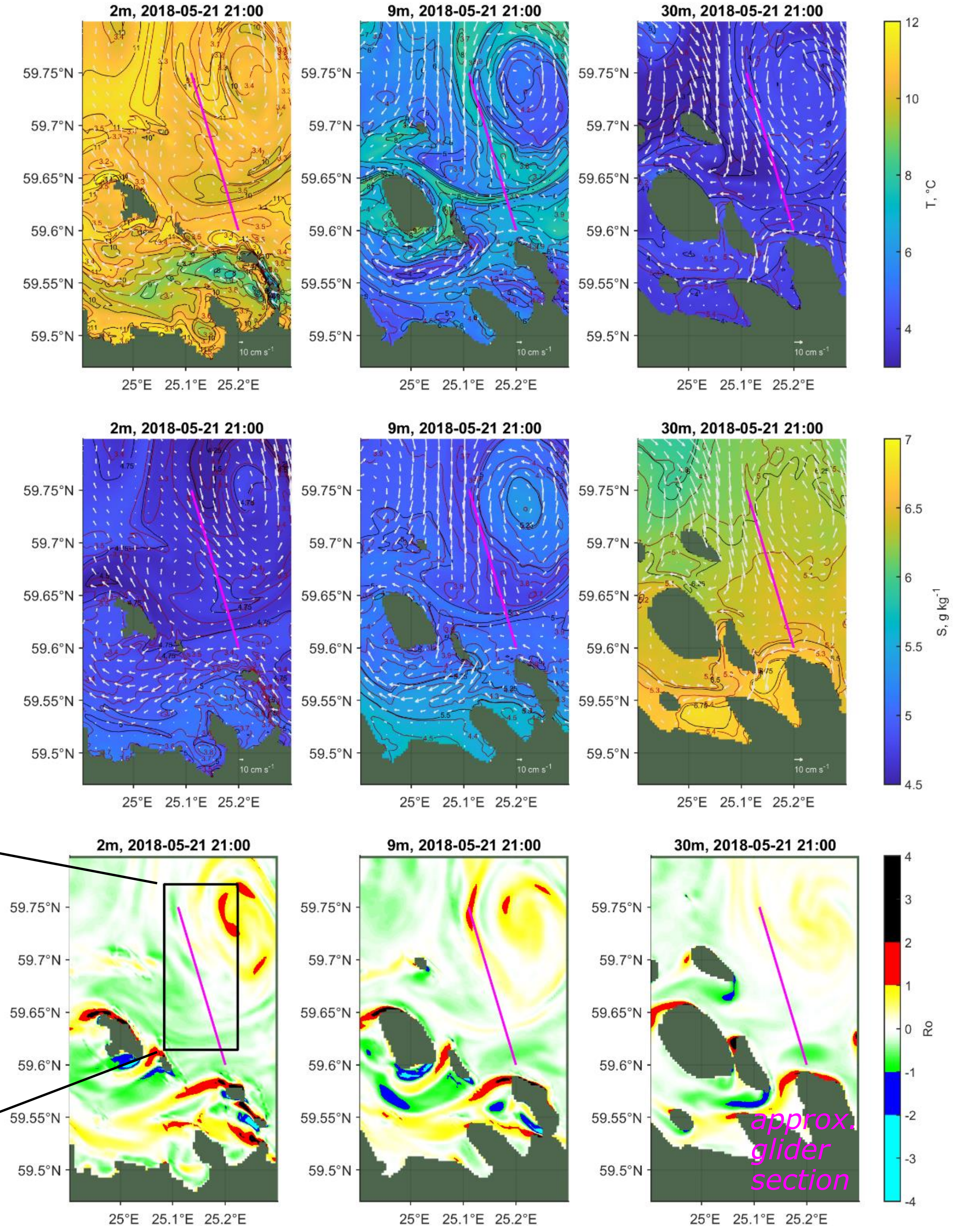


Temperature deviations along isopycnals feature the significant difference in the temperature from the surrounding average at horizontal scales of >4 km.

NUMERICAL EXPERIMENTS

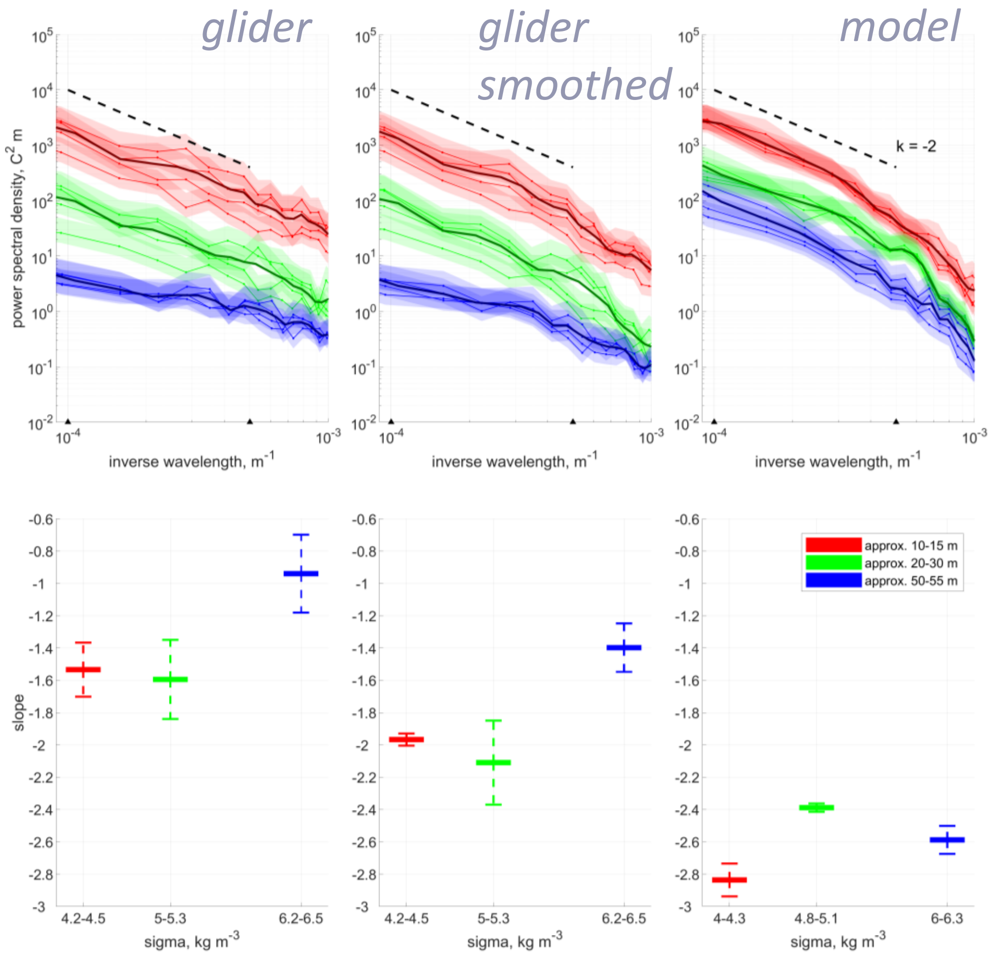
- A three-dimensional hydrodynamic model GETM (General Estuarine Transport Model)
  - the grid spacing of 0.125 nautical miles
- Maps of T, S, and Ro at 2 m, 9 m, 30 m
  - noticeable variability in the upper 10 m
  - a vortex characterized by Ro>1
- Statistical parameters
  - percentage of |Ro|>1 in the study area (a black rectangle indicates the subset of the model domain)





WAVENUMBER SPECTRUM OF ISOPYCNAL TEMPERATURE

- Preliminary spectra estimates
- Slopes estimated between 2-10 km
- Observations
  - shallowing of spectral slopes with increasing depth
  - the tendency toward k^{-1} on isopycnals positioning at 50-55 m (i.e., layers below the developing thermocline)
  - upper water layers exhibit slopes near -5/3
  - spectrum steepens with smoothing
- Model
  - depth-dependence not clear
  - steeper slopes



The wavenumber spectrum of isopycnal temperature. Thin lines present spectra along individual isopycnal surfaces (with a step of 0.1 kg m^{-3}) in the density ranges of 4.2–4.5 (red), 5.0-5.3 (green), and 6.2–6.5 kg m^{-3} (blue) with the shadowing showing the 95% confidence limits. Thick lines demonstrate the averages of the individual spectra. Black line show the slope of -2.

CONCLUSIONS

- The observations revealed patterns with a width of a few km emerging within the front
  - contribution to the development of the stratification (enhancing)
  - probable relevance throughout the year because of the rich mesoscale variability of the Baltic Sea (upwelling and downwelling events, fronts, and eddies)
- The wind has a substantial role
  - the analysis suggests that a temporary decrease in wind stress enabled the smaller scale motions to evolve

- In situ measurements are discrete and limited in time and/or space, but numerical models could fill the entire sea with simulation data
- Showing that the model simulates the variability captured in the measurements successfully suggests that the submesoscale occurs in the sea with similar characteristics

THANK YOU!

Kai Salm, kai.salm@taltech.ee

This work was supported by the Estonian Research Council grant (PRG602)