Combining glider surveys and vertical profilers for process studies in the stratified estuaries (Gulf of Finland, Baltic Sea)

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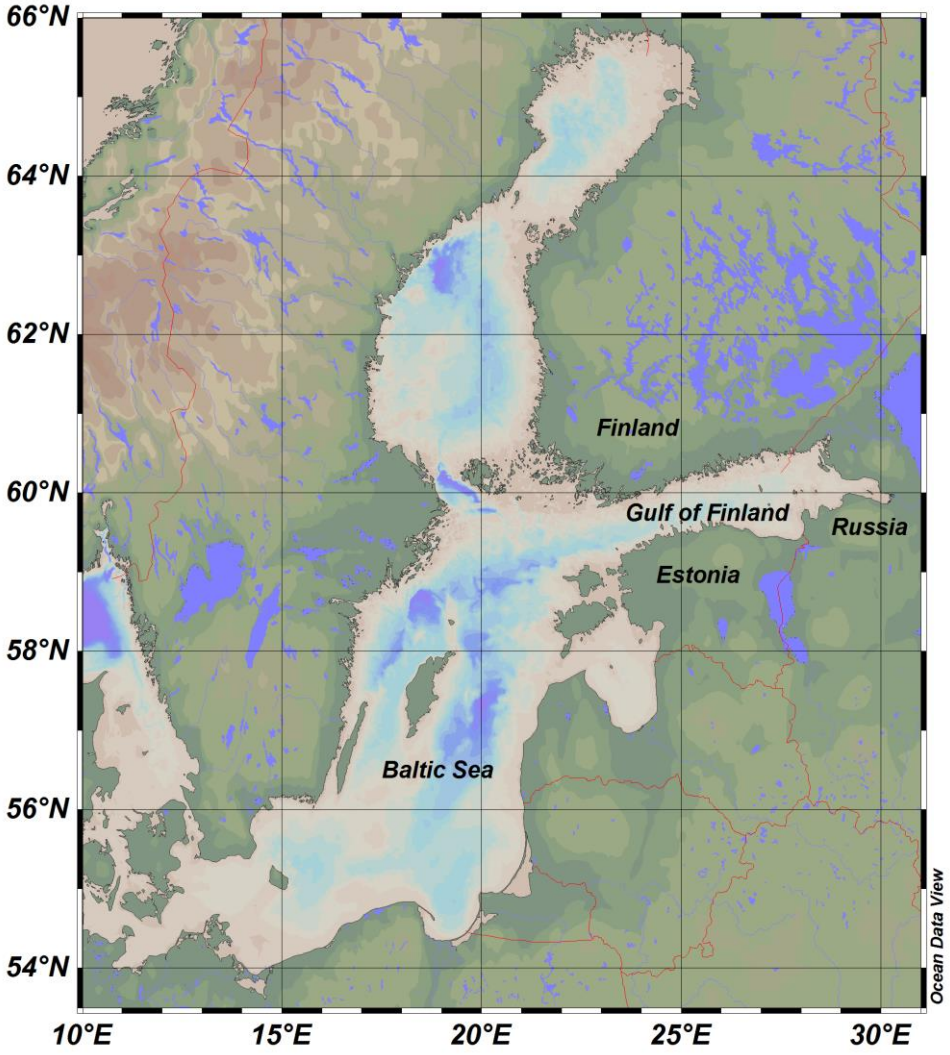
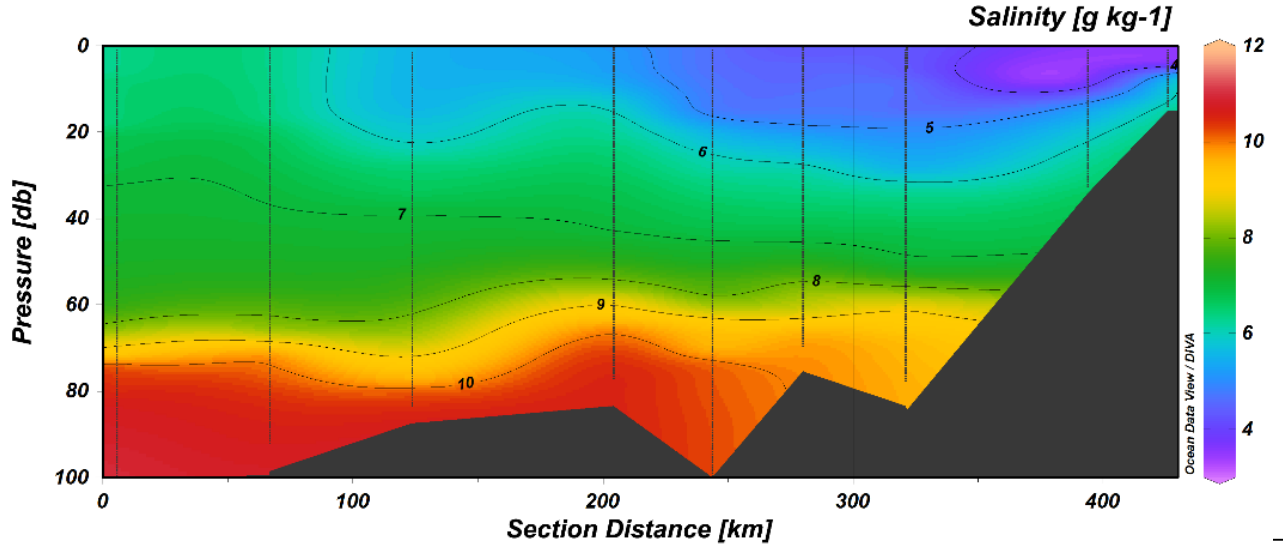
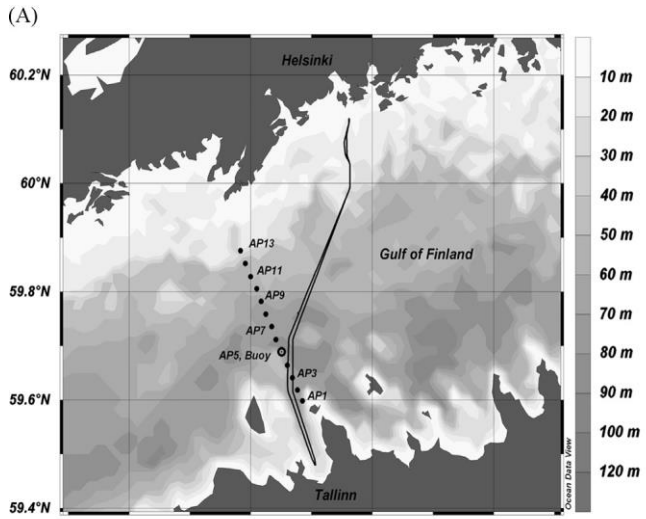
Study area

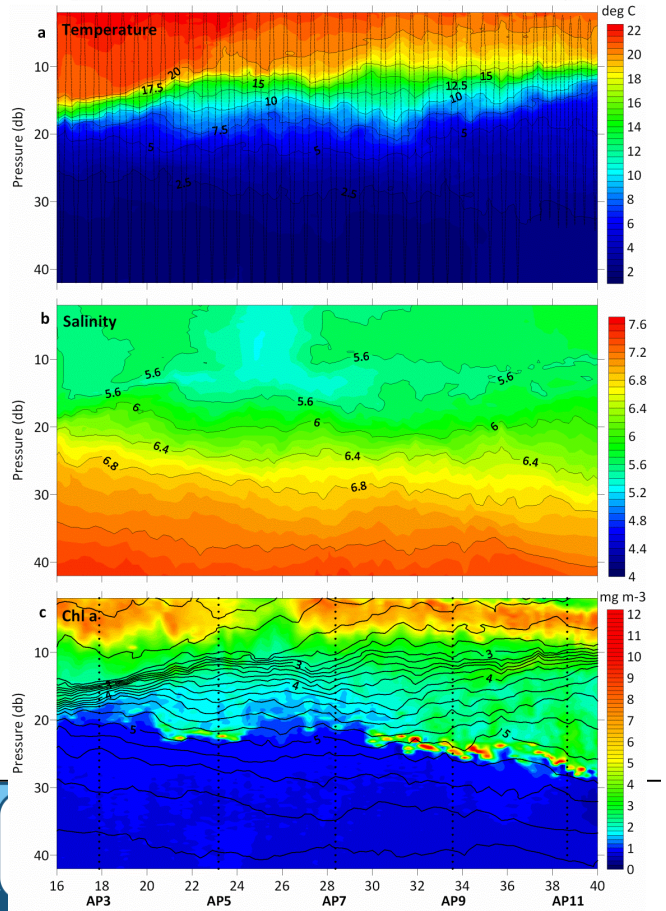


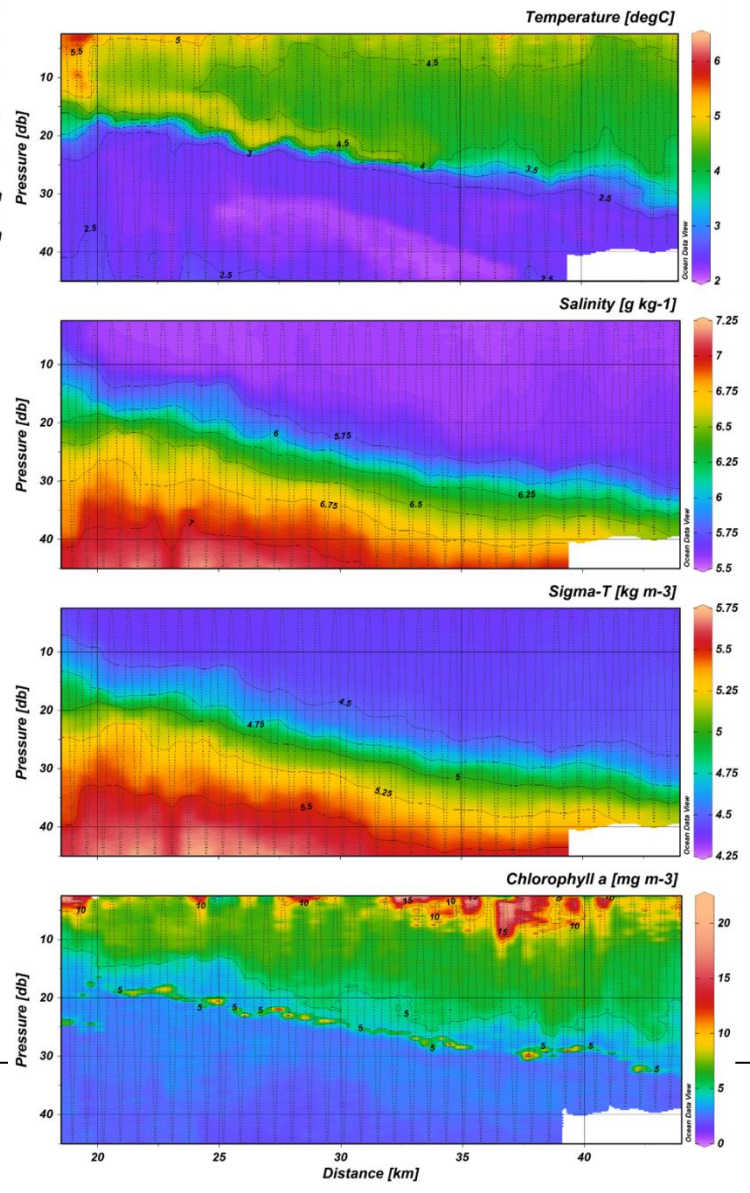
- The Gulf of Finland is a **stratified estuary** (depth up to 115 m) of the **non-tidal Baltic Sea**.
- The overall horizontal and vertical gradients of salinity are maintained by the **fresh water discharge** mainly in the north-eastern part and **saline water inflows** at the south-western corner of the sea.
- Two pycnoclines exist – **seasonal thermocline** (at about 15-25 m depth) and **quasi-permanent halocline** (60-80 m). Salinity range in the central Gulf of Finland is from about 4-5 g/kg in the surface to 9-10 g/kg in the near bottom layer.



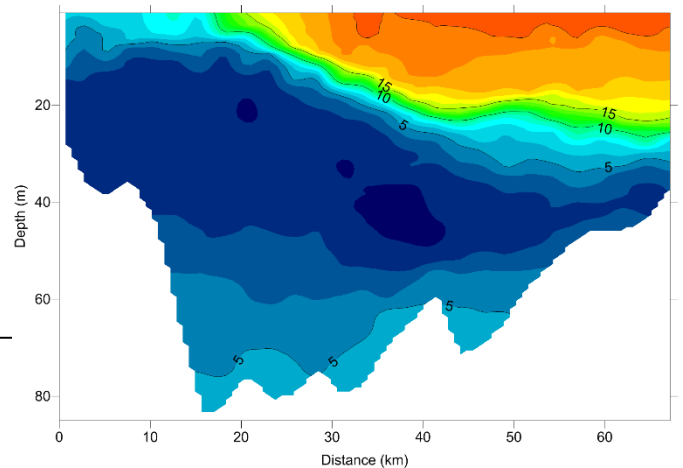
Study area and background







- The variability at the shorter time scales largely depends on the **wind forcing**.
- Wind forcing alters the location and strength of the pycnoclines and creates horizontal gradients of buoyancy between the coastal and offshore areas.
- **Coastal upwelling and downwelling events** are frequent phenomena.
- At the submesoscale, intrusions of water with different TS-characteristics and subsurface thin layers of phytoplankton biomass maxima are observed

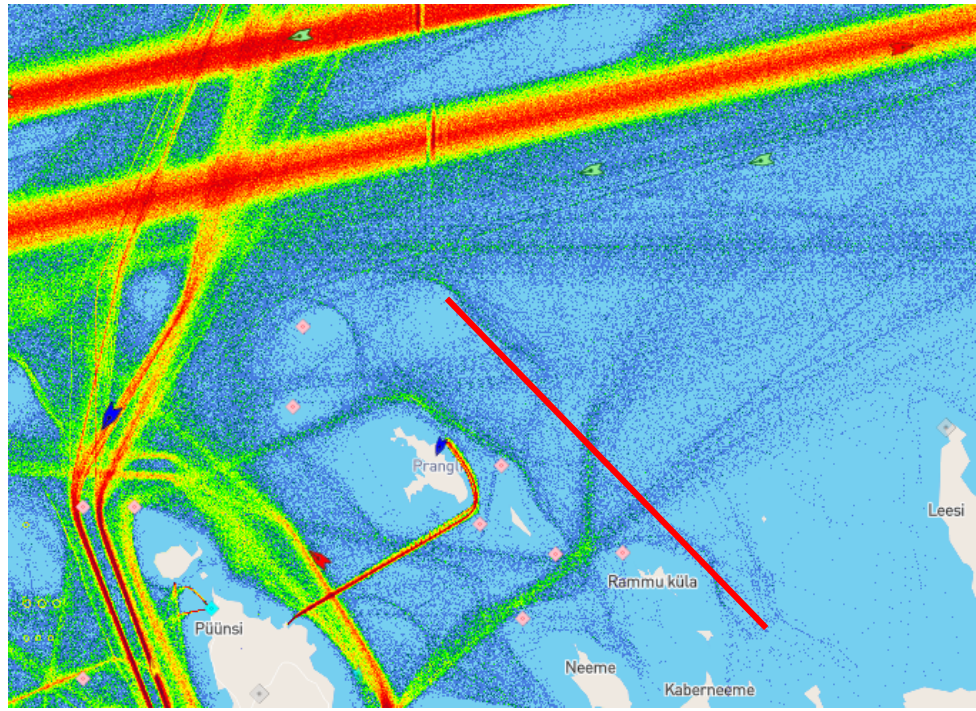


Background and objectives

Overall aim is to enhance the predictability of the Baltic Sea, both in short-term (operational forecasts) and long-term.

Motivation –

- Comparison of observational data and model results has identified some major problems in relation to description of physical processes at scales relevant to phytoplankton dynamics (e.g. dynamics of the seasonal thermocline) and short-term transport and dispersion of particles in the sea.
- Submesoscale features (lateral scales comparable or less than internal Rossby radius, 2-5 km in the Gulf of Finland) can significantly shape the distribution pattern of tracers in a stratified sea area.
- Observations of submesoscale processes has been difficult when applying separately autonomous profilers at fixed positions and research vessel based measurements (including towed devices). Gliders could help to resolve required spatial and temporal variability if applied together with fixed profilers.
- The study site and area were selected to map repeatedly the cross-shore distributions during the initial phase of development of the seasonal thermocline – we expected to catch differential warming and related lateral transport.

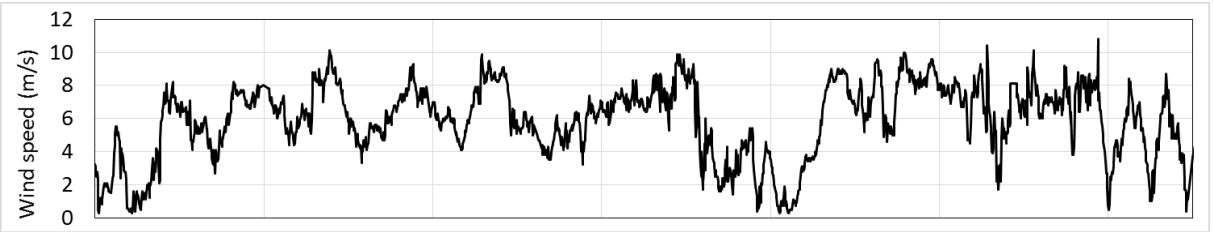


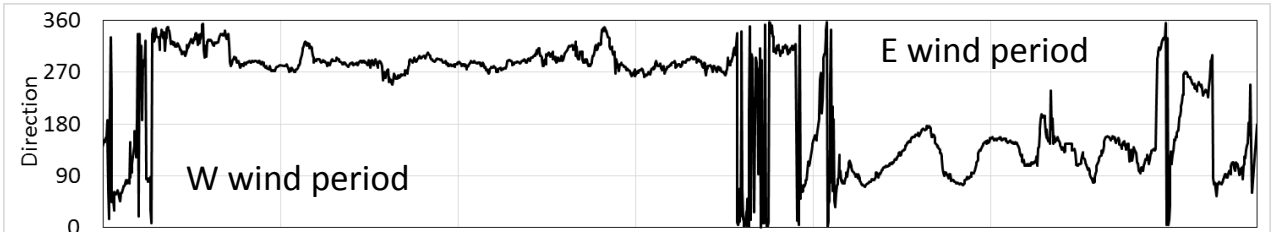
Measurement campaign

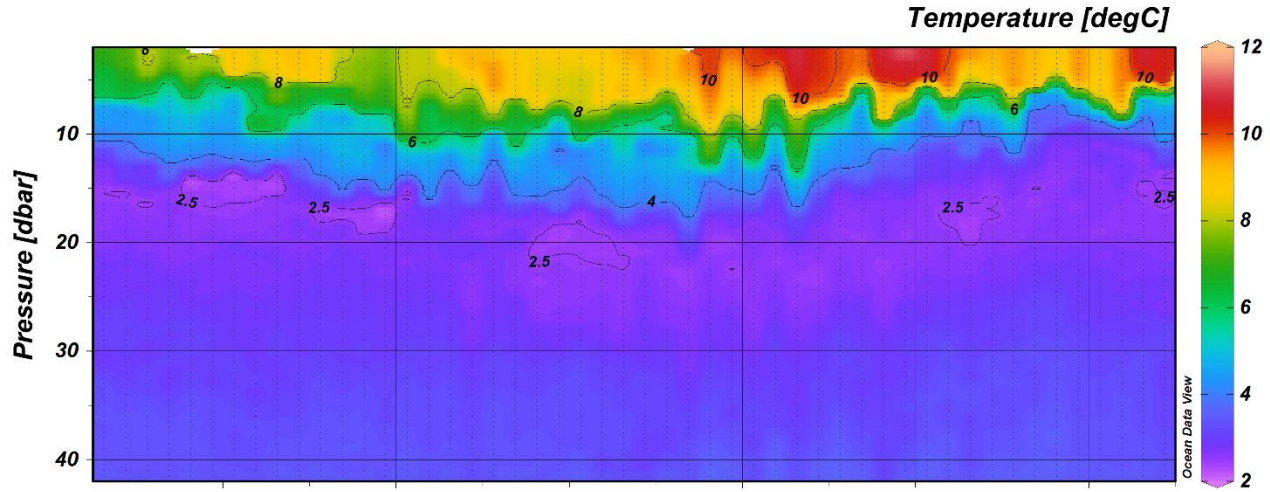
We present the data of a measurement campaign conducted in May 4-16, 2016 when a cross-shore section was repeatedly mapped by an underwater glider in the vicinity of fixed profilers:

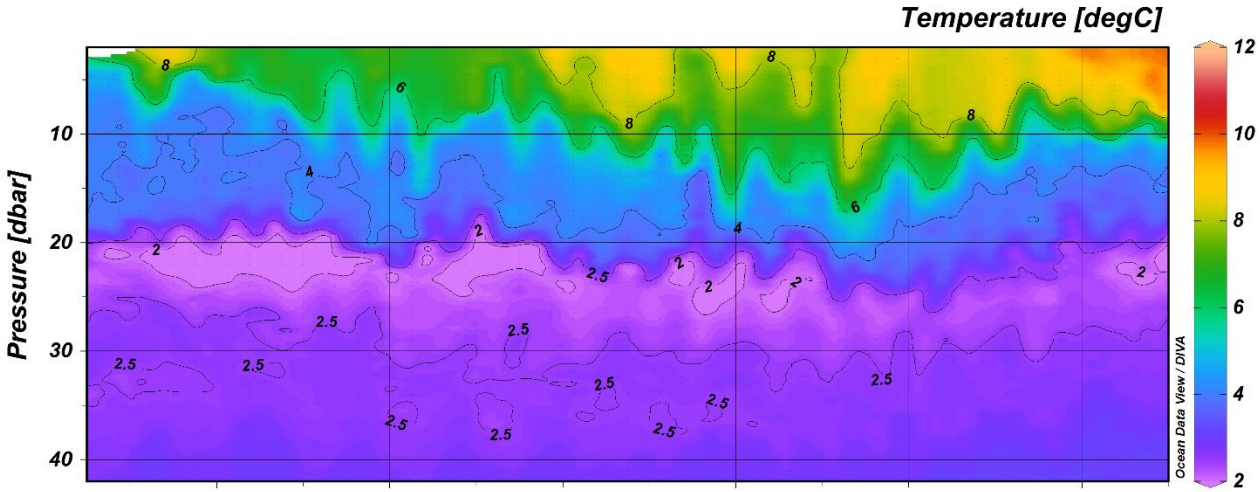
- a deep sea bottom mounted profiler (Flydog Solutions), connected with a cable to the power supply and communication devices at Keri Island; profiles of T, S, Chl a, O2, and turbidity, 8 times a day, from surface to 100 m.
- a coastal sea buoy based profiler (Idronaut); profiles of T, S, and Chl a, 4 times a day, from surface to 42 m.
- 12-day glider mission (TWR Slocum G2 shallow water glider) along a section between the two profilers; recording T, S, Chl a, O2 and turbidity while diving, from surface to 80 m, section length 26 km.
- research vessel based measurements on 4 May, 10-11 May, and 16 May 2016; T, S, Chl a, O2 and turbidity profiles, sampling for laboratory analyses of salinity, Chl a, nutrients, and phytoplankton species composition.
- meteorological data (wind, air temperature, pressure, PAR) recorded at Keri lighthouse

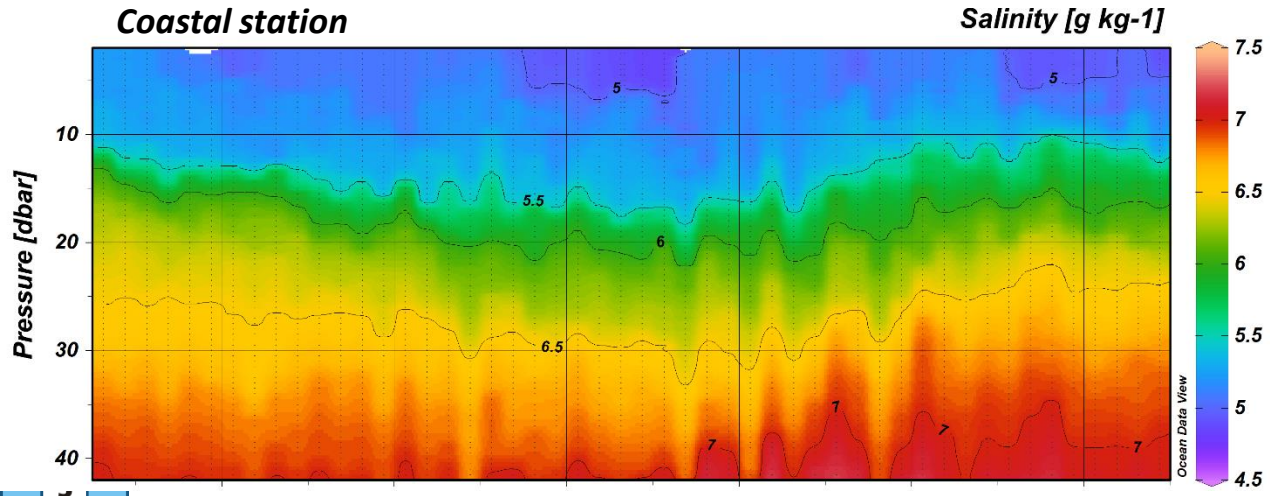
Forcing and general background

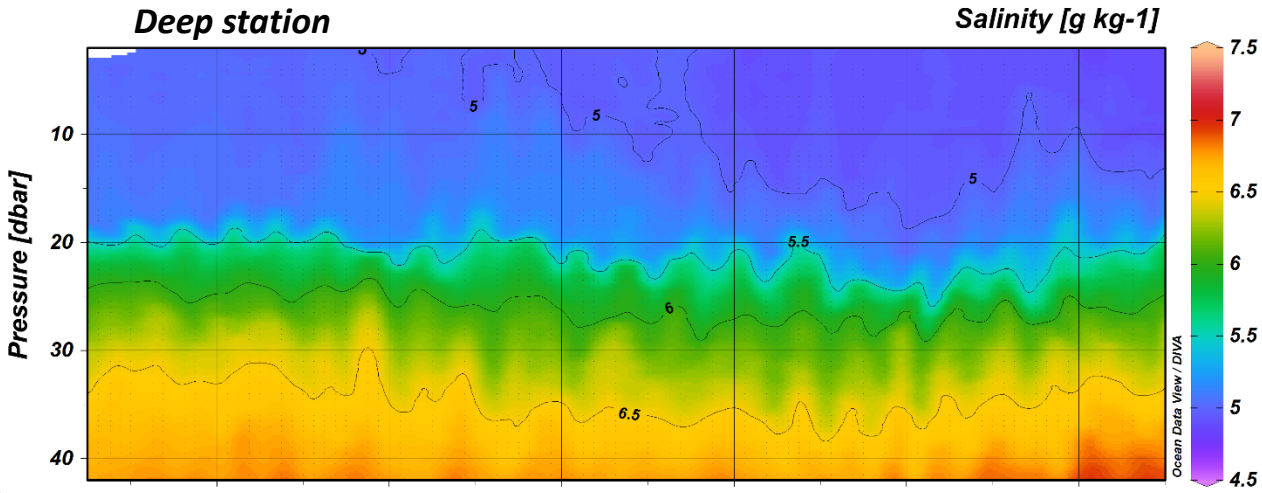




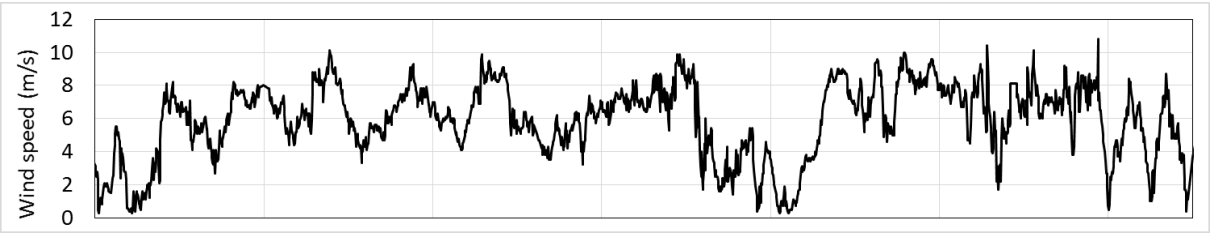


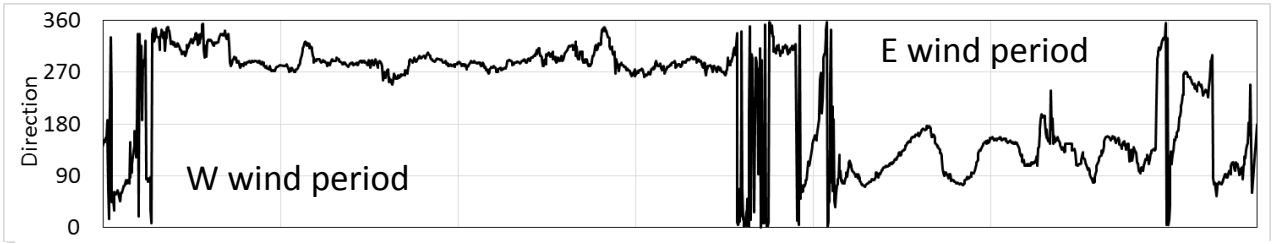


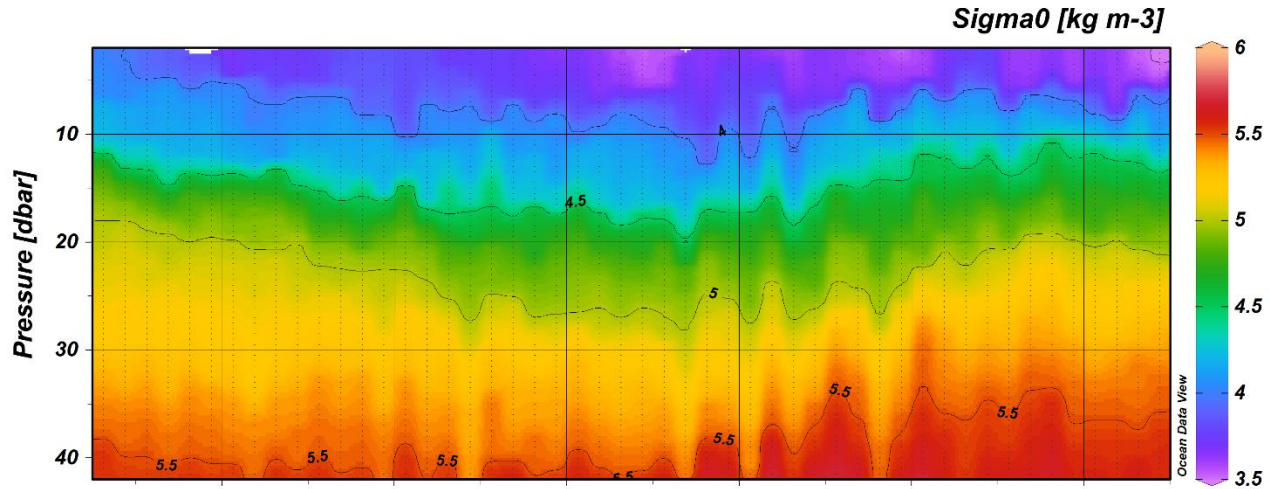


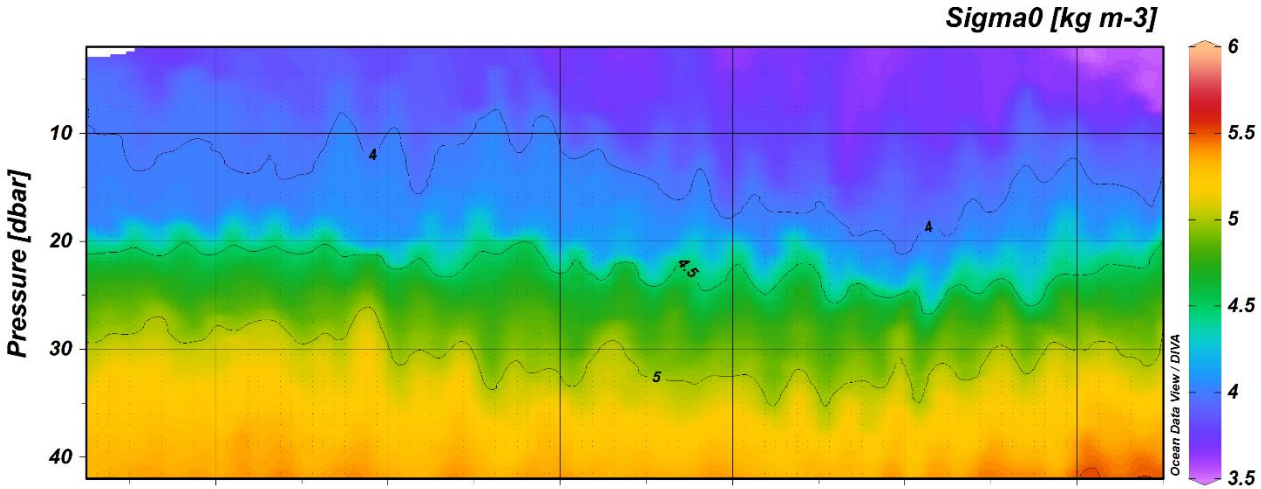


Forcing and general background

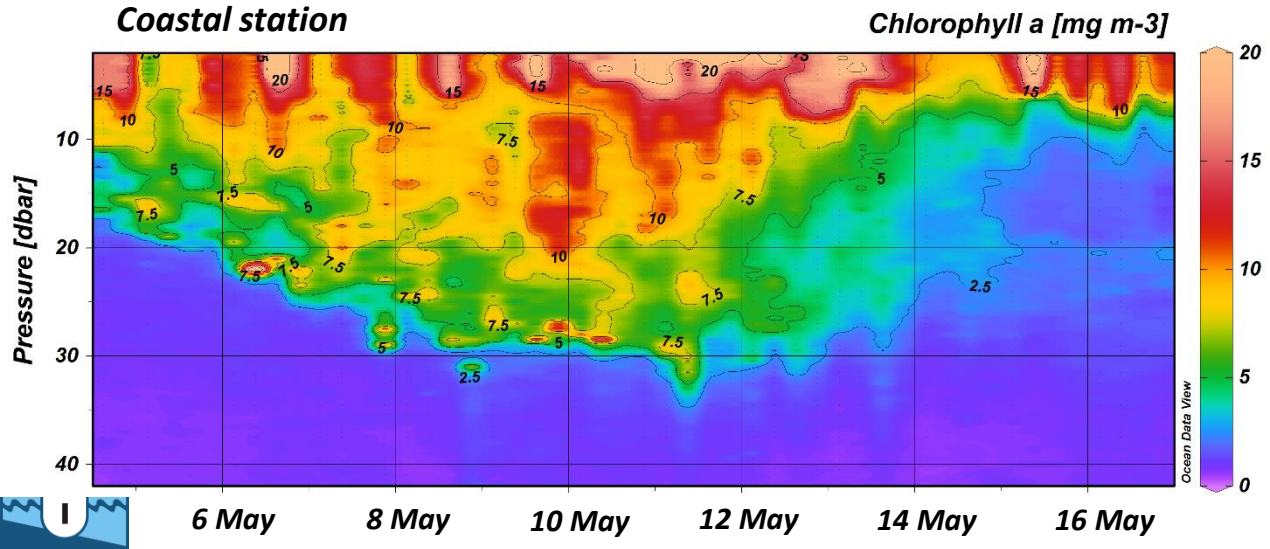




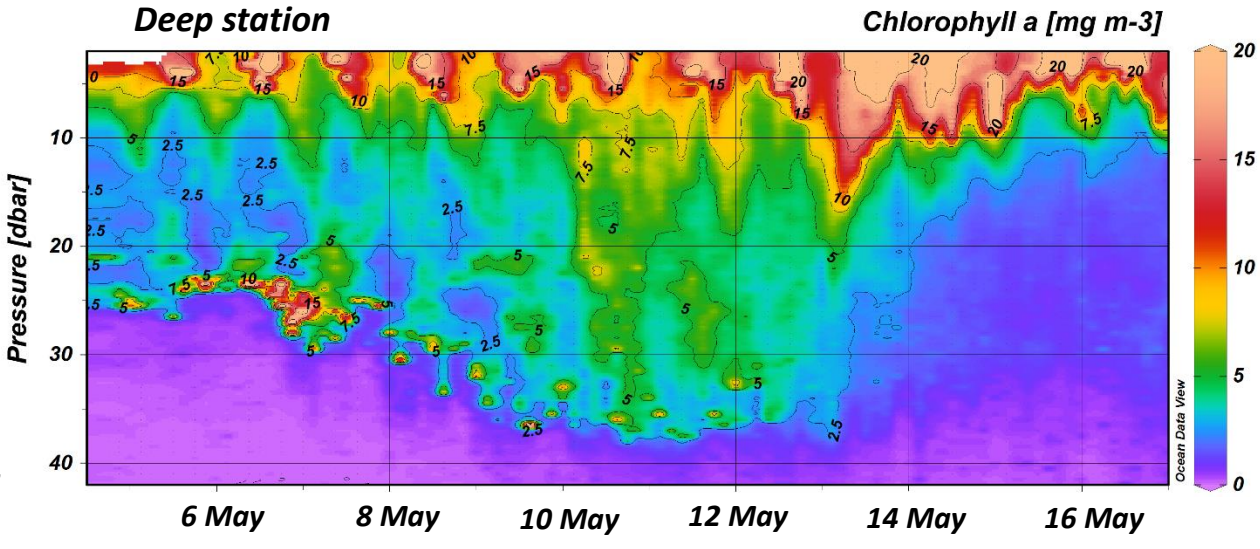




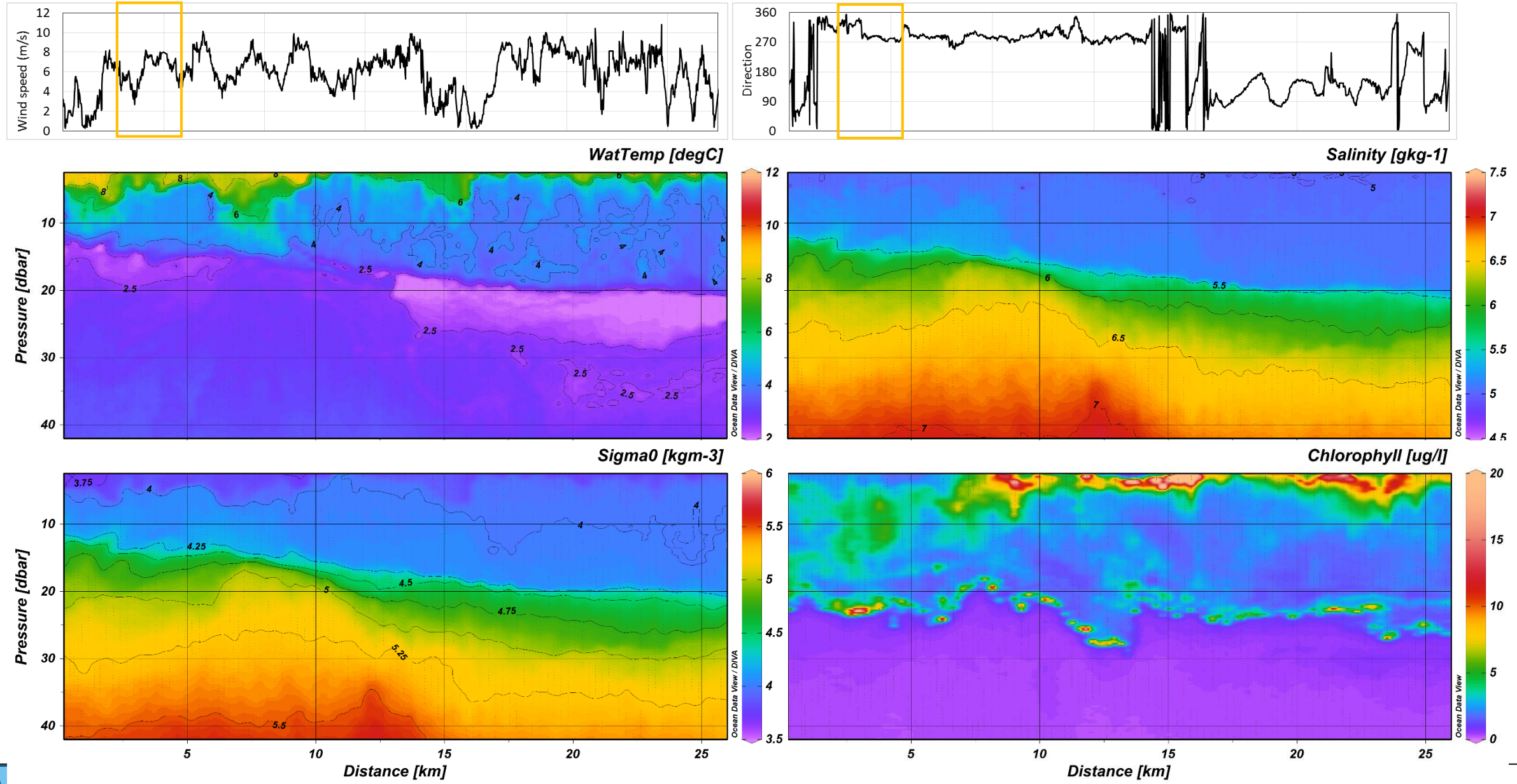
Coastal station



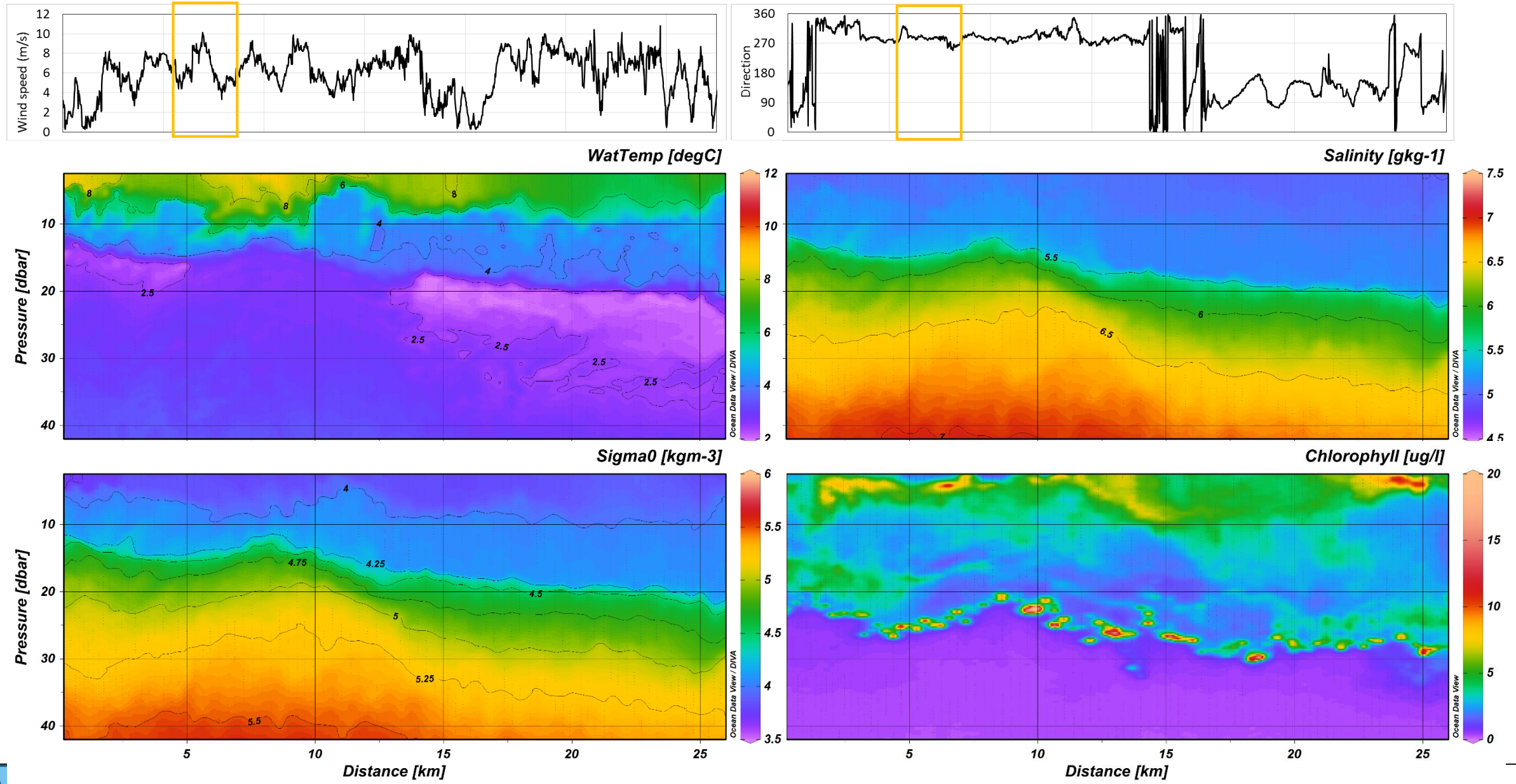
Deep station



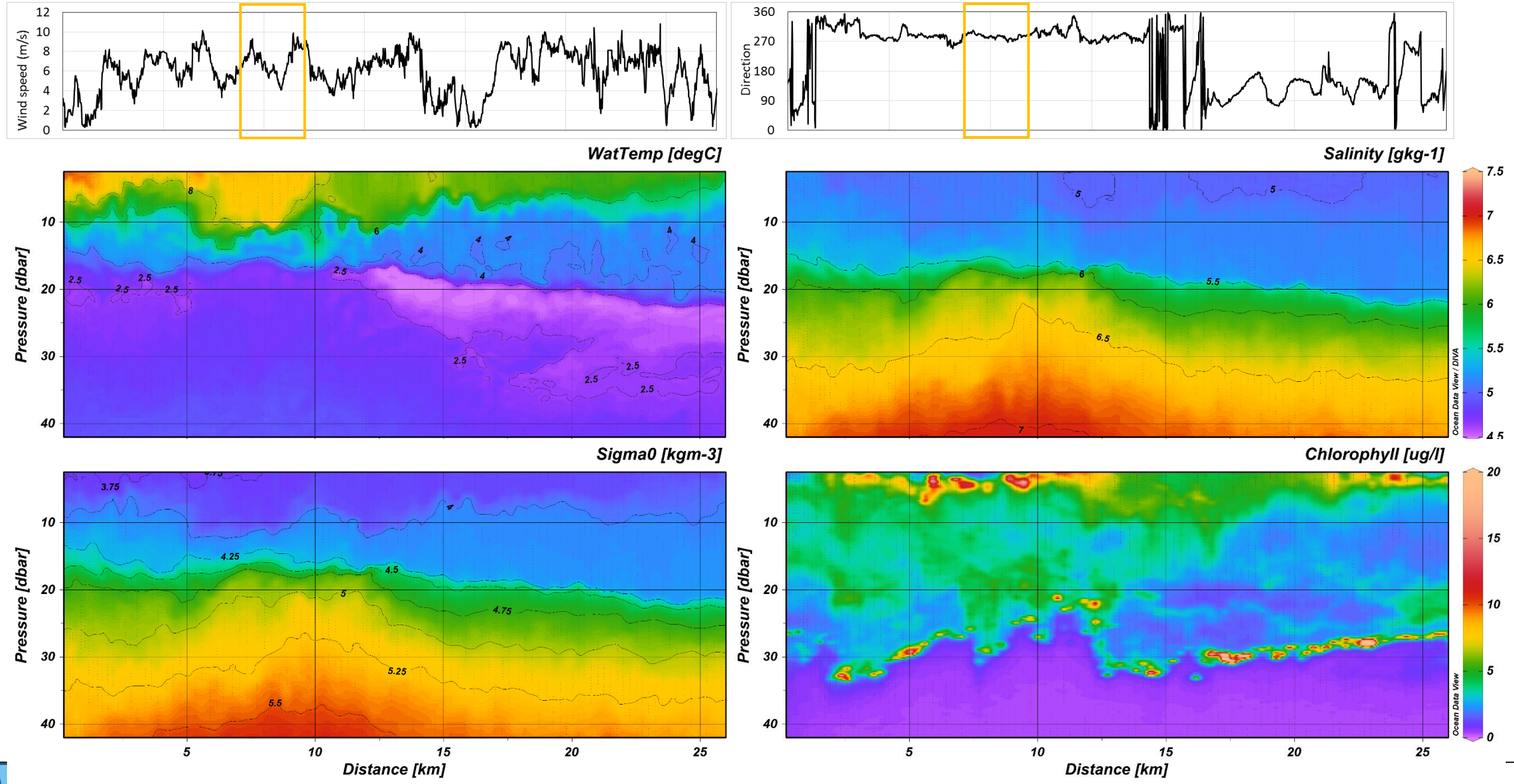
Results – glider section2 (5 May 04:21 – 6 May 06:06)



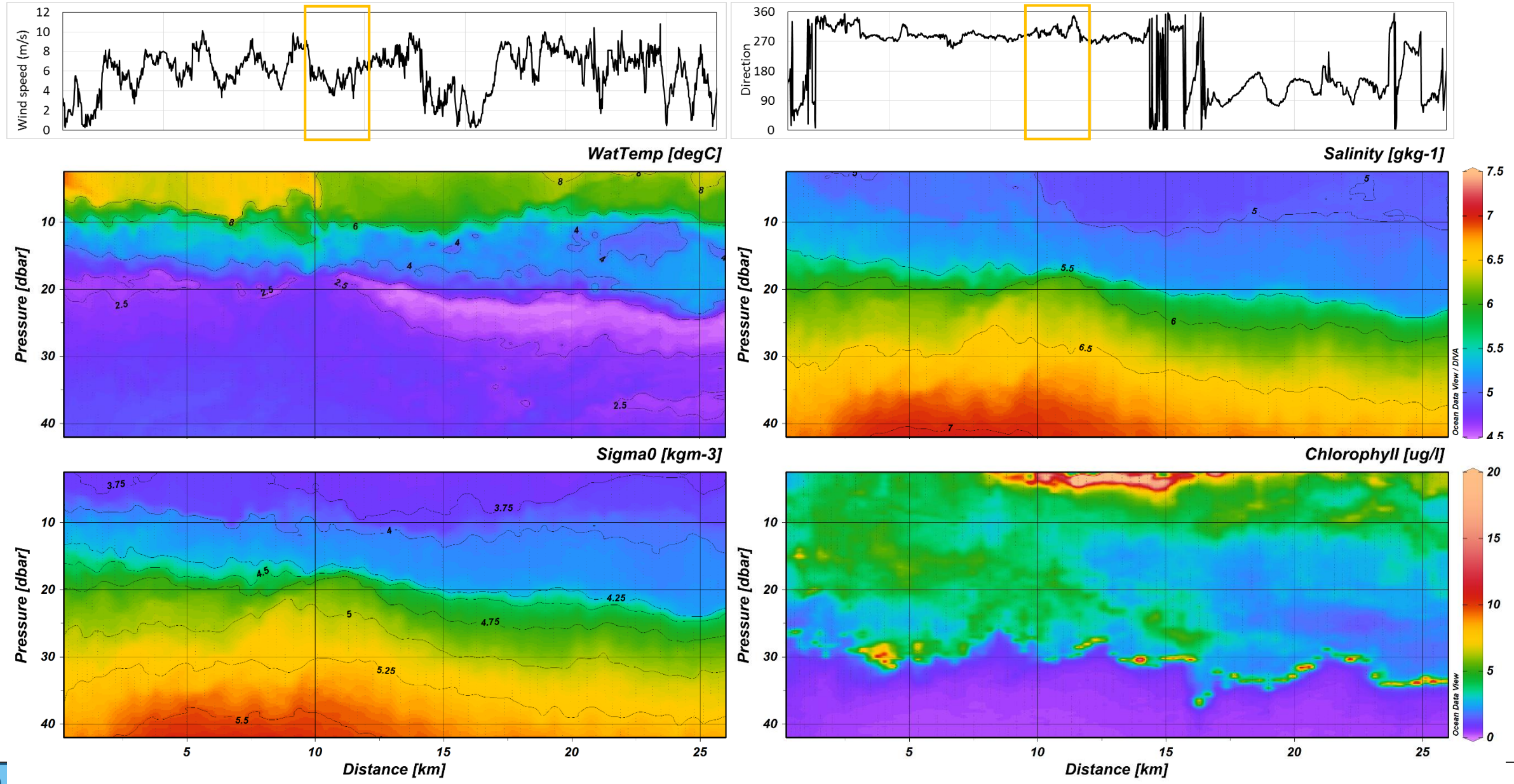
Results – glider section3 (6 May 06:25 – 7 May 12:21)



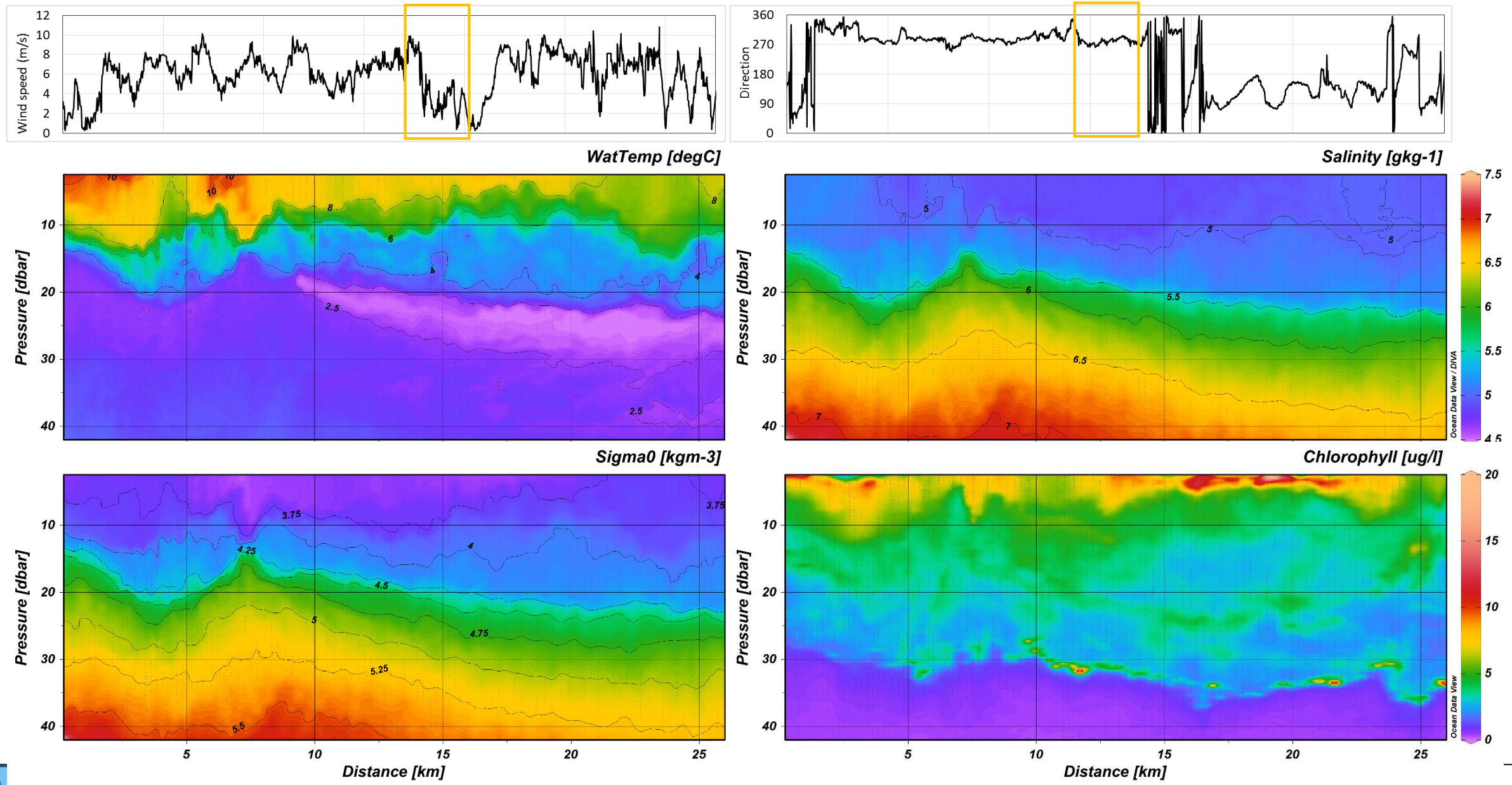
Results – glider section4 (7 May 12:37 – 8 May 22:37)



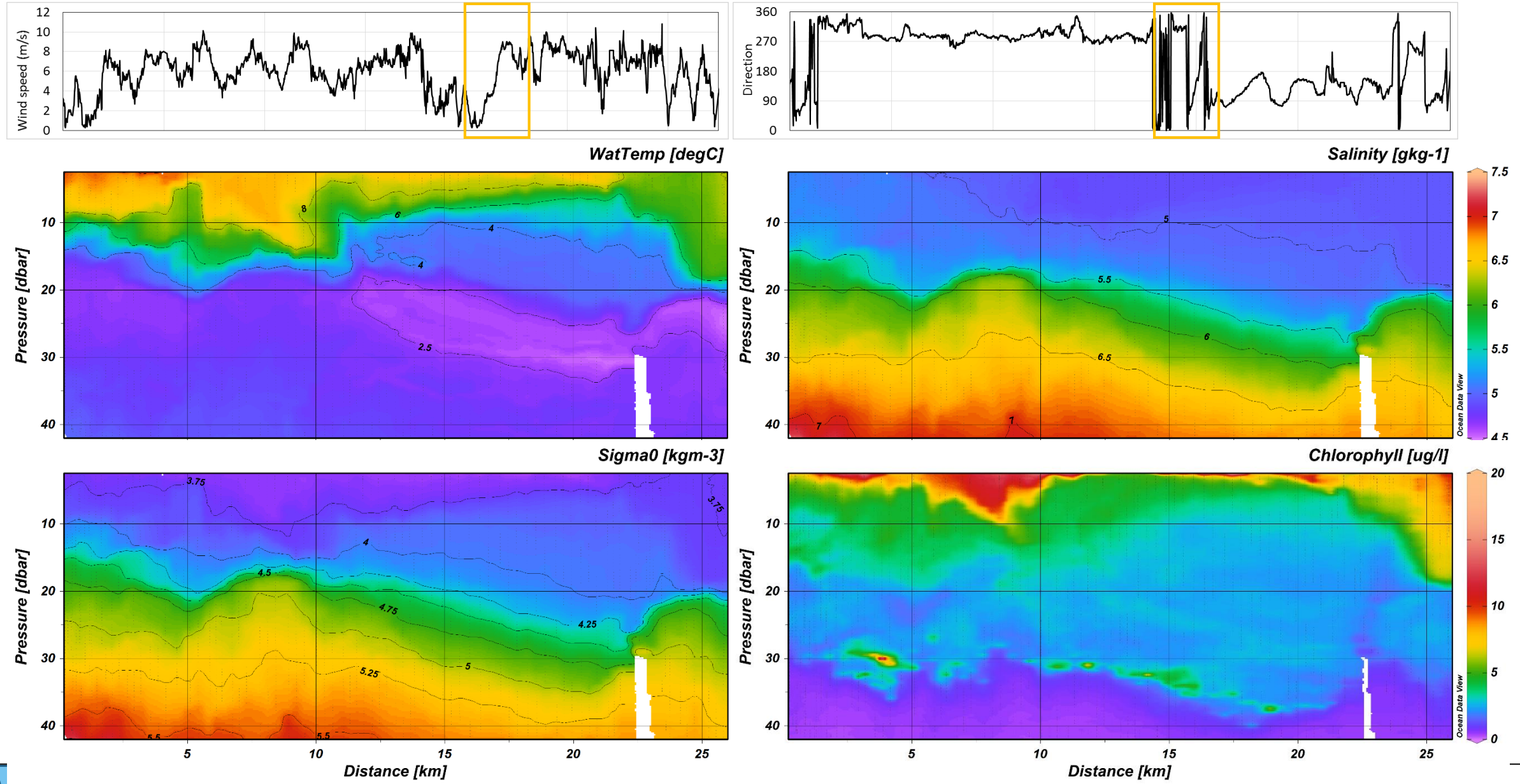
Results – glider section5 (8 May 22:52 – 10 May 03:28)



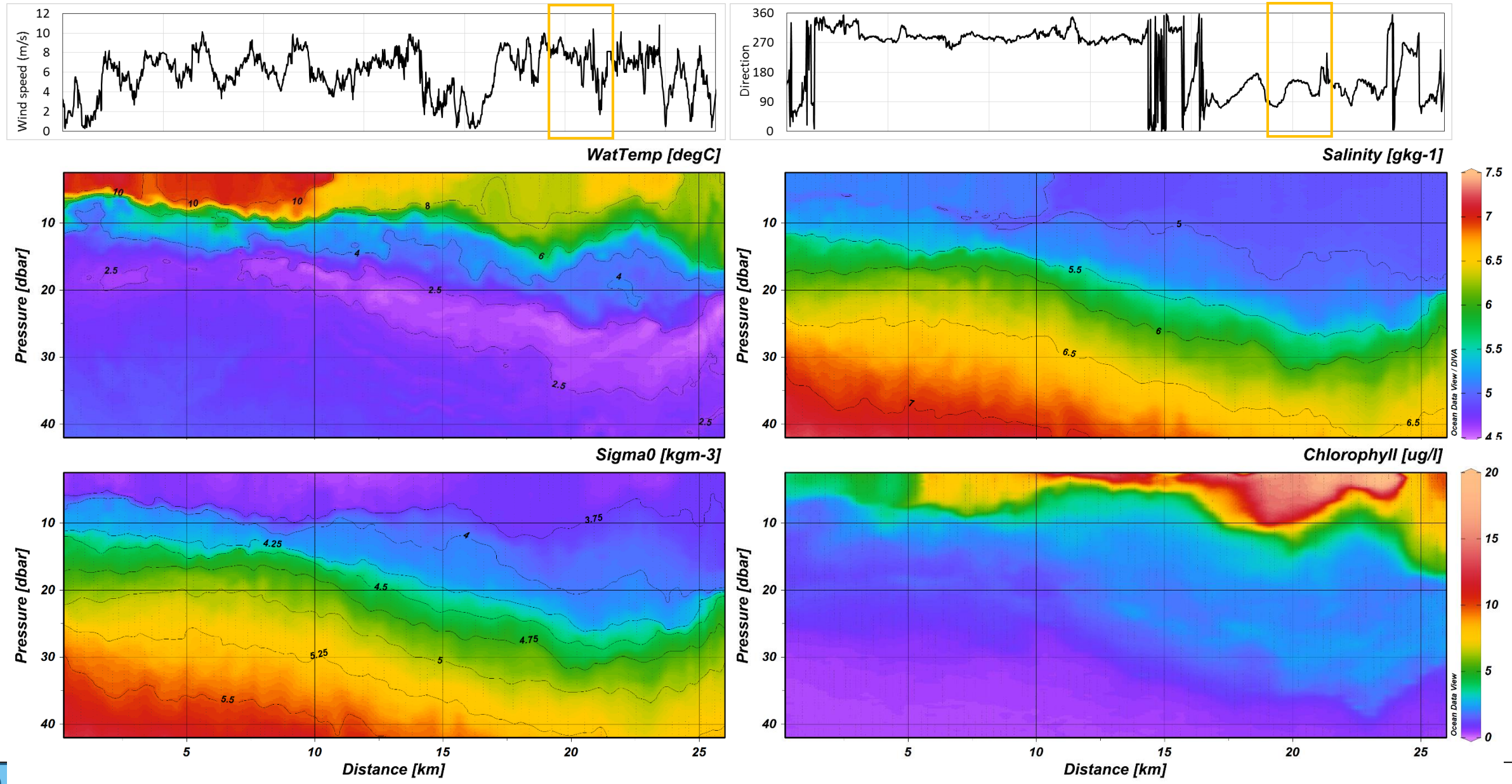
Results – glider section6 (10 May 03:52 – 11 May 16:31)



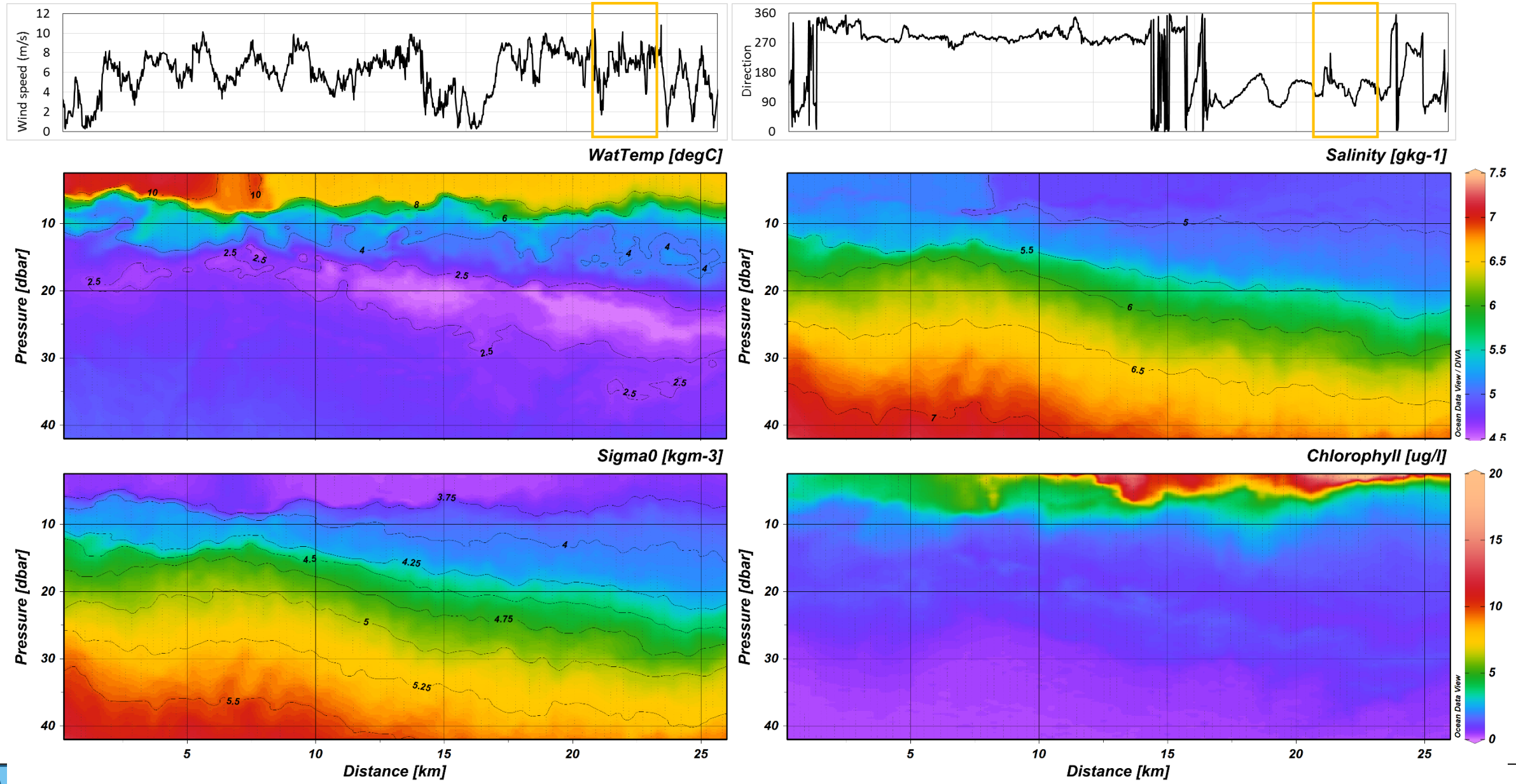
Results – glider section7 (11 May 16:54 – 12 May 22:06)



Results – glider section8 (12 May 22:27 – 14 May 09:46)

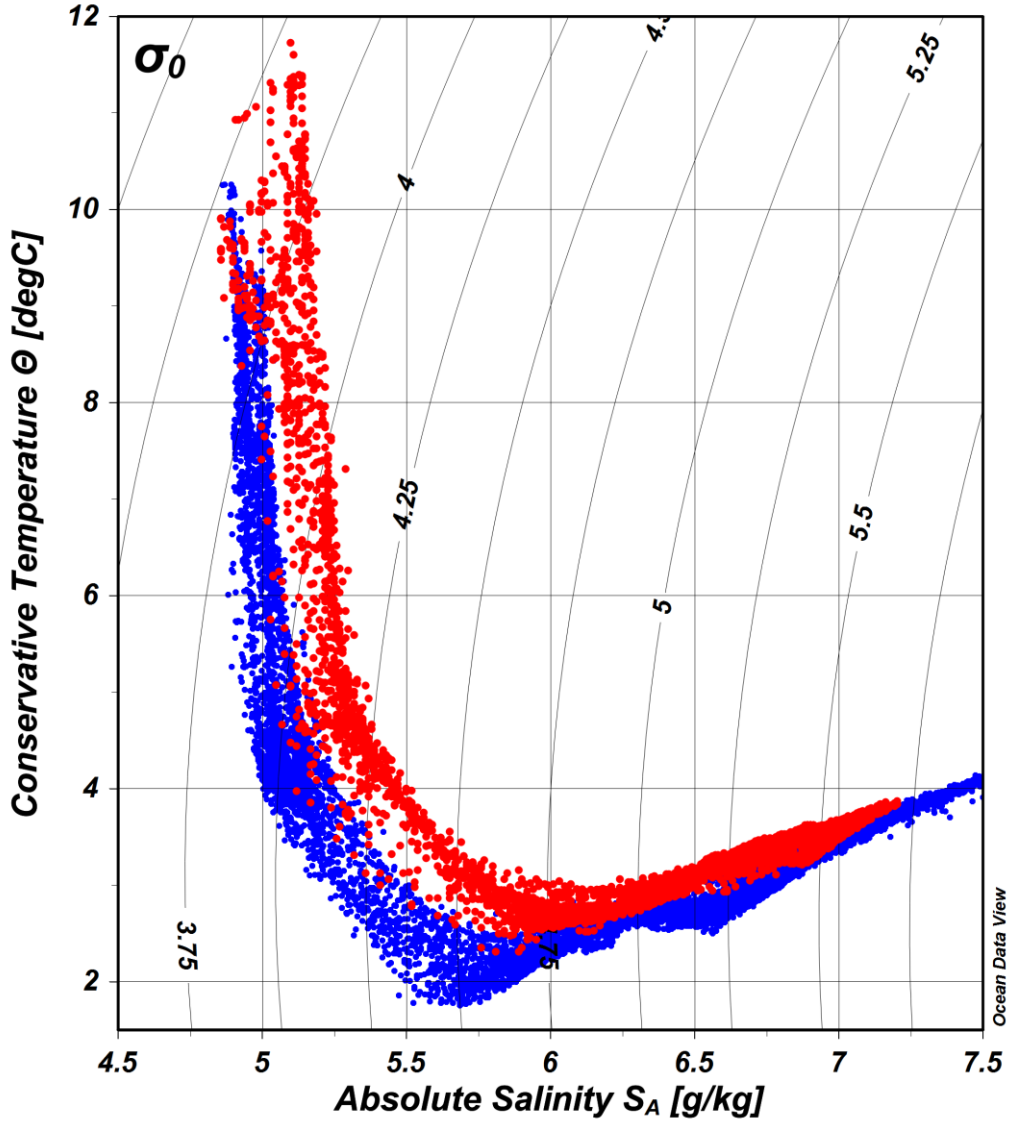


Results – glider section9 (14 May 10:06 – 15 May 16:30)

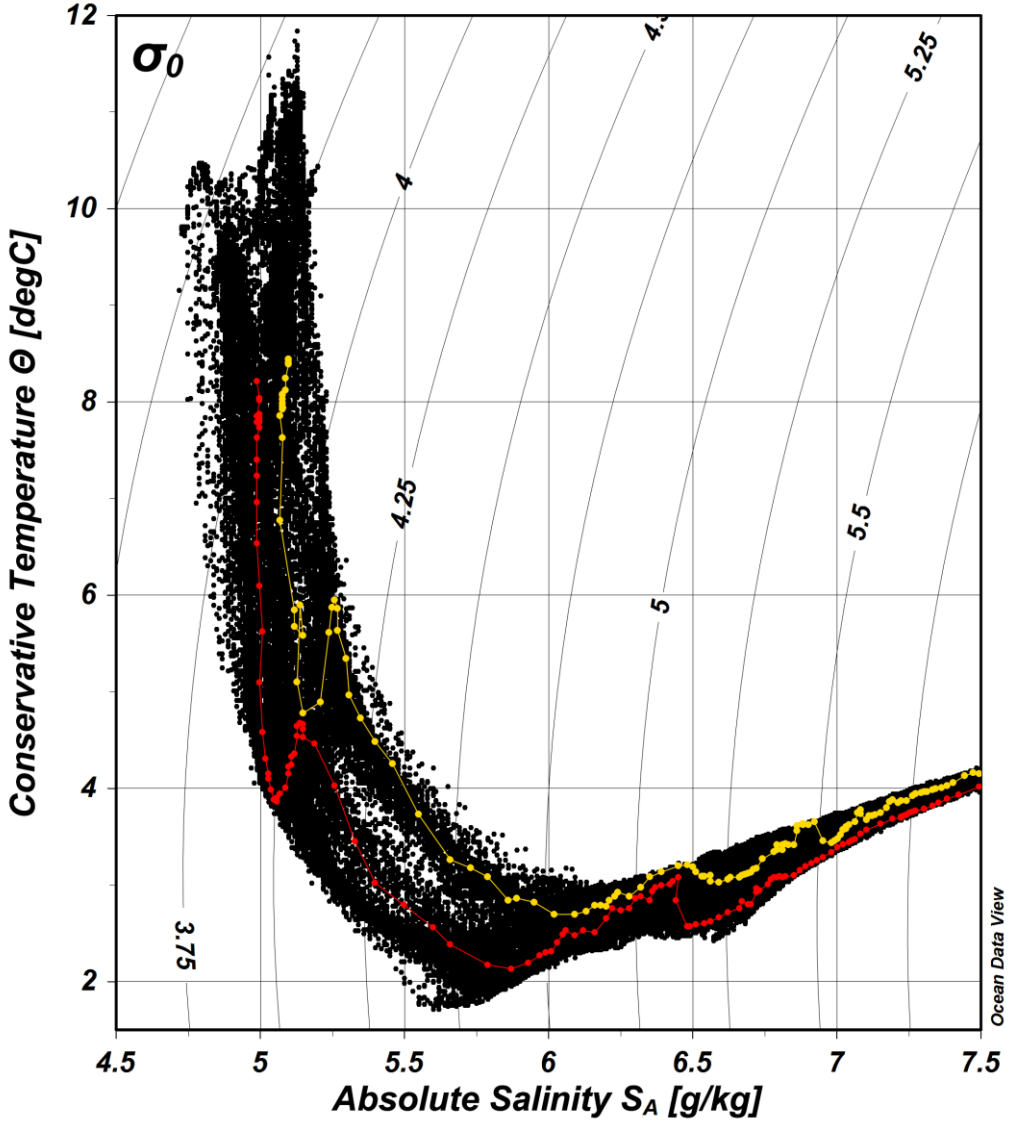


Results – TS-plots

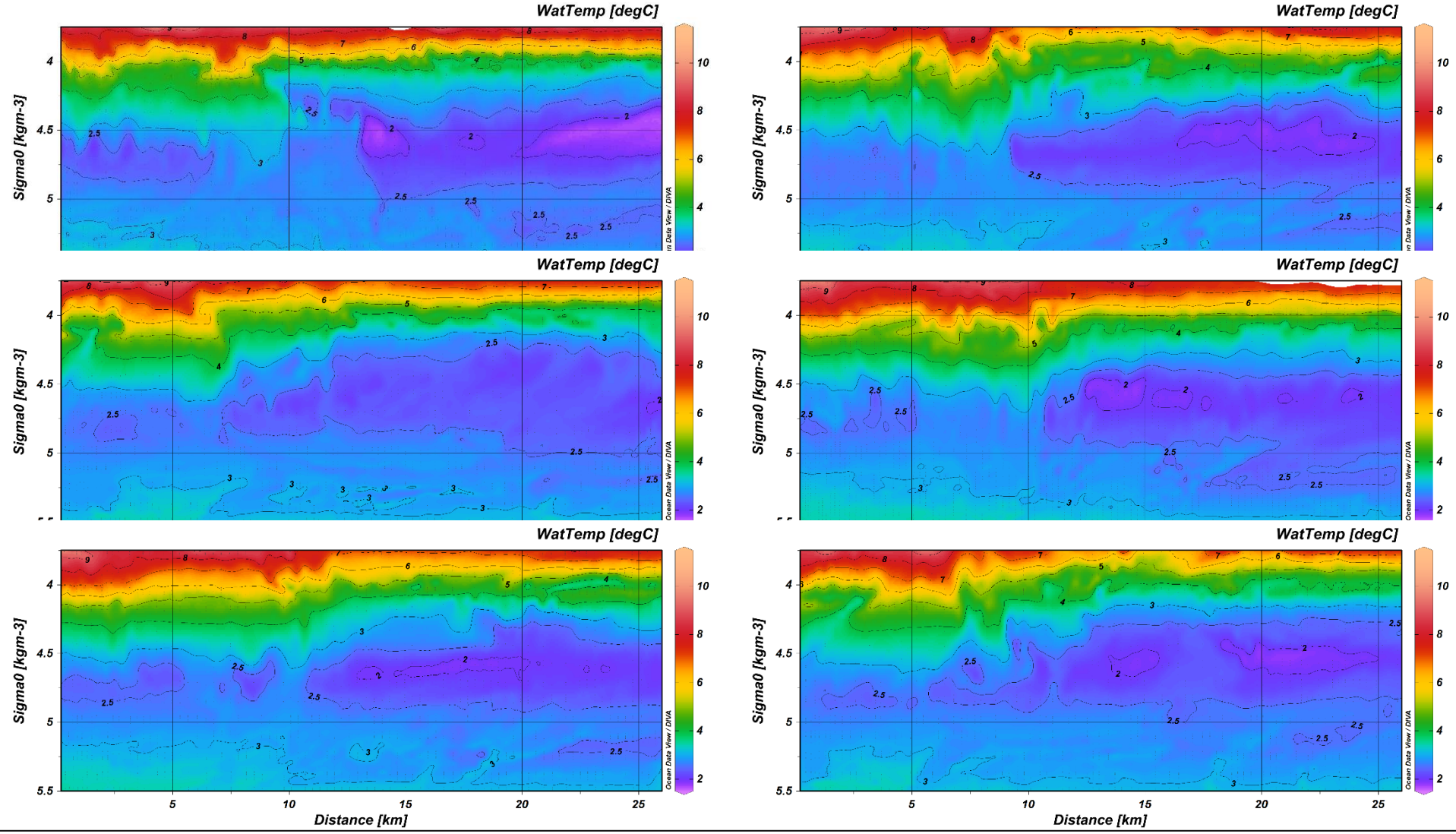
Profilers: deep station (blue) and coastal station (red), measurements from 4 May to 16 May 2016



Glider: all profiles along the entire section, measurements from 4 May to 16 May 2016



Results – variability along isopycnal surfaces



Conclusions

- Combination of autonomous measurements at fixed profiling stations and glider surveys allows to study processes at a large range of temporal and spatial scales, as well as to differentiate between the spatial and temporal variability.

- The wind forcing as the main forcing factor determining the vertical stratification and across-shore slope of the pycnocline, as well as horizontal gradients of temperature and salinity.

- The sub-surface biomass maxima of phytoplankton in late spring are formed in areas / periods of convergence in the surface layer, and they rapidly disappear in case of near-shore divergence in the surface layer.

- Glider is about 10 times slower than towed Scanfish; the main advantage of the glider is that it conducts surveys autonomously and the research vessel presence is not required, except when deploying and recovering the glider. When sampling along a gradient, spatial variability can be studied.

Still to be analysed:

- What are the characteristic spatial scales of intrusions and what determines them?

- Can we estimate the lateral transport / across-shore diffusivity using glider surveys repeated along a fixed track?

Thank you for your attention!