Physical Oceanography
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Find a title.

Abstract: *TODO*

Keywords: *CTD, Field work, TODO*

Contents

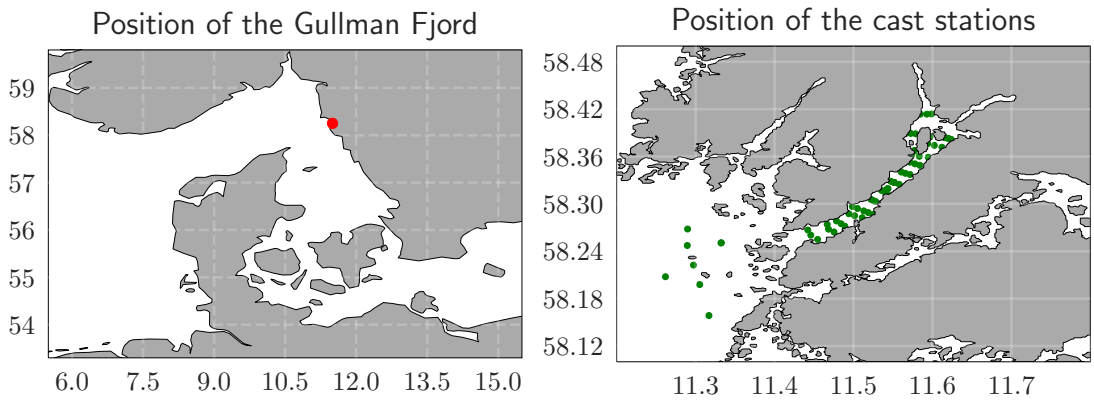

Figure 1: Situation of the Gullman Fjord (red dot) and position of the CTD casts (green dots).

1 Introduction

TODO find references about fjords, skagerrak

2 Materials and methods

2.1 Presentation of the field work and data acquisition

This report focuses on a field work that has been conducted on December 2018, the 10th and 11th, as part of the course OC4920 of the University of Gothenburg. Two days have been spent on two ships, the Skagerrak and the Trygve. Both ships had fully equipped CTD, with temperature, salinity, and oxygen concentration sensors. Some other variables have been recorded but not discussed on this report. Niskins bottle have been used for the oxygen calibration on board of the Skagerrak.

We got more than 50 casts, covering the fjord with a very good spatial coverage. We also made 3 mooring measurements, setting the CTD at a certain depth for 30 minutes, recording the temporal variations instead of the spatial variations. Figure 1 presents the position of the Gullman Fjord, on the western coast of Sweden, as well as the position of the CTD casts.

2.2 Data processing

For a better readability, we will refer to potential temperature as temperature and to absolute salinity as salinity. If needed, we will explicitly use the term *in situ* to refer to measured temperature and salinity.

To ensure coherence in the whole dataset and between the two ships, all the data have been regridded on a 1 meter grid, from 0 to 119 meters depth. Depths without any measurement points have been filled with NaN.

Processing Using the library provided by TEOS-10 (*McDougall and Barker*, 2011), *in situ* temperatures and practical salinities have been converted to potential temperature and absolute salinity. Potential density anomaly has also been derived.

Calibration One cast has been conducted at the same position with the two ships each day, so that all the measured variables can be calibrated between the two datasets. The Skagerrak data have been chosen as reference data, because of a more recent recalibration of the CTD sensors than the Trygve sensors. After a linear regression between Trygve and Skagerrak calibration profiles under the thermocline, the coefficients have been used to recalibrate Trygve profiles for each day. See Table 2 for the used coefficients.

2.3 Turner angle

One way to estimate the role of the salinity and the temperature on the stratification is to use the Turner angle. (*Ruddick*, 1983; *Johnson et al.*, 2012)

2.4 Geostrophy TODO compute

2.5 Profile fitting and layers

Temperature profiles in the fjord all look very similar, with 1. an upper thermocline; 2. a warm water mass; 3. a lower thermocline; 4. the lowest layer where temperature is approximately constant. It is not easy to compute the depth of these layer by using a threshold (on the value or on the gradient) due to the irregularities of the temperature. Inspired by the work of *Pauthenet et al.* (2017), we decided to approximate the profiles with a function and then extract the layers information from the functions properties. As the studied profiles have all the same shapes, we used a mutli-linear fit, fitting the 4 layers. The parameters of the fitted function are the depths and the temperatures of the interface between each layers. We considered that for the lowest layer, the fitted temperature will be a constant. An *a priori* model was set for these 8 parameters, with values set by eye to be a good candidate. Table 1 in Appendix presents the parameters. The least squares approximation has been used to find the best parameters. For the profiles that are not deep enough, only the part where data are present has been used for the least squares method. The *a priori* model has been set for the lower part, with a confidence flag set to 0. Figure 2 presents two examples of profiles: one where the 4 layers are present and one where the fjord was not deep enough, so only the upper layer is fitted.

No sub-mesoscale heat fluxes because no mixed layer

3 Results

T-S diagram see figure 3

we recognize Skagerrak and Kattegat water (*Björk and Nordberg*, 2003; *Gustafsson and Stigebrandt*, 1996)

Kattegat salinity 15/20(depending on the source)-25

Skagerrak salinity between 33 (surface) to 35 (100m depth)

warm water layer warm water in the fjord, see mean depth, std depth, mean T and S, see spatial distribution

strong halocline

Turner angle

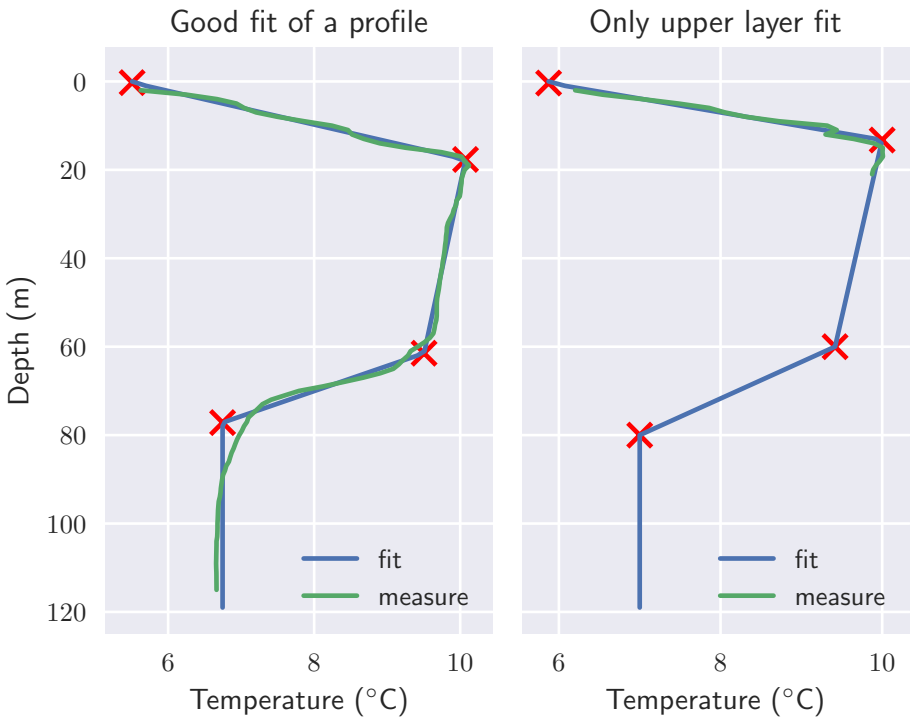

Figure 2: Profile fitting with a multi-linear function. The measured profiles are plotted in green, the fitted functions in blue, and the red crosses represent depth and temperature at the interfaces between the different layers. On the right plot, the fit corresponds to the *a priori* model for the two lowest interfaces.

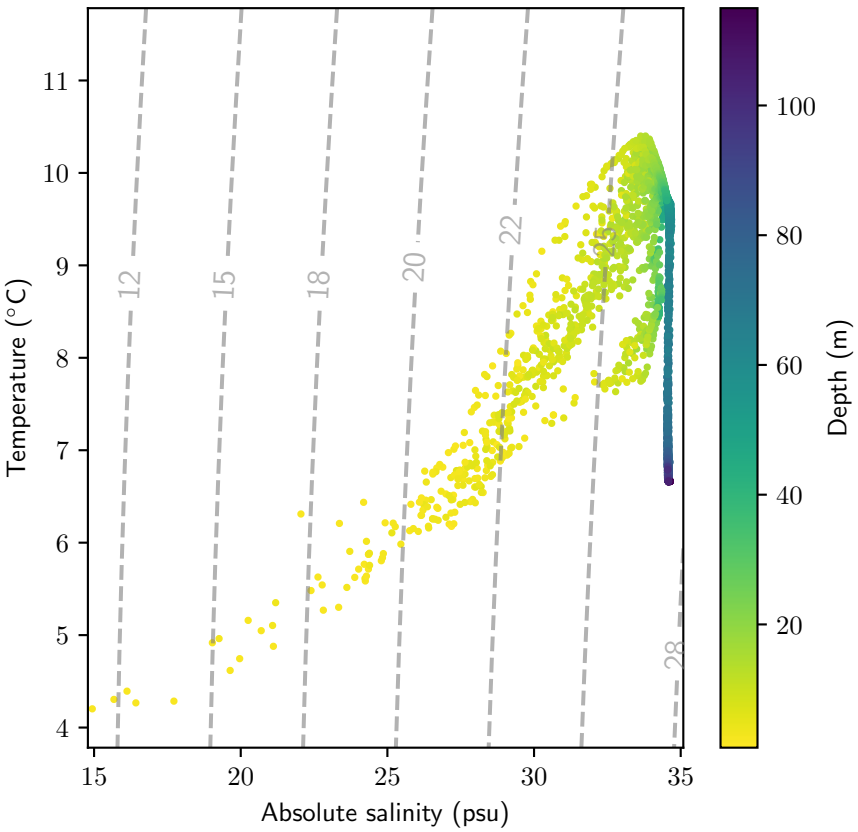

Figure 3: T-S diagram

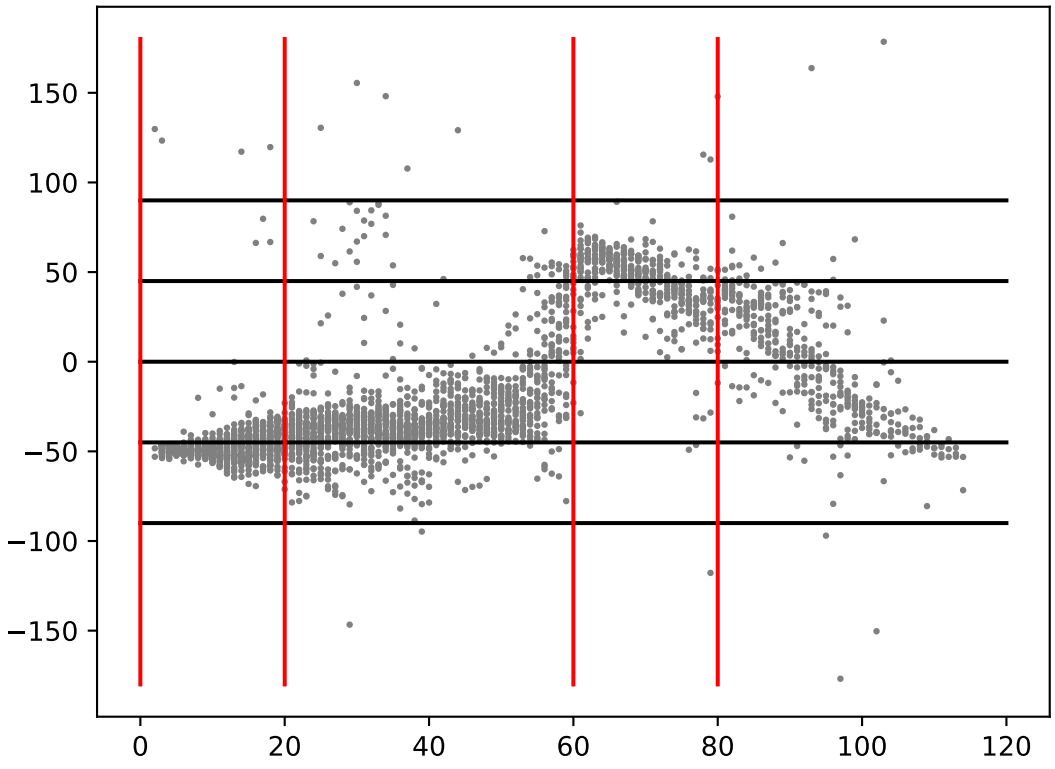

Figure 4: Turner angle as a function of depth.

Geostrophy What is happening here?

Upwelling event? Mixing? (*Arneborg*, 2004)

4 Discussion

TODO
fitting of the profile, using spline could be better. but here maybe not necessary.

5 Conclusion

See what is the context
What we did
What we showed/saw
What is the conclusion

References

Arneborg, L. (2004), Turnover times for the water above sill level in gullmar fjord, *Continental Shelf Research*, *24*(4), 443 – 460, doi:https://doi.org/10.1016/j.csr.2003.12.005.

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A Complementary data and figures

Depth (m)	Temperature (°C)	Comment
0	5	Surface
20	10	Bottom of the upper thermocline / top of the warm water
60	9	Bottom of the warm water / top of the lower thermocline
80	7	Bottom of the lower thermocline / top of the lowest layer

Table 1: Values of the *a priori* model for the multi-linear fit.

Temperature

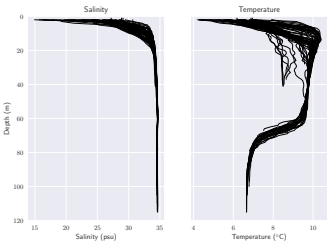
Date	a_T	b_T
2018-12-10	0.9938598212928323461	0.07856246515108189499
2018-12-11	1.006636216123387273	-0.09514920786826941423

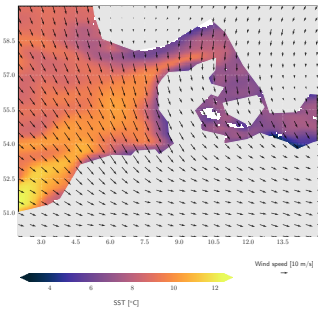
Salinity

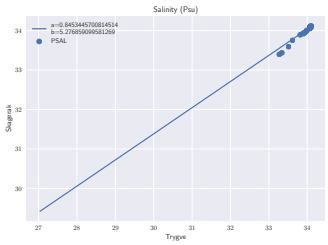
Date	a_S	a_S
2018-12-10	0.8453445700814513630	5.276859099581269419
2018-12-11	0.8190729895351881451	6.231978296168669829

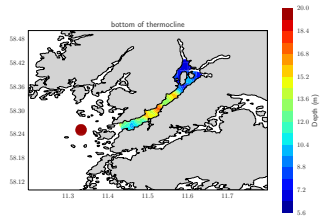
Table 2: Regression coefficients, the calibration has the following shape: $X_{Trygve} = a_X \cdot X_{Skagerrak} + b_X$, with X the temperature or the salinity.

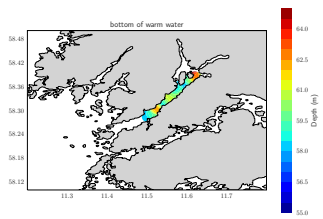
TODO
ALL THE FIGURES I WANT TO PUT ON THE REPORT
For all profiles, put 2 different color for offshore and fjord

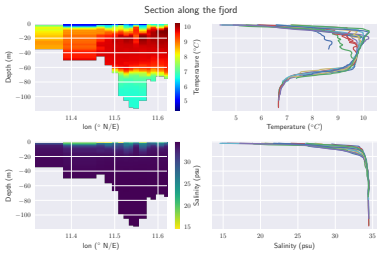

Salinity
Temperature
Depth (m)
Salinity (psu)
Temperature (°C)

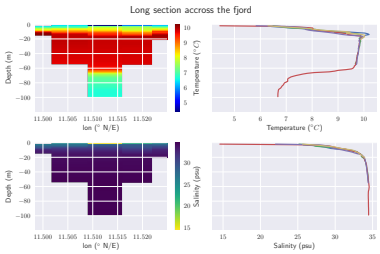

Wind speed [10 m/s]
SST [°C]


Salinity (Psu)
PSAL
Skagerak
Trygve


bottom of thermocline
Depth (m)


bottom of warm water
Depth (m)


Section along the fjord
Depth (m)
lon (° N/E)
Temperature (°C)
Salinity (psu)


Long section accross the fjord
Depth (m)
lon (° N/E)
Temperature (°C)
Salinity (psu)