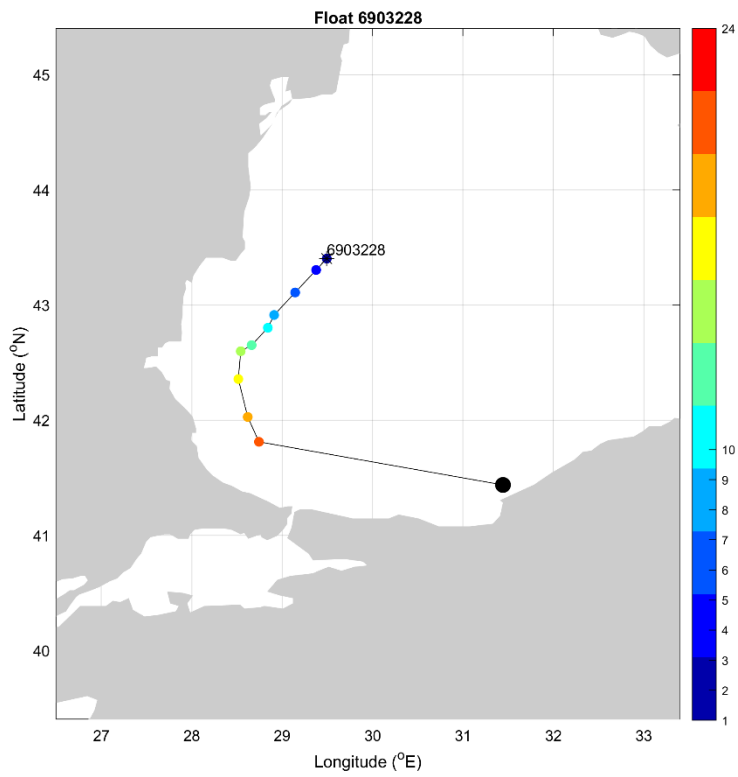


Delayed Mode Quality Control of Argo float WMO 6903228

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1 Introduction

This report includes the delayed mode analysis performed for float 6903288. It was deployed in Black Sea in October 2017 and after performed 24 cycles died. Before the analysis, real-time QC flags were visually inspected. The list of flags applied is QC=1 for all cycles. Plots of temperature and salinity time series and plots of temperature, salinity and density plotted against the nearby historical CTD profiles was generated. This visual analysis can help in detecting sensor salinity anomalies and spikes.

The reference dataset used is composed of the following CTD and Argo historical datasets:

CTD:

- CMEMS: INSITU_BS_TS_REP_OBSERVATIONS_013_042
- Coriolis: CTD_for_DMQC_2018V01
- Historical CTD profiles provided through personal contact

Argo:

- ARGO_for_DMQC_2018V01

Float 6903228 is the Nova float where the pressure sensor is auto corrected and no adjustment is required. The OWC was run to estimate a salinity offset and a salinity drift (Cabanès et al., 2016).

2 Quality Check of Argo Float Data

2.1 Verification of Real-time Mode QC flags

The list of flags applied to the float in real-time mode is as follows.

Cycle number:

1-24 PSAL QC=1

2.2 Time Series of Argo Float Temperature and Salinity

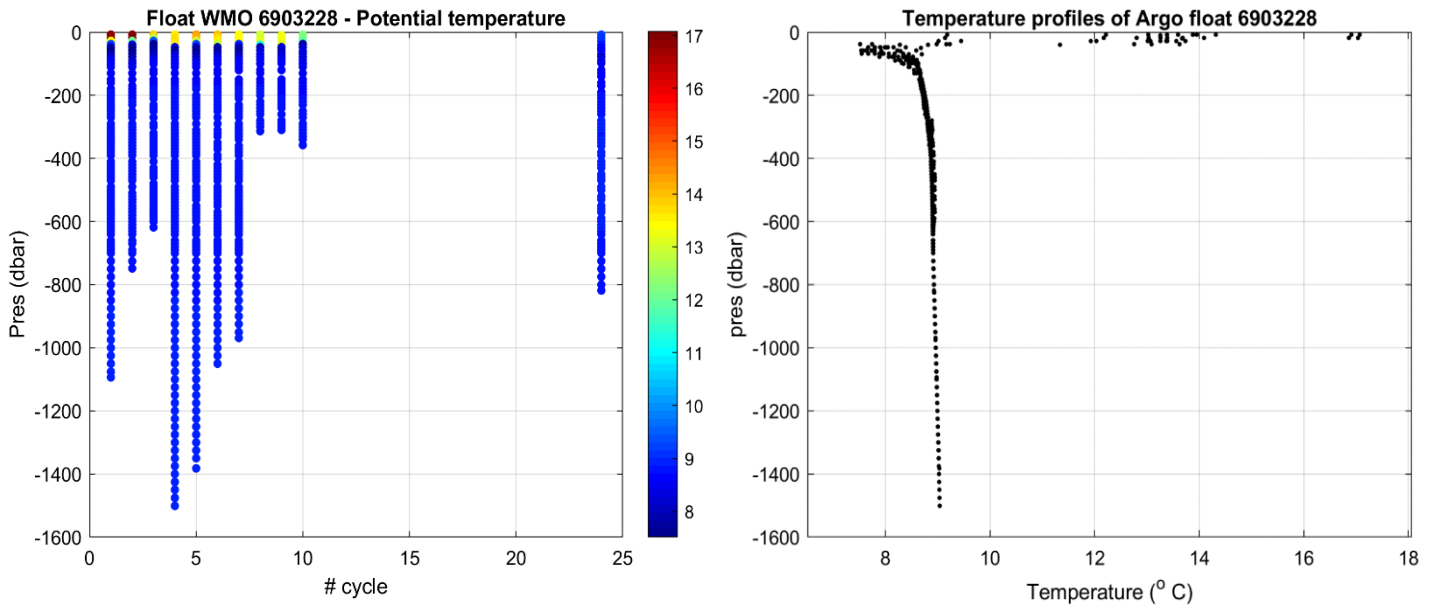


Figure 2: Float 6903228. Time series of Argo float potential temperature ($^{\circ}\text{C}$) on the left, and potential temperature profiles color-coded per cycle number on the right.

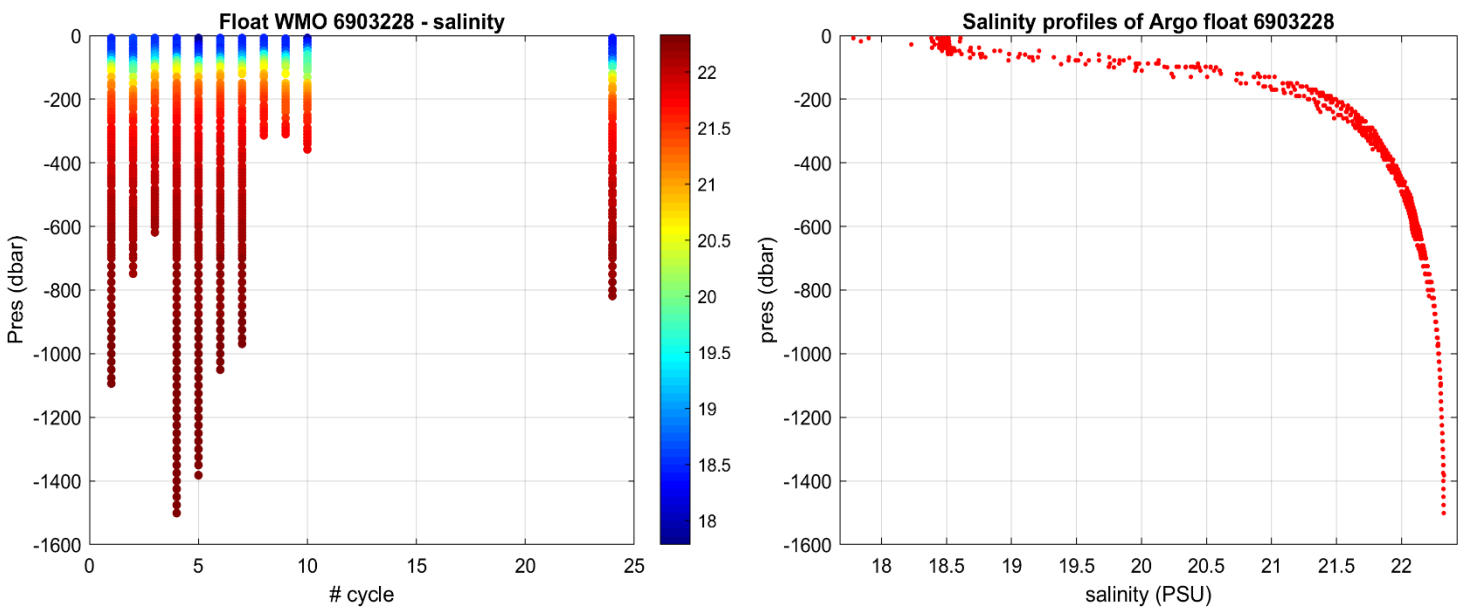


Figure 3: Float 6903228. Time series of Argo float potential salinity (PSS-78) on the left, and salinity profiles color-coded per cycle number on the right.

Before running the Owens and Wong method, referred to as OW hereafter, the theta-salinity (θ -S) diagram of the float is analyzed (Figure 4) and in particular the area where the θ -S relationship is the tightest (Figure 5). No significant salinity drift is observed.

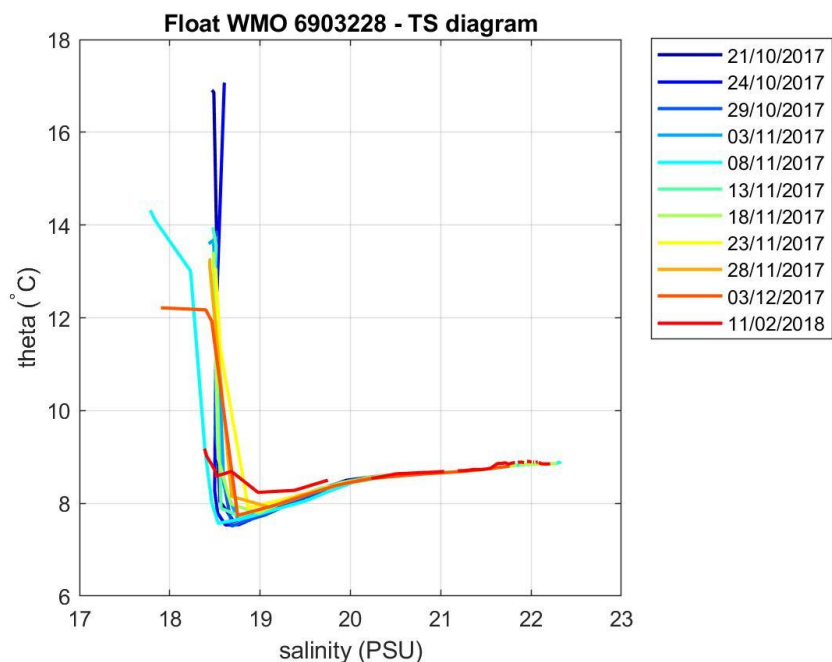


Figure 4: Float 6903228. θ -S diagram color-coded per cycle number.

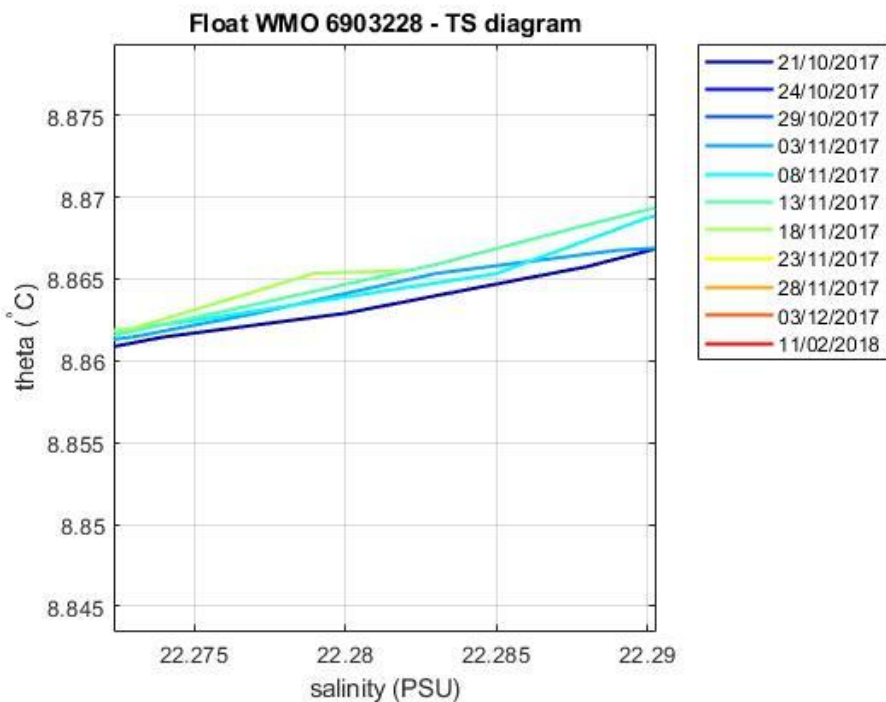


Figure 5: Float 6903228. Area of the θ -S diagram (color-coded per cycle number) where the θ -S relationship is more uniform.

2.3 Comparison Between Argo Float and Climatology

Three salinity float profiles are selected to perform a comparison (in time and space) with the historical data. In figure 6, 7 and 8 each selected profile is compared with all reference data used in this analysis. The salinity float profile is depicted in black while other colors represent the salinity reference profiles. The red color means that the historical data are more recent with respect to the float ones, while magenta states that the float data are more recent than the historical ones (the maximal difference is 6 years). A time difference between 3 and 6, 6 and 9 and larger than 9 years is depicted in green, cyan and blue, respectively.

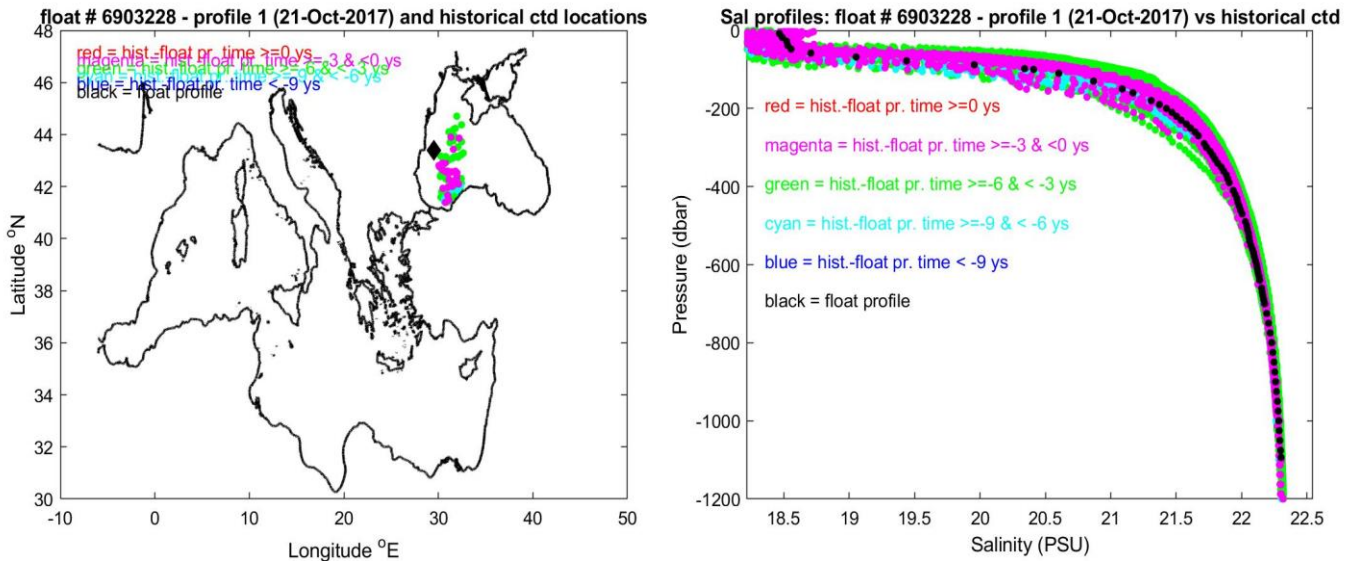


Figure 6: Float 6903228. Locations of the salinity float profile number 1 and historical CTD data (right panel) and the respective salinity profiles (left panel).

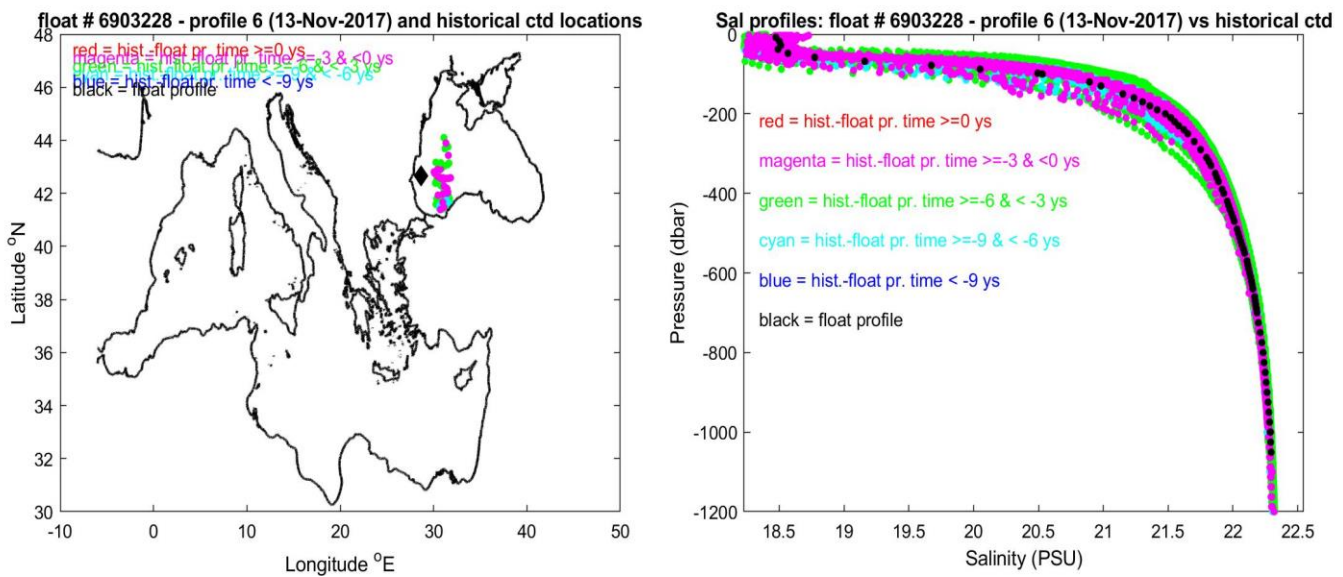


Figure 7: Float 6903228. Locations of the salinity float profile number 6 and historical CTD data (right panel) and the respective salinity profiles (left panel).

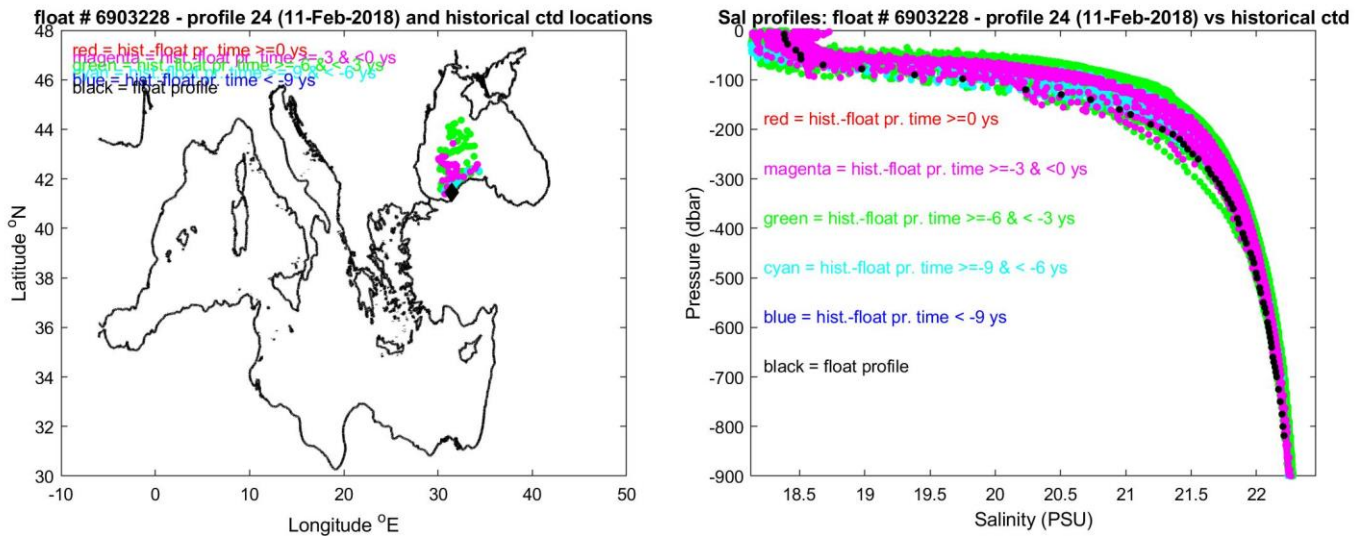
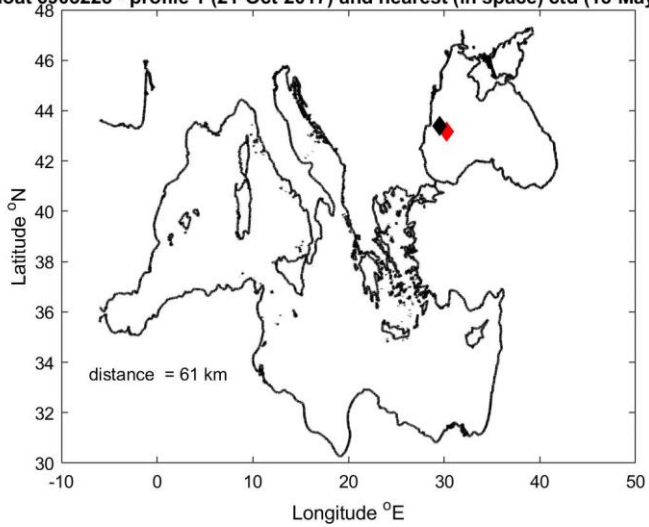


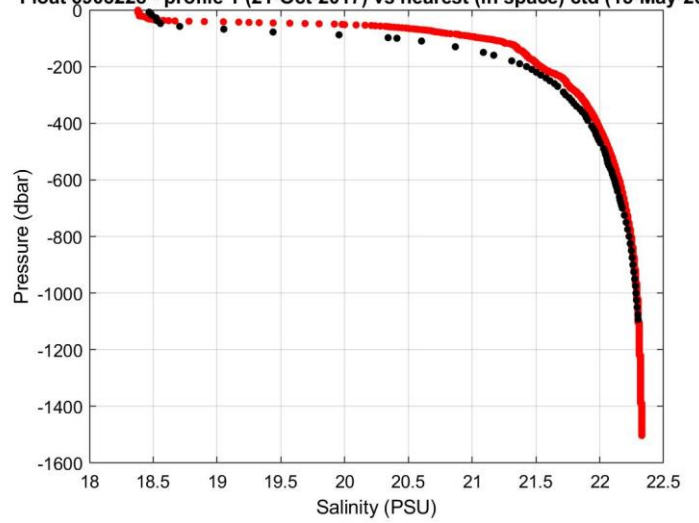
Figure 8: Float 6903228. Locations of the salinity float profile number 24 and historical CTD data (right panel) and the respective salinity profiles (left panel).

The comparison of these 3 selected salinity float profiles with the closest (in space and time) salinity reference profile is shown in Figures from 9 to 11. The agreement between the selected float salinity profiles and the historical salinity profiles is quite good in the intermediate and deep layers.

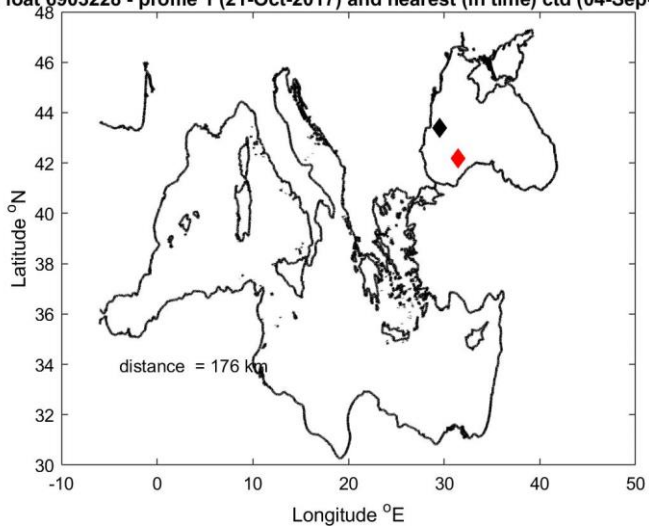
Float 6903228 - profile 1 (21-Oct-2017) and nearest (in space) ctd (15-May-2012)



Float 6903228 - profile 1 (21-Oct-2017) vs nearest (in space) ctd (15-May-2012)



Float 6903228 - profile 1 (21-Oct-2017) and nearest (in time) ctd (04-Sep-2017)



Float 6903228 - profile 1 (21-Oct-2017) vs nearest (in time) ctd (04-Sep-2017)

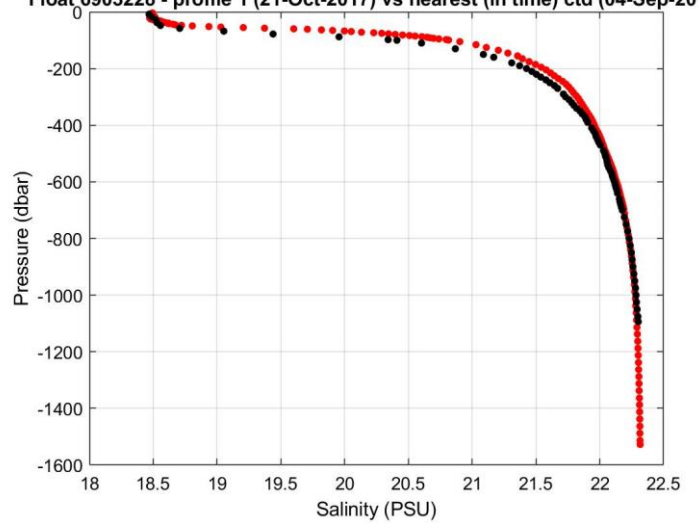
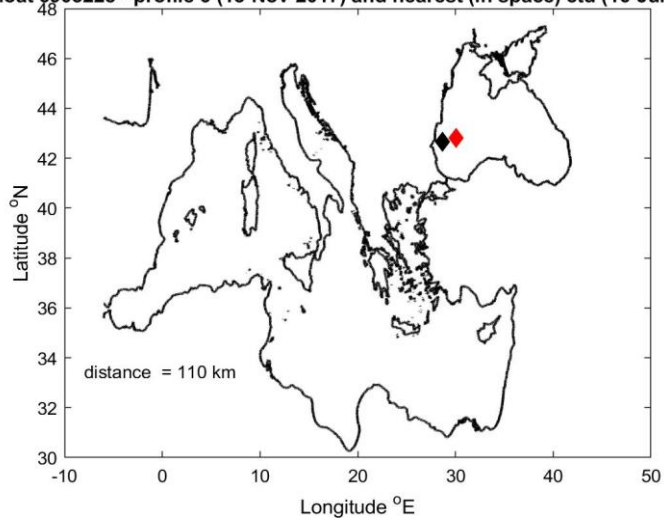
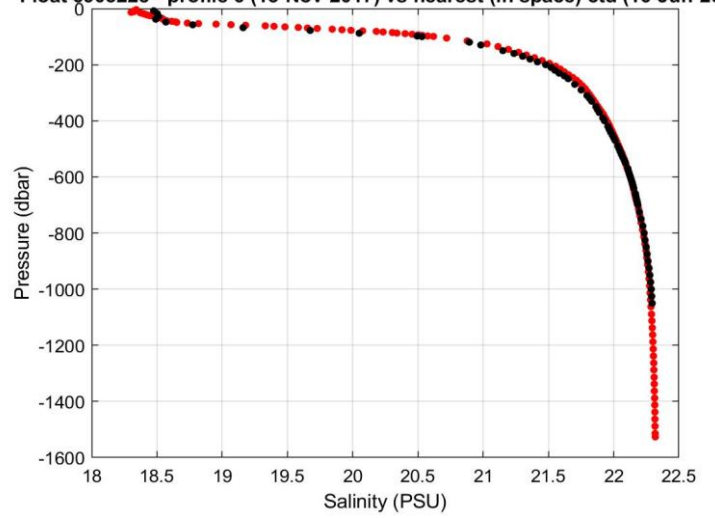


Figure 9: Float 6903228. The salinity float profile number 1 (black dots) are compared to the nearest in space (top) and in time (bottom) reference profile (red dots). The locations of the two profiles and their distance is given in the left panel.

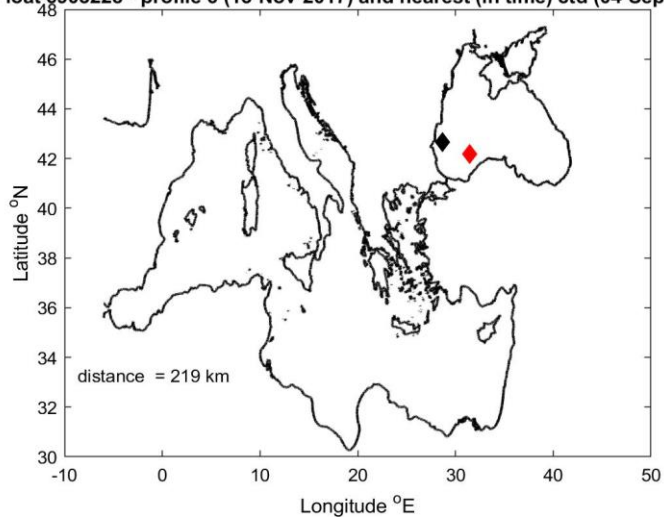
Float 6903228 - profile 6 (13-Nov-2017) and nearest (in space) ctd (16-Jun-2017)



Float 6903228 - profile 6 (13-Nov-2017) vs nearest (in space) ctd (16-Jun-2017)



Float 6903228 - profile 6 (13-Nov-2017) and nearest (in time) ctd (04-Sep-2017)



Float 6903228 - profile 6 (13-Nov-2017) vs nearest (in time) ctd (04-Sep-2017)

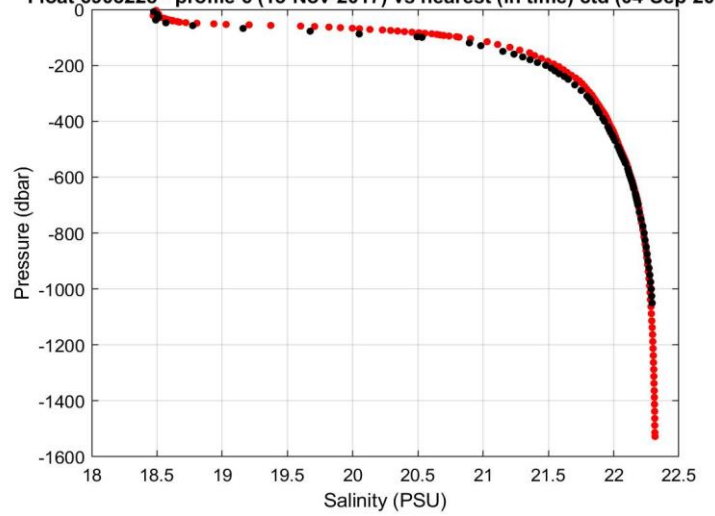
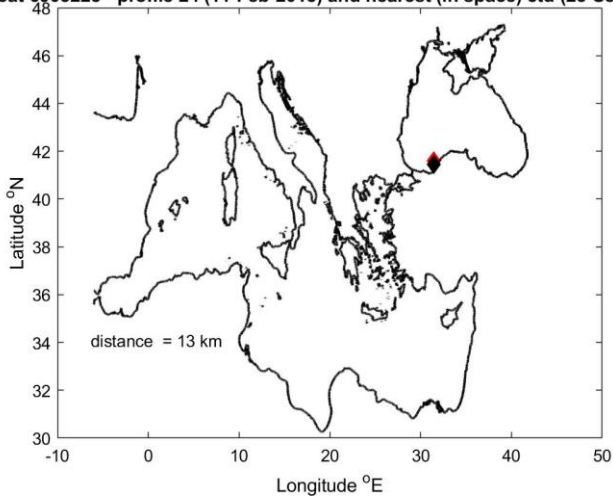
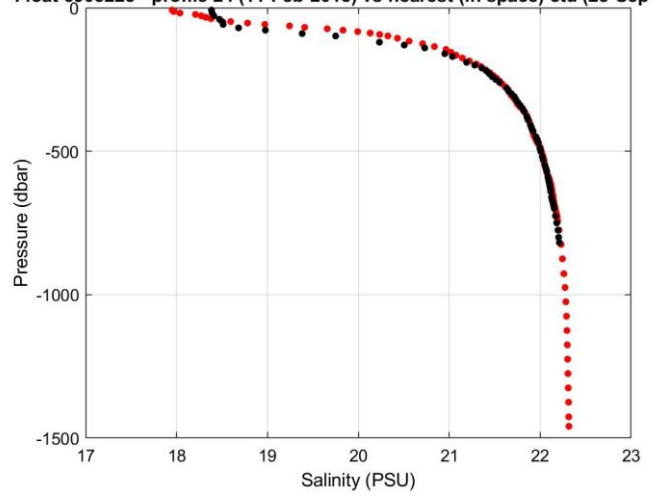


Figure 10: Float 6903228. The salinity float profile number 6 (black dots) are compared to the nearest in space (top) and in time (bottom) reference profile (red dots). The locations of the two profiles and their distance is given in the left panel.

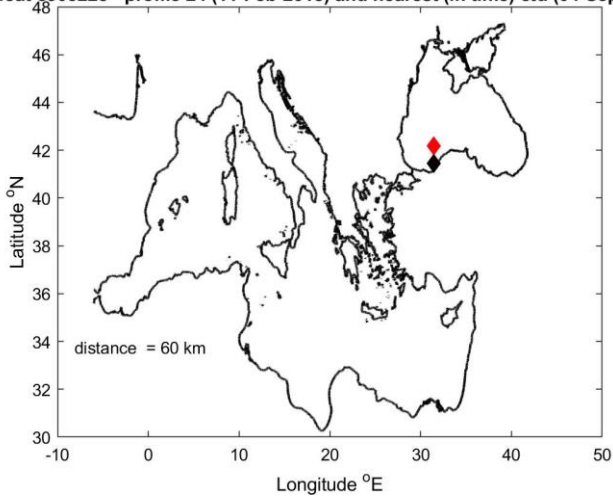
Float 6903228 - profile 24 (11-Feb-2018) and nearest (in space) ctd (28-Sep-2012)



Float 6903228 - profile 24 (11-Feb-2018) vs nearest (in space) ctd (28-Sep-2012)



Float 6903228 - profile 24 (11-Feb-2018) and nearest (in time) ctd (04-Sep-2017)



Float 6903228 - profile 24 (11-Feb-2018) vs nearest (in time) ctd (04-Sep-2017)

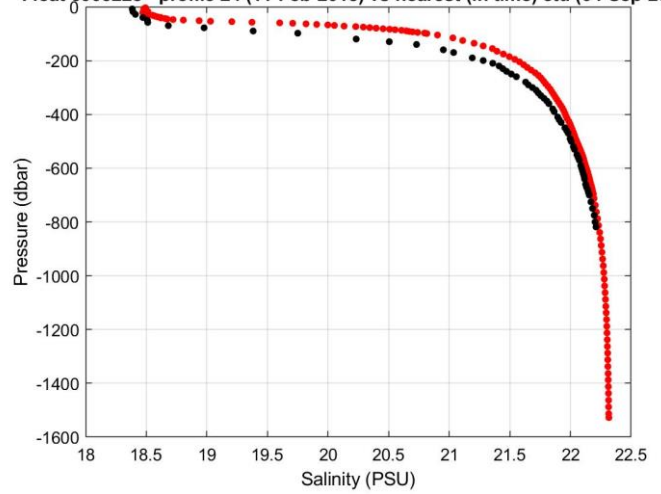


Figure 11: Float 6903228. The salinity float profile number 24 (black dots) are compared to the nearest in space (top) and in time (bottom) reference profile (red dots). The locations of the two profiles and their distance is given in the left panel.

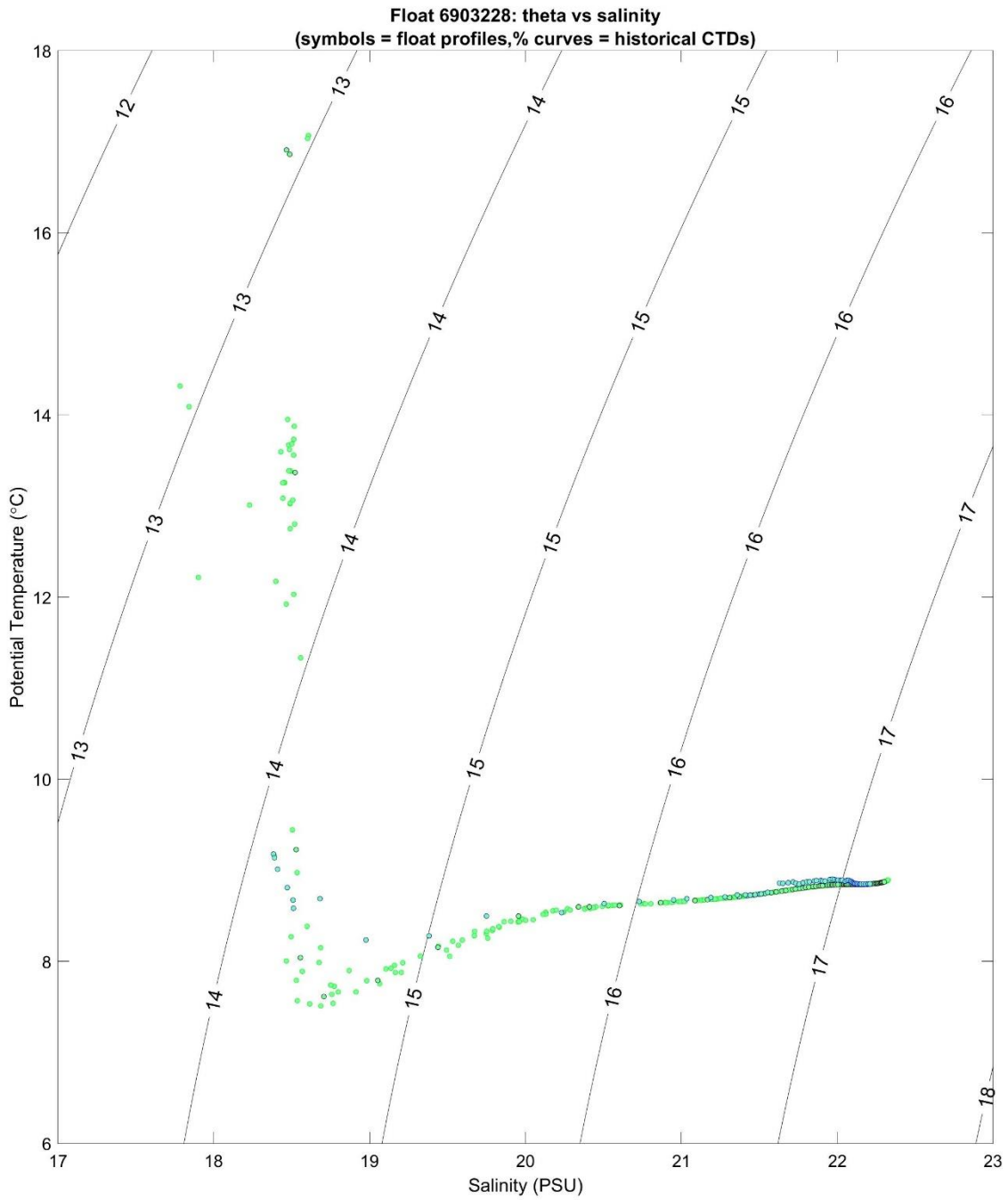


Figure 12: Float 6903228. T/S diagram plotted with and data from WMO boxes of CTD reference data +/- 10° of latitude and longitude. The black and blue circles indicate the first and the last Argo profile, respectively. Green symbols represent other Argo profiles from this float. The thin colour lines indicate the reference data.

3 Correction of Salinity Data

3.1 Comparison between Argo Float and CTD Climatology

3.1.1 Configurations

Parameters	Value
CONFIG_MAX_CASTS	300
MAP_USE_PV	1
MAP_USE_SAF	0
MAPSCALE_LONGITUDE_LARGE	4
MAPSCALE_LONGITUDE_SMALL	1.33
MAPSCALE_LATITUDE_LARGE	4
MAPSCALE_LATITUDE_SMALL	1.33
MAPSCALE_PHI_LARGE	0.5
MAPSCALE_PHI_SMALL	0.1
MAPSCALE_AGE	10
MAP_P_EXCLUDE	900
MAP_P_DELTA	100

3.1.2 Results

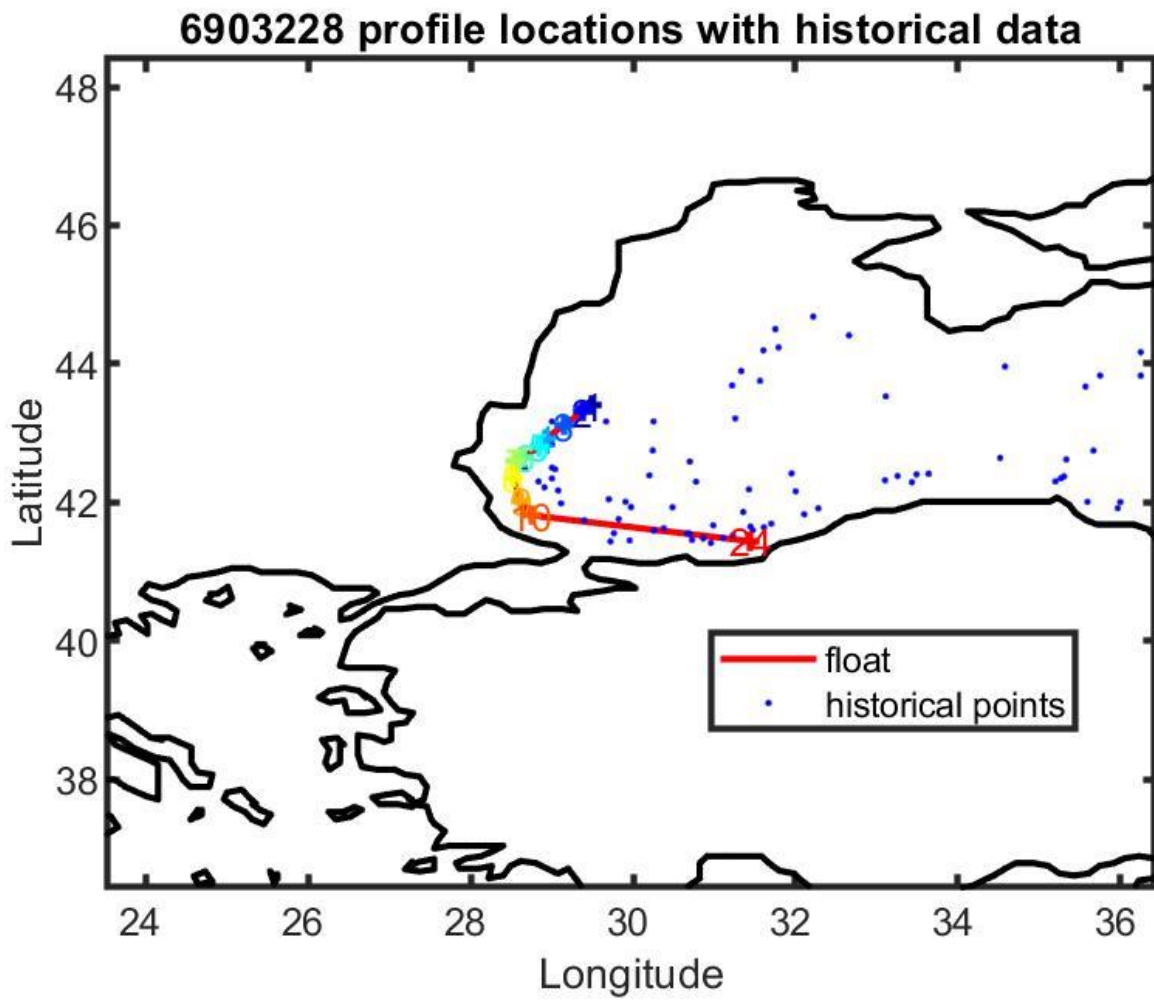


Figure 13: Float 6903228. Location of the float profiles (red line with colored numbers) and the reference data selected for mapping (blue dots).

6903228 uncalibrated float data (-) and mapped salinity (o) with objective errors

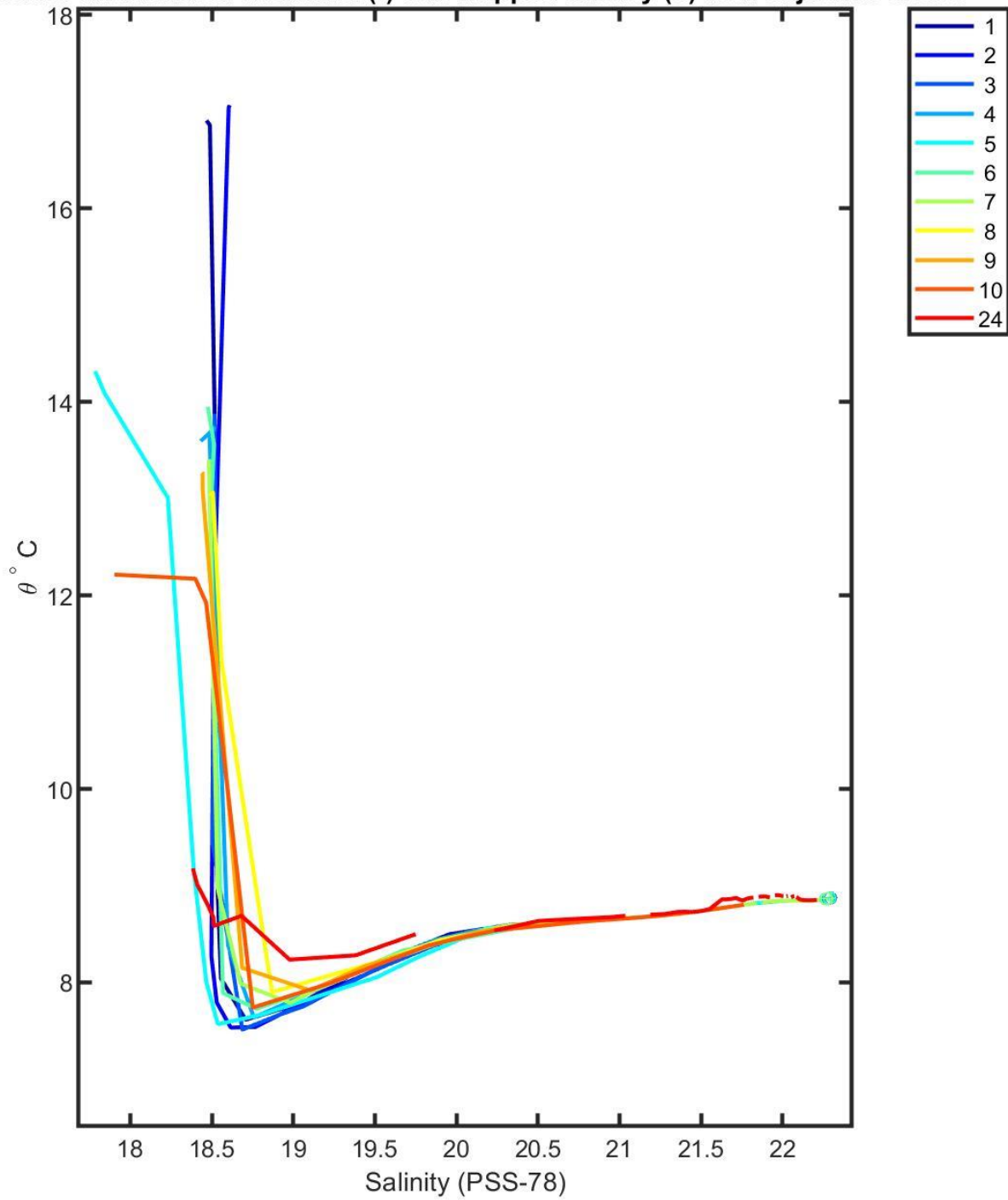


Figure 14: Float 6903228. Plot the original float salinity and the objectively estimated reference salinity at the 10 float theta levels that are used in calibration.

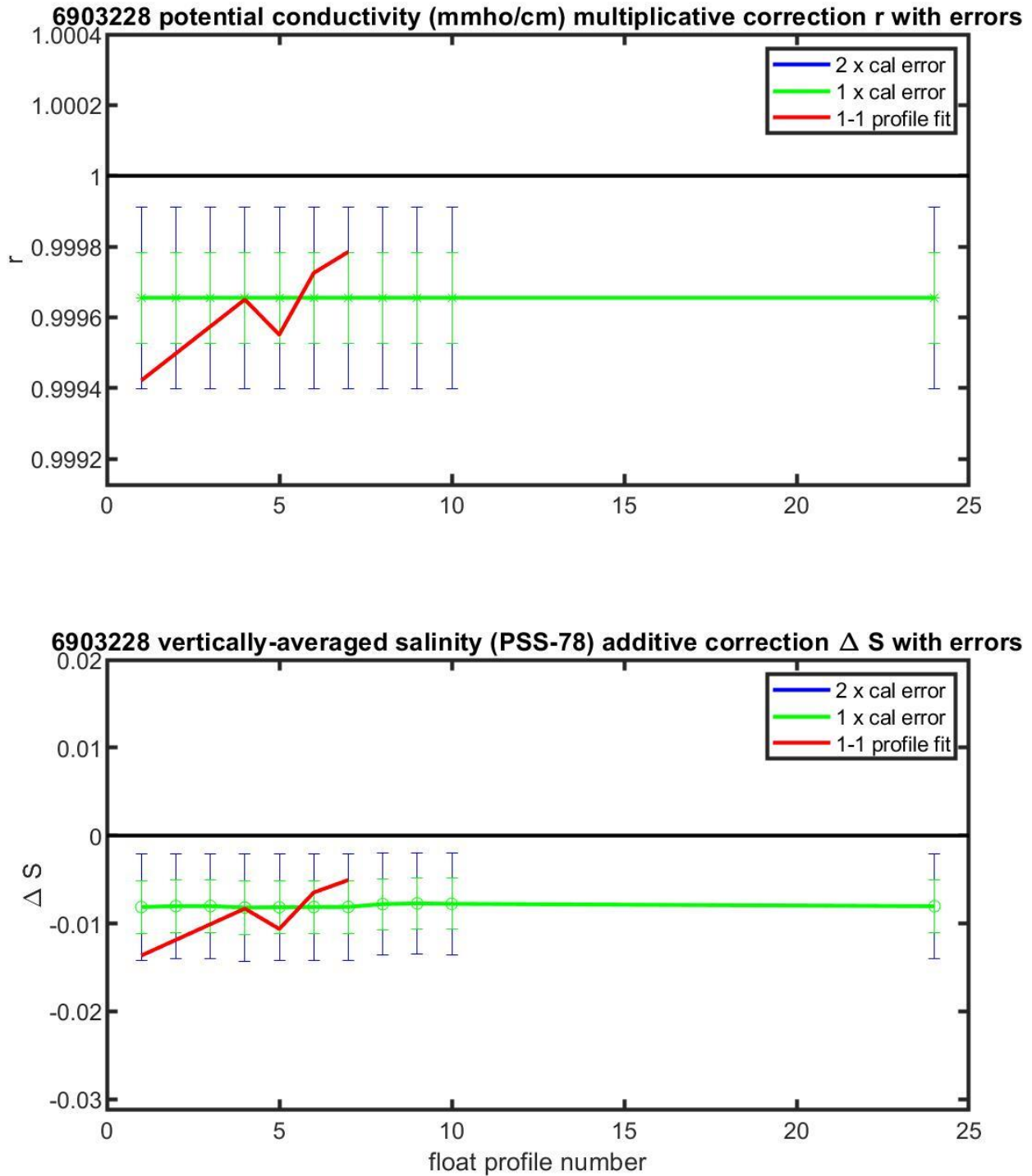


Figure 15: Float 6903228. Evolution of the suggested adjustment with time. The top panel plots the potential conductivity multiplicative adjustment. The bottom panel plots the equivalent salinity additive adjustment. The red line denotes one-to-one profile fit that uses the vertically weighted mean of each profile. The red line can be used to check for anomalous profiles relative to the optimal fit.

6903228 calibrated float data (-) and mapped salinity (o) with objective errors

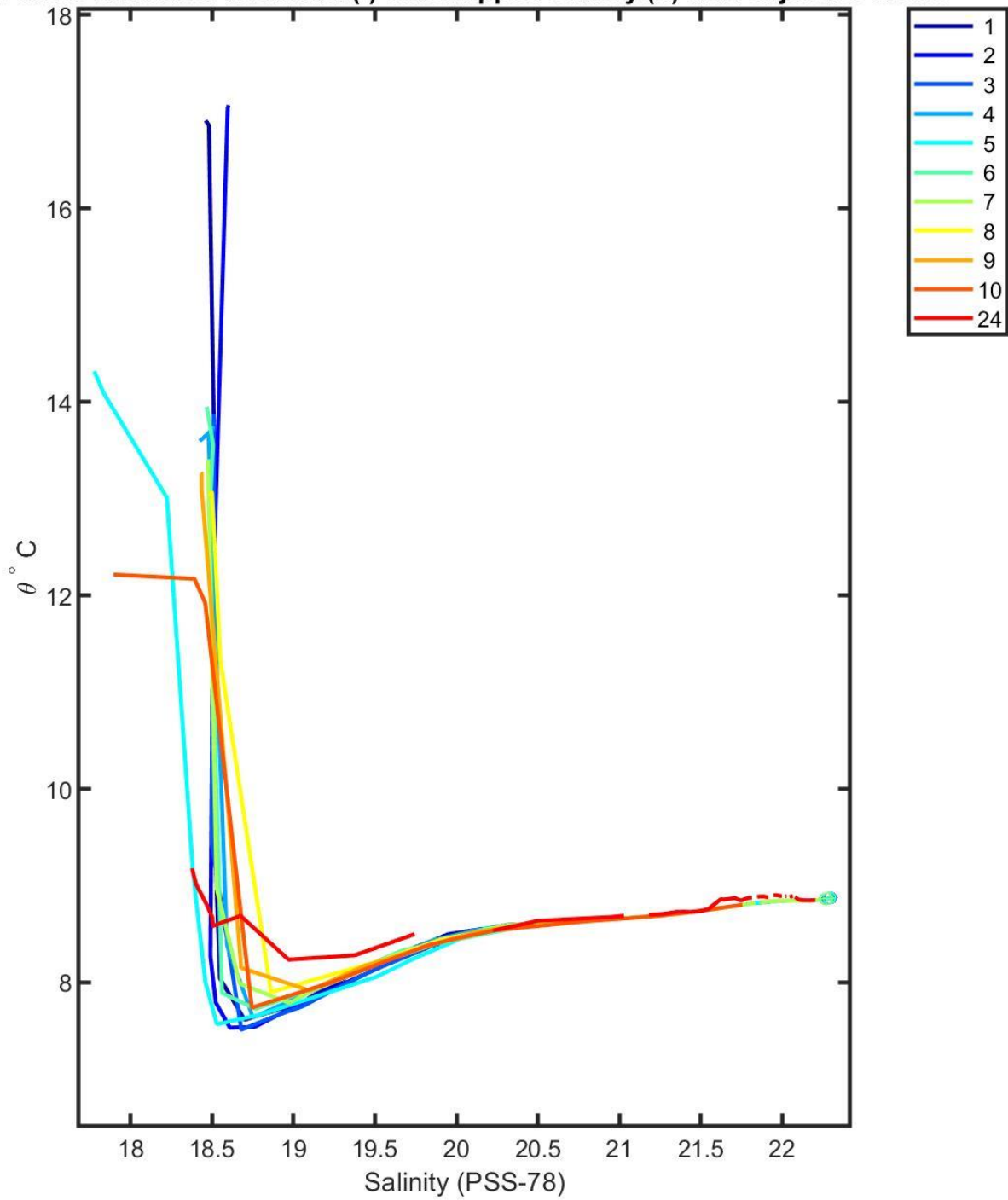


Figure 16: Float 6903228. The plot of calibrated float salinity and the objectively estimated reference salinity at the 10 float theta levels that are used in calibration.

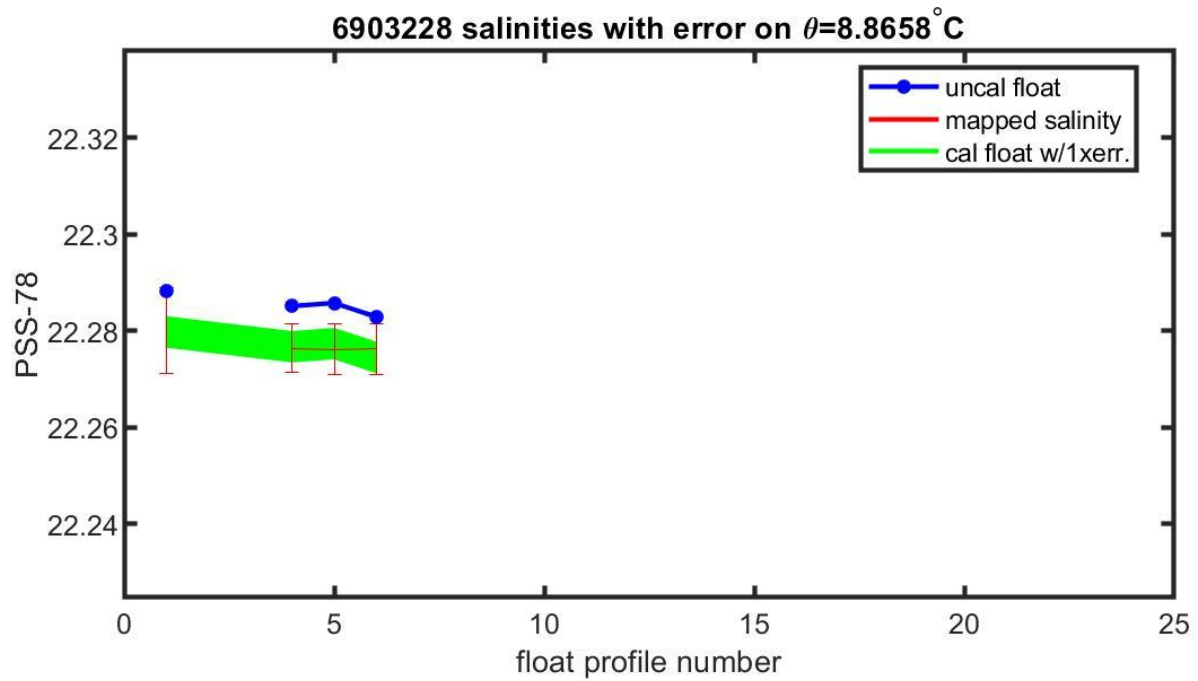
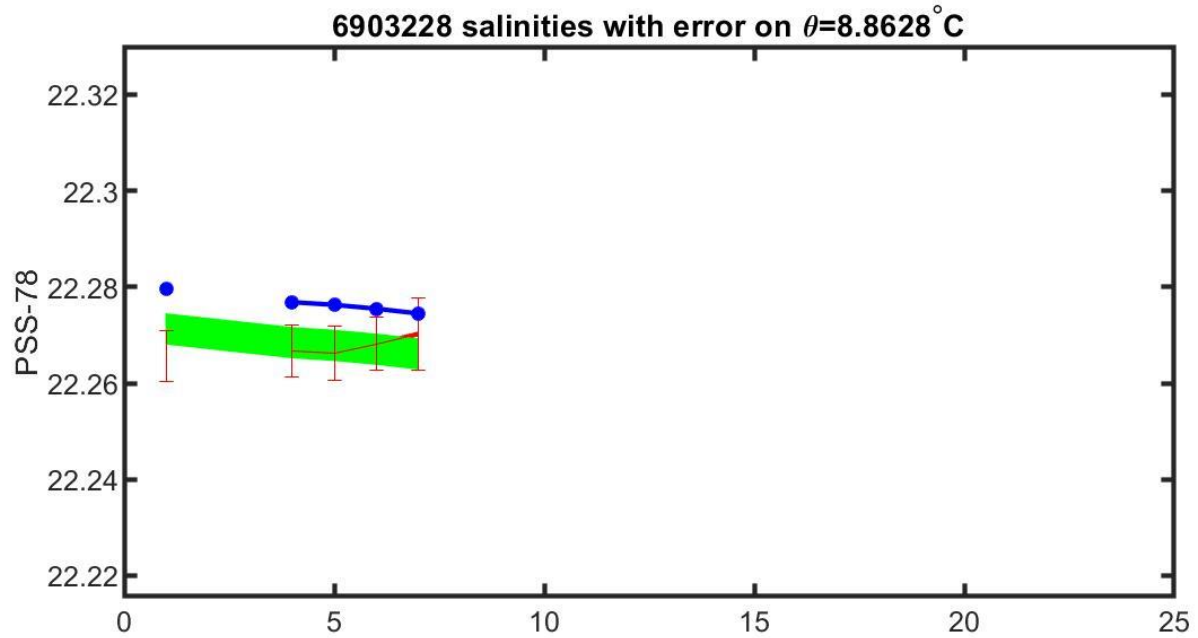


Figure 17: Float 6903228. Plots of the evolution of salinity with time along with selected theta levels with minimum salinity variance.

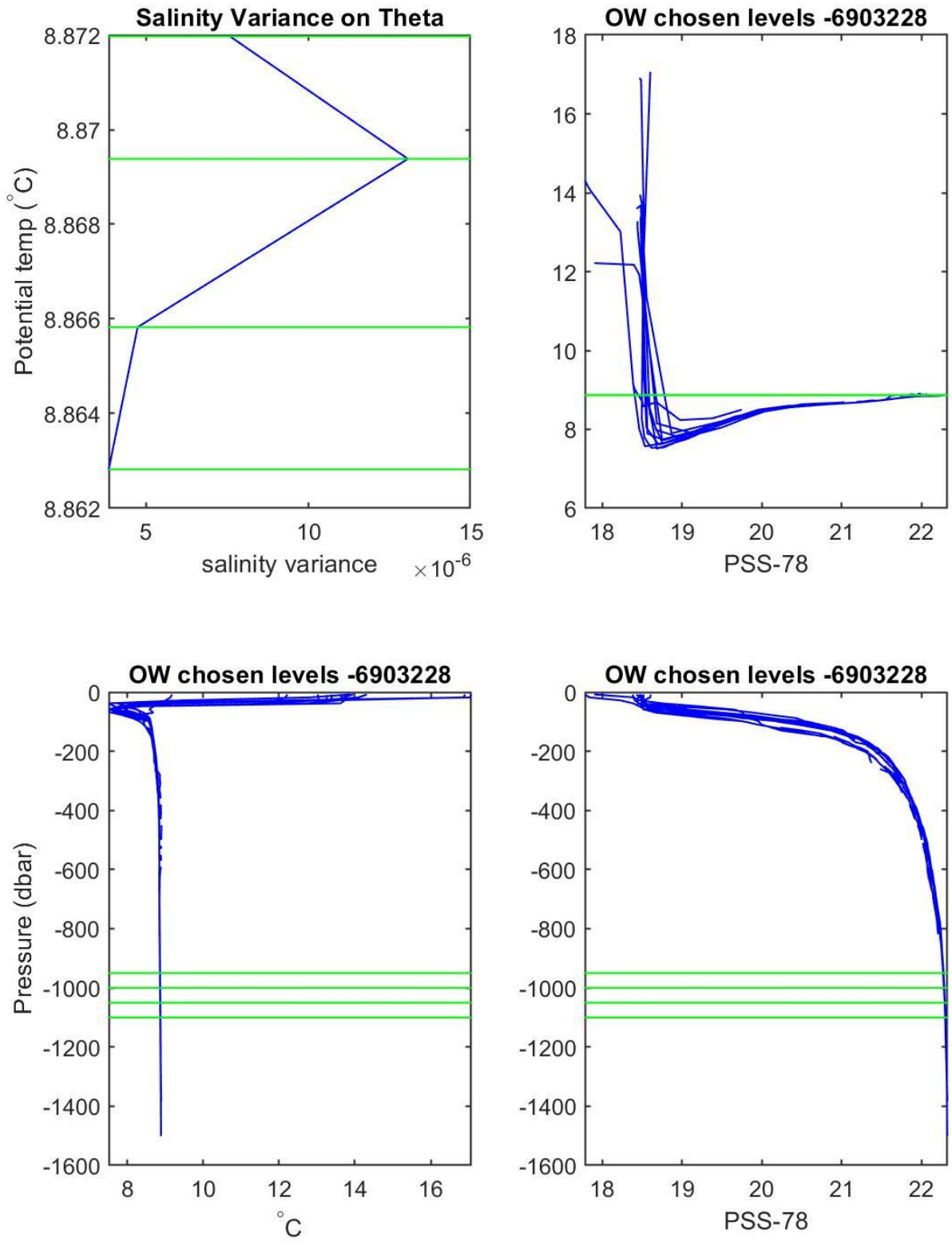


Figure 18: Float 6903228. Plots include the theta levels chosen for calibration: Top left: Salinity variance at theta levels. Top right: T/S diagram of all profiles of Argo float. Bottom left: potential temperature plotted against pressure. Bottom right: salinity plotted against pressure.

The analysis of the θ -S diagram of profile segments (Figure 19) shows that the OW method was run where the θ -S relationship is the tightest.

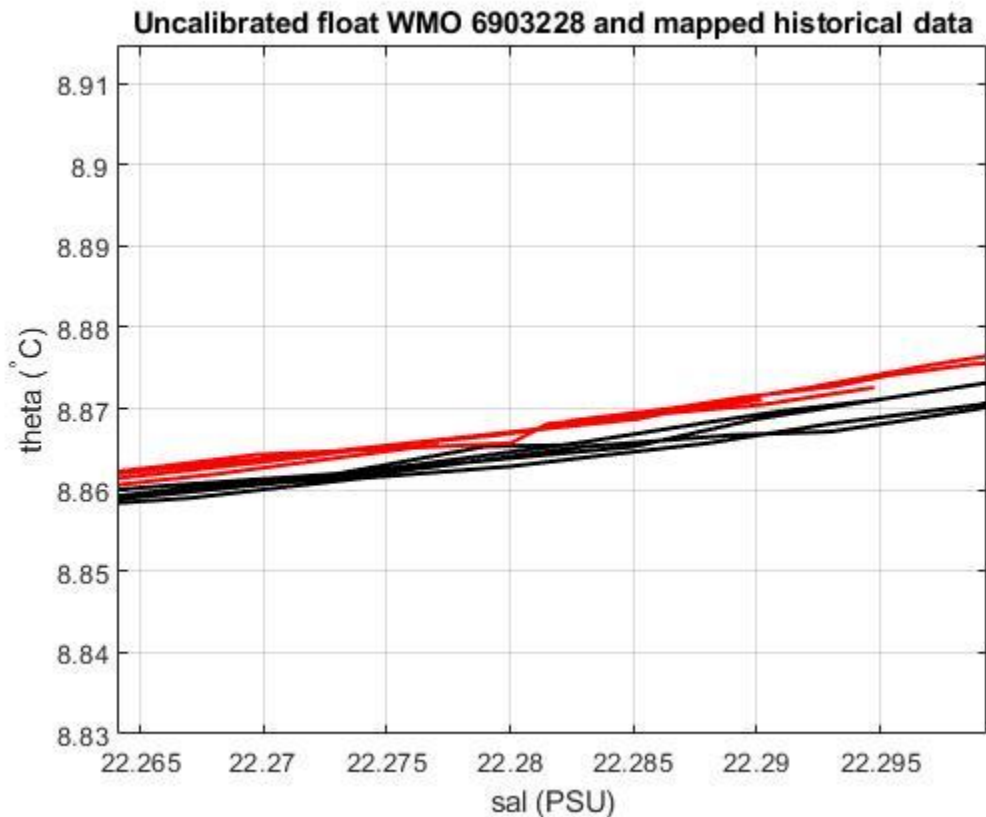


Figure 19: Float 6903228. Uncalibrated float salinity profile (black lines) and mapped historical data (red lines), in the most uniform part of the θ -S curve.

4 Comparison between Argo float under study and other Argo float in the same area

Two floats, WMO 3901852 and WMO 3901855 (Figure 20), are selected to perform a comparison with the float under study, to obtain additional qualitative analysis.

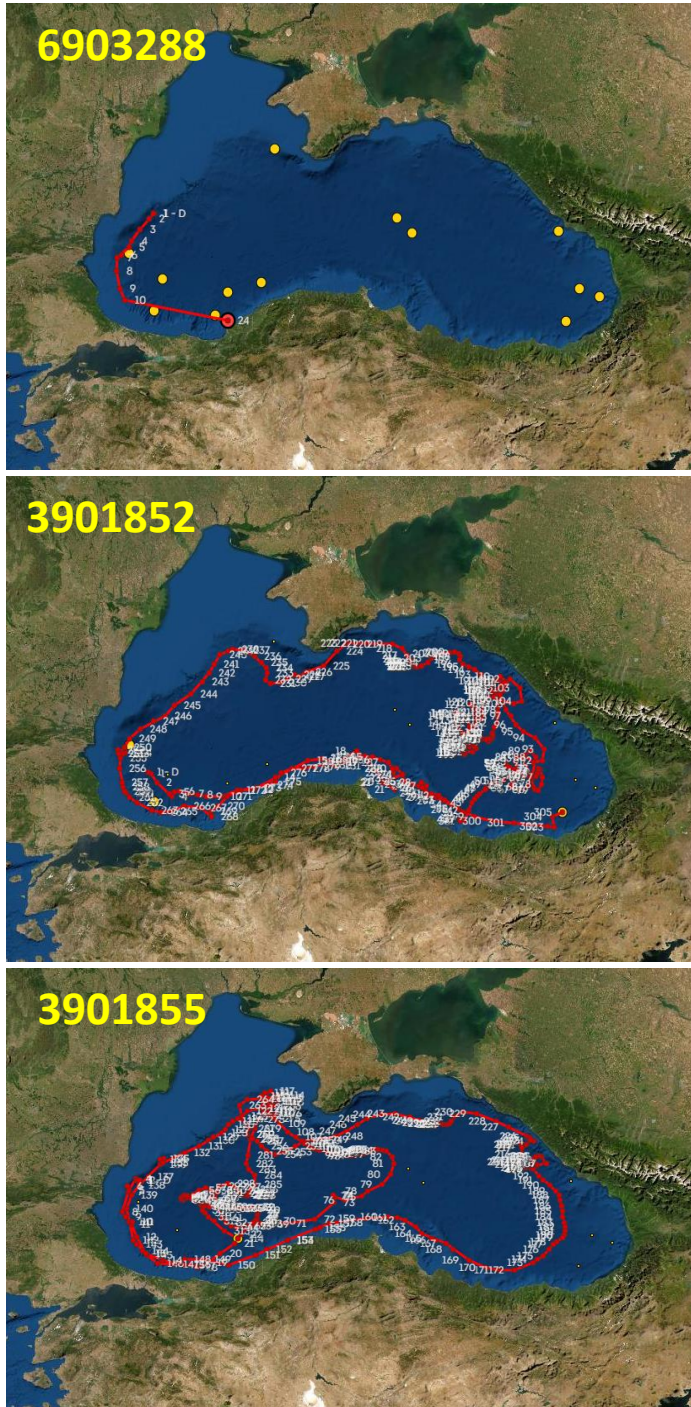


Figure 20: Float 6903288. Trajectory of the floats used for the comparison.

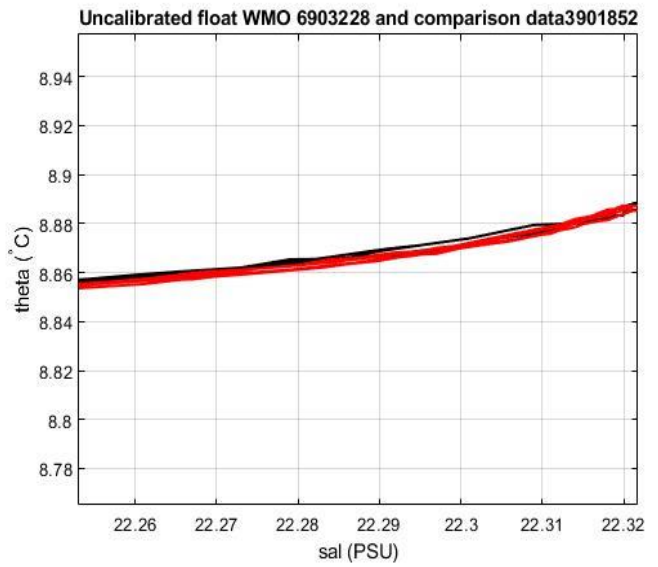
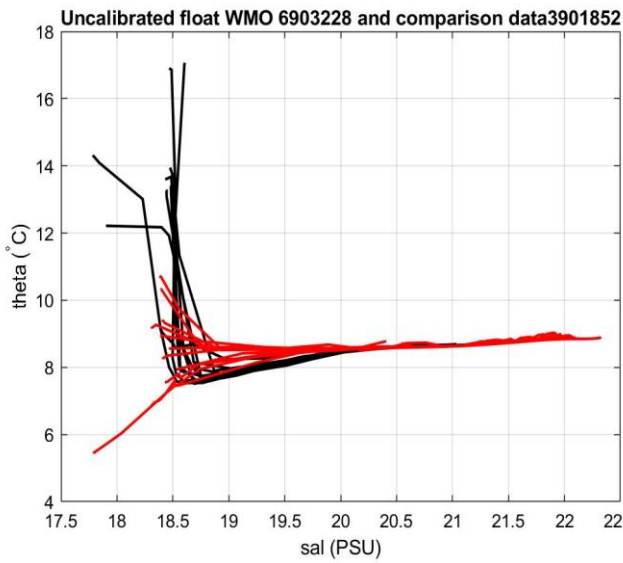


Figure 21: Float 6903228. Comparison between float 6903228 (black line) and float 3901852 (red line), on the left. On the right zoom in the most uniform part of the θ -S curve.

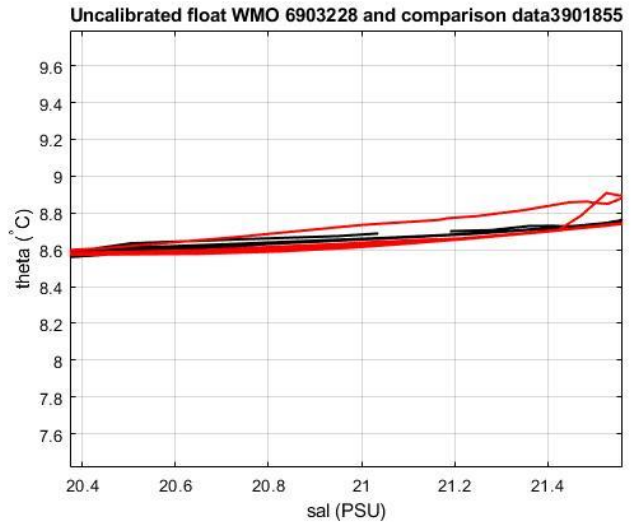
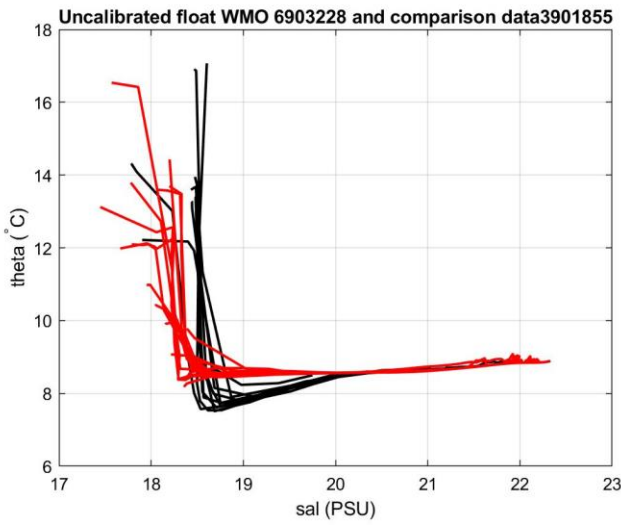


Figure 22: Float 6903228. Comparison between float 6903228 (black line) and float 3901855 (red line), on the left. On the right zoom in the most uniform part of the θ -S curve.

5 Summary

Float was deployed in the Black Sea. The most favorable water masses, which are useful for comparison with climatology is relatively stable intermediate and deep waters from around 900 m. The initial comparison between Argo float and reference data shows that the float sample shallow depth. No significant drift is showed. This float was not DMQC-ed before.

The OWC analysis showed no significant salinity drift. Figure 17 shows the salinity is quite linear on selected θ -levels. Due to the very little number of profile, a comparison with two float in the same area is performed to better delayed mode check data and give a more reliable statistic.

After several analyses, the last decision is that the salinity data of float WMO 6903228 are accurate and don't need a delayed mode correction. The correction is quite small and below the Argo requested accuracy (0.01). QC=1 is applied.

PSAL_ADJUSTED=PSAL from cycle 1 to 24

The quality flags applied are the following:

PSAL_ADJUSTED_QC='1' from cycle 1 to 24

The delayed-mode files (Dfiles) have been created accordingly and sent to the Coriolis GDAC.

6 References

Cabanes, C., Thierry, V., & Lagadec, C. (2016). Improvement of bias detection in Argo float conductivity sensors and its application in the North Atlantic. *Deep-Sea Research Part I: Oceanographic Research Papers*, 114, 128–136. <https://doi.org/10.1016/j.dsr.2016.05.007>