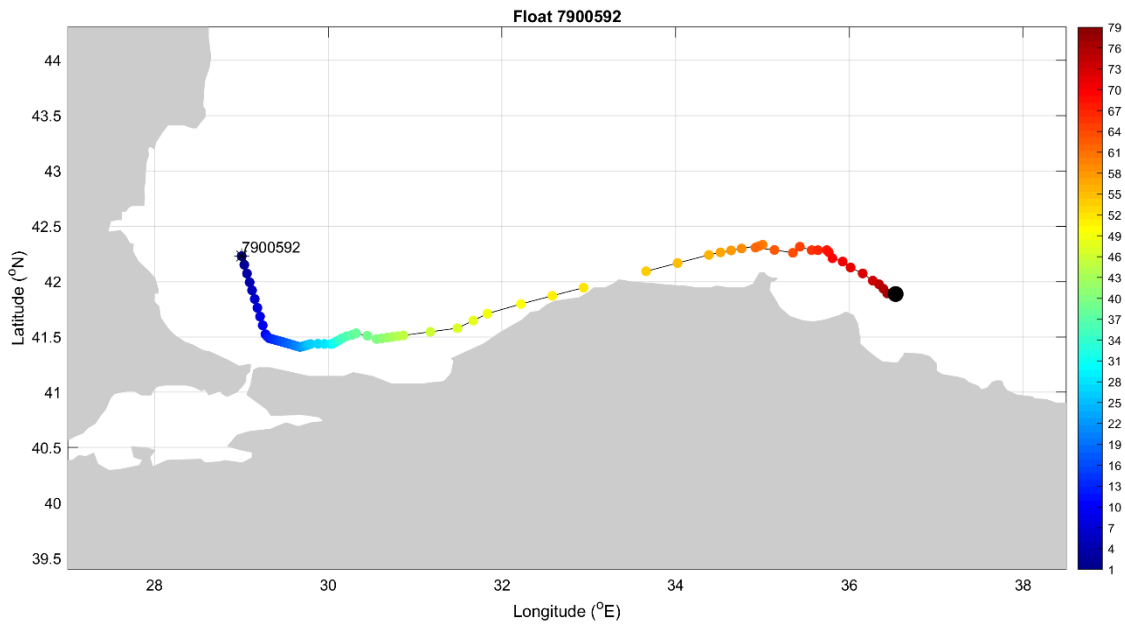


Delayed Mode Quality Control of Argo float WMO 7900594

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1 Introduction

This report includes the delayed mode analysis performed for float 7900594. It was deployed in Black Sea in June 2015 and after performed 142 cycles died. Before the analysis, real-time QC flags were visually inspected. The list of flags applied is QC=1 to cycles from 3 to 86, QC=3 to cycles from 87 to 142. Then, the satellite altimeter comparison plot between the sea surface height and dynamic height anomaly, constructed for this float by Ifremer, was analyzed. 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 7900594 is the Provor 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:

3-86 PSAL QC=1

87-142 PSAL QC=3

2.2 Satellite Altimeter Report

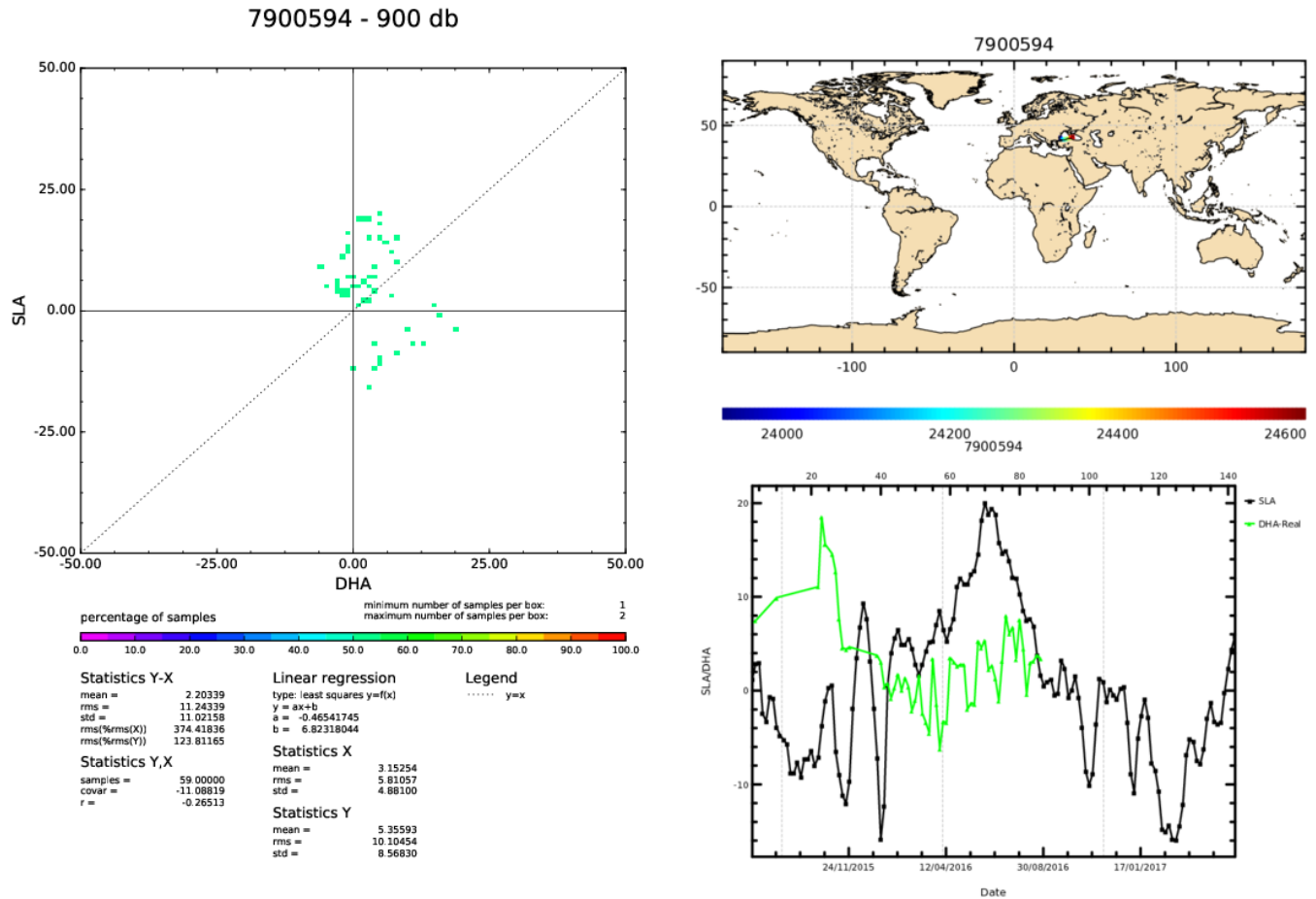


Figure 1: Float 7900594. The comparison between the sea surface height (SSH) from the satellite altimetry and dynamic height anomaly (DHA) extracted from the Argo float temperature and salinity. The figure is created by the CLS/Coriolis and distributed by Ifremer (<http://ftp.ifremer.fr/ifremer/argo/etc/argo-ast9-item13-AltimeterComparison/figures/>).

2.3 Time Series of Argo Float Temperature and Salinity

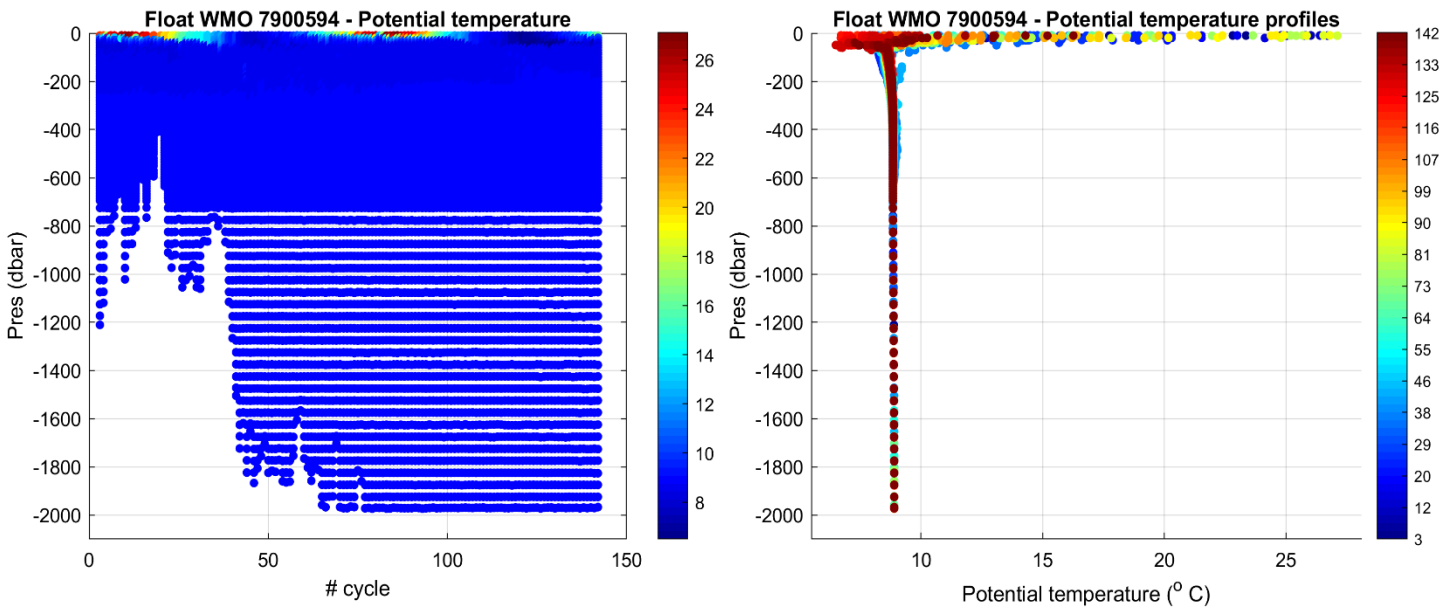


Figure 2: Float 7900594. Time series of Argo float potential temperature ($^{\circ}\text{C}$) on the left, and potential temperature profiles color-coded per cycle number on the right.

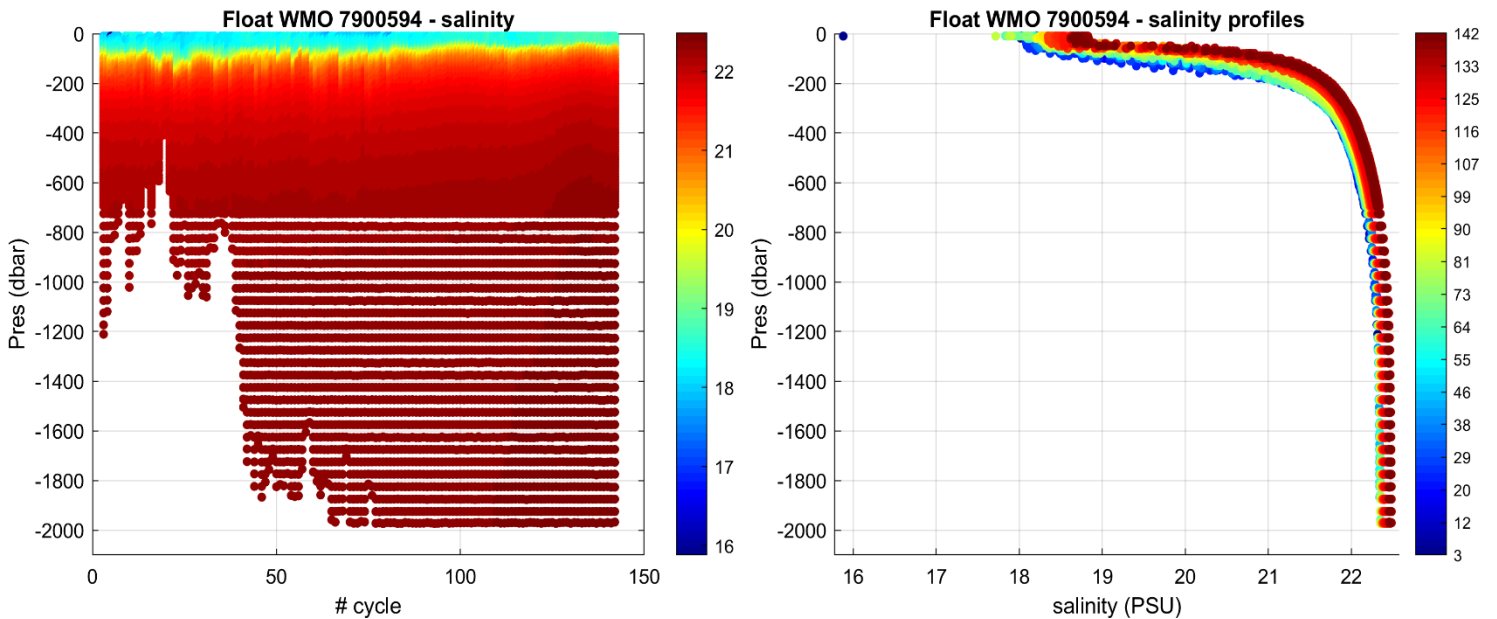


Figure 3: Float 7900594. Time series of Argo float potential salinity (PSS-78) on the left, and salinity profiles color-coded per cycle number on the right.

A spike was detected in salinity profile 5 at the pressure level of 9.7 dbar (Figure 3). The quality flag associated to this salinity value was change to 4.

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). A significant salinity drift is observed.

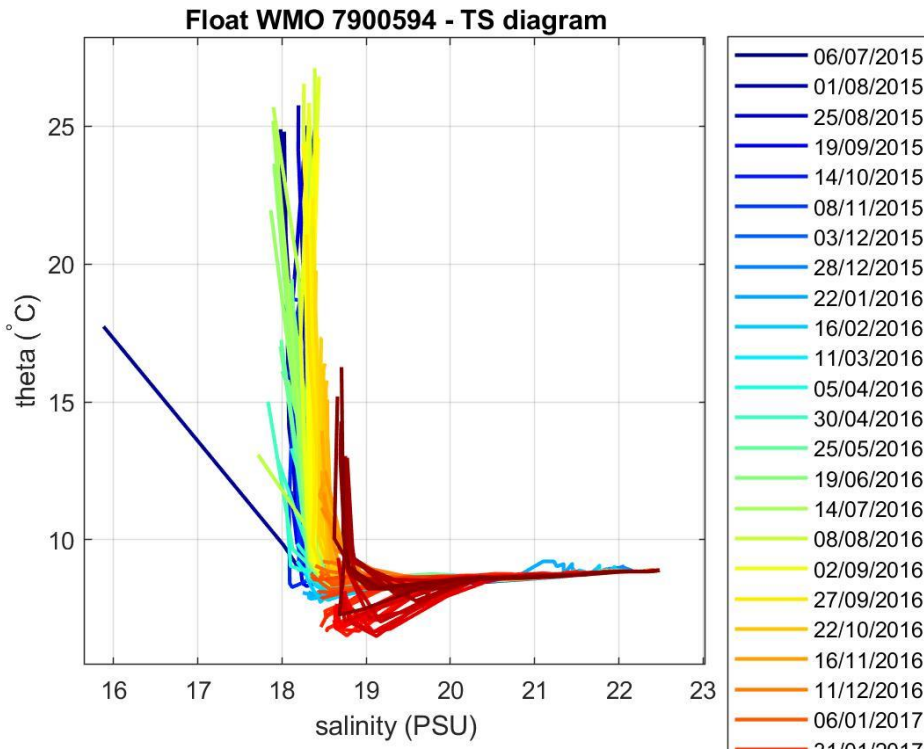


Figure 4: Float 7900594. θ -S diagram color-coded per cycle number.

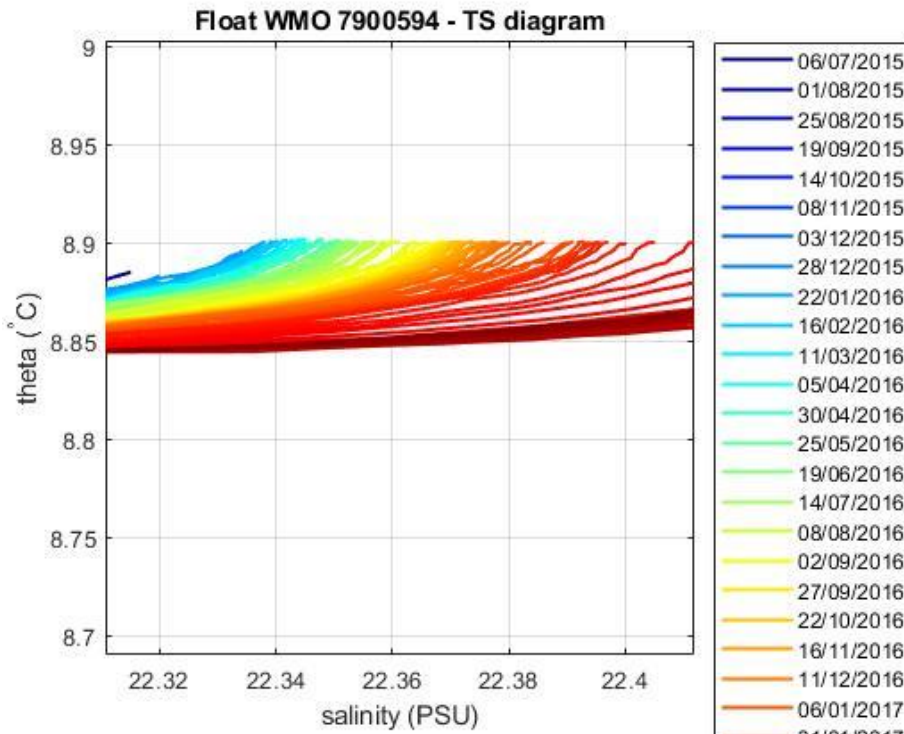


Figure 5: Float 7900594. Area of the θ -S diagram (color-coded per cycle number) where the θ -S relationship is more uniform.

2.4 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 3 years). A time difference between 3 and 6, 6 and 9 and larger than 9 years is depicted in green, cyan and blue, respectively.

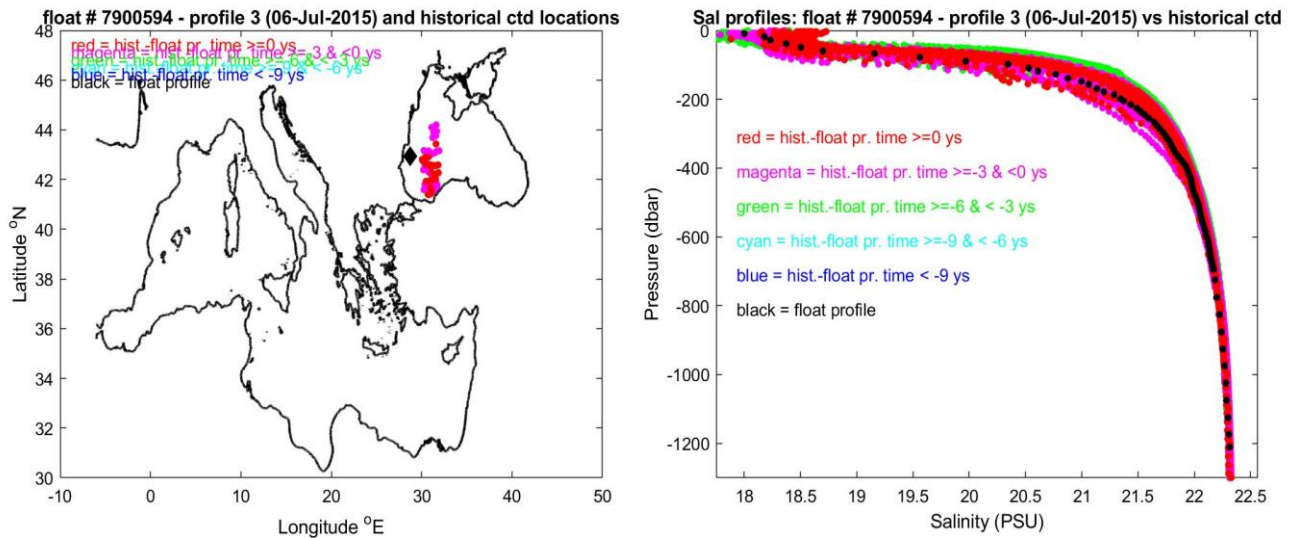


Figure 6: Float 7900594. Locations of the salinity float profile number 3 and historical CTD data (right panel) and the respective salinity profiles (left panel).

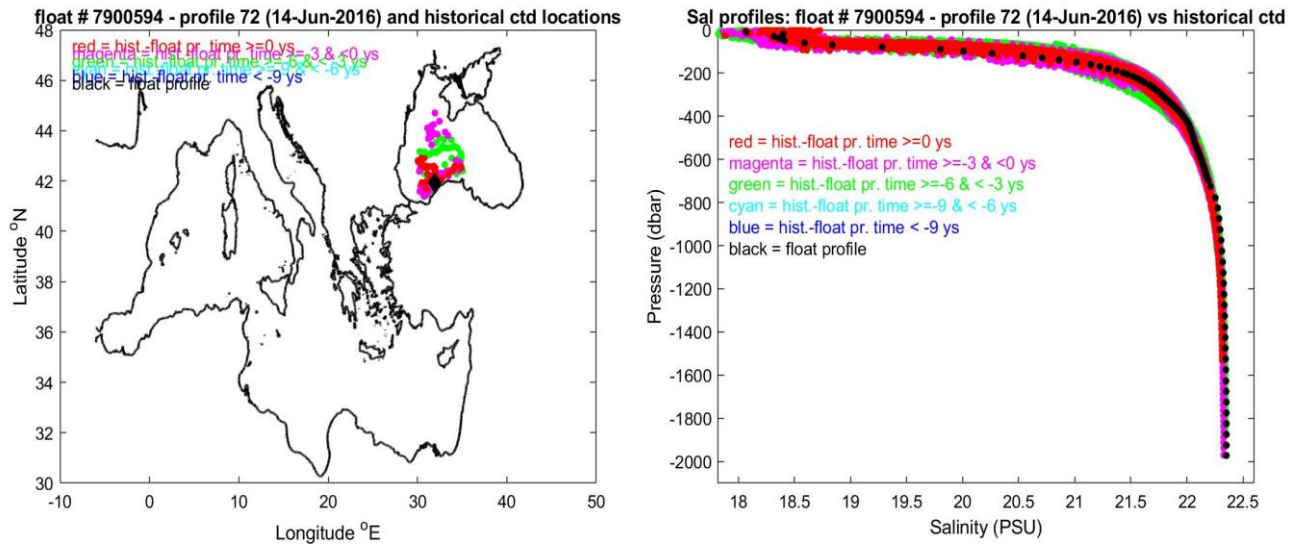


Figure 7: Float 7900594. Locations of the salinity float profile number 72 and historical CTD data (right panel) and the respective salinity profiles (left panel).

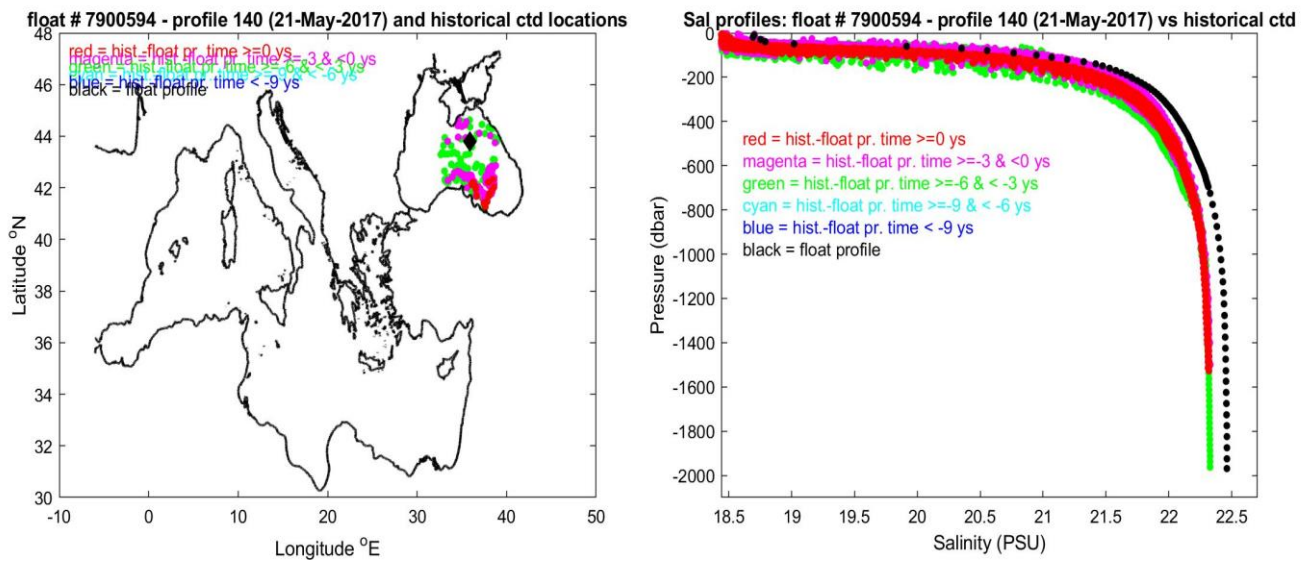


Figure 8: Float 7900594. Locations of the salinity float profile number 140 and historical CTD data (right panel) and the respective salinity profiles (left panel).

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 deeper layers, where the water column is more stable, for profiles 3 and 72. Figure 11 shows a significant salinity drift.

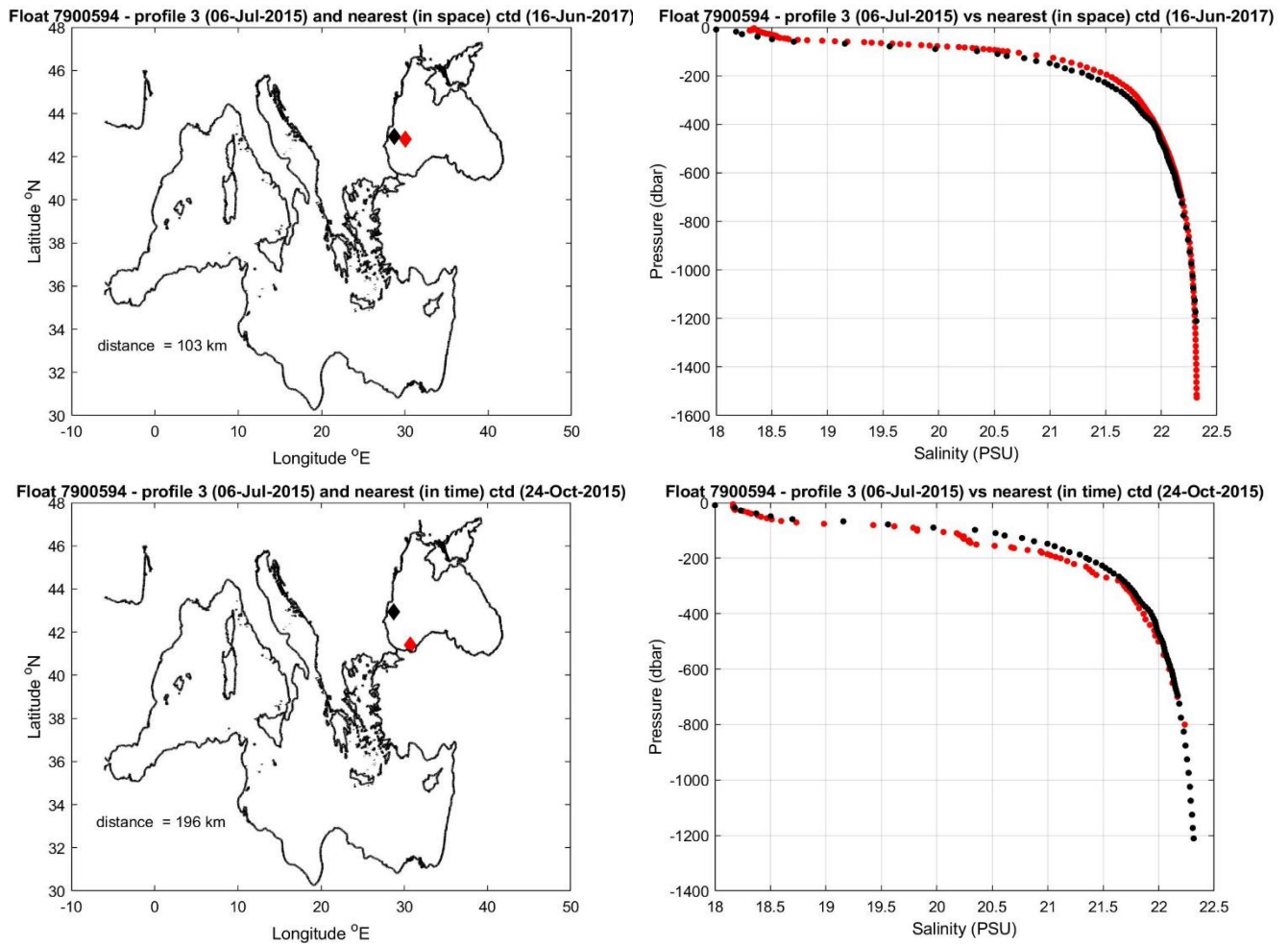


Figure 9: Float 7900594. The salinity float profile number 3 (black dots) are compared to the nearest in space (top) and in time (bottom) reference profile (red dots). The locations of the two profiles and their distance is given in the left panel.

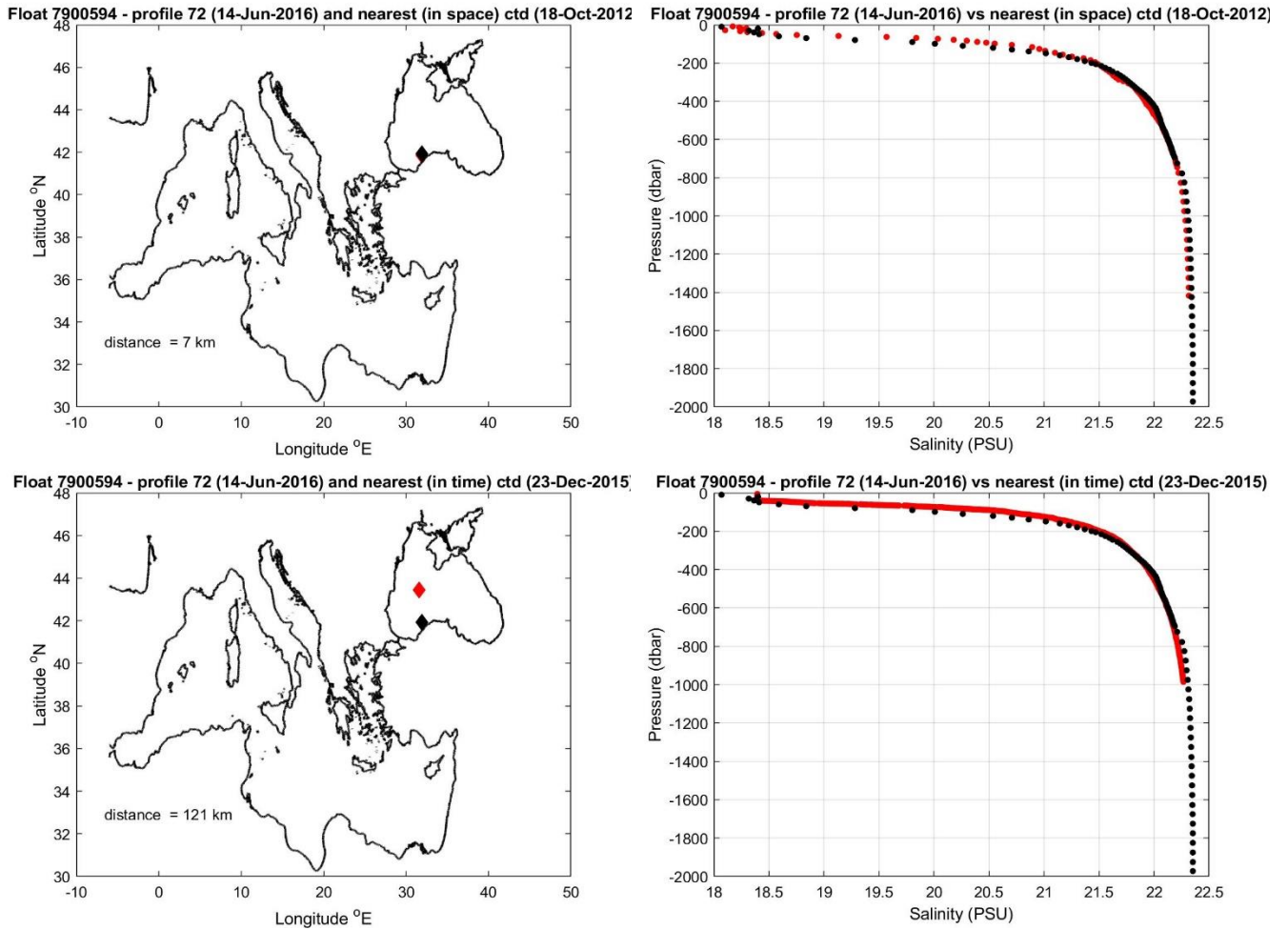


Figure 10: Float 7900594. The salinity float profile number 72 (black dots) are compared to the nearest in space (top) and in time (bottom) reference profile (red dots). The locations of the two profiles and their distance is given in the left panel.

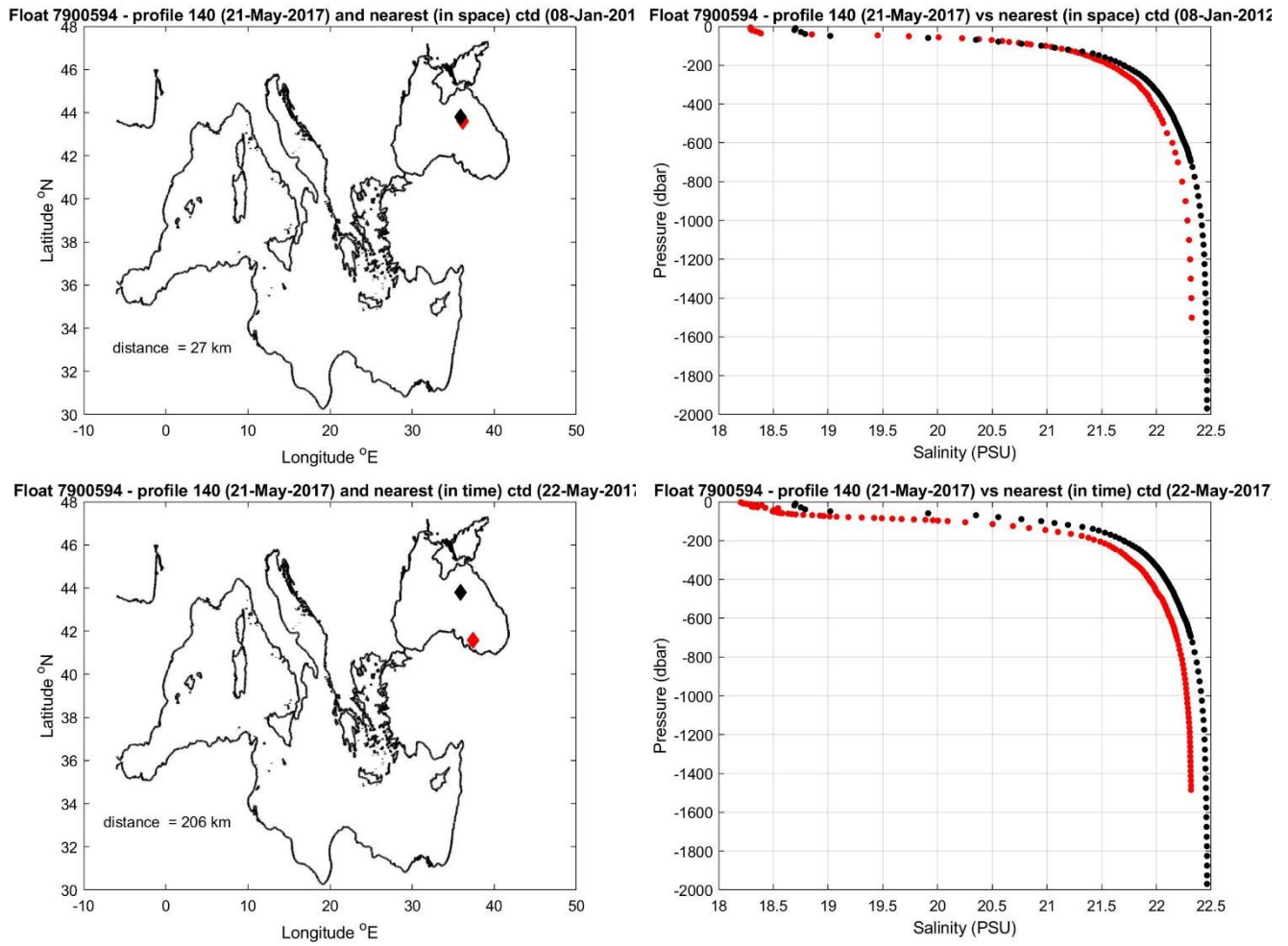


Figure 11: Float 7900594. The salinity float profile number 140 (black dots) are compared to the nearest in space (top) and in time (bottom) reference profile (red dots). The locations of the two profiles and their distance is given in the left panel.

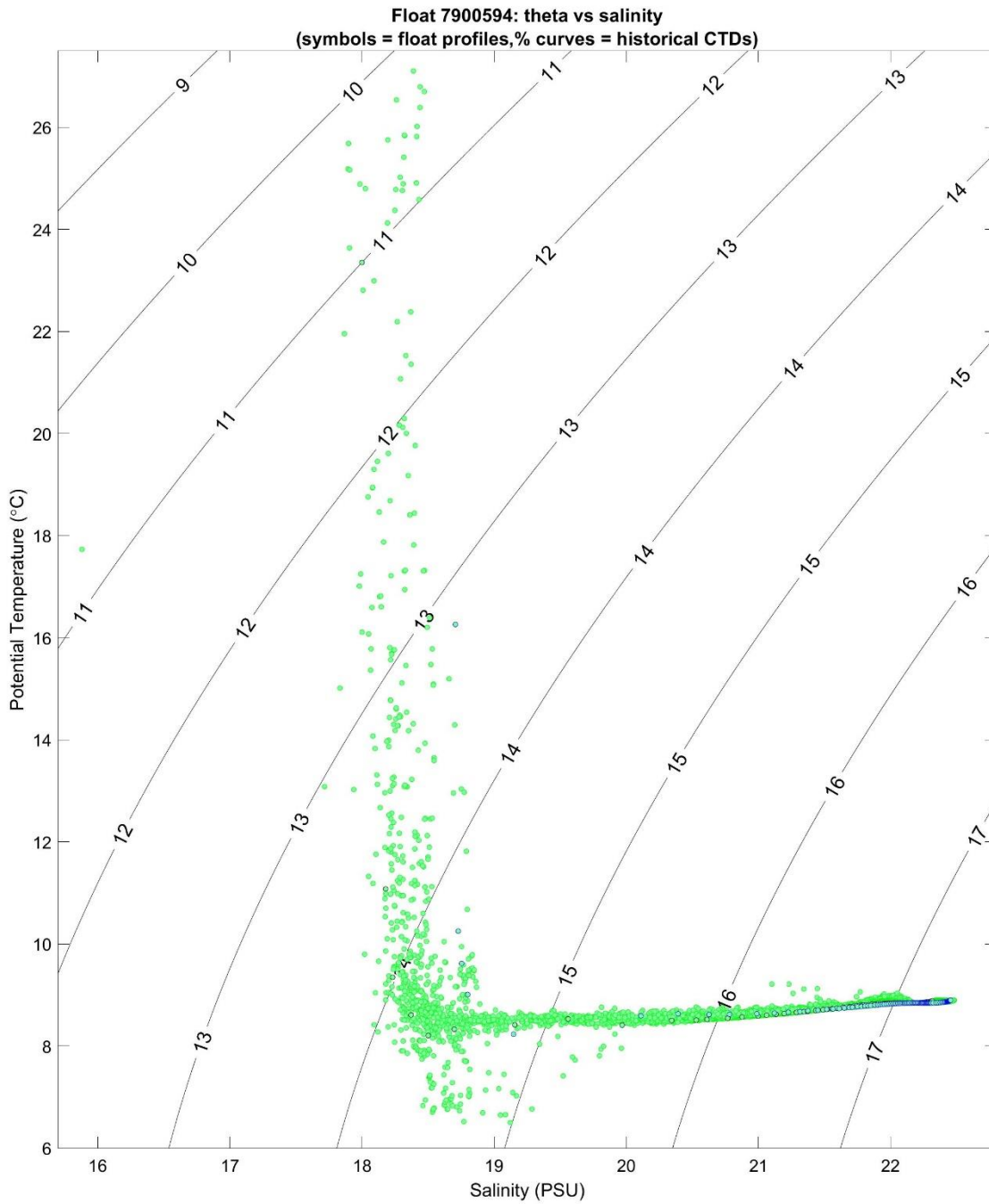


Figure 12: Float 7900594. T/S diagram plotted with and data from WMO boxes of CTD reference data +/- 10° of latitude and longitude. The black and blue cycles indicate the first and the last Argo profile, respectively. Green symbols represent other Argo profiles from this float. The thin colours lines 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

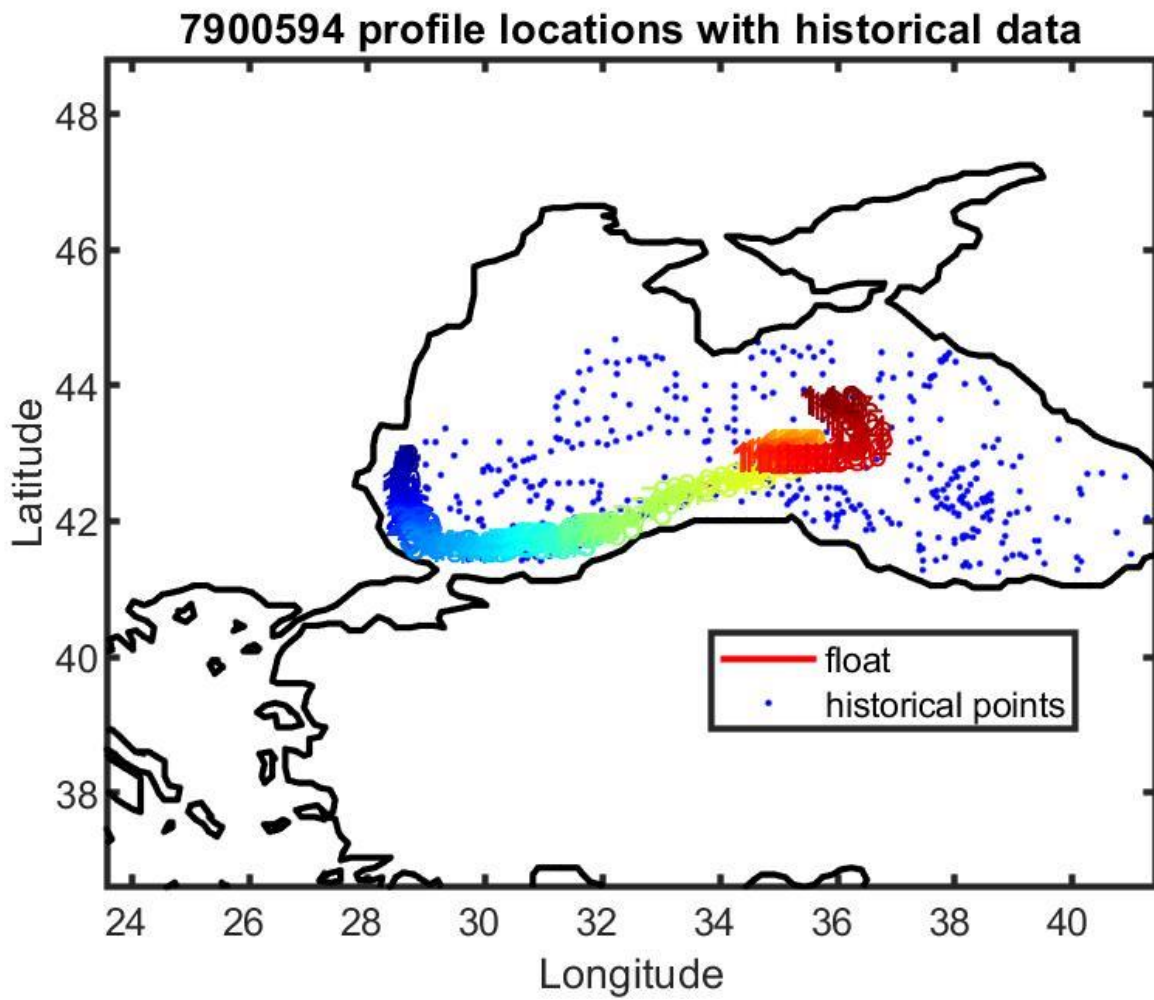


Figure 13: Float 7900594. Location of the float profiles (red line with colored numbers) and the reference data selected for mapping (blue dots).

7900594 uncalibrated float data (-) and mapped salinity (o) with objective errors

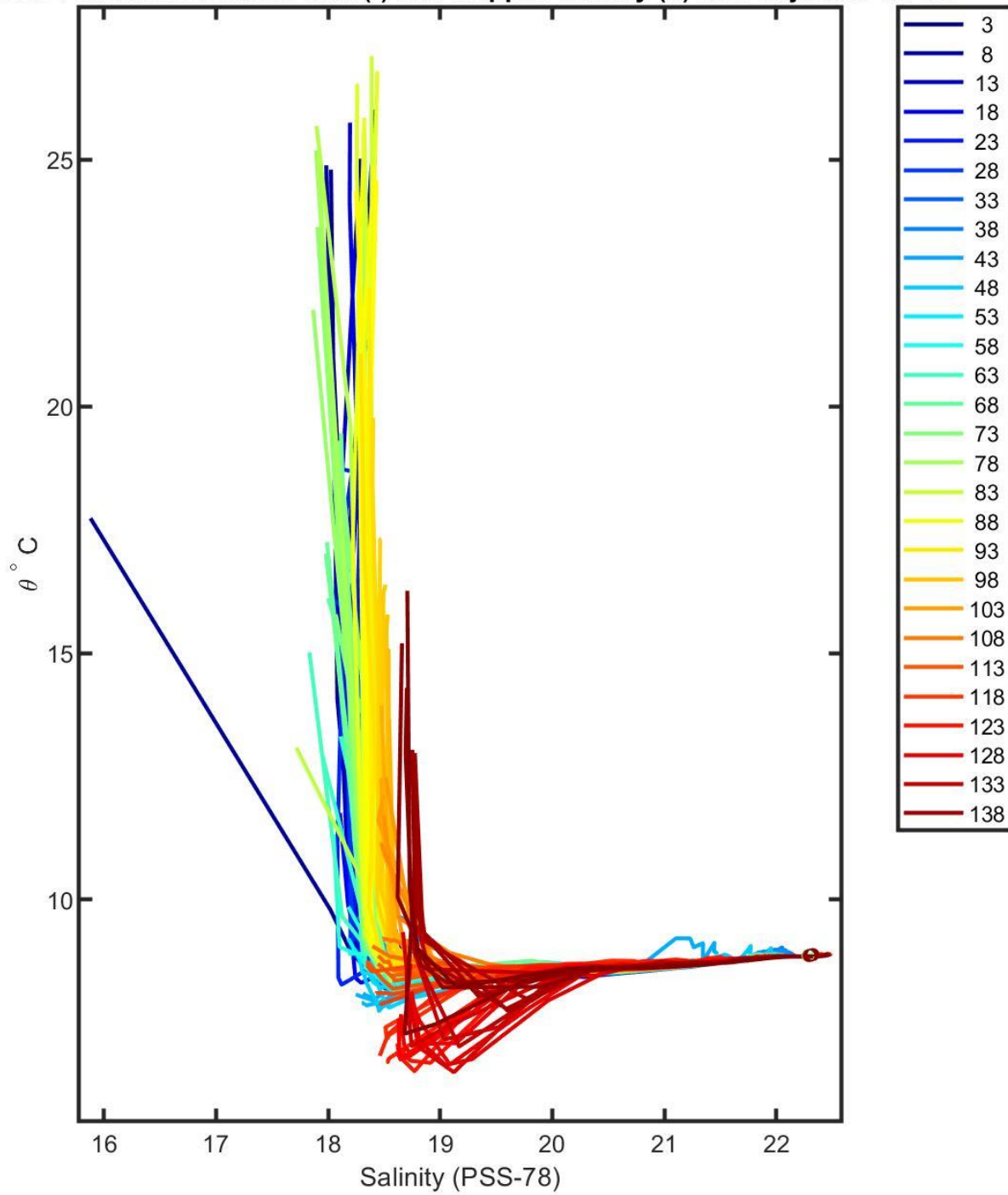


Figure 14: Float 7900594. Plot the original float salinity and the objectively estimated reference salinity at the 10 float theta levels that are used in calibration.

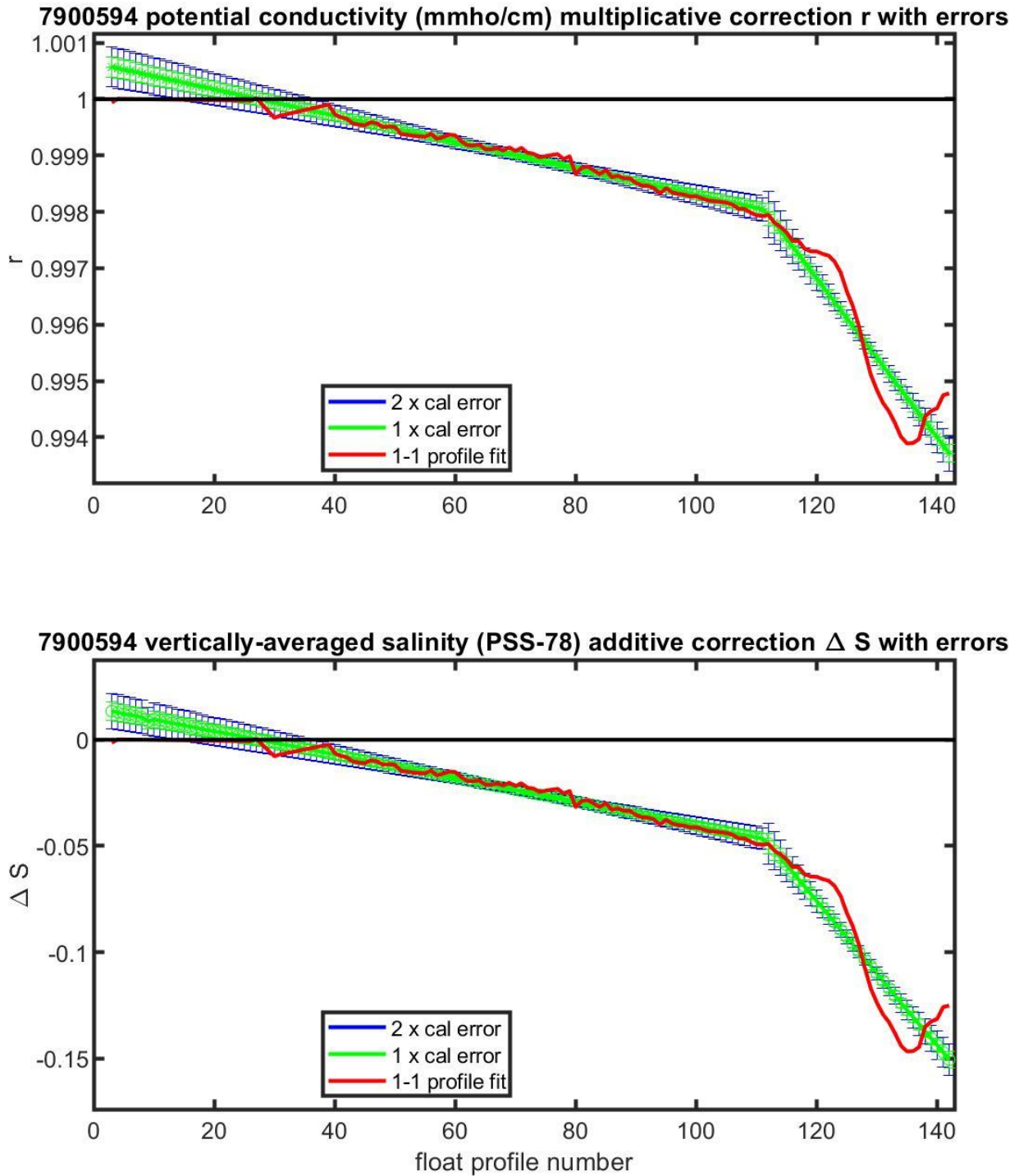


Figure 15: Float 7900594. Evolution of the suggested adjustment with time. The top panel plots the potential conductivity multiplicative adjustment. The bottom panel plots the equivalent salinity additive adjustment. The red line denotes one-to-one profile fit that uses the vertically weighted mean of each profile. The red line can be used to check for anomalous profiles relative to the optimal fit.

7900594 calibrated float data (-) and mapped salinity (o) with objective errors

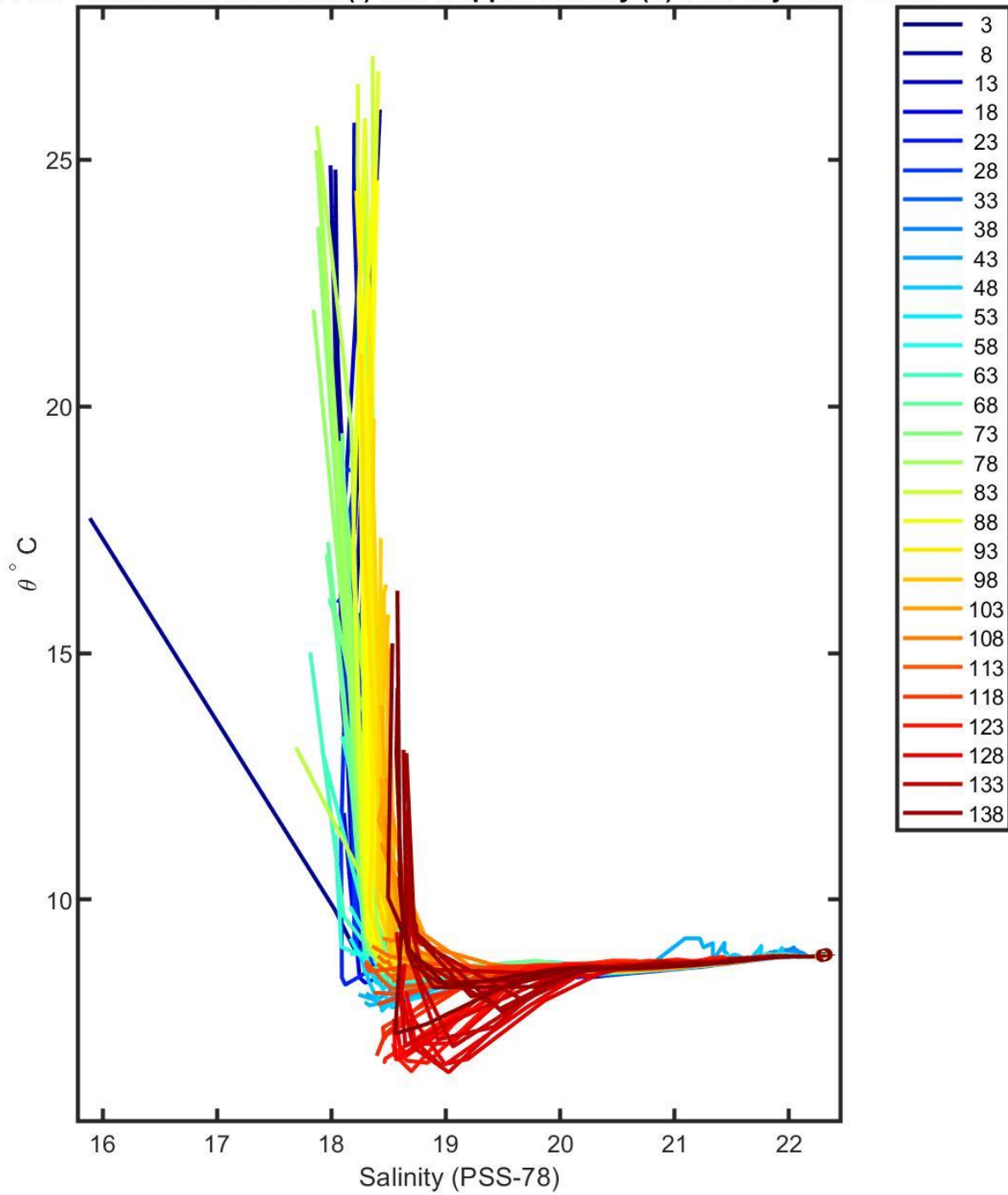


Figure 16: Float 7900594. The plot of calibrated float salinity and the objectively estimated reference salinity at the 10 float theta levels that are used in calibration.

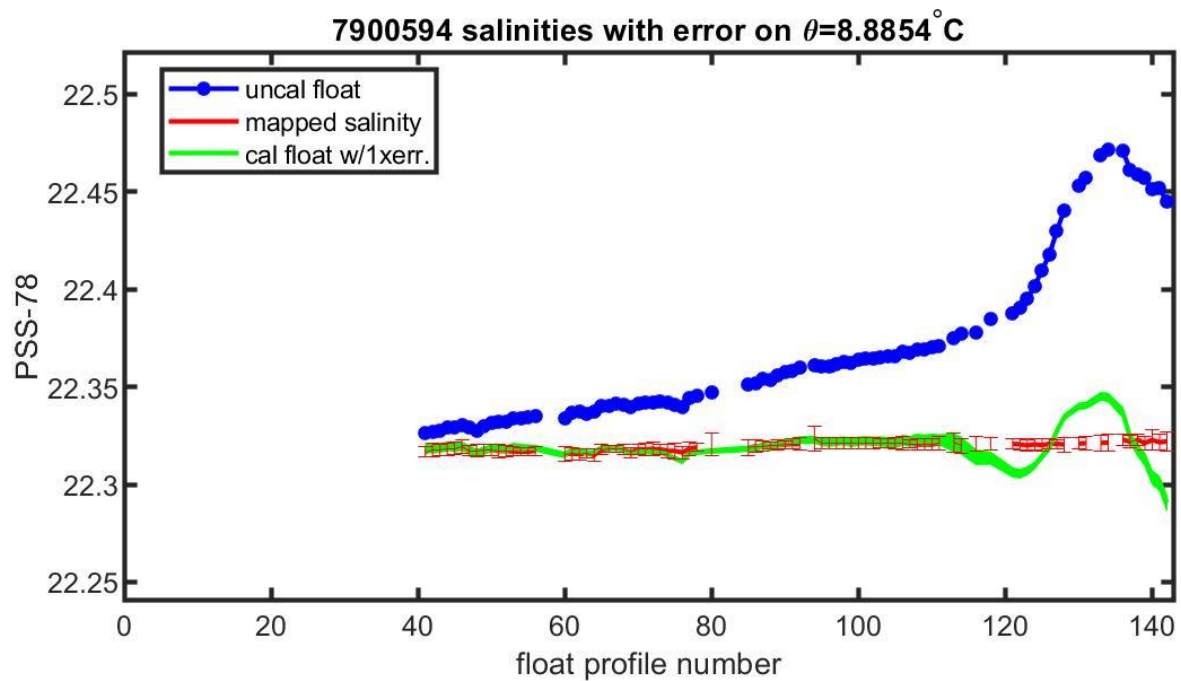
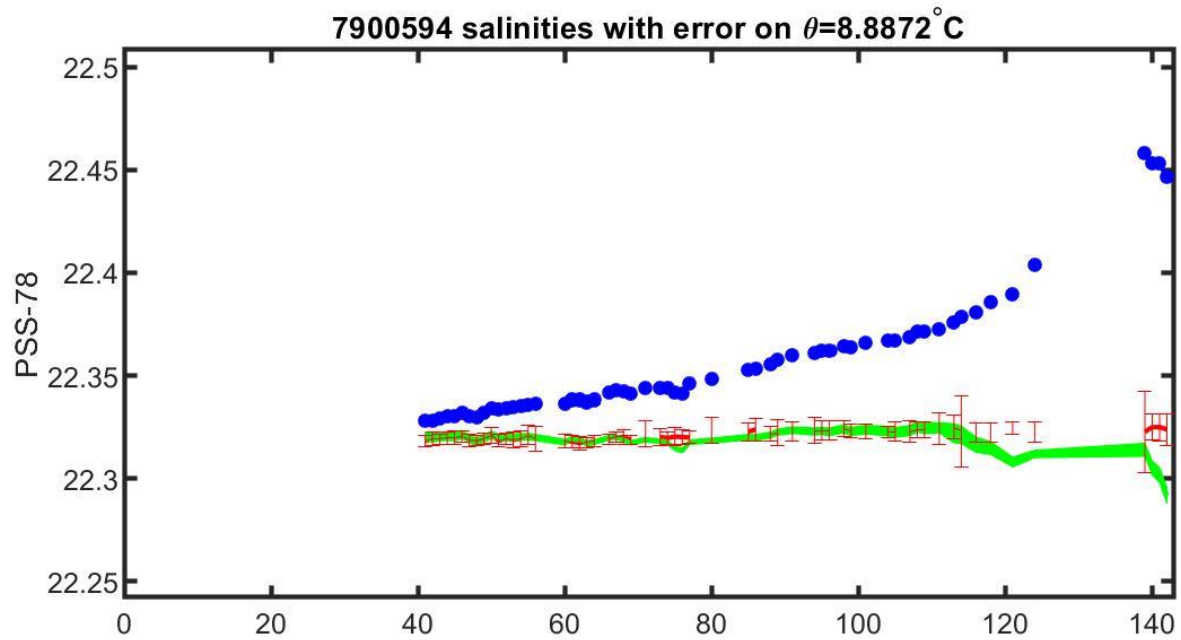


Figure 17: Float 7900594. Plots of the evolution of salinity with time along with selected theta levels with minimum salinity variance.

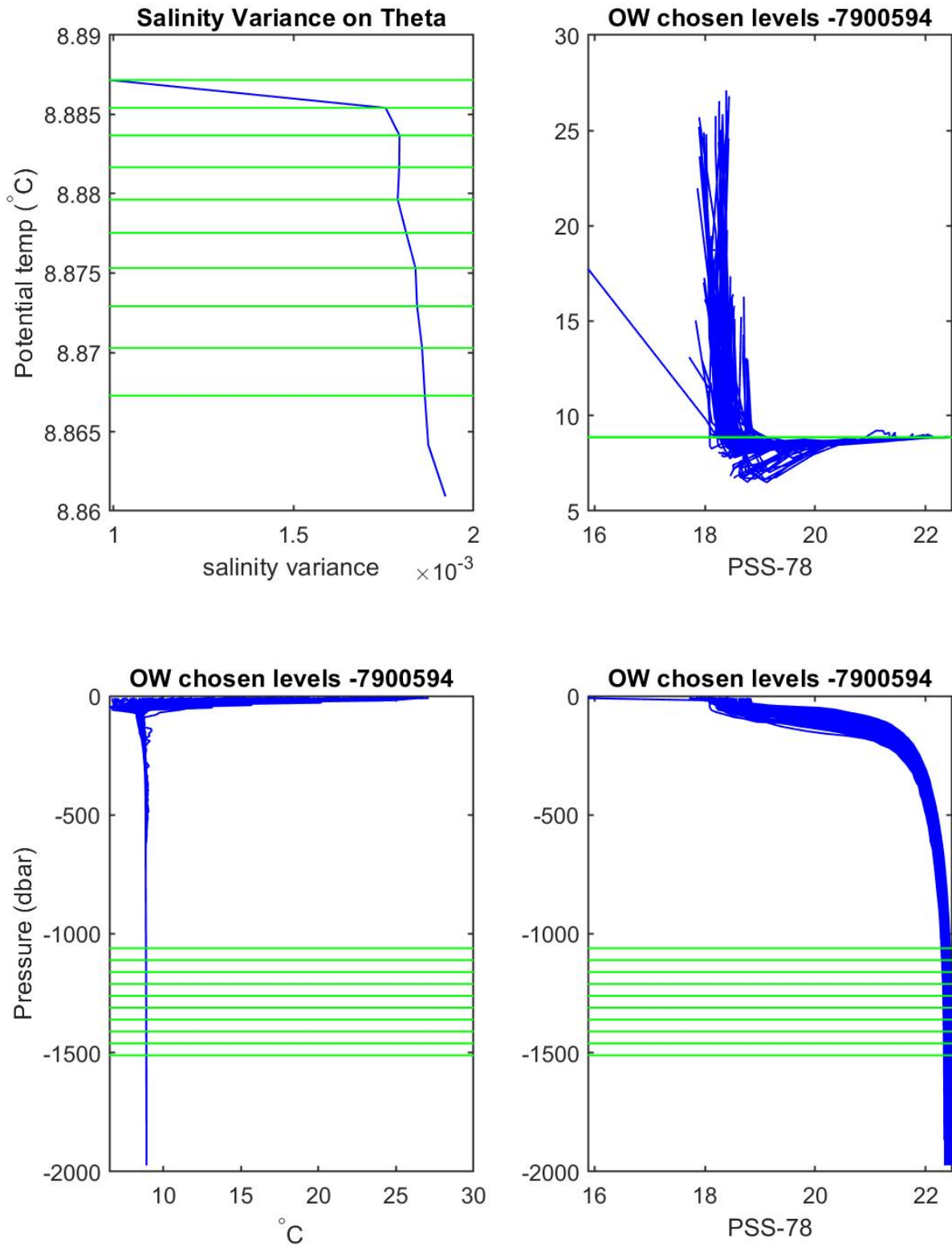


Figure 18: Float 7900594. Plots include the theta levels chosen for calibration: Top left: Salinity variance at theta levels. Top right: T/S diagram of all profiles of Argo float. Bottom left: potential temperature plotted against pressure. Bottom right: salinity plotted against pressure.

The analysis of the θ -S diagram of profile segments deeper than 700 dbar (Figure 19) shows that the OW method was run where the θ -S relationship is the tightest.

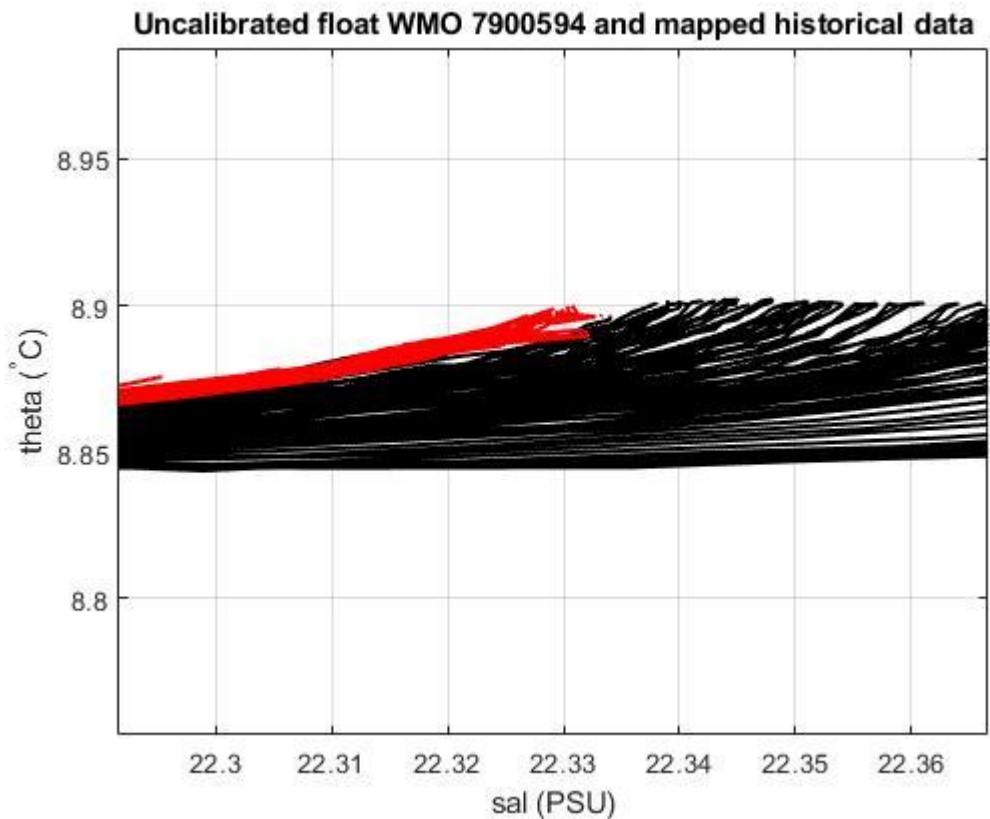


Figure 19: Float 7900594. Uncalibrated float salinity profile (black lines) and mapped historical data (red lines) in the most uniform part of the θ -S curve.

4 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 a significant salinity drift. This float was not DMQC-ed before.

The OWC analysis showed a significant salinity offset/drift. Figure 15 reveals that the least square fit could have uncertainties. Figure 17 shows that the salinity drift start from cycle 40 and increasing strongly on selected θ -levels. This float has some characteristics of a fast salty drifter: the correction gets larger than 0.01 within 1yr after deployment and reaches 0.05 within 2 years after deployment.

After several analyses, the last decision is that the salinity data of float WMO 7900594 needs a delayed mode correction. QC 1 is applied for cycles from 1 to 86 and QC 4 is applied for cycles from 87 to 142.

PSAL_ADJUSTED= PSAL + ΔS from cycle 3 to 86

PSAL_ADJUSTED= PSAL from cycle 87 to 142

The quality flags applied are the following:

PSAL_ADJUSTED_QC='1' from cycle 3 to 86

PSAL_ADJUSTED_QC='4' from cycle 87 to 142

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

5 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>