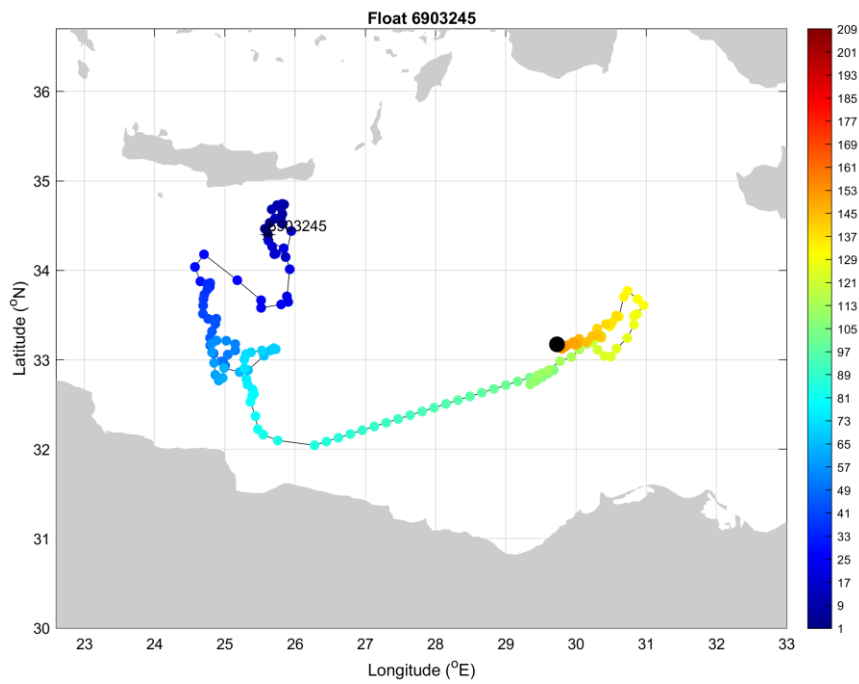


# Delayed Mode Quality Control of Argo float WMO 6903245

Antonella Gallo  
ORCID ID: 0000-0002-8836-1550

National Institute of Oceanography and Applied Geophysics - OGS  
Borgo Grotta Gigante 42/C - 34010 - Sgonico (TS) – Italy  
07/10/2021



# Contents

- 1 Introduction..... 3**
- 2 Quality Check of Argo Float Data..... 4**
  - 2.1 Verification of Real-time Mode QC flags.....4
  - 2.2 Time Series of Argo Float Temperature and Salinity .....5
  - 5
  - 2.3 Comparison Between Argo Float and Climatology .....7
- 3 Correction of Salinity Data .....13**
  - 3.1 Comparison between Argo Float and CTD Climatology.....13
    - 3.1.1 Configurations.....13
    - 3.1.2 Results.....14
- 4 Summary..... 23**
- 5 References..... 23**

## 1 Introduction

This report includes the delayed mode analysis performed for float 6903245. It was deployed in Mediterranean Sea (Cretan sub-basin) in October 2018 and performed 214 cycles. The float is still active. Before the analysis, real-time QC flags were visually inspected. The list of flags applied is QC=1 to cycles from 1 to 180 and QC 3 to cycles from 181 to 214. 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\_MED\_TS\_REP\_OBSERVATIONS\_013\_041
- Coriolis: CTD\_for\_DMQC\_2018V01
- Historical CTD profiles provided through personal contact

Argo:

- ARGO\_for\_DMQC\_2018V01

Float 6903245 is the Arvor 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 (Cabanes et al., 2016).

## **2 Quality Check of Argo Float Data**

### **2.1 Verification of Real-time Mode QC flags**

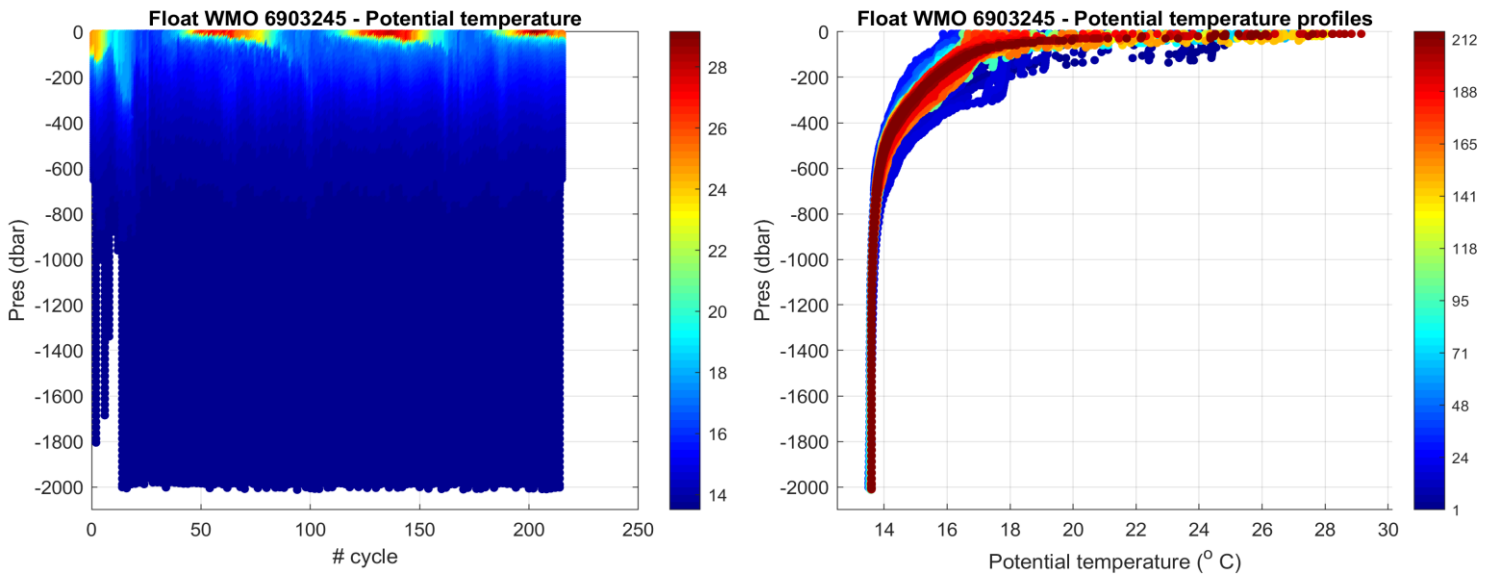
The list of flags applied to the float in real-time mode is as follows.

Cycle number:

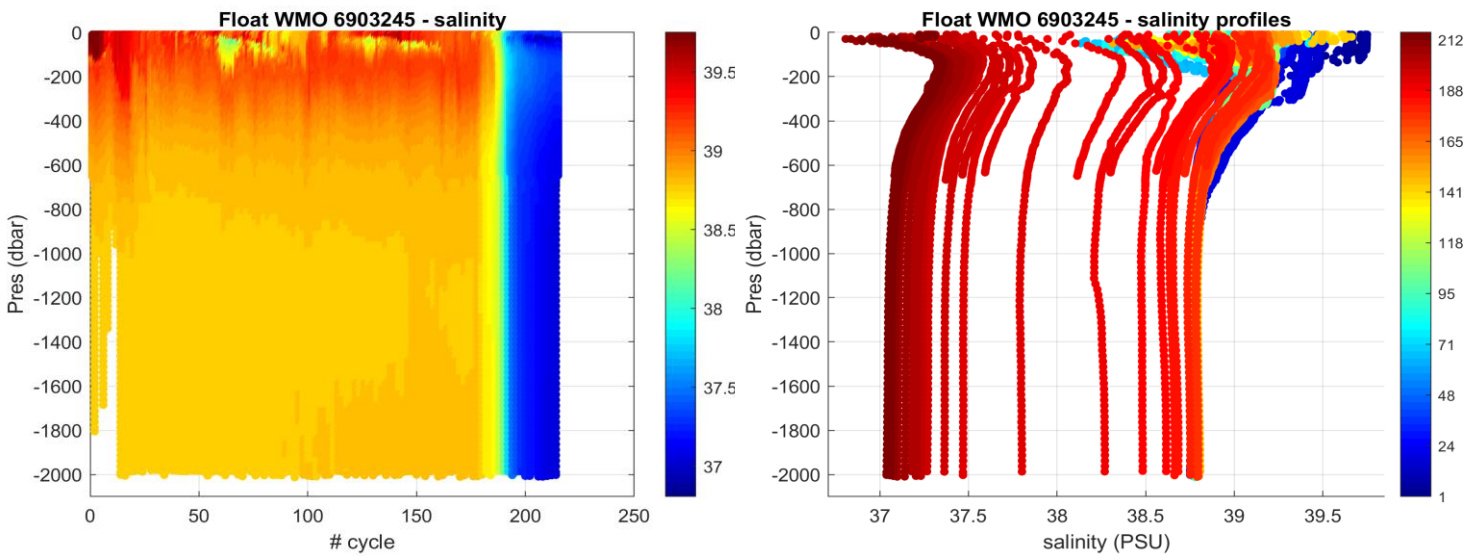
1-180 PSAL QC=1

181-214 PSAL QC=3

## 2.2 Time Series of Argo Float Temperature and Salinity

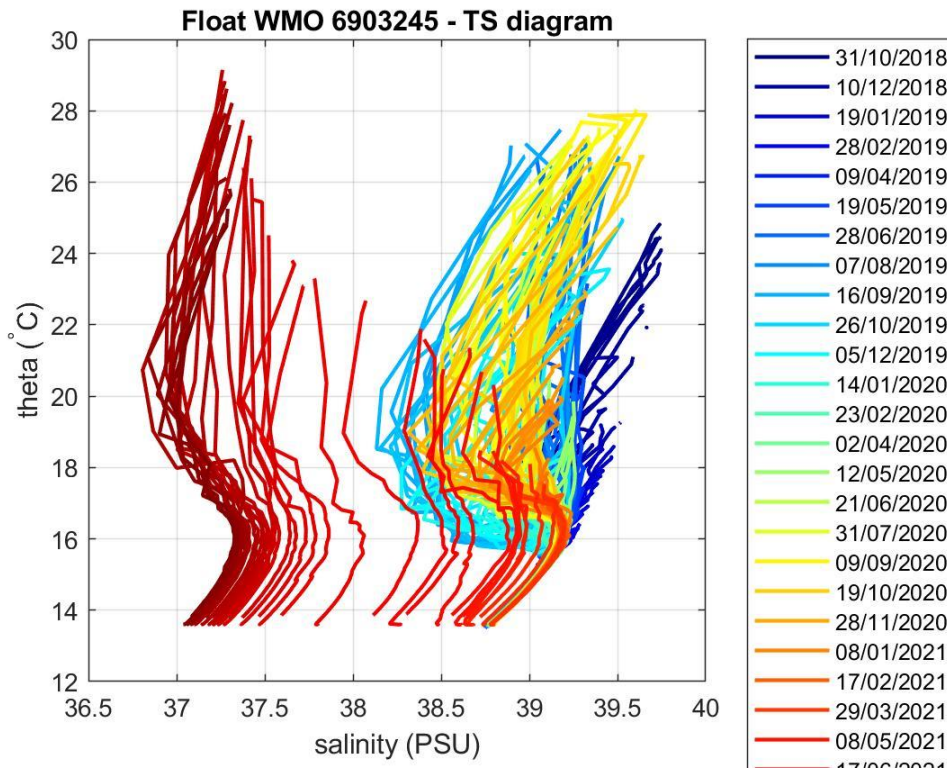


**Figure 1:** Float 6903245. Time series of Argo float potential temperature ( $^{\circ}\text{C}$ ) on the left, and potential temperature profiles color-coded per cycle number on the right.

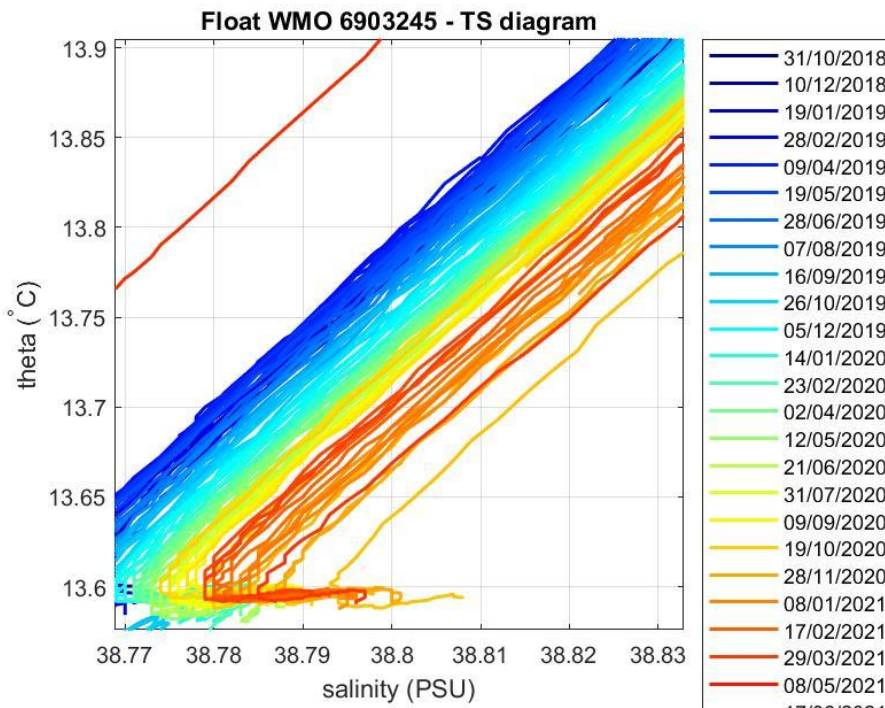


**Figure 2:** Float 6903245. Time series of Argo float potential salinity (PSS-78) on the left, and salinity profiles color-coded per cycle number on the right.

Before running the Owens and Wong method, referred to as OW hereafter, the theta-salinity ( $\theta$ -S) diagram of the float is analyzed (Figure 3) and in particular the area where the  $\theta$ -S relationship is the tightest (Figure 4). A significant salinity drift/offset is observed.



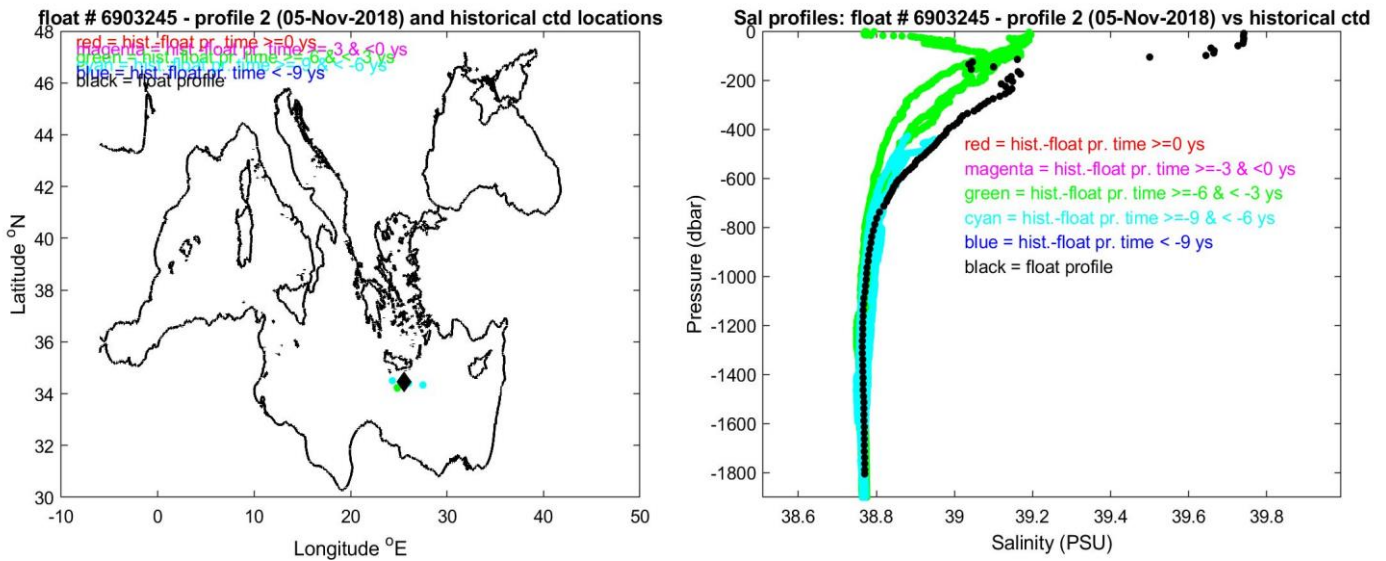
**Figure 3:** Float 6903245.  $\theta$ -S diagram color-coded per cycle number.



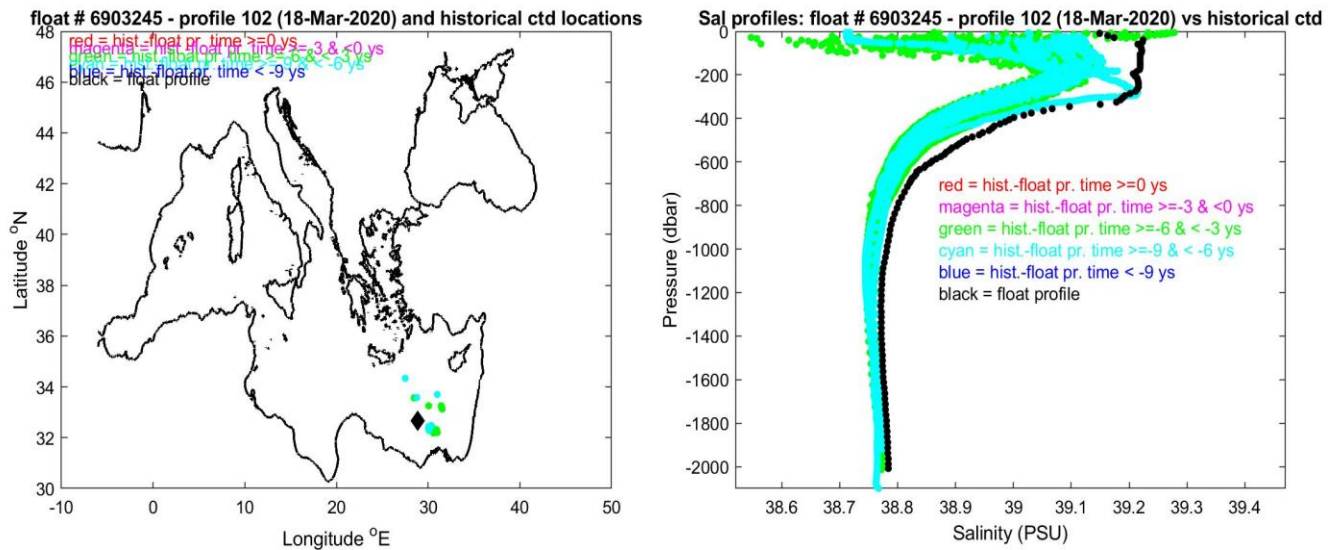
**Figure 4:** Float 6903245. Area of the  $\theta$ -S diagram (color-coded per cycle number) where the  $\theta$ -S relationship is more uniform.

### 2.3 Comparison Between Argo Float and Climatology

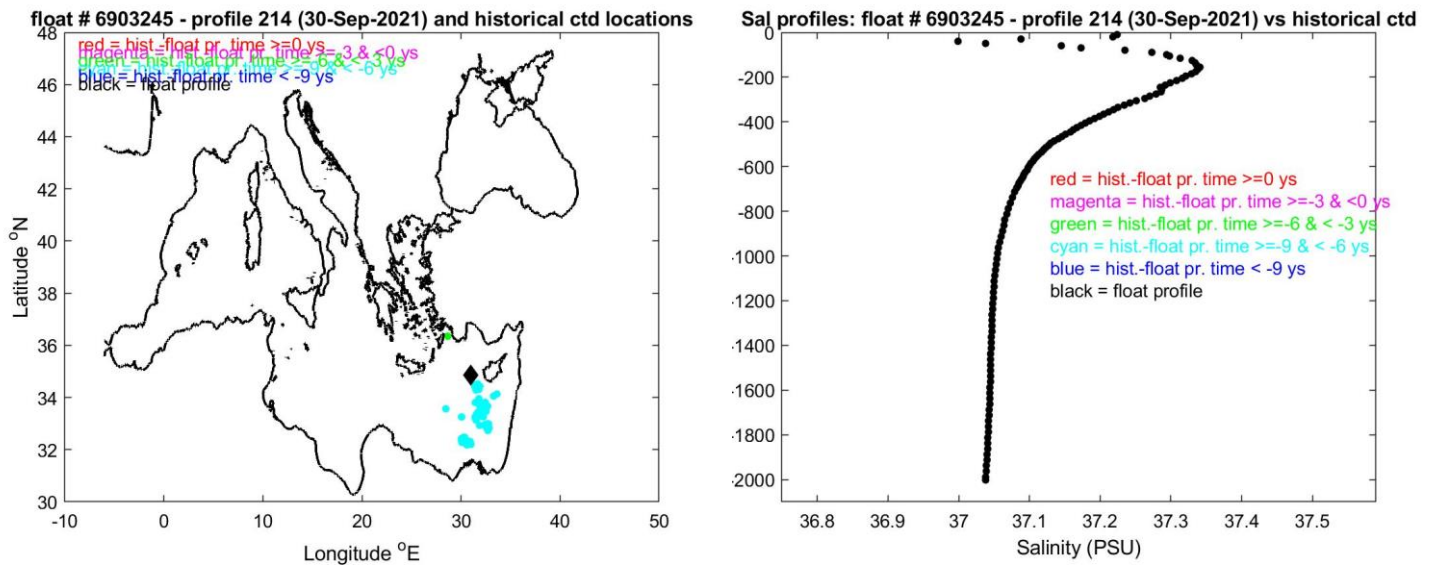
Three salinity float profiles are selected to perform a comparison (in time and space) with the historical data. In figure 5, 6 and 7 each selected profile is compared with all reference data used in this analysis. The salinity float profile is depicted in black while other colors represent the salinity 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 5:** Float 6903245. Locations of the salinity float profile number 2 and historical CTD data (right panel) and the respective salinity profiles (left panel).



**Figure 6:** Float 6903245. Locations of the salinity float profile number 102 and historical CTD data (right panel) and the respective salinity profiles (left panel).

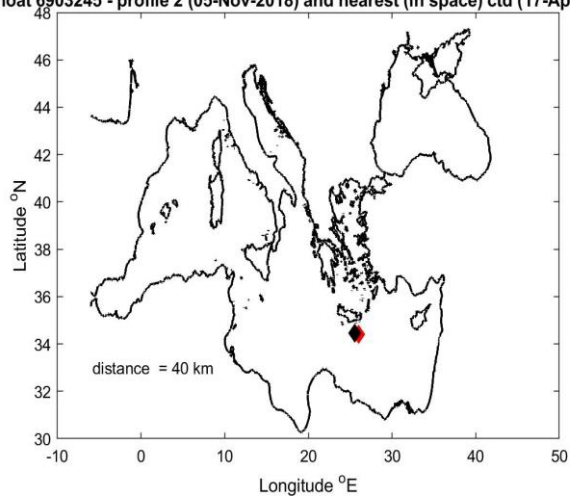


**Figure 7:** Float 6903245. Locations of the salinity float profile number 214 and historical CTD data (right panel) and the respective salinity profiles (left panel).

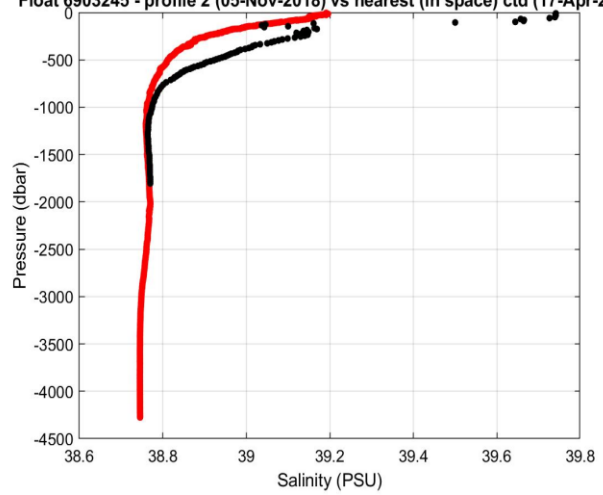
The comparison of these 3 selected salinity float profiles with the closest (in space and time) salinity reference profile is shown in Figures from 8 to 10. The agreement between the selected float salinity profiles and the historical salinity profiles is quite good in the intermediate and deeper layers, where the water column is more stable, for cycle 2. For cycle 102 the comparison shows a drift, while for cycle 214 is bad.



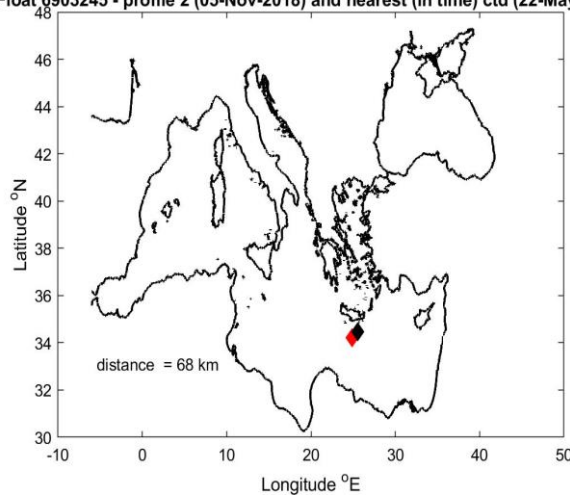
Float 6903245 - profile 2 (05-Nov-2018) and nearest (in space) ctd (17-Apr-2014)



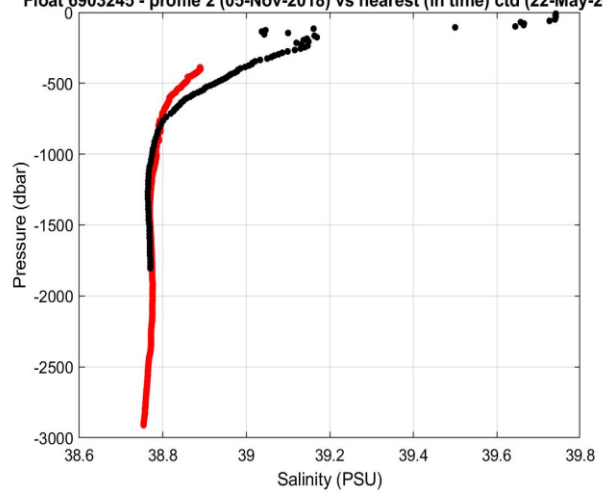
Float 6903245 - profile 2 (05-Nov-2018) vs nearest (in space) ctd (17-Apr-2014)



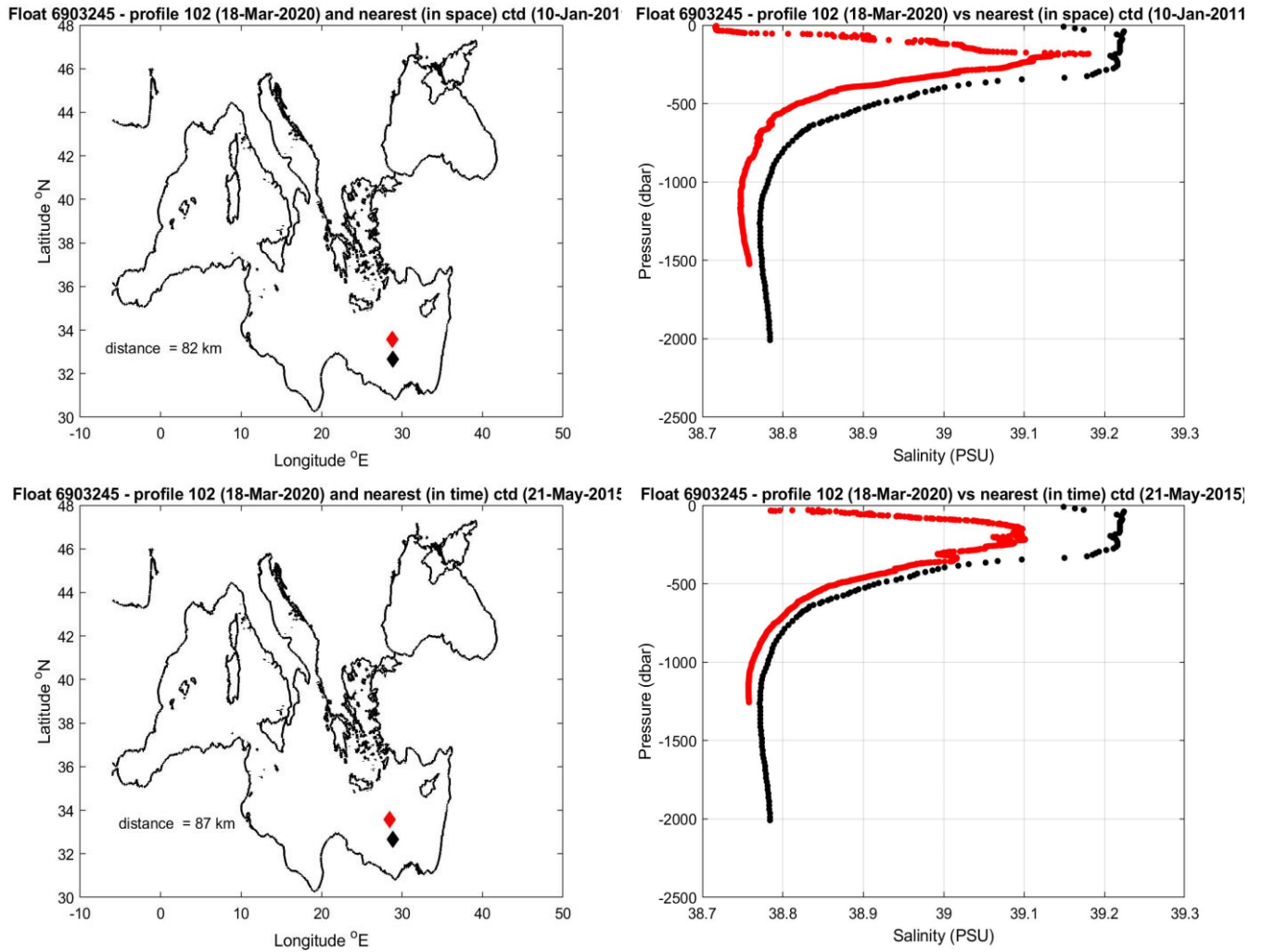
Float 6903245 - profile 2 (05-Nov-2018) and nearest (in time) ctd (22-May-2015)



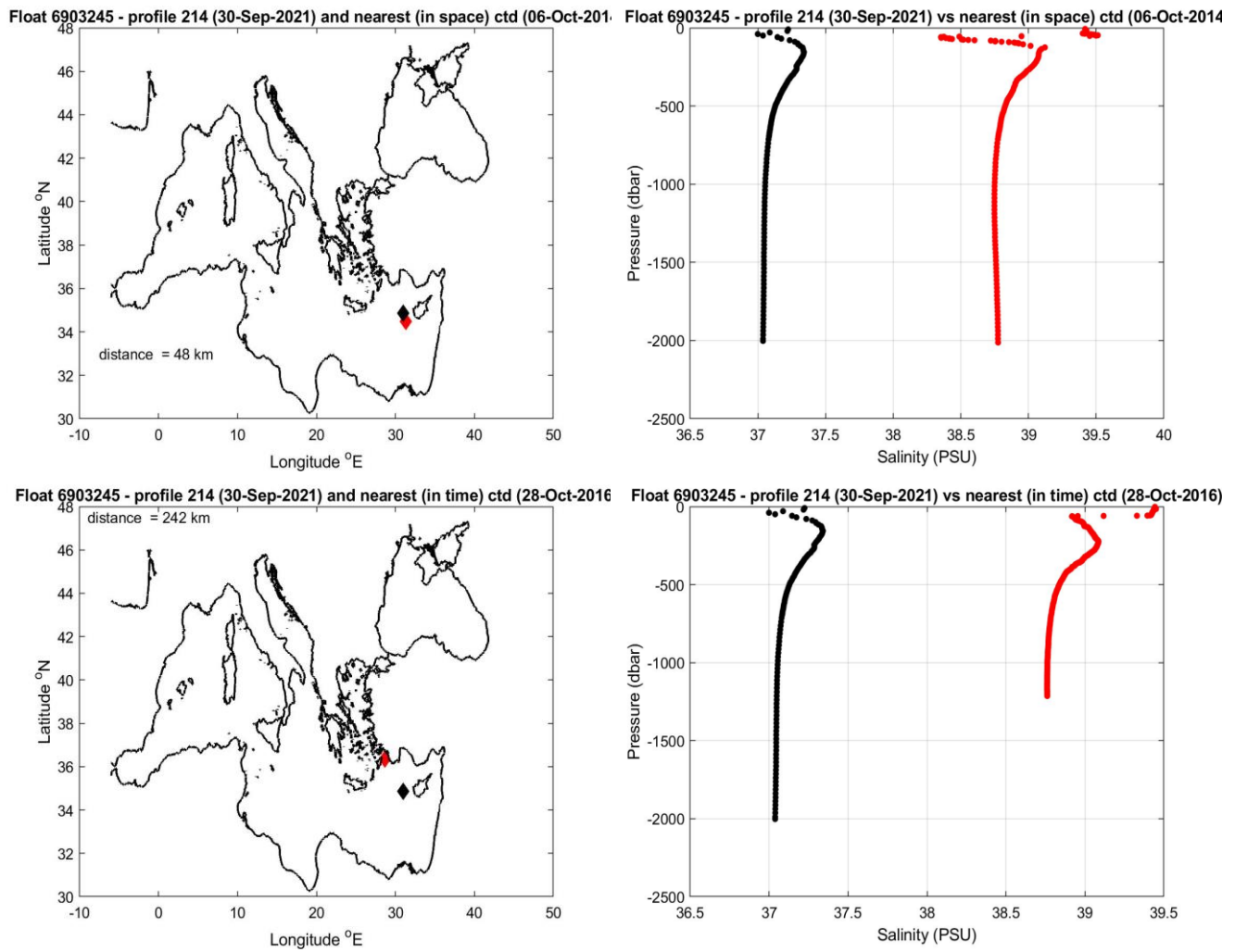
Float 6903245 - profile 2 (05-Nov-2018) vs nearest (in time) ctd (22-May-2015)



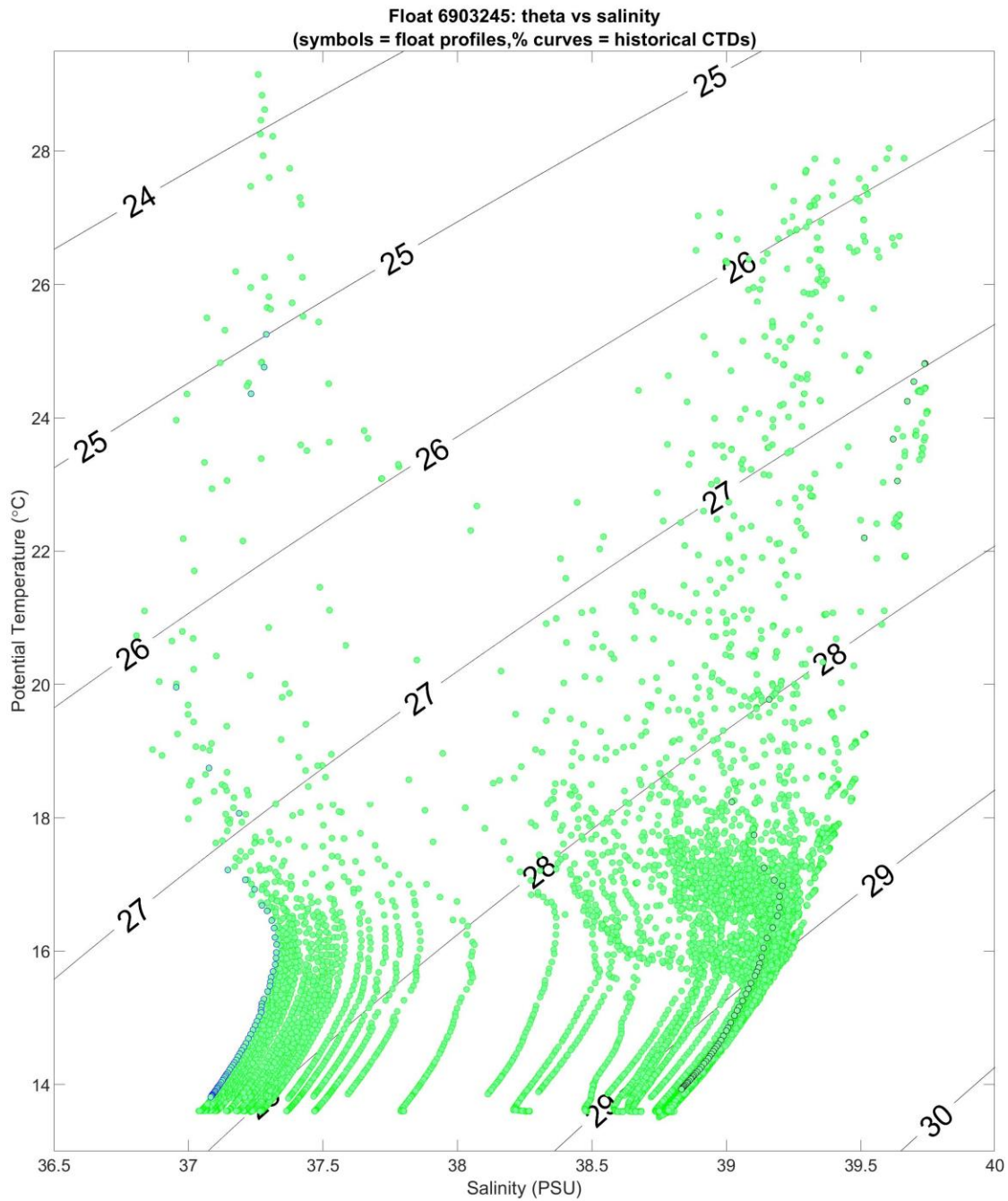
**Figure 8:** Float 6903245. The salinity float profile number 2 (black dots) are compared to the nearest in space (top) and in time (bottom) reference profile (red dots). The locations of the two profiles and their distance is given in the left panel.



**Figure 9:** Float 6903245. The salinity float profile number 102 (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 6903245. The salinity float profile number 214 (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 6903245. 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.

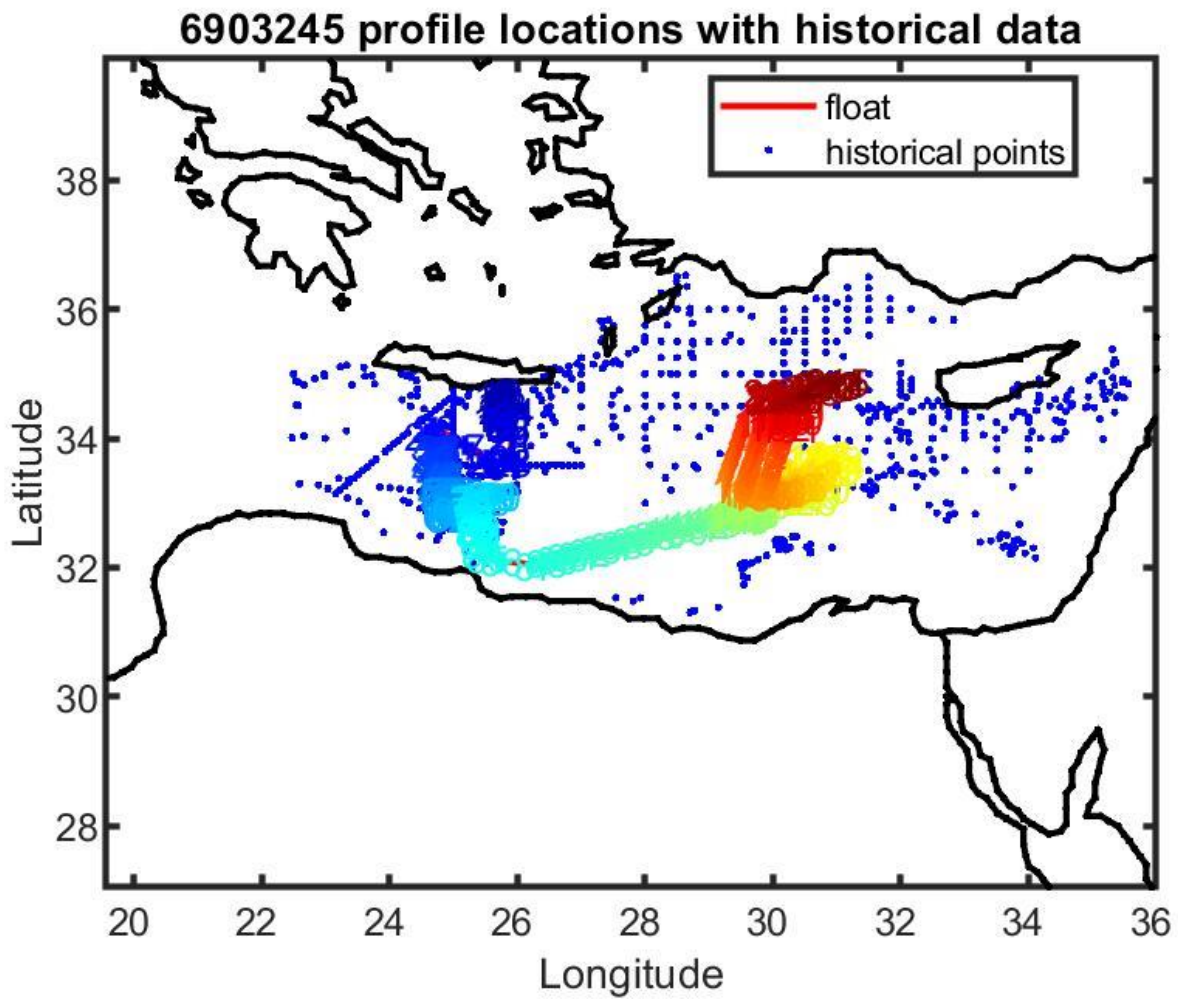
### 3 Correction of Salinity Data

#### 3.1 Comparison between Argo Float and CTD Climatology

##### 3.1.1 Configurations

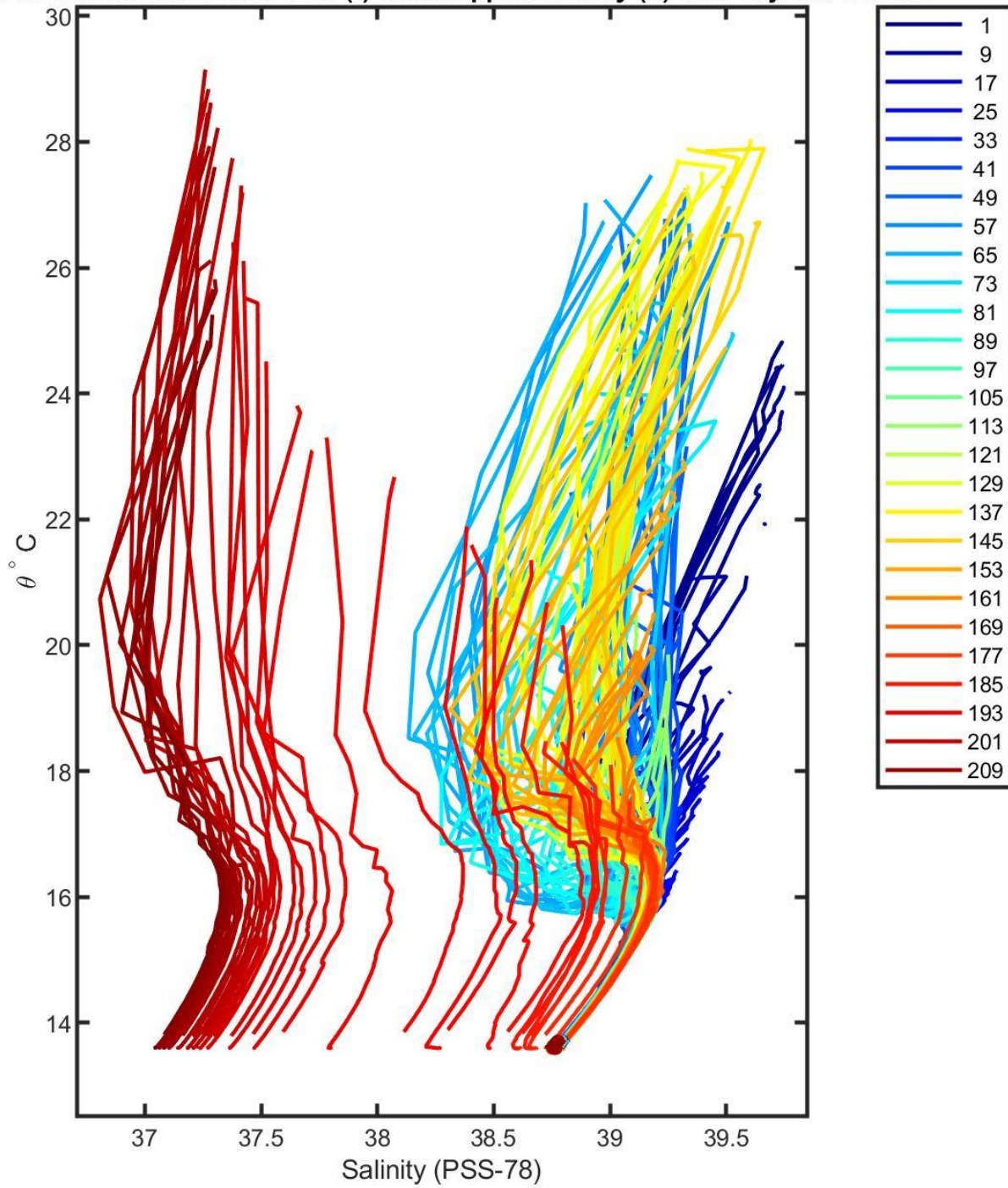
| Parameters               | Value |
|--------------------------|-------|
| CONFIG_MAX_CASTS         | 300   |
| MAP_USE_PV               | 1     |
| MAP_USE_SAF              | 0     |
| MAPSCALE_LONGITUDE_LARGE | 4     |
| MAPSCALE_LONGITUDE_SMALL | 1.33  |
| MAPSCALE_LATITUDE_LARGE  | 4     |
| MAPSCALE_LATITUDE_SMALL  | 1.33  |
| MAPSCALE_PHI_LARGE       | 0.5   |
| MAPSCALE_PHI_SMALL       | 0.1   |
| MAPSCALE_AGE             | 10    |
| MAP_P_EXCLUDE            | 700   |
| MAP_P_DELTA              | 250   |

### 3.1.2 Results

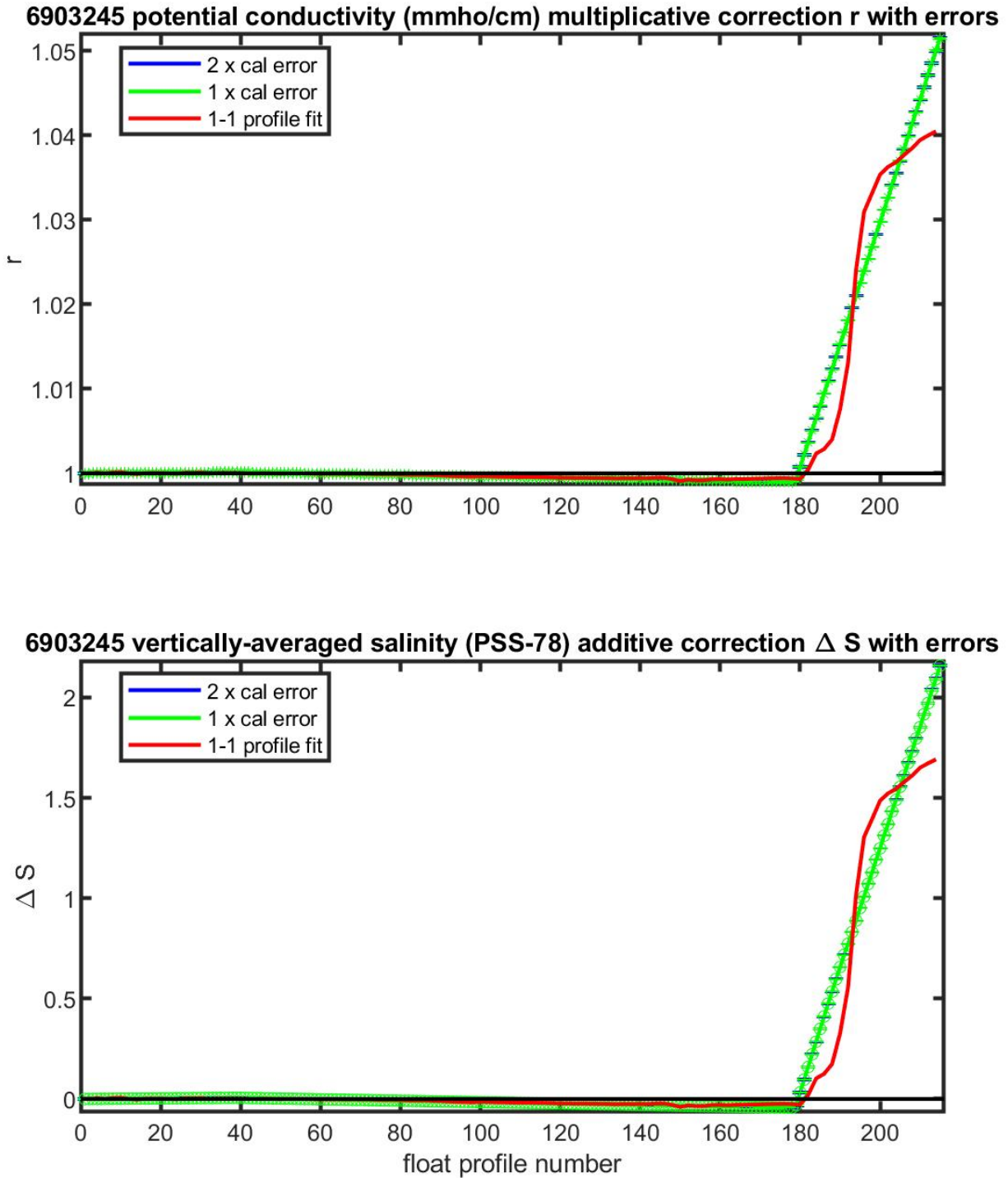


**Figure 12:** Float 6903245. Location of the float profiles (red line with colored numbers) and the reference data selected for mapping (blue dots).

6903245 uncalibrated float data (-) and mapped salinity (o) with objective errors



**Figure 13:** Float 6903245. Plot the original float salinity and the objectively estimated reference salinity at the 10 float theta levels that are used in calibration.



**Figure 14:** Float 6903245. 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.



6903245 calibrated float data (-) and mapped salinity (o) with objective errors

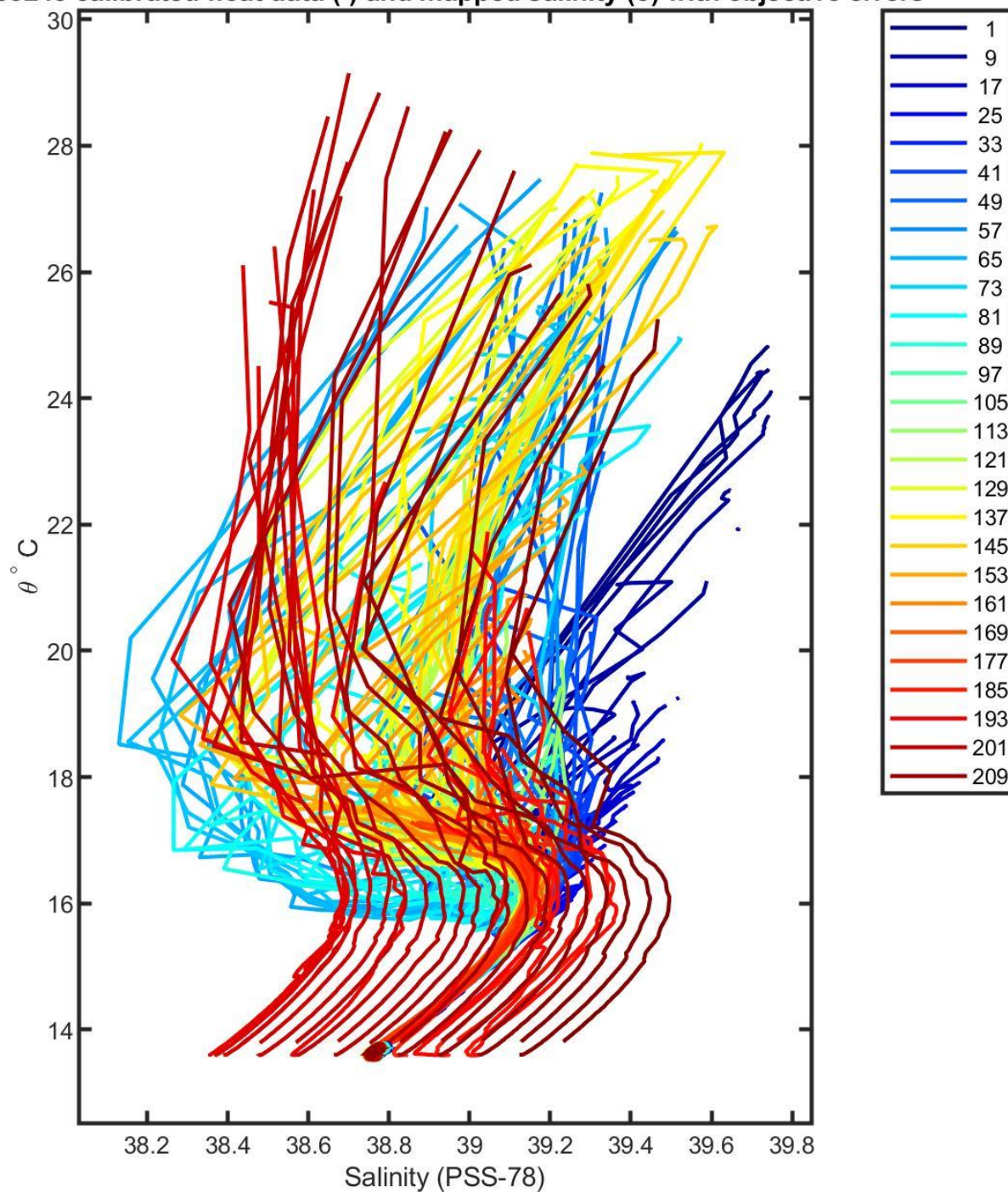
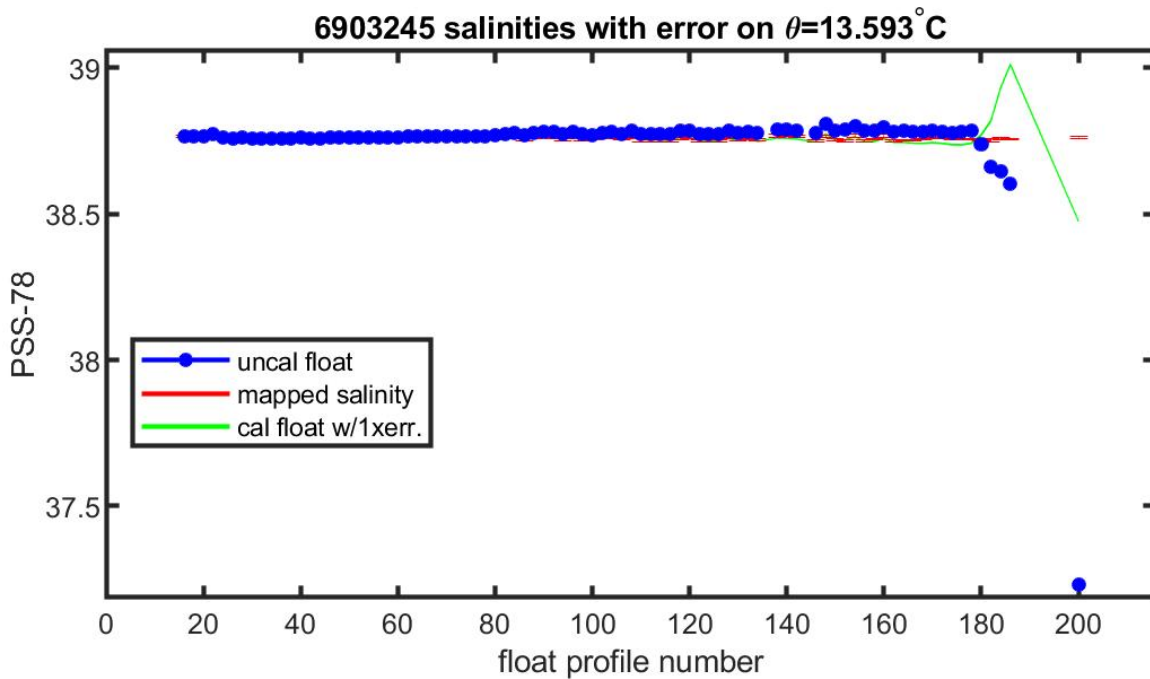
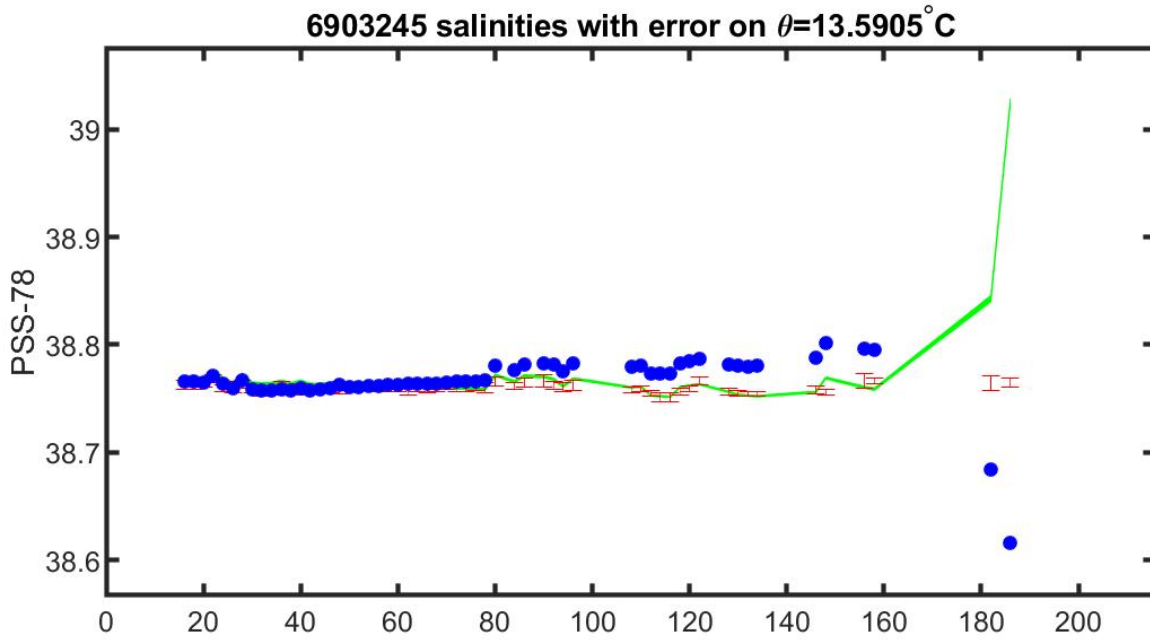
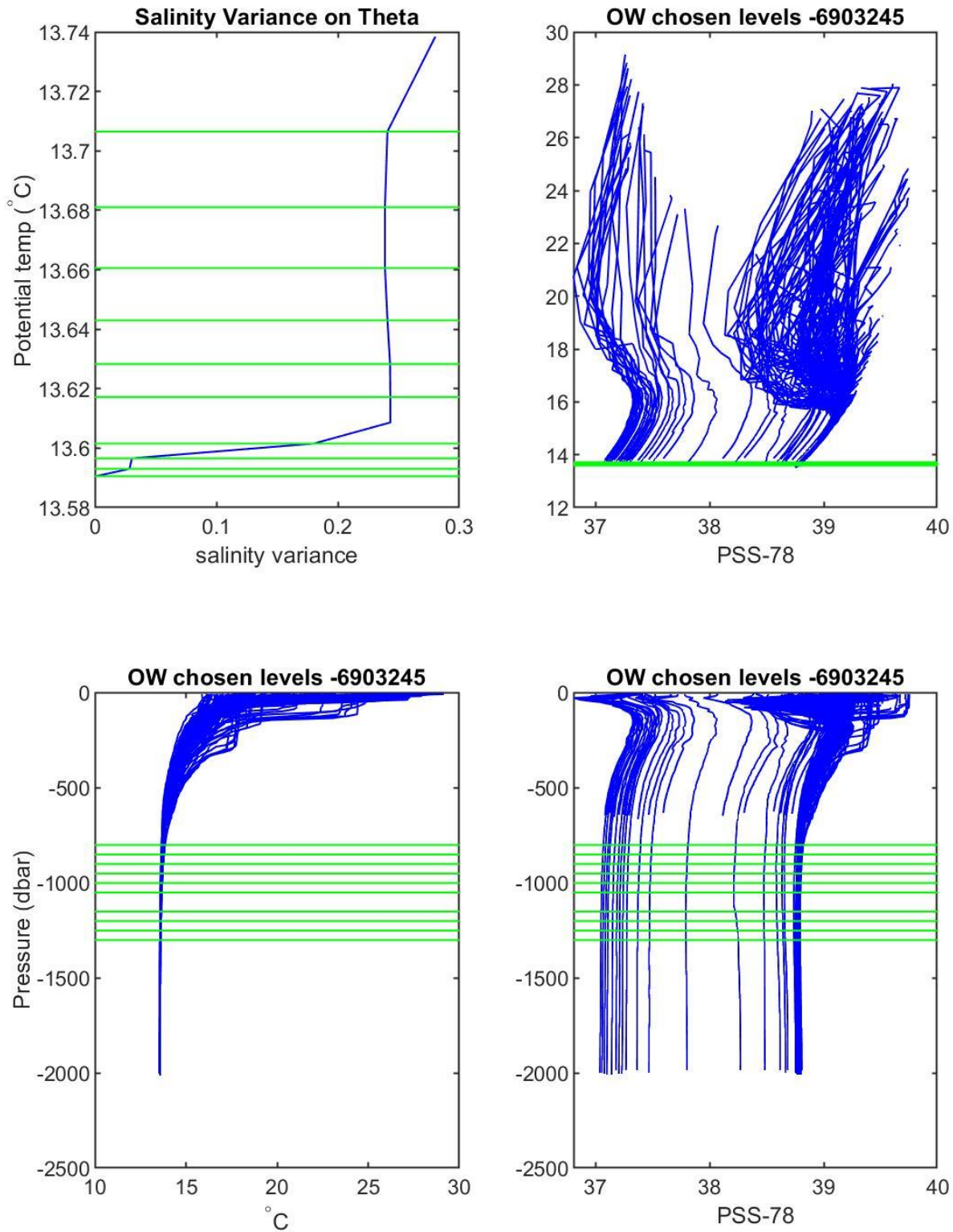


Figure 15: Float 6903245. The plot of calibrated float salinity and the objectively estimated reference salinity at the 10 float theta levels that are used in calibration.

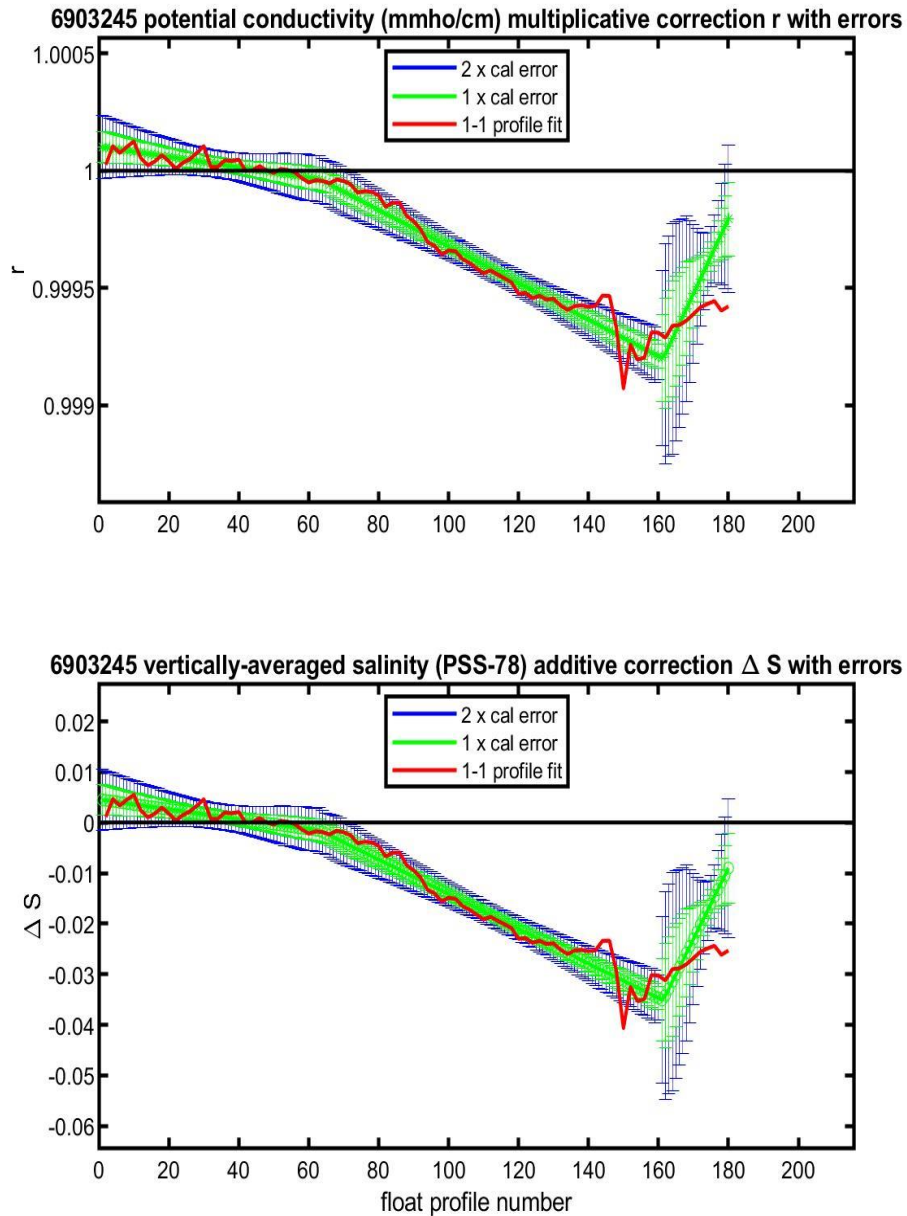


**Figure 16:** Float 6903245. Plots of the evolution of salinity with time along with selected theta levels with minimum salinity variance.

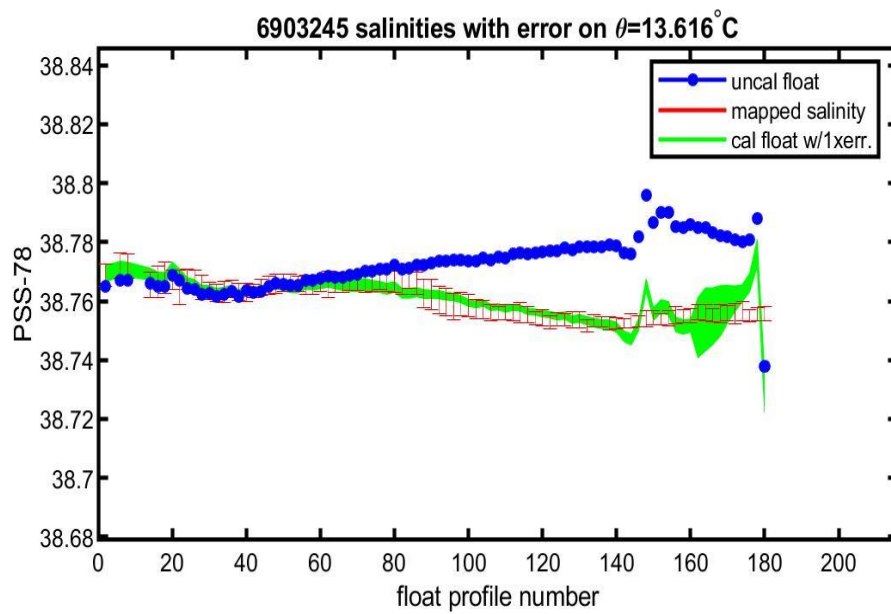
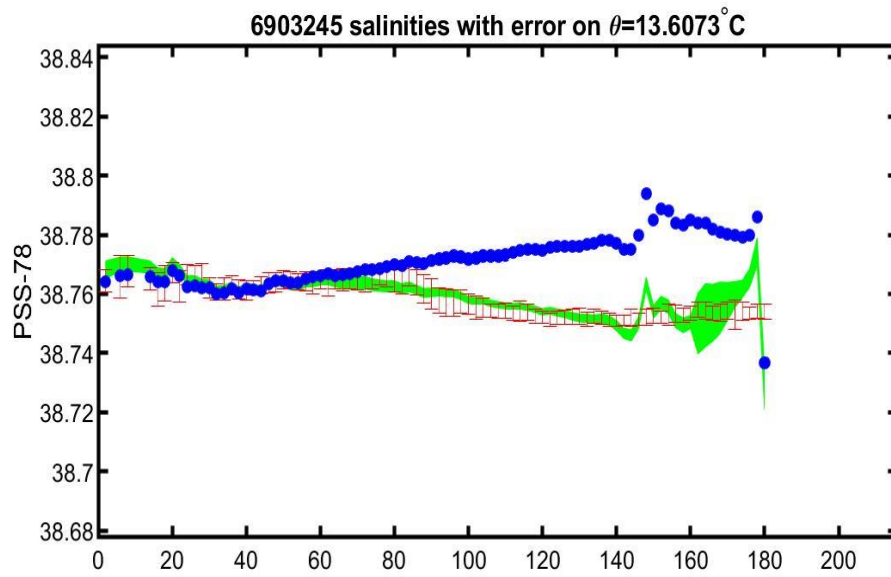


**Figure 17:** Float 6903245. Plots include the theta levels chosen for calibration: Top left: Salinity variance at theta levels. Top right: T/S diagram of all profiles of Argo float. Bottom left: potential temperature plotted against pressure. Bottom right: salinity plotted against pressure.

To understand when the drift stars figures 18 and 19 show the results of OWC obtained only for cycles with QC 1.

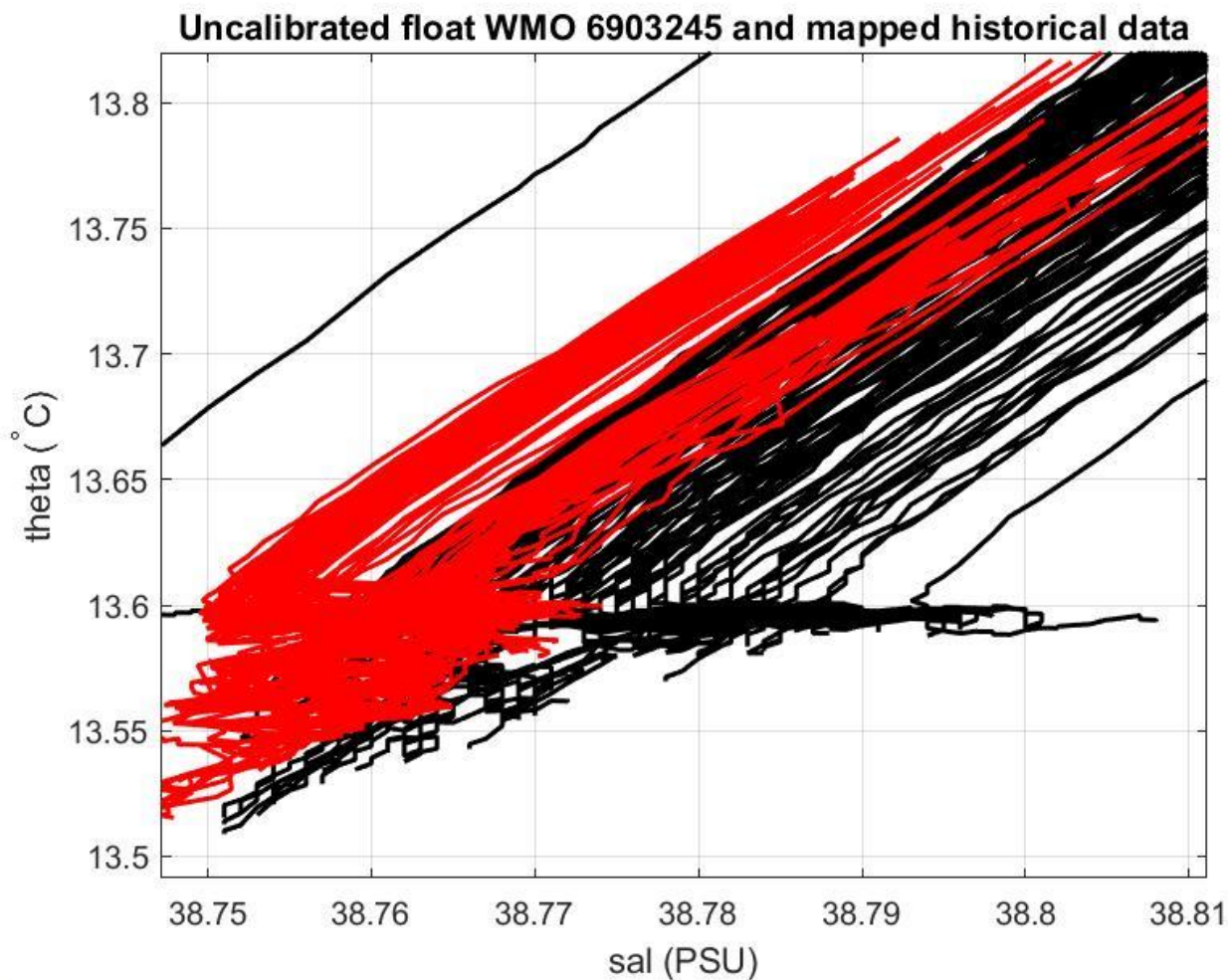


**Figure 18:** Float 6903245. On the left evolution of the suggested adjustment with time for cycles with QC 1. The top panel plots the potential conductivity multiplicative adjustment. The bottom panel plots the equivalent salinity additive adjustment. The red line denotes one-to-one profile fit that uses the vertically weighted mean of each profile. The red line can be used to check for anomalous profiles relative to the optimal fit.



**Figure 19:** Float 6903245. Plots of the evolution of salinity with time along with selected theta levels with minimum salinity variance, for cycles with QC 1.

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



**Figure 20:** Float 6903245. Uncalibrated float salinity profile (black lines) and mapped historical data (red lines) in the most uniform part of the  $\theta$ -S curve.

## 4 Summary

Float was deployed in the Cretan sub-basin, in the Mediterranean Sea. During its life passes in Leventine sub basin and is still active. The most favorable water masses, which are useful for comparison with climatology is relatively stable intermediate and deep waters from around 700 m. The initial comparison between Argo float and reference data shows a significant salinity offset/drift. This float wasn't DMQC-ed before.

The OWC analysis showed a significant salinity offset. Figure 14 reveals that the least square fit could have uncertainties. Figure 16 shows that the float salinity is quite constant on selected  $\theta$ -levels until cycle 180, then a significant drift starts. To understand when the drift starts, OWC is done only for cycles with PSAL QC 1. Figure 19 shows a positive drift that starts from cycle 60. 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 3 years after deployment. The correction proposed by OW is over the Argo requested accuracy (0.01). After several analyses, the last decision is that the salinity data of float WMO 6903245 needs a delayed mode correction for cycles from 1 to 179. QC 1 is applied. No correction is done to cycles from 180 to 214 and QC 4 is applied.

PSAL\_ADJUSTED=PSAL +  $\Delta S$  from cycle 1 to 179

PSAL\_ADJUSTED=PSAL from cycle 180 to 214

The quality flags applied are the following:

PSAL\_ADJUSTED\_QC='1' from cycle 1 to 179

PSAL\_ADJUSTED\_QC='4' from cycle 180 to 214

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>

Annie Wong, Robert Keeley, Thierry Carval and the Argo Data Management Team (2020). Argo Quality Control Manual for CTD and Trajectory Data. <http://dx.doi.org/10.13155/33951>