Delayed Mode Quality Control of Argo float WMO 6903203

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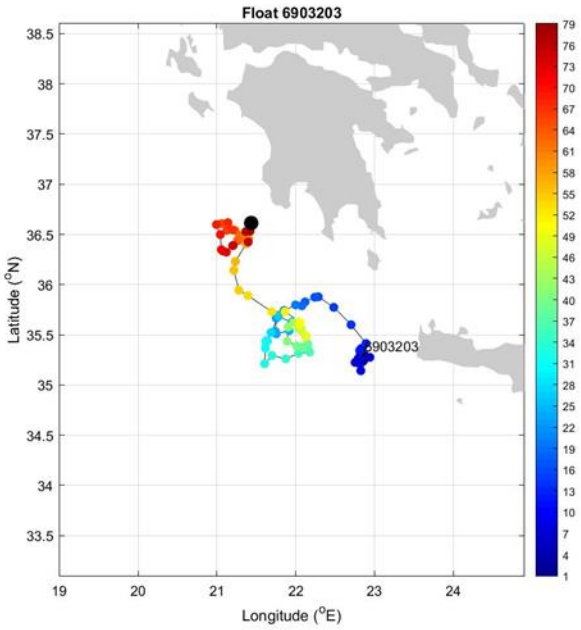

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1 Introduction

This report includes the delayed mode analysis performed for the WMO 6903203 Deep float. It was deployed in the Mediterranean Sea (Ionian sub-basin within the Hellenic Trench area) in December 2016 and performed 81 cycles. The float is inactive. The real time flag applied to pressure, temperature and salinity is QC=1 to all cycles. For this type of floats (Deep-Argo), the salinity data show a bias that is dependent on pressure. Therefore, is necessary to correct for pressure effects on conductivity (CPcor correction). Plots of salinity plotted against the nearby historical CTD profiles were generated to understand if the sensor was well calibrated at deployment. This visual analysis can also 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_GLO_TS_REP_OBSERVATIONS_013_001_b
- Coriolis: CTD_for_DMQC_2021V01
- Historical CTD profiles provided through personal contact

Argo:

- ARGO_for_DMQC_2020V03

Float 6903203 is an Arvor float, where the pressure sensor is auto corrected and no adjustment is required.
The OWC method was run to estimate a salinity offset and a salinity drift (Cabanes et al., 2016).

2 Cpcor correction

Three CPcor values are used: the nominal CPcor value used by Sea-Bird, the recommended standard CPcor_new values and the optimized estimate of CPcor_new. They are applied to correct the salinity bias due to the pressure effect. The CTD closest in space and time is used to calculate the optimized CPcor value because there is no CTD at deployment. The choice of the default CPcor value shows the smallest deviation between the CPcor corrected float salinity profile and the reference CTD profile (Fig. 1). Hence the best solution is achieved by using the standard CPcor recommended by Deep Argo Team, already applied in real time.

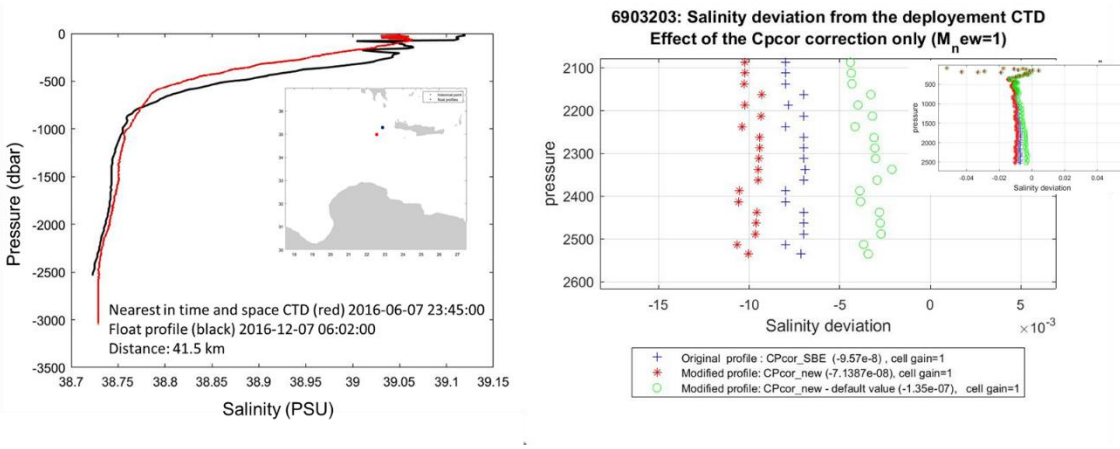

Figure 1: Float 6903203. Left panel: The salinity of the first float profile (black line) compared to the nearest in time and space CTD reference profile (red line). Right panel: Salinity deviation from the CTD due to the CPcor correction using the three values: the nominal CPcor value from Sea-Bird, the CPcor_new default value obtained by Deep-Argo deep team and the optimized CPcor value obtained in delayed-mode by comparing a deep float profile to a reference profile.

3 Quality Check of Argo Float Data

Before applying the OWC method, additional analyses are applied in complement of the main analysis, to provide the best quality control analysis.

3.1 Time series of Argo Float Temperature and Salinity

The visual inspection of profiles diagrams: pressure versus temperature (P-T) (Fig. 2, right panel) and versus salinity (P-S) (Fig. 3, right panel) helps in detecting salinity anomalies and spikes.

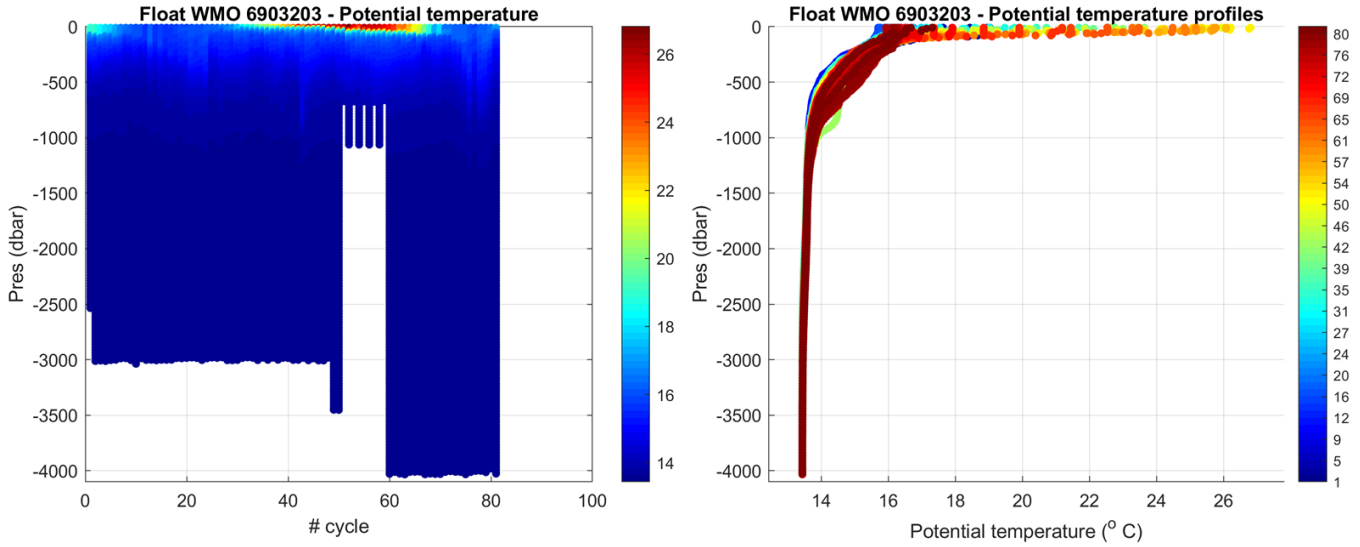

Figure 2: Float 6903203. Time series of Argo float potential temperature (°C) on the left, and potential temperature profiles color-coded per cycle number on the right.

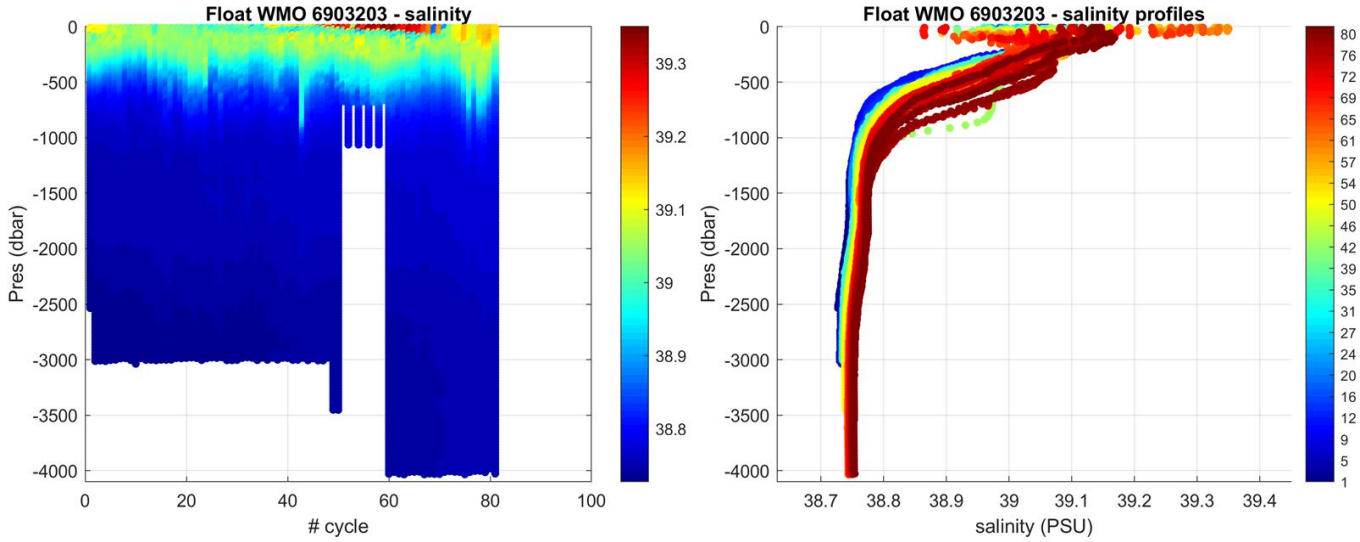

Figure 3: Float 6903203. Time series of Argo float potential salinity (PSS-78) on the left, and salinity profiles color-coded per cycle number on the right.

The theta-salinity (θ-S) diagram of the float is analyzed and in particular the area where the θ-S relationship is the tightest (Fig. 4). The systematic vertical shift suggests the salinity drift.

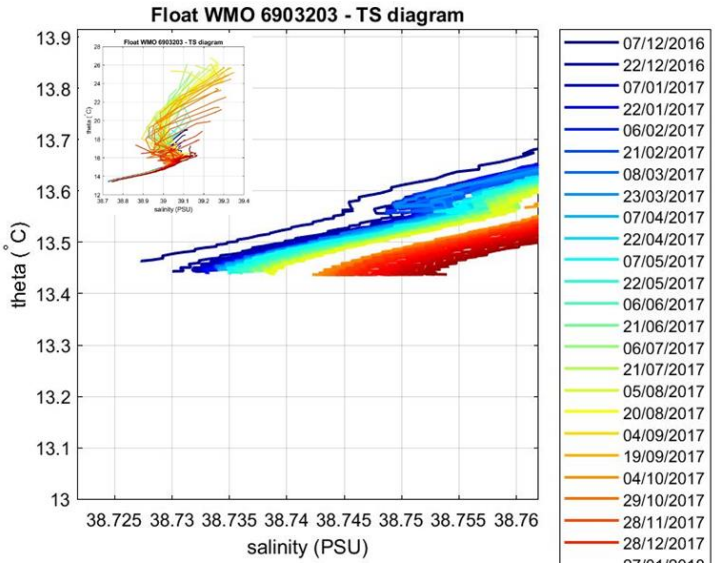

Figure 4: Float 6903203. Area of the θ-S diagram (color-coded per cycle number) where the θ-S relationship is more uniform.

3.2 Comparison Between Argo Float and Climatology

Two salinity float profiles are selected to perform a comparison (in time and space) with the historical data. In figure 5 and 6 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 9 years). A time difference between 3 and 6, 6 and 9 and larger than 9 years is depicted in green, cyan and blue, respectively.

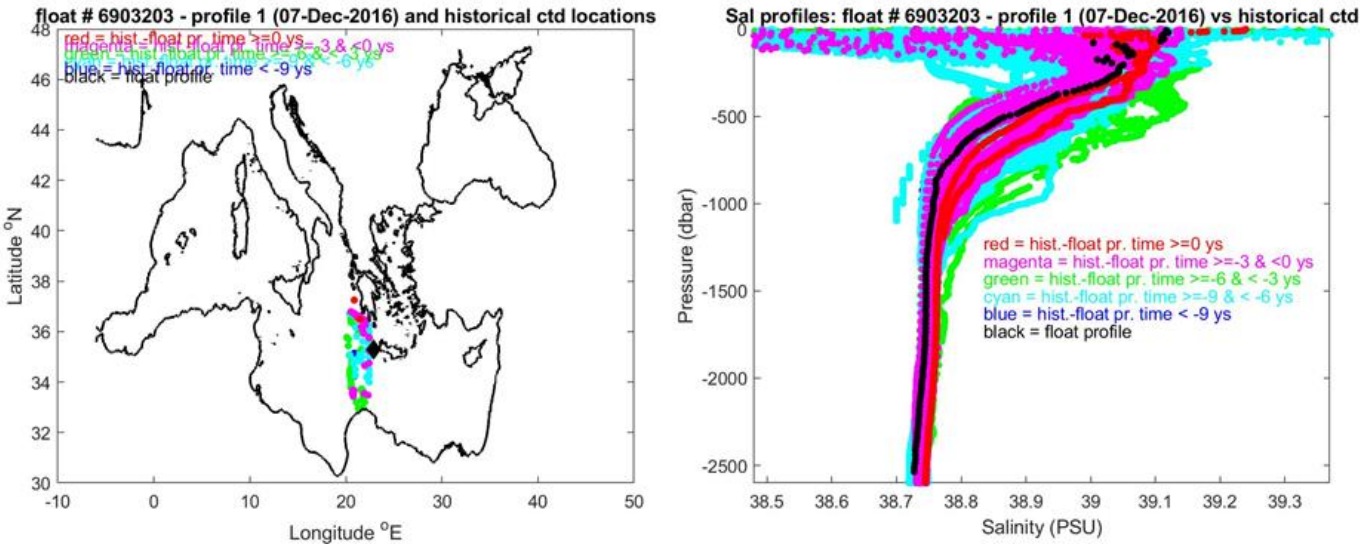

Figure 5: Float 6903203. Locations of the salinity float profile number 1 and historical CTD data (right panel) and the respective salinity profiles (left panel).

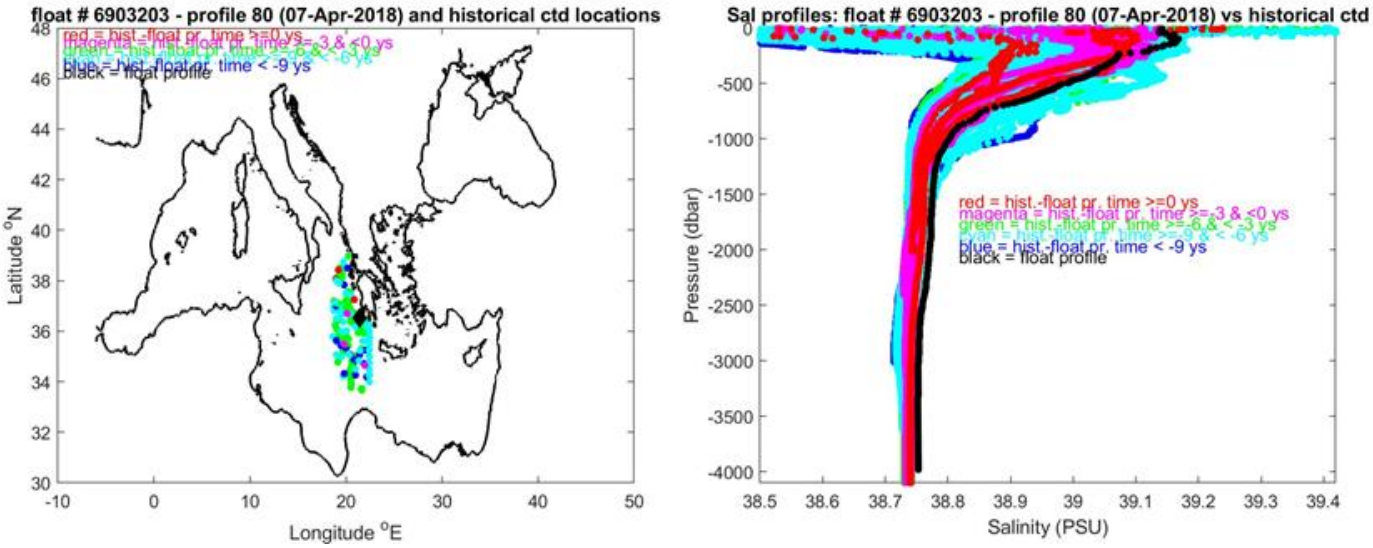

Figure 6: Float 6903203. Locations of the salinity float profile number 80 and historical CTD data (right panel) and the respective salinity profiles (left panel).

The comparison of these two salinity float profiles with the closest (in space and time) salinity reference profile is shown in Figure 7. The agreement between the first float salinity profile and the historical salinity profiles is good in the intermediate and deeper layers, where the water column is more stable. The comparison between salinity profile 80 and CTD evidences a bias. This is an indication of a potential drift.

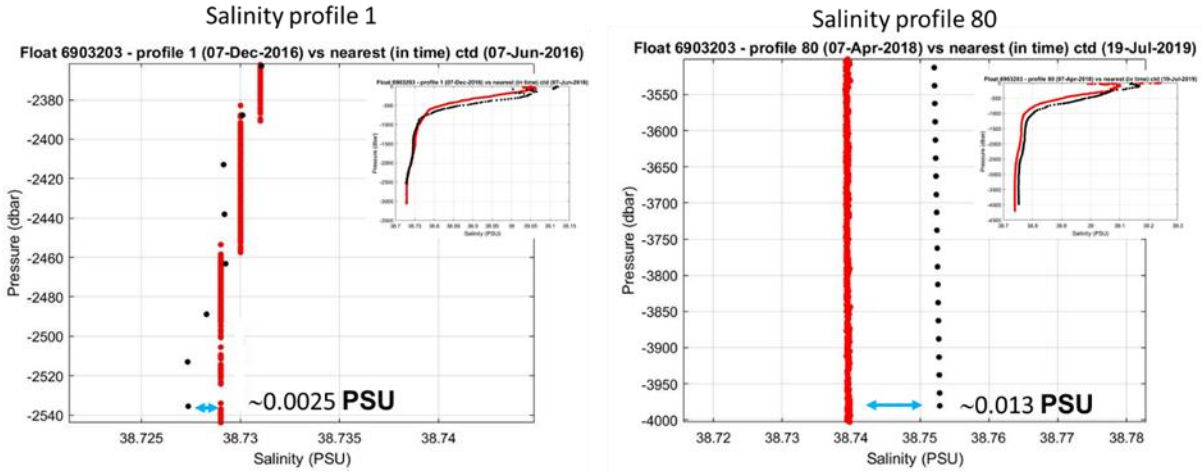

Figure 7: Float 6903203. The salinity (black dots) of profile 1 (on the left) and profile 80 (on the right) are compared to the nearest in time reference profile (red dots). The deviation of the two profiles indicates the drift.

4 Correction of Salinity Data

4.1 Comparison between Argo Float and CTD Climatology

4.1.1 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	2000
MAP_P_DELTA	250

4.1.2 Results

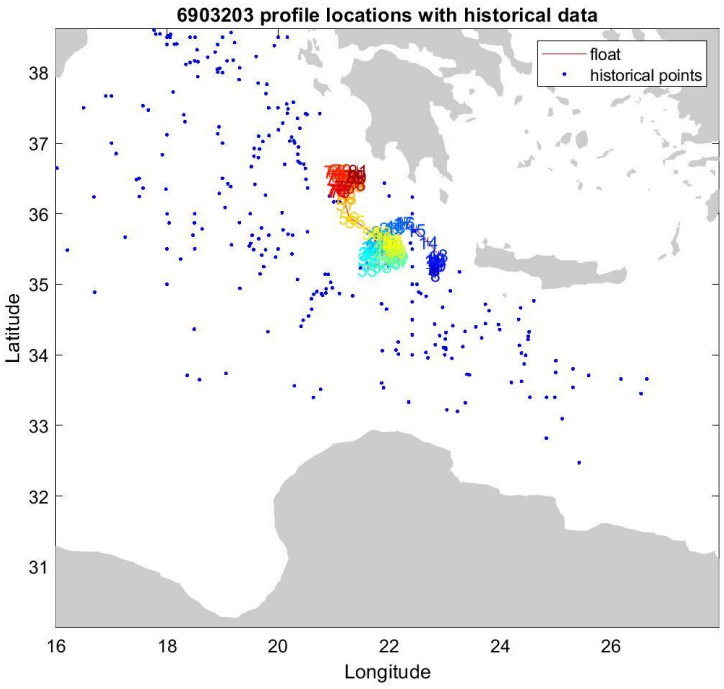

Figure 8: Float 6903203. Location of the float profiles (red line with colored numbers) and the reference data selected for mapping (blue dots).

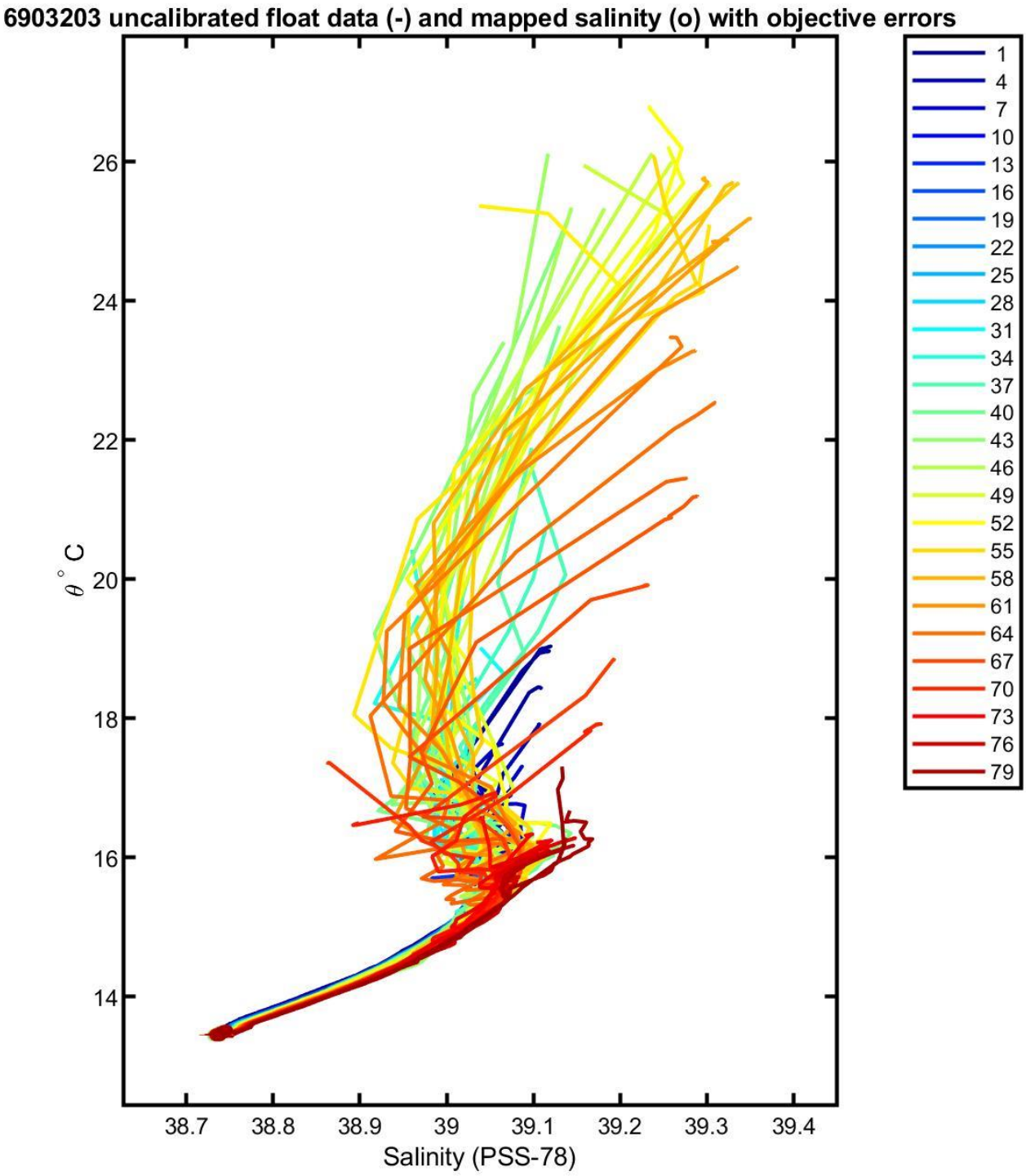

Figure 9: Float 6903203. Plot the original float salinity and the objectively estimated reference salinity at the 10 float theta levels that are used in calibration.

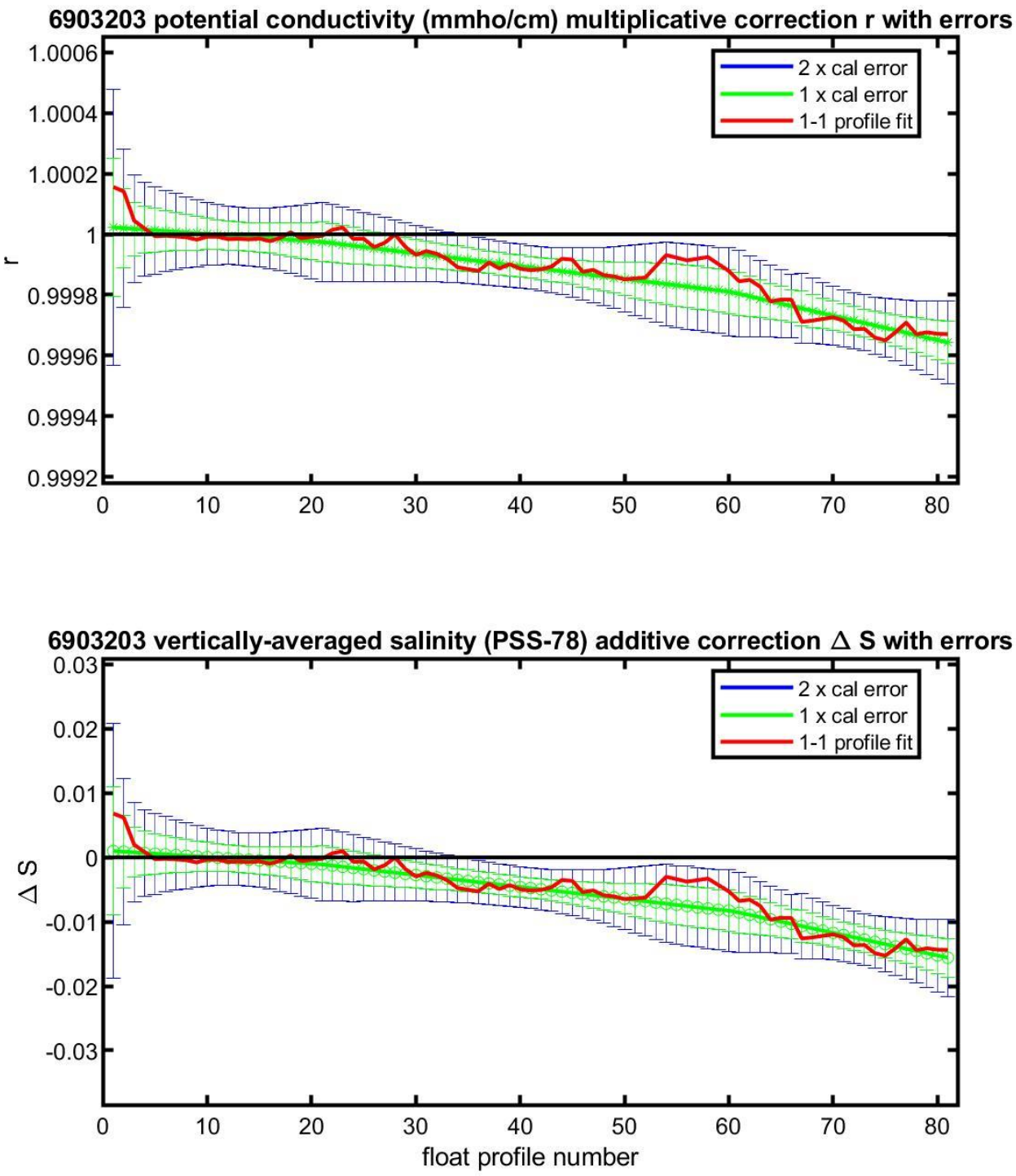

Figure 10: Float 6903203. Evolution of the suggested adjustment with time. The top panel plots the potential conductivity multiplicative adjustment. The bottom panel plots the equivalent salinity additive adjustment. The red line denotes one-to-one profile fit that uses the vertically weighted mean of each profile. The red line can be used to check for anomalous profiles relative to the optimal fit.

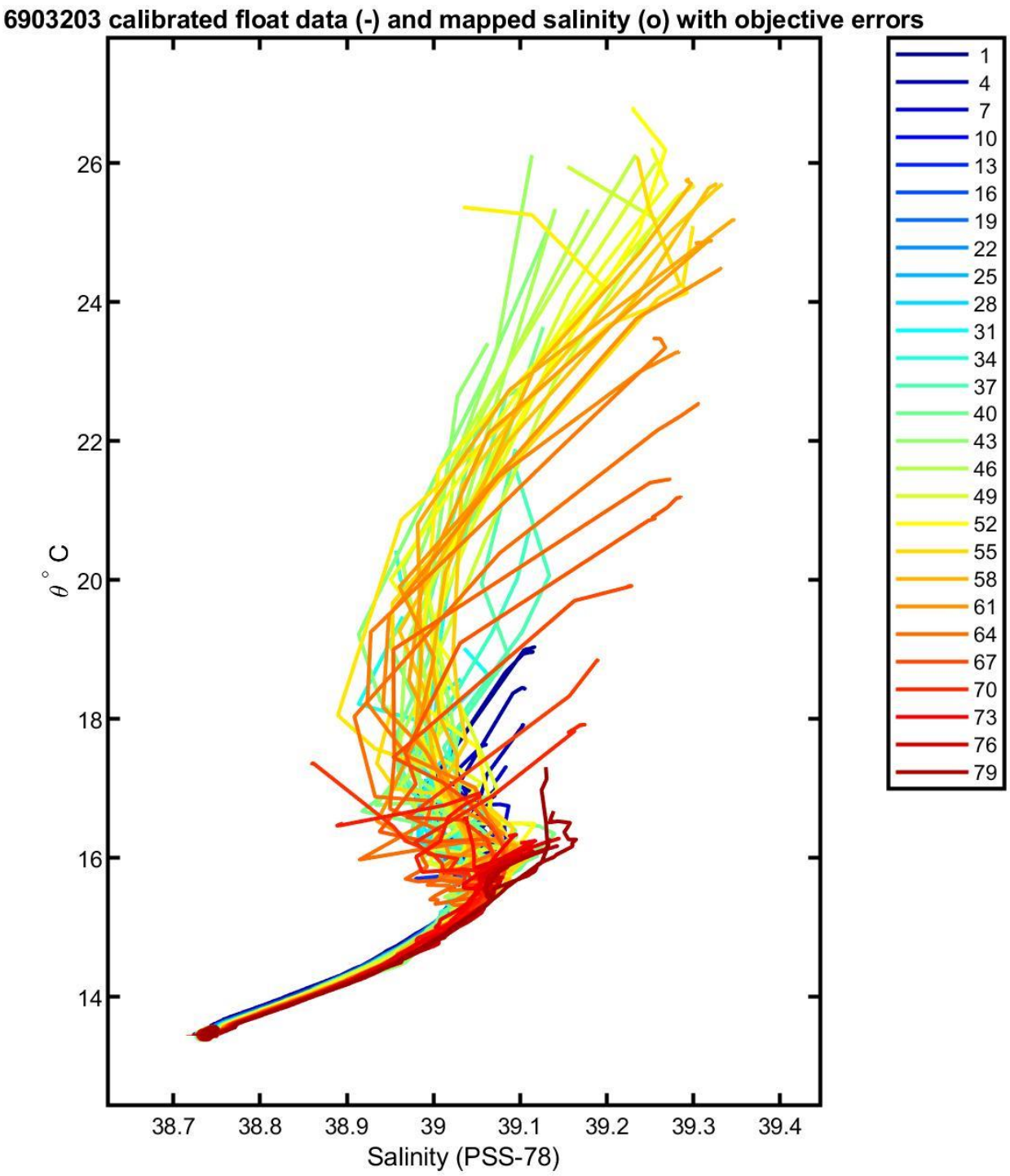

Figure 11: Float 6903203. The plot of calibrated float salinity and the objectively estimated reference salinity at the 10 float theta levels that are used in calibration.

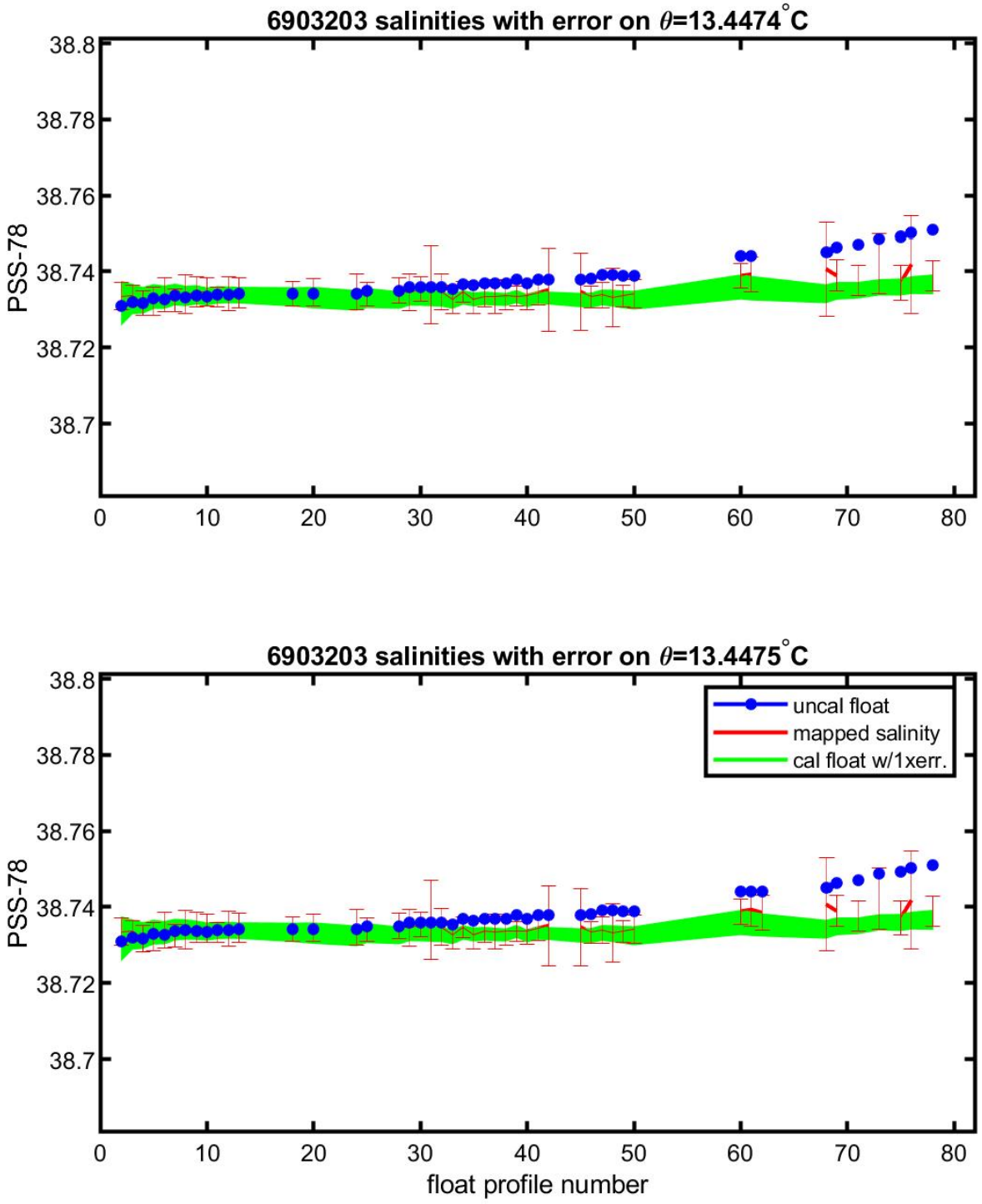

Figure 12: Float 6903203. Plots of the evolution of salinity with time along with selected theta levels with minimum salinity variance.

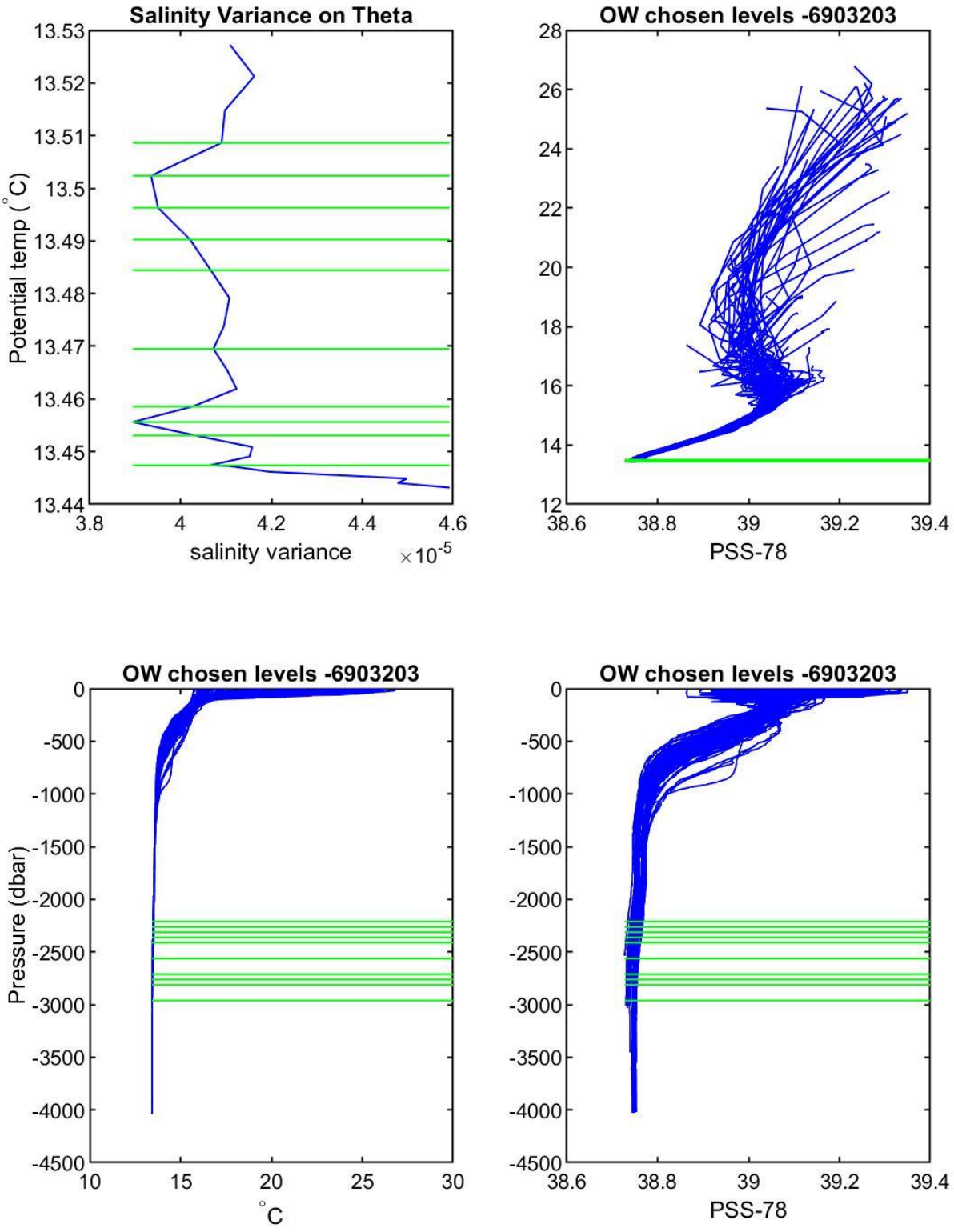

Figure 13: Float 6903203. Plots include the theta levels chosen for calibration: Top left: Salinity variance at theta levels. Top right: T/S diagram of all profiles of Argo float. Bottom left: potential temperature plotted against pressure. Bottom right: salinity plotted against pressure.

The float salinity data were compared to the mapped historical data (Fig 14) and the shift between reference and float profiles indicates a sensor drift.

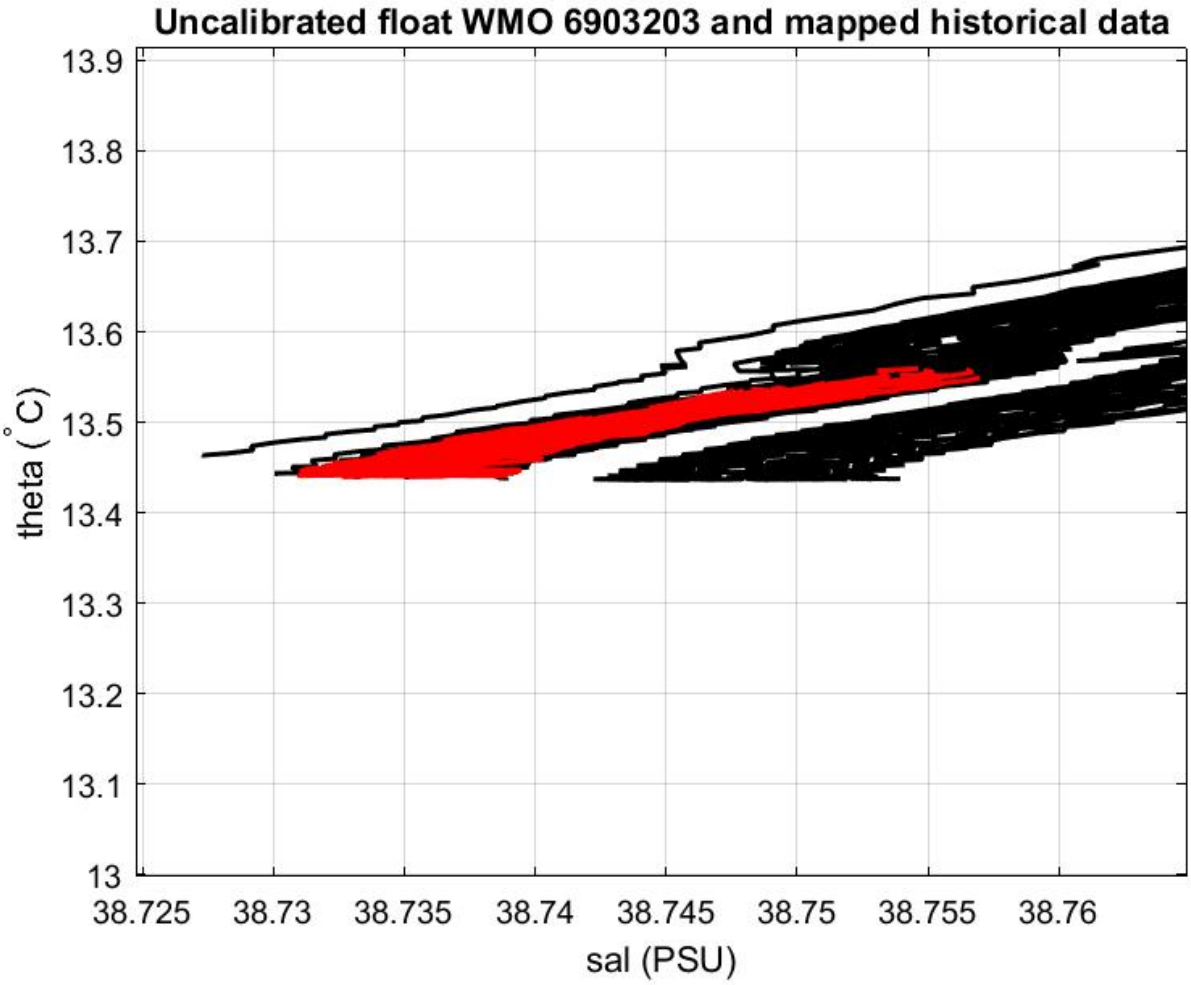

Figure 14: Float 6903203. Uncalibrated float salinity profile (black lines) and mapped historical data (red lines) in the most uniform part of the θ-S curve.

The salinity data of WMO 6903203 Deep-Argo float were corrected in delayed-mode from cycle 30 to 81 applying the correction proposed by the OWC method (Fig. 15).

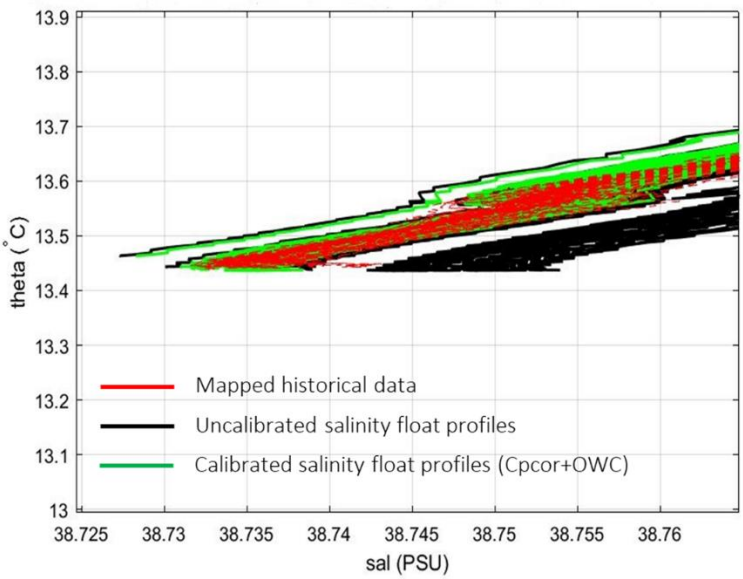

Figure 15: Float 6903203. Mapped historical data (red) compared with uncalibrated (black lines) and calibrated (green), corrected with CPcor and suggested OWC correction, salinity profiles.

5 Summary

The float was deployed in the Ionian sub-basin, in the Mediterranean Sea. It is a Deep float and performed 81 cycles. Before performing the DMQC analysis of the Deep-Argo floats, the CPcor correction for pressure effects on conductivity that is effective in the deep layers, is applied. Three CPcor values are used:

- the nominal CPcor value from Sea-Bird;
- the CPcor_new default value obtained by the Argo deep team (recommended value);
- the optimazed CPcor value obtained in delayed-mode by comparing a deep float profile to a reference profile.

The best solution is obtained using the recommended value. After the CPcor correction, the DMQC analysis was performed. This float wasn't DMQC-ed before. The most favorable water masses, which exhibits a uniform θ-S relationship and are useful for comparison with climatology, are deep waters from around 2000 m. This depth provides the best results in terms of the requested accuracy (0.004 psu). The theta-salinity (θ-S) diagram inspection and the comparison between selected Argo float profiles and reference profiles show a potential salinity drift.
The OWC analysis confirmed the salinity drift. Figure 10 reveals that the least square fit is quite reliable. The correction proposed by OWC suggests that the sensor started to drift at cycle 30 and that such correction (extended up to 0.015) is larger than the Argo requested accuracy (0.004). Figure 12 highlights the salinity drift on selected θ-levels from cycle 30. Hence, the salinity data of float WMO 6903203 needs a delayed mode correction. QC 1 is applied.

PSAL_ADJUSTED= PSAL+ ΔS from cycle 1 to 81

The quality flag applied is the following:

PSAL_ADJUSTED_QC='1' from cycle 1 to 81

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