DELAYED MODE QUALITY CONTROL CORRECTION FOR A SALINITY OFFSET OF ARGO FLOAT WMO 6900952 IN THE MEDITERRANEAN SEA

G. Notarstefano and P.-M. Poulain

Produced by the Mediterranean Argo Regional Centre (MedArgo), OGS, Trieste, Italy

April 15th, 2013

1. Float data

The float data were downloaded on March 2013 from the Coriolis Data centre IFREMER (a GDAC centre), Brest, France, in NetDCF format. The data were converted in Matlab binary file.

2. Status of the float

The float was deployed in the Ionian Sea, southeast of Sicily (Figure 1), in February 2011 and performed more than 200 cycles (Table 1). The salinity, potential temperature and potential density profiles are depicted in Figures 2, 3 and 4, respectively.

Model	**WMO**	**Argos**	**Deploy Date**	**Lat**	**Lon**	**Cycle**	**Last Date**	**Lat**	**Lon**	**Status**
Arvor-a3	6900952	82389	20-Feb-2011 15:32	35.91	16.01	233	11-Aug-2012 14:25	32.77	21.25	Dead

Table 1. Status of the float.

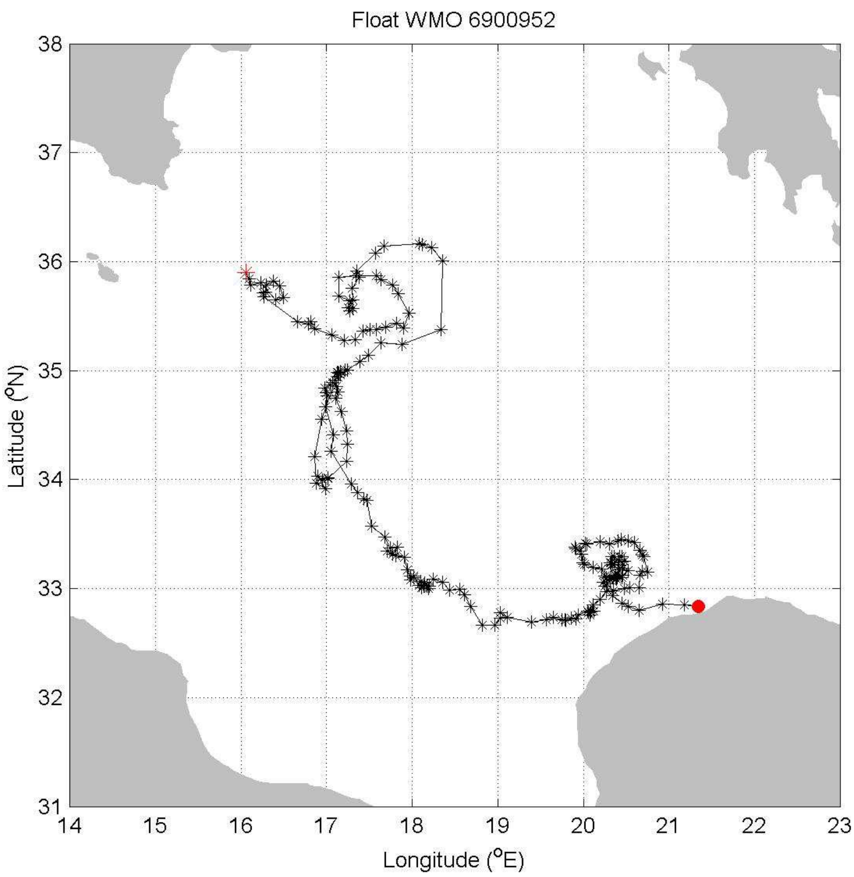
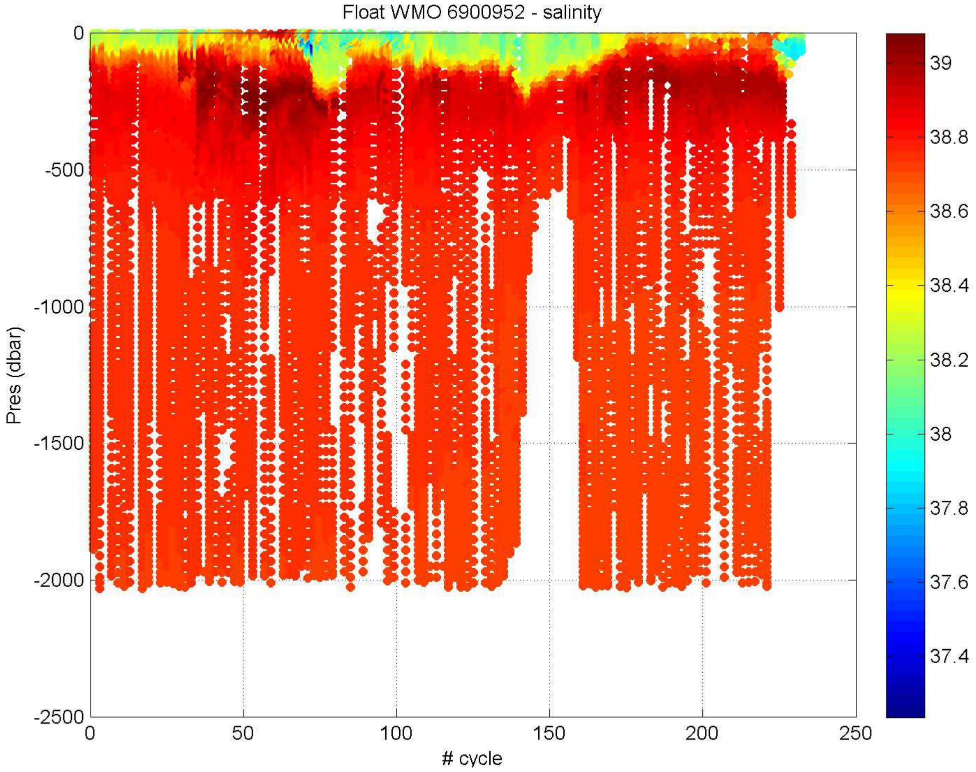


Figure 1. Float trajectory (the red dot represents the last float position).



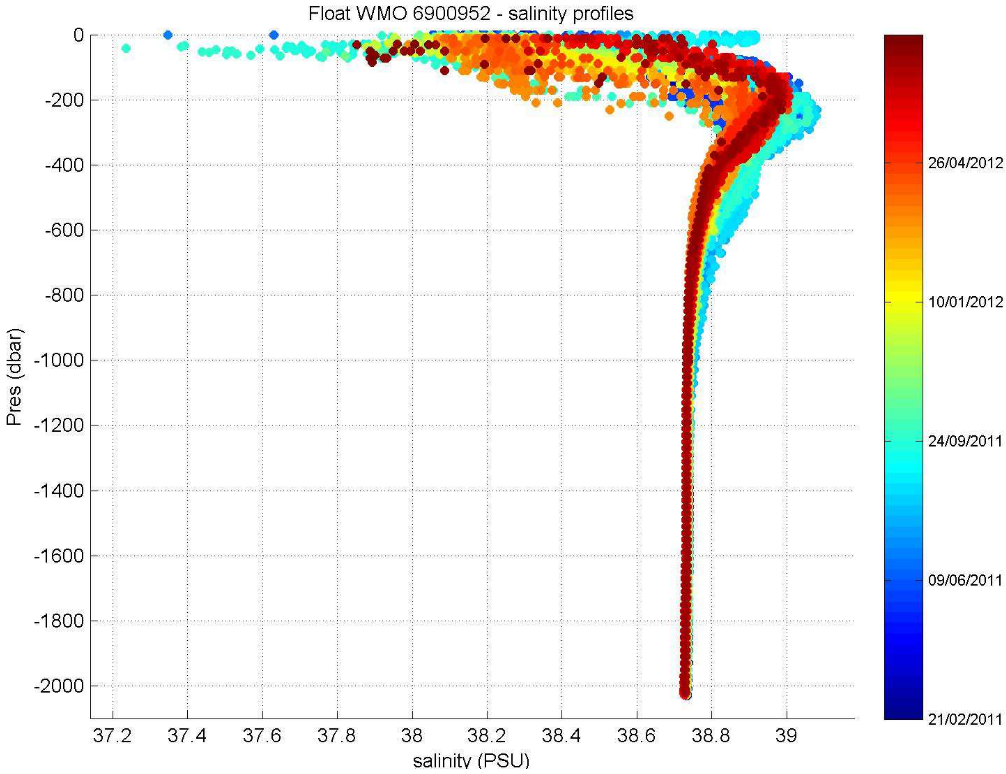


Figure 2. Salinity section along the float trajectory (upper panel) and salinity profiles (bottom panel).

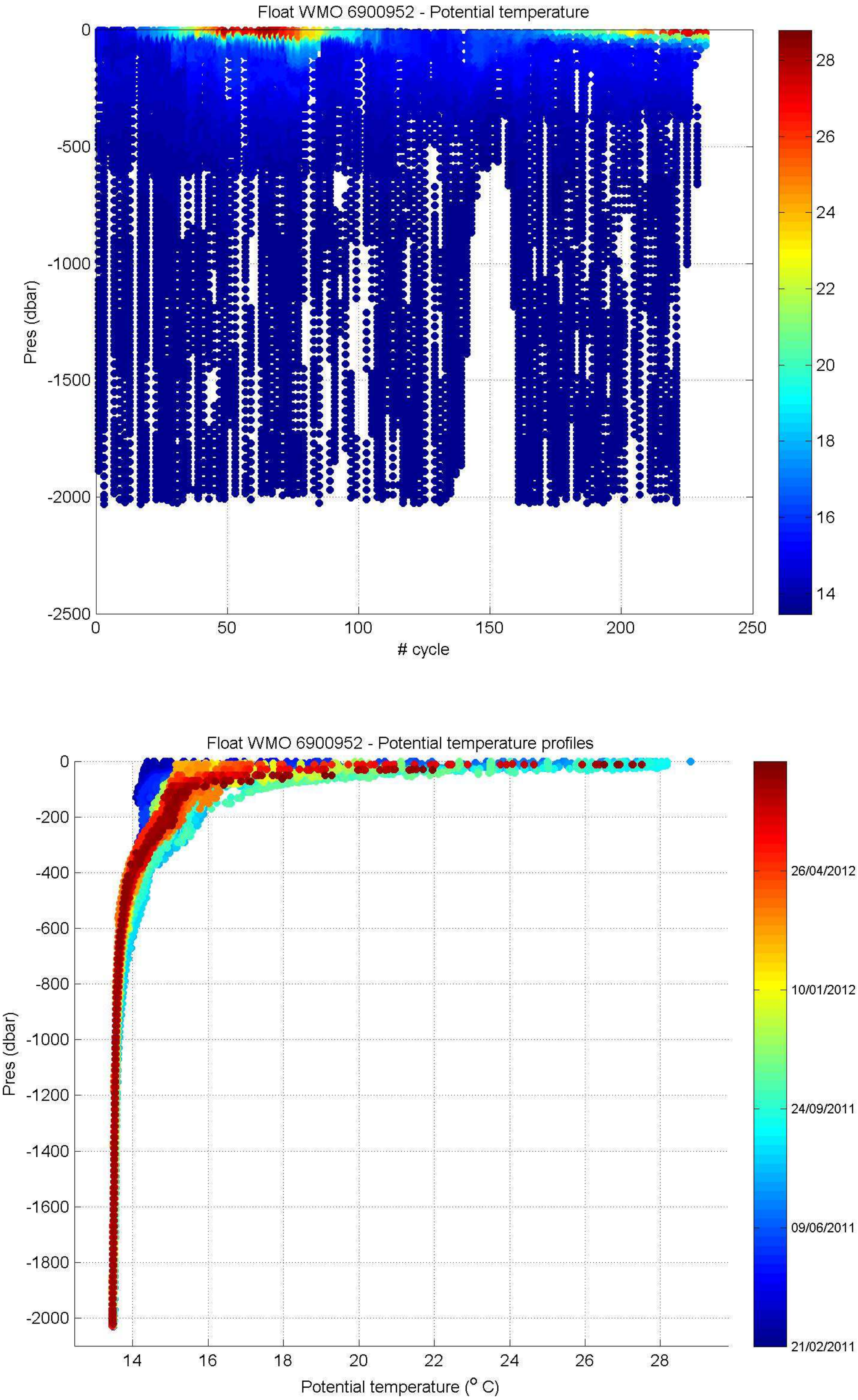


Figure 3. Potential temperature (°C) section along the float trajectory (upper panel) and potential temperature profiles (bottom panel).

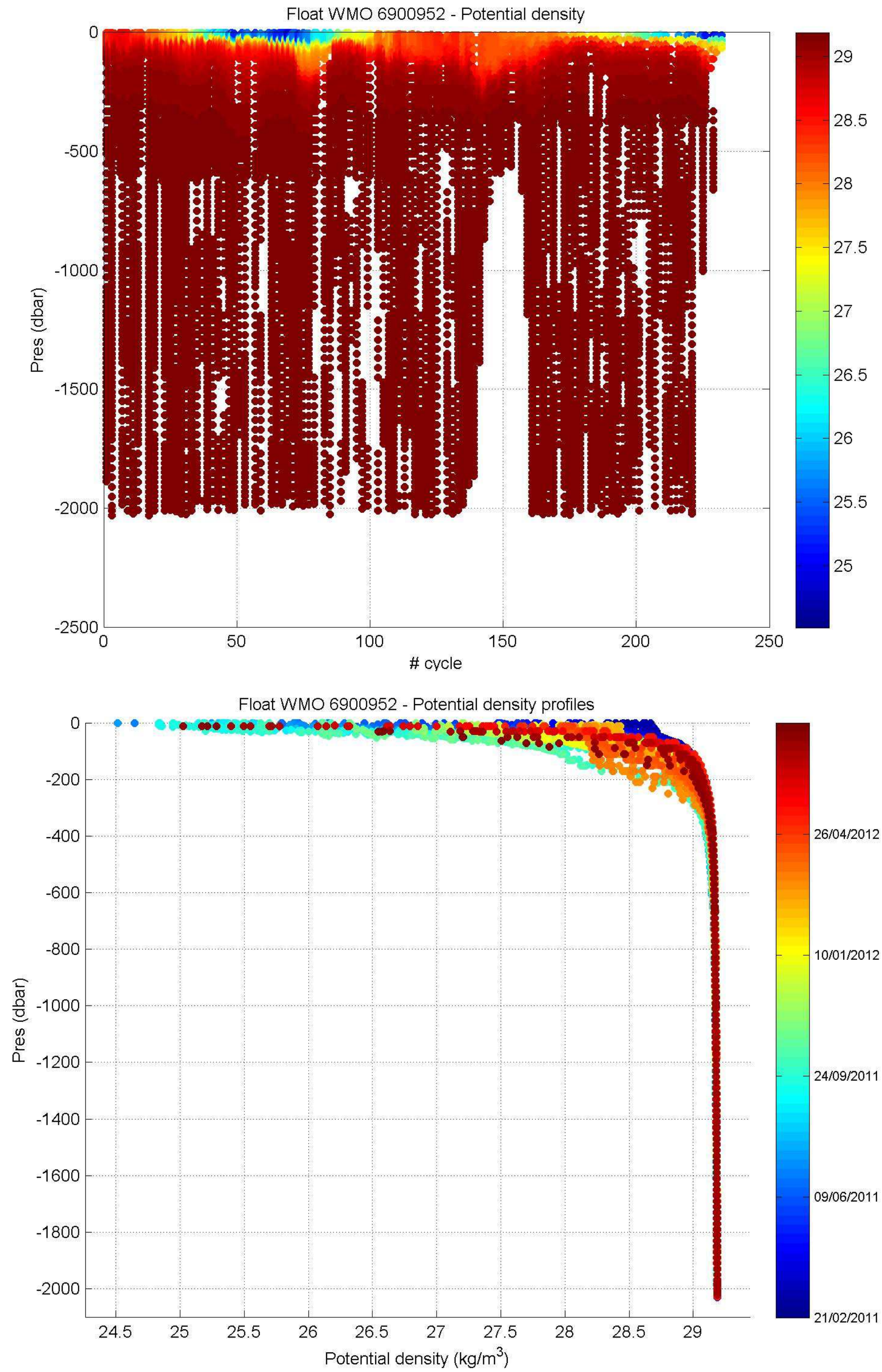


Figure 4. Potential density (°C) section along the float trajectory (upper panel) and potential density profiles (bottom panel).

3. Surface pressure

The adjusted surface pressure is plotted in Figure 5. Surface pressure is extracted from the Argo technical file: the variable name is "PRES_SurfaceOffsetCorrectedNotResetNegative_1cBar Resolution_dBAR". No adjustment of the CTD pressure profiles is required because the correction is much less than the manufacturer quoted accuracy of the pressure sensor (2.4 dbar); moreover the data is auto-corrected on board the float.

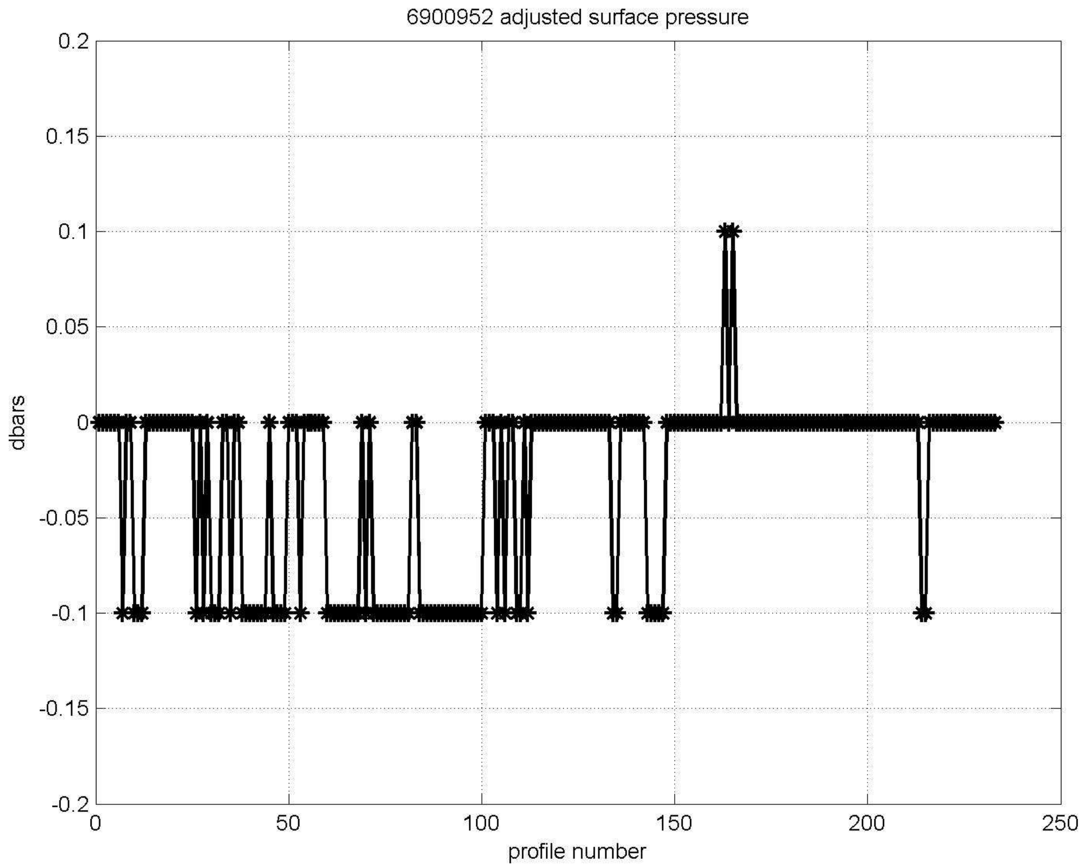
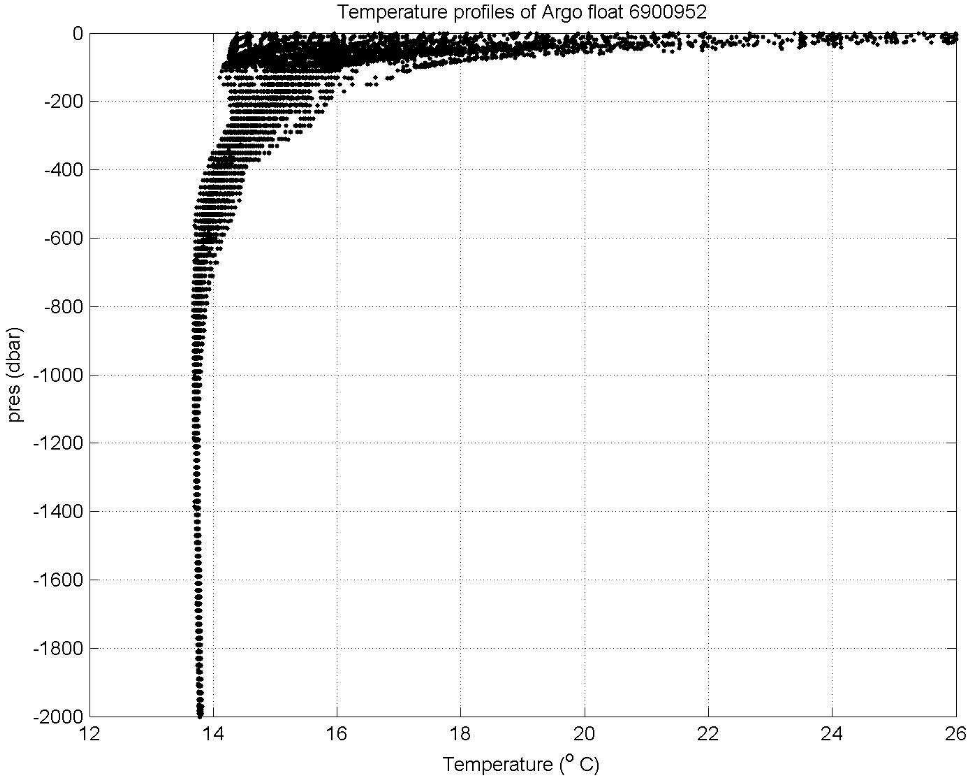


Figure 5. Adjusted surface pressure values versus time.

4. Manual inspection and identification of major spikes in temperature and salinity

No major spikes or jumps were detected in both temperature and salinity (Figure 6) profiles.



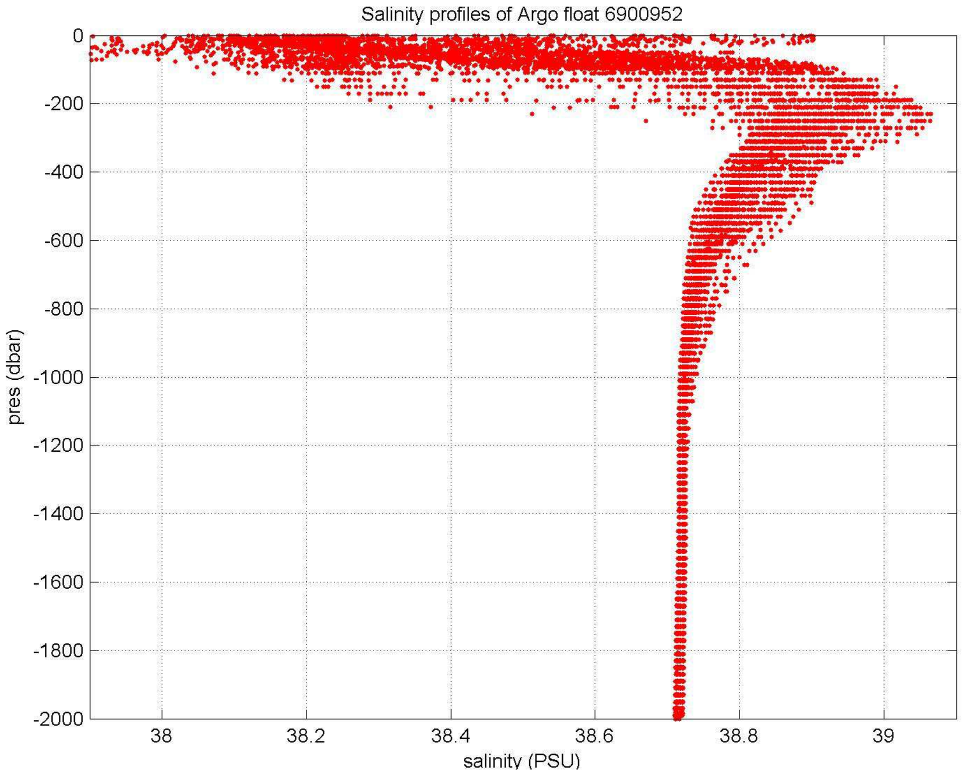


Figure 6. Temperature (upper panel) and salinity (bottom panel) profiles as they are in real time correction mode at Coriolis Data Centre.

5. Reference dataset

The reference data used in the delayed mode quality control (DMQC) method, as of January 2013, are composed of the following CTD and Argo historical datasets (see the historical locations in Figure 7):

- Ref. Database Eflubio-2 (2005)
- Ref. Database Eflubio-3 (2004)
- Ref. Database CTD_for_DMQC_2010V2 (1970-2008)
- Ref. Database Egitto-1 (2006)
- Ref. Database Enea (Borghini – 2004-2006)
- Ref. Database Enea (Santoleri - 2004)
- Ref. Database MFSTEP (2003)
- Ref. Database MREA07 – IT_NAVY Aretusa (2007)
- Ref. Database MREA07 – IT_NAVY Galatea (2007)
- Ref. Database MREA07 – NURC Leonardo (2007)
- Ref. Database MREA07 NURC Leonardo LASIE07 (2007)
- Ref. Database MREA07 – TNO Snellius (2007)
- Ref. Database NODC odv-1 (2000)
- Ref. Database NODC odv-2 (2006)
- Ref. Database SESAME IT2 (2008)
- Ref. Database IT6 SESAME (2008)
- Ref. Database MEADAR/MEDATLAS (1975-1997)
- Ref. Database SINAPSI (1997-2002)
- Ref. Database METEOR/URANIA 1999 (1999)
- Ref. Database TRANSMED (2007)
- Ref. Database MSM (2009)
- Ref. Database ARGO_for_DMQC_2011V4 (2002-2011)

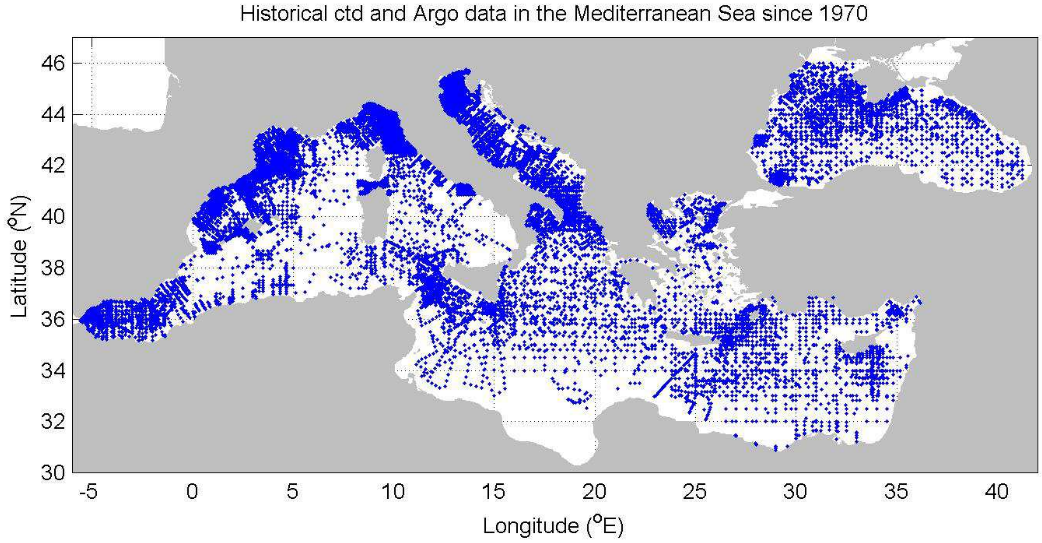


Figure 7. Location of the historical CTD and Argo data, spanning from 1970 to 2011, used in the DMQC.

6. Qualitative comparison between float and historical CTD profiles

In Figure 8 the float trajectory and the historical CTD locations are plotted. The salinity profiles of the Argo float are superimposed on the spatially closest historical profiles in Figure 9.

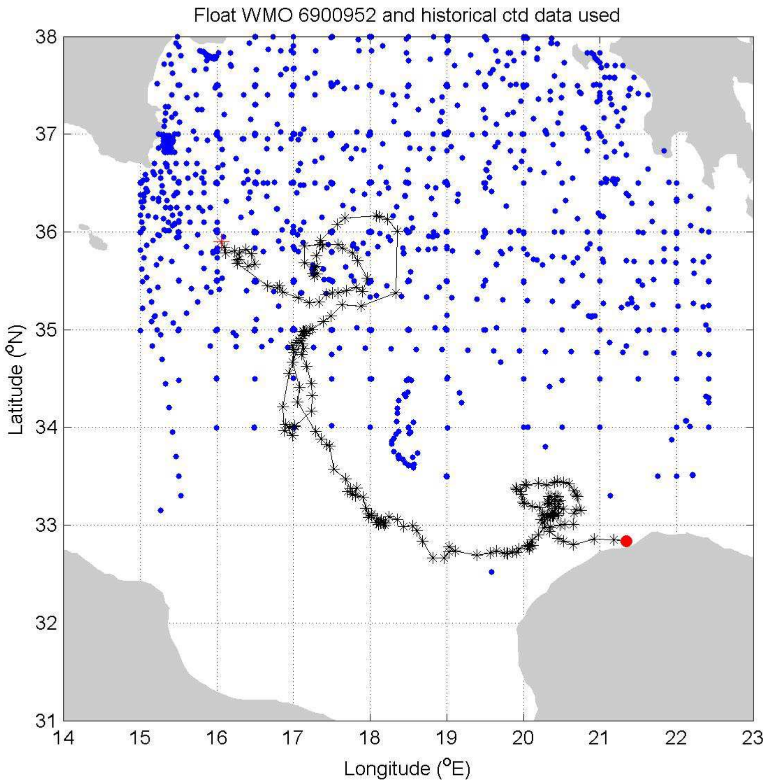


Figure 8. Float trajectory (black line; the last float position is depicted by a red dot) and locations of the historical CTD data.

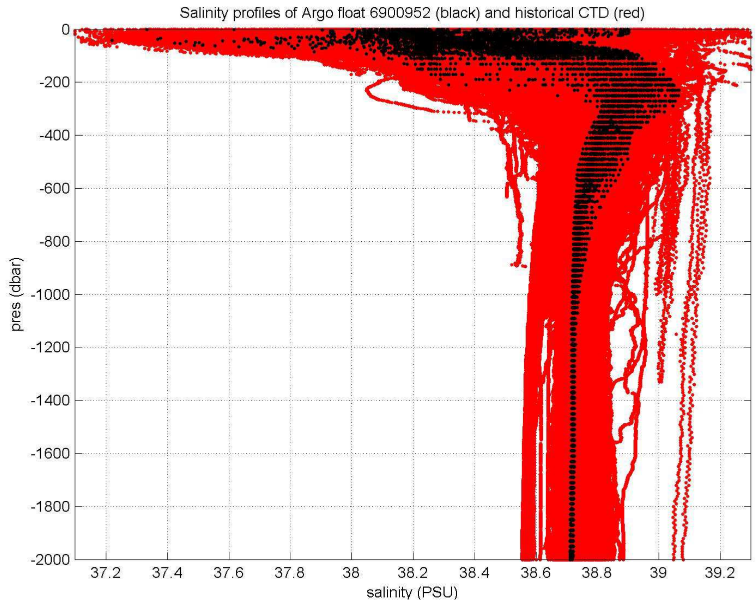


Figure 9. Salinity profiles of the Argo float (black lines) and historical CTD (red lines).

In Figure 10A, three float profiles are selected to perform a comparison (in time and space) with the historical data. The float profile is depicted in black while other colours represent the reference profiles. The red colour 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.

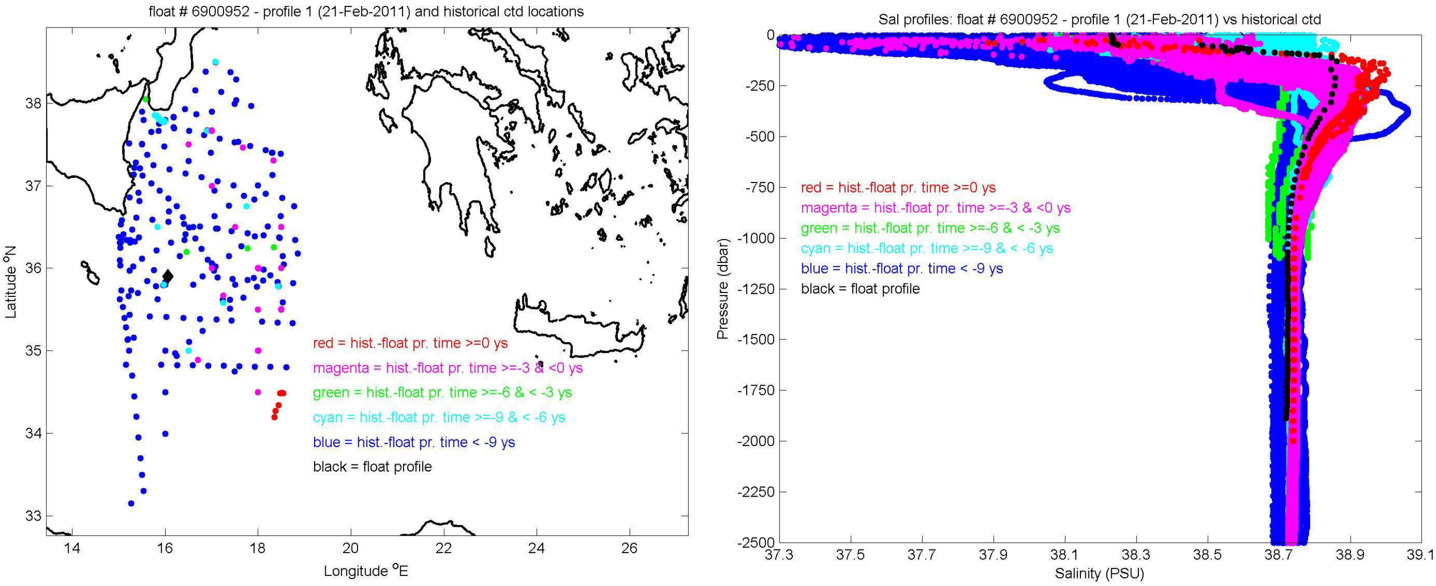


Figure 10A. Location of selected float profiles and historical CTD data (left panels) and the respective salinity profiles (right panels).

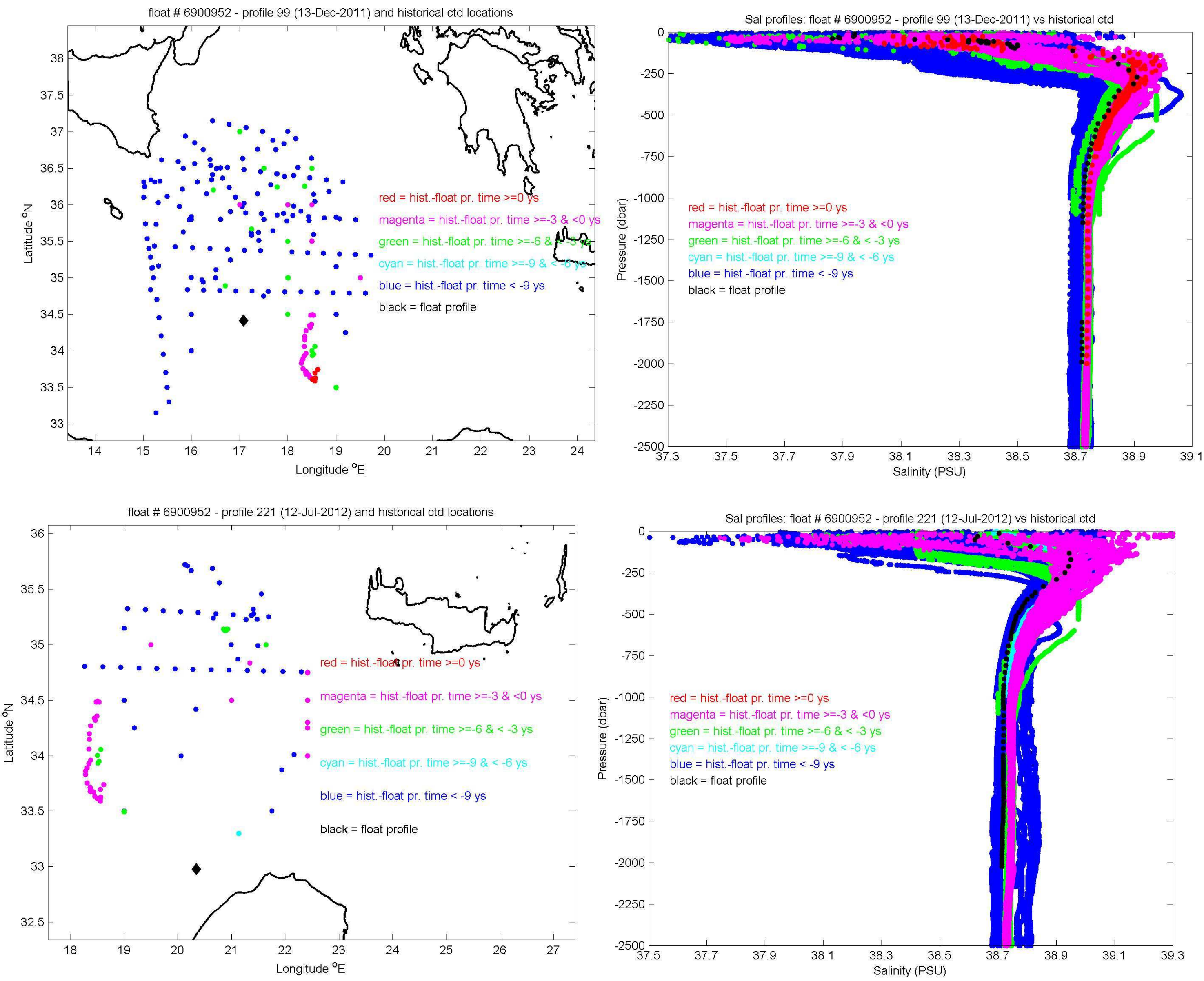


Figure 10A. Continued.

The smallest temporal difference between the two datasets is observed for the float profile number 99: the float data are more recent than the historical ones by about 2 days.
A comparison with the closest (in time) reference profile in shown in Figure 10B.

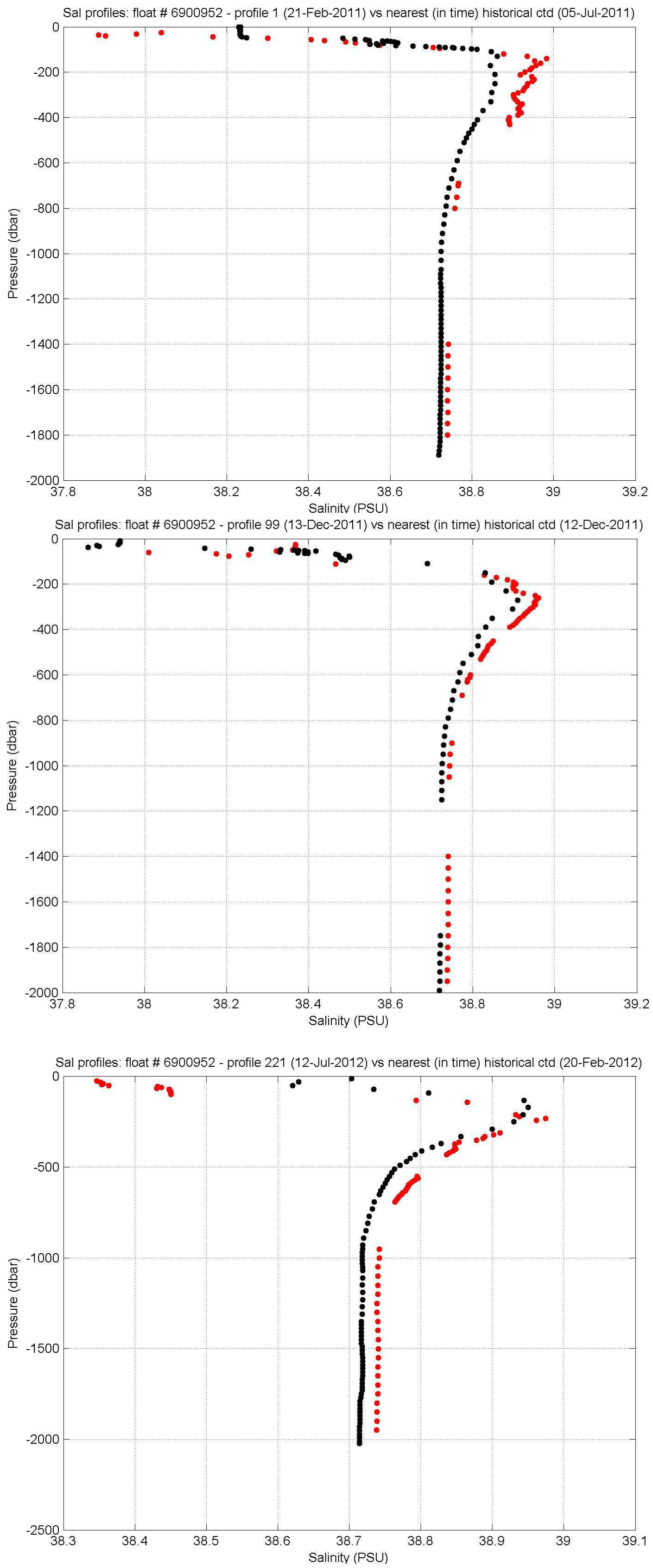


Figure 10B. The float profile (black dots) are compare to the nearest in time reference profile (red dots).

7. DMQC: configuration and results

We applied the DMQC method of Owens and Wong, referred to as OW hereafter (Owens and Wong, 2009) to floats operating in the Mediterranean and Black Sea (Notarstefano and Poulain, 2008). The parameters used for the objective mapping are listed in Table 2. A maximum of 4 break points are allowed in the piece-wise linear fit.

Parameters	Value
CONFIG_MAX_CASTS	300
MAP_USE_PV	1
MAP_USE_SAF	0
MAPSCALE_LONGITUDE_LARGE	6
MAPSCALE_LONGITUDE_SMALL	2
MAPSCALE_LATITUDE_LARGE	5
MAPSCALE_LATITUDE_SMALL	1.67
MAPSCALE_PHI_LARGE	0.5
MAPSCALE_PHI_SMALL	0.1
MAPSCALE_AGE	1
MAP_P_EXCLUDE	200
MAP_P_DELTA	250

Table 2. Objective mapping parameters of the OW method.

The results of the OW method are presented in Figures from 11 to 14. The 10 θ-levels chosen for the correction are reported in Figure 11. The corrected and uncorrected float salinity and the mapped salinity on θ-levels are depicted in Figure 12. The float data corrected by the OW method are presented in Figure 13. The correction proposed (Figure 14) is always positive and between 0.01 and 0.02 PSU; the correction term ***r*** is computed by the piece-wise liner fit and the additive correction ***ΔS*** is calculated using:

$$\Delta S = (r-1)\cdot C_0 + (r-1)\cdot C'$$

where C_0 is the vertical mean conductivity and C’ is the variation around C_0.

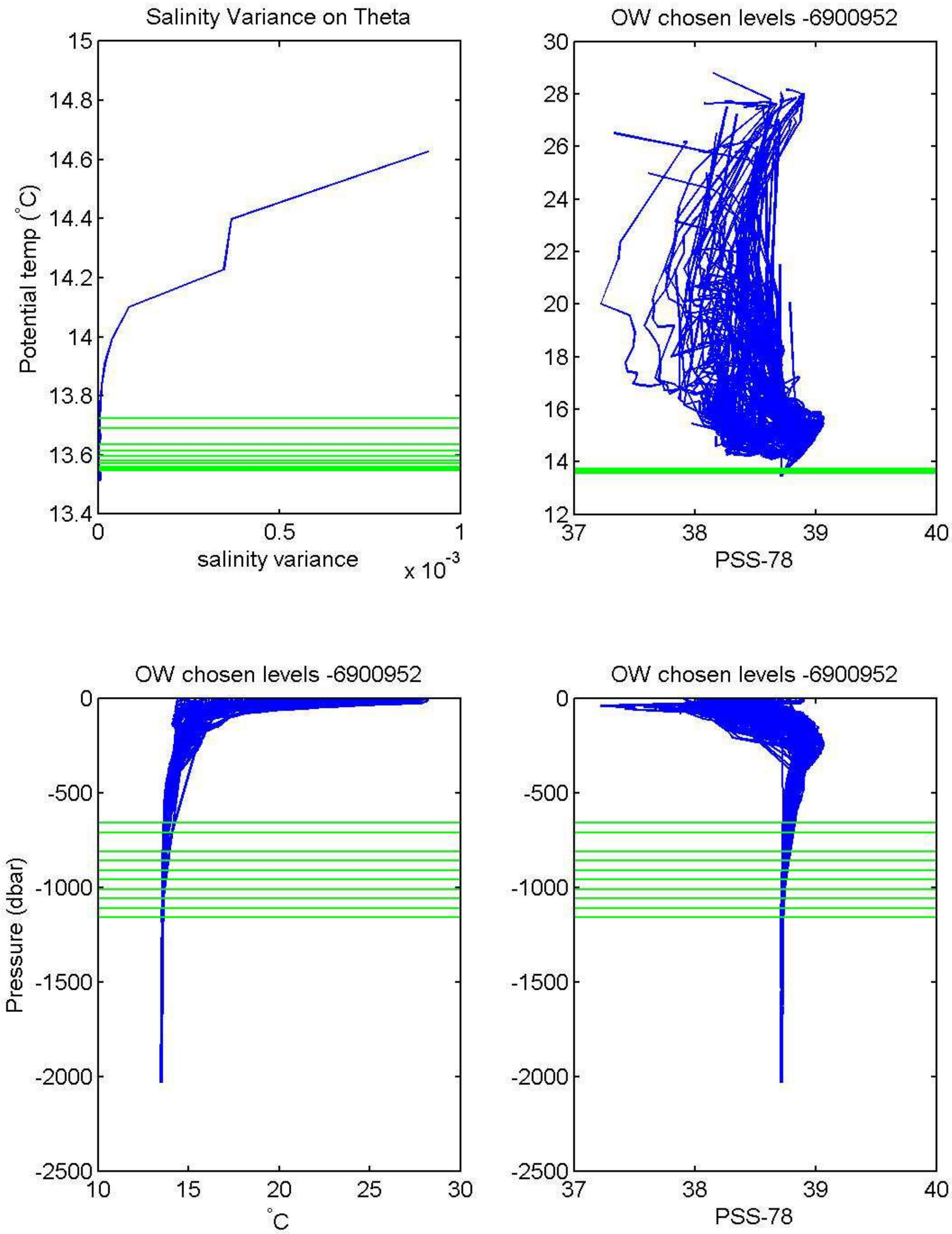


Figure 11. The 10 θ-levels chosen for the correction.

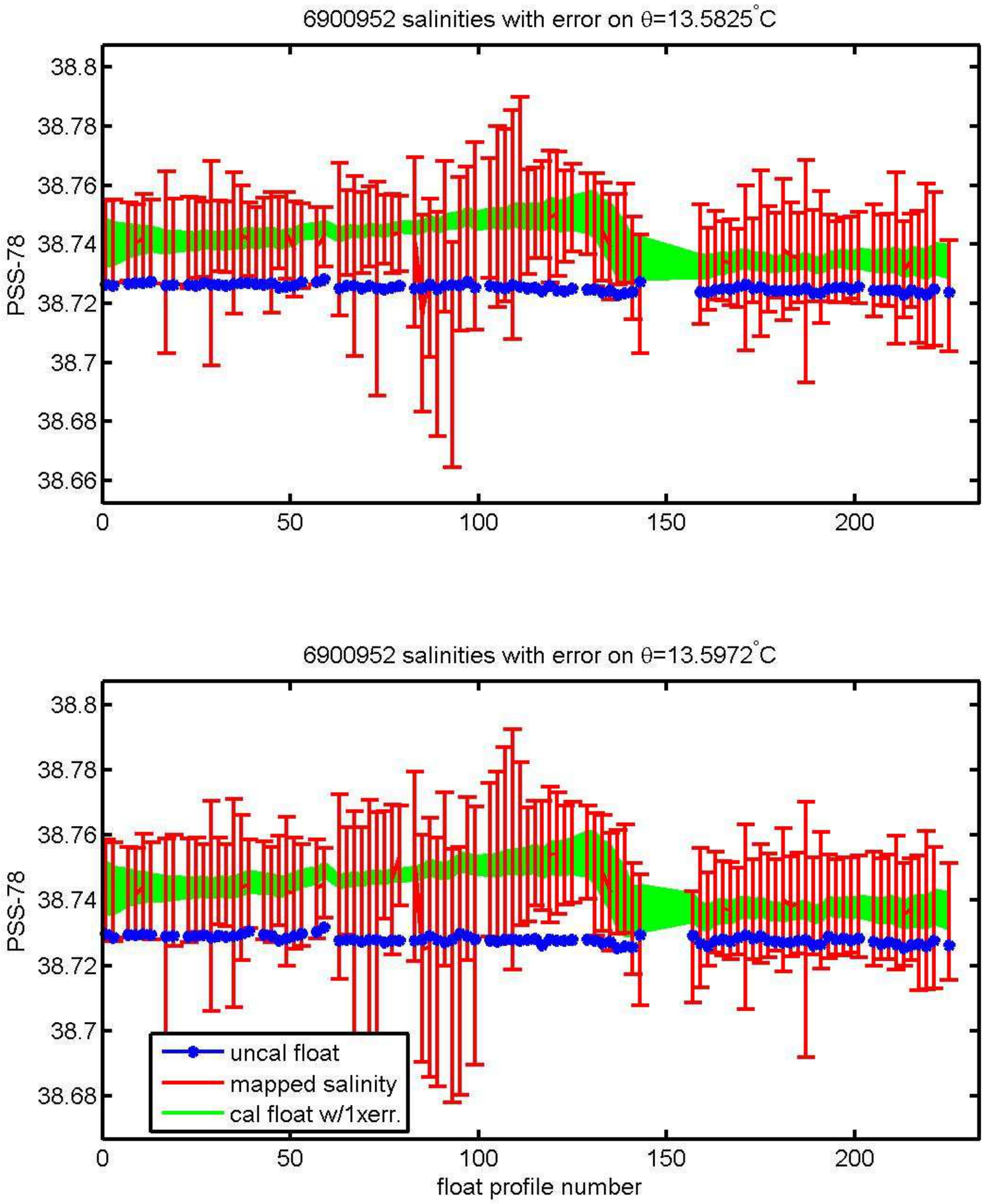


Figure 12. Comparison between the float salinity data and the mapped salinity, on θ-levels.

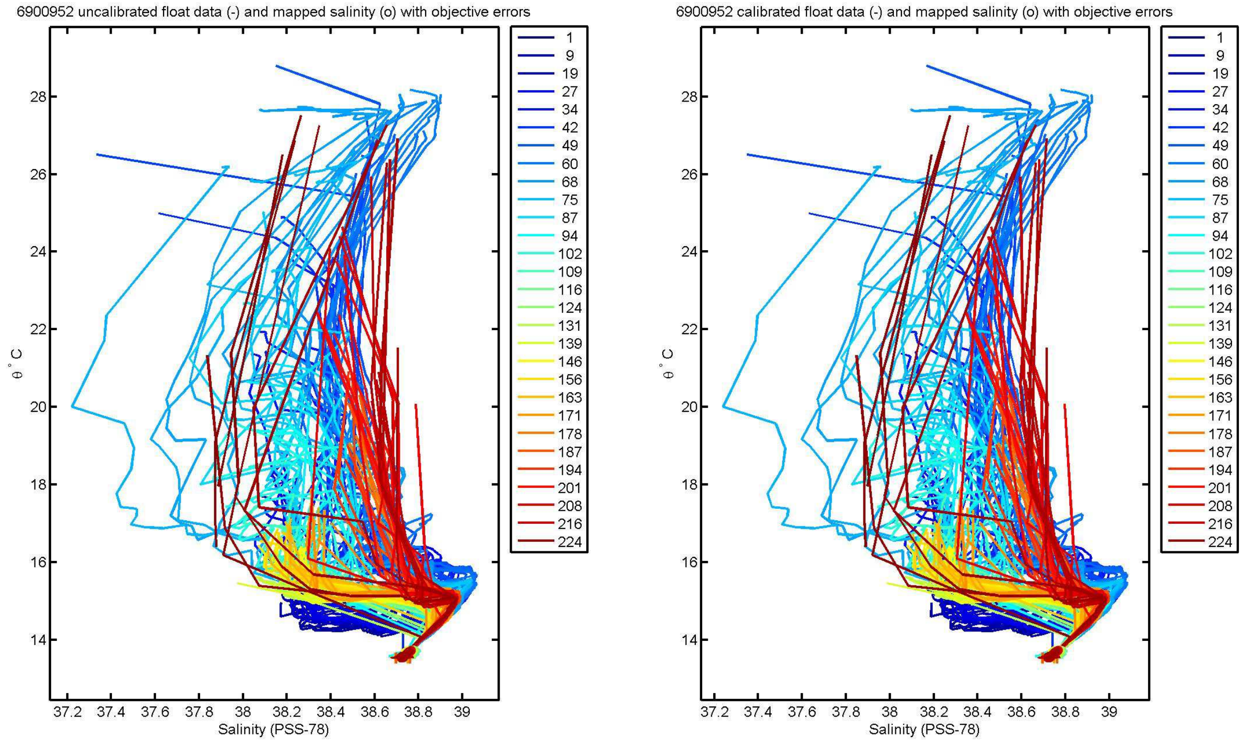


Figure 13. θ-S diagram of uncorrected (left) and corrected data (right).

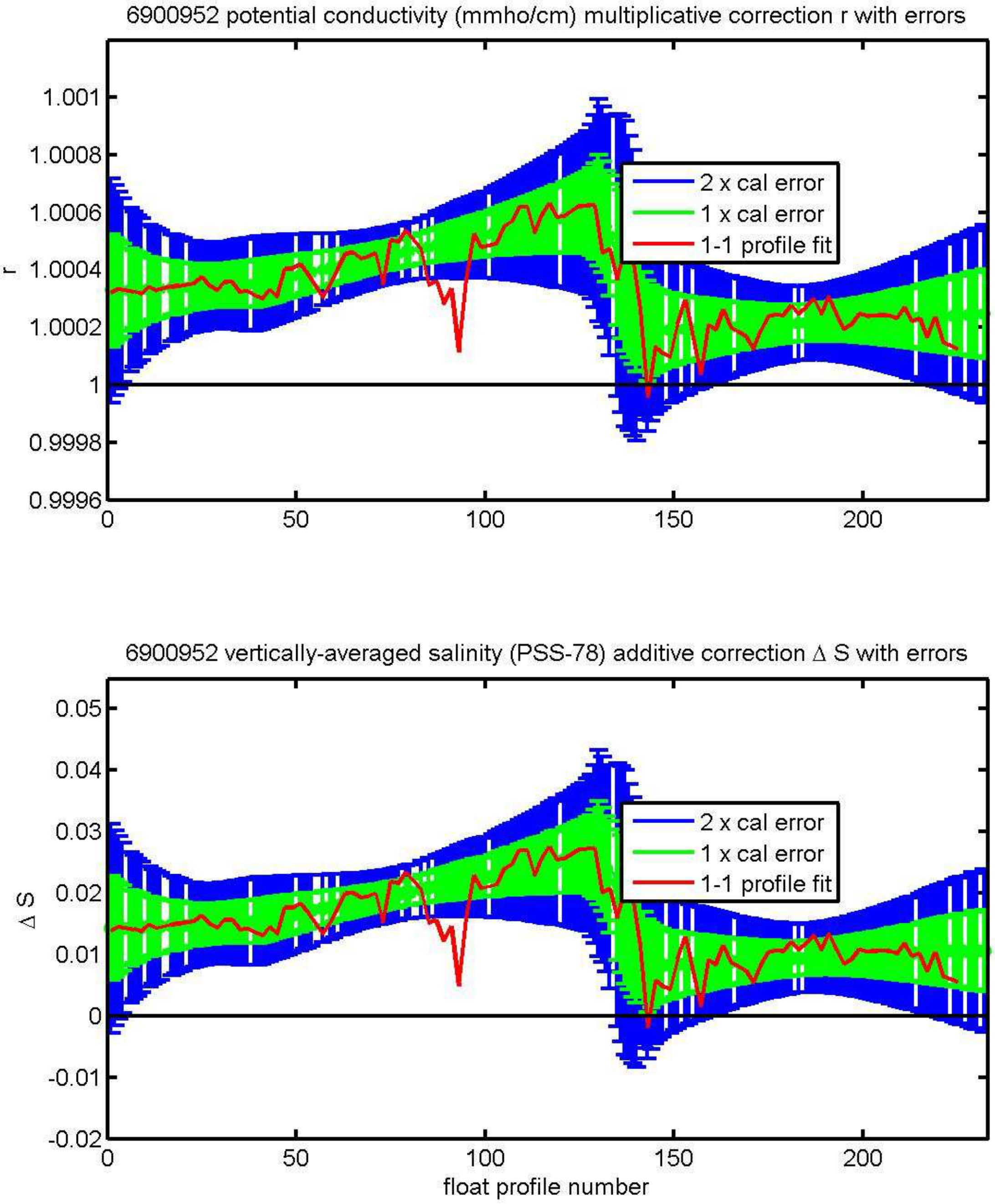


Figure 14. Correction proposed by the OW method.

The observations in the θ-S diagram of profile segments deeper than 1000 dbar (Figure 15A) show that the tightest θ-S relationship is just below this depth. Hence, the analysis of this portion of the θ-S curve can be useful to detect sensor salinity anomalies.

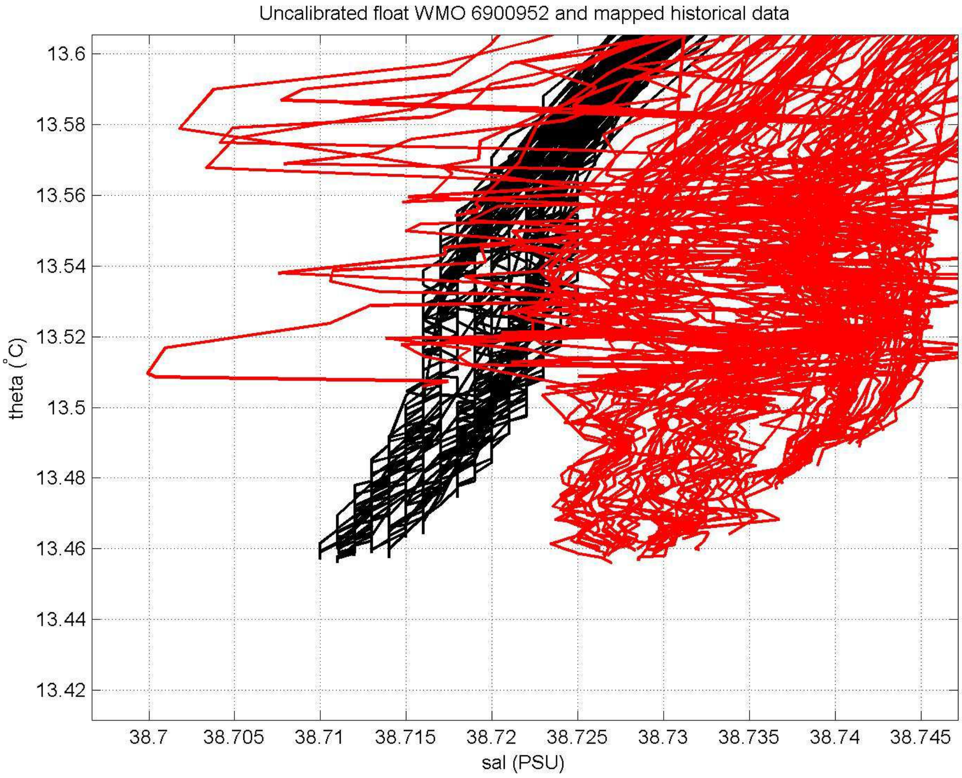


Figure 15A. Uncalibrated float salinity profiles (black lines) and mapped historical data (red lines) in the most uniform part of the θ-S curve.

The color-coded θ-S diagram of profile segments in the most uniform part of the water column, that gives an indication on any potential conductivity sensor drift is shown in Figure 15B. The θ-S curve of float 6900952 is also compared to the θ-S diagram of float 6900844 (Figure 15C), an Apex German profiler that was deployed quite close in time and position and also performed a similar trajectory.

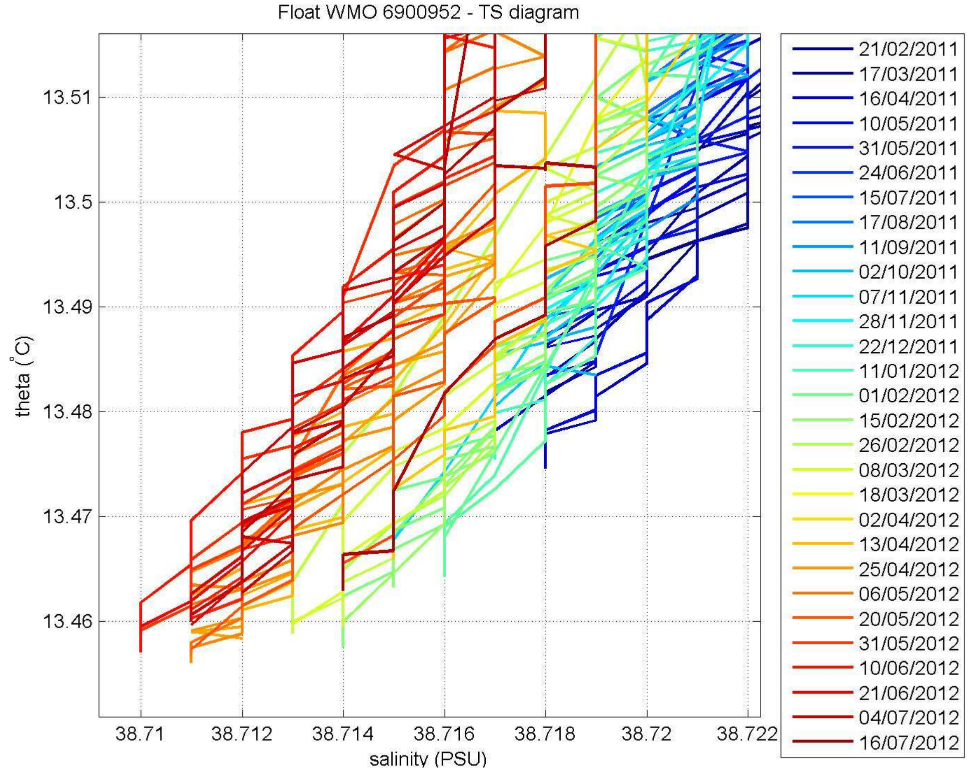


Figure 15B. Uncalibrated float salinity profiles in the most uniform part of the θ-S curve.

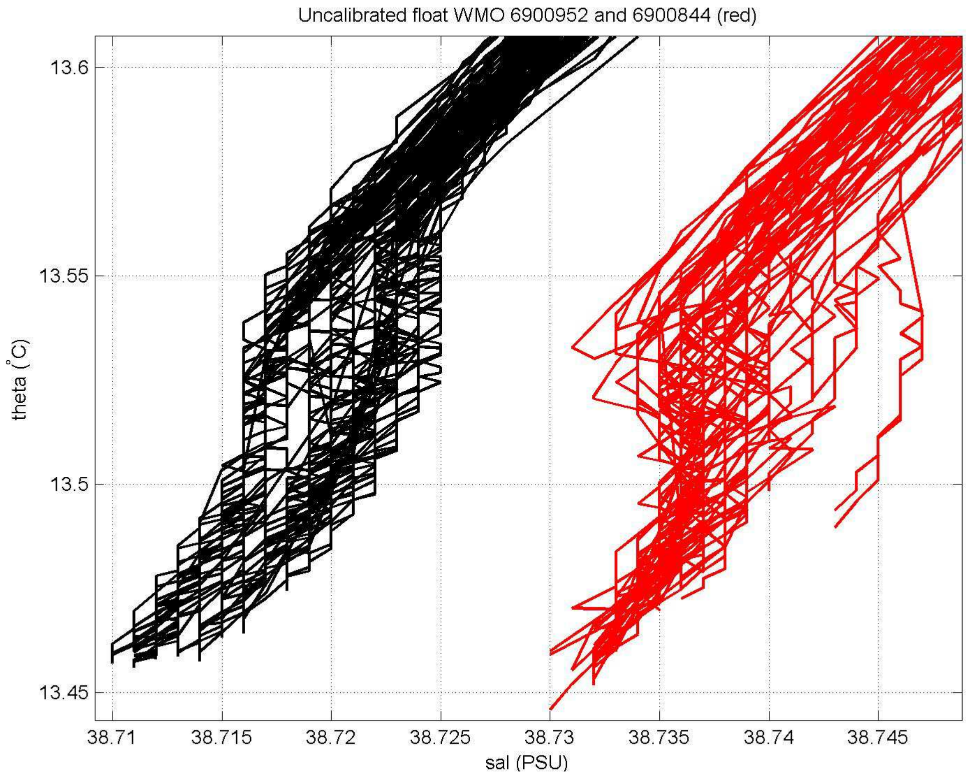


Figure 15C. Uncalibrated float 6900952 and 6900844 salinity profiles in the most uniform part of the θ-S curve.

8. Conclusions

The correction proposed (Figure 14) is always positive and between 0.01 and 0.02 PSU. Figure 12 shows that the float salinity is quite constant on the θ-levels and this could be an indication of the good behavior of the conductivity sensor; moreover, in the most uniform section of the θ-S curve (15B) the variability of the float salinity is less than 0.005 PSU and this is an indication that salinity measurements from this Argo float are accurate to within 0.005 PSU (potential drift). But, a more precise analysis reveals that the mapped historical salinities are saltier than the float data by about 0.015 PSU (Figure 15A) and the deep selected float salinity profiles (Figure 10B) are fresher than the closest (in time) historical profiles by about 0.01-0.02 PSU; moreover, the same salinity difference is observed by comparing the θ-S curve of float 6900952 to the one of float 6900844 (15C) that is quite close in time and space. This difference can represent the sensor offset and it is about of the same order of the variability of the climatology and also larger than the Argo accuracy. We can conclude that there is no evidence of a potential salinity drift in the float measurements but there is certainly a negative offset of the conductivity sensor. Hence, the salinity data of Float WMO 6900952 need a delayed mode correction, that is the following:

PSAL_ADJUSTED=PSAL+ ΔS;

r = 1.0004 (± 0.0001);

vertically averaged ΔS = 0.0151 (± 0.004)

References

Notarstefano G. and Poulain P.-M. (2008). Delayed mode quality control of Argo floats salinity data in the Tyrrhenian Sea. Rel 2008/125 OGA 43 SIRE, Trieste, Italy, 33 pp.

Owens W. B. and Wong A. P. S. (2009). An improved calibration method for the drift of the conductivity sensor on autonomous CTD profiling floats by θ-S climatology, Deep Sea Research Part I: Oceanographic Research Papers, 56(3), 450-457.