Technical report on the intercalibration of the sensors on the LION mooring line

Technical Report · December 2014

DOI: 10.13140/RG.2.1.4787.3044

1 author:

Loïc Houpert
National Oceanography Centre, Southampton
52 PUBLICATIONS **536** CITATIONS

Technical report on the intercalibration of the sensors on the LION mooring line

by Loïc Houpert, Friday 12th December 2014

The mooring site was chosen in the center of the convection zone at 42° 02.4'N, 4° 41.0'E with a water depth of 2350m. There were seven deployments during which the line was gradually equipped between September 2007 and July 2013 with initially 8 (4 Microcat SBE37) and up to 26 (11 SBE37) instruments. In this report we will only discuss about the Conductivity-Depth-Temperature sensors (Seabird Microcat SBE37). They were located all along the line between 150m deep and 2300 m (see table 1).

Since the recovery of LION4 (in June 2010), an intercalibration of the moored instruments after each deployment are done. Niskin bottles are removed from the shipboard Rosette, then Microcat and RBR (or SBE56) are attached instead. We perform an hydrographical cast with a 20 minutes stop at 1000m depth, thus we can have a relative calibration of the moored instruments with the CTD probe SBE 19plus.

	DEEP1	DEEP2	DEEP3	MOOSE 2010	MOOSE 2011	MOOSE 2012	MOOSE 2013
Depth	serial nber	serial nber	serial nber	serial nber	serial nber	serial nber	serial nber
170	3018	3018	6389	6393	6393	6393	6393
300		5058	5058	5058	5058	9065	9065
500		5602	5602	5602	5602	9066	9066
700	5419	5419	5419	5419	5419	5419	5419
850			5574	5574	5574	9067	9067
1100			6390	6390	6390	4302	7928
1300			6391	6391	6391	6391	6391
1500	4924	4924	4924	4924	4924	4924	7929
1750			6392	6392	6392	6392	6392
2000			6393	6389	6389	6389	6389
2300	4581	4581	4581	4581	4293	6390	6153

Table1: Depth of the SBE37 Microcat for the different deployments

These intercalibrations (before the deployement and after the deployement), together with an accurate shipboard CTD (pre- and post-cruise calibration, spare conductivity-temperature sensors) are essential to detect and correct errors in the salinity records (offset, drift) and are crucial if one wants to have accurate and consistent long-time series.

Recently the postcruise calibration of most of the SBE37 deployed before July 2012 were available (see table 2). We will present here briefly the corrections performed

for the different deployements, and the temporary corrections applied on the most recent data.

	DEEP1	DEEP2	DEEP3	MOOSE 2010	MOOSE 2011	MOOSE 2012	MOOSE 2013
	Sep.07-Mar.08	Mar.08-Sep.08	Sep.08-Avr.09	Sep.09-Jun.10	Jun.10-Jun.11	Jun.11-Jul.12	Jul.12-Jun.13
n° Mcat	**depth Mcat**	**depth Mcat**	**depth Mcat**	**depth Mcat**	**depth Mcat**	**depth Mcat**	**depth Mcat**
3018	170	170					
4293					2300		
4302						1093	
4321							0
4324							0
4581	2300	2300	2300	2300			
4924	1500	1500	1500	1514	1500	1493	
5058		300	300	300	300		
5419	700	700	700	700	700	702	702
5574		860	860	860	850		
5602		500	500	506	500		
6153							2293
6389			170	2014	2000	2000	2000
6390			1100	1114	1100	2293	0
6391			1300	1314	1300	1293	1293
6392			1750	1764	1780	1750	1750
6393			2000	170	165	165	165
7928							1093
7929							1493
9065						297	297
9066						502	502
9067						856	856
10629							0
10757							0

Table 2: Serial numbers of the different SBE37 Microcat for the different deployments. Black shaded lines correspond to instruments for which the postcruise calibration was not available at the time of the writing of this report. The gray shade line indicate instruments with a postcruise calibration but not consistent with the other sources of data.

Corrections using the instrument postcruise calibration coefficients

We used the recommendations in the Application Note no. 31 from Seabird (http://ftp.seabird.com/application_notes/AN31.htm) to compute the temperature and conductivity slope and offset correction coefficients. The correction formula are:

(corrected conductivity) = slope_cond * (computed conductivity) + offset_cond

(corrected temperature) = slope_temp * (computed temperature) + offset_temp

For newly calibrated sensors slope = 1.0, offset = 0.0. “Sea-Bird recommends that conductivity drift corrections be made by assuming no offset error, unless there is strong evidence to the contrary or a special need”. Concerning the temperature corrections: “Sea-Bird recommends that drift corrections to temperature sensors be made by assuming no slope error, unless there is strong evidence to the contrary or a special need.”

Following these recommendations, the correcting formula applied are:

(corrected conductivity) = slope_cond * (computed conductivity)

(corrected temperature) = (computed temperature) + offset_temp

with :

slope_cond= 1+ ((timemc - precaldate)/(postcaldate - precaldate)*((1/postslope) – 1))

offset_temp = (timemc - precaldate)/(postcaldate - precaldate)*residual

where

slope_cond = interpolated slope calculated for each time step;

timemc = time of the measurement that need to be corrected

precaldate = date of the pre-cruise calibration

postcaldate = date of the post-cruise calibration

postslope = slope from the calibration sheet of the post-cruise calibration

residual = residual from calibration sheet of the post-cruise calibration

Postlope and residual coefficients used in the correction formula are indicated in table 3 (white shaded lines). The results on the potential temperature, salinity and density at 170m, 700m, 1300m and 2000m are showed on the figures 1 to 4. Even if there were postcruise calibrations for the SBE37 SN: **4581** and SN: **5574**, we chose to not used in since the results of these correction were not consistent with the other data (CTD, other SBE37).

Specific corrections without using the instrument specific postcruise calibration coefficients

For the SBE37 SN: **4581**, the postcruise calibration did not explain the large difference in salinity compared to ship CTD and to other SBE37 deployed at the same depth (figure 5). We applied for this instrument a constant salinity correction of 0.012 for the whole deployment period (2007-2010) in order to be more consistent with the other sensors deployed at the same depth and with the results from CTD casts carried out in the surrounding of the mooring line (figure 6).

For the SBE37 SN: **5574**, the postcruise calibration did not explain the difference in salinity and potential density before and after the recovery in June 2011 (figure 7). We suspect also a problem in the calibration of the sensor since in the calibration report from Seabird, there are two different calibration sheets for the same sensor but made at two different date (the 8 October 2011 and the 15 October 2011) and with different postslope correction factors. We cannot use the results from the intercalibration casts since the precision in the calibration in the CTD probe is not accurate enough (large biais in conductivity of the ship CTD probe in 2010, salinity analysis not accurate enough because they were performed a few months later.

By making the hypothesis that this instrument has the same kind of drift than other sensors, we first applied the postcruise calibration coefficient of the SBE37 SN: **5419**, since it was the only instrument deployed each year, and with a relative small drift (table 2, 3 and figure 2). Then in a second time after the correction on the conductivity, we corrected this drift using the results from the intercalibration cast in June 2011, where the SBE37 **5574** showed a difference of -0.00125 PSU with the SBE37 **5419**. This additional correction is computed as:

salinity_drift = (timemc - date1)/(date2 – date1)*(salinity_difference);

and **final_salinity = salinity_derived_from_cond + salinity_drift**

where

salinity_drift = interpolated drift calculated for each time step

timemc = time of the measurement that need to be corrected

date1 = date of the first deployment of the sensor

date2 = date of the end of the deployment (= date of the intercalibration cast)

salinity_difference = difference between the sensor and the reference salinity (specific SBE37 or the ship CTD) during the intercalibration cast.

We used the coefficients indicated in table 3 to correct the SBE37 **5574** and the results are shown on figure 8. Compared to the figure 7, one can clearly see that, by using this method, the deployements of the sensor **5574** are more consistent with the results from the other deployements at the same depth (SBE37 **9067**).

Serial number	Precalib Date	Postcalib Date	Residual T (mdeg)	Slope correction	Offset Salinity	salinity_difference from intercalib	Date1 for salinity corrections	Date2 for salinity corrections
3018	22/06/2007	10/11/2008	2.19	0.9999271	0			
4293	17/10/2009	08/11/2011	-0.15	1.0000646	0			
4302	04/05/2010	15/11/2012	0.39	1.0000534	0			
4581	06/01/2006	06/11/2010	0.96	1	0.012			
4924	20/07/2007	08/01/2013	0.13	1.0002838	0			
5058	11/01/2008	08/10/2011	0.81	1.0000861	0			
5419	25/08/2007	28/11/2013	-0.82	1.0001921	0			
5602	11/10/2007	11/08/2011	-0.25	1.0002349	0			
6389	17/08/2008	28/11/2013	-0.7	1.0003069	0			
6390	15/08/2008	08/01/2013	-0.78	1.0000156	0			
6391	15/08/2008	28/11/2013	-1.35	1.0000431	0			
6393	15/08/2008	18/12/2013	-0.03	1.0001671	0			
5574	28/12/2007	15/11/2011	-0.82	1.0001921	0	1.25E-03	15/09/2008	01/07/2011
6153	25/08/2007	28/11/2013	0	1	0	-2.08E-03	15/06/2012	20/08/2013
6392	25/08/2007	28/11/2013	0	1	0	-7.13E-03	15/09/2008	20/08/2013
7929	25/08/2007	28/11/2013	0	1	0	-3.44E-03	15/06/2012	20/08/2013
7928	25/08/2007	28/11/2013	0	1	0	-5.11E-03	15/06/2012	20/08/2013
9065	25/08/2007	28/11/2013	0	1	2.22E-02			
9066	25/08/2007	28/11/2013	0	1	0			
9067	25/08/2007	28/11/2013	0	1	1.75E-03			

Table 3: Corrections coefficents of the different SBE37 Microcats used on the LION mooring lines from 2007 to 2013. Black shaded lines correspond to instruments for which the postcruise calibration was not available at the time of the writing of this report. The gray shade lines indicate instruments with a postcruise calibration but not consistent with the other sources of data.

Specific corrections for instruments without postcruise calibration coefficients

For the SBE37 SN **6153**, **6392**, **7929**, **7928**, **9065**, **9066**, **9067** no postcruise calibration coefficients are available at that time. In these cases we applied empirical corrections using the results from the intercalibration made in 2013 (see coefficients in the table 3). We applied a drift correction for the SBE37 **6153**, **6392**, **7929** and **7928**. While for the SBE37 **9065**, **9066** and **9067**, we only applied a constant salinity correction on each deployment since the salinity difference of each of this sensor with the SBE37 **5419** didn't change between the intercalibration cast carried out in 2012 and the one in 2013. Results of these corrections are shown on figures 6 for the SBE37 **6153**, figure 9 for the SBE37 **6392**, figure 10 for the SBE37 **7928**, figure 11 for the SBE37 **7929**, figure 12 for the SBE37 **9065**, figure 8 for the SBE37 **9066**, and figure 13 for the SBE37 **9067**.

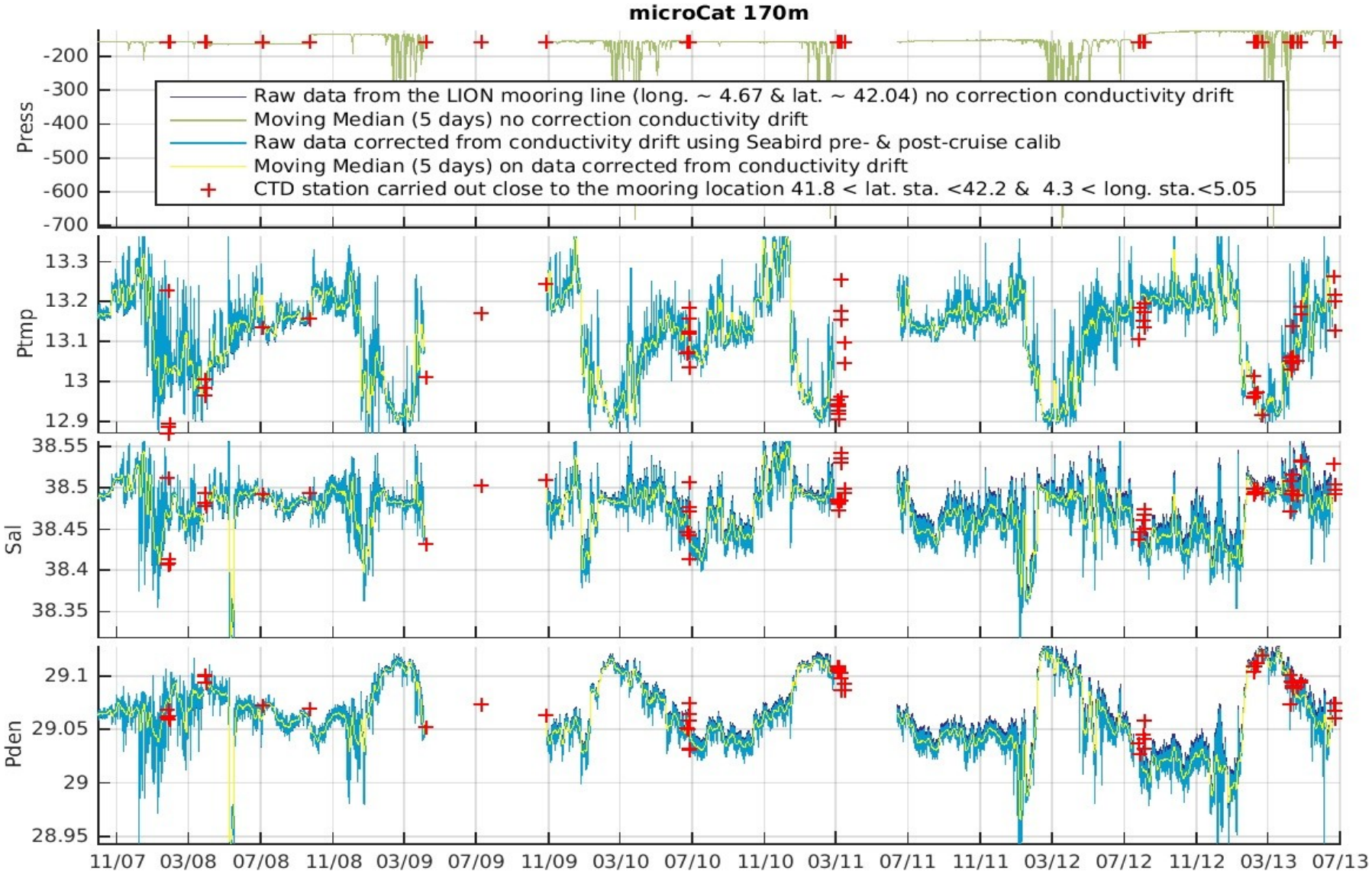

Figure 1: Pressure, potential temperature, salinity, and potential density at 170m . See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

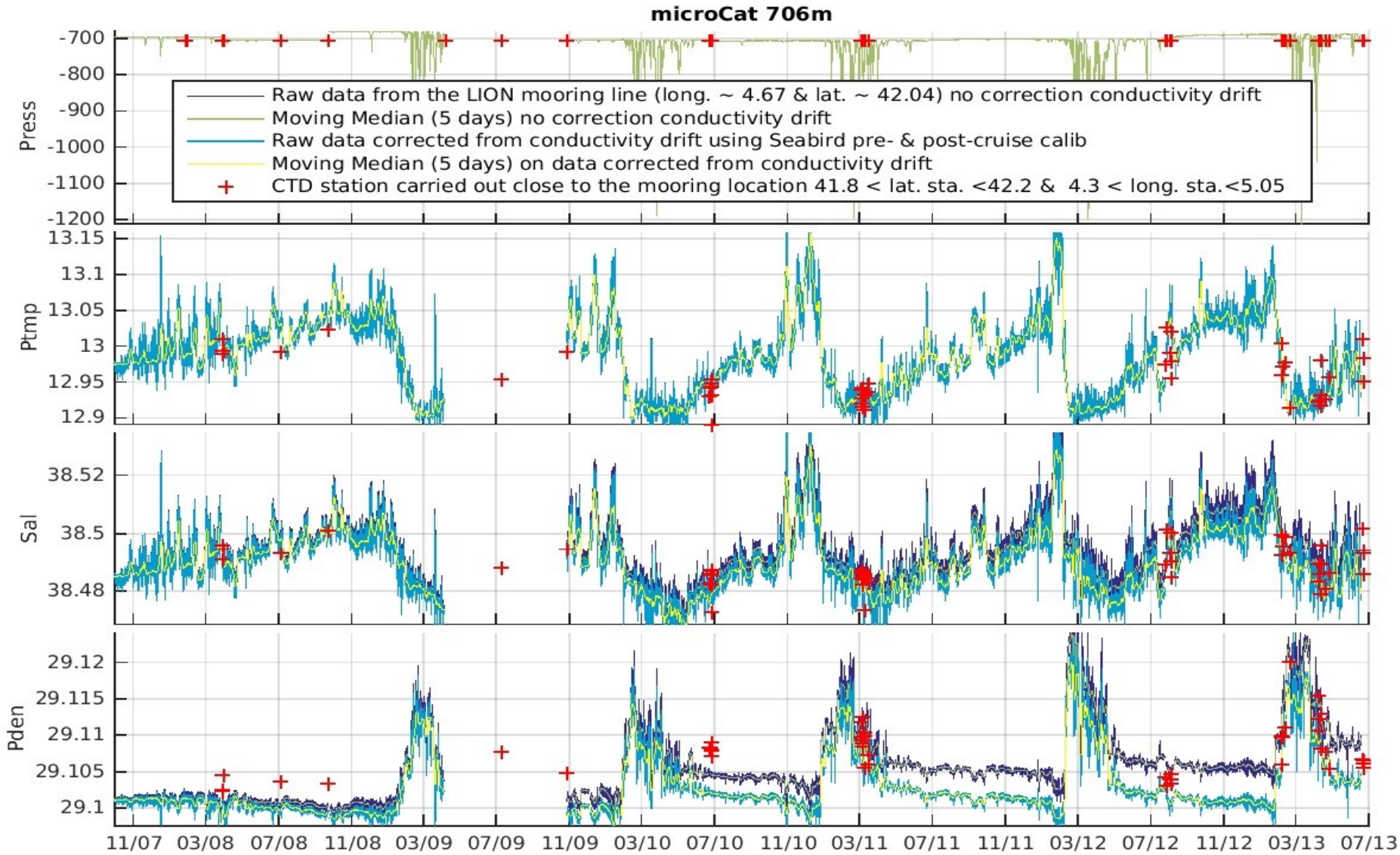

Figure 2: Pressure, potential temperature, salinity, and potential density at 700m . See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

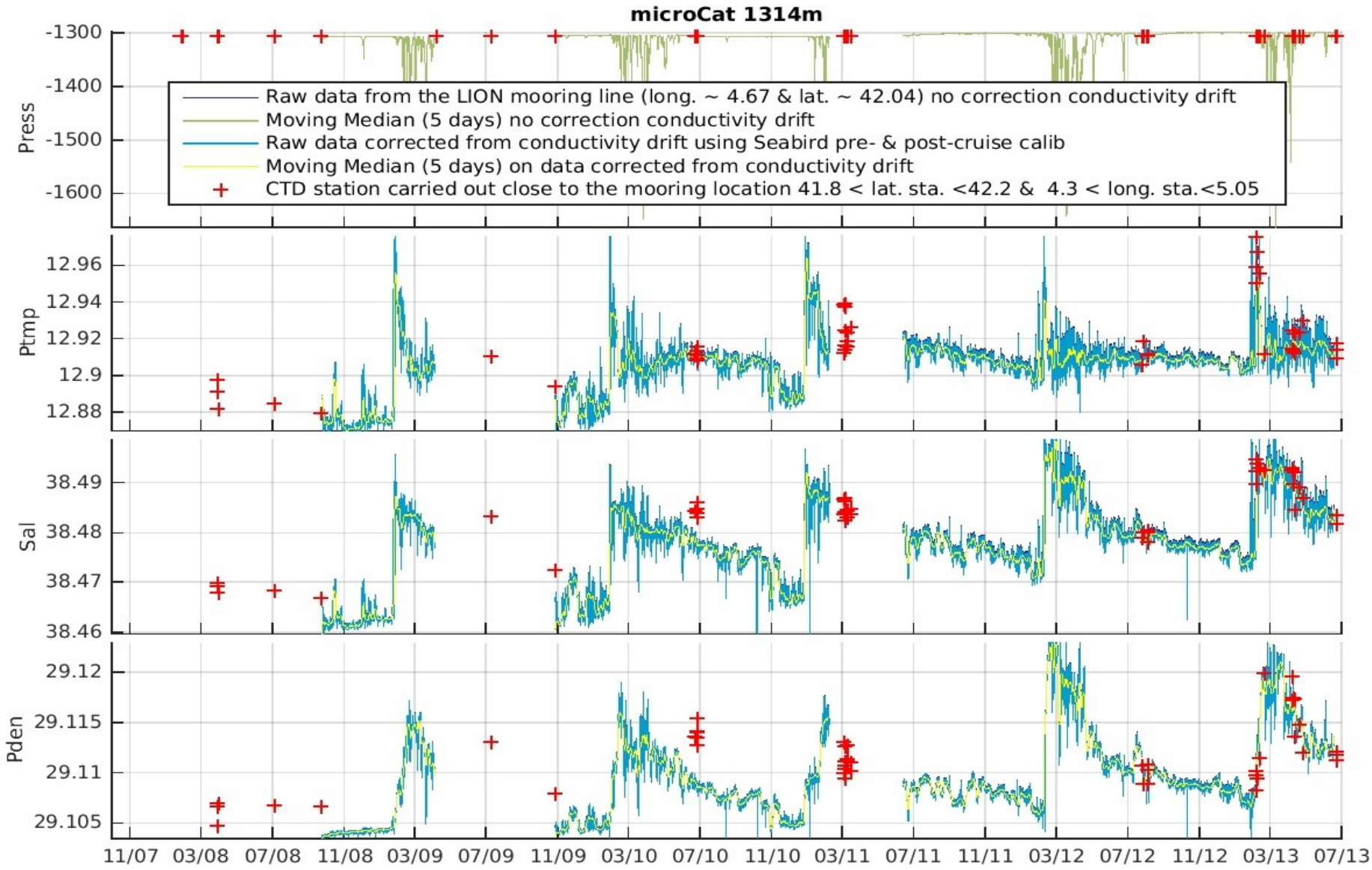

Figure 3: Pressure, potential temperature, salinity, and potential density at 1300m . See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

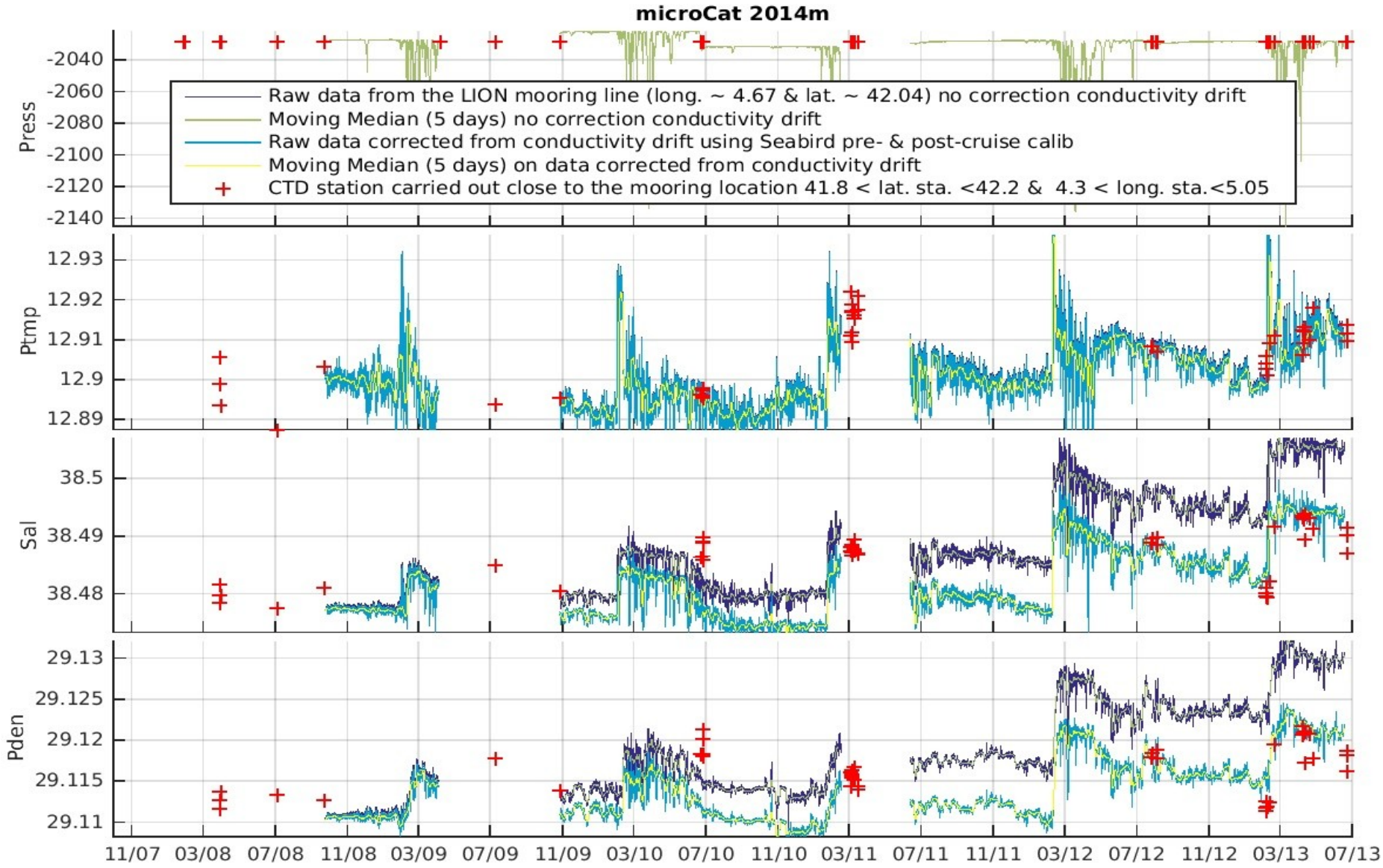

Figure 4: Pressure, potential temperature, salinity, and potential density at 2000m . See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

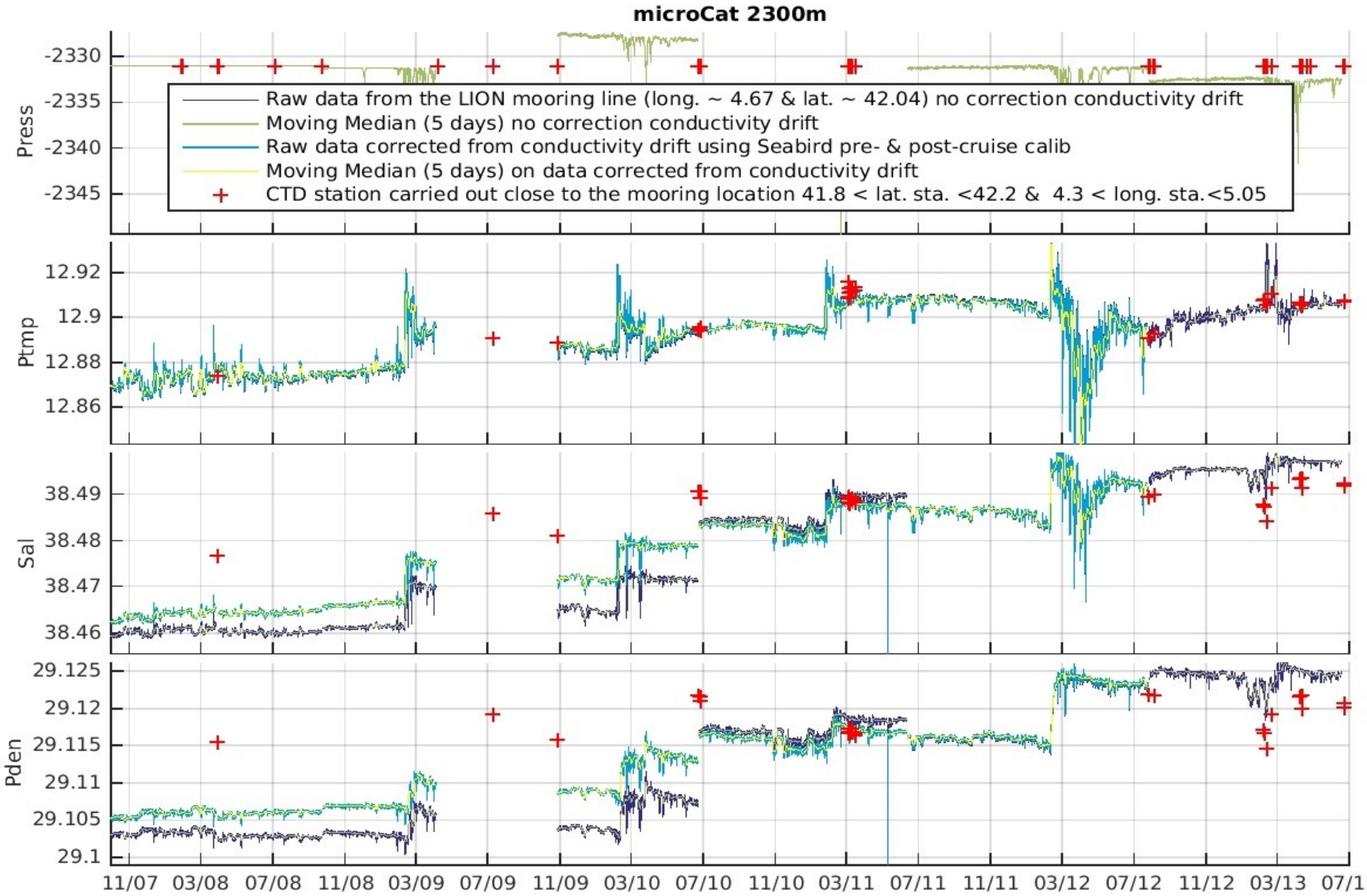

Figure 5: Pressure, potential temperature, salinity, and potential density computed at 2300m using only the Seabird postcruise calibration. See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

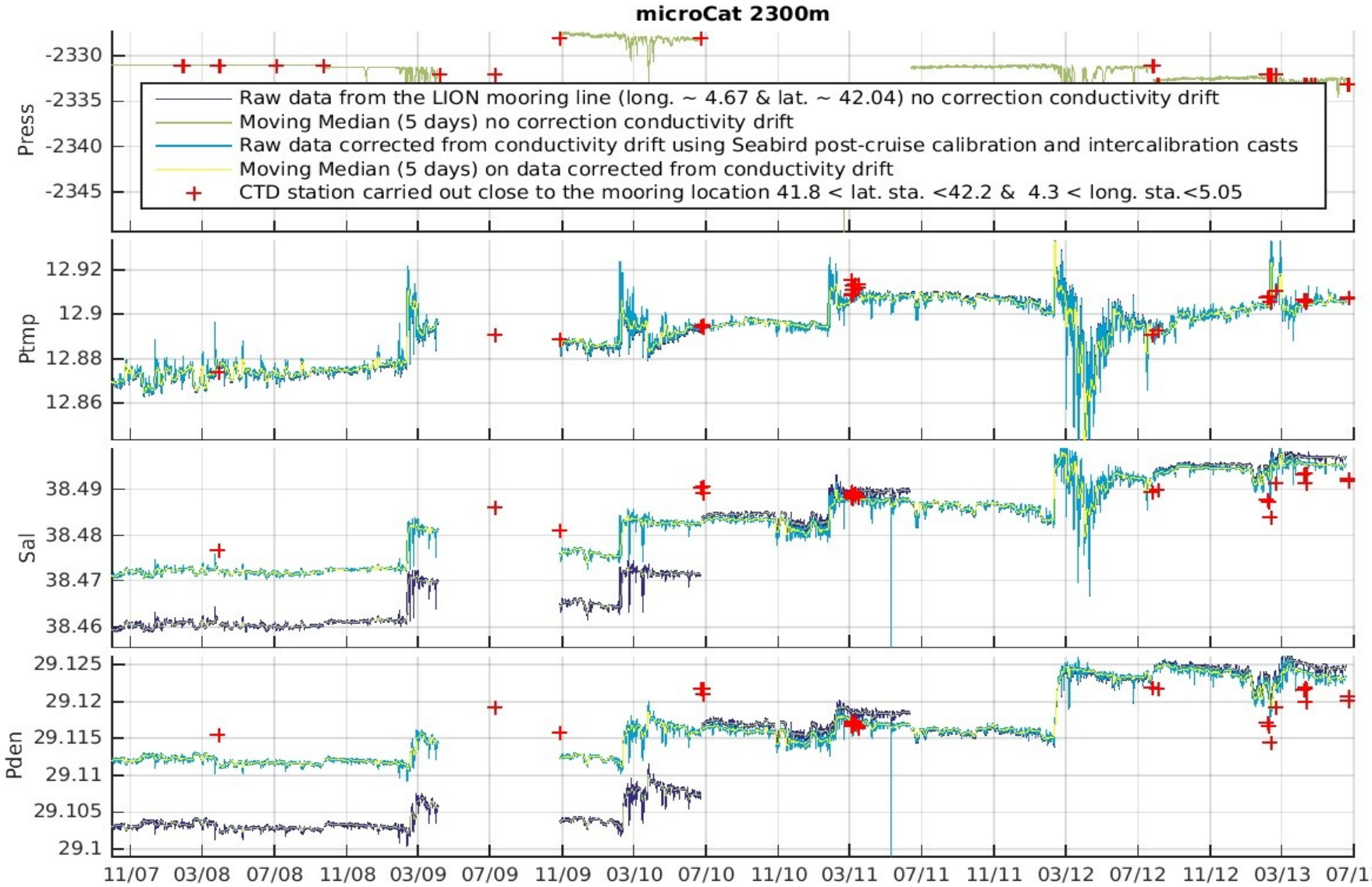

Figure 6: Pressure, potential temperature, salinity, and potential density computed at 2300m using the Seabird postcruise calibration, except for the SN:4581 for which a constant salinity correction of 0.012 was applied without postcruise calibration. See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

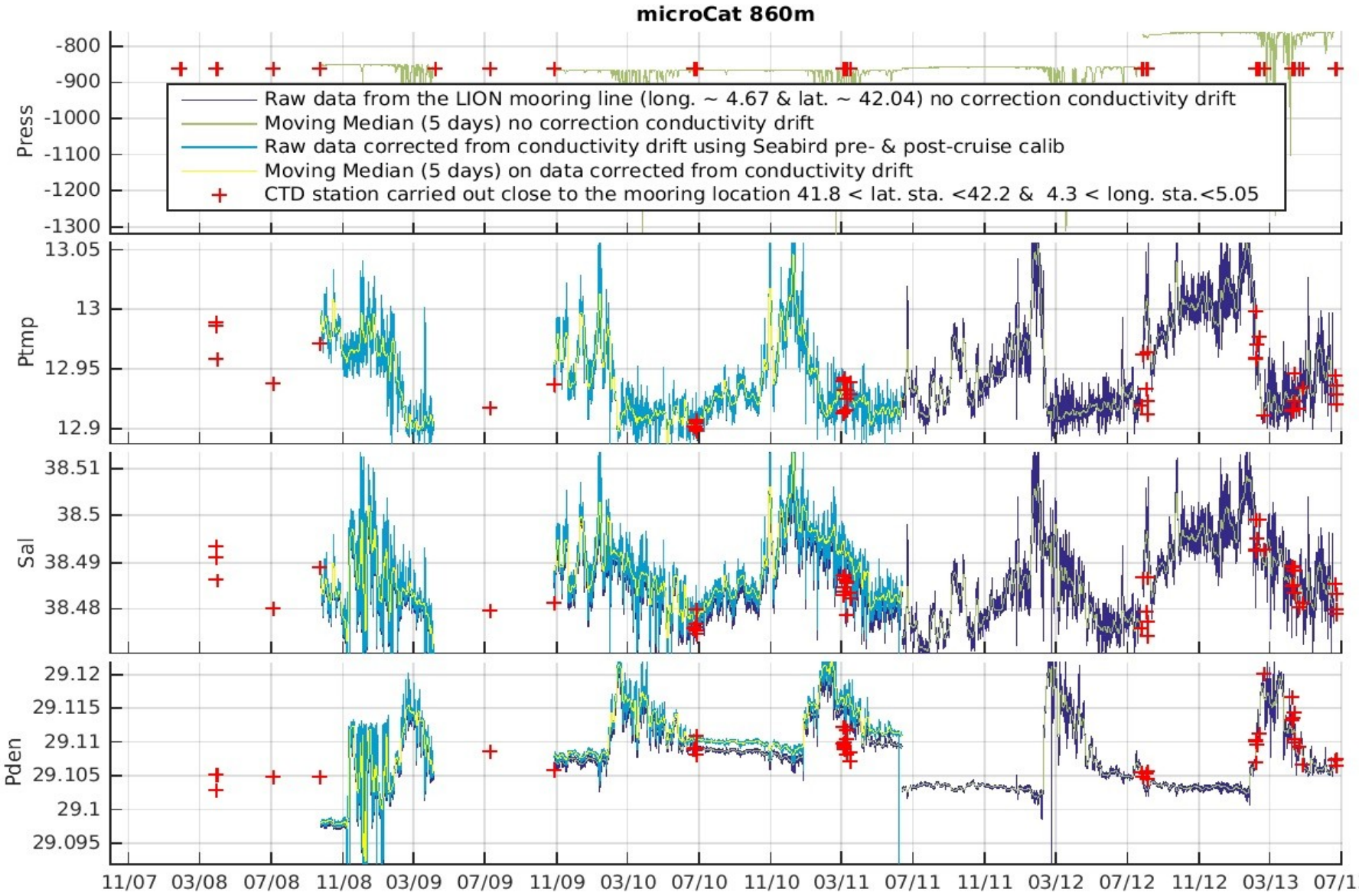

Figure 7: Pressure, potential temperature, salinity, and potential density computed at 900m using only the Seabird postcruise calibration. See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

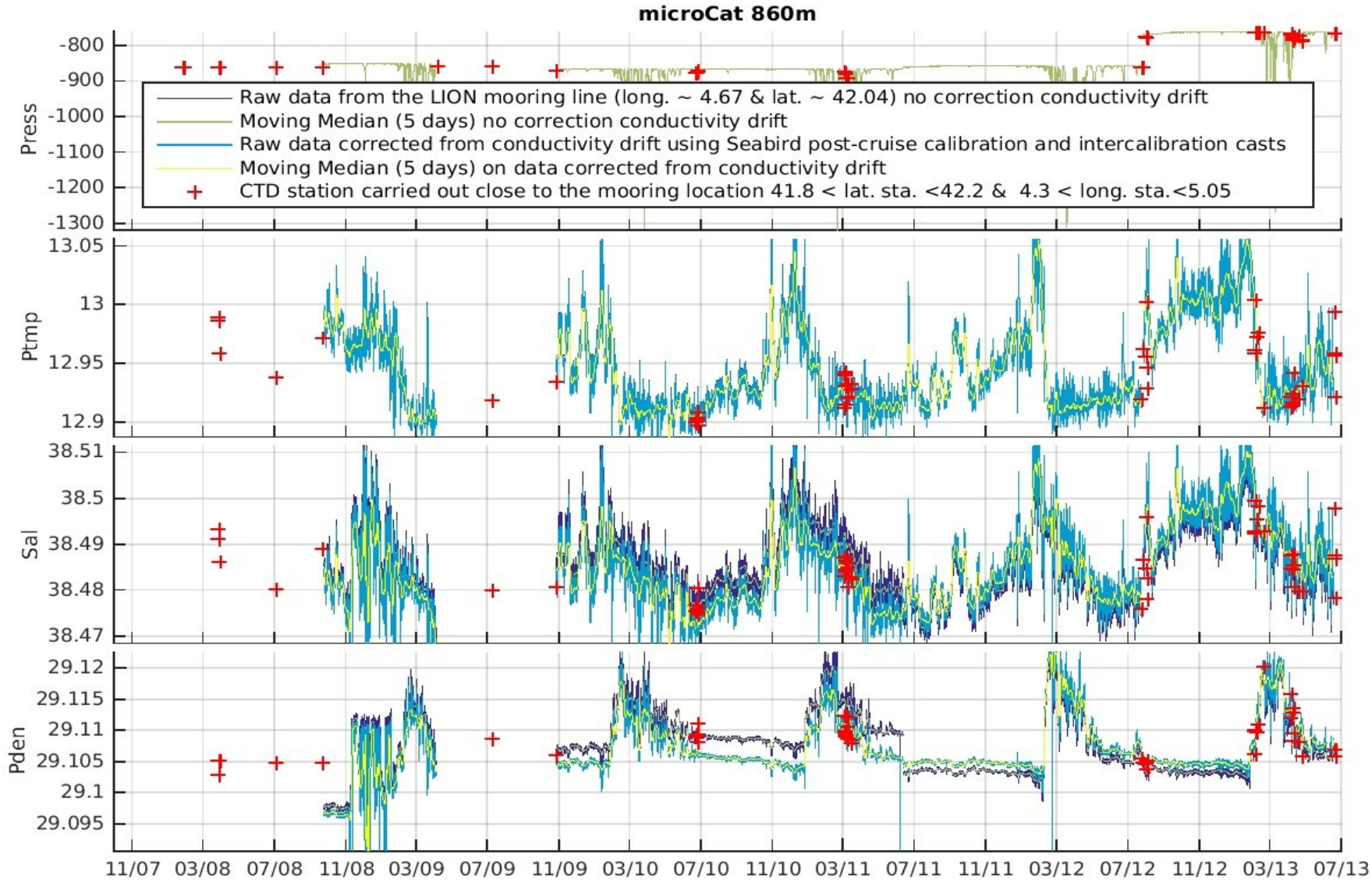

Figure 8: Pressure, potential temperature, salinity, and potential density computed at 900m using the Seabird postcruise calibration, except for the SN:5574 for which a salinity slope correction was applied. See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

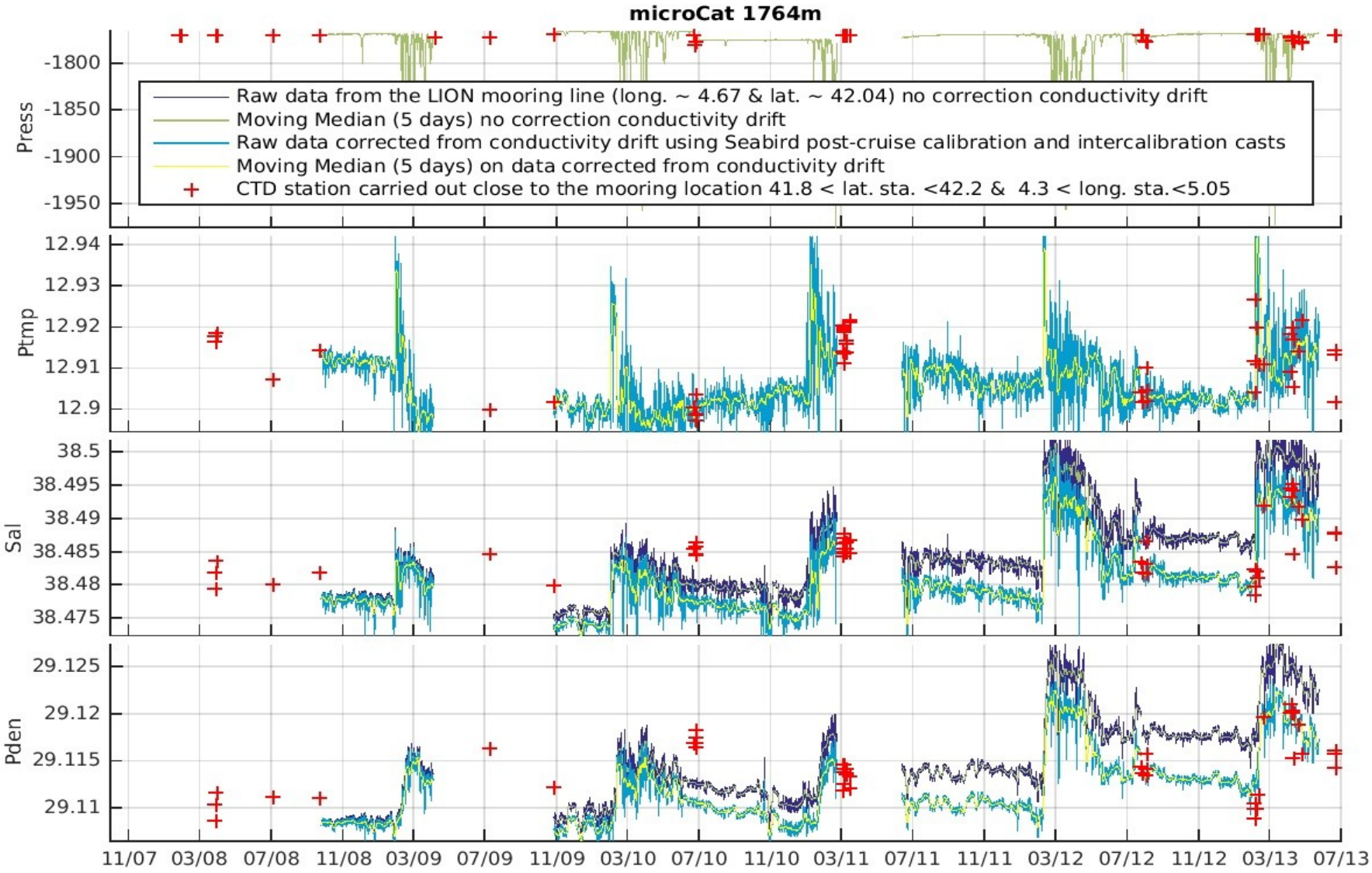

Figure 9: Pressure, potential temperature, salinity, and potential density computed at 1750m using the Seabird postcruise calibration, and the intercalibration casts. See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

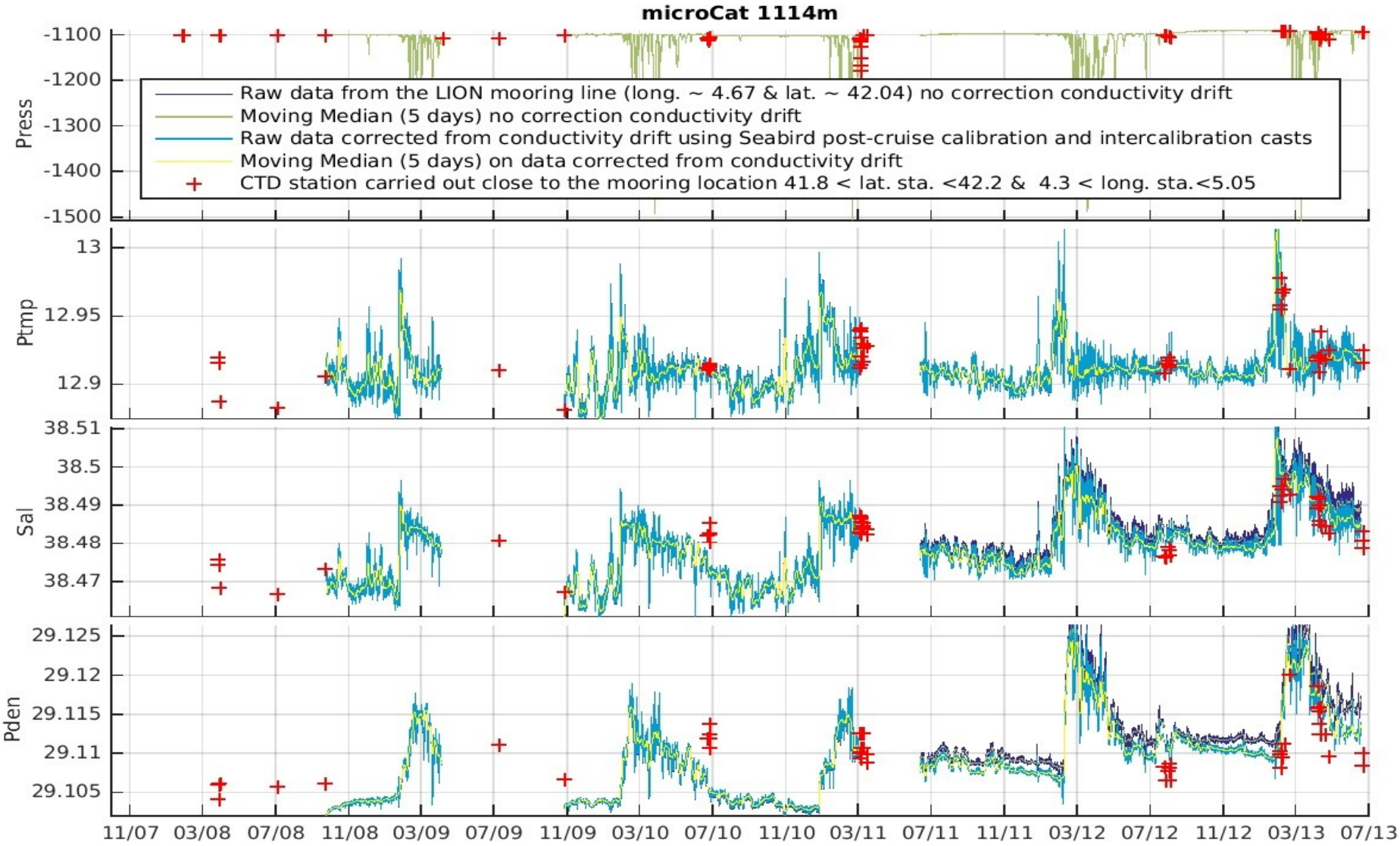

Figure 10: Pressure, potential temperature, salinity, and potential density computed at 1100m using the Seabird postcruise calibration, and the intercalibration casts. See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

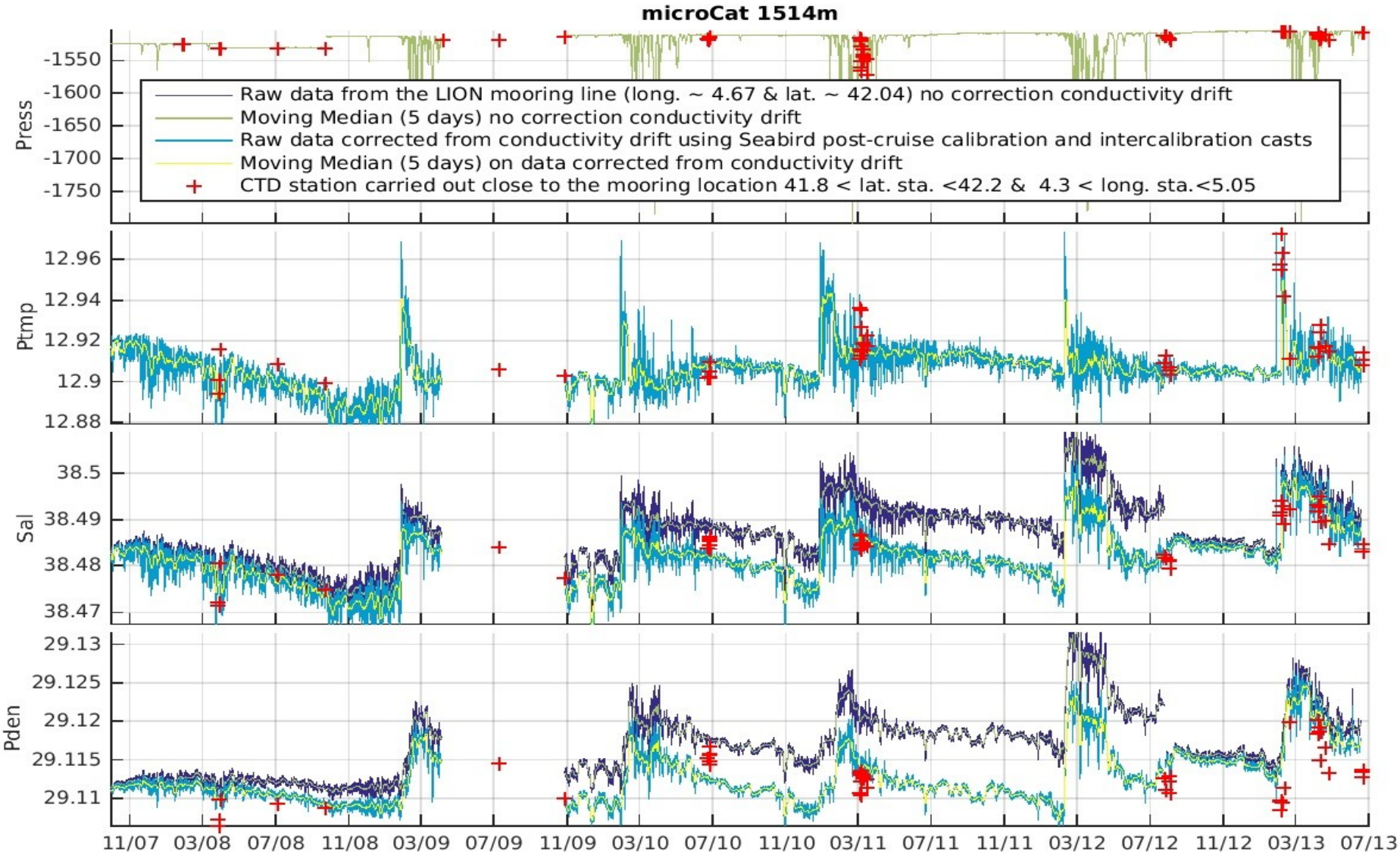

Figure 11: Pressure, potential temperature, salinity, and potential density computed at 1500m using the Seabird postcruise calibration, and the intercalibration casts. See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

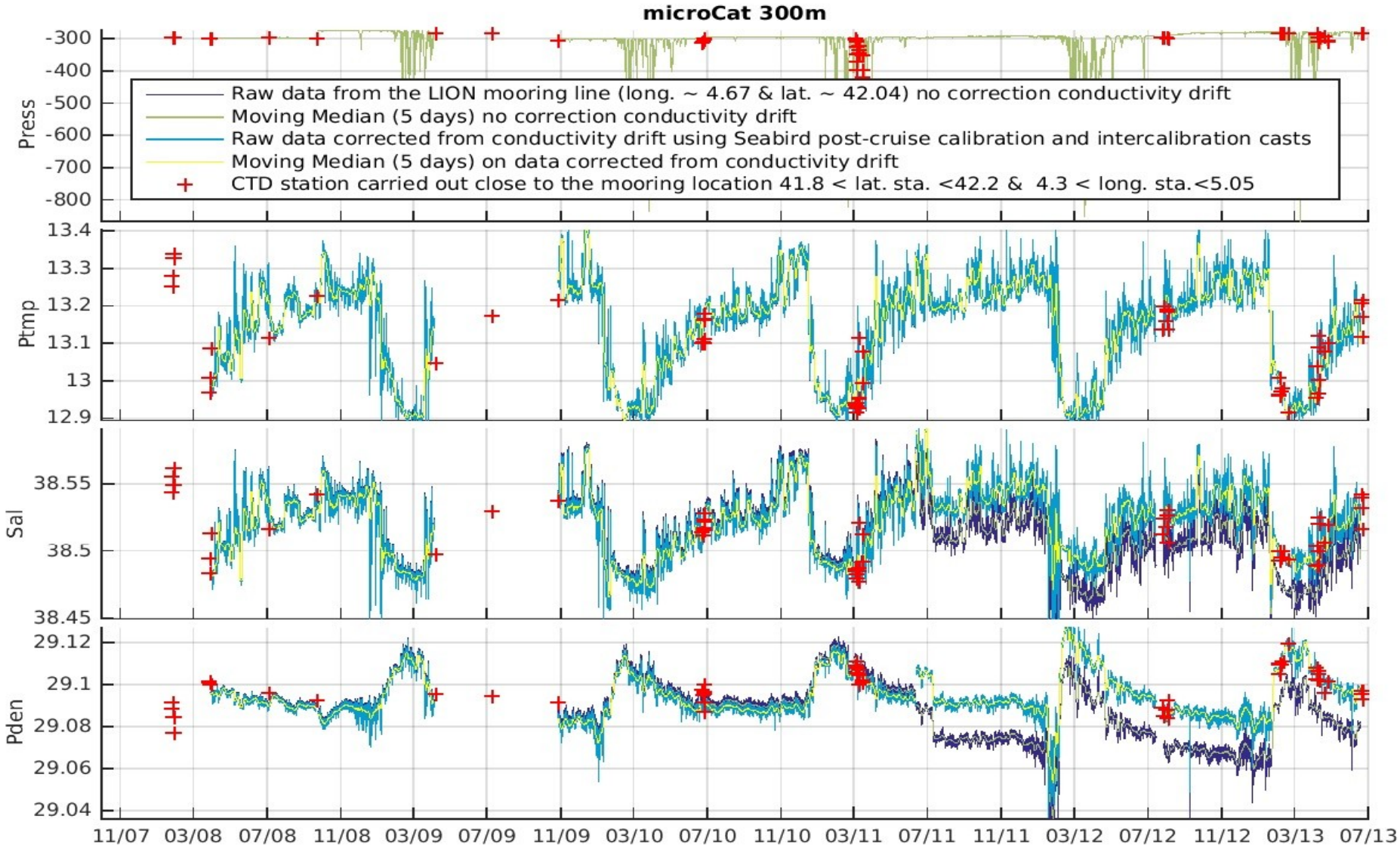

Figure 12: Pressure, potential temperature, salinity, and potential density computed at 300m using the Seabird postcruise calibration, and the intercalibration casts. See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.

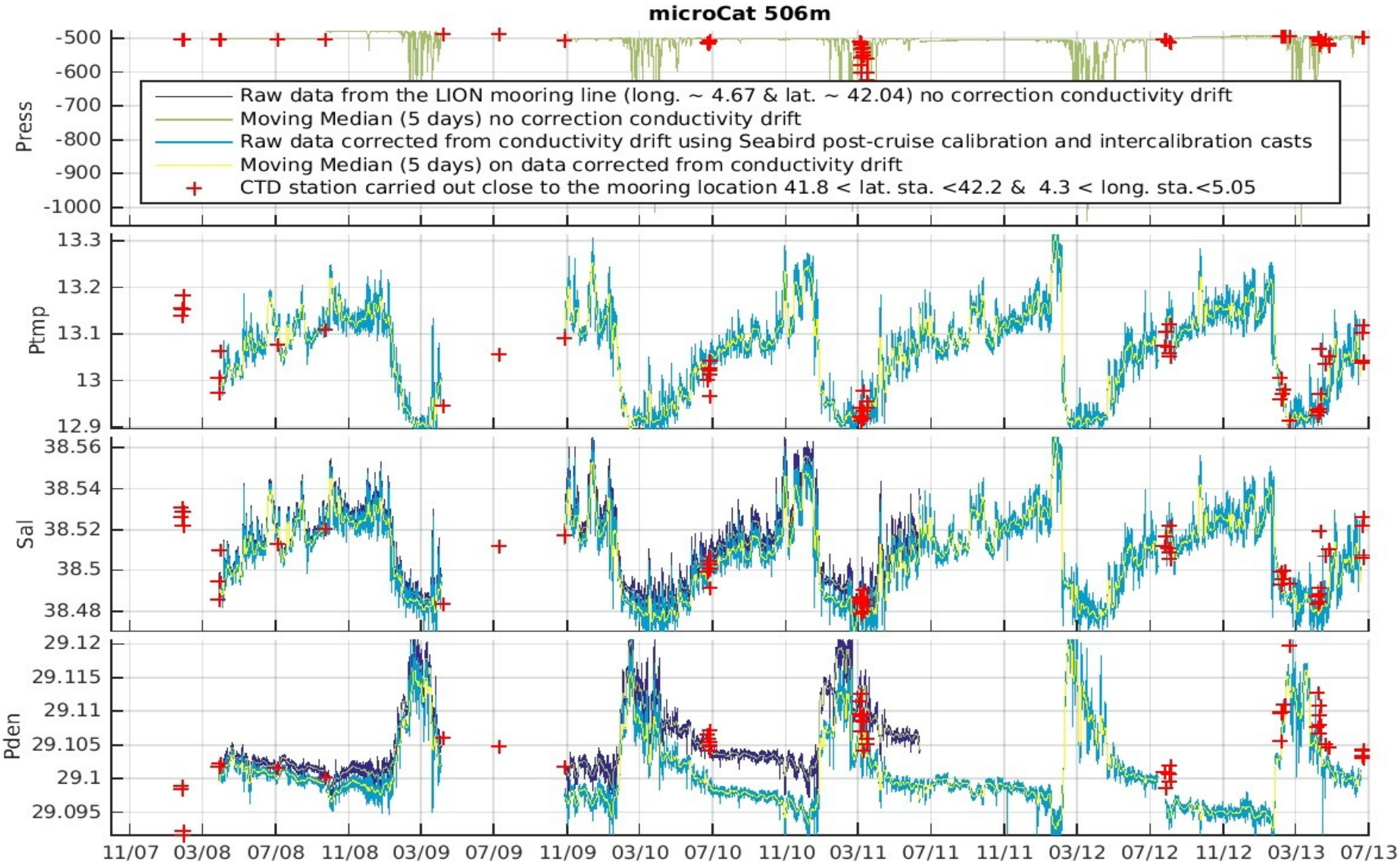

Figure 13: Pressure, potential temperature, salinity, and potential density computed at 500m using the Seabird postcruise calibration, and the intercalibration casts. See table 1 for a description of the different SBE37 Microcat deployed. The red crosses indicate shipboard CTD data close to the mooring location.