General processing report of continuous thermosalinograph oceanography

from RV POLARSTERN cruises: PS116, PS117, PS118, PS119, PS120

(11.11.2018 - 29.06.2019)

Contents

Contact:
Gerd Rohardt
Alfred-Wegener-Institute
Am Handelshafen 12, D-27570 Bremerhaven, GERMANY
Mail: info@awi.de

Processing Agency:
FIELAX
Gesellschaft für wissenschaftliche Datenverarbeitung mbH
Schleusenstr. 14, D-27568 Bremerhaven, GERMANY
Tel: +49 (0) 471 30015 0
Fax: +49 (0) 471 30015 22
Mail: info@fielax.de

Ref.: Polarstern_PS116toPS120_TSG.pdf	Vers.: 1	Date: 2019/08/26	Status: final

1 Introduction

This report describes the processing of raw data acquired by the thermosalinographs on board RV Polarstern during the expeditions PS116, PS117, PS118, PS119, PS120 to receive cleaned up and corrected salinity data.

2 Workflow

The different steps of processing are visualized in Figure 1. Two thermosalinographs (SBE21, Sea-Bird GmbH) are installed in the same tank in the keel of RV Polarstern for simultaneous measurements of temperature and conductivity. Both sensors are equipped with an internal and an external temperature sensor (SBE38, Sea-Bird GmbH). The external temperature sensors are installed close to the sea water inlet. After the cruise, the measured conductivity and temperature data of both sensors are extracted in hexadecimal form as 1 sec values from the DAVIS SHIP database (https://dship.awi.de). Data of every cruise are processed separately. First, the hexadecimal sentences are converted to raw data according to the instruction given by the manufacturer and time shifts between the sensors of max. 1sec are aligned. Afterwards the raw data are converted to temperature and conductivity values using the calibration coefficients from the calibration before deployment. However, data can only be finally processed after replacement and renewed calibration because correction values for the sensor drift can only be obtained by the post cruise calibration. The sensor drift is treated as a linear function during deployment and correction factors are calculated and applied for every day of deployment. See chapter 5 for further details on conductivity slope and temperature offset corrections. From the obtained internal temperature and conductivity data the salinity can be calculated according to the instructions from the Practical Salinity Scale PSS-78. Afterwards 10-min-means are calculated with outliers outside a 2-times standard deviation range being removed from the calculations of the 10-min-means. Statistics about the differences between both sensors are calculated and referred to in this report. The 10-min-means are visually inspected and - if necessary - manually despiked. Finally, the positions from the corrected mastertracks are assigned as spot-positions for the corresponding times. A speed filter of 0.5 knots minimum speed is applied to avoid redundant data.
Measurements of salinity with an OPTIMARE Precision Salinomter conducted during the cruises are represented for comparison in the Appendix of this report. Drift corrections using bottle samples were not attempted.
Both sensors are processed together and treated as equal. If there are no further objections, data from the sensor with the slope correction closer to 1.0 are prepared for the upload in PANGAEA. Also see the single detailled processing reports for each cruise.

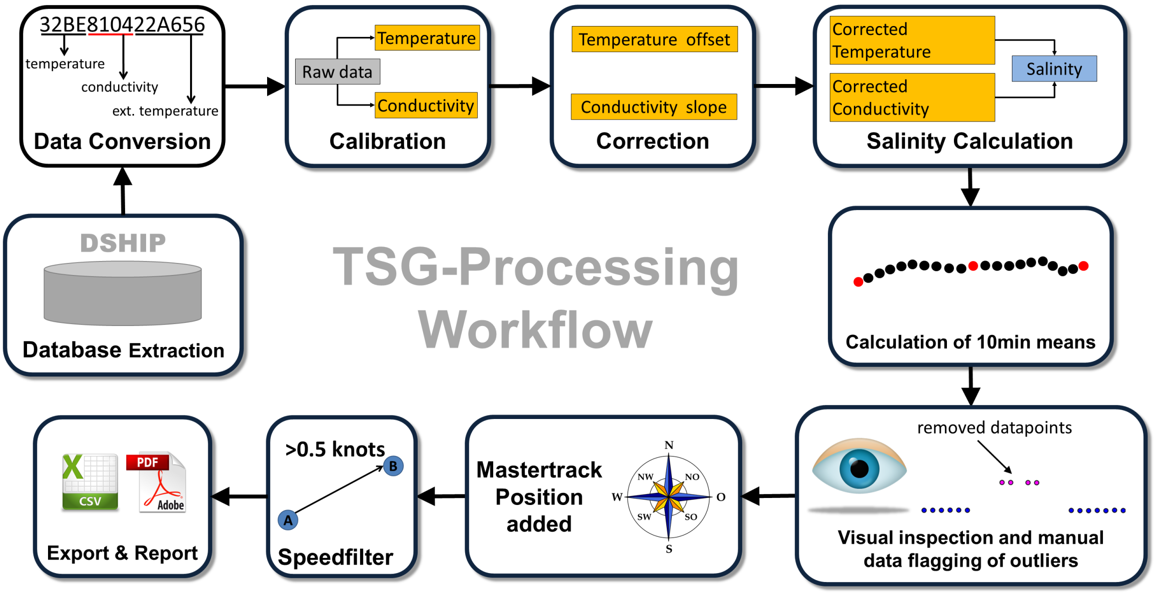

Figure 1: Workflow of Salinity data processing

3 Sensor Details

	TSG1	TSG2
Serial number	SBE21-3203	SBE21-3271
Installation	2018-10-16	2018-10-16
Deinstallation	2019-06-28	2019-06-28
Days installed	255	255
External temperature sensor	SBE38-110	SBE38-119
Calibration before installation	2018-07-12	2017-11-15
Calibration after installation	2019-07-09	2019-07-09
Temperature offset	-0.00362	-0.00116
Conductivity slope	1.0004949	1.0000546

4 Campaign Details

Data of following cruises were processed with the above mentioned sensors and calibration data. (Data extracted from **https://www.pangaea.de/expedition**)

Campaign	Start	Stop	From	To	Days
PS116	2018-11-11	2018-12-11	Bremerhaven	Cape Town	30
PS117	2018-12-15	2019-02-07	Cape Town	Punta Arenas	54
PS118	2019-02-09	2019-04-10	Punta Arenas	Punta Arenas	60
PS119	2019-04-13	2019-05-31	Punta Arenas	Port Stanley	48
PS120	2019-06-02	2019-06-29	Port Stanley	Bremerhaven	27

Following table shows the data details of the cruises considered in this report. The number of TSG1 and TSG2 messages is the number of data downloaded from DSHIP for the individual cruises. The number of result messages is the number of data remaining after calculation of 10min means, manual flagging and speed flagging.

Campaign	first message	last message	TSG1 messages	TSG2 messages	Result messages
PS116	2018-11-12T15:36:47	2018-12-10T06:28:58	736569	736749	3295
PS117	2018-12-16T07:56:30	2019-02-03T19:24:35	1045891	1046029	4787
PS118	2019-02-09T04:00:02	2019-04-05T15:03:11	861937	862027	3203
PS119	2019-04-17T22:55:30	2019-05-29T21:08:32	897843	897844	4243
PS120	2019-06-03T11:27:32	2019-06-28T12:39:59	531332	531329	3341

5 Processing results

Correction for conductivity and temperature drift

Correction for conductivity and temperature drift of the sensors was accomplished following the instructions by SEA-BIRD Application Note 31 (Revision June 2016). Conductivity slope and temperature offset values were calculated for each day of deployment of the TSG1 and TSG2 sensors using following equations.

Correction of conductivity data: islope = 1.0 + (b / n) [(1 / postslope) - 1.0]
b = number of days between begin of deployment and day of measurement
n = number of days between deployment and deinstallation
postslope = slope from post-cruise calibration sheet
corrected conductivity = islope * computed conductivity

Correction of temperature data: offset = b * (residual / n)
b = number of days between begin of deployment and day of measurement
n = number of days between deployment and deinstallation

residual = residual from post-cruise calibration sheet

corrected temperature = offset + computed temperature

Data for the correction values are given in the following two table for TSG1 and TSG2 respectively. The deployed days columns indicate the number of the first and the last day of each cruise within the deployment interval of TSG1 (255 days) and TSG2 (255 days). The start and stop values in the columns conductivity slope and temperature offset show the correction values for the first and last day of the cruise.

TSG1	**deployed days**		**Conductivity slope**		**Temperature offset**	
Cruise	first	last	start	stop	start	stop
PS116	27	55	0.99994762	0.99989331	-0.00038329	-0.00078078
PS117	61	110	0.99988167	0.99978662	-0.00086596	-0.00156157
PS118	116	171	0.99977498	0.99966829	-0.00164675	-0.00242753
PS119	183	225	0.99964501	0.99956354	-0.00259788	-0.00319412
PS120	230	255	0.99955384	0.99950534	-0.00326510	-0.00362000

TSG2	**deployed days**		**Conductivity slope**		**Temperature offset**	
Cruise	first	last	start	stop	start	stop
PS116	27	55	0.99999422	0.99998822	-0.00012282	-0.00025020
PS117	61	110	0.99998694	0.99997645	-0.00027749	-0.00050039
PS118	116	171	0.99997516	0.99996339	-0.00052769	-0.00077788
PS119	183	225	0.99996082	0.99995183	-0.00083247	-0.00102353
PS120	230	255	0.99995076	0.99994540	-0.00104627	-0.00116000

Measured data

Data from the time range considered are show in Figures 2 and 4. Salinometer measurements of bottle samples are depicted in the plots of the salinity of TSG1 and TSG2 (also see Appendix: Measurements of salinity with the OPTIMARE salinometer). Also given are plots of the standard deviations of the 10min means for every parameter (Figures 3 and 5).

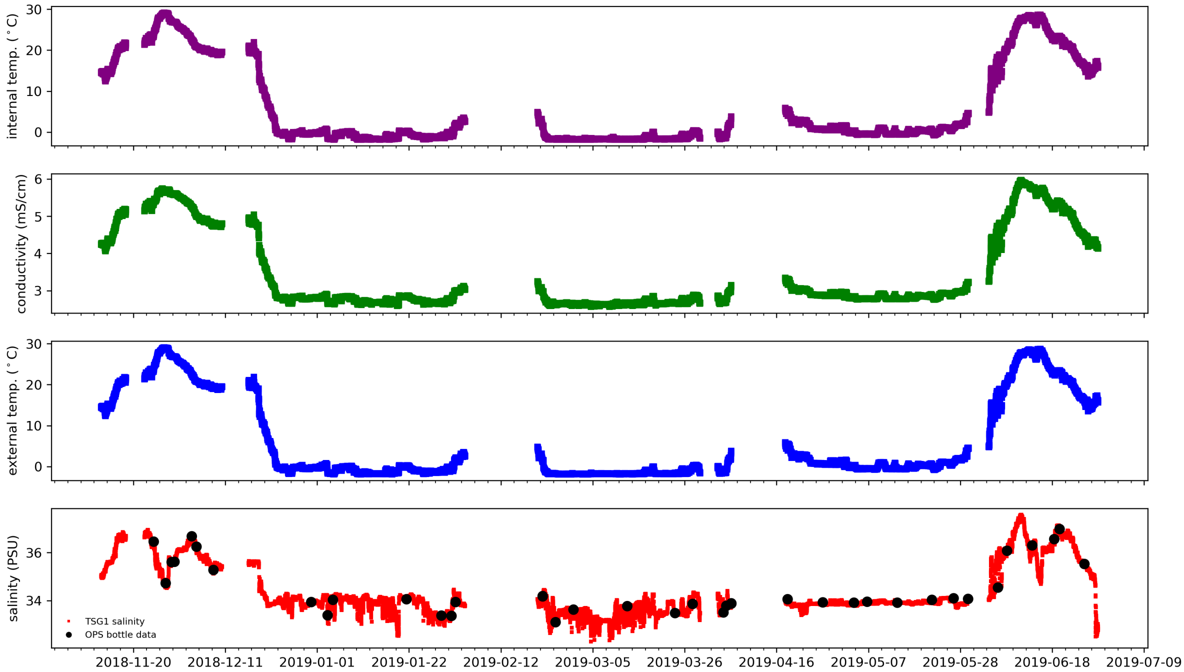

Figure 2: 10min means of data from TSG1

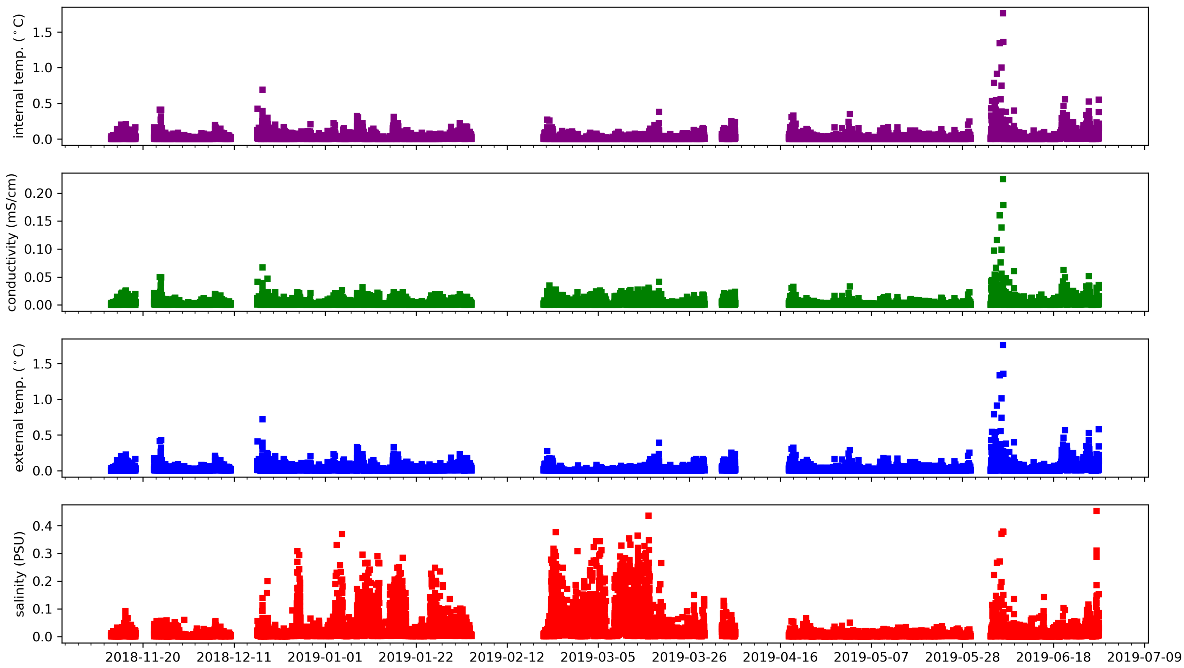

Figure 3: Standard deviations of 10min means of data from TSG1

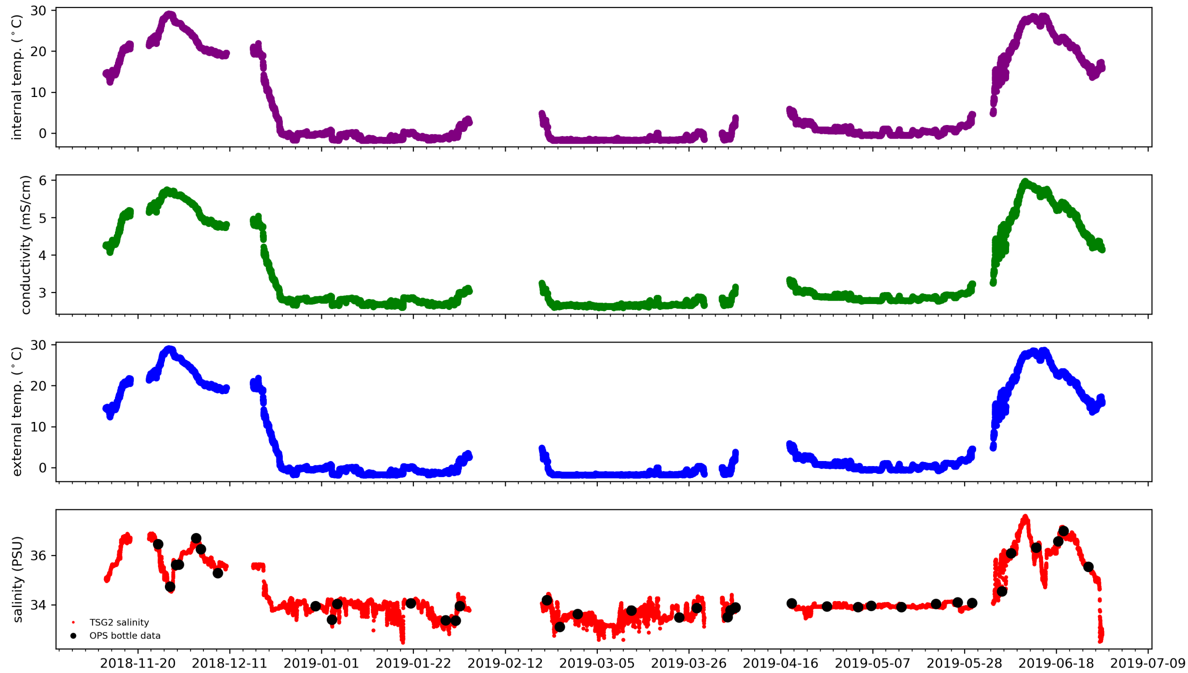

Figure 4: 10min means of data from TSG2

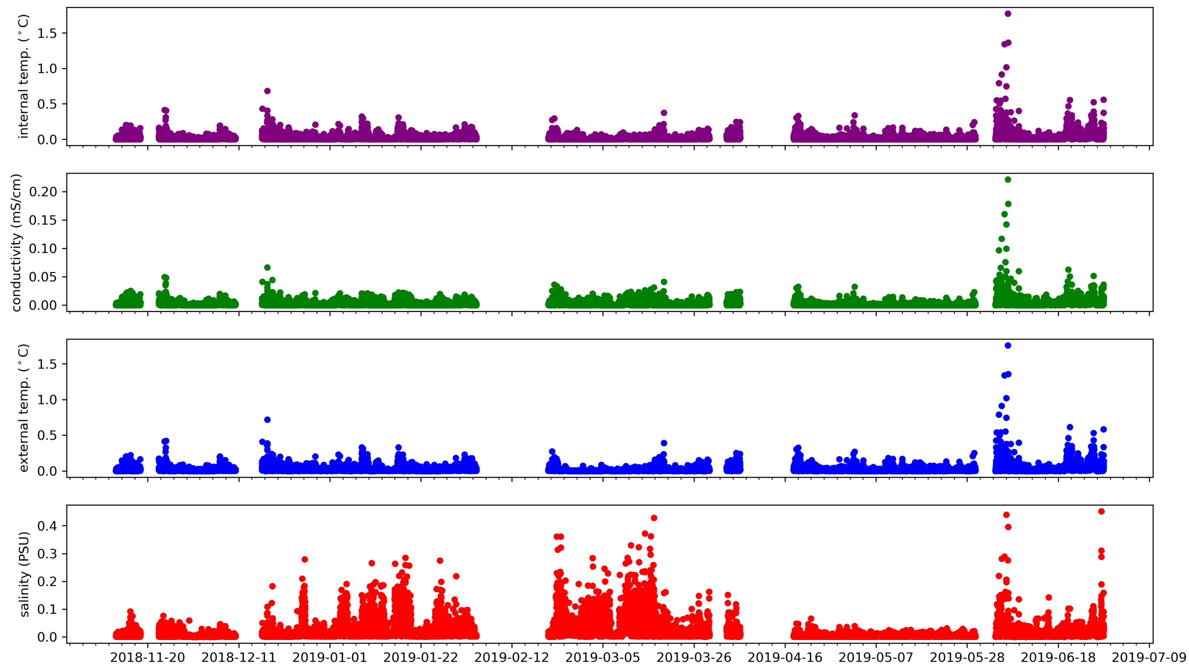

Figure 5: Standard deviations of 10min means of data from TSG2

Differences between TSG1 and TSG2

Differences between the two thermosalinographs are show in Figure 6. Only data within 2-times standard deviation are depicted. For the comparison of the spot values only data with a maximum time difference of 1sec between TSG1 und TSG2 are considered.

Parameter	Spot measurements	10min means
Internal temperature [°C]	-0.00434 ± 0.00779	-0.00434 ± 0.00408
Conductivity [mS/cm]	-0.02125 ± 0.07339	-0.02113 ± 0.04683
External temperature [°C]	-0.00014 ± 0.00780	0.00009 ± 0.00077
Salinity [PSU]	-0.01944 ± 0.09540	-0.01960 ± 0.06172

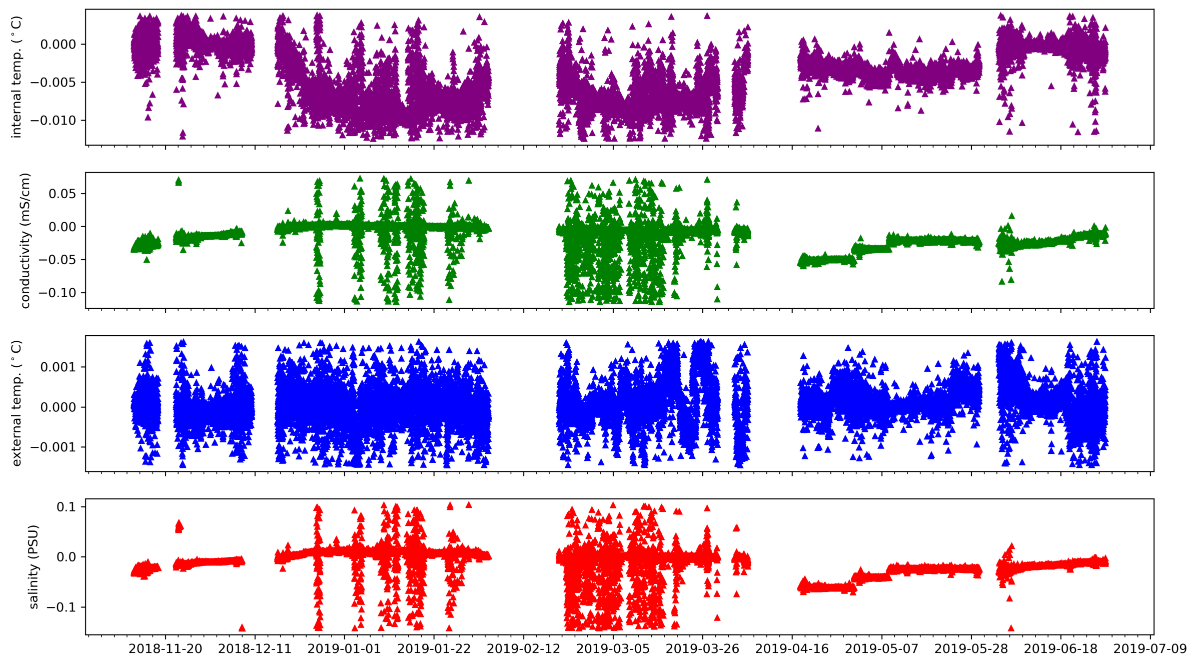

Figure 6: Differences between 10min means TSG1 - TSG2

Post calibration values show a greater temperature offset (-0.00362) and greater slope correction values (1.0004949) for TSG1 compared to TSG2 (-0.00116 and 1.0000546).Therefore the TSG2 (SBE21-3271) data of the cruises dealed with in this report are uploaded to PANGAEA.
The histograms for the differences between TSG1 and TSG2 shown in Figure 7 show some strange effects for the comparison of the internal temperatures of TSG1 and TSG2. Three major groups can be distinguished in the histogram. Cruises PS117 and PS118 took place in very cold regions with water temperatures below -1°C. During these cruises the differences between TSG1 and TSG2 internal temperatures range between -0.005 and -0.01°C causing one of the maxima in the histogram. The second maxima around -0.003°C correlates with water temperatures below 5°C. Smallest dif-

ferences of -0.001 till +0.001°C are found together with water temperatures greater than 15°C. This behaviour may be explained by calibration data of the TSG which are calibrated only in the temperature range between +1 and +32°C. Although measurement range is given with -5 till +35°C the cold water cruises approximate the lower limit of the measurement range where small deviations from the ideal behaviour seem likely. Additionally, the accuracy of the sensor is given with 0.01°C and even the higher differences are well within the accuracy range. Furthermore, occasional pollution and blocking of the filter system by biological material as well as malfunction of the system pump may have disturbed flow conditions in the TSG tank causing temperature inhomogeneities in the tank. The system pump was exchanges after PS118 at the beginning of April resulting in less scatter during the following cruises (Figure 6). Also, especially cruises PS117 and PS118 took place in areas with possible sea ice conditions probably causing some of the scatter in the conductivity values.

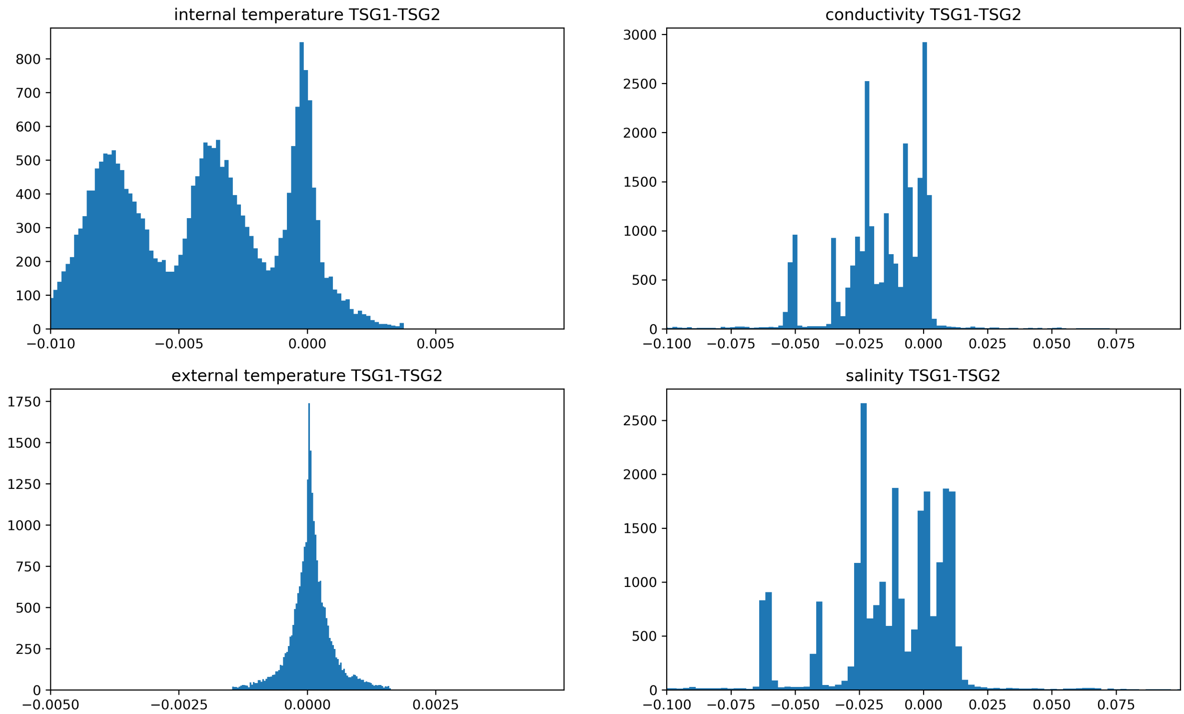

Figure 7: Histogramm of differences TSG1 - TSG2

Differences between internal and external temperature of TSG1 and TSG2 sensors

Temperature differences between the internal and the external temperature sensors have to be small under normal circulation conditions. Means and standard deviations for the temperature differences are given in the following table and are shown in Figure 8.

	TSG1 (mean ± std. dev.)	**TSG2** (mean ± std. dev.)
Spot values	0.03044 ± 0.06056°C	0.03438 ± 0.05994°C
10-min means	0.02868 ± 0.03389°C	0.03307 ± 0.03665°C

Some abnormalities are obvious for the first half cruise PS120 between 2019-06-03 and 2019-06-20 where internal temperatures are lower than external temperatures for both TSG systems (Figure 8). This is contradictory to all other cruises considered so far. No further explanations could be obtained by concrete demands among Polarsterns crew. It is only known that after port time in Las Palmas and restart of the system on 2019-06-20 the ratio between internal and external temperatures changed back to normal with internal temperatures being higher than external temperatures. Since the internal temperature is included in the salinity calculations we suggest careful handling of the data of PS120.

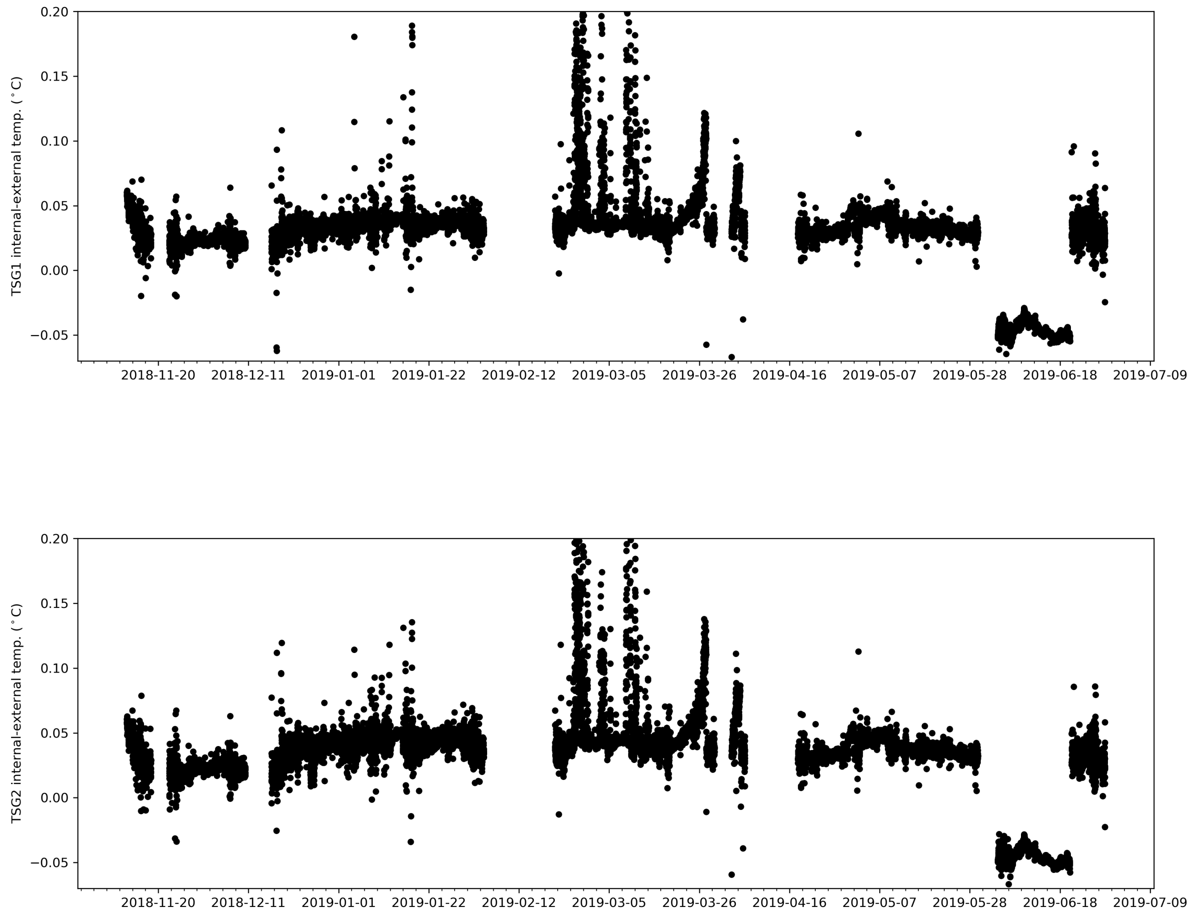

Figure 8: Temperature differences between internal and external temperature sensors of 10min means

Result file

Result files are given for each cruise individually. The result file is a plain text (tab-delimited values) file named *Cruise*_surf_oce.tab with one data row in 10-min interval. The water depth in the result file is the depth of the water inlet for the thermosalinographs. Further information about processing of the data of each cruise can be obtained from following cruise reports: PS116_nav.pdf, PS117_TSG_nav.pdf, PS118_TSG_nav.pdf, PS119_TSG_nav.pdf, PS120_TSG_nav.pdf .

Column separator	Tabulator "\t"
Column 1	Date and time expressed according to ISO 8601
Column 2	Latitude in decimal format, unit degree
Column 3	Longitude in decimal format, unit degree
Column 4	Water depth, unit metre
Column 5	Temperature, unit degree Celsius
Column 6	Salinity PSU

6 Appendix

Measurements of salinity with the OPTIMARE salinometer

Bottle samples of sea water were continously taken during the cruises. Those samples were measured with the Optimare Salinometer onboard after temperature equalization. The bottle data are given here for reference. Drift correction using the bottle data was not applied.

Time of sampling	OPS Salinity [PSU]
2018-11-24T14:51:00	36.4602
2018-11-27T08:54:00	34.7333
2018-11-28T16:31:00	35.6079
2018-11-29T08:35:00	35.6234
2018-12-03T08:12:00	36.6935
2018-12-04T08:53:00	36.2524
2018-12-08T06:48:30	35.2769
2018-12-30T15:14:05	33.9439
2019-01-03T08:49:00	33.3955
2019-01-04T14:07:30	34.0319
2019-01-21T09:29:00	34.0602
2019-01-29T09:41:00	33.3754
2019-01-31T15:29:30	33.3652
2019-02-01T14:29:00	33.9454
2019-02-21T11:40:30	34.1867
2019-02-21T11:42:00	34.1839
2019-02-24T11:23:00	33.1050
2019-02-28T12:58:00	33.6229
2019-03-12T19:50:00	33.7709
2019-03-23T18:56:30	33.4842
2019-03-27T19:07:00	33.8635
2019-04-03T19:34:30	33.5033
2019-04-04T11:25:00	33.7783
2019-04-05T14:37:00	33.8922
2019-04-05T14:40:30	33.8795
2019-04-18T12:33:00	34.0644
2019-04-26T12:09:00	33.9336
2019-05-03T15:57:00	33.9112
2019-05-06T16:05:00	33.9607
2019-05-13T13:16:00	33.9130
2019-05-21T10:36:00	34.0281
2019-05-26T11:08:00	34.0994
2019-05-29T17:28:00	34.0664
2019-06-05T13:41:00	34.5421
2019-06-07T15:03:00	36.0793
2019-06-13T10:05:00	36.3129
2019-06-18T09:19:00	36.5659
2019-06-19T15:40:00	36.9871
2019-06-25T07:59:00	35.5347