General Processing Report of Surface T/S Data

RV Polarstern Cruises: PS106, PS107, PS108, PS109

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Contents

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1 Introduction

This report describes the processing of raw data acquired by the thermosalinographs on board RV Polarstern during the expeditions PS106, PS107, PS108, PS109 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.

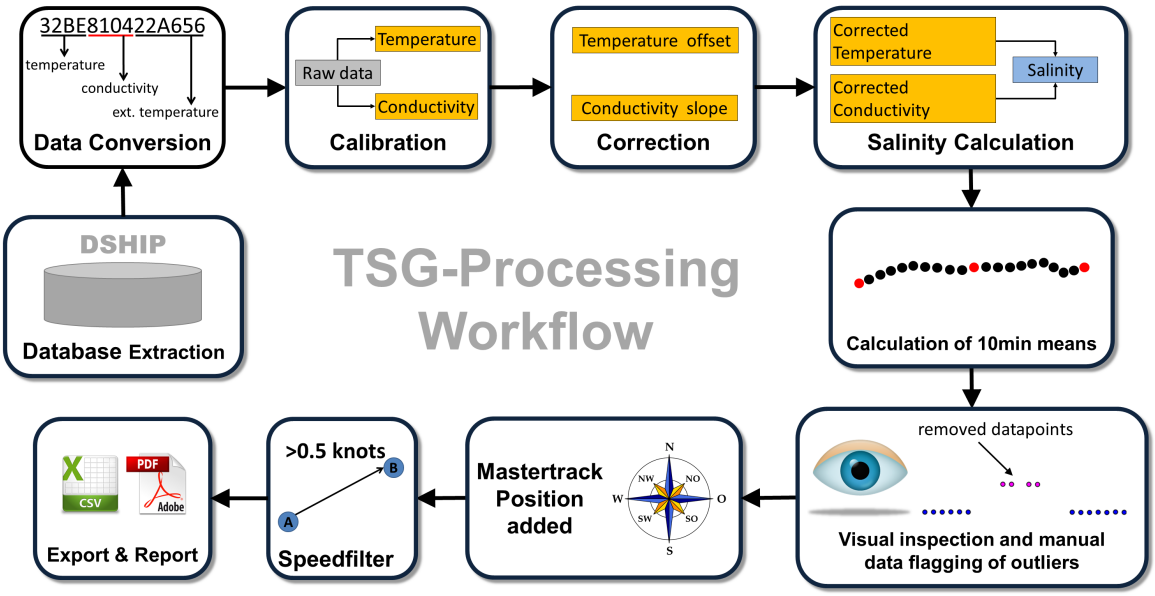

Figure 1: Workflow of Salinity data processing

3 Sensor Details

	TSG1	TSG2
Serial number	SBE21-3191	SBE21-3271
Installation	2016-11-19	2017-06-23
Deinstallation	2017-10-11	2017-10-11
Days installed	326	110
External temperature sensor	SBE38-110	SBE38-119
Calibration before installation	2015-04-15	2017-04-29
Calibration after installation	2017-11-15	2017-11-15
Temperature offset	-0.00073	-0.00048
Conductivity slope	0.9999939	0.9999366

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
PS106	2017-06-23	2017-07-20	Longyearbyen	Tromsoe	27
PS107	2017-07-23	2017-08-19	Tromsoe	Tromsoe	27
PS108	2017-08-22	2017-09-09	Tromsoe	Tromsoe	18
PS109	2017-09-16	2017-10-14	Tromsoe	Bremerhaven	28

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
PS106	2017-06-23T11:00:01	2017-07-20T06:24:30	577793	577794	2768
PS107	2017-07-24T06:46:58	2017-08-18T19:14:36	524507	524503	1872
PS108	2017-08-23T06:49:16	2017-09-08T15:44:05	352715	352713	1581
PS109	2017-09-12T04:00:04	2017-10-11T14:12:51	635588	635588	3088

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 (326 days) and TSG2 (110 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
PS106	216	243	1.00000404	1.00000455	-0.00048368	-0.00054414
PS107	247	272	1.00000462	1.00000509	-0.00055310	-0.00060908
PS108	277	293	1.00000518	1.00000548	-0.00062028	-0.00065610
PS109	297	326	1.00000556	1.00000610	-0.00066506	-0.00073000

TSG2	**deployed days**		**Conductivity slope**		**Temperature offset**	
Cruise	first	last	start	stop	start	stop
PS106	1	28	1.00000057	1.00001599	-0.00000432	-0.00012108
PS107	31	56	1.00000172	1.00000311	-0.00020573	-0.00037164
PS108	61	77	1.00000338	1.00000427	-0.00040482	-0.00051100
PS109	81	110	1.00000449	1.00000610	-0.00053755	-0.00073000

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).

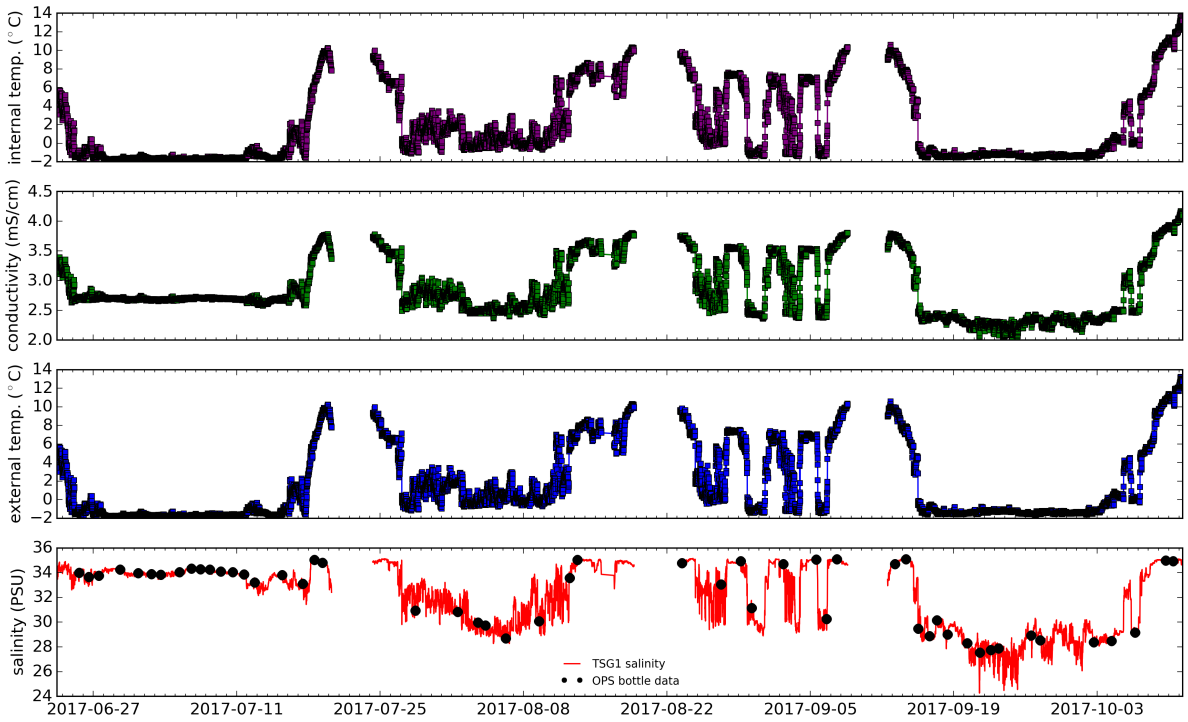

Figure 2: 10min means of data from TSG1

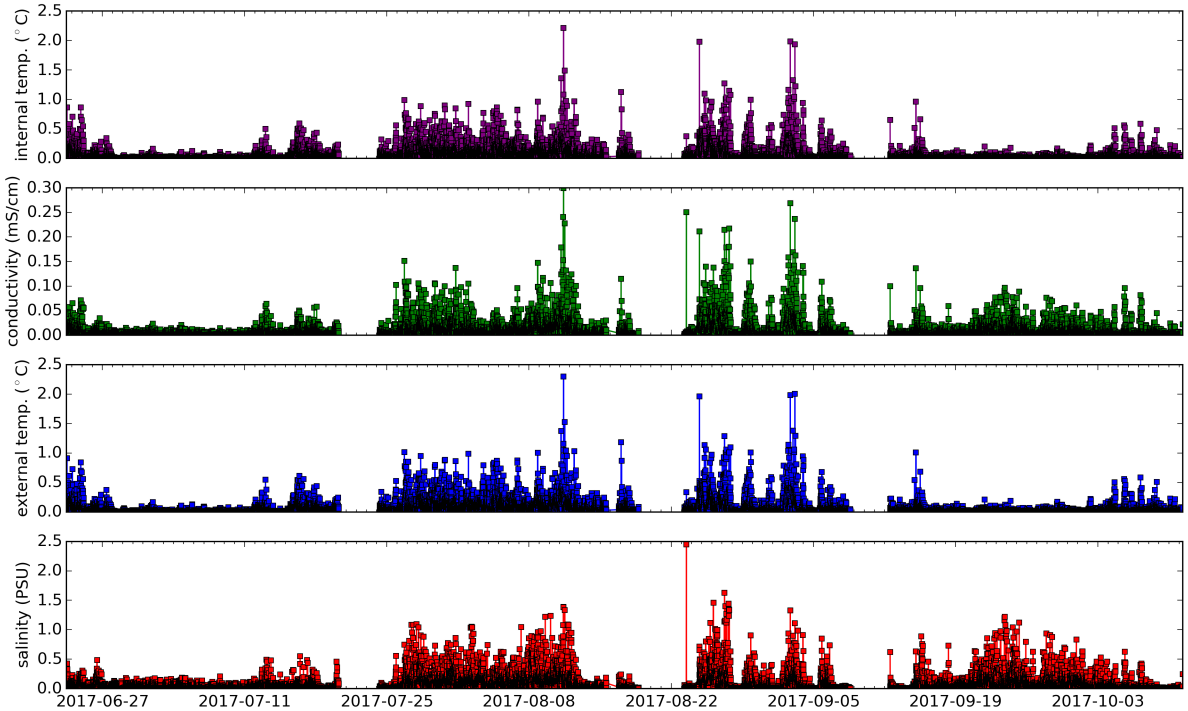

Figure 3: Standard deviations of 10min means of data from TSG1

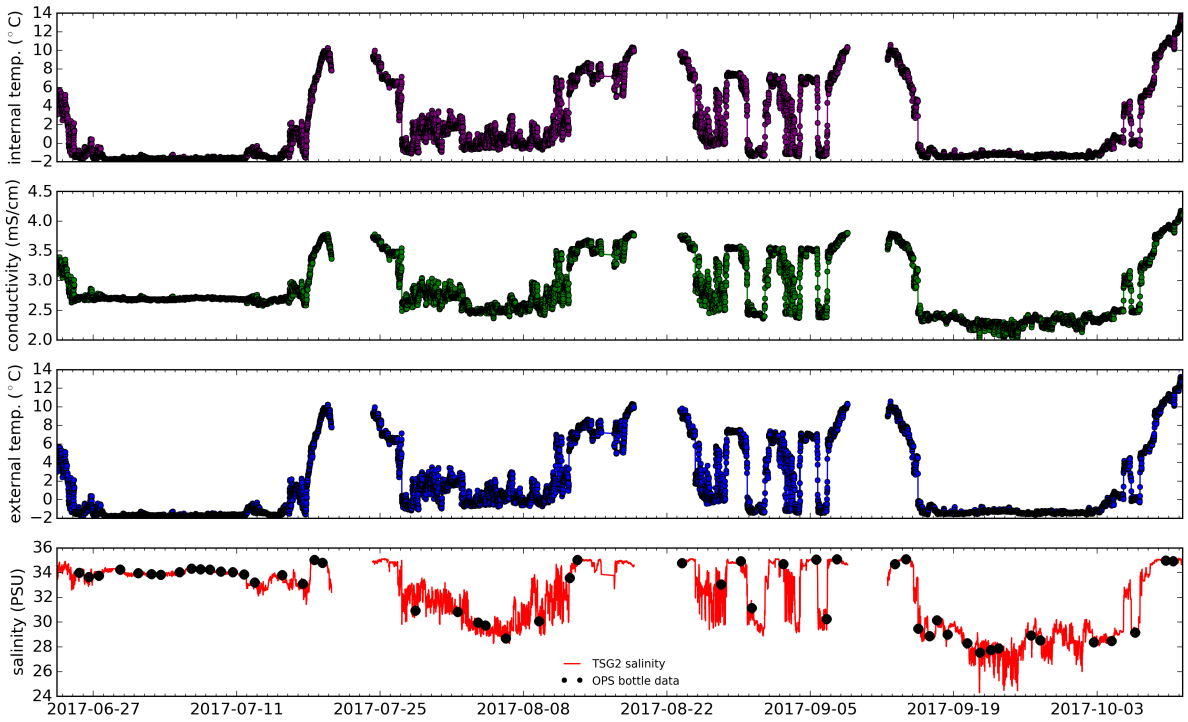

Figure 4: 10min means of data from TSG2

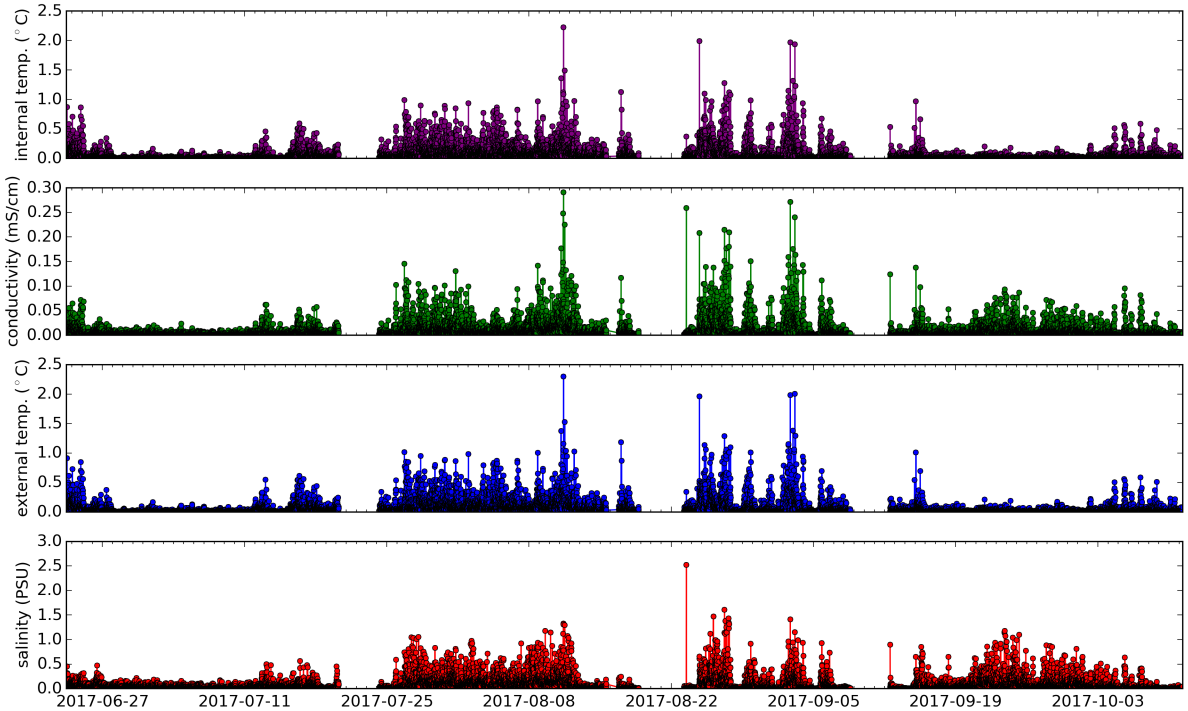

Figure 5: Standard deviations of 10min means of data from TSG2

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]	0.00163 ± 0.01477	0.00172 ± 0.00354
Conductivity [mS/cm]	-0.00002 ± 0.08811	-0.00168 ± 0.02387
External temperature [°C]	-0.00082 ± 0.00602	-0.00061 ± 0.00138
Salinity [PSU]	-0.00153 ± 0.08683	-0.00371 ± 0.03193

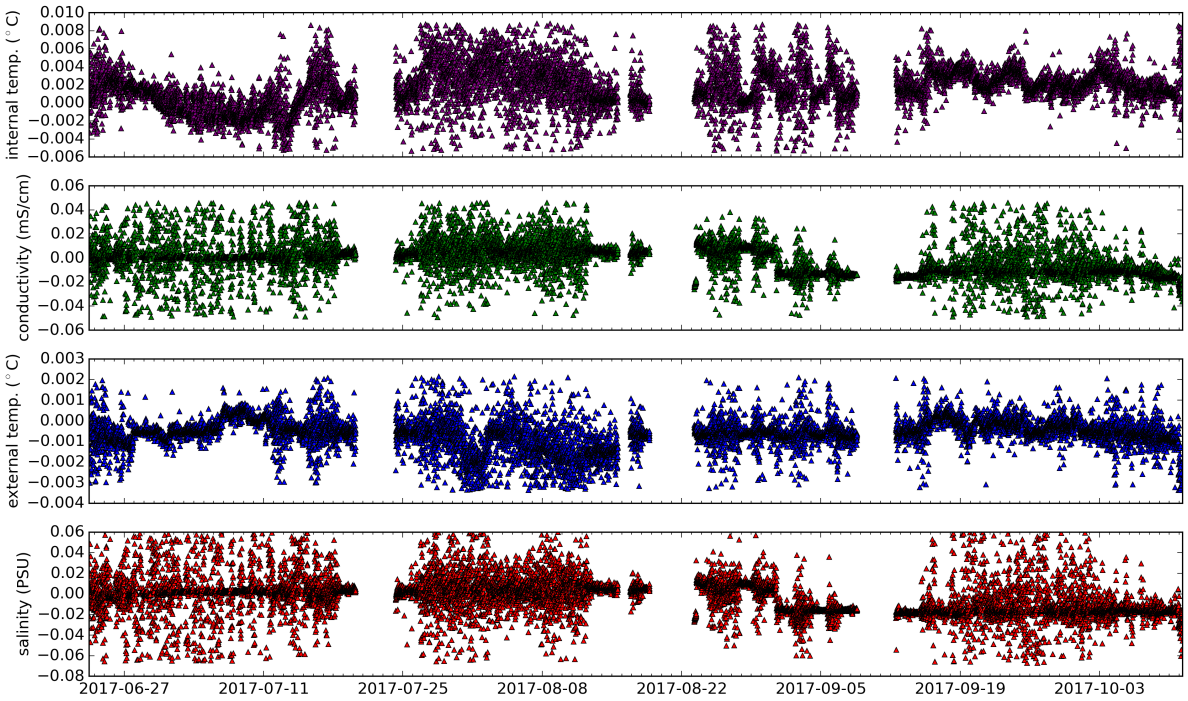

Figure 6: Differences between 10min means TSG1 - TSG2

The comparison of TSG1 and TSG2 data clearly shows a change in behaviour at the end of August 2017. In the first half of the considered period TSG1 conductivity values are higher than those of TSG2 (TSG1-TSG2 > 0) leading to higher calculated salinity values for TSG1. After a short data gap on 31 August 2017 the situation changes towards higher TSG2 conductivity and salinity (TSG1-TSG2 < 0). This can also be seen in the bimodal behaviour of the conductivity and salinity histograms Figure 7. There is no clear explanation for this behaviour. The TSG1 sensor (SBE21-3191) was deployed for 326 days while the TSG2 sensor (SBE21-3271) was used for a much shorter period of 110 days. Still the post cruise calibration gives a higher conductivity slope correction value

for TSG2 which may indicate that SBE21-3271 is the sensor with the higher drift. Therefore the TSG1 (SBE21-3191) data of the cruises dealed with in this report are uploaded to PANGAEA.

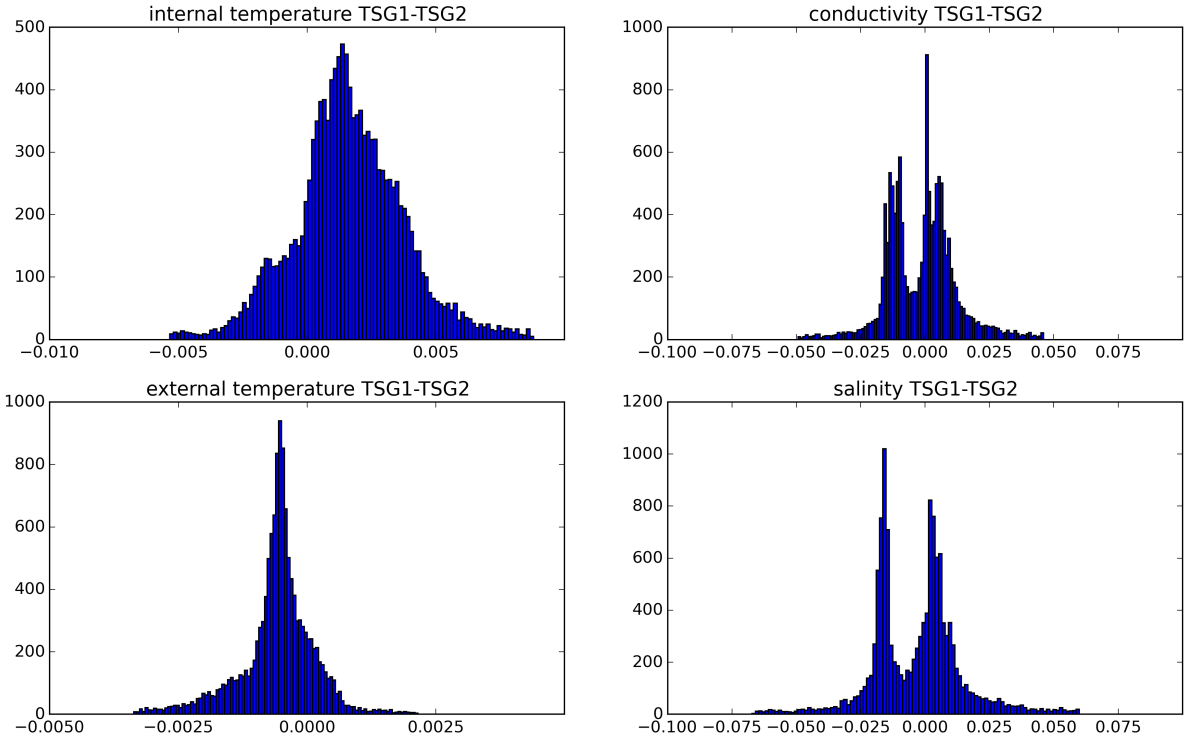

Figure 7: Histogramm of differences TSG1 - TSG2

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	0.04122 ± 0.09203°C	0.03845 ± 0.08443°C
10-min means	0.03614 ± 0.03323°C	0.03381 ± 0.03201°C

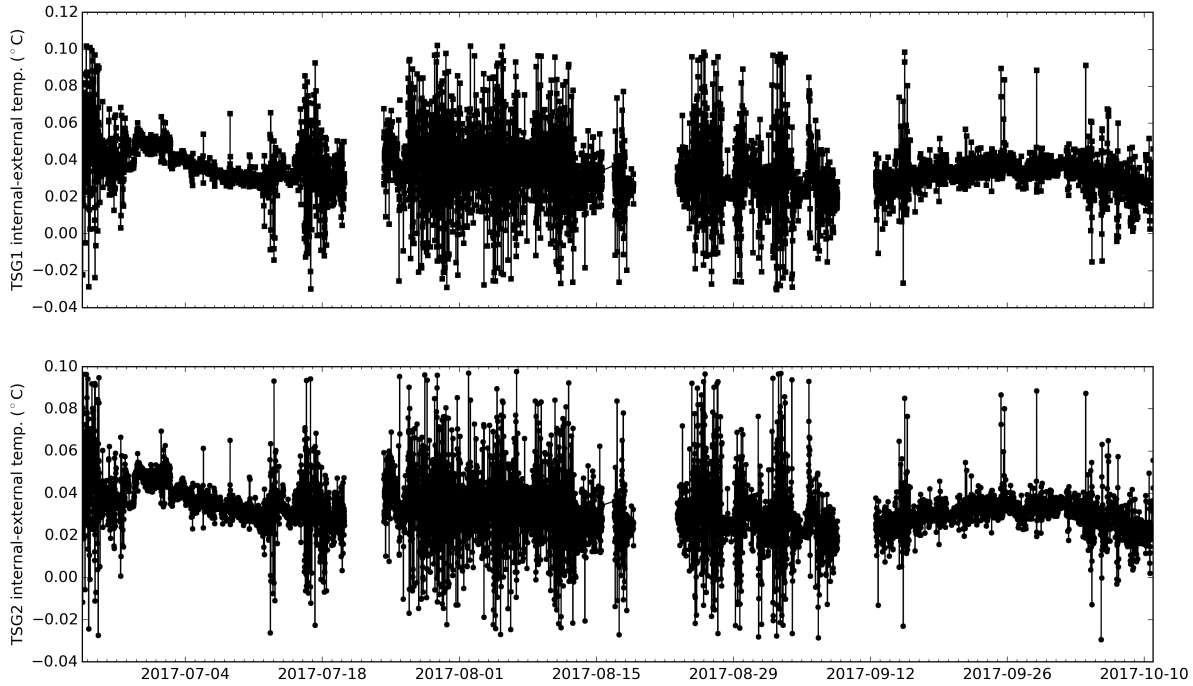

Figure 8: Temperature differences between internal and external temperature sensors of 10min means

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: PS106_TSG_nav.pdf, PS107_TSG_nav.pdf, PS108_TSG_nav.pdf, PS109_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]
2017-06-25T14:59:00	33.9860
2017-06-26T13:56:00	33.6369
2017-06-27T13:29:00	33.7345
2017-06-29T14:57:00	34.2434
2017-07-01T09:48:00	33.9578
2017-07-02T16:41:00	33.8784
2017-07-03T14:13:00	33.8276
2017-07-05T10:44:00	34.0382
2017-07-06T14:18:00	34.3292
2017-07-07T11:12:00	34.2779
2017-07-08T09:11:00	34.2474
2017-07-09T11:03:00	34.0739
2017-07-10T15:23:00	34.0230
2017-07-11T17:25:00	33.8522
2017-07-12T18:34:00	33.2006
2017-07-15T11:10:00	33.8008
2017-07-17T11:06:00	33.1006
2017-07-18T14:23:00	35.0261
2017-07-19T08:59:00	34.7905
2017-07-28T11:19:00	30.9243
2017-08-01T14:30:00	30.8310
2017-08-03T14:12:30	29.9635
2017-08-04T06:52:00	29.7177
2017-08-06T06:53:00	28.6907
2017-08-09T12:28:00	30.0507
2017-08-12T12:43:30	33.5548

Time of sampling	OPS Salinity [PSU]
2017-08-13T07:01:00	35.0130
2017-08-23T11:30:00	34.7642
2017-08-27T07:31:30	33.0447
2017-08-29T05:00:00	34.9223
2017-08-30T06:42:00	31.1351
2017-09-02T08:48:30	34.6930
2017-09-05T14:10:30	35.0402
2017-09-06T14:46:00	30.2532
2017-09-07T14:23:00	35.0828
2017-09-13T06:43:30	34.6706
2017-09-14T08:15:30	35.0696
2017-09-15T13:04:00	29.4657
2017-09-16T15:50:00	28.8507
2017-09-17T08:48:00	30.1403
2017-09-18T10:01:30	29.0053
2017-09-20T08:32:00	28.2998
2017-09-21T13:38:30	27.5438
2017-09-22T15:44:30	27.7406
2017-09-23T09:39:00	27.8617
2017-09-26T13:39:00	28.9058
2017-09-27T10:57:00	28.5177
2017-10-02T16:28:30	28.3694
2017-10-04T10:04:00	28.4743
2017-10-06T17:14:00	29.1525
2017-10-09T17:06:30	34.9720
2017-10-10T10:30:00	34.9053