

CTD Calibration Report
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Cruise summary

Ship: R/V Knorr
Project Name: OSNAP
Dates: 5 August 2014 – 2 September 2014
Ports: Reykjavik, Iceland – Reykjavik, Iceland

Data files included as part of this distribution

kn221_CTD_Calibration_Report.pdf

This document in pdf format

KN221_*.dcc***

One 2 dB pressure-averaged file per station following WOCE format specifications for CTD data. Final .dcc files contain primary and secondary sensor pressure, temperature, salinity and oxygen data. CTD temperatures, pressures, and conductivities have been scaled with pre-cruise calibrations from the sensor manufacturer. All CTD salinity data have been post-calibrated using bottle salinity measurements.

KN221_*.cnut_qc***

One file per station following the WOCE format specifications for cruise bottle data. The final .cnut_qc files contain fully calibrated pressure, temperature, salinity, and oxygen data at the location of each salinity bottle sample.

Variable definitions

Final .dcc variable definitions

Pres	Binned pressure (dB)
T90(1)	Calibrated primary temperature (°C)
T90(2)	Calibrated secondary temperature (°C)
Sal(1)	Calibrated primary salinity (psu)
Sal(2)	Calibrated secondary salinity (psu)
OxCur	Oxygen Current (V)
OXYG	Dissolved Oxygen (ml/l)
Trans	Beam Transmission (%)
Flur	Fluorescence (mg/m ³)
Turbidity	Turbidity (NTU)
Altimeter	Bottom-finding altimeter reading (m)
nscans	Number of CTD scans used in pressure bin-averaging
wocecode	WOCE quality word for each variable

Final .cnut_qc variable definitions

CTD Bottle Number	CTD rosette trigger position (Niskin number)
Pres	CTD pressure (dB)
T90(1)	Calibrated primary temperature (°C)
T90(2)	Calibrated secondary temperature (°C)
TH1	Calculated potential temperature (°C)
TH2	Calculated secondary temperature (°C)
Sal(1)	Calibrated primary salinity (psu)
Sal(2)	Calibrated secondary salinity (psu)
OXY	Dissolved Oxygen (ml/l)
Meas SAL	Bottle salinity (psu)
QUAL	WOCE quality word for each variable

WOCE quality word definitions:

- 1 = Not calibrated with water samples
- 2 = Acceptable measurement
- 3 = Questionable measurement
- 4 = Bad measurement
- 9 = not sampled

CTD configuration***General***

195 casts were performed using a SeaBird 911plus CTD and deck unit configured to measure pressure, temperature, conductivity, oxygen current, beam transmission, fluorescence, and turbidity. Data from the CTD were acquired at 24 Hz. The CTD data were acquired by an SBE Model 11 plus V2 CTD Deck Unit providing demodulated data to a personal computer running SEASAVE (SeaBird). Bottom approach was controlled by real time altimeter data and ship provided ocean depth information. For each cast, water samples were collected at up to 23 discrete intervals and analyzed for salinity. A rosette frame holding 23 10 L Niskin bottles was used for collecting water samples.

CTD calibrations

Calibrations for CTD sensors were performed by the manufacturer before the cruise. A listing of sensors and calibration dates are presented in the following table. The configuration report file for the SBE 911plus containing sensor calibration coefficients can be found in appendix A.

CTD sensor calibration dates

Sensor Type	Sensor Number	Manufacturer	Calibration Dates	Stations Used
Pressure	63505	Sea-Bird	15-Mar-12	2 – 196
Temperature 1	4195	Sea-Bird	11-Oct-13	2 – 196
Temperature 2	4252	Sea-Bird	10-Oct-13	2 – 196
Conductivity 1	2147	Sea-Bird	10-Oct-13	2 – 196
Conductivity 2	2768	Sea-Bird	10-Oct-13	2 – 196
Oxygen 1	1679	Sea-Bird	23-Oct-13	2 – 196
Oxygen 2	0794	Sea-Bird	22-Oct-13	178 – 196
Fluorescence	FLNTURTD-304	Wetlabs	10-Mar-08	2 – 196

SeaBird processing

As per manufacturer recommendations, CTD data were processed using SeaBird data processing software (ver. 7.22.0). The raw CTD data were converted from HEX to ASCII, lag corrected, edited for large spikes, smoothed according to sensor, and pressure averaged into 2 dB bins for final data quality control and analysis. The following table summarizes the processing routines used together with SeaBird-recommended parameters for the sensor configuration used.

SeaBird processing routines

SeaBird Module	Description (SeaBird, Version 7.22.0)
DATCNV	Convert the raw data to pressure, temperature, conductivity, and dissolved oxygen current
BOTTLESUM	Writes out a summary of the bottle data to a file with a .btl extension
ALIGNCTD	Advance conductivity approximately 0.073 seconds relative to pressure
WILDEDIT	Checks for and marks 'wild' data points: first pass 2.0 standard deviations; second pass 20 standard deviations
CELLTM	Conductivity cell thermal mass correction $\alpha = 0.03$ and $1/\beta = 7.0$
FILTER	Low pass filter pressure and depth with a time constant of 0.15 seconds to increase pressure resolution for LOOPEDIT
LOOPEDIT	Mark scans where the CTD is moving less than the minimum velocity (0.1 m/s) or traveling backwards due to ship roll
DERIVE oxy	Compute oxygen from oxygen current (filtered), temperature, and pressure
BINAVG	Average data into the 1 dbar pressure bins
DERIVE sal	Compute salinity
STRIP	Extract columns of data from .cnv files
SPLIT	Split .cnv file into upcast and downcast files

Post
-
processing conductivity calibrations

Basic fitting procedure:

CTD salinity data were then further calibrated by utilizing water sample salinity measurements. WHOI post-processing fitting procedures are modeled after methods used in Millard and Yang, 1993. CTD conductivity and water sample salinity differences were characterized as a function of pressure and time. One fit was created by grouping together data from all CTD stations occupied. The group was fit for a slope and bias adjustment using only water sample data that was within a defined physical range of CTD values. A threshold of 0.01 psu difference was used for water samples take above 1200 dbar and 0.005 psu difference below 1200 dbar. The slope term is a polynomial function of the station number based upon chronological station collection order. A linear pressure term (modified beta) was applied to conductivity slopes using a least-squares minimization of CTD and bottle conductivity differences.

The function minimized was:

$$BC - m * CC - b - \beta * CP$$

BC - bottle conductivity [mS/cm]
CC - pre-cruise calibrated CTD conductivity [mS/cm]
CP - CTD pressure [dbar]
m - conductivity slope
b - conductivity bias [mS/cm]
β - linear pressure term [mS/cm/dbar]

The final conductivity, FC [mS/cm] is:

$$FC = m * CC + b + \beta * CP$$

The polynomial functions determined for both primary and secondary sensor data are presented in the following table. Once calibrated, the overall standard deviation of the primary CTD conductivity sensor (s/n 2147) and water sample differences is **0.00802 psu**. The overall standard deviation of the secondary CTD conductivity sensor (s/n 2768) and water sample differences is **0.00783 psu**. Figures that summarize conductivity calibrations are included in Appendix B.

Sensor	% samples used	Bias	Slope (min/max)	Final standard deviation of all differences
2147	74.7%	-0.01445	1.00045/1.00062	0.00802 psu
2768	75.1%	-0.0062267	1.00018/1.0003	0.00783 psu

Salinity water sample measurements

Summary

586 water samples were collected from most stations occupied during the kn221 cruise. Samples were analyzed for concentrations and used to post-calibrate the CTD sensors.

Methods

Water was collected in 200 ml glass bottles. The bottles were rinsed three times, and then filled to the neck. After the samples reached the lab temperature of approximately 22 °C, they were analyzed for salinity using a Guildline Salinometer model 8400 B. The salinometer's bath temperature was set to 24 °C and was standardized once a day using IAPSO Standard Seawater (batch, P-156). Accuracies of salinity measurements were ± 0.002 psu. Bottle salinities were assigned a quality control flag based upon the difference between CTD salinity (calibrated) at the same pressure and/or at the same potential temperature.

Appendix A.

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 2
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : deck unit
Surface PAR voltage added : Yes
Scan time added : No

1) Frequency 0, Temperature

Serial number : 4195
Calibrated on : 11-Oct-13
G : 4.37157395e-003
H : 6.44649362e-004
I : 2.28880376e-005
J : 1.96120418e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 2147
Calibrated on : 10-Oct-13
G : -1.00444181e+001
H : 1.40306110e+000
I : -2.56196619e-003
J : 2.42588888e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 63505 SBE090462
Calibrated on : 2012-03-15
C1 : -4.872453e+004
C2 : 2.143123e-002
C3 : 1.347220e-002
D1 : 3.959500e-002
D2 : 0.000000e+000
T1 : 2.994567e+001
T2 : -2.488396e-004
T3 : 3.985300e-006
T4 : 7.998620e-010
T5 : 0.000000e+000
Slope : 0.99989000
Offset : -1.74580
AD590M : 1.282050e-002
AD590B : -9.111540e+000

4) A/D voltage 0, Fluorometer, WET Labs ECO-AFL/FL
Serial number : FLNTURTD-304
Calibrated on : 2008-03-10
Dark output : 0.0710
Scale factor : 1.00000000e+001

5) A/D voltage 1, Turbidity Meter, WET Labs, ECO-NTU
Serial number : FLNTURTD-304
Calibrated on : 20080310
ScaleFactor : 5.000000
Dark output : 0.048000

6) A/D voltage 2, Transmissometer, WET Labs C-Star
Serial number : CST-1118DR
Calibrated on : 2008-04-30 20140131update
M : 21.8770
B : -1.3560
Path length : 0.250

7) A/D voltage 3, Free

8) A/D voltage 4, Altimeter
Serial number : PSA916-1632
Calibrated on :
Scale factor : 15.000
Offset : 0.200

9) A/D voltage 5, Oxygen, SBE 43
Serial number : 1679
Calibrated on : 23-Oct-13
Equation : Sea-Bird
Soc : 4.55930e-001
Offset : -4.97100e-001
A : -3.66900e-003
B : 1.91110e-004
C : -2.62760e-006
E : 3.60000e-002
Tau20 : 2.23000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

10) A/D voltage 6, Free

11) A/D voltage 7, Oxygen, SBE 43, 2
Serial number : 0794
Calibrated on : 22-Oct-13
Equation : Sea-Bird
Soc : 4.89460e-001
Offset : -4.93200e-001
A : -2.95050e-003
B : 1.10480e-004
C : -1.42420e-006
E : 3.60000e-002
Tau20 : 1.99000e+000
D1 : 1.92634e-004

D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

12) SPAR voltage, Unavailable

13) SPAR voltage, SPAR/Surface Irradiance

Serial number :
Calibrated on :
Conversion factor : 0.00000000
Ratio multiplier : 0.00000000

Appendix B.



