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Processing Logbook

CTD post processing of RV "Heincke"

V1

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1 Introduction

This report describes the processing of CTD raw data acquired by Seabird CTD SBE911 plus sensors on board RV Heincke.

2 Workflow

The different steps of processing and validation are visualized in figure 1. The CTD raw data are delivered from Gerd Rohardt (AWI). The station book of the RV Heincke cruise is extracted from the DAVIS SHIP data base (<https://dship.awi.de>). The first CTD station and cast is processed manually in SBE Data Processing to configure the *.psa Seabird routines Data Conversion, Wild Edit, Bottle Summary, Split, Translate, Cell Thermal Mass, Loop Edit and Bin Average. The Seabird routines are then run in a batch job CTDjob in ManageCTD to process the complete CTD data set. The downcast of each CTD station/cast is used for further processing. In CTDjob the start record and the lowest altimeter point of the downcast is selected. With the “Utilities – Dship Ebook” function of ManageCTD the DAVIS SHIP station book extraction is used for getting the header information of all CTD stations/casts of the RV Heincke cruise. ManageCTD “Utilities – Find Profile” function compares station times of the header with the entries in the station book to find out the correct naming of the stations and casts. In CTDheader in ManageCTD the header information of each CTD station/cast is displayed, controlled and corrected if necessary. CTDdespike in ManageCTD is used for a visual check of the data and to erase/interpolate spikes in the data if necessary. Additionally, a sensor pair (Temp1/Sal1 or Temp2/Sal2) is chosen for each station/cast of the RV Heincke cruise in CTDdespike. ManageCTD “Utilities – CheckDoubleSensors” controls the quality of temperature and conductivity sensors. For this purpose outliers of too high sensor pair differences could be removed. The data is then converted to spreadsheet format with dsp2odv for visualization of the data in Ocean Data View (ODV).

The second visual inspection of the CTD data allows a comparison with data from other CTD casts from close-by stations to verify the oxygen sensor data. Therefore, potential reference cruise data is downloaded from PANGAEA (<http://www.pangaea.de>). The reference data is converted to *.mat format. In the ManageCTD Final Processing the CTD data is displayed together with the reference data. Bad data points, sensors or casts are interpolated or erased from the data set and filters are applied if necessary. The processed CTD data are written to text files and imported to PANGAEA (<http://www.pangaea.de>) for publication. For each cruise an individual CTD Data RV Heincke Data Processing Report is uploaded to the electronic Publication Information Center (ePIC; <http://epic.awi.de>).

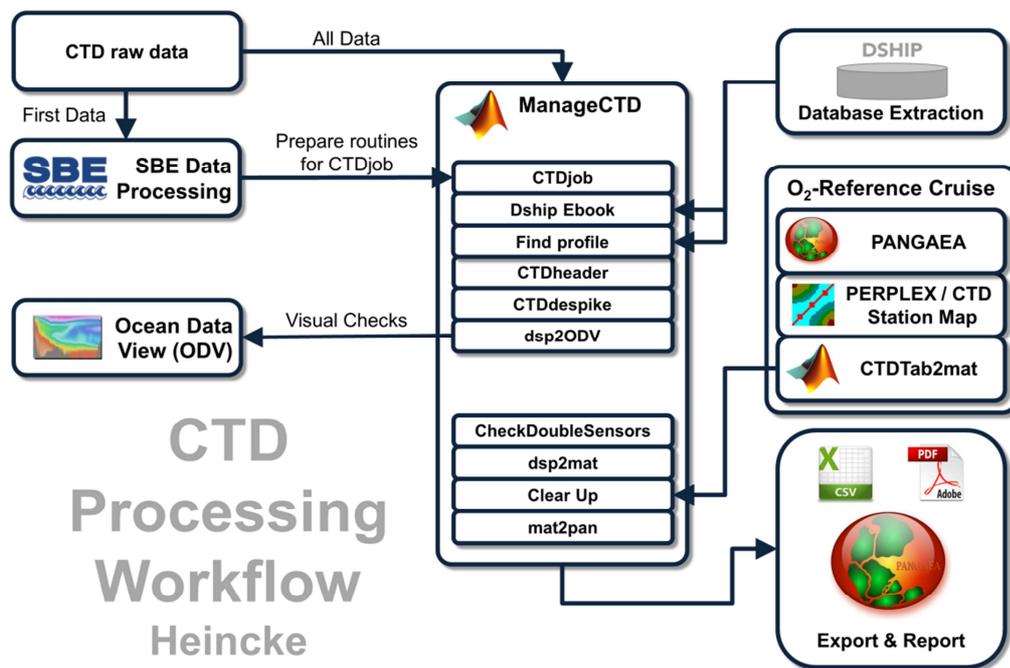


Figure 1: CTD data Processing Workflow

3 Sensor Configuration

Two temperature/conductivity sensor pairs, a pressure and an altimeter are mounted to the CTD SBE 911plus by default. Salinity values are automatically calculated from the temperature/conductivity sensor pairs and the pressure sensor measurements. Additional sensors measuring e.g. oxygen, turbidity and chlorophyll can be mounted.

For each RV Heincke cruise there is at least one configuration file containing the information of sensors used, their serial numbers and calibration dates. Usually there is only one configuration per cruise. Nevertheless, if sensors were exchanged during the cruise, one additional configuration is used. The information of sensors used during a RV Heincke cruise is found in the individual CTD Data RV Heincke Data Processing Report in chapter 4 “Sensor Layout” (ePIC; <http://epic.awi.de>).

4 Processing

The different steps of processing are summarized in chapter 2 “Workflow” with figure 1. Details of processing procedures and processing parameters are described in the following chapters.

4.1 First manual run in SBE data processing

The SBE data processing package is needed to do the sensor corrections and finally creating an ASCII file of the profile and a bottle file. To do the SBE data processing a number of routines must be started in a prescribed sequence:

1. Data Conversion (4.1.1.)
2. Wild Edit (4.1.2.)
3. Bottle Summary (4.1.3.)
4. Split (4.1.4.)
5. Translate (4.1.5.)
6. Translate (4.1.5.)
7. Cell Thermal Mass (4.1.6.)
8. Loop Edit (4.1.7.)
9. Bin Average (4.1.8.)

All individual jobs must be executed manually first, later their setup files (*.psa) were used by SBEbatch which was executed by ManageCTD (4.2). No further manual executions are needed except the CTD configuration was changed. The SBE data processing routines and their parameters are summarized below.

4.1.1. Data Conversion

CTD raw data are converted from *.hex format to *.cnv format and stores the water bottle data in *.ros file.

Data Setup	
Process scans to end of file	[true]
Scans to skip over	0
Output format	Binary output
Convert data from	Upcast and downcast
Create file types	Create both data and bottle file
Source of scan range data	Scans marked with bottle confirm bit
Scan range offset [s]	0
Scan range duration [s]	2
Select Output Variables	
1	Pressure, Digiquartz [db]
2	Temperature [ITS-90, deg C]
3	Temperature 2 [ITS-90, deg C]
4	Conductivity [mS/cm]
5	Conductivity 2 [mS/cm]
6	Salinity, Practical [PSU]
7	Salinity, Practical 2 [PSU]
8	Scan Count
9	Altimeter [m]
10	Oxygen, SBE 43 [ml/l]
11	Fluorescence, WET Labs ECO AFL/FL [mg/m ³]
12	Beam Transmission, WET Labs C-Star [%]
13	Voltage 0
14	Voltage 2
15	Voltage 4
16	Voltage 6
Miscellaneous	
Latitude when NMEA is not available	0
Average sound velocity	
Minimum pressure [db]	20

Minimum salinity [psu]	20
Pressure window size [db]	20
Time window size [s]	60
Plume anomaly	
Theta-B	0
Salinity-B	0
Theta-Z/Salinity-Z	0
Reference pressure [db]	0
Descent and Acceleration	
Window size [s]	2
Oxygen	
Window size [s]	2
Apply Tau correction	[true]
Apply hysteresis correction to SBE 43 when Sea-Bird equation selected in .con file	[true]
Potential Temperature Anomaly	
A0	0
A1	0
A1 Multiplier	Salinity

Table 1: Data Conversion parameters. The selected output variables will change with other sensor configurations.

4.1.2. Wild Edit

Wild points in the data are marked by replacing the data value with “badflag”. The Algorithm requires two passes through the data: the first pass obtains an accurate estimate of the data’s true standard deviation, while the second pass replaces the appropriate data with “badflag”.

Data Setup	
Standard deviations for pass one	2
Standard deviations for pass two	20
Scans per block	100
Keep data within this distance mean	0
Exclude scans marked bad	[true]
Select Wild Edit Variables	
Pressure, Digiquartz [db]	[true]

Table 2: Wild Edit parameters

4.1.3. Bottle Summary

Water sampler bottle *.ros file created by Data Conversion (4.1.1.) is read and a bottle data summary is written to a *.btl file.

Data Setup	
Output min/max values for averaged variables	[true]
Select Averaged Variables	
Pressure, Digiquartz [db]	[true]
Temperature [ITS-90, deg C]	[true]
Temperature, 2 [ITS-90, deg C]	[true]
Conductivity [mS/cm]	[true]
Conductivity, 2 [mS/cm]	[true]
Salinity [PSU]	[true]
Salinity, 2 [PSU]	[true]
Oxygen, SBE 43 [ml/l]	[true]
Beam Transmission, WET Labs C-Star [%]	[true]
Fluorescence, WET Labs ECO AFL/FL [mg/m^3]	[true]

Table 3: Bottle Summary parameters. The selected averaged variables will change with other sensor configurations.

4.1.4. Split

CTD data is split into upcast (pressure decreasing) and downcast (pressure increasing) files.

Data Setup	
Output files	Upcast and downcast
Exclude scans marked bad	[true]

Table 4: Split parameters

4.1.5. Translate (2x)

The converted data file format is changed from binary to ASCII or vice versa. Translate needs to be run twice because in the batch job the *Altimeter Reading* and the *Start Record* are selected in the Matlab program CTDjob running on ASCII-format while the Seabird procedures are running on BIN-format (figure 2).

Data Setup	
Translation	Translate to opposite

Table 5: Translate parameters

4.1.6. Cell Thermal Mass

A recursive filter is used to remove conductivity cell thermal mass effects from the measured conductivity.

Data Setup	
Correct primary conductivity values	[true]
Temperature sensor to use	Primary
Thermal anomaly amplitude [alpha]	0.03
Thermal anomaly time constant [1/beta]	7
Correct secondary conductivity values	[true]
Temperature sensor to use	Secondary
Thermal anomaly amplitude [alpha]	0.03
Thermal anomaly time constant [1/beta]	7

Table 6: Cell Thermal Mass parameters

4.1.7. Loop Edit

Scans are marked bad associated with the scan to “badflag” in input *.cnv files that have pressure slowdowns or reversals.

Data Setup	
Minimum velocity type	Fixed minimum velocity
Minimum CTD velocity [m/s]	0
Exclude scans marked bad	[true]

Table 7: Loop Edit parameters

4.1.8. Bin Average

CTD data are averaged using averaging intervals based on pressure range, depth range, scan number range or time range.

Data Setup	
Bin type	Pressure
Bin size	1
Include number of scans per bin	[true]
Exclude scans marked bad	[true]
Scans to skip over	0
Cast to process	Downcast

Table 8: Bin Average parameters

4.2 ManageCTD procedures before first visual check

ManageCTD is an integrated interface between the Seabird software and additional software procedures. The following ManageCTD procedures prepare the data for the visual checks and manual data correction:

1. CTDjob (4.2.1.)
2. DShip Ebook (4.2.2.)
3. Find Profile (4.2.3.)
4. CTDheader (4.2.4.)

4.2.1. CTDjob

After the first manual run, the SBE data processing routines are automatically run in the batch job "CTDjob" by ManageCTD (figure 2).

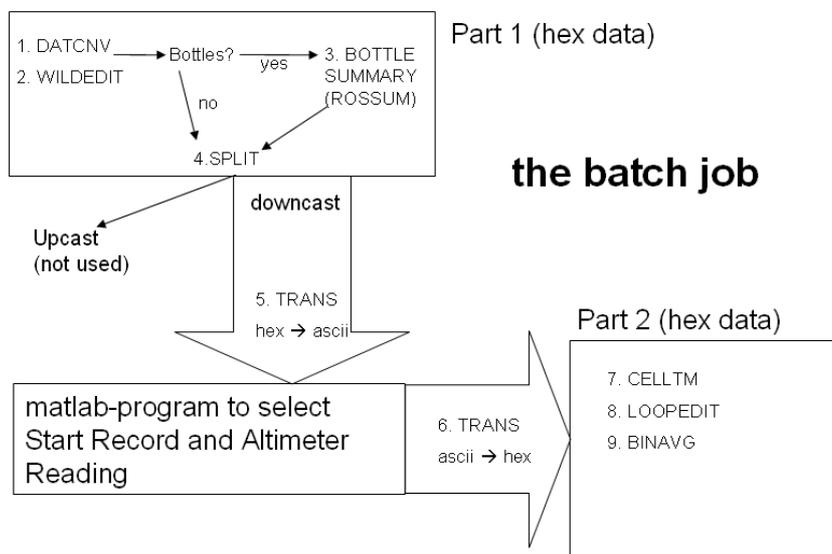


Figure 2: The ManageCTD batch job CTDjob

CTDjob displays a matlab figure to get start record and altimeter reading (figure 3).

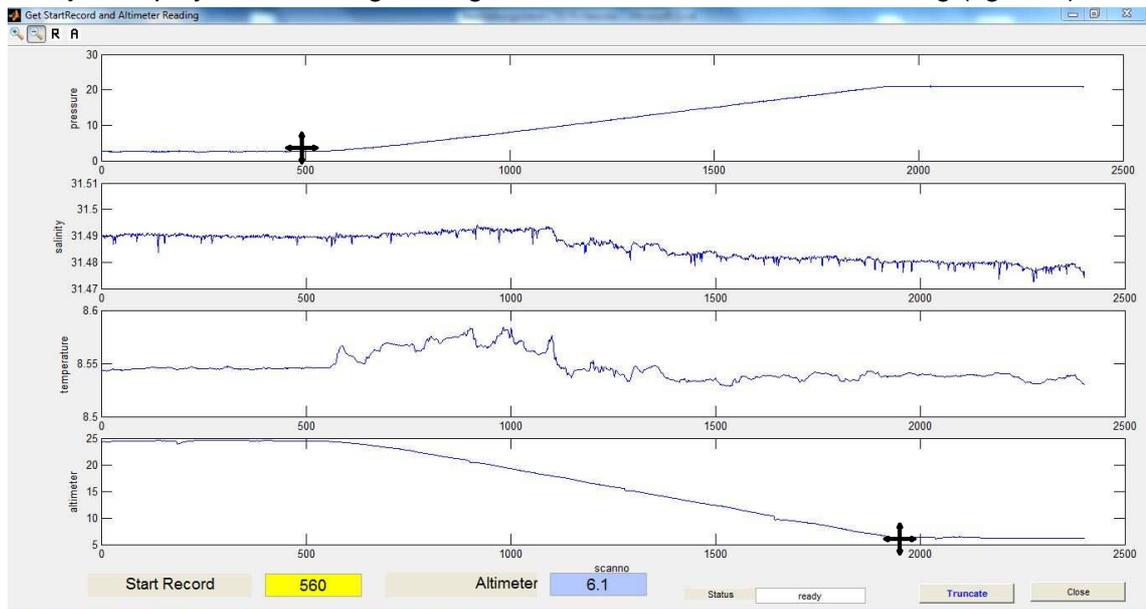


Figure 3: CTDjob Get StartRecord and Altimeter Reading

4.2.2. DShip Ebook

DShip Ebook function in ManageCTD is used to convert the station book extraction from DShip database to DShip-out.txt, which is the readable format file for CTDheader and “Find Profile” functions in ManageCTD.

4.2.3. Find Profile

The “Find Profile” function of ManageCTD compares CTD casts date and time from the DShip-out.txt file generated by DShip Ebook with the CTD casts date and time in the header files of the CTD data. The text file DSHIPvsHDR.txt is generated pairing CTD stations with the least offset between DShip and Header cast time. The processed CTD data will be uploaded with the station/cast information as used in the station book, which might differ from the CTD raw data naming.

4.2.4. CTDheader

The information of the DShip Ebook extraction DShip-out.txt is used by CTD header for an automatically infill of the cruise, station and cast data. The correct naming of the station is controlled with DSHIPvsHDR.txt and the altimeter reading from CTDjob is added. The fields Cruise, Ship, Instrument Type and SN and the variables with their units are checked manually with the information of the config-file of the cruise.

4.3 First visual check in ManageCTD: Manual flagging in CTDdespike

The ManageCTD routine CTDdespike allows the first visual check and manual flagging of bad data points. To facilitate the visual check, two density inversion criteria can be chosen. Values with exceed the density inversion thresholds are marked with red boxes and red dots, respectively (figure 4). The choice of the density inversion criteria is documented in the individual CTD Processing RV Heincke Cruise Report in “5 Processing”.

Data points to edit:

- Badflag values

Data points which were marked with “badflag” by the SBE Data Processing routines were replaced with the “badflag” value zero. These zero-point spikes are then found in all sensors during the first visual check (figure 4).

Zero-point spikes of all sensors are interpolated or, if these are at the beginning or end of a profile, erased. The number of data points interpolated and/or erased is documented in a documentation table in the individual CTD Processing RV Heincke Cruise Report.

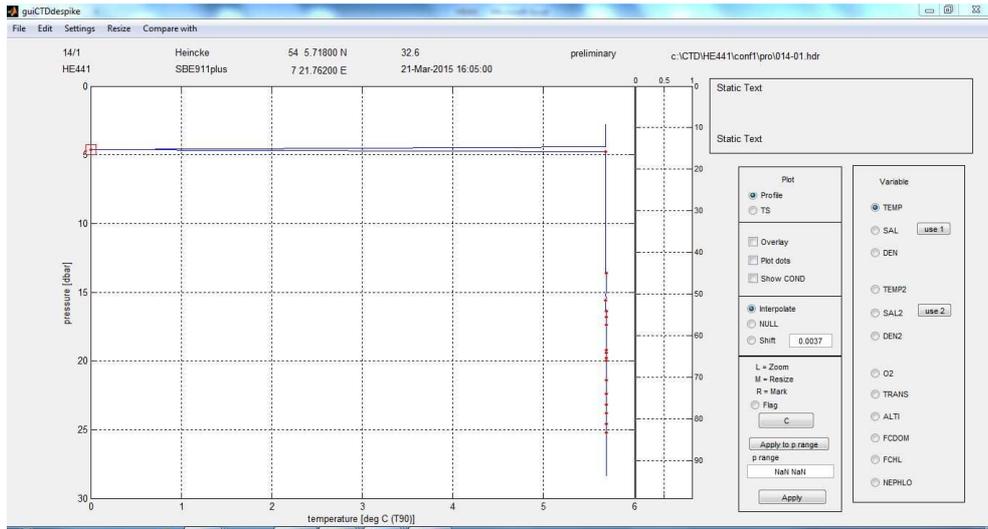


Figure 4a: CTDdespike example from expedition HE441 station 14 cast 1: Temperature zero-point spike

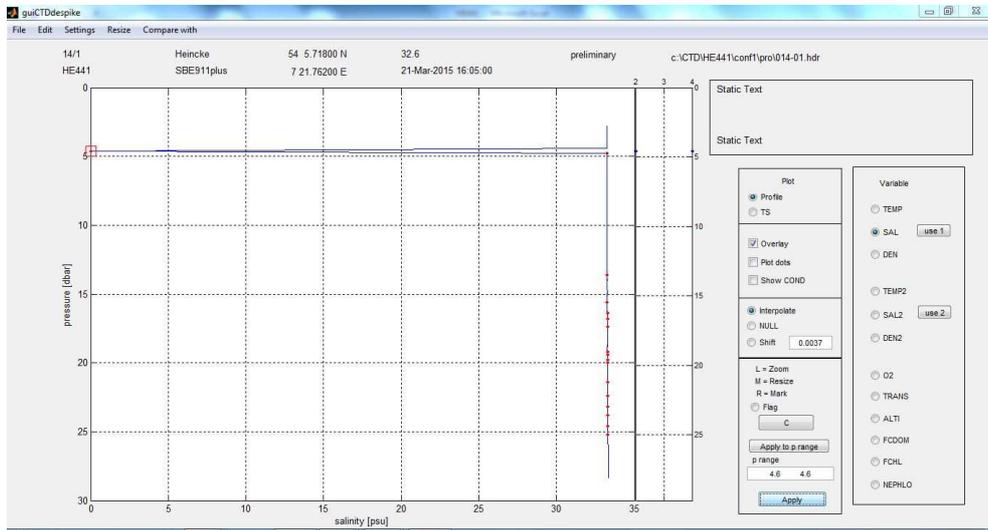


Figure 4b: CTDdespike example from expedition HE441 station 14 cast 1: Salinity zero-point spike

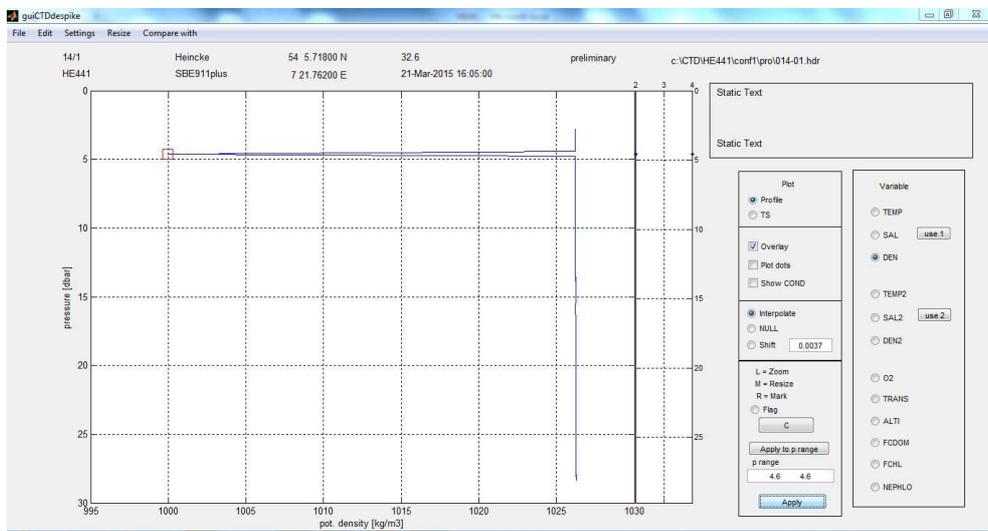


Figure 4c: CTDdespike example from expedition HE441 station 14 cast 1: Density spike derives from Temperature and Salinity zero-point spike

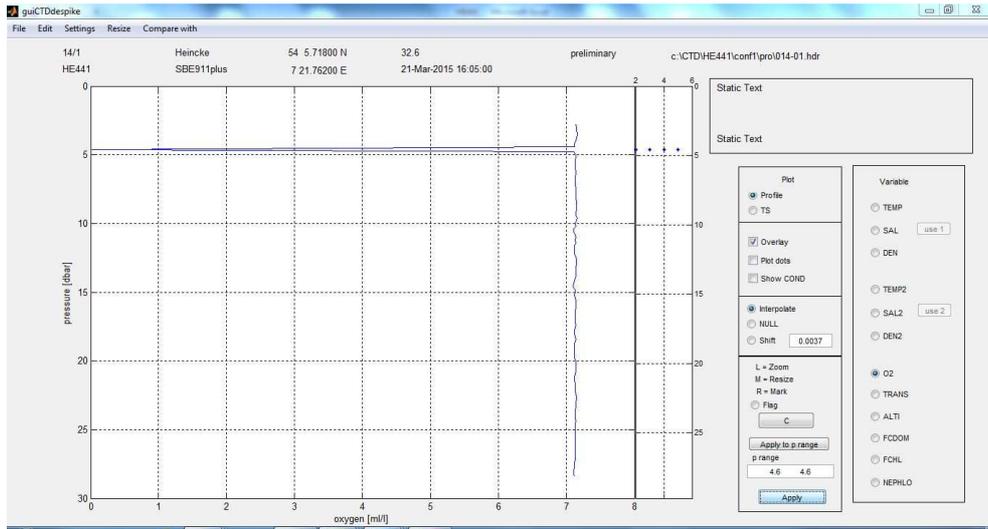


Figure 4d: CTDdespike example from expedition HE441 station 14 cast 1: Oxygen zero-point spike

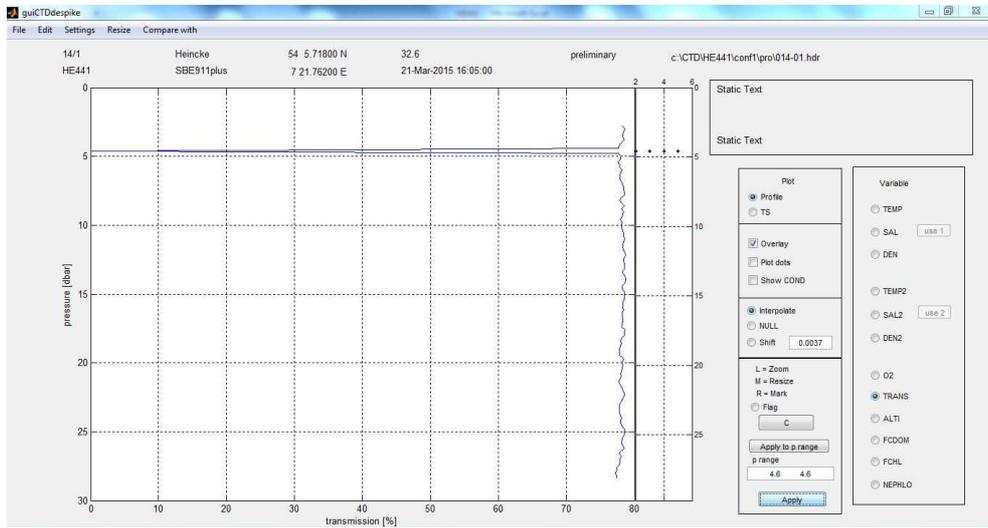


Figure 4e: CTDdespike example from expedition HE441 station 14 cast 1: Transmission zero-point spike

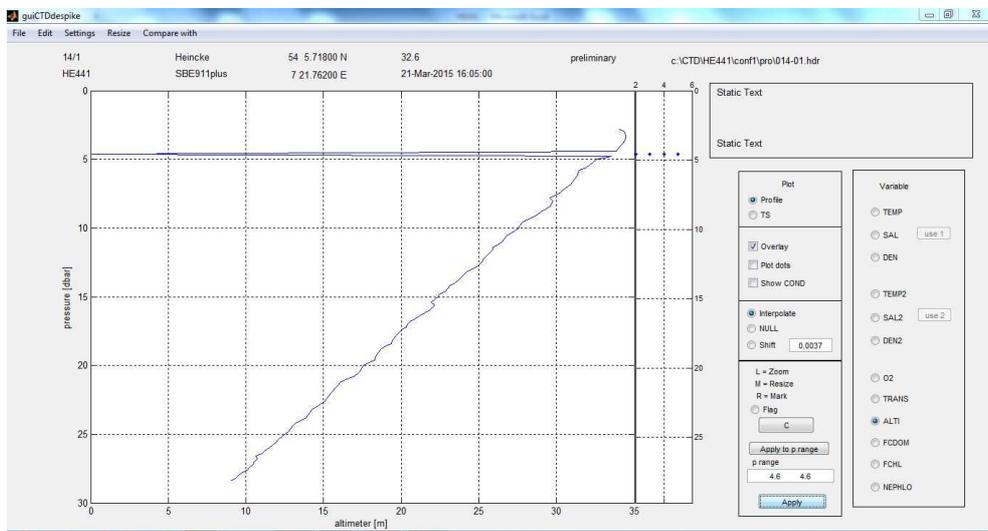


Figure 4f: CTDdespike example from expedition HE441 station 14 cast 1: Altimeter zero-point spike

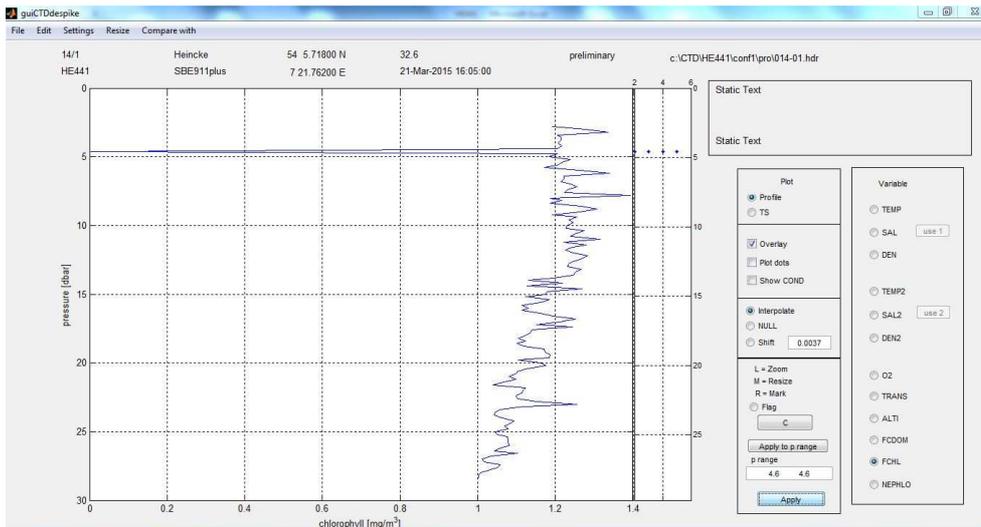


Figure 4e: CTDdespike example from expedition HE441 station 14 cast 1: FCHL zero-point spike

- Individual spikes

For other spikes in the CTD data a decision has to be made whether these spikes are real data or bad values to edit. The red dots/boxes marker from the density criteria helps to sense problematic values in the data (figures 4 and 5).

For each problematic value the decision to edit the data point(s) or not is based on the following questions:

- Does the second sensor (pair) show a similar spike?
- Does the data point match in the T/S plot?
- Is there a similar or an unusual feature in the other sensors (Oxygen/Transmission/FCHL) at the problematic depth range?
- Is the station located in a mixing region, e.g. close to the coast?

If these questions are answered with “yes” the data point is considered as true data (figure 5). If the answers are “no” the data points are interpolated or, if these data points are at the beginning or end of a profile, erased. The number of data points interpolated and/or erased is documented in a documentation table in the individual CTD Processing RV Heincke Cruise Report.

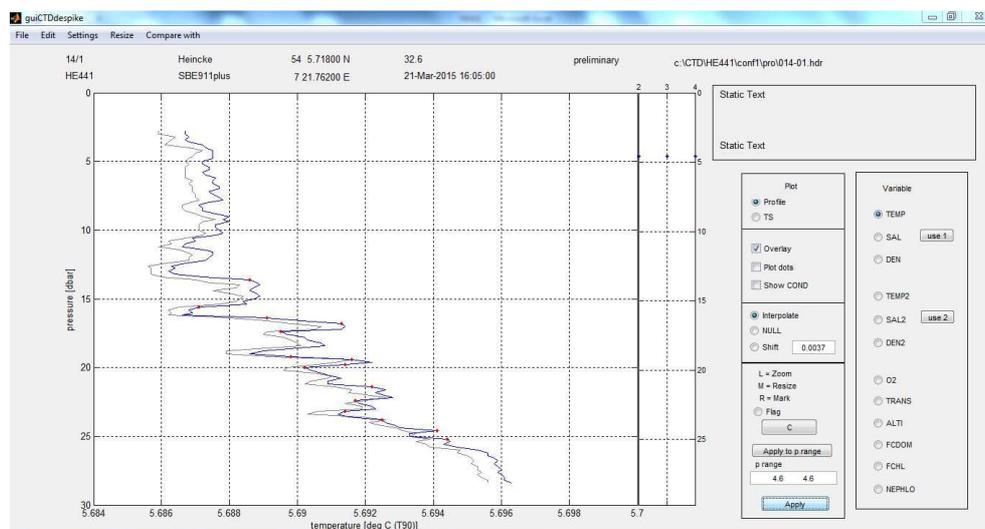


Figure 5a: CTDdespike example from expedition HE441 station 14 cast 1: Temperature sensors plotted as overlay. Red dots mark the data points to consider editing. Both temperature sensors show similar patterns.

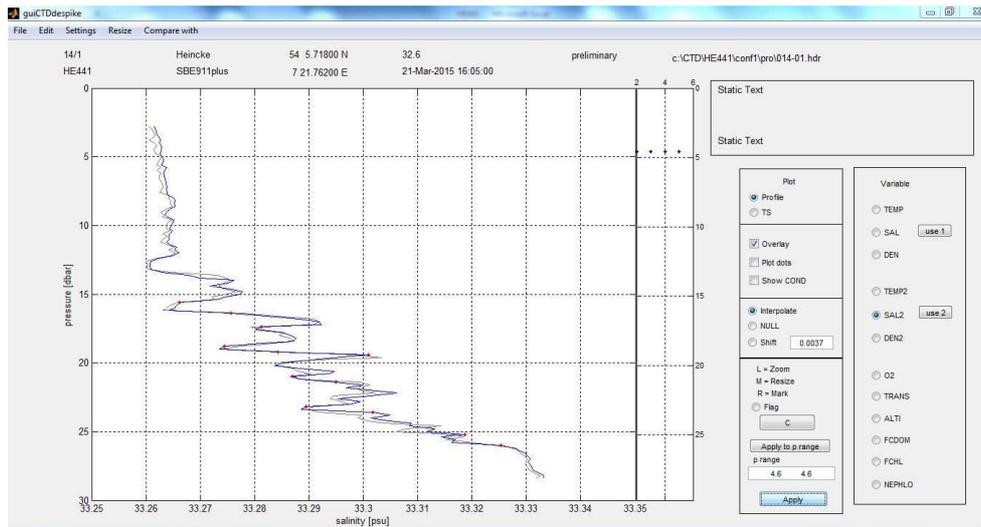


Figure 5b: CTDdespike example from expedition HE441 station 14 cast 1: Salinity sensors plotted as overlay. Red dots mark the data points to consider editing. Both salinity sensors show similar patterns. The pattern is also similar to that of the temperature sensors (figure 5a).

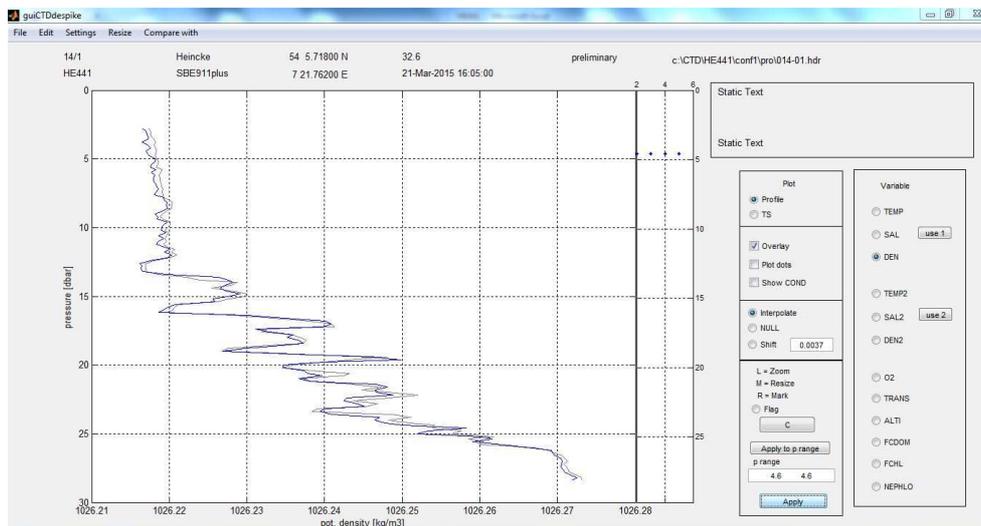


Figure 5c: CTDdespike example from expedition HE441 station 14 cast 1: Density profiles plotted as overlay. Both density profiles show similar patterns. However, the stratification of these density profiles is not stable as in some depth ranges the density decreases with depth. Unstable density profiles indicate mixing, which occurs in the vicinity of fronts from different water mass types. Expedition HE441 station 14 cast 1 is located in the Northern Sea close to the Weser estuary, i.e. the station is located in a mixing zone. Therefore, the CTD data of the station is considered as real.

After editing the data a decision is made which temperature/salinity sensor pair to use. The sensor pair which needs less editing is taken. The chosen sensor pair is documented in a documentation table in the individual CTD Processing RV Heincke Cruise Report. The number of data points interpolated and/or erased in this list refers to the chosen sensor pair.

4.4 ManageCTD procedures before second visual check

Before the final check in ManageCTD the following procedures are conducted:

1. Import to ODV (4.4.1.)
2. Check double sensors (4.4.2.)
3. Find reference cruise (4.4.3.)

4.4.1. Import to ODV

ODV is a powerful visualization tool for hydrographic data. ODV allows a quick view of the cruise data including a station map. The output file from CTDdespike is converted into a spreadsheet format with ManageCTD function dsp2odv. The spreadsheet is then imported into ODV for display.

4.4.2. Check double sensors

The ManageCTD function "CheckDoubleSensors" is used check the quality of temperature and conductivity sensors. The differences between sensor pair 1 and sensor pair 2 was taken if the vertical gradient is below a selectable value; 0.002 is the standard setup. Then the average differences are displayed for each cast versus date/time to show e.g. a sensor drift. In addition differences can displayed for different depth layers. The result is documented by a screenshot in the individual CTD Processing RV Heincke Cruise Report.

4.4.3. Find reference cruise

For the visual validation of the Oxygen data during Final Processing the CTD data is compared with CTD data from a station close by from a different cruise. Therefore, a reference cruise is selected and its CTD data is extracted from PANGAEA (<http://www.pangaea.de>). CTD_Station_Map.exe (needs PERPLEX Version 5) is a map plotting tool which helps to find the matching reference cruise. The PANGAEA data from the reference cruise is then converted to Matlab format with CTDTab2mat.m

4.5 Second visual check in ManageCTD: Final Clear Up

In the ManageCTD Final Processing the CTD data profiles are displayed again. Obvious outliers in temperature or salinity, which might have been overlooked in the first visual check, are interpolated or erased. The T/S plot function in the final processing is a helpful tool for the decision whether to edit data point(s) or not as well as the ODV overview (4.4.1.). The T/S plot function also displays the T/S data of the reference station. The oxygen profile is displayed together with the reference cruise oxygen profile (figure 6). The shape of the two profiles is compared. If the shape is similar, the oxygen profile is kept and the offset between the two oxygen profiles is documented for the individual CTD Processing RV Heincke Cruise Report. If the shape of the oxygen profile differs from that of the reference cruise, single data points are interpolated or erased or the complete oxygen profile is deleted (figure 6). Information about the reference cruise, station and cast number, the distance between the station and the reference station, the rough oxygen offset between the station and the reference station, the number of interpolated/erased data points and the information if a complete profile/cast is deleted are documented in a documentation table in the individual CTD Processing RV Heincke Cruise Report.

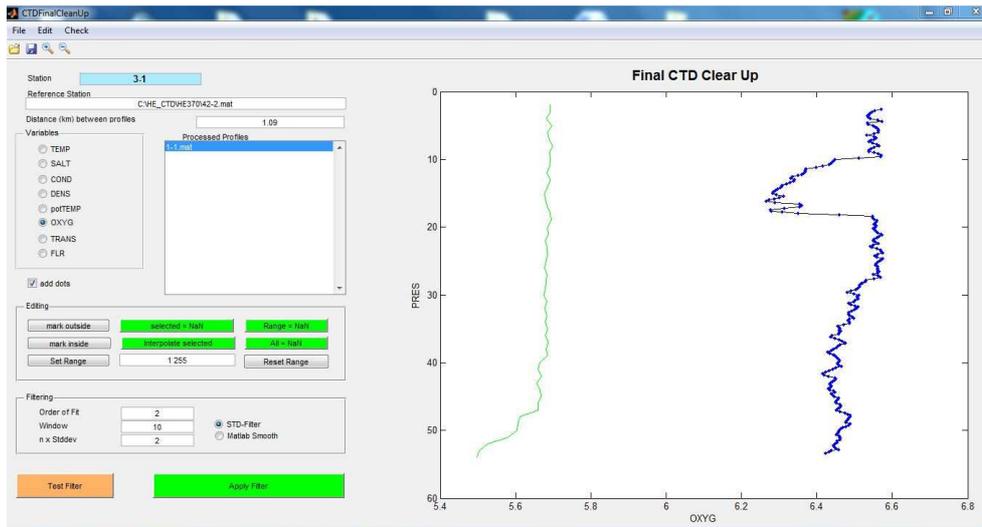


Figure 6: CTDFinalClearUp example from expedition HE443 station 3 cast 1: The shape of the oxygen profile differs from that of the reference station HE370 42-2 and therefore the oxygen profile is deleted. Distance between the stations: 1.09 km.

The Final Processing is completed by the conversion of the final processed CTD data to PANGEA format by ManageCTD function mat2pan and the data import to PANGEA (<http://www.pangea.de>) for publication:

Data.txt
 Event_inp.txt
 [cruise_name].txt
 Meta_inp.txt
 Campaign_inp.txt
 [cruise_name].zip (containing *.txt files named above)

The [cruise_name].txt file is used to create an ODV screenshot for the individual CTD Processing RV Heincke Cruise Report.

5 Reports

For each processed cruise, an individual CTD Processing RV Heincke Cruise Report is created and uploaded to the electronic Publication Information Center (ePIC; <http://epic.awi.de>).

These reports include the cruise details (duration, harbors, start/end, and numbers of CTD casts conducted), sensor layout (sensors, serial numbers, and calibration date) and the choice of the density criteria for the processing.

Besides this, the report includes a documentation table which gives a detailed overview about each CTD station and cast with position, water depth, raw file name along with the processing details sensor pair choice, interpolated/erased data points or profiles, reference cruise including distance and offset and comments on the processing.

Additionally, screenshots of ManageCTD function CheckDoubleSensors and of an ODV overview of all CTD stations and sensors including a station map are presented.