Documentation of CTD Data from RV Sonne Cruise No. 117

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1. General information

The Data on RV Sonne cruise No. 117 were collected during the German JGOFS Programme. The cruise took place in the Arabian Sea from the 26.02.1997 until 30.03.1997, chief scientist was Prof.Dr. W. Balzer from at the Departmen of Marine Chemistry, University of Bremen, Germany.

The Data were collected by:	The Data were provided by:
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<u>Temperature / Salinity calibration:</u>

The CTD data were not calibrated or corrected for Temperature or Salinity. Comparisons during the cruise have shown that the temperature sensor is as good as the reverse thermometer and the salinity compared with bench analysis (AUTOSAL) is as good as the bottle data.

<u>Oxygen:</u>

The Oxygen sensor had an offset from station 1 to 17, it was changed during the cruise and seemed to deliever better results from station 18. The oxygen data have not been calibrated because of too less Winkler hand measurements. The available oxygen data have been used to correct the measurements of the sensor. The data are not (!) calibrated.

<u>Fluorescense:</u>

The Haardt-Fluorometer quit at station 17, the data from station 1 to 17 could not be calibrated nor calculated to chlorophyll_a contents because the water bottle data have shown a strong dispersion of the fluorescense signal. It was not possible to spot the chlorophyll maximum in a correct way.
The signal dispersion seems to be a problem of the Niskin Water bottles in combination with a too short period of adaptation.

2. Standard Processing

The data were processed with the SEABIRD standard software. The common parameter proposed by Seabird was used to process these data. **Neither a Salinity nor a Temperature calibration was applied onto the data because of missing reference values.** For accuracy refer to the sections 3.1 and 3.2.

The following routines and parameters were used:
- **DATCNV** converts the raw data to pressure, temperature and salinity
- **ALIGNCTD** Advance oxygen 1 to 5 seconds relative to pressure (5 seconds were used)
- **CELLTM** Conductivity cell thermal mass correction. Typical values are alpha = 0.03 and 1/beta = 7.0. (These standard values were used).
- **FILTER** Low pass filter pressure with a time constant of 0.15 seconds to increase pressure resolution.
- **LOOPEDIT** Mark scans where the CTD moves less than the minimum velocity or travelling backwards due to ship roll. (0.3 m/s was used)
- **DERIVE** Compute oxygen
- **BINAVG** Average data into 1db pressure bins.
- **DERIVE** compute salinity, Theta, Sigma-theta

3. Description of Sensor (SBE 9/11)

3.1 <u>Conductivity Sensor SBE 4</u>

SBE 4 series conductivity sensors are modular, self contained instruments that measure conductivity from 0 to 7 S/m (Siemens/meter) thus covering the full range of lake and oceanic applications. Using an upgraded electronic technique (Version 2; S/N 2000 and higher), these new sensors have electrically-isolated power circuits and optically-coupled outputs to eliminate any possibility of noise and corrosion caused by ground loops. Interfacing is also simplified by the square-wave variable frequency output signal (nominally 2.5 to 7.5 kHz corresponding to 0 - 7 S/m). The sensors offer improved temperature compensation, smaller fit residuals, and faster turn-on stabilization times. Supply voltage range has been increased to 6 - 24 volts.

The SBE 4C is a primary sensor for Sea-Bird's SBE 9 CTD Underwater Unit and SBE 25 Sealogger CTD. Available in 6800 m aluminium or 10500 m titanium housings, the 4C have a quick-disconnect for plumbing to the CTD pump. Supplied without the quick-disconnect fitting, the SBE 4M is also available with a low-corrosion 6061 aluminium 3400 m housing for long-term moored deployments.

The sensing element is a cylindrical flow-through borosilicate glass cell with three internal platinum electrodes. The electrode arrangement offer distinct advantages over inductive or "open" external field cells. Because the outer electrodes are connected together, electric fields are confined inside the cell, making the measured resistance (and instrument calibration) independent of the calibration bath size or proximity to protective cages or other objects. In particular, the internal field permits effective antifoul protection using toxic "gatekeepers" positioned at the cell ends. The cell resistance controls the output frequency of a Wien Bridge oscillator circuit. A unique Sea-Bird design feature introduces a fixed conductivity offset, permitting the instrument to measure conductivity down to 0 for "fresh" water work.

APPLICATION:

Because of the SBE 4's low noise characteristics, hybrid frequency measuring techniques (used in Sea-Bird's CTD instruments) may be used to obtain rapid sampling with very high temporal and spatial resolution. The SBE 4 is ideally suited for obtaining horizontal data with towed systems or vertical data with lowered systems. Because of its small size, it is especially useful for moorings, portable CTD systems, or through-the-ice work. In moored applications, anti-foulant attachments (PN 24012) may be used to protect the cell from biological growth. After a 5 month mooring at depths of 80 to 290 meters, four SBE4s with anti-foulant protection showed drifts of <0.0015 S/m over a year's interval between calibrations. The anti-foul is effective for 6 to 12 months in areas of high biological activity.

CALIBRATION:
Sea-Bird calibrates the sensors over the range of approximately 3 to 6 S/m in computer controlled baths using natural seawater; a water sample at each point is compared to IAPSO seawater using a Guildline AutoSal. A least squares fitting technique (also including a zero conductivity point in air) yields calibration coefficients for use in the following equation:

Conductivity [S/m] = $g + hf^2 + if^3 + jf^4 / 10 (1 + dt + ep)$

where f is the instrument frequency [kHz], t is temperature [℃], p is pressure [decibars], d represents the bulk compressibility (-9.57e-08) and e the thermal coefficient of expansion (3.25e-06) of the borosilicate cell. The resulting coefficients g, h, i, & j are listed on the calibration certificate. Residuals are typically less than 0.0002 S/m.

3.2 SBE 3 Temperature Sensor Calibration

SBE 3 sensors are calibrated to ITS-90 temperature using Sea-Bird's computer-controlled calibration bath. Extremely well insulated, the baths provide a uniform toroidal circulation yielding an overall transfer accuracy against an SPRT within 0.0002℃. Repeatability at each of twelve individually mapped sensor positions is better than 0.0001℃. Sea-Bird's metrology laboratory underpins the new temperature calibration baths. Following consultation with the U.S. National Institute of Standards and Technology, the met lab was configured to achieve temperature precision of 50 µK and accuracy of 0.0005 ℃. To obtain this performance, premium primary references including four Jarrett water triple-point cells (with maintenance bath) and an Isotech gallium melt cell are operated in conjunction with two YSI 8163 standards-grade platinum resistance thermometers and an ASL F18 Automatic Temperature Bridge.

Calibration Equation:

The calibration yields four coefficients (g, h, i, j) that are used in the following equation (Bennett):

$$T = [1 / (g + h\ln(fo/f) + i\ln^2(fo/f) + j\ln^3(fo/f))] - 273.15, [℃]$$

where T is temperature [℃.] and ln is the natural lo g function, and f is the SBE 3 output frequency in Hz. Note that fo, an arbitrary scaling term used for purposes of computational efficiency, was historically chosen as the lowest sensor frequency generated during calibration. For all calibration results expressed in terms of ITS-90 temperatures, the fo term is set to 1000. Calibration fit residuals are typically less than 0.0001℃.