ISUS Nitrate

Parent Category: References (/references.html)
Category: Methods (/about-calcofi/methods.html)
C Last Updated: 07 May 2015

ISUS Nitrate Sensor

SUMMARY: Since November 2004, a Satlantic ISUS nitrate sensor has been integrated with a Seabird 911+ CTD-Rosette system deployed on CalCOFI cruises. Cruises typically occupy 75 stations, collecting approximately 1400 discrete seawater samples throughout the water column. The discrete seawater samples are analyzed at-sea for nitrate, nitrite, silicate, phosphate and ammonia within 24 hours of collection. The ISUS voltage data are processed along with other sensor data using Seabird's SBE Data Processing Suite. Processed CTD-ISUS data are merged with bottle data. The ISUS voltages are plotted versus corresponding nitrate data, generating a voltage-to-nitrate regression. These regression coefficients are applied to all ISUS voltages, converting voltages to estimated nitrate.

1. Principle

The Satlantic ISUS (In Situ Ultraviolet Spectrophotometer) is a real-time, chemical-free ultraviolet spectrophotometer detecting absorption characteristics of inorganic compounds in the UV light spectrum. The ISUS uses the UV (200-400 nm) absorption characteristics of nitrate and bromide to provide in situ measurements of their concentrations in solution. The sensor has four key components: a stable UV light source, a UV spectrophotometer, a bifurcated fibre optic sampling probe, and a processing microcomputer housed in a pressure case rated to 1000 meters. The ISUS measures the in situ absorption spectrum and then uses the calibrated coefficients and a least-squares curve fitting routine to calculate an absorption spectrum matching the measured spectrum. It then calculates the concentrations of nitrate and bromide required to generate the matching spectrum. This response is exported to the Seabird CTD as voltage logged with other sensor data at 24Hz.

2. CTD Integration

2.1. Clean the sensor: prior to mounting, the ISUS sensor optical path is cleaned with an alcohol-dipped cotton swab following the method described in the Satlantic ISUS manual. Basically, the alcohol-dipped swab it pulled across the optical surfaces in one direction. Using a fresh swab each time, the process is repeated until the optical surface is clean. This process should be performed whenever the sensor response seems effected by bio-fouling.

2.2. The ISUS is mounted on the rosette so the sensor has unobstructed seawater flow. An ISUS battery is mounted nearby to provide power (ISUS v1 or v2 draws more amps at startup than can be provided by the Seabird 911+ CTD).

2.3. Cable connections: connect the ISUS analog-out port to an open CTD channel; rig the battery cable so it can be easily, securely attached to the ISUS power connector several minutes prior to deployment. Note that internal data logging will begin when the battery is attached but the sensor generates better in-situ data when warmed-up for several minutes.

2.4. Software setup: Seasave, the Seabird CTD data acquisition software, will record the voltage from the ISUS on the channel it is installed. To display a real-time estimated nitrate cast profile, a 'user-polynomial' is setup to display ISUS data. Coefficients from a previous discrete-nitrate vs ISUS voltage comparison are entered as second-order polynomials.

3. Data Processing

3.1. Using Seabird's SBE Data Processing Suite, apply the 911+ recommended (by the help or data processing manual) modules:

3.1.1 Datcnv – ascii-formatted cnv files are generated for all casts

3.1.2 Window filter - median filter all data; 9 is used for all data channels except the ISUS voltage channel - 500 is used to smooth the sensor oscillation.

3.1.3 Filter – low pass filter A equal to 3 secs is applied to ISUS voltage; low pass filter B equal to 0.15 secs applied to pressure

3.1.4 AlignCTD – oxygen sensors 4 secs offsets applied

3.1.5 Cell Thermal Mass – standard corrections applied to both conductivity sensors

3.1.6 Derive – depths, salinities, oxygens, densities, potential temperatures, specific volume anomaly, dynamic meters (heights) are (re)calculated using processed cnvs.

3.1.7 Ascii-out - export the basic parameters: scans, pressure, temperatures, salinities, oxygens, depths & voltages to asc files.

3.2. A preliminary IEH (legacy data processing & archival ascii format) data file of bottle sample data is generated using CODES & DECODR, two 'in-house' data processing programs.

3.3. The CTD data is merged with bottle data using another 'in-house' developed Windows software program, BtlVsCTD.exe.

3.3.1 During each CTD cast, Seasave generates a .bl file which indexes the scan value when a bottle-trip is initiated and when the bottle closure is confirmed. Using the .bl file indexes as end points, BtlVsCTD bin-averages 4 seconds of CTD data prior to the bottle closures.

3.3.2 The matching bottle data are appended to the comma-delimited CTD data records into a csv. This csv includes data from all CTD records with matching bottle data.

3.3.3 Importing the csv into Excel, the 4-sec average ISUS voltages are plotted vs the bottle nitrate data. A linear regression is applied and the coefficients tabulated.

3.3.5 In addition to ISUS/nitrate, CTD oxygen (ml/L) and fluorometer voltage are regressed vs bottle data, coefficients tabulated; CTD salinities are compared to bottle salts > 340m, offsets derived for both conductivity sensors.

3.3.5 BtlVsCTD.exe - using the bottle vs CTD regression/correction coefficients, csvs of 1m bin-avg upcast CTD data merged with bottle data are generated. These data (temperature, salinity, oxygen, chlorophyll, & nitrate) vs depth are plotted using Matlab for point-checking and CTD data-quality assessment.

3.4. Final CTD data processing is performed using Seasoft modules.

3.4.1 CTD data files are split into down and up casts using the Split module.

3.4.2 The Loopedit module is applied to downcast data; Settings: type = 'Fixed Minimum Velocity', 'Minimum CTD Velocity' = 0.0333m/s, 'Bad Scans Excluded'

3.4.3 Binavg module applied to both down and up cast files, averaging CTD data into 1 meter depth bins.

3.4.4 Ascii-out of up and downcast CTD data.

3.5. Once final bottle data are available, they are merged with final CTD data using BtlVsCTD.exe. Resulting csvs are plotted using Matlab for final data QC. Data are considered final once the final plots are assessed and final corrections applied, if necessary.

4. Calculations

4.1 Linear regression of ISUS voltage vs discreet nitrate data generates cruise-average correction coefficients.

4.2 BtlVsCTD calculates individual station regressions of ISUS voltage vs discreet nitrate data. This 'on-the-fly' linear regression generates station-specific corrections coefficients which are applied to the specific cast.

Both cruise and station-corrected nitrate estimates (and the coefficients) are tabulated in the final csvs.

5. Equipment/Supplies

- Satlantic ISUS v2 Nitrate Sensor
- Three 12v Wet-labs rechargeable battery packs
- ISUS analog signal to Seabird 9 interface cable
- ISUS power to battery cable
- ISUS Rs-232 interface cable to download internal data files
- Windows laptop with serial interface to program the ISUS and download data.
- Alcohol & cotton swabs
- Nutrient collection tubes for seawater samples
- Seal QuAAtro nutrient analyzer & in-house analyst

6. References

- Johnson, K.S.; & L.J. Coletti. 2002. In situ ultraviolet spectrophotometry for high resolution and long-term monitoring of nitrate, bromide and bisulfide in the ocean. *Deep Sea Research I* 49: 1291-1305.
- Maillet, Gary and Geoff MacIntyre. 2009 Real-Time Monitoring of Nitrate With the Satlantic-ISUS Sensor. Online at: http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/documents/docs/bulletin_6_10.pdf (http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/documents/docs/bulletin_6_10.pdf)
- Satlantic Incorporated. 2005. MBARI-ISUS V2 Operation Manual, Document Number: SAT-DN-272, Revision G.1, August 2006