Calibration and data processing of acs 103 used on the deployment cruise:
Chesapeake 2011-11-15
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NAME: WET Labs ac-s
S/N: 103

I) Introduction and Summary

The ac-s is a hyperspectral absorption and attenuation meter. It employs dual 25-cm pathlength flow cells. The light source is a linear variable filter imaged with a collimated beam from a tungsten lamp. The absorption side has a reflecting tube and a large area diffuse detector, whereas the attenuation side has a non-reflective tube and a collimated detector. The instrument provides an 80+ wavelength output from approximately 400–730 nm with approximately 4 nm steps. Individual filter steps have a FWHM that range between about 10 to 18 nm.

Wetlabs Archive Processing was used to convert raw binary data to engineering units (inverse meters). This program uses constants in the instrument's device file to correct for instrument temperature and a clean water calibration performed at the factory. Details are in the ac-s user's manual. The formula is presented here without derivation.

$$c(\lambda) = (c_{off} - 1/x\ [\ln(C_{sig} / C_{ref})]) - \Delta_T$$

and

$$a(\lambda) = (a_{off} - 1/x\ [\ln(A_{sig} / A_{ref})]) - \Delta_T$$

where

$c(\lambda)$, $a(\lambda)$ is the attenuation coefficient and absorption coefficient, respectively in m^{-1}
c_{off}, a_{off} is the water offset value (provided on the Calibration Sheet) in m^{-1}
C_{sig}, A_{sig} is the measured amount of light that reaches the receiver detector from the ac-s data stream in raw digital counts
C_{ref}, A_{ref} is the amount of light measured by the reference detector from the ac-s data stream in raw digital counts
x is the sample volume path-length in meters (0.25 meters in this instrument).
Δ_T is the internal temperature compensation correction value in m^{-1}.

A. Manufacturer calibration / coefficients

Manufacturer temperature compensation correction values and clean water offset are provided in the device file 'acs103_20111021.dev'.

B. Self-calibration methods and results

The acs-103 was calibrated using the method described in the ac Meter Protocol Document, with pressurized clean water from our Barnstead Diamond water treatment system. The resistance was greater than 18 MΩ*cm^2. The mean of 2 repetitions with less than 0.003 m-1 difference at all wavelengths was used to subtract the pure water offset. The calibration was normalized to 12C by using the offsets from Sullivan et al 2006.

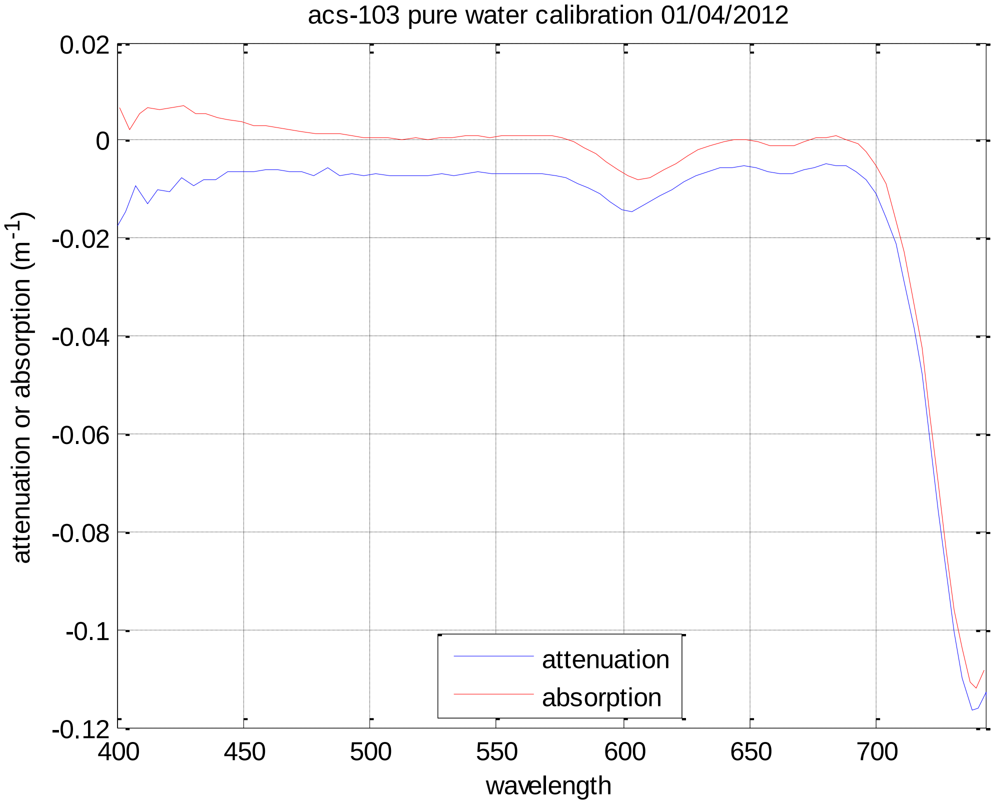

Figure 1: Plot of acs 103 calibration, normalized to 12C, used for pure water offset.

III) Deployment

A) Measurement Methods

Profiles were made at each station, some with 0.2 µm pre-filters to measure dissolved absorption. The ac-s was monitored in real-time, and files were collected directly to the computer

B) Package Design

The package containing this ac-s also had one more ac-s, a Seabird SBE-49 CTD, a Wetlabs bb9, and a Wetlabs DH4 data handler. It was powered by a 48VDC power supply, which was converted to 12VDC under water using a Wetlabs PCCS power converter/RS422-RS232 converter.

IV) Data Processing

A) Data Analysis

Post processing began with merging the CTD with the ac-s. Rows with outliers were then removed, using ± 4 standard deviations from the median value for each wavelength. On casts which were pre-filtered, the ac-s data were lagged to correct for the time required for water to pass through the filtered. This was accomplished by taking advantage of the positive correlation between water temperature and a_{740} . After this, corrections for salinity, temperature, and instrument drift were made, utilizing Sullivan et al's (2006) temperature and salinity dependencies and the calibration performed on 01/04/2011. The equations used are:

$$c = c_m - \left(\Psi_T * (T - T_{ref})\right) - (\Psi_S * S) - c_w$$

and

$$a = a_m - \left(\Psi_T * (T - T_{ref})\right) - (\Psi_S * S) - a_w$$

where c_m and a_m are measured values, c_w and a_w are from the calibrations,
T_{ref} is the temperature to which all data are referenced (12C in this case),
T and S are temperature and salinity measured by the CTD, and
Ψ_T and Ψ_S are the temperature and salinity dependencies of water taken from Sullivan et al 2006.

The absorption values were then corrected using Zaneveld et al's 1992 method.

$$a_{pg}(\lambda) = \frac{a(\lambda)}{[c(\lambda_{ref}) - a(\lambda_{ref})]} * [c(\lambda) - a(\lambda)]$$

where a_{pg} is the absorption due to particles and CDOM, and the λ_{ref} is 730 nm.

Matlab was used for all post processing. Scripts were based on those available from the ac Protocol document.

IV) References

ac Protocol Document Revision Q. From http://wetlabs.com/products/pub/ac9/acprotq.pdf

Sullivan, J.M., M.S. Twardowski, J.R. V. Zaneveld, C.M. Moore, A.H. Barnard, P.L. Donaghay and B. Rhoades, The hyperspectral temperature and salt dependencies of absorption by water and heavy water in the 400 - 750 nm spectral range. *Applied Optics*, 45:5294-5309. 2006

Zaneveld, J.R.V., J.C. Kitchen, A. Bricaud, C. Moore. Analysis of in-situ spectral absorption meter data, *Ocean Optics XI*, Proc. Soc. Photo-Optical Instrum. Eng. (SPIE), 750, 187–200, 1992.