

Kudela Lab ac-s Data Acquisition and Processing Protocols

Jesse Bausell, jbausell@ucsc.edu

Professor Raphael Kudela, kudela@ucsc.edu

Data Acquisition

Before and after each field campaign, WET Labs ac-s Spectral Absorption and Attenuation Sensor (ac-s) is calibrated in the laboratory by running the instrument while pumping deionized (Milli-Q) water through absorption (a) and attenuation (c) flow chambers. The resulting pure water spectral measurements are used later to calibrate raw field-collected ac-s spectra. During a cast, ac-s is deployed off of an ocean-going vessel using a mechanized wench. It is first lowered 5-7m into the water column to dispel bubbles in the flow chambers. ac-s is then raised and lowered through the water column in succession for a duration of 10 minutes (typically three cycles). It records a and c at ~ 80 channels centered between ~ 400 -750 nm. Additionally, ac-s is typically equipped with an ancillary CTD.

Data Processing

ac-s uses separate detectors to measure the upper and lower ends of a and c spectra. Therefore, there is commonly a 'jump' or 'step' in raw a and c spectra occurring close to 555nm. We correct this spectral 'jump' by calculating the difference between the two adjacent a/c channels on either side of 555nm, and then subtracting this difference from all a/c values measured at channels greater than 555nm.

Second, we adjust a and c cast spectra using the aforementioned pure water (Milli-Q) calibration data (see 'Data Acquisition'). To do this, we create average pure-water a and c spectra and subtract them from each a or c cast spectra. To create average spectra, we first plot a and c data over time for all instrument channels separately. For each a and c channel, a subset of the time series is selected for averaging based on the criterion that a/c values in this subset must be consistent over time (Fig. 1). This indicates that ac-s was measuring non-contaminated Milli-Q H_2O . Averaged a and c spectra are then corrected for the spectral 'jump' (see above paragraph) then and temperature-adjusted to the mean water column temperature of the ACS cast using methods described in Sullivan et al. (2006) (eq. 1).

We then normalize a and c cast spectra for salinity, again using the methods explained Sullivan et al. (2006). Spectra are first temperature-adjusted from the mean temperature of their ac-s cast, to a constant temperature of 15 degrees Celsius (eq. 1). They are then adjusted for salinity (eq. 2), and returned to the original mean temperature of their respective ac-s cast (eq. 1). After salinity corrections are applied, a spectra only are corrected for scatter-induced contamination following procedures outlined in Rottgers et al. (2013) (eq. 3).

Finally, a and c cast spectra underwent QA/QC. c spectra are discarded from the cast if they contained any values less than 0 or any value greater than 4 for a

channel measuring 700nm or less. a spectra are discarded from the cast if they contained a value that was negative, greater than the maximum of value of its respective cast. Additionally, a spectra were discarded if their corresponding c spectra did not pass QA/QC and vice versa. We display a and c spectra using two formats: 1. Individual paired a/c spectra ordered sequentially, and 2. Depth-averaged spectra calculated at different depth bin sizes.

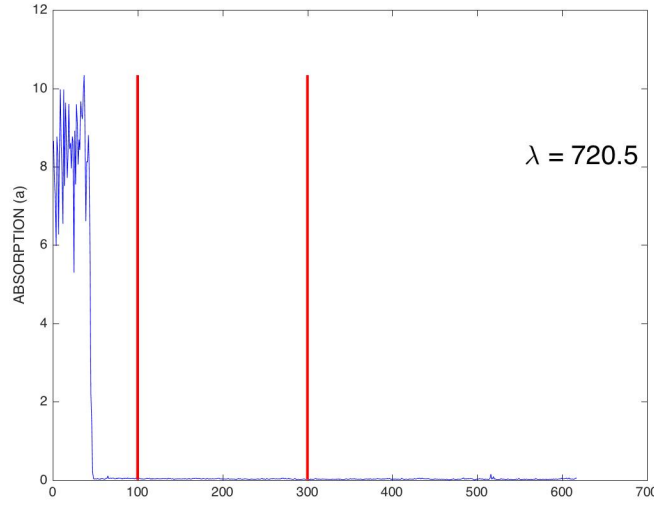


Fig 1: An example plot depicting pure-water a plotted over relative time for the 720.5 nm a channel. Values located between the two red lines were averaged as part of the pure-water a spectra. The same method was used to create pure-water c spectra.

$$a_{tcorr}(\lambda) = a_{meas}(\lambda) - (T_i - T_{norm}) * \Psi_T(\lambda)$$

Eq. 1: Temperature adjustment equation, in which a_{tcorr} represents temperature-adjusted absorption, a_{meas} represents measured absorption, T_i represents in-situ temperature, and T_{norm} represents the temperature to which a is adjusted (degrees Celsius). Ψ_T denotes a wavelength-dependent temperature normalization coefficient. This equation is interchangeable for c . For more information, see Sullivan et al. (2006).

$$a_{scorr}(\lambda) = a_{meas}(\lambda) - S_i * \hat{\Psi}_{s,a}(\lambda)$$

Eq. 2: Salinity adjustment equation, in which a_{scorr} represents salinity-adjusted absorption, a_{meas} represents measured absorption, and S_i represents in-situ temperature. $\hat{\Psi}_{s,a}$ denotes a wavelength-dependent salinity normalization coefficient. This equation assumes a water temperature of 15 degrees Celsius and is interchangeable for c . For more information, see Sullivan et al. (2006)

$$a_{corr}(\lambda) = a_m(\lambda) - a_{m715} \frac{\left[\left(\frac{1}{e_c} \right) c_m(\lambda) - a_m(\lambda) \right]}{\left[\left(\frac{1}{e_c} \right) c_{m715} - a_{715} \right]}, a_{715} = 0.212 * a_{m715}^{1.35}, e_c = 0.56$$

Eq. 3: Scattering adjustment equation, in which a_{corr} represents corrected absorption, a_m and c_m represents measured a and c respectively, and e_c represents a wavelength-independent correction

factor. a_{715} represents an empirically-derived correction for a at 715nm, which represents scatter. For more information, refer to Röttgers et al. (2013).

Bibliography

Röttgers, R., D. McKee, and S.B. Woźniak, *Evaluation of scatter corrections for a_c -9 absorption measurements in coastal waters*. Methods in Oceanography, 2013. **7**: p. 21-39.

Sullivan, J.M., et al., *Hyperspectral temperature and salt dependencies of absorption by water and heavy water in the 400-750 nm spectral range*. Applied Optics, 2006. **45**(21): p. 5294-5309.