

Radiometry lab (modified from labs written by Ken Voss)

1. **The class will divide into 4 groups (for the homework each group will analyze one of the stations' result in depth – they may choose the data from another group if conditions were easier to interpret).** Note the time of your measurements so you can compare to measurements done by the other groups at similar times relative to the tide.

Group 1 – PAR as function of depth using a LICOR radiometer.

2. Using the LiCOR PAR in-water spherical sensor and the reference cosine sensor, measure the profile of PAR keeping track of the reference values for each depth observation.
3. Deploy a Secchi disk from both sides of the dock and compare your observation. With the data after the class answer the following questions:
 1. What radiometric quantity are you measuring?
 2. Correct the in-water measurements for variations in incident PAR.
 3. Compute the diffuse attenuation coefficient for your PAR observations.
 4. What model for K_{PAR} did you use and why? There are a few ways to calculate the diffuse attenuation coefficient, how do the various approaches compare? What are the assumptions in each approach?
 5. Compute the depth of the euphotic zone for these waters. What model are you using?
 6. How do your values for PAR compare to those computed from the hyperspectral observations? Is there any variation in the relationship as a function of depth? Why do you think this is?

Group 2– Diffuse attenuation coefficients with HyperPro radiometers.

Using a HyperPro radiometer, deploy radiometers (Ed and Lu) off the dock both on the sunny side as well as the shaded side (two sets of measurements). Collect measurements (from about 25cm depth below the surface between down to 2m depth), at a time when the surface radiometry does not vary significantly. Use a meter reel to figure out the depth of each sensor.

With the data after the class:

1. Plot the radiometry data as function of spectra with a different color for each depth.
2. Compute and plot the spectral diffuse attenuation for this profile.
3. Attempt to interpret its shape WRT what you have measured last week for Harpswell Sound and the absorption by pure water. What substances contribute the most for light attenuation at different part of the spectra?

Group 3 – Measuring hyperspectral reflectance with radiometers.

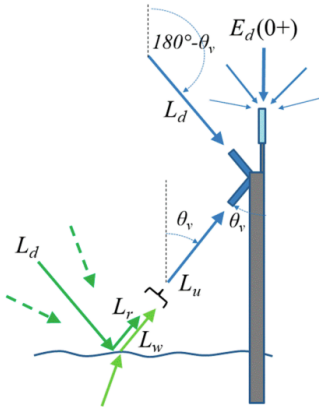


Figure 1. The 'Mobley' method to obtain reflectance using a radiometer. Azimuth angle is typically 135degrees while angle to the vertical is 40 degrees.

1. Explore the spectra obtained by a planar radiometer with and without the sun disk shaded. Is the spectrum consistent with your expectations?
2. As in Figure 1, collect radiometry with radiance meter pointing at sky , then at water and with irradiance meter pointing upwards.
3. Also measure an estimate of downwelling planar irradiance by measuring the radiance coming off a 99% spectralon plaque.
4. Side by side make measurements at the same time with the Hydrocolor App at a 18% reflectance photographer card so they could be compared when you work the data up.
5. Measure the light reflected by the 18% cards with a radiance meter.

With the data after the class:

1. Compute reflectance using one radiometer and a plaque as well as using a radiance and an irradiance meters.
2. Compare reflectance measured with the above measurement methods with that of the HydroColor at the same angles. Use Mobley's (1999) equation to compute remote-sensing reflectance: $R_{rs} = (L_r - 0.028L_{sky}) / E_d$. Note that Hydrocolor assumes the same factor of 0.028.
3. Compare E_d and radiance reflected from spectralon plaque and photographer cards. Are they consistent with the nominal reflectance value (99% and 18% respectively)?
4. Compare the E_d measured with that calculated with Greg and Carder for a clear sky (script provided by Emmanuel).

Group 4 – Hyperspectral reflectance with a buoy.

1. Using a Hyperspectral tethered radiometer buoy (HTSRB), measure upwelled radiance and downwelling irradiance above the surface.
2. Measure on both sun side of dock and shade side of dock.
3. Comment about the measurements. Do they make sense to you?

After class:

1. Compute for sunny and shady side of dock:

$$Rrs = (Lu(z) T(z) Taw) / Es$$

Where Taw is the transmission of the air-water interface = 0.54

$T(z)$ is the radiance transmission from the measurement depth to the water surface:

$$T(z) = \exp(KLu * z) \text{ assuming the } KLu \text{ obtained from group 2.}$$

2. Compute PAR from the spectra of E_d .

Appendix:

Calculating PAR

$$PAR = \sum_{400nm}^{700nm} E \Delta\lambda \text{ Note need } E \text{ in Watt m}^{-2} \text{ nm}^{-1}.$$

One usually compute PAR in terms of quanta where:

$$PAR = \sum_{400nm}^{700nm} \frac{E}{hc} \lambda \Delta\lambda \text{ Note that } E \text{ needs to be in Watt m}^{-2} \text{ nm}^{-1}.$$

Where h is Planks constant ($6.63 \times 10^{-34} \text{ m}^2 \text{ kg/s}$), and c is the speed of light ($3 \times 10^8 \text{ m/s}$).

Are your values reasonable (find values on the WWW to compare with).