Calibration and Sky measurements:

Group 1)

Break this group into two parts. One part will start with Part A (calibrate then measure), the other will start with Part B (measure then calibrate).

Part A)

We need to calibrate the detectors. We have to calibrate both the radiance and irradiance detectors (separate spectrometers for each). So we need an appropriate source for each. REMEMBER, YOU NEED A DARK MEASUREMENT IN EACH MEASUREMENT SEQUENCE, PREFERABLY AT THE SAME INTEGRATION TIME.

1) For the irradiance detector we can look directly at a lamp (source of irradiance) and take a measurement of this known irradiance at a specific distance.

   $E(\lambda) = (Cal\,\#)(InstrumentCounts) / IntegrationTime$ or

   $Cal\,\# = Eo(\lambda) * IntegrationTime / InstrumentCounts$

   We will give you a file for $Eo(\lambda)$, the lamp data at 20cm.

2) For the radiance sensor we need a source of radiance. We use the light from a known source of irradiance which has been reflected from a plaque with a known reflectance.

   $$Erefl = \int_0^{2\pi} d\phi \int_0^{90} [L\cos(\theta)]\sin(\theta)\,d\theta$$
   $$Erefl = 2\pi L / 2 = \pi L$$
   $$R = Erefl / Einc \Rightarrow L = REinc / \pi$$

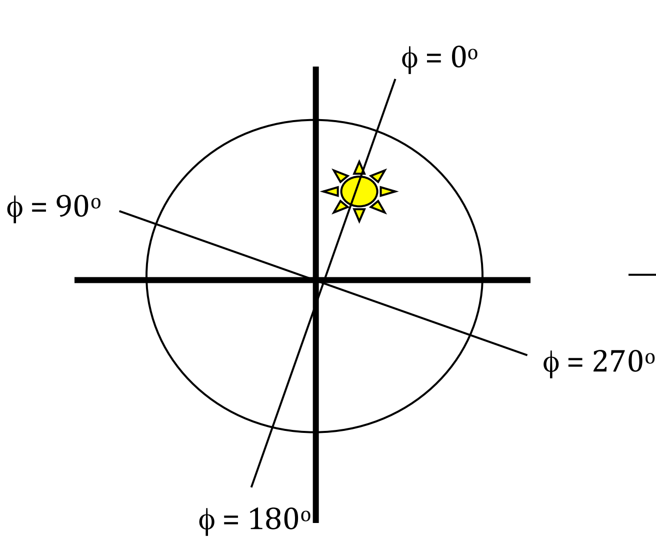
   We will assume R for the plaque is 0.9, and that it is a lambertian reflector (explained in class).

3) to take a measurement with the Ocean Optics Spectrometer:
   a) Open the Spectra Suite software
   b) Notice Integration time in the upper part of the window. Change the integration time to 1 second. If fiber optic probe is pointed at a source, should see the screen update every second. Integration time should be varied to get a reasonably sized signal.
   c) Once a reasonably sized signal is obtained, to store a file,
      a. locate the little picture of a floppy disk along the tool bar (towards the right of the upper window) and push that.
      b. Save as file type Tab delimited.
      c. Type a good filename (keep track of what it is in your data log), push return then save.

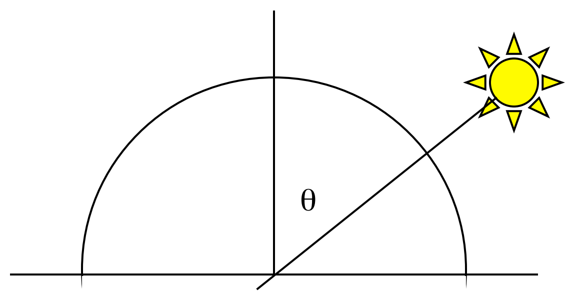
d. MAKE SURE TO SAVE A DARK FILE WITH THE SAME INTEGRATION TIME!

Part B)

Now (if the sky is clear) we will measure the radiance distribution of the sky along specific angles using the radiance sensor. Using a protractor, divide the sky into azimuthal angles, where $\phi = 0$ is defined as the solar azimuthal angle, and θ is the solar zenith angle (use the protractor to determine the solar zenith angle in some way).



Plan View

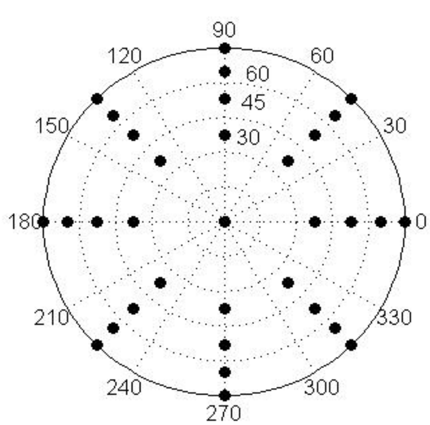


Nadir View ($\phi = 0^{\circ}$)

Collect observations for the suite of angles $\theta = 0^{\circ}, 30^{\circ}, 45^{\circ}, 60^{\circ}, 90^{\circ}$ and $\phi = 0^{\circ}, 45^{\circ}, 90^{\circ}, 135^{\circ}, 270^{\circ}, 315^{\circ}$. (This represents a total of 30 measurements!)

With the irradiance sensor, measure the total downwelling irradiance, then shadow the direct sun from the measurement and measure the diffuse sky irradiance. Best to repeat these measurements several times.

a. Describe your expectation of the sky radiance distribution.
b. Construct a contour, polar plot of radiance on the graph below (for 2 -10 nm bands: one blue and one red).



c. How homogeneous is the sky radiance distribution?
d. Comment on the practical aspects of measuring the sky radiance distribution.
e. Plot the radiance, at the three 10nm wavelengths, as a function of scattering angle from the sun, is it a simple function of scattering angle (Curt's first lecture)? What other factors would influence this?
f. Use the radiance measurements you made of the sky (or interpolating those) to calculate the sky-diffuse irradiance. How does this compare with your measurement of the diffuse irradiance.

Group 2. Radiometry measurements off the dock, PAR measurements.

A) Down on the dock deploy the radiometer buoy, placing the buoy between sun and dock (if possible). Compare Ed and Lu spectra. Observe qualitatively how the Lu spectrum changes as you pull the buoy slowly vertically out of the water.
B) Make measurements with the buoy in full sunlight and in various positions around the dock (shadowed and non-shadowed).
C) Deploy the radiometer with the "Lee" configuration and make measurements in full sunlight.

Computations

a. How do the irradiance spectra change when the buoy is in full sun light, in the shadow of dock, and when the direct beam of the sun is occluded?
b. Calculate Rrs from this system, how does the Rrs for the various situations.
c. Compute Ed(PAR) from hyperspectral data (400 to 700nm) and SeaWIFS bands (extrapolate if needed) and compare these to each other.

Group 3. Radiometry and reflectance from above the surface.

A) With the SAS radiometer system, explore collecting data with radiometers at several sensor zenith angles (30, 35, 40 and 45 degree, for both Li and Lt at one azimuth angle of your choice), and several azimuth angles (0, 45, 90, 135 and 180 for one sensor zenith angle). Mobley's (1999) recommended values are 40 degrees for Li and Lt and at 135 degrees azimuth angle away from the sun. Remember that this system also logs a reference irradiance measurement. Note changes in the sky and water during the measurements.

B) With the WISP system, make measurements at various positions along the dock. Try to keep at 135 degree azimuth angle. Measure over the water, over shallow water, over land, then over grass on the end of the dock. You can see the spectra on the screen of the WISP, how do the spectra (and computed values for Chl) compare?

C) Arrange for a simultaneous measurement with the WISP system, SAS, and Group 2, all making optimum measurements.

COMPUTATIONS:

a) From the data collected in part A, compute the above-water remote-sensing reflectance's for different measurement angles. How variable are they? Use Mobley's (1999) equation to compute remote-sensing reflectance: Rrs=(Lt-0.028Li)/Ed.

b) Compare the spectra measured with the WISP at the different measurement locations, how do they compare, what would you use in the spectrum to indentify the scene, if just given the reflectance?

c) Obtain the simultaneous data from the people in group 2 and compute the remote sensing reflectance obtained with each technique. How do they compare? Are there regions of the spectrum, or locations where one method might be advantageous over another?

Calibration Setup:

Irradiance

Position irradiance sensor 20 cm from the center of the lamp. Obtain dark (sensor covered) and light (looking at lamp) measurements.

Simplified measurement equation is:

Irradiance = cal# (light reading – dark reading)/integration time

So to get the cal#:

Cal# = (known lamp irradiance at 20cm)*(Integration time)/(light-dark)

I have placed a file with the known lamp irradiances of the light bulb at 20cm on the class site (interpolated at the correct wavelengths for you).

Radiance:

Known source of irradiance is placed 20 cm from reflecting surface (plaque). Radiance detector views this radiance source from an angle of 45 degrees.

Simplified measurement equation is :

Radiance = cal# (light reading-dark reading) /integration time

Radiance = Irradiance *R/PI

Cal#=(irradiance)*R/PI *integration time/(light reading – dark reading).

R is reflectance of surface

Calculating remote sensing reflectance: (Rrs = Lw/Es)

Above water method:

Here one is measuring the light coming out of the water by using instruments above the surface. The corrections that must be applied need to correct for sky glint coming from the surface.

Rrs = (Lt-Lg)/Es

Lg= Lsky *Reflectivity of surface

In water method (floating device):

Here one measures the upwelling light below the surface of the water, and must correct for the attenuation of the light from the measurement depth to the surface and then for the transmission through the air-sea interface. A meausurement of Es, above the surface is used to form Rrs.

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

New Lee method:

This shouldn't have any corrections:

Rrs = Lmeasured/Es

In water method, casts:

Here one forms the Lu(-), upwelling radiance just below the surface from subsurface casts using a profiling radiometer or buoy with multiple measurement depths. Es comes from a reference measurement above the surface. If the measurements are done with a profiling radiometer, multiple casts (10) are done very quickly over the first 20m or so of the water column. These multiple casts are combined to determine Lu(-) and then this Lu(-) is propogated through the surface.