HydroLight and EcoLight Exercises Part 2

John Hedley, Ocean Optics XXV, 2022

These exercises demonstrate how to model more complex water bodies, input depth profiles of Chl or mineral particle concentrations, input measured absorption and scattering data, put bottoms at finite depths, etc., and examine the various kinds of output.

Closure: A common use of HydroLight is to check closure (internal consistency) between IOPs and radiometric variables or AOPs. For example, you read in your ac-9 or ac-S absorption and scattering data, let HydroLight predict E_d and K_d and R_{rs} and such, and then compare HydroLight's E_d or K_d or R_{rs} with your measured E_d or K_d or R_{rs}. Then try to figure out why the predicted and measured values disagree, which they almost always do.

Exercise 1: Inputting measured Chl(z) data.

What you learn: How to input measured Chl(z) data and then use an IOP model to define the IOPs for Case 1 water. How sky conditions affect irradiances, K's, R_{rs}, etc.

There is a "HydroLight Standard Format" (HSF) for any type of data file to be read by HydroLight, e.g. for files containing Chl profiles, ac-9 data, or measured sky irradiances. Example data files of various types are found in the data\Examples directory. These files use "\begin_header" and "\end_header" lines between which any amount of text metadata can be included, the actual data read by HydroLight follows on subsequent lines.

The "Classic Case 1" IOP model uses *Light and Water* Eqns (3.27) and (3.40) to convert a Chl concentration to the absorption coefficient a and the scattering coefficient b, as functions of depth and wavelength. You still have to pick a scattering phase function. The "New Case 1" IOP model determines everything from the Chl value.

Create a file with depth vs. Chl data, and use it to input a Chl(z) profile. Start with the example file HE60\data\examples\Chlzdata.txt and modify it. Be sure to save your file as an ASCII text file (not a Word or Excel file, and not a Unicode file) with a new name, like Test_Chlz.txt. If you use Notepad or Wordpad use save as → save as type MS DOS format, or encoding is "ANSI". The recommended place for such files is the HE60\data\user directory.)

Run 1. Pick the Classic Case 1 IOP model and browse for this file in the concentration profile box option "by a standard format user-supplied data file" box. Pick a bb/b value of 0.01 or 0.02, and other typical values for sun angle, etc. Run from 400-700 nm by 10 nm. Do the run to 25 m, say, and save the output every 5 m, with an infinitely deep bottom.

Run 2. Use the same Chl(z) data file and do a run with the New Case 1 IOP model, and all else the same. Compare the two sets of output for things like $E_d(z)$, R_{rs}, Secchi depth, etc.

For these runs, you can use the Excel spreadsheet outputs starting with "M" (under HE60\output\HydroLight\excel) to look at and plot the results. The "M" spreadsheets are arranged with one variable (e.g., the absorption coefficient or E_d) per page as a function of depth and wavelength. The "S" spreadsheets group related variables (e.g., all of the irradiances or all of the K functions) and show the depth dependence in blocks of one wavelength per block.

Notice how the various K functions (K_d, K_u, K_{Lu}, etc) depend on depth and wavelength. Ditto for $R = E_u/E_d$ and the mean cosines. Plot the R_{rs} spectra for these two runs.

Repeat one of your runs with the IOPs the same, but change the sky conditions. Put the sun at 0, 30, 60, and heavy overcast (100% cloud cover). How do the different sky conditions affect the irradiances, K functions, reflectances, and mean cosines?

Exercise 2: Inputting IOPs from *a*, *c*, and b_b sensors.

What you learn: How to input measured IOPs, rather than using an IOP model to define the IOPs.

You are always better off measuring the IOPs than trying to estimate them from Chl or mineral concentrations and a bio-geo-optical model to obtain the IOPs from the concentrations. The most common way to do this is with ac-9 data (or ac-S, or data from other instruments).

File HE60\data\examples\ac9_data.txt contains some ac-9 data in the HSF for a and c data. Take a look at this file to see the format for this type of data. Note that if you have ac-S data, the format is the same, but then you would have 80 wavelengths instead of 9. **Note that ac-9 and ac-S data are assumed to have had water *a* and *c* values subtracted out; HydroLight will automatically add pure water values to the *a* and *c* values in the file.**

File HE60/data/examples/Hydroscat6_withH2O.txt contains some Hydroscat-6 data in the HSF for bb data. Take a look at this file to see the format for this type of data. **Note that *bb* data usually include the water *bb* values, as indicated by the name of this file. However HydroLight asks you whether or not the pure water *bb* values are included in the *bb* data.**

Use these files and the "MEASURED IOPs" IOP option to do some runs with measured data. If you have your own ac9 or bb data, put it on files of the same format, and use your own data.

WARNING on ac-S data. With the ac-S the wavelengths are not exactly the same for a as for c. Therefore, spline the a and c spectra to a common set of wavelengths (say at 5 nm resolution) before inputting into HydroLight. Otherwise, the a anc c values won't match for a given wavelength.

Exercise 3: Simulating Case 2 water.

What you learn: How to build up a water body with Chl, extra CDOM, or mineral components.

Now use the "CASE 2" IOP model to do a series of runs to simulate the transition in R_{rs} as you go from Case 1 to Case 2 water with increasing mineral and/or CDOM concentrations. For example, you might: set Chl = 1 mg/m^3, let the CDOM be a function of Chl like in Case 1 water, and then do runs with a mineral concentration of 0, 0.25, 0.50, 1.0, 2.0, 5.0, 10.0 gm/m^3, with all else being held constant. Maybe use a phase function with 1% backscatter fraction for Chl-bearing particles and 3% for the mineral particles. Then plot R_{rs} as a function of wavelength and mineral concentration.

Alternatively, you might hold the mineral concentration fixed at 1 gm/m^3, but vary the type of mineral (from the selection of calcareous sand, red clay, yellow clay, and brown earth).

Exercise 4: Simulating optically shallow water.

What you learn: How to put a finite-depth bottom in HydroLight, and see the effect of bottom reflectance on R_{rs} and K functions.

File ac9_bahamas.txt has ac9 data that were measured in very clear water in the Bahamas. You can get a copy of this file from me in class. Use the IOP DATA option to read in this ac9 data. Do a run from 400 to 700 by 10 or 20 nm. On the Bottom Boundary Condition form, pick the options for a finite depth, and bottom reflectance dependent on wavelength, and then pick the coral sand bottom reflectance file. Do runs with the bottom placed at 5, 10, 20, and 30 m, and infinitely deep water run down to 30 m. Save the output at 1 m intervals. Plot R_{rs} for the different bottom depths to see how deep the water has to be before you don't "see" the bottom in R_{rs}. Now plot K_{Lu} at 550 nm vs depth to see how the bottom reflectance affects K_{Lu} as you get near the bottom. How is K_d (550) affected by the bottom?