HydroLight and EcoLight Exercises Part 1

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Note on finding output files:

Windows: On Windows HydroLight is installed in a directory called HE60 which by default is directly under C:, e.g. at C:\HE60, but can be set elsewhere in the installation. The output files will be found under HE60\output wherever HE60 has been installed.

Mac OS: On Apple machines the outputs appear under your personal user Documents directory.

Exercise 1: Optical Depth.

What you learn: it's optical depth, not geometric depth, that light cares about

In radiative transfer theory, the non-dimensional optical depth ζ corresponding to geometric depth z (in m) is defined as

$$\zeta(z,\lambda) = \int_0^z c(z',\lambda)\, dz'$$

where $c(z,\lambda)$ is the beam attenuation coefficient at wavelength λ. For homogeneous water, this is just the depth multiplied by the beam attenuation, $\zeta(z,\lambda) = c(\lambda)z$. (Note: optical depth is *not* $K_d z$, as Kirk uses, which should be called something like "non-dimensional diffuse attenuation depth".) Any two water bodies that have the same $\omega_o = b/c$, same phase function, and same boundary conditions will have the same radiance distribution as a function of optical depth (see *Light and Water*, page 252 in Chapter 5). Make two HydroLight runs to verify this, as follows:

Run 1. Using the CONSTANT IOP model, enter a and b values and select a phase function. For example, let $a = 0.1$ m^{-1}, b = 0.4 m^{-1}, and pick the Petzold phase function. Pick reasonable values for the other inputs like sun angle (say 30°) and wind speed (say 5 ms^{-1}). Select infinite depth but make a run to 20 OPTICAL depths and save the output every 1 optical depth.

Run 2. Go through the GUI again, and change *only* the a and b to values by some factor, so that you have the same ω_o as before; for example let $a = 1$ and $b = 4$. Make another run to 20 optical depths.

Compare the two printouts (files in the HE60\output\HydroLight\printout directory with names like PRun1.txt and PRun2.txt, for example). Are the irradiances and everything else the same at the same optical depths? What geometrical depths z correspond to 20 optical depths in your runs? Did the runs take about the same amount of computer time, even though the geometric depths were much different? (run time is at the bottom of the printout files).

Note that since attenuation is typically a function of wavelength, optical depth is different at different wavelengths, which is why HydroLight only allows optical depth to be specified for single wavelength runs.

Exercise 2: IOP error effects on computed light fields

What you learn: a small error in an IOP can make a big difference in the light field at depth

Suppose your ac-S gives $a = 0.30$ m^{-1} and $b = 1.0$ m^{-1} at 440 nm. Make a run (Run3) using the CONSTANT IOP model and these values. Go to 50 m GEOMETRIC depth and save the output every 5 m.

Now suppose your ac-S absorption is accurate to ±20%. Do two more runs (Run4 and Run5) with everything the same, but let $a = 0.24$ and $a = 0.36$ m^{-1}, respectively. How much difference do these 3 runs have in E_d or L_u near the surface? How much difference is there in E_d and L_u at 10 m depth, and at 50 m depth? Explain your results.

Note: An easy way to look at these outputs is via Excel, HydroLight 6.0 now creates Excel spreadsheets automatically as part of the outputs. Go to the directory HE60\output\HydroLight\excel, and you should find run the files SRun3.xlsx, SRun4.xlsx and SRun5.xlsx files created by the runs. Look at the 'irrad' page of each spreadsheet, the various irradiances are tabulated and can easily be plotted.

Exercise 3: R_{rs} dependence on backscatter.

What you learn: R_{rs} is roughly proportional to $b_b/(a + b_b) \approx b_b/a$

Do a run (Run6) using the "CLASSIC" CASE1 IOP model and enter a Chl concentration, say 2.3 mg Chl m^{-3}, for homogeneous water. Pick a phase function with a particle backscatter fraction of $B_p = b_{bp}/b_p = 0.01$. Include chlorophyll and CDOM fluorescence and Raman scatter in the run. Do a run from 350 to 750 nm by 10 nm, down to 10 m, with output saved every 5 m. Use typical values for other inputs, e.g., put the sun at 30° in a clear sky, wind speed of 5 ms^{-1}.

Now do another run (Run7) with everything the same except use a particle phase function with $B_p = 0.02$. Tip – this is easier if you click on "save this input as the default values for the next run" when the previous run is finished, then all the other settings are retained.

Note: You can easily plot spectral $R_{rs}(\lambda)$ using the Excel output files beginning with 'M', MRun6.xlsx and MRun7.xlsx, under HE60\output\HydroLight\excel.

How did doubling the backscatter fraction affect $R_{rs}(\lambda)$? Is the percent change in R_{rs} from Run6 to Run7 the same at every wavelength? What do you think is the role of fluorescence in these results (maybe try a run without fluorescence)? Why did it take HydroLight longer to solve the RTE at 745 nm than at 445 nm?

Exercise 4: Comparison of the "classic" and "new" Case 1 IOP models.

What you learn: There's no such thing as the "correct" model for converting Chl to IOPs.

Run8: Use the "NEW" Case 1 IOP model and enter the same Chl value as in Exercise 3. Note that you don't get to select the phase function with this IOP model, as the phase function is part of the model. Keep all other inputs the same. Compare the computed R_{rs} spectra from the two IOP models. Which one is correct?

If you're interested, the "classic" and "new" Case 1 IOP models are described in detail in the technical manual HE60\documents\HE60TechDoc.pdf and on the Ocean Optics Web Book at https://www.oceanopticsbook.info/view/optical-constituents-of-the-ocean/level-2/new-iop-model-case-1-water

Exercise 5: Comparison of HydroLight and EcoLight outputs.

Run9: Repeat the last run (Run8) using EcoLight (just hit the "run EcoLight" button; you don't need to work through the GUI again.) Check to see if the computed irradiances, R_{rs}, etc. are the same as for HydroLight (the EcoLight results will be under HE60\output\EcoLight) How much faster was EcoLight? Why?