EARTHSYS 123A/223/ESS 123/223: Biosphere-Atmosphere Interactions

Problem Set 4, due Thursday March 2nd, 2023 at 11:59 PM PDT

Please submit your problem set on Gradescope

Problem 1: Limiting factors in photosynthesis (3 points)

Consider a C_3 leaf characterized by the parameter values below. Assume that all parameter values are at a reference temperature of 25°C, which is the temperature of the leaf. Plot the response of photosynthesis rates A_j, A_C, and net assimilation A_n to leaf internal CO_2 concentration, over the range from 0 to 600 ppm (equivalent to 0 to 600 μmol/mol). Please use a different color for each line

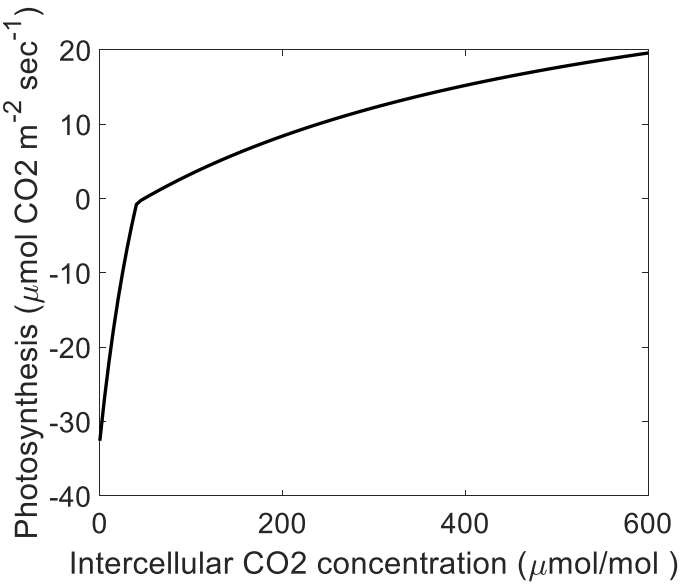
Symbol	Value	Units	Description
Φ_{PS2}	0.64	mol/mol	Maximum photochemical yield of PS II
K_{app}	510	μmol/mol	Rubisco apparent Michaelis-Menten constant
V_m	70	μmol m^{-2} s^{-1}	Rubisco capacity
Γ_*	40	μmol/mol	CO_2 compensation point
α_l	0.8	unitless	Leaf absorptivity for PAR
Q	1200	μmol photons m^{-2} s^{-1}	Light flux

Problem 2: V_{max} estimation from observations (4 points)

The file "Aspen_CO2_curve.csv" contains measurements of an aspen leaf. Import these data into R or the programming environment of your choice, and plot an A (assimilation) vs. C (internal CO_2 concentration) curve. What is the V_m (also referred to as V_{max}) of this leaf? Assume all parameters except V_m are as in problem 1, and temperature-induced parameter value variations over the range of temperatures measured are negligible.

Hint: one approach would be to optimize V_{max} so that the predicted A vs. Cc curve most closely matches the observed values

Hint 2: For this problem, you'll want to make sure you have working photosynthesis code. To double-check your code, you can note that using the values of problem 1, except using Q = 1000 μmol photons m^{-2} s^{-1} and Vm = 40 μmol photons m^{-2} s^{-1}, should give you the following assimilation curve



Problem 3 (2 points, for EARTHSYS 223/ESS223 students only)

Included in this Canvas assignment is a 2013 paper by Trevor Keenan and co-authors, who compare the ratio of ET and photosynthesis to look at the 'water use efficiency' of different ecosystems, and how it is responding to atmospheric CO_2 increases. This paper uses data from eddy covariance towers across a network called "FLUXNET" - these are similar instruments to those mentioned when introducing the Manaus coupled modelling code in class. We'll discuss these more in a later lecture, but for now what's useful to remember is that they can be used to measure GPP and ET.

Please write a roughly 2-paragraph evaluative discussion for this article. Possible topics incorporated in your discussion could include:

1) What do you find particularly effective or insightful about the analyses?
2) How would you further investigate this topic and build on this paper?
3) How do these papers relate to and extend beyond the material learned in other components of the class?

Note that this list is not limiting and that not all of these topics need to be addressed. There is no single right or wrong answer – we want to see how you can apply the concepts of the class in the context of a critical reading of the literature