Carbon Cycle — Computer Lab

Farquhar photosynthesis model — April 18, 2012

Implement the photosynthesis model introduced in the lecture notes, section 3.4.1. Explore the simulated assimilation for a range of pCO_2, temperature and PAR values. From playing around with the model, you will get a more intuitive understanding of the sensitivity of photosynthesis to these variables.
The assimilation is given by the minimum of the RuP_2-saturated and the RuP_2-limited case, where the two cases are described by Eqs. 3.58 and 3.59 in the lecture notes. For the temperature dependence of $Kc, Ko, V_{c,\max}$, and Rd use Eq. 3.61. The activation energy E for the respective parameters are $E(Kc) = 59356$, $E(Ko) = 35948$, $E(V_{c,\max}) = 58520$, and $E(Rd) = 66405$ J/mol, resp. The temperature dependent $J_{\max}(T)$ is given by

$$J_{\max}(T) = J_{\max 25} \cdot f_{\text{temp-Jmax}}(T) \tag{1}$$

with $f_{\text{temp-Jmax}}(T)$ as given by

$$f_{\text{temp-Jmax}}(T) = \frac{\mathrm{e}^{\frac{-E}{RT}}}{1 + \mathrm{e}^{\frac{ST-H}{RT}}} \tag{2}$$

and $J_{\max 25} = 210$ μ mol m^{-2} s^{-1} (compare with Eq.3.62 in lecture notes). Use parameter values $(E, S, H) = (37000, 710, 220000)$. Parameter B in Eq.3.62 is just $J_{\max 25}$. Use the a value of 8.314 J/(mol K) for the universal gas constant R. For the temperature dependence of the compensation point Γ^*, use

$$f_{\text{temp-}\Gamma^*} = \frac{Kc(T)}{Ko(T)} \,, \tag{3}$$

with a $\Gamma^*(298K) = 31$ μbar.

1. Implement the model by defining seperate functions for
   (a) the temperature dependence of $Kc, Ko, V_{c,\max}$, and Rd
   (b) the temperature dependence of $J_{\max}$
   (c) the temperature dependence of Γ^*
   (d) the saturated assimilation (calling functions defined above)
   (e) the limited assimilation (calling functions defined above)
   (f) the actual assimilation as the minimum of the limited and saturated case

2. Visualize the functions for the temperature dependent parameters and the limited, saturated and actual assimilation over a range of values for pCO_2, temperature and PAR. Compare your results with Figures 3.24-3.26 in the lecture notes.