GEOG:4470 Ecological Climatology
Lab 5: Stomatal Conductance
Due: 5:00 p.m. on Friday April 10, 2020

Goals:
- Continue practicing programming in R.
- Calculate stomatal of the canopy using the Ball-Berry model.
- Think about assumptions and uncertainties in modeling stomatal conductance.

Hints:
- Follow best practices for creating graphs (units, labels, etc.), *even if you are not explicitly told to do some in the question*.
- Don't forget units!
- Include an informative legend on all graphs.
- When in doubt, check (and copy-paste-modify) your code from previous labs!

Inputs:
- Outputs from previous labs
- Photosynthetically active radiation (Par), air temperature (Ta), soil moisture (Tdr), and vapor pressure deficit (Vpd)

0. Load the data and ecological model

Double-click your Labs.Rproj file to open RStudio and begin where we left off after Lab 4. Download Lab5_Dannenberg.R from ICON, and save it to your Labs folder, <u>replacing my last name with your last name</u>.

Open Lab5_<your lastname>.R in RStudio. Run all of the lines up until the "New for Lab 5" comment (through line 77). Once this is done, we can pick up where we left off.

In this lab, we will use three new functions from eco_model.R:

- `compute_psn_parameters()`: computes parameters necessary for the Farquhar photosynthesis model (V_{cmax}, CO_2 compensation point, dark respiration, etc.)
- `compute_bwb_farq_psn()`: solve the Farquhar and Ball-Berry system of equations for net photosynthesis (A) and stomatal conductance (g_s)
- `canopy_bwb_stomatal_conductance()`: compute stomatal conductance for water (g_s) and CO_2 (g_c) using the Ball-Berry model

1. Stomatal conductance.

Calculate photosynthesis and stomatal conductance for sunlit and shaded leaves by running lines 82-116. This solves a system of equations with two unknowns: photosynthetic rate (A) and stomatal conductance for CO_2 (g_c). We solve this system of equations for both the electron-transport and Rubisco-limited rates of photosynthesis (A_j and A_v, respectively), and then calculate net photosynthesis (A_n) as the minimum of these rates minus "dark" (i.e., mitochondrial) respiration. We then calculate stomatal conductance using the Ball-Berry model based on A_n, VPD, temperature, and CO_2.

Make a time series of stomatal conductance for sunlit and shaded leaves (`gs_sunlit` and `gs_shaded`, respectively, both in units of m/s). Describe the temporal (diurnal to seasonal) variation of stomatal conductance. Based on your understanding from class and the Bonan textbook, do these patterns make sense? What do you think are the major meteorological factors that drive the temporal patterns that you observe in the stomatal conductance time series?

2. Environmental drivers of stomatal conductance.

Now make four scatterplots of `gs_sunlit` (y-axis) vs. photosynthetically active radiation (Par), vapor pressure deficit (Vpd), temperature (Ta), and soil moisture (Tdr). Describe how stomatal conductance is related to each of these meteorological variables. How do these compare to the relationships shown in the Bonan textbook (figure below)? For those that are different than expected, why do you think this is? How would you make them more comparable?

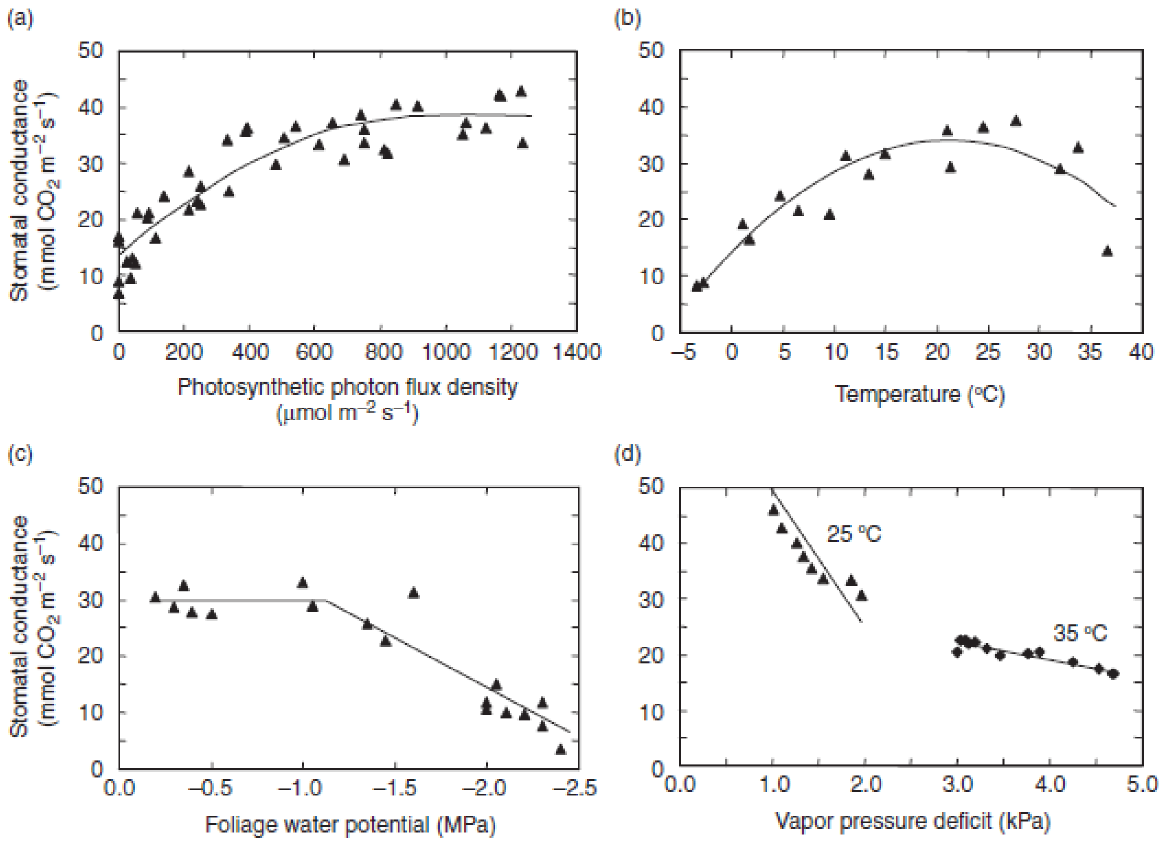

Fig. 16.6 Environmental controls of stomatal conductance for jack pine. Stomatal conductance is shown in response to (a) photosynthetic photon flux density, (b) temperature, (c) foliage water potential, and (d) vapor pressure deficit. Data from Dang et al. (1997a,b, 1998).

3. Calculate latent heat flux of the ecosystem.

Now use the Penman-Monteith model to calculate latent heat fluxes from sunlit and shaded leaves and from the understory (run lines 122-139), like we did in Lab 4 but using our Ball-Berry calculated stomatal conductance instead of the constant conductance that we used before. Also load in the measured fluxes (GppLeHMay2001-Daytime.txt) using Line 142.

As in question 4 of Lab 4, make a scatterplot of measured LE (x-axis) vs. our modeled *total* LE (y-axis). How well did our model do? What assumptions or uncertainties do you think led to mismatch between the model and the observations? How do these results compare to the results from Lab 4 with the constant stomatal conductance?

4. Do something fun.

There are a lot of variables that go into these functions: CO_2 concentration (`CA`), photosynthetically active radiation, temperature, soil moisture, vapor pressure deficit, etc. Think of a simple experiment you could run using these models but changing one or more of these input variables. Modify the functions or inputs to run this experiment. What did you test (i.e., what is your research question)? What did you expect to happen? What actually happened?

Submit your answers as a PDF document (Lab5_<your lastname>.pdf) on the Assignments page of ICON. Also submit your final R script (Lab5_<your lastname>.R) with your assignment.