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

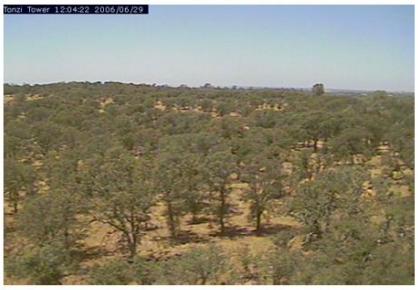
Problem Set 1, due Thursday February 2nd, 2023 at 11:59 PM PDT

Please submit your problem set on Gradescope. For quantitative problems, please make sure to write out the equations you used to calculate your answers in your write-up, and include a copy of your code.

Problem 1 (5 points)

The files TonziSample.csv and VairaSample.csv are CSV files that contain a subset of eddy co-variance files based on observations at the Tonzi Ranch and Vaira Ranch sites near Ione, CA (southeast of Sacramento). For each site, data are included for a single day: August 10th, 2006. The two sites are nearby each other, but Tonzi Ranch is covered by an oak-grass savanna, and Vaira Ranch is covered by a grassland. Below are two pictures to give you an idea of what these sites are like, both taken on June 29th, 2006 by a webcam. Assume a surface pressure of 1000 mbar.

Tonzi Ranch



Vaira Ranch

a) Plot the net radiation in the two sites. Why might it differ between the two sites?
b) Why does the sign of the net radiation you calculated above change between nighttime and mid-day?
c) Which of these two sites do you expect to have the greatest ET rates on this day (or could they be the same?)? Why?
d) Which of these two sites do you expect to have the greatest atmospheric specific humidity on this day (or could they be the same?)? Why?

Problem 2 (4 points, 2 of which for EARTHSYS 223/ESS223 students only)

You are moving across the country. Fortunately, the former tenant of your new place is as interested in land surface processes as you are, and has helpfully given you some typical average measurements from a meteorological station at 2-m height above the ground: T_a =20°C, u = 1 m s^{-1}, relative humidity is 65%, ρ_{air} = 1.2 kg m^{-3}, ρ_{water} = 1000 kg m^{-3}, and γ = 0.67 mb °C. The net radiation at the surface is 280 W m^{-2} and the ground heat flux is 25 W m^{-2}.

a) What is the vapor pressure deficit, in hPa? What is the vapor pressure deficit in millibar?

You decide you want to do some gardening in your new house. You can't decide between two different plant types, but know that because you don't have an easy hook-up, providing water for the plants will take some care. You decided to base your decision solely on the water needs of each plant. The characteristics corresponding to each crop type are listed below:

	Stomatal resistance (s/m)	Vegetation height (cm)
Option 1	30	30
Option 2	60	100

b) For the typical day whose measurements you have, what is the aerodynamic resistance for each plant?
c) For the typical day whose measurements you have, what would the evapo-transpiration (in mm day^{-1}) be for each of these plant choices? Use the Penman-Monteith equation.

Problem 3 (2 points, for EARTHSYS 123A/ESS123 students only)

During rainfall, evapotranspiration is usually fairly low. Name two possible reasons.

Problem 4 (4 points, for EARTHSYS 223/ESS223 students only)

In winter, heated indoor air reduces the relative humidity inside buildings. This is especially a problem inside hospitals in cold climates where the air temperature and relative humidity must be kept at 20.6^{o}C and 75% respectively for health and hygiene reasons. Consider a cold winter day in Chicago when the outside air temperature is -6.7^{o}C and the outdoor relative humidity is 80%. Assume air density is 1.2 kg m^{-3} and air pressure is 1000 mb.

a) What is the relative humidity inside the hospital building if the air is brought from outside and heated to the required temperature, but not humidified?
b) Consider a hospital building with 1500 m^3 volume. It has a humidifier system that vaporizes 4 liter/hr of water. How many hours should the humidifier be in operation to increase the relative humidity of the indoor air to the regulation limit?