Meteorology 455/555 - Sample Questions

1. Estimate Africa's annual average {E} if leaf conductance suddenly was reduced to 25% of maximum on average instead of 50% (but all else remained the same). You may assume g = 65 Pa/deg; $S(T_a)$ = 100 Pa/deg; density of liquid water = 1000 kg/m^3, C_{at} = 0.2 m/s, max{C_{can}}=$4 \cdot 10^{-3}$ m/s. (Be careful with units!)

2. The planet *Noceanus* is much like the Earth, but it has no oceans. Furthermore, it turns out that every river that flows across Noceanus's equator flows *from south to north*. The two questions below refer to long-term average (i.e., steady state) conditions for Noceanus.

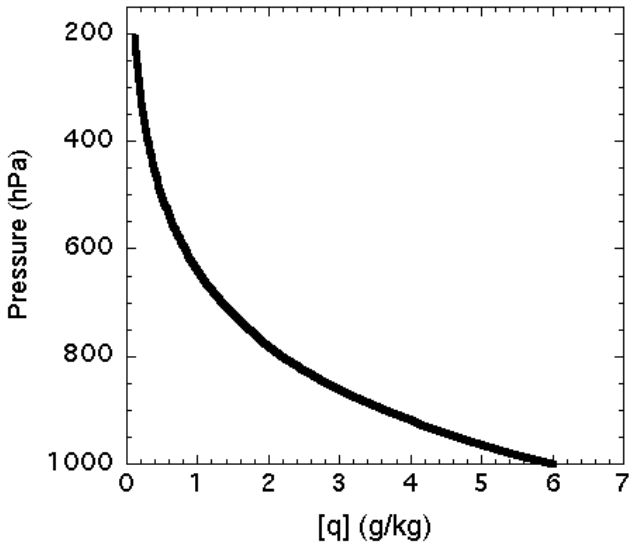
(a) What can we infer about the transport of water vapor across the equator by the atmosphere of Noceanus?

(b) What can we infer about the amount of evaporation versus precipitation in the Northern Hemisphere of Noceanus?

3. A typical profile of atmospheric specific humidity $[\bar{q}]$ at 45 N appears at right.

(a) Why would Hadley's theory of the general circulation with this specific humidity profile give at 45 N a net southward (equatorward) moisture flux $[\overline{Q_\phi}]$?

(b) Why would Ferrel's theory with this specific humidity profile give at 45 N a net northward (poleward) moisture flux $[\overline{Q_\phi}]$?



4. The table below gives the time average precipitation (P) and evaporation (E) in mm/yr for Antarctica, Africa and the Arctic Ocean. Also given is the runoff (Ro) *from* the continents and the runoff *into* the Arctic Ocean from surrounding land.

Domain	P	E	Ro
Antarctica	169	28	141
Africa	696	582	114
Arctic Ocean	97	53	307

(a) Compute the sum P-E-Ro for both continents. What does the result tell us in each case?

(b) Compute the ratio E/P for both continents. Why is this ratio substantially higher for one continent that the other?

(c) From the information given for the Arctic Ocean, what can we conclude about the net flow of water by ocean currents going into and out of this ocean?

(d) Suppose all precipitation over the Arctic Ocean ceased, but E over the ocean and Ro into the ocean remained the same as given above. How much would the net in/out flow of water by ocean currents change (in mm/yr)?

(e) What must be the net transport of water vapor by the atmosphere into each of these domains (in mm/yr.

5. For a large region, we can write

$$\left\{\overline{S}\right\} = \left\{\overline{P} - \overline{E}\right\} - \left\{\overline{R}_o\right\} \tag{2.1}$$

for the terrestrial water balance, and

$$\left\{\frac{\overline{\partial W}}{\partial t}\right\} + \left\{\overline{\vec{\nabla} \cdot \vec{Q}}\right\} = \left\{\overline{E} - \overline{P}\right\} \tag{2.2}$$

for the atmospheric water balance, where the symbols have the definitions given in class (the same as Oort and Peixoto, p. 273-276).

Suppose the large region is the basin of the Great Salt Lake, for which there is no river outflow (no runoff).

(a) Explain why during a long-term period when the lake is on average *drying up* (i.e., the lake is shrinking), that we must have $\left\{\overline{E}\right\} > \left\{\overline{P}\right\}$ for the basin.

(b) Given that $\left\{\overline{E}\right\} > \left\{\overline{P}\right\}$, why should we expect $\left\{\overline{\vec{\nabla} \cdot \vec{Q}}\right\} > 0$?

6. The "G" factor for reducing maximum canopy conductance that is a function of vapor pressure deficit can be written as

$$G(\Delta e) = MAX\{1\text{-}D, 0.25\},$$

where e is vapor pressure, e_{air} is the vapor pressure of air, T is temperature and

$$e_{sat}(T) = \{611\ Pa\}\exp\left\{5411\left(\frac{1}{273} - \frac{1}{T}\right)\right\}$$

This factor reduces transpiration when $\Delta e = e_{sat} - e_{air}$ becomes large. [All units are MKS.]

(a) For constant relative humidity, $RH = 100*\{e_{air}/e_{sat}(T)\}$, plot how G varies with temperature. Why is it reasonable for G to behave this way when RH = constant (from the perspective of how the plant's guard cells control transpiration)?

(b) For constant temperature, plot how G varies with RH. Why is this behavior reasonable (again from the plant control of transpiration)?

7. General circulation theories [15 points]

How did Hadley's theory of the circulation satisfy

(a) mass balance?

(b) momentum balance?

8. Water cycle

(a) Suppose we have the following set of observations for one day in the region 50˚ - 90˚ S:

$$-\left\{\overline{\nabla \cdot \vec{Q}}\right\} = 0.5 \text{ mm/day} \quad \left\{\overline{P}\right\} = 0.6 \text{ mm/day} \quad \left\{\overline{E}\right\} = 0.2 \text{ mm/day}$$

How much does the region's precipitable water {W} change during this day?