ATM 651 First homework

Due Weds 9/5 end of day

1. "Flux" questions

We saw that the flux of any intensive "stuff" has units of $\frac{(\text{Stuff})}{m^2 s}$. Using this definition (essentially) of flux,

a. What is another name for volume flux? Construct the units & say what the resulting units imply. (oceanographers use this term).

b. What familar quantity's flux can be boiled down to units of $kg\ s^{-3}$?

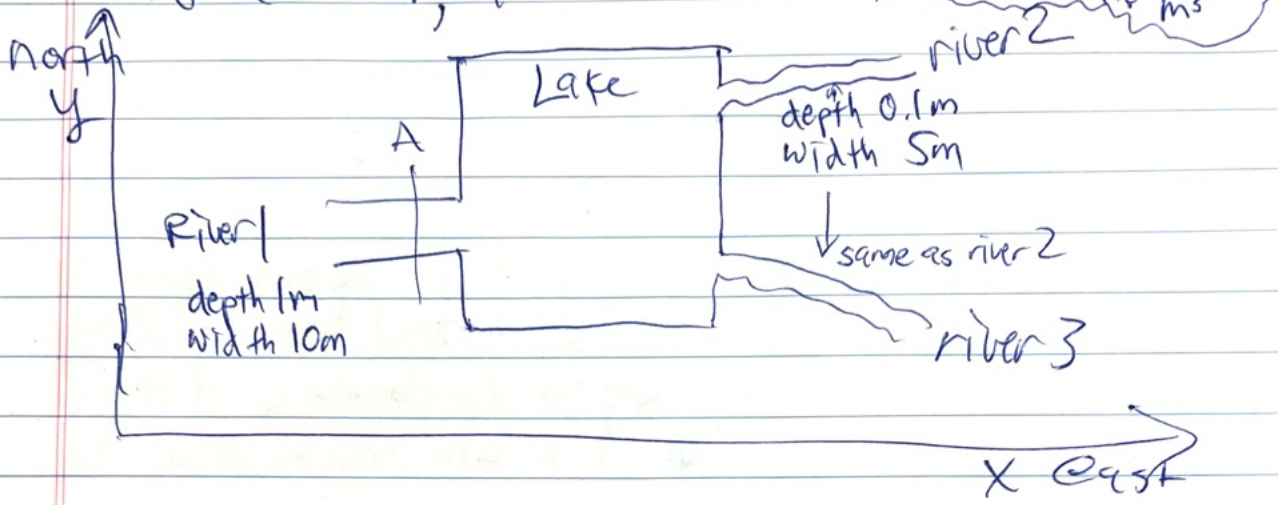
c. What are the units of $\rho\vec{V}$ (ρ=density, $\vec{V}$ velocity)? What is it a flux of?

d. Specific humidity q has units $\left(\frac{kg_{water}}{kg_{air}}\right)$. ("per unit mass")
What is $\rho q \vec{V}$? a flux of what?

e. Atmospheric Rivers are defined by vertically integrated "IWT" (integrated water transport), units $(kg_{water}\ m^{-1}\ s^{-1})$. What is the "m" in the denominator? meters in what direction?

f. Flux convergence is written $(-\vec{\nabla}\cdot\vec{F})$ for a flux field $\vec{F}(x,y,z,t)$. Expand this into xyz components. What are the units of $-\vec{\nabla}\cdot(q\rho\vec{V})$? What does it mean?

2. Application of flux reasoning & "continuity" (conservation through time) of mass. Clear for liquid water, a lake (top view). Recall $\rho_{liq} = \frac{10^3 kg}{m^3}$



a. River 1 has a total mass flux, integrated over plane A, of 10^5 kg/s. What is its velocity?

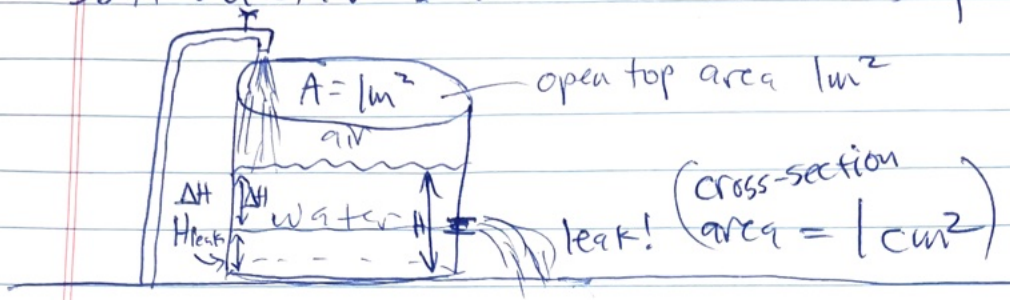
b. Outflow river speeds are 1 m/s. What is their IWF, and the total flux out of the lake?

c. What is the vertical water flux at the lake's surface? (this is the conservation/continuity physical statement!) If its area is $(1 km)^2$, what is the vertical velocity w of the surface?

d. A mine leak causes $q = \frac{1 g_{salt}}{1 kg_{water}}$ to be the salt concentration of River 1. What is $\frac{dq}{dt}$ averaged over the lake volume, if its depth is 10m and no salt initially reaches rivers 2, 3?

651 HW1
page 3

3. A subtler bathtub (leaky bucket) problem.



A faucet dumps 1 kg/s into a bucket of area $1m^2$, with a $1cm^2$ hole in the side. The outflow at the leak is proportional to pressure, which is the weight of water above the leak, $V_{leak} = C \cdot \rho g \Delta H$.

a. Write an equation (a budget, or diffeq) for ΔH. Does it have a steady-state solution? How deep?

b. What is $\frac{d}{dC}(\Delta H_{steady})$? How much does depth H change if a screen reduces C by half, or tape covers half the leak area?

c. How does H change if the spigot input is halved? Is this the same as b. or different? Explain why.

d. Is this a stable system? discuss, explain. Is there some dependence of outflow on H that would make it interestingly more or less stable/unstable? (show you understand the concept of stability)

e. What is the net convergence (in-out) of water flux (force) for a cube of space submerged in the water?