GEOG 3511 HYDROLOGY
Review for Second Midterm

Your second midterm will be similar to the first one: several fill-in-the-blank questions, several short-answer questions and several longer questions, plus this time I will have you do a calculation. I realize that I have given you a lot of equations. Focus only on the equations discussed in class and make sure you understand the following things:

- what is the equation used for, or why is one equation used instead of another?
- what are the various terms in the equation, and what do they represent physically?
- what field data are needed to use a particular equation?

You don't need to memorize any complex equations; however, you should know simple equations, such as those for SWE, moisture content, bulk density, or porosity. With respect to the more complex equations, I will provide these and either ask you what the terms are, what they represent physically, or ask you to calculate something. Otherwise focus on the following information:

Snow

- you should be able to describe the processes/conditions of snow formation in the atmosphere and explain how measurements are made on the ground;
- know the processes of snow metamorphism (equi-temp vs. temp-gradient metamorph.);
- you should be able to describe seasonal changes in snow properties such as density & SWE
- understand the basic components of the snowmelt energy balance, and be able to describe how certain environmental conditions (aspect, tree cover, relative humidity, etc.) affect various terms; know what the various terms in the turbulent transfer equations represent; you should be able to do a latent- or sensible- heat flux calculation, similar to the one I did in class; make sure you understand the relation between SVP, T and RH.
- review the lecture on seasonal variations in snow-energy balance, and the case studies from Danville, VT and Niwot Ridge. Under what conditions does snowmelt reach maximum rates?

Soil Moisture:

- you should be able to define various soil properties, such as bulk density, porosity and hydraulic conductivity, and various soil moisture states, such as saturation, field capacity and wilting point.
- make sure you understand all aspects of the process of infiltration. Why does hydraulic conductivity vary? What is important about tension? How do these vary with moisture content, and why? Were you able to follow my derivation of Darcy's Law and do you understand how this leads to the Green-Ampt model of infiltration?
- the lab exercise in which you modeled infiltration should have improved your understanding of the infiltration process. If it didn't, then I suggest you go back over your lab and try to extract the important points.

<u>Additional thoughts</u>:

- we have used three different terms for vapor pressure; these are defined as follows

  e_a: vapor pressure at some height above the ground, snow, lake or vegetation;

  e_s: vapor pressure at the ground, snow, or lake surface;

  e_{sat}: saturation vapor pressure, i.e. vapor pressure at 100% RH; could be with respect to the reference height "a" or the surface;

- example: the turbulent transfer equation for latent heat flux contains the term (e_a - e_s), which is just the difference between the vapor pressure at "a" and the vapor pressure at the surface. To find either of these terms you need to know the RH and be able to compute e_{sat}.

- the mass transfer equations contain the same variables, but reversed, i.e. (e_s - e_a); I assume that this is done simply to give a positive value for the evaporation rate;
- the Penman and Penman-Montieth equations contain the term (e_{sat_a} - e_a), which is different from above; in this case (e_{sat_a} - e_a) represents the difference between the potential maximum (saturation) vapor pressure at "a" and the observed vapor pressure at "a"; think of this as a vapor pressure deficit.

- Another equation that we've seen a lot is the logarithmic equation for velocity:

$$u = u_* \frac{1}{\kappa} \ln \frac{z}{z_o}$$

where u is the velocity at height z , u_* is the shear velocity, k is von Karman's constant (0.4) and z_o is the roughness height. The term u_* has the units of velocity, but it is really a measure of the shear stress of force per unit area that is driving the air to create the wind in the first place, and the intensity of the turbulence. If u or u_* go up, the turbulence will be more intense and more sensible and latent heat will be transferred from the snowpack or lake surface to the atmosphere. The term z_o is theoretically the height above the ground (or lake) where the velocity is zero; in practice this is impossible to measure because it is usually a fraction (~1/10) of the height of the roughness itself. Thus, if the snow or lake surface, or vegetation get rougher, z_o gets bigger, and, for the same u_* , u gets smaller.

- the equations for sensible and latent heat transfer both have the following term:

$$\frac{u}{6.25 \left[\ln \frac{z}{z_o}\right]^2}$$

This term is essentially $u_*^{\,2}$, which is sort-of what you get if you rearrange the above equation.

- The mass transfer equation also contains a term for velocity, i.e.

$$E = N\, u_a\, (e_s - e_a)$$

In this case, u_a is just the velocity measured at height a above the ground.

- Final note on mass transfer equations: these are *empirical* equations, meaning they are based on some "best fit" relation between two variables. Assuming you had the appropriate data, you could develop a mass transfer equation for the movement of water vapor from a lake, a pool, a snowfield, the ocean, vegetated surfaces, animals in a stockyard, or whatever. The coefficient N is just that- it's a coefficient that would have to be determined for separate situations.