Utah State University
Department of Civil and Environmental Engineering
CEE 6400 Physical Hydrology

Midterm exam. Date: 10/20/2011
D.G. Tarboton Time: 50 min
50 Points

Open Book. Answer all questions. Please answer on separate sheets of paper. You may refer to the textbook, notes, solutions to homeworks and any other written or printed reference material that you have brought with you.
Calculator use. You may use a programmable calculator or equivalent calculating device (e.g. calculator functionality on a phone). You should limit the use of the calculating device to the performance of calculations. You may use programs that you have written to evaluate quantities commonly used in this class (e.g. saturation vapor pressure). You may not use your calculating device to retrieve stored reference material in any form. You may not send messages or access the internet or communicate in any way with anyone other than the instructor or moderator regarding solutions to these questions.

Question 1 refers to the global hydrologic cycle water and energy balance as depicted in Dingman Fig 3-16 (p54) and Dingman Fig 3-2 (p38). These figures are reproduced below for convenience.

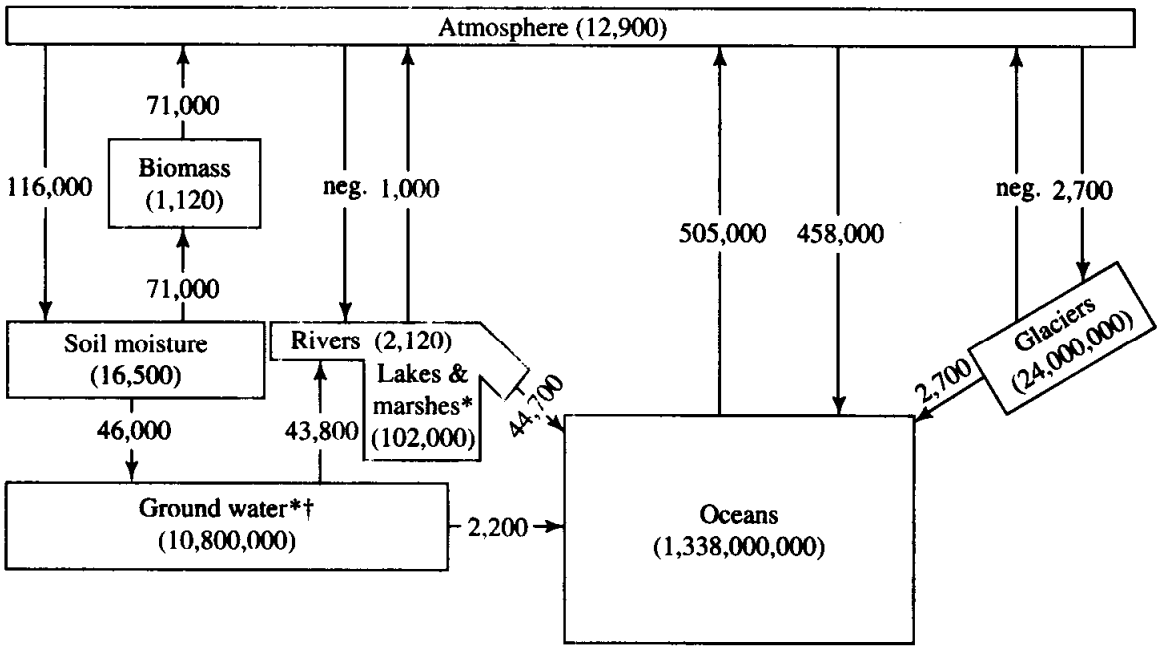


Figure 3-16. In this figure storage units are km^3 and flux units are km^3/yr.

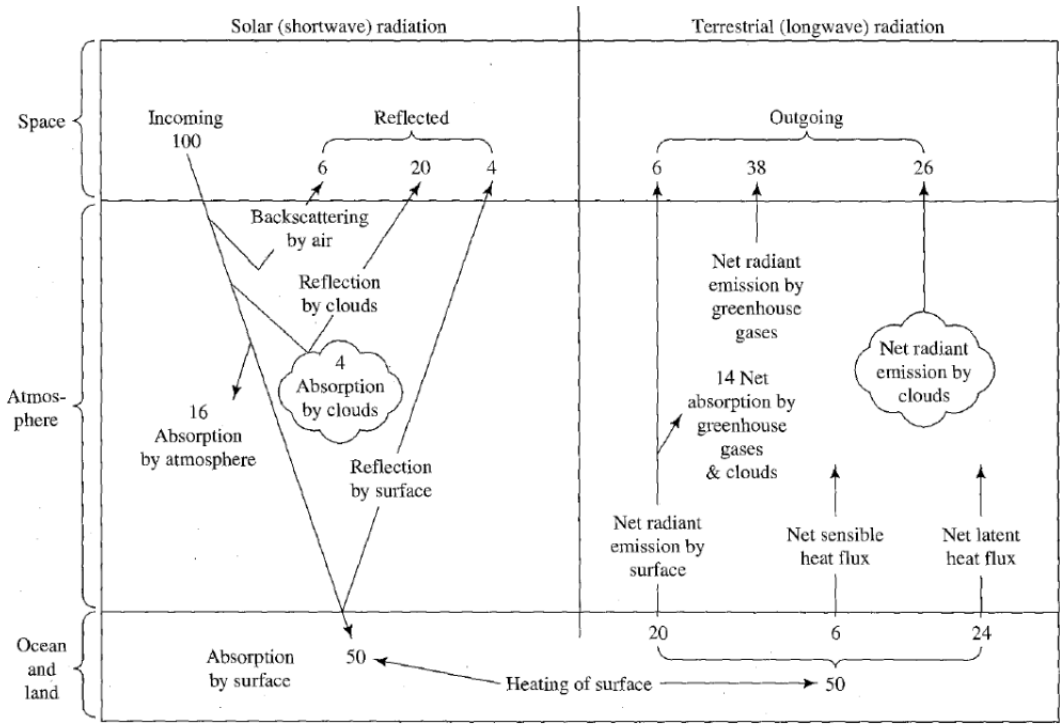


FIGURE 3-2
Average global energy balance of the earth–atmosphere system. Numbers indicate relative energy fluxes; 100 units equals the solar constant, 1367 W m^{-2}. Modified from Shuttleworth (1991); data from Peixoto and Oort (1992).

Reference quantities
Earth Land surface area = 149 x 10^6 km^2
Earth Ocean surface area = 361 x 10^6 km^2
Water latent heat of vaporization = 2.45 x 10^6 J kg^{-1}
Water density = 1000 kg m^{-3}

1. a) Calculate from Figure 3-16 the average annual evaporation from land surface area expressed in m/yr [4]
   b) Calculate the land area latent heat flux in W/m^2 equivalent to your result from (a) [4]
   c) Calculate from Figure 3-16 the average annual evaporation from ocean surface area expressed in m/yr [4]
   d) Calculate the ocean area latent heat flux in W/m^2 equivalent to your result from (c) [4]
   e) Express the net latent heat flux depicted in Figure 3-2 in terms of W/m^2 and reconcile your result with your answers in (b) and (d), commenting on any differences. [4]
   [20 points]

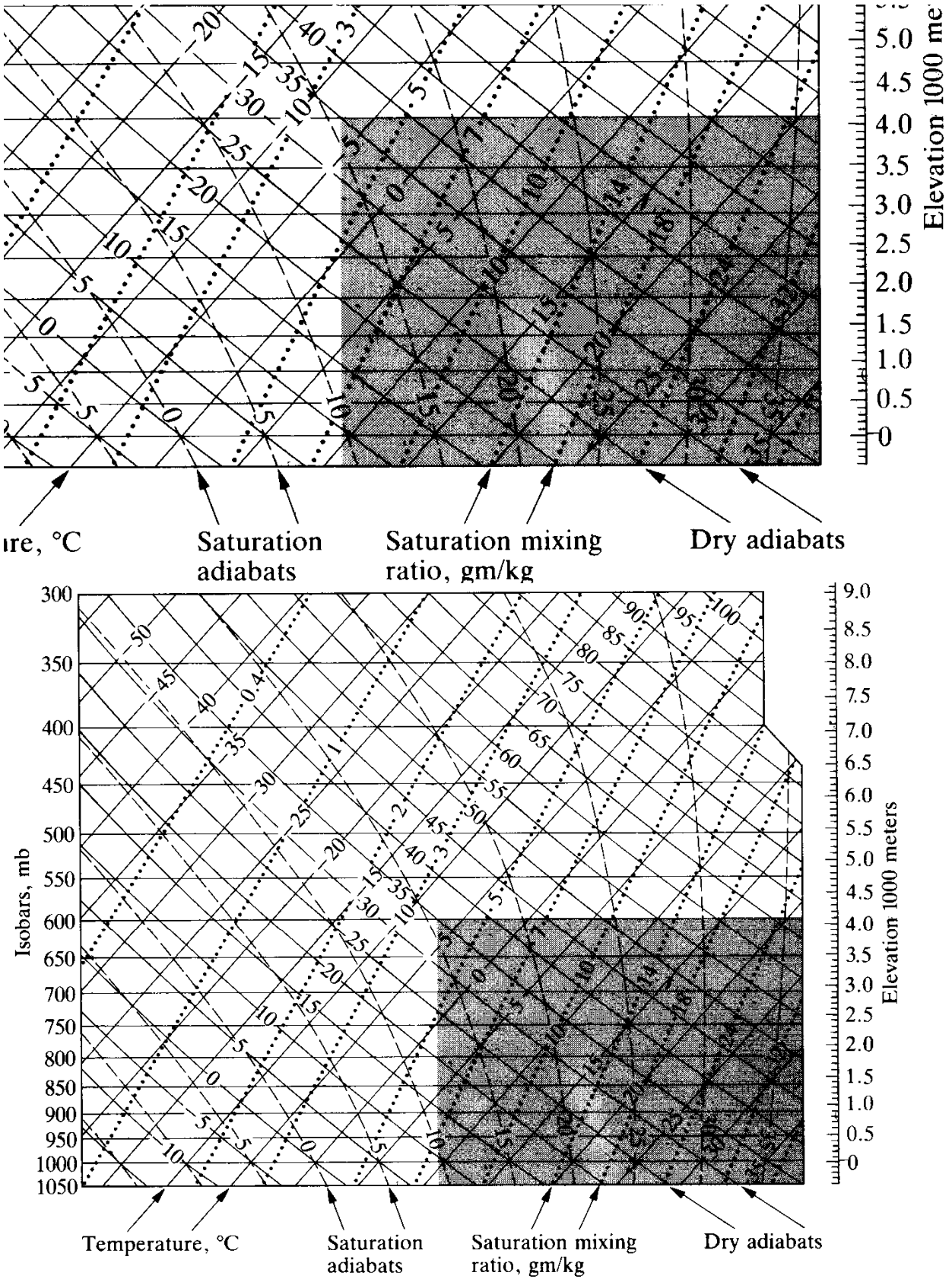
2. Consider a parcel of air near sea level with the following conditions:
   Atmospheric pressure = 1000 hPa
   Temperature = 25 ^oC
   Relative humidity = 70%

   a) Calculate the actual vapor pressure. [5]
   b) Calculate the mixing ratio of the air. [5]
   c) Assume that this parcel is lifted adiabatically in a hydrostatic atmosphere what is the elevation at which condensation occurs? (Refer to the Pseudo-Adiabatic diagram, next page) [5]
   [15 points]

3. Two TDR soil moisture sensors are buried in soil at depths of (A) 10 and (B) 50 cm. The soil is a sandy loam with properties from Table 1 (page 4:18) of the Rainfall Runoff Processes module
   n=0.435
   K_{sat} = 12.49 cm/hr
   $|\psi_a|$ = 21.8 cm
   b = 4.9

   The moisture content at sensor A (10 cm deep) is measured to be 0.35
   The moisture content at sensor B (50 cm deep) is measured to be 0.38

   a) Calculate the suction head at each sensor. [5]
   b) Determine if the flow of water is downwards (infiltration from A to B) or upwards (uptake from B to A). [5]
   c) Approximate the flow rate (infiltration or upwelling). [5]
   [15 points]


Elevation 1000 me
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
ıre, °C
Saturation adiabats
Saturation mixing ratio, gm/kg
Dry adiabats
Isobars, mb
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
Elevation 1000 meters
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
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1.5
1.0
0.5
0
Temperature, °C
Saturation adiabats
Saturation mixing ratio, gm/kg
Dry adiabats