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

Midterm exam. Date: 10/19/2009
D.G. Tarboton Time: 75 min
60 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.

1. Consider the earth's radiation balance as depicted in the figure below

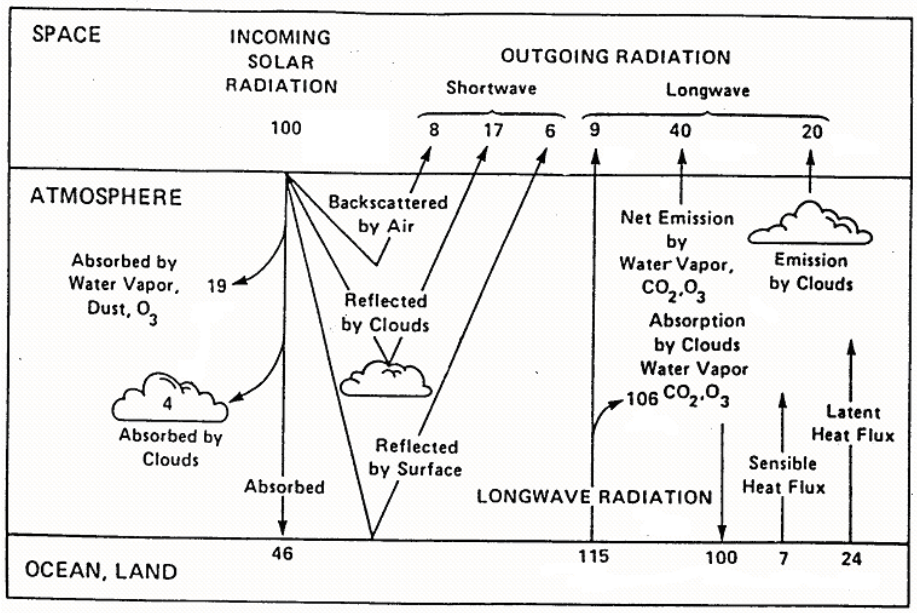


FIG. 6. Schematic representation of the atmospheric heat balance. The units are percent of incoming solar radiation. The solar fluxes shown on the left-hand side, and the longwave (thermal IR) fluxes are on the right-hand side (from MacCracken and Luther 1985).

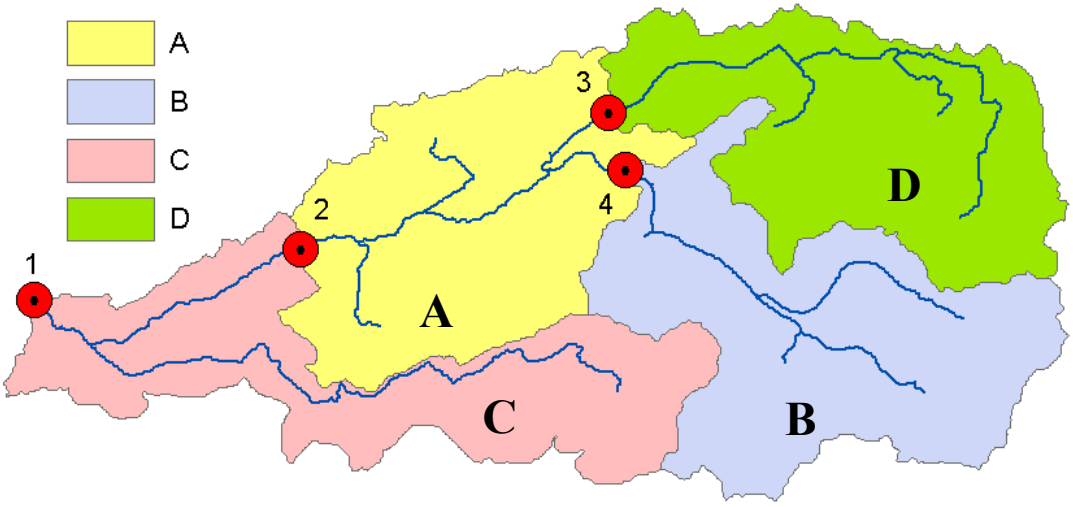
In this figure 100 units of incoming solar radiation may be equated with the planetary average solar radiation forcing of 342 W/m^2.

Estimate based on values from this figure

a) The planetary albedo [5]
b) The surface albedo [5]
c) The surface radiative temperature (a planetary average) [5]
d) The planet average precipitation [5]

[20 points]

2. Consider the following watershed with four stream gages and subwatersheds draining directly to each gage as indicated.



The mean annual streamflow at each gage is

Gage #	m^3/s
1	7.7
2	6.4
3	2.4
4	2.3

This mean annual streamflow includes baseflow.

Subwatershed area and mean annual precipitation for each subwatershed is

Region	Area (km^2)	Precip (mm)
A	62	1400
B	75	1600
C	50	1300
D	58	1900

a) Estimate the mean annual evapotranspiration and runoff ratio for each subwatershed, assuming that deep infiltration losses to groundwater are negligible. [10]

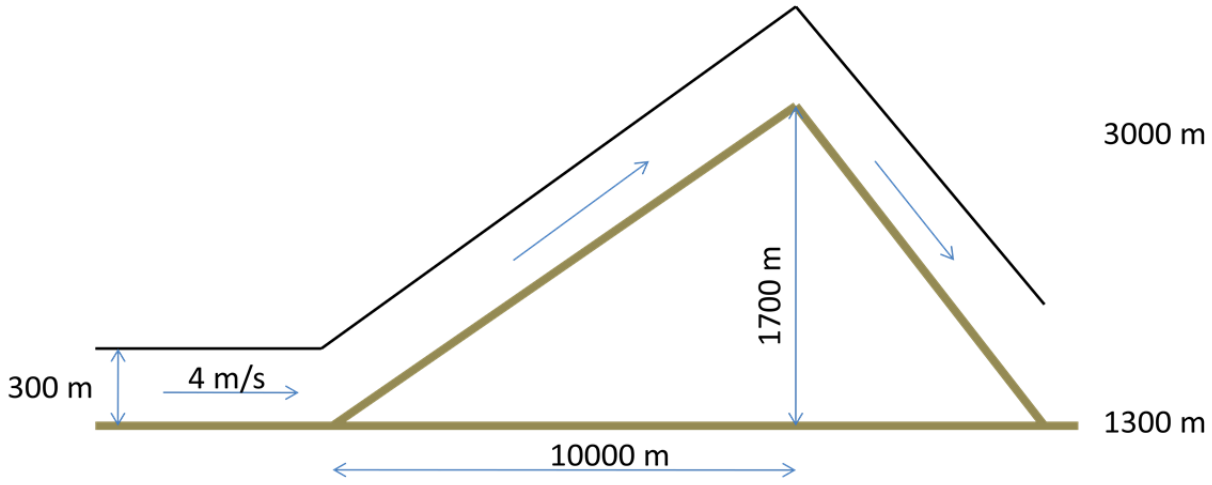
b) Consider a land use change in watershed A that converts 20% of the area from natural vegetation to urban. Indicate the stream gauges where you expect the mean annual streamflow to change and whether it is likely to increase or decrease. Explain why? Estimate upper and lower limits to these changes and explain the basis for your estimates. [10]

[20 points]

3. Consider orographic precipitation due to wind blowing off the Great Salt Lake up the Wasatch front. The lake is at elevation 1300 m above sea level and mountaintop at elevation 3000 m above sea level. Assume a wind layer 300 m thick is at 80% relative humidity and 6°C before being pushed up and over the mountain range.

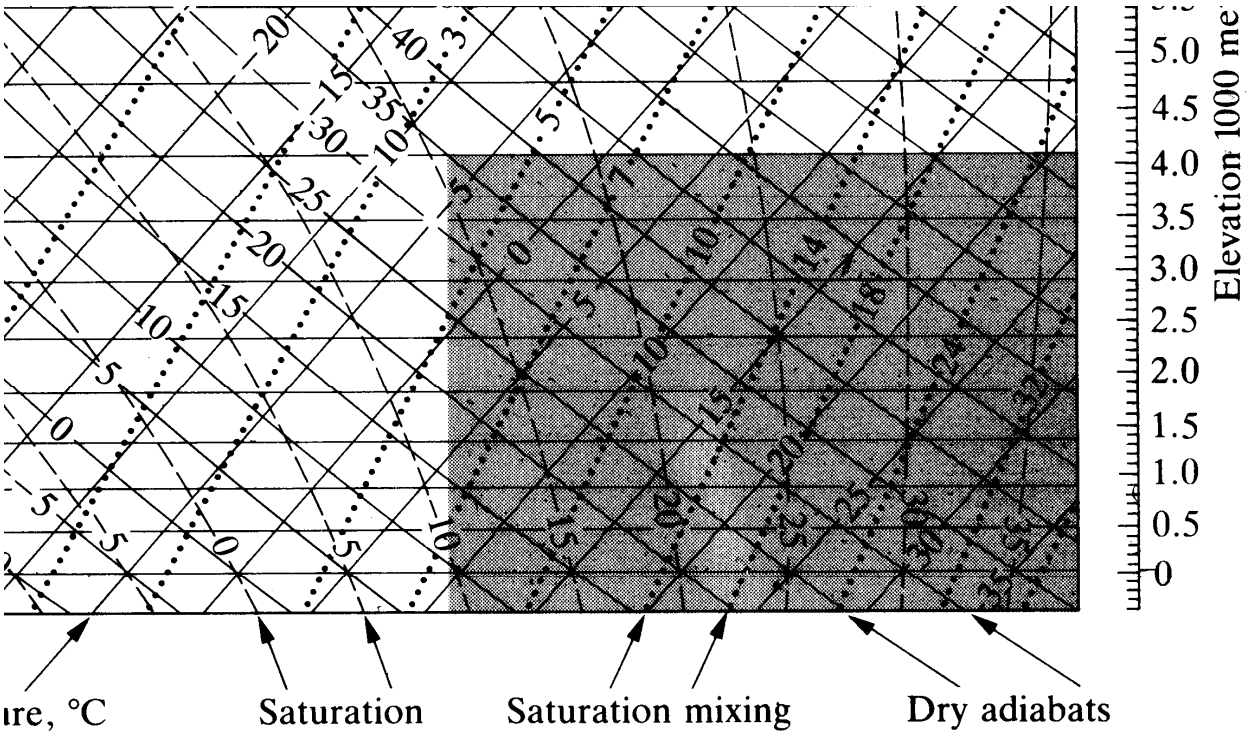
a) Estimate the specific humidity of this air at the initial level (1300 m) (you may assume in doing this question that specific humidity and mixing ratio are equivalent). [3]
b) Use the Pseudo-Adiabatic diagram to estimate the condensation level. [2]
c) Use the Pseudo-Adiabatic diagram to estimate the snow level. Assume that snow forms when the air temperature is below freezing. [2]
d) Use the Pseudo-Adiabatic diagram to estimate the mixing ratio of moisture remaining in the air after condensation as it passes over the top of the mountain. [2]
e) What fraction of moisture in the air falls as precipitation? [3]
f) Assume that the horizontal length over which lifting occurs is 10000 m and that the average horizontal wind speed of the air layer off the lake is 4 m/s. Assume also that all the water that condenses falls as precipitation. Estimate the average precipitation rate between the level at which condensation occurs and the top of the mountain. Express your answer in mm/hr. [5]
g) Estimate the temperature and humidity of the air stream after it has descended down the back side of the mountain [3]

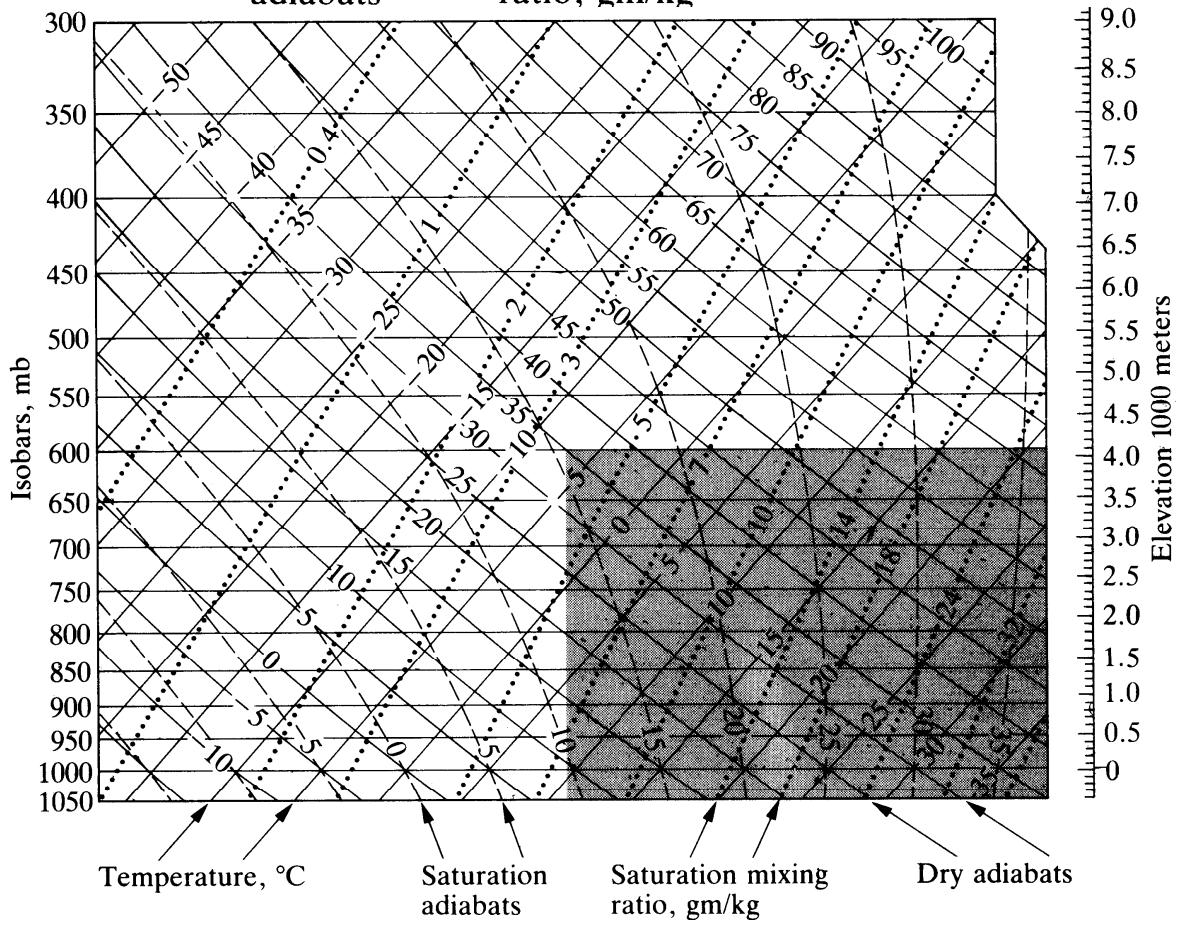
[20 points]



See next page for Pseudo-Adiabatic Diagram. Show your working on the Pseudo-Adiabatic diagram which should be handed in with your test answer.

Name: _____


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
2.5
2.0
1.5
1.0
0.5
0
Temperature, °C
Saturation adiabats
Saturation mixing ratio, gm/kg
Dry adiabats