Land-atmosphere-climate interactions: exercise 1

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Solutions will be handed out on 05.12.2006

Compulsory for students who need a 'testat' (old system); optional for other students (masters etc.)

1 Soil moisture calculations

Floods on the Alpine southside are typically associated with troughs over western Europe. The flow field that is associated with such synoptical patterns leads to strong southern, moisture laden winds (due to the Mediterranean) along the cold-fronts. Convection triggered by the Alps or longer lasting stratiform rainfall can then produce large amounts of precipitation (Foehn situation). If the soils are already wet, only some of the precipitation can be stored in the soil and therefore most of it goes into runoff. This can lead to floods. On the 13th and 14th of October 2000 405 mm of rain fell on a soil that was already wet, due to precipitation in the previous days. How much of the precipitation (in %) could be stored in the soil? Make the following assumptions:

- soil depth: 1.1m / underneath there is rock

- clay with a porosity of n=0.5
- at the beginning of the 13th the volumetric water content θ of the soil was 0.6

2 Water in the climate system: residence time

Use the diagram from the lecture notes 2 on slide 16. Compute the mean residence times for the oceans and the glaciers/polar ice.

3 Moist air and phase changes in mid-latitudes

a. Calculate the specific humidity for a typical mid-latitudinal spring day: T=15°; U=70%; p=1000 hPa. You will need the Clausius-Clapeyron equation and the equation for U (lecture note 3, slide 12), as well as the approximation for the water vapour pressure (lecture note 3, slide 10).

b. Calculate the density of this moist air using the ideal gas law and:

- i. the virtual temperature T_v ($R = 287.04\, J\, kg^{-1}\, K^{-1}$)
- ii. the temperature T ($R = 287.04\, J\, kg^{-1}\, K^{-1}$)

Compare the results.

c. Assume that the first 500 m of the atmosphere were isotherm. Calculate the precipitation rate [mm/h] if 40% of the water would fall out in 12 h.

d. Assume now that all the water vapour in the air condenses. What is the new air temperature? (dry air: $c_p = 1 * 10^3\, J\, kg^{-1}\, K^{-1}$)