Examination Climate and Atmosphere, 19 juni 2013

All problems count the same.

Final mark = 0.9 * mark examination + 1 for active cooperation at practicum City Climate.

Some equations and constants:

S_0 = 1361 Wm^{-2}; g = 9.81 ms^{-2}; R = 287 J $kg^{-1}K^{-1}$; c_p = 1005 J/kg; Earth radius = 6.37 10^6 m; albedo earth = 0.298; p_0 = 1013 hPa; average temperature near the earth surface 288 K; σ = 5.67 10^{-8} W $m^{-2}K^{-4}$. Saturated water vapor pressure $e_s = 611\exp[17.67\,T/(T+237.3)]$ (T in ^{0}C)

Equation of motion: $\frac{D\mathbf{u}}{Dt} + \frac{1}{\rho}\nabla p + g\hat{\mathbf{z}} + f\hat{\mathbf{z}} \times \mathbf{u} = F$

Frontal slope by Margules: $\tan\gamma = \frac{2\,\rho\,\Omega\Delta u}{g\,\Delta\rho}$

Problem 1

a) Calculate the temperature of the earth surface without atmosphere.
b) Calculate the temperature of the earth with a thin atmosphere that is fully transparant for solar radiation and fully absorbing for heat radiation.
c) Calculate the transparancy for heat radiation to get the right temperature near the earth surface of this thin and for solar radiation transparant atmosphere. Recommendation: make a sketch of the situation and argue which requirements hold for the terms of the energy balance.

Problem 2

a) Argue from the Margules equation how baroclinic instability arises.
b) Explain which type of weather situations arise due to baloclinic instability.

Problem 3

a) Calculate the maximum geostrphic wind around a low pressure system at 45^{0}N and a temperature of 260 K. Air pressure versus distance r to the center of low pressure is given by:

$p = 1013 - 25\, e^{-r^2/R^2}$ hPa with R = 600 km.

b) At which radius is the the highest geostrpic wind velocity?
c) Is the geostropic assumption valid? Compare the Coriolis acceleration with the centripital acceleration.

Problem 4

a) Give as many as possible causes why Arctic sea ice cover declined more quickly than expected. Add whether this is an uncertain hypothesis or almost certain.
b) And how about sea ice around Antarctica?

Problem 5. Given: The atmosphere above the Sahara emits net 20 Wm^{-2} radiation and the vertical temperature gradient is 6.9 ^0C/km.

a) Give equations for the dry adiabatic and vertical gradient of pressure.
b) Derive an equation for energy release when a unit volume air above the Sahara sinks with velocity w while keeping the temperature of the surrounding.
c) Derive the integrated equation between average vertical velocity and energy release.
d) Calculate the mean vertical velocity (with sign) above the Sahara.