Written Exam

Science of Environmental Change (FFR 166)

1. Modeling materials turnover (6 p)
a) Define the *residence time* and *age*, respectively, used when dealing with materials fluxes in the environment. (2p)

b) Explain the relation (<, ≈ or >) between average residence time and average age for carbon (C) in the soils. (2p)

c) What is meant by parameterization in atmospheric modelling? (2p)

2. If the solar energy reaching Earth is set to 1, of which sizes are the following energy fluxes: (3 p)
a. global photosynthesis,
b. global kinetic energy generation in the atmosphere,
c. global energy use in the "technosphere" ?

3. Black body radiation (4p)

a) Define the concept of black body. (1p)
b) How does the wavelength corresponding to the peak of black body radiation spectrum vary with temperature? (1p)
c) What does that mean when comparing the solar emission spectrum with the terrestrial emission spectrum? (knowing that the surface temperature of the Sun is ~6000K and the surface temperature of the Earth is ~255K.) In which spectral regions do these spectra have their peak of emission? (2p)

4. Interaction between solar radiation and the atmosphere (4p)

a) How do you explain that the sky is blue, while the clouds are white? What is the physical process behind this difference? (3p)
b) What do we call an "atmospheric window"? (1p)

5. Atmospheric composition (7p)

a) What are the two main atmospheric components? Give the corresponding percentage, by volume of dry air. (1p)
b) What do we call ”trace gases”? Give at least three examples. (1.5p)
c) Explain why these trace gases play a very important role in the atmospheric system? Give at least three example reasons. (1.5p)
d) Define the term ”aerosol”. Give at least four examples of different kinds of aerosols, and explain what can be their sources. (3p)

6. Vertical stability of the atmosphere (4p)

a) Define the lapse rate. How is it calculated? Explain what important information it gives about an atmospheric layer? (2p)
b) What can you say about the lapse rate in the stratosphere? What consequence does that have for pollutants injected into this atmospheric layer? (2p)

7. Ozone (7p)

a) Ozone is considered as a pollutant in the troposphere, while its presence in the stratosphere is an essential protection for life on Earth. Explain what is the harmful impact of tropospheric O_3 and what is the beneficial role of stratospheric O_3. (2p)
b) Explain how ozone is formed and lost in the stratosphere, when its natural chemical cycle is not disturbed by any catalytic reaction. Four chemical equations must accompany your answer. (2p)
c) Explain how anthropogenic activities can contribute to the rapid destruction of the stratospheric ozone layer. Give a few examples of ozone depleting substances and describe the principle of O_3 catalytic destruction cyles. (The chemical equations are not required.) (3p)

8. Global atmospheric circulation (3p)

a) What is the intertropical convergence zone (ITCZ)? What can you say about the wind and the typical weather in this region? (2p)
b) How does the ITCZ location change throughout the course of a year? Explain why. (1p)

9. One important characteristic of a soil is its CEC value (4 p)

a) How is CEC defined?

b) Which are the two most important components that gives a soil a high CEC?

10. Soil colloids (4 p)
a) What are “soil colloids”? Specify their typical properties. (2p)

b) Characterize briefly the importance of soil colloids for a soil’s chemical and biological properties. (2p)

11. Explain the mechanisms by which weathering of rocks control atmospheric CO_2 levels on time scales of million years. Make a drawing to illustrate your explanations. (4 p)

12. Describe the change in carbonate buffer chemistry in seawater in response to addition of carbon dioxide. Why does adding carbon dioxide make seawater more acidic? (4 p)

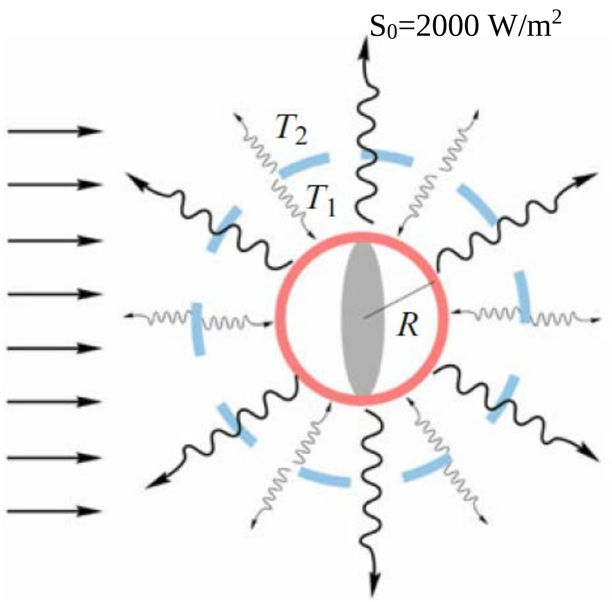
13. Explain the mechanisms of the “organic carbon pump” in the ocean. Make a drawing to illustrate your explanations. Also, explain how this pump influence the CO2 concentrations in the ocean and the atmosphere, respectively. (4 p)

14. The ocean has absorbed about 30% of human CO_2 emissions since 1750, and is likely to be a net sink of future emissions. How does the ocean take up this *additional* CO_2? Describe the mechanisms involved and some of their key characteristics, such as timescales. (4 p)

15. The effect of the land carbon cycle response to climate change is very uncertain, because its mechanisms are not fully understood. Through which mechanisms do higher temperatures and atmospheric CO_2 levels influence the land carbon reservoirs and flows? And how do these changes in the land carbon cycle in turn influence back on atmospheric CO_2 levels? Describe these “feedback” mechanisms and their respective directions (positive/increasing or negative/decreasing). Make a drawing to illustrate your explanations. (4 p)

16. A substantial amount of human emissions of fixed nitrogen comes from engines and other combustion processes. Describe and state the chemical reactions (in a simplified way) of the ***two** most important* mechanisms through which NOx is generated in combustion. Identify which factors that influence the magnitude of NOx emissions from combustion and in which direction (increasing or decreasing). (4 p)

17. Assume that a planet's surface is behaving as a black body for the part of the radiation that is not reflected and that the homogenous atmosphere is transparent for short wave solar radiation, but act as a grey body with absorptivity /emissivity ε=0.95 for long wave heat radiation. The planet's surface has an albedo of α=0.1 for the incoming short wave radiation. The shortwave radiation, S_0, is 2000 W/m^2. R in the figure below is representing the radius of the planet, which we assume is 4 km. The earth has a surface temperature T1 (K) and an atmospheric temperature T2 (K).



With the use of the information presented above and Stefan Boltzmanns law estimate the surface temperature (T1) and atmospheric temperature (T2). Stefan-Boltzmanns constant σ = 5.67·108 Wm^{-2}K^{-4}. Present your calculations! (8 p)

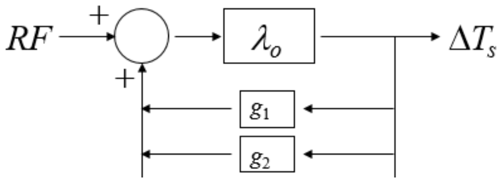
18. The greenhouse effect (5 p)

a) Define the "natural greenhouse effect". How large is it? Which are the two major gases contributing to the effect? (3 p)

b) Which are the major contributors (4 gases/gas groups) to the anthropogenic greenhouse effect? (2p)

19.

Assume RF=2, λ_0=0.3, g_1=0.6, g_2=-0.3. What is the temperature response (ΔT_S)? (3p)



20. The cloud feedback (6 p)

The cloud feedback is one of the most critical and uncertain feedbacks within the climate system. Answer the following questions with respect to the cloud feedback.

a) Is the temperature effect of the cloud feedback taken into account in the climate sensitivity value? (1 p)

b) Explain why some types of clouds tend to cool the earth surface, while others tend to warm the earth's surface. Answer also which type of clouds tend to cool and which type of clouds tend to warm the earth surface? (4p)

c) Is the net cloud feedback likely to be positive of negative? (1p)