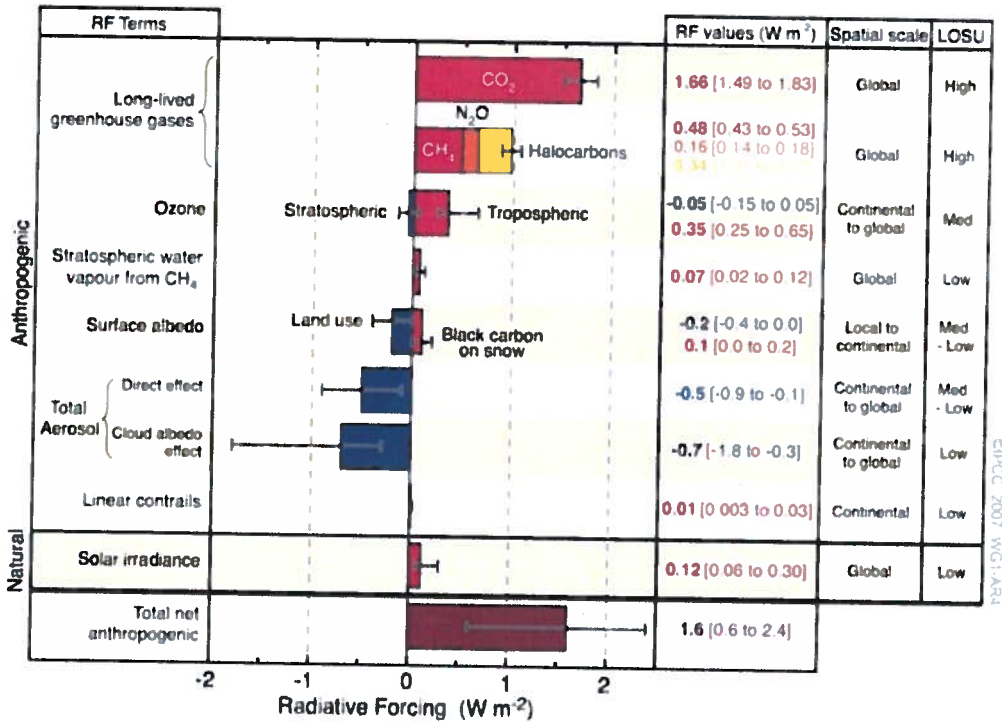
2e Toets Klimaatdynamica 25 Juni 2012 9-12

1. Climate Sensitivity



Assume an equilibrium climate sensitivity (S) of 0.75 °C per W/m^2 and no feedbacks. The current climate change can be described by the figure above, which is from the IPCC AR4 report.

a) Calculate the temperature increase (ΔT) according to the figure above.

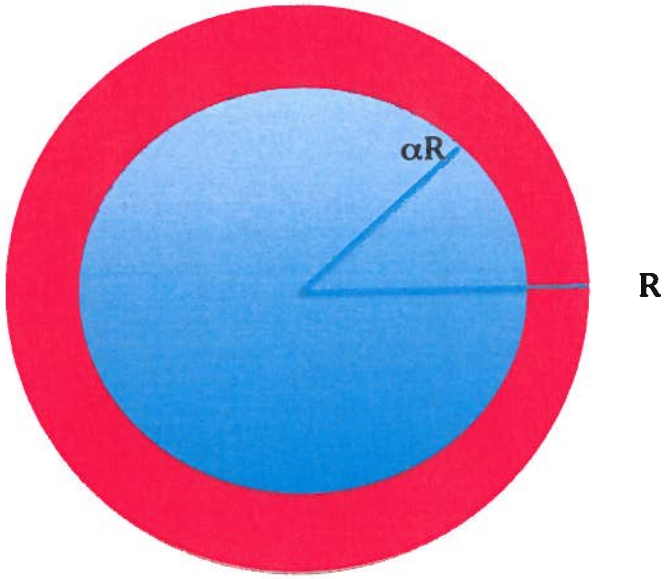
This climate sensitivity value is based on paleodata over the period from LGM to present, by correcting for the strength of the land ice feedback. We may assume that the land ice feedback is the only feedback in the system.

b) To what extent is the outcome consistent with the observed temperature increase over the last century, and explain why data from the last century are not so good to test S.

The simplest approach for climate sensitivity is that the climate sensitivity is 1 over the Planck feedback. It is also argued that climate sensitivity is state dependent.

c) Explain that the climate sensitivity is state dependent even if we only have the Planck feedback.

2. Sea Level Rise



A circular ice sheet (top view) has an inner accumulation area with radius αR, and an outer ablation area. The ice sheet is in equilibrium and the ratio between ablation and accumulation is 3. Ablation is constant and negative in the entire ablation region. The accumulation is constant and positive in the accumulation region.

a) Sketch the mass balance as a function of distance (0 is the centre of the ice sheet, R the ice margin). Explain your sketch.

b) Calculate the position of the equilibrium line.

During climate change the only change is the change in the equilibrium line position. The ablation rate is still the same everywhere in the new ablation area.

c) Explain the dynamic response of the ice sheet, both for a warming or a cooling of the climate.

In reality the mass balance depends on elevation rather than on position.

d) Explain what the consequences are for the evolution of the ice sheet for a sudden increase in the equilibrium line altitude.

In addition we assume that the ice sheet is resting on a flat bed and marine based everywhere. Ice berg production increases for increasing water depth.

e) Explain whether the gravitational effect is a positive or negative feedback for the evolution of the ice sheet.

3. Paleo Climate

a) Sketch global CO_2, Temperature, ice volume, and benthic marine isotopes over the last 60 Myrs and explain your sketch.

b) Explain the Milankovitch theory qualitatively and indicate dominant periodicities.

c) What caused the inception and deglaciation of the Laurentide ice sheet 1.4 Myr ago and 0.4 Myr ago?

d) What are the grant challenges for the scientifical community with respect to our understanding of the climate over the last 1 Myrs.

4. Stable isotopes

a) Explain what fractionation is, and why stable oxygen isotopes are widely used in paleoclimatology.

b) Explain the differences between marine and ice cores with respect to the interpretation of stable isotopes.

c) Formulate an equation expressing the relation between stable isotopes in the ocean and the ice based on mass conservation.

d) Calculate the change in $\delta^{18}O$ in the ocean if all the ice in the world melts completely. (Estimate the quantities needed).

e) Explain what the change in the seasonal cycle of the precipitation over time implies for the interpretation of the isotope record of an ice core.

f) Indicate the $\delta^{18}O$ values in the 5 circles in the figure below and explain your choices.