Global Climate Dynamics, Summer term 2016
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Exercises series 6b
Due 15 June 2016

1. Feedback analysis

The radiative forcing, F, top-of-atmosphere energy imbalance, ΔR, and surface temperature change, ΔT_s, are approximately linearly related using the climate feedback parameter λ:

$\Delta R(t) = F + \lambda \, \Delta T_s (t)$

At a time t = 0 when the (sustained) forcing is applied, the surface temperature has not yet responded ($\Delta T_s (0) = 0$), and at t → ∞, climate is at equilibrium again ($\Delta R = 0$).

The feedback parameter can thus be obtained by a linear regression between top-of-atmosphere radiation and surface temperature. In general, the equation is defined for the net radiation, and at global average. However, one can learn about processes by performing the linear regression at each grid-point, and for each radiation contribution (solar and terrestrial, cloud radiative effects and clear-sky fluxes).

Note that this time you should use the top-of-the-atmosphere incoming short wave flux to calculate the change in the net radiation at the top of the atmosphere[1]. Why is it better to use the net radiative balance at the top of the atmosphere rather than the difference in the outgoing radiation between tow points in time?

(i) Calculate the global F and λ.

Notes: First average the data to global and annual means and then apply the "Gregory" (linear regression) analysis; remember to weight every grid point by its surface area.

(ii) Calculate F and λ for every grid point, for every contribution to the net radiation flux. Remember to use the global mean temperature rather than the temperature in every grid point (because the feedback parameter is defined with respect to the average global temperature change). Discuss the forcing, F, in its geographical distribution for the four contributions to the net radiation flux.

(iii) Analyse the geographical distributions of the four feedback parameters with respect to the feedbacks that you know.

1 The results from a simulation abruptly quadrupling the atmospheric CO_2 concentrations with the MPI Earth system model can be found in /home_local/tgoren/ex6. "tas" is near-surface temperature, "rsut" top-of-atmosphere reflected solar flux density, "rlut" terrestrial flux density, and "cs" the same, but assuming clear sky. "rsdt" is the top-of-atmosphere incoming short wave flux.