Climate Dynamics
Summer Semester 2017

UNIVERSITÄT LEIPZIG

Homework 10
Due 28 June 2017

Problem 1 Feedback analysis

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

$$\Delta R = \lambda \Delta T_S + F \tag{1}$$

One way to diagnose the feedback strength in models is to apply an abrupt GHG forcing at $t = 0$, then let the model run to a state approaching a new equilibrium. Often, $4 \times CO_2$ is used so that the forcing is strong compared to internal variability.

The files in `/home_local/jmuelmenstaedt/hw10/` contain the near-surface air temperature (tas) and the TOA incident shortwave (rsdt), outgoing shortwave (rsut), and outgoing longwave (rlut) radiative fluxes for the preindustrial control climate (piControl) and for an abrupt $4 \times CO_2$ run in the MPI–ESM model.

(a) Using the radiative fluxes provided, calculate an annual-mean, global-mean ΔR for each year of the abrupt $4 \times CO_2$ simulation. Plot ΔR as a function of ΔT_S. *Note: when calculating the global mean, remember that not all grid boxes have the same area.*

(b) Does the climate system reach a new equilibrium? If not, why not?

(c) Fit a straight line to the ΔT_S–ΔR plot. Determine the values of effective radiative forcing (ERF), feedback parameter, and the equilibrium temperature change.

(d) Assuming that the radiative forcing is logarithmic in CO_2 concentration, what is the equilibrium climate sensitivity (ECS) of this model? *Note: by convention, ECS is the equilibrium ΔT_S resulting from doubled CO_2 concentration.*