Homework 11
Due 5 July 2017

Problem 1   Geoengineering and its termination

This week we will look at a modeling study of geoengineering. The scenario is the following. After some amount of warming has occurred (following the RCP4.5 scenario, which stabilizes at 4.5 W m^{-2} radiative forcing in 2100), society decides in the year 2020 that further rapid temperature increases need to be avoided. The method of geoengineering is stratospheric sulfate aerosol, which decreases the solar radiation absorbed by the climate system. The amount of sulfate aerosol is chosen to stabilize the radiative forcing at its 2020 value. (See Figure 1.)

In 2070, the sulfate-aerosol geoengineering is terminated. Due to the short lifetime of the stratospheric aerosol (compared to the CO_2 lifetime), the radiative forcing rapidly approaches the RCP4.5 value.

(a) What are the surface temperature increases in 2050–2069 (the geoengineering period) and 2070–2089 (the termination period), for RCP4.5 and G3 (the geoengineering program)? Denote the temperature in 2006–2035 as T_1, 2050–2069 as T_2, temperature in 2070–2089 as T_3. Denote the temperature under the RCP4.5 scenario as T^R, and under the G3 scenario as T^G. You may wish to arrange the plots on a 3×3 grid as follows:

$$
\begin{array}{ccc}
T_2^R - T_1^R & T_3^R - T_1^R & T_3^R - T_2^R \\
T_2^G - T_1^R & T_3^G - T_1^R & T_3^G - T_2^G \\
T_2^G - T_2^R & T_3^G - T_3^R &
\end{array}
$$

and divide the temperature differences by time elapsed between the midpoints of the periods (3.9 decades between T_1 and T_2, 2 decades between T_2 and T_3) to get temperature increases per decade. The files containing the 2D temperature fields are on ora in /home_local/tgoren/ex8/tas_<scenario>_<time period>_mean.nc.

(b) Plot the time series of the global annual-mean temperatures under RCP4.5 and G3 from 2006 to 2089. The files containing the time series are called
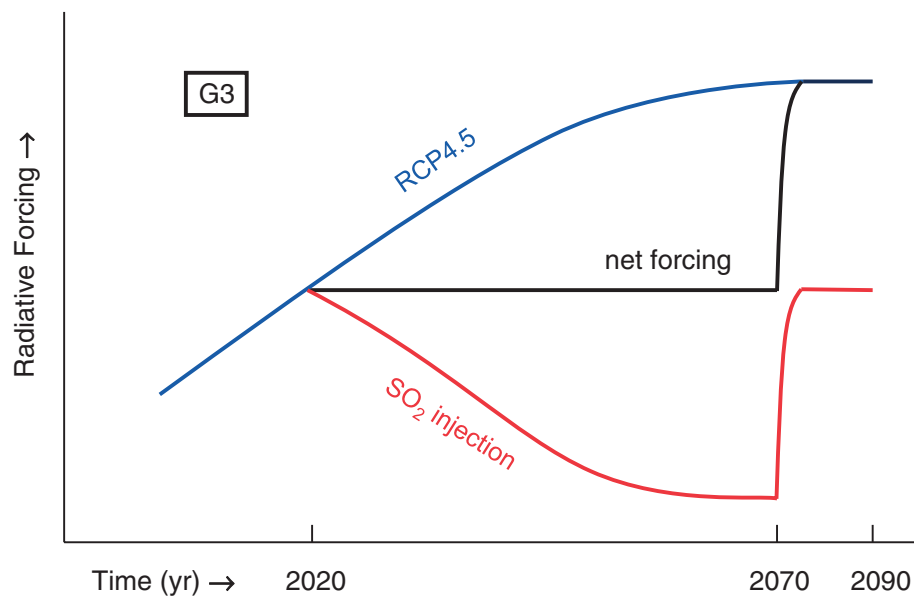/home_local/tgoren/ex8/tas_<scenario>.nc.

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Figure 1: Time evolution of radiative forcing under RCP4.5 and under the G3 geoengineering scenario. From Kravitz et al., 2011.