Critical Earth March 2024
Exercise Response Theory, March 5, 2024

In this tutorial, we are going to explore the response of atmospheric CO_2 and global mean temperature T to increased greenhouse gas emissions, translating into an increased radiative forcing F.

Key of this approach is the response model for the temperature anomaly ΔT, which is formulated as

$$\Delta T(t) = \int_0^t G(t)\Delta F(t-t')dt' \quad (1)$$

where ΔF is the radiative forcing change and G is the Green's function.

The first issue is the computation of the Green's function.

[a.] Show that one can compute the Green's function by a special case where the forcing is in the form of a Heaviside function.

The second issue is the computation of the temperature and CO_2 concentration as a function of specified emissions.

[b.] Use the python code for the deterministic model with the historical emission data to compute temperature and concentration up to the year 2010.

The third issue is the computation of the temperature and CO_2 concentration with the stochastic model under the RCP scenarios.

[c.] Take the RCP4.5 as a representative scenario in the python code to compute the probability density function for the temperature and concentration up to the year 2100.

To determine the Safe Carbon Budget under random (but plausible) mitigation scenarios (abation is set to zero), use 100 emission reduction strategies $m = m_0 + m_1(t - t_0)$. For each emission scenario, integrate a 1000-member ensemble starting in 2015 (t_0). Ensure that emissions will go to zero by the year 2080. An example of a python code for the emission scenarios is

def sample_policy():
*m0 = np.random.rand() * .7*
m1 = np.random.beta(.5, 5)
 # make sure emissions are 0 by 2080:
$m1 = max(m1, (1 - m0)/(2080 - STARTING\_YEAR))$
return create_policy(m0, m1) where m_1 is taken from a Beta-distribution $B(\alpha, \delta)$.

The last issue is the computation of the safe carbon budget.

[d.] Compute the Safe Carbon Budget for different tolerance probabilities β under these random emission scenarios. Determine the sensitivity of these values under the noise in the temperature model.