Carbon Cycle — Computer Lab

2-Box Atmosphere-Ocean Model — December 12th, 2013

The 1-Box model we encountered in an earlier exercise was not a very realistic description of how an atmospheric CO_2 perturbation decays. We would like to implement a more mechanistic description that considers the processes of gas exchange at the ocean surface. For this we need a 2-Box model for the atmosphere-ocean system. Initialize the atmospheric and oceanic CO_2 partial pressure with the preindustrial concentration of 270 ppm. Further assume that the oceanic inventory of DIC is 5000 GtC, representing the surface ocean only. The net gas exchange between the ocean and the atmospher is described by

$$F_{\mathrm{net}} = A_{\mathrm{oc}}\, k\, \left(\Delta pCO_{2,\mathrm{a}} - \Delta pCO_{2,\mathrm{oc}}\right) . \tag{1}$$

Chose k so that the preindustrial gross exchange flux ($F_{\mathrm{gross}} = A_{\mathrm{oc}}\, k\, (pCO_{2,\mathrm{oc}})$) becomes 60 GtC/yr. The oceanic partial pressure increase in response to a change in its DIC inventory is described by the buffer factor ξ.

$$\xi = \frac{\Delta pCO_2}{pCO_2} / \frac{\Delta \Sigma CO_2}{\Sigma CO_2} \tag{2}$$

Design experiments, each spanning 1000 years, as follows:

1. Prescribe a pulse emission of 1000 GtC in year 100. Plot the perturbation of atmospheric CO_2 over time.

2. Prescribe a step change in emissions: from 0 GtC/yr before year 100 to 10 GtC/yr thereafter. Plot the perturbation of atmospheric CO_2 over time.

3. Prescribe linearly increasing emissions (from 0 GtC/yr in year 1 to 20 GtC/yr in year 1000). Plot atmospheric CO_2 over time.