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12.842 / 12.301 Past and Present Climate
Fall 2008

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Climate Physics and Chemistry Fall 2008

1. You will calculate the amount of anthropogenic CO₂ taken up by the ocean when ocean parameters have changed in response to global climate change. Follow the method given in the course notes, and apply corrections for the changed conditions. All of the proposed changes are random and hypothetical; the real world may change in the opposite sense. In order to keep the calculation simple, you are to suppose that CO₂ was added in a single pulse 56 years ago (where today=2059 A.D.), then emissions controlled so as to keep atmospheric CO₂ constant during the next 56 years. We will ignore biospheric carbon uptake.

Assume that the following factors apply uniformly during the 56 year period:

- (a) the Revelle buffer factor $R = 9$ (lower because the ocean has warmed)
- (b) the mean life of CO₂ in the atmosphere has doubled to 56 years (because of emission controls).
- (c) total atmospheric CO₂ just before the 56 year period begins is 130×10^{15} moles (doubled from 1800 A.D.)
- (c) the mixed layer is 50 m deep (less than today because of decreased wind speeds), and the ocean averages 3810 m depth (because of melting polar ice).
- (d) the mass of CO₂ in the mixed layer of the ocean just prior to the CO₂ pulse was 34×10^{15} moles (the CO₂ concentration is higher than in 2004 A.D. because of higher atmospheric CO₂ but the total in the mixed layer is lower because of the thinner mixed layer).
- (e) 56 years ago, 30×10^{15} moles of anthropogenic CO₂ were added to the atmosphere (increasing the total to 160×10^{15} moles) at a time when the ocean was already at steady-state with respect to CO₂ (this assumption made to simplify the problem), and since that time emission controls have mandated that additional CO₂ can only be added at a rate that keeps atmospheric CO₂ levels constant)
- (f) during this time, 4 meters/year of bottom water has formed (cold water mass formation having perversely increased despite global warming)
- (g) during this time, 250 m of surface water has penetrated into the thermocline below the mixed layer (less than would occur during 56 years today because of a more stable thermocline caused by an increased vertical temperature gradient).

Calculate how much anthropogenic CO₂ is added to the whole system over this period (the initial increment 56 years ago plus that added since that time to keep the atmosphere constant), and what percentage of it goes into the ocean.