

Carbon Cycle and Global Warming

Reading:

1. Siegenthaler U. and Sarmiento J.L. (1993) Atmospheric carbon dioxide and the ocean. *Nature* **365**, 119-125.
2. Sarmiento J.L., T. M. C. Hughes, R.J. Stouffer and S. Manabe (1998) Simulated response of the ocean carbon cycle to anthropogenic climate warming. *Nature*, 393, 245-249.

1. All groups read both papers before class and be prepared to discuss their assigned sections on Monday. The Siegenthaler and Sarmiento paper is divided into three study groups. Study questions are attached to help focus discussion. Murray will work with Group 4 in class.
2. On Tuesday groups will cross-fertilize and explain their sections to the other students.
3. After class prepare a 3 page (double-spaced) answer to the Group Study Synthesis Questions. This assignment is due any time Wednesday December 5 in Jim Murray's office or mail box.

The Questions are: **What is the fate of anthropogenic carbon added to the atmosphere and how does it influence the global carbon cycle? How will the global carbon cycle be modified by global warming?**

Study Questions:

Siegenthaler and Sarmiento (1993)

Group 1: Carbon Cycle and the atmospheric record

What is the largest pool of carbon in the ocean?

What are the mechanisms by which C is transferred between boxes?

What are the major sources and sinks of C? What is the ultimate sink of C from the ocean? Was the preindustrial ocean at steady state?

What were the residence times of carbon in the different reservoirs in preindustrial times?

What are some reasons why we can argue that the present excursions in CO₂ are not natural excursions of the carbon cycle?

Group 2: Uptake of CO₂ by the ocean

How do we calculate the uptake of CO₂ by the ocean from the atmosphere?

What is the main rate-limiting step for oceanic CO₂ uptake?

How much variability is there in estimates of ocean uptake?

Why can we calculate the CO₂ uptake with bomb ¹⁴C? What are the characteristics of ¹⁴C input?

Why do we know that the ocean is taking up CO₂? Can we measure its uptake directly?

What clues do we get from ¹³C and O₂ distributions?

What do interhemispheric concentration differences for CO₂ tell us?

Group 3: Carbon Budget with anthropogenic perturbations

What are the similarities and differences between the pre-industrial and present day carbon cycle? What does this say about the nature of the anthropogenic signal?

What chemical/physical processes do we need to understand to evaluate fossil fuel C uptake?

What is the so-called missing sink?

What effect does fossil fuel CO₂ have on ocean biology

What factors will control future CO₂ levels?

Sarmiento et al (1998)

Group 4: How will the carbon cycle respond to global warming?

Review how the different models were constructed.

Explain the distributions in Fig 1 and 2.

If there was no biological pump now would CO₂ uptake change?

Why does the constant-biota GW model take up almost as much CO₂ as the constant-biota baseline model?

What is the cause and impact of increased stratification?

Why do the most important impacts occur in the southern ocean?

What will be the response of the carbon cycle to global warming?