Here comes the ocean, and the global climate change

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Today's brief guest blog, in interview form, is with an oceanographer who works with a certain climate-tracking agency for a certain large government. In the spirit of not getting fired, she asked that I refer to her as missmeridian. This will make it hard for you to track down her credentials, so you'll have to take my word for it that when people say 'we should only listen to scientists who study climate change regarding climate change issues,' they mean we need more people like missmeridian.

The context is in how we understand carbon exchange. For example, there are the carbon offset credits that hipsters are buying, and other situations where people characterize Global Warming as a simple stock and flow model: carbon comes out of our tailpipes, floats around in the air, and eventually dissipates or is eaten by trees. Temperature is just an increasing function of carbon stock.

This makes basic sense, is easy to comprehend, and is basically wrong. Missmeridian points out that the oceans are a major destination for our tailpipes' carbon, but even that isn't so simple.

MM: The rate at which oceans suck up carbon varies over time and space. The southern ocean is net suck in the summer, the equatorial Pacific is balanced unless under el niño, the north Atlantic is net suck in the spring. Search for "ocean carbon flux" for details.

B: Is it ever the case that oceans dump more carbon into the atmosphere than they absorb?

MM: Yes. Late fall is famous for that. Sunlight is decreasing at an increasing rate, and faster than temperature is cooling (due to magical properties of water). So you have heterotrophs (= not plants) eating a decreasing stock and exhaling lots of carbon. Also, several large portions of the ocean go hypoxic [oxygen deficient] in the subsurface at various times during the year (i.e. Arabian Sea during the monsoon)—this is very complicated, but basically you get a huge bloom that is eaten so fast it pulls all the oxygen out of the water column, and all that plant biomass is turned into carbon dioxide very quickly.

Also keep in mind that carbon sucked into the ocean isn't removed from play until it is exported to depth (ie under a layer that does not ventilate to the surface on the scale of centuries). Export in the dissolved phase is controversial. Particulate export is much better understood, and is pretty small: only, say, 1% of a surface bloom reaches the bottom intact in that season.

So 99% is converted to either dissolved organic carbon or gaseous carbon dioxide. The gas part may or may not enter the atmosphere depending on the temperature, solubility, partial pressure, etc.; and the dissolved part may eventually be turned into gas, or may just stick around as stale, inedible carbon for centuries.

B: So if we dump a megaton of carbon into the air, is is possible that next year that would turn into 1.2 megatons, or are we guaranteed that some percentage will get sucked into the oceans, leaving .8 megatons?

The carbon flux is ultimately controlled by the quantity and ratio of nitrogen and phosphorus in the deep ocean, which is constant over century scales (this is because biomass [sugars, proteins, DNA] grows in a mostly fixed ratio of C:N:P [carbon:nitrogen:phosphorous], which is usually 106:16:1 [the Redfield ratio]). Greater than millennial variation is possible, but not well understood. So, on a year to year basis, the ocean is in steady state with respect to C:N:P. The most likely candidate for throwing that out of whack is temperature, which controls the solubility of gases in water. See the "southern ocean iron experiment" (sofex), iron experiments 1 and 2 (ironexI, ironexII) and the "southern ocean iron enrichment experiment" (soiree) for studies that measurably altered the carbon flux. Note that these increased photosynthesis in the ocean—the atmosphere was not manipulated. I don't think anyone's done that, mostly because the ocean-atmosphere carbon flux is so delightfully governed by gas chemistry—it's difficult to squeeze a gas into a liquid.

B: You've mentioned (in prior correspondence) that the term *Global Warming* is misleading, because some parts of the world will get colder. Do you have any readings on why Europe would get colder with climate change?

Readings: look up "western antarctic ice sheet (wais)" and "global ocean conveyor belt" or "global ocean deep circulation." Basically, warming (global or local) causes the ice sheet to fall into the ocean, turns off deep circulation, which is what drives the gulf stream, which is what transfers Caribbean heat to northern Eurasia. Europe freezes.