On track of the missing carbon sink: An isotope adventure

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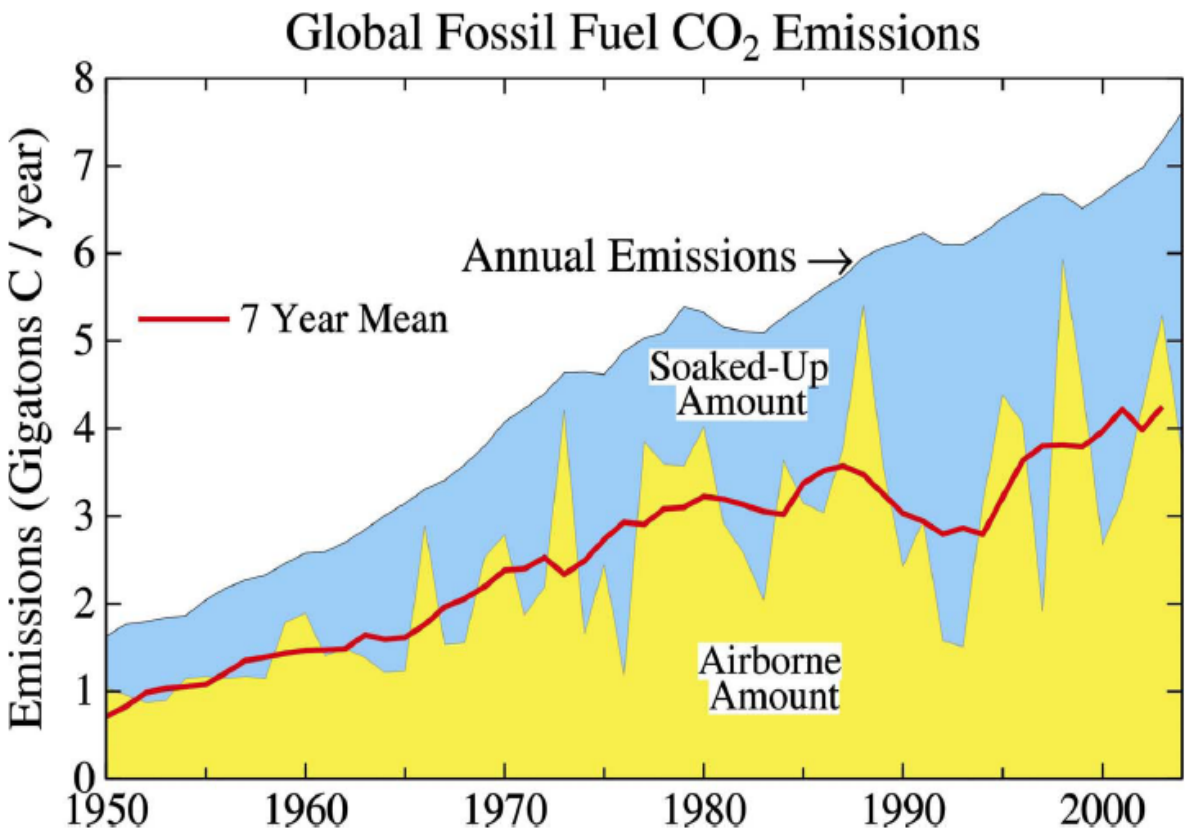
WPClipArt

Carbon cycle conundrums

- **Consistently, the atmospheric CO_2 increase amounts to 55-60% of emissions from fossil-fuel burning**
- **What are the *sinks* that absorb over 40% of the CO_2 that we emit?**
  - **Land or ocean? Where? What processes?**
  - **Why the interannual variability?**
- **How will CO_2 sinks change?**



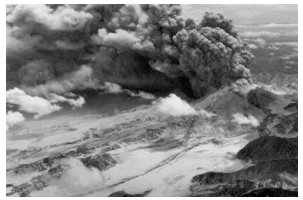
Global fossil fuel CO_2 emissions with division into portions that remain airborne or are soaked up by the ocean and land.

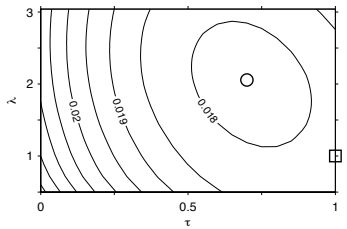
Source: Hansen and Sato, *PNAS*, **101**, 16109, 2004.

Thesis work

Tracing Recent Carbon Uptake by Oceans and Land Plants

1) The impact of volcanic eruptions on global tree productivity: *What causes interannual variability?*
2) Inferring flux patterns from atmosphere CO_2 concentrations: *Should we trust the numbers we get?*



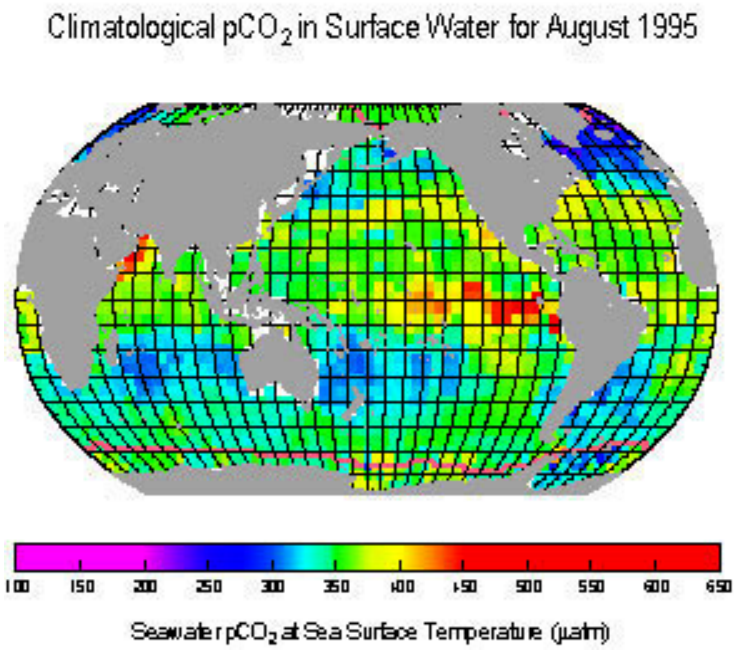


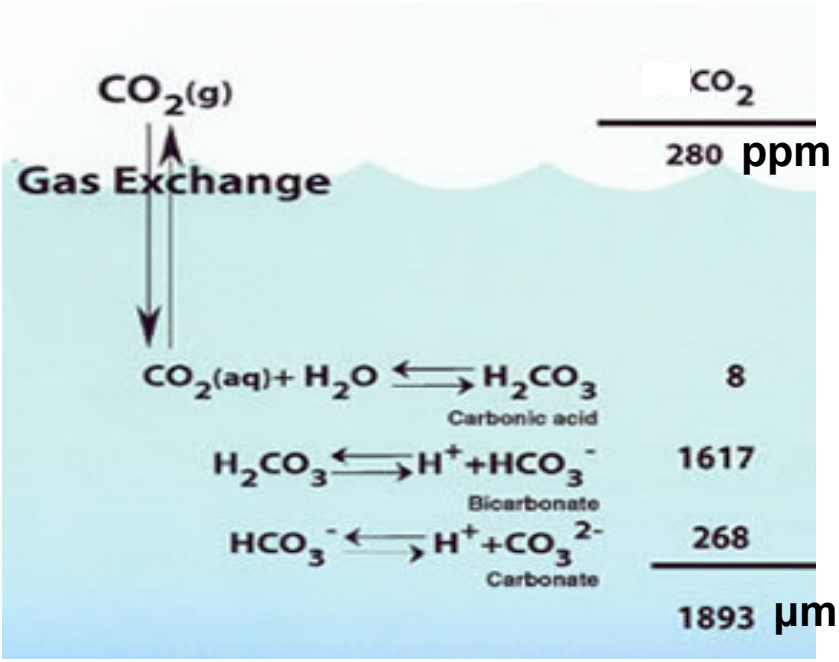
3) The regional distribution of air-sea gas exchange: *Where is the ocean taking up carbon?*

Pictures: USGS; LTRR; Ruth Brownlee; Photofusion (via the UK Science Museum)

The ocean surface can take up atmospheric CO_2

LDEO

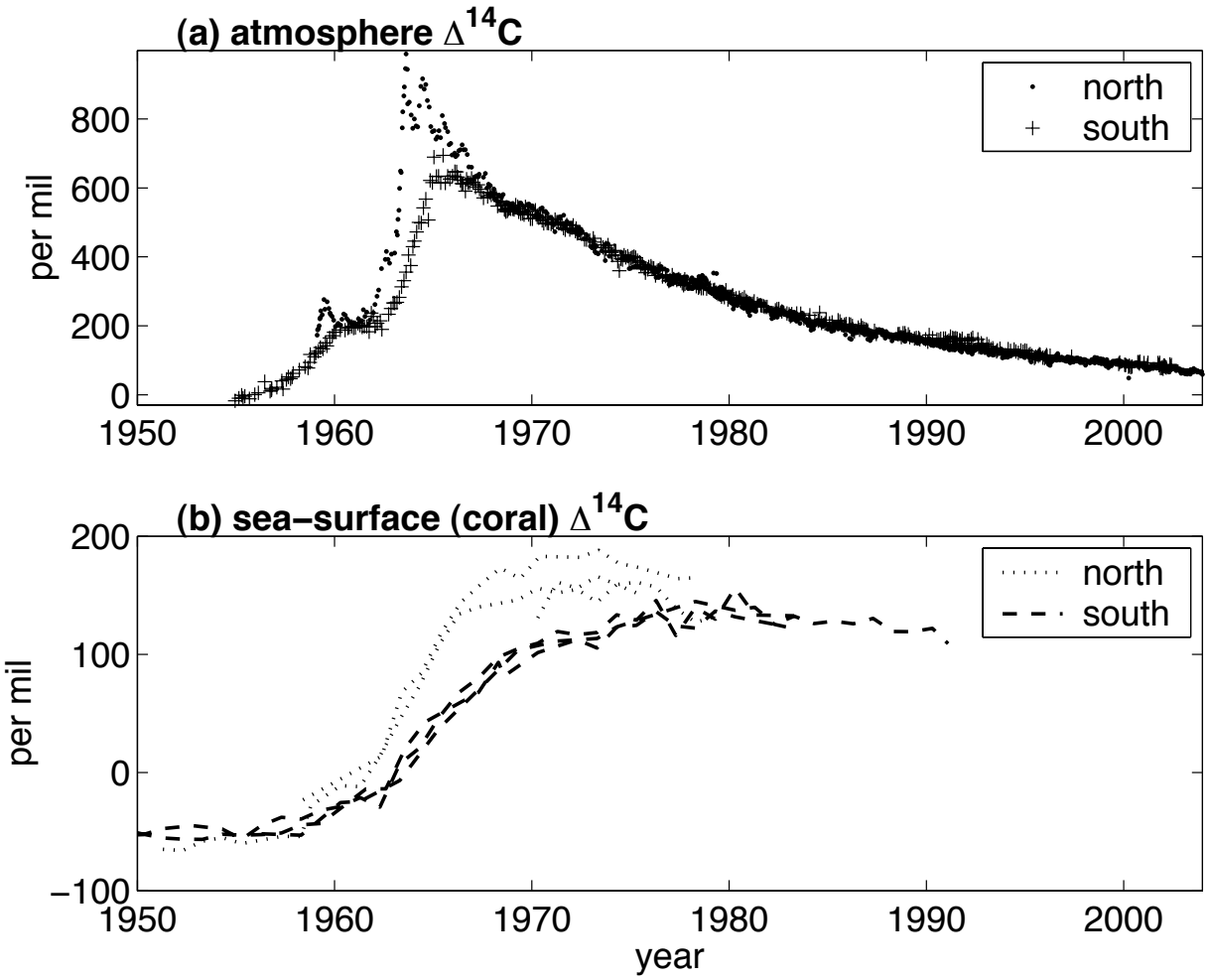




Ocean carbonate speciation (Feely et al 2001)

- The ocean takes up CO_2 if the surface water contains relatively less of it than the atmosphere (blue on map)
- Uptake pattern depends both on the surface-water CO_2 concentration (reasonably easily to measure) and on the gas transfer velocity (hard to measure)

Idea: Track where the ocean took up carbon-14

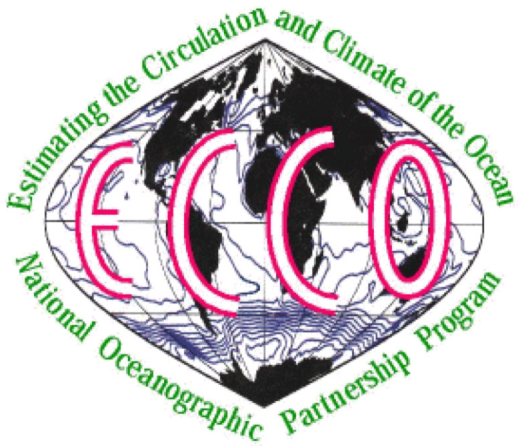


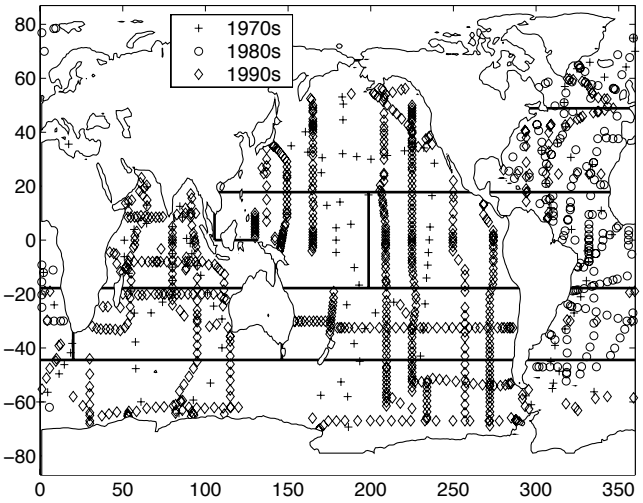
bomb spike

- Massive production in nuclear tests ca. 1960 ("bomb ^{14}C")
- The ocean took up ~half of the bomb ^{14}C by the 1980s
- The ^{14}C taken up by the ocean stands up more against the natural background than the fossil-fuel CO_2 taken up, so is easier to measure;
- The gas transfer velocity would be the same for both processes!

data: Levin & Kromer 2004; Manning et al 1990; Druffel 1987; Druffel 1989; Druffel & Griffin 1995

Modus operandi

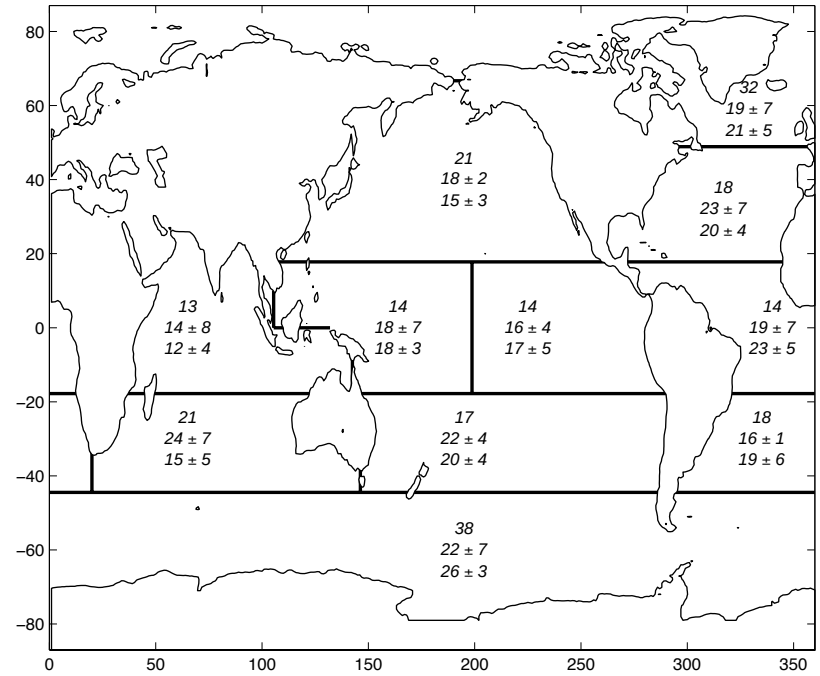


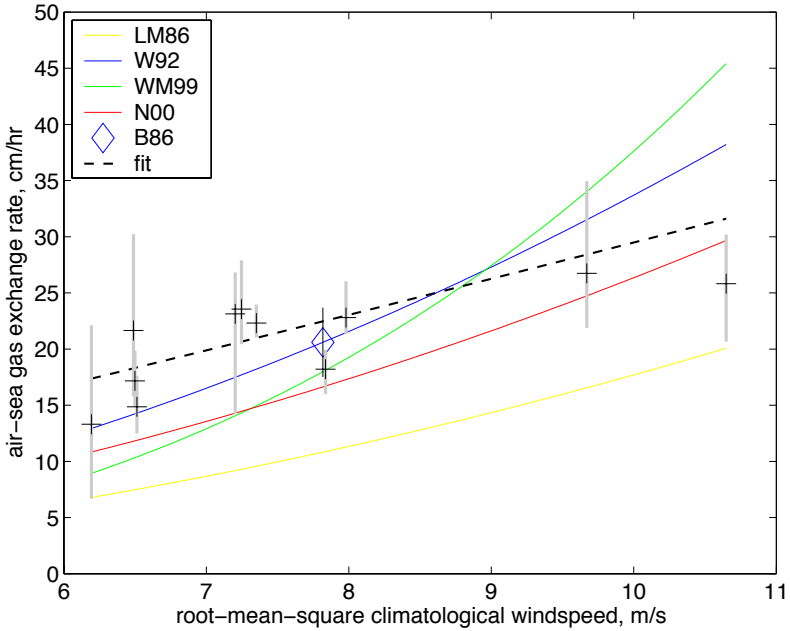


- Simulate ocean ^{14}C uptake with an ocean-circulation model assuming some gas transfer velocity for each region
- Compare with ocean ^{14}C measurements
- Adjust gas transfer velocities until the simulated fields match observations (as well as possible!)

Results:
Gas transfer velocities by region

- Higher transfer velocities in tropical ocean regions than previously assumed





- Less dependence on wind speed, usually taken to be the factor with the biggest influence on gas transfer velocity, than expected

To be determined…

- Can ^{14}C uptake help in deducing what processes control gas exchange beside wind speed?
- Might climate change affect these processes, and hence ocean uptake of CO_2?

- Stay tuned…

Bruce van Patter