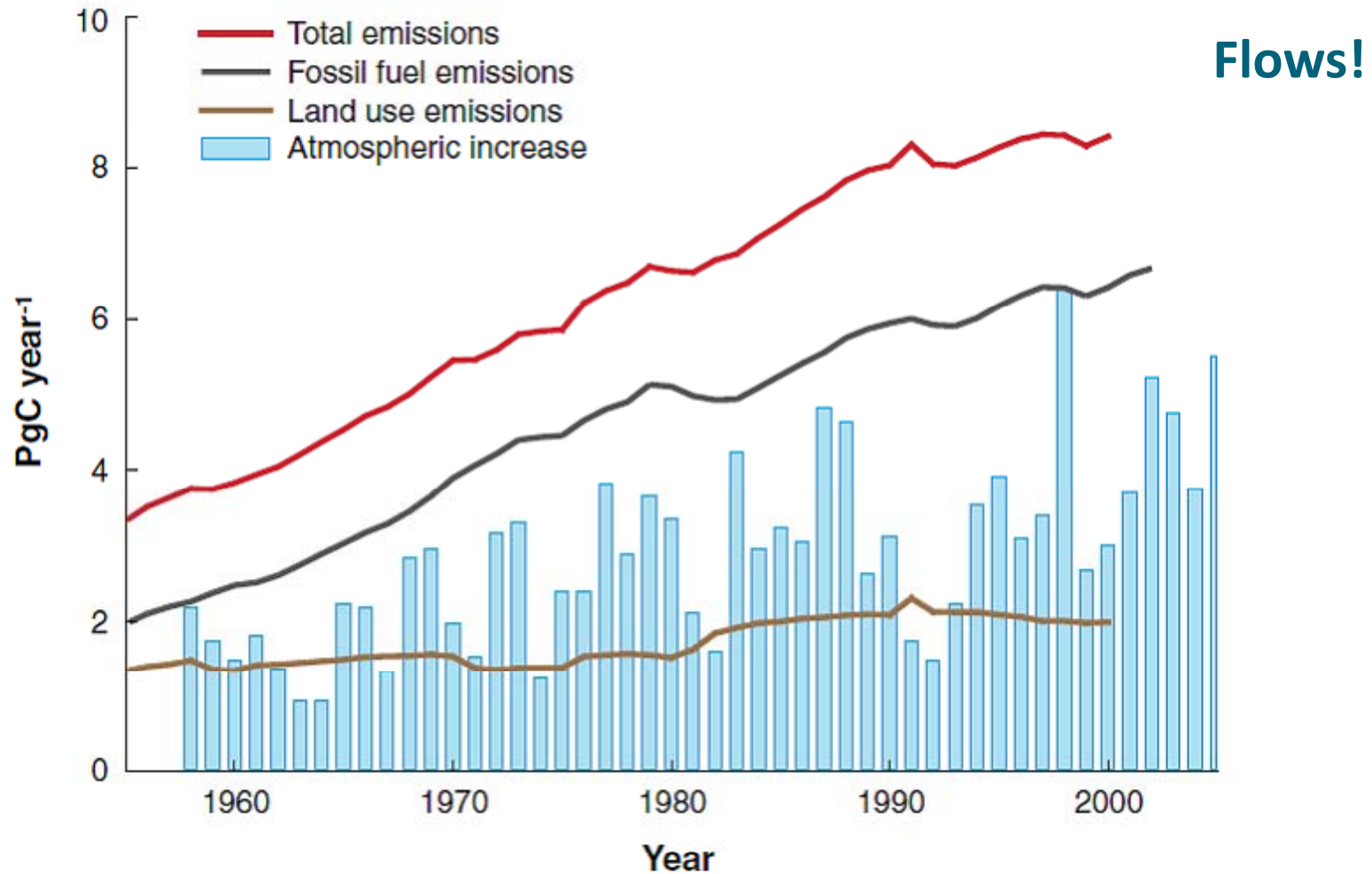


The Carbon Cycle

Antropogenic Carbon Emissions and Atmospheric Accumulation



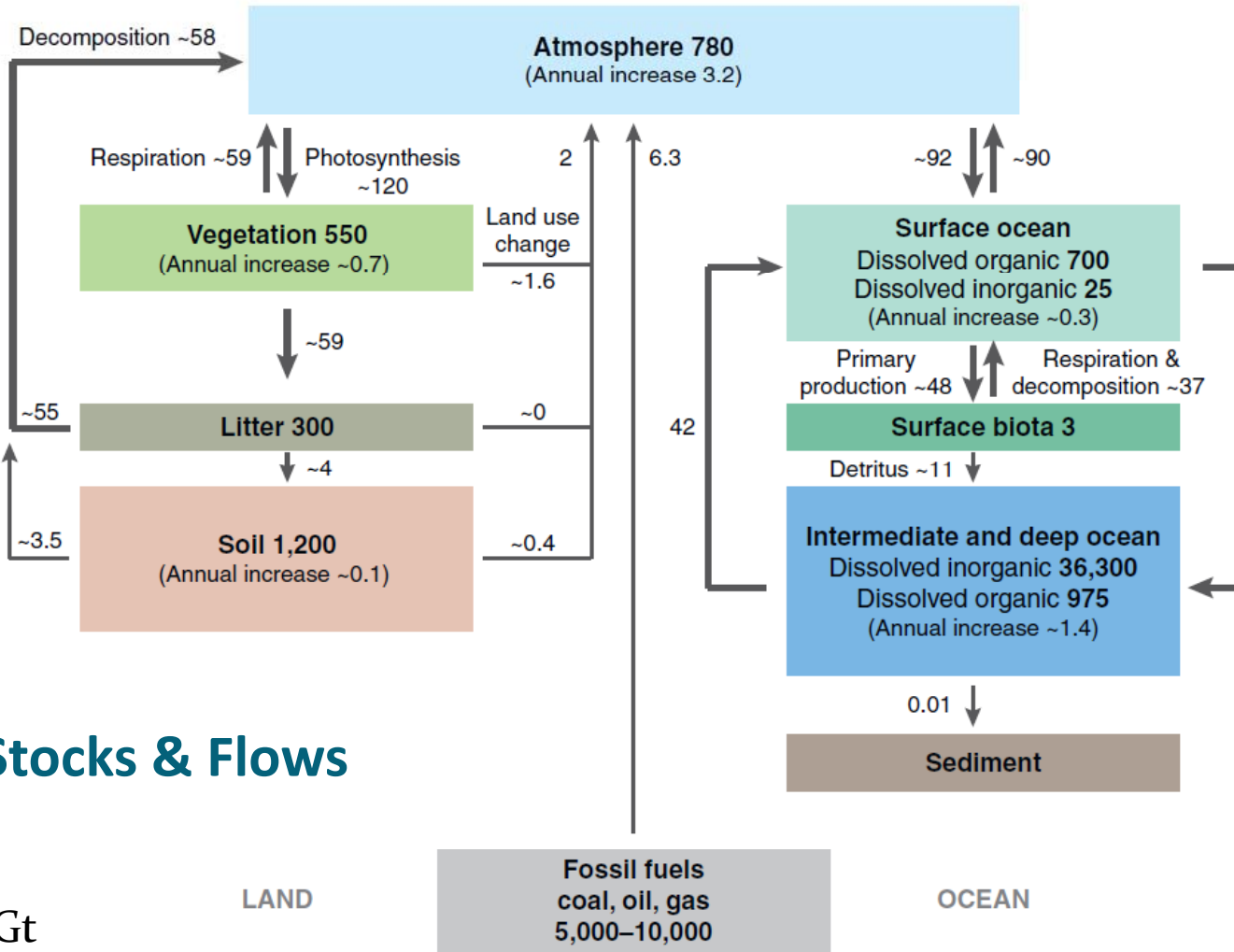
Source: Houghton, R.A. (2007), Balancing the Global Carbon Budget, *Annu. Rev. Earth Planet. Sci.* 35:313–47.

Where is all the Carbon? (2005)

- Atmosphere:
 - **CO₂: 805 Gt**
 - Methane: 1.7 Gt
- **Oceans: 38 000 Gt**
 - Surface, contact with atmosphere: 700-1000
- Terrestrial Systems:
 - **terrestrial vegetation: 540 - 560 Gt**
 - **organic matter in soils: 1 500 – 2 000 Gt (in the top meter)**

Note: 50% of dry (water removed) organic matter is carbon
- **Fossil Fuels:**
 - Recoverable reserves of coal, oil, and gas: **5 000–10 000 Gt**

Stocks!



Carbon Stocks & Flows

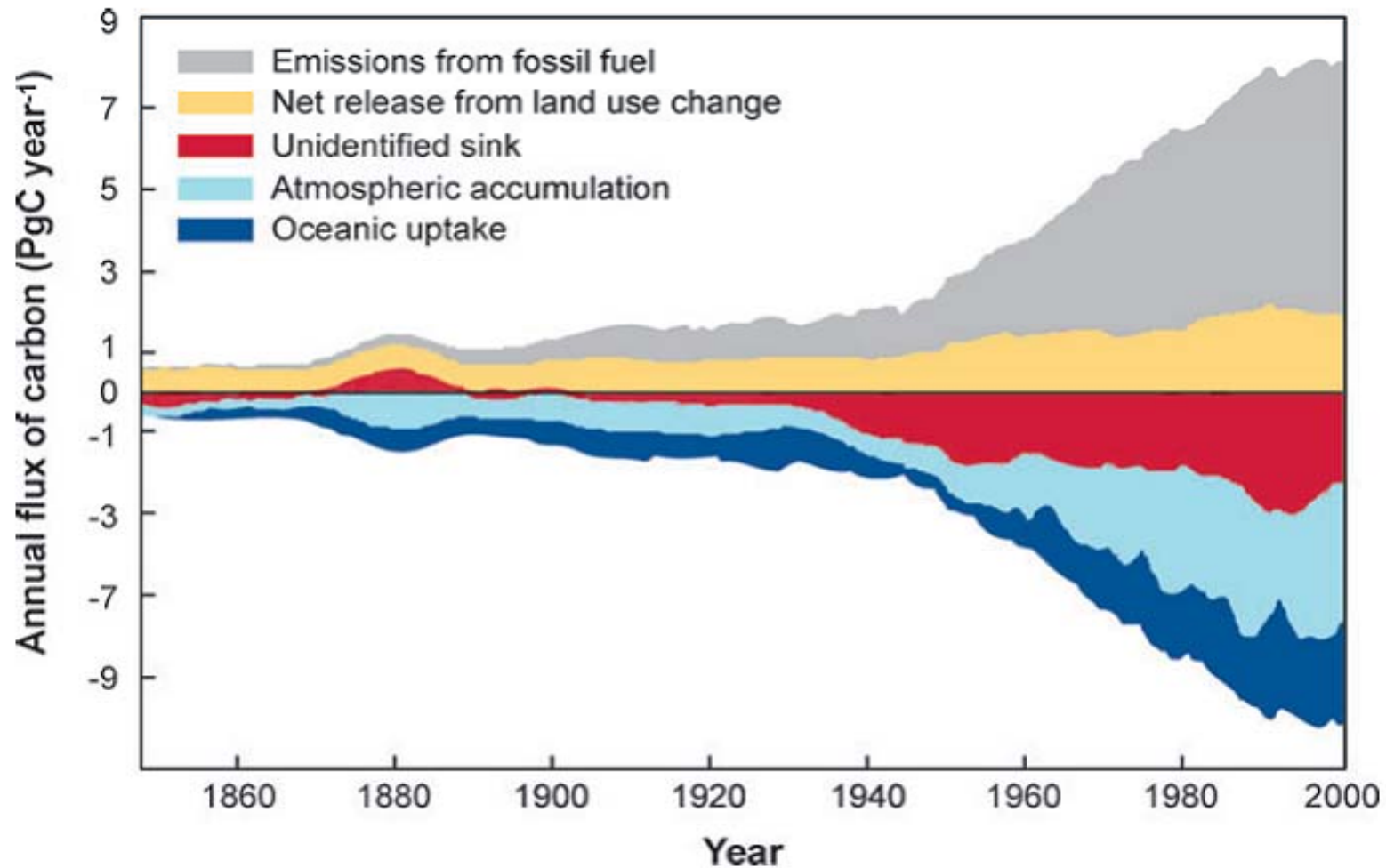
Units: 1 Pg
 = 10^{15} g = 1 Gt
 = Billion tons

Figure 1

The global carbon cycle in the 1990s. Units are PgC or PgC year⁻¹.

Houghton, R.A. (2007), Balancing the Global Carbon Budget, *Annu. Rev. Earth Planet. Sci.* 35:313–47.

Budgeting the Anthropogenic Changes



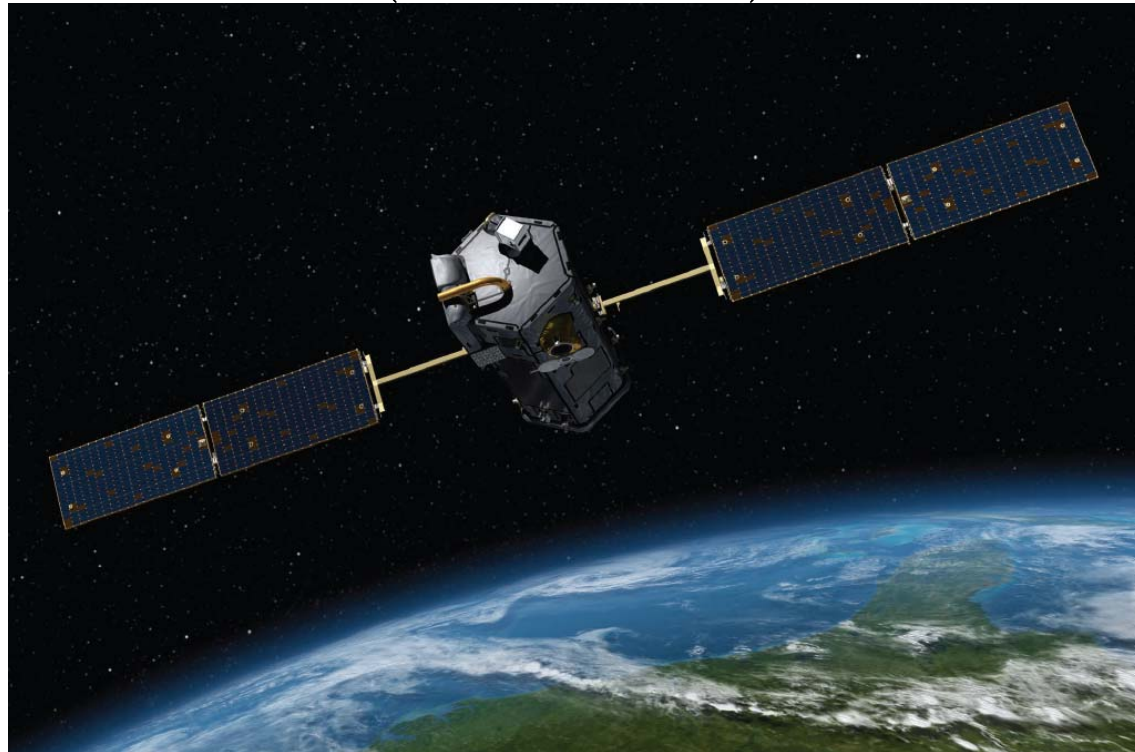
How to find the ‘Missing Carbon’?



Last Friday (01/23/09) Japan's Aerospace Exploration Agency lauched “**IBUKI**”
...not to search for little C's in outer space, but to...

monitor the change in infrared radiation caused by the presence of CO₂

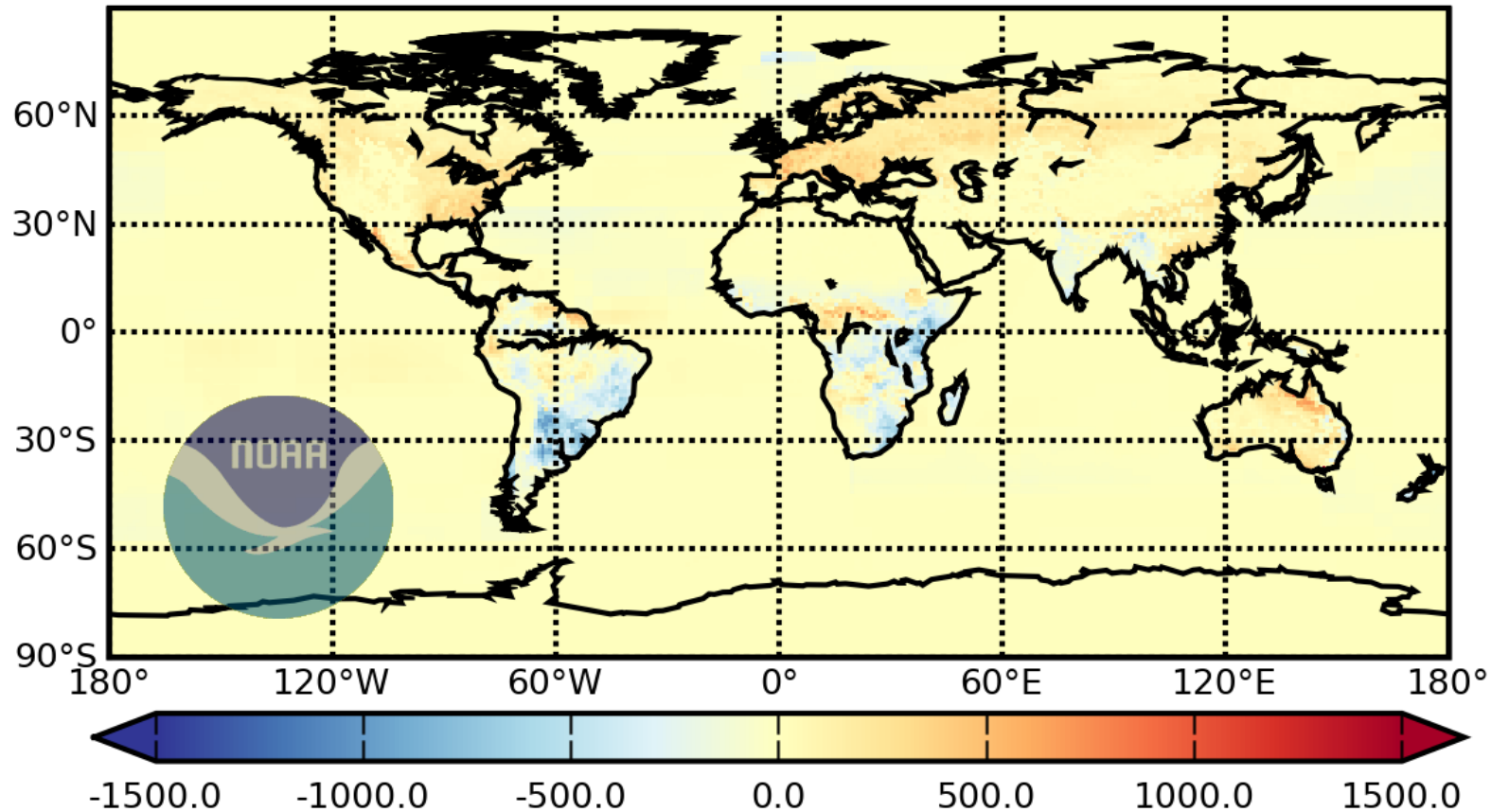
- “IBUKI”=GOSAT= Greenhouse Gases Observing Satellite
- Next month (02/23/09) NASA launches OCO from the Vandenberg Air Force Base in California (~Santa Barbara)



- As we learned during the course of the lecture sleeps now in Antarctic Waters...

Hope to get more precise maps of sinks and sources

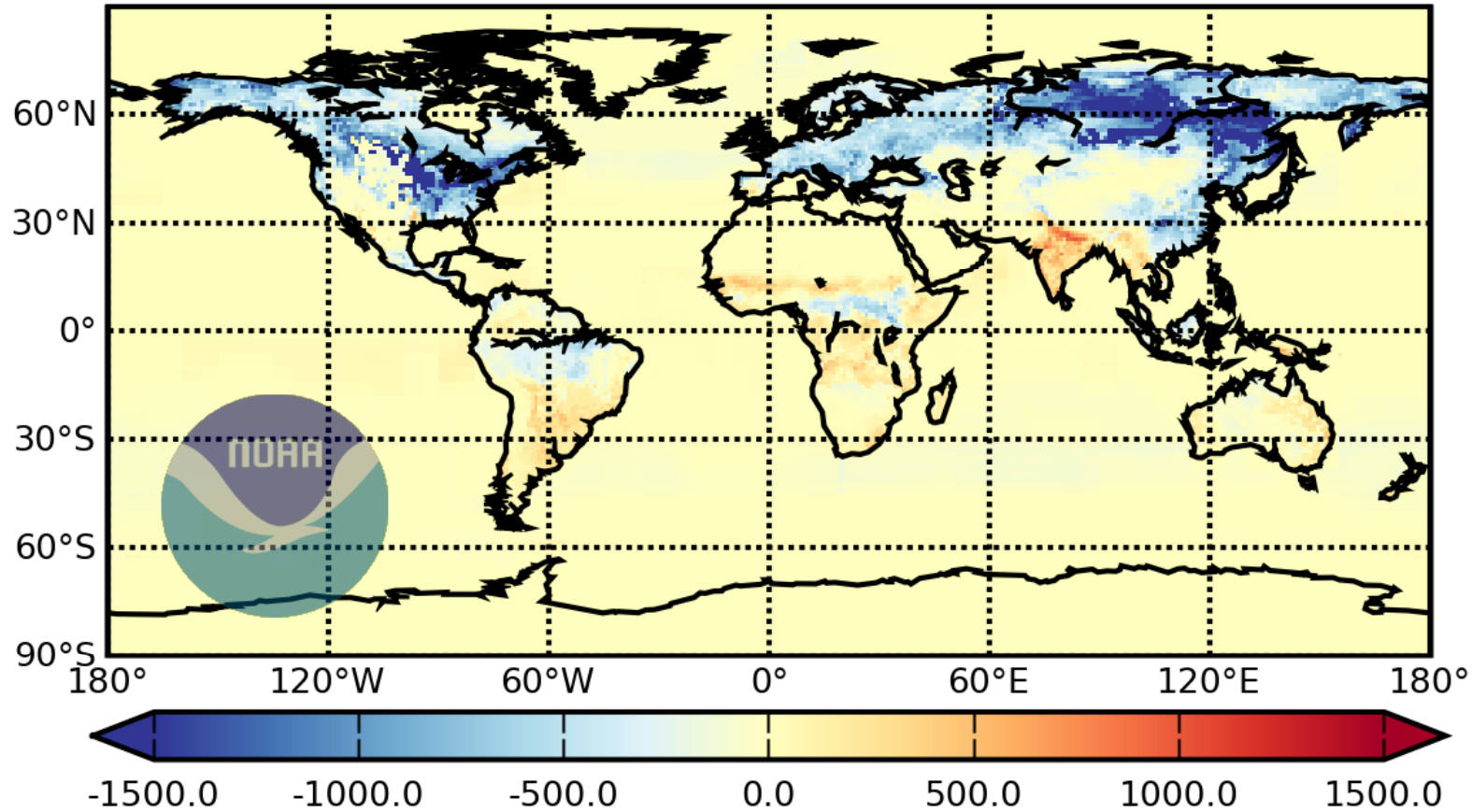
mean flux [$\text{gC}/\text{m}^2/\text{yr}$]
for 2007-01-15 \pm 15.0 days



The Carbon Tracker Project. Map depicts model based interpolation of changes in Carbon flux, watch the date!

Hope to get high resolution maps of sinks and sources

mean flux [$\text{gC}/\text{m}^2/\text{yr}$]
for 2007-07-15 \pm 15.0 days

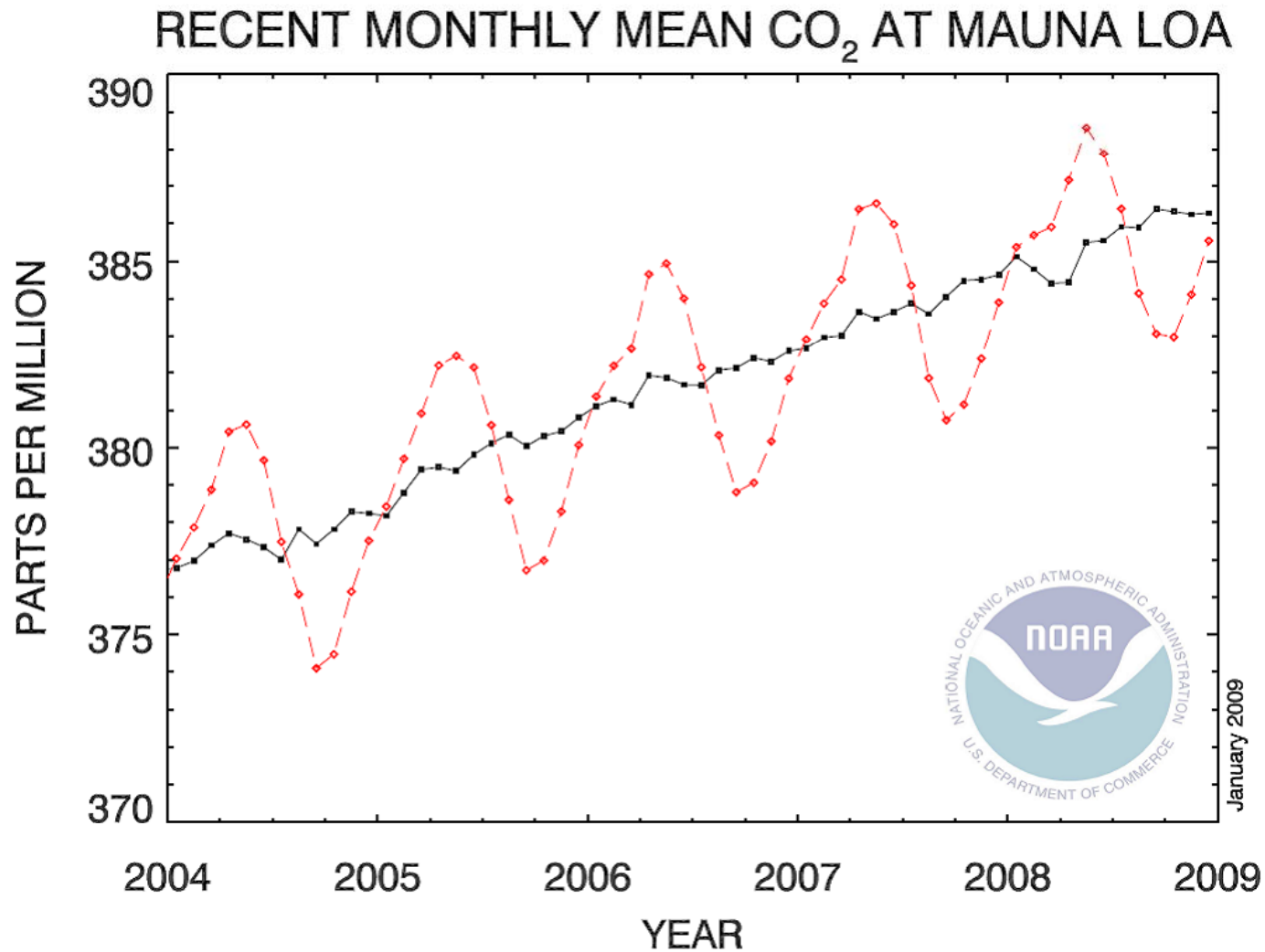


CT2008, Created 28 October 2008

The Carbon Tracker Project, Northern summer.

<http://www.esrl.noaa.gov/gmd/ccgg/carbontracker/fluxmaps.php?type=global#imagetable>

Seasonal pattern of CO₂ concentrations:



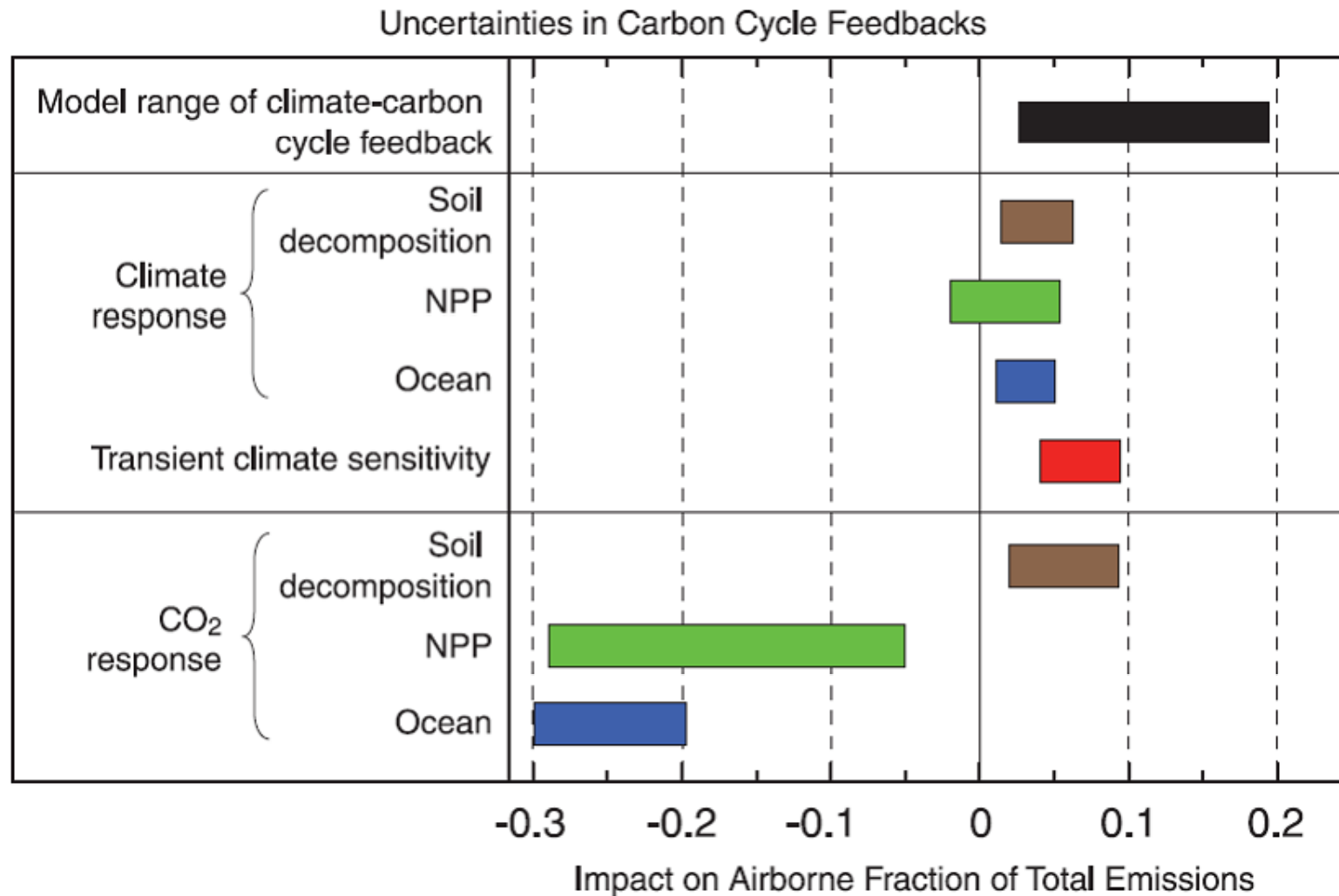
Source: Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/)

Finding the missing carbon

Why are we interested in these details?

- Natural Sinks and Sources can change over time, in particular, in response to climate change.
- To predict these changes we need to find and understand the sinks, sources, and mechanisms at work.

Carbon Cycle & Feedback Effects



Source: IPCC (2007), WG1.

- The current terrestrial carbon sink represents a subsidy that has kept the airborne fraction of total CO₂ emissions between 40% and 50% for at least the past five decades.
- Most projections of future climate have been based on the assumption that the current terrestrial sink will not only continue but will grow in proportion to concentrations of CO₂.
- Recent findings and feedback effects challenge this assumption

For more:

Houghton, R.A. (2007), Balancing the Global Carbon Budget, Annual Review of Earth and Planetary Science 35:313–47.