Agenda

• Posters from 1:30 to 2:00. Talks start at 2:00
  • Big Picture
    – John Miller: Why study the Carbon Cycle?
    – Arlyn Andrews: Carbon Cycle Research in ESRL and beyond
  • Observations/Synthesis
    – Pieter Tans: A brief history of the ESRL global carbon cycle observing system
    – Andy Jacobson: The CarbonTracker Modeling Effort
  • ESRL Linkages
    – Greg Frost: Carbon Cycle Linkages to Air Quality
    – Adam Hirsch: The Need for Accurate Atmospheric Transport in Carbon Cycle Research
    – Randy Dole: Looking Ahead: Toward Development of an Integrated Earth System Analysis
Science Questions

• Carbon Cycle Basics
  – Paleo CO$_2$
  – Surface Fluxes

• Fossil Fuel Emissions and their fate

• Rising CO$_2$: what is the impact?
  – Climate change
  – Ocean Acidification

John B. Miller
Paleo-CO$_2$

![Graph showing CO$_2$ levels over thousands of years before present. The graph includes Ice core CO$_2$ and MLO CO$_2$.](image-url)
\[
d[\text{CO}_2]_{\text{atm}}/dt = +4 \text{ PgC/yr}
\]
\[ \frac{d[CO_2]_{atm}}{dt} - F_{fos} = F_{surface} = -4 \text{ PgC} \]
\[ \frac{d[C\text{O}_2]}{dt} - F_{\text{fos}} = F_{\text{ocean}} + F_{\text{land}} = -4 \text{ PgC} \]
\[ \frac{\text{d}[\text{CO}_2]_{\text{atm}}}{\text{d}t} = F_{\text{fos}} + F_{\text{atm-oce}} + F_{\text{oce-atm}} + F_{\text{ph}} + F_{\text{resp}} \]
Fossil Fuel Emissions

IPCC 95th %ile!

IPCC A2 (~67 %ile)
If all the fossil fuel CO₂ ended up in the atmosphere
Fate of Fossil Fuel Emissions

Our ~50% climate discount from ocean and land uptake

What does end up in the atmosphere

How long will we keep getting our discount?
Coupled Climate Carbon Cycle (C^4) Models

Permafrost releases not accounted for!
Ocean Acidification

As CO$_2$ increases, ocean pH decreases

- Independent of warming
- Ability of marine organisms to form CaCO$_3$ is reduced.
- Potential for radical changes to marine food webs.

Courtesy Dick Feely
Controls on Atmospheric CO₂

Anthropogenic

Ocean

Land

ESRL

CO₂ Variability

Frequency

diurnal seasonal interannual decadal centennial millennial

w/surprises!?