Carbon is an important elemental biogeochemical cycle

Take home message

‘Natural processes [affecting carbon dynamics] are linked to physical conditions, chemical reactions, and biological transformations and they respond themselves to perturbed atmospheric composition and climate change. Therefore, the physical climate system and the biogeochemical cycles of CO₂, CH₄, and N₂O are coupled.’

IPCC 2013

Long-term atmospheric CO₂ from Antarctic ice

Why should we know or care about carbon and its pools and fluxes?
Fletcher’s (2013) six C cycle processes:

1. Limestone formation in the ocean traps CO₂
   \[ 2\text{CO}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{HCO}_3^- + 2\text{H}^+ \]
   \[ 2\text{HCO}_3^- + \text{Ca}^{2+} \rightarrow \text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} \]

2. Limestone formation in freshwater traps CO₂

3. Limestone weathering consumes CO₂
   \[ \text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{Ca}^{2+} + 2\text{HCO}_3^- \]

4. Silicate rock weathering consumes CO₂
   \[ \text{CaSiO}_3 + 2\text{CO}_2 + 2\text{H}_2\text{O} \rightarrow \text{Ca}^{2+} + 2\text{HCO}_3^- + \text{SiO}_2 \]

5. Photosynthesizing organisms trap CO₂ and convert it to organic C
   \[ 6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2 \]

6. Respiration and decomposition or organic C releases CO₂
   \[ \text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} \]

Global carbon cycle – pools and fluxes

- Inverse relationship between size of pool and flux rate
  - Fast exchanges with atmosphere, e.g. vegetation
  - Big, slow exchanges with atmosphere important on long timescales, e.g. rocks

Organic matter and organic C

OM is a complex and varied mixture of organic substances
All organic substances contain C, ~½ of OM is C

Global vegetation: 350-550 Gt C
Global soils: 1500 -2400 Gt C
[Atmosphere: 800 Gt C]

Atmospheric CO₂ concentration

Mauna Loa Observatory, Hawaii
Monthly Average Carbon Dioxide Concentration

[Graph showing CO₂ concentration over time]
Atmospheric $^{13}$CO$_2$ values

...see Fletcher’s Chapter 2 ‘Fingerprint #1’...

Forcings of climate change

The largest contributor to the uptake in energy by the climate system clearly is the increase in atmospheric CO$_2$ concentration since 1750.

The global carbon cycle

A global balance in fluxes between reservoirs – today's atmosphere is out of balance owing to anthropogenic C emissions.

Case study: impacts of invasive species in Hawai‘i on C dynamics

Is invasion by Sphagnum palustre impacting ecosystem C processes on Ka‘ala?

Partner: O‘ahu Army Natural Resource Program
Case study: impacts of invasive species in Hawai’i on C dynamics

Is invasion by Sphagnum palustre impacting ecosystem C processes on Ka‘ala?

What’s next?

Case study: Antarctic terrestrial ecosystem project

US science academy report calls for ‘bipolar research’

Arctic and Antarctic scientists are urged to share data, ideas and infrastructure.

The Arctic and Antarctic share more than forty degrees. Both experience rapid and extreme climate change, and provide critical belt-bracketing the effects of global warming. Yet, scientific studies that shape the reality of the Earth are polar apart in more than just geographical terms, with widely different methods and datasets. Data sharing between these two polar extremes is key to our understanding of the impact of climate change.

A recent report from the National Science Foundation calls for an integrated approach to research in the polar regions. The report states, "The Antarctic and Arctic are important ‘polar regions’ that are continuously changing due to climate change. This integrated approach is important to our understanding of the impact of climate change.

Both the Arctic and Antarctic are ‘highly coupled systems’ where changes in one region can have significant effects on the other. The report states, "The Arctic and Antarctic are unique ecosystems that are changing in response to climate change. This integrated approach is important to our understanding of the impact of climate change.

Etchfield Island February 2014

Case study: Antarctic terrestrial ecosystem project
Case study: Antarctic terrestrial ecosystem project

How is plant growth responding to recent rapid warming of the Antarctic Peninsula?

Galindez Island February 2014

Additional reading


Mahalo!