Analysis of a Greenland ice core oxygen isotope proxy

Source: Wallace Broecker
CO₂ for the Last 600,000 Years

Currently 385 ppm
2007

1750

Siegenthaler U et al. (2005) Science 310:1313
Edith’s Checkerspot

- Range shift northward and upward during the 20th century
- Most extinctions in south and low elevations

Oceans II • By Thomas E. Lovejoy

Rising acidity threatens marine life

WASHINGTON

The problems of acid rain and acid lakes, which came to public attention in the 1980s, have been addressed to a considerable degree. Today we face a far more profound challenge: increasingly acid oceans.

It is little known outside of scientific circles that a fundamental change has already taken place in the chemistry of the two thirds of the earth's surface occupied by oceans. The change, of 0.1 of a pH unit, sounds trivial when expressed in the logarithmic scale that science uses, but it translates to the upper layers of the oceans already being 30 percent more acid than in preindustrial times.

The change is being caused by increased atmospheric levels of greenhouse gases, in particular carbon dioxide. In addition to forcing climate change, more carbon dioxide combines with water and produces carbonic acid.

The consequences for marine ecosystems are only beginning to be understood but are bound to be far-reaching.
Why is a CO$_2$ target of 450ppm too high?

1. Arctic sea-ice
2. Greenland ice-sheet stability
3. Antarctic ice-sheet stability
4. Major ecosystem disruption
When will the 2°C and 4°C thresholds will be breached?
Projected temperature rise for A1B & A1F1 scenarios (Hadley, 2009)
The impact of a global temperature rise of 2 °C

Change in temperature from pre-industrial climate

- More heatwaves
- Some risk of melting ice
- Some increased crops
- Reduced crops
- Forest fire
- Ocean acidification

Embargoed
What is a “safe” level?

James Hansen, et al., 2008

350 ppm
The Role of Life Processes

The graph shows the concentration of CO₂ in parts per million (ppm) over time (Ma, millions of years ago). The graph includes data from Proxies (LOESS) and GEOCARB III. Key events marked on the graph include:

- **Origin of land plants**: This event is indicated by a red arrow and corresponds to a significant increase in CO₂ concentration. It suggests a major shift in the evolution of land plants, which likely led to increased CO₂ absorption and higher atmospheric CO₂ levels.

- **Expansion of angiosperms**: This event is indicated by a green arrow, signifying the growth and diversification of angiosperms, another significant phase in the evolution of plant life. The expansion of angiosperms is linked with a notable rise in CO₂ concentration, possibly due to increased respiration and photosynthesis.

- **Present-day CO₂**: The red line represents the current concentration of CO₂ in the atmosphere, indicating a relatively stable level after significant fluctuations in the past.

The graph provides a visual representation of how changes in CO₂ levels correlate with major biological events throughout geological history, highlighting the role of life processes in shaping Earth's atmospheric composition.
Over the past three centuries, ecosystems have lost 200-250 billion tons of carbon
Fate of Anthropogenic CO2 Emissions (2000-2007)

Canadell et al. 2007, PNAS (updated)

1.5 Pg C y\(^{-1}\) + 7.5 Pg C y\(^{-1}\)

Atmosphere
- 4.2 Pg y\(^{-1}\)
  - 46%

Land
- 2.6 Pg y\(^{-1}\)
  - 29%

Oceans
- 2.3 Pg y\(^{-1}\)
  - 26%

Canadell et al. 2007, PNAS (updated)
Re-Greening the Emerald Planet