What can surface fCO$_2$ measurements tell us about the evolution of the Southern Ocean CO$_2$ sink?

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Background

Atmospheric CO2 data and ocean model suggest a reduction of the total southern ocean carbon sink since 1980.

Changes associated with wind speed change in the Southern hemisphere

What can oceanic fCO2 measurements tell us about this evolution?

Le Quéré et al., Science, 2007
Southern and Indian Oceans
OISO cruises onboard R.V. Marion-Dufresne

La Réunion
Amsterdam
Crozet
Kerguelen
Atmospheric CO₂ Ship and Amsterdam Island

Ship Obs. Trend: 1.722 (+0.004) ppm/year

Ams. Station Trend: 1.701 (+0.003) ppm/year
A « big-box » view

Trend atmosphere: + 1.7 μatm/yr
Trend ocean: + 2.1 μatm/yr

South-Western Indian sector, south of 20°S
Summer and winter ocean fCO2 (South-Indian, 1991-2007)

20-35°S

35-40°S

fCO2 always increases
Summer and winter ocean fCO2 (South-Indian, 1991-2007)

fCO2 always increases
Overview: Austral summer and winter ocean fCO2 trends (μatm/yr)
In four regions in the South-Western Indian Ocean

Almost always above the atmospheric CO2 rate
Decreased Sink & Increased Source
Normalising to T -> Mechanisms driving these trends

Shipbased fCO$_2$

Contrasting results in winter, north and south of 40°S

Normalized fCO$_2$

Less DIC? More DIC?
Large Scale Climate Forcing?

Physical

Carbon Cycle

$\text{CO}_2$ Flux

$\text{DIC}$

$\text{STF}$

Sen Gupta and England, 2006

Lenton and Matear, 2007
Decadal evolution modelled $\text{pCO}_2$

Lenton and Metzl, 2007
Conclusions

• Decadal CO2 trends based on observations (1991-2007)
• Ocean pCO2 increases faster than in the atmosphere, but never far
• Normalised pCO2 (T) highlights:
  - Large contrast north and south of 40°S
  - likely linked to change of DIC vertical import (SAM)
  - Consistent with observed atmospheric response (LeQuéré et al 2007)
• Oceanic pCO2 tells us about the evolution of the system, particularly DIC
  , but evolution is complex temporal and spatially
• Future work
  - Comparing trends in several S.O. regions
  - Analysing observed DIC trends
  - Trends related to natural and anthropogenic carbon
References

Le Quéré, C. et al. (2007), Saturation of the Southern Ocean CO₂ Sink Due to Recent Climate Change, Science, 316(5832), 1735 - 1738, DOI: 10.1126/science.1136188


Lenton, A. and N. Metzl (2007), Model/observation comparison: focus on interannual variability, Carbooocean Annual Meeting, WG 5, Bremen, Germany