Changes of the ocean carbon cycle and ecosystems

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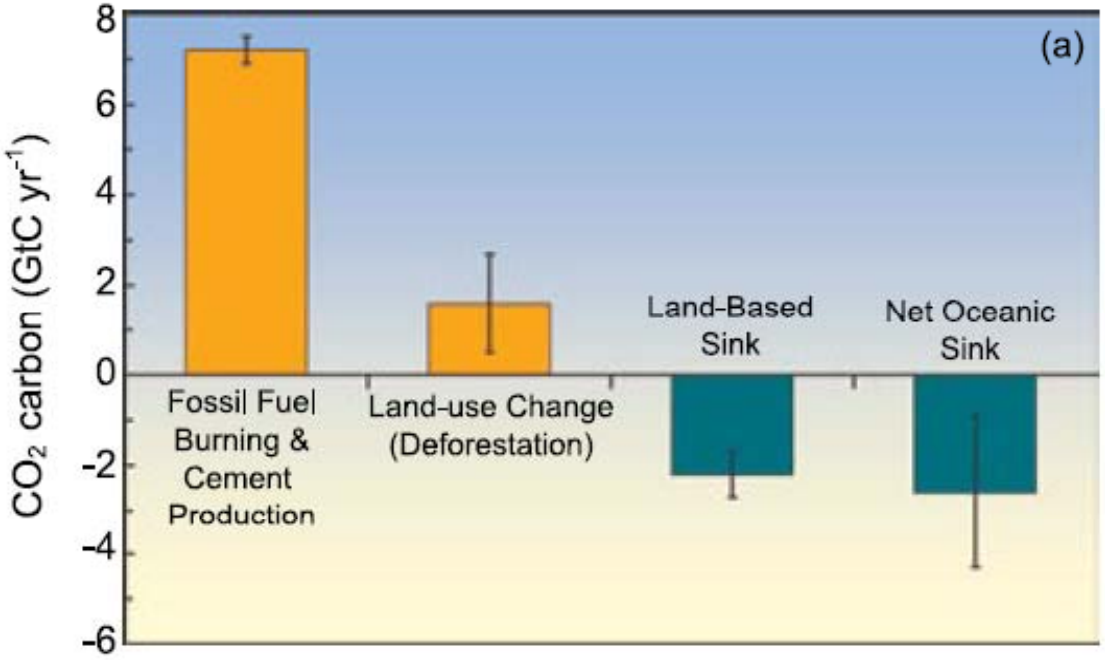
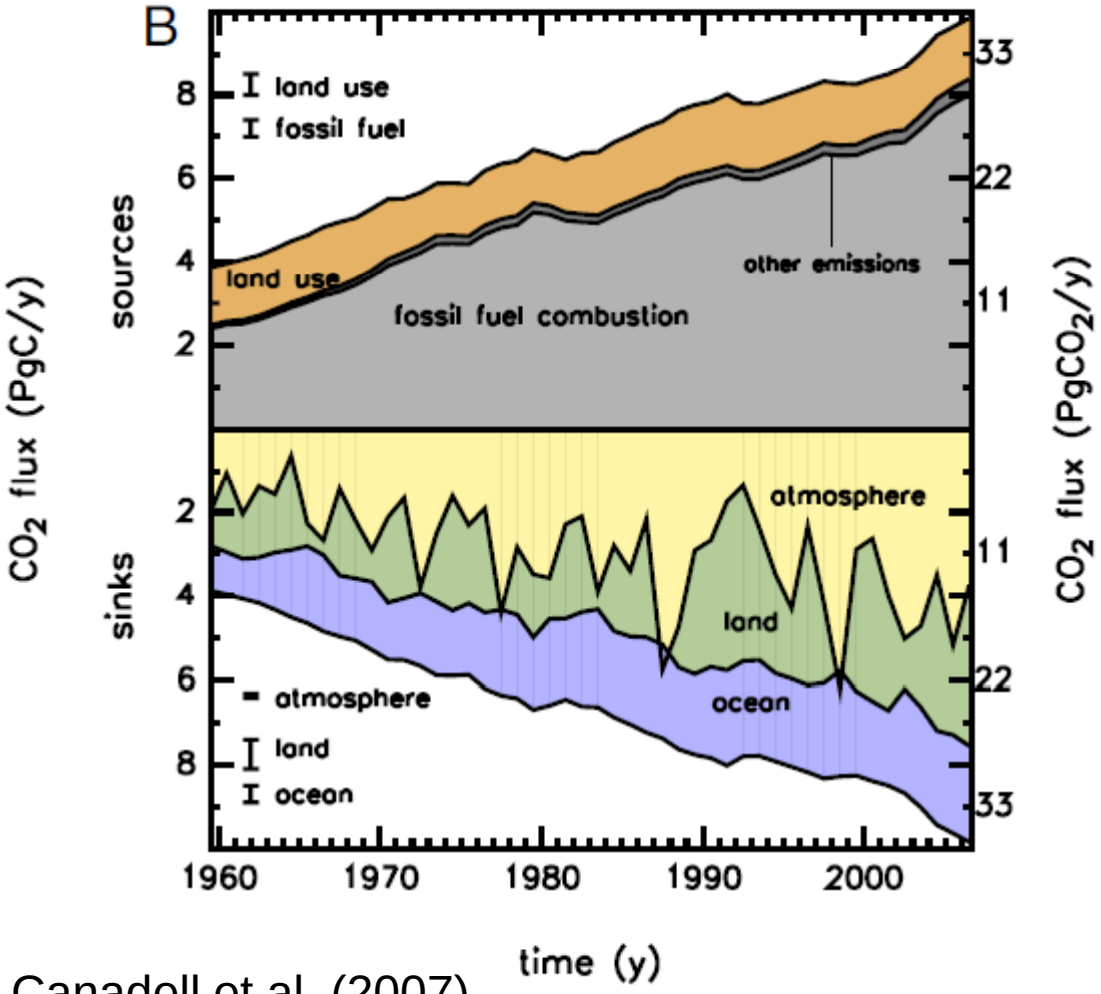
Contemporary Carbon Budget



IPCC (2007)

Oceanic sink: ~25% of total anthropogenic emission
Airborne Fraction (AF, ⊿CO2/Emission) ~ 0.4-0.5

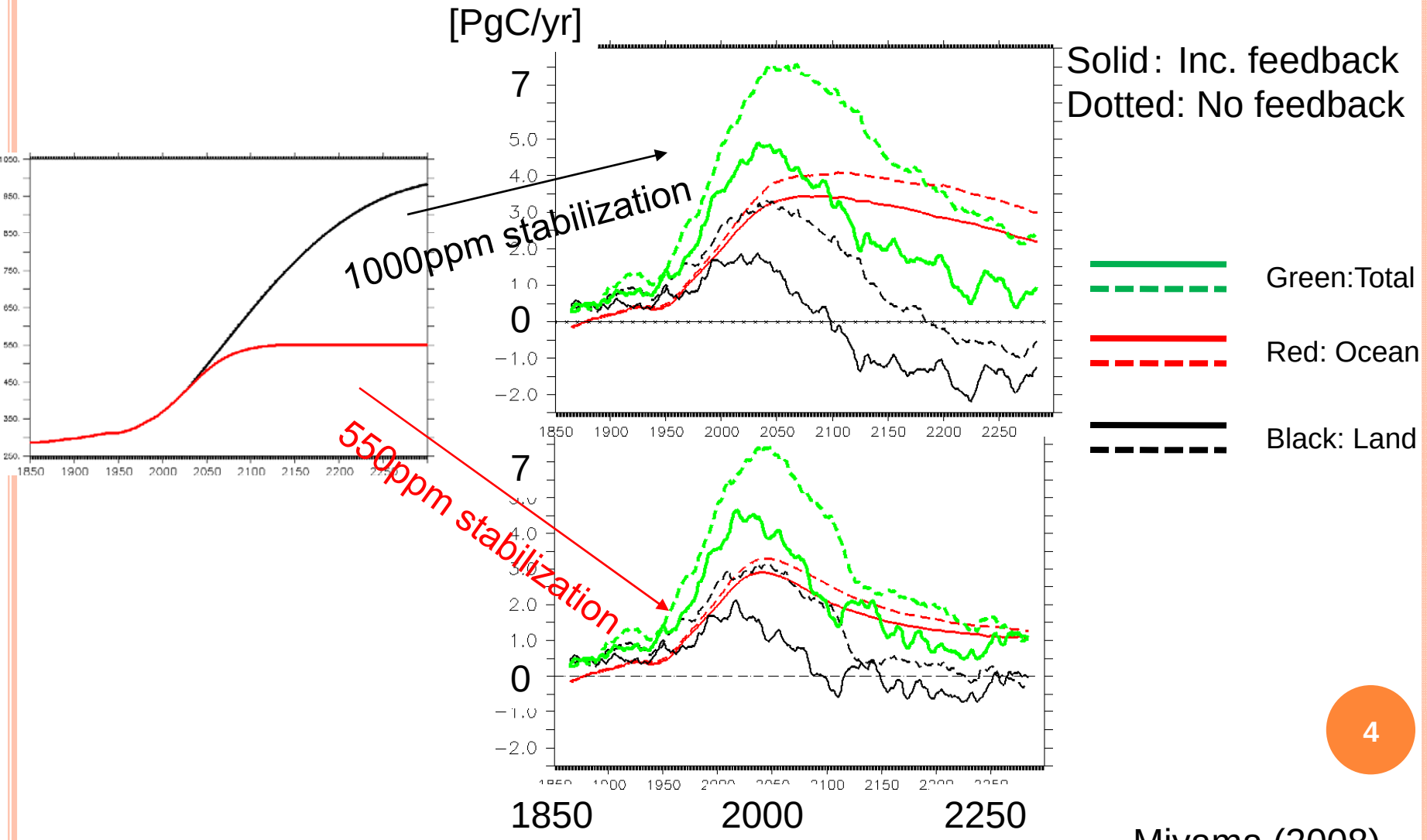
Temporal evolution of carbon budget



Canadell et al. (2007)

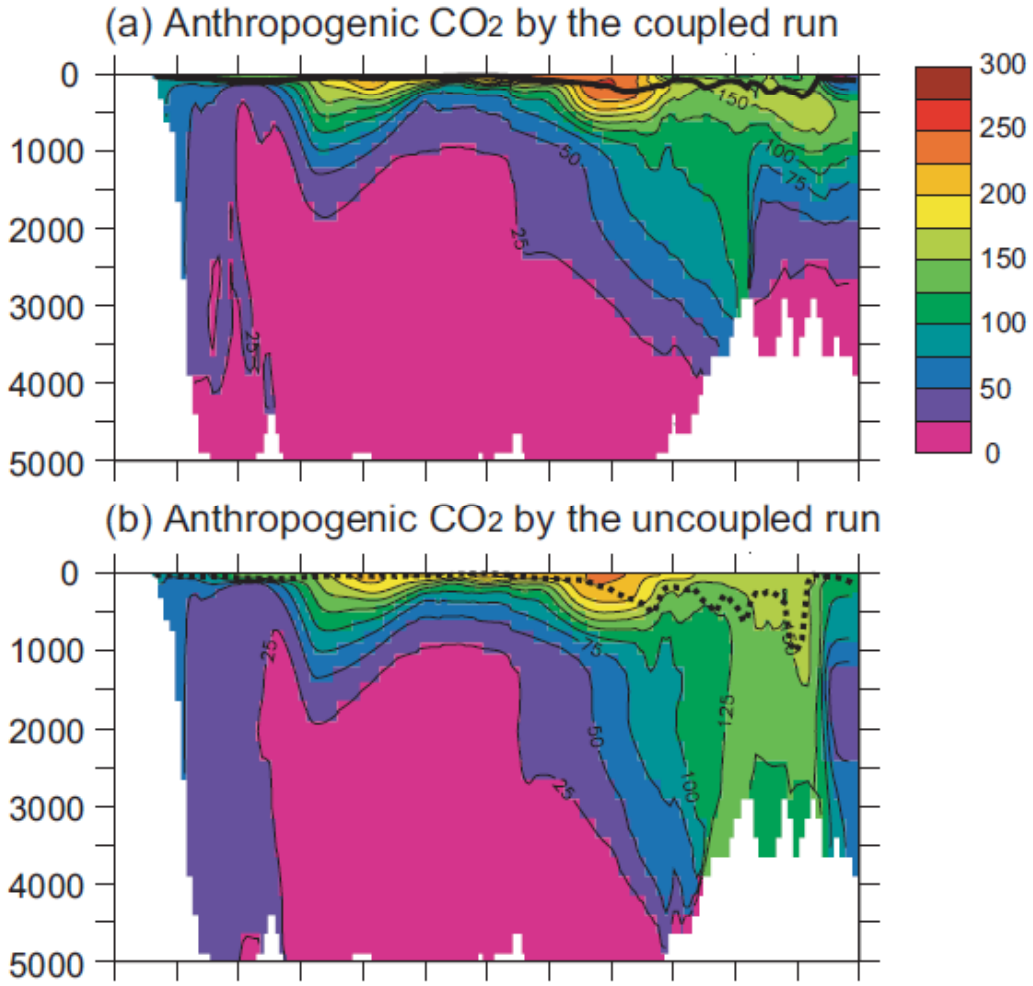
- Temporal evolution of the oceanic sink was computed by an OGCM, and that of the land was estimated as the residual.
- Year-to-year variations are dominated by the land sink.

Simulated CO2 uptake by land and ocean for stabilization scenarios



Miyama (2008)

Simulated impact of future warming on oceanic CO2 uptake (at year 2100)



Zonal mean for the Atlantic

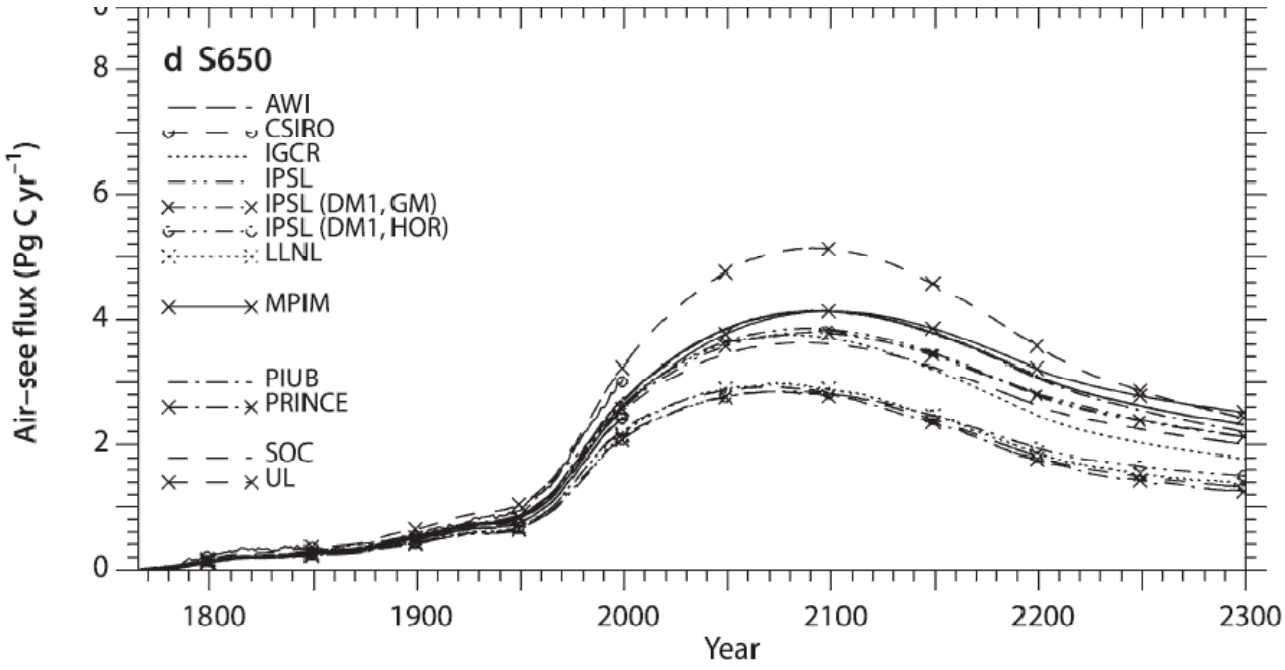
Inc. effects of warming

No warming

Yoshikawa et al. (2008)

MODEL-MODEL DIFFERENCES

An outstanding problem in ocean carbon cycle modeling:
Model-model difference of future CO2 uptake by the ocean



(result from OCMIP, Fasham et al., 2003)

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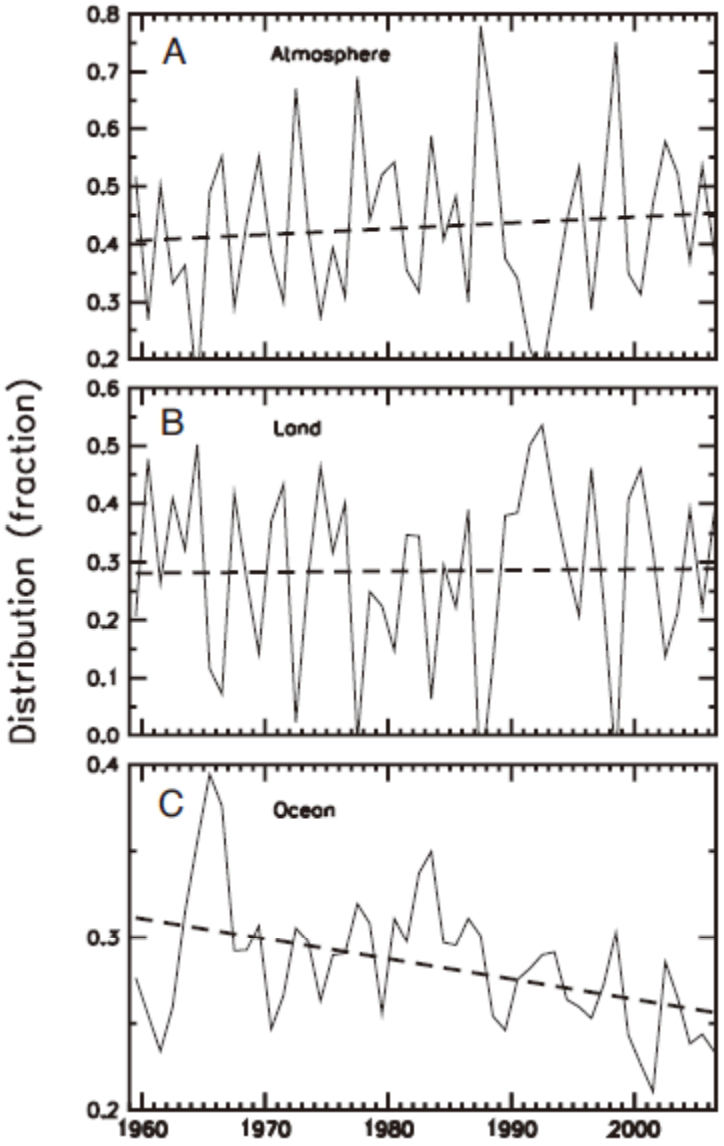
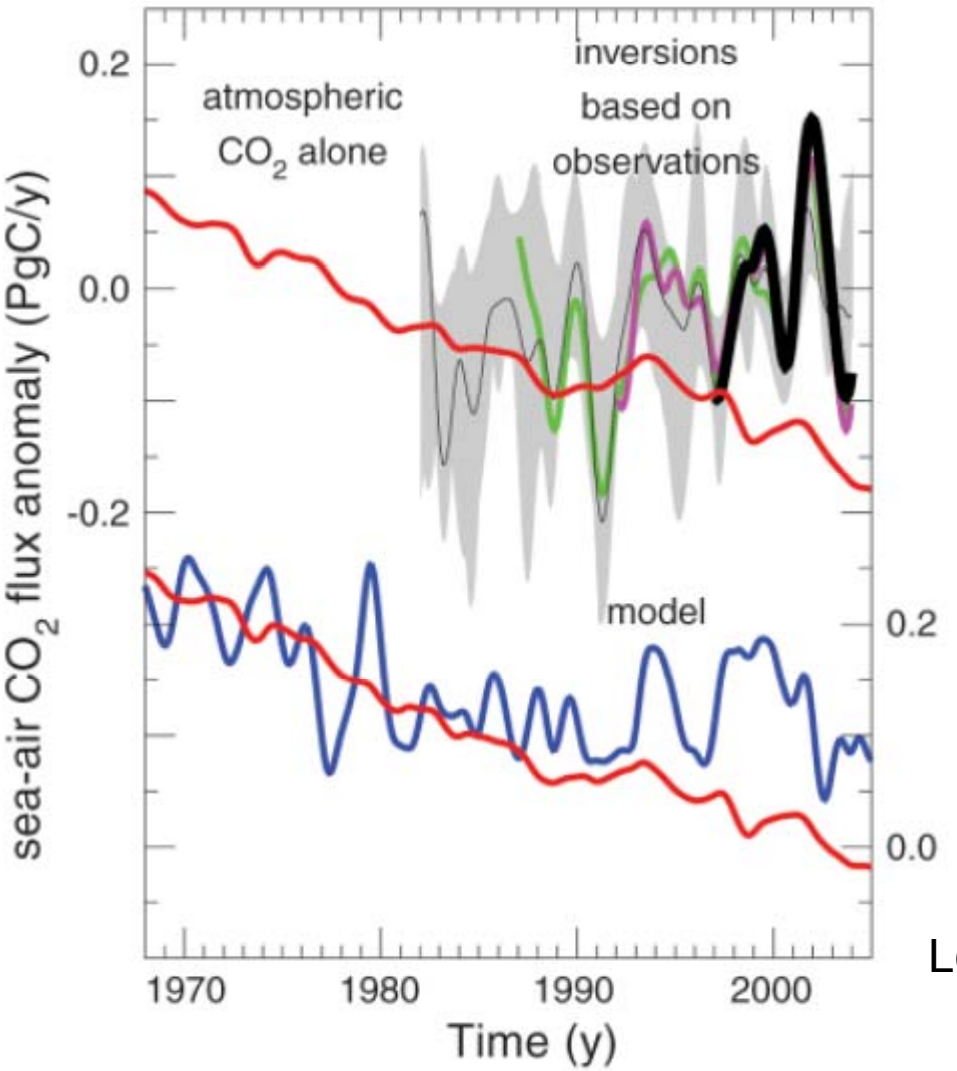
Airborne, land-uptake & ocean-uptake fraction

AF has a increasing trend of +0.25 ± 0.21 %/year, which is a reflection of decreasing trend in ocean uptake fraction.



Canadell et al. (2007)

Sea-air Co2 flux anomalies in the Southern Ocean



LeQuere et al. (2007)

Ocean acidification: Basic theory

-Formation of calcium carbonate by some plankton species

$$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 + H_2CO_3$$

-Dissolution of calcium carbonate

$$CaCO_3 \rightarrow Ca_2^+ + CO_3^{2-}$$

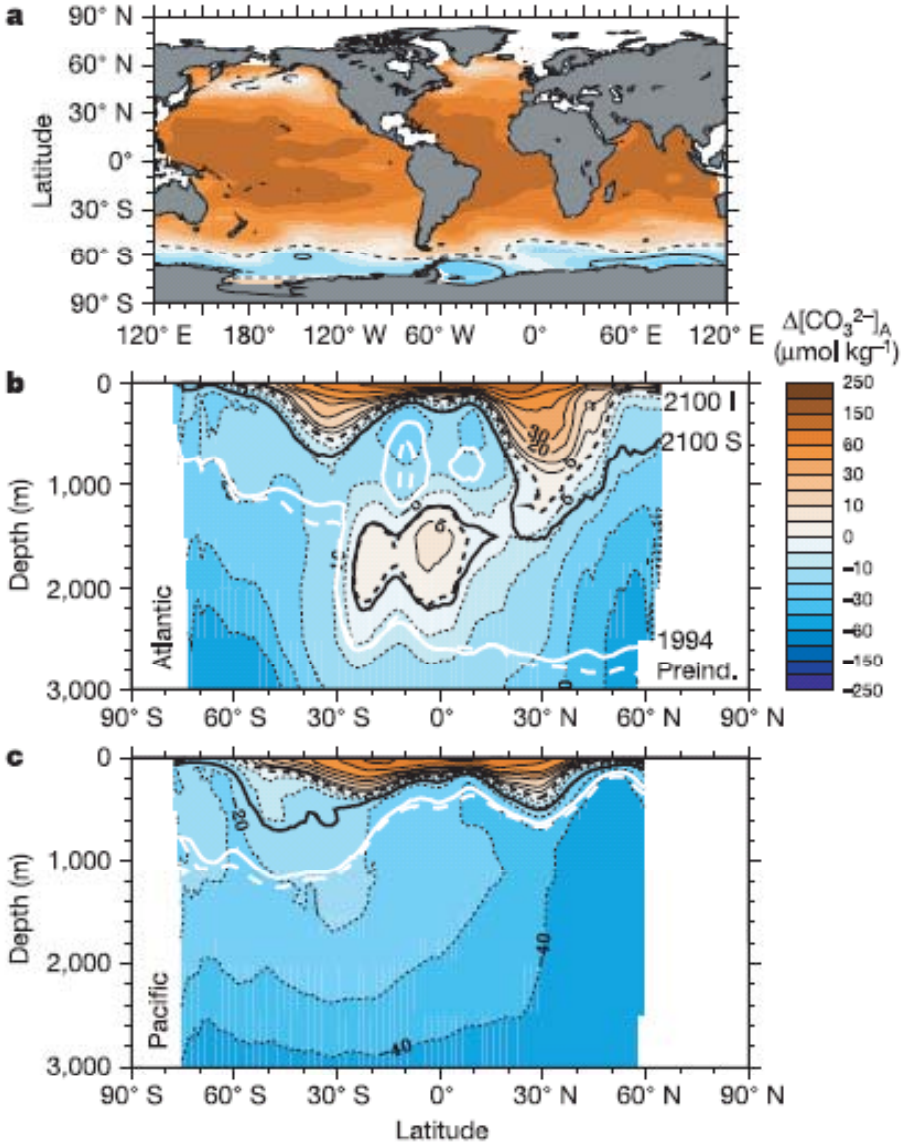
can only exist when $[CO_3^{2-}]$ is higher than $[CO_3^{2-}]_{sat}$

-Carbonate system

$$H_2O + CO_2 + CO_3^{2-} \leftrightarrow 2HCO_3^-$$

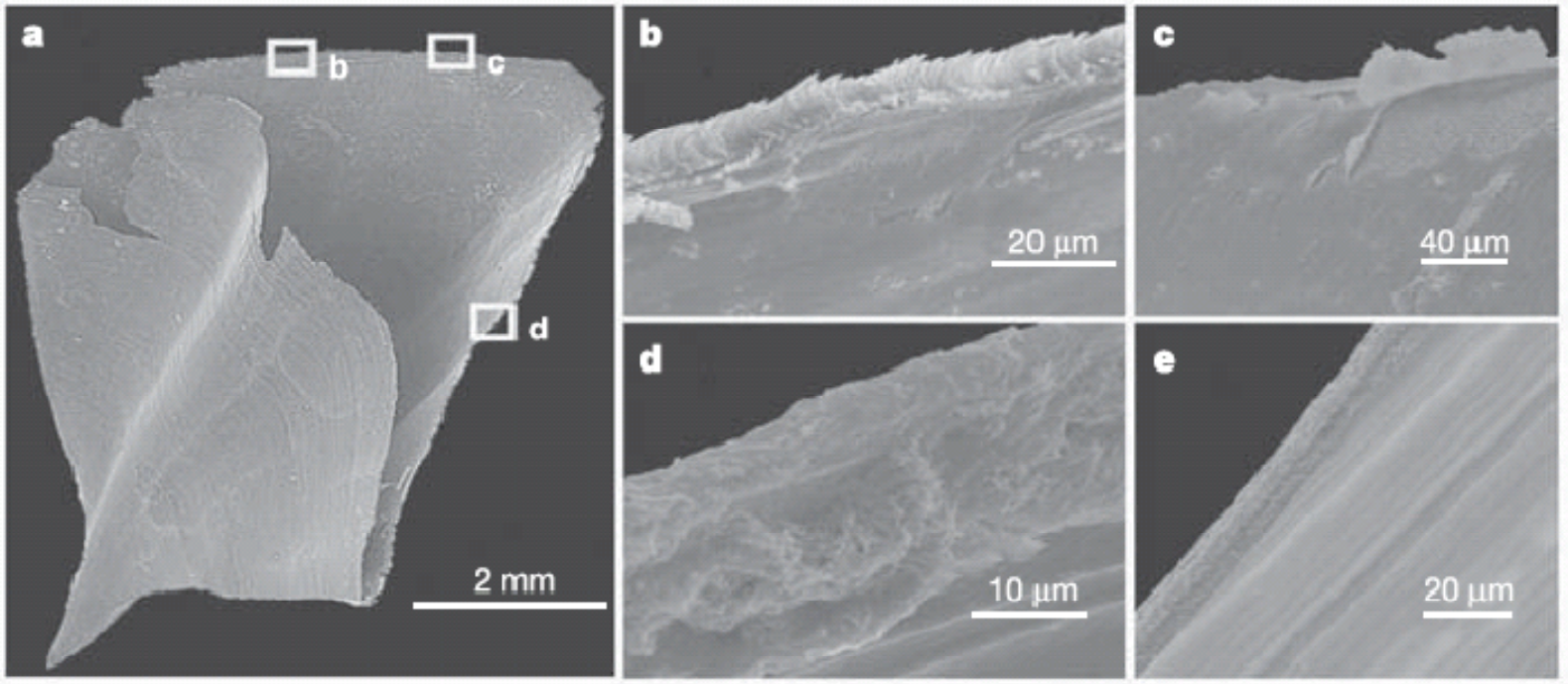
Distribution of undersaturated water at 2100

More blue area -> harmful for aragonite-forming planktons



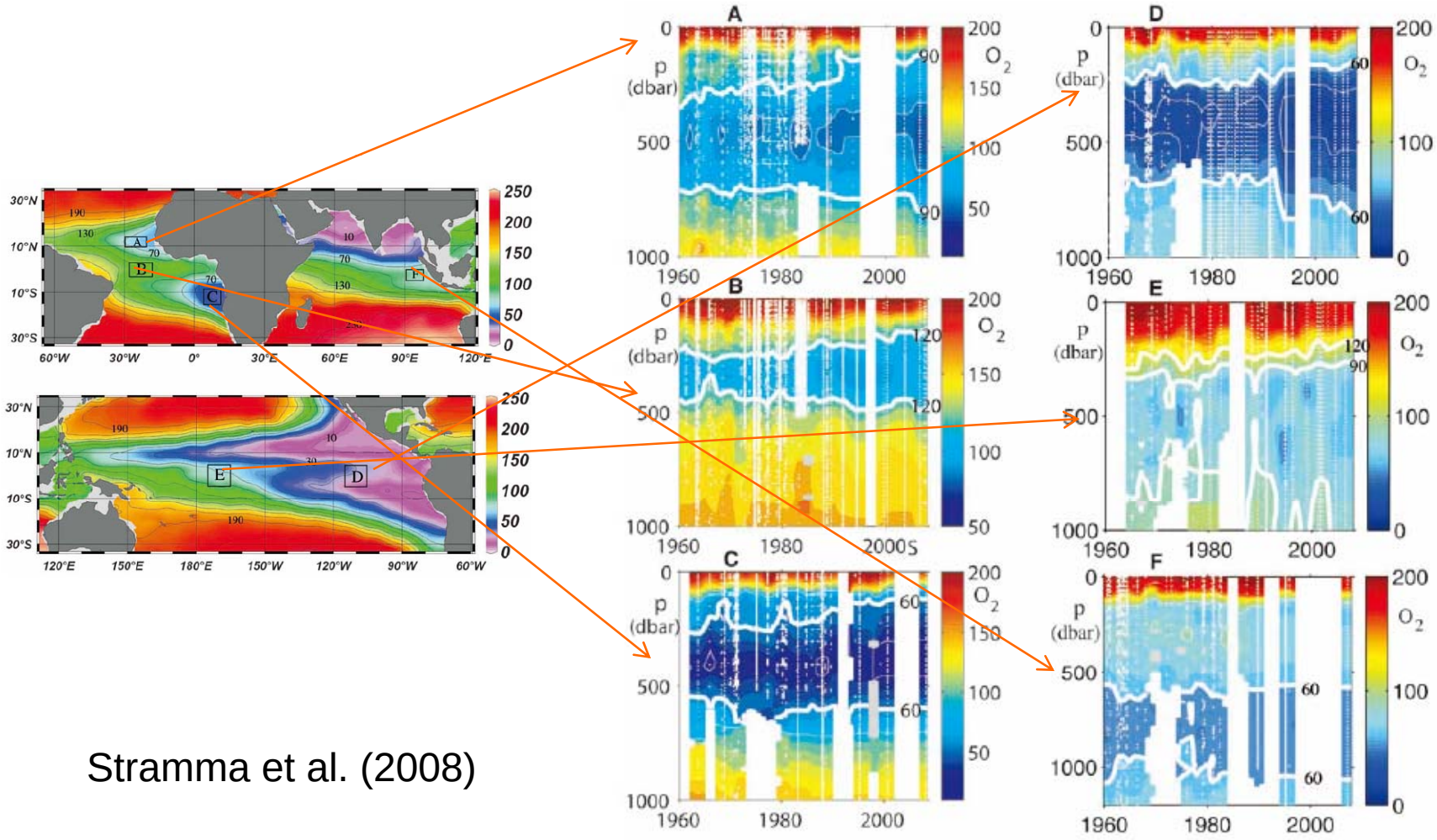
Orr et al. (2005)

Pteropods damaged by acidification



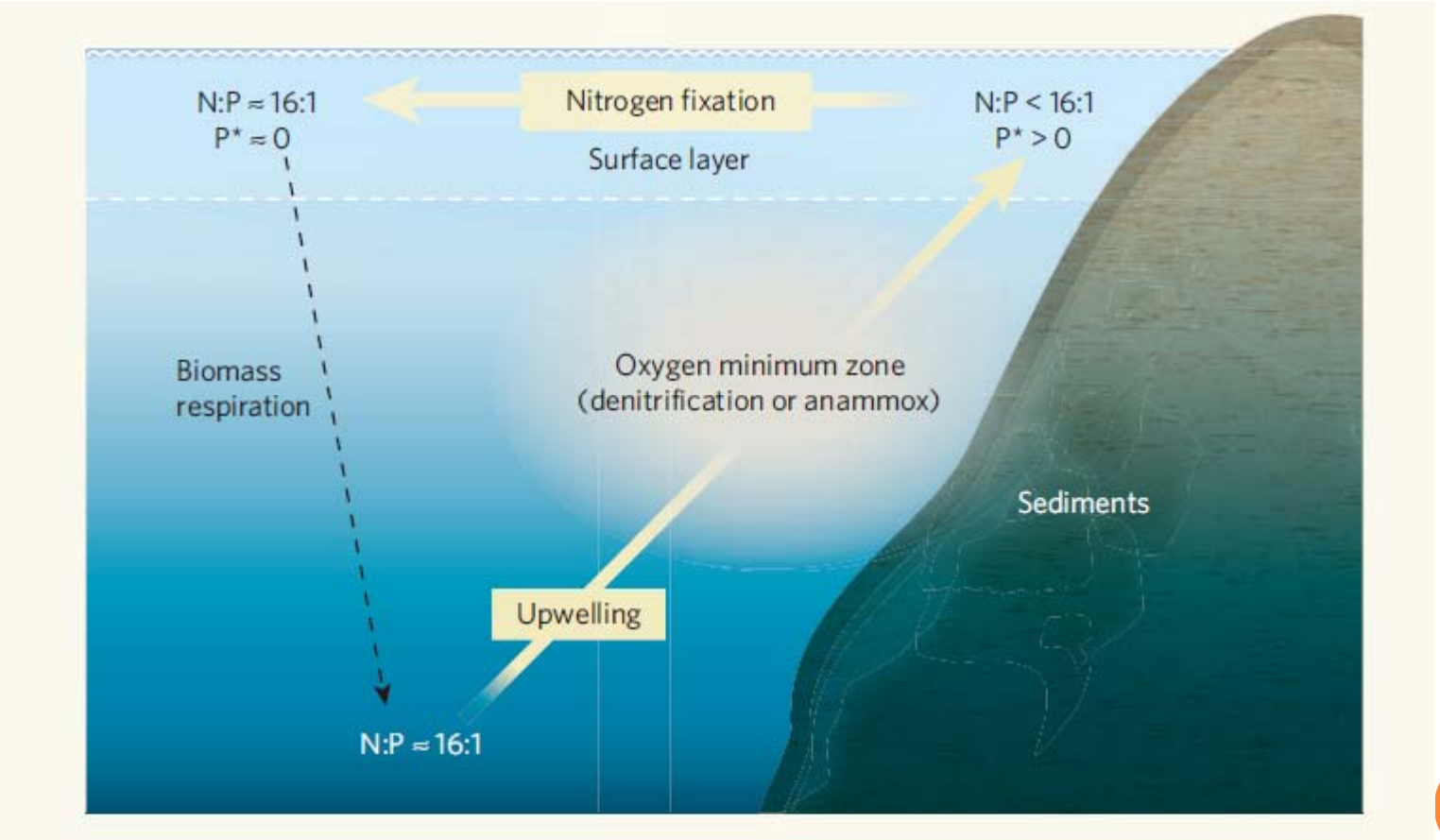
Orr et al. (2005)

OMZ is vertically expanding in the Atlantic and Pacific (but not in the Indian Ocean)



Stramma et al. (2008)

OMZ IS THE PLACE FOR DENITRIFICATION AND N2O PRODUCTION.



Capone and Knapp (2007)

Summary

- GCM calculations suggest that the ocean will continue to be a stable sink for anthropogenic CO2, though there are significant model-model differences regarding the absolute values.
- The GCM calculations include some of the effects of climate change that potentially collapse oceanic carbon sink, e.g., temperature effect on the carbonate system.
- Unaddressed in the GCM calculations are:
  - changes in wind due to stratospheric O3 variations
  - impact of acidification and expanded OMZ on GHG dynamics
  - etc.