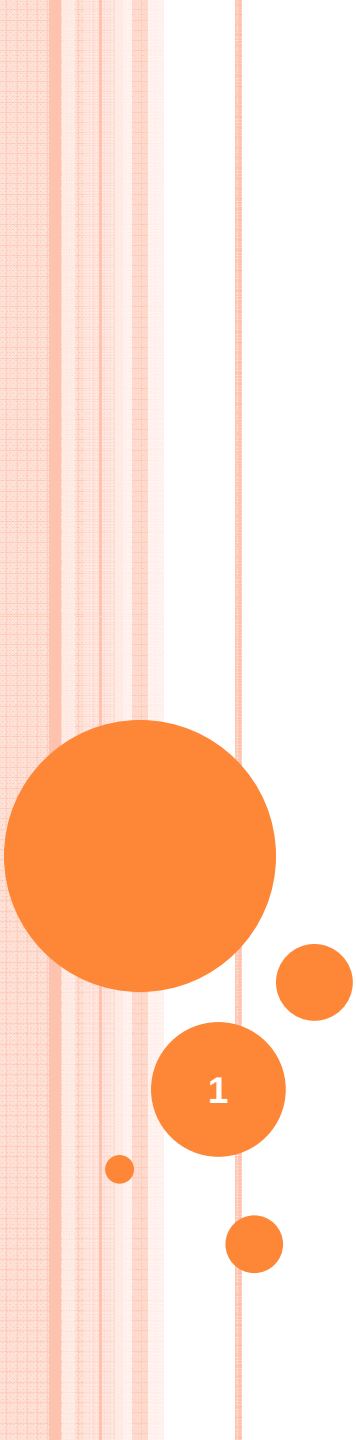




HOKKAIDO UNIVERSITY

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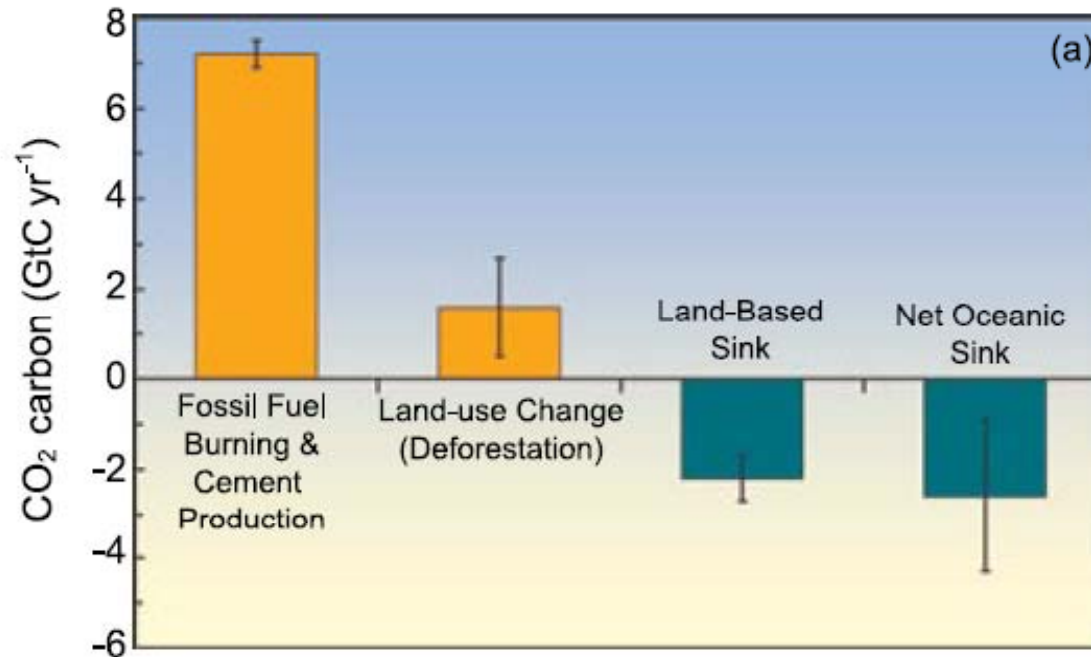
CHANGES OF THE OCEAN CARBON CYCLE AND ECOSYSTEMS

Michio Kawamiya

Frontier Research Center for Global Change /
Japan Agency for Marine-Earth Science and
Technology

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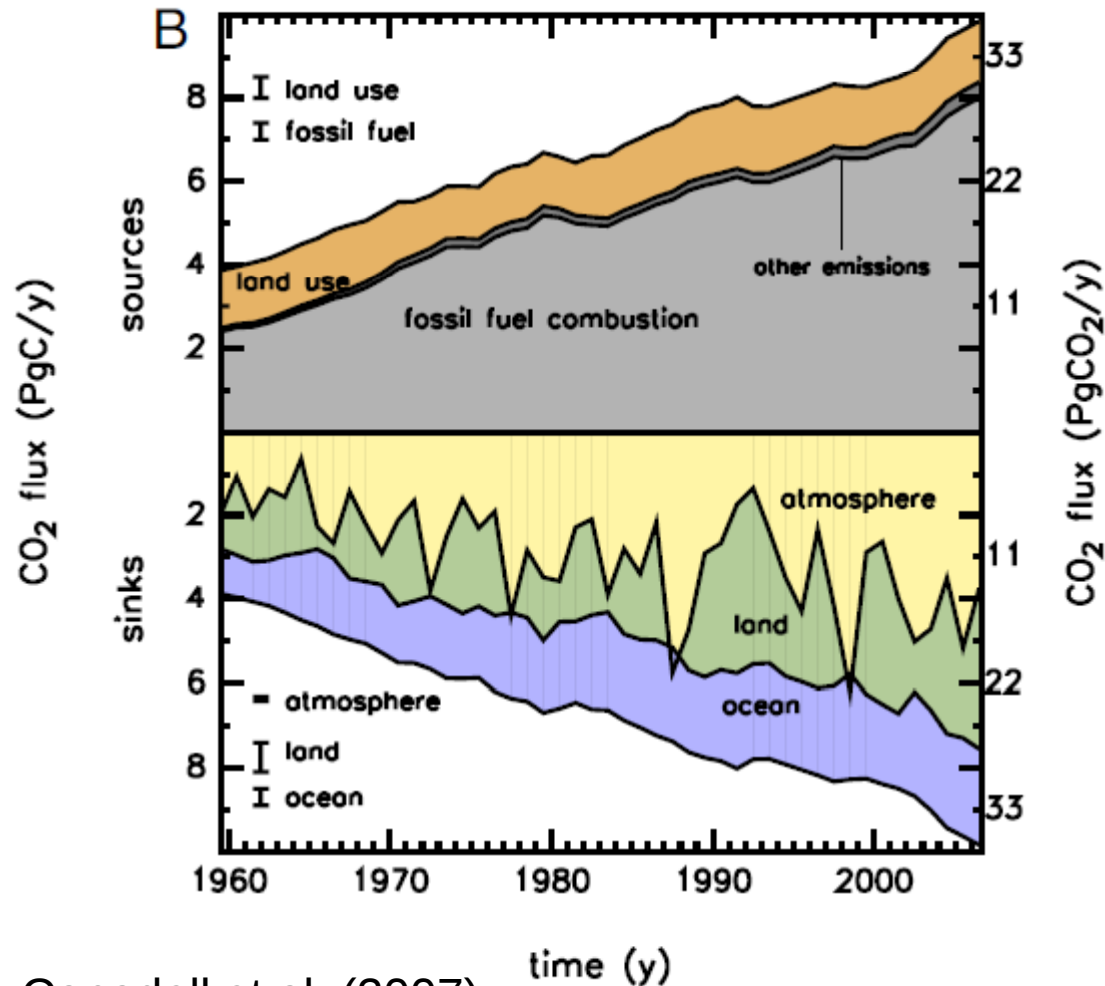
CONTEMPORARY CARBON BUDGET



IPCC (2007)

Oceanic sink: ~25% of total anthropogenic emission
Airborne Fraction (AF, $\Delta\text{CO}_2/\text{Emission}$) ~ 0.4-0.5

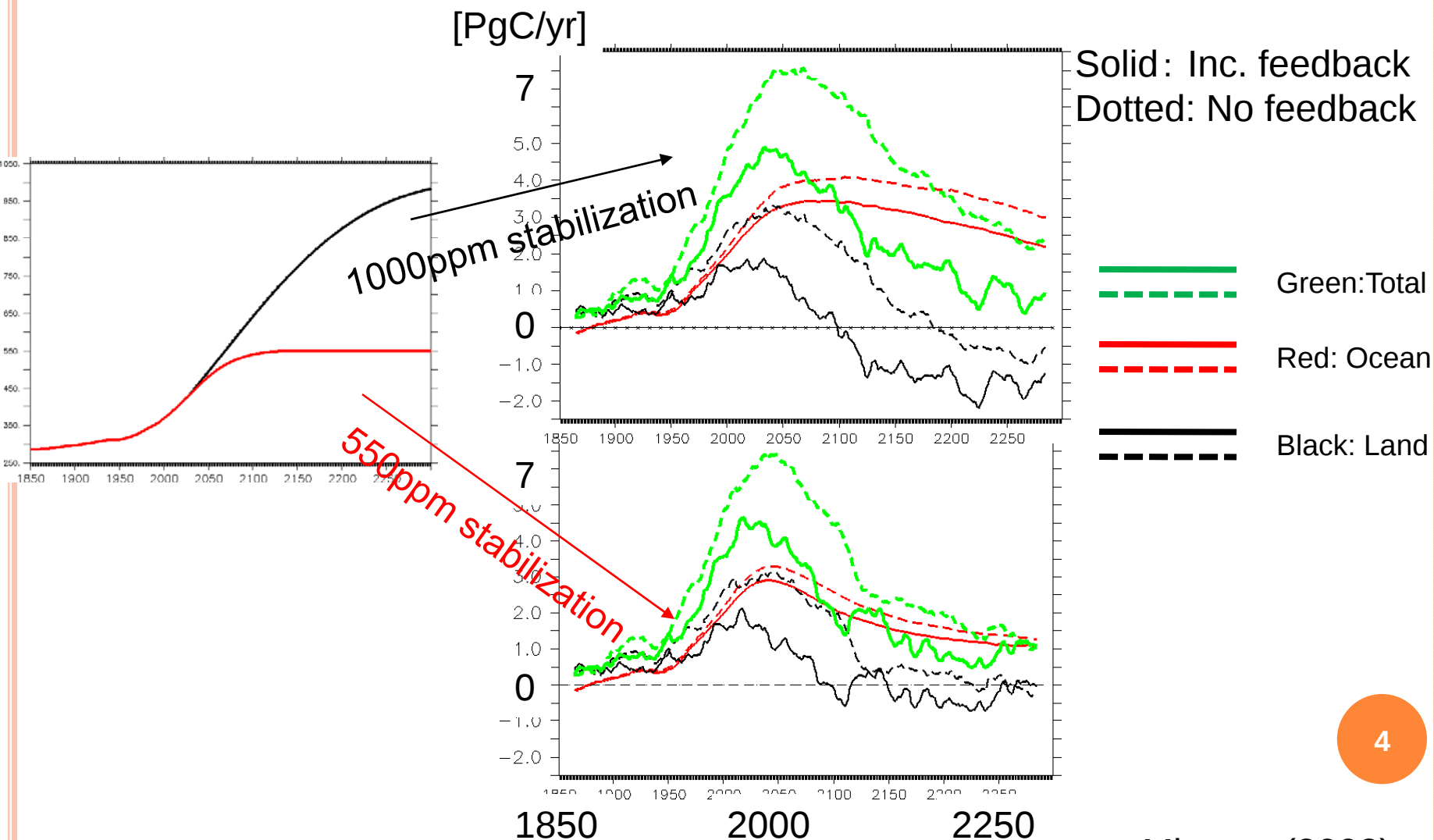
TEMPORAL EVOLUTION OF CARBON BUDGET



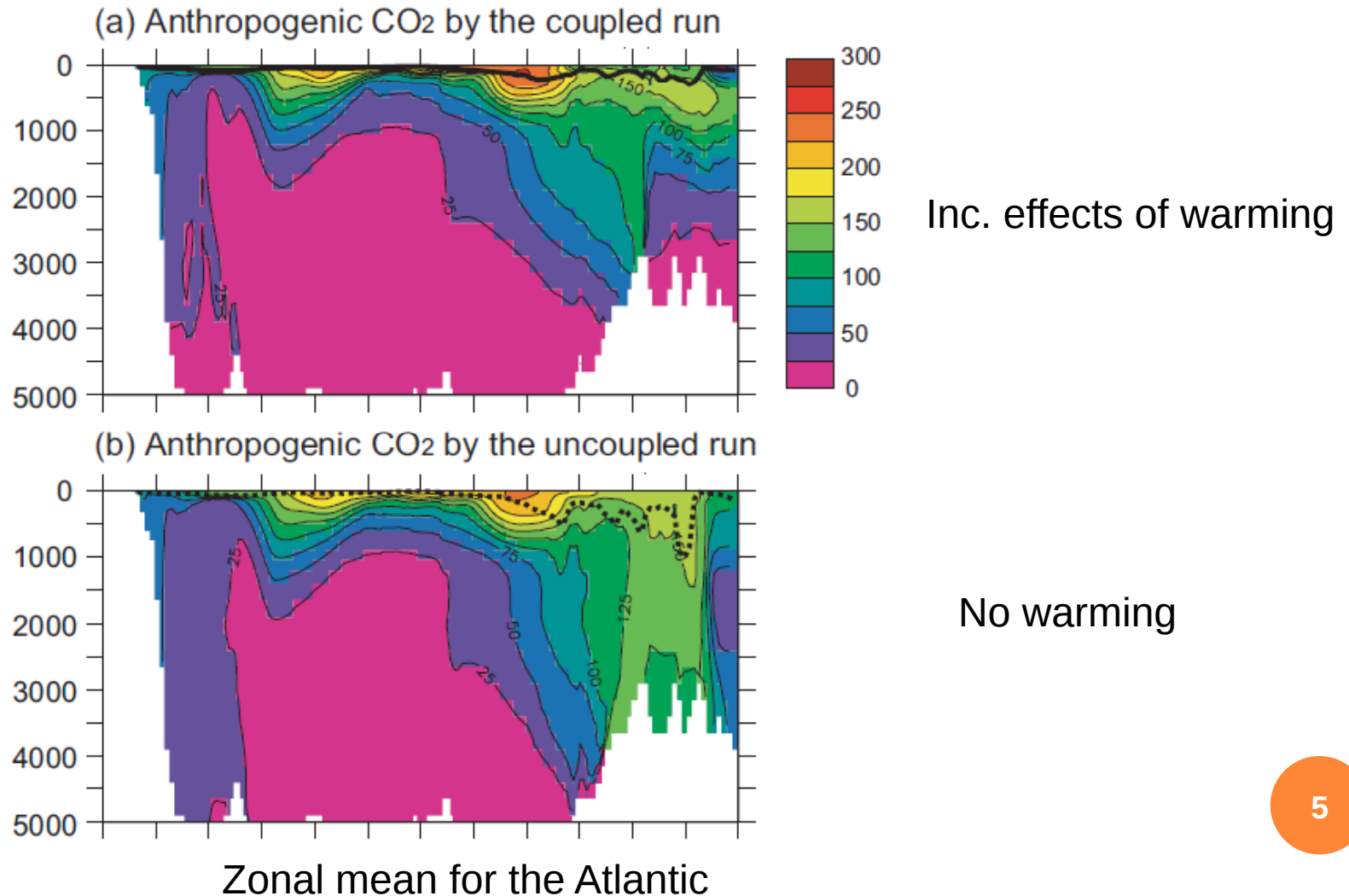
- Temporal evolution of the oceanic sink was computed by an OGCM, and that of the land was estimated as the residual.

- Year-to-year variations are dominated by the land sink.

SIMULATED CO₂ UPTAKE BY LAND AND OCEAN FOR STABILIZATION SCENARIOS

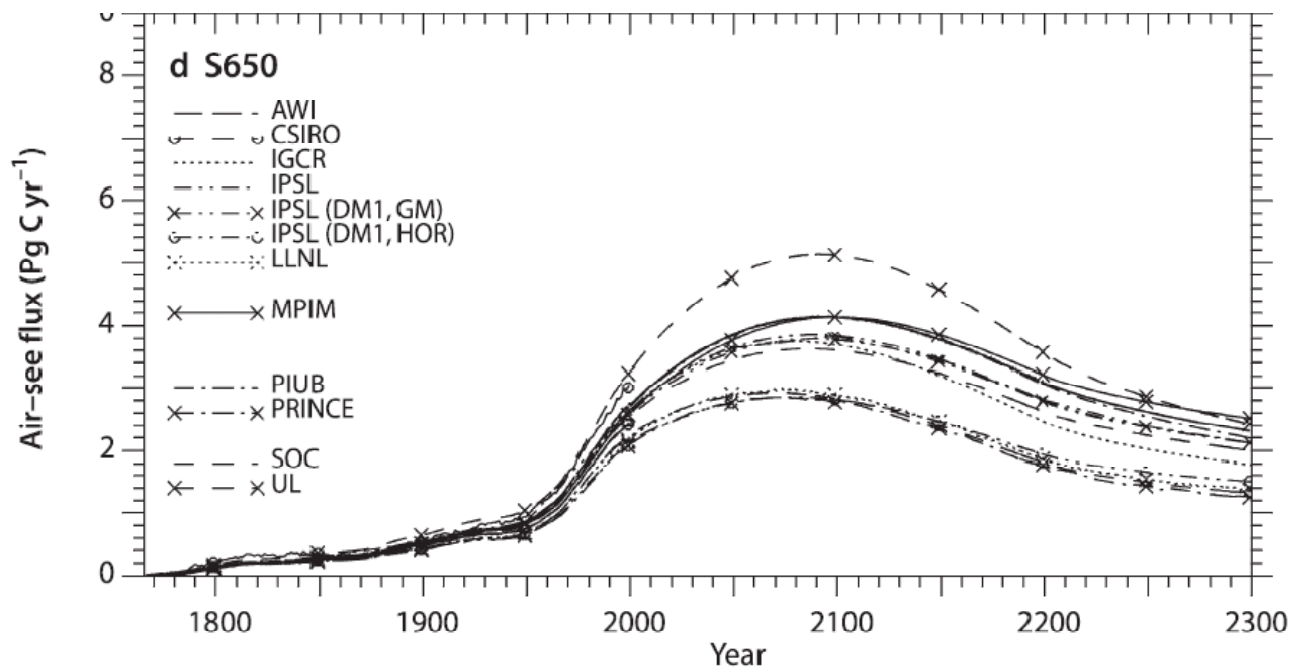


SIMULATED IMPACT OF FUTURE WARMING ON OCEANIC CO₂ UPTAKE (AT YEAR 2100)



MODEL-MODEL DIFFERENCES

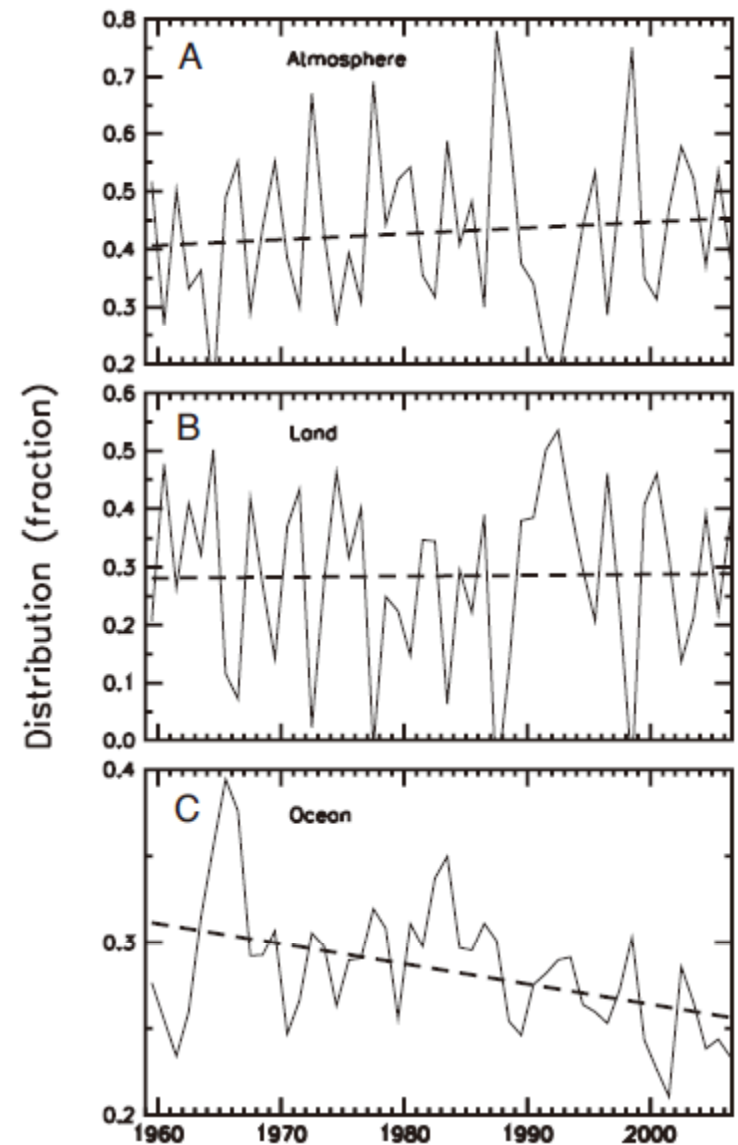
An outstanding problem in ocean carbon cycle modeling:
Model-model difference of future CO₂ uptake by the ocean



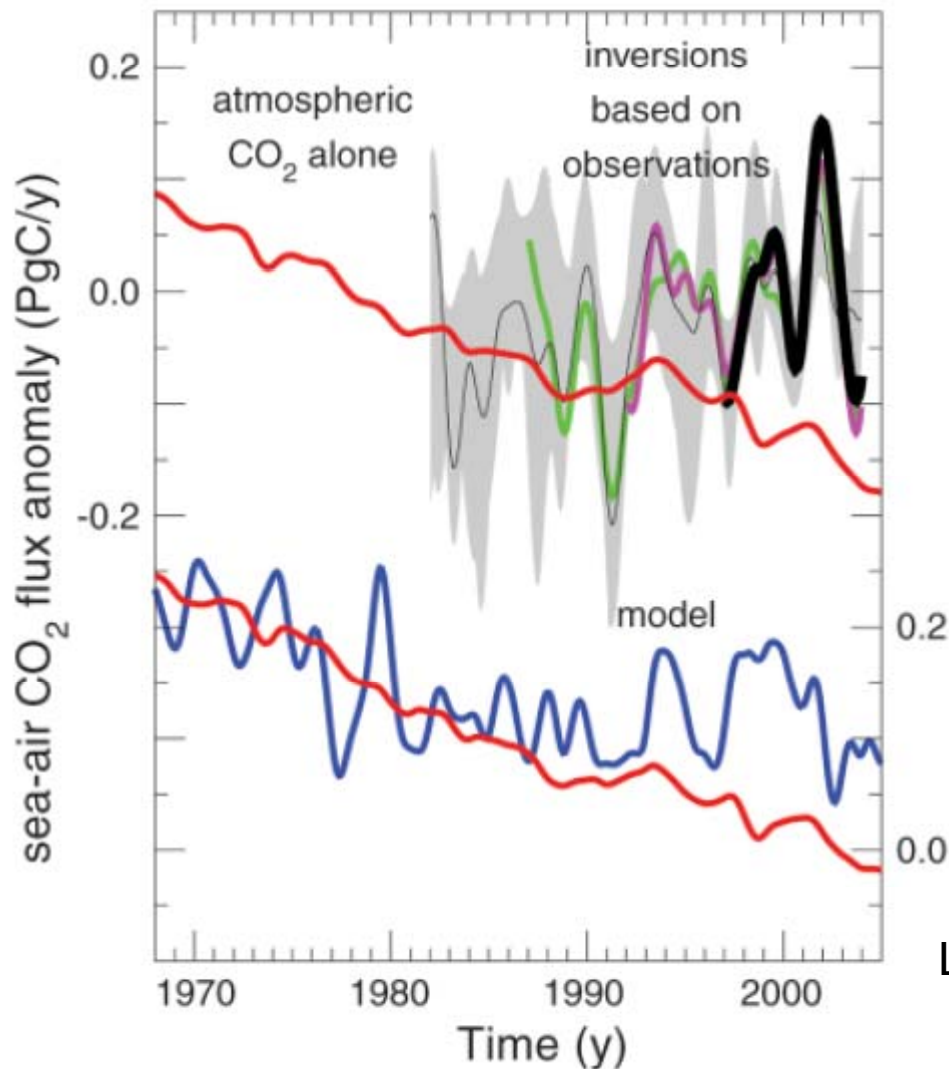
(result from OCMIP, Fasham et al., 2003)

AIRBORNE, LAND-UPTAKE & OCEAN- UPTAKE FRACTION

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



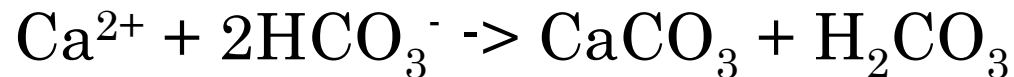
SEA-AIR CO₂ FLUX ANOMALIES IN THE SOUTHERN OCEAN



LeQuere et al. (2007)

OCEAN ACIDIFICATION: BASIC THEORY

-Formation of calcium carbonate by some plankton species



-Dissolution of calcium carbonate



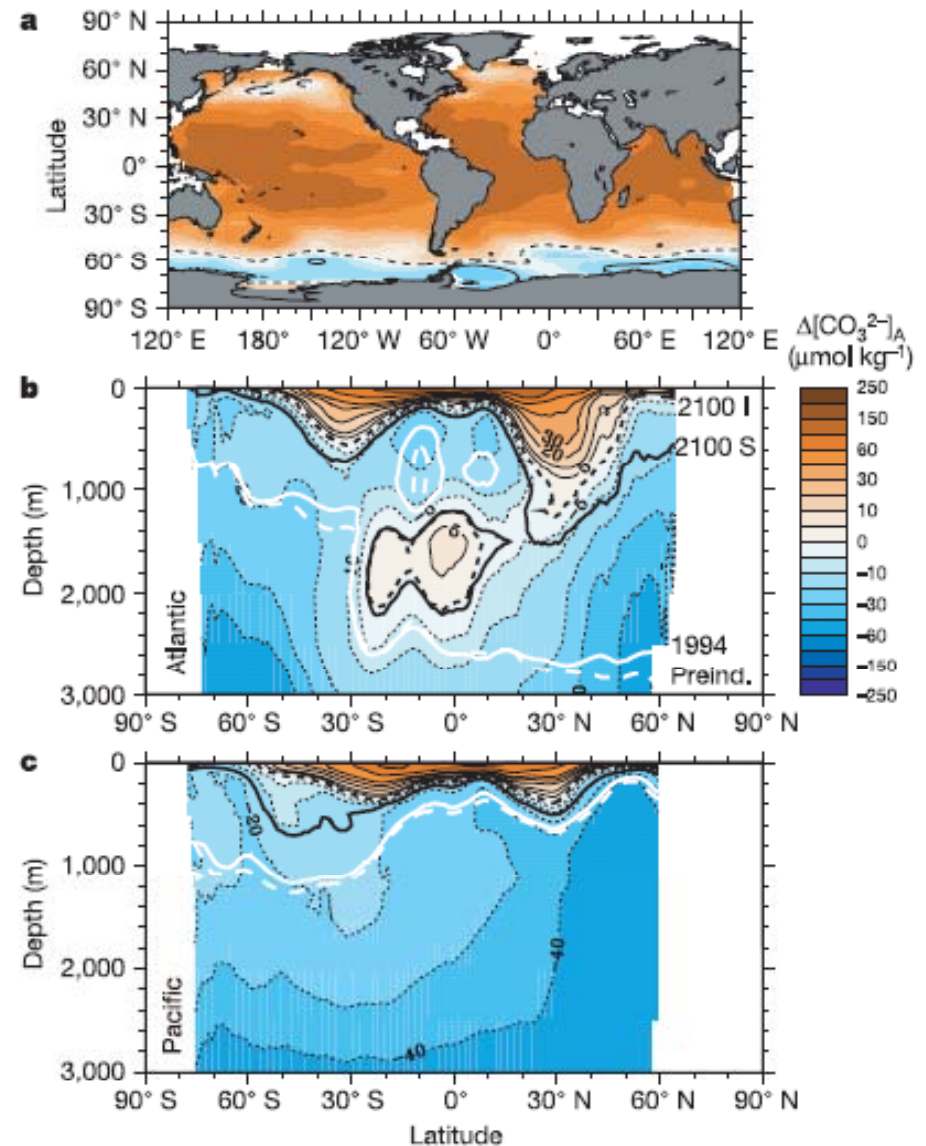
can only exist when $[\text{CO}_3^{2-}]$ is higher than $[\text{CO}_3^{2-}]_{\text{sat}}$

-Carbonate system



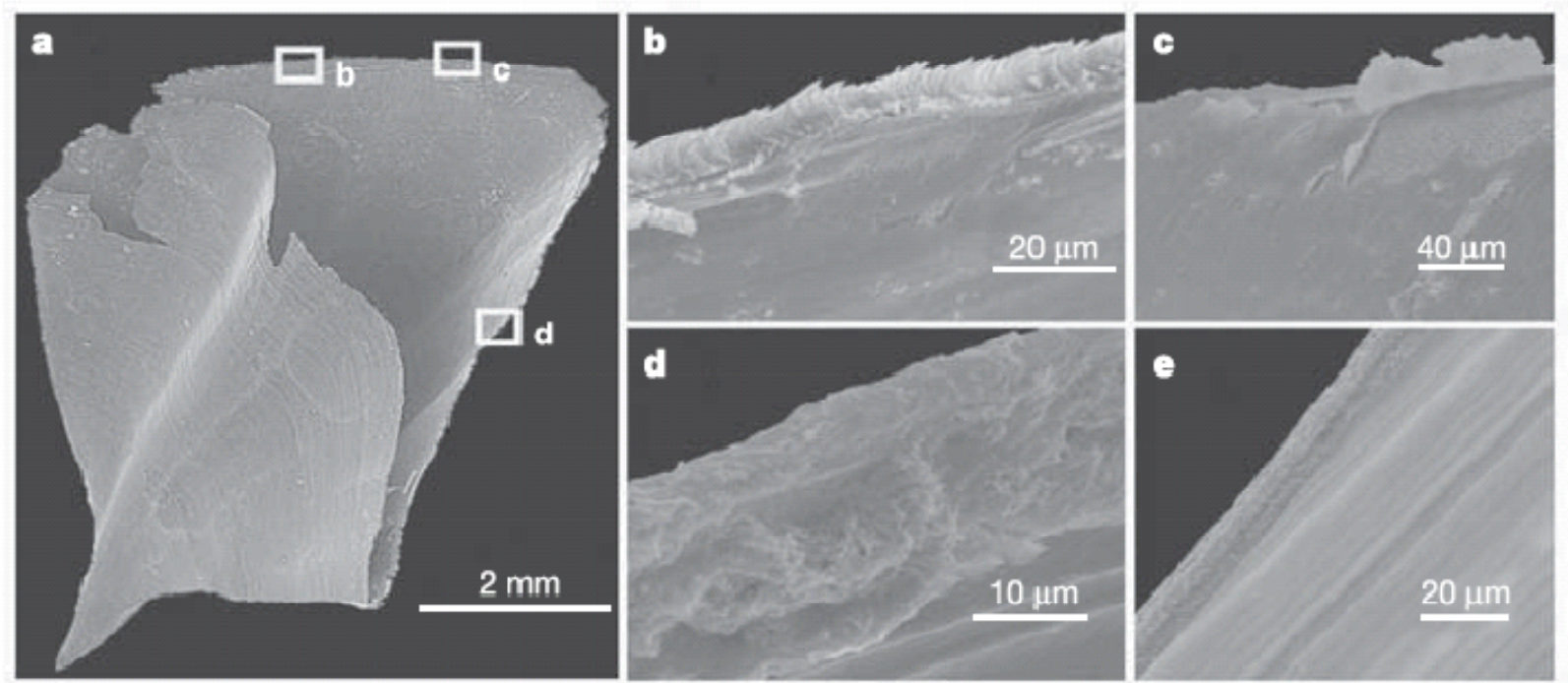
DISTRIBUTION OF UNDERSATURATED WATER AT 2100

More blue area -> harmful
for aragonite-forming
planktons

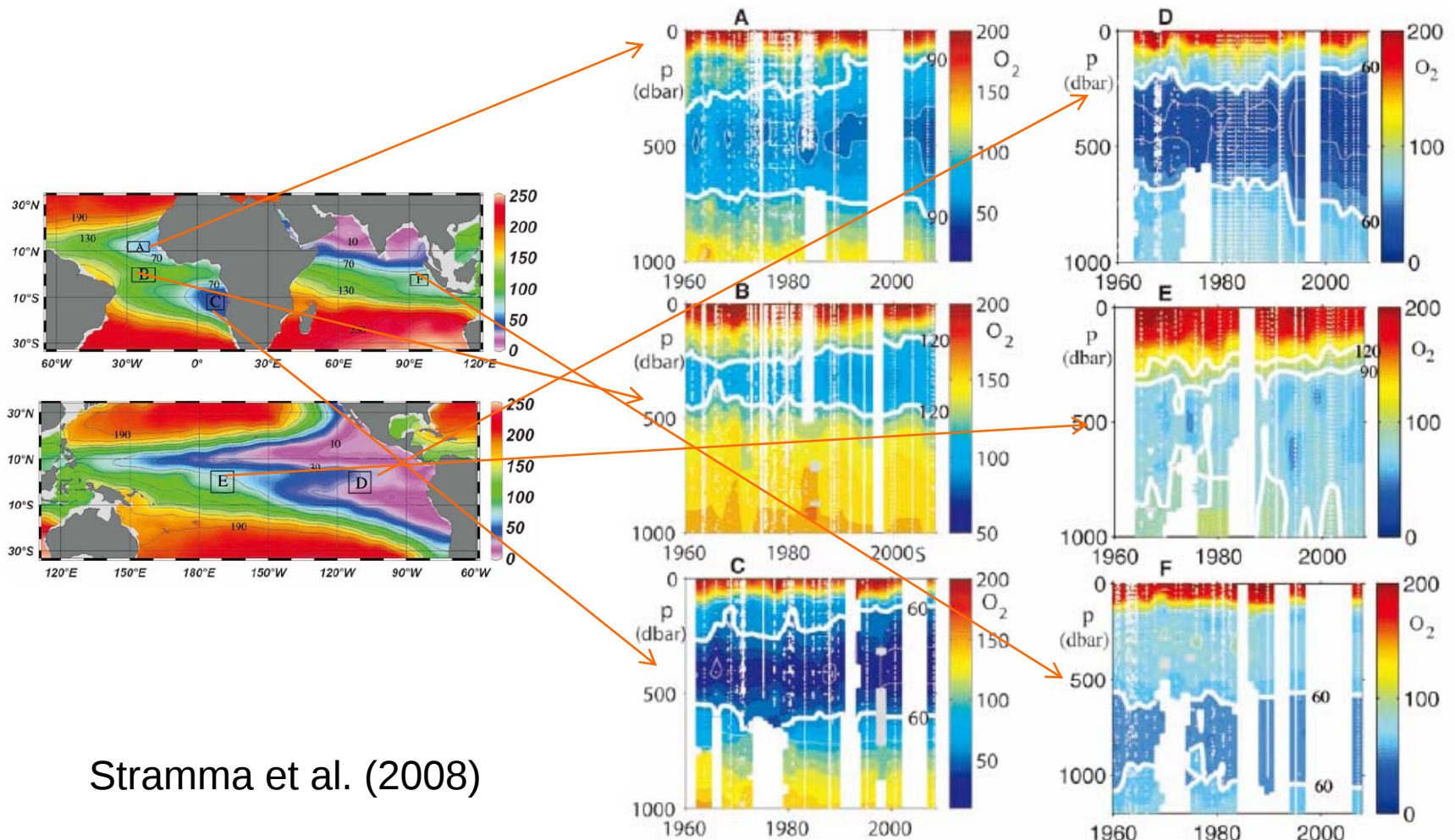


Orr et al. (2005)

PTEROPODS DAMAGED BY ACIDIFICATION

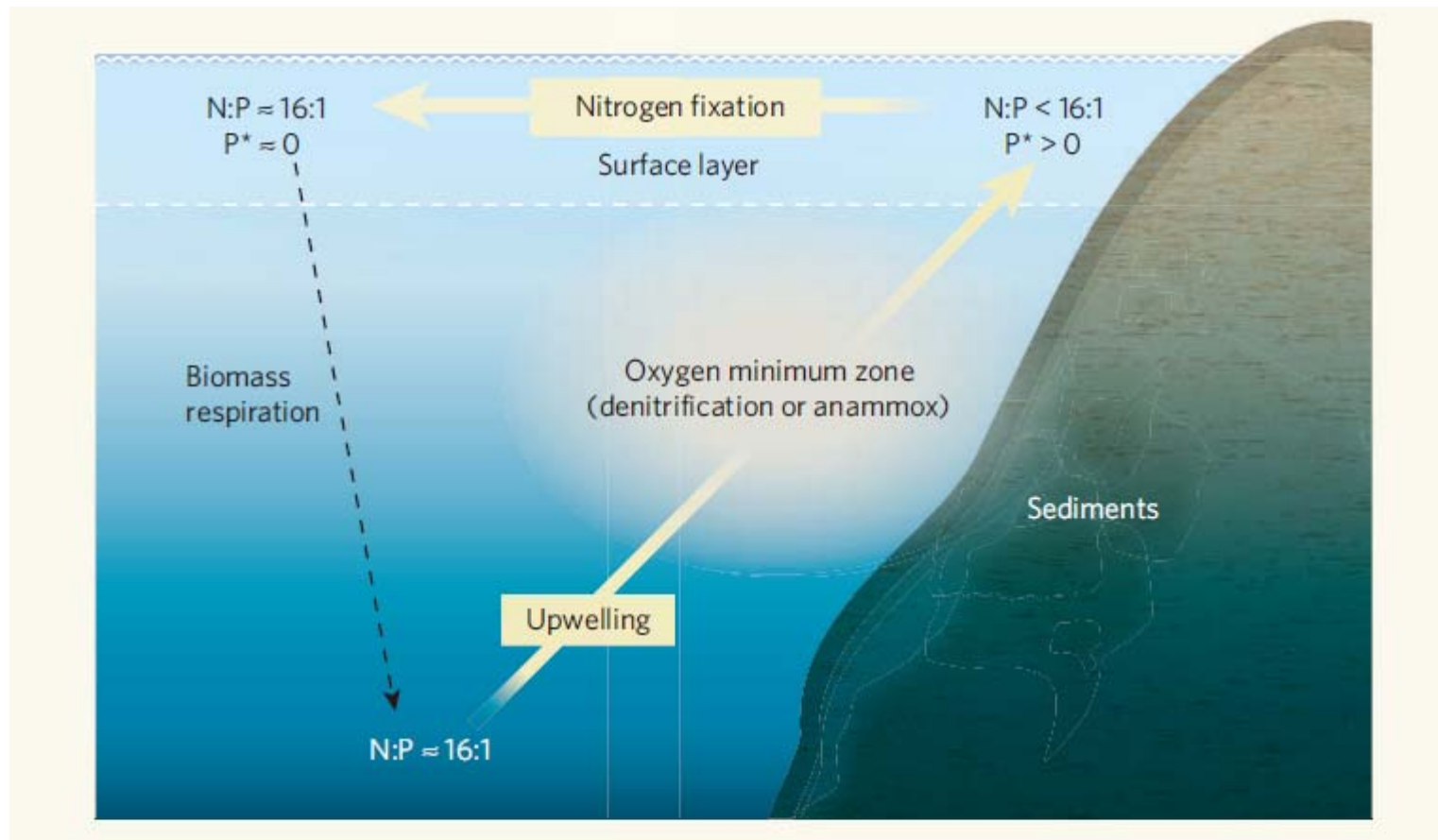


OMZ IS VERTICALLY EXPANDING IN THE ATLANTIC AND PACIFIC (BUT NOT IN THE INDIAN OCEAN)



Stramma et al. (2008)

OMZ IS THE PLACE FOR DENITRIFICATION AND N₂O PRODUCTION.



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.