Geophysical Fluid Dynamics Laboratory Review

June 30 - July 2, 2009

Ocean Ecology and Biogeochemistry in GFDL's Earth System Model

Presented by

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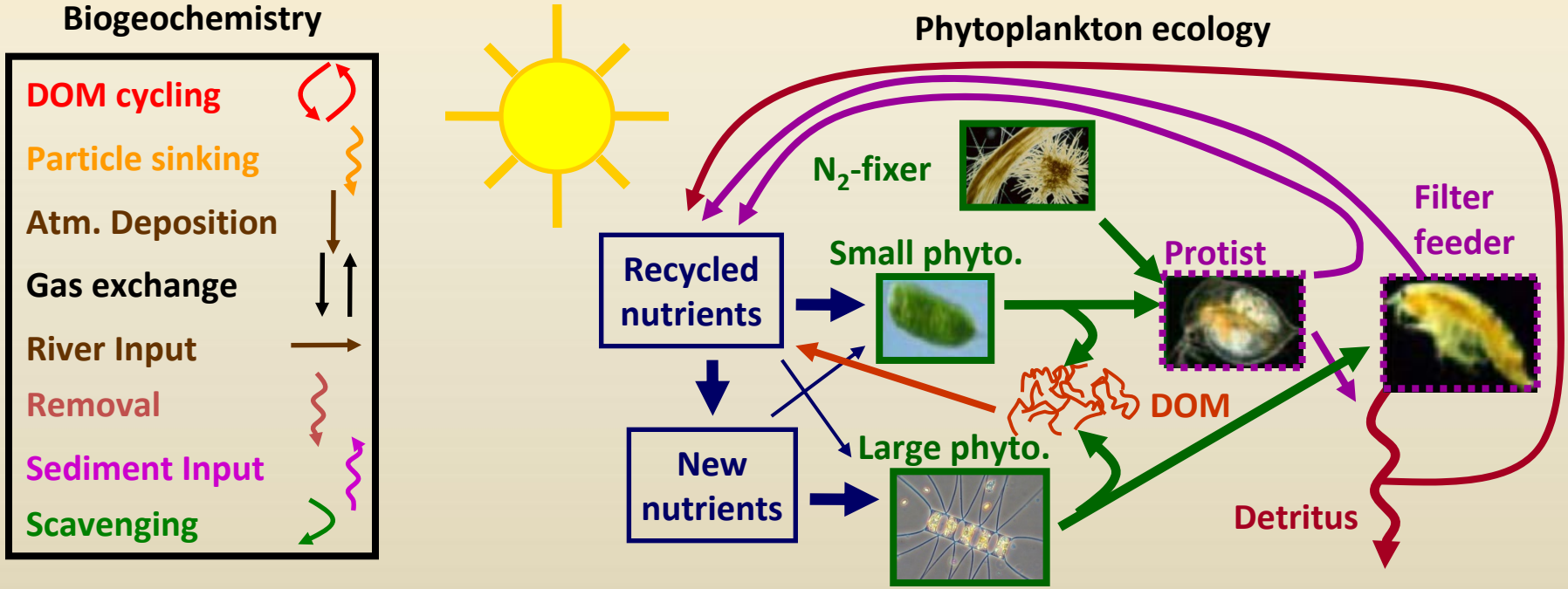
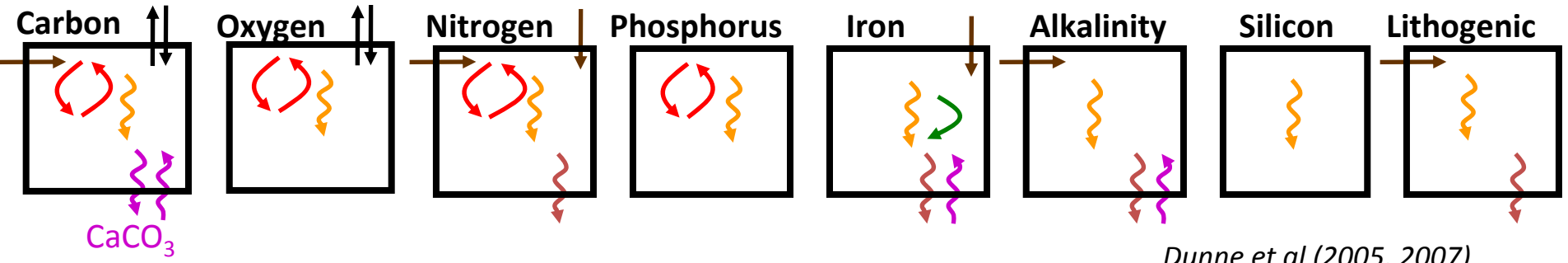
Ocean Ecology and Biogeochemistry in GFDL's Earth System Model

- TOPAZ representation of the Carbon Cycle
- Results of 'HISTORICAL' ocean/ice simulation forced by atmospheric reanalysis (Common Ocean Reference Experiment Inter-annually variable forcing version 2)
- Results of ESM2.1 IPCC SRES A1B simulation

Tracers Of Phytoplankton with Allometric Zooplankton (TOPAZ) simulates the mechanisms that control the ocean carbon cycle

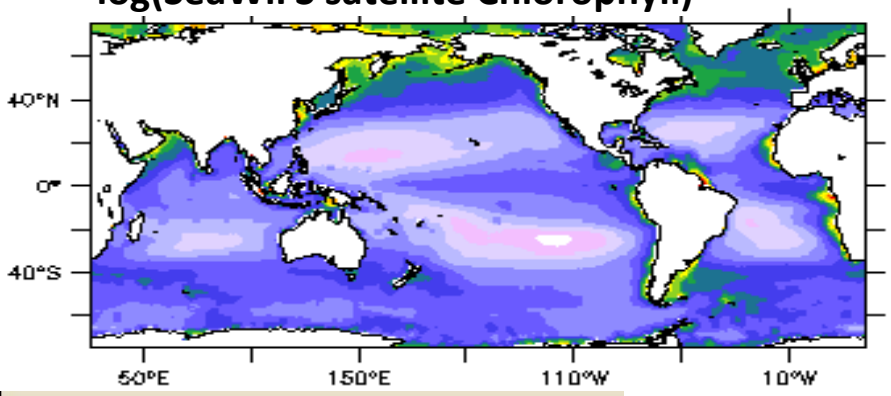




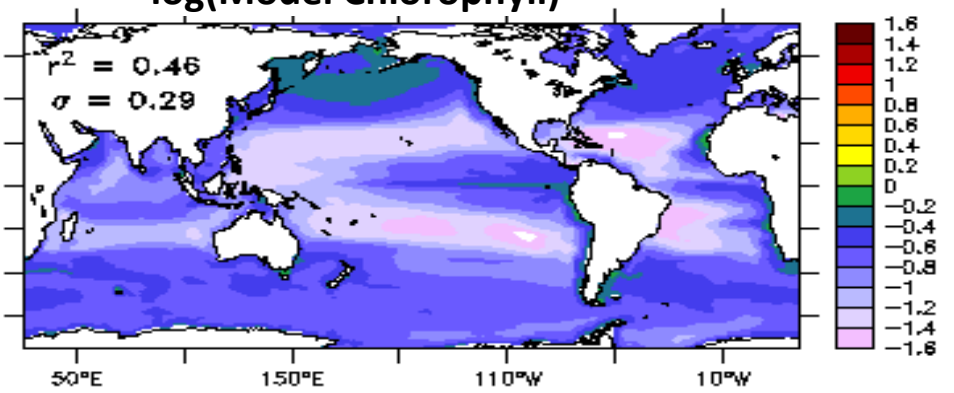
Dunne et al (2005, 2007)

HISTORICAL simulation reproduces SeaWiFS chlorophyll variability and puts it in a multidecadal context

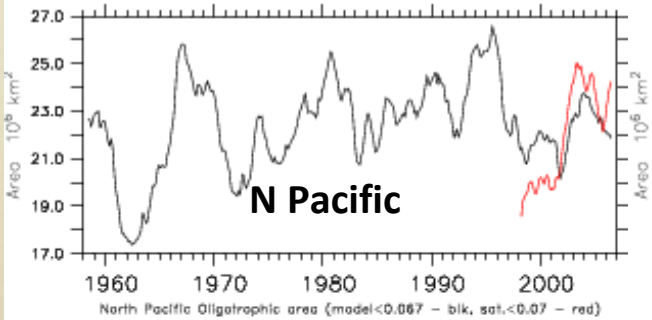
log(SeaWiFS satellite Chlorophyll)

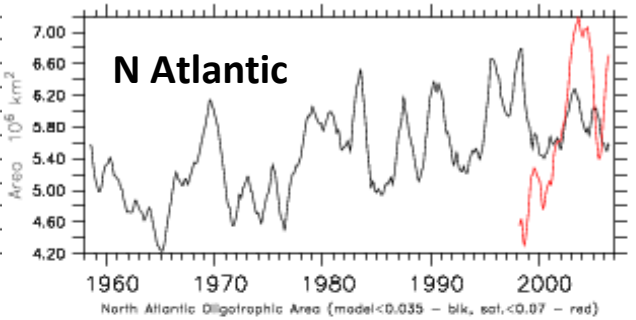


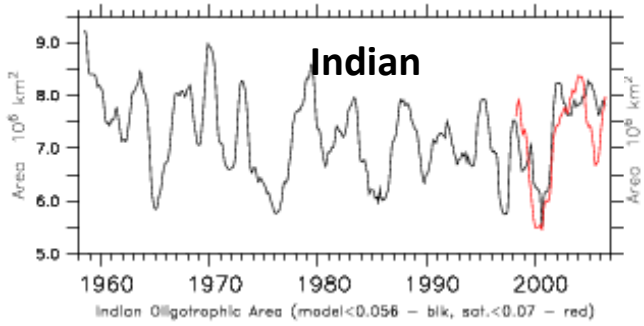
log(Model Chlorophyll)

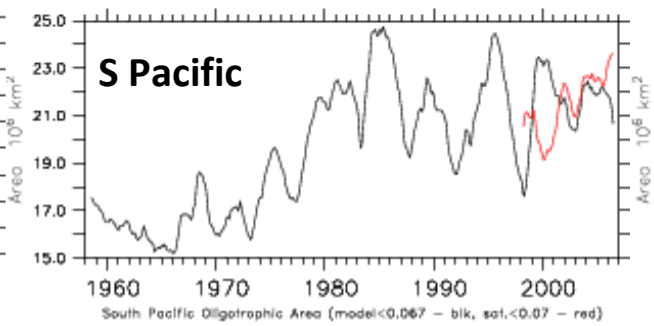


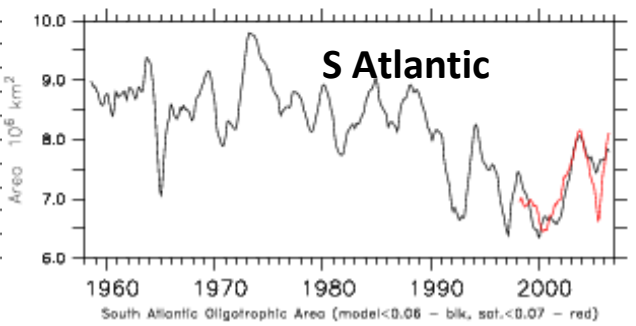
Simulated expansion of oligotrophic gyres (ocean deserts) is similar to SeaWIFS (Polovina et al, 2008) and within a large, multidecadal envelope.



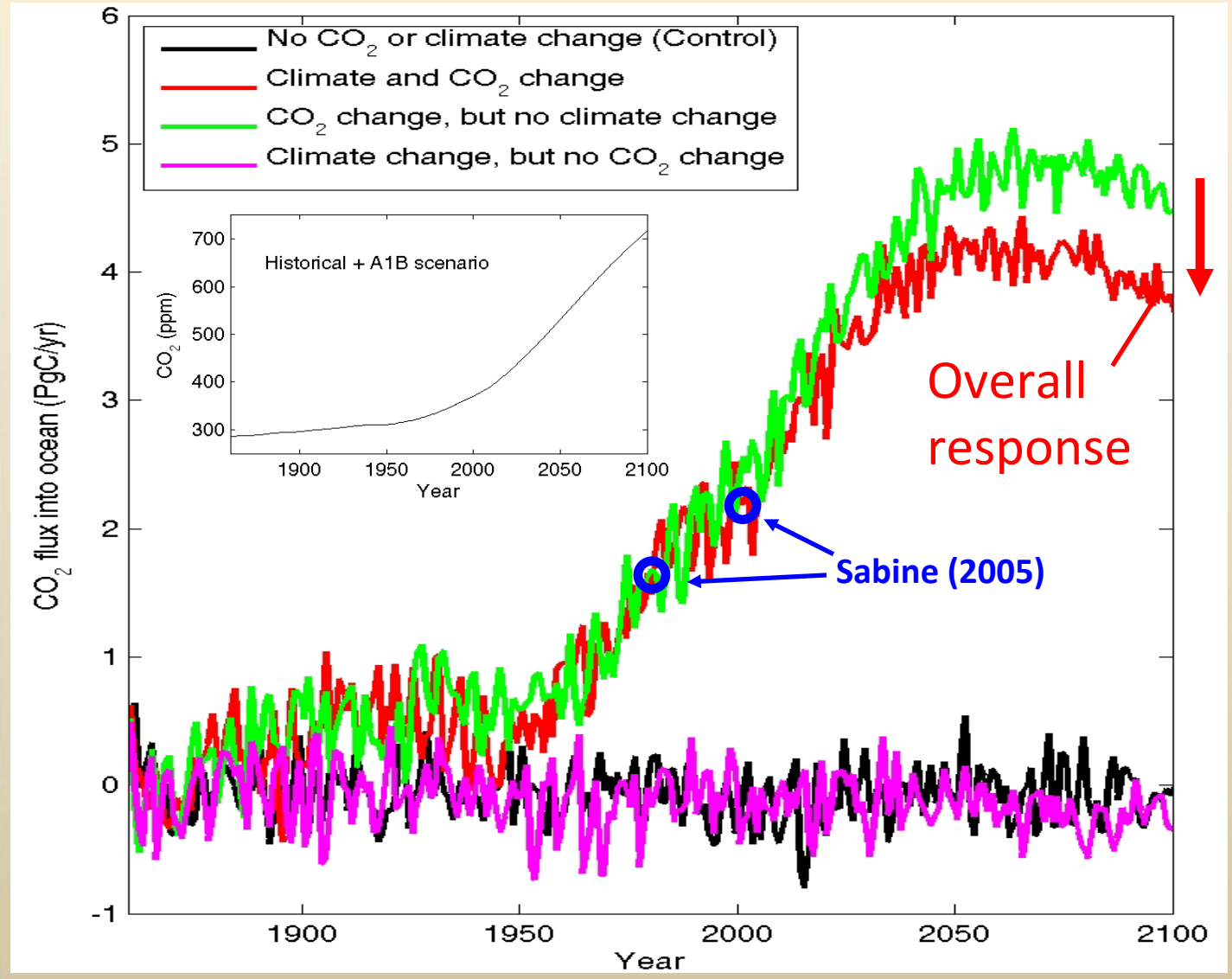








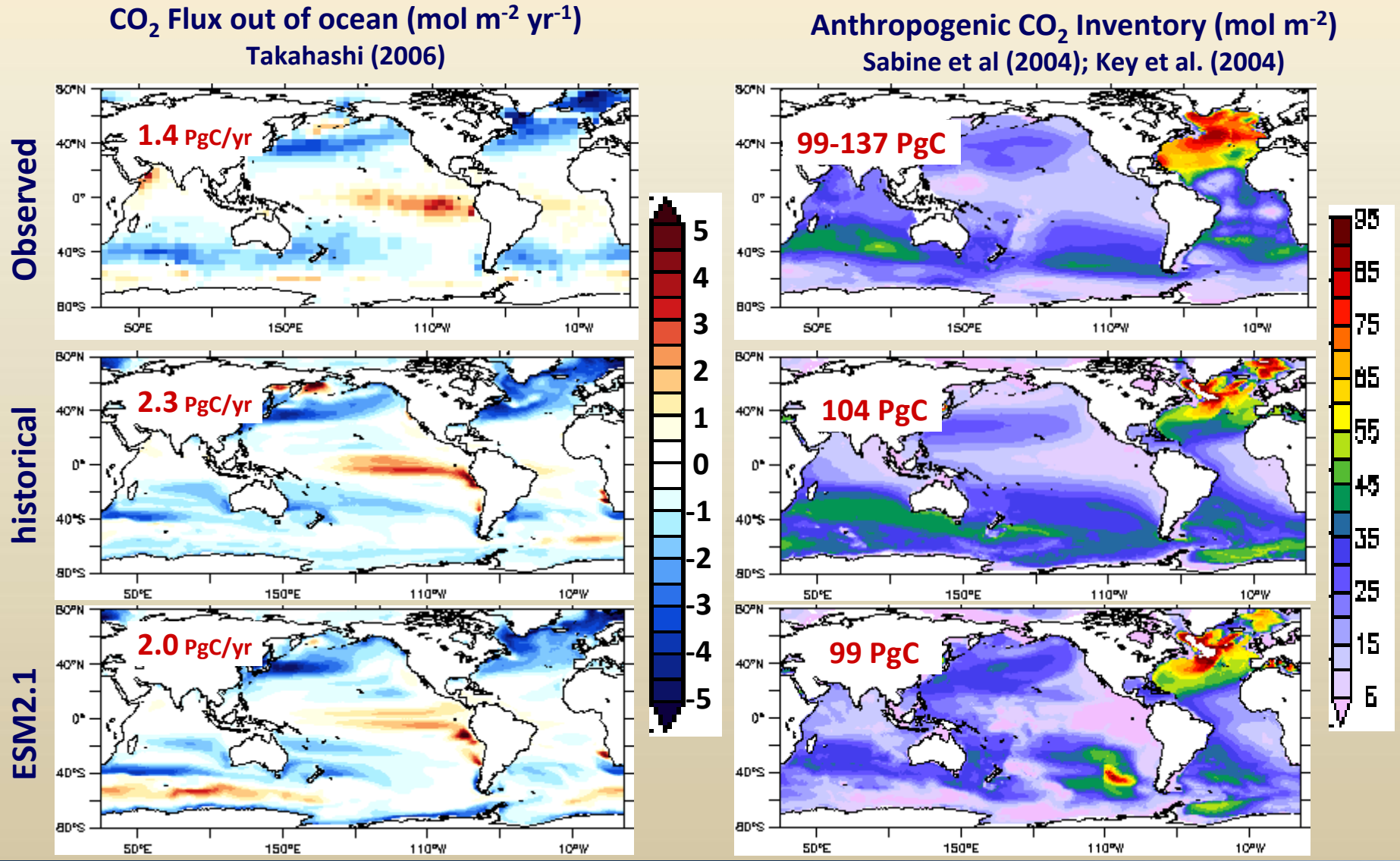
ESM2.1 ocean CO_2 uptake response to atmospheric CO_2 and climate forcing similar to previous work



Significant reduction in anthropogenic CO_2 uptake due to climate change (Sarmiento and Le Quere, 1996; Sarmiento et al., 1998)

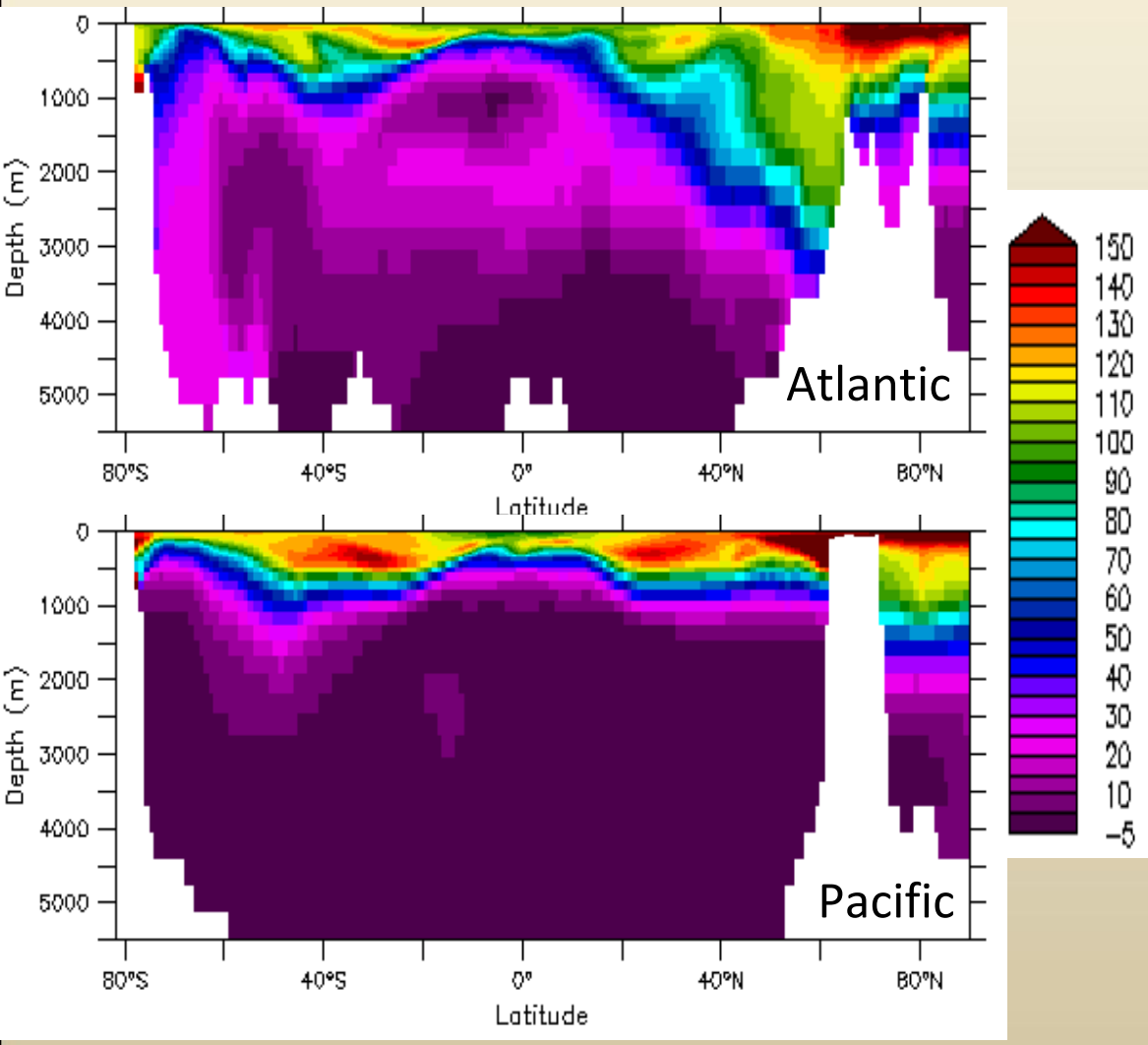
Little climate change effect on natural CO_2 partitioning

Model captures natural CO_2 cycling and anthropogenic CO_2 invasion

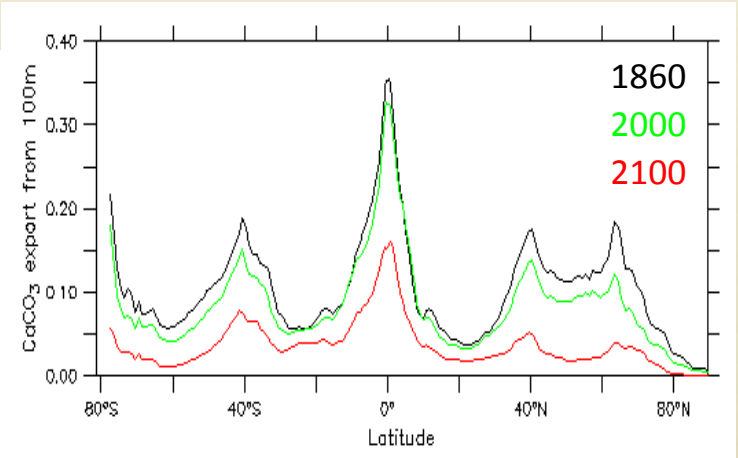


ESM2.1 projects ocean acidification changes with severe implications for $CaCO_3$ cycling

Acidification from 1860 to 2100 (% $[H^+]$ change)



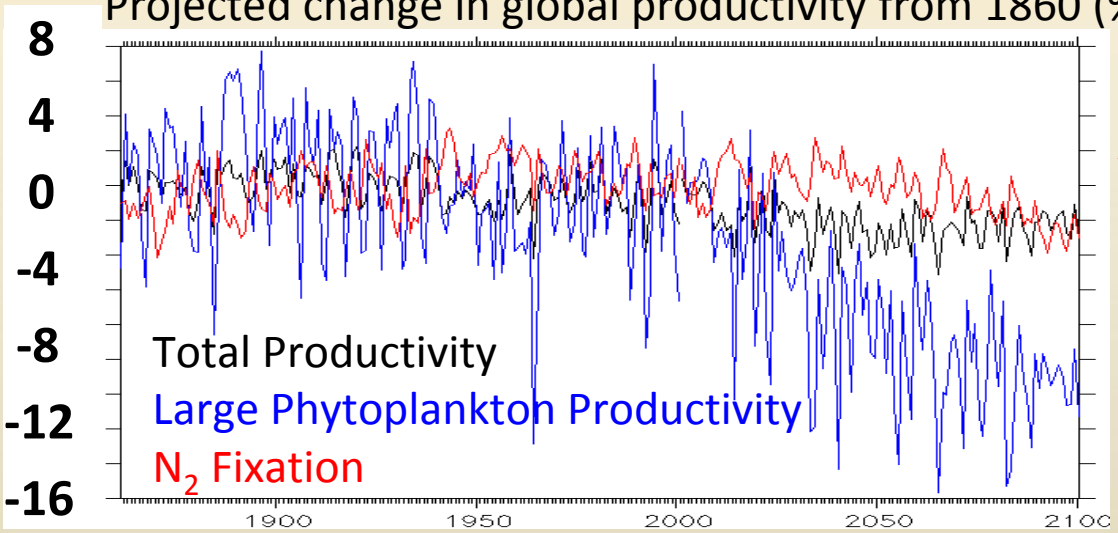
Resulting 52% decrease in calcite export from 100m



This reduction in calcite export similar to previous work (Ridgewell et al. 2006)

This reduction in calcite export reduces the efficiency of sinking organic material to 1000 m by 16%

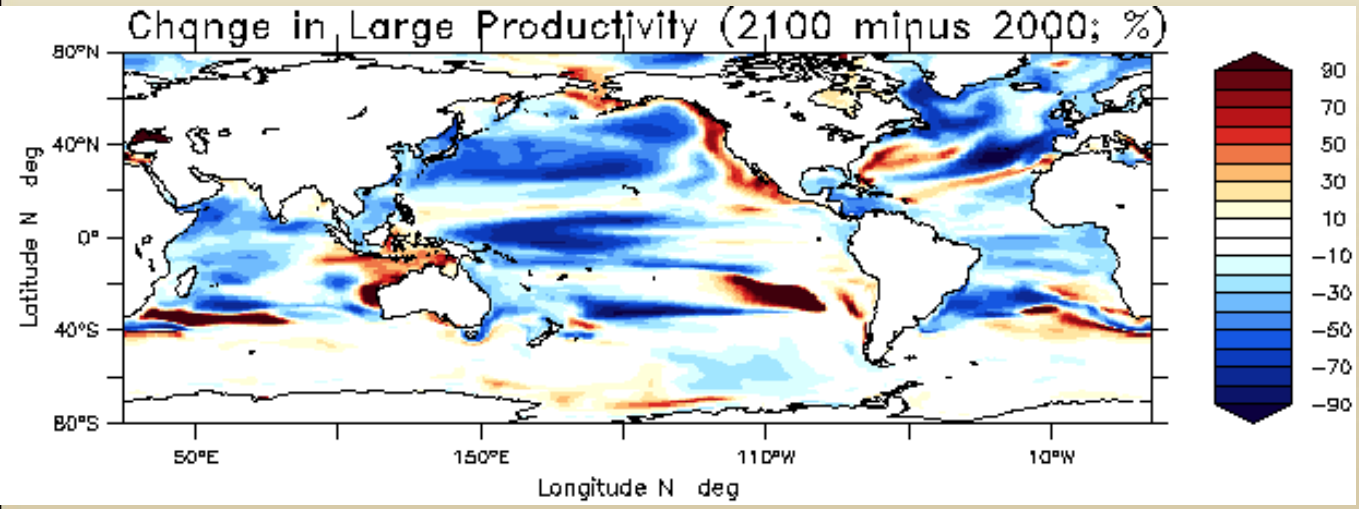
ESM2.1 projects modest decrease in total productivity and major decrease in large phytoplankton



Little change in N_2 fixation

2% decrease in total productivity

11% decrease in large phytoplankton productivity



'winners and losers', but more losers than winners

13% increase in oligotrophic gyre (ocean desert) area

Summary of Ocean Biogeochemical Results

- GFDL's TOPAZ ocean biogeochemical model has been developed to simulate ocean carbon cycling and its biogeochemical controls
- TOPAZ reproduces regional and temporal variability in chlorophyll and suggests the recent expansion of oligotrophic gyres (ocean deserts) is within the envelope of multi-decadal variability
- TOPAZ reproduces observations of natural CO_2 cycling and historical anthropogenic CO_2 invasion and predicts future CO_2 uptake consistent with previous work
- ESM2.1 predicts significant decrease in $CaCO_3$ cycling and large phytoplankton production and increase in oligotrophic areas over this century

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