

# The Southern Ocean in a high-CO<sub>2</sub> world: Changes in inorganic and organic carbon fluxes

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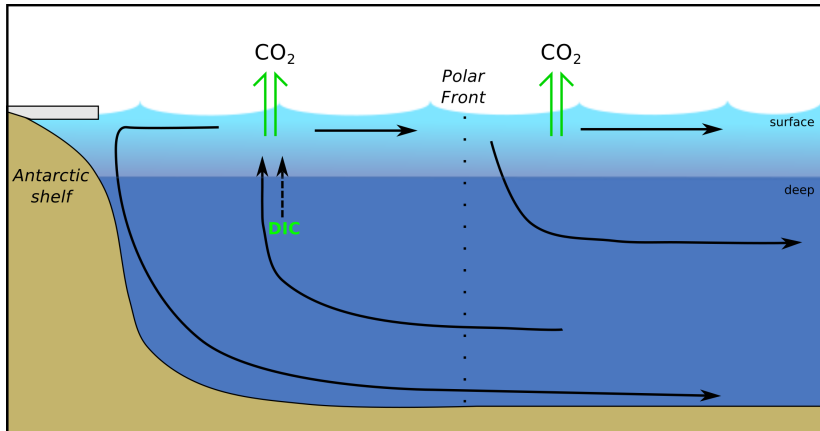
Biological Impacts of Ocean ACIDification

The Ocean in a High CO<sub>2</sub>-World  
25 September 2012



# THE SOUTHERN OCEAN

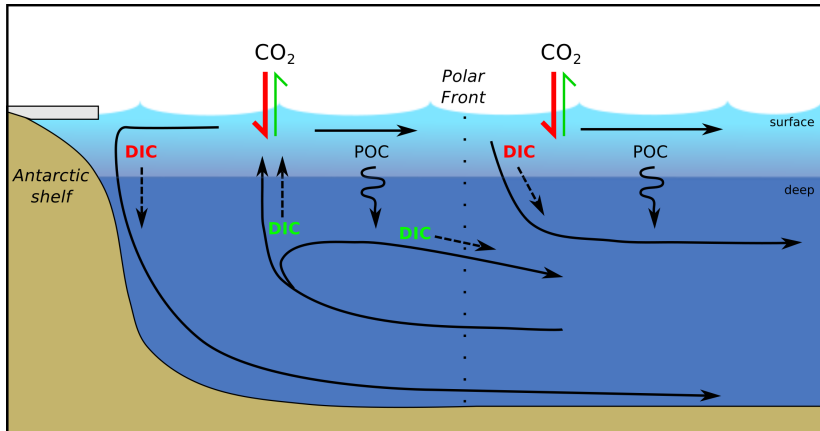
## THE PREINDUSTRIAL CARBON CYCLE





# THE SOUTHERN OCEAN

## THE CONTEMPORARY CARBON CYCLE

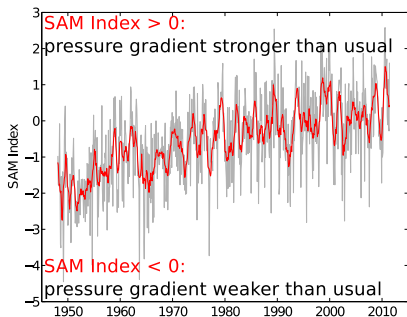


# SOUTHERN ANNULAR MODE (SAM)

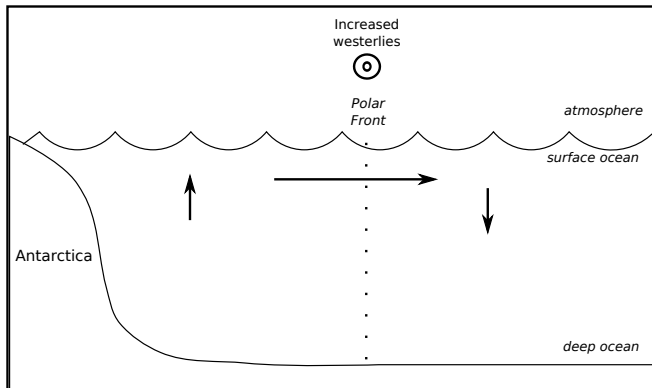
- SAM Index:
  - Sea level pressure anomalies between the subpolar low and the subtropical high-pressure systems

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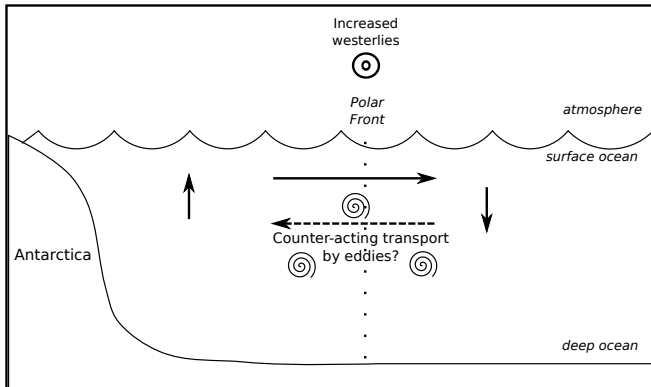
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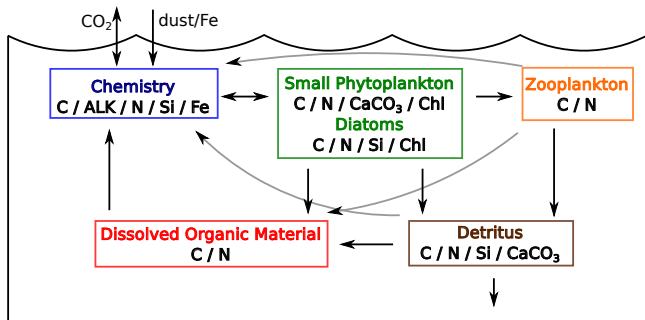


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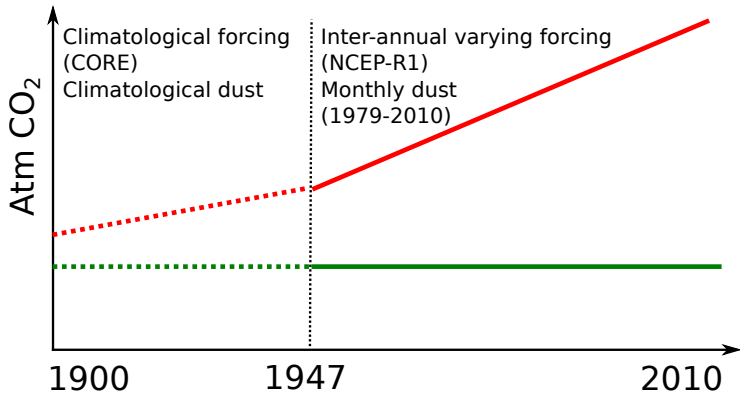


## ECOSYSTEM MODEL RECOM-2

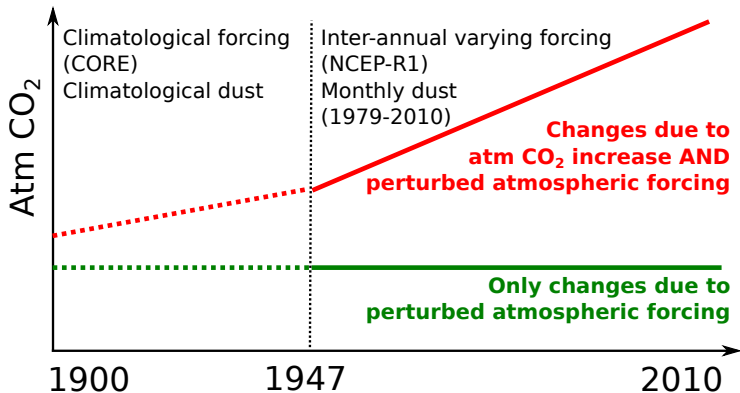


Geider et al., 1998; Schartau et al., 2007; Hohn et al., 2009; Hauck et al., GBC, under review

## MODEL RUNS



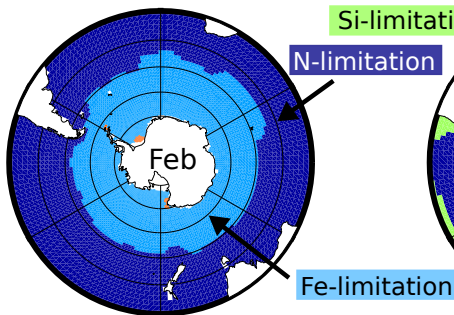
## MODEL RUNS



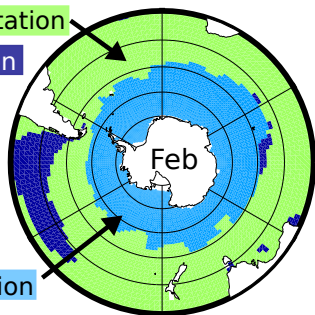
# MEAN MODEL STATE

## MOST LIMITING FACTORS FOR PHYTOPLANKTON GROWTH

### Nanophytoplankton

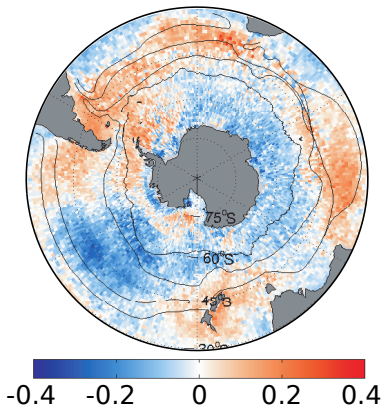


### Diatoms

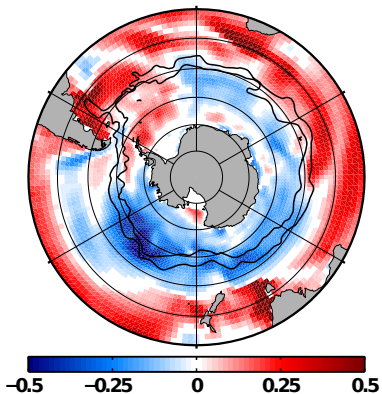


# RESPONSE TO SAM

Satellite-derived SST ( $^{\circ}\text{C}$ ) response  
per unit increase SAM Index



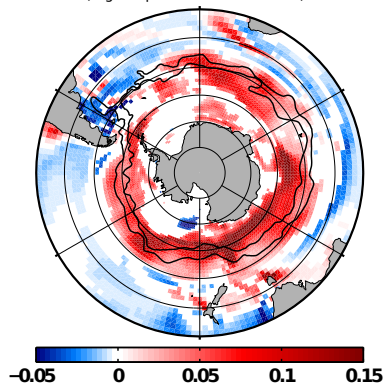
Modelled SST ( $^{\circ}\text{C}$ ) response  
per unit increase SAM Index



Lovenduski and Gruber 2005

# RESPONSE TO SAM

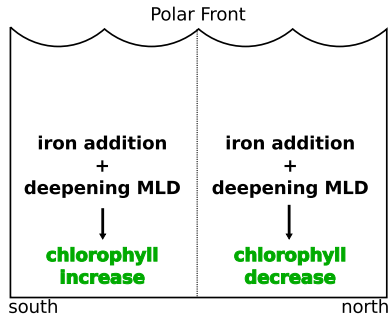
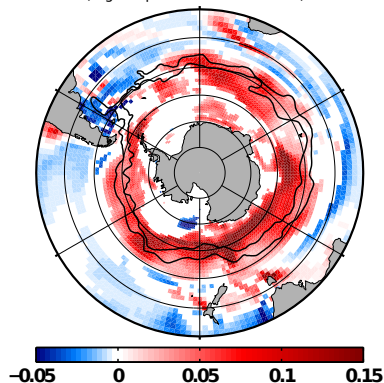
Modelled total chlorophyll response  
( $\text{mg m}^{-3}$  per unit increase SAM)



# RESPONSE TO SAM

## Modelled total chlorophyll response

( $\text{mg m}^{-3}$  per unit increase SAM)

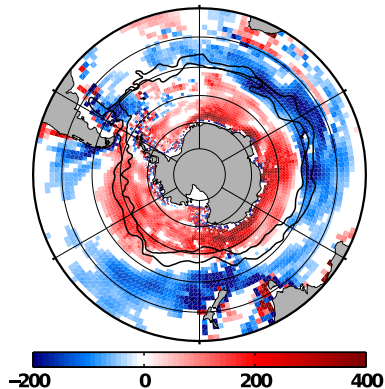






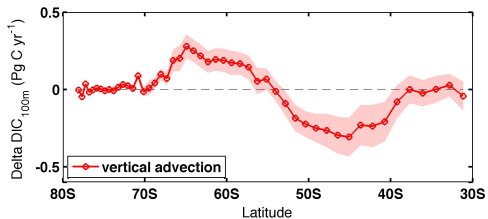
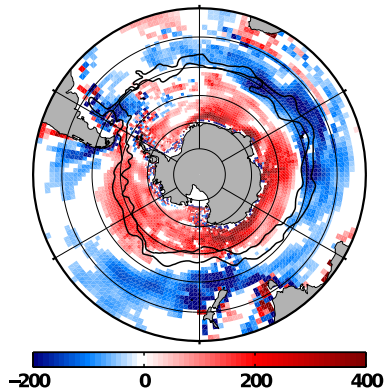
# CARBON BUDGET

Response of upward DIC advection  
( $\text{mmol m}^{-2} \text{y}^{-1}$  per unit increase SAM at 100 m)

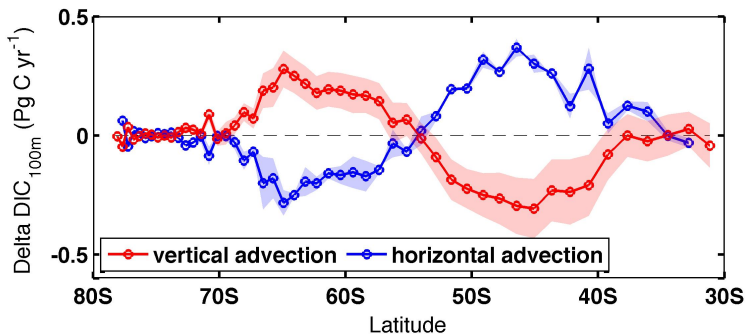


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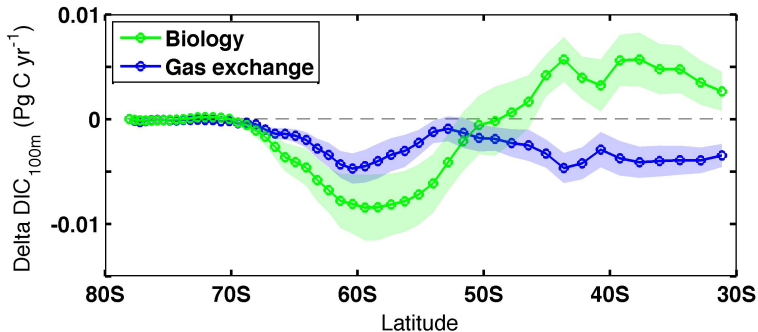
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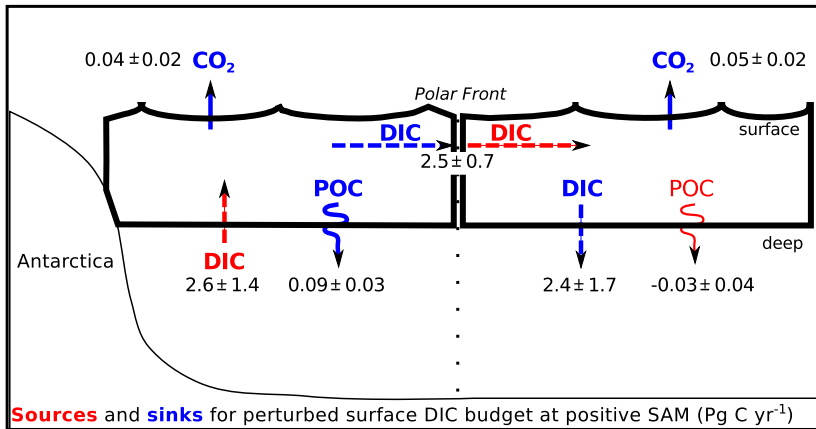
## CARBON BUDGET



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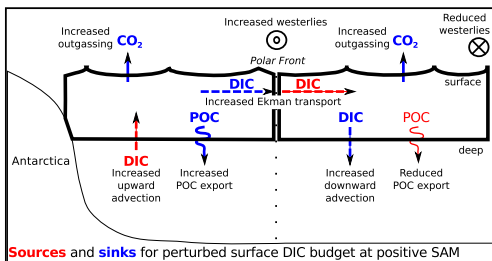


# CARBON FLUX ANOMALIES AT POSITIVE SAM



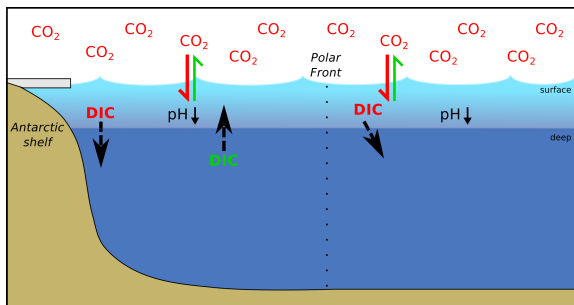
Hauck et al., GBC, under review

# SAM-RELATED CARBON BUDGET SUMMARY



- Upwelling of DIC south of Polar Front  $\approx$  balanced by northward Ekman transport and downwelling north of Polar Front
- Changes in gas exchange and biological carbon export are of similar magnitude, but much smaller than advective changes
- SAM related sea-air CO<sub>2</sub> flux in SO is  $0.09 \pm 0.03 \text{ PgC yr}^{-1}$ , similar to a recent eddy-resolving study (Dufour, 2011)

# THE SOUTHERN OCEAN IN A HIGH-CO<sub>2</sub> WORLD



- CO<sub>2</sub> uptake rate might grow slower than atm. CO<sub>2</sub> concentrations due to circulation changes as response to the positive SAM (Le Quéré et al., 2007)
- Anthropogenic ocean acidification will proceed, might even be amplified by upwelling of carbon-rich deep water (Lenton et al., 2009)