Southern Ocean response to the Annular Mode: Inorganic and organic carbon fluxes

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AWI

Alfred Wegener Institute for Polar and Marine Research

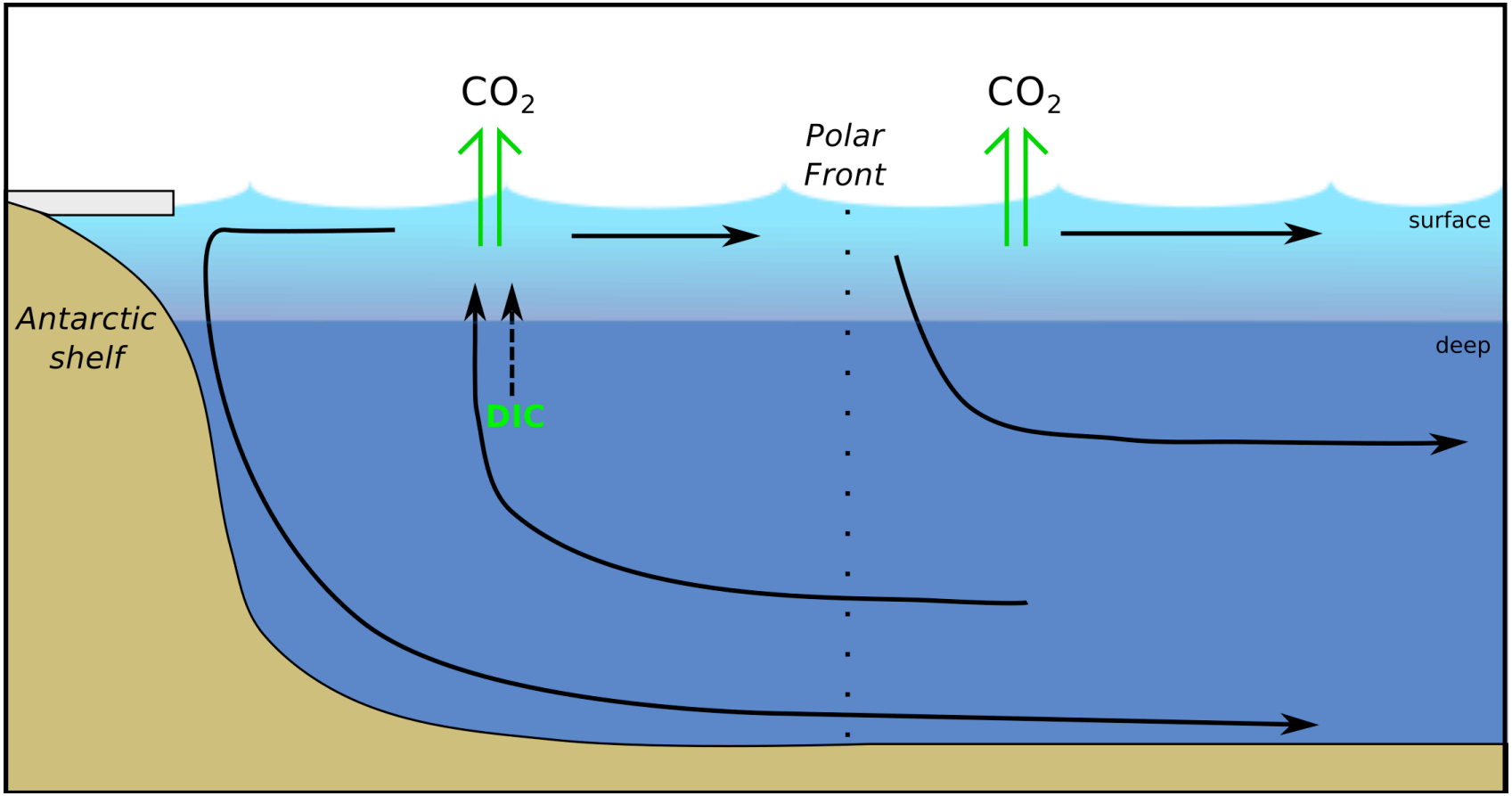
BIOACID

Biological Impacts of Ocean ACIDification

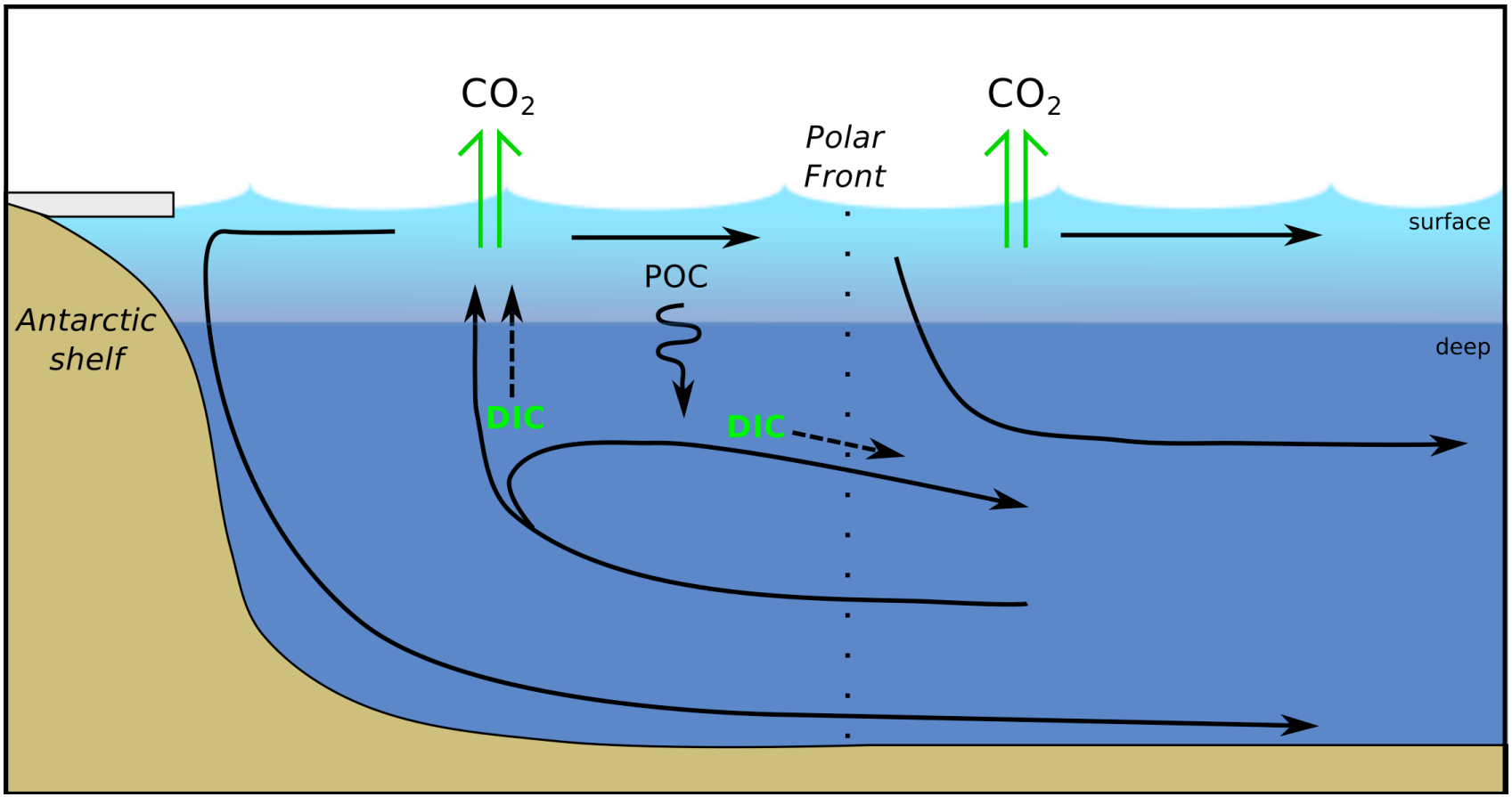
Bjerknes coference
5 September 2012

CARBOCHANGE

The Southern Ocean

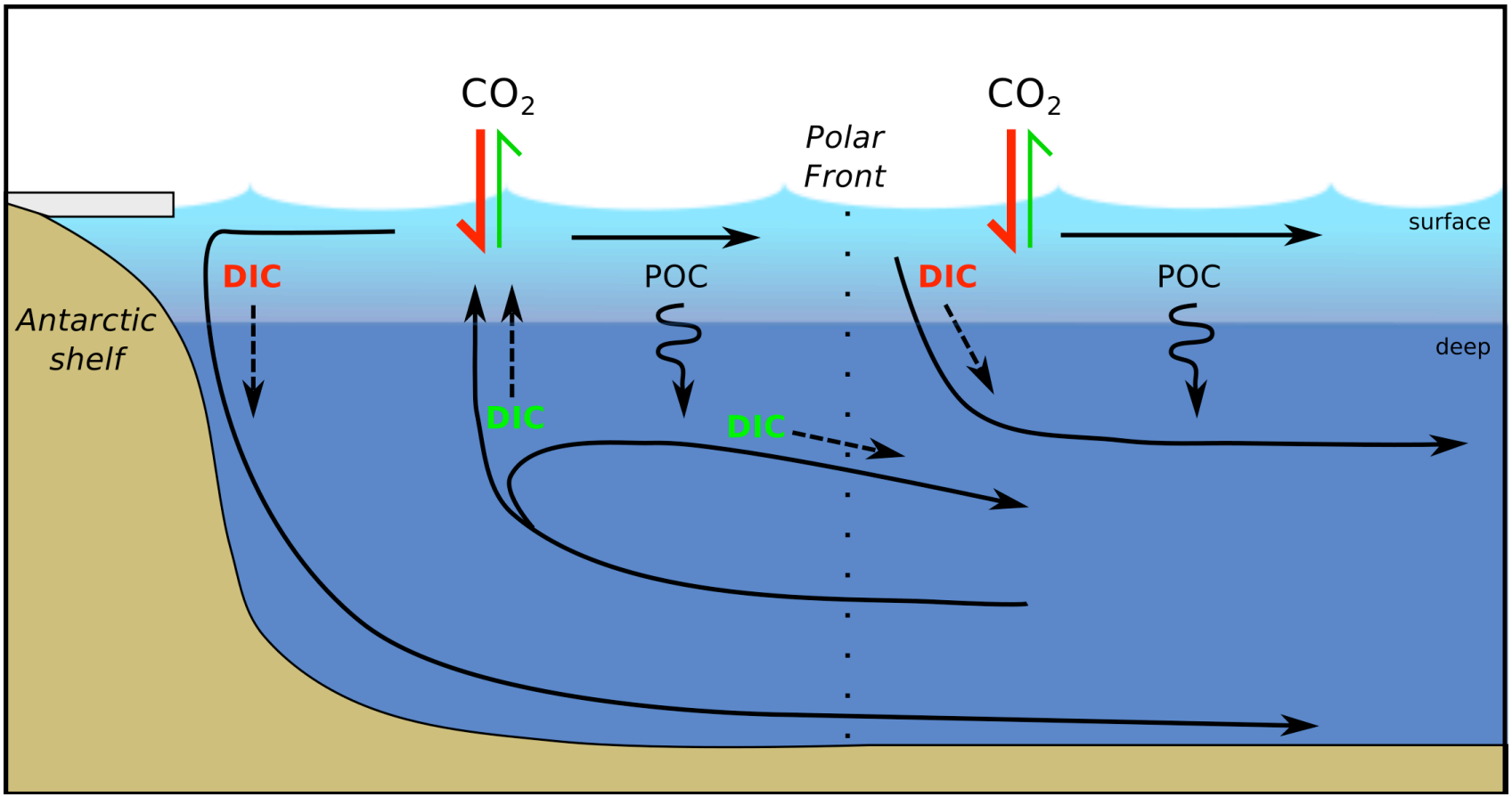


The Southern Ocean



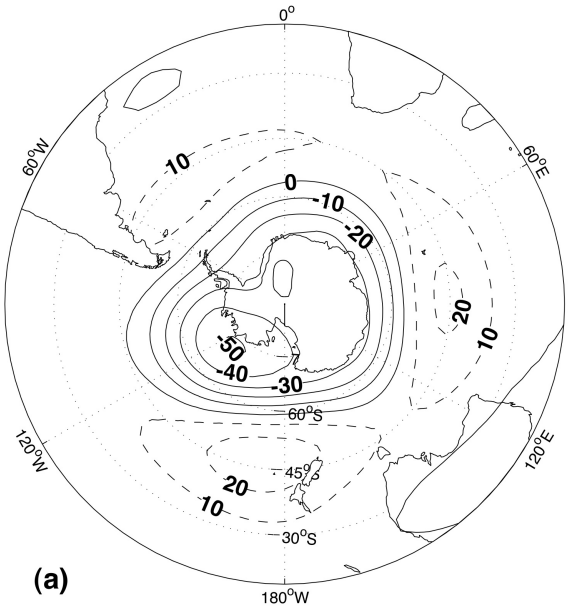
Hoppema et al., 2004

The Southern Ocean



Southern Annular Mode (SAM)

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



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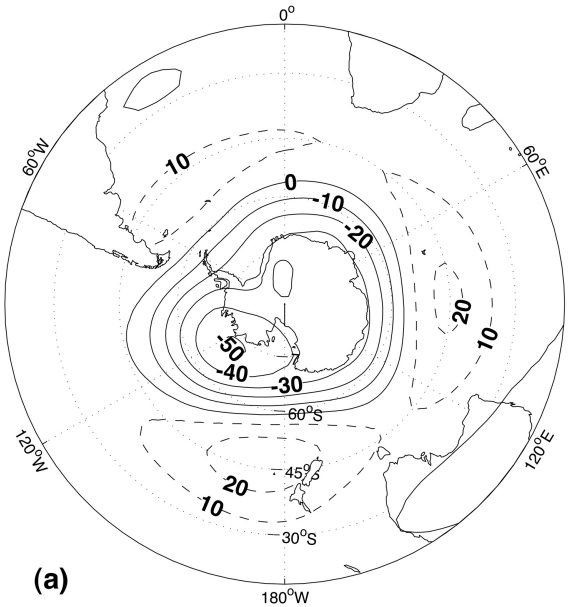
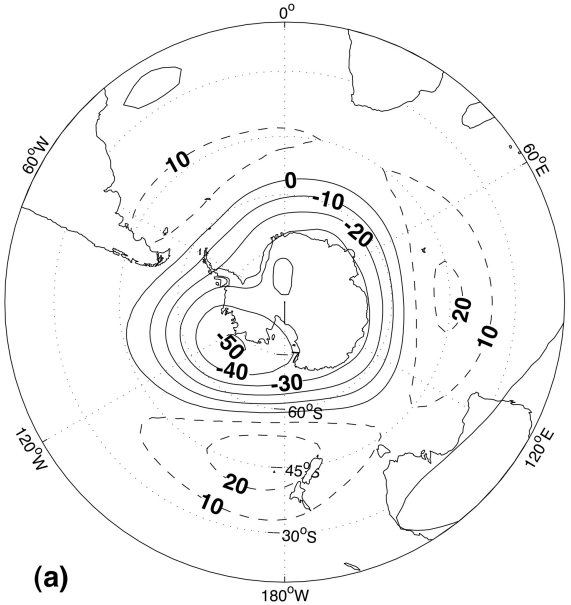
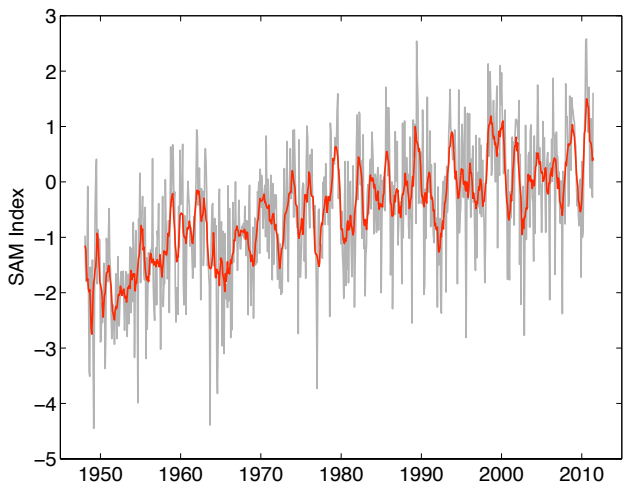
  - Sea level pressure anomalies between the subpolar low and and the subtropical high-pressure systems
  - Positive: pressure gradient stronger than usual
  - Negative: pressure gradient weaker than usual



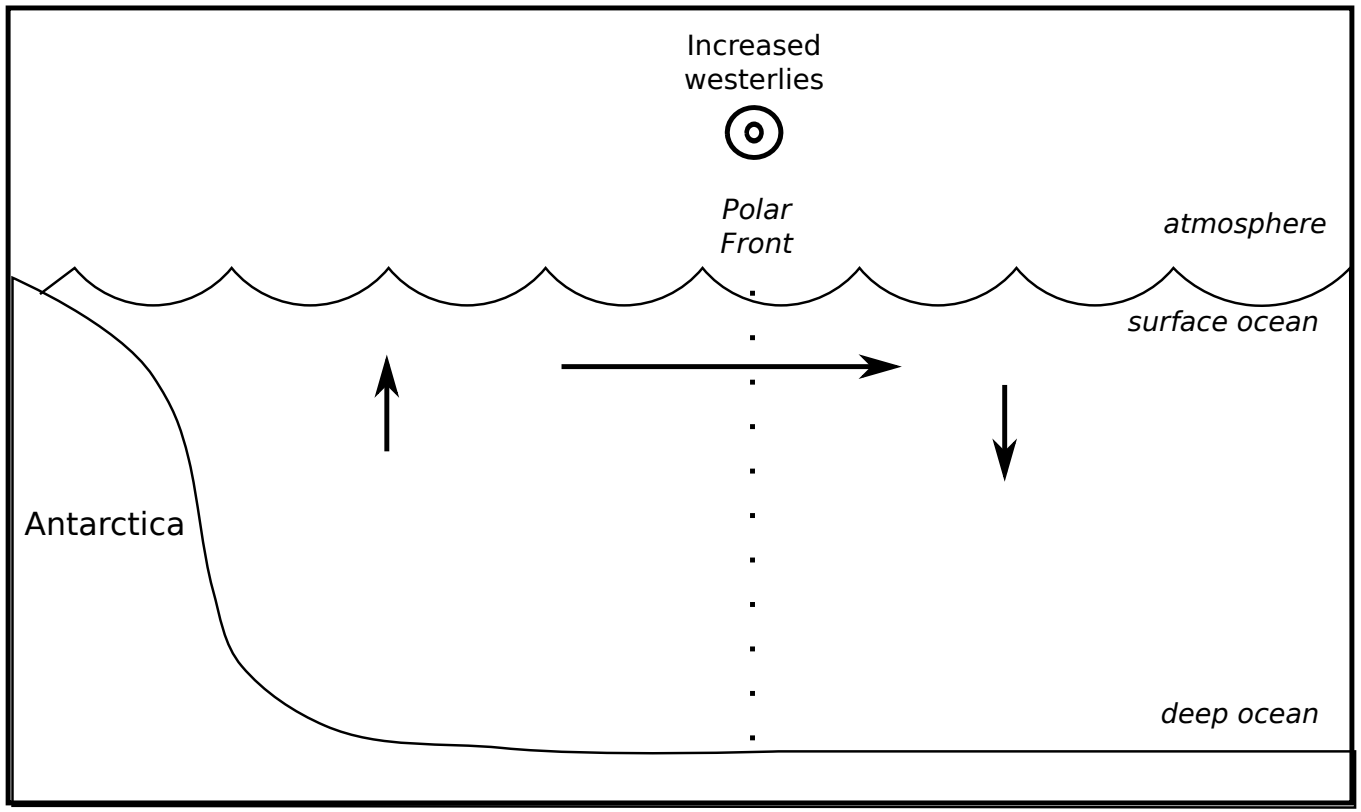
Southern Annular Mode (SAM)

- SAM Index:
  - Sea level pressure anomalies between the subpolar low and and the subtropical high-pressure systems
  - Positive: pressure gradient stronger than usual
  - Negative: pressure gradient weaker than usual
- Trend toward its positive phase (Marshall et al., 2003, Thompson et al., 2011)





Southern Annular Mode (SAM)



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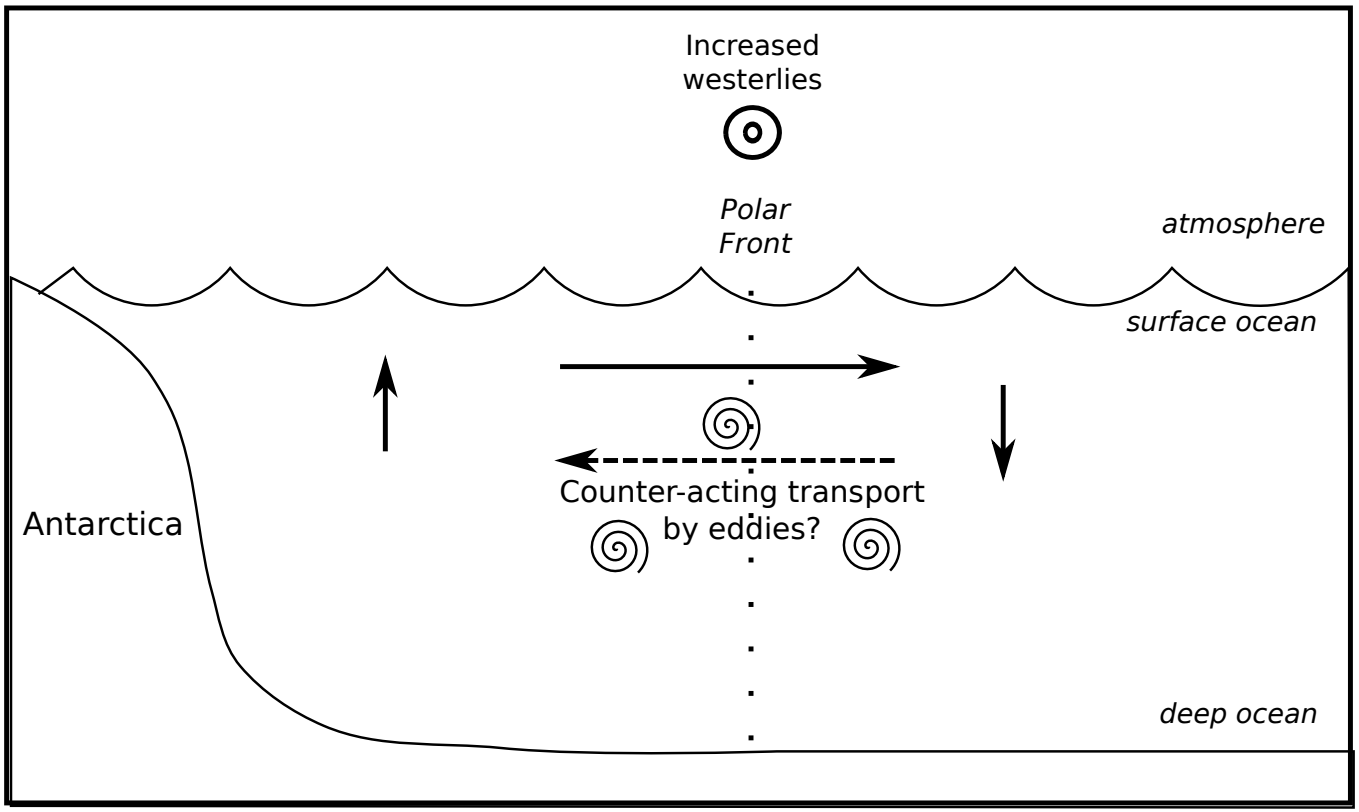
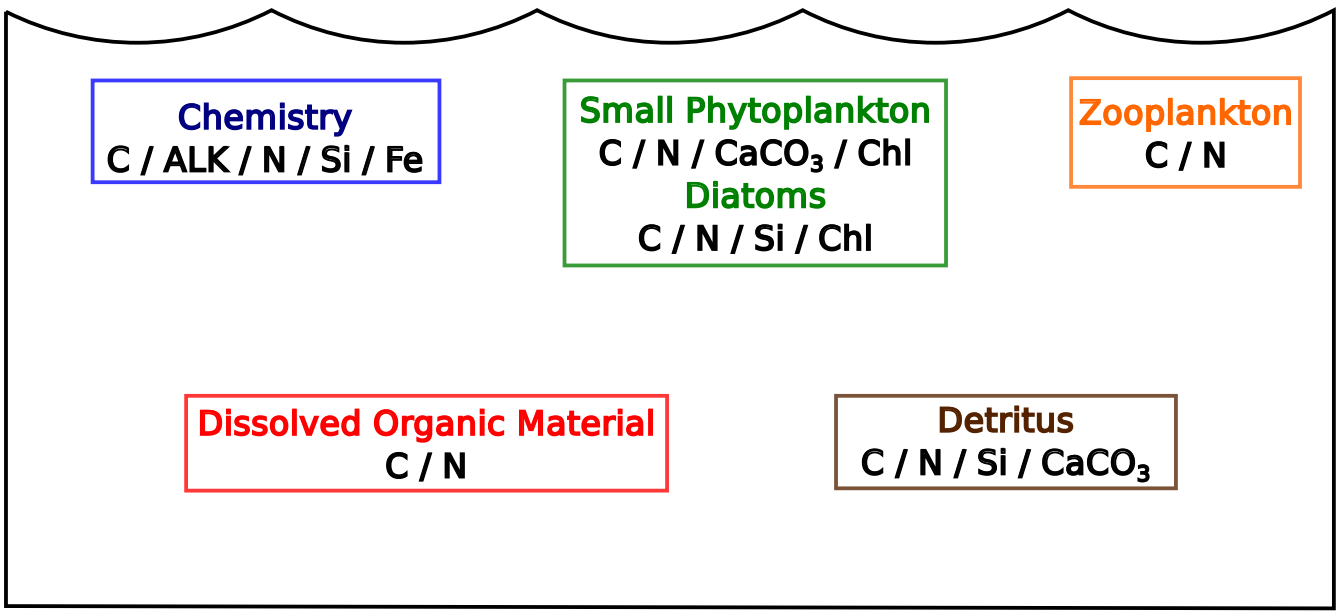
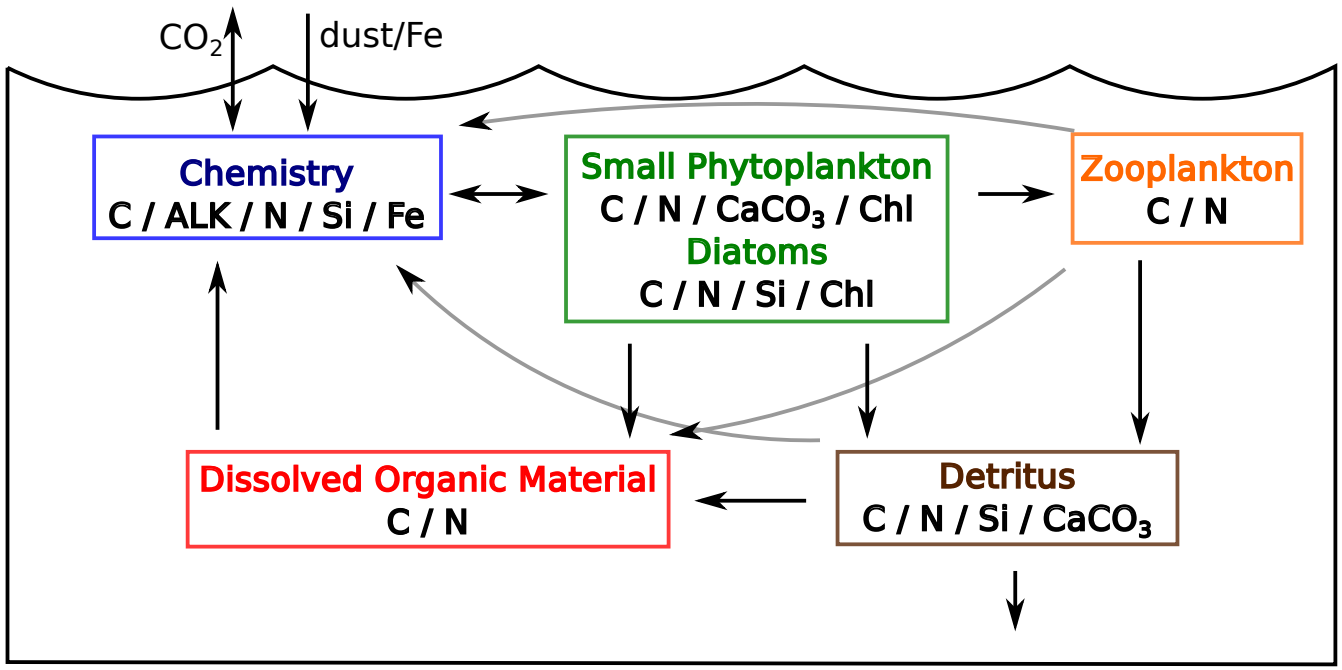


Ecosystem Model REcoM-2



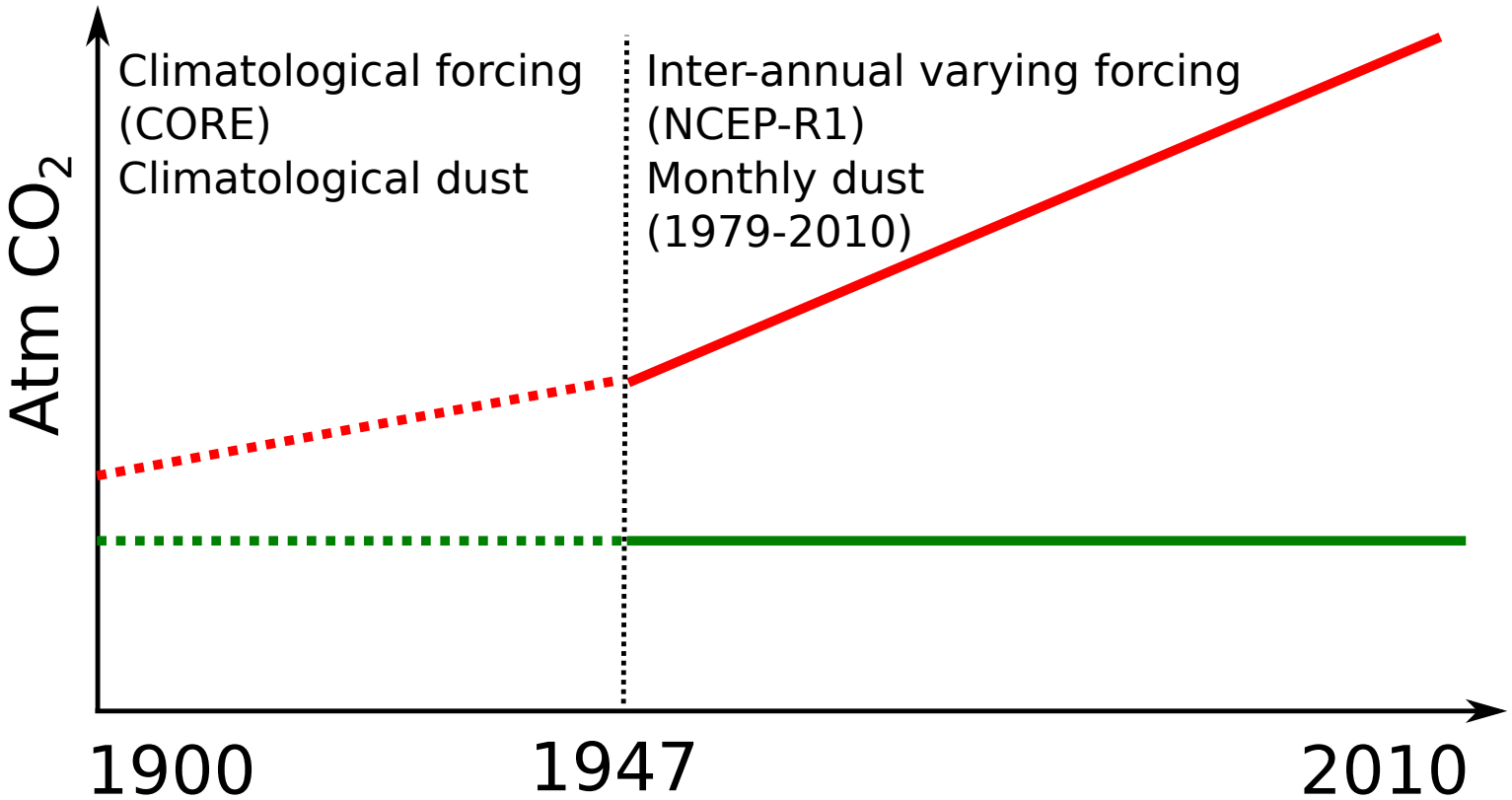
Geider et al., 1998; Schartau et al., 2007; Hohn et al., 2009; Hauck et al., GBC, under review

Ecosystem Model REcoM-2

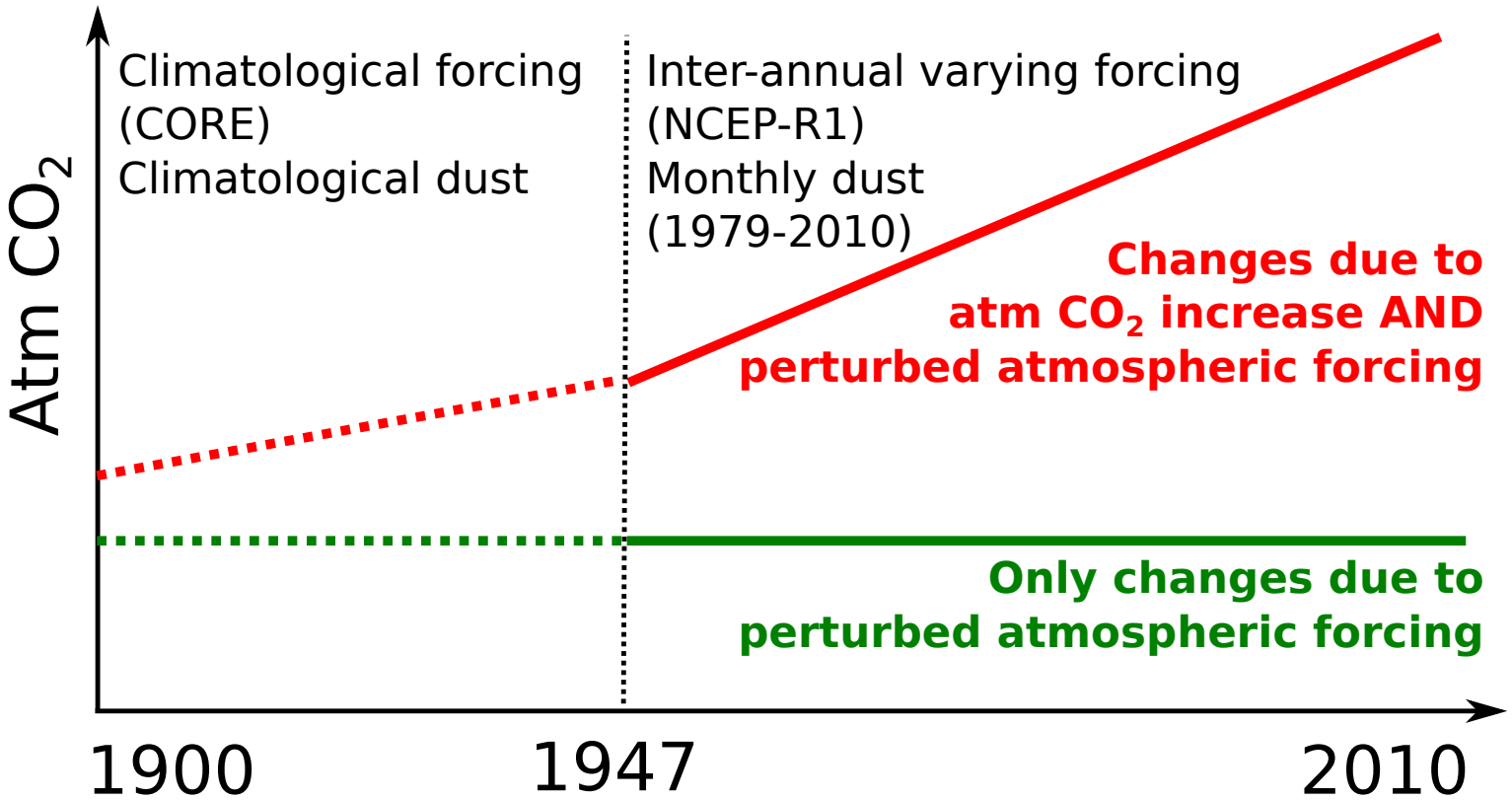


Geider et al., 1998; Schartau et al., 2007; Hohn et al., 2009; Hauck et al., GBC, under review

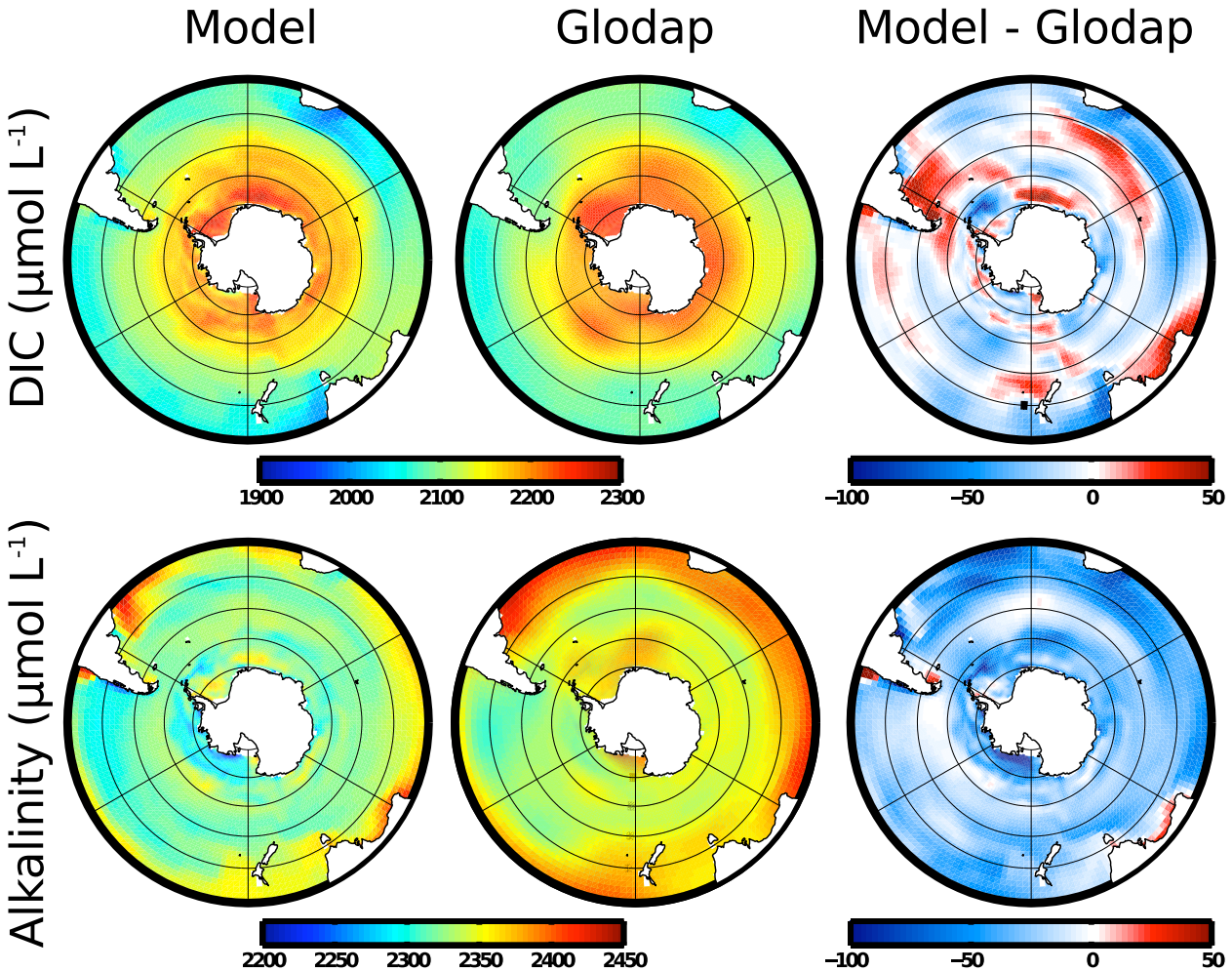
Model runs


Atm CO_2
Climatological forcing
(CORE)
Climatological dust
Inter-annual varying forcing
(NCEP-R1)
Monthly dust
(1979-2010)
1900
1947
2010

Model runs


Atm CO_2
Climatological forcing
(CORE)
Climatological dust
Inter-annual varying forcing
(NCEP-R1)
Monthly dust
(1979-2010)
Changes due to
atm CO_2 increase AND
perturbed atmospheric forcing
Only changes due to
perturbed atmospheric forcing
1900
1947
2010

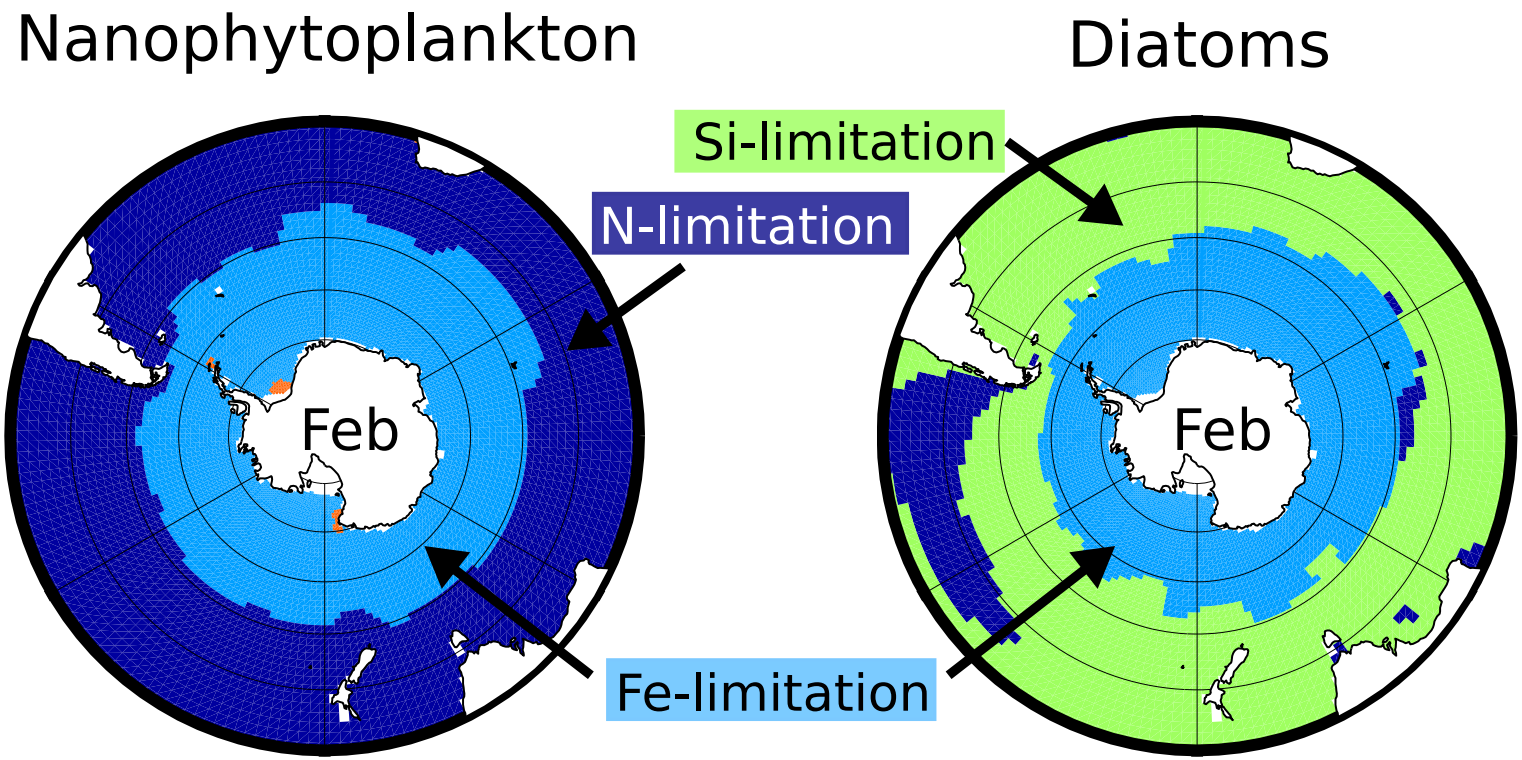
Mena model state: carbonate system



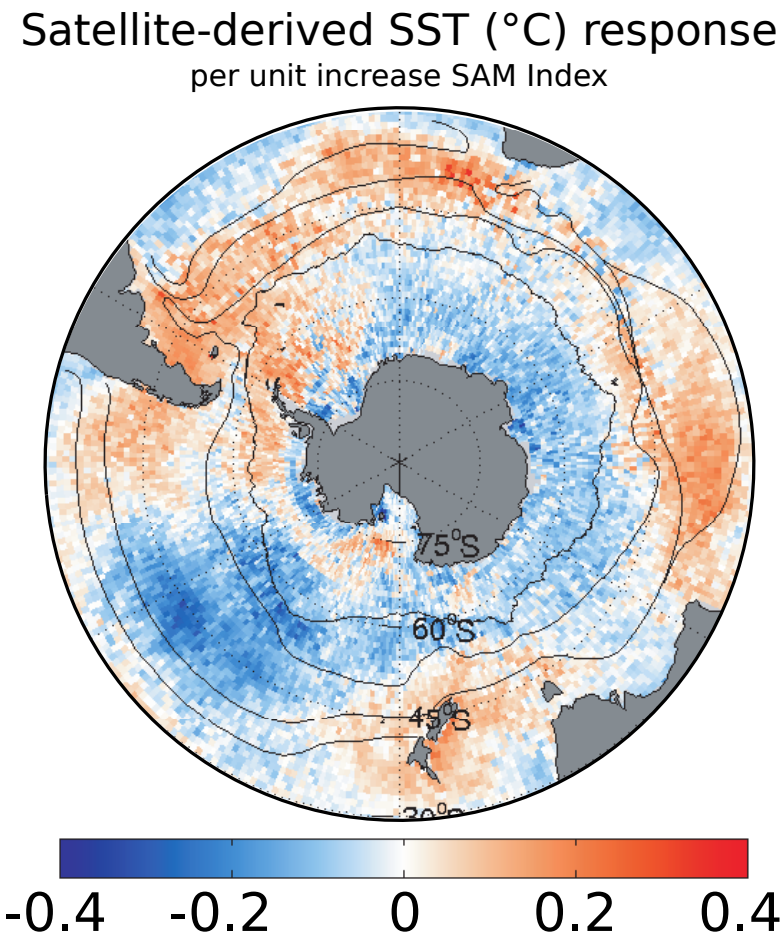
average ΔDIC
9.6 μmol L^{-1}

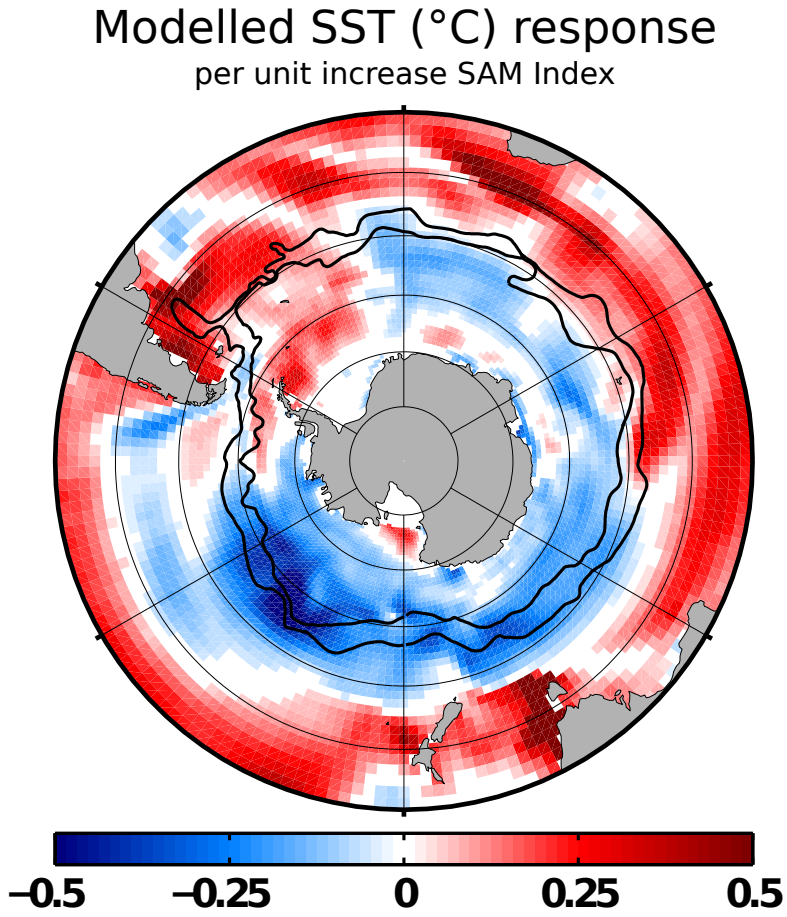
average ΔAlk
30.2 μmol L^{-1}

Mean model state: phytoplankton limitations



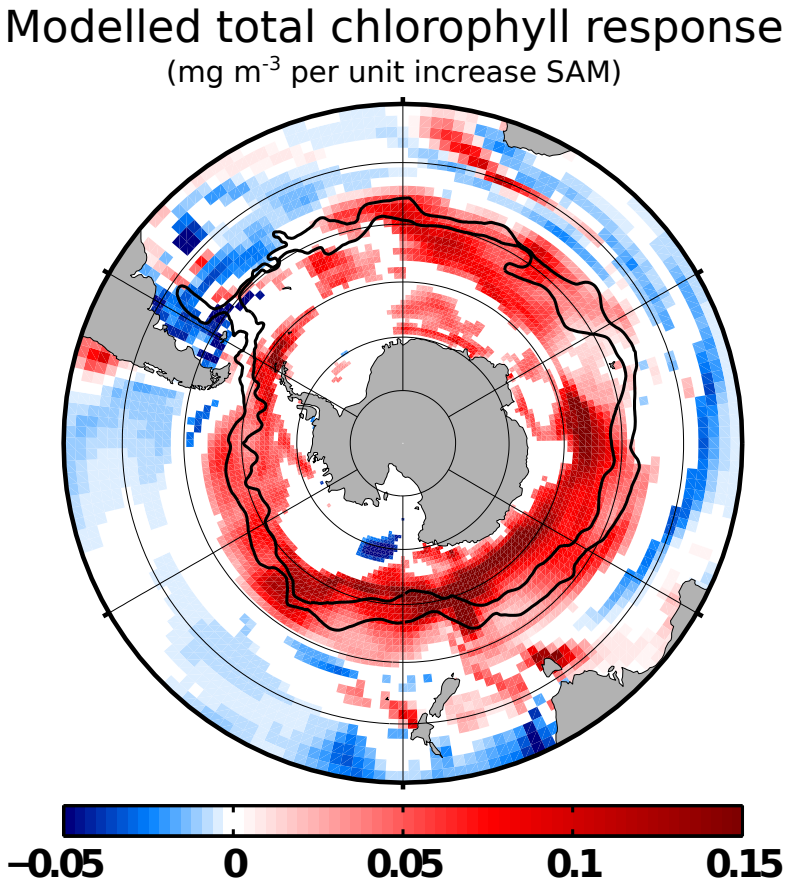
Regression to SAM





Lovenduski and Gruber 2005

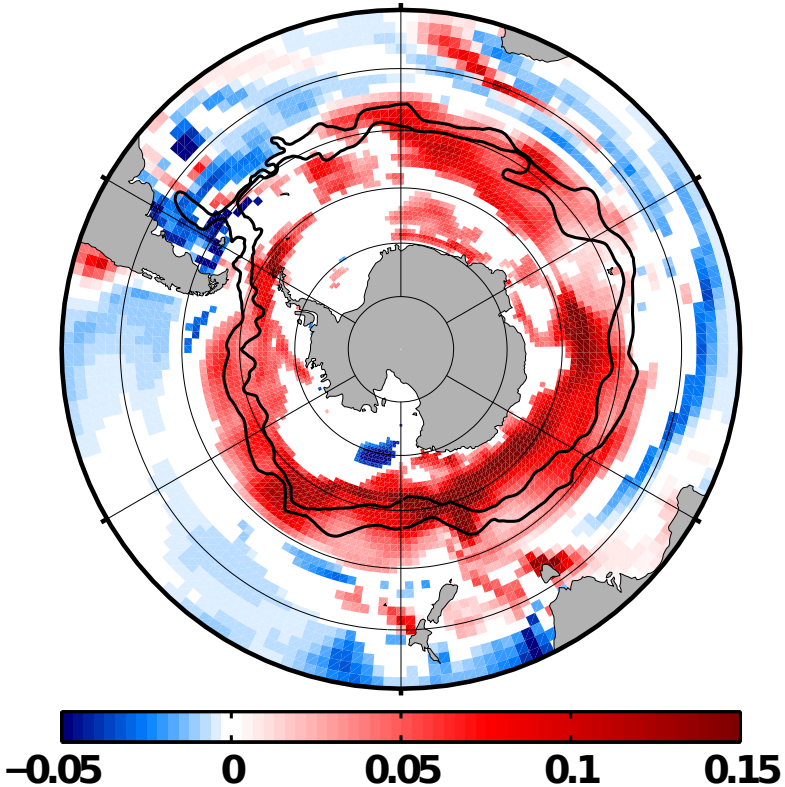
Regression to SAM

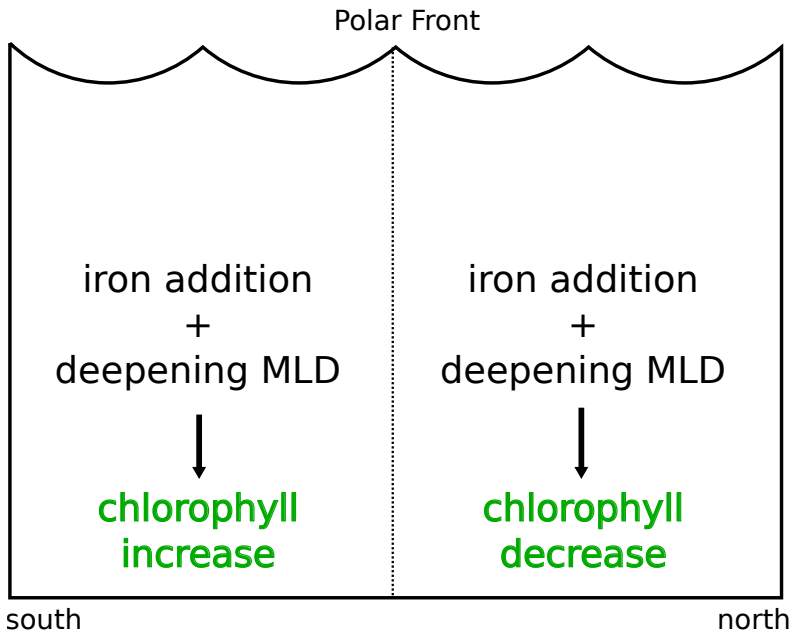


Regression to SAM

Modelled total chlorophyll response

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





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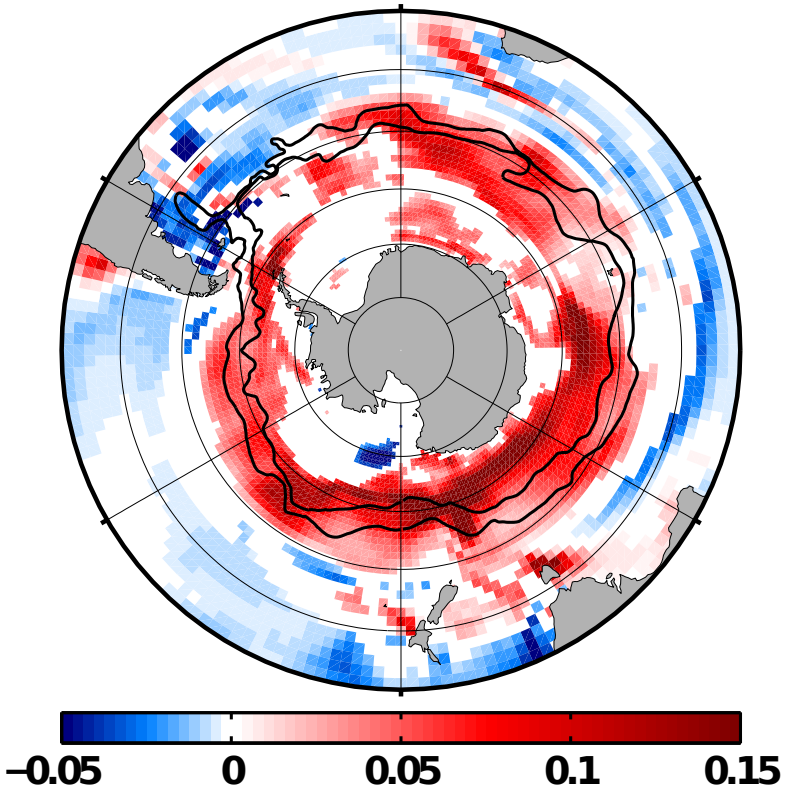
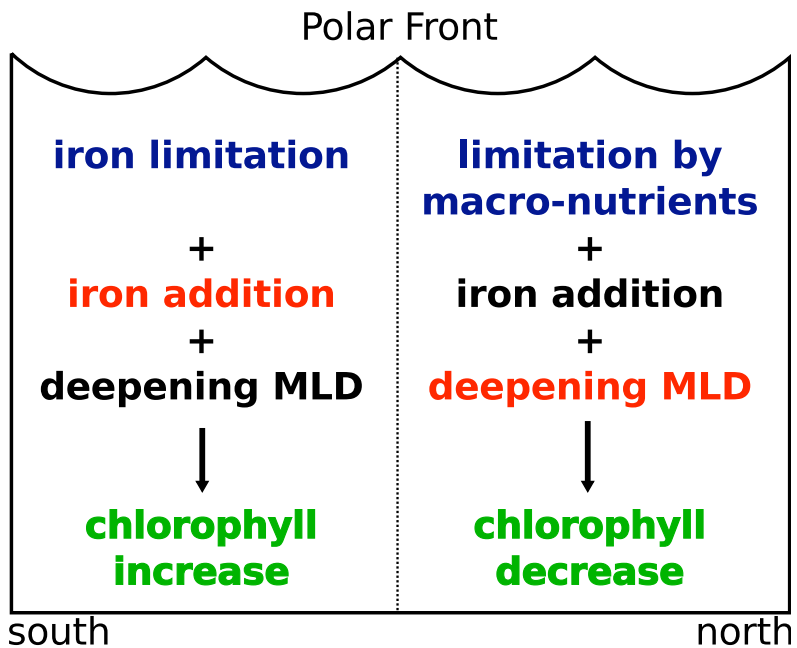
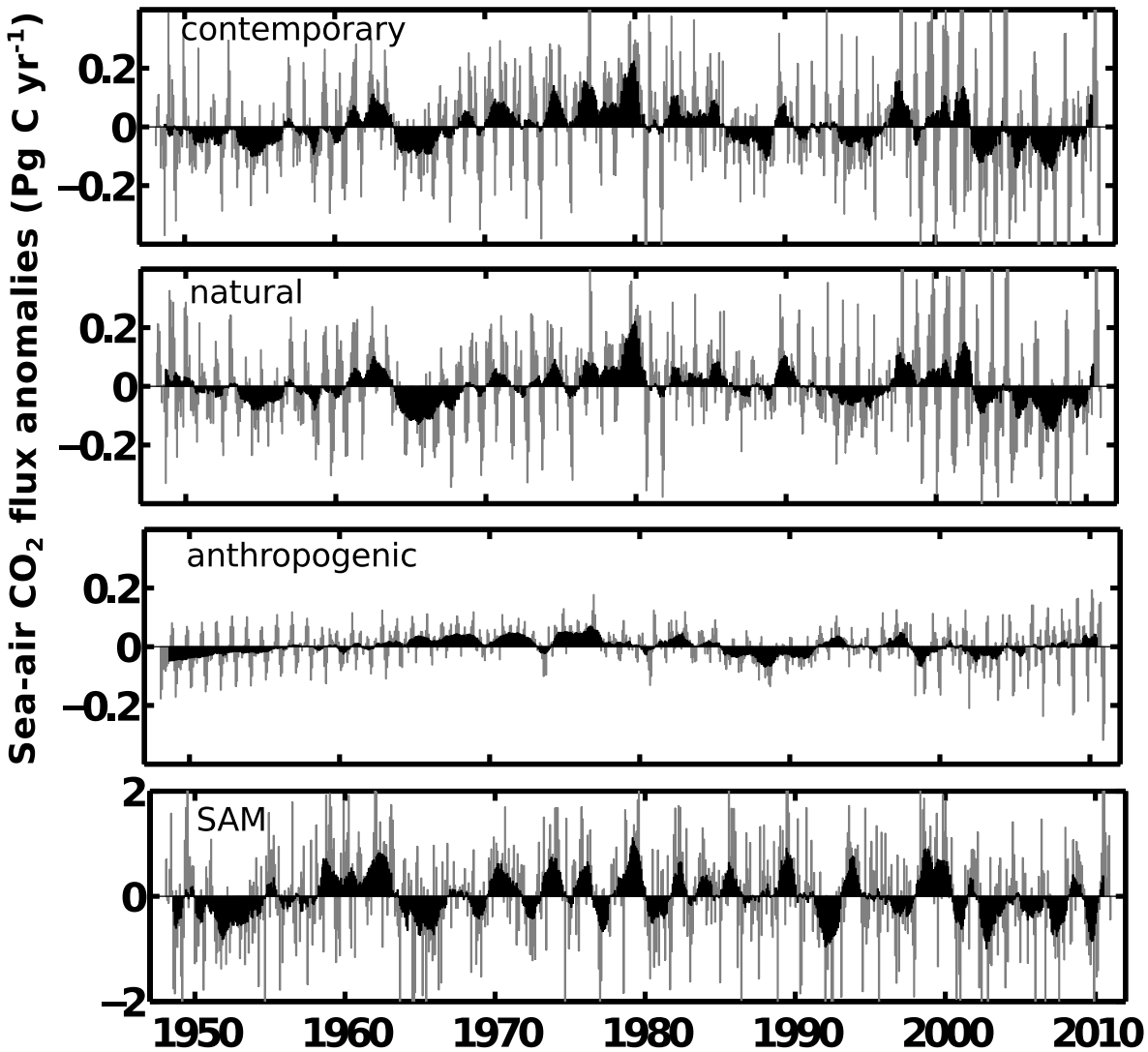




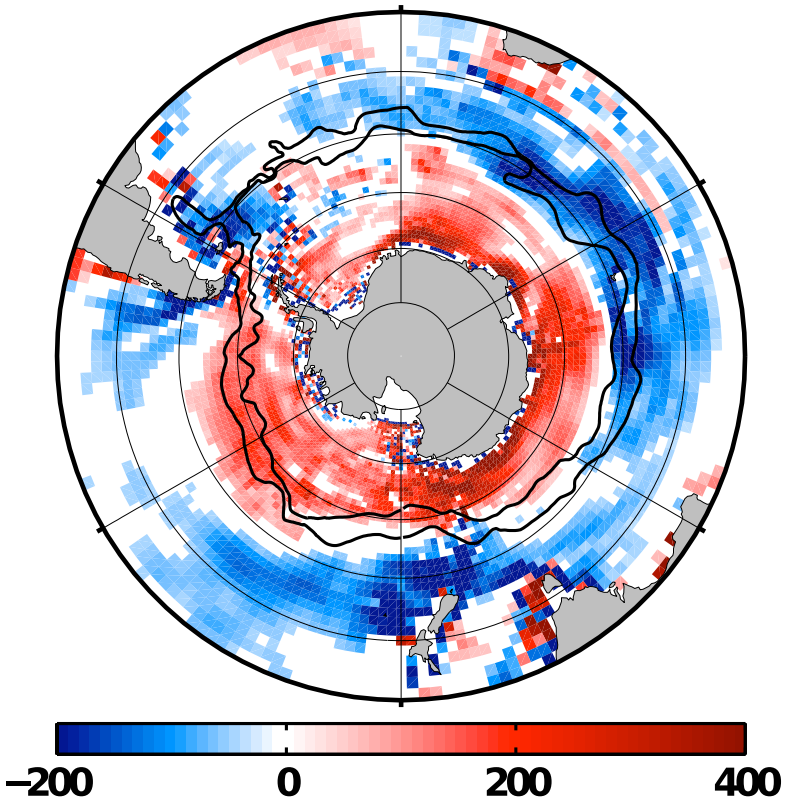
Inter-annual variability



Carbon budget

Response of upward DIC advection

(mmol m^{-2} y^{-1} per unit increase SAM at 100 m)



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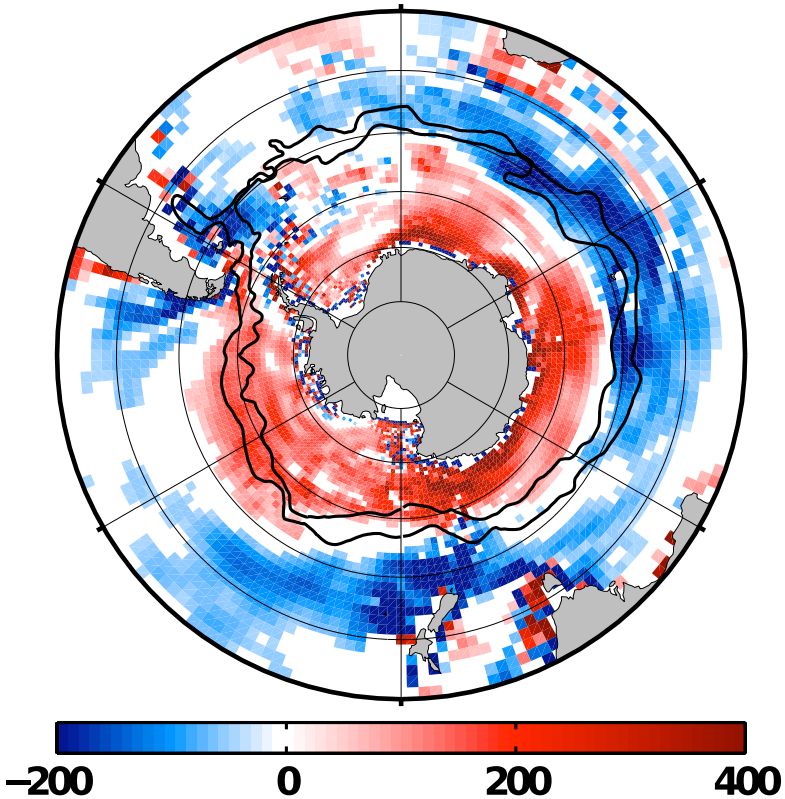

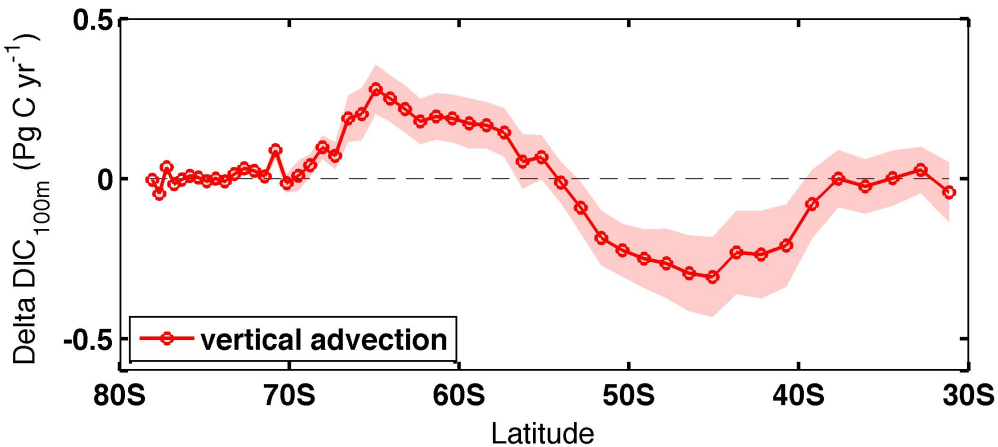

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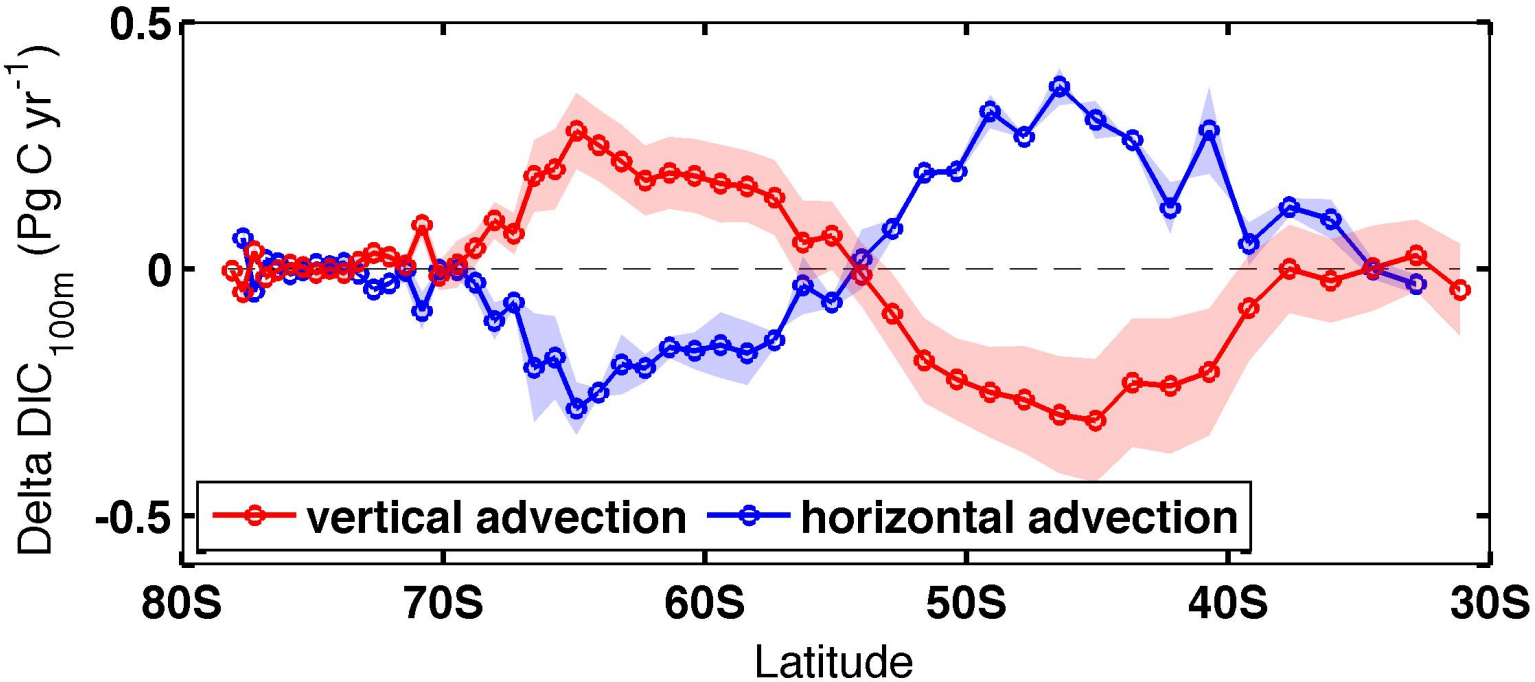

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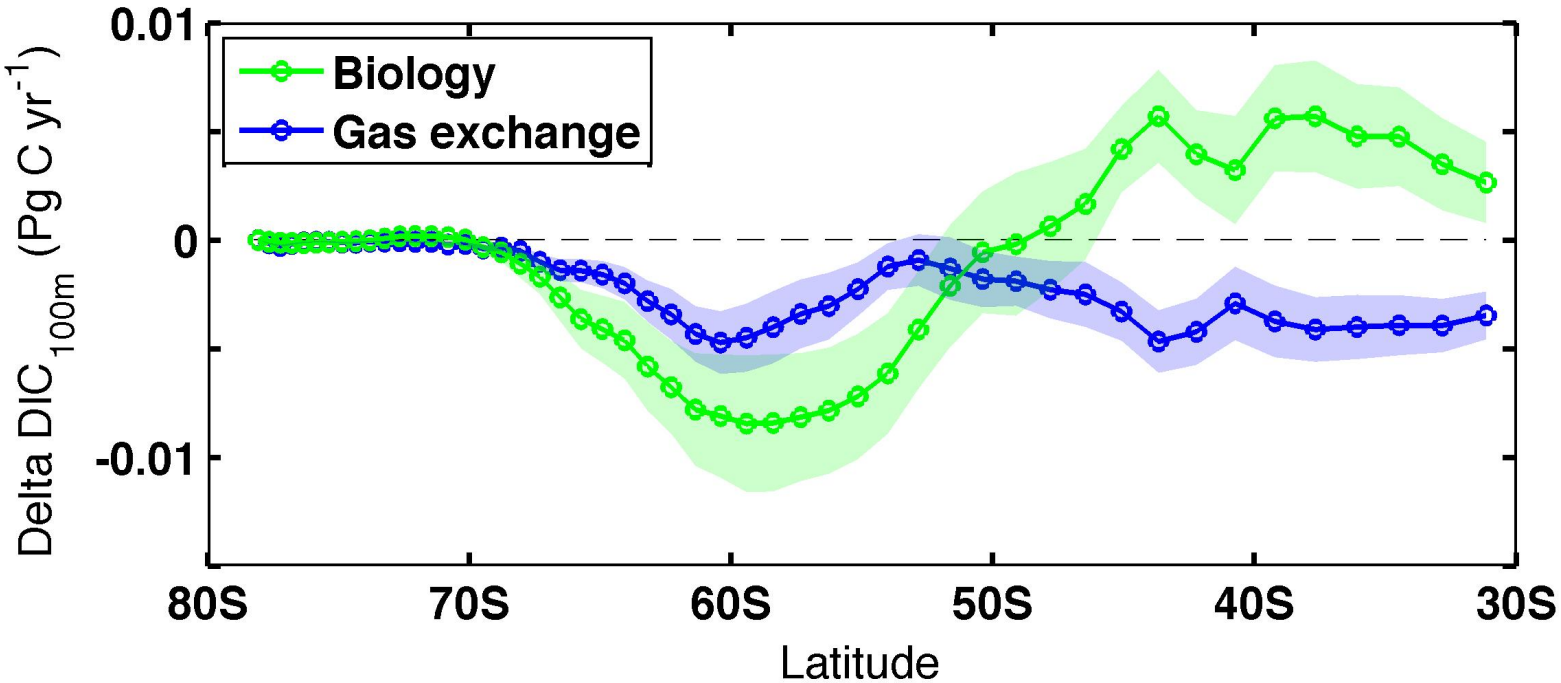
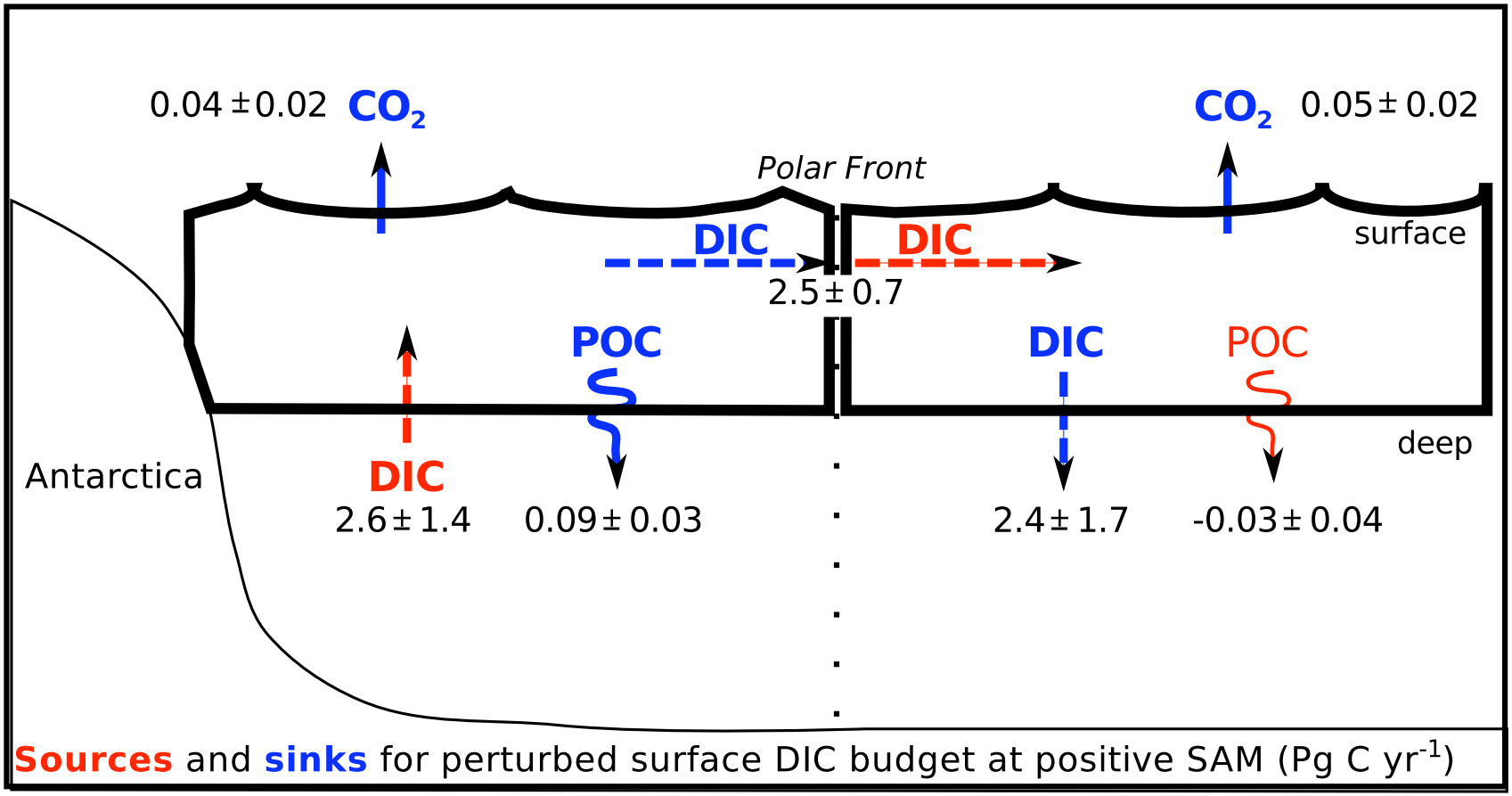
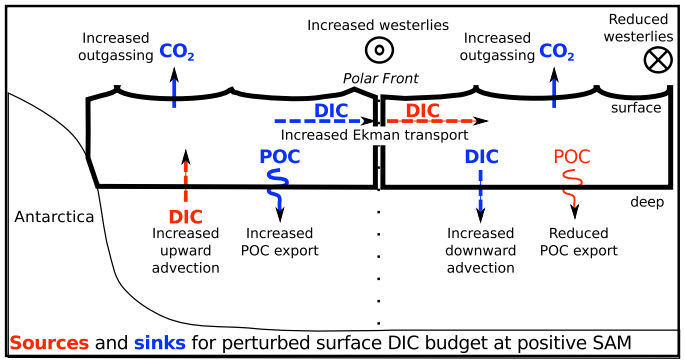


summing up: carbon flux anomalies for +SAM



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 air-sea CO_2 flux in S.O. is 0.09 ± 0.03 PgC yr^{-1}, similar to a recent eddy-resolving study (Dufour, 2011)