The Dimethylsulfide (DMS) cycle in the ocean-atmosphere system and its response to anthropogenic perturbations

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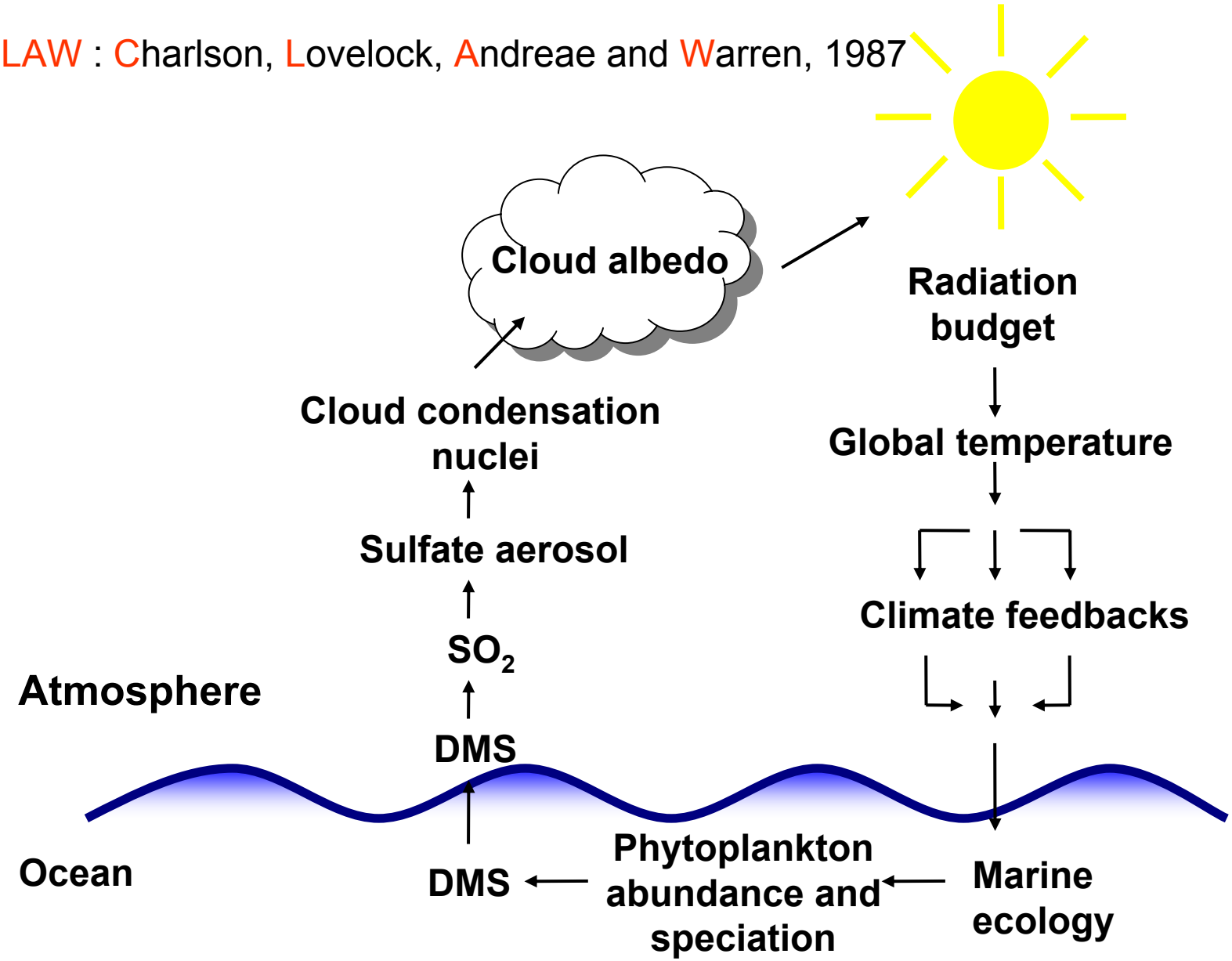
S. Kloster et al. (2007): Response of dimethylsulfide (DMS) in the ocean and atmosphere to global warming, J. Geophys. Res., 112, G03005, doi:10.1029/2006JG000224

S. Kloster et al. (2006), DMS cycle in the marine ocean-atmosphere system - a global model study, Biogeosciences, 3, 29-51.

Motivation

CLAW : Charlson, Lovelock, Andreae and Warren, 1987



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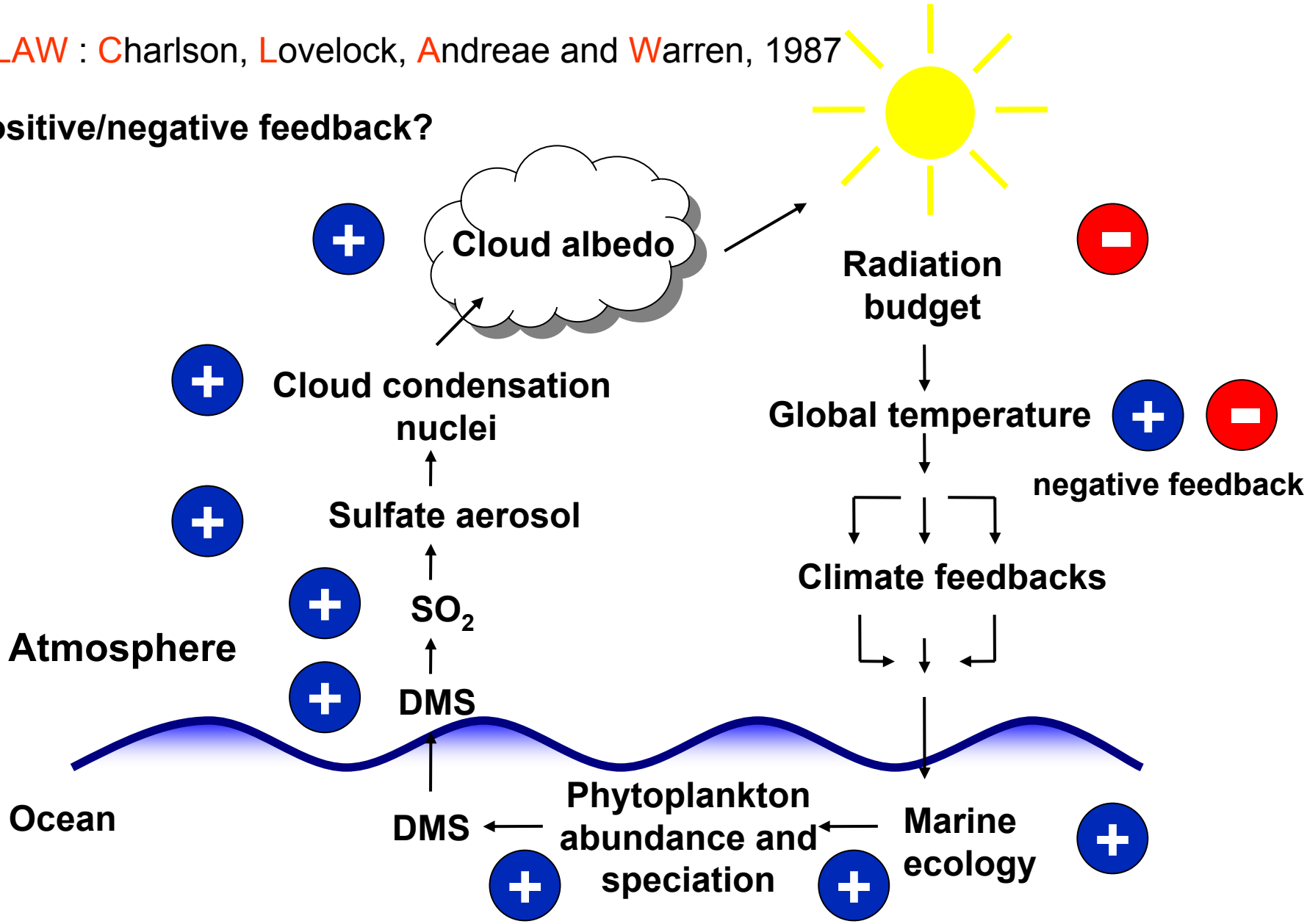
positive/negative feedback?



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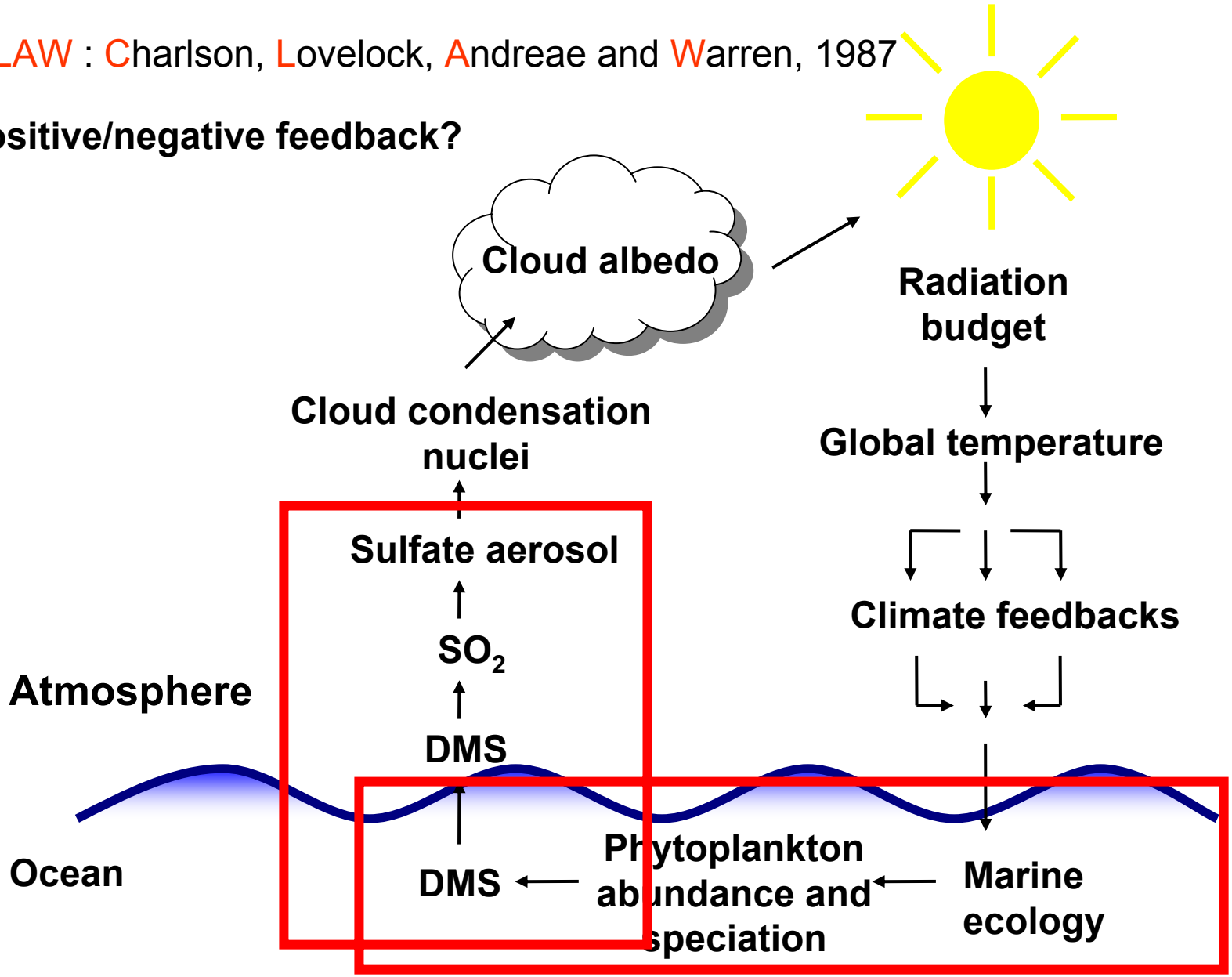
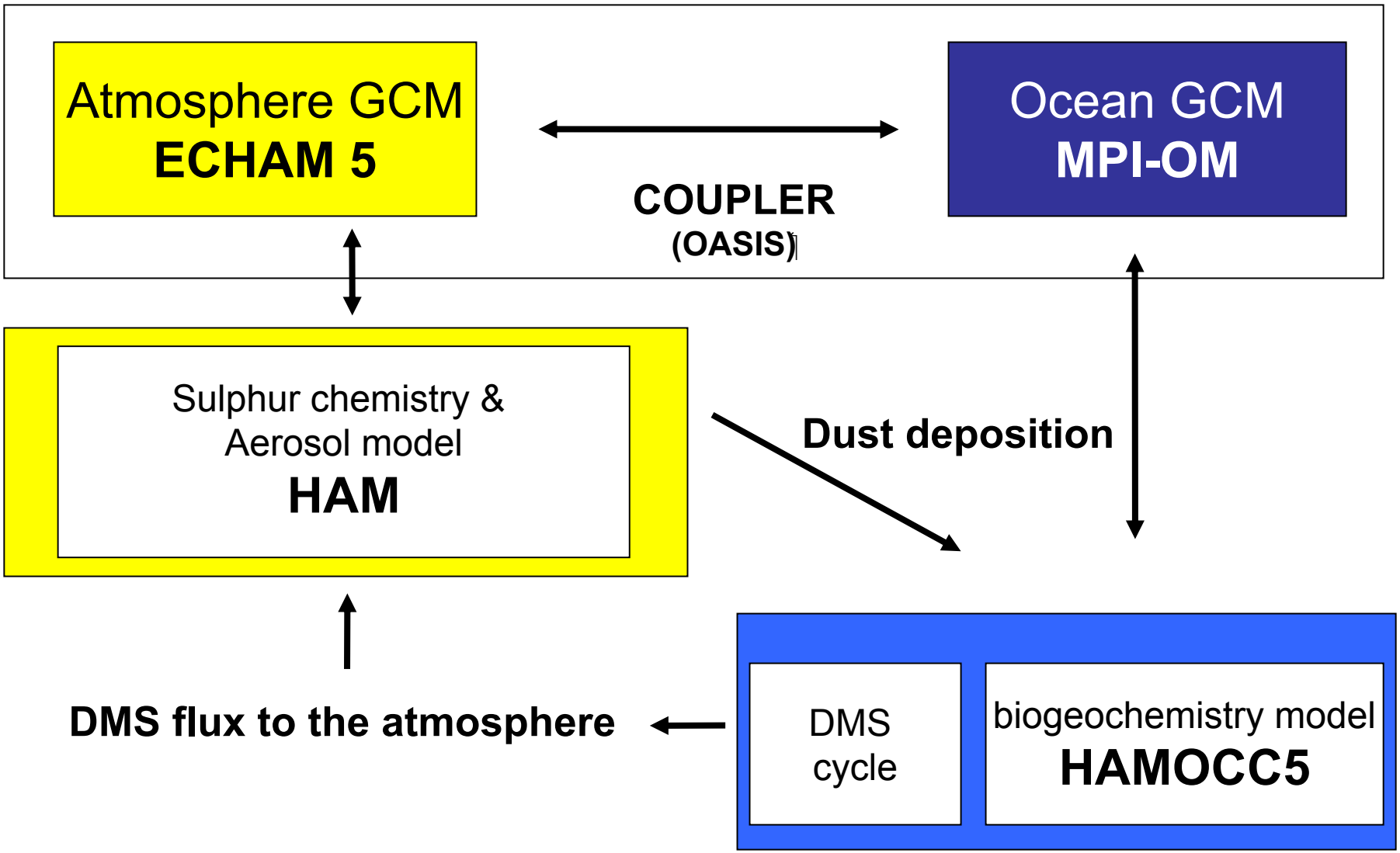


MODEL setup

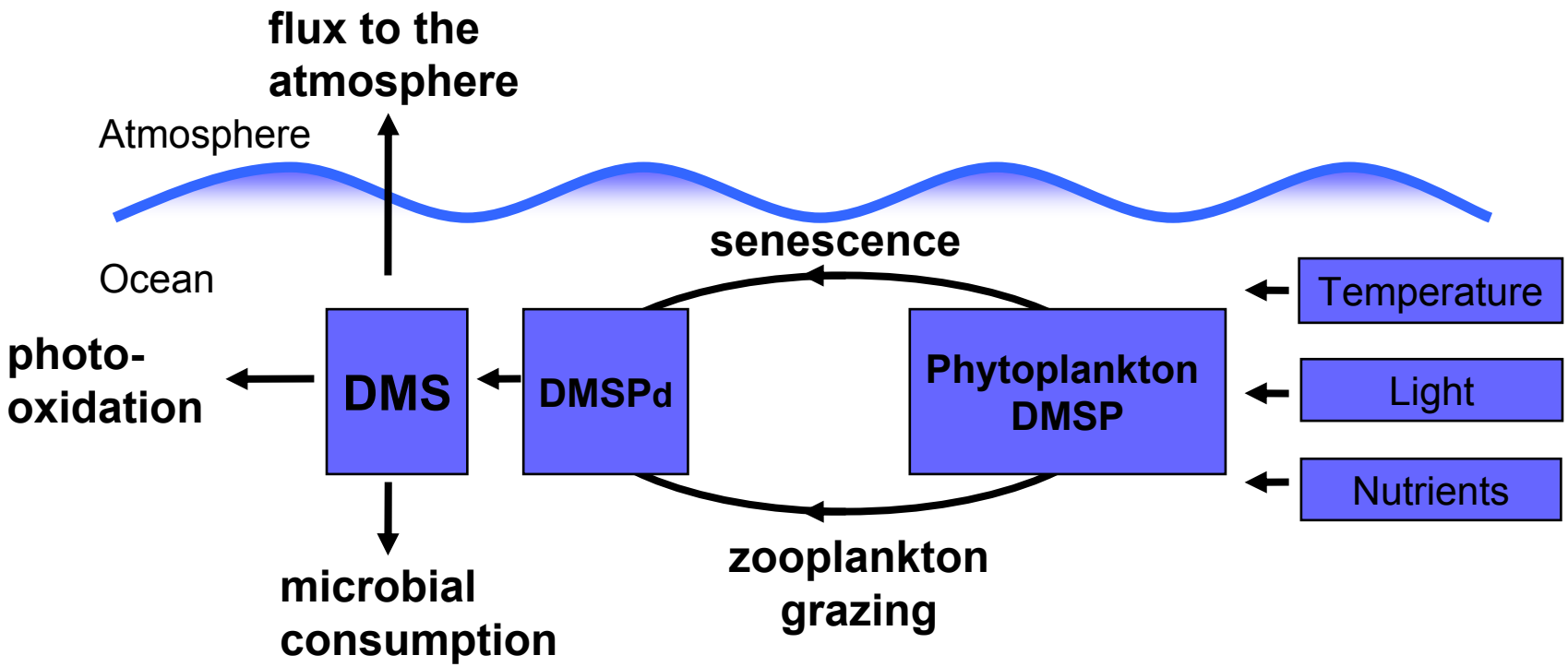

Atmosphere GCM
ECHAM 5
COUPLER
(OASIS)
Ocean GCM
MPI-OM
Sulphur chemistry &
Aerosol model
HAM
Dust deposition
DMS flux to the atmosphere
DMS
cycle
biogeochemistry model
HAMOCC5

MPI-OM/HAMOCC5

- Marine carbon cycle (Maier-Reimer, 1993)
- NPZD ecosystem model (Six and Maier-Reimer,1996, Maier-Reimer, 2005)
  - simulates the plankton dynamic
  - compartments: Nutrients, Phytoplankton, Zooplankton, Detritus
  - Limiting Nutrients: Phosphate, Nitrate and Iron
- DMS cycle in the ocean (Kloster et al., 2005)

HAMOCC5/DMS cycle ocean

- DMS cycle in the ocean



HAMOCC5/DMS cycle ocean

• DMS cycle in the ocean (Kloster et al., 2006)

DMS production:

DMS_{prod} : depending on the destruction of diatoms and coccolitophorids
f(export of silicate, export of calcium carbonate)

DMS decay:

DMS_{UV} : photo-oxidation f(solar irradiance)
DMS_{bac} : microbial consumption f(temperature)
DMS_{flux} : flux to the atmosphere f(temperature, wind speed)

$$\frac{d[DMS]}{dt} = DMS_{prod} - DMS_{bac} - DMS_{UV} - DMS_{flux}$$

The parameterization has been optimized to fit observed DMS sea surface concentration measurements reported in the Kettle and Andreae, 2000 database (more than 15,000 observations).

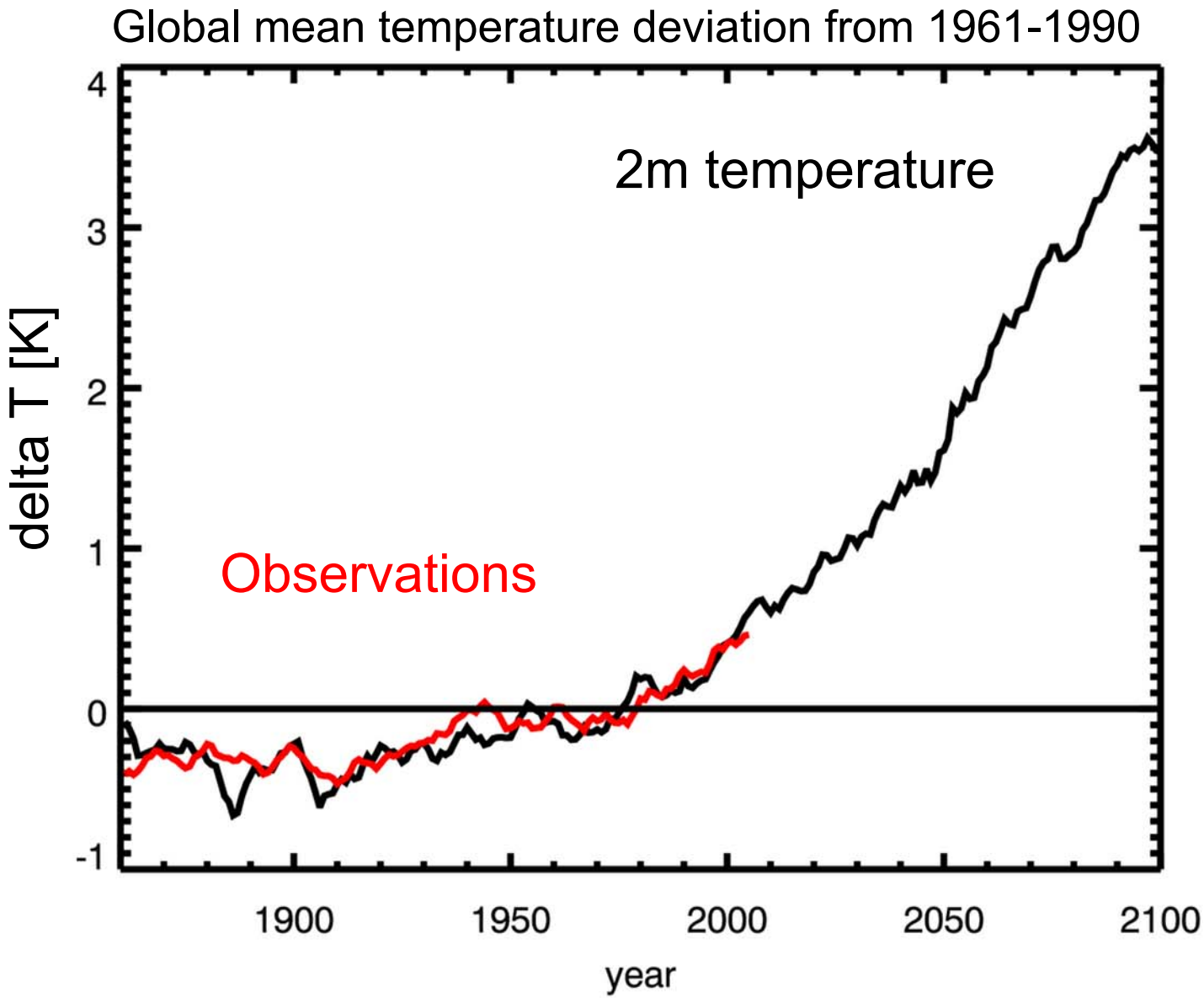
DMS cycle in a warmer climate

Transient climate simulation (IPCC 4AR simulation)

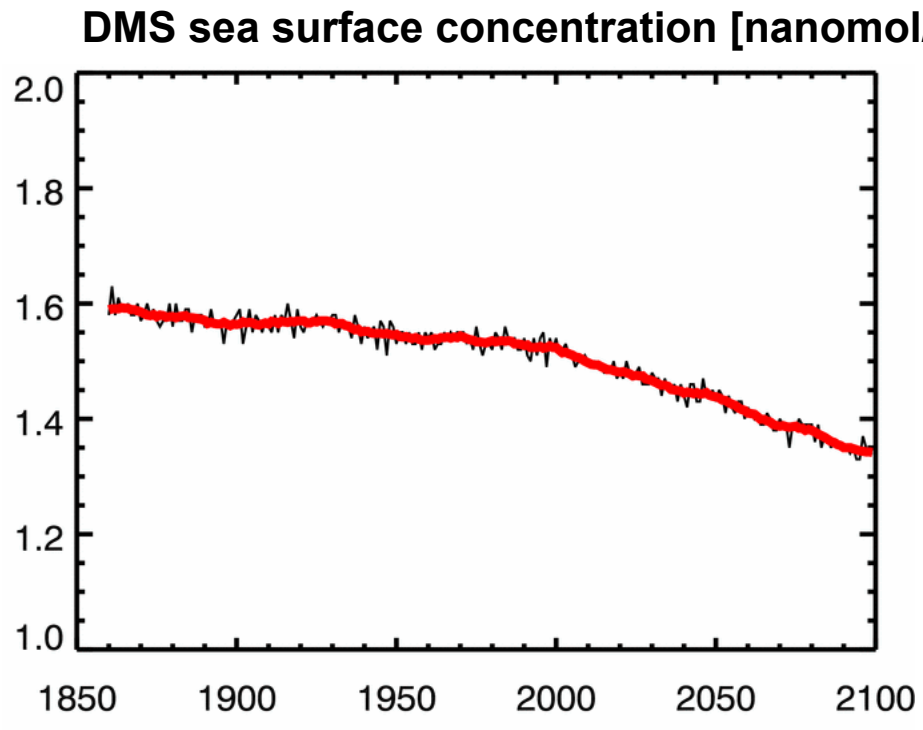
simulation period: 1860 - 2100

- solar and volcanic forcing (1860-2000)
- greenhouse gases forcings
  2001-2100: SRES A1B scenario
- aerosol and aerosol precursor emissions (BC, POM, SO_2) from the NIES emission scenario
  2001-2100: SRES A1B scenario
- DMS emissions are calculated interactively (Kloster et al., 2007)

Transient climate simulation



Global trend



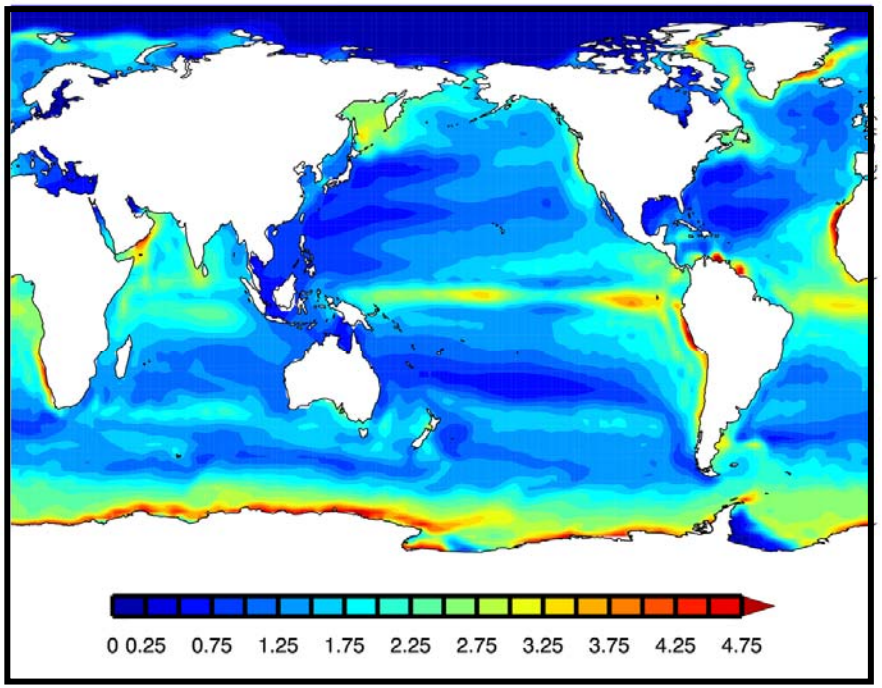
-10 %

CLAW: warmer climate → increase in the DMS sea surface concentration
This study: warmer climate → decrease in the DMS sea surface concentration

What happens in the ocean?

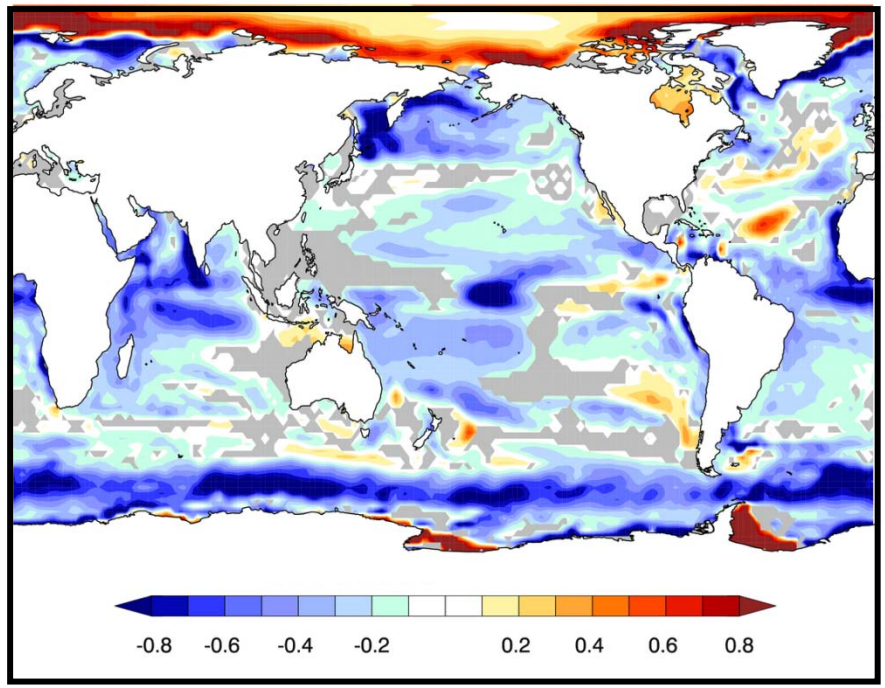
DMS sea surface concentration

annual mean



[nanomol/l]

1861/1890



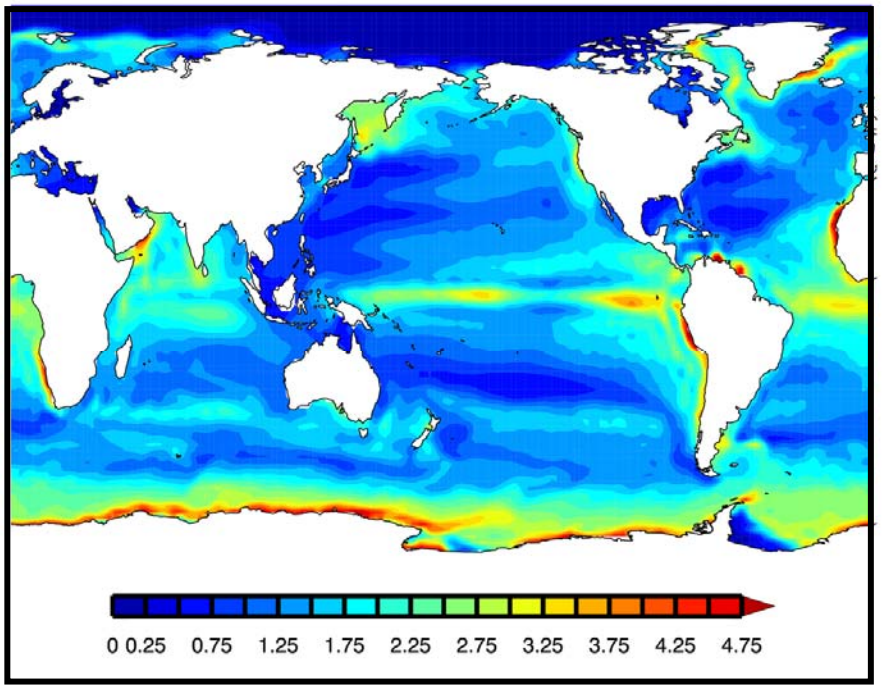
[nanomol/l]

2061/2090 - 1861/1890

-10%

DMS sea surface

annual mean



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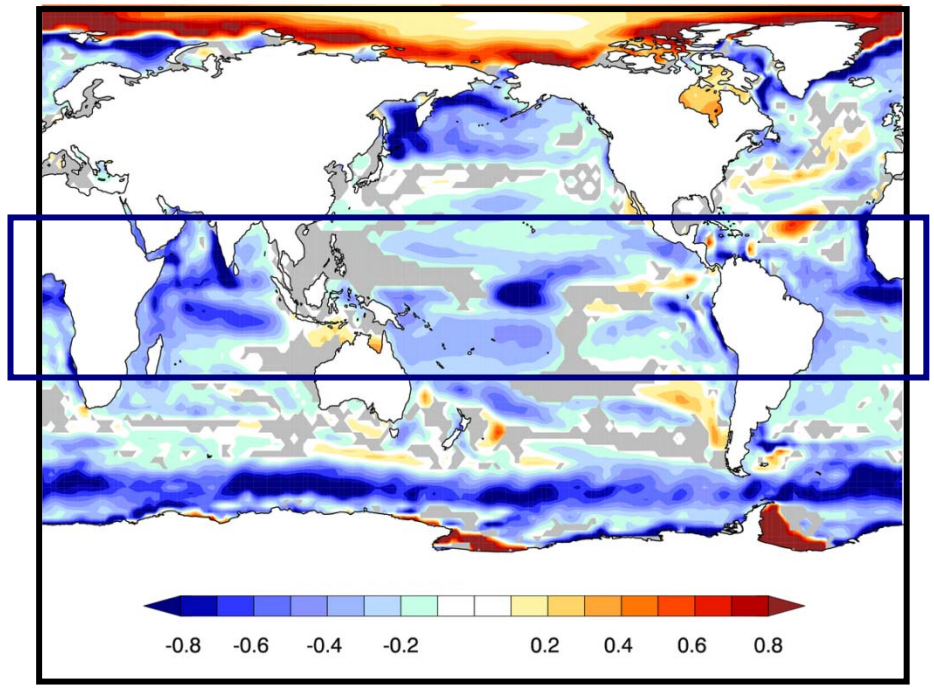
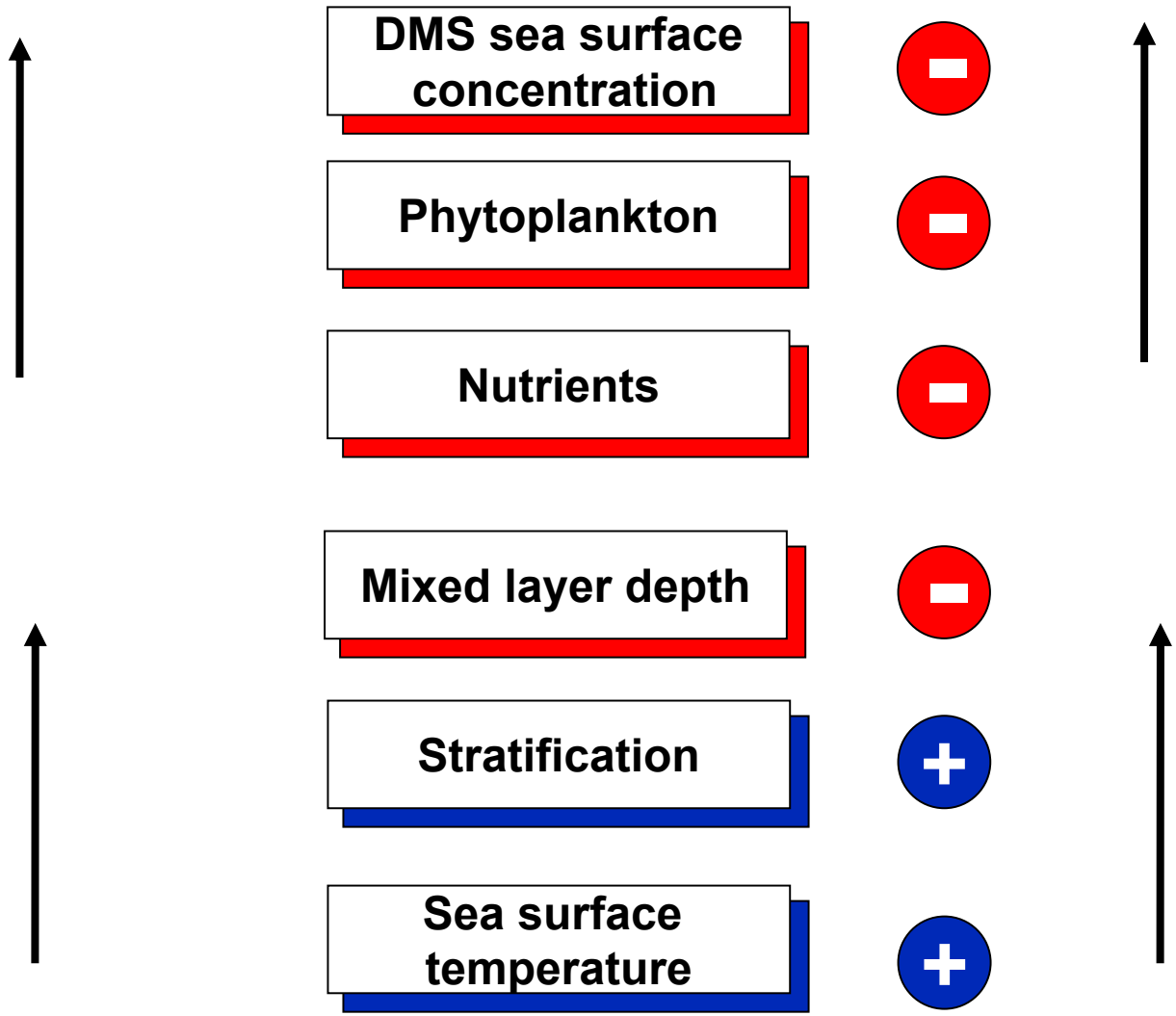


[nanomol/l]

2061/2090 - 1861/1890

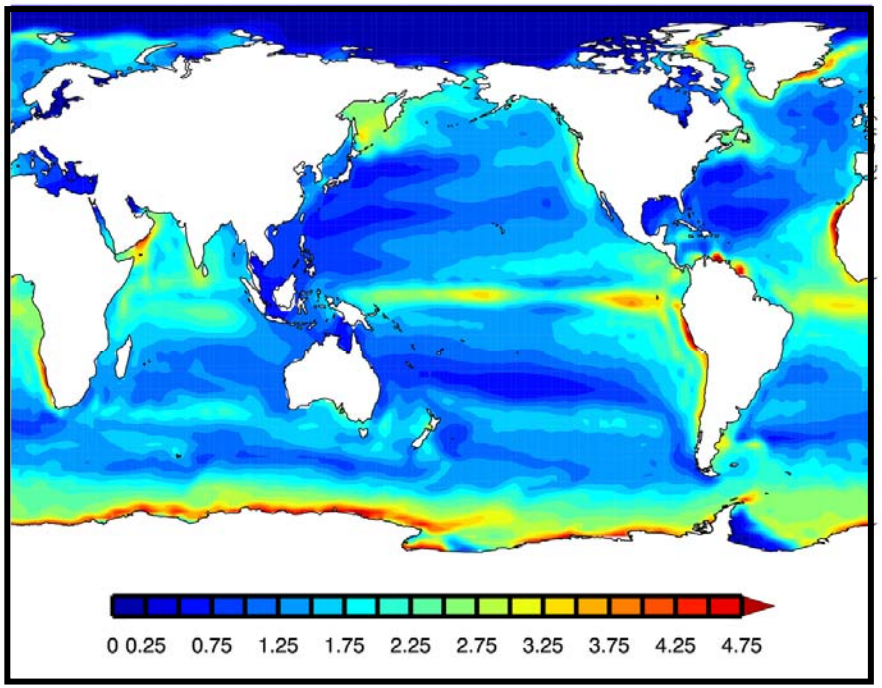
-10%

Response to climate change



DMS sea surface concentration

annual mean



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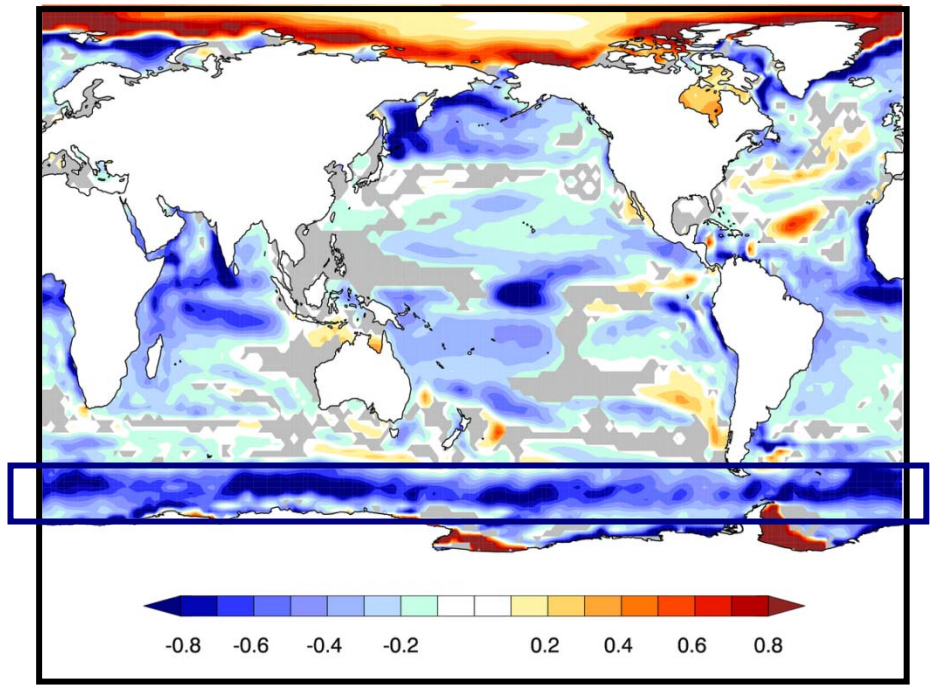


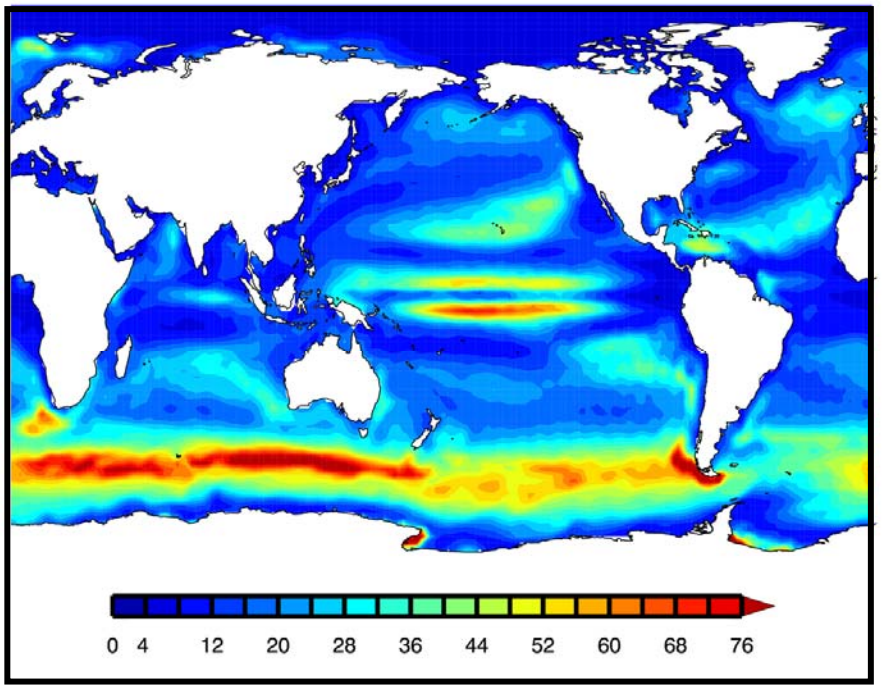
[nanomol/l]

2061/2090 - 1861/1890

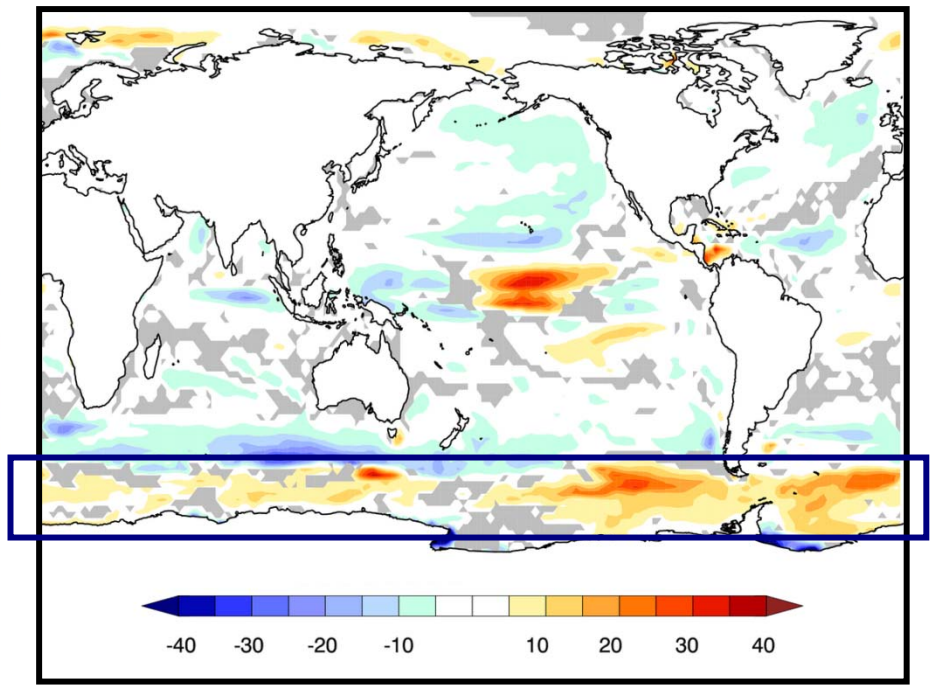
-10%

minimum MLD

annual mean



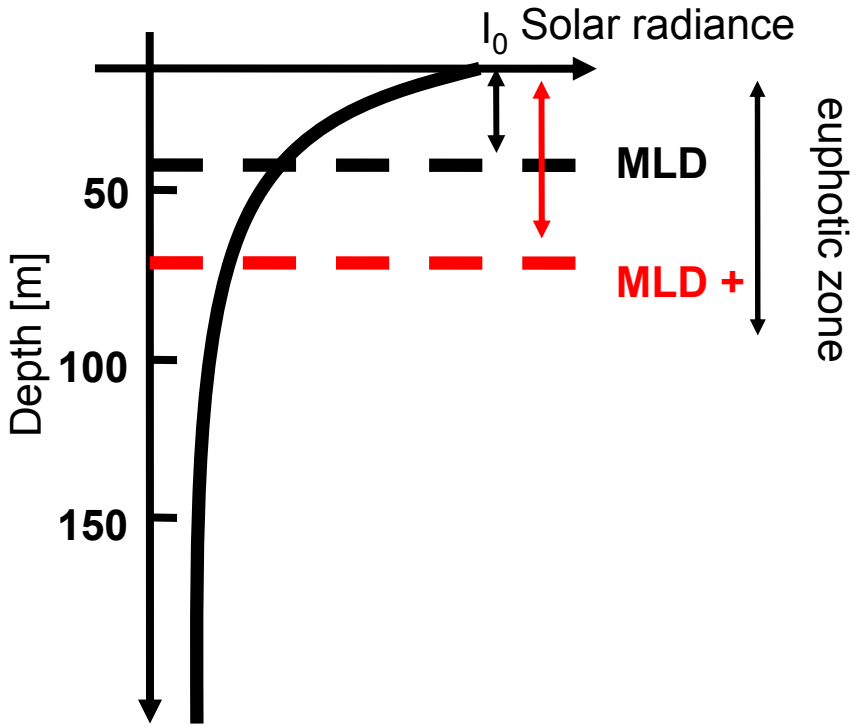
1861/1890

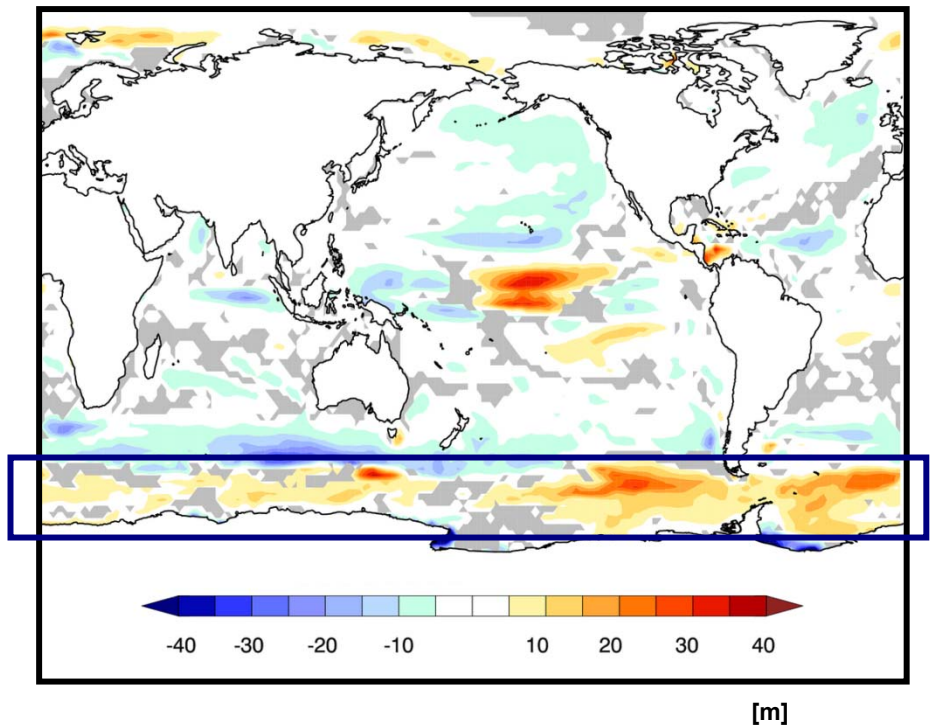


2061/2090 - 1861/1890

-6%

minimum MLD

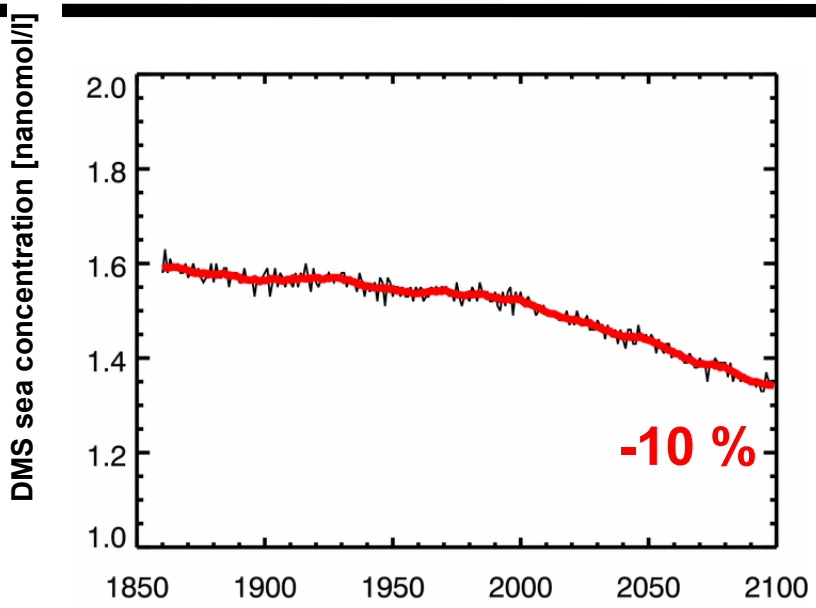


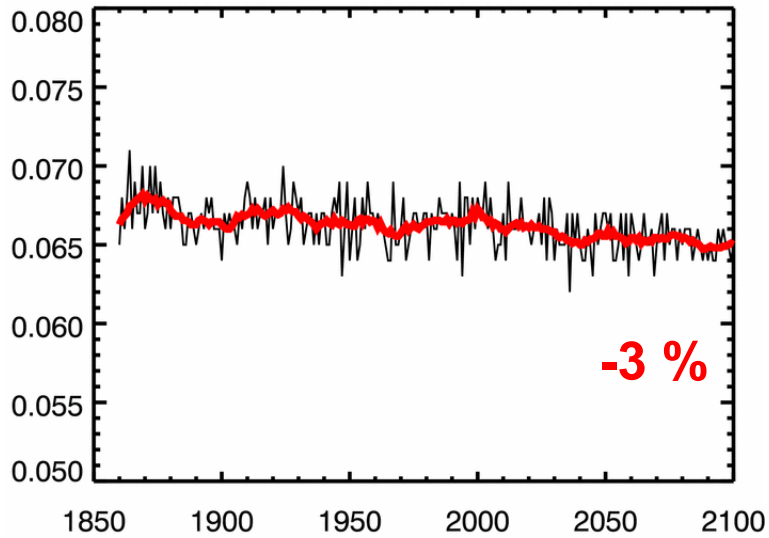


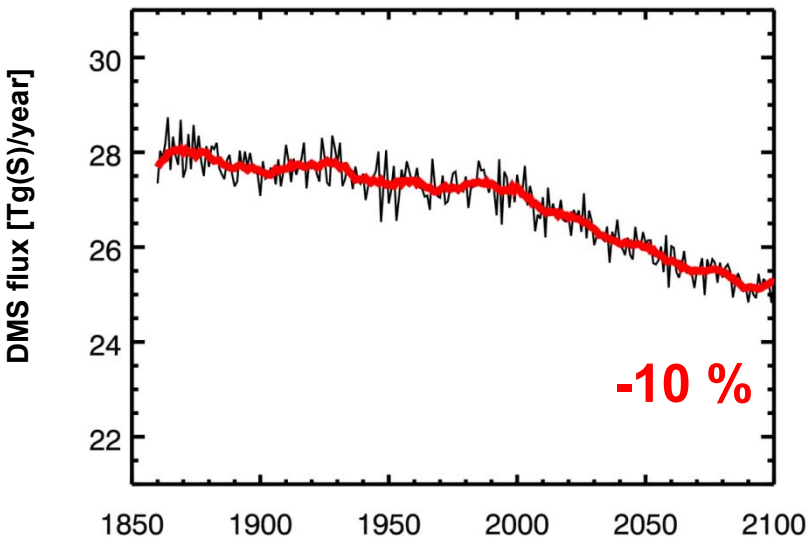
minimum MLD
2061/2090 - 1861/1890

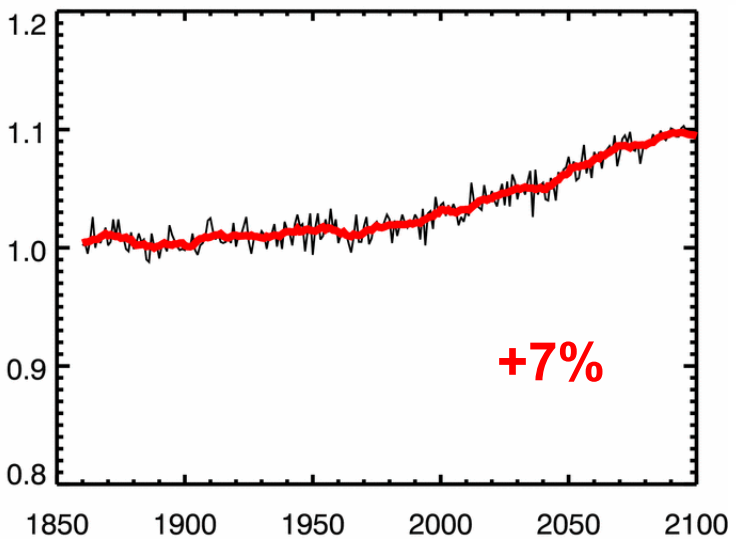
-6%

Summary/Global trends









Conclusion

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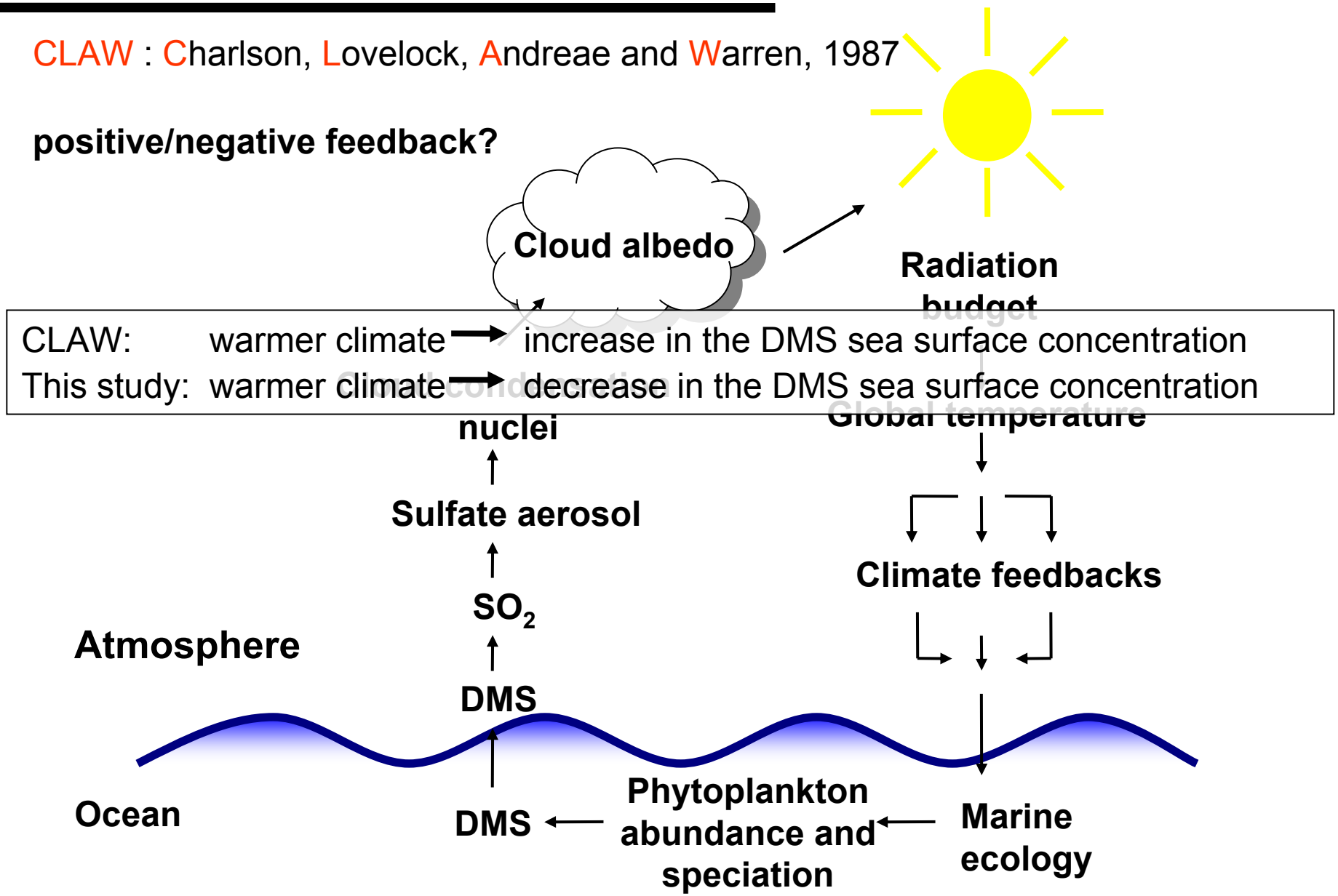

Conclusion

This study:

- changes in the ocean dynamic control the DMS production and DMS sea surface concentration, like:

  - enhanced ocean stratification $\Rightarrow$ reduced nutrient transport
  - enhanced summer mixed layer depth in the Southern Ocean $\Rightarrow$ reduced light exposure of phytoplankton

  which lead to a reduction of the DMS sea surface concentration in a warmer climate

- Changes in the atmospheric DMS concentration are not only controlled by changes in the DMS emissions, but also by changes in the DMS lifetime in the atmosphere.

- Kloster S., K. D. Six, J. Feichter, E. Maier-Reimer, E. Roeckner, P. Wetzel, P. Stier, and M. Esch (2007): Response of dimethylsulfide (DMS) in the ocean and atmosphere to global warming, J. Geophys. Res., 112, G03005, doi:10.1029/2006JG000224
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Future Plans

Fire at the intersection of the

global carbon and water cycles

- Improved fire algorithm in CLM-CN
- How does the fire strengthen the feedback between the carbon cycle and the climate system during the 21st century
- Fire interact with the climate through:
    - atm. CO2 concentration
    - aerosol concentration
    - albedo; via deposition of BC on snow and sea ice
    - ecosystem carbon and energy fluxes; mediated by aerosol diffuse radiation, changes in albedo and ozone concentrations