Impact of the Ocean Sulfur Cycle on Climate using CESM

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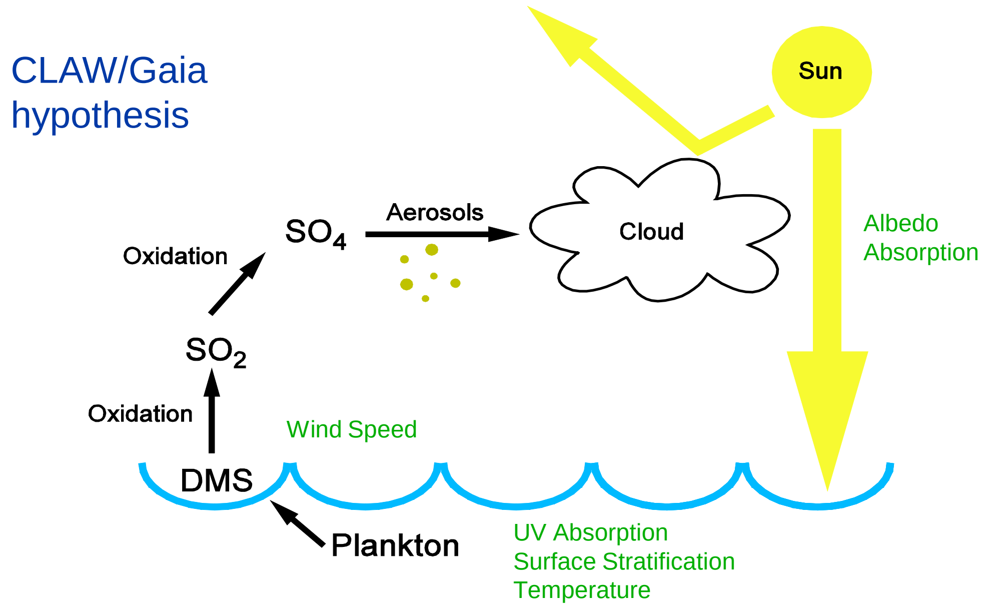
Earth System Model Simulations of Dimethyl Sulfide (CLAW hypothesis)

- We are modeling some of the ways biosphere and atmospheric chemistry interact to affect climate through the sulfur and methane cycles.
- End goal is to
  a. Quantify the climate feedbacks.
  b. Test the CLAW/Gaia climate stabilization hypothesis.



Plankton blooms observed to increase cloud reflectivity, decrease precipitation

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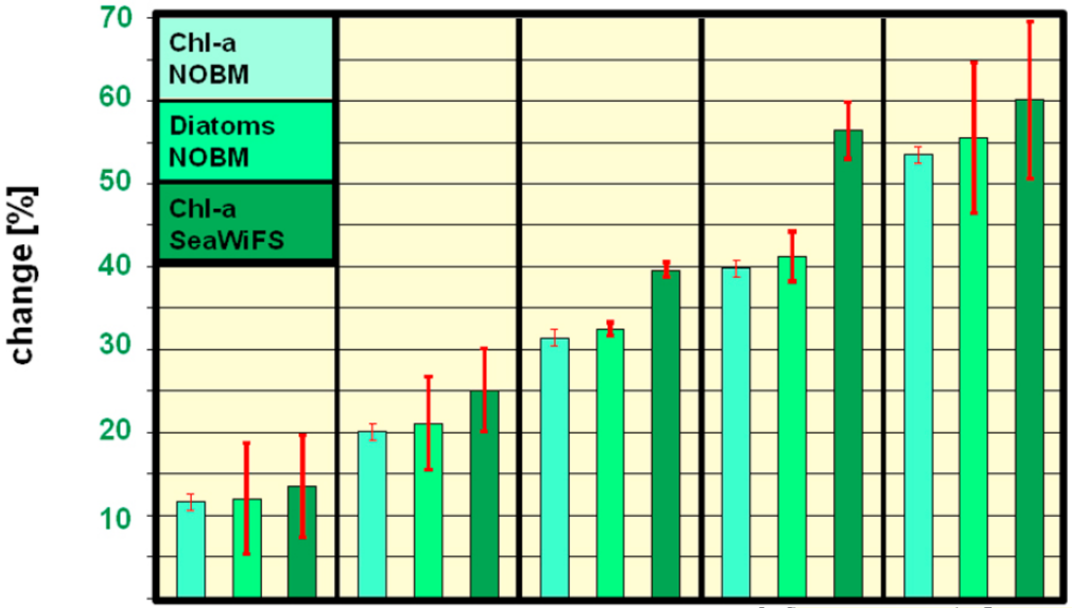
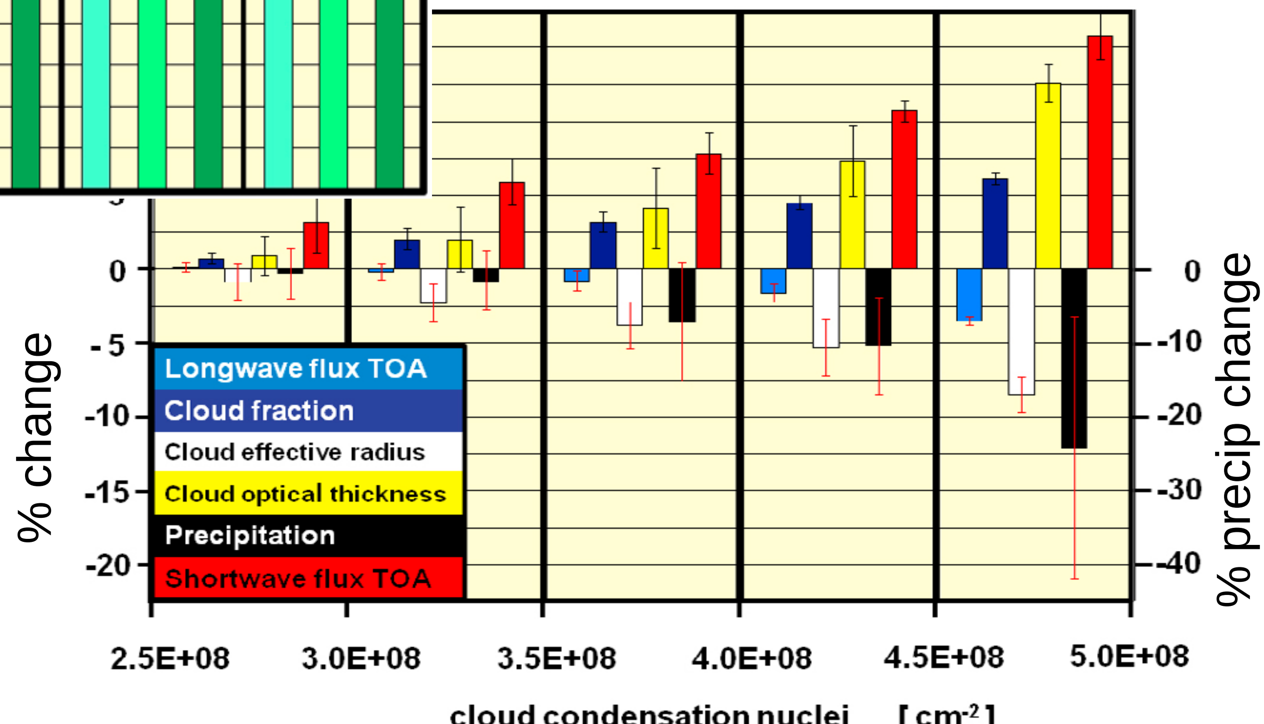
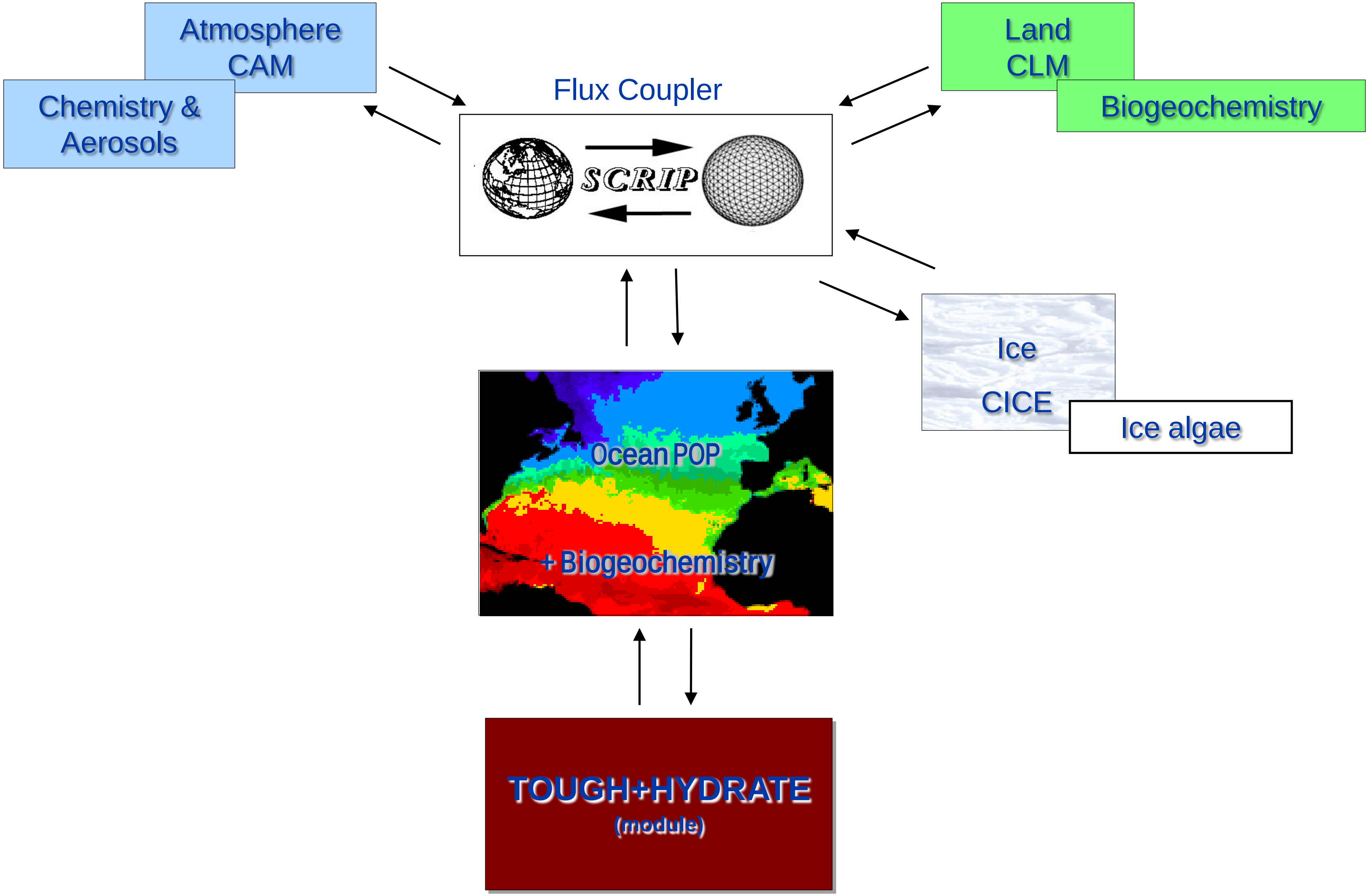


Satellite correlations between plankton blooms and clouds



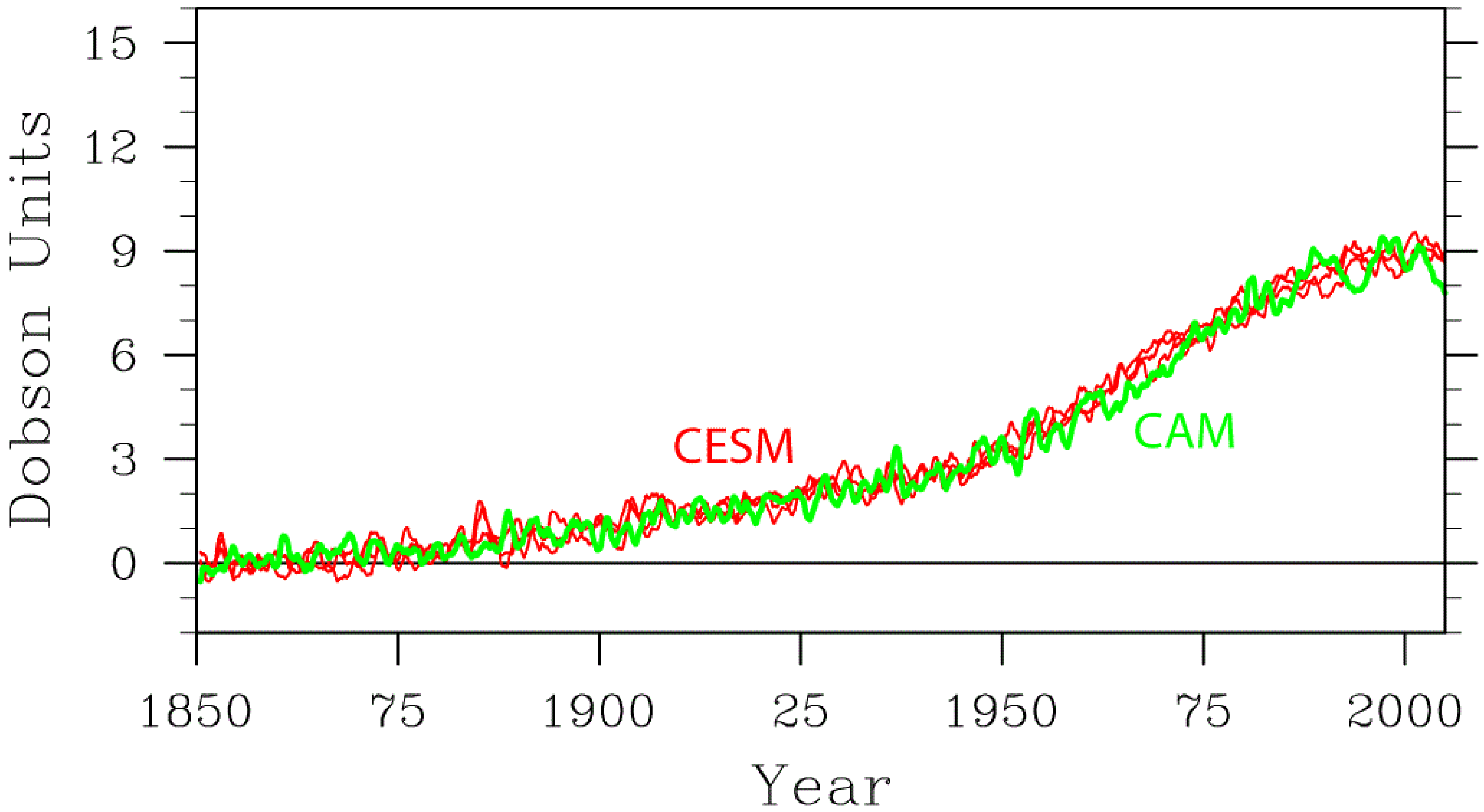
O. Krüger, H. Graßl, Southern Ocean phytoplankton increases cloud albedo and reduces precipitation. *Geophys. Res. Lett.* **38**, L08809 (2011).

Sulfur & Methane ESMs

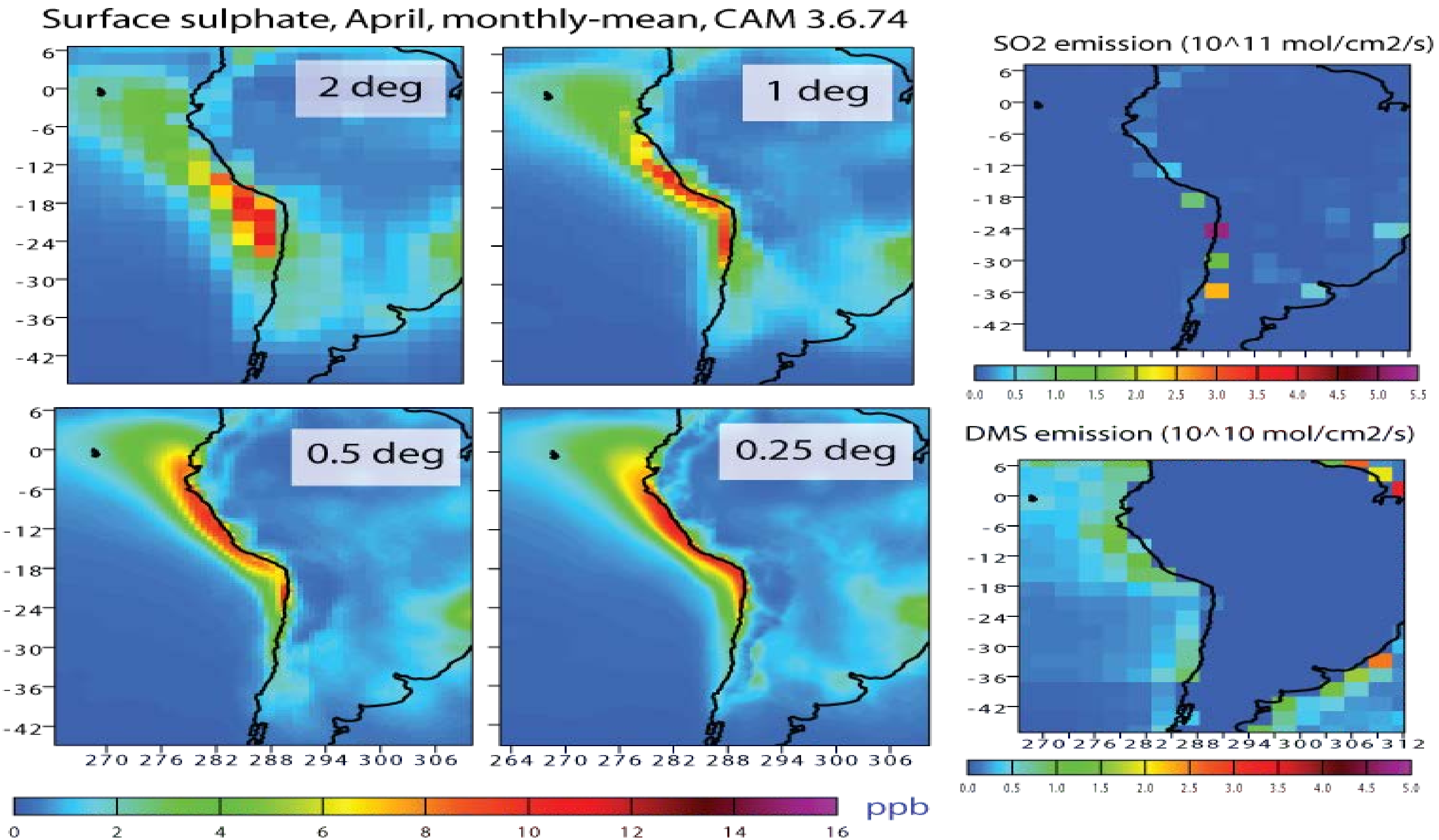


Hot off the press: Our IPCC ensemble simulations show internal variability.

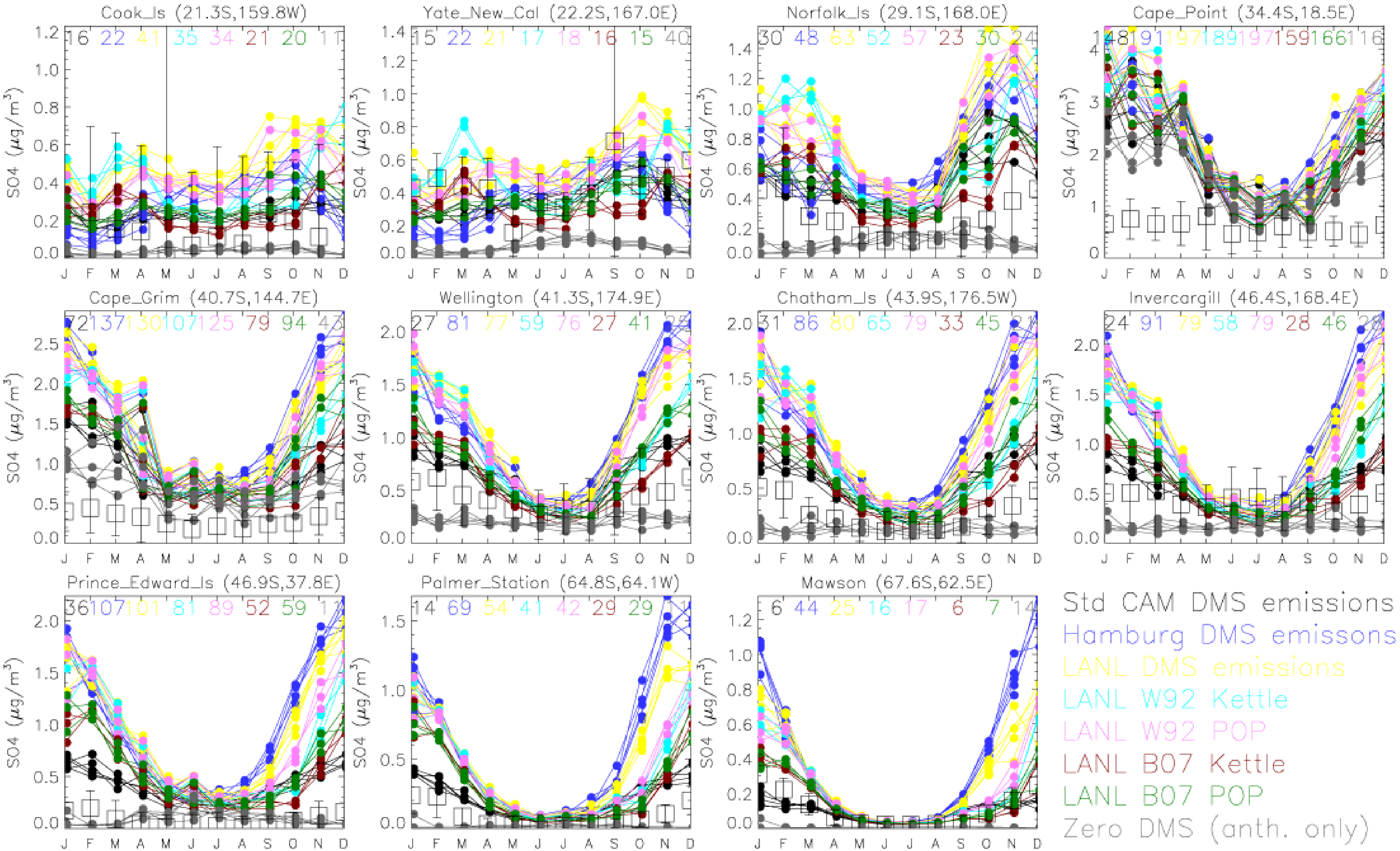
Change in global mean tropospheric ozone column



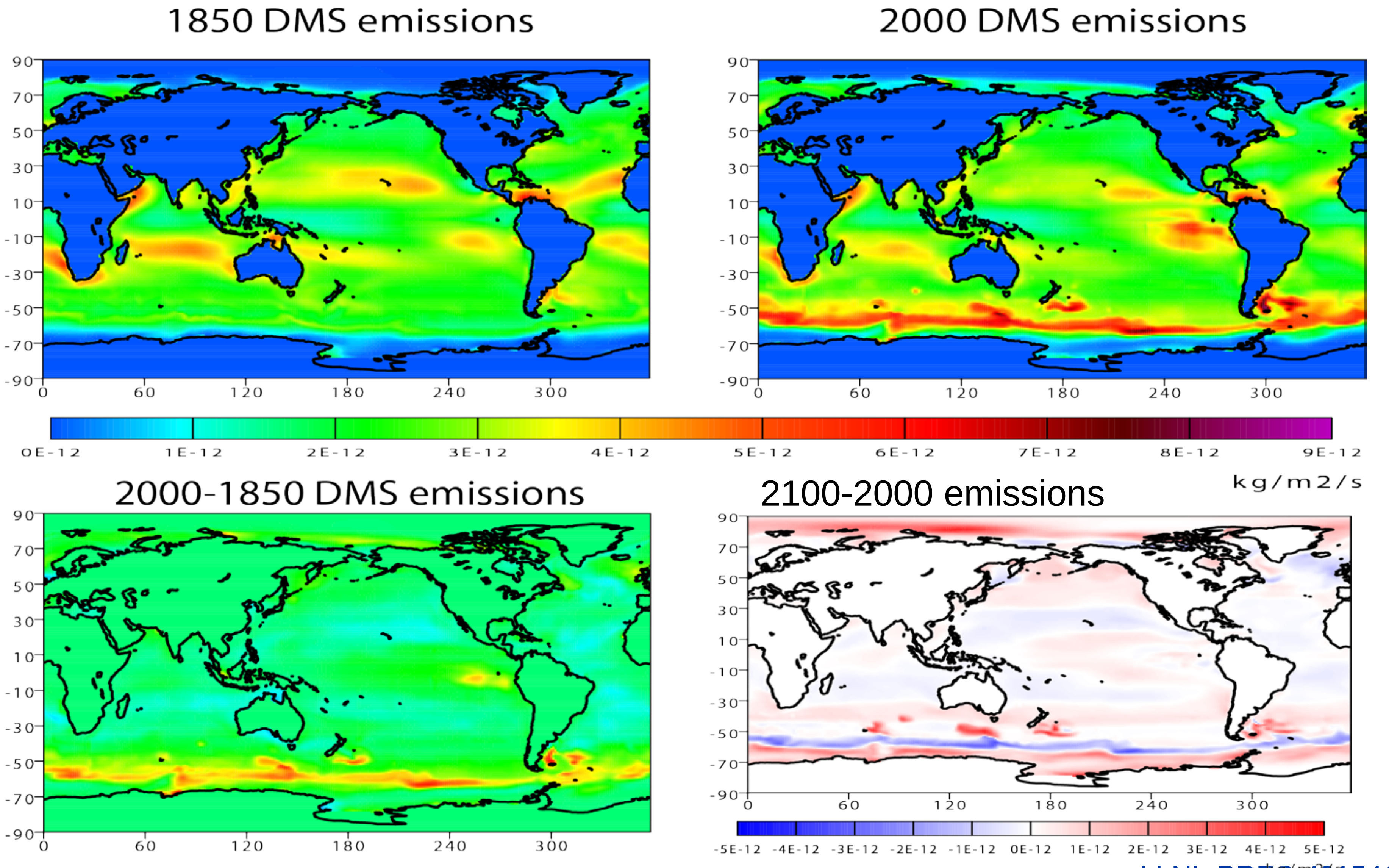
Hi-res chemistry shows narrower sulfate band off South America.



Sulfate aerosols validate well against surface observations.



DMS flux changes dramatically from 1850 to 2000 to 2100, especially in S. Ocean



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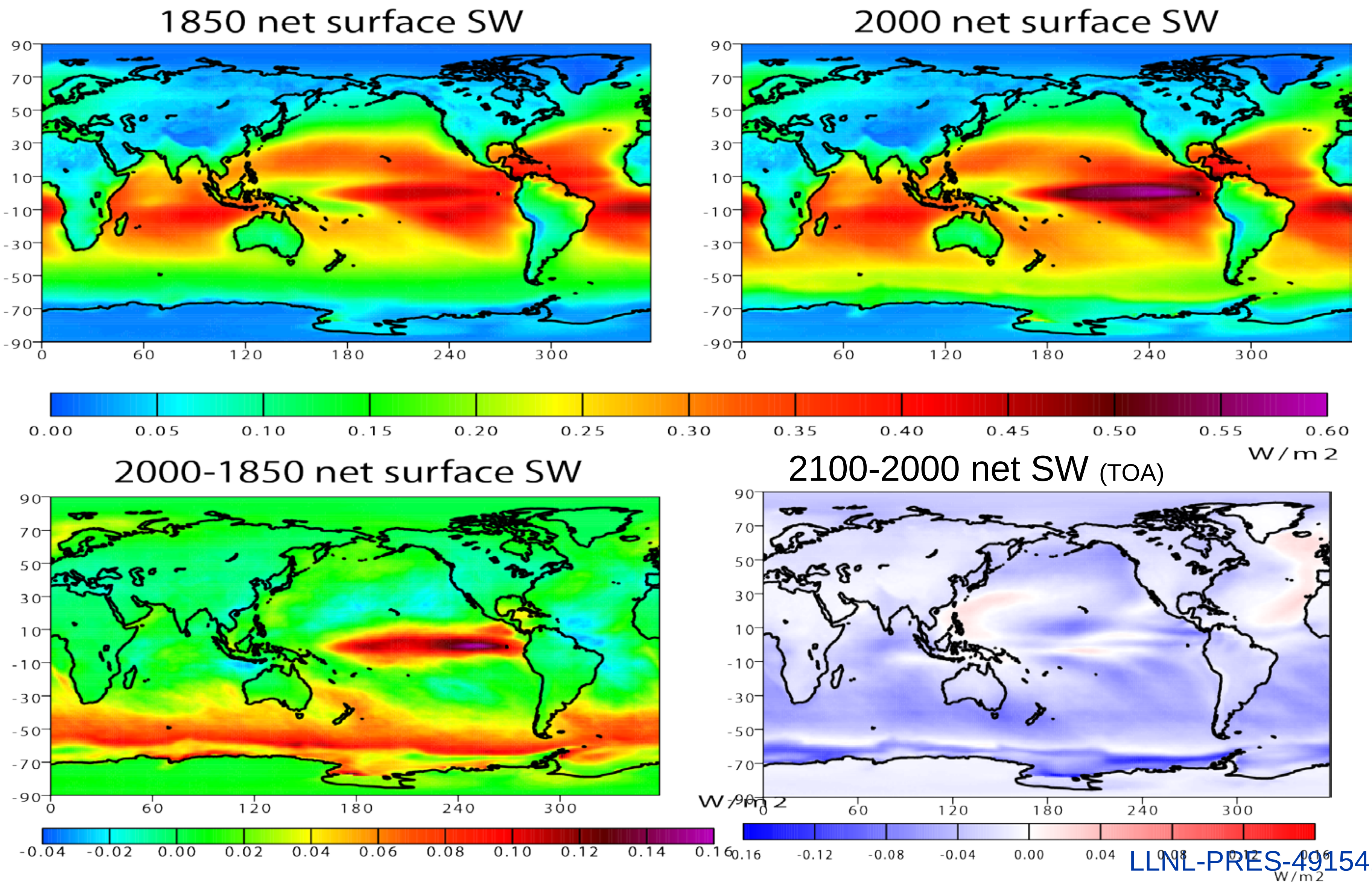
20th Century change in net SW radiation from *direct* DMS sulfate of 0.1 W/m^2



Changes in DMS are strongly affected by changes in ecosystem structure.

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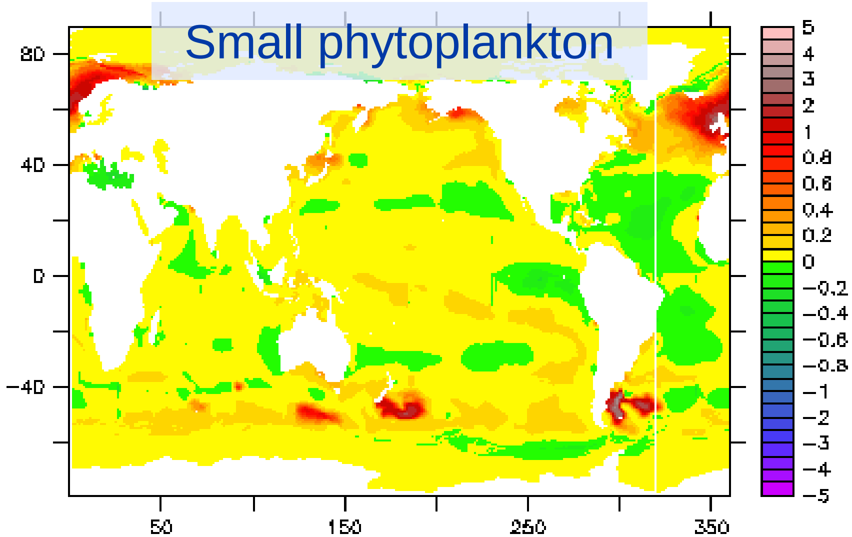

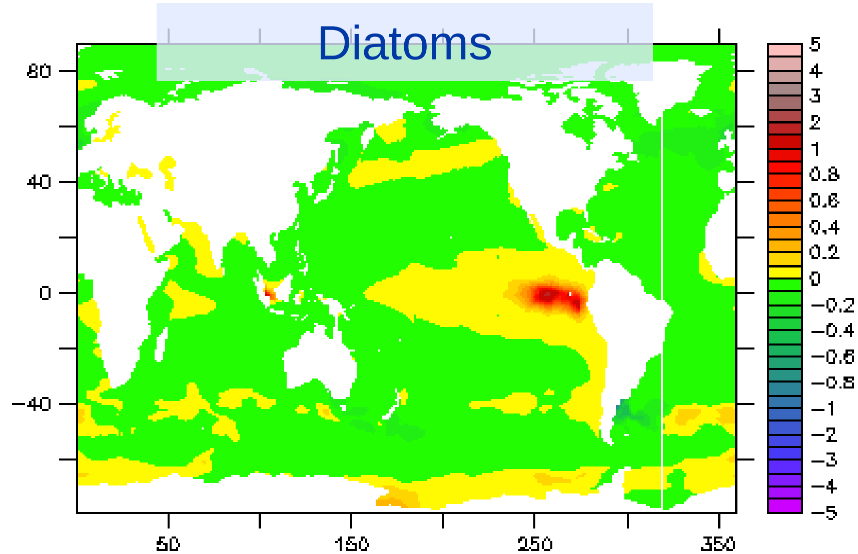

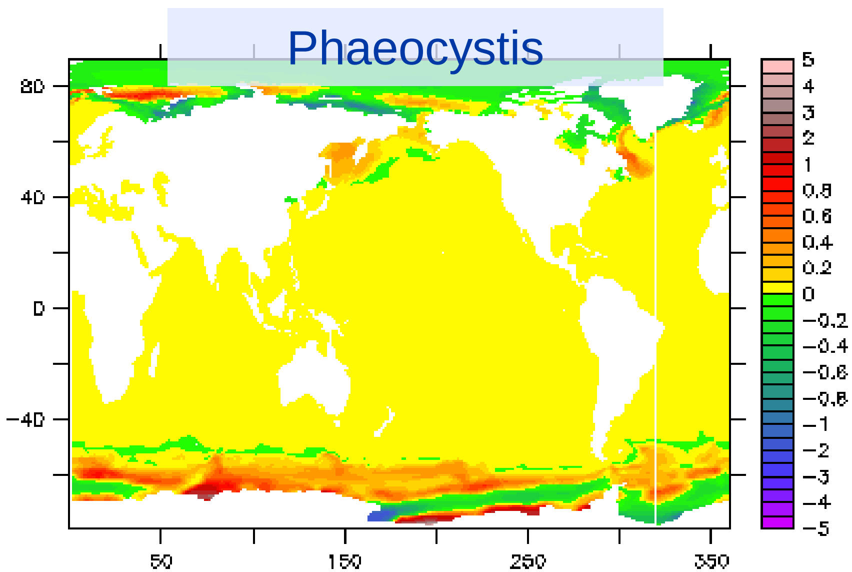

Change in DMS concentration (in sea-water) contributed by different phytoplankton types.

Units are normalized DMS concentrations, and are comparable across panels.

Conclusions.

Sulfur

- 3x increase of DMS in southern ocean (2000-1850).
- Poleward shift of DMS and forcing (2100-2000)
- Change in local *direct* forcing of 0.1 W/m^2 (2000-1850).
  - Indirect forcing should be larger still.
- Importance of DMS *increases* as anthropogenic SO_2 *decreases* due to pollution controls (2100-2000).

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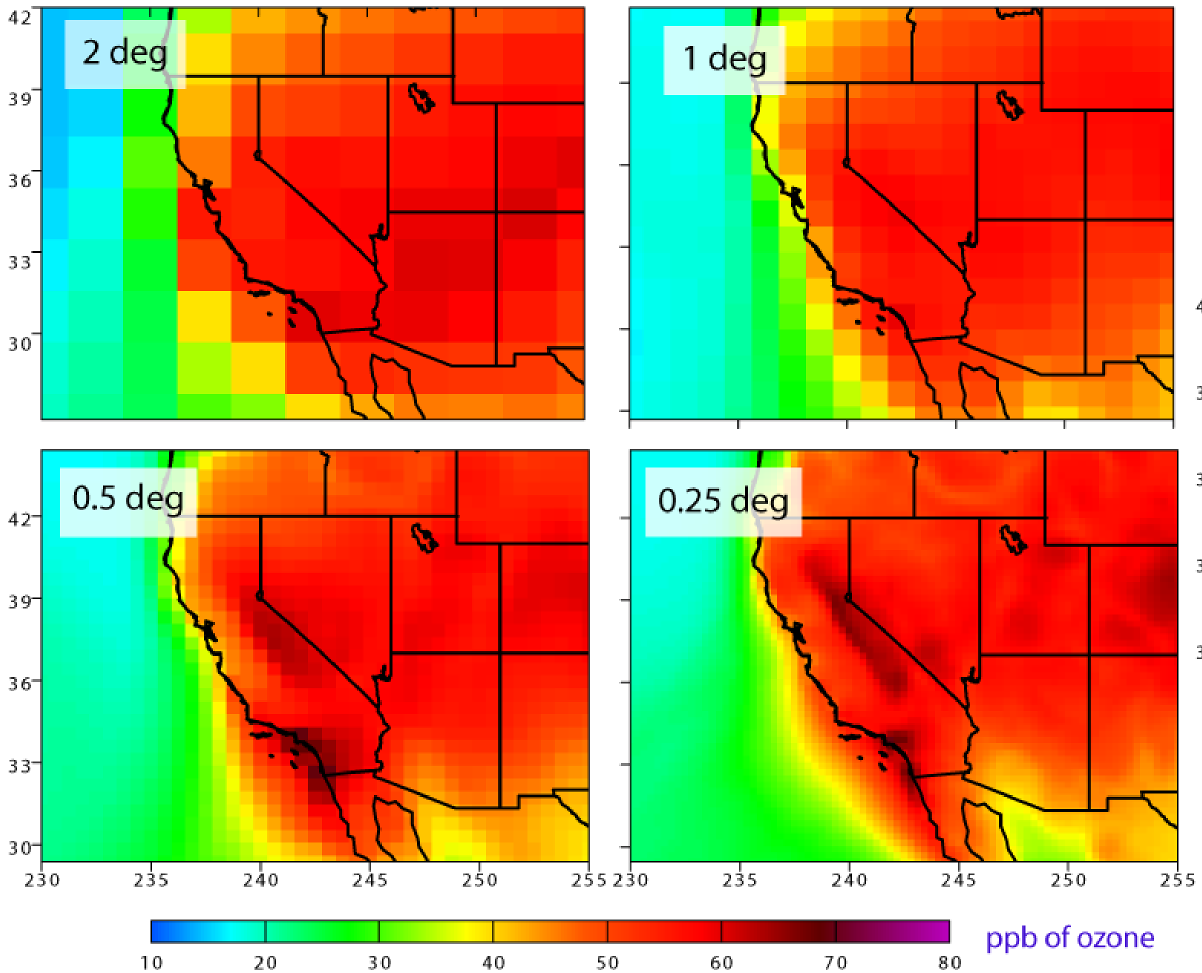
The End

Hi-res chemistry shows smog over Los Angeles due to orographic enhancement.

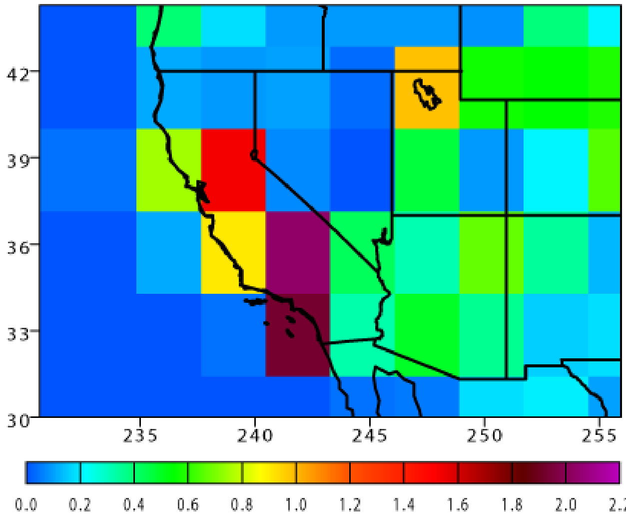
Surface ozone, July, monthly-mean, CAM 3.6.74



Livermore Computing

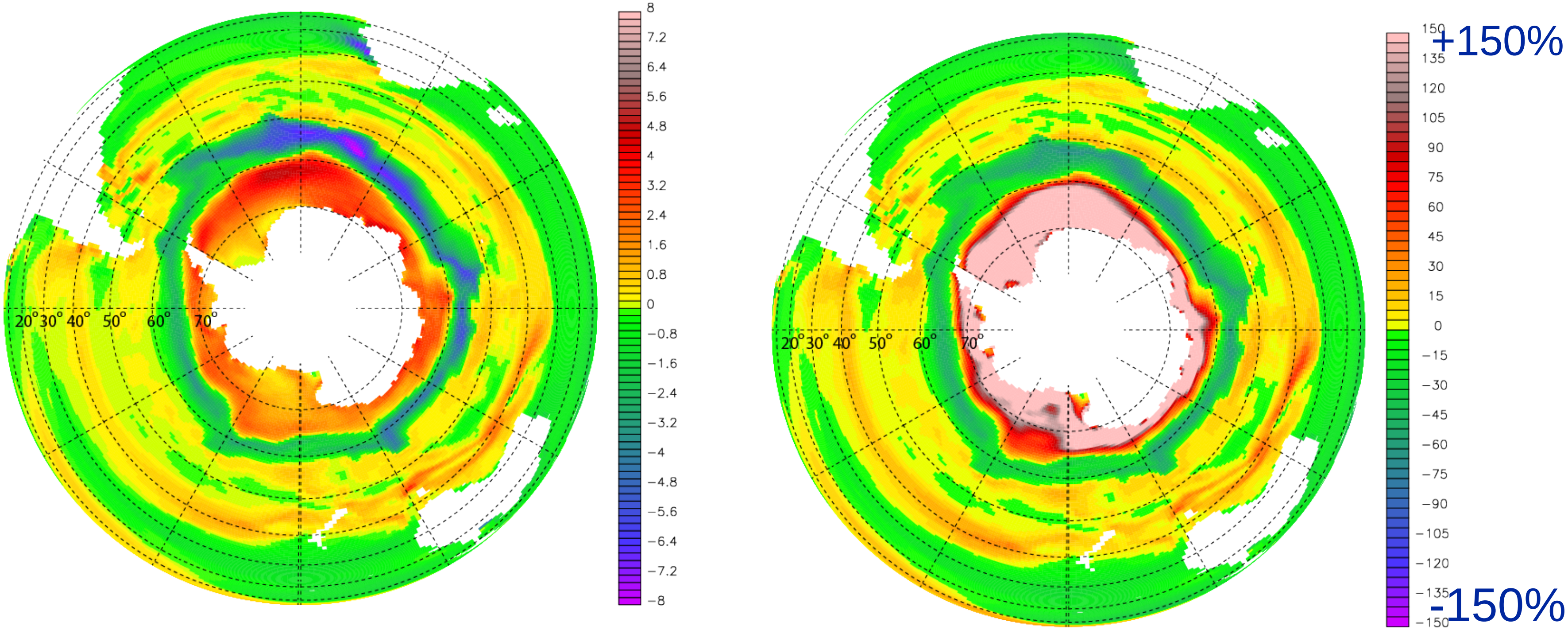
Grand Challenge 2009-2011

Emission of NO (10^11 mol/cm2/s)



DMS emissions shifts over 21st century could be larger then previously thought.

Change in DMS emissions to the atmosphere over 21st century



Raw difference nmoles/m^2/s **% difference**

P. Cameron-Smith, S. Elliott, M. Maltrud, D. Erickson, O. Wingenter, *Geophys. Res. Let.*, **38**, L07704, 5 pp., doi:10.1029/2011GL047069, 2011.

Highlighted in "If Gaia could talk", Maurice Levasseur, Nature Geoscience, **4**, pp 351–352, doi:10.1038/ngeo1175, May 2011.