

CCSM4 Sensitivity Experiments with Black Carbon Aerosols

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NCAR



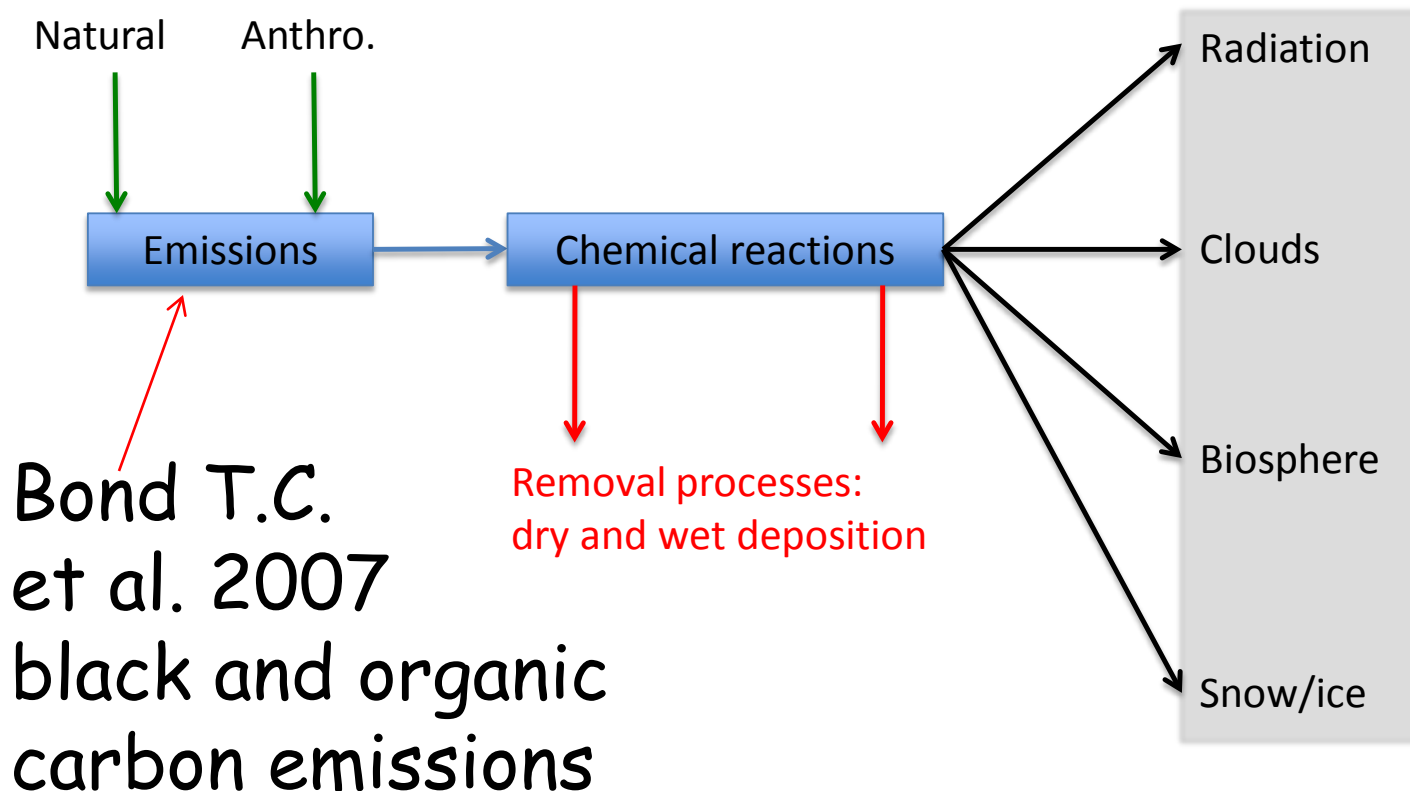
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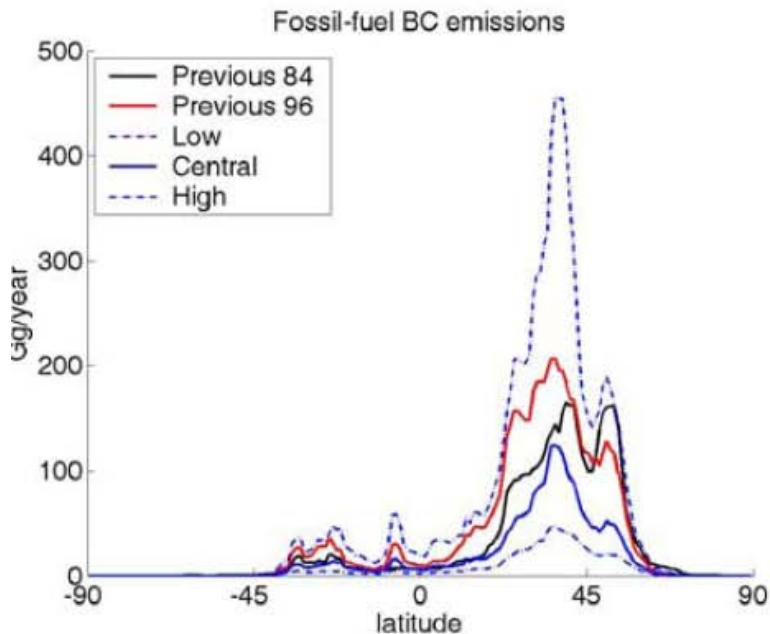
Overview

- CCSM4 simulations of future sensitivity of black carbon aerosol concentrations on changes in the Indian and Asian monsoons and other regional effects.
- Design of experiment: Sensitivity simulations using RCP 4.5 from 2005 to 2024.
- Questions: Are our results similar to earlier work? What should we expect for future climate change over India and Asia? What climate change can be "avoided" if society decreases the carbon aerosol effect?

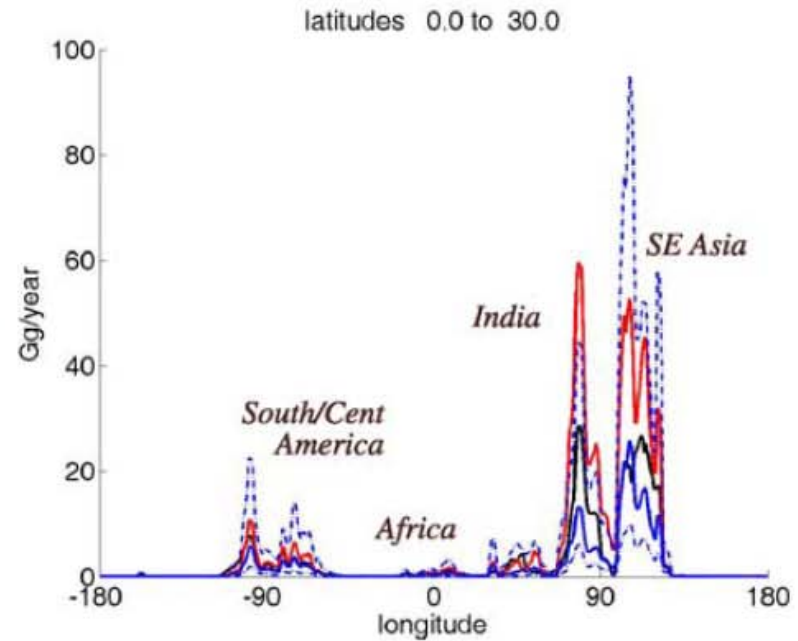
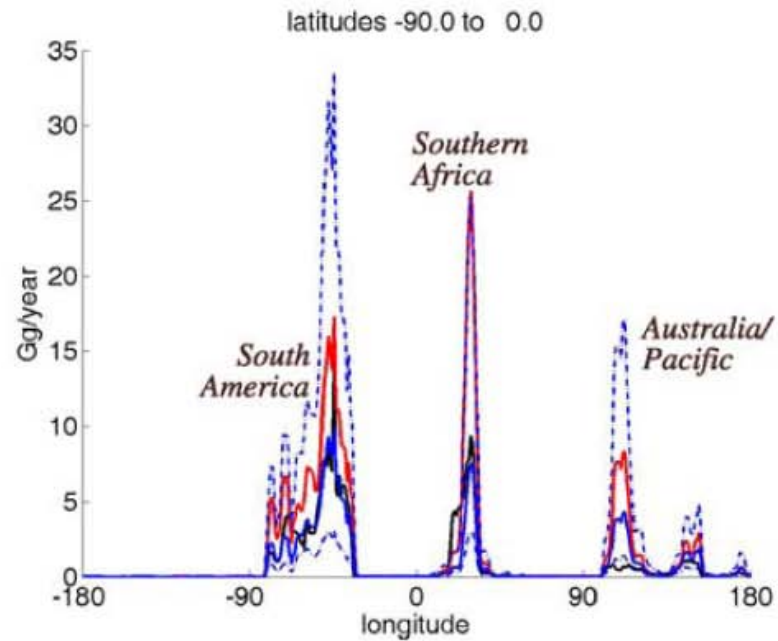
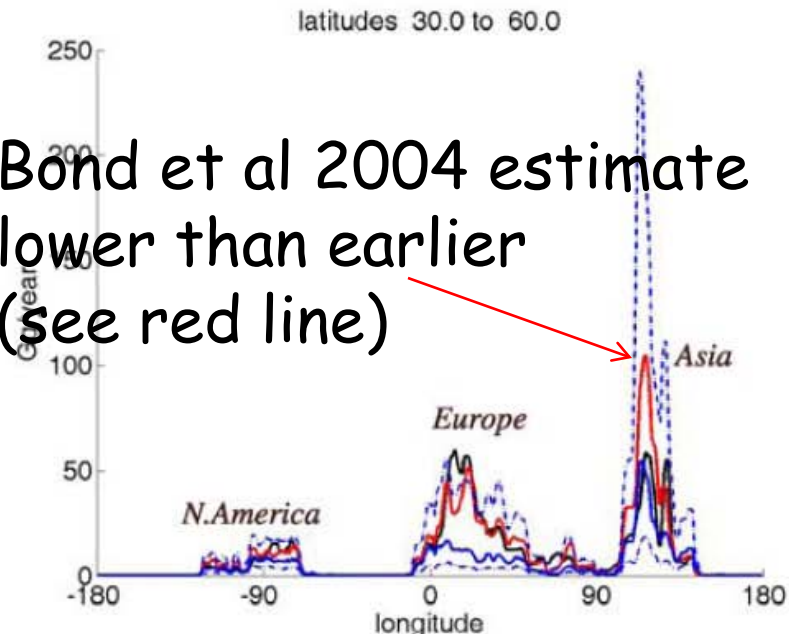
Chemistry in a model



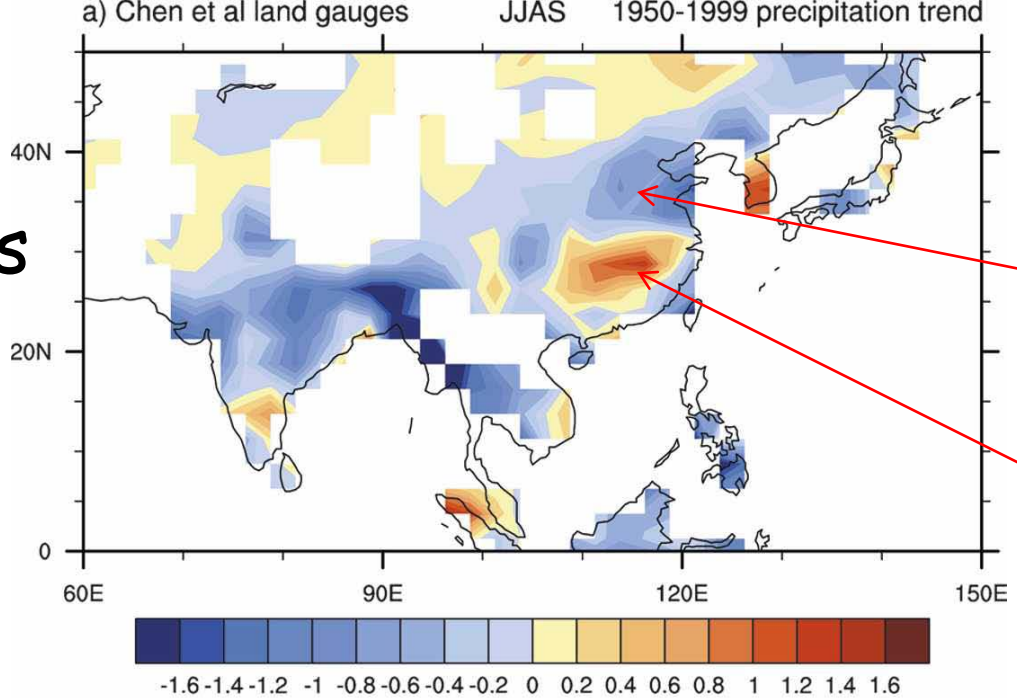
From J-F Lamarque, NCAR ACD/CGD



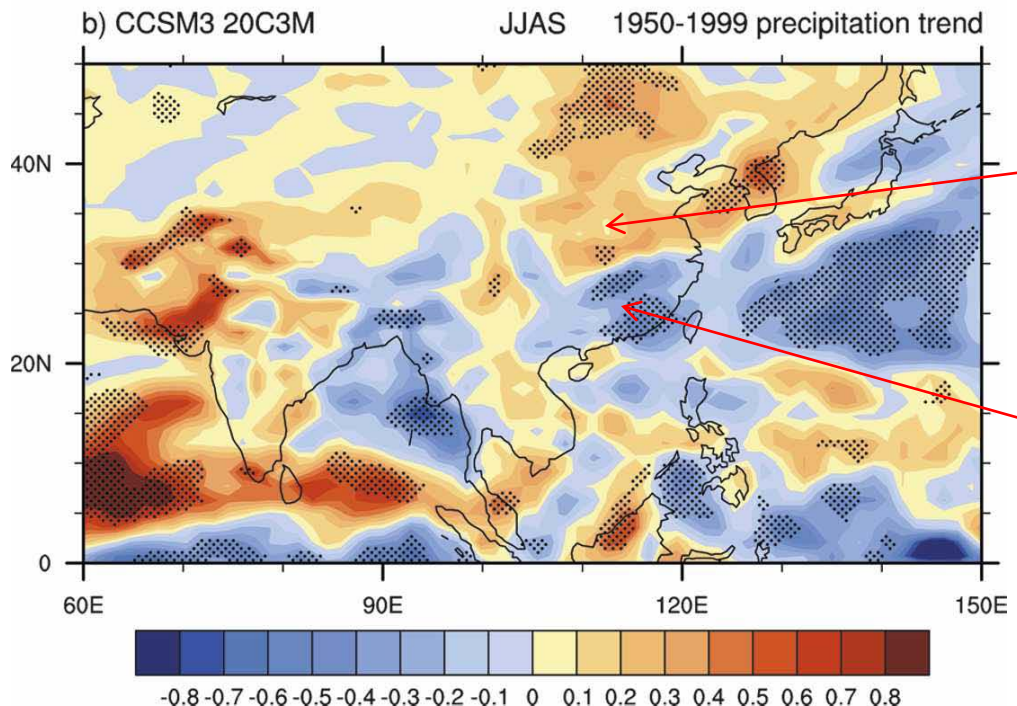
Bond et al 2004 estimate lower than earlier (see red line)



Observations
1950-1999



CCSM3
Meehl et al.
2008

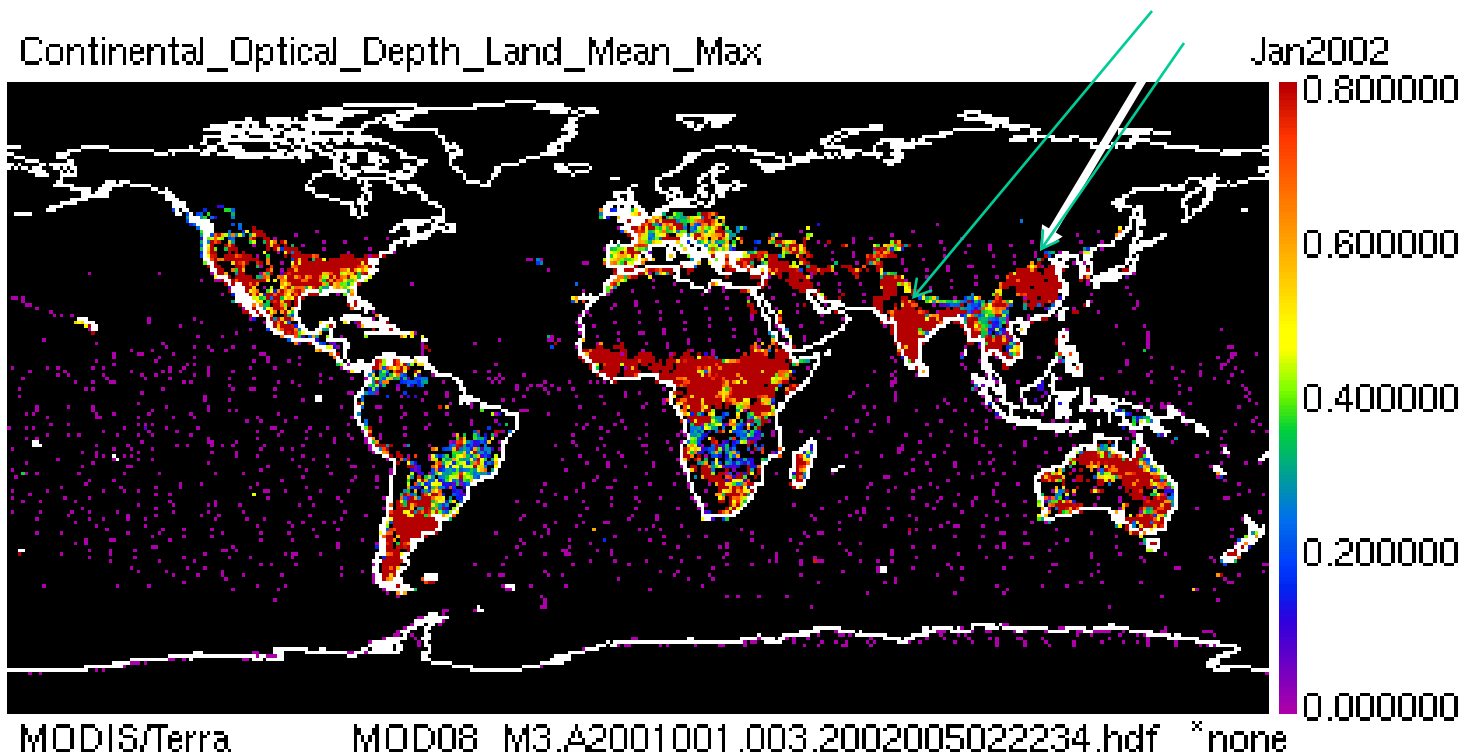


Emissions and Processes

- BC aerosols heat lower troposphere and reduce solar radiation reaching surface (previous work Menon et al 2002, Meehl et al. (2008), etc.)
- Bond et al (2004) emission data suggests future health effects and new technology will drive down emissions...note... not just climate change concerns.

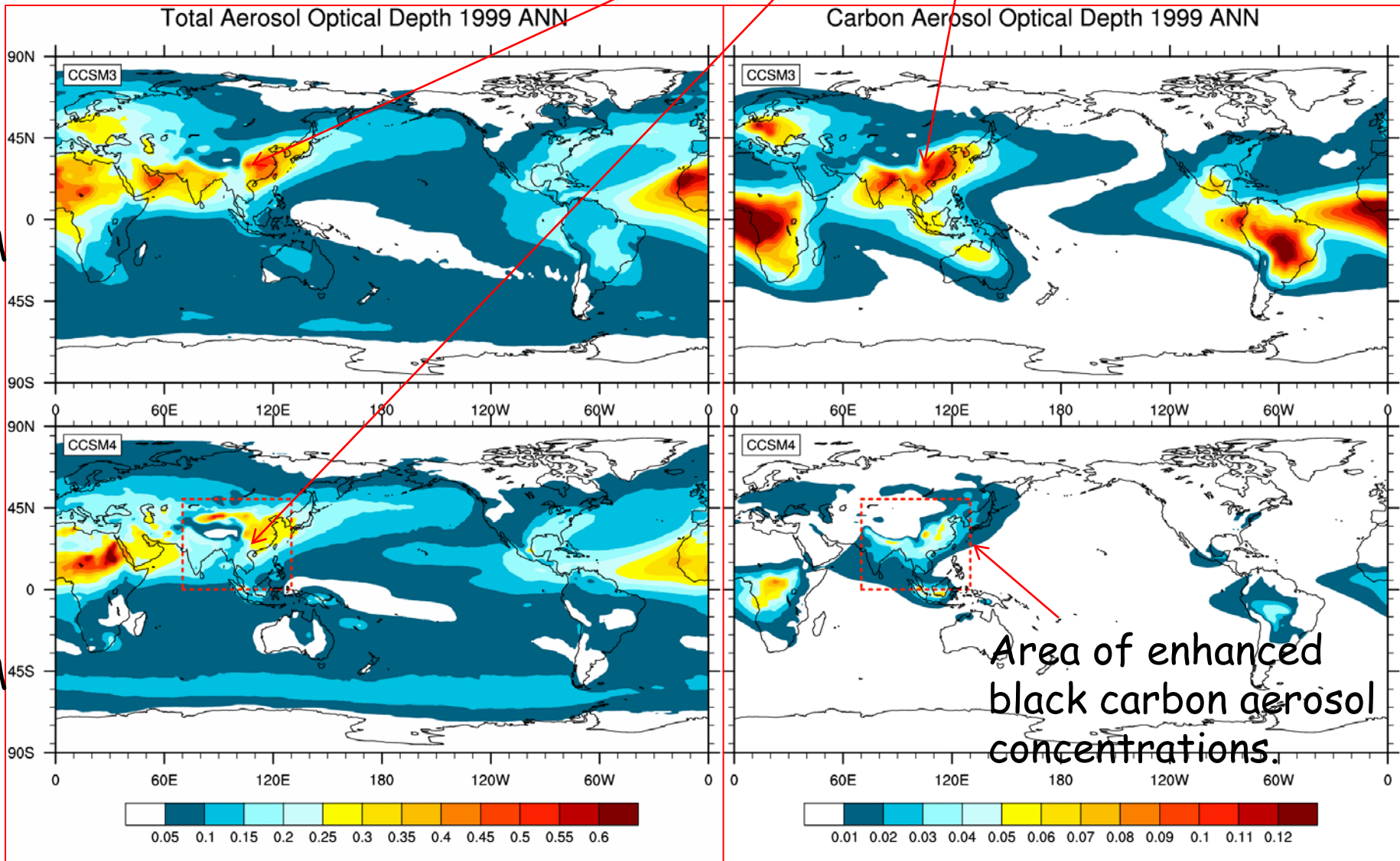
Total aerosol Optical Depth over land from MODIS/TERRA

Note maxima near India and China near 0.8



From Menglin Jin, Un. of Maryland

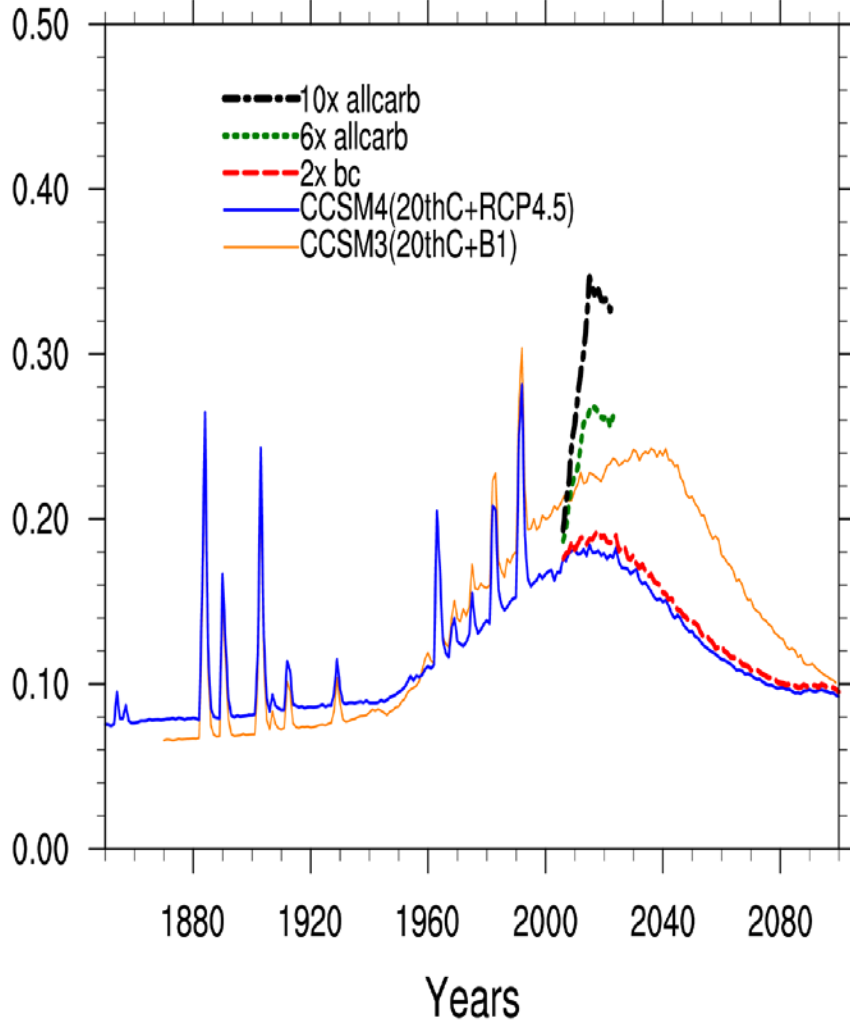
Note optical depths are small



Different scaling!!!!!!

ANN Total Aerosol Optical Depth

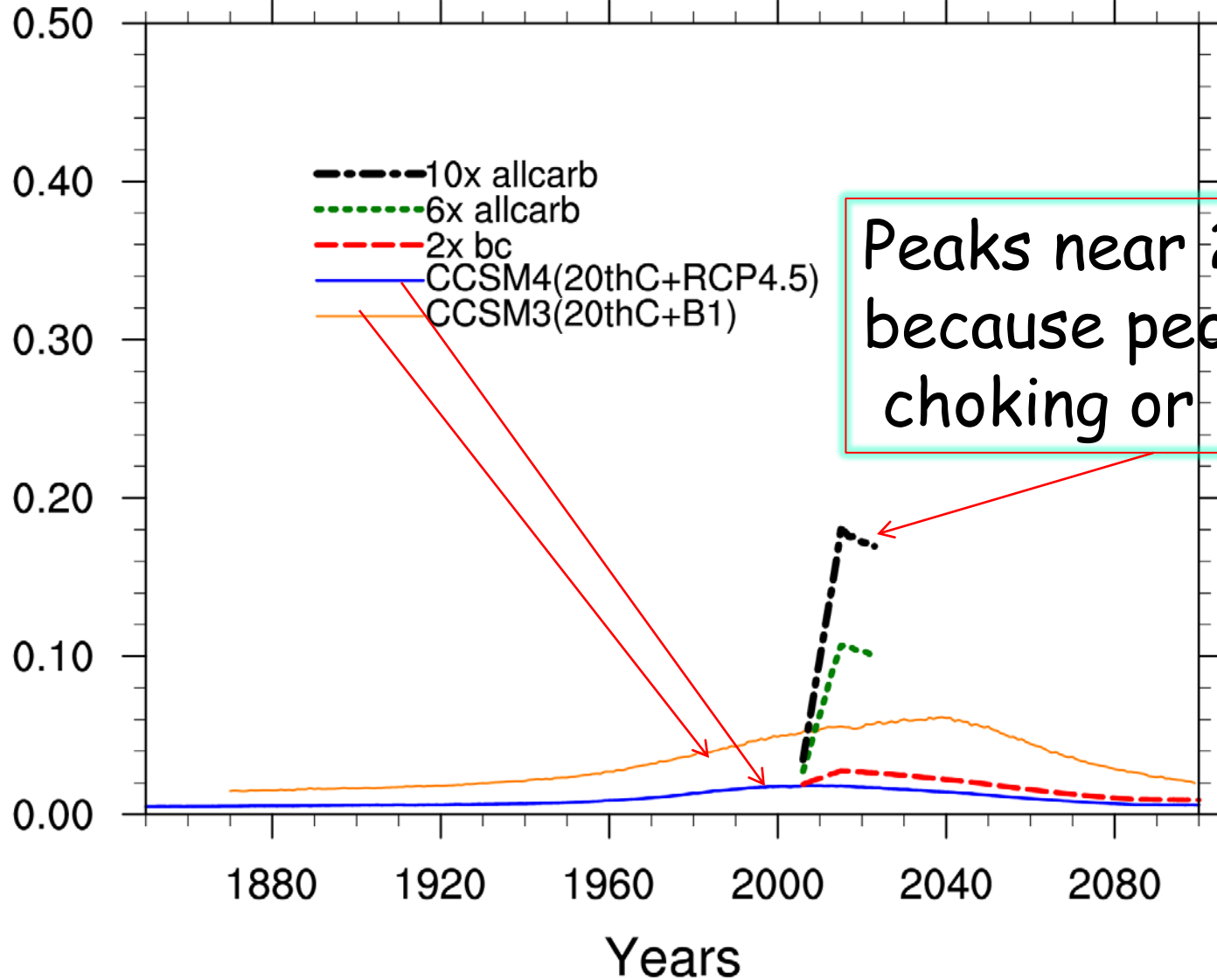
domain avg 70-130E, 0-50N



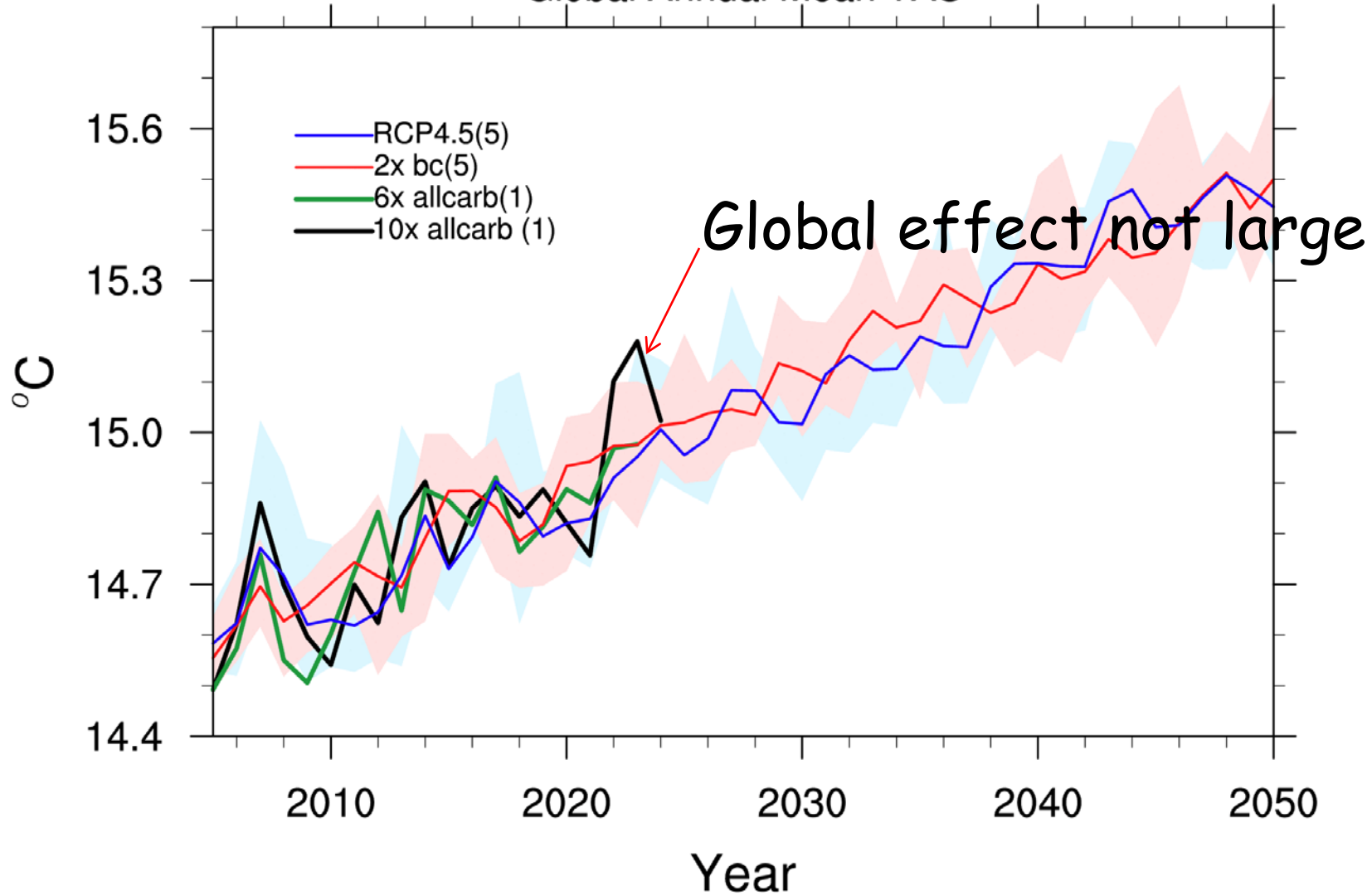
- For the 2 times black carbon aerosol simulation ensemble size is 5
- For 6 times and 10 times we did only one simulation with all carbon (both black and organic)
- Time averages were from 2005 to 2024 when the forcing difference between the RCP 4.5 and enhanced carbon aerosol simulations were largest.

ANN Carbon Aerosol Optical Depth

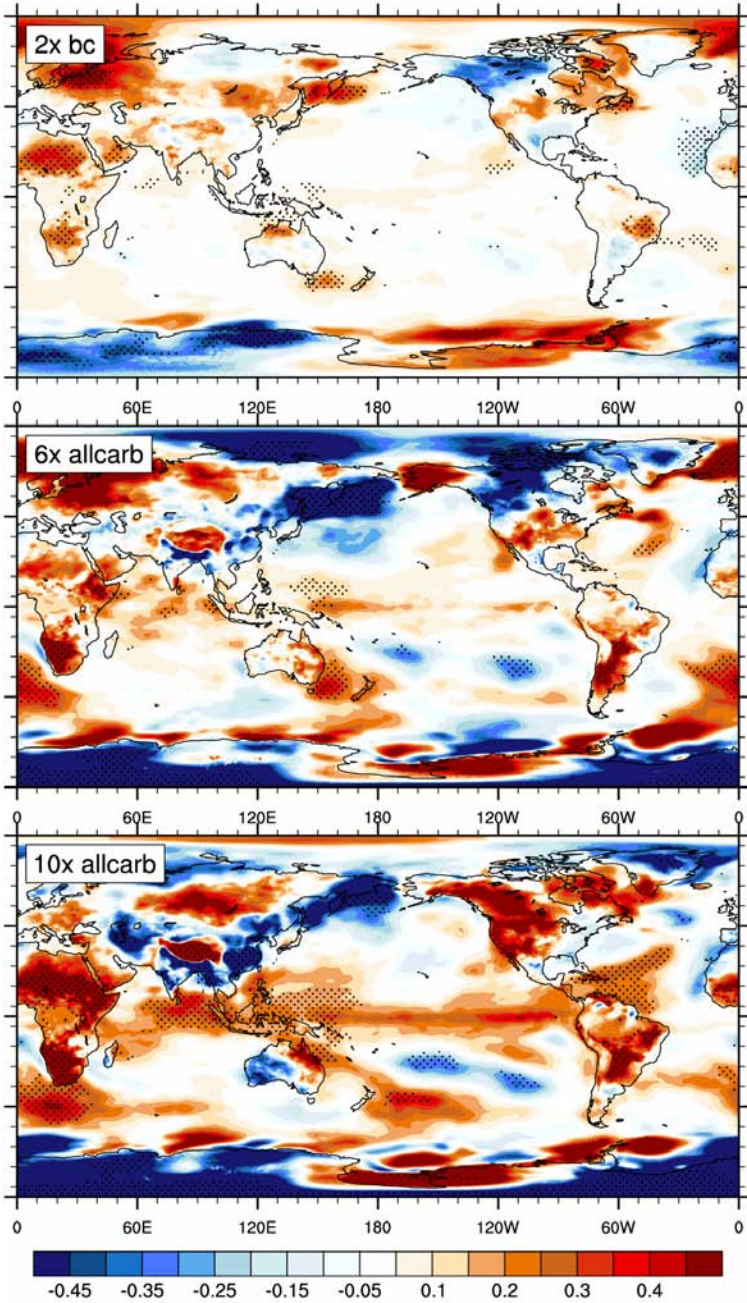
domain avg 70-130E, 0-50N



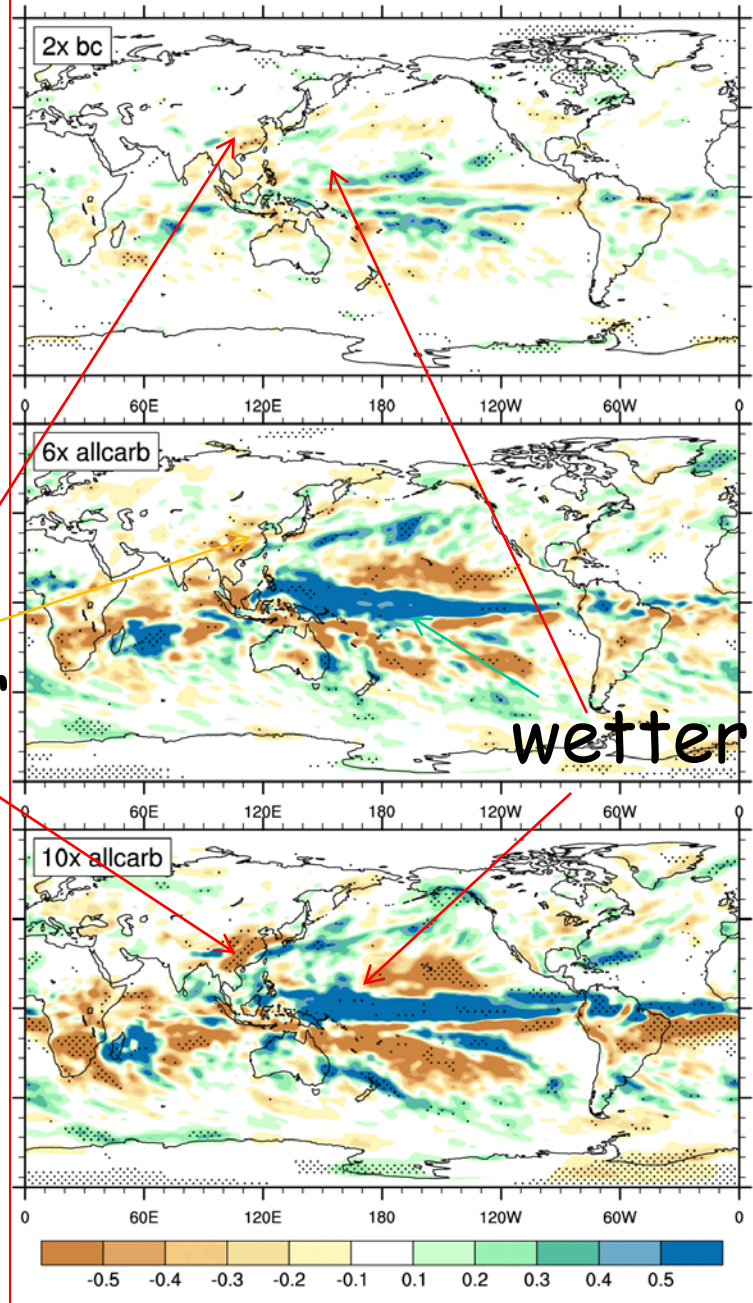
Global Annual Mean TAS



MAM TAS diff from RCP4.5 2005-2024



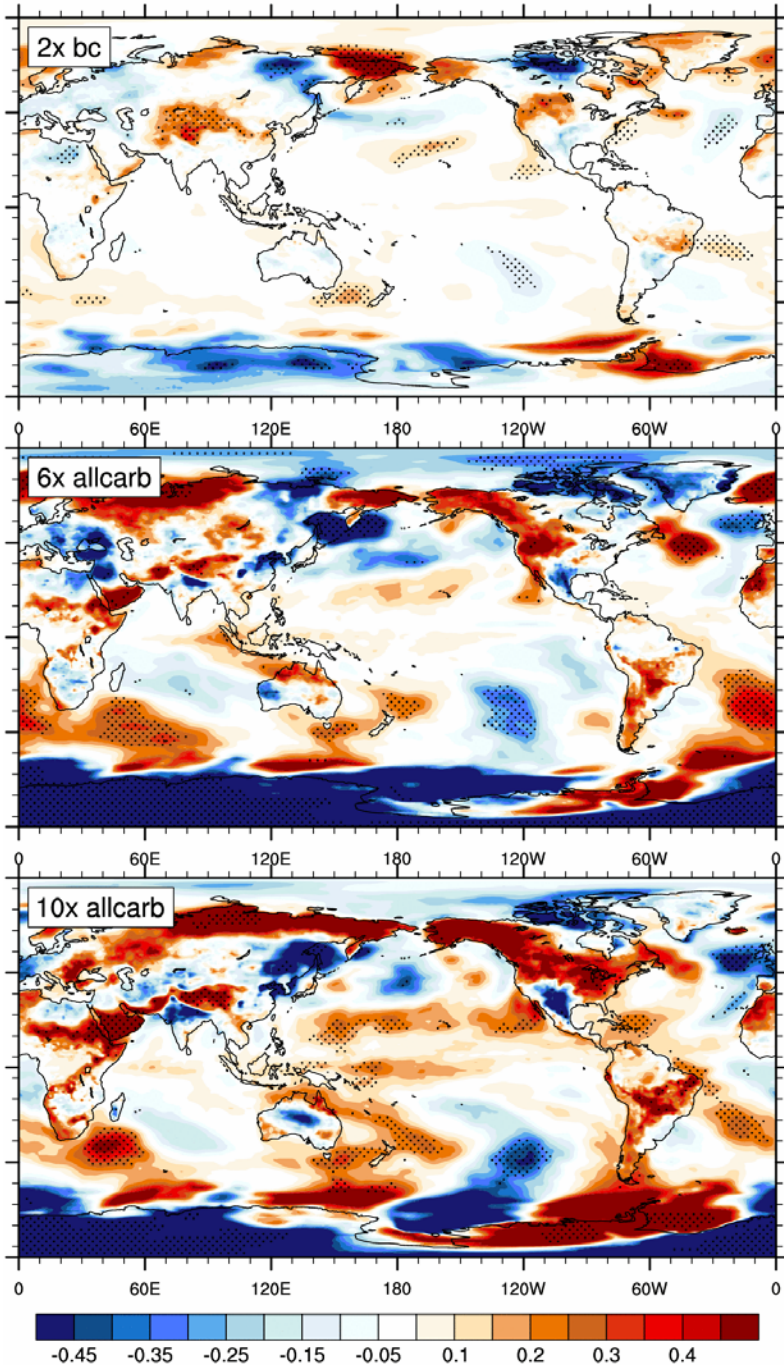
MAM Precip diff from RCP4.5 2005-2024



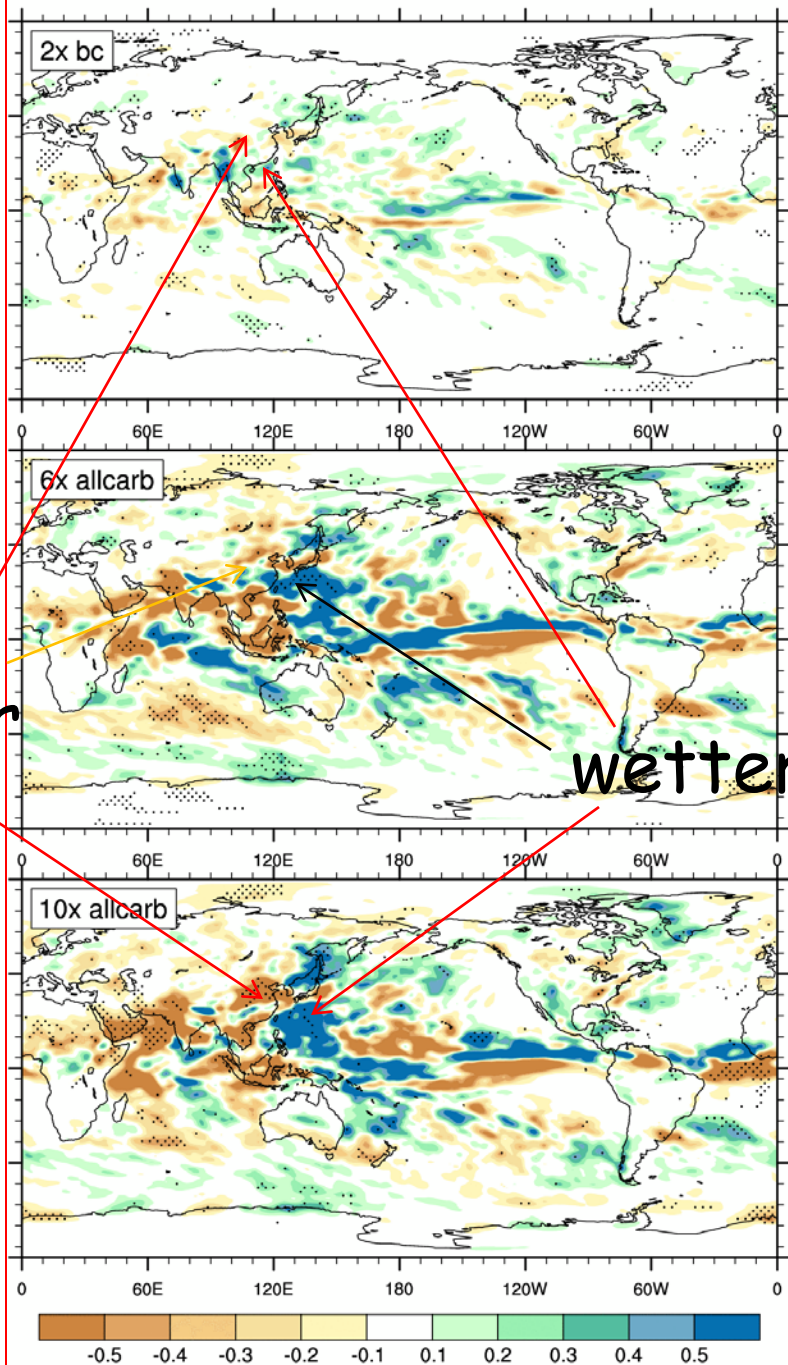
Drier

wetter

JJA TAS diff from RCP4.5 2005-2024



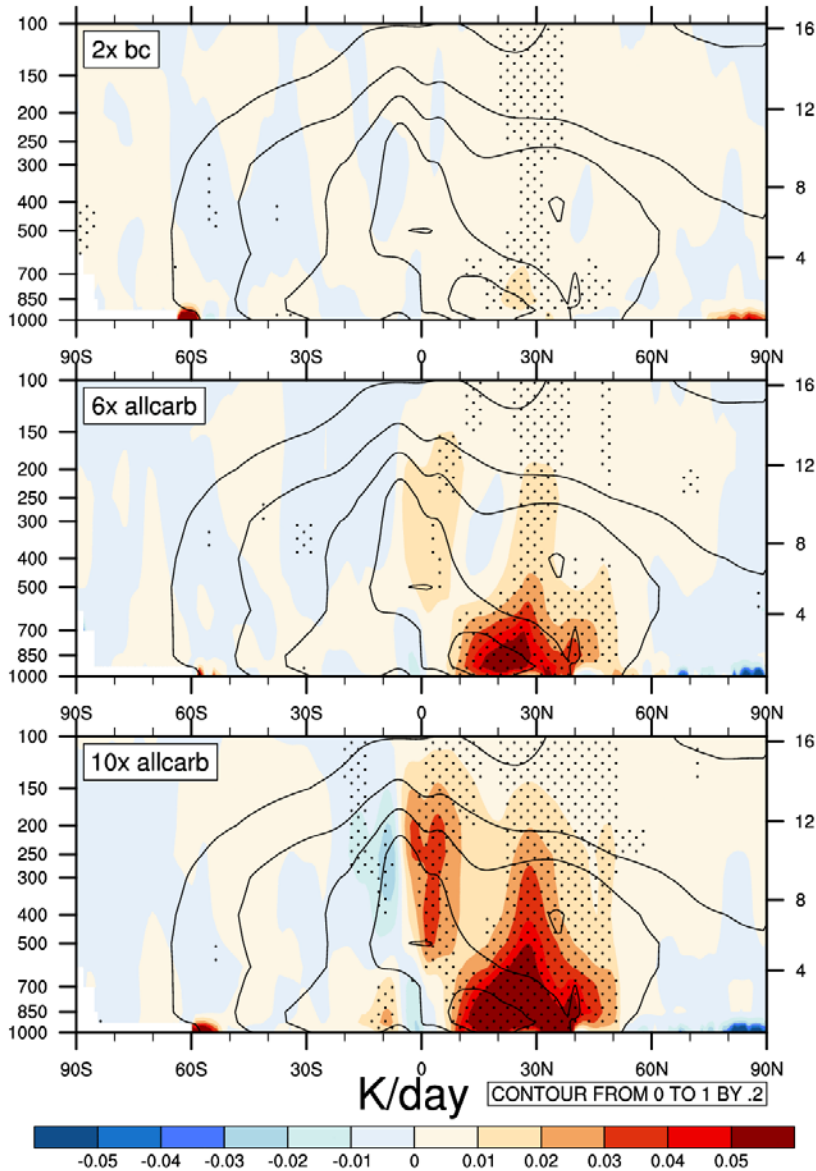
JJA Precip diff from RCP4.5 2005-2024



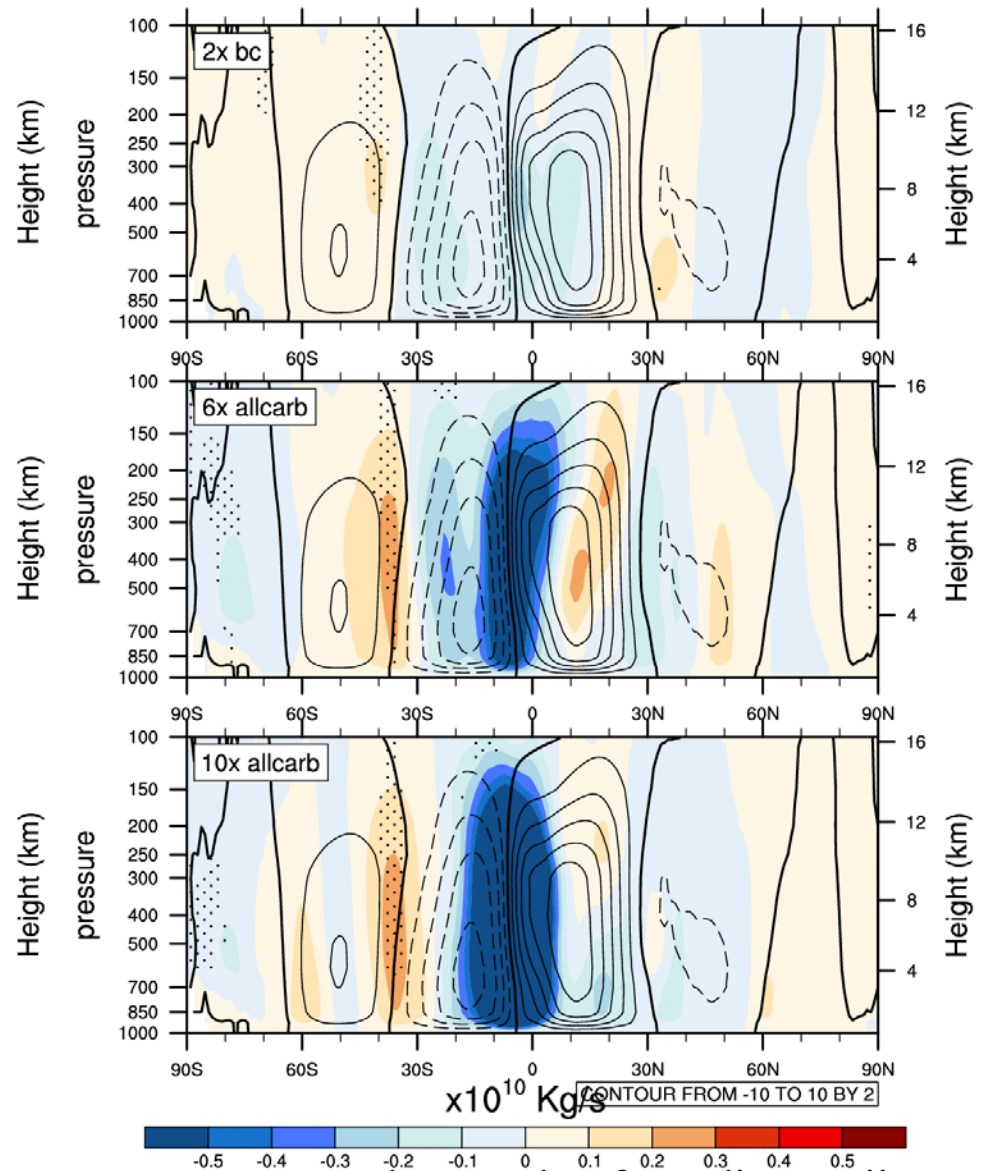
Solar heating rate

Zonal mean meridional stream function difference

MAM QRS diff from RCP4.5 2005-2024

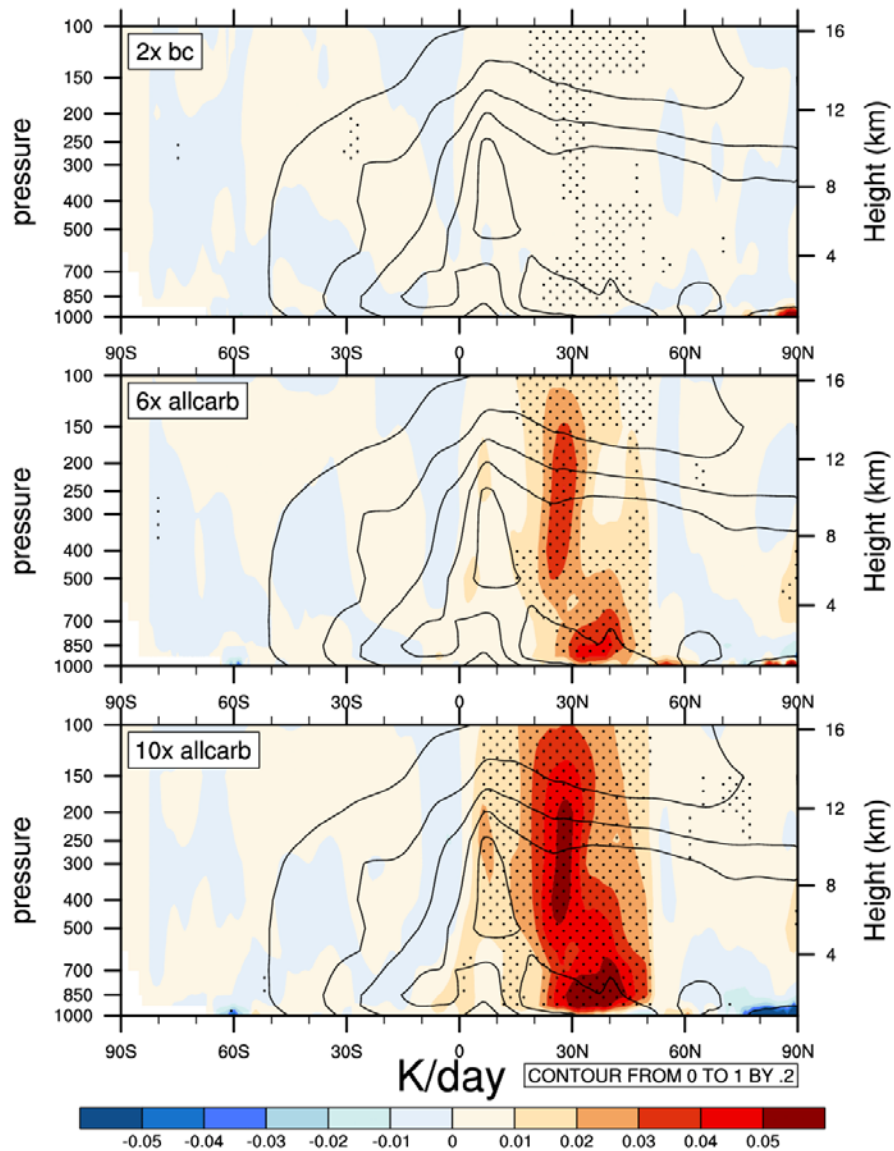


MAM mpsi diff from RCP4.5 2005-2024

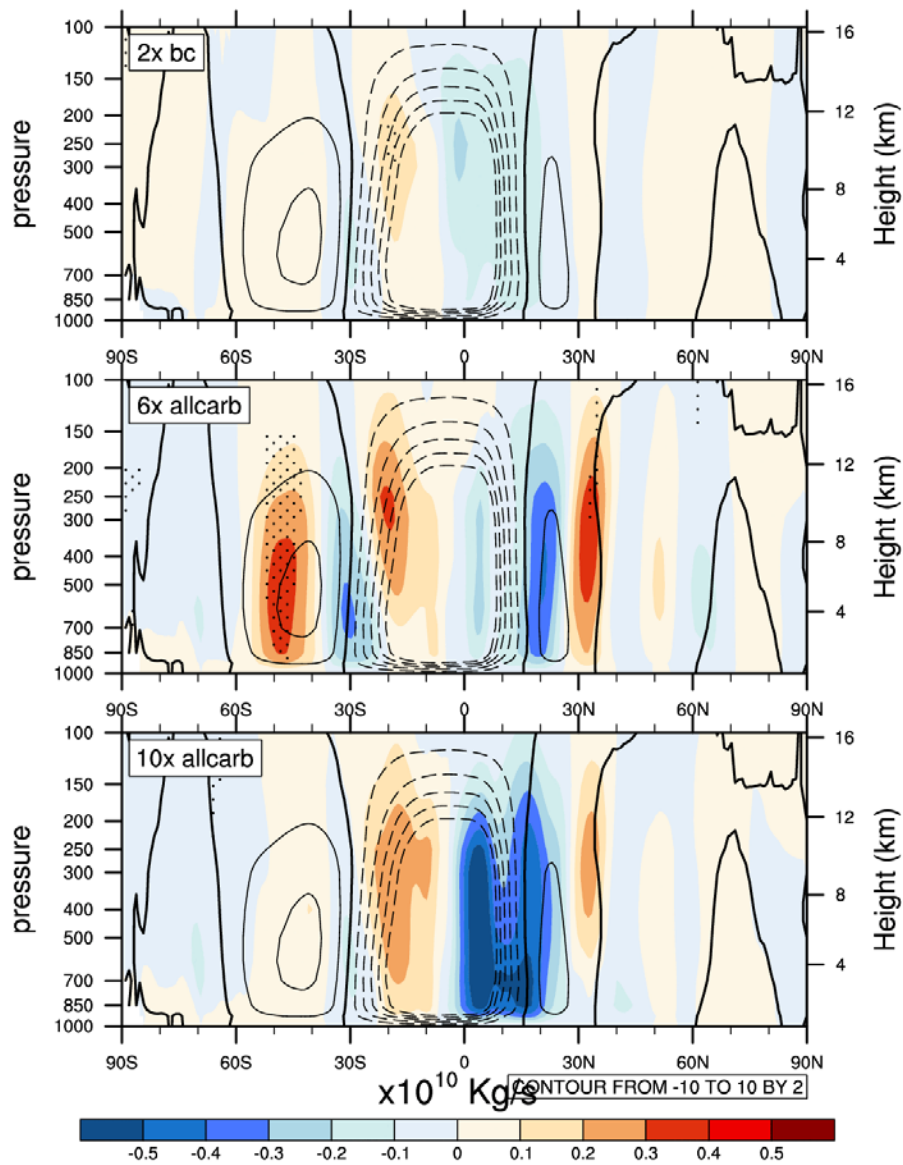


Weaken upward branch of Hadley cell

JJA QRS diff from RCP4.5 2005-2024



JJA mpsi diff from RCP4.5 2005-2024

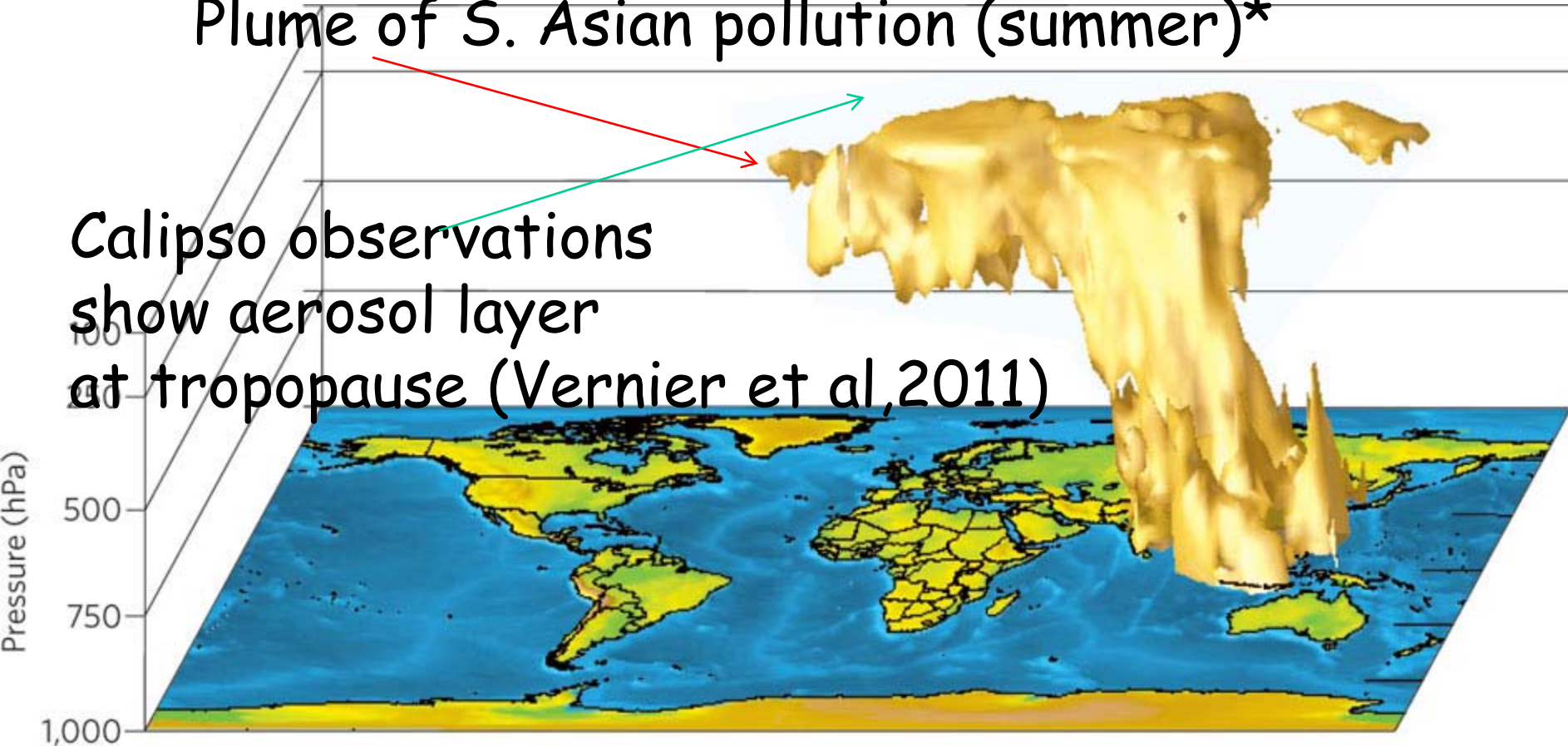


Conclusions

- Aerosol chemistry is complex in the monsoon and not fully known.
- We do not see a major change in global annual mean temperature but large regional changes in seasonal means.
- Global teleconnection (stationary wave) patterns emerge from enhanced solar heating over India-Asian region.

Plume of S. Asian pollution (summer)*

Calipso observations show aerosol layer at tropopause (Vernier et al, 2011)

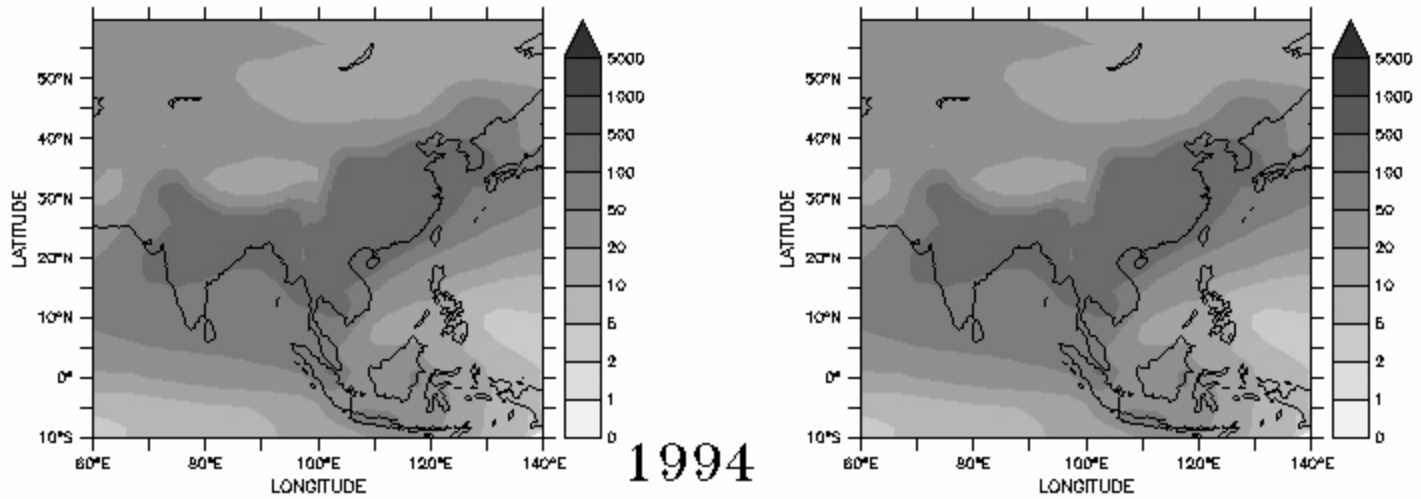


Computer simulation of CO. The assumption is that aerosols have similar distribution due to transport of aerosol precursors...how much is removed by precipitation mechanisms?

The End

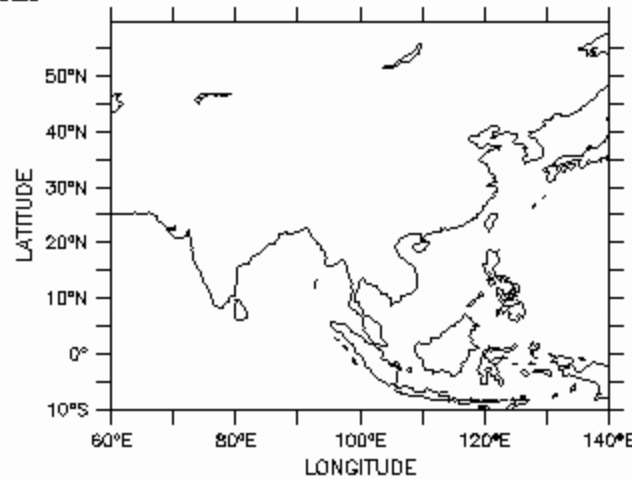
This research is
supported by
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Time change of BC aerosols



Original

10X factor



Difference