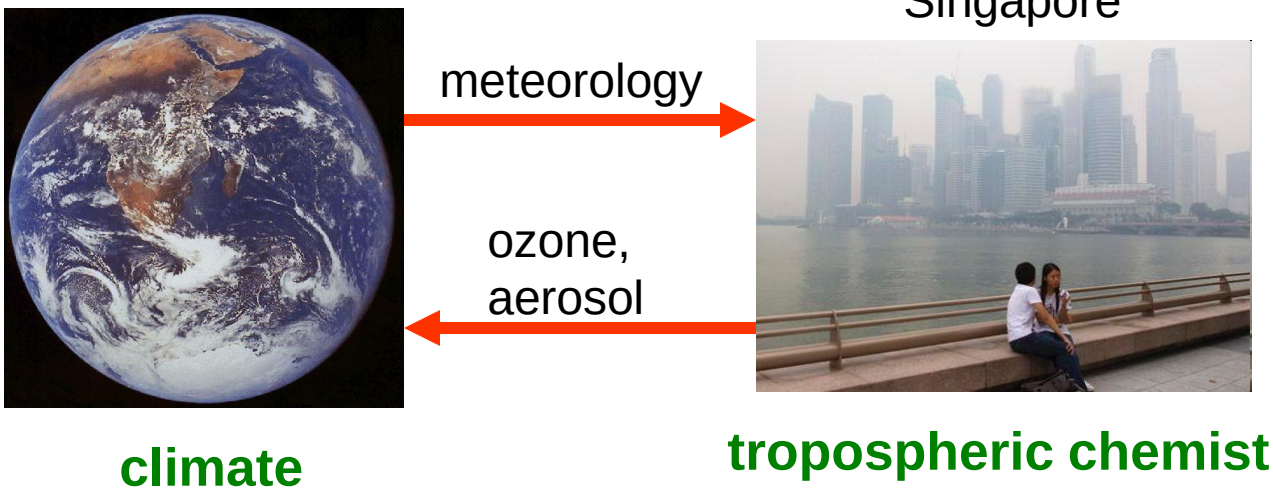
New directions in studies of chemistry-climate interactions in GEOS-Chem.

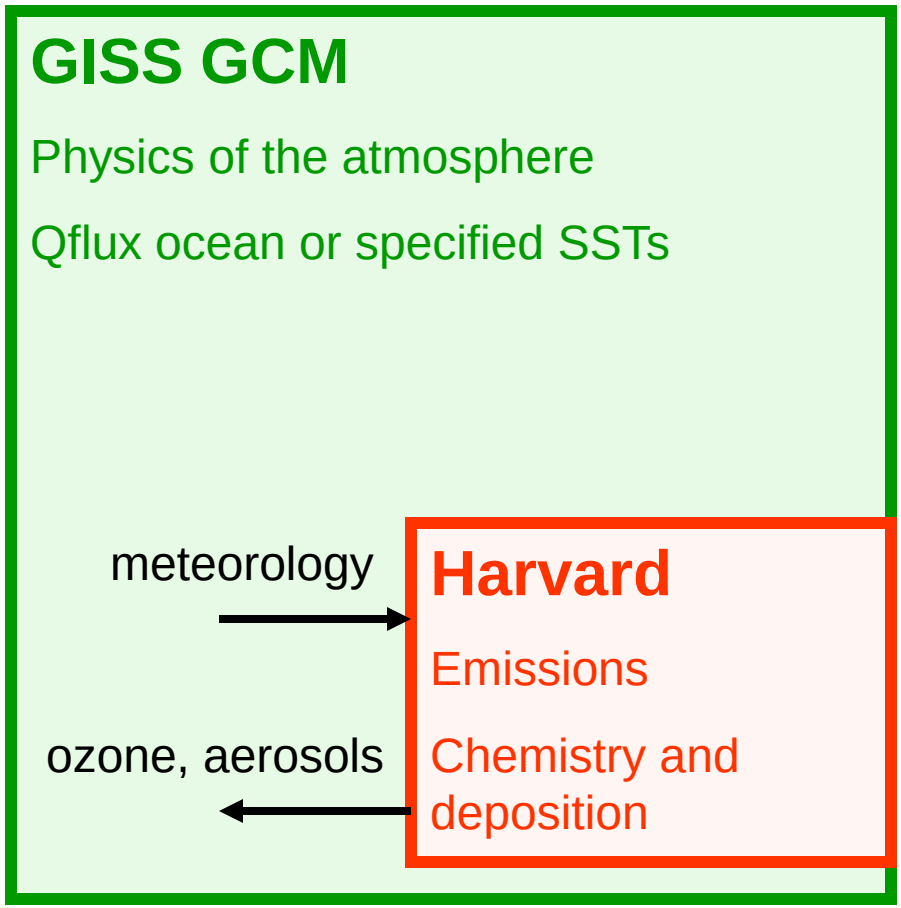
Thanks to students/ postdocs/ Daniel/ Jennifer/ Bob/ Claire.



Loretta J. Mickley, Tuesday p.m., 5th GEOS-Chem meeting, 2011

CACTUS model, ca. 1996:

Chemistry, Aerosol, Climate: Unified Tropospheric Simulation, funded by NASA



First attempts to study chemistry-climate interactions at Harvard involved online chemistry in GISS GCM.

Problems:

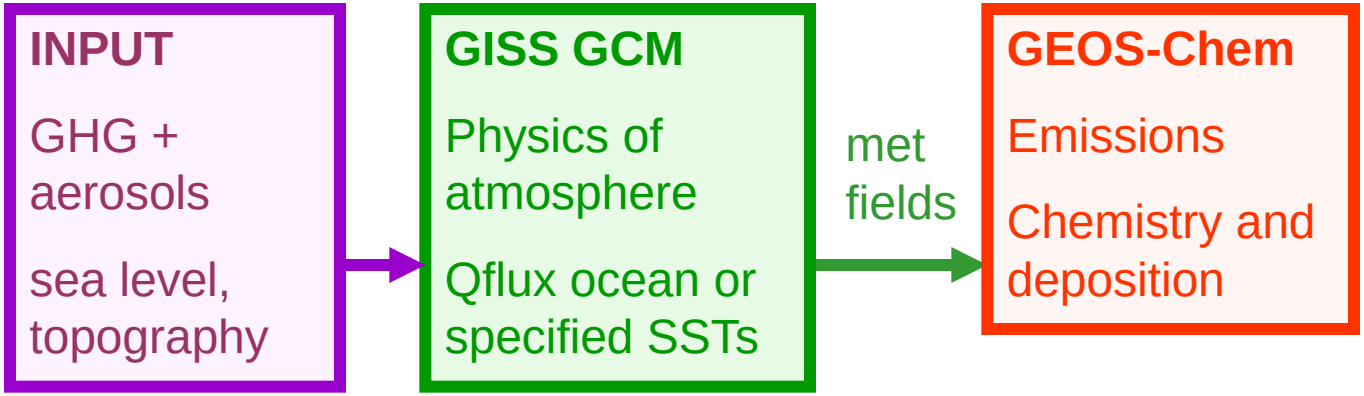
- Computational expense
- Hard to keep chemistry up-to-date (difficult to capitalize on Harvard's strength).

Move toward offline studies:

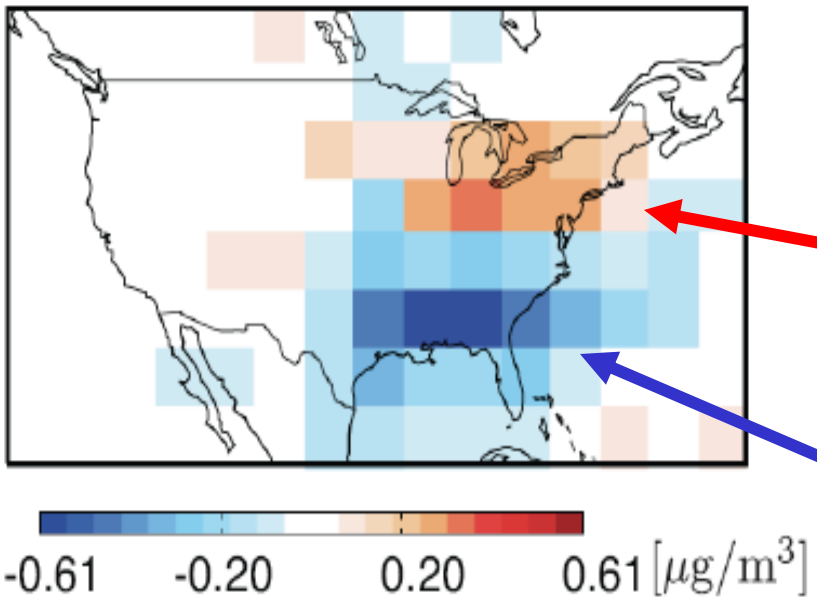
- Climate effects on chemistry
- Chemistry effects on climate

1. Climate effects on chemistry

Basic setup of GCAP:
Global Change and Air Pollution, funded by EPA



Pye et al., 2009



Annual mean change in surface inorganic aerosol due to 2000-2050 climate change

Climate penalty: Increase in Northeast due to increased temperature and accelerated oxidation rates

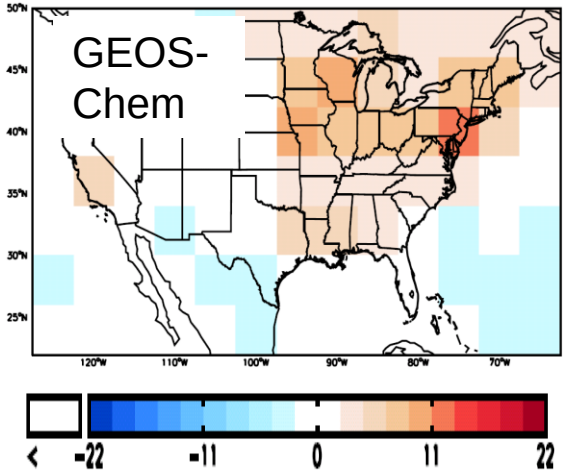
Decrease in Southeast due mainly to increased precipitation.

But how well do we model PM sensitivity to meteorology? see AmosTai's talk!

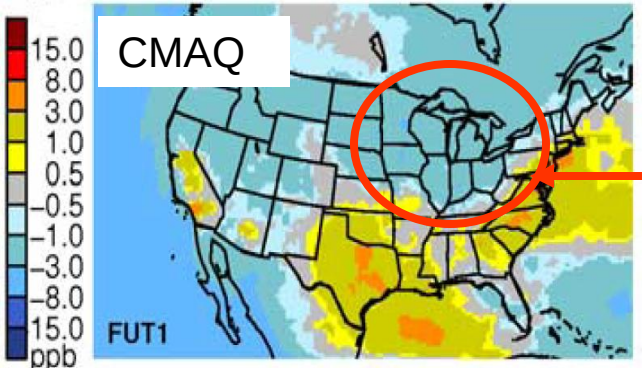
1. Climate effects on chemistry, continued

We've seen previous discrepancies in projections of surface ozone.

2000-2050 change in max daily 8-hour average JJA ozone



Wu et al., 2008



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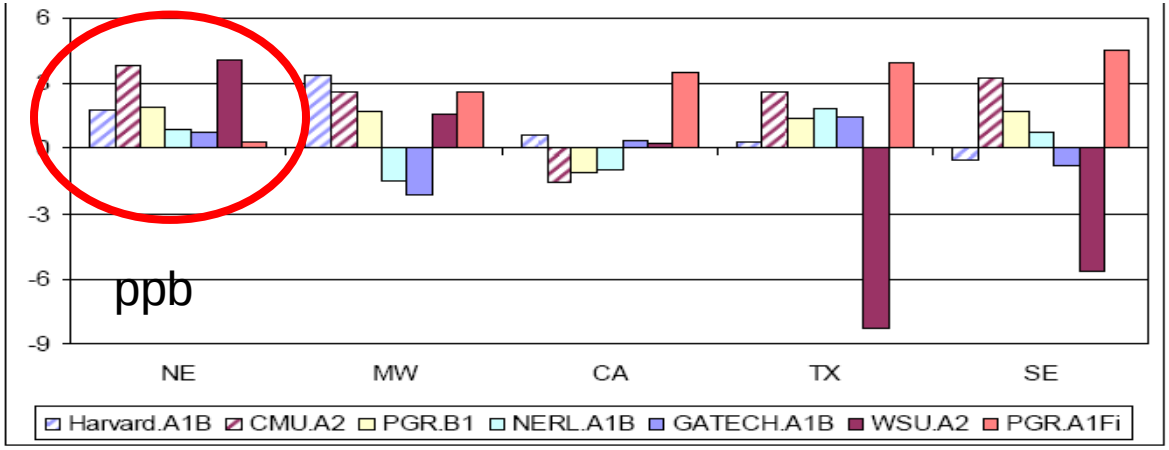
Ozone decreases due to increased cloud cover.

Same parent GCM as Wu et al., 2008

Nolte et al., 2008

2000-2050 change in max daily 8-hour average JJA ozone



Most models agree that surface ozone will increase over the Northeast. Disagreement occurs elsewhere due to differences in chemistry and cloud cover change.

Multi-model comparison

Weaver et al., 2009

GCAP + land cover component

INPUT

GHG and aerosol content

Sea level, topography

GISS GCM

Physics of the atmosphere

Qflux ocean or specified SSTs

met fields

GEOS-Chem

Emissions

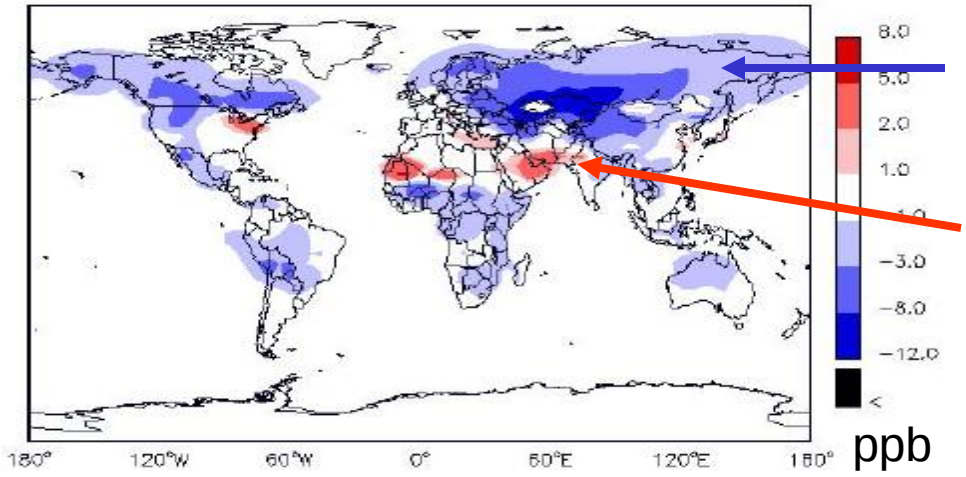
Chemistry and deposition

met fields, Δ CO_2

LPJ + BIOME4
dynamic vegetation models, Kaplan et al.

Vegetation types + leaf area indices

Response of surface ozone to 2000-2100 climate change + Δ CO_2



Broadleaf trees move poleward, ozone deposition increases.

Increased soil NOx emissions, increased ozone.

Wu et al., 2011, NASA

GCAP + land cover component

INPUT

GHG and aerosol content

Sea level, topography

GISS GCM

Physics of the atmosphere

Qflux ocean or specified SSTs

met fields

GEOS-Chem

Emissions

Chemistry and deposition

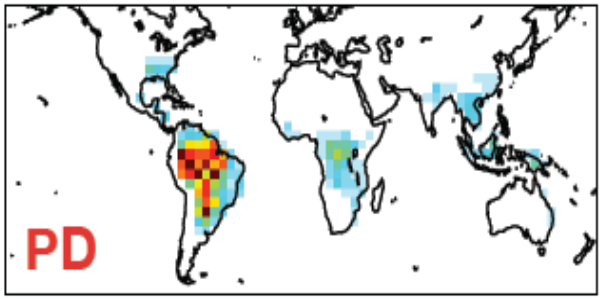
met fields, ΔCO_2

LPJ + BIOME4
dynamic vegetation models, Kaplan et al.

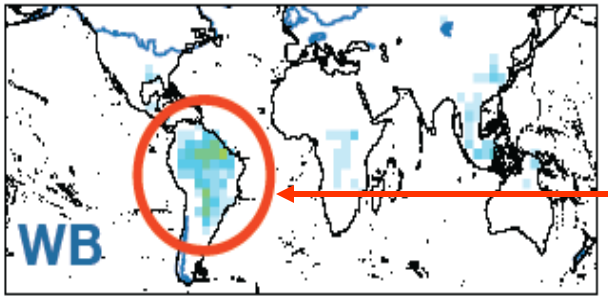
Vegetation types + leaf area indices

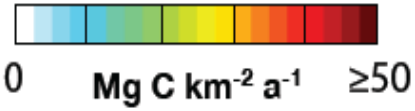
Investigation of oxidation capacity during Last Glacial Maximum

Isoprene emissions



present-day





Cold version of Last Glacial Maximum

Severe cold shuts off Amazon as major biogenic source

Murray et al., ms., NSF

Investigation of 2000-2050 change in wildfires on air quality in the Western US

IPCC AR4 GCMs

Physics of the atmosphere

GISS met fields

GEOS-Chem

Chemistry and deposition

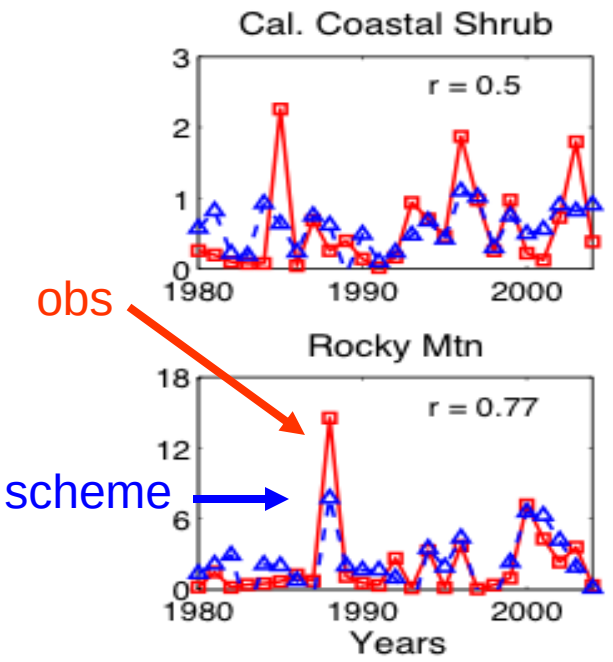
met fields

Area burned

Area burned prediction scheme

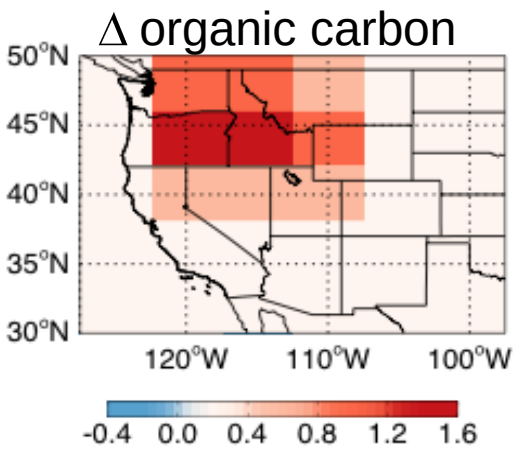
Uses observed relationships between meteorology and area burned

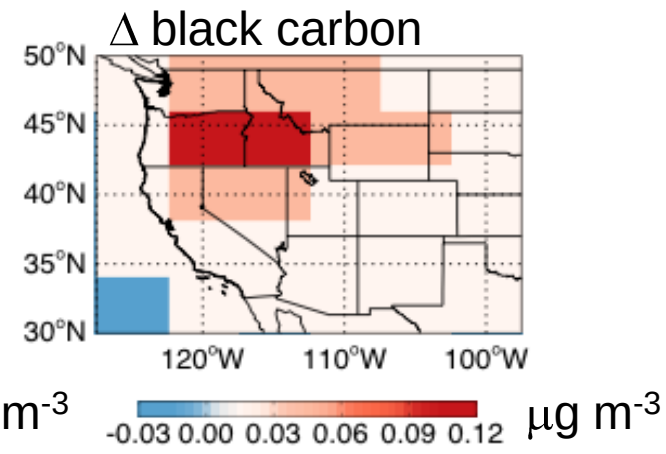
Test of fire prediction scheme: Area burned



Change in surface PM2.5 due to 2000-2050 change in area burned.

More wildfire PM2.5 in hotter climate.





Yue et al., 2010; EPA

2. Effects of tropospheric chemistry on climate

GEOS-Chem

Chemistry and deposition

ozone + aerosols

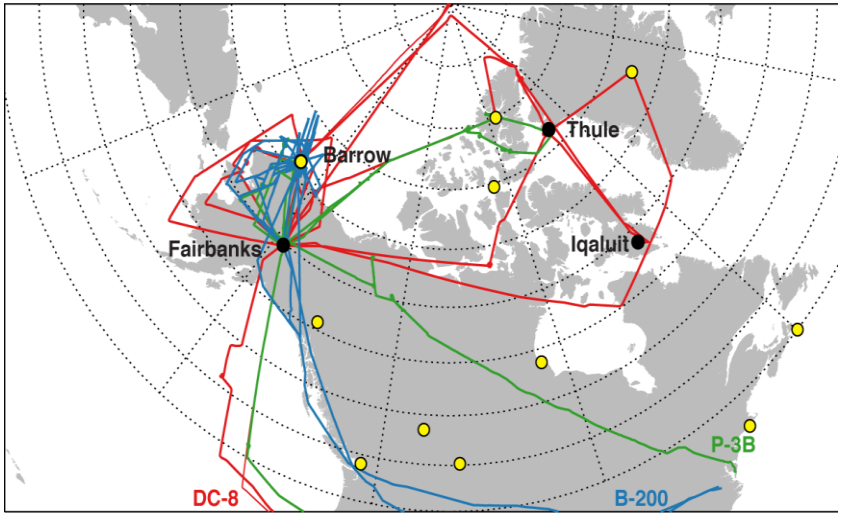
Climate model

(CAM3, GISS, CESM. . .)

- **Effects of 2003 Siberian fires,** Park et al., 2011
- **Effects of 1950-2050 US aerosol trends**, Leibensperger et al., 2011
- **Impact of short-lived species on 1980-2010 Arctic climate,** in pipeline

Will build on our previous work with ARCTAS, includes both haze + BC deposition on snow

ARCTAS campaign, 2008



NSF, EPRI, NASA

Return of CACTUS model with column GEOS-Chem?

Climate model

Physics of the atmosphere

meteorology →

ozone, aerosols ←

GEOS-Chem

Emissions

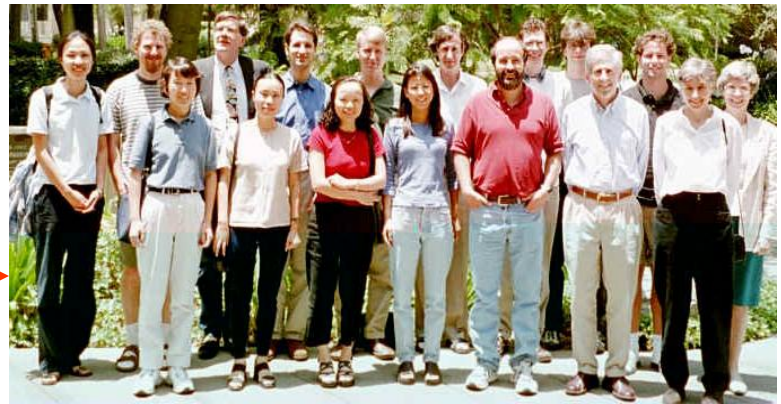
Chemistry and deposition

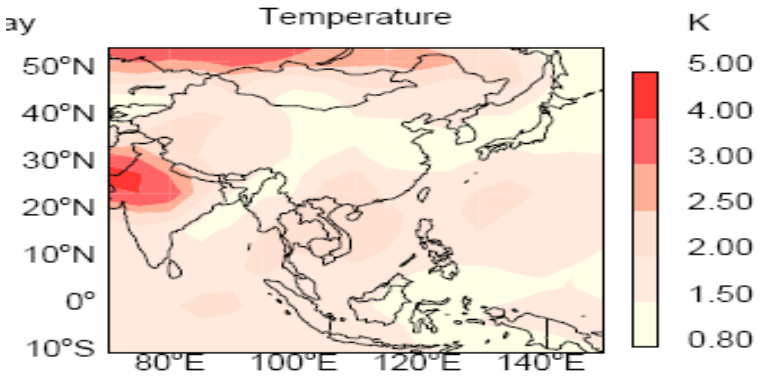
Column model opens new directions for research.

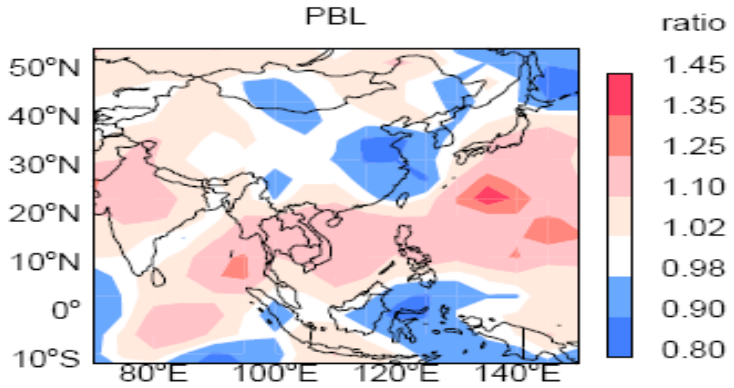
Online chemistry capability, with impact on meteorology as off-on switch?

Thanks!

Old CACTUS crew →







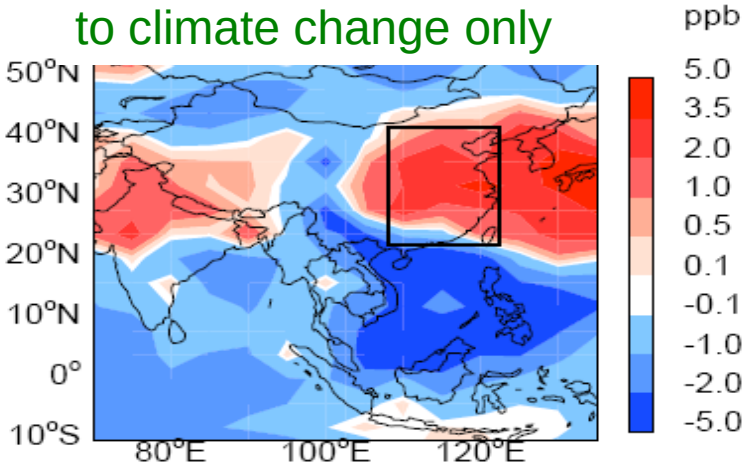
Effects of 2000-2050 trends in climate + global emissions in Asia.

Surface ozone increases, especially in summer, due to:

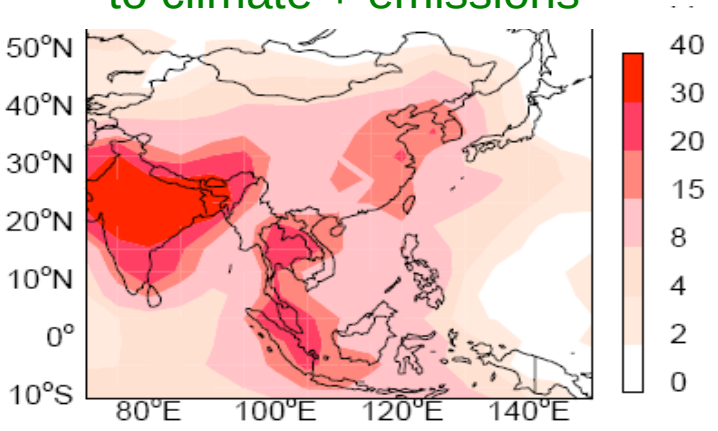
- Increasing temperatures
- Increasing biogenic emissions
- Lower planetary boundary layer

But A1B emissions of ozone precursors will huge effect.

Δ JJA surface ozone due to climate change only



Δ JJA surface ozone due to climate + emissions



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Yuxuan Wang et al., 2011