Impacts of Changes in Land Use and Land Cover on Atmospheric Chemistry and Air Quality

Shiliang Wu (slwu@mtu.edu)
Michigan Technological University

EPA RTP, NC
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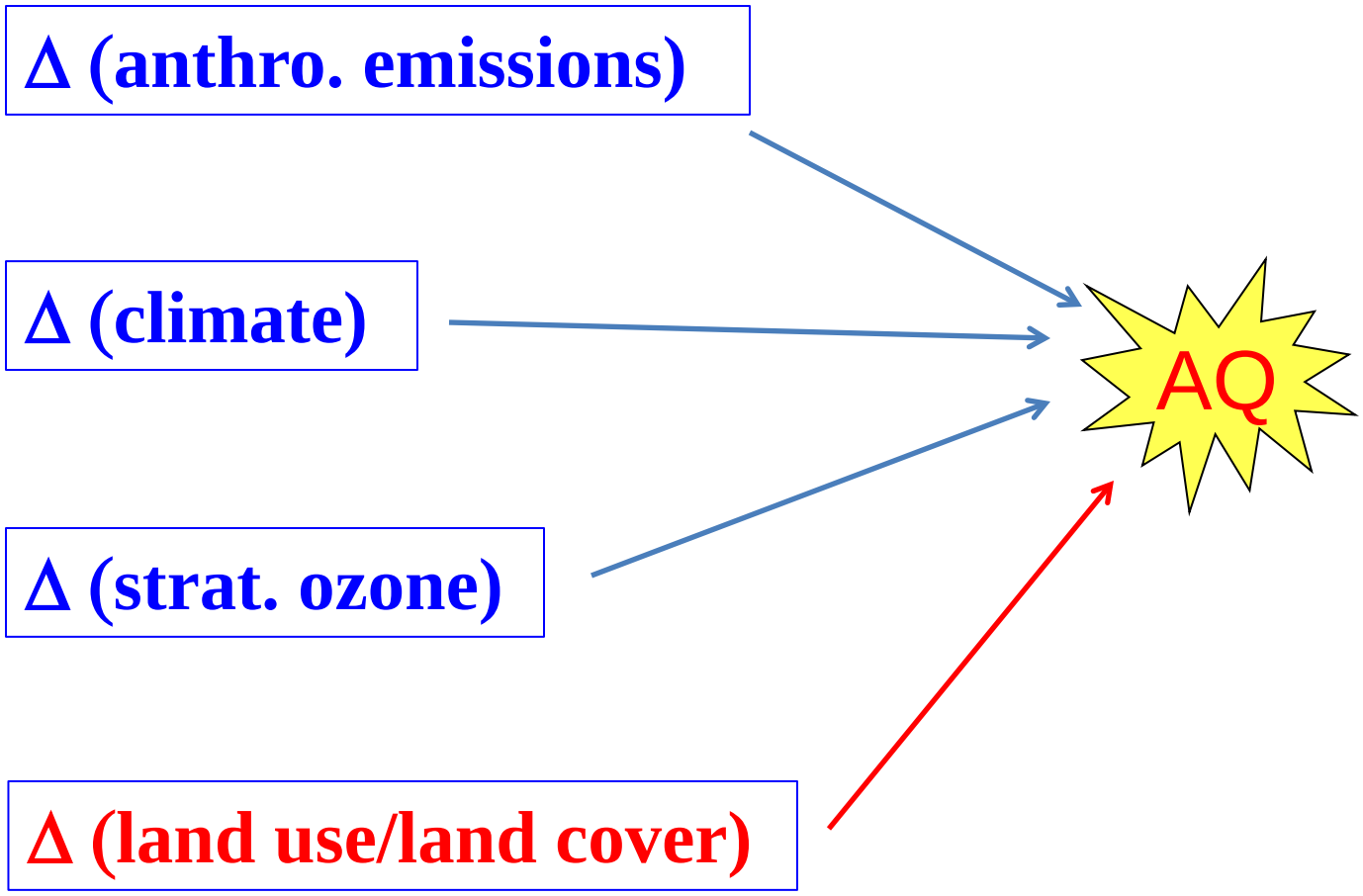
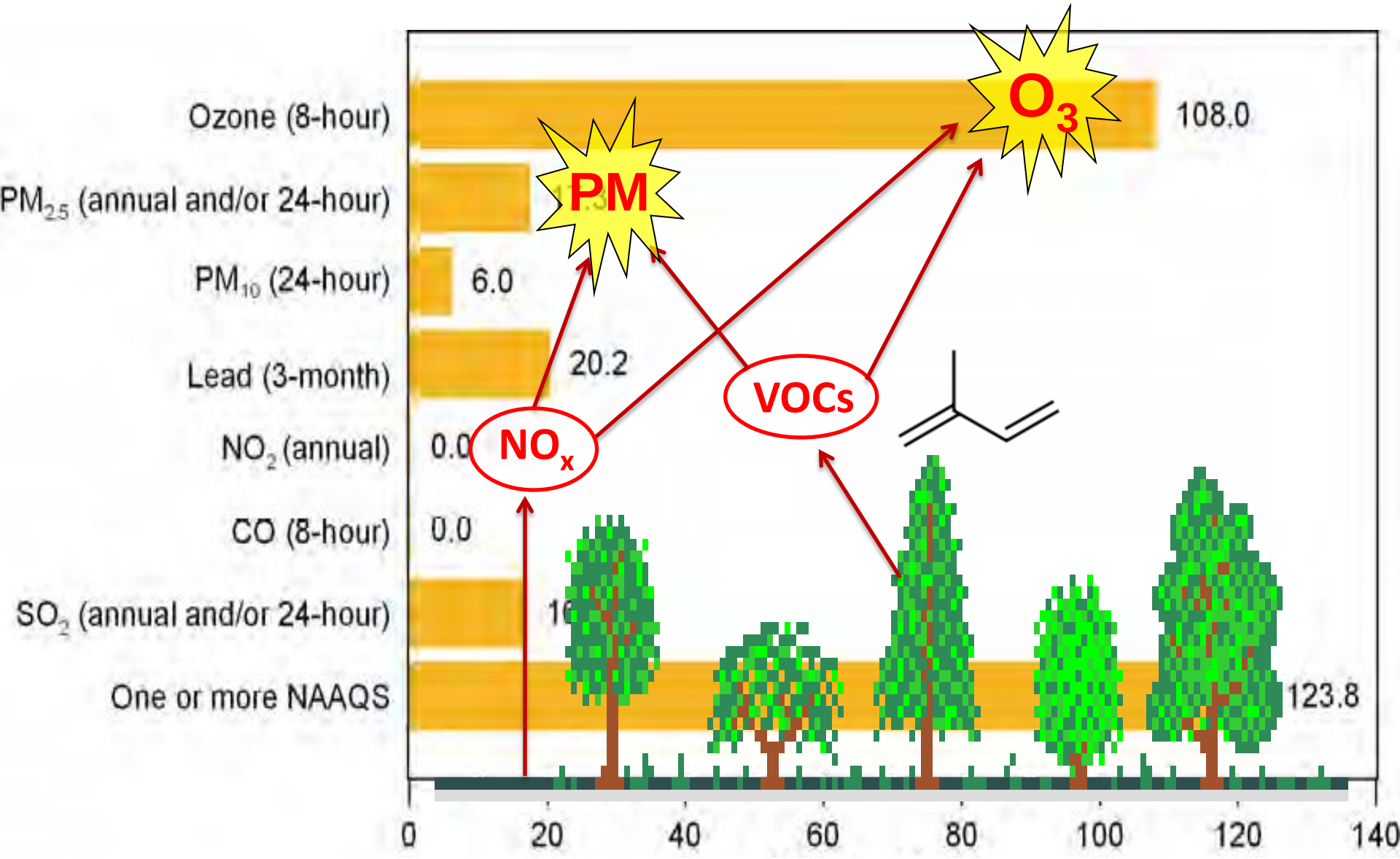
Global Change and Air Quality



Vegetation is important affecting air quality



millions of people living in area violating NAAQSS, 2010 [EPA, 2011]

Perturbations to vegetation

http://www.worldproutassembly.org

http://www.coalvalleynews.com

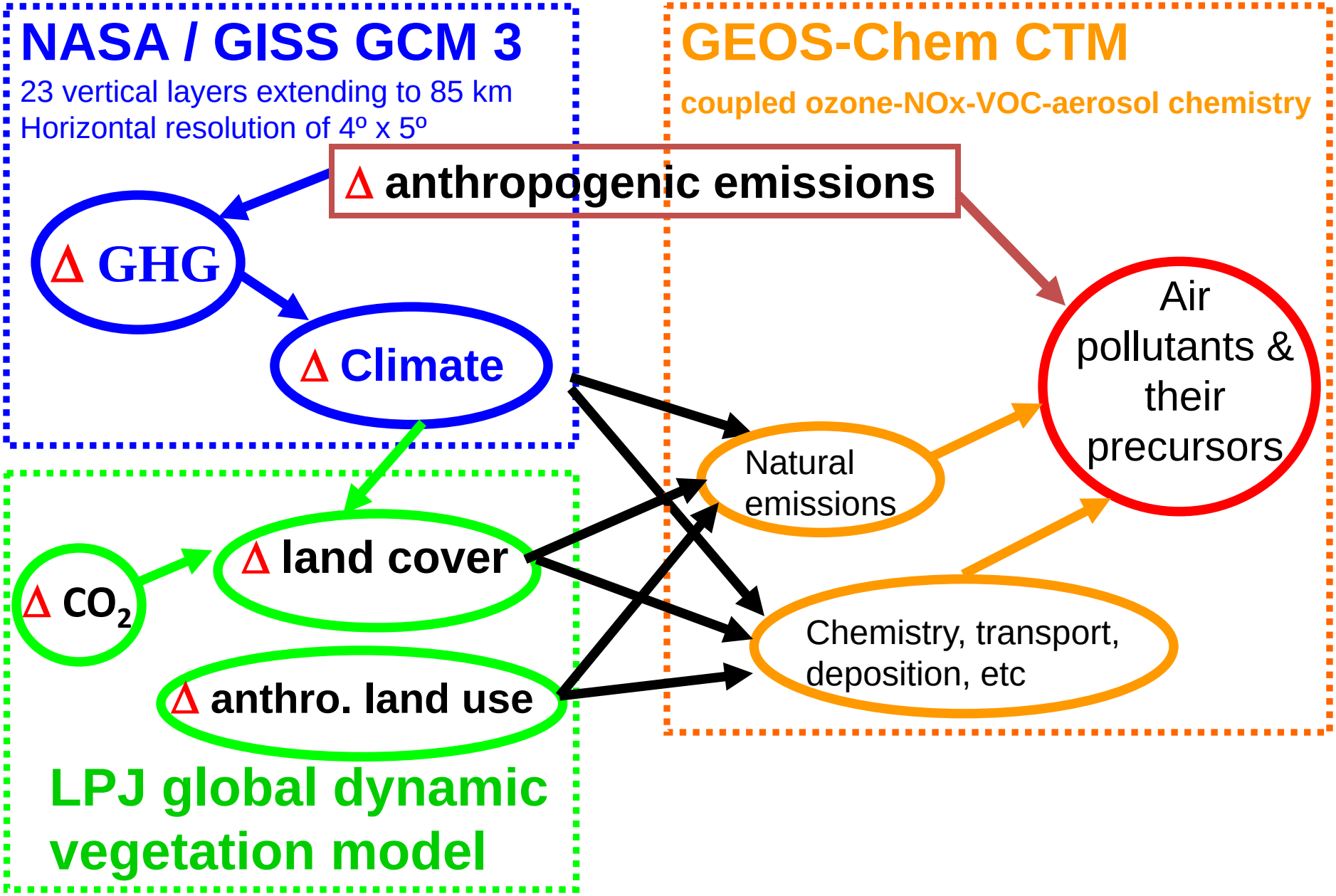
http://geology.com/climate-change

Perturbations to vegetation

http://www.mtri.org/firehealth.html

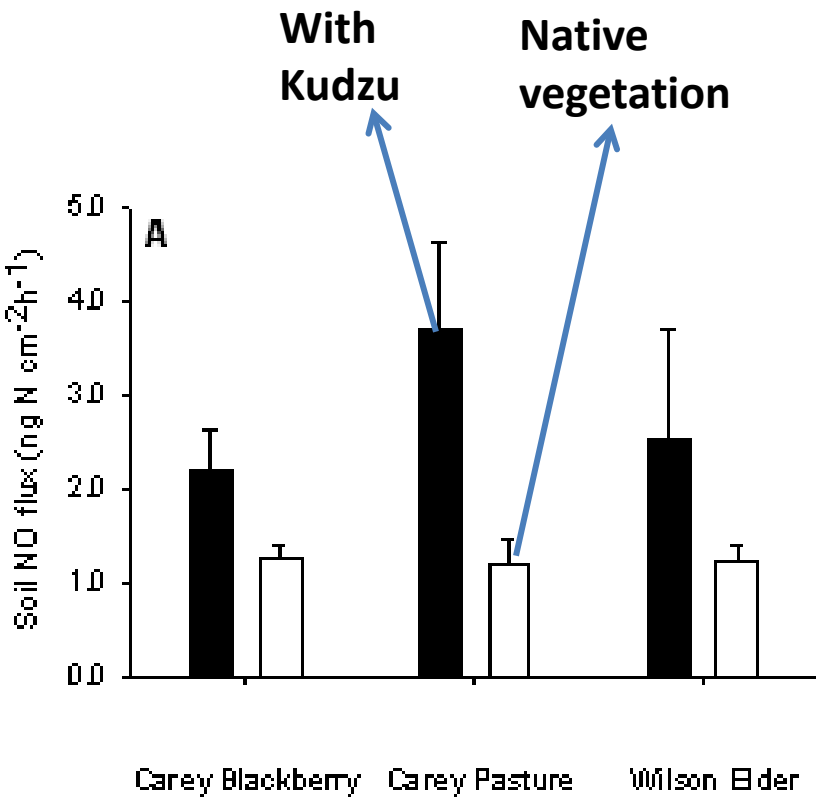
http://www.rockymountaingreen

Modeling framework



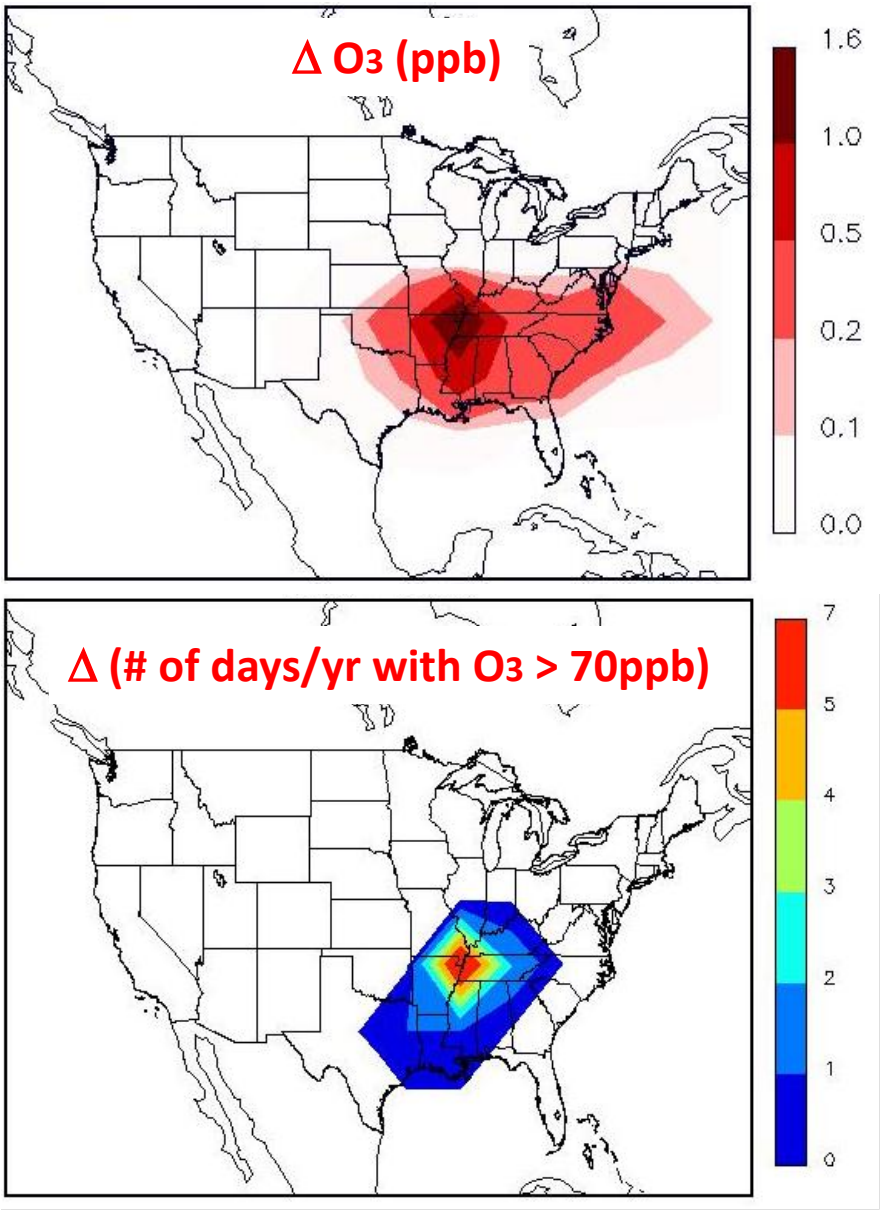
Invasive species Kudzu and air quality

Kudzu: from bad to worse



(Data from 3 sites in Madison County, Georgia)

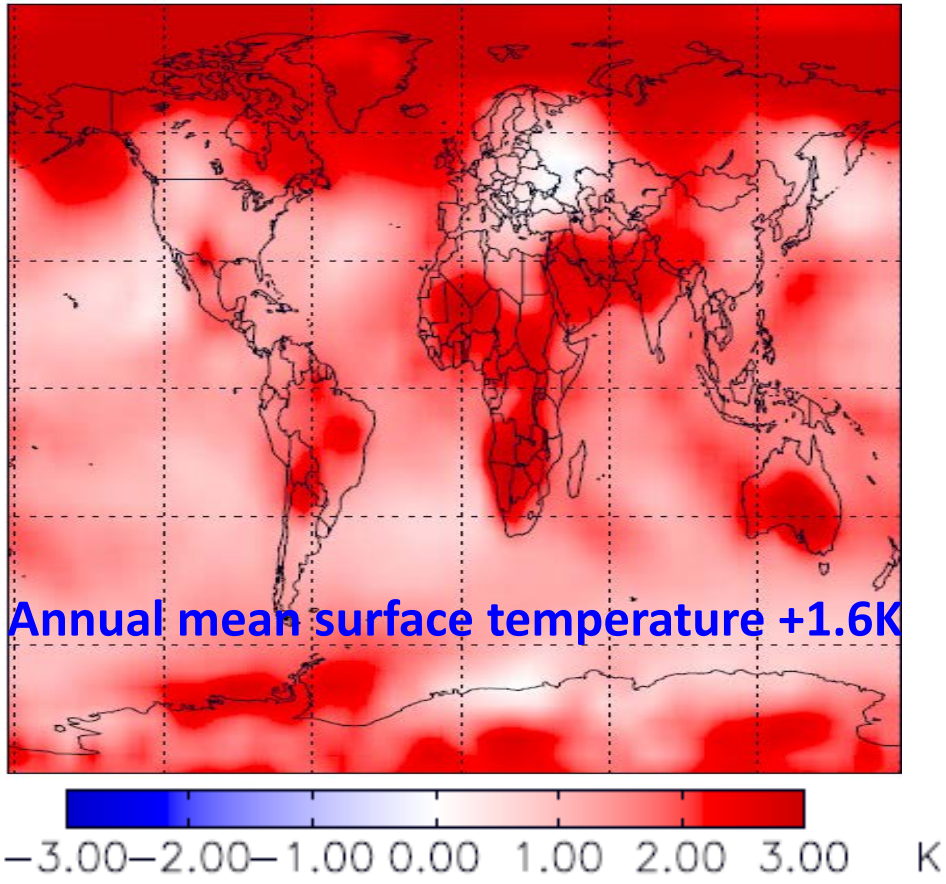
If Kudzu covers all non-agricultural, non-urban soils → +28% soil NOx



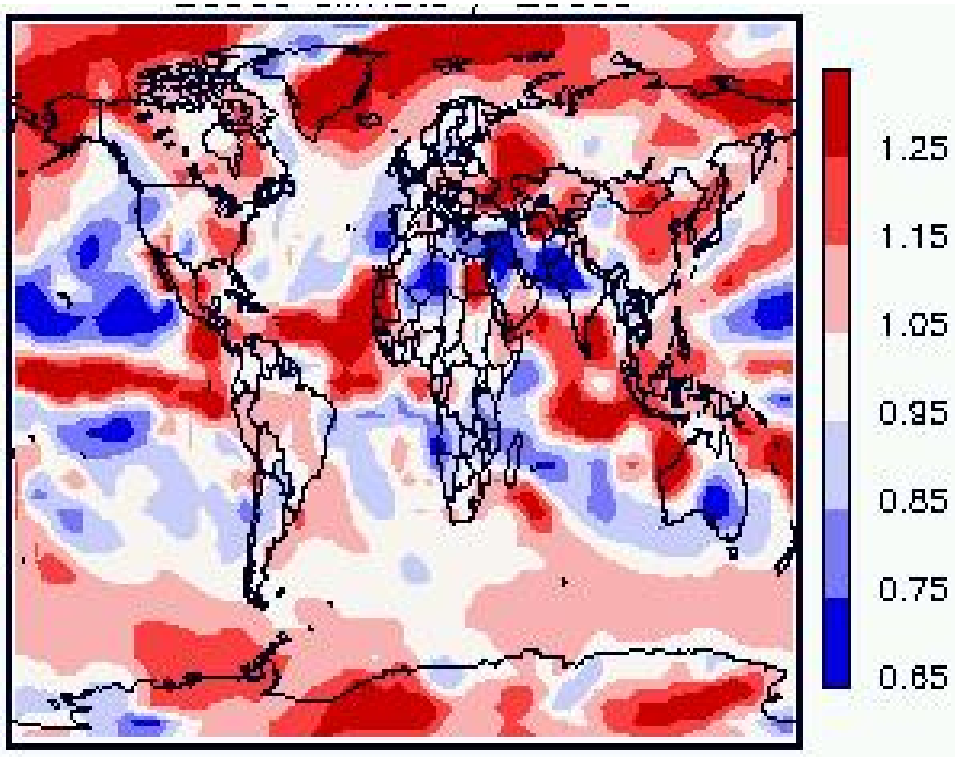
[Hickman et al., 2010, PNAS]

Changes in temperature and precipitation simulated by the GISS model (annual mean; A1B scenario)

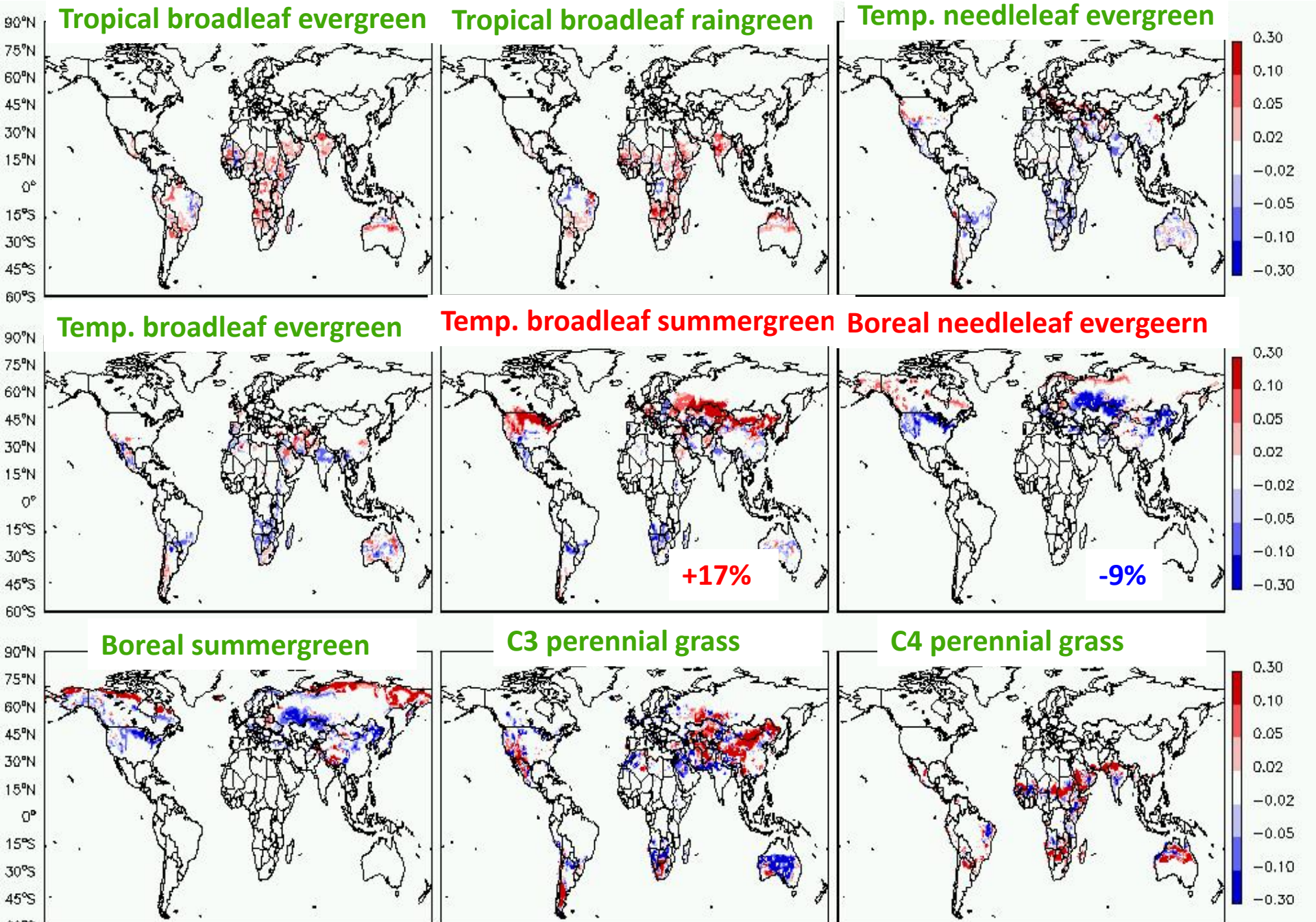
Temperature (2050s – 2000s)



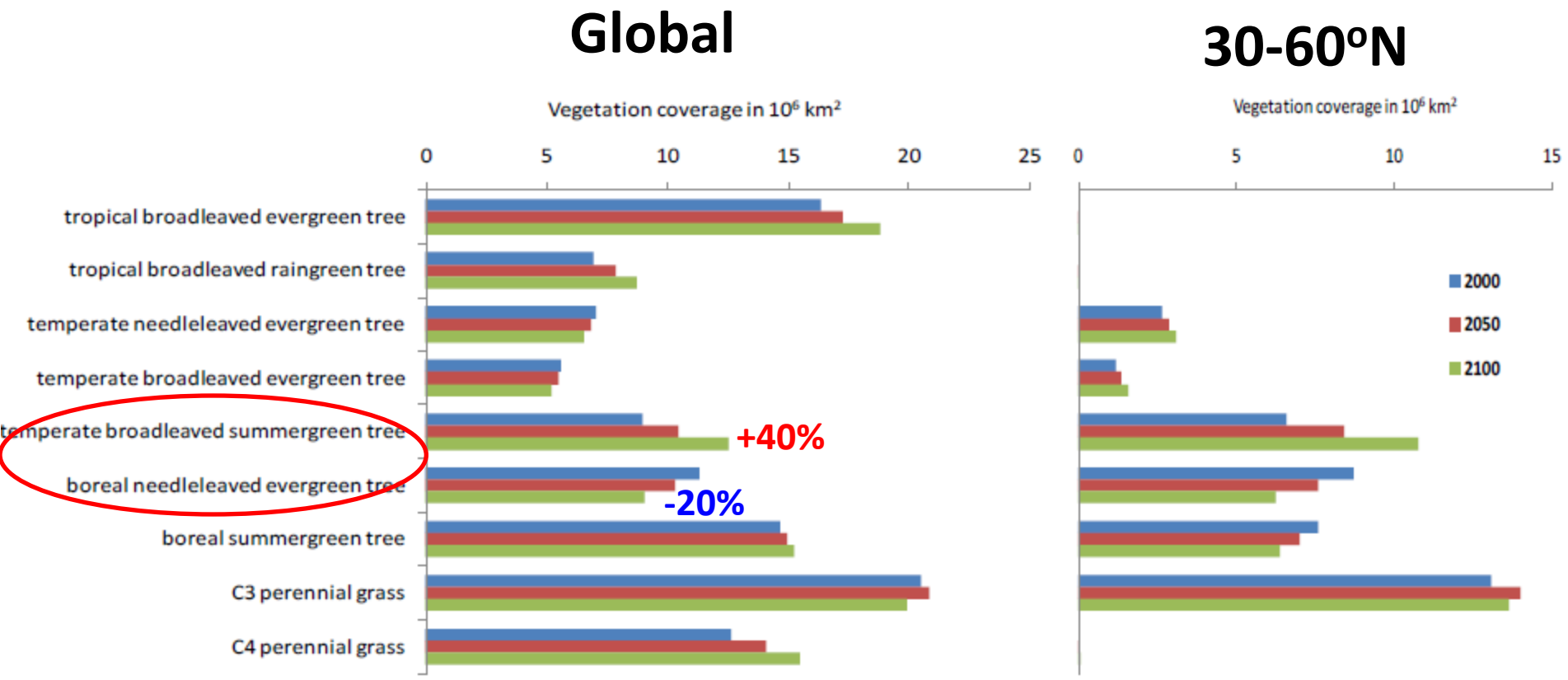
Precipitation (2050s / 2000s)



Climate-driven changes in vegetation for 2000-2050

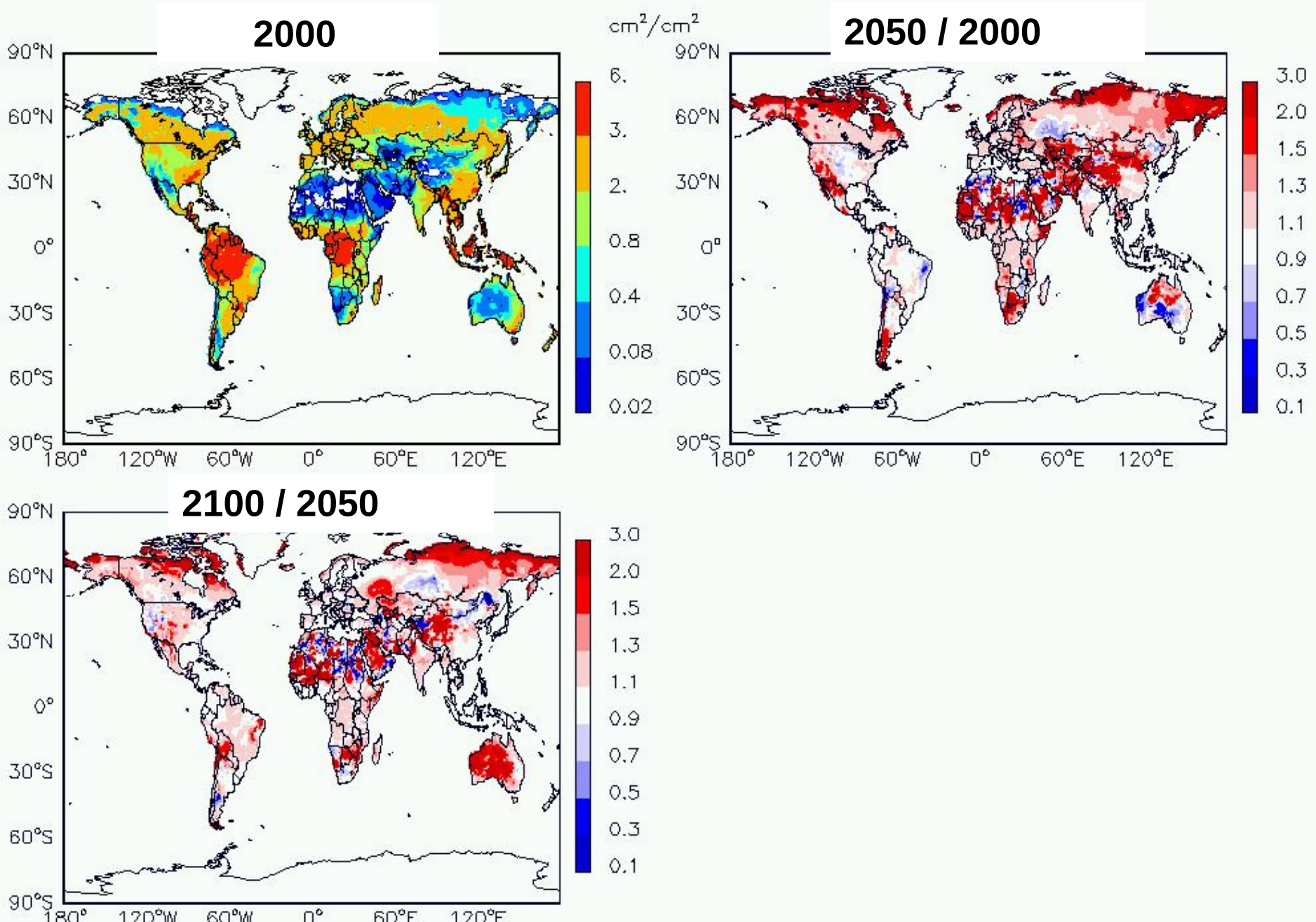


Climate-driven changes in vegetation (total area coverage)

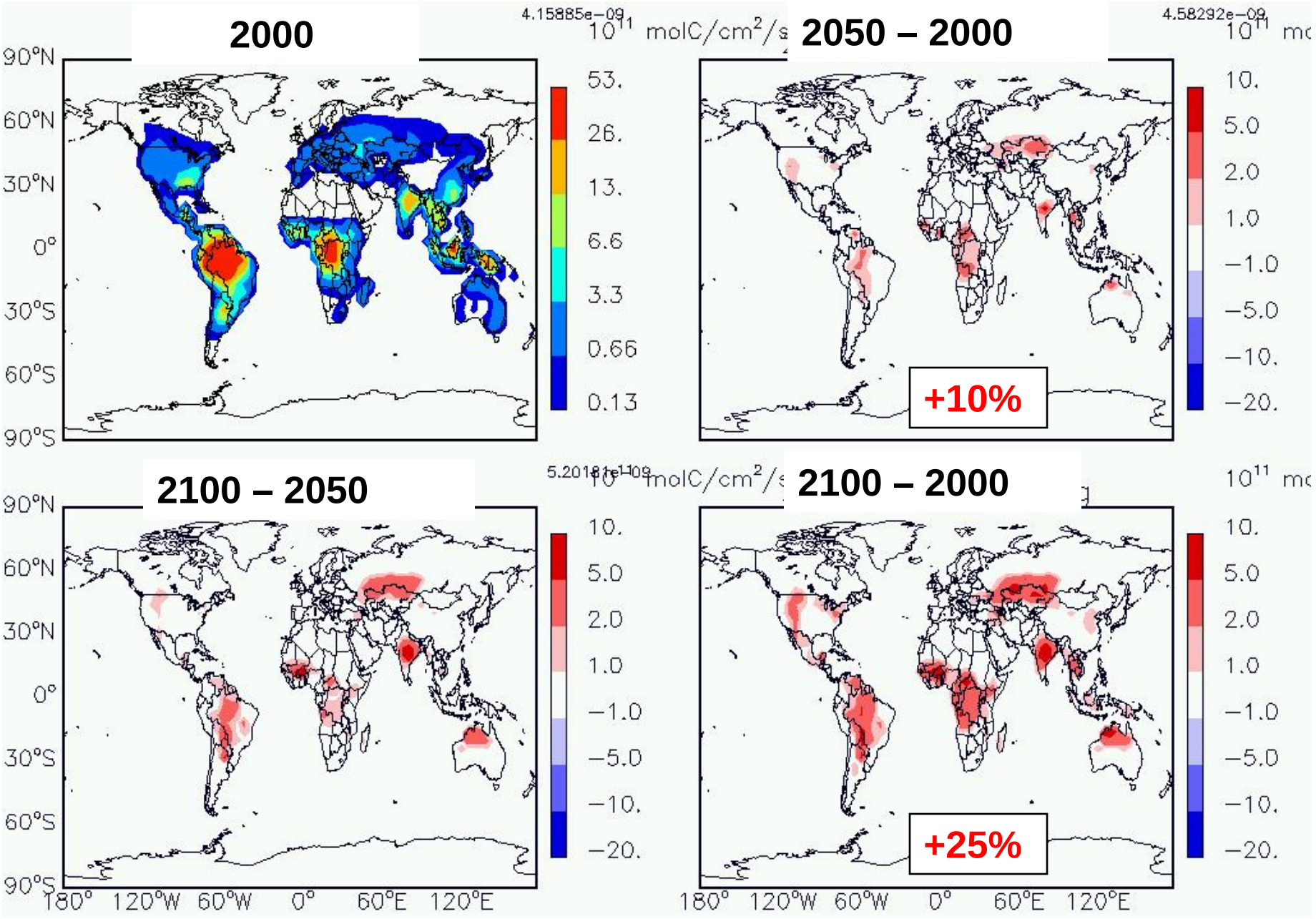


[Wu et al., 2012, ACP]

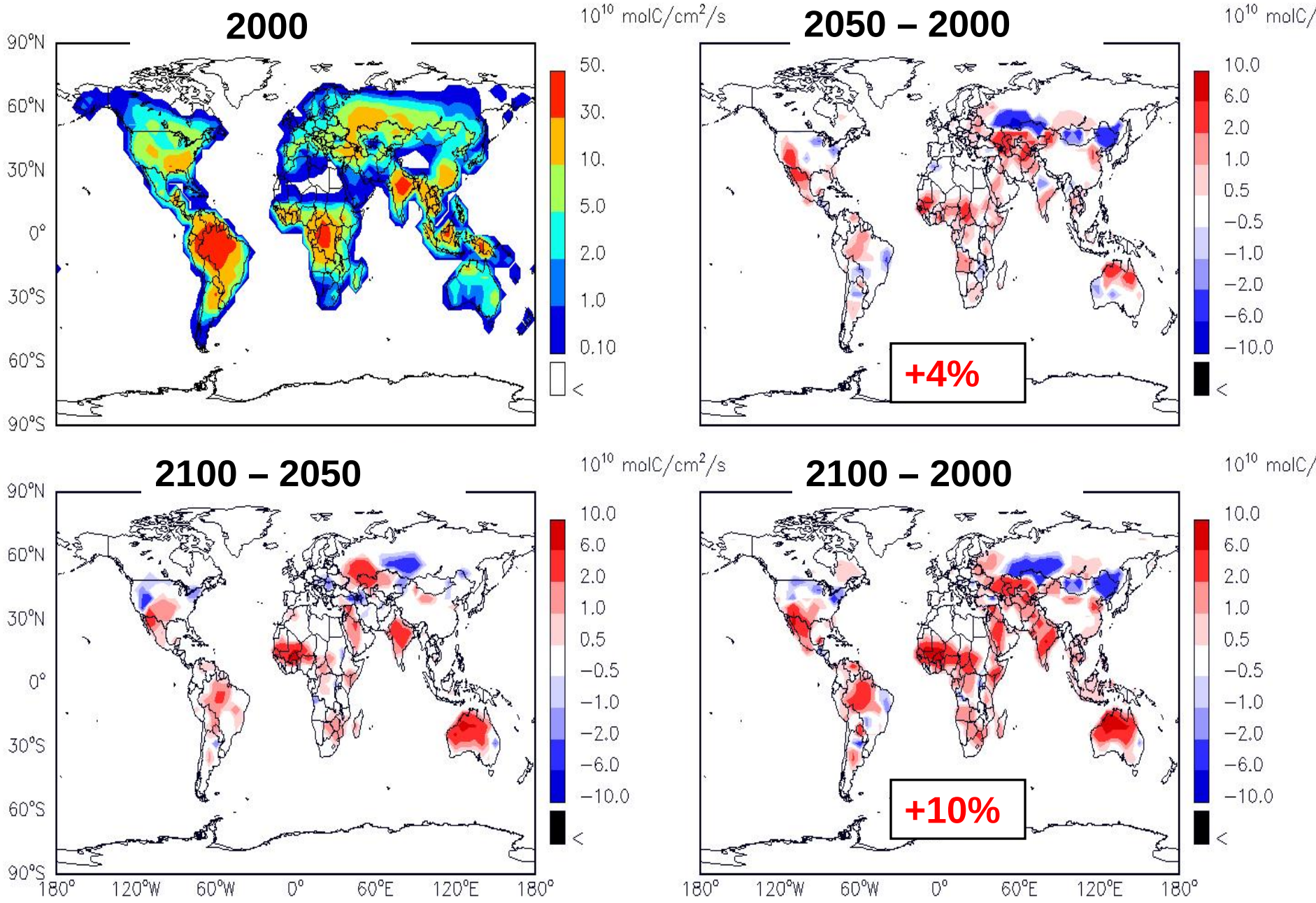
Climate-driven changes in leaf area index (LAI)



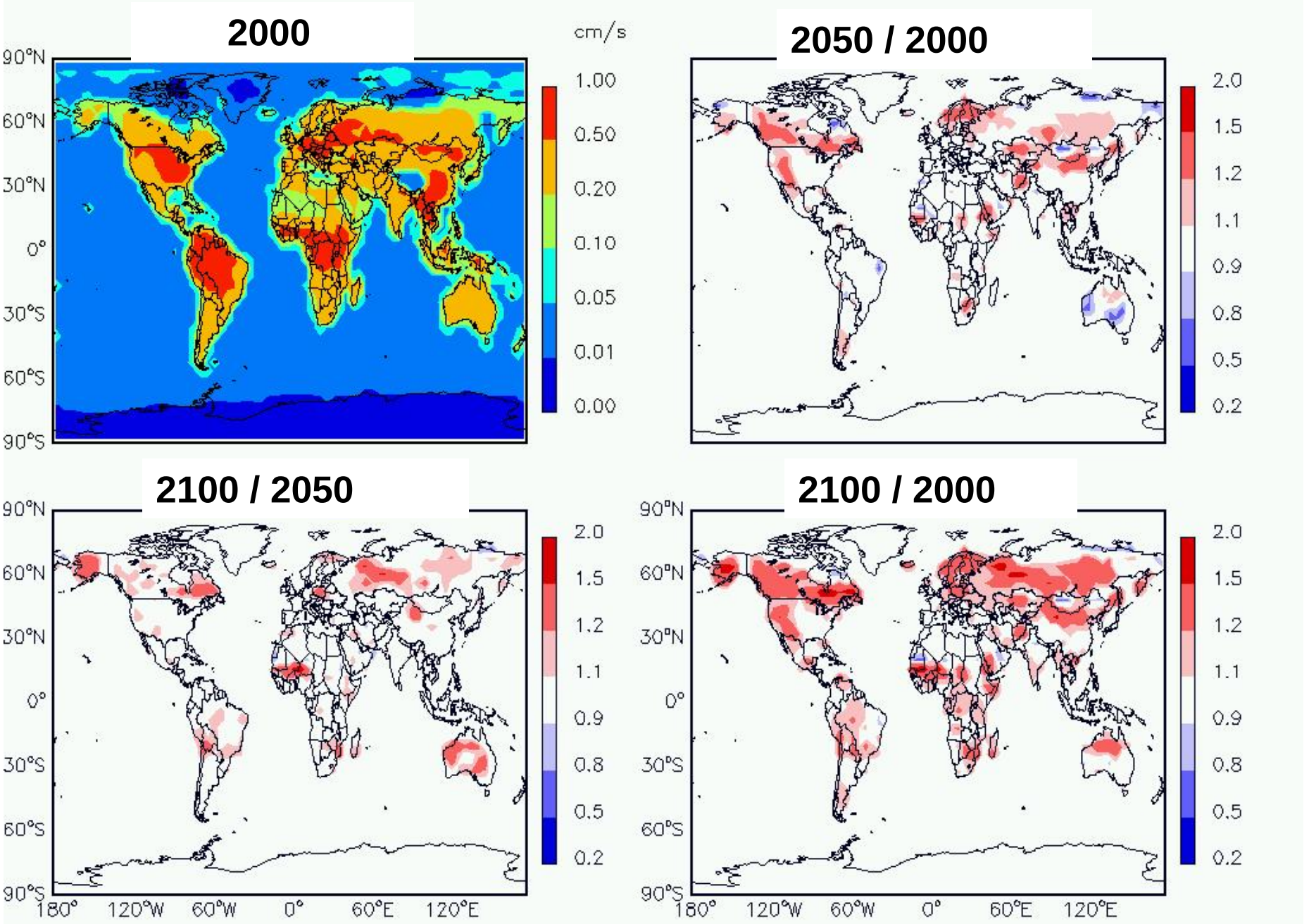
Changes in isoprene emissions due to land cover change



Changes in monoterpene emissions due to land cover change

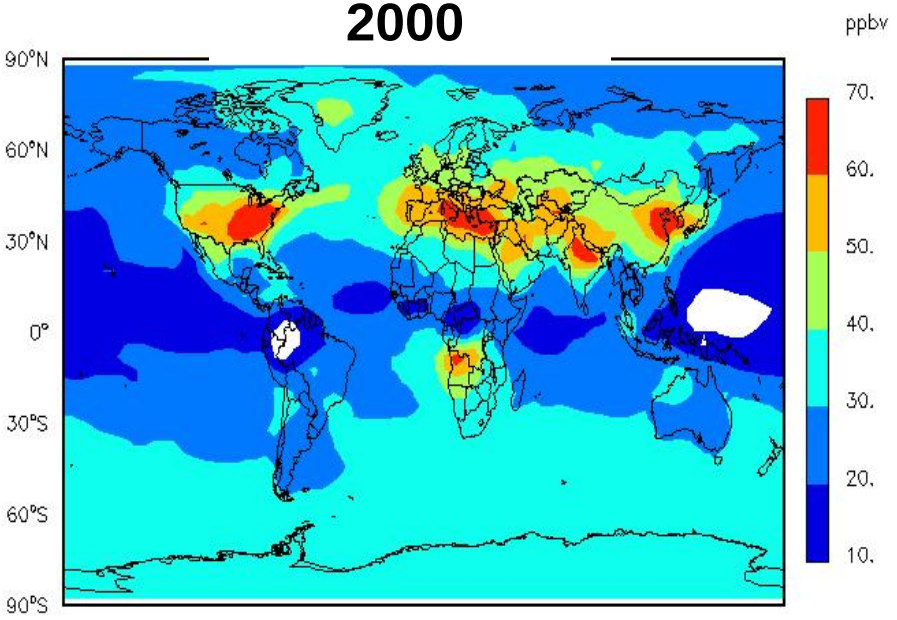


Changes in ozone dry deposition velocity due to land cover change

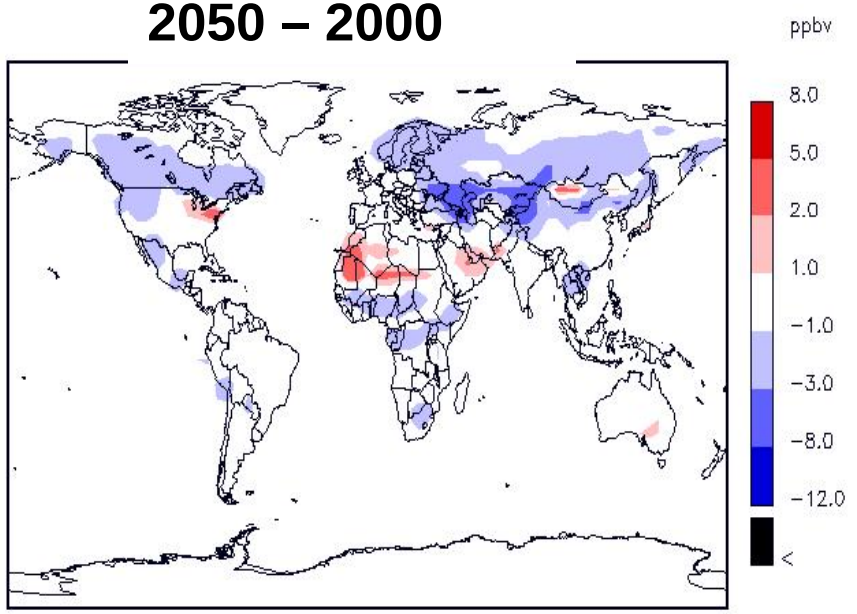


Changes in JJA surface ozone (ppb) due to land cover change

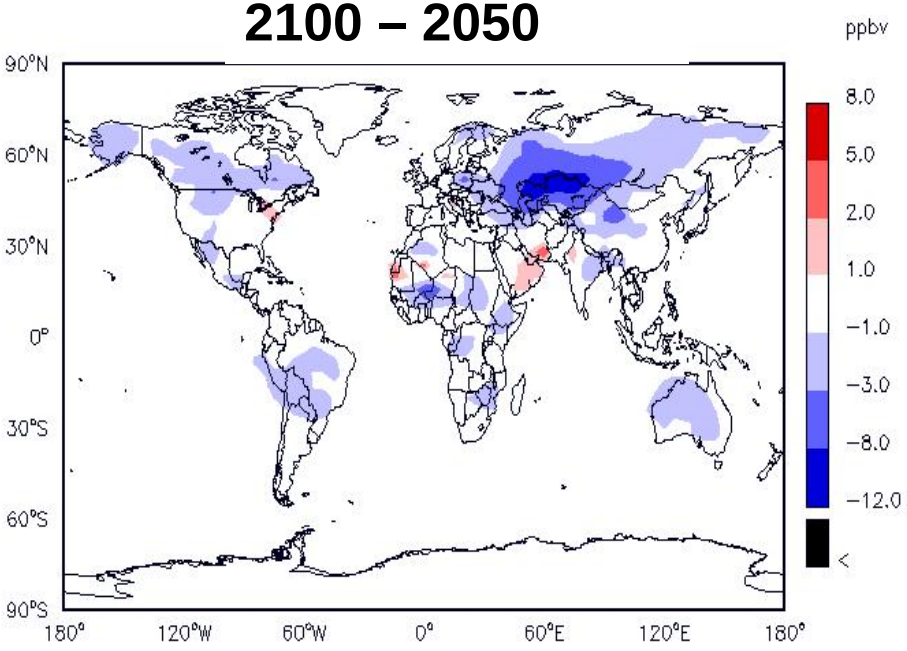
2000



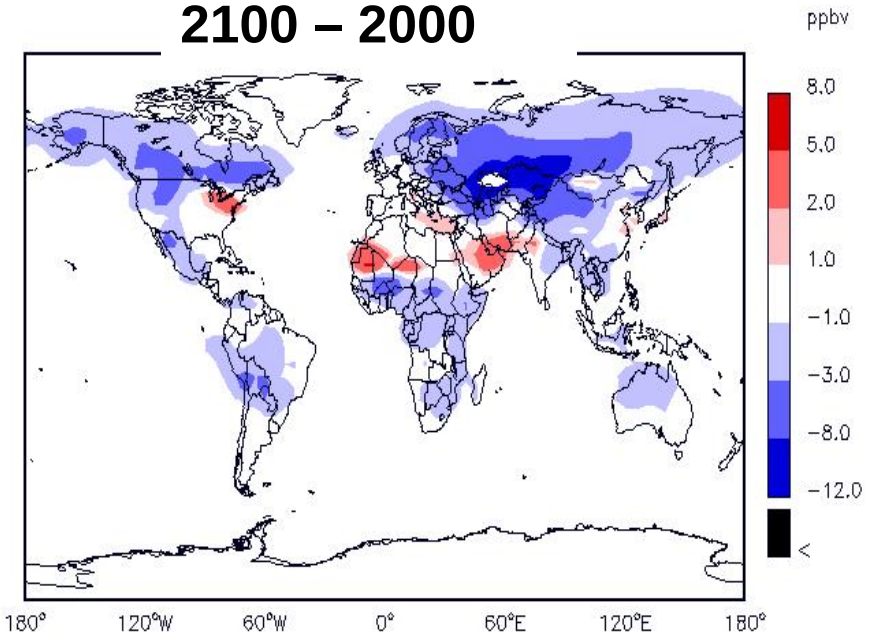
2050 – 2000



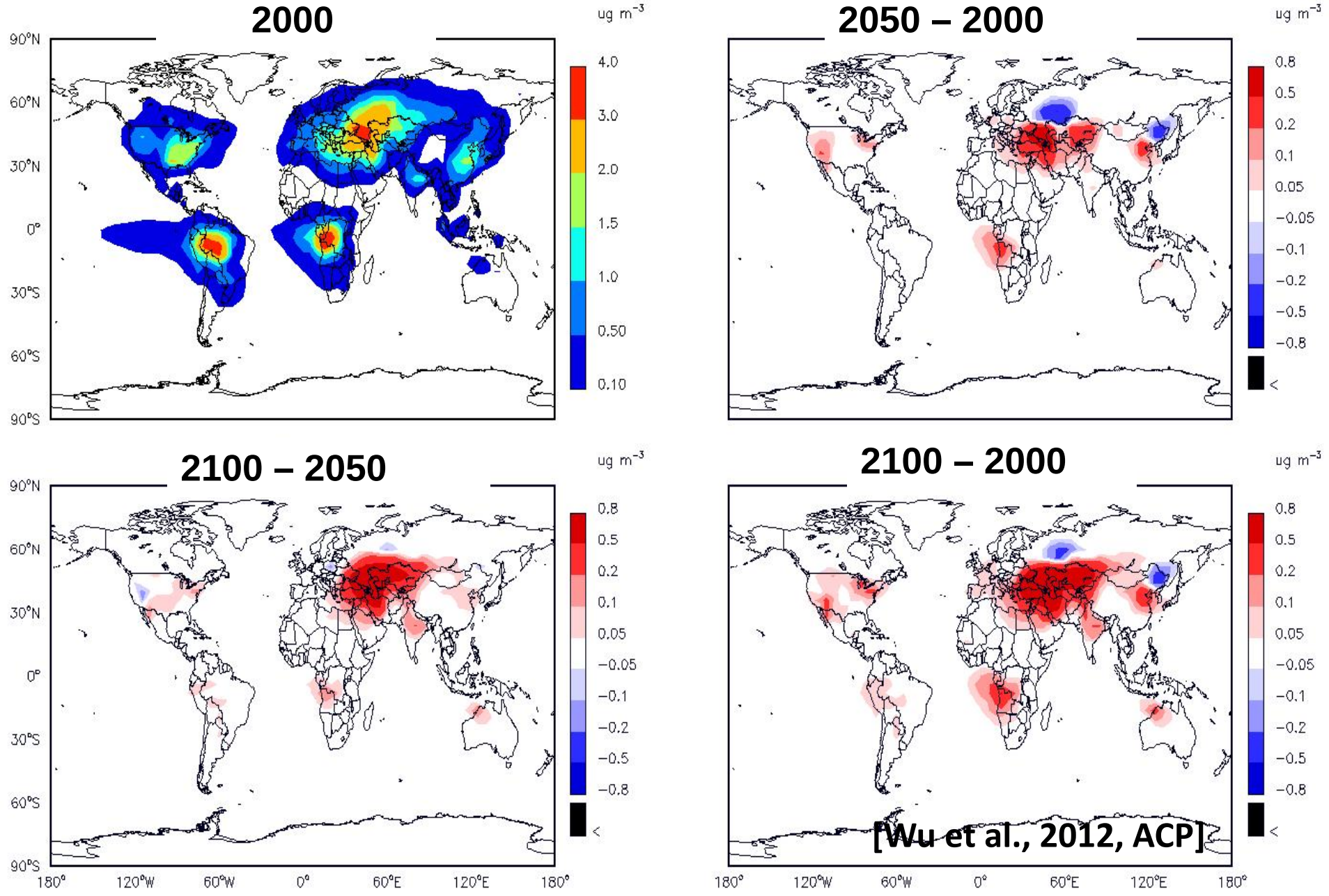
2100 – 2050



2100 – 2000

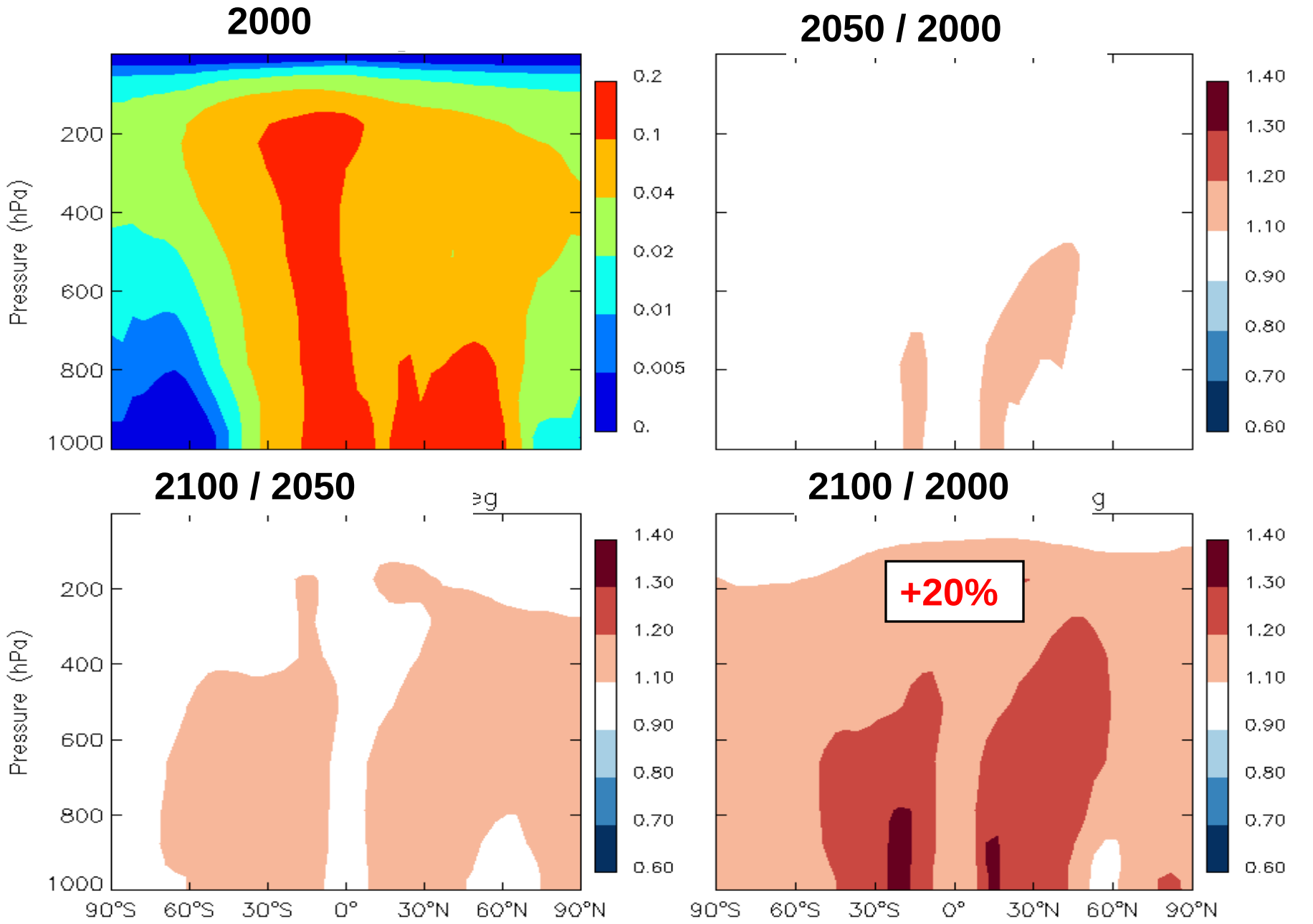


Changes in JJA surface SOA (μg/m³) due to land cover change

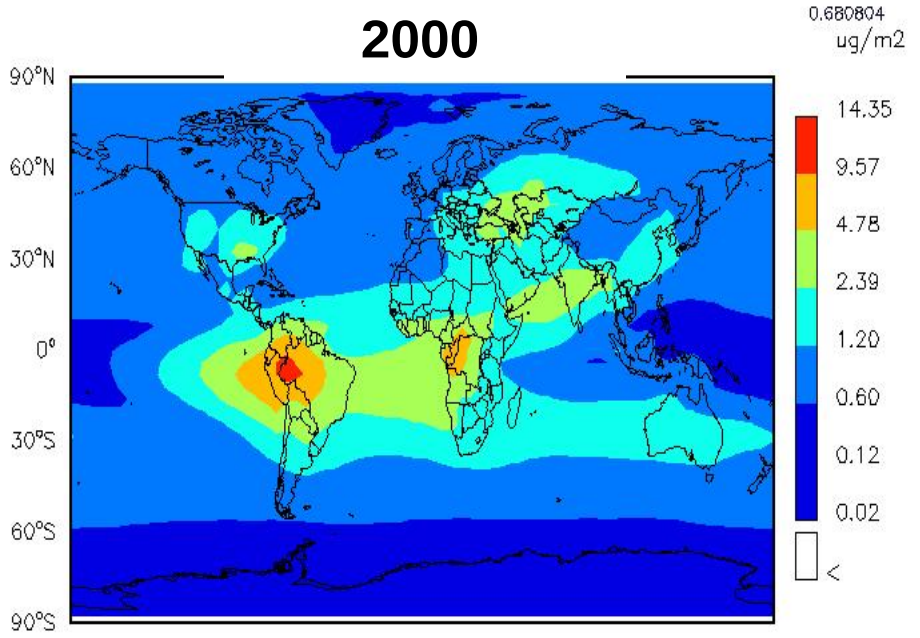


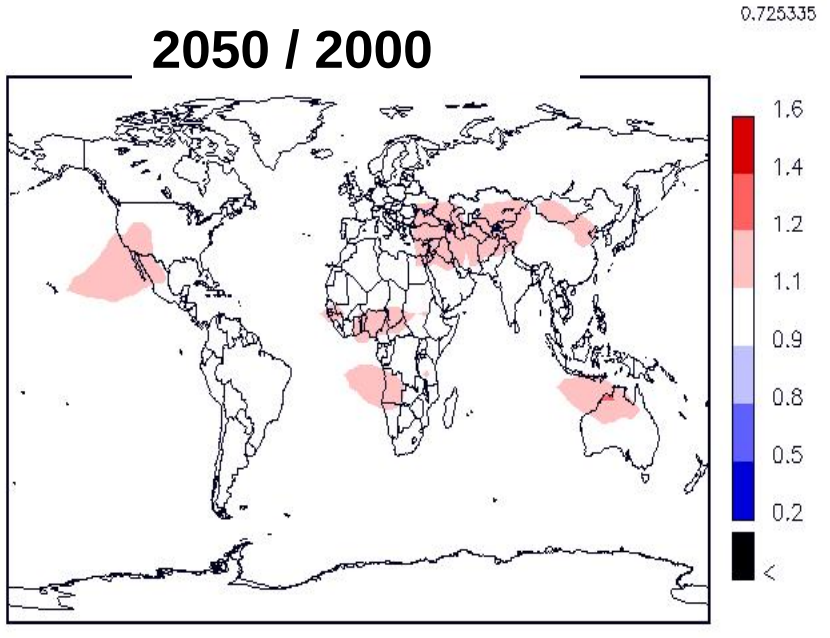
[Wu et al., 2012, ACP]

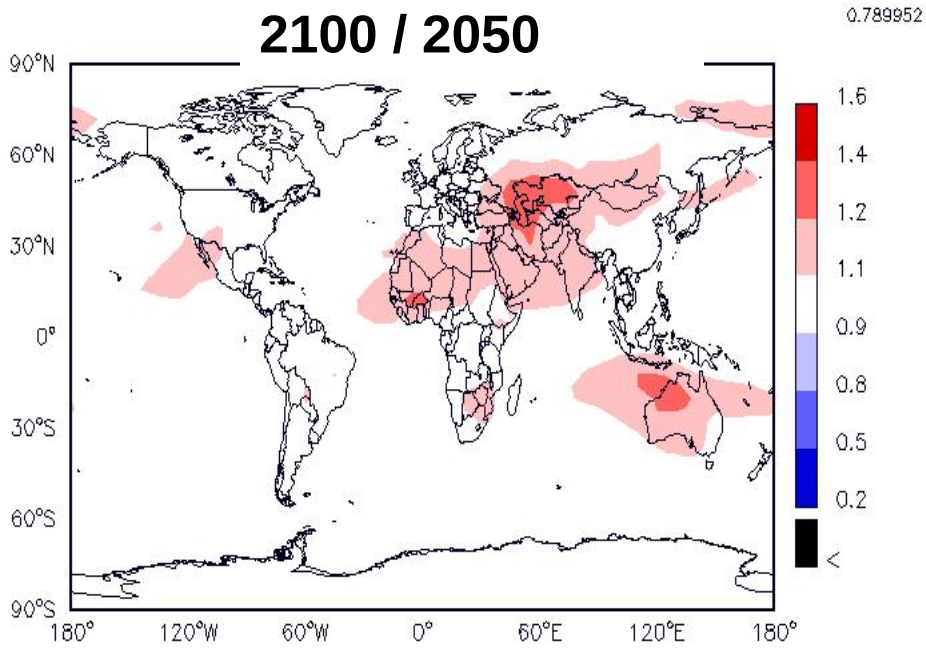
Changes in zonal mean SOA (ratio) due to land cover change

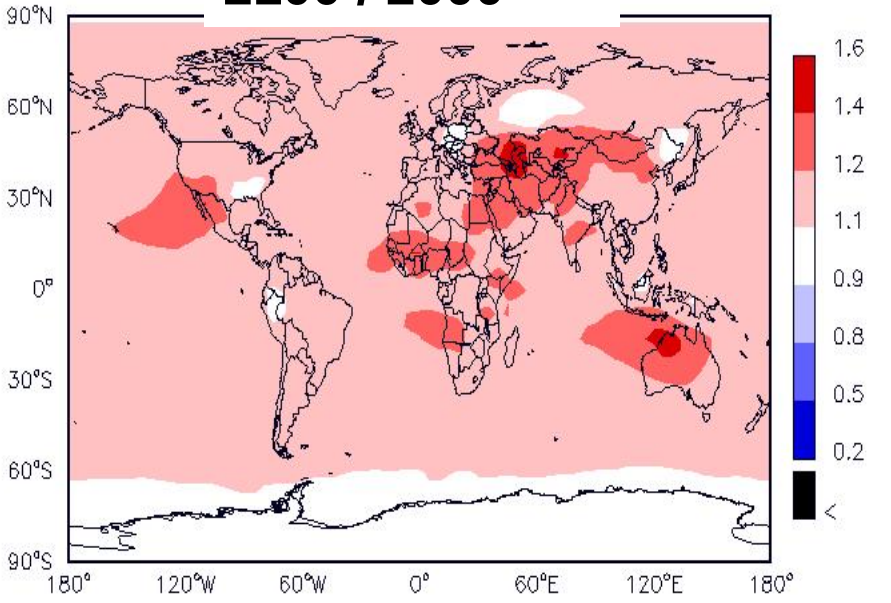


Changes in column SOA (ratio) due to land cover change







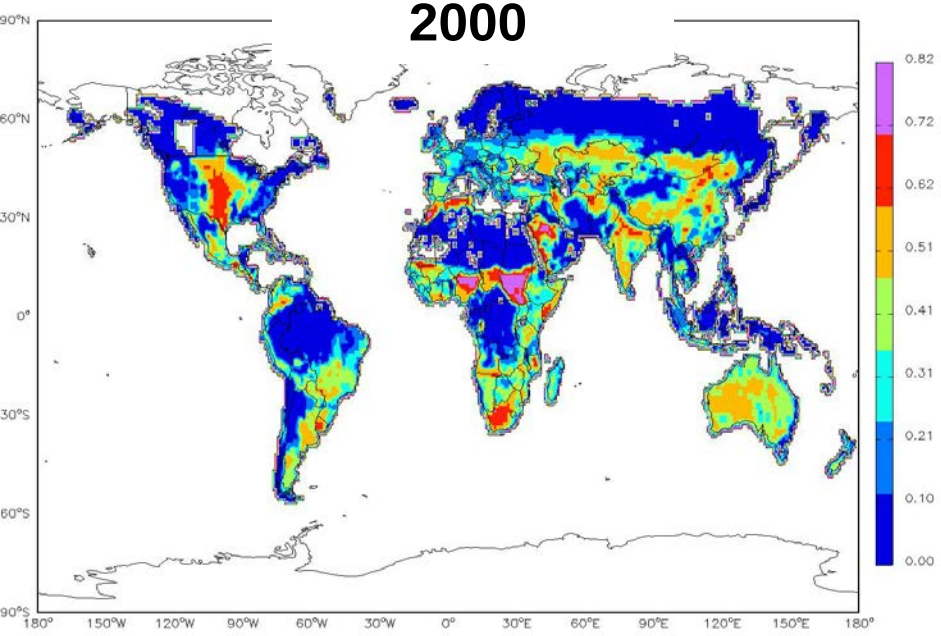


Changes in biogenic emissions and atmospheric composition due to land cover change

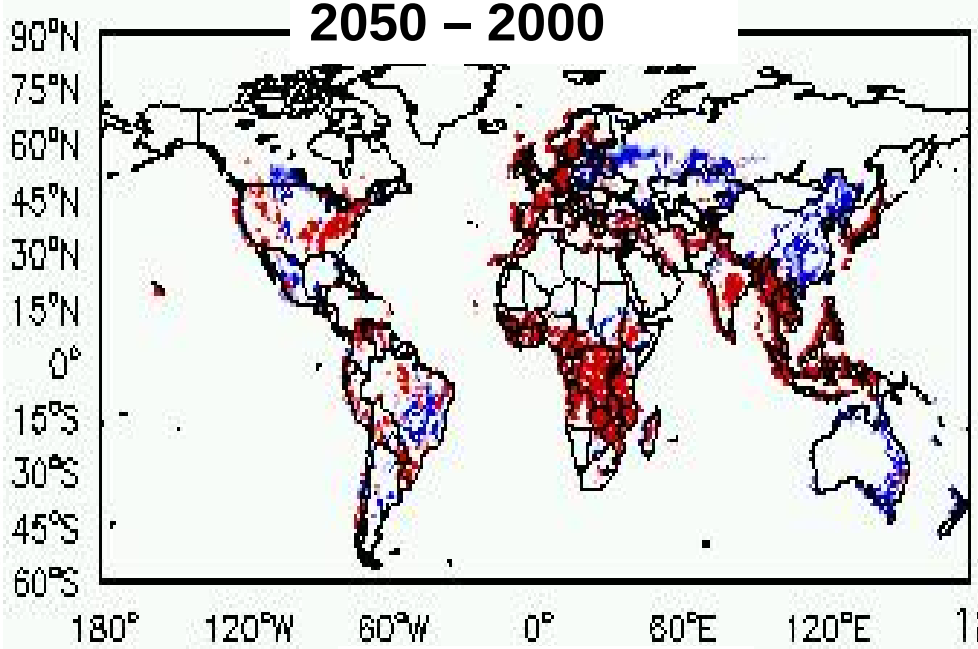
	Simulations including climate change and CO_2 trend		
Model year	2000	2050	2100
Ozone burden (Tg)	305	304 (−0.3 %)	303 (−0.7 %)
SOA burden (Tg)	0.51	0.55 (+10 %)	0.61 (+20 %)
Annual isoprene emissions (Tg C)	429	469 (+10 %)	532 (+25 %)
Summer[c] isoprene emissions(Tg C)	112	130 (+15 %)	152 (+34 %)
Annual monoterpene emissions (Tg C)	80	83 (+4 %)	88 (+10 %)
Summer[c] monoterpene emissions (Tg C)	27	28 (+3 %)	29 (+8 %)
OH (10^6 molec cm^{-3})	1.13	1.11 (−2 %)	1.08 (−4 %)

Changes in anthro. land use/crop coverage

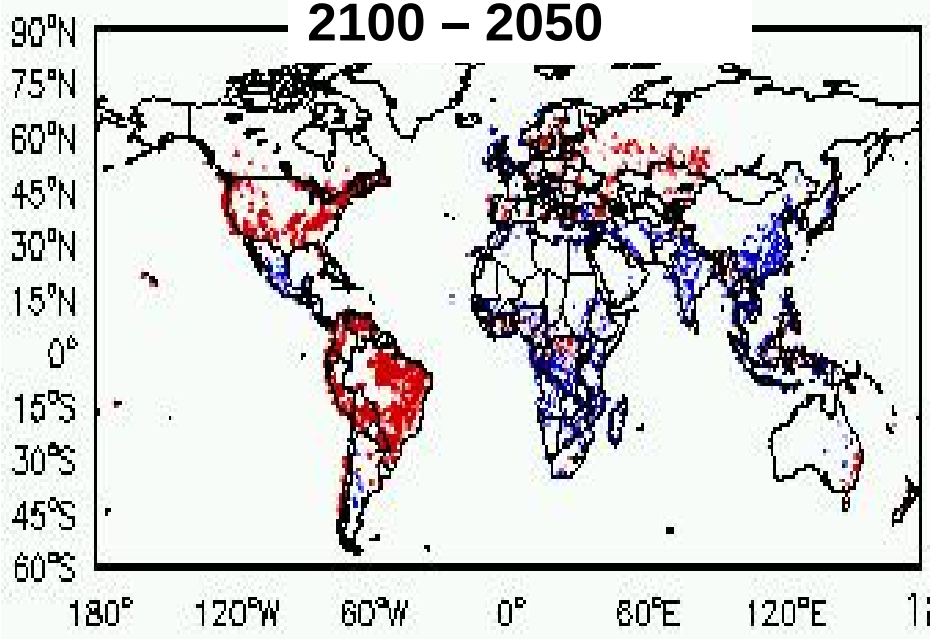
2000



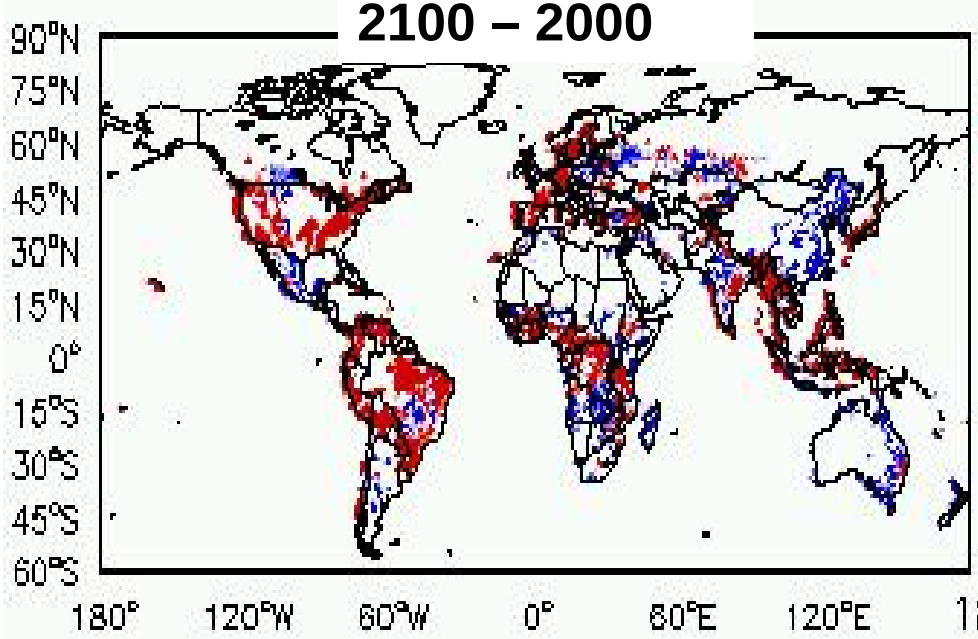
2050 – 2000



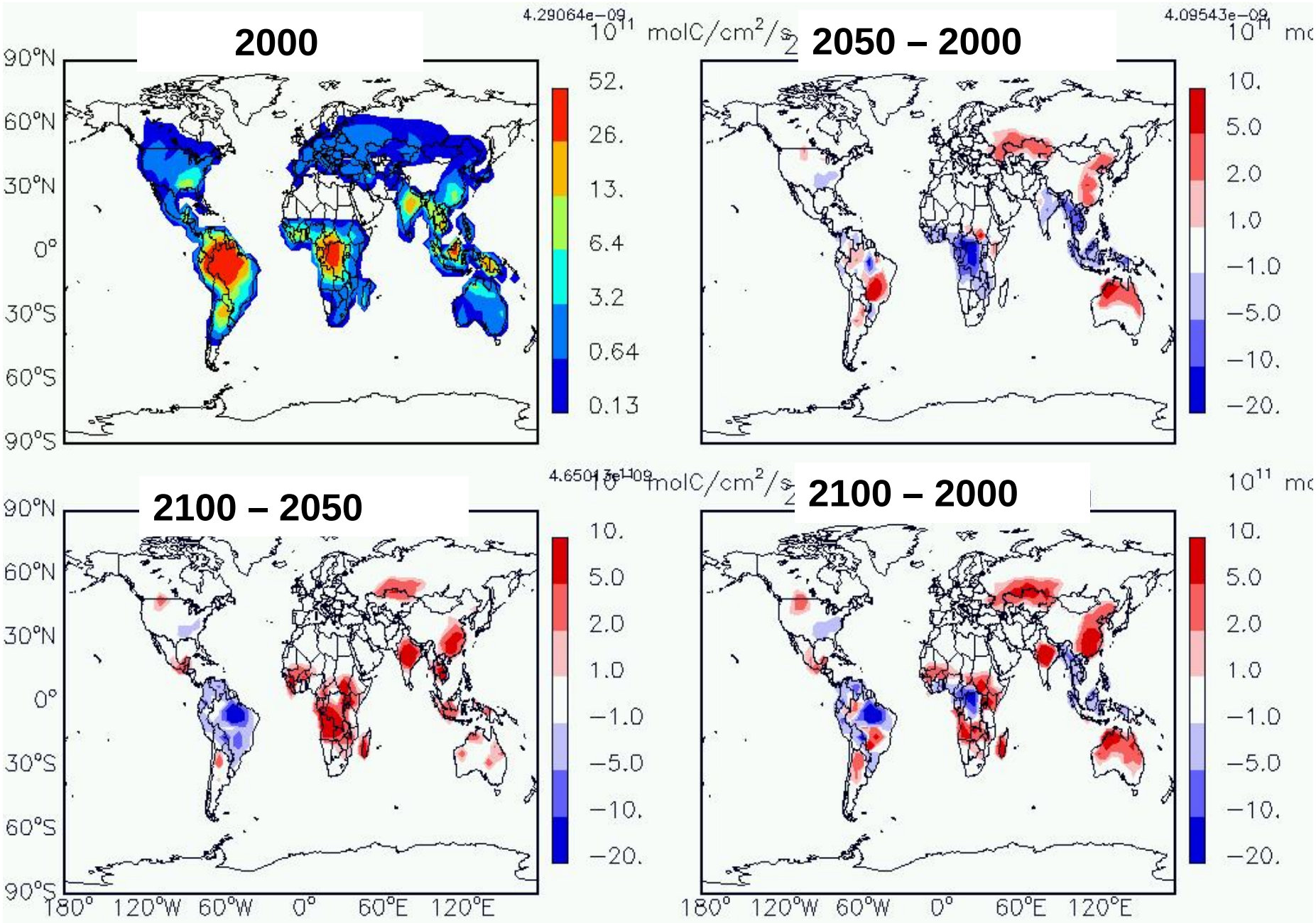
2100 – 2050



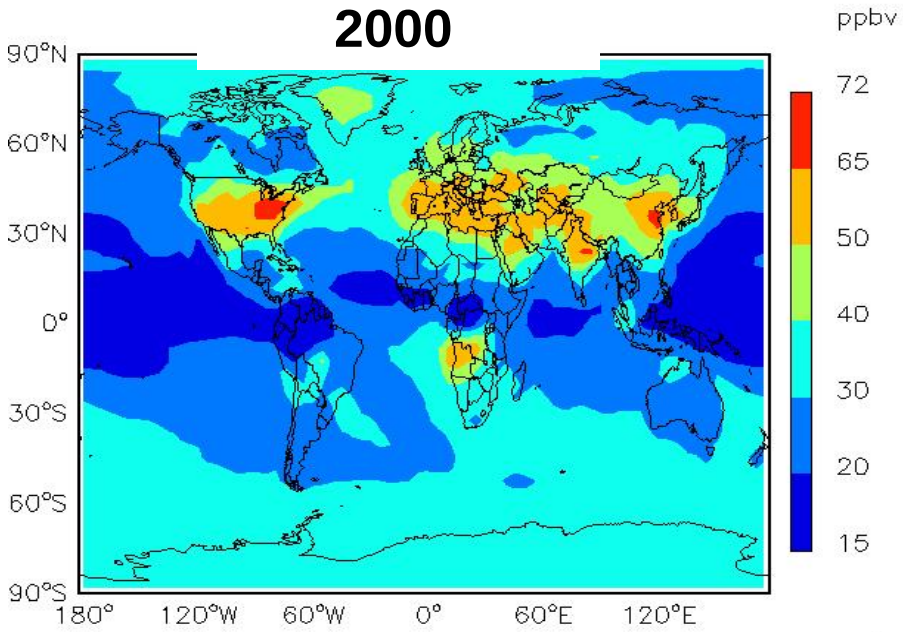
2100 – 2000

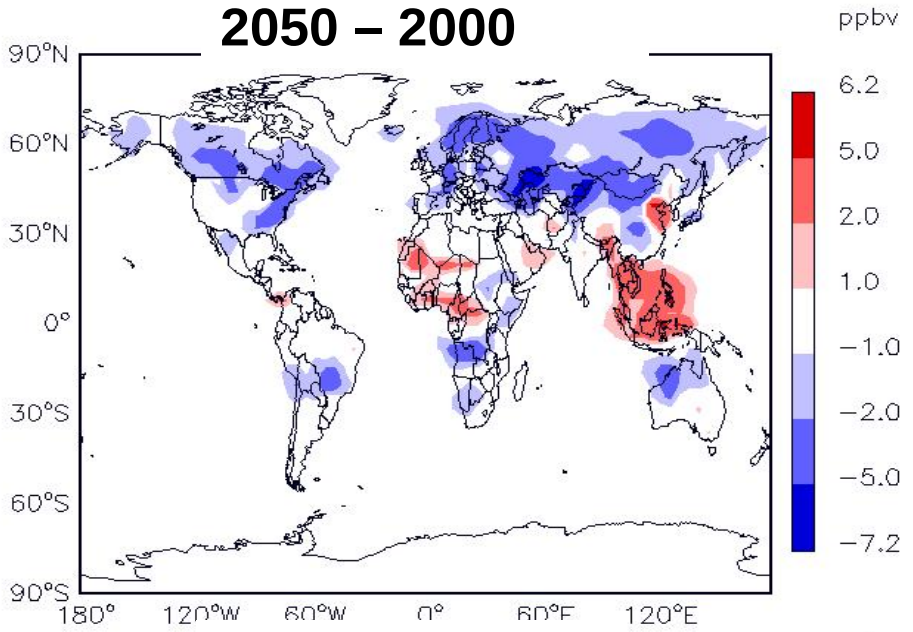


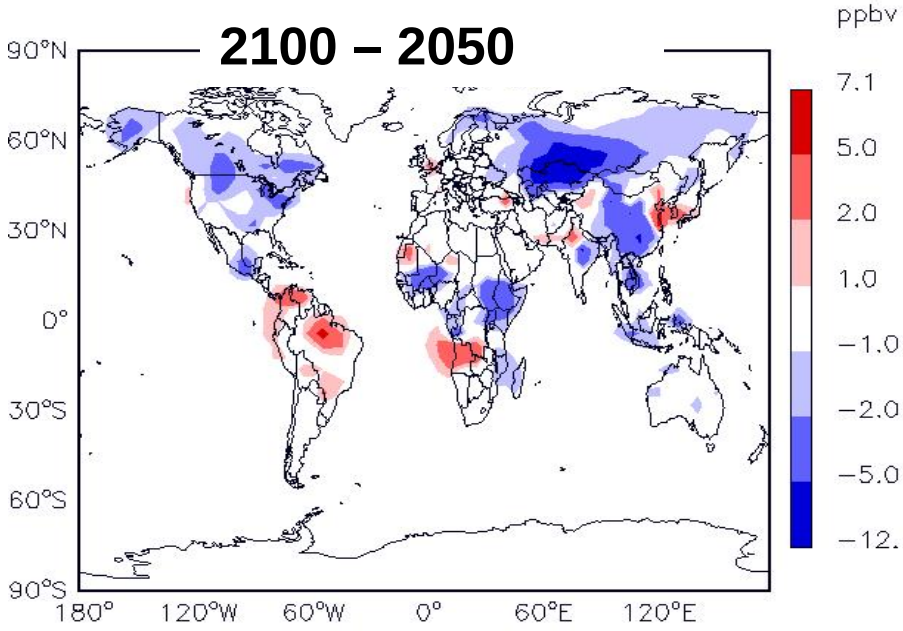
Changes in isoprene emissions due to LU/LC change

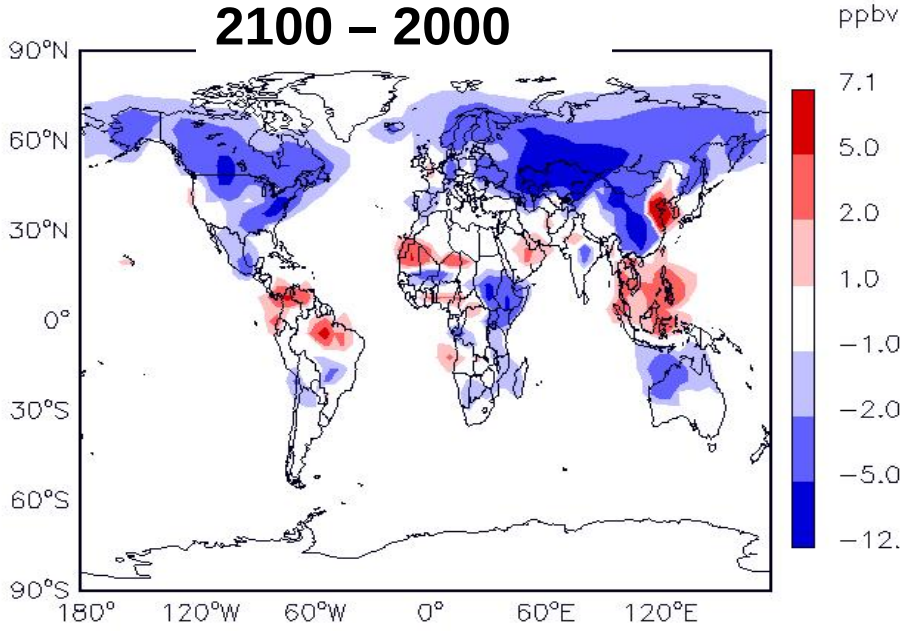


Changes in surface O_3 (JJA) due to LU/LC change

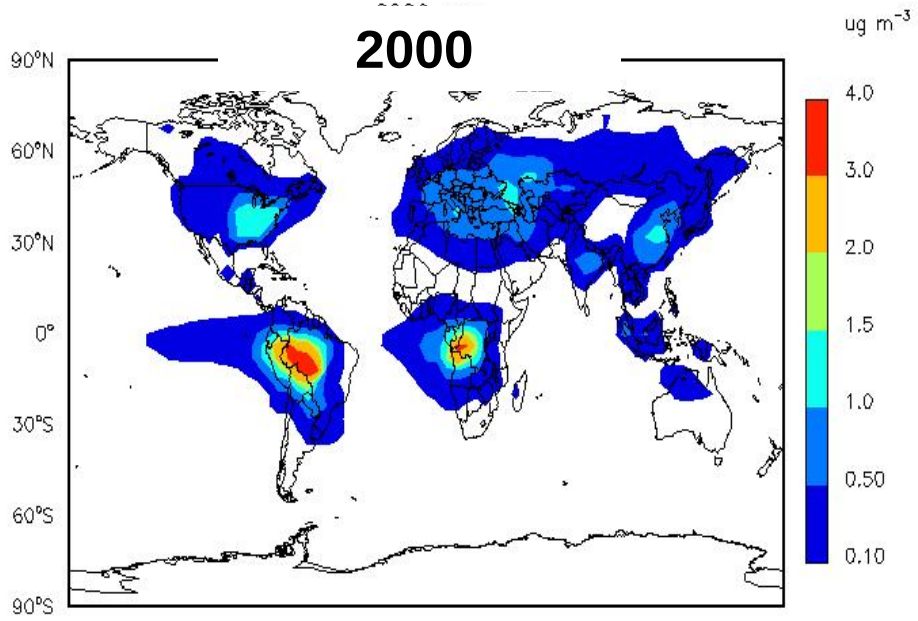


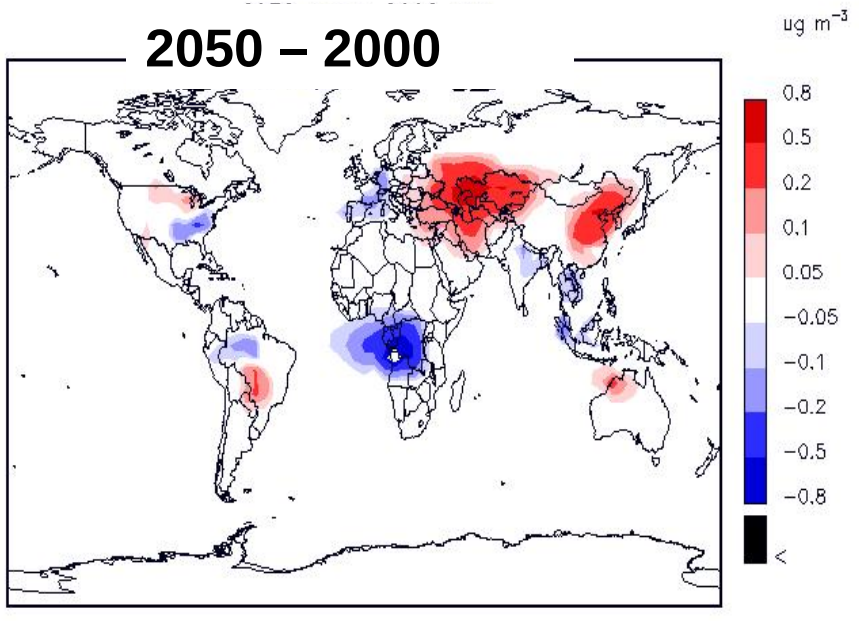


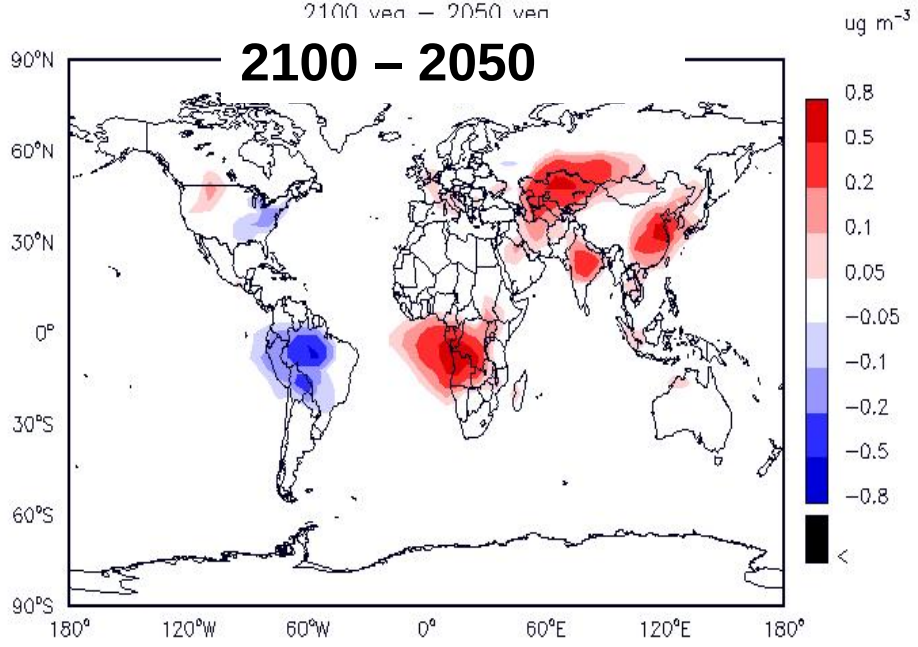


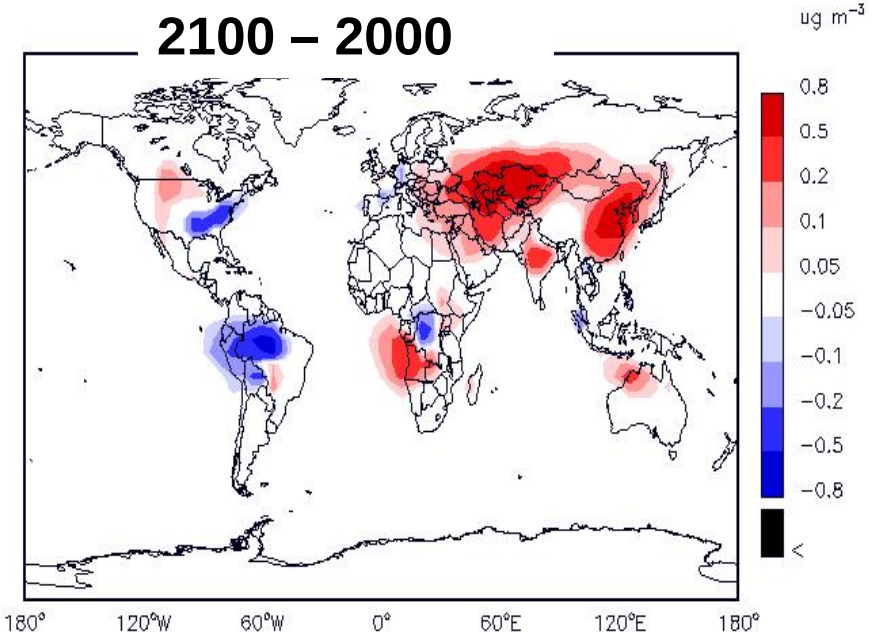


Changes in surface SOA (JJA) due to LU/LC change



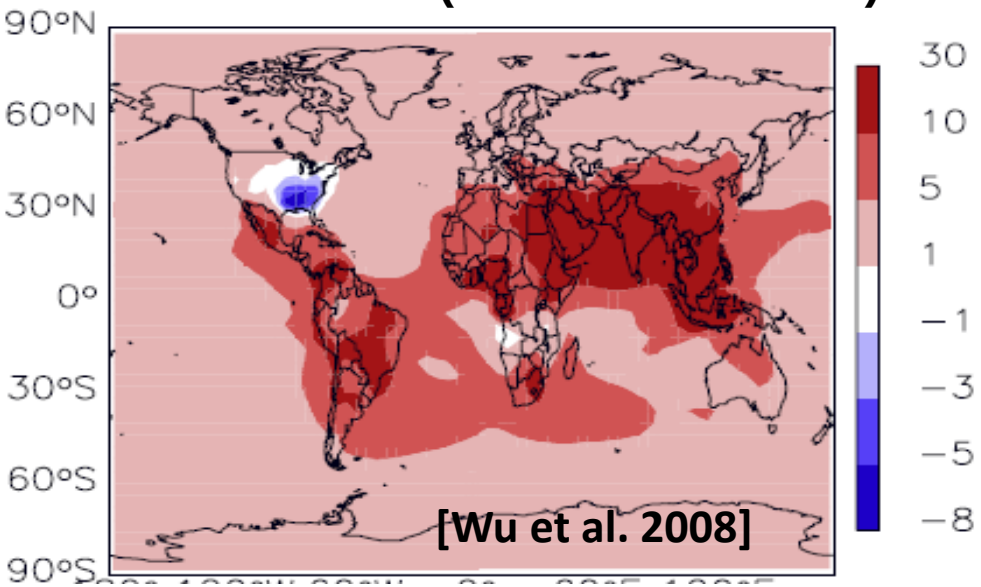




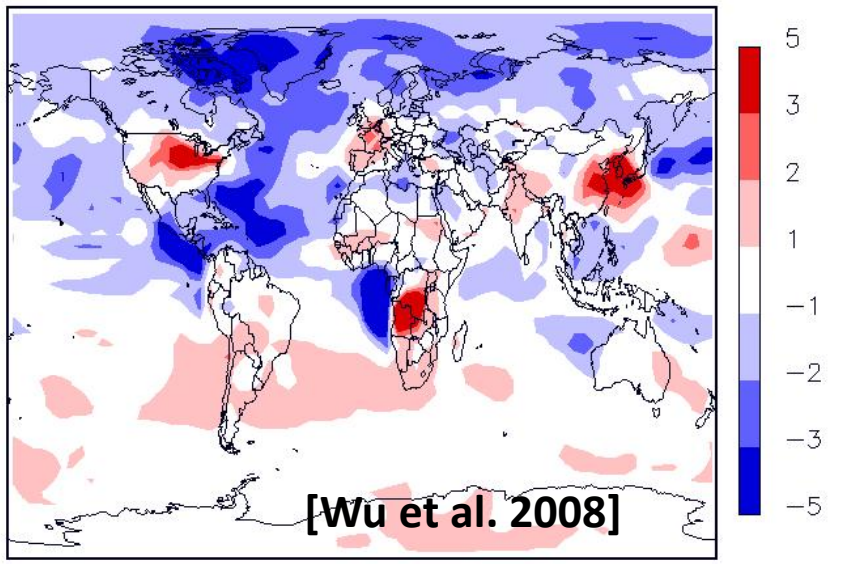


Intercomparison to other global change factors - 2000-2050 changes in summer (JJA) surface ozone (ppb)

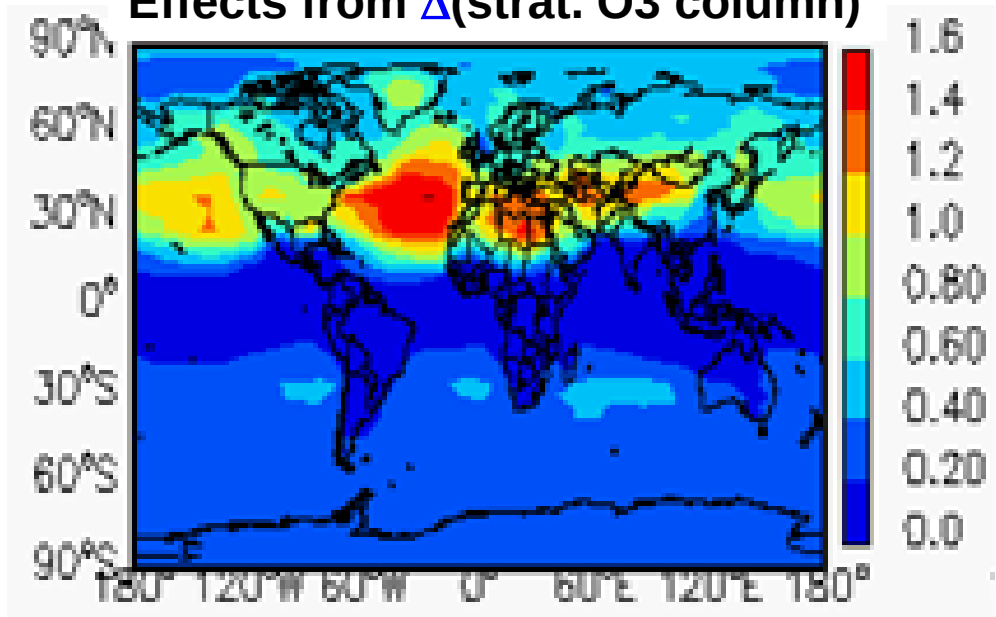
Effects from Δ(anthro. emissions)



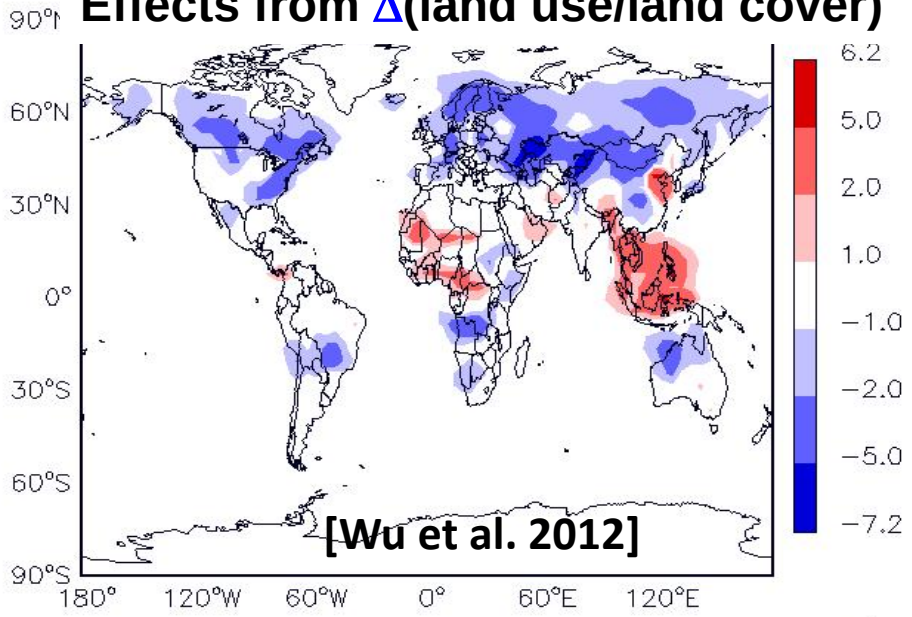
Effects from Δ(climate)



Effects from Δ(strat. O3 column)



Effects from Δ(land use/land cover)



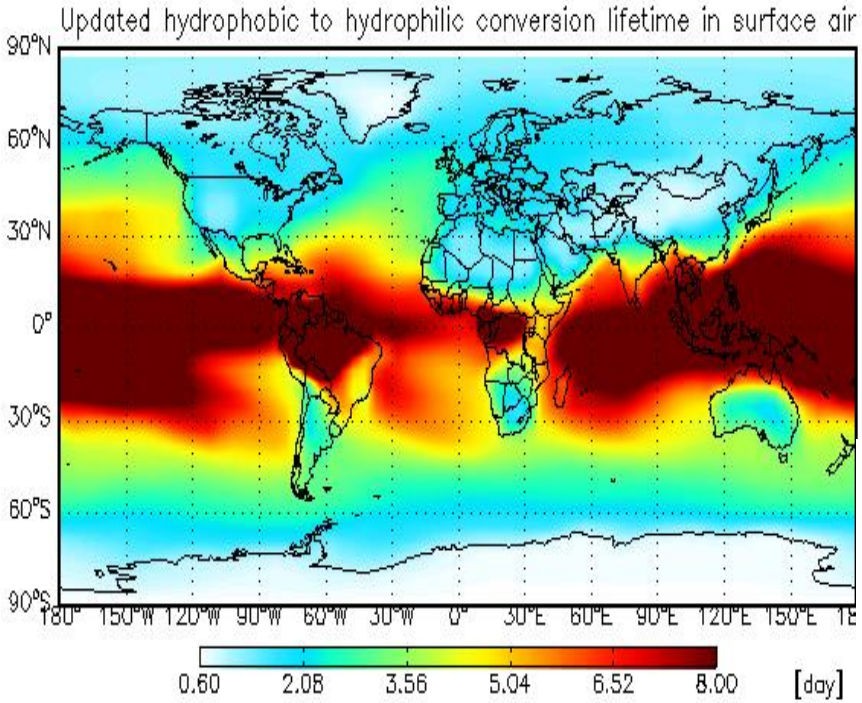
Further and ongoing work

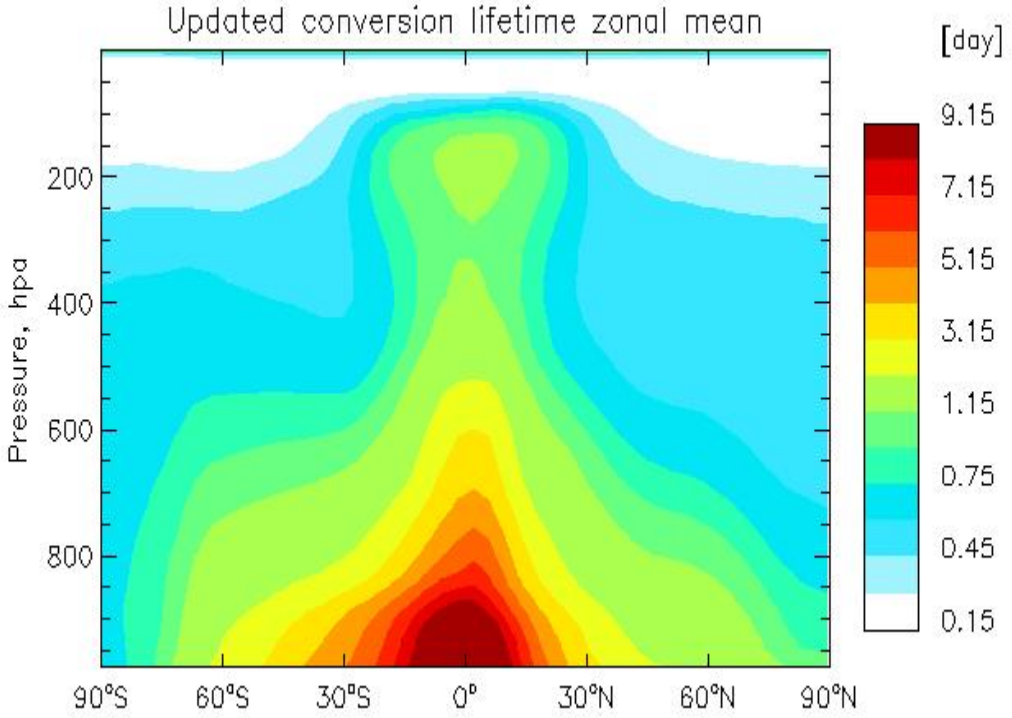
1. **Additional factors/processes related to LU/LC that affect air quality (e.g. wild fires; mountain beetle killing, etc.)?**

2. **Higher resolution / CMAQ?**

3. **Updates in the modeling system/processes, e.g.**
   a). CO_2 inhibition effect on isoprene emissions;
   b). aging mechanism for carbonaceous aerosols.

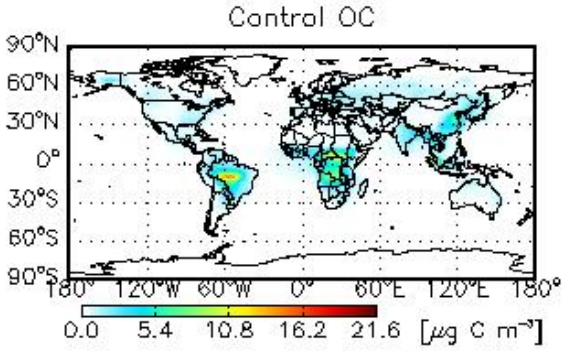
Updates in the hydrophobic-hydrophilic conversion rates for carbonaceous aerosols in the model

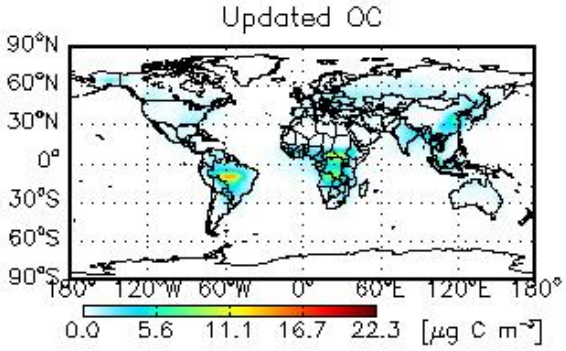


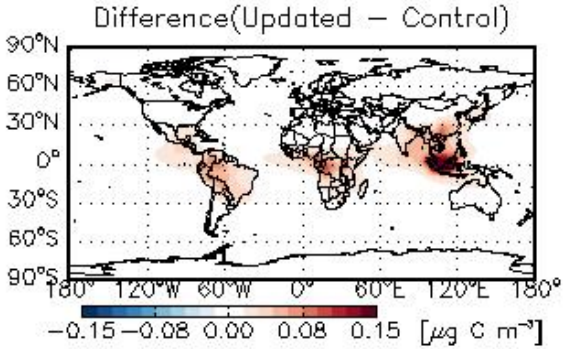


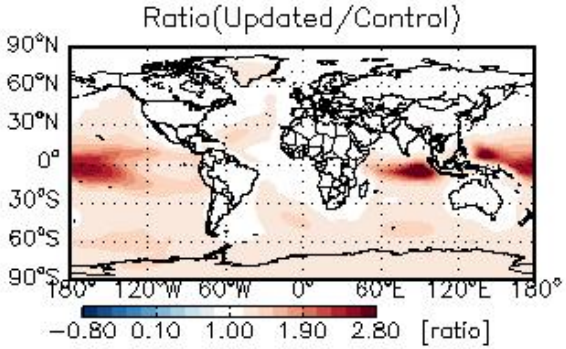
[Huang et al., 2012]

Sensitivity of simulated OC/BC to the aging scheme









[Huang et al., 2012]

"Prediction is very difficult, especially about the future"

-- Niels Bohr

Nobel Prize in Physics (1922)
http://nobelprize.org

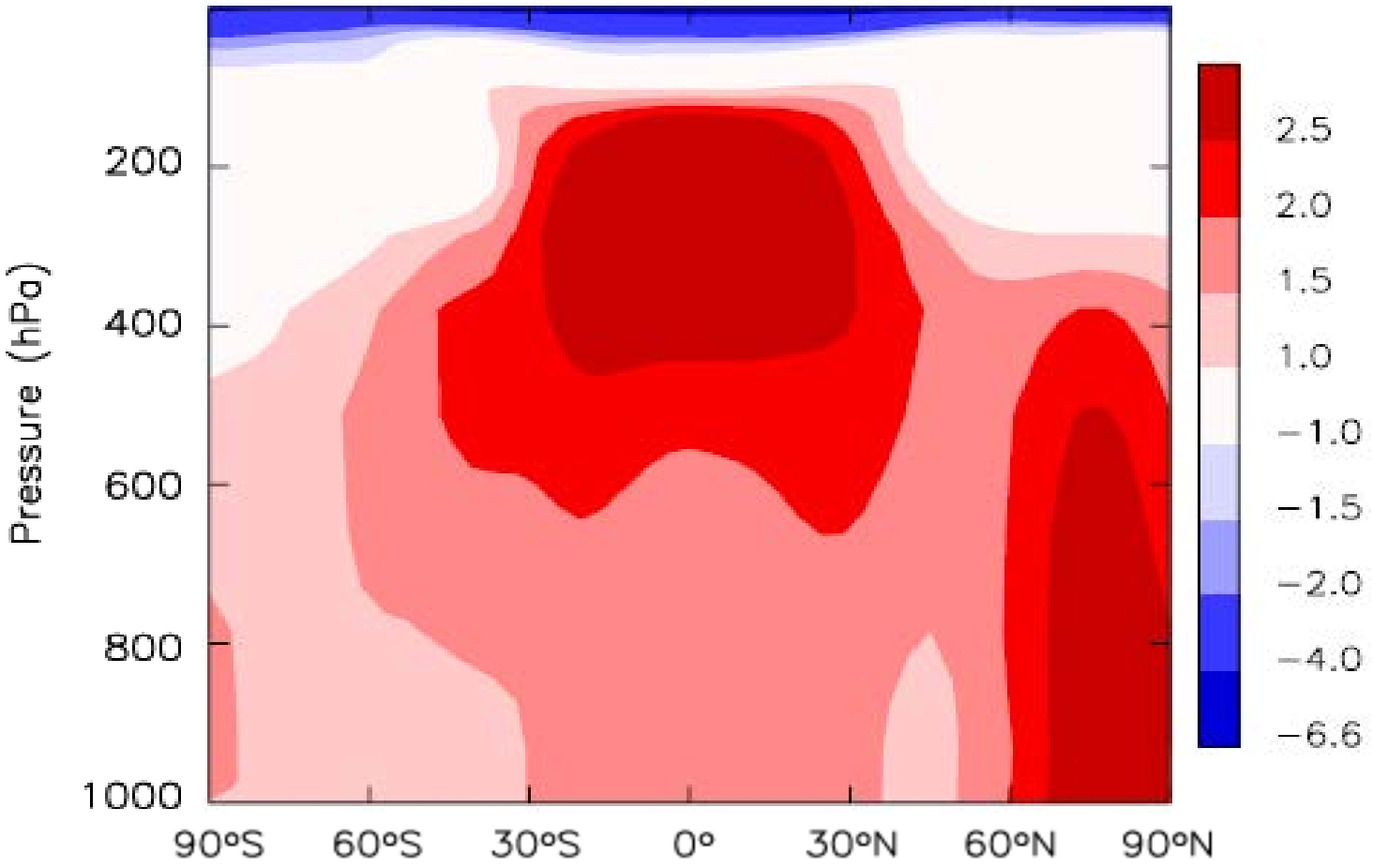
Take home message

- LU/LC changes in the coming decades have significant implications for atmospheric composition and air quality (by affecting biogenic emissions and dry deposition);
- The integrated modeling system increases our capacity in understanding the interactions between global change and air quality;
- The potential impacts on chemistry and air quality from vegetation change should be considered in long-term planning of anthropogenic land use (e.g. afforestation activities) and air quality management.

Backups

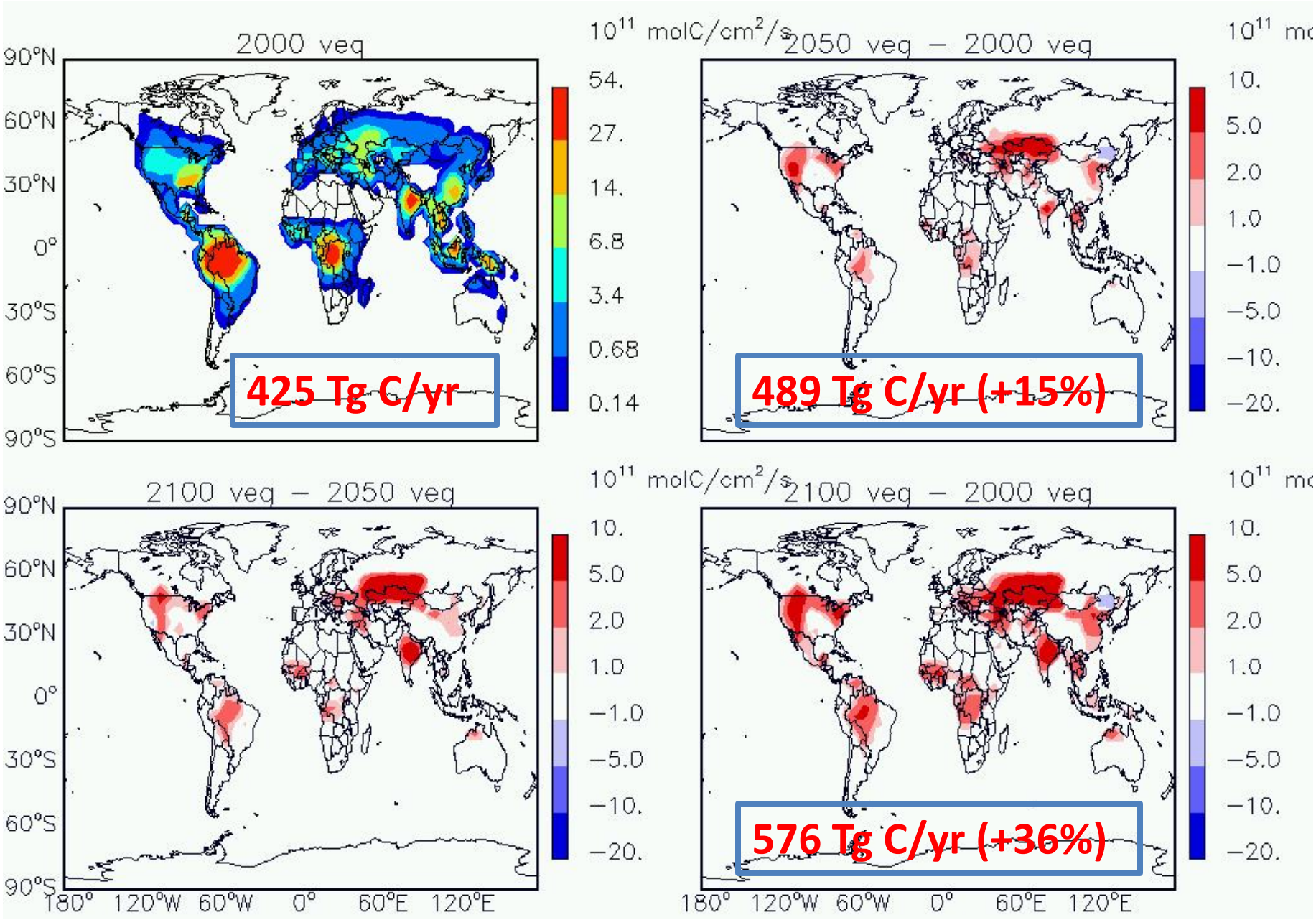
Changes in zonal mean Temperature

Temperature: 2050 – 2000

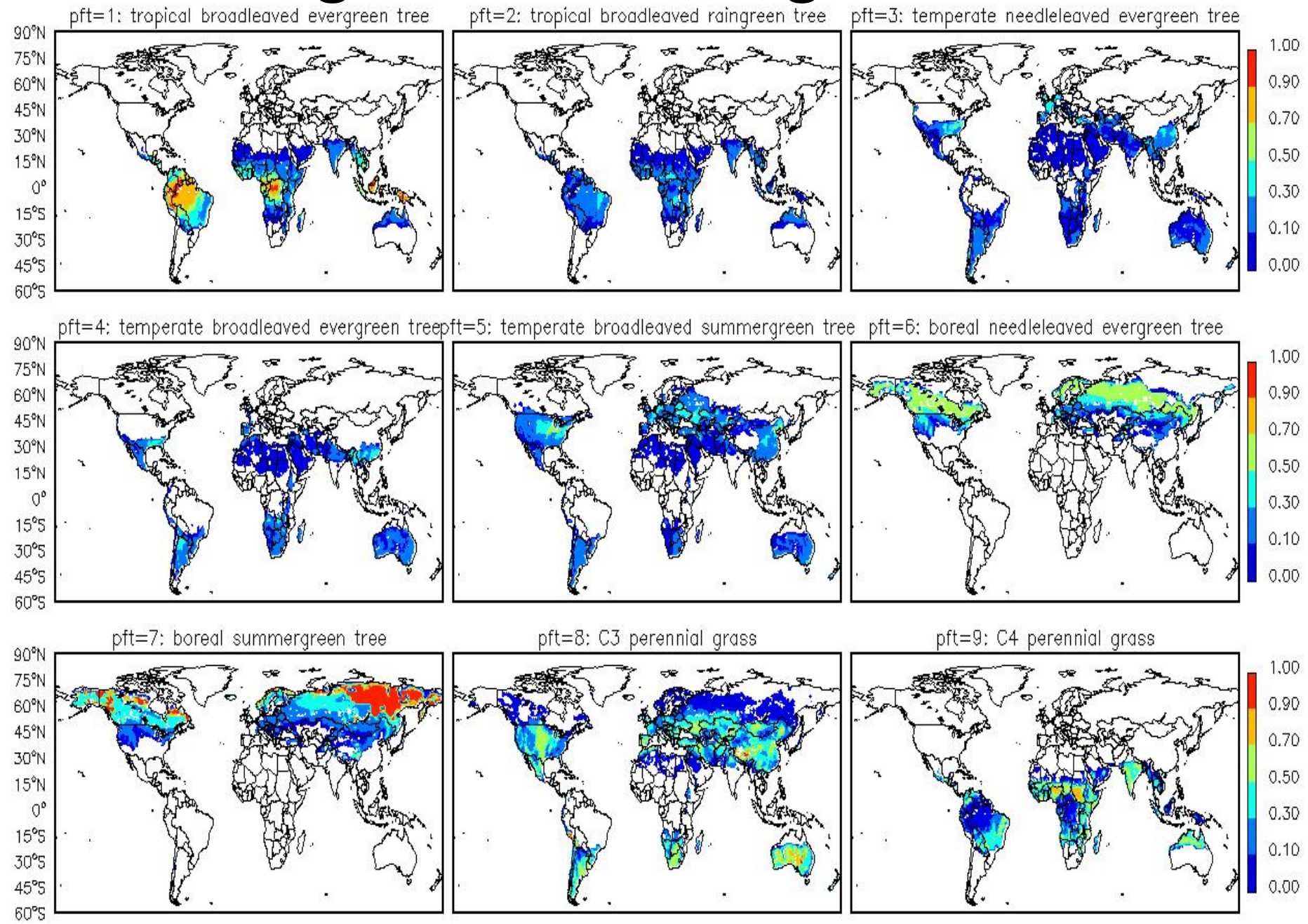


Annual mean surface temperature +1.6 K

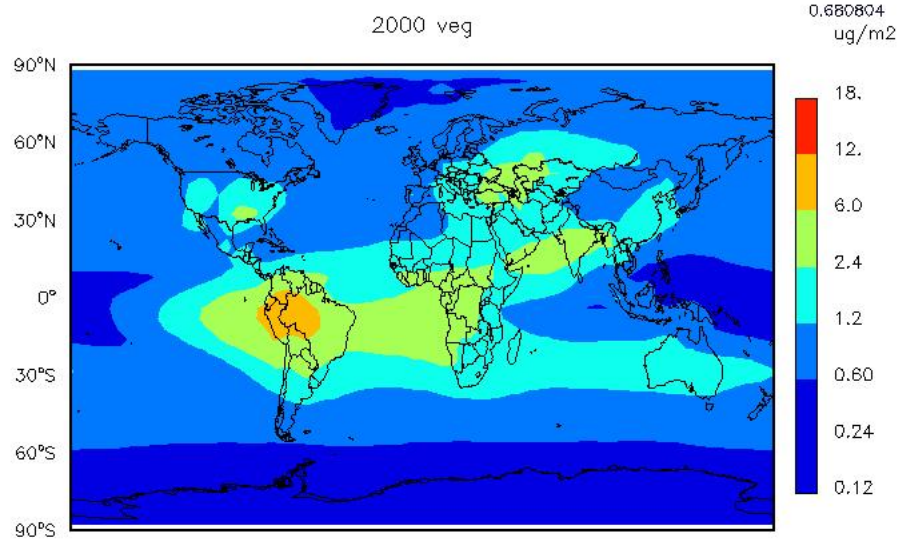
Changes in summer (JJA) isoprene emissions

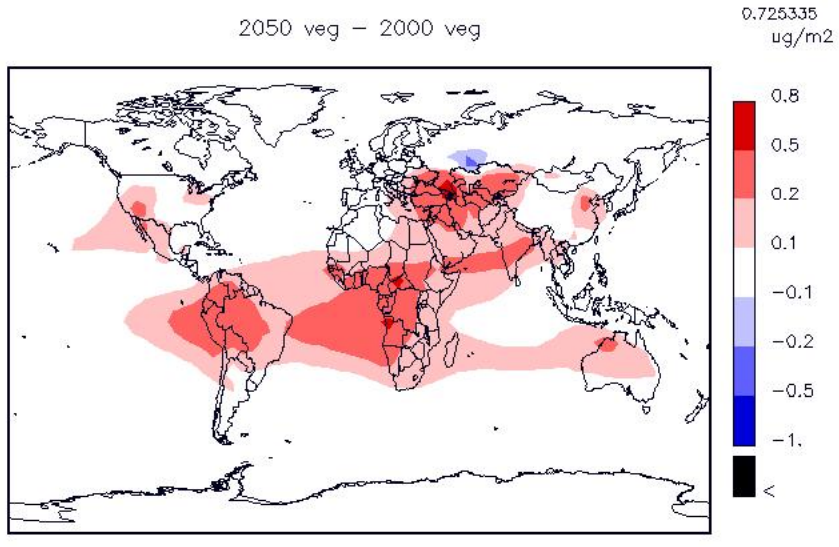


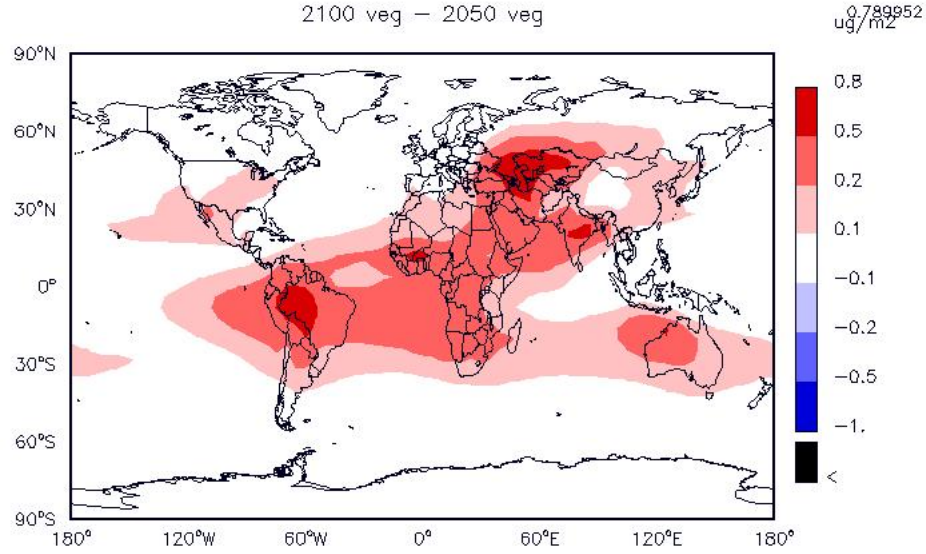
Vegetation coverage for 2000

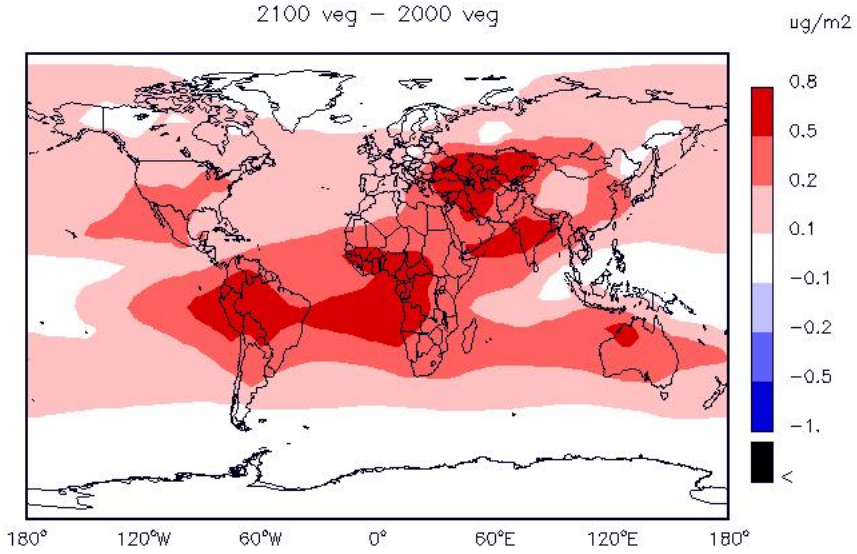


Changes in column SOA (difference)

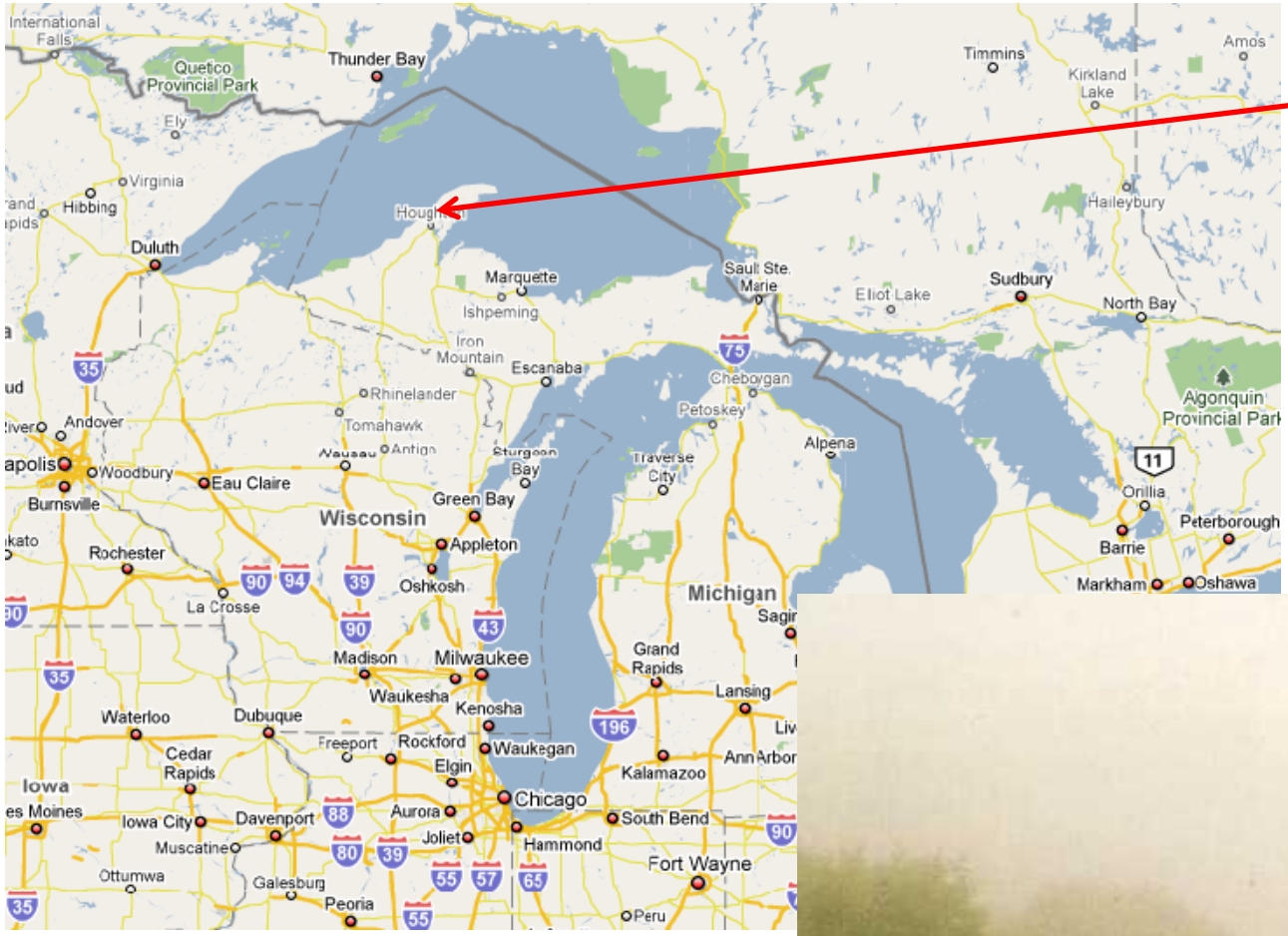








Where's Michigan Tech



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