Effects of Historical Climate and Land Cover Changes on East Asian Air Quality

Tai Group for Atmosphere-Biosphere Interactions

Yu Fu* and Amos P. K. Tai

Earth System Science Programme

Faculty of Science, CUHK

5 May 2015

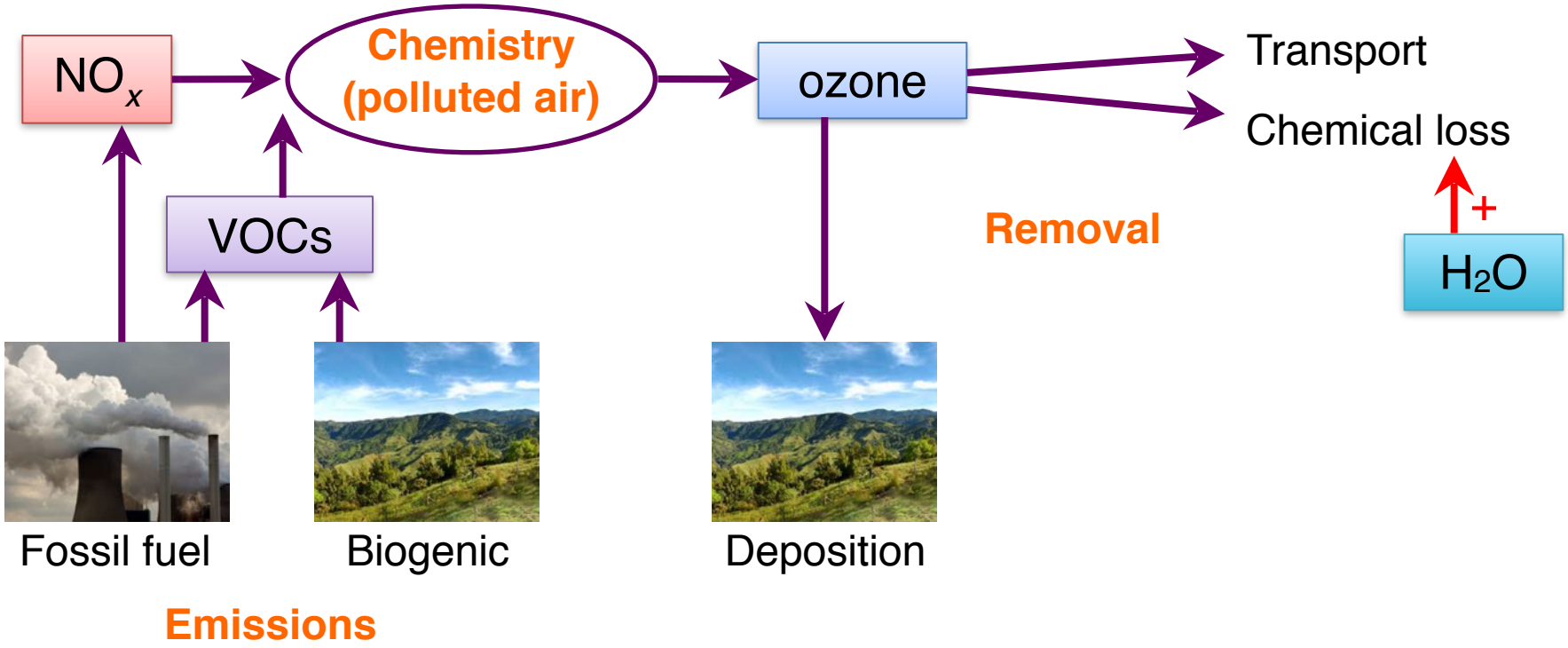
7th International GEOS-Chem Meeting

* Now at Inst. of Atmospheric Physics, CAS



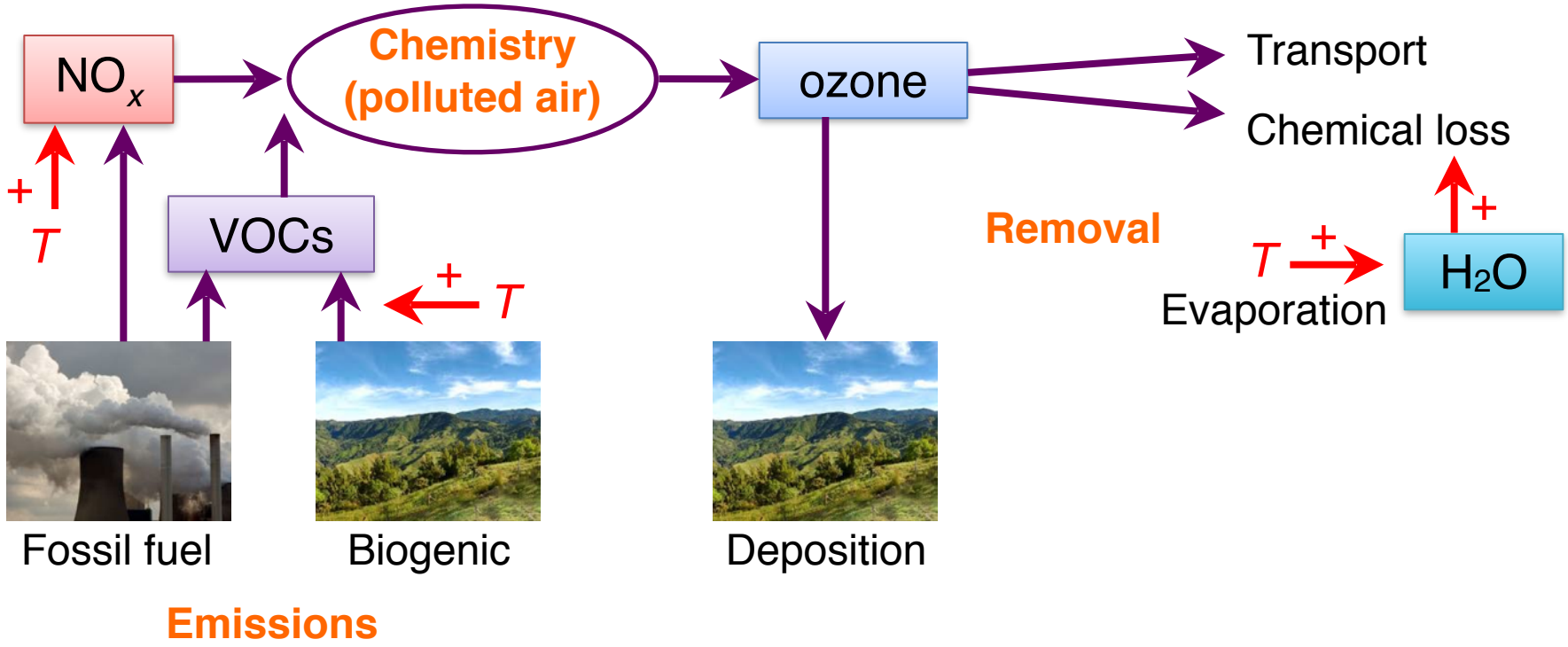

Background and Motivation

- **Climate change** and **land cover change** are potentially major drivers of future ozone air quality [e.g., Wu et al., 2012; Tai et al., 2013].



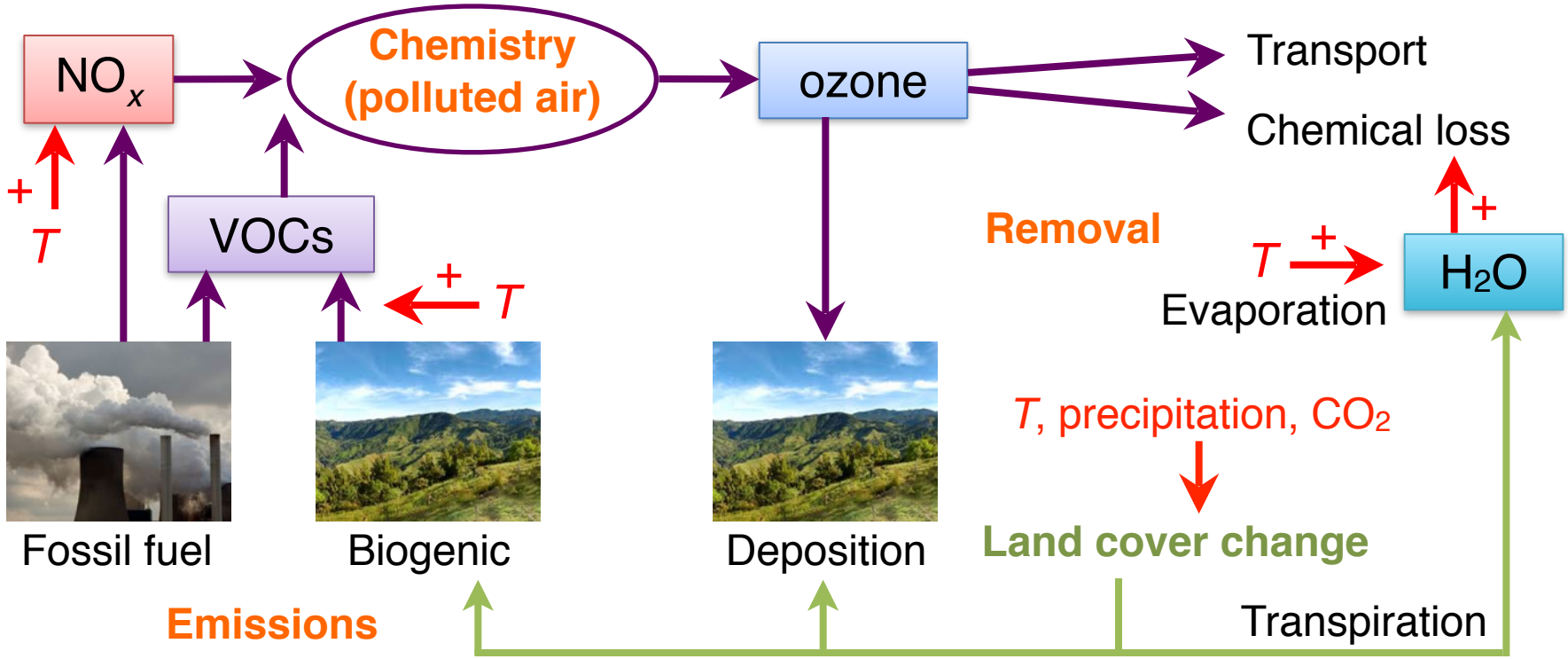
Background and Motivation

- **Climate change** and **land cover change** are potentially major drivers of future ozone air quality [e.g., Wu et al., 2012; Tai et al., 2013].



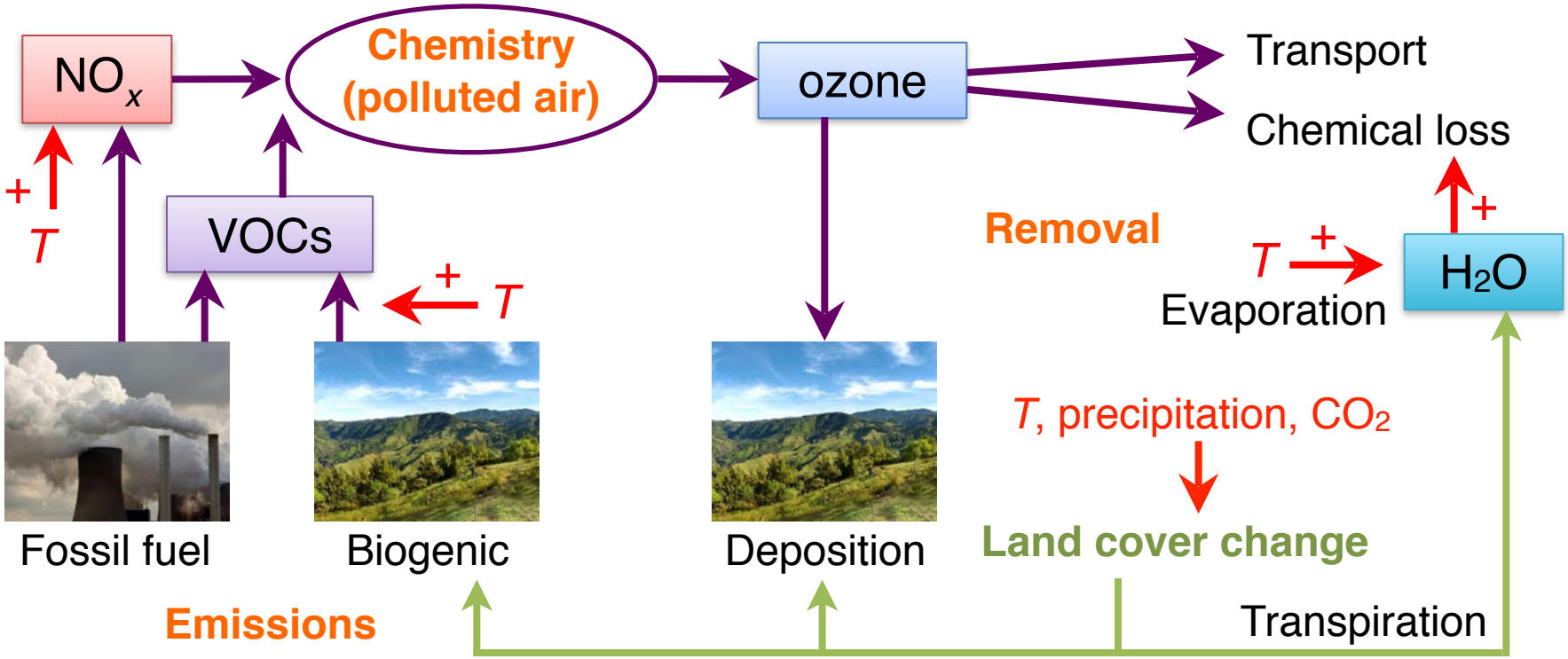
Background and Motivation

- **Climate change** and **land cover change** are potentially major drivers of future ozone air quality [e.g., Wu et al., 2012; Tai et al., 2013].

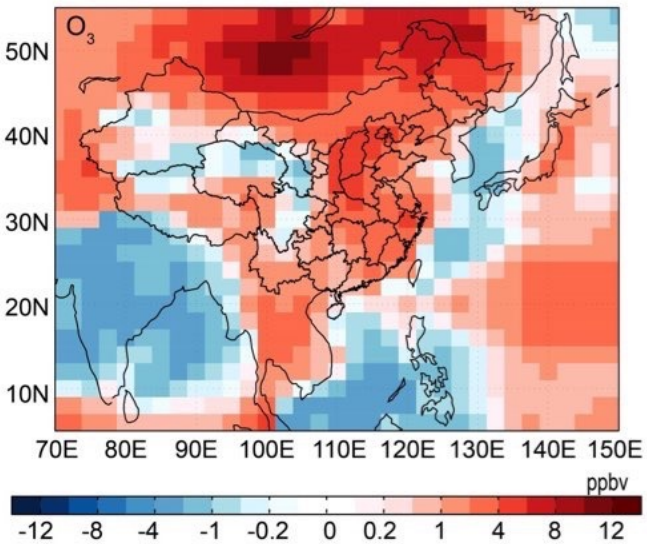


Background and Motivation

- **Climate change** and **land cover change** are potentially major drivers of future ozone air quality [e.g., Wu et al., 2012; Tai et al., 2013].
- Large uncertainties in future projections due to climate-chemistry-biosphere coupling, and varying background oxidation chemistry.
- Attribution of ozone trends in the past may help identify key factors and shed light on possible course of future evolution.

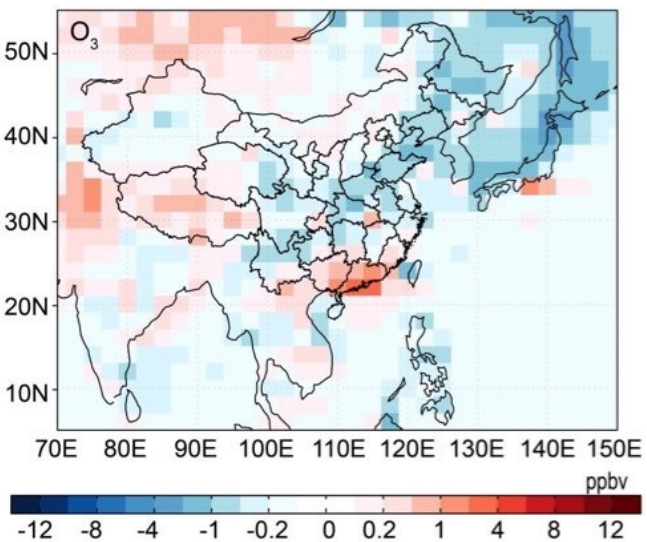


Climate and Land Cover Change Affected Ozone



Climate change effect only

"Penalty"



Land cover change effect only

"Benefit"

- GEOS-Chem (2°×2.5°) for 1981-1985 vs. 2007-2011 driven by:
  - MERRA assimilated meteorology (0.5°×0.667°)
  - Combined MODIS/AVHRR LAIs (8km) [Liu et al. 2012]
  - Combined MODIS/NLCD/ RCP land cover types (1km)

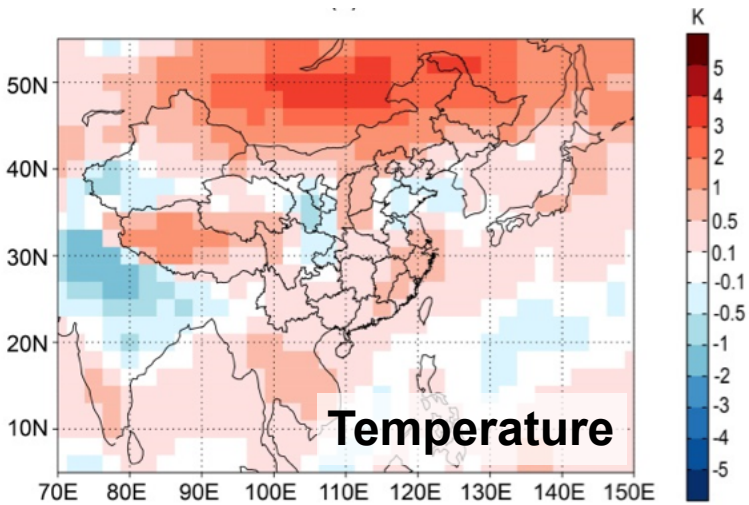
Anthropogenic emissions led to **10-20 ppbv** increase in ozone.

1980-2010 changes in JJA surface ozone (MDA8)

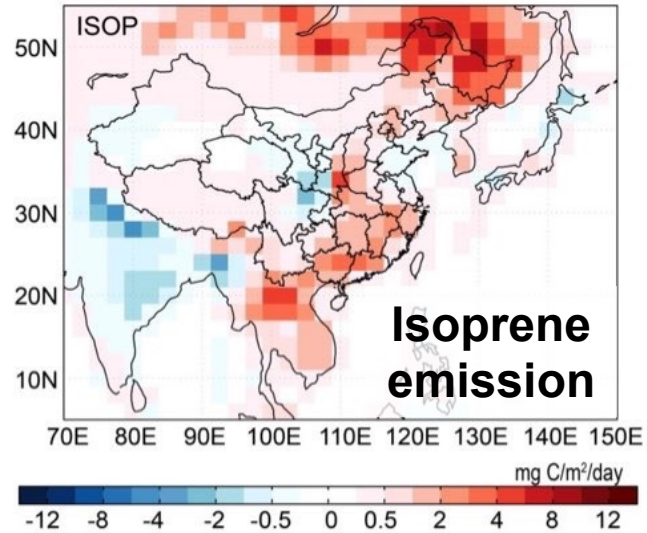
[Fu & Tai, ACPD]

Why Did Climate Change Increase Ozone?

1980-2010 changes (JJA) due to climate change effect only

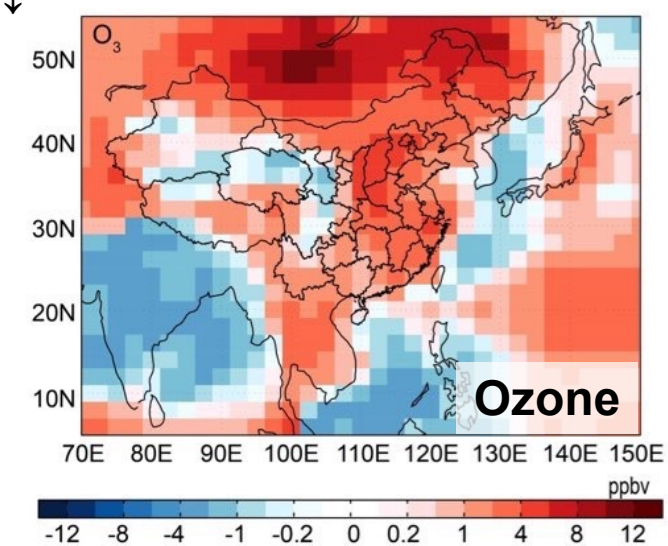


Isoprene emission ↑



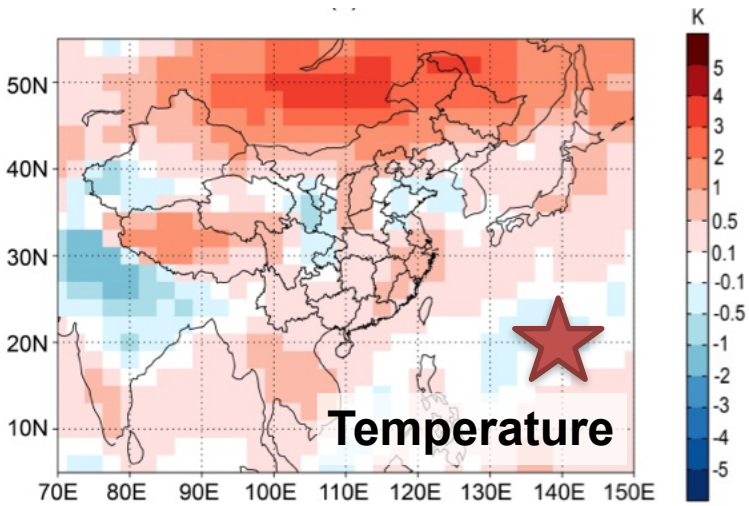
PAN lifetime ↓

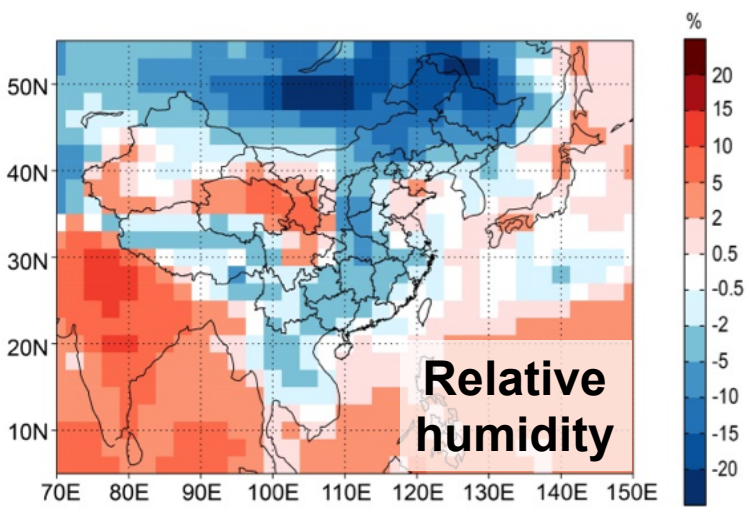
High NO_x



Why Did Climate Change Increase Ozone?

1980-2010 changes (JJA) due to climate change effect only

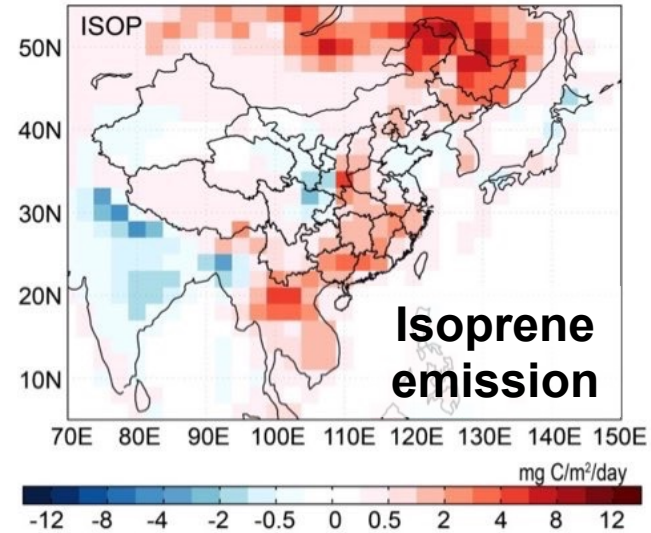




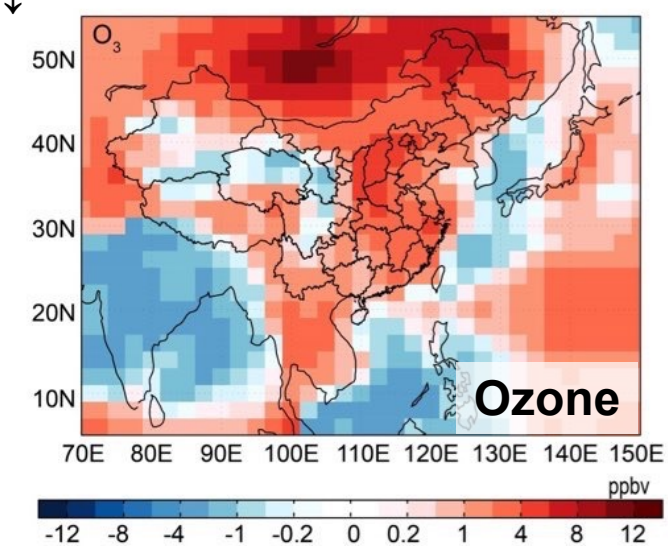
Isoprene emission ↑

PAN lifetime ↓

Chemical loss ↓

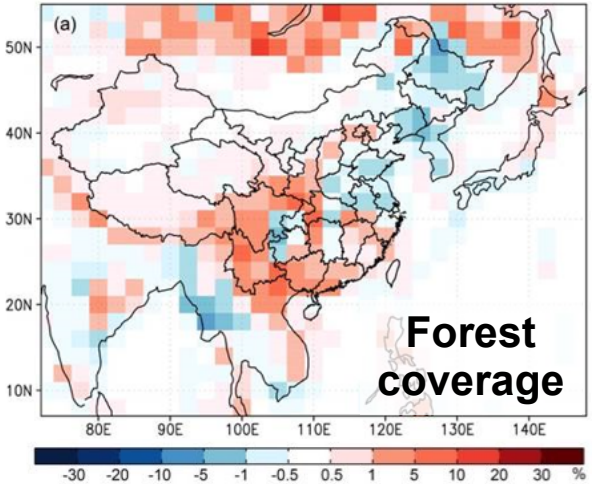


High NO_x

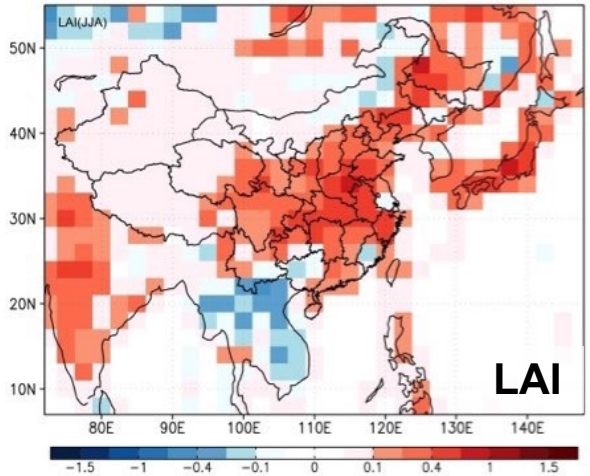


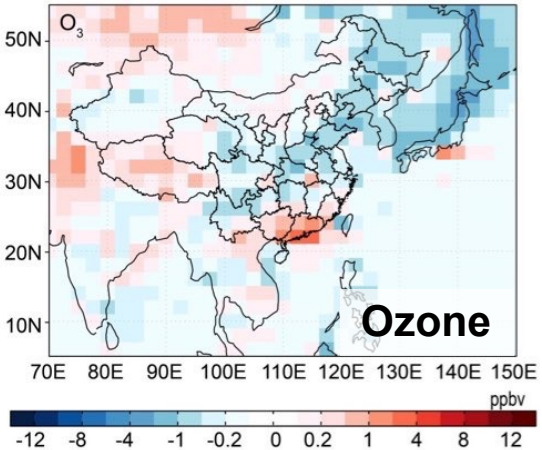
Why Did Land Cover Change Decrease Ozone?

1980-2010 changes (JJA) due to land cover change effect only



Cropland expansion, reforestation, warming, CO_2 fertilization

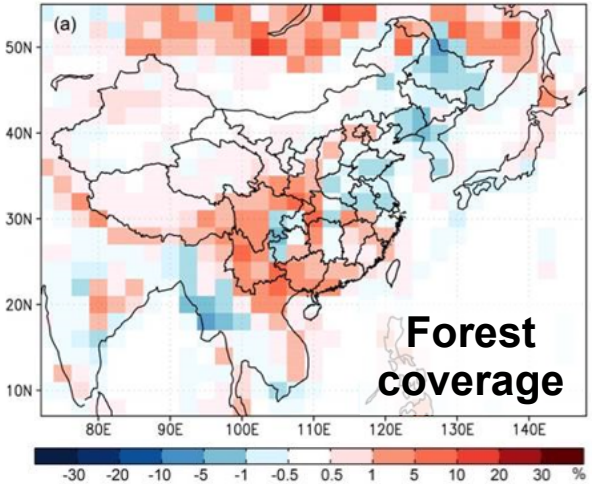


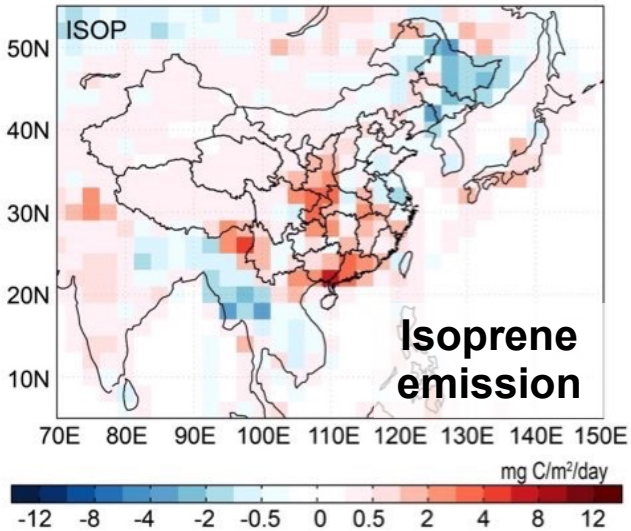


[Fu & Tai, ACPD]

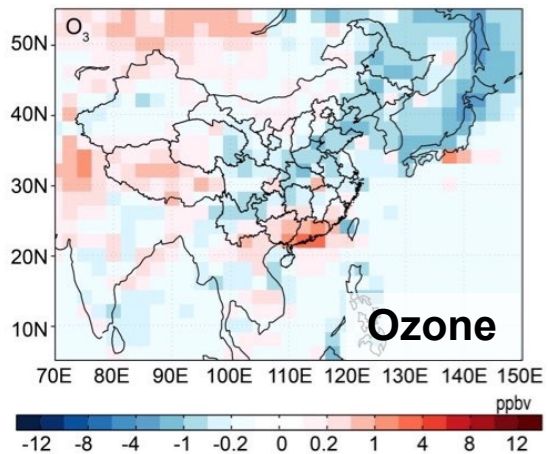
Why Did Land Cover Change Decrease Ozone?

1980-2010 changes (JJA) due to land cover change effect only

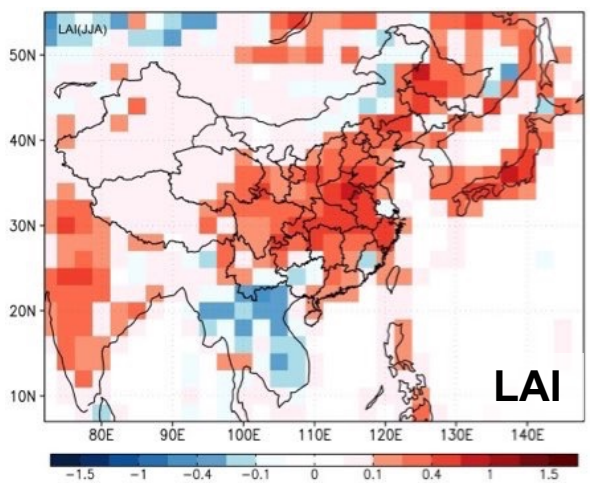




Mostly high NO_x except in far west; may be important in NE China



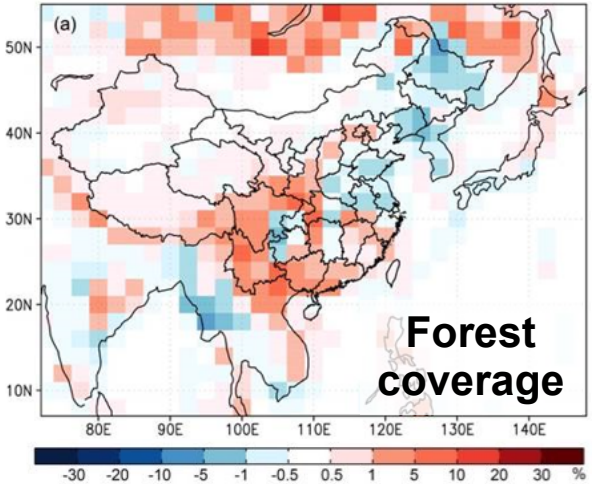
Cropland expansion, reforestation, warming, CO_2 fertilization

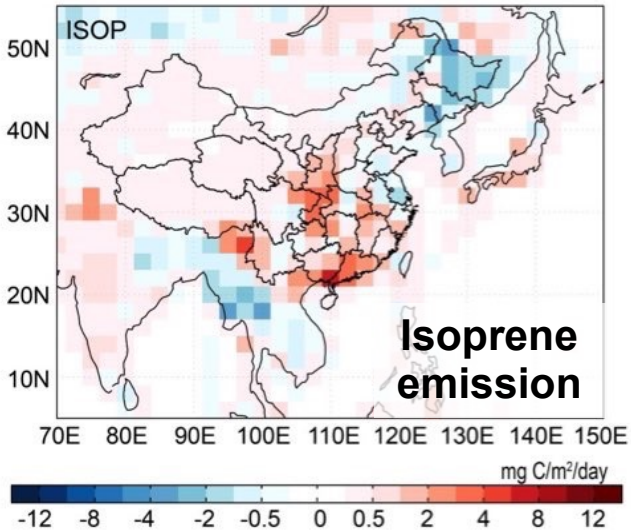


[Fu & Tai, ACPD]

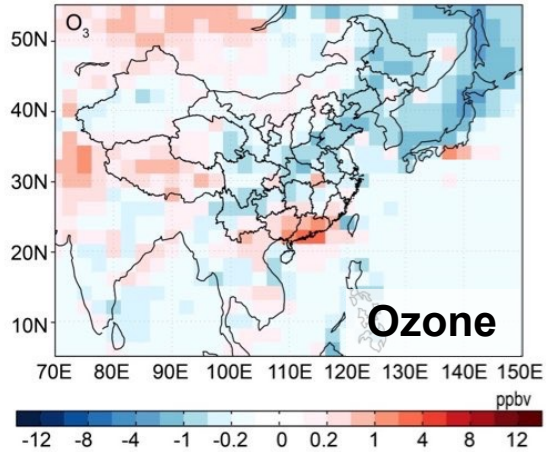
Why Did Land Cover Change Decrease Ozone?

1980-2010 changes (JJA) due to land cover change effect only

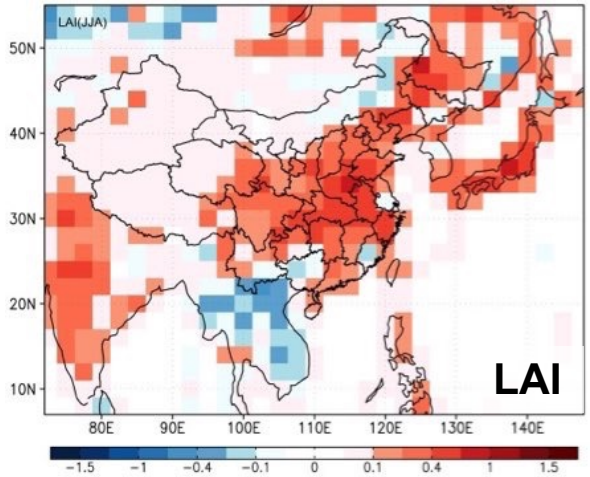


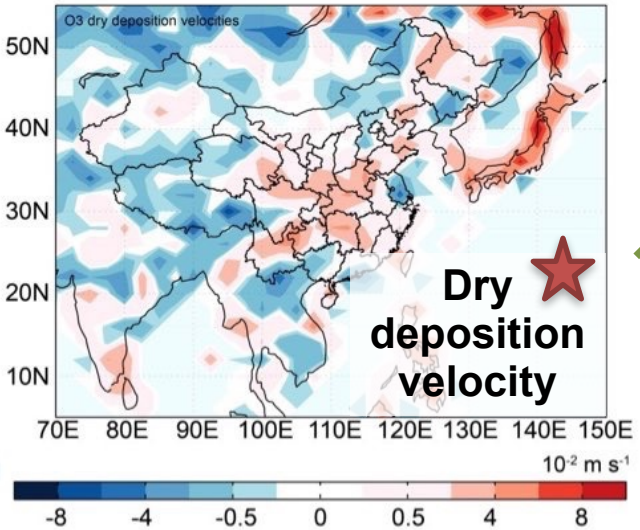


Mostly high NO_x except in far west; may be important in NE China



Cropland expansion, reforestation, warming, CO_2 fertilization





Dry deposition important throughout, esp. central China

[Fu & Tai, ACPD]

Conclusions and Future Work

- In China over the past 30 years:
  - **Climate change** might have caused an **ozone penalty** of up to +6 ppbv mostly due to warming;
  - **Land cover change** might have caused an **ozone benefit** of up to -4 ppbv mostly due to climate/CO_2-driven increase in LAI;
  - Land cover effect depends on competition between dry deposition and isoprene emission under low- vs. high-NO_x regimes (perhaps also transpiration);
  - Land cover effect is more shaped by dry deposition than isoprene emission in China (as opposed to eastern US).
- Future work:
  - Reasons behind regional differences in ozone sensitivity to land cover: VOC/NO_x ratios? Baseline LAI and biogenic emissions?
  - New isoprene chemistry: will it modify ozone sensitivity to land cover?
  - Implement LAI-dependence of stomatal conductance in dry deposition
  - Future ozone projections following RCP4.5 and 8.5 land use change