
Wintertime Investigation of Transport, Emissions, and Reactivity
WINTER
2015

Motivations

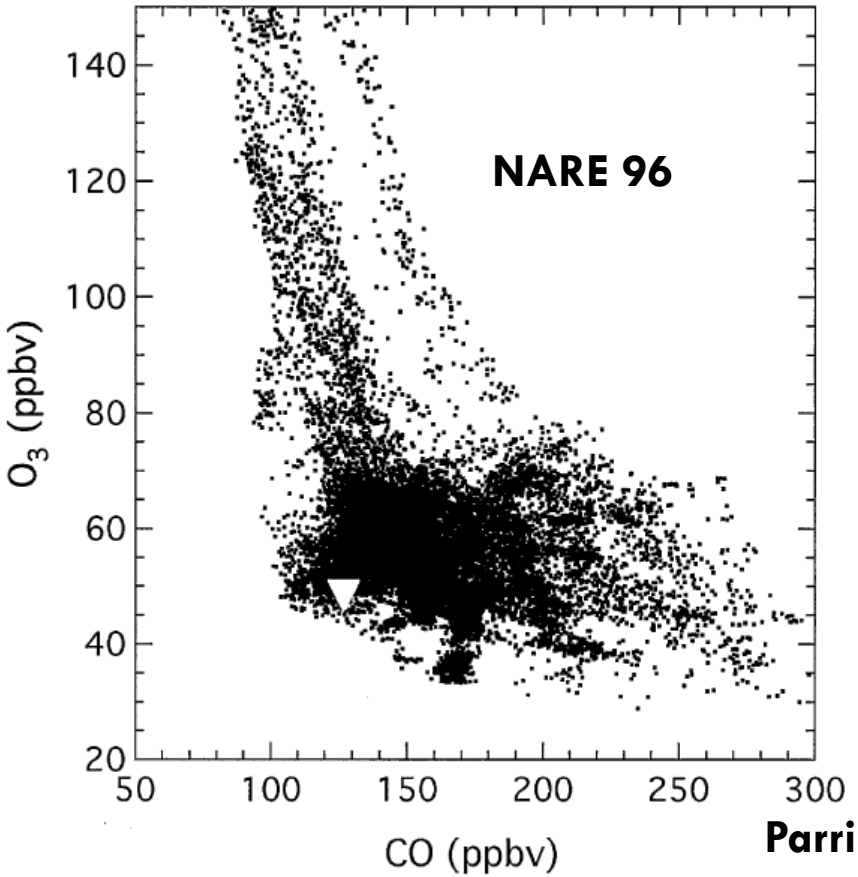
- Anthropogenic emissions of reactive pollutants occur year-round (NO_x, SO_2, CO, NMHC) while biogenic or agricultural emissions have strong seasonality (BVOC, NH_3).

- There are large seasonal changes in:
  - chemical mechanisms by which pollutants are transformed
  - meteorology/thermodynamics
  - transport pathways

- Direct observations of key intermediates and end products in winter are lacking, with implications for determining processes important to global tropospheric chemistry and local air quality.

Science Questions

- How do anthropogenic emissions affect O_3 and oxidants in winter, and over what scales do these effects extend?



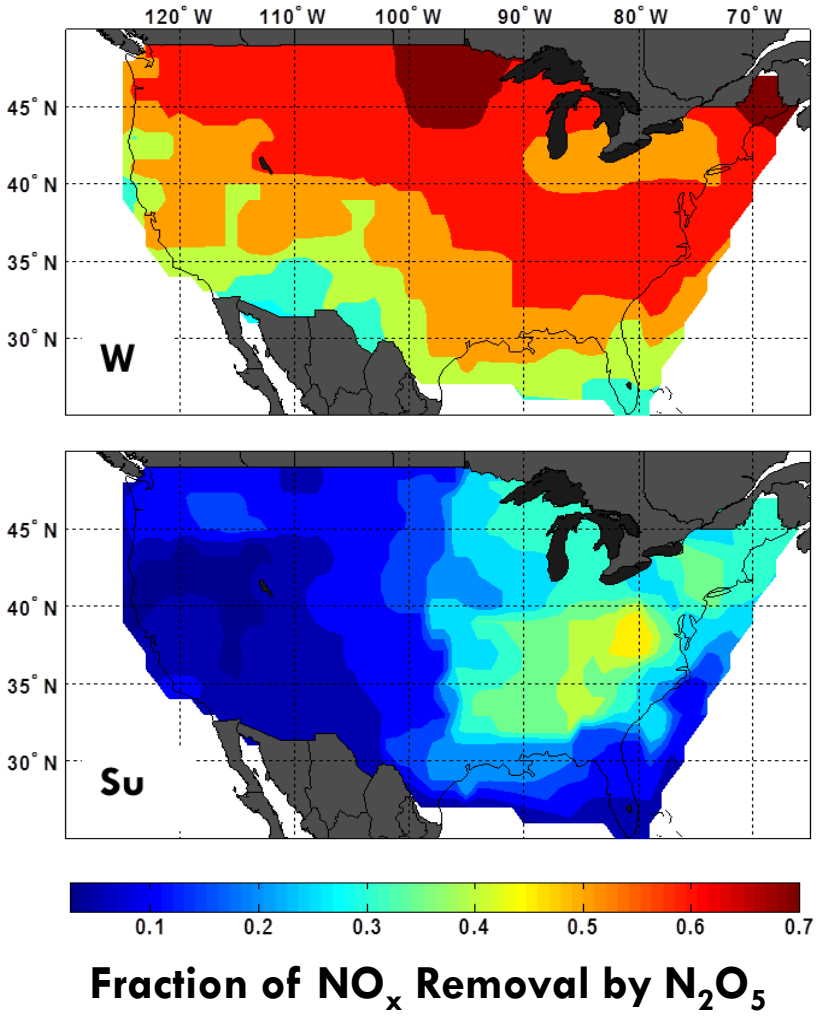
Parrish, et al ATM ENV 1999

Wintertime O_3 and Oxidants

$$NO + O_3 \rightarrow NO_2 + O_2$$
$$NO_2 + O_3 \rightarrow NO_3 + O_2$$
$$NO_3 + NO_2 \rightleftarrows N_2O_5$$

$$N_2O_5 + \text{(aerosol)} \rightarrow 2HNO_3$$

deposition

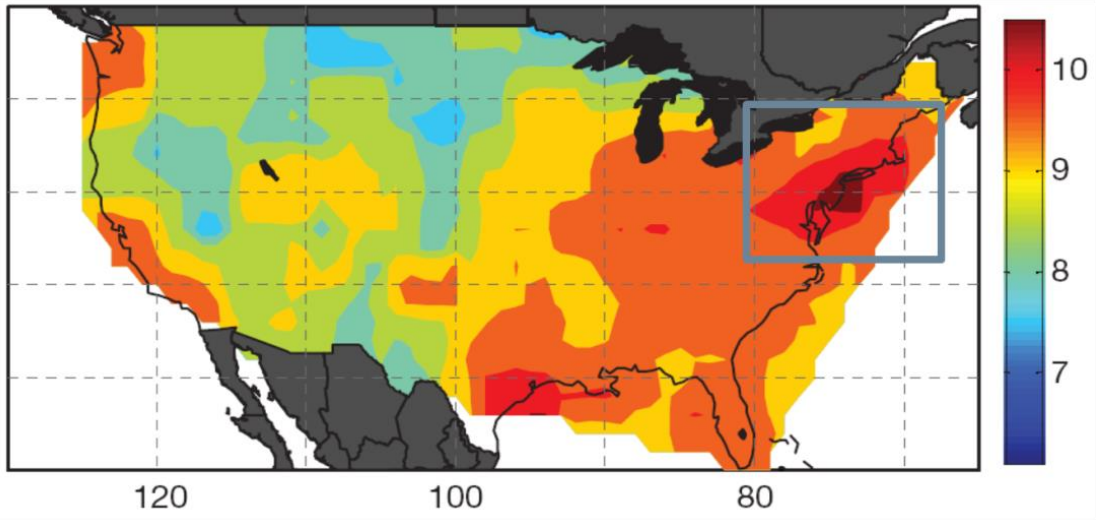


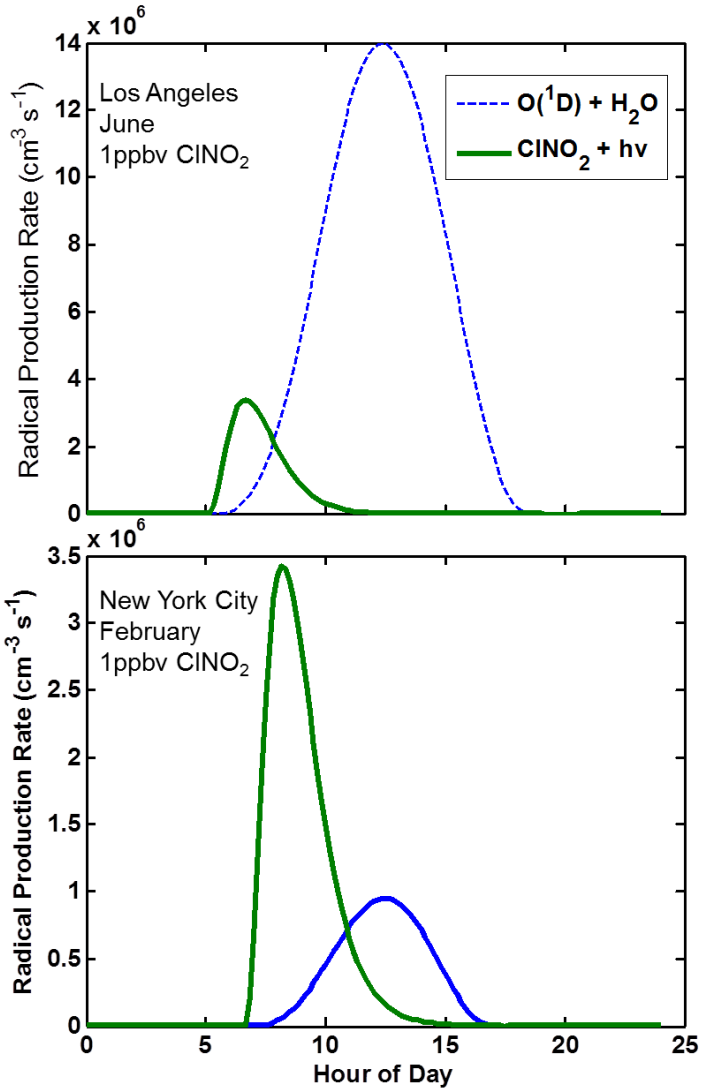
Wintertime O_3 and Oxidants

- N_2O_5 +  → $(2-\phi)HNO_3 + \phi ClNO_2$

$ClNO_2 + hv \rightarrow Cl + NO_2$
$HONO + hv \rightarrow OH + NO$
$HCHO + hv \rightarrow 2HO_2 + CO$

- P_{ClNO2} g/yr (log color scale)

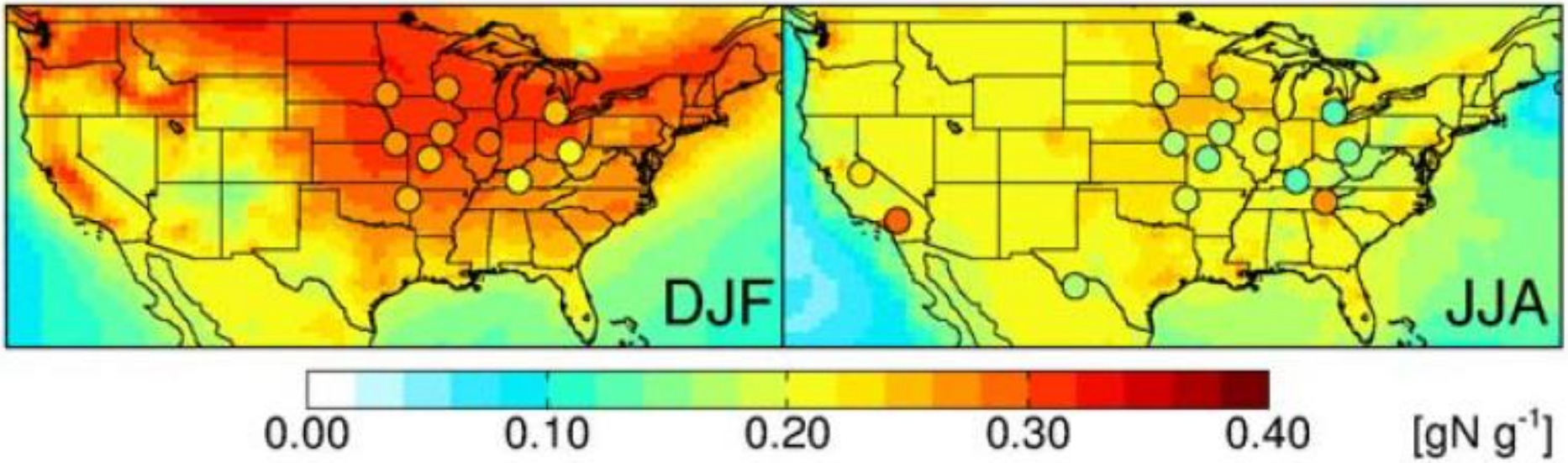




Science Questions

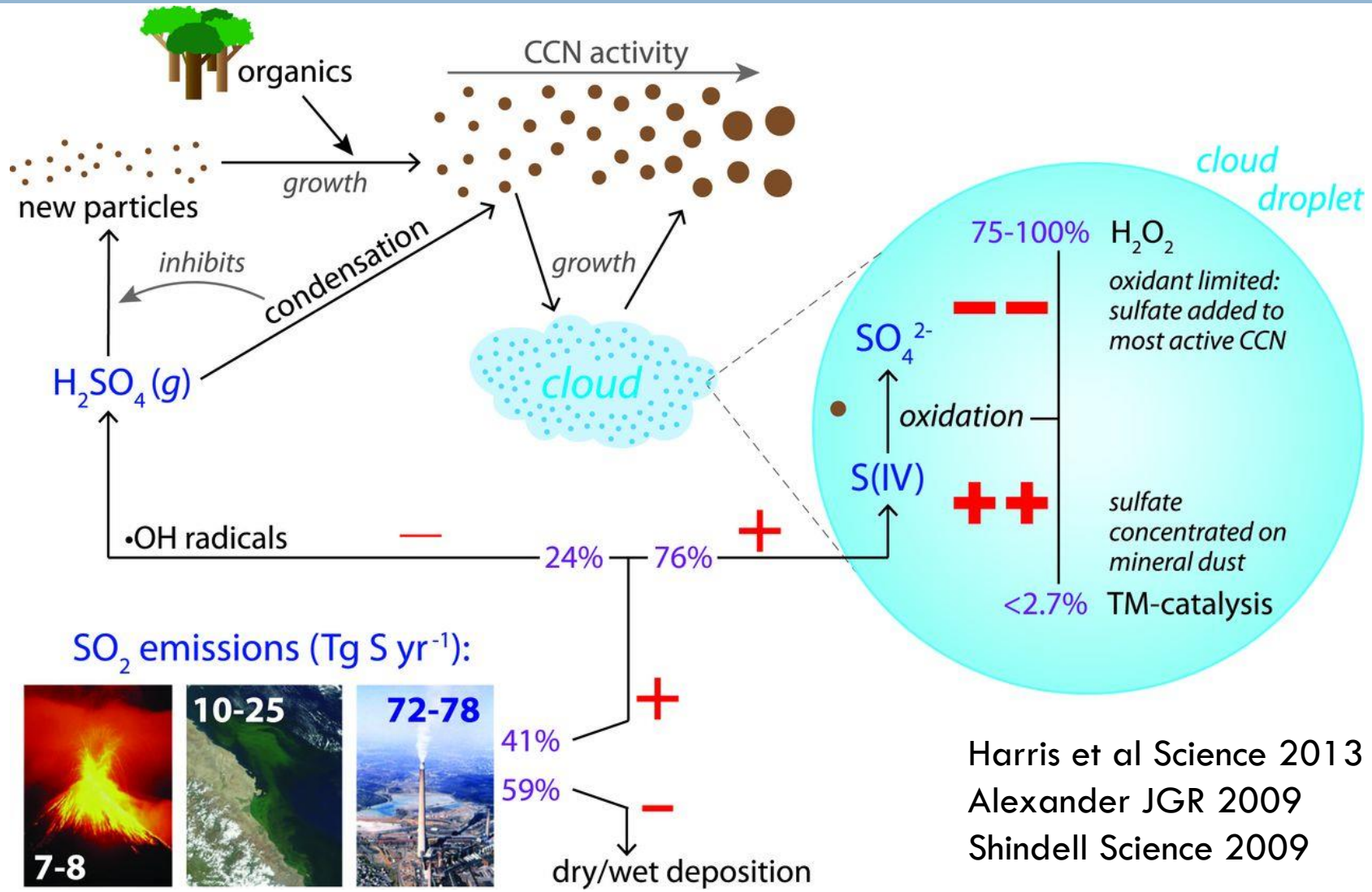
- What are the chemical and physical processes that control the formation and transport of secondary aerosol during winter?

Fraction of PM2.5 that is nitrogen



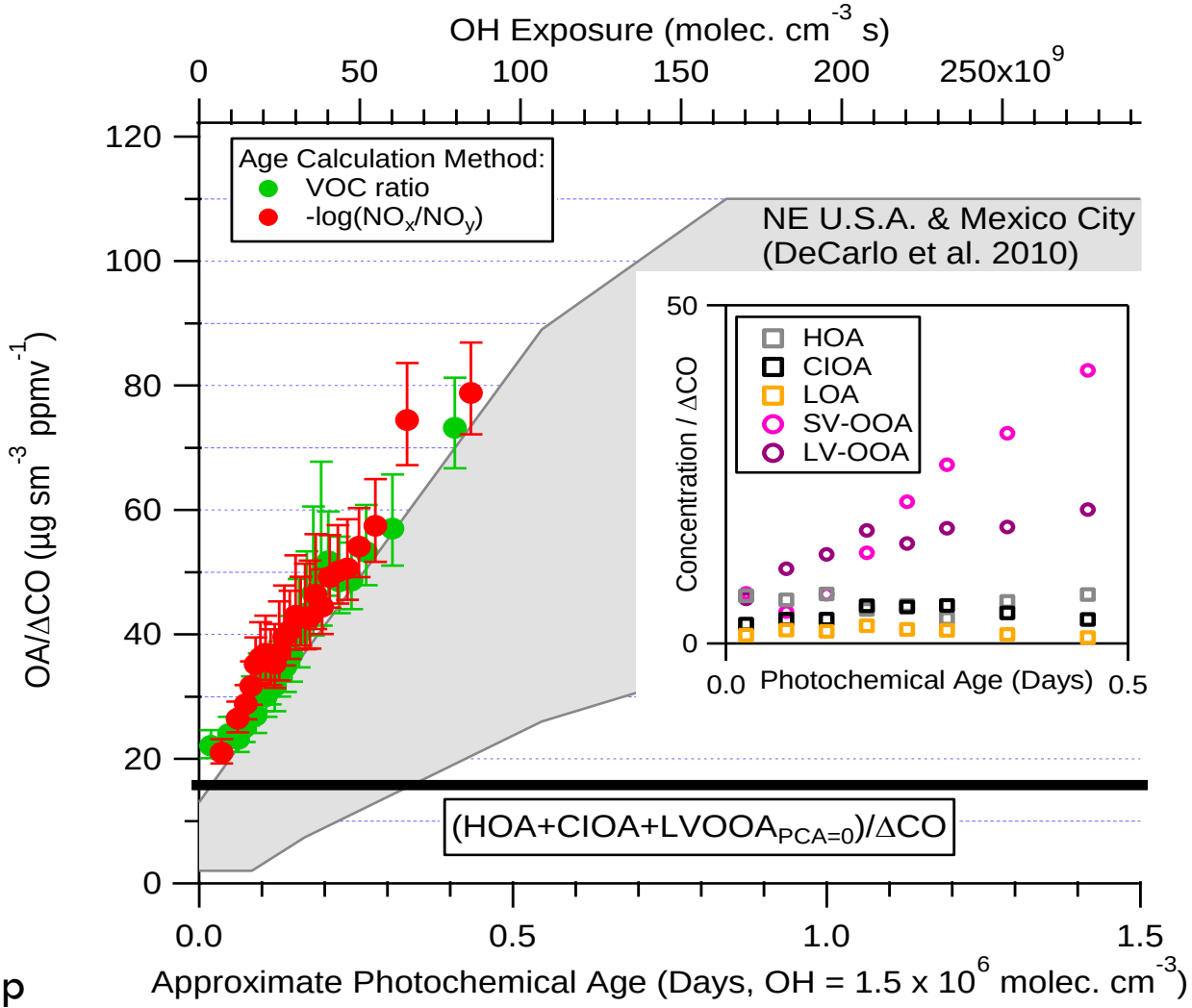
Heald et al, ACP 2012
Stanier et al ACP 2012
Silva et al Atmos. Env 2004

Secondary Aerosol Sources



Harris et al Science 2013
Alexander JGR 2009
Shindell Science 2009

Secondary Aerosol Sources



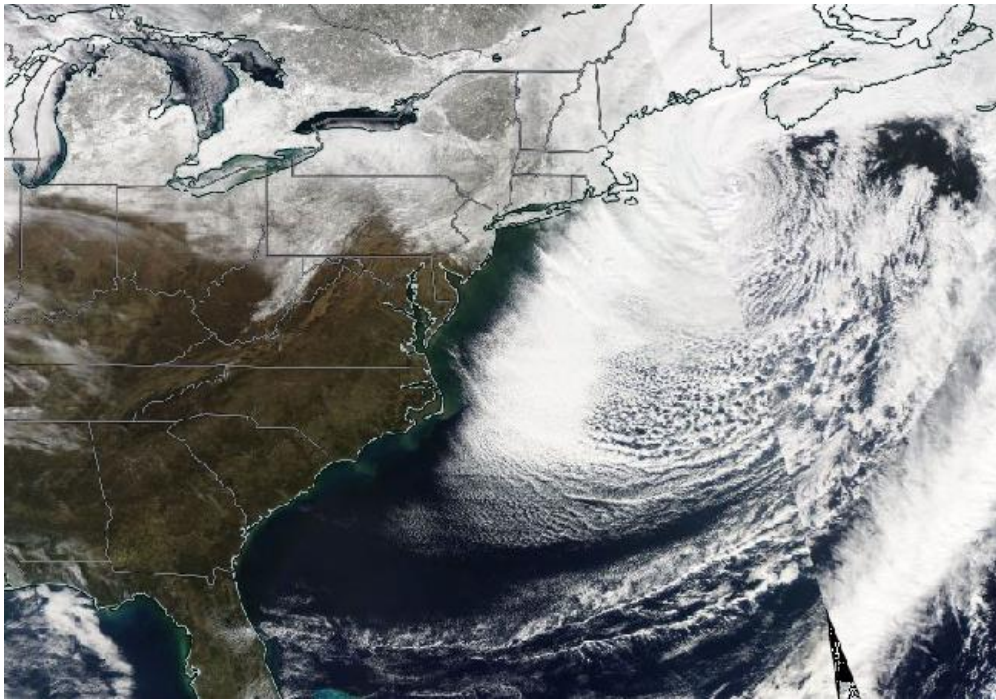
Jimenez Group

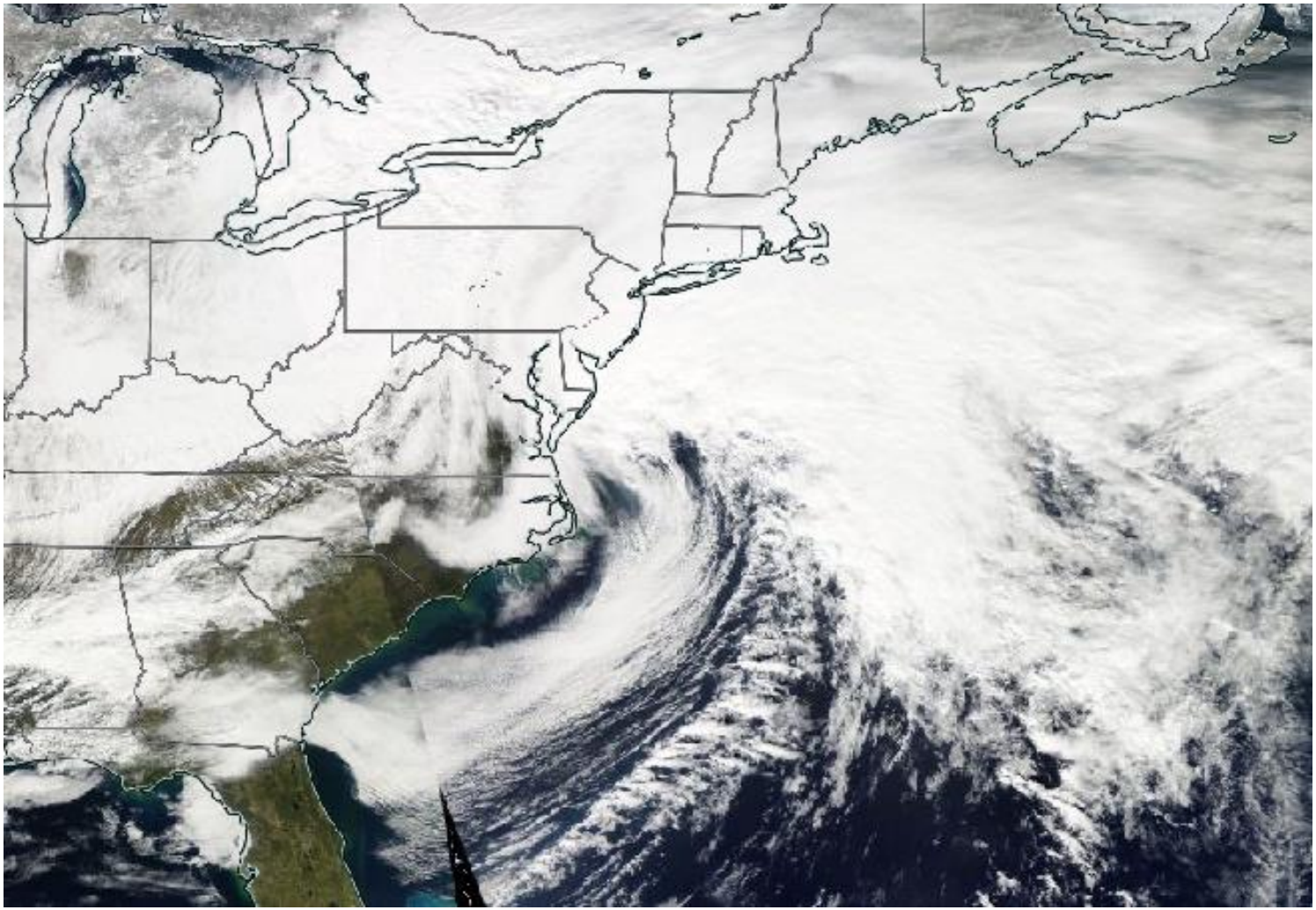
Science Questions

- How do emissions of reactive trace gases change summer to winter, and what are the mechanisms governing their export from source regions?

Horizontal export via cold fronts

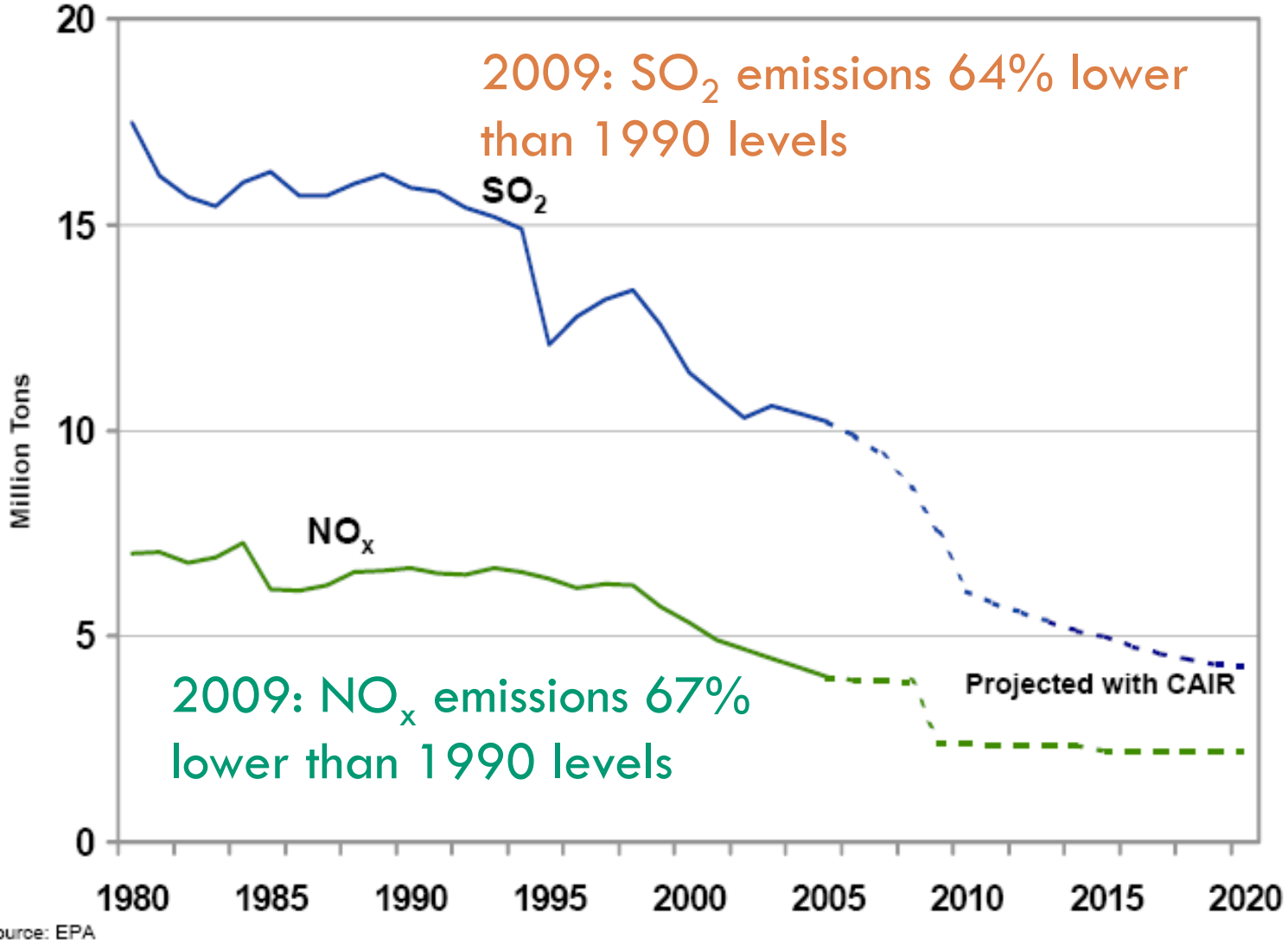
100's of km transport within 1 – 2 km over ocean behind front





earthdata.nasa.gov

Emissions and Transport



Source: EPA

Emissions and Transport

- Large changes in NO_x and SO_2 from power plants in CAIR states since 2009, but still potentially large relative differences between winter and summer emissions.

- A relatively dormant biosphere, together with slow photochemistry and inefficient vertical mixing, allows anthropogenic emissions to be identified and quantified

- An uncertain but potentially important role for biofuel combustion (residential wood smoke) and agricultural burning

Approach

- ~96 research flight hours with the C-130, Feb. 1– Mar. 15, 2015
  - daytime, nighttime, and transitions
- GEOS-Chem chemical forecasting and post-analysis
- NASA Langley base provides access to following objectives:
  - Northern and southern urban areas
  - Power plants in OH river valley
  - N. American outflow “days” downwind
- UMD and Purdue collaborators bringing additional capabilities with light aircraft

Emissions and Transport

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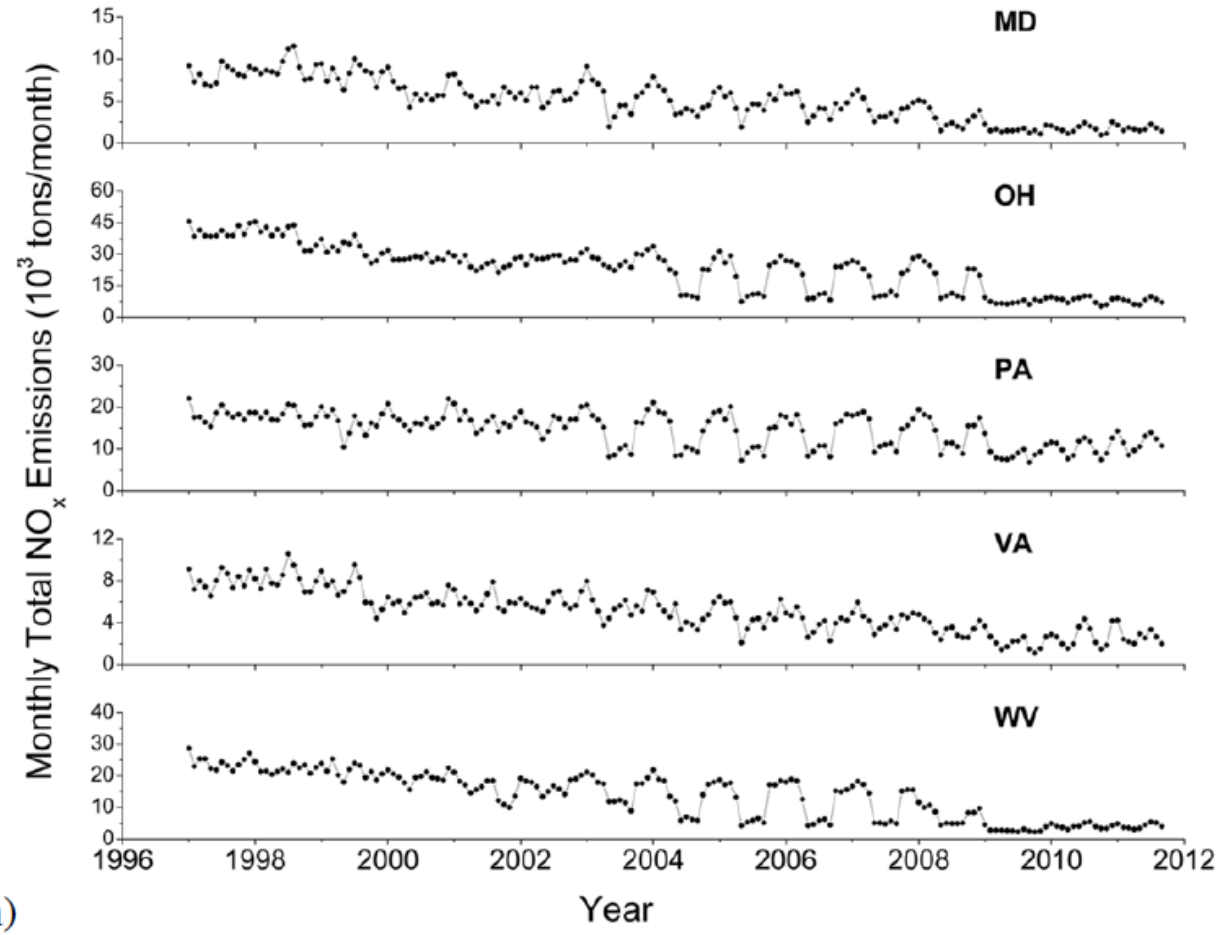

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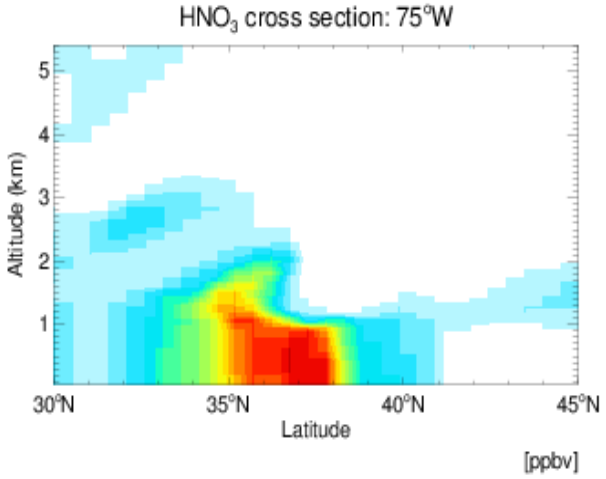
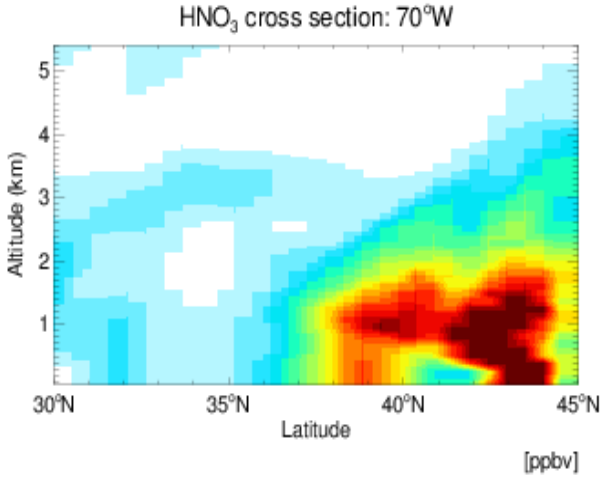
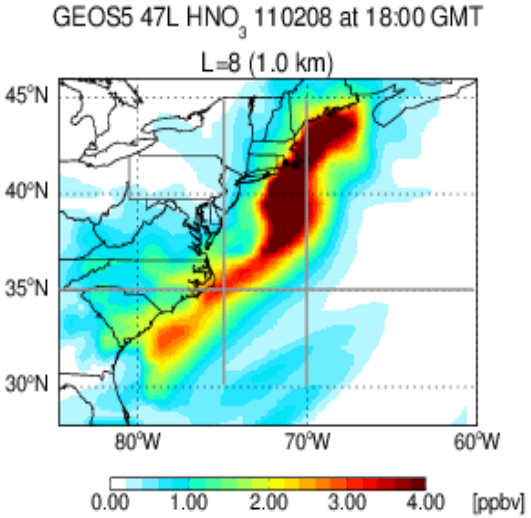
He, et al ACP 2013

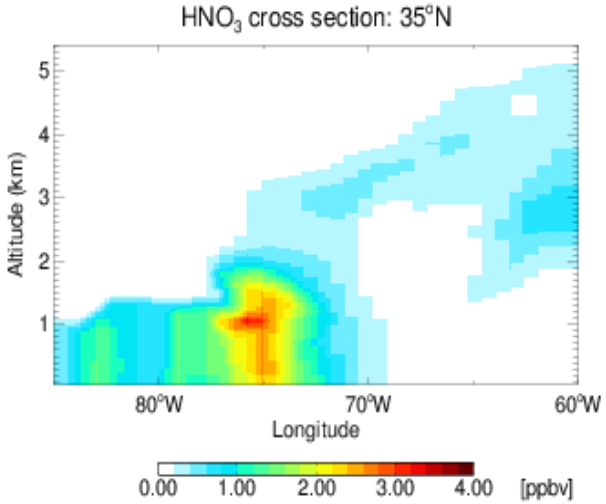
Emissions and Transport

GEOS-Chem Hindcasts







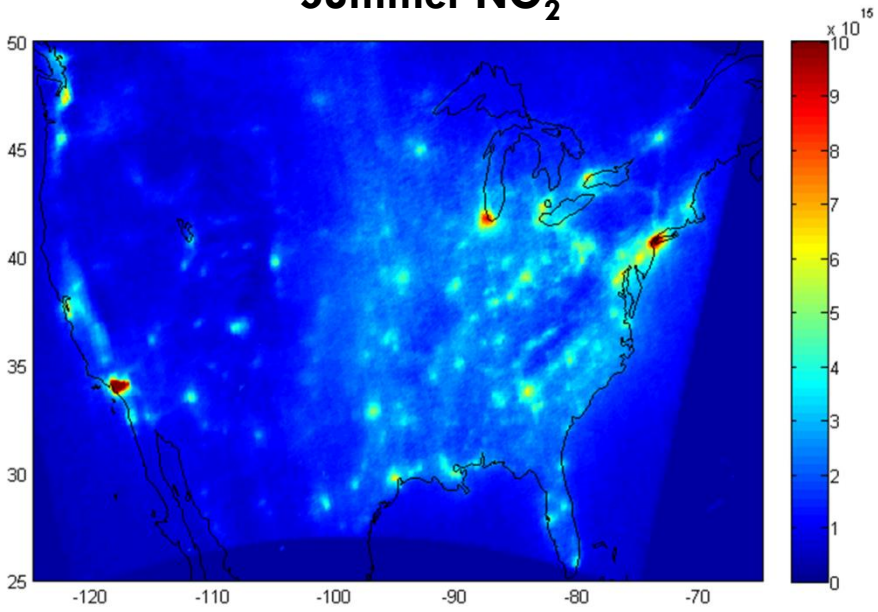


Impact of Emissions on O_3 and Oxidants

- What are the dominant wintertime oxidant sources and degradation mechanisms of in polluted regions?

$$P_{OH} \propto 2J_{O1D}[O_3][H_2O]$$

Summer NO_2



Winter NO_2