Key drivers of surface ozone variability, from WUS background to EUS extremes

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NASA AIR QUALITY APPLIED SCIENCES TEAM

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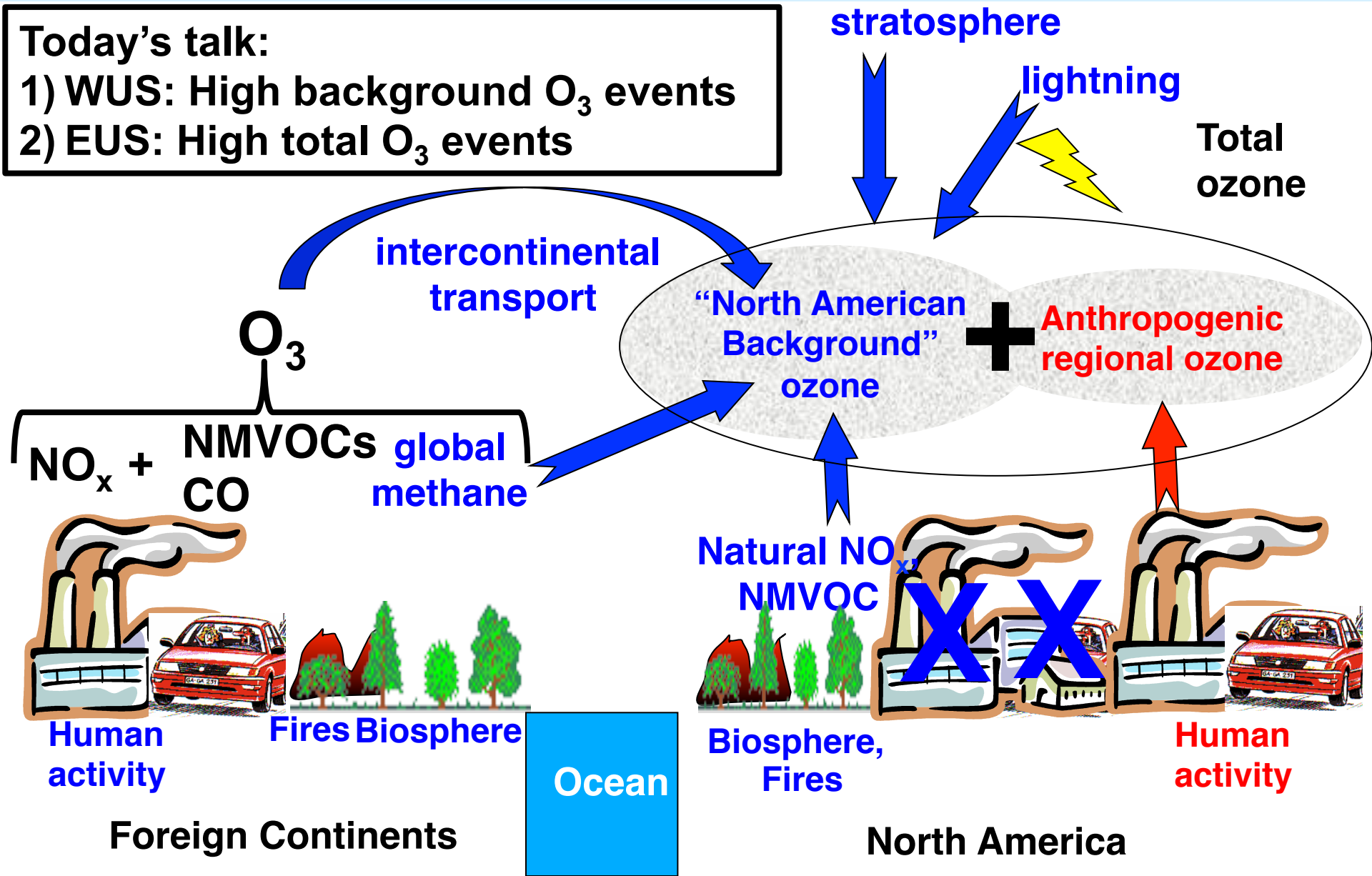
Total O_3 in surface air over North America = "N. Amer. Background" + Anthropogenic regional O_3

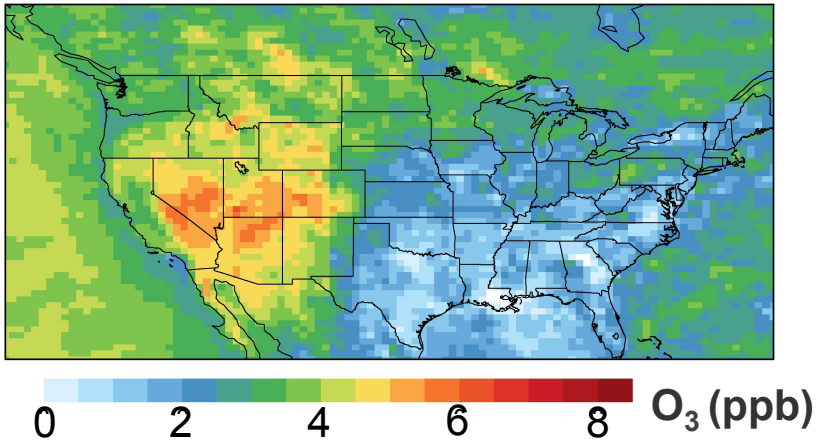
Today's talk:
1) WUS: High background O_3 events
2) EUS: High total O_3 events



Estimates of Asian and stratospheric influence on U.S. surface ozone (MDA8) in spring

Mean MDA8 O_3 in surface air
(GFDL AM3 model global strat-trop chemistry, 50 km^2, nudged)

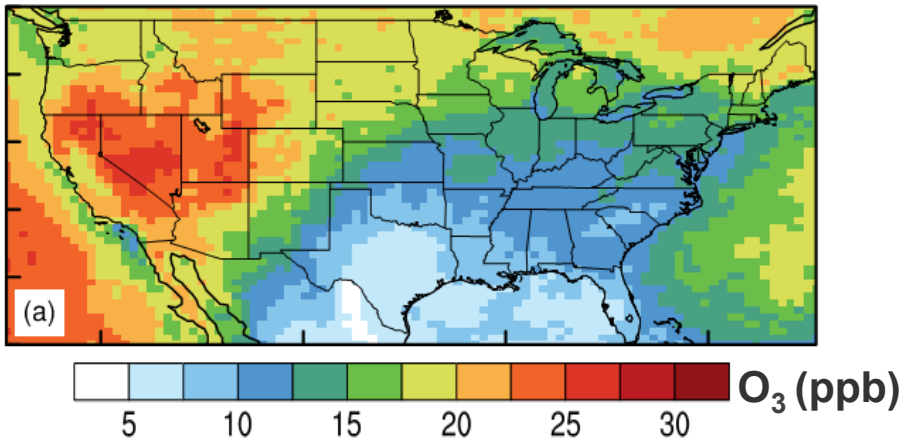
Asian: May-June 2010



Base Simulation – Zero Asian anth. emissions

[Lin et al., JGR, 2012a]

Stratospheric (O3S): April-June 2010



Tagged above e90 tropopause [Prather et al., 2011] + subjected to same loss processes as tropospheric O_3.

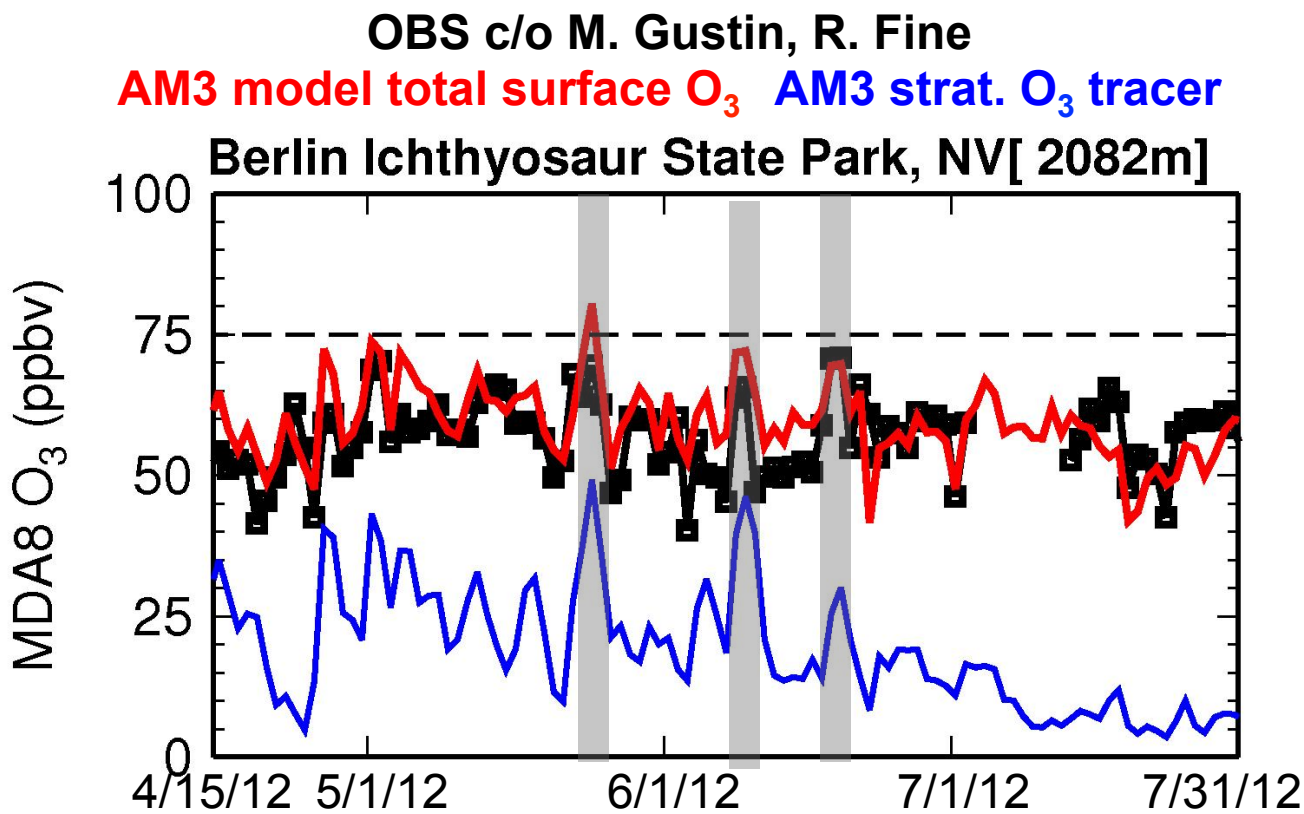
[Lin et al., JGR, 2012b]

→ **Model indicates NV particularly susceptible; observations lacking**

→ **New 6-site network: Nevada Rural Ozone Initiative (NVROI) led by M. Gustin, U NV-Reno [*Gustin et al.; Fine et al., submitted*]**

Stratospheric ozone intrusions contribute to springtime high-O_3 events observed at a new NVROI site

R. Fine,
U NV - Reno

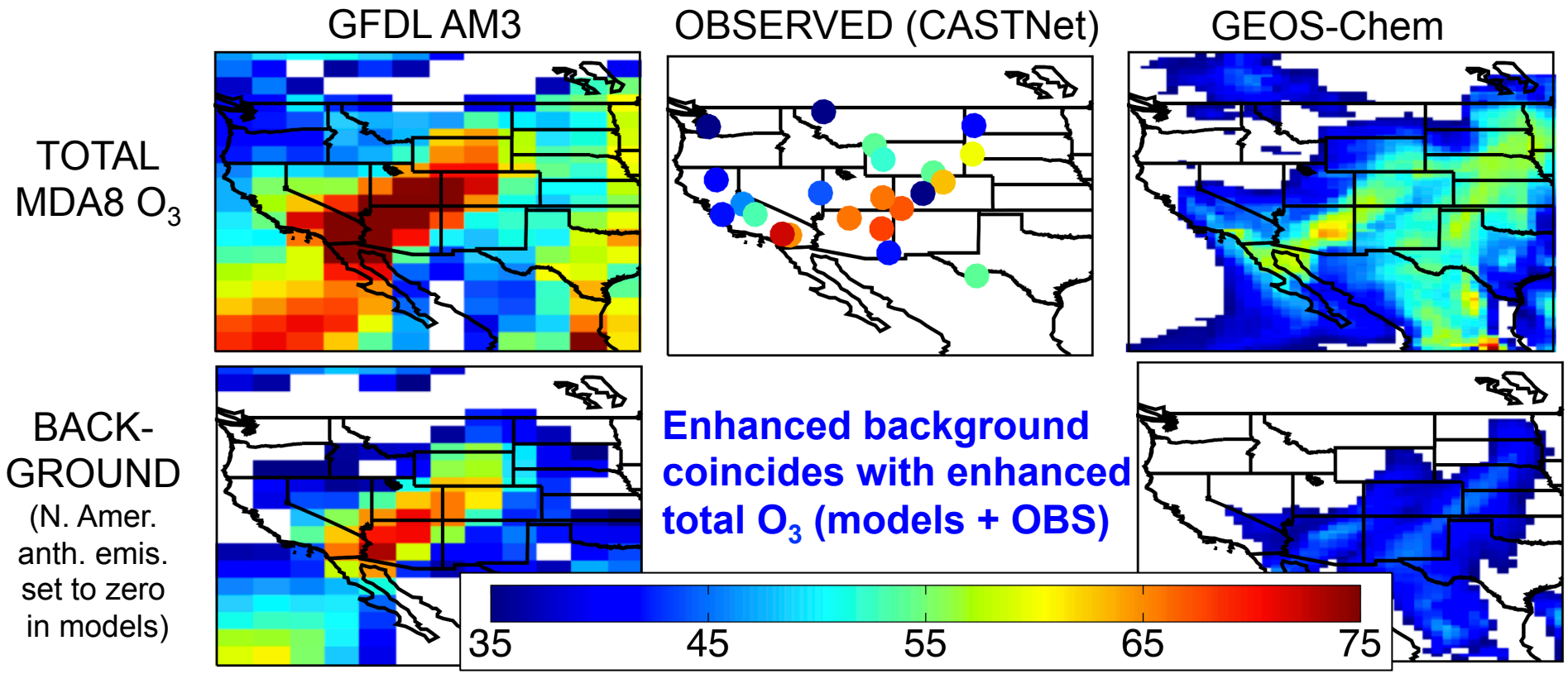


M. Lin, Princeton/GFDL

→ **Similar findings for other NVROI sites, consistent with earlier findings for Apr-June 2010** (based on satellite, sonde, aircraft, surface obs, AM3 [*Lin et al., 2012ab*])

Identifying process-level differences in model estimates of N. American Background via analysis of observed daily variations

Observed high surface O_3 event in Four Corners Region on May 28, 2006



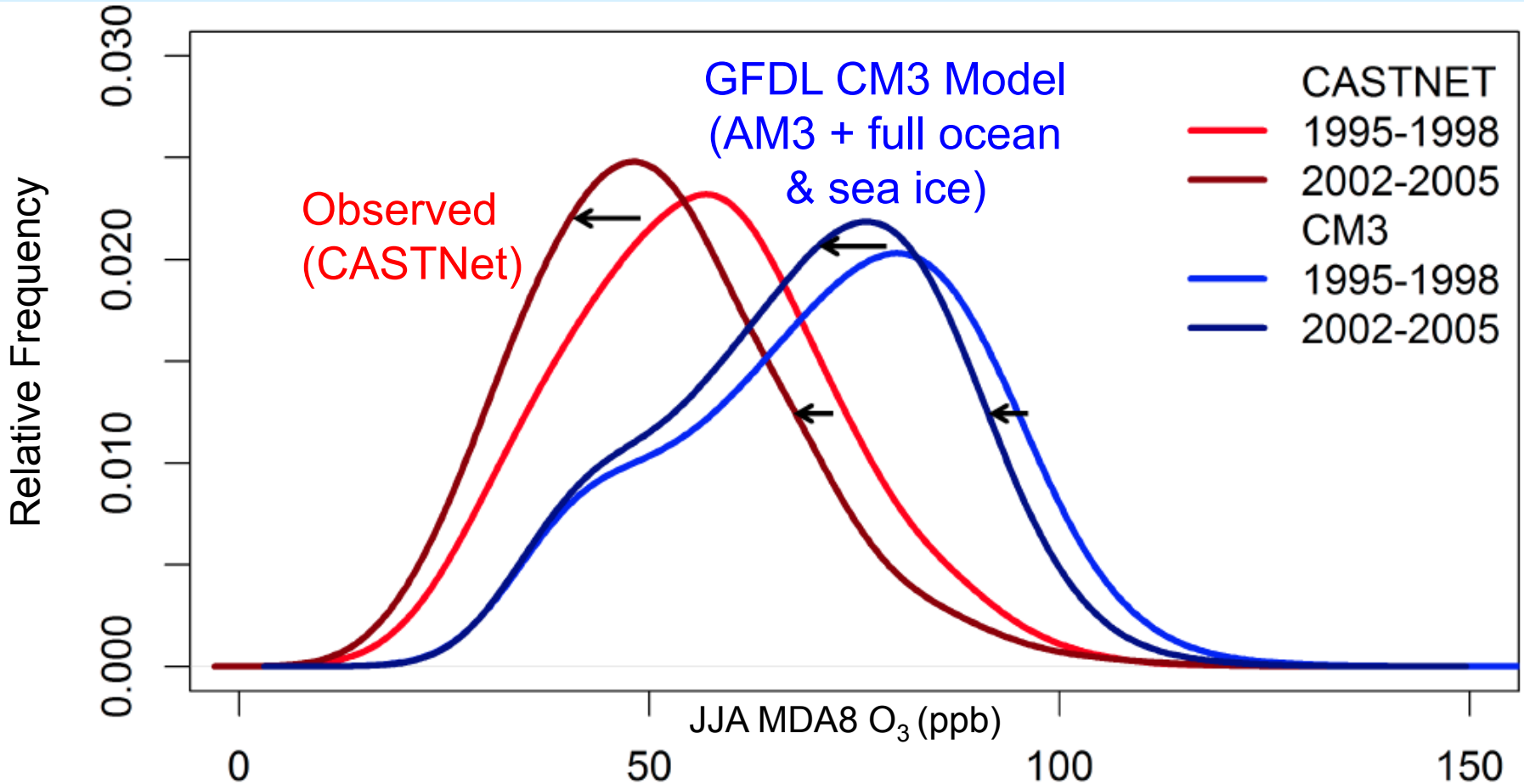
Fiore et al., submitted to Atmos. Environ.

→ **Attributed to strat. intrusion (OMI total column O_3 & OMI/MLS trop. O_3)**

→ **Models frequently bracket obs** (not limited to WUS spring)**, implying value in multi-model obs-constrained approach**

How best to extract useful information from biased models?

Over NE USA JJA, evaluate model processes in light of biases: GFDL CM3 generally captures surface O_3 response to 25% decrease in regional NO_x emissions (early 1990s to mid-2000s)



→ **Implies bias correction based on present-day observations can be applied to scenarios with NO_x changes (RCPs for 21st C)**

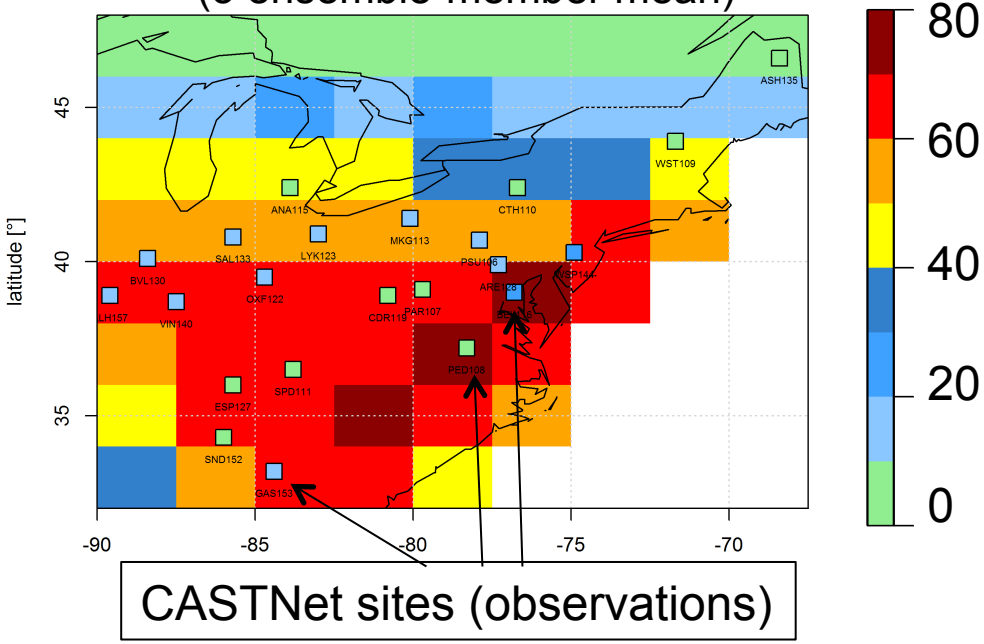
→ **Caveat: Model response smaller than observed, worst at low tail**

Rieder et al., in prep

Bias correction (regional quantile mapping) for NE USA summertime high-O_3 events

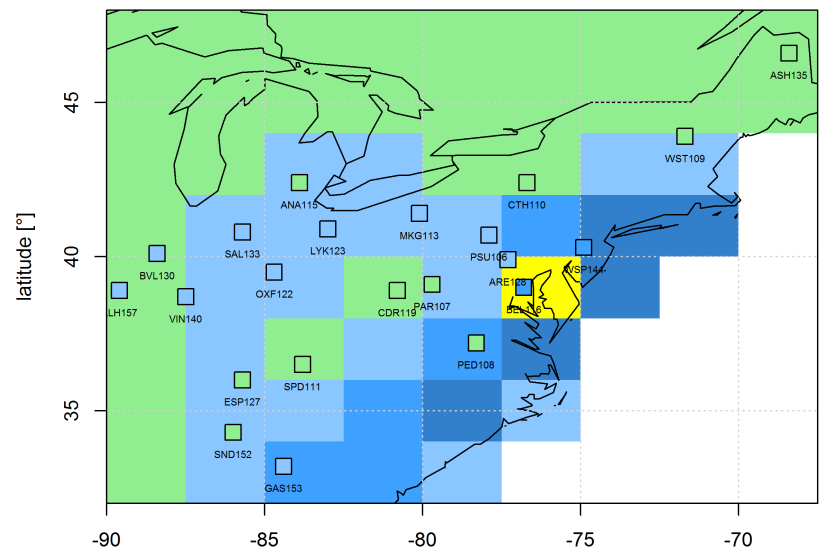
Average (1988-2005) number of summer days with MDA8 O_3 > 75 ppb (NAAQS)

CM3 Historical simulation
(3 ensemble-member mean)



CASTNet sites (observations)

Corrected CM3 simulation
(3 ensemble-member mean)



Rieder et al., in prep

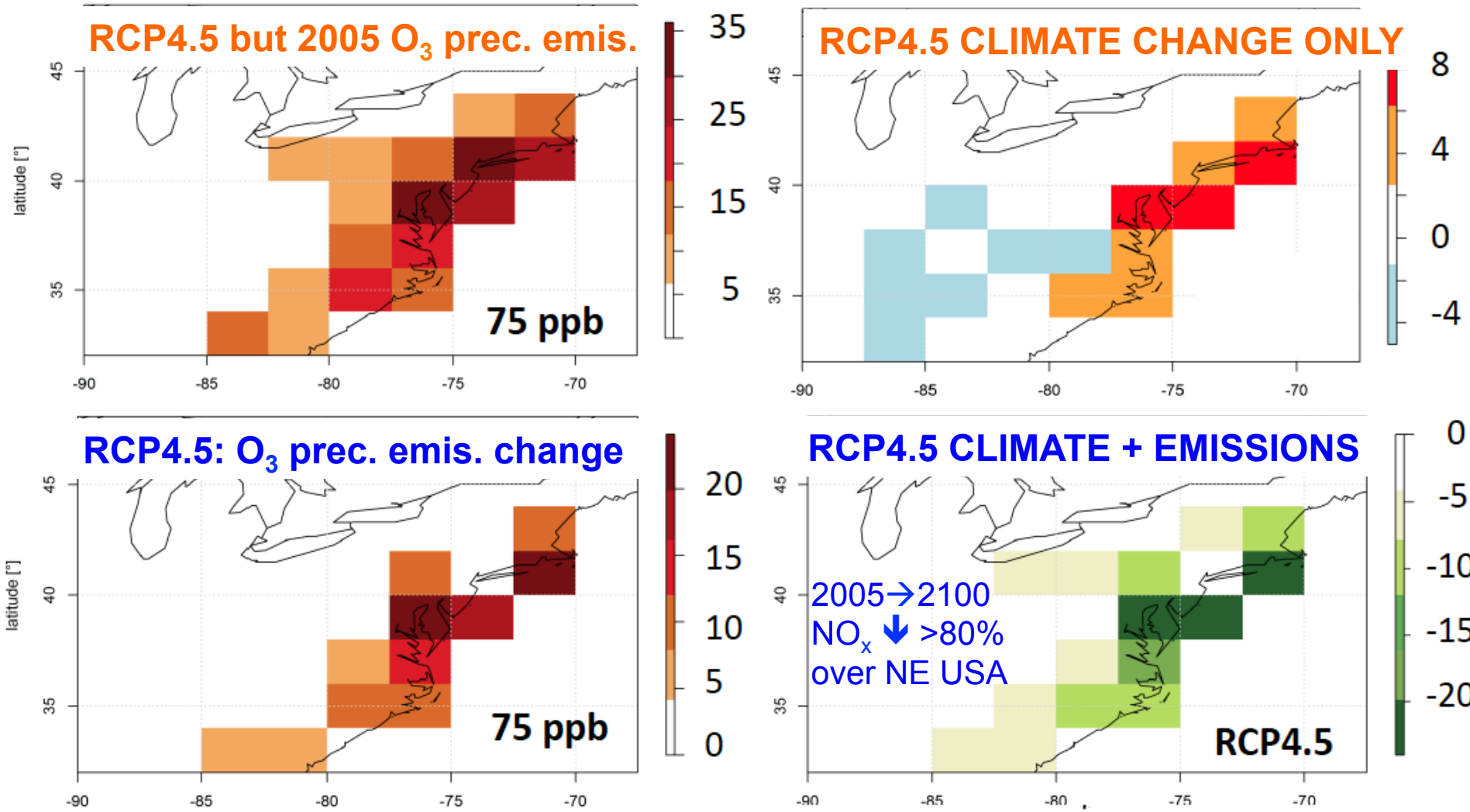
→ **Maps raw model summertime MDA8 distribution** (over all model cells in region) **to observed** (all sites in region)

→ **Apply correction to 21st century projections with CM3 chemistry-climate model using Representative Concentration Pathways (RCPs)**

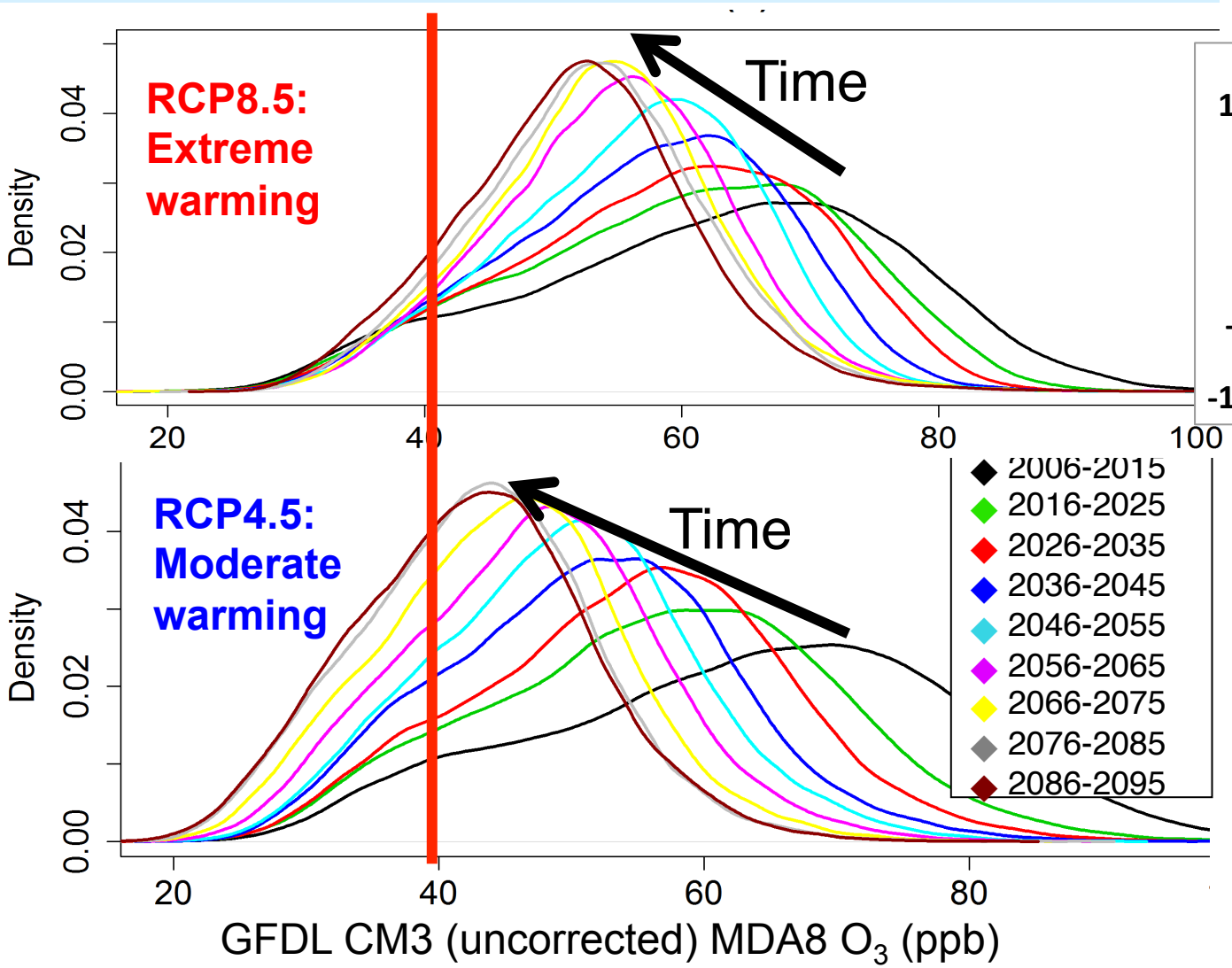
Large NO_x reductions offset climate penalty on O_3 extremes over the NE USA (moderate climate scenario: RCP4.5)

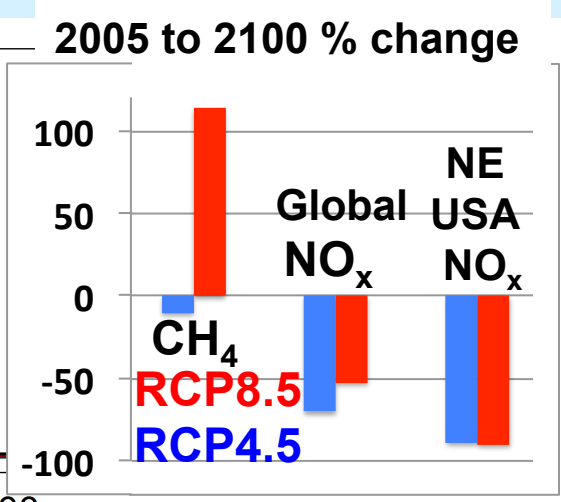
days in JJA with MDA8 O_3 > 75 ppb
2006-2015

Change in # JJA days with MDA8 O_3 > 75 ppb
2091-2100



Under RCPs, NE USA high-O_3 events decrease; beware 'penalty' from rising methane (via background O_3)





→ Rising CH_4 in RCP8.5 partially offsets O_3 decreases otherwise attained with regional NO_x controls (RCP4.5)

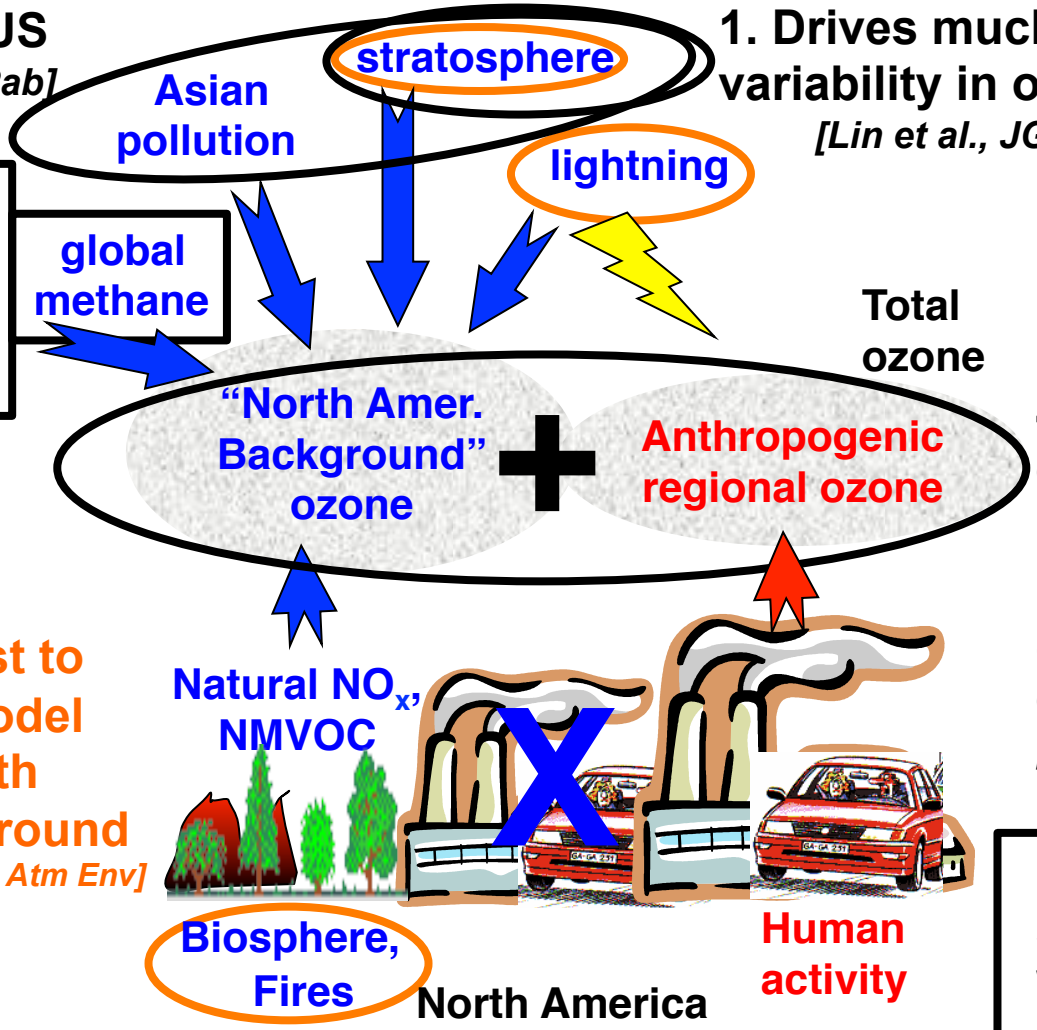
H. Rieder

Key drivers of surface ozone variability (from WUS background to EUS extremes)

2. Can push O_3 above NAAQS over WUS
[Lin et al., JGR, 2012ab]

1. Drives much of springtime WUS variability in observed surface O_3
[Lin et al., JGR, 2012b]

Constraints on oxidation from space?? [VALIN POSTER]

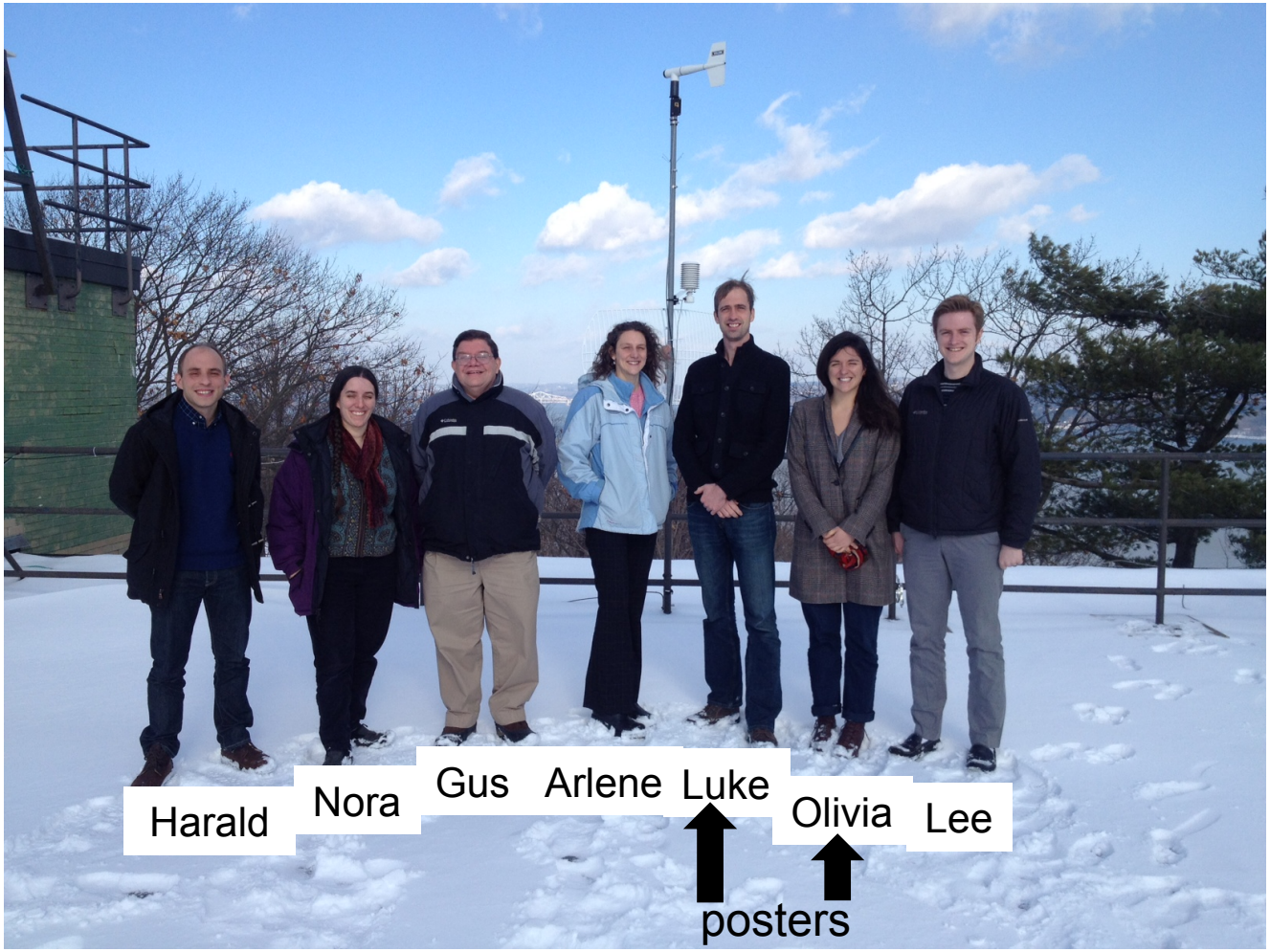


4. Future EUS O_3 extremes depend on regional climate change + global and regional emission changes
[Rieder et al., in prep]

3. Processes contributing most to differences in model estimates of North American Background
[Fiore et al., submitted to Atm Env]

NE USA surface O_3 seasonal cycle → WUS background by end of 21st C?? [CLIFTON POSTER]

Atmospheric Chemistry Group at LDEO/CU



On the roof of our building following mid-Dec snowfall
(missing from photo: undergraduate researcher Jean Guo)