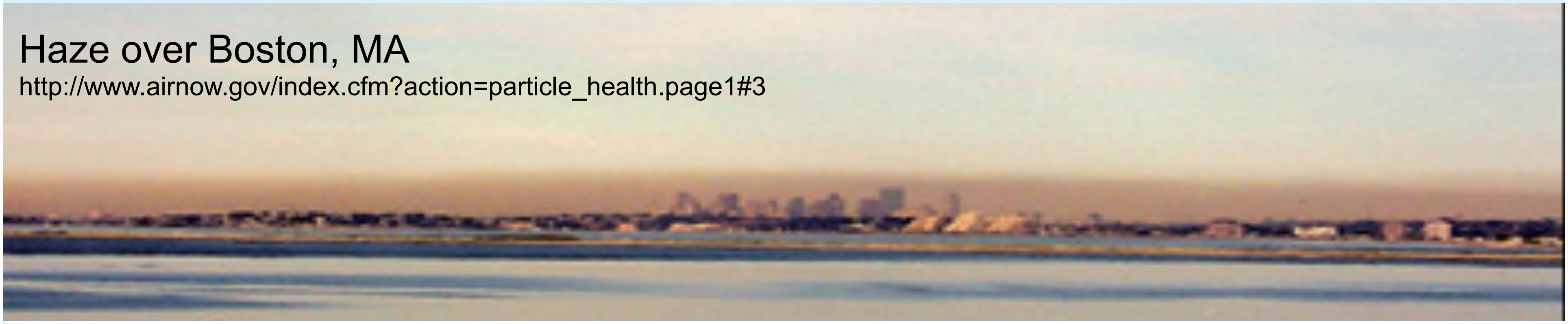
Haze over Boston, MA
http://www.airnow.gov/index.cfm?action=particle_health.page1#3

Ozone smog in surface air: Background contributions and climate connections

Arlene M. Fiore
www.ldeo.columbia.edu/~amfiore

Lamont-Doherty Earth Observatory
Columbia University | Earth Institute
Columbia University in the City of New York

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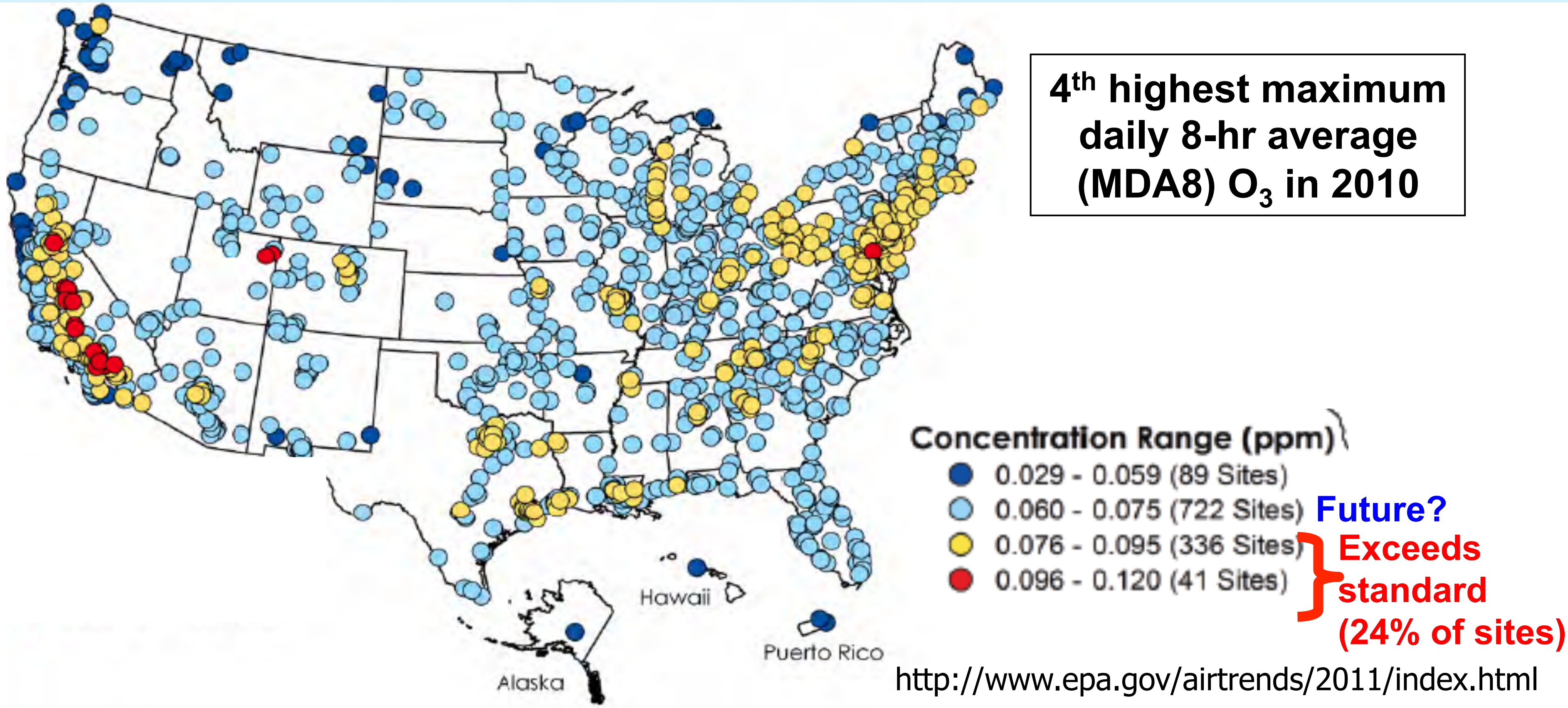
SIPA ESP MPA Program
LDEO, Palisades, NY
July 1, 2013

The U.S. ozone smog problem is spatially widespread, affecting ~108 million people [*U.S. EPA, 2012*]

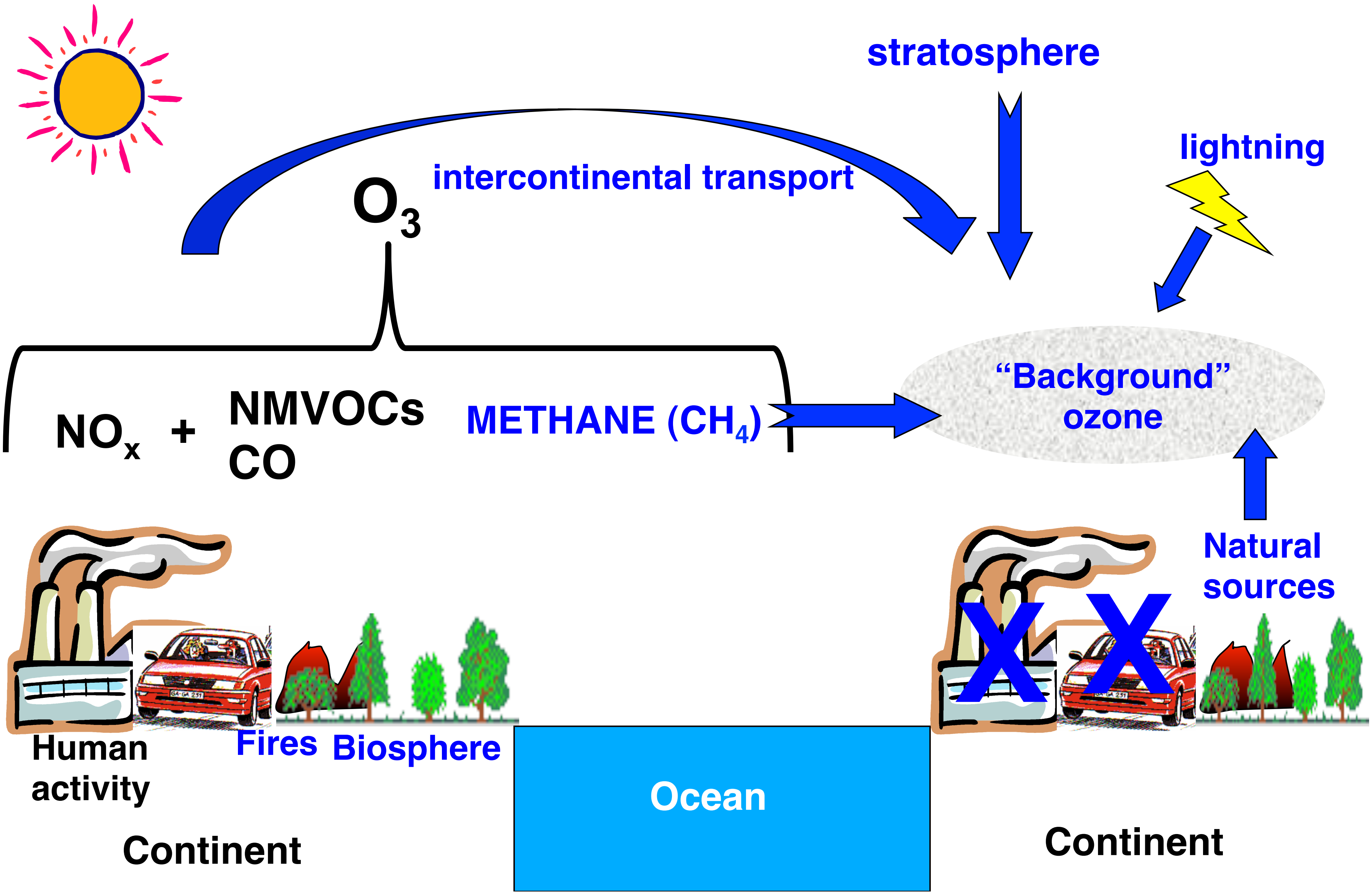


http://www.epa.gov/airtrends/2011/index.html

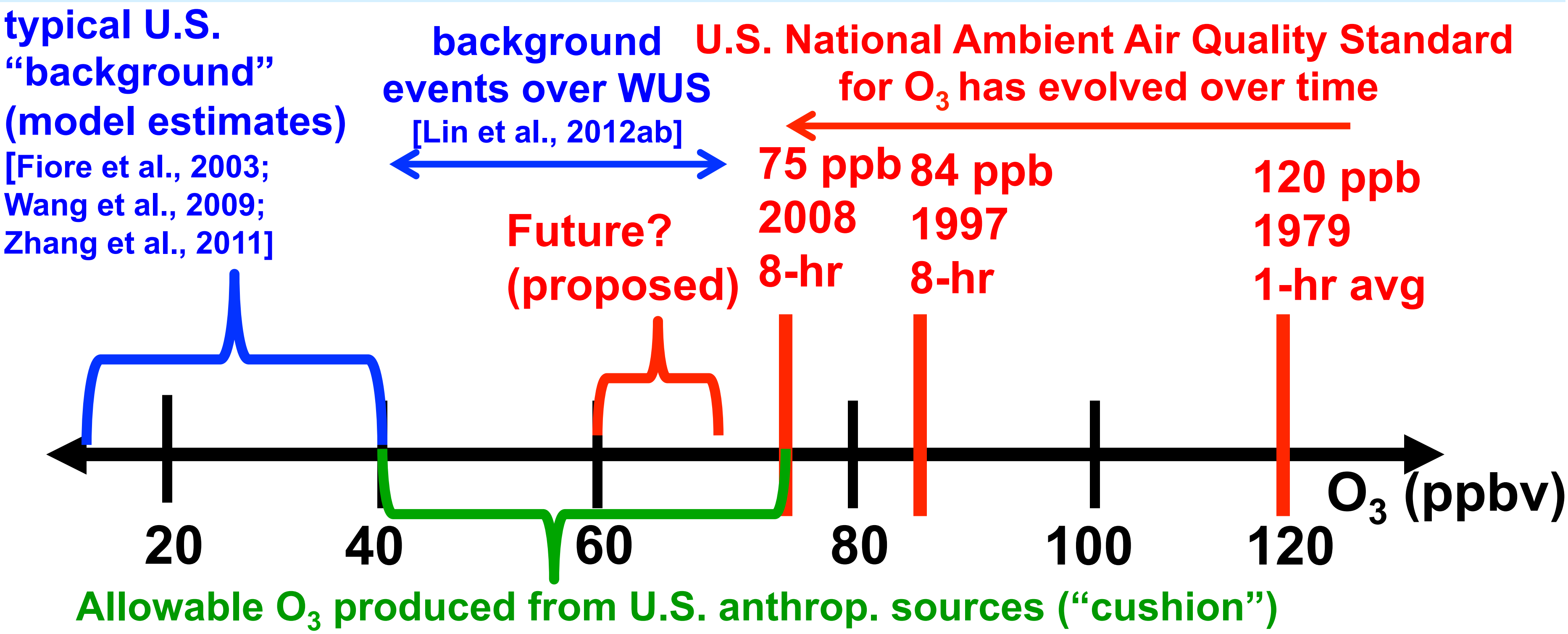
High-O_3 events typically occur in
-- densely populated areas (local sources)
-- summer (favorable meteorological conditions)

→ Lower threshold would greatly expand non-attainment regions

Tropospheric O_3 formation & "Background" contributions



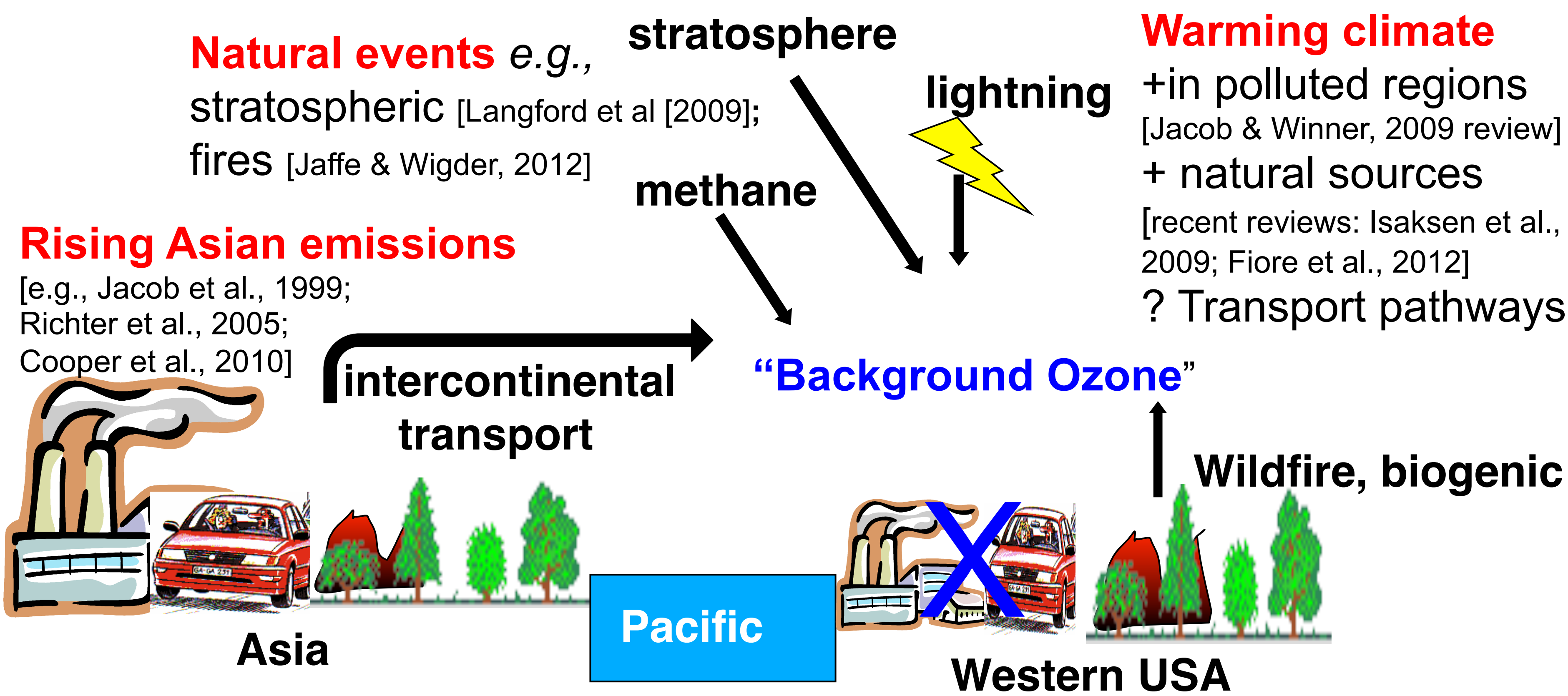
Setting achievable standards requires accurate knowledge of background levels



Lowering thresholds for U.S. O_3 NAAQS implies thinning cushion between regionally produced O_3 and background

Clean Air Act has provisions for States to be exempted from pollution beyond their control but in practice may need clarification

Some challenges for WUS O_3 air quality management



Need process-level understanding on daily to multi-decadal time scales

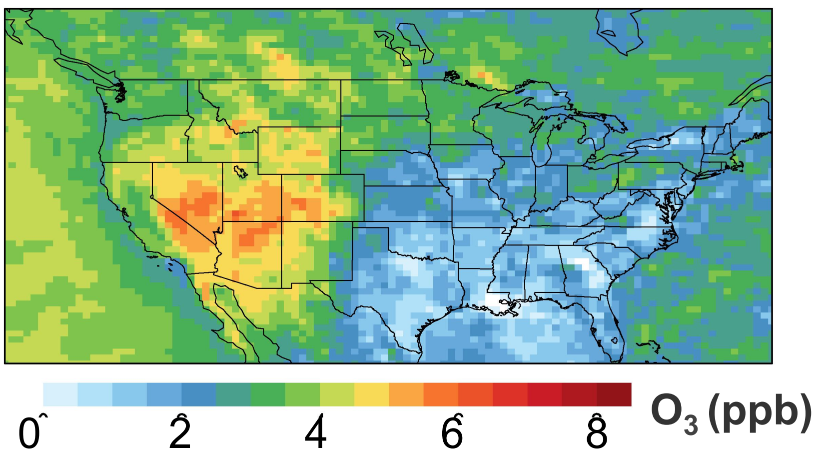
Estimates of Asian and stratospheric influence on WUS surface ozone in spring

TOOL: GFDL AM3 chemistry-climate model [Donner et al., J. Clim. 2011]

- ~50x50 km^2 Jan-Jun 2010 – overlaps period of intensive field measurements (CalNex)
- Nudged to GFS ("real") winds – allows direct comparison with snapshot observations
- Fully coupled chemistry in the stratosphere and troposphere within a climate model

Mean MDA8 O_3 in surface air

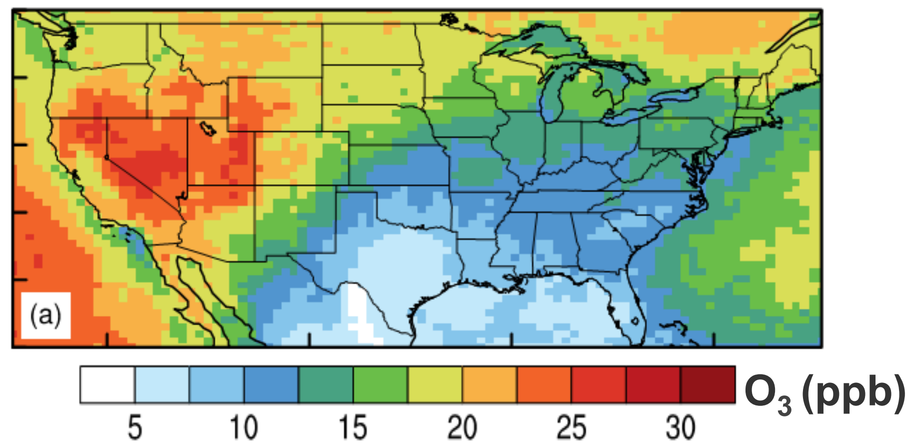
Asian: May-June 2010



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.

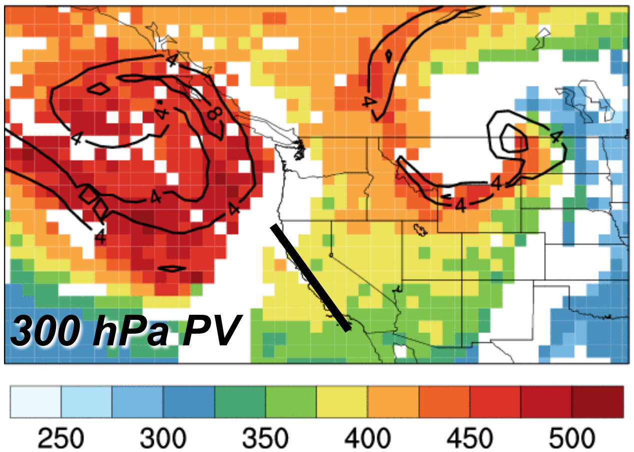
[Lin et al., JGR, 2012b]

Do they influence high-O_3 events in populated regions?

Stratosphere-to-troposphere (STT) O_3 transport influence on WUS high-O_3 events

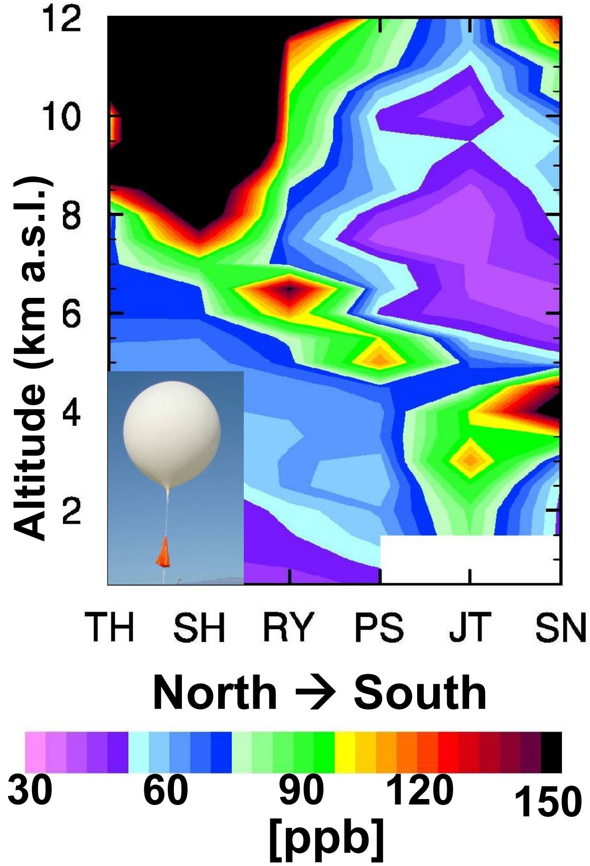
AIRS, May 25-29

2010.05.25T01:30am



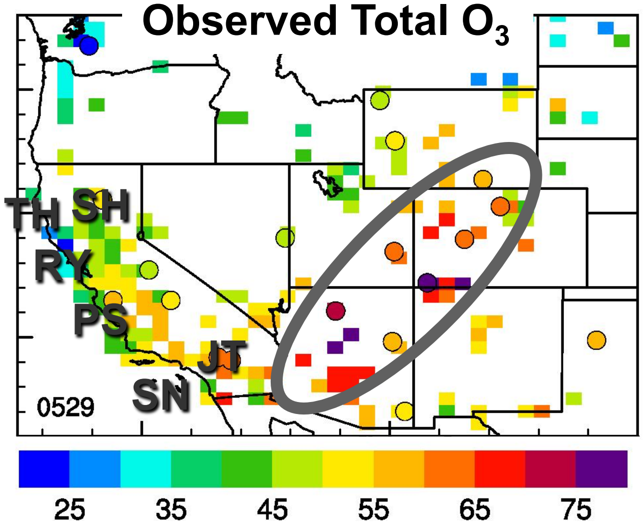
Total column O_3 [DU]

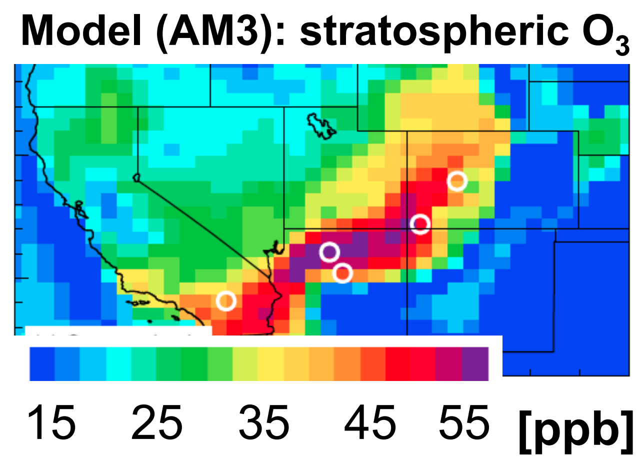
Sonde O_3, May 28



Surface MDA8 O_3, May 29

M. Lin et al., JGR, 2012b





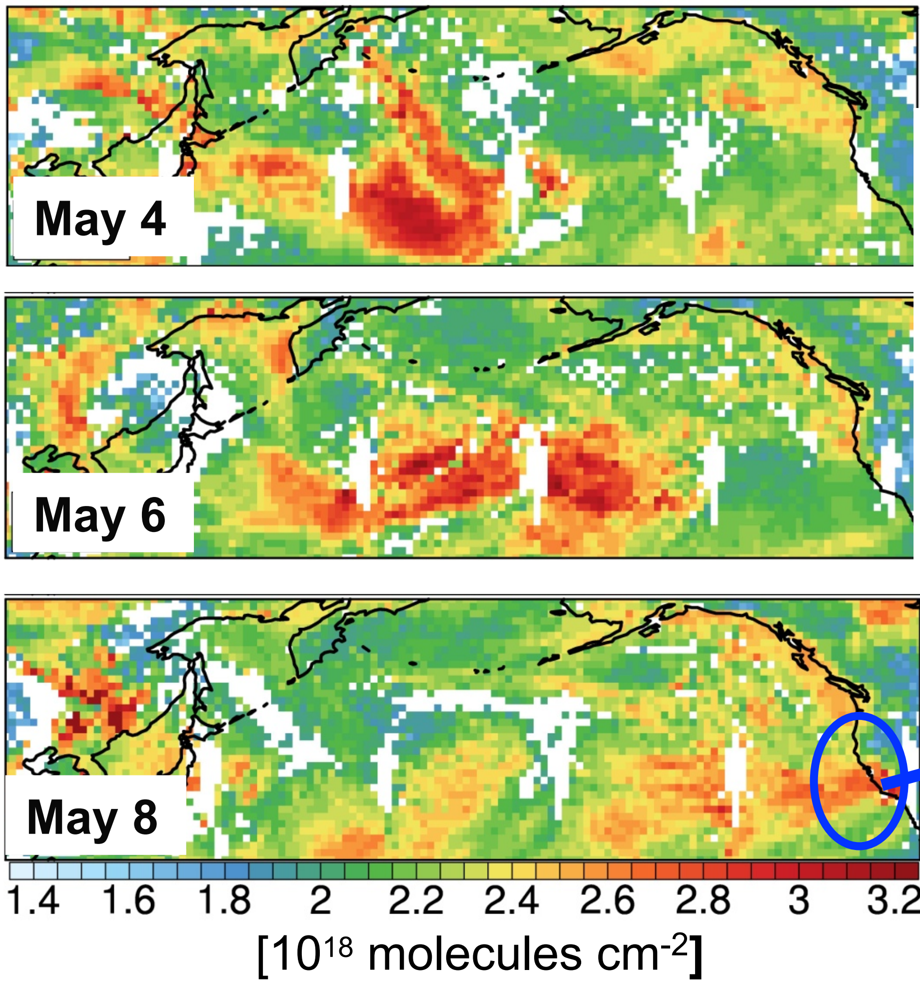
Would STT confound attainment of tighter standards in WUS?

Are exceptional events accurately identified?

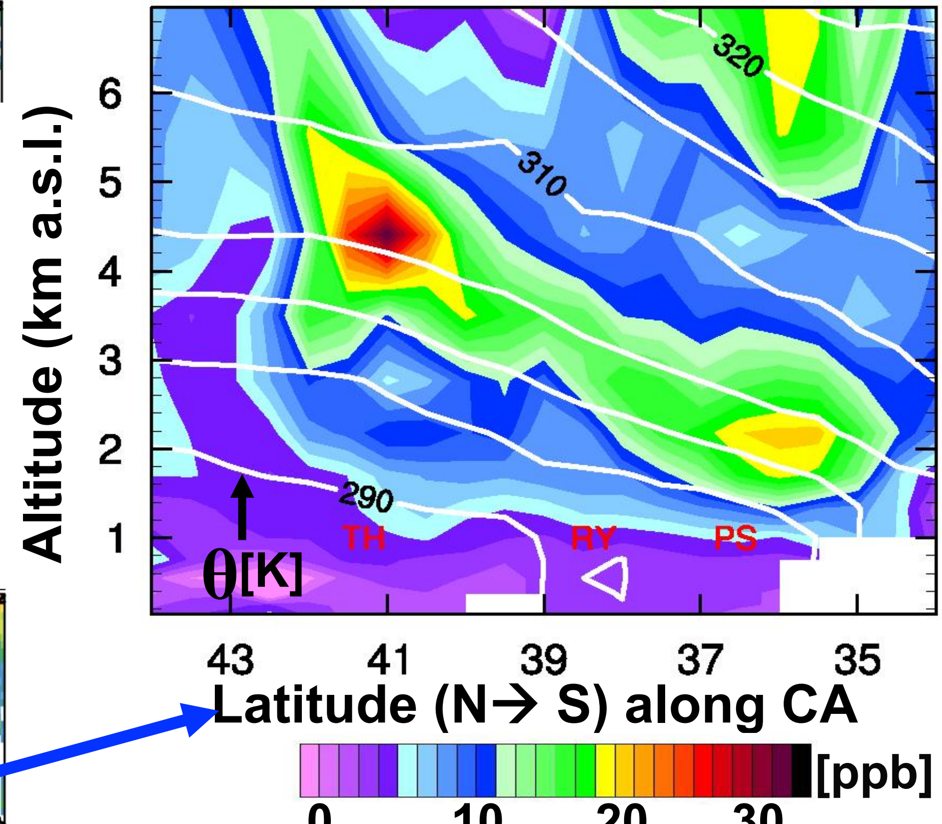
→ **Ongoing work exploring development of space-based indicators**

Asian O_3 pollution over S. CA: Trans-pacific transport + subsidence to lower troposphere

Satellite CO columns (AIRS)



GFDL AM3 Model Asian O_3



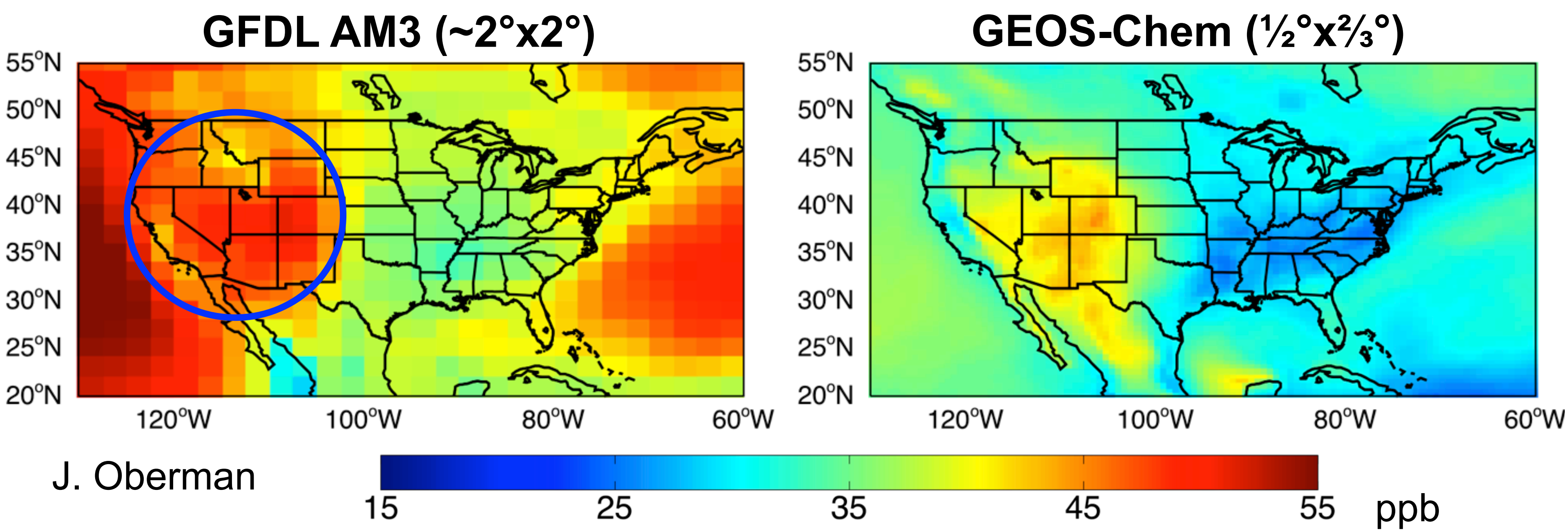
Consistent with sonde and aircraft [Lin et al., JGR, 2012a]

→ We find these events sometimes contribute to 'pushing' O_3 in surface air above thresholds of 60 and 70 ppb [Lin et al., JGR, 2012a]

Models differ in estimates of North American background

(estimated by simulations with N. American anth. emissions set to zero)

Average Springtime (March-April-May) North American background
MDA8 O_3 in model surface layer



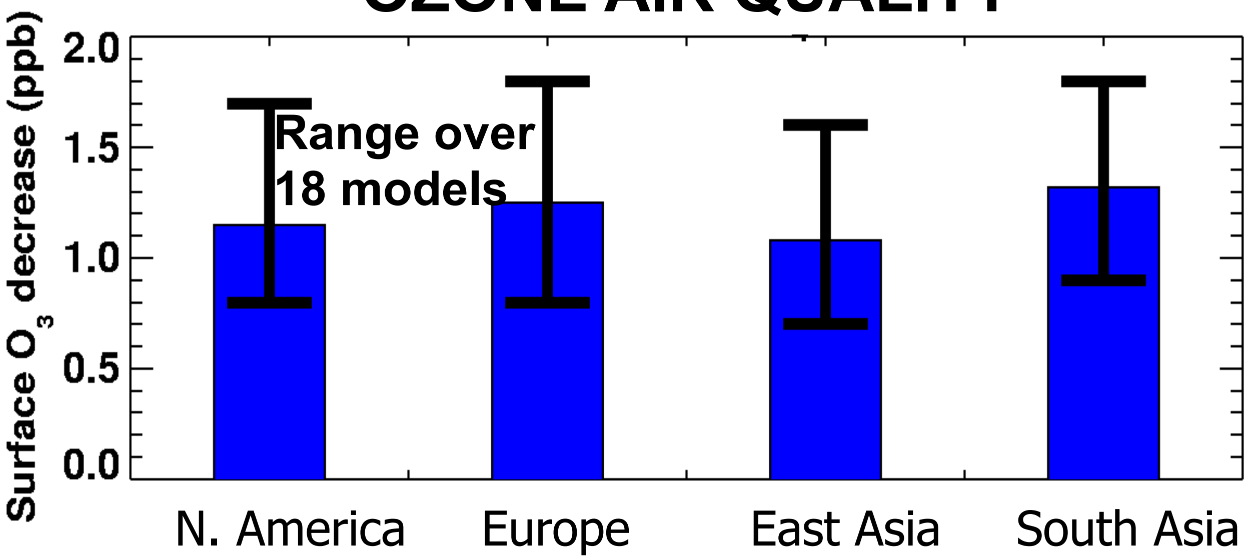
GFDL AM3: Generally more mixing of background O_3 to the surface?

→ Model differences provide an error estimate
→ Need careful, process-oriented evaluation with observations

Air pollution-climate connection via methane

Benefits of ~25% decrease in global anthrop. methane emissions

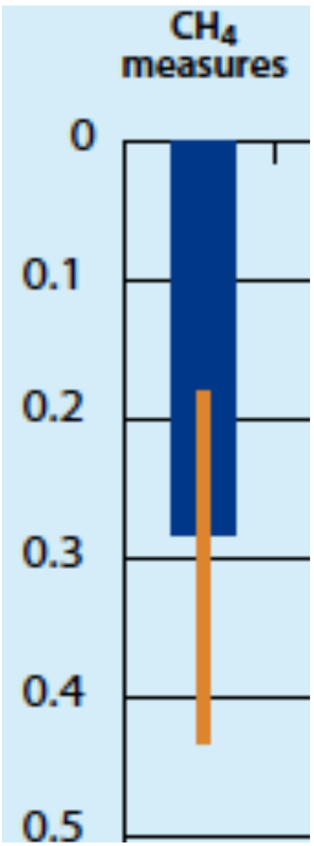
OZONE AIR QUALITY



[Fiore et al., JGR, 2009; TF HTAP, 2007, 2010; Wild et al., ACP, 2012]

CLIMATE

Global mean avoided warming in 2050 (°C)
[WMO/UNEP, 2011]



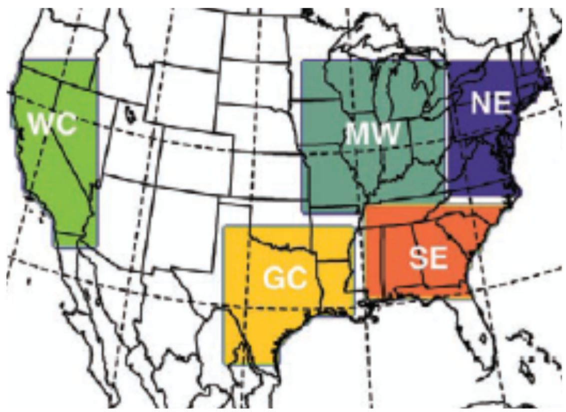
→ **Possible at cost-savings / low-cost** [West & Fiore 2005; West et al.,2012]

→ **$1.4 billion (agriculture, forestry, non-mortality health) within U.S. alone** [West and Fiore, 2005]

→ **7700-400,000 annual avoided cardiopulmonary premature mortalities in the N. Hemisphere**

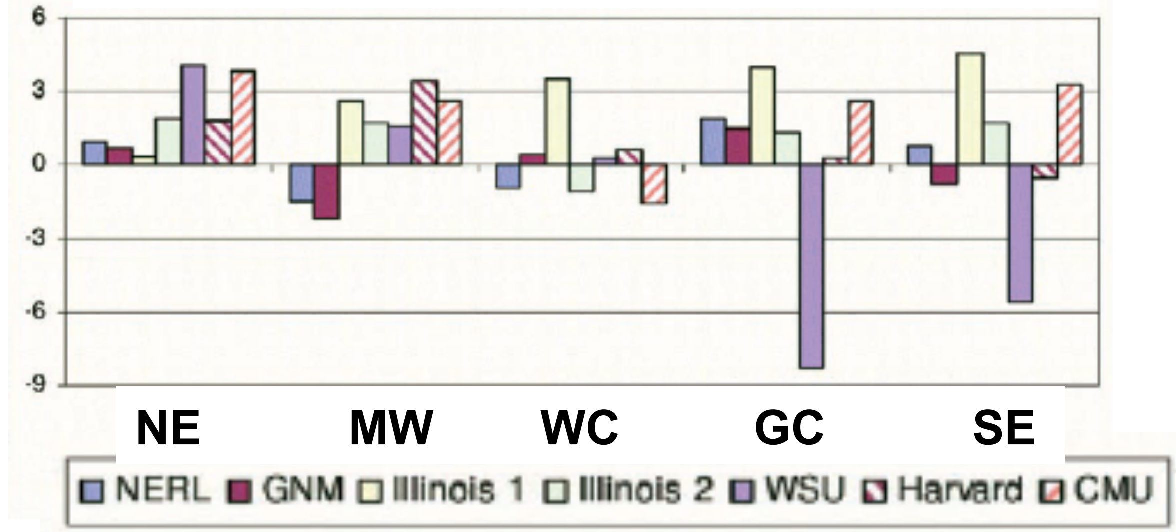
uncertainty in concentration-response relationship only [Anenberg et al., ES&T, 2009]

Models estimate ‘climate change penalty’ on surface O_3 over wide U.S. regions but often disagree in sign regionally



Weaver et al., BAMS, 2009

Modeled changes in summer mean of daily max 8-hour O_3 (ppb; future – present)



Increases (2 to 8 ppb) in all models over large U.S. regions

→ **Uncertain regional climate responses to global warming**
→ **Gap in analysis over much of mountainous West**
→ **How will background change?** (e.g., frequency of fires, strat. intrusions)

Ozone smog in surface air: background and climate connections- Summary and intersections with public policy

Background generally well below NAAQS thresholds in populated regions

High-altitude western U.S. is susceptible to natural events (stratospheric O_3 intrusions; wildfires) and international pollutant transport

→ formulation of standard (4th highest, 3 year average) allows some room

→ 'Exceptional event' and 'international transport' provisions in Clean Air Act but implementation needs clarification

→ Ongoing review (every 5 years) of science supporting O_3 NAAQS; related Congressional hearing June 12, 2013

http://science.house.gov/hearing/subcommittee-environment-background-check-achievability-new-ozone-standards

NASA Air Quality Applied Sciences Team (www.aqast.org):
Earth Science Serving Air Quality Management Needs

Methane controls: 'win-win' for near-term climate, air quality; also economic

→ Climate and Clean Air Coalition (http://www.unep.org/ccac/)

Climate warming expected to alter pollutant levels

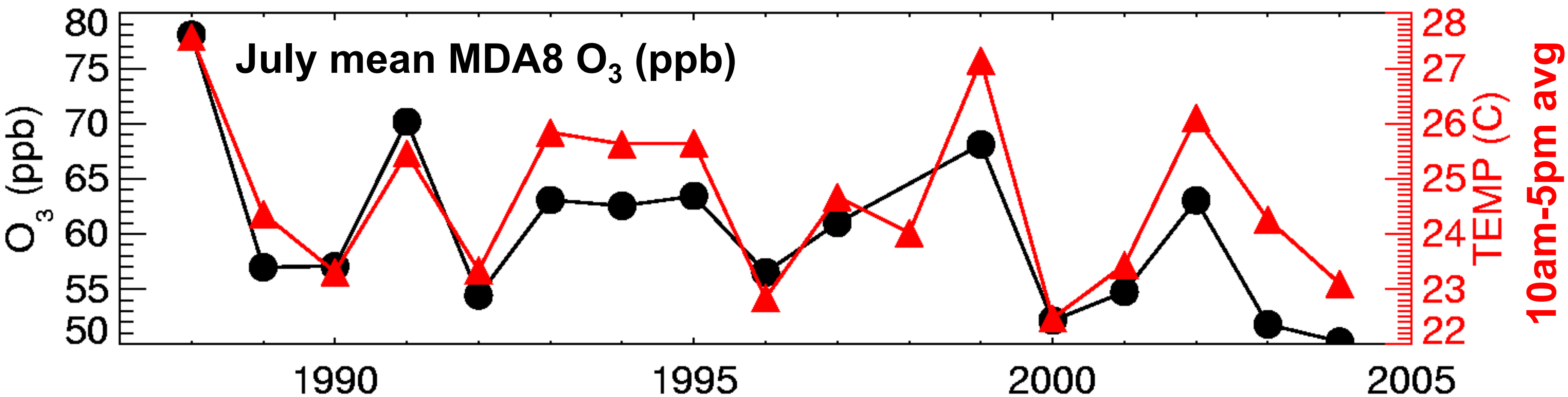
→ increase O_3 in already polluted regions ('climate penalty')

→ alter natural sources (wildfires, stratospheric, biogenic emissions)

→ occur in context of future global and regional emission changes

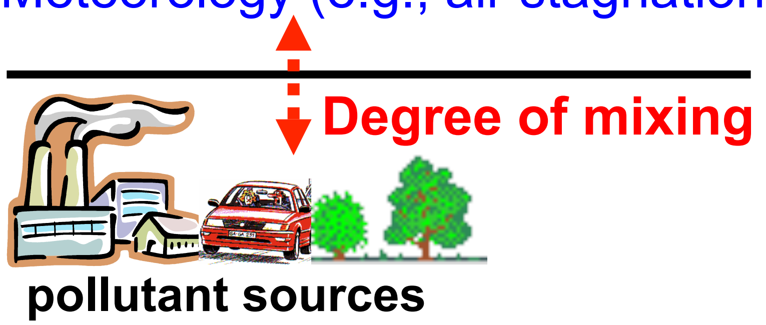
Strong correlations between surface temperature and O_3 measurements on daily to inter-annual time scales in polluted regions [e.g., Bloomer et al., 2009; Camalier et al., 2007; Cardelino and Chameides, 1990; Clark and Karl, 1982; Korsog and Wolff, 1991]

Observations at U.S. EPA CASTNet site Penn State, PA 41N, 78W, 378m

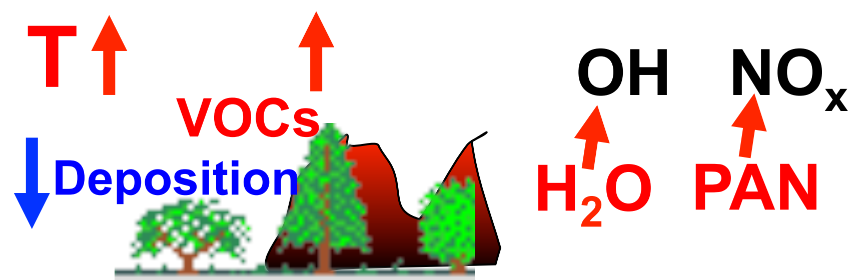


What drives the observed O_3-Temperature correlation?

1. Meteorology (e.g., air stagnation)



2. Feedbacks (Emis, Chem, Dep)



→ Implies that changes in climate will influence air quality