

Issues associated w/ background ozone and the secondary ozone standard

Pat Dolwick (w/ material from **many** within/outside of USEPA/OAQPS)

Western Meteorological, Emissions, and Air Quality Modeling Workshop

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Purpose / outline / key question

- Purpose of presentation is to introduce issues and begin conversations related to background ozone and the secondary ozone standard
 - Promote consistent terminology w.r.t. “background”
 - Show results from recent data and modeling analyses
 - Start to establish a common technical understanding of these issues
 - Identify places where additional analyses are needed
- Outline:
 - What is policy-relevant background and how is it used in NAAQS setting/implementation?
 - What modeling analyses are underway to inform assessments of background?
 - What do we know about current background levels of ozone?
 - Will EPA have updated guidance on specification of base & future year boundary conditions?
 - Do we expect to have issues attaining the secondary ozone standard?
- Key question: What the most efficient path to attainment of the new ozone standards in the western U.S.?
 - Developing an analytical understanding of natural background, international transport, exceptional events, and other non-local contributions are important elements of the puzzle.



Policy-relevant background (PRB)

- What is PRB and what role does it play in the NAAQS setting & implementation process?
 - PRB is only used in the health risk and exposure assessments
 - 12 cities (2 in CA, rest in EUS), traditionally warm-season only
 - See samples on next slide
- PRB in the 2008 NAAQS review:
 - Defined to be those ozone levels associated with all sources except North American anthropogenic NO_x, VOC, and CO,
 - Concentrations were estimated through GEOS-Chem (Fiore et al., 2003),
 - Vary spatially and temporally, highest in Spring and at high-altitude sites,
 - Range from 25 +/- 10 ppb, tend to decline during conditions of high episodic O₃,
 - Criticized by some as underestimating this background and therefore inflating risks associated w/ O₃ above PRB.

Policy-relevant background (PRB)

- For the next NAAQS review (2013/14), EPA is considering alternate definitions of PRB.
 - Ranging from only natural background ozone to all ozone not formed by U.S. anthropogenic emissions
 - Likely to be informed by GEOS-Chem modeling
 - Likely to include consideration of CH₄
- Despite its name, “PRB” has no relevance in the implementation & attainment context.

Figure 2A-10. Sacramento CSA: Diurnal Policy Relevant Background Ozone Patterns.

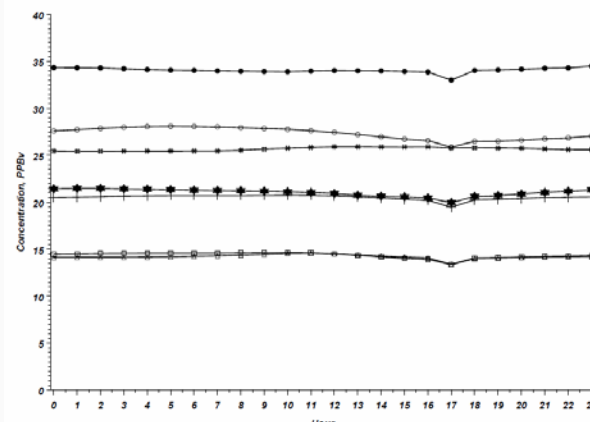
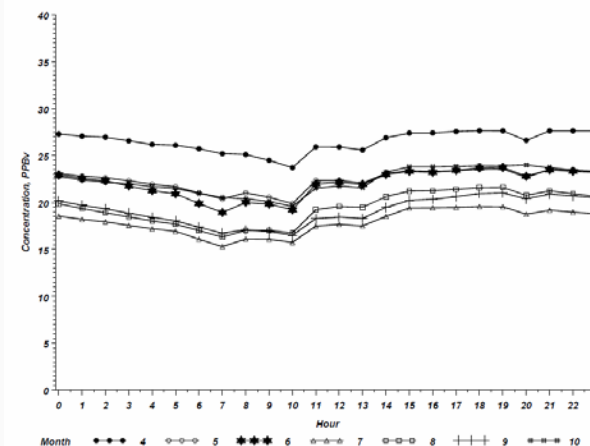
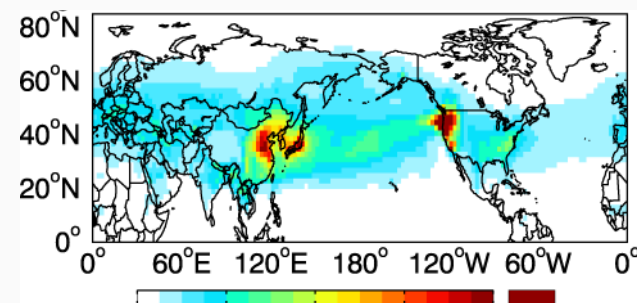


Figure 2A-9. Philadelphia CSA: Diurnal Policy Relevant Background Ozone Patterns.



Policy implications of background

- Of course, background ozone does influence observed ozone concentrations and will need to be considered in implementation/attainment of the ozone NAAQS:
 - Exceptional events
 - Rural transport / overwhelming transport
 - International transport (Sec 179b)
 - Boundary conditions in attainment demonstrations
- Background AQ means different things to different people. Must be clear in how one defines background.



Zhang et al. (2009)



What's known about current ozone background?

- There is a trove of on-going global modeling exercises designed to assess contributions to ozone background (slide 7)
- Background ozone results from several different sources (slides 8-14)
 - Can vary significantly in space/time
 - Models can be used to estimate background magnitude and strength of each contributing element
- Global models have mixed success in replicating AQ at remote sites thought to be more influenced by background sources (slides 12-15)
- Global background ozone appears to be on the rise (slide 16)



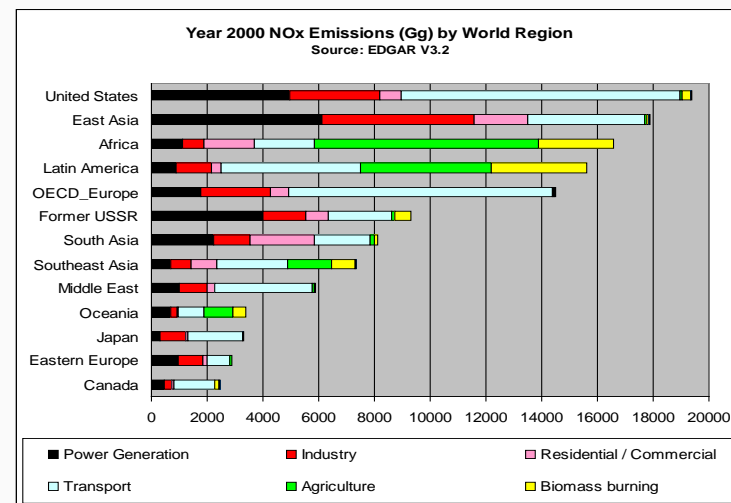
Known ongoing background modeling exercises

- Multiple models
 - GEOS-Chem
 - Hemispheric CMAQ
 - AM3
 - MOZART-IV
- Multiple resolutions
 - 2.0 x 2.5 degrees -> ~ 50km
- Multiple inputs
 - esp. on the emissions side
- Multiple purposes
 - Variety of sensitivity runs
 - Develop BC -> assess PRB

Who	Sponsor	Model	Grid	Years	Runs	Status	Takeaway
Harvard (Zhang & Jacob)	BP, EPRI, NASA	GEOS-Chem	Global 2.0 x 2.5 NAmer: 0.50 x 0.67	2006-2008	1. Baseyear 2. NA anthro zeroed 3. US anthro zeroed 4. All anthro zeroed 5. CA anthro zeroed	Evaluated Results mostly available (base, NAB 06-08; USB- NB 06 only) Used in 2nd draft ISA - pending acceptance for pub Being used for REA?	NA bkg ~ 40 +/- 7ppb at high alt WUS sites, rarely exceeds 60 NA bkg averages 27 +/- 8ppb over rest US NA bkg increases w/ increasing concs in West; basically flat in East Intercontinental adds ~ 5-8ppb Can/Mex adds ~ 1-3ppb Rest is natural (strat, fire, lightning, etc.)
ICF/Harvard (Haney & Zhang)	NCEA	GEOS-Chem	Global 2.0 x 2.5 NAmer: 0.50 x 0.67	2006-2008	1. Baseyear 2. NA anthro zeroed 3. US anthro zeroed 4. All anthro zeroed	Coarse grid spinup complete Targeting Aug completion CH4 updated for USB, NAB To be used for 2nd draft ISA?	
Environ (Emery)	API	GEOS-Chem	Global 2.0 x 2.5 Nested CMAQ/CAMx	2006	1. Baseyear 2. double lap/Kor NOx 3. STE treatment 4. TBD PRB tests 5. Future year tests	Evaluation underway, very poor model performance Some global PRB modeling	Expect difficulties attaining lower std given high bkg amts of 60-70ppb (focused on WUS). Fire VOC, NOx emissions need to be verified.
U. of Tennessee / Harvard (Fu, Lam, Jang, Jacob)	EPA - OAQPS	GEOS-Chem	Global 2.0 x 2.5 Nested CMAQ/CAMx	2006-2008	1. Baseyear 2. NA anthro zeroed 3. US anthro zeroed 4. Asia anthro zeroed 5. Can anthro zeroed 6. Mex anthro zeroed 7. All anthro zeroed	Evaluated Stratospheric input zeroed	Average NA bkg ~ 40ppb in WUS Average NA bkg ~ 25ppb in EUS Can/Mex impacts small outside of border states Asian impact ~ 3-5 ppb Interannual variability of ~ 3-5 ppb
UNC - Chapel Hill	EPA - OAQPS	MOZART-IV	Global 1.9 x 1.9 Nested CMAQ/CAMx	2005, 2025?	1. Baseyear 2. Global/regional CO/VOC emiss 3. Fut baseyear (business-as-is) 4. Fut baseyear (best-estimate) 5. Fut baseyear (aggress internat)	Just getting started. Results by Dec 2011?	
EPA - ORD (Napelenok et al)	EPA - ORD	GEOS-Chem	Global 2.0 x 2.5 Nested CMAQ	2006	1. Baseyear		Updated version of GC/CMAQ interface is needed Prelim comparison against UTK GC shows slightly better performance
EPA - ORD (Mathur et al)	EPA - ORD	CMAQ - hemispheric	108 km	2006	1. Baseyear	Still testing w/ very preliminary emissions	Need to spur R&D here. Ultimately would be most convenient tool to mesh w/ regional and local analyses
TVA (Mueller and Mallard)	TVA	CMAQ-GEOS- Chem	CMAQ with GEOS- Chem boundary conditions.	2002	1. Baseyear 2. NA anthro zeroed 3. Boundaries only	Pub. EST, 2011; ACP 2010, 2011	Very high natural background due to fires. Large contribution from lightning. No explicit stratospheric input.
NOAA GFDL (Fiore, Lin et al)	NOAA - GFDL	GFDL - AM3	200 km 200/50 km	1980-2007 2010	1. Baseyear 2. NA anthro zeroed	Evaluated Can be made available	Can be part of multimodel ensemble approach to PRB (NASA-AQAST)

Contributions to Background O3

- Natural emissions
 - VOCs from vegetation
 - Methane
 - Lightning and natural soil NO_x
 - VOCs, NO_x and CO from wildfires
 - Stratospheric O₃ intrusion
- Natural background
- Additions from anthropogenic contributions
 - Local sources (NO_x, VOCs, CO)
 - Regional (NO_x, VOCs, CO)
 - Intercontinental sources (NO_x, VOCs, CO)
 - Global /extended lifetime sources (CH₄, CO)

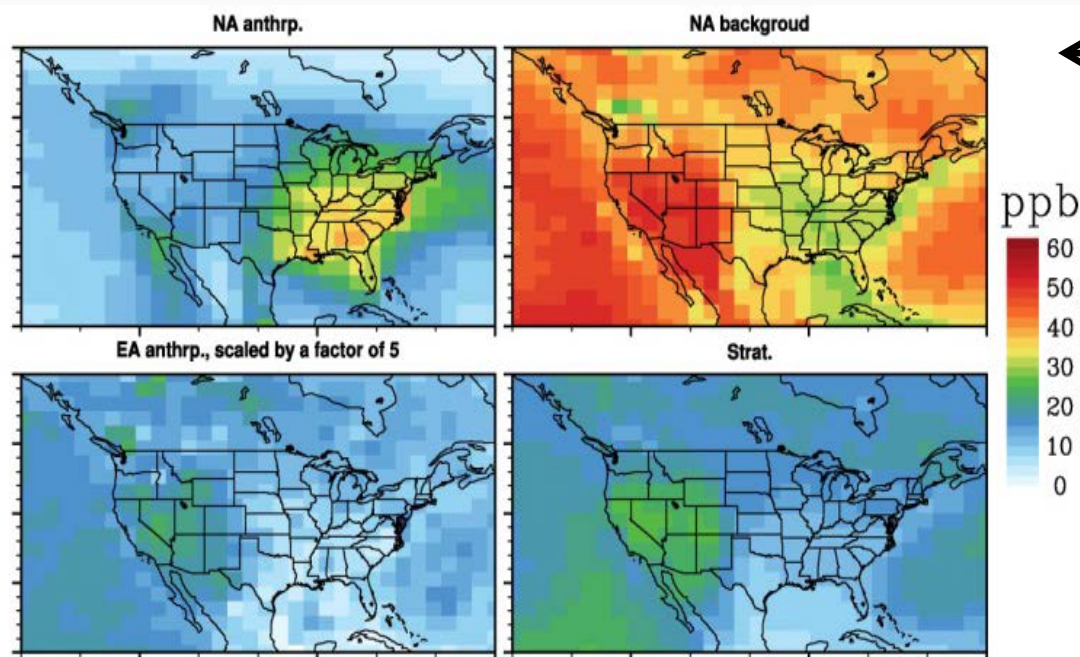




Contributions to Background O₃ (HTAP assessment)

- Task force on Hemispheric Transport of Air Pollution (HTAP)
 - Ensemble global modeling intercomparison effort
 - Sensitivity modeling of regional controls (e.g., 20% NO_x from N. America)
- Annual average surface ozone is ~ 35-40 ppb and is due to:
 - stratospheric inputs (20-25%), other natural precursors (20-25%)
 - anthropogenic precursors from outside continental region (>25%)
 - anthropogenic precursors from inside the continental region (>25%)
- “... this simple attribution masks strong regional, seasonal and daily variability in both O₃ abundance and in the contribution of different sources.” (HTAP Draft Assessment, 2010)
 - Decreasing local or regional emissions is more effective at decreasing the highest ozone levels

Contributions to Background O₃ (recent analyses)



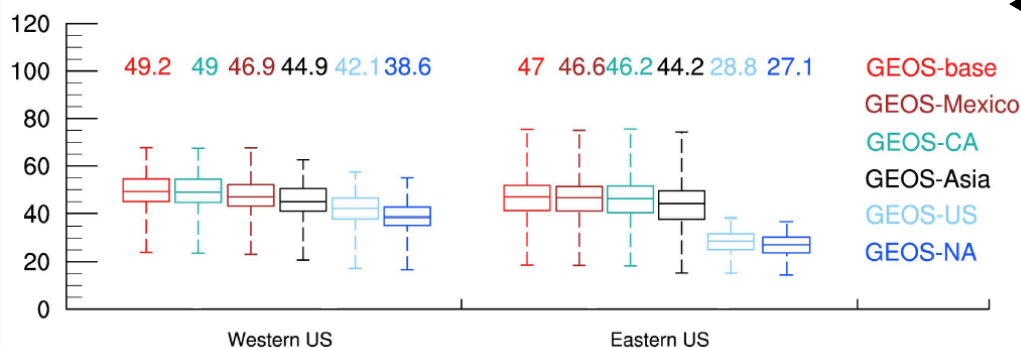
Preliminary results from Lin and Fiore (2011)

Note: Estimates of the stratospheric influence in GFDL AM3 are w/ fully-coupled stratospheric and tropospheric chemistry.

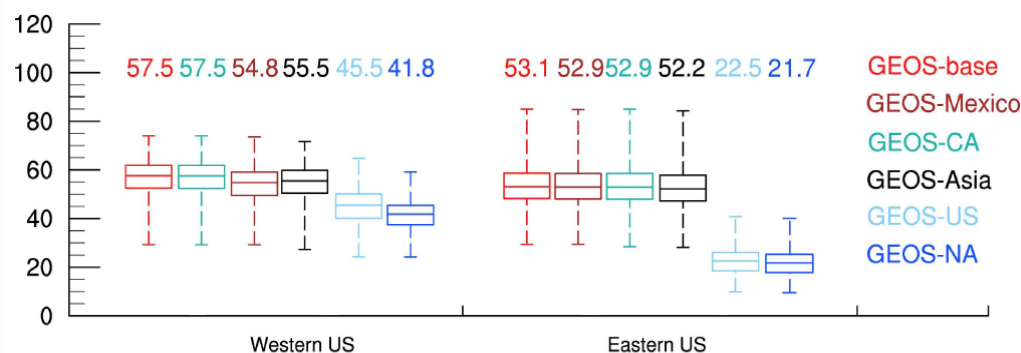
- GFDL AM3 model estimates of monthly mean daily max 8-hour O₃ in May 2010
- NA background concentrations can average 40-50 ppb in intermountain WUS
- Stratospheric contribution appears to be ~ 5x higher than Asian influence over intermountain WUS

Contributions to Background O₃ (recent analyses)

Spring

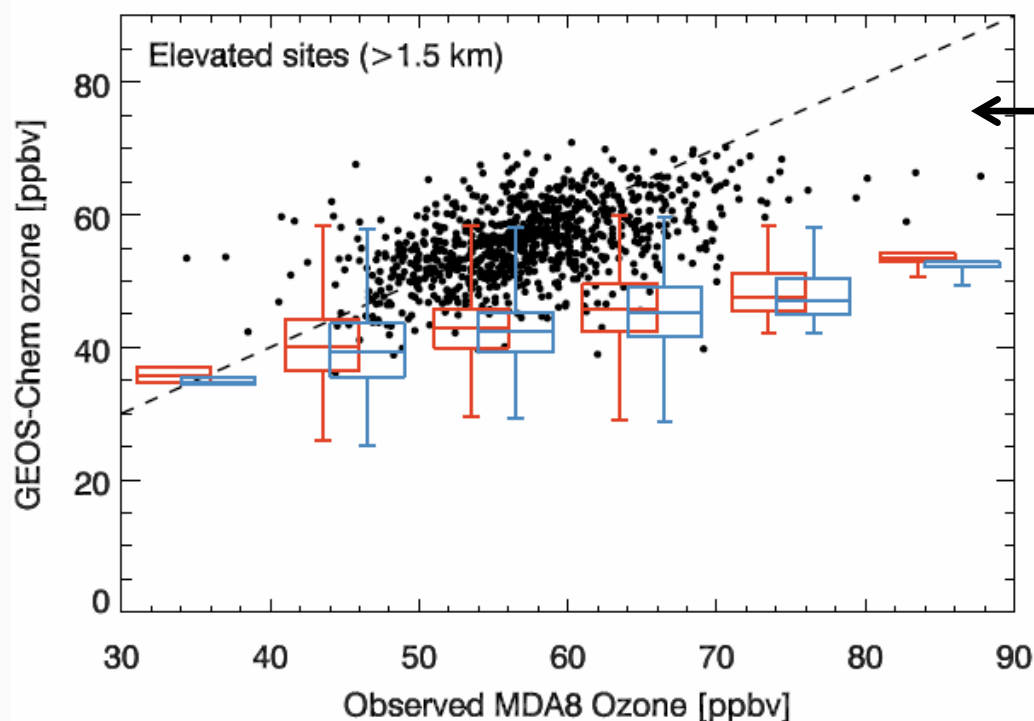


Summer



- ← GEOS-Chem model estimates of seasonal mean daily max 8-hour O₃ based in 2006-08
- N. American background concentrations average ~ 40 ppb in WUS
- Background contributions are largest at high-altitude sites
- Asian impacts ~ 3-5 ppb

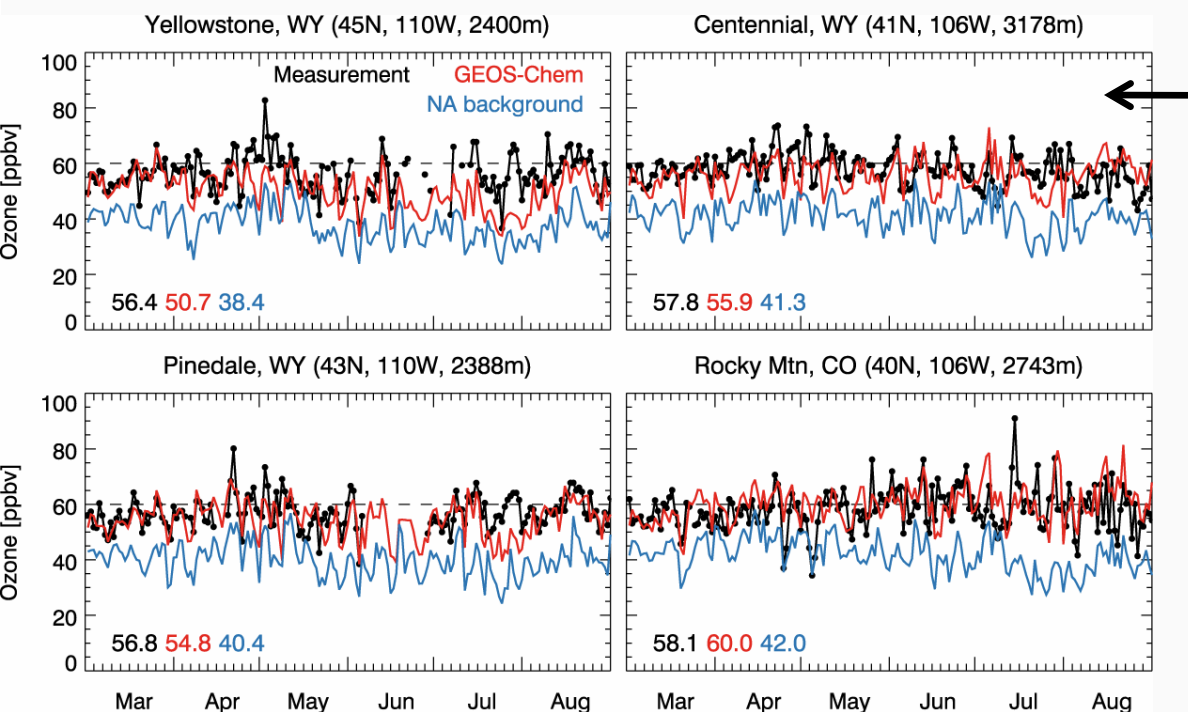
Contributions to Background O₃ (recent analyses)



Zhang and Jacob (2011)

- GEOS-Chem model estimates of US and NA background MDA8 O₃ at high-altitude WUS sites
- Background contributions increase slightly as observed concentrations increase
 - NA background when obs between 40-50: ~ 39ppb
 - NA background when obs between 60-70: ~ 45 ppb

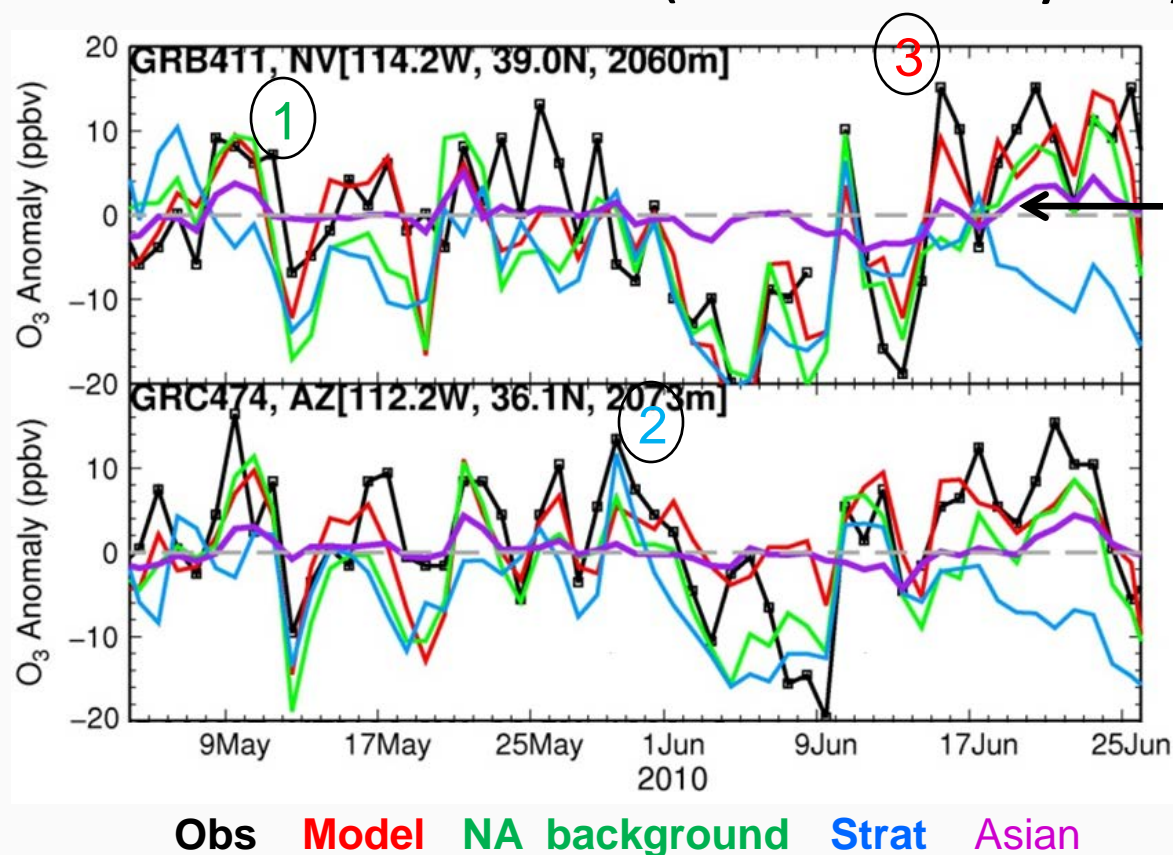
Contributions to Background O₃ (recent analyses)



Zhang and Jacob (2011)

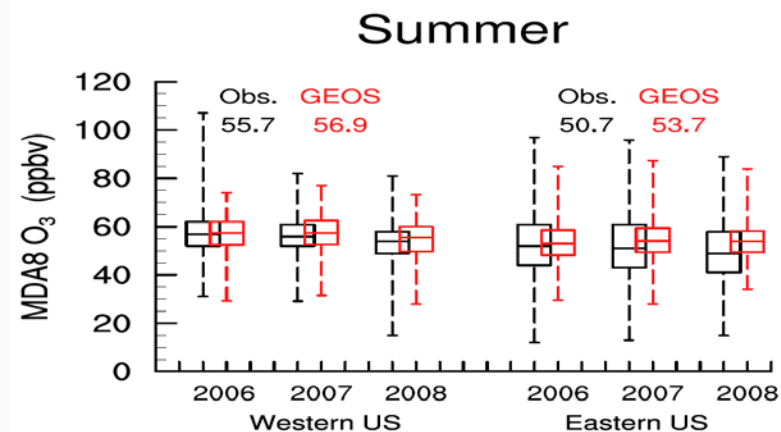
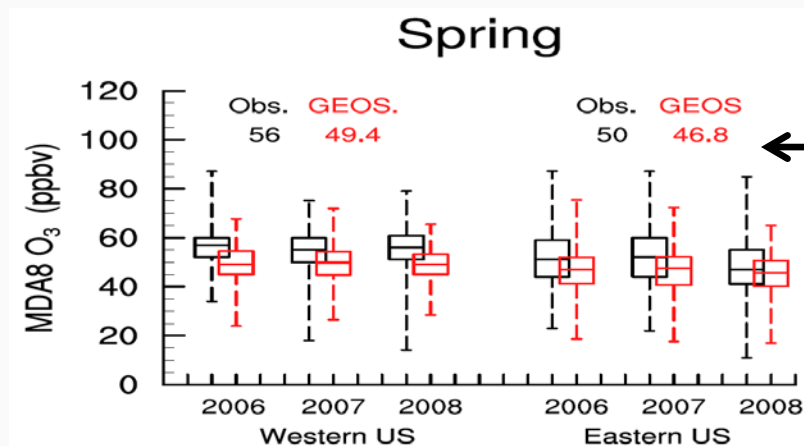
- GEOS-Chem model estimates of N American background MDA8 O₃ at four WUS sites
- N. American background concentrations average ~ 40 ppb
- N. American background almost never exceeds 60 ppb in modeling

Contributions to Background O₃ (recent analyses)



- GFDL AM3 time series of background source contribution from May-June at two WUS sites
(note: stratospheric intrusions were active during this period)
- Daily 8-hr peaks can vary by +/- 20 ppb
- Highest observed O₃ can be marked by higher than usual contributions from: NA background (1), stratosphere (2), or NA sources (3)

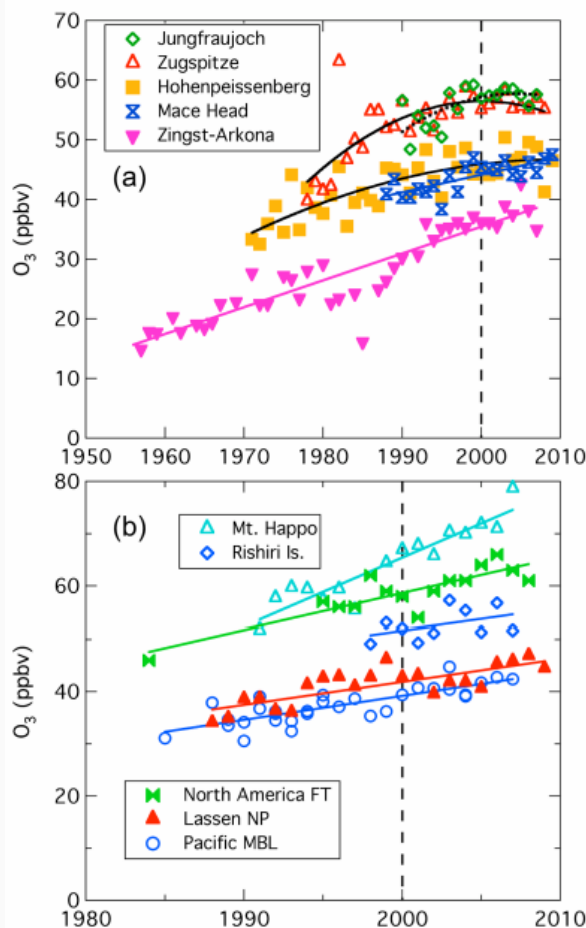
Contributions to Background O₃ (recent analyses)



Lam et al., (2011)

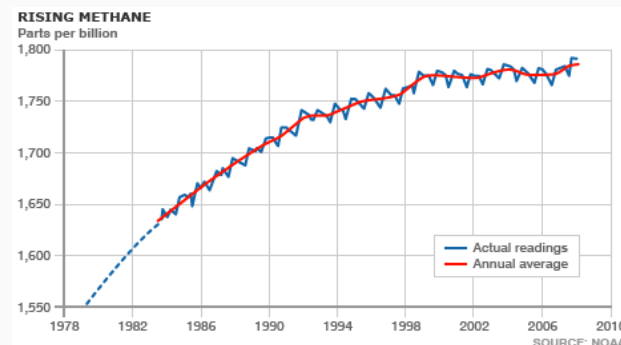
- GEOS-Chem model prediction distributions of MDA8 O₃ for multiple years @ CASTNET sites
- Tendency (in this exercise) for model to underestimate ozone in Spring.
- Interannual variation in MDA8 ozone ranges from 3-5 ppb (higher in WUS)

Increasing trends in background ozone



HTAP (2010): Final Report

- From satellite observations and other analyses, NO_x, VOC, and CO emissions continue to rise in many parts of the world.
- Cooper et al. (2010) showed springtime, mid-tropospheric increase of ~ 0.6 ppb/yr (+/- 0.3 ppb/yr) from 1995 to 2008.
- Fusco and Logan (2009) indicated that recent increases in methane concentrations have contributed to this increasing trend.





Guidance on assigning model boundary conditions?

- Procedures for developing base-year boundary conditions (BC)
 - If minimal impacts expected (clean conditions / “off-the-shelf” larger-scale modeling)
 - If conceptual model shows larger impacts than need to accurately characterize BC:
 - Use of global/hemispheric/larger-scale regional modeling
 - Evaluate model performance as best as possible
 - Try to minimize disconnects in the downscaling process (e.g., species, layers, met., etc.)
 - Consider limited diagnostic testing to determine influence of BC on model predictions
- Procedures for developing future-year boundary conditions?
 - If boundary conditions impact the AQ over the area of interest, then should consider how/if those contributions will change between the base and the attainment year.
 - Note recent ozone trends at sentinel sites which may help/hinder attainment.
 - May be necessary to use global/hemispheric modeling to estimate future BC.
 - Careful consideration of upstream emissions projections would be needed.
 - It will likely be left to the discretion of States as to whether varying future boundary conditions are part of core attainment demonstration or WOE analysis.



What additional technical work is needed?

- Improved ability to delineate contributions associated with local, regional and international sources
- Make progress in linking global and regional scale modeling systems
- Make progress in treating complex terrain and meteorology characteristic of the Western U.S.
- Collect additional observations in rural locations and throughout the vertical column of the atmosphere to assist model improvement efforts and exceptional event identification
- Engage with existing and emerging Western partnerships and the research community to leverage various resources (e.g., NASA ACAST)



Secondary Ozone Standard

- The proposed secondary ozone ambient air quality standard is a seasonal standard expressed as a sum of weighted hourly concentrations, cumulated over the 12-hour daylight period from 8:00 a.m. to 8:00 p.m. local standard time, during the consecutive 3-month period within the ozone monitoring season with the maximum index value. The design value is the average of the maximum 3-month sum from each year in a 3-year period.
 - Also known as W126
 - 40 CFR 50, Appendix P has all the details
 - Proposed a range from 7 to 15 ppm-hours
 - EPA has resource page: <http://www.epa.gov/ttn/analysis/w126.htm>

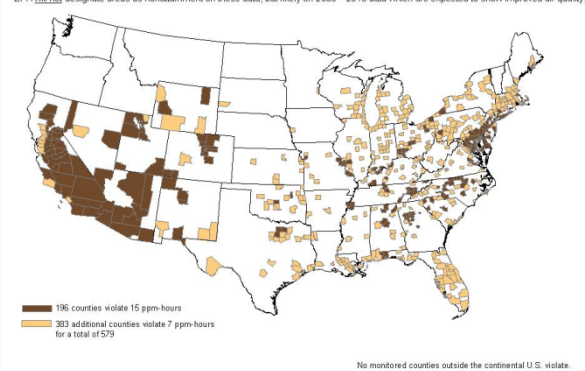


Attainment of Secondary O₃ Standard

- Generally speaking, and depending upon the eventual levels of the standard, most areas that violate the secondary ozone standard will also violate the primary standard.
- Possible exception would be elevated locations in the intermountain WUS.
 - Small diurnal amplitudes (flattish 8a-8p profiles)
 - High O₃ persistence from day to day
 - Hourly values of ~ 60 ppb may lead to exceedance
- Reducing impacts of background ozone (i.e., from non-US sources) are likely to be critical in attaining secondary NAAQS in these areas.

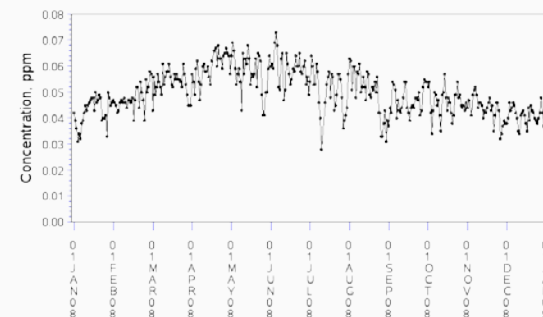
Counties With Monitors Violating Proposed Secondary Seasonal Ground-Level Ozone Standards
7 – 15 parts per million – hours
(Based on 2006 – 2008 Air Quality Data)

EPA will not designate areas as nonattainment on these data, but likely on 2008 – 2010 data which are expected to show improved air quality.



No monitored counties outside the continental U.S. violate.

Daily Ozone Concentrations from 01/01/08 to 12/31/08
STATE=Arizona COUNTY=Cochise MSA_NAME=Not in a MSA AQ5_SITE_ID=04-003-8001 POC=1



Source: EPA's Air Explorer (<http://www.epa.gov/air/explorer/>)
Generated on: 22JAN10



Questions/comments?

