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ENVIRON

Estimating Ozone Response to US Anthropogenic Emission Reductions Using HDDM Sensitivity

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2013 CMAS Conference

BACKGROUND

- EPA is reviewing alternative ozone standards and impacts to health risk (EPA, 2012)
  - Considering new standard in 60-70 ppb range
  - Health risk models need long-term site-specific hourly ozone data
  - Site-specific ozone data are "projected" to meet alternative standards
- Ozone modeling with HDDM is a good projection tool
  - Tracks ozone sensitivity to US anthropogenic emissions
  - Captures realistic non-linear ozone responses
  - Eliminates multitude of "brute-force" emission scenarios
  - Subject to usual model uncertainty and higher-order truncation errors
- CAMx/HDDM was run for 2006 at 12 km resolution over the entire US (Yarwood et al., 2013)

OBJECTIVES

- Estimate emission reductions needed to meet alternative standards
- Analyze impacts to ozone frequency distributions and exposure

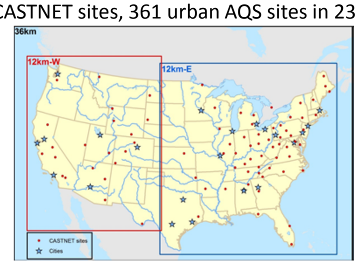
SUMMARY

We estimate the response of hourly, maximum daily 8-hour (MDA8), and time-integrated ozone (exposure) throughout 2006 for four cities to US anthropogenic NOx and VOC emissions reductions. Projections are derived from 2006 annual CAMx photochemical model runs of the entire US at 12 km resolution using the High Order Decoupled Direct Method (HDDM) of sensitivity analysis (Yarwood et al., 2013). HDDM tracks first and second-order ozone sensitivity to US anthropogenic emissions. A post-processing tool calculates hourly ozone for any NOx and VOC level at all AQS monitoring sites in 23 US cities and at every rural CASTNET monitoring site across the US. We report emission reductions needed to meet current (75 ppb) and proposed (60-70 ppb) US ozone standards in two cities. We further calculate how simple "exposure" metrics (time-integrated 1-hour and MDA8 ozone frequency distribution) are impacted by emission reductions between 0 to 100%. Results suggest that deep cuts (>50%) are needed to meet current and proposed US ozone standards, and that net exposure may be relatively non-responsive to changes in precursor emissions.

APPROACH AND RESULTS

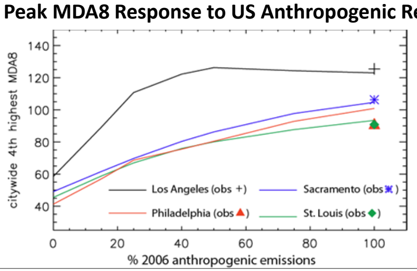
APPROACH

- HDDM calculates 1st and 2nd order sensitivities (derivatives) of ozone to changes in NOx (ΔN) and VOC (ΔV)
- Comprehensive Air quality Model with extensions (CAMx v5.40)
  - 2006 12-km US-wide CAMx modeling (Emery et al., 2012)
  - AQMEII US emissions/meteorological dataset (Rao et al., 2010)
  - HDDM configuration of Yarwood et al. (2013)
  - At 79 rural CASTNET sites, 361 urban AQS sites in 23 US cities



- Selected cities with good statistical agreement with hourly observations
  - 12 cities met 4th high MDA8 bias within 10%
  - 7 cities met frequency distribution total error within 25%
  - 4 cities chosen to represent different geography and size

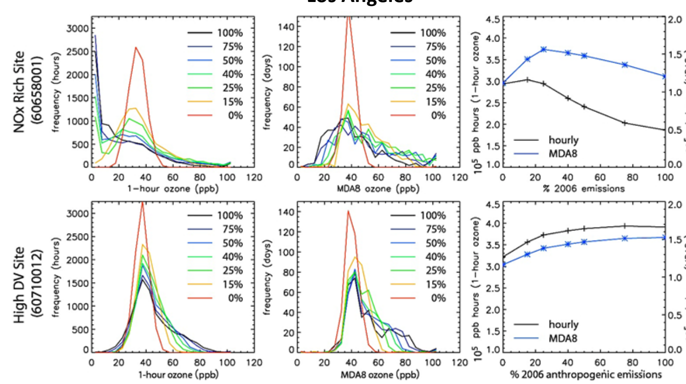
City-wide Peak MDA8 Response to US Anthropogenic Reductions



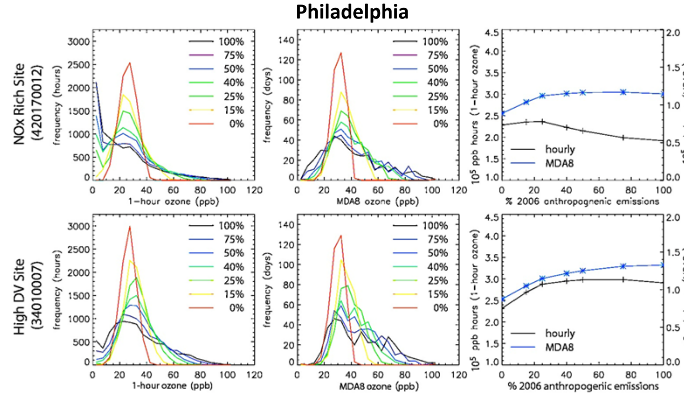
RESULTS

Two Example Cities

Los Angeles



Philadelphia



DISCUSSION

- Deep cuts (>50%) are needed at many cities to achieve alternative standards <75 ppb
- Tails of hourly and MDA8 frequency distributions shift toward mid-range (back-ground ozone)
- At NOx-rich sites, hourly exposure tends to increase with reduced emissions, then decrease with further reduc-tions
- Most sites show decreased MDA8 (daytime) exposure as emissions decrease
  - Little change down to ~25% remaining emissions
- Los Angeles shows increased MDA8 (daytime) exposure with decreasing emissions
  - The only city we analyzed with this feature – very NOx heavy LA Basin
- Single-year modeled responses should not be applied to other years with different emissions and meteorology

FUTURE DIRECTIONS

- Conduct HDDM modeling for more recent years
- These results could be used in risk models to quantify health impacts

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Yarwood, G., Emery, C., Jung, J., Nopmongcol, U., Sakulyanontvittaya, T., 2013. A method to represent ozone response to large changes in precursor emissions using high-order sensitivity analysis in photochemical models, *Geosci. Model Dev.*, 6, 1601–1608, doi:10.5194/gmd-6-1601-2013.