

Policies for Addressing PM_{2.5} Precursor Emissions



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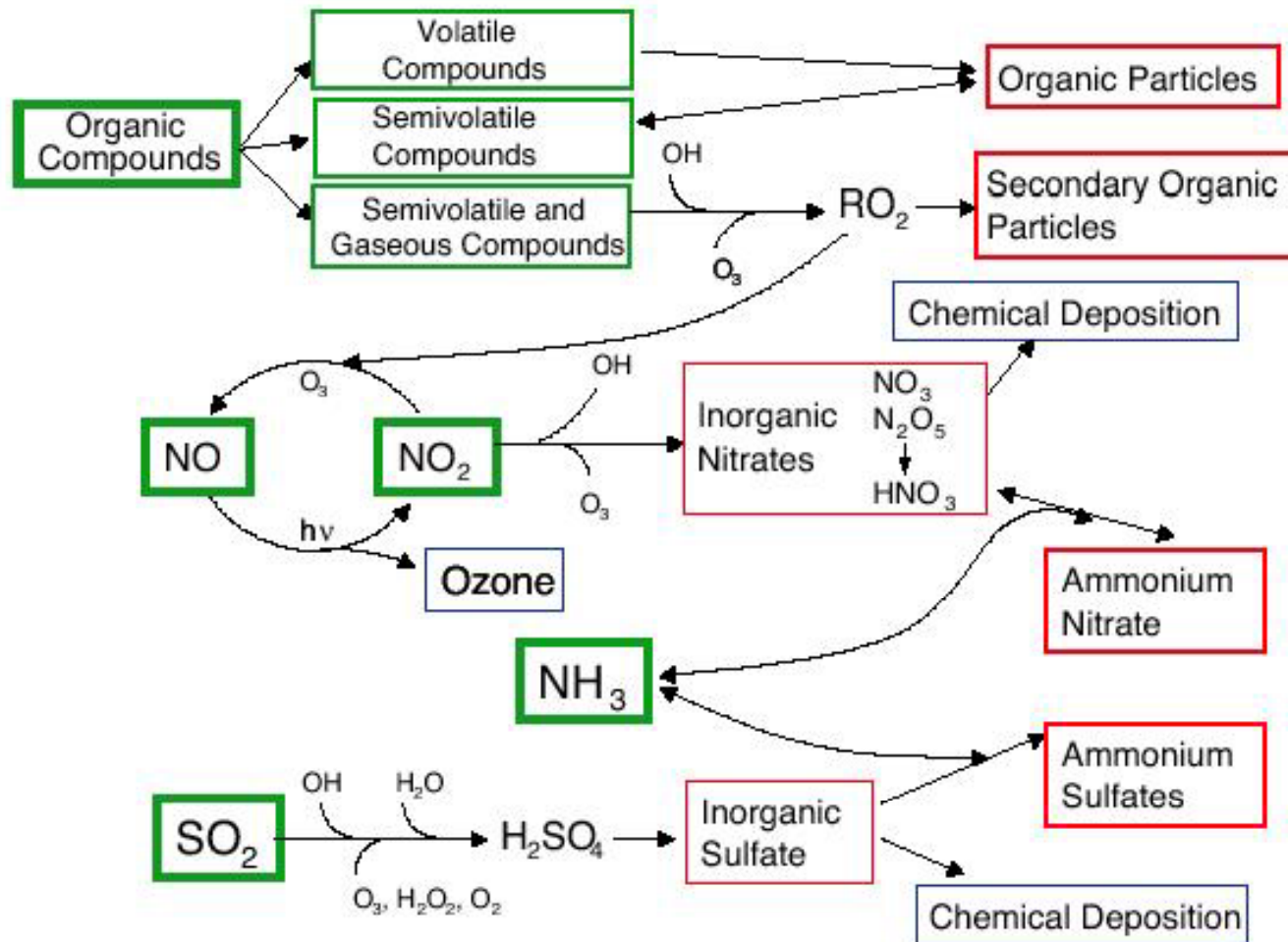
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Overview

- Sources of direct PM_{2.5} and SO₂ must be evaluated for control measures in all nonattainment areas
- For a specific area, the presumptive policy for NO_x, VOC, or ammonia can be reversed if the State and/or EPA provide a robust technical demonstration
- Implication: if statewide emissions of the precursor contribute significantly to PM_{2.5} concentrations in the area, then the state will need to evaluate sources of that precursor for reasonable control measures
 - These measures could include RACT/RACM for sources in the nonattainment area, and measures on other sources located in the state as needed for expeditious attainment

ATMOSPHERIC AEROSOL PROCESSES



Source: Particulate Matter Science for Policy Makers
 – A NARSTO Assessment, 2003.

Direct PM_{2.5} and SO₂

- Sulfate and carbon are significant fractions of PM_{2.5} mass in all nonattainment areas.
- Reductions in SO₂ lead to net reductions in PM_{2.5} mass concentrations despite potential slight increases in particulate nitrate levels.
- Policy: Direct PM_{2.5} emissions (includes organic carbon, elemental carbon, and crustal material) and SO₂ must be addressed in all areas

VOC

- The organic carbon component of ambient PM_{2.5} is a complex mixture of hundreds or even thousands of organic compounds.
- High molecular weight VOC condense readily when emitted to ambient air and are considered direct organic carbon particle emissions.
- The relative importance of anthropogenic and biogenic VOC in the formation of secondary organic aerosol (SOA) varies from area to area, depending upon local emissions sources, atmospheric chemistry, and season of the year.
- While significant progress has been made in understanding the role of gaseous organic material in the formation of organic PM, this relationship remains complex. SOA remains probably the least understood component of PM_{2.5}.

VOC (cont.)

- Organic carbon typically exhibits higher mass during the summer, when photochemical SOA formation and biogenic VOC emissions are highest.
- Aromatic compounds such as toluene, xylene, and trimethyl benzene are considered to be the most significant anthropogenic SOA precursors and have been estimated to be responsible for 50 to 70 percent of total SOA in some airsheds. Man-made sources of aromatic gases include mobile sources, petrochemical manufacturing and solvents.
- Policy: States are not required to address VOC in PM_{2.5} implementation plans and evaluate control measures for VOC unless the State or EPA makes a technical demonstration that emissions of VOCs from sources in the State significantly contribute to PM_{2.5} concentrations in a given nonattainment area.

Ammonia

- Ammonia reacts with sulfuric acid and nitric acid to form ammonium sulfate and ammonium nitrate. Ammonium sulfate formation is preferential under most conditions, though ammonium nitrate is favored by low temperature and high humidity.
- Emission inventories of ammonia contain uncertainties. Researchers are seeking improvements through process-based inventory approaches for animal feeding operations.
- Monitoring of ammonia gas and nitric acid is important for identifying when PM_{2.5} formation in an area is limited by ammonia or by nitric acid. However, there are a limited number of such monitoring sites.

Ammonia (cont.)

- Reducing ammonia emissions in some areas may increase the acidity of particles and of deposition. Increased acidity is linked to adverse ecological effects and is suspected to be linked with human health effects and with an increase in the formation of secondary organic compounds.
- In areas with high SO₂ emissions, ammonia reductions may marginally reduce PM_{2.5} concentrations, but particle and precipitation acidity may increase.
- After substantial SO₂ reductions in the east, in general PM_{2.5} changes are predicted to be less responsive to reductions in ammonia than to reductions in nitric acid.
- Policy: A State is not required to address ammonia in its attainment plan or evaluate sources of ammonia emissions for reduction measures unless the State or EPA makes a technical demonstration that emissions of ammonia from sources in the State significantly contribute to PM_{2.5} concentrations in a given nonattainment area.

NO_x

- Nitrate continuously transfers between the gas and the condensed phases through condensation and evaporation processes in the atmosphere.
- The formation of aerosol ammonium nitrate is favored by the availability of ammonia, low temperatures, and high relative humidity.
- Because ammonium nitrate is semivolatile and not stable in higher temperatures, nitrate levels are typically lower in the summer months and higher in the winter months.
 - Similarly, PM_{2.5} concentrations typically will respond most effectively to NO_x reductions in the winter.
- Under warm temperatures, Federal Reference Method monitors retain less nitrate in measured PM_{2.5}.

NO_x (cont.)

- Ammonia reacts preferentially with SO₂, but in the absence of significant amounts of SO₂, nitric acid will readily form ammonium nitrate (such as in many western cities).
- A decrease in NO_x can reduce the oxidation process and thereby reduce sulfate formation.
- Policy: States are required to address NO_x as a PM_{2.5} attainment plan precursor and evaluate reasonable controls for NO_x in PM_{2.5} attainment plans, unless the State and EPA make a finding that NO_x emissions from sources in the State do not significantly contribute to PM_{2.5} concentrations in the relevant nonattainment area.

Technical Demonstrations

- Any proposed technical demonstrations should be developed in advance of the attainment demonstration and in consultation with the EPA Regional Office
- Demonstration should consider all available scientific and technical information
- As part of the SIP, it will be subject to public review and comment under State administrative process
- If the administrative record related to development of the SIP shows that the presumption for a precursor is not technically justified for that area, the State must submit a demonstration to reverse the presumption [40 CFR 51.1002 (c)(5)]

Technical Demonstrations (cont.)

- Weight of evidence approach based on a number of technical analyses
 - Potential analyses vary by pollutant
- Demonstrations will be reviewed on case-by-case basis

Tools for Assessing Significance / Insignificance of Contribution from All Statewide Sources to Nonattainment Area PM_{2.5} Concentrations

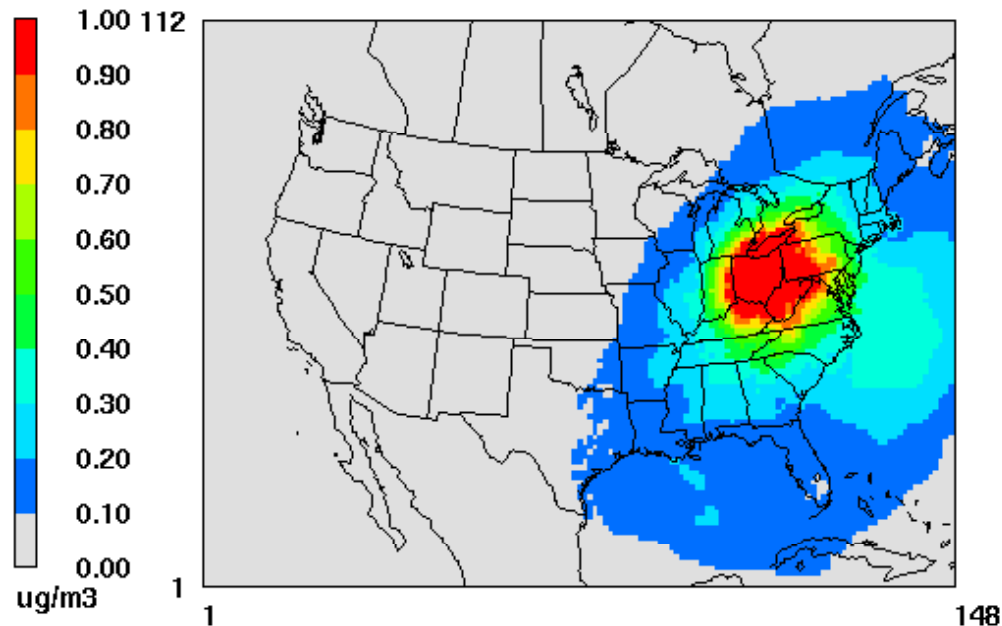
- Photochemical modeling – zero-out analysis; sensitivity analysis
- Photochemical source apportionment tools (PSAT, DDM, TSSA, etc.)
 - For estimating impact of all sources
- Receptor modeling (e.g. PMF, CMB)
- Analysis of ambient monitoring data, speciation data, and trends
- Analysis of emissions inventories and trends
- Others...

Questions to Address in Technical Demonstrations

- 1) What is the contribution of all Statewide sources of the precursor (e.g. NO_x, VOC, or ammonia) towards annual average PM_{2.5} concentrations in the nonattainment area?

Impact on PM_{2.5} of Ohio SO₂+NO_x

Based on 2010 Ohio Zero-Out Modeling
b=cmp5_2010af_us36b_ANNUAL.nc, c=cmp5_2010af_zoh_us36b_ibm_ANNUA



Example

January 1,0 0:00:00
Min= -0.01 at (21,57), Max= 1.84 at (112,64)

Questions to Address in Technical Demonstrations (cont.)

- 2) Do contributions from the precursor to PM_{2.5} vary by season?
- If so, are the contributions small in one or more seasons, but possibly significant in other seasons?
 - Is the precursor a key contributor to high concentrations on individual days?

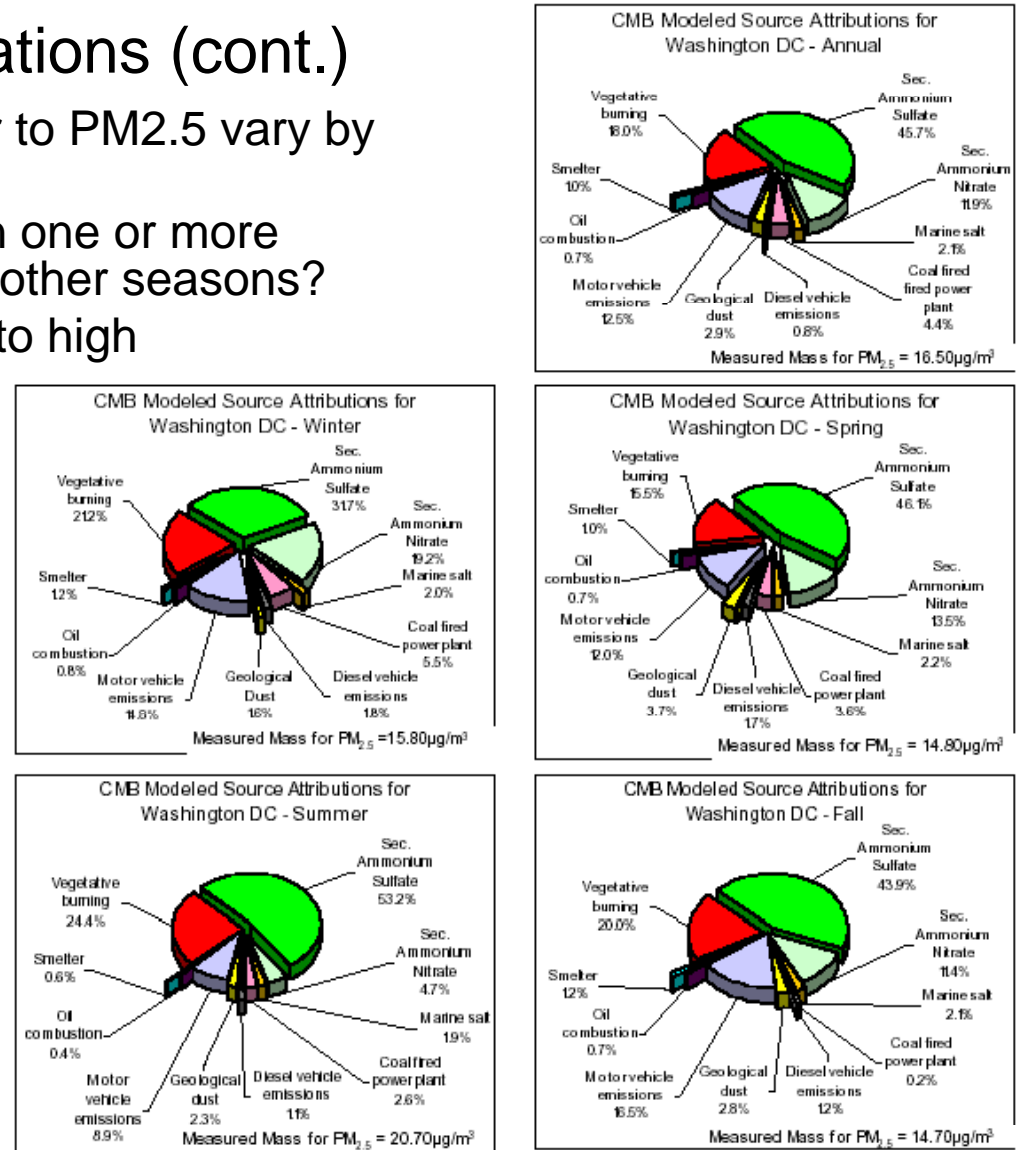
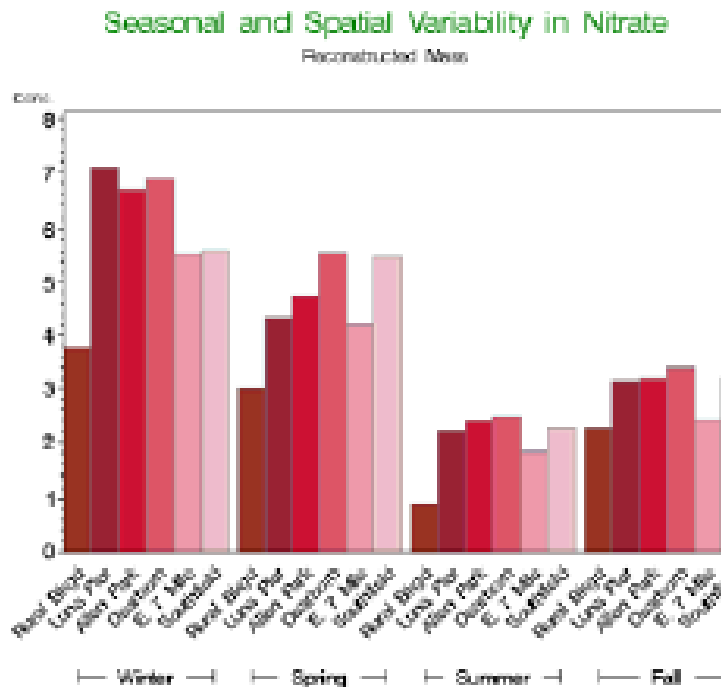
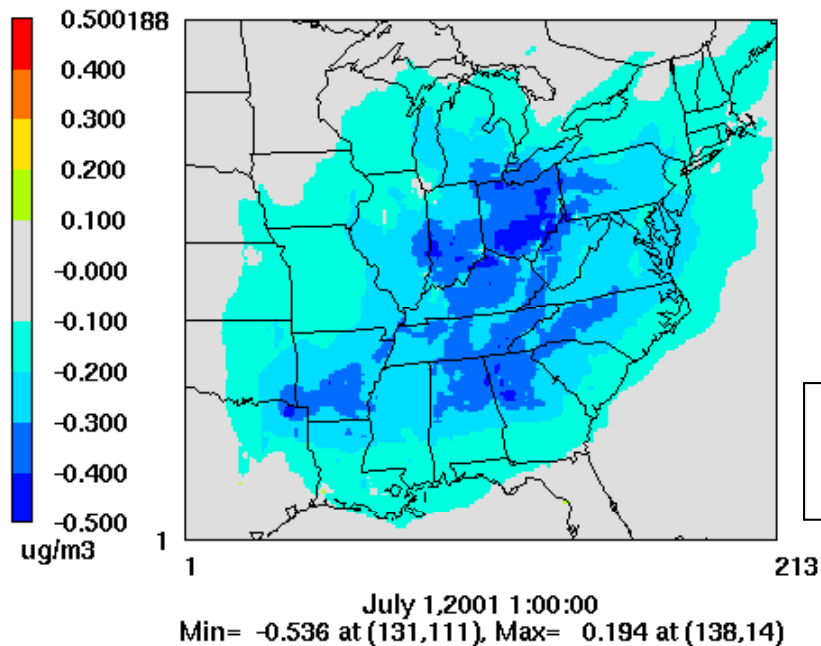


Figure 6.6-5 CMB modeled source attributions for mean annual and seasonal data subsets from Washington DC
Source: "Source Apportionment Analysis of Air Quality Monitoring Data: Phase II," prepared by Desert Research Institute, March 2005, for the Mid-Atlantic/Northeast Visibility Union And Midwest Regional Planning Organization

Questions to Address in Technical Demonstrations (cont.)

- 3) Do reductions or increases in the precursor affect the concentrations of other PM_{2.5} species? If so, what is the individual impact on each PM_{2.5} species?
- Effect of ammonia reductions on atmospheric acidity
 - Effect of NO_x reductions on sulfate and SOA
 - Effect of anthropogenic VOC reductions on SOA, sulfate, and nitrate



Impact on Sulfate Concentrations from
a Domainwide 50% NO_x reduction

Questions to Address in Technical Demonstrations (cont.)

- 4) Does ambient monitoring support the conclusions?
 - Are there available monitoring data to determine whether an area is ammonia-limited or nitric acid limited?

Questions to Address in Technical Demonstrations (cont.)

- 5) Are there uncertainties in the emissions inventories that might lead to inconclusive findings regarding significance/insignificance of a precursor?
- 6) Do the uncertainties in the air quality models lead to inconclusive findings regarding significance/insignificance of a precursor?