About this presentation

This EPA staff presentation was delivered to an October 18 meeting of a subcommittee of EPA's Clean Air Act Advisory Committee (CAAAC). The subcommittee was meeting as part of their work to address the recommendations of the National Academy of Sciences for improving air quality management in the United States.

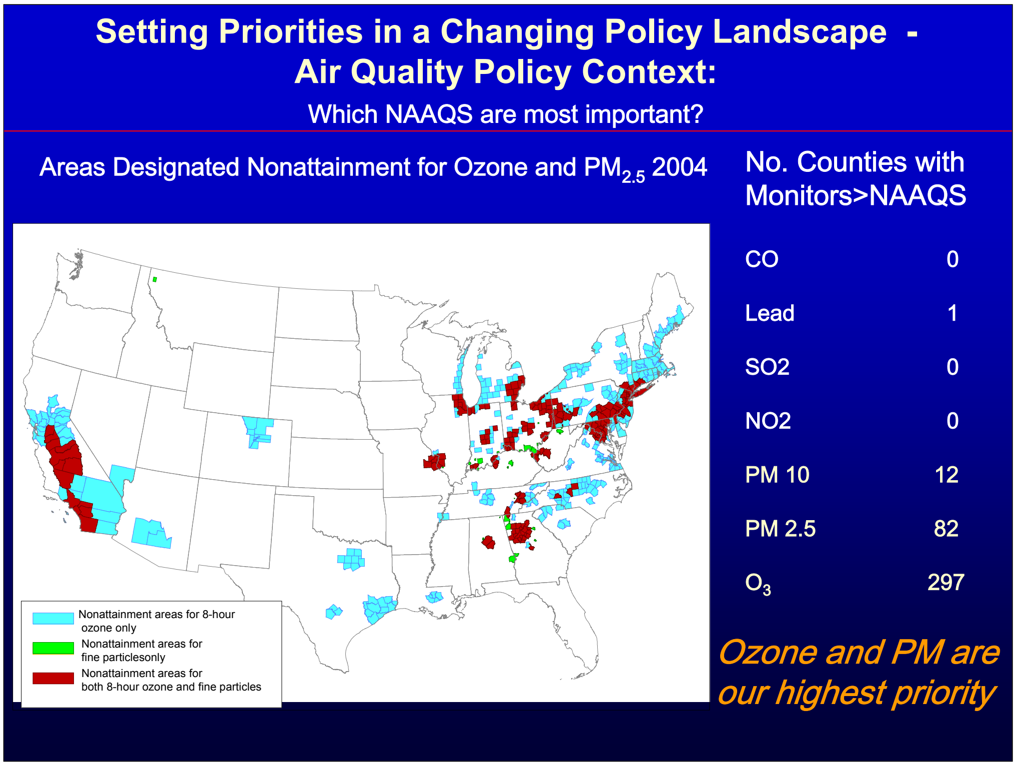
Purpose: The purpose of this presentation is to stimulate discussion of the kinds of challenges air quality managers could face in the next 10-15 years. It is intended to assist the CAAAC Subcommittee on Air Quality Management in its discussions regarding improvements to the current AQM system. The 2004 NRC report listed a number of likely challenges to air quality management in the US over the foreseeable future. This briefing examines the basis for the NRC findings and expands upon some of them to provide more specifics. The approach uses a combination of qualitative and quantitative forecasts and analyses developed by EPA and others to cover a range of relevant air quality problems and other factors that air quality mangers may need to address. It includes some scenarios, forecasts and alternative policy choices related to criteria pollutants and air toxics, emerging issues related to long-range transport, the multi-faceted ways in which climate and air quality/policy might interact, and touches on emerging themes and societal issues.

Limitations and uncertainties: The quantitative emissions and air quality forecasts summarized here were gathered from a variety of sources and projects. The numerous uncertainties inherent in such forecasts are documented elsewhere but are important to keep in mind here. The alternative policy scenarios are not the only possible ones, and several topics are treated only as a qualitative reminder of their potential importance. The issues included and highlighted represent one EPA staff perspective and not Agency policy. Further, the presentation is not definitive. We encourage readers, especially CAAAC subcommittee participants, to articulate a variety of alternative views on these and to identify other potential issues not highlighted.

NRC: Challenges for Air Quality Management

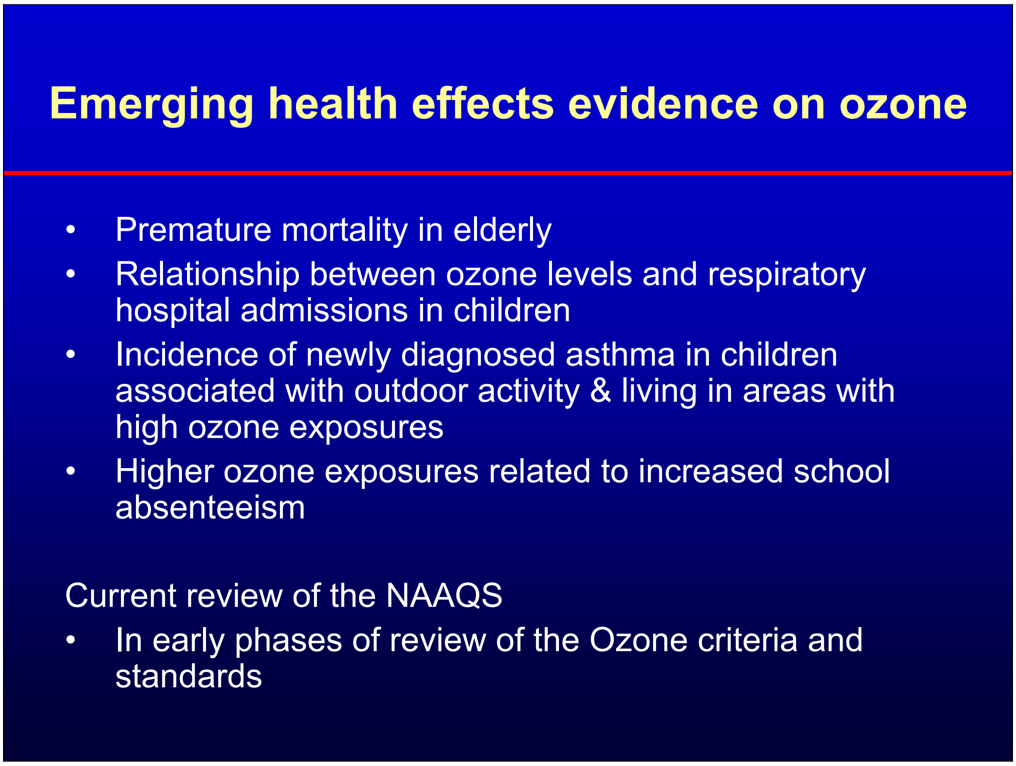
- Meeting NAAQS for O_3 and $PM_{2.5}$ and Reducing Regional Haze
- Designing and Implementing Controls for Hazardous Air Pollutants
- Protecting Human Health and Welfare in the Absence of a Threshold
- Ensuring Environmental Justice
- Assessing and Protecting Ecosystem Health
- Mitigating Intercontinental and Cross-Border Transport
- Maintaining AQM System Efficiency in the face of Changing Climate

The NRC summarized these seven major challenges for air quality management. This presentation focuses more on the quantifiable and technical, rather than normative, aspects of these challenges. As such, it touches only briefly on the the issues of addressing thresholds, environmental justice, and protecting ecosystems.



This slide depicts the most current single year (2004) of valid US monitoring data for the six criteria pollutants (including two PM indicators). Note that for most of the NAAQS, 3 years of valid data are required to determine attainment status, so the data here are only indicative of potential attainment/nonattainment. Nevertheless, levels of these pollutants have been dramatically reduced over the last two decades, a measure of some success for the US system of addressing air quality problems. In terms of the current NAAQS, it is clear that PM and ozone are by far the most significant problems remaining today.

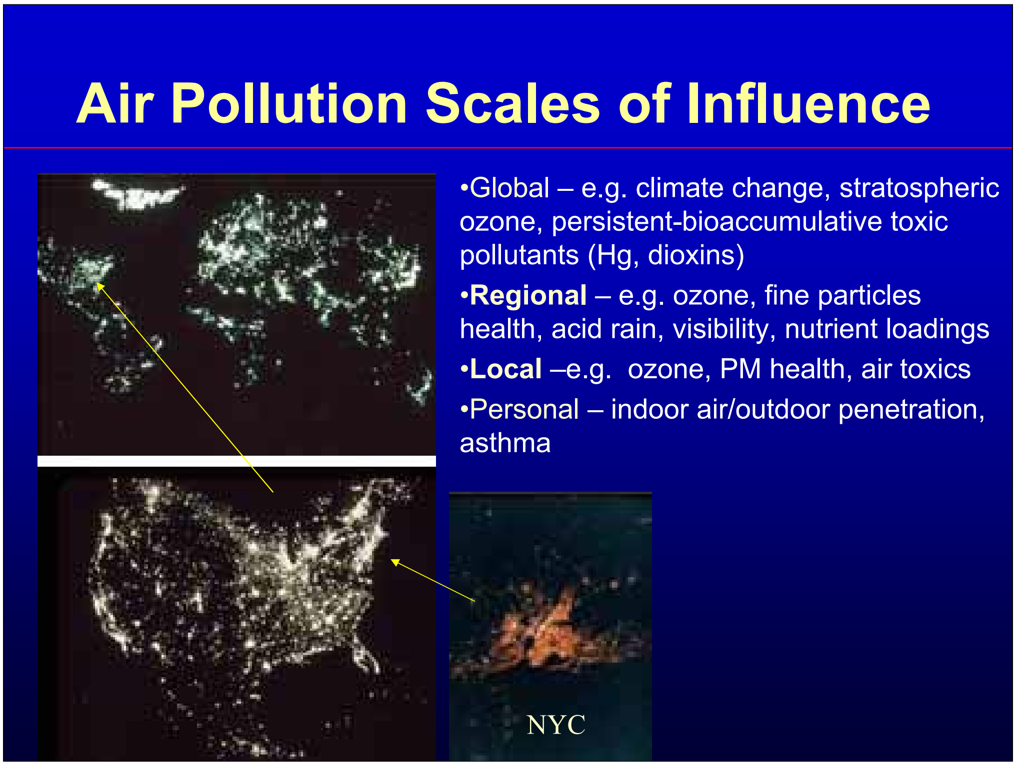
The map illustrates the pattern of persistent problems for fine particles and ozone, including much of the eastern US, the gulfcoast, and California. The red areas show where the problems strongly overlap. It is of note that comprehensive strategies to address PM and ozone in these areas will require control of sources of SOx, NOx, volatile organic compounds (including some air toxics), and possibly CO.



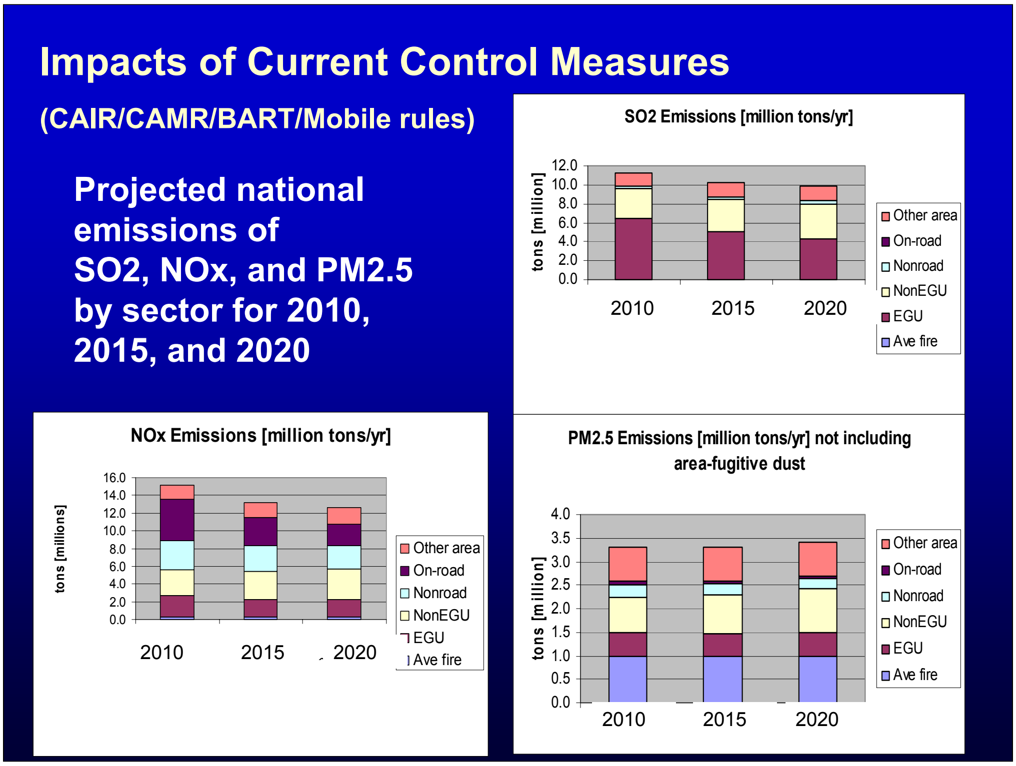
Besides being the most pervasive criteria pollutants, scientific evidence continues to grow that PM and ozone can produce significant health effects. Mentioned in the verbal presentation, but not shown here, are the now well recognized relationships between PM and a number of significant effects, including premature mortality, hospital admissions for cardiovascular and respiratory conditions, and effects on children. Importantly, scientists have found a link between ambient fine particles and heart rate in controlled human and animal studies as well as in epidemiological studies that strengthens the plausibility of these effects.

This slide focuses on emerging evidence that, in addition to the familiar lung function changes and symptoms in controlled human studies, ozone is linked to mortality, hospital admissions, school absenteeism, and asthma incidence.

Not shown here are the links between these pollutants, their precursors and effects on public welfare, including visibility impairment, crop and ecosystem damage from ozone, acids, and nutrients, and materials damage.

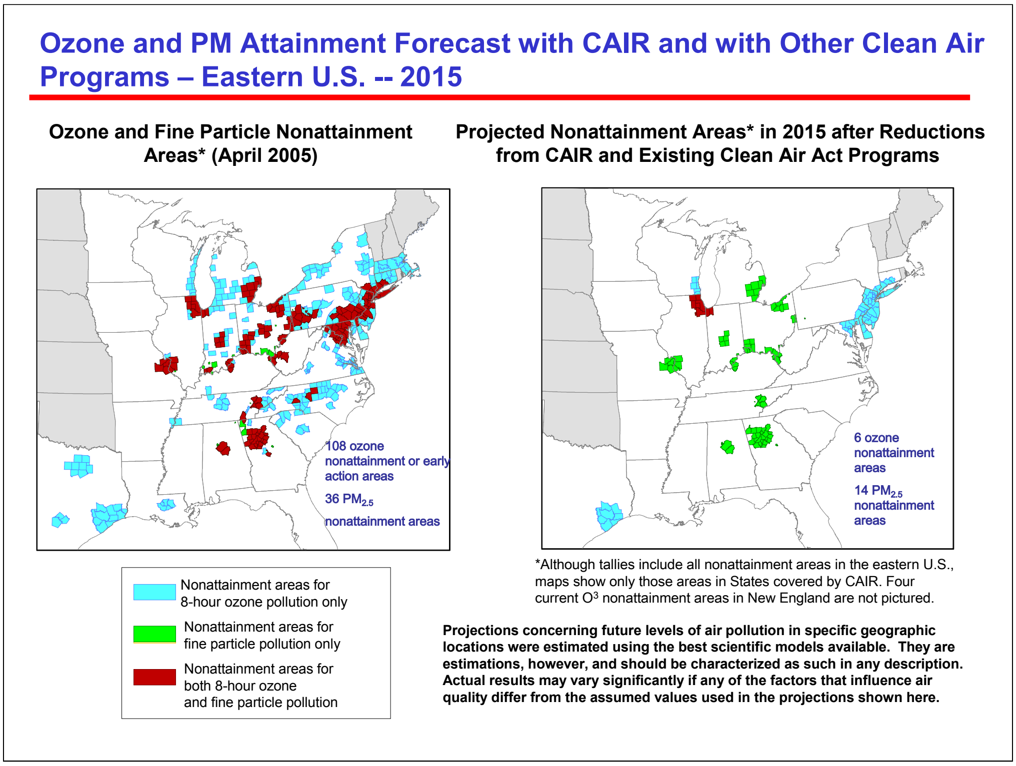


One of the themes that the NRC noted was the need to address air quality on the appropriate geographical scale. Both criteria and toxic air pollution problems and solutions can very significantly across multiple scales both larger (regional/global) and smaller (personal) than the traditional focus of early AQM programs, which was on local/urban scales.



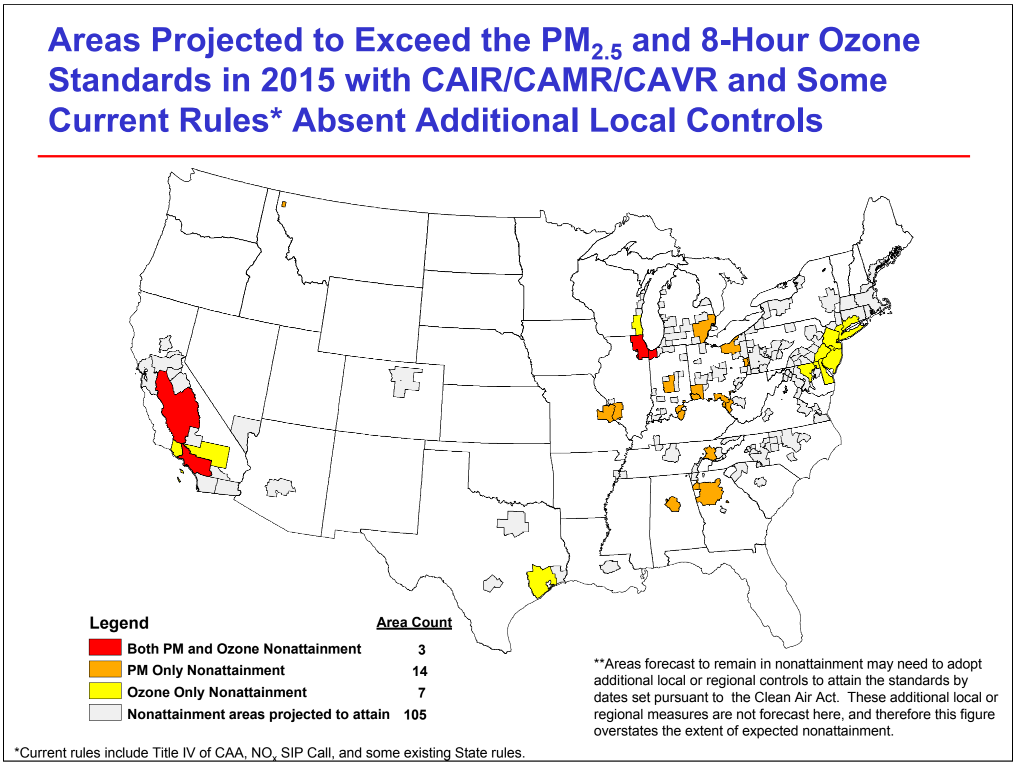
This is the first in a series of emissions/air quality forecasts for 2010, 2015, and 2020 that are based on recent and ongoing regulatory impact analyses (RIA), including the Clean Air Interstate Rule, the Clean Air Mercury Rule, and the Clean Air Visibility Rule. Shown are emissions forecasts for pollutants needed to model fine particle concentrations and ozone (VOC not shown) under a 'regulatory base case' scenario. That is, the forecasts reflect one scenario of projected activity growth in key emitting sectors (e.g. EGU, mobile source VMT, industrial sources) as limited by regulations at the state, local, and federal levels that are in State Plans or National Rules/requirements that have been promulgated (e.g. NOx SIP call, CAIR/CAMR/Mobile diesel, Tier 2 rules, NC Clean Smokestack program). This means the forecast does not include additional strategies that States will need to adopt to make progress towards attaining the ozone and PM NAAQS over this period. It is one picture of what the States might start with in developing such strategies and plans.

Key Uncertainties: All activity and rule forecasts are subject to substantial uncertainty regarding the economy and other factors. Because growth is applied to current estimates, the inherent uncertainties in current inventories affect these estimates. Our EGU inventory and forecast models for SOx and NOx are likely significantly better than for industrial and other sources. In some cases, forecasts are biased high because expected improvements in future controls can not be objectively determined. The lack of progress or increase in some categories over time may not be realistic. Direct PM emissions estimates for all categories are particularly uncertain, both in the base and future cases. While individual mobile source technologies are well characterized, significant uncertainties are suggested by comparisons between emissions and ambient measurements. These uncertainties are more fully discussed in the relevant RIA and background Technical support

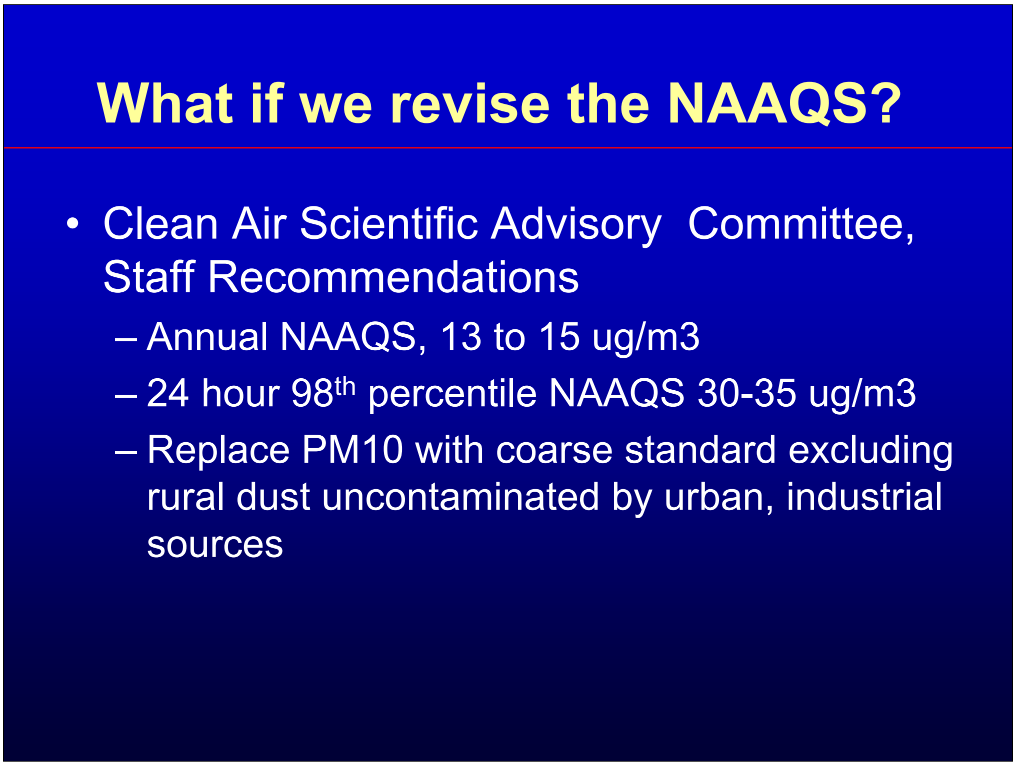


These maps reflect the ozone and PM air quality attainment forecast consistent with the emissions projections in the previous slides. It is taken from the CMAQ and CAMx modeling done for CAIR/CAMR in the eastern US. These results suggest that the current patterns of regional air quality will significantly improve, but that substantial residual nonattainment may be expected without further controls beyond the regulatory base case. Further, the overlap between ozone and PM nonattainment has greatly diminished, with ozone nonattainment most prevalent in high population areas along the NE corridor, Houston, and Chicago coasts and PM more concentrated in the midsection. Except for Chicago, these heavily populated areas (the NE corridor and Houston) would meet the current PM2.5 NAAQS, with nonattainment occurring in the midsection from Michigan down to Alabama and Atlanta. The common thread in eastern projected PM nonattainment areas appears to be higher regional PM2.5 levels, frequently combined with a concentration of local sources of direct PM emissions such as industrial activities.

Key Uncertainties: In addition to the emissions uncertainties noted previously, these air quality models are subject to a number of well-documented uncertainties related to meteorology, chemistry, and transport simulation and forecasts. In addition, the meteorology that drives these models is likely to vary from that in any particular forecast year.

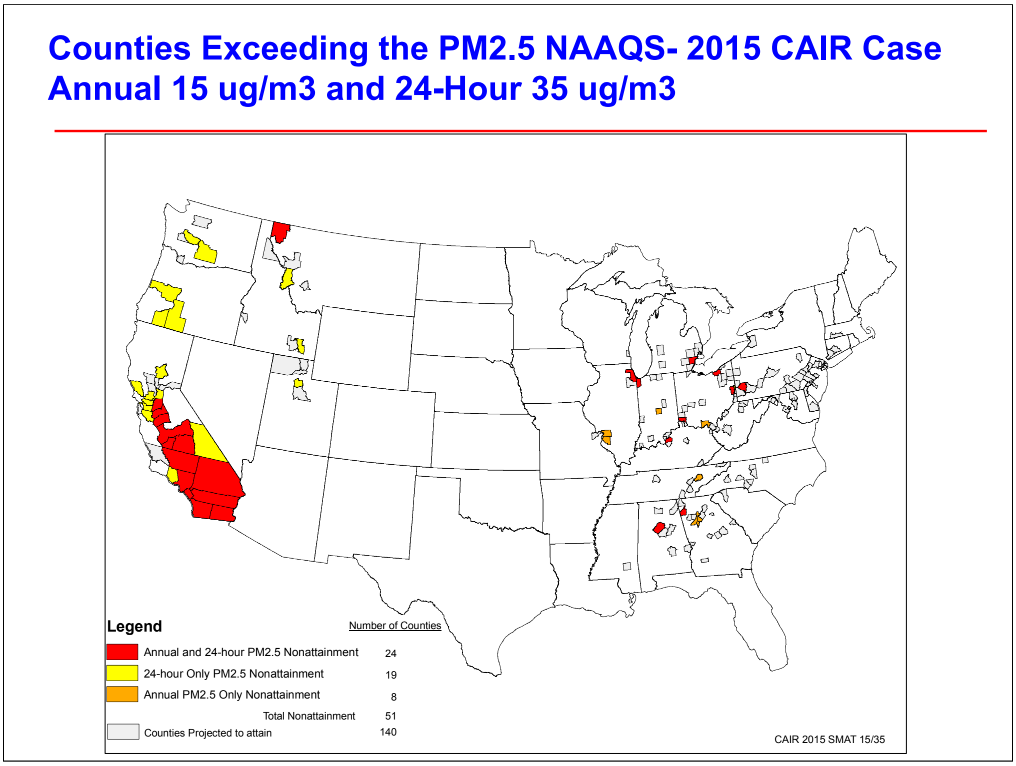


This map expands the 2015 regulatory base case scenario forecast to the entire country. Residual nonattainment in the West is confined to California. The CAIR/CAMR/CAVR programs are not expected to produce much impact on attainment in the West, so other programs (mobile, local) likely account for the forecast improvements. It is clear that attainment strategies in the East may involve additional local or regional controls, but less clear which strategies would be most cost-effective. In the West, all controls would be intra-state, but this does not exclude long-range transport considerations in a state the size of California.



While the previous slides provide a snapshot of projected issues under the current standards, both the PM and ozone criteria and standards are under review. The PM review, in particular, is nearing completion with a proposal on whether to revise the standards set for December 20th of this year and a final decision by September 27th, 2006. The review of the fine particle NAAQS provides an illustration of one of the challenges the NRC listed, that is, selecting an appropriate level of protection for pollutants that do not have a clearly defined threshold below which there is no effect. This issue of assessing the health effects evidence and conducting quantitative risk assessments given such uncertainties is addressed in the PM staff paper (ref), and with reviews and recommendations of the Clean Air Scientific Advisory Committee (CASAC) in a June 6, 2005 letter on the staff paper (ref).

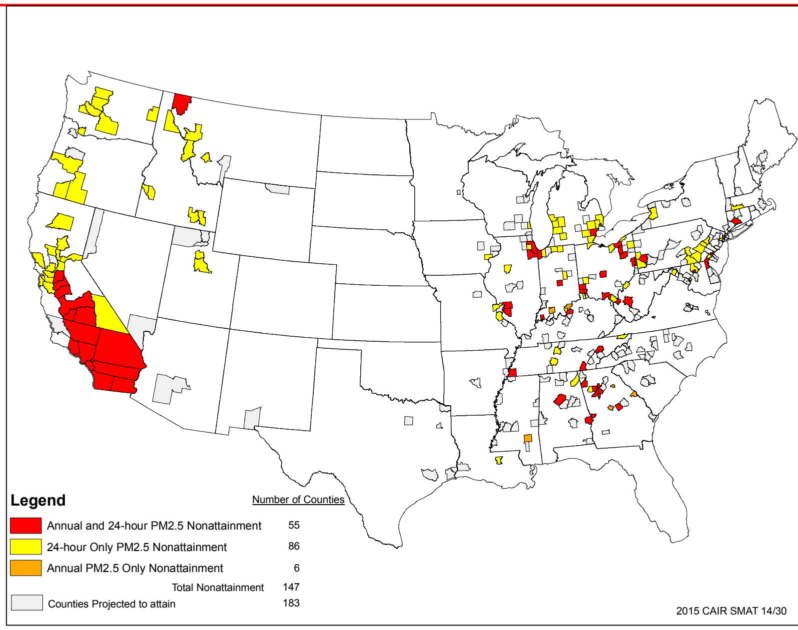
The combined range of standards recommended by staff and CASAC is summarized briefly above. The next two slides illustrate projected air quality in 2015 under two of the alternatives PM2.5 NAAQS taken from the upper to lower portion of the above ranges.



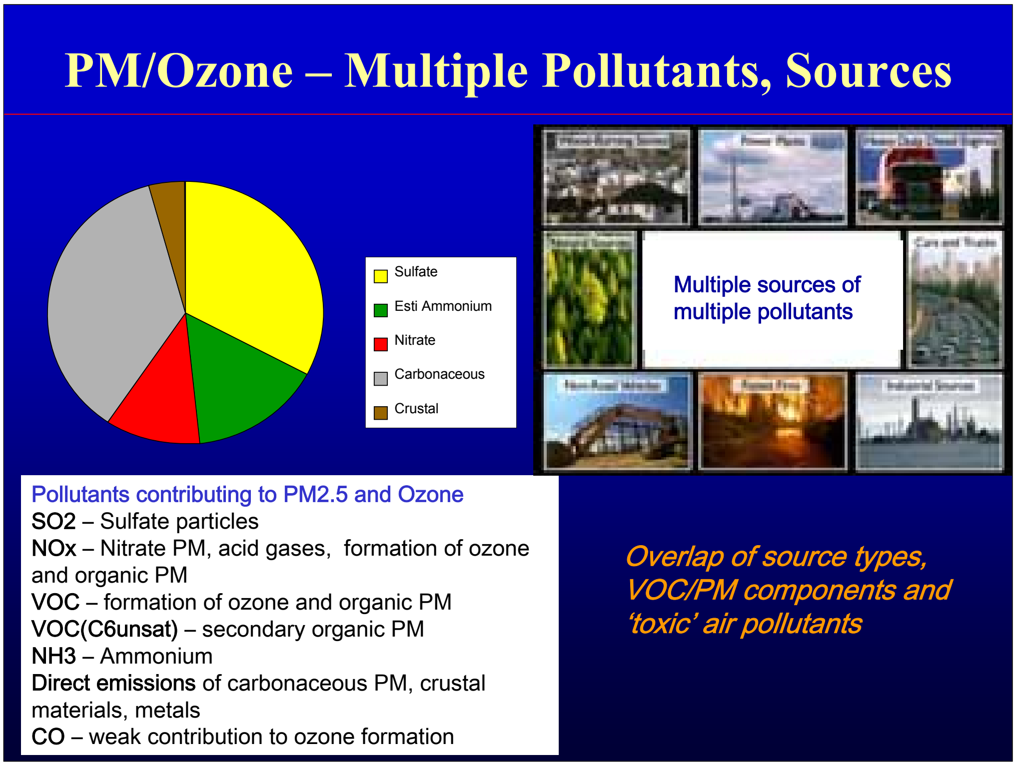
This map shows forecast PM2.5 levels in 2015 with the current regulatory base case but compared to an alternative NAAQS that maintains the current annual standard but establishes a tighter 24-hour standard taken from the upper bound of the CASAC range. The results suggest that CAIR and other base programs will be very effective in attaining the 24-hour standard – only one county in the East would exceed the tighter 24-hour standard but not the current annual standard. It is possible that additional local or regional strategies adopted by eastern States to meet the annual standard would result in compliance with both standards in many eastern areas where both are forecast to be in violation. The major new residual non-attainment counties forecast for a tighter 24-hour standard under the current regulatory base case scenario are almost entirely in the West, particularly in the Northwest where seasonally high levels of PM2.5 are often caused by wintertime wood smoke.

Major Uncertainties: In addition to those noted previously, the daily CMAQ results used to generate 24-hour 98th percentile values are likely to be more uncertain than the annual averages – because of meteorological, current air quality, and emissions inputs as well as modeling uncertainties. Nevertheless, the predicted effectiveness of regional SOx and, to a lesser extent, NOx controls on reducing peak 24-hour values in the East is consistent with the observed composition of PM2.5 on peak days.

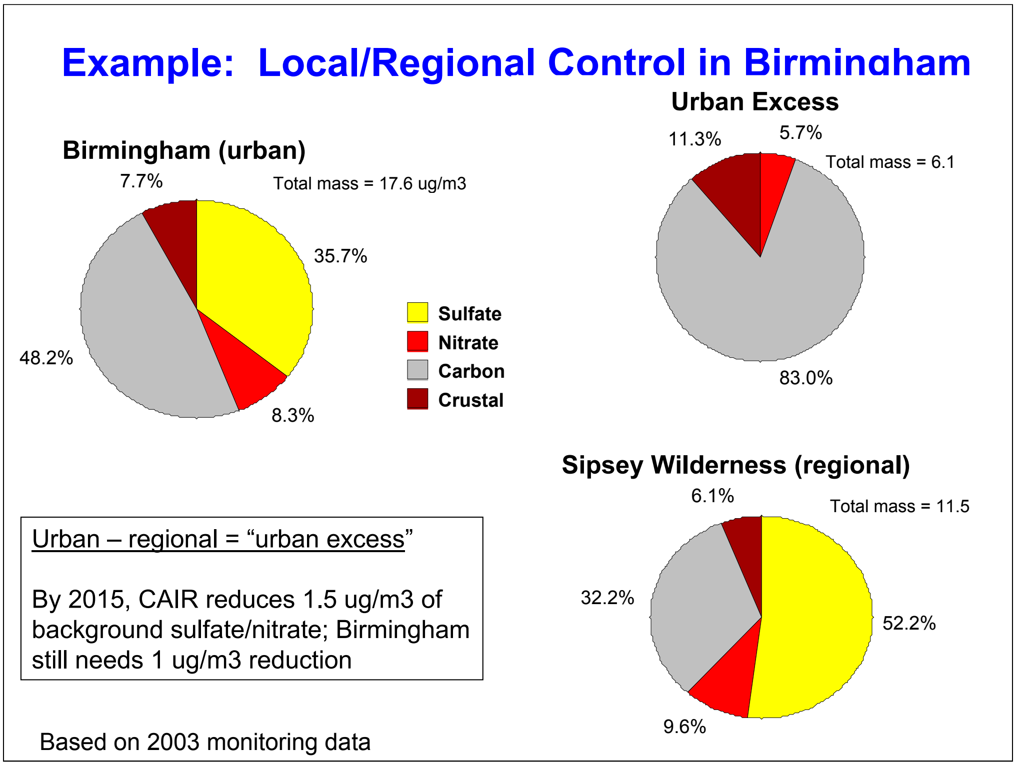
Counties Exceeding the PM2.5 NAAQS- 2015 CAIR Case
Annual 14 ug/m3 and 24-Hour 30 ug/m3



Same as previous slide, but under alternatives taken from the lower portions of the recommended CASAC range of alternatives. This alternative shows a larger number of residual nonattainment areas in both the East and the West. The results suggest that tighter annual standards in this range have their major effect in the East where even in 2015 a higher regional background remains. The West appears more affected by tighter 24-hour standards, but at the levels depicted here, a significant number of additional 24-hour violations occur in the East as well.

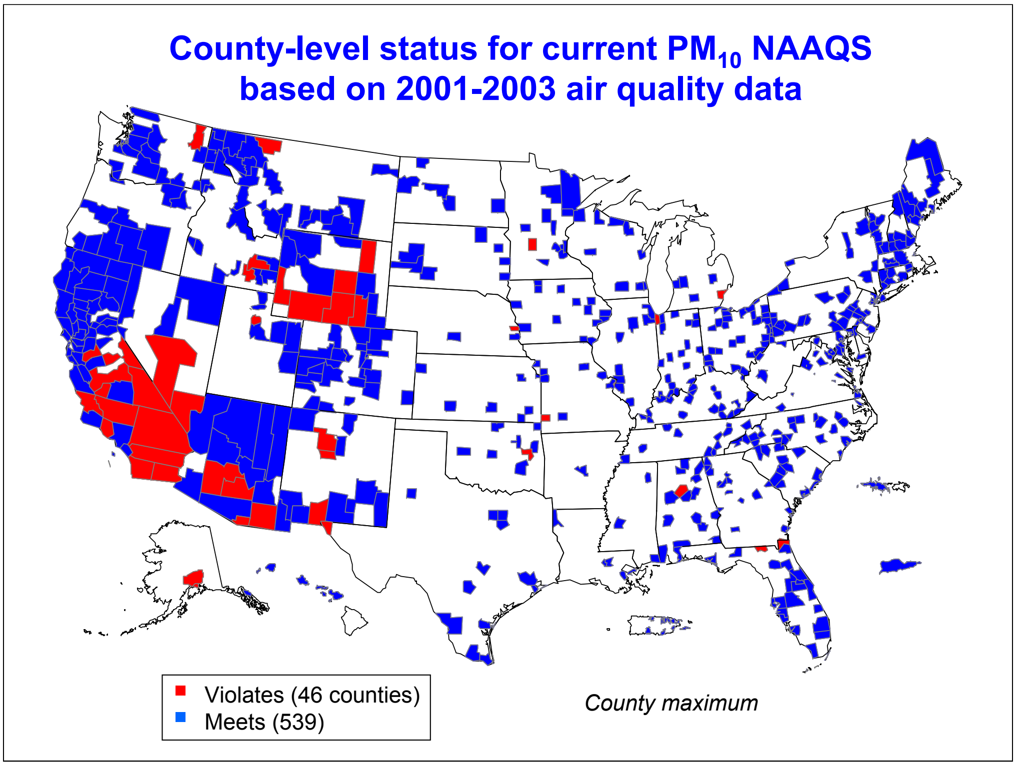


In further posing potential attainment strategy considerations, it is useful to illustrate the major sources and emissions of interest to ozone and PM. In many cases, the pollutants and sources of interest overlap for criteria and toxic air pollutants. This perspective is consistent with the NRC recommendations for multi-pollutant and sector-based strategies.



As an example of the alternative combinations of strategies air managers need to address for PM, this slide illustrates the composition of local and transported PM2.5 from data collected in 2003 for Birmingham and nearby Sipsey Wilderness (IMPROVE). The Sipsey site is used here to provide a rough index of the transported particles as they affect Birmingham and the difference in measured values (Birmingham – Sipsey) approximates the quantity and quality of locally generated particles (urban excess). The regional background today is over half of the PM2.5 concentrations in Birmingham. Our modeling suggests that by 2015, CAIR would reduce that background (ammonium acid sulfate/nitrate) by about 1.5 ug/m3, bringing this site within about 1 ug/m3 of the current annual PM2.5 NAAQS. If the State chooses to adopt local controls, this suggests about a 17% reduction in key local emissions (carbonaceous PM being the largest fraction) would be needed. Otherwise, additional regional controls would need to be considered.

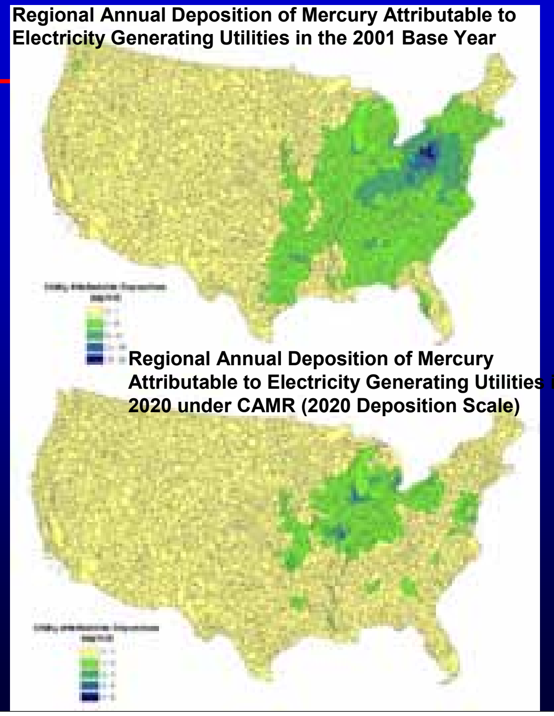
Major sources of PM in Birmingham include commonly found sources such as diesel and other mobile emissions as well as steel and other industries. EPA is planning local modeling of this and a few other areas to examine the effectiveness of local strategies for an upcoming RIA for the PM NAAQS review.



This map shows 46 counties that exceed the current PM10 standard based on 2001-2003 data. Under the alternative coarse particle indicator recommended by EPA staff and CASAC (PM10-2.5 qualified to exclude coarse particles uncontaminated by urban/industrial sources), a number of the monitoring sites illustrated here would no longer be measuring particles of concern.

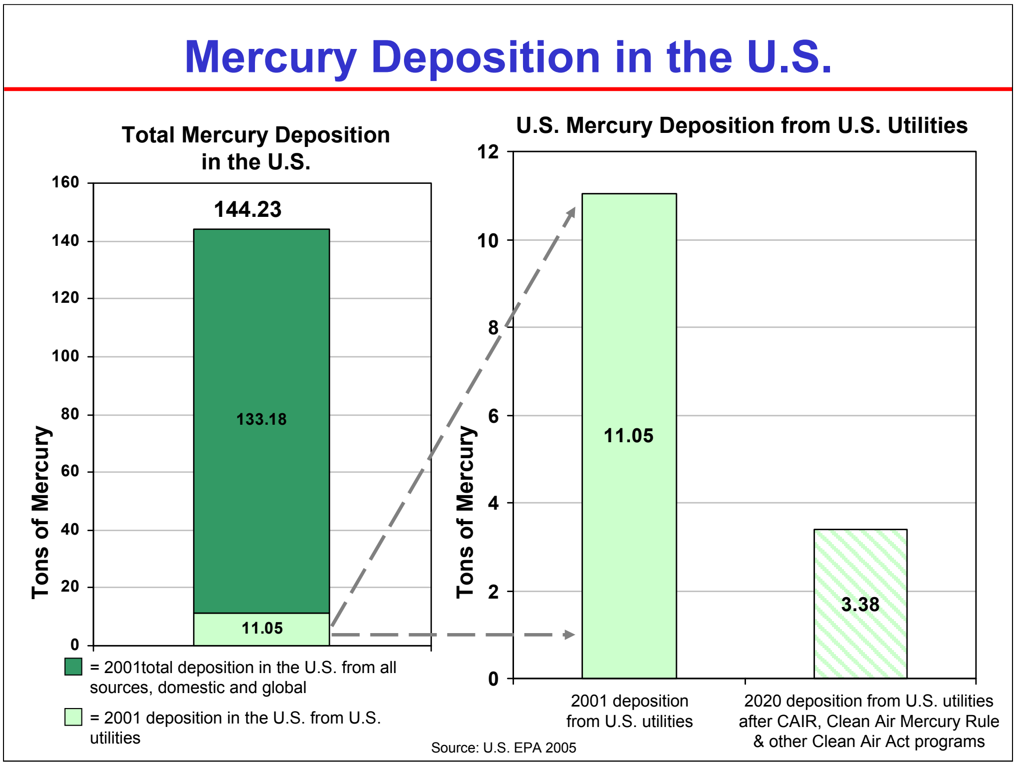
Reductions in Hg Deposition under CAMR

- By 2020, EPA projects significant reductions in utility attributable Hg deposition.
- Reductions in deposition are largely due to the implementation of CAIR controls at utilities, and CAMR is projected to make additional reductions in regional and worldwide deposition.

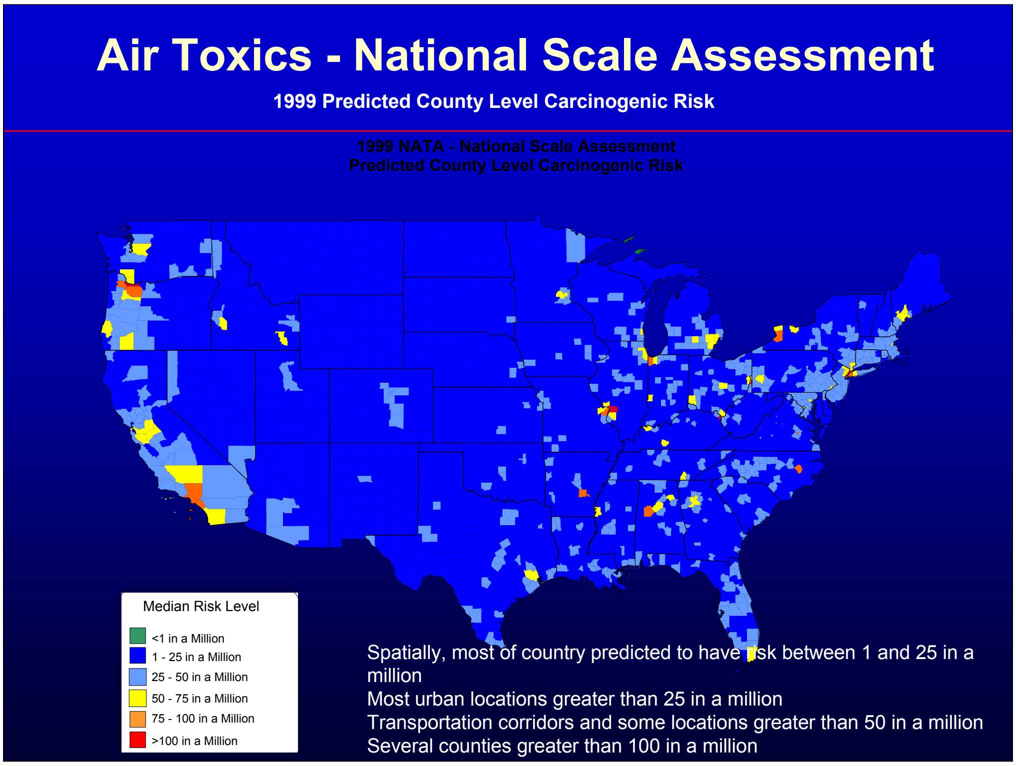


The CAIR/CAMR rules illustrates the multipollutant link between criteria pollutants addressed by CAIR and a persistent bioaccumulative toxic air pollutant, mercury. These maps focus on the CMAQ modeled reductions in deposition of mercury ascribed to EGUs under the CAIR/CAMR rules.

There are additional uncertainties in forecasting and modeling mercury emissions, deposition and chemistry documented in the CAMR RIA and Technical Support Documents.

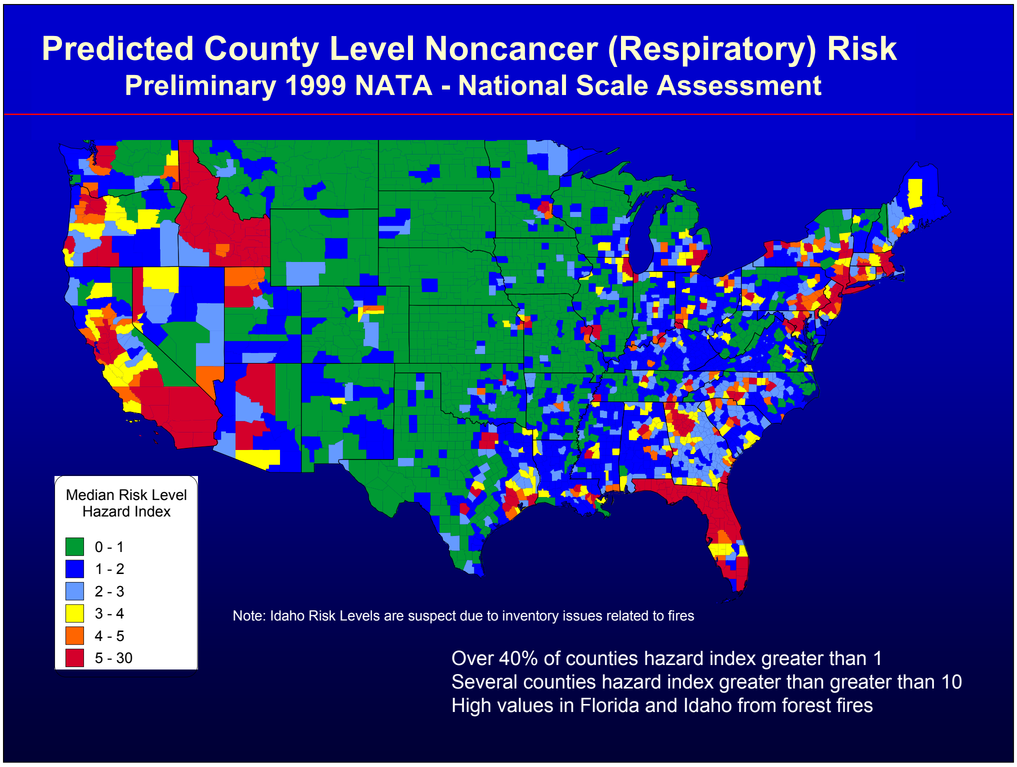


This provides an overall comparison of the contribution of US EGUs to total mercury deposition in the US. As shown on the map, the fraction coming from EGUs is higher in portions of the eastern US than in the country overall.

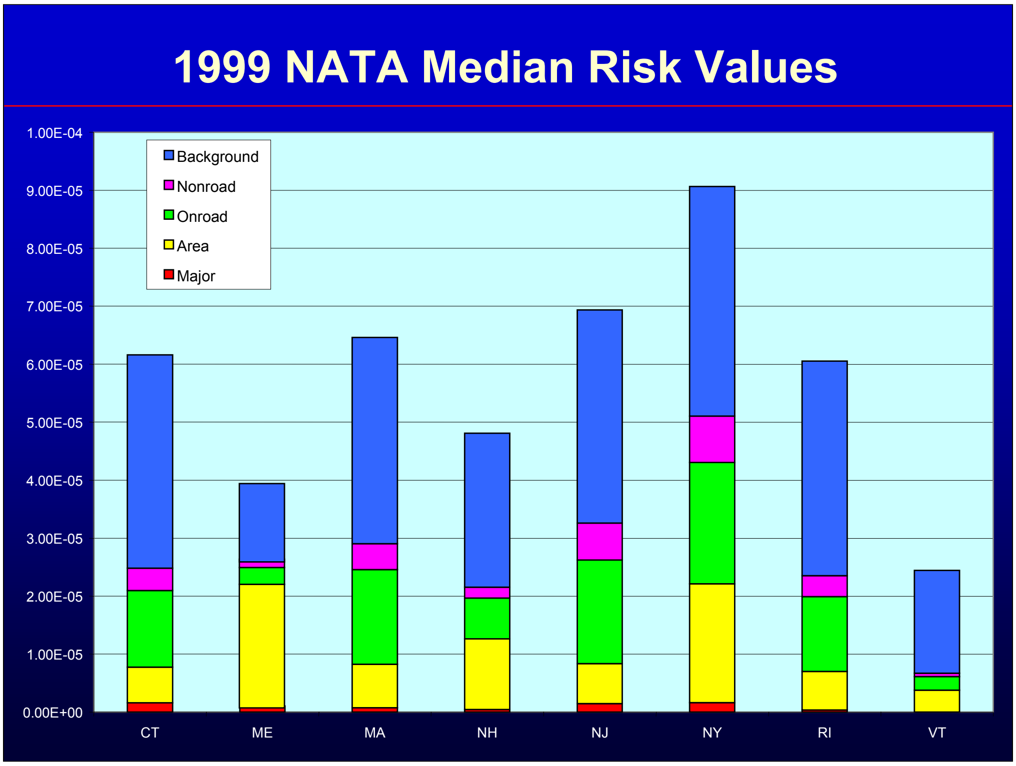


The National Air Toxics Assessment (NATA) has been examining the geographical patterns of cancer and other effects associated with multiple air toxics. This map represents a preliminary cumulative cancer risk assessment from the major known air toxic contributors for 1999. It is currently undergoing review by States and others and is provided only as a rough benchmark for comparison to the future.

Details and numerous uncertainties in these calculations appear in an upcoming NATA report. The monitoring for air toxics is not as comprehensive or long-running as for criteria pollutants and substantial modeling is necessary to provide coverage. The results indicate a background risk for much of the nation in the range of between 1 and 25 in a million, with much of that coming from a single compound, benzene. The areas of higher risk occur in populated urban areas and the East that tend to overlap the ozone/PM non-attainment maps.

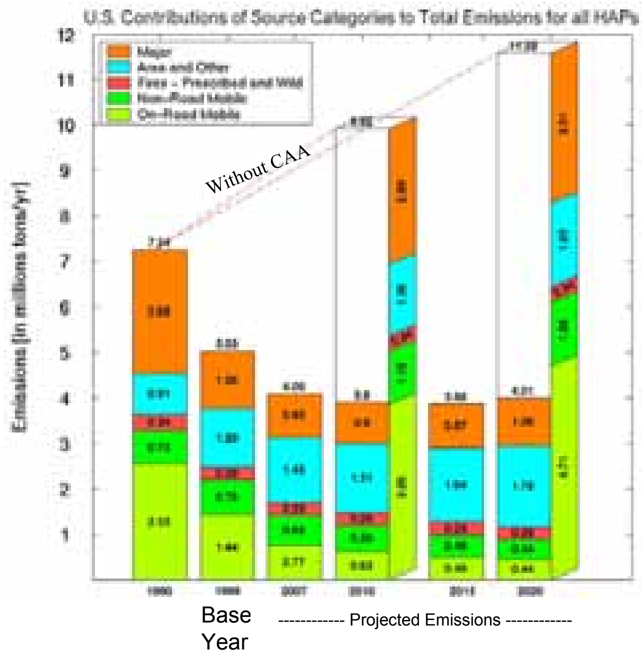


This provides the same kind of preliminary NATA map for respiratory noncancer effects. Here, cumulative toxic concentrations are referenced against a conservative benchmark value to derive a 'hazard index.' The green areas are below the index threshold of 1. Some of the spatial patterns (e.g. Idaho) are artifacts due to the fact that the underlying data are derived from state reporting and variations exist among states. The Idaho data will be corrected in a future version. These results are also undergoing further review. Areas of high HI are coincidental with areas that are in nonattainment for PM/O3.



This figure illustrates the relative contribution of various source categories to cancer in a number of northeastern states. The figure shows variability across states with background, area, on-road mobile being the largest contributor to risks. Again these are preliminary data. Background results are mainly from long-range transport as well as un-inventoried sources.

US (All 50 States) Emissions of HAPs by Source



* After 2010, stationary source emissions are based only on economic growth. They do not account for reductions from ongoing toxics programs such as the urban air toxics program, residual risk standards and area source program, which are expected to further reduce toxics. In addition, mobile source reductions are based on programs currently in place. Programs currently under development will result in even further reductions.

Key Findings

- CAA has been very effective in reducing overall tonnage of air toxics
- In absence of CAA, total emissions would be more than twice those projected in 2020

From NATA: This chart shows historical emissions from 1990 (sum across all HAPs), the 1999 baseline from which we did the projections, and future year emissions for several years which we projected from the 1999 inventory. We grouped the emissions into the major (i.e. stationary sources of certain size), area and other, fires (which is typically aggregated in with area and other, as it is for NATA), onroad mobile and nonroad mobile. Fires is typically aggregated within area and other but we separated it out from other area and other categories for the purposes of showing its influences on the results because of the issues and uncertainties in the base and historical emissions and its future year projection.

The dashed line represents our estimate of emissions that would have occurred without the CAA, considering emissions growth from 1990.

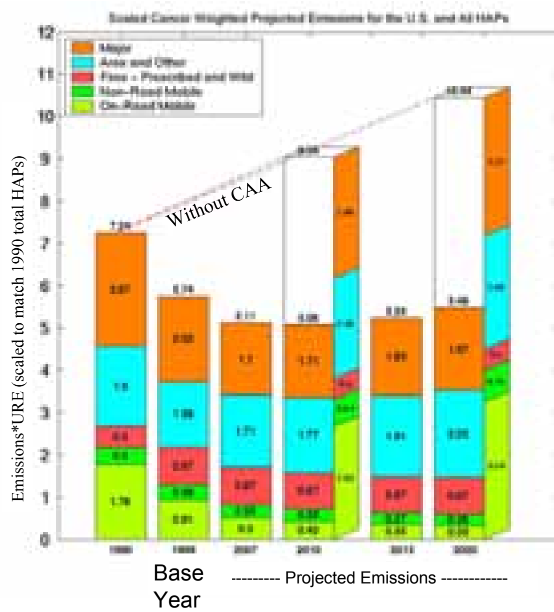
The data show that the CAA has been very effective in reducing overall tonnage of air toxics: Without EPA's programs, we would have seen a 50% increase in emissions from 1990 to 2020; however, with EPA's programs, we expect a 40% decrease from 1990 levels by 2020.

Major source emissions decrease through 2010, reflecting reductions associated with MACT program. Significantly, area and other are projected to increase without further controls. Most of the standards resulting from the area program are not included, however.

Mobile source emissions decrease thru 2020 with additional decreases likely from future programs (e.g., MSAT2)

As mobile source emissions decrease, the contribution of stationary source emissions to total HAP increases over time.

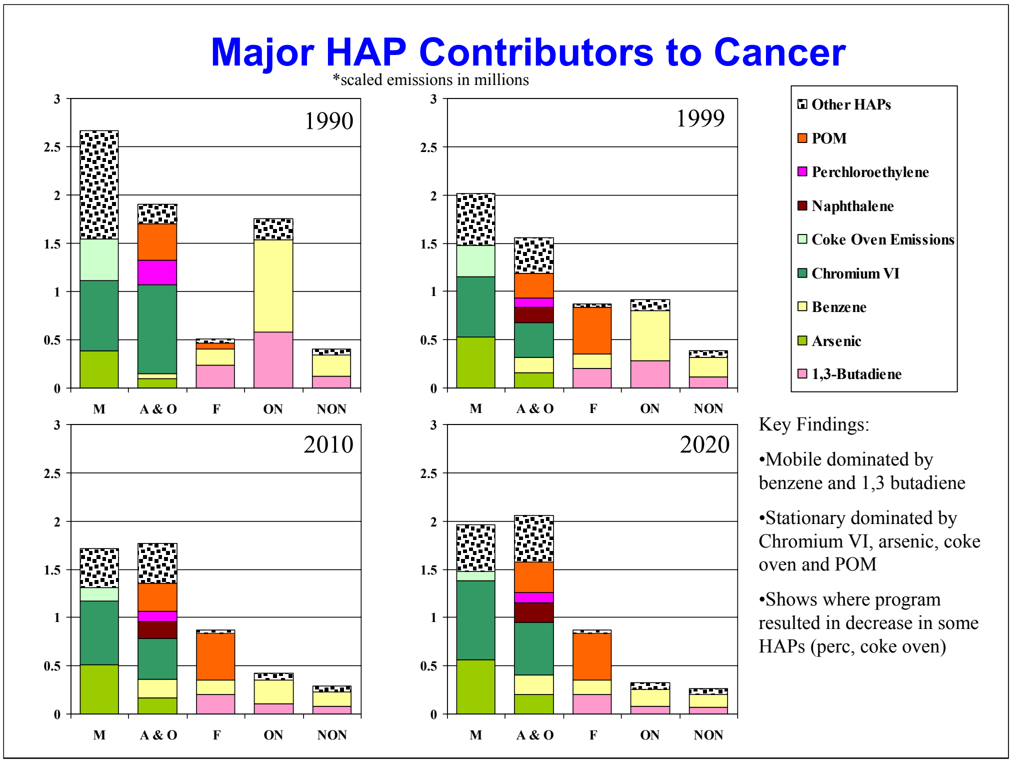
Toxicity-Weighted Emissions (Cancer)



Key Findings

- Major source programs target overall tonnage more than toxicity weighted tonnage
- Initial area source efforts have reduced some of the most toxic HAPs (Perc and Chromium VI)
- Mobile source tox -weighted trends closely follow total HAP trends
- Fires plays larger role for in toxicity-weighted situation; trends cannot be obtained due to methodology differences in emissions estimation

This is similar to previous slide, however the emissions have been "weighted" by their respective toxicity factors to depict cancer effects. In other words a ton of Chromium VI would be depicted to be more (is much more toxic) than a ton of benzene. Future projections show reduction of cancer-weight tons are less than those expected for straight tons, thus future reduction efforts must target more toxic pollutants. The next phase of CAA will target these toxic HAPs, such as the residual risk program.



This slide depicts the relative pollutant contribution to cancer weighted emissions for each year/source sector.

Key Findings:

Mobile dominated by benzene and 1,3 butadiene

Stationary dominated by Metals (Chromium VI, arsenic) and coke oven and POM (PAHs)

The slide shows where program resulted in decrease in some HAPs (perc-dry cleaning MACT, coke oven -Coke oven MACTs)

Chart Key

M = Major Sources

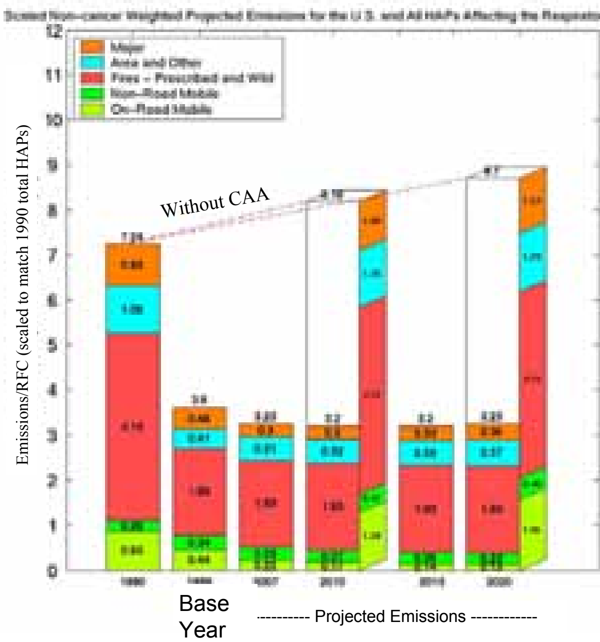
A&O= Area Sources and Other

F= Fires

ON= On road Mobile Sources

NON= Nonroad Mobile Sources

Toxicity-Weighted Emissions for NonCancer



Key Findings

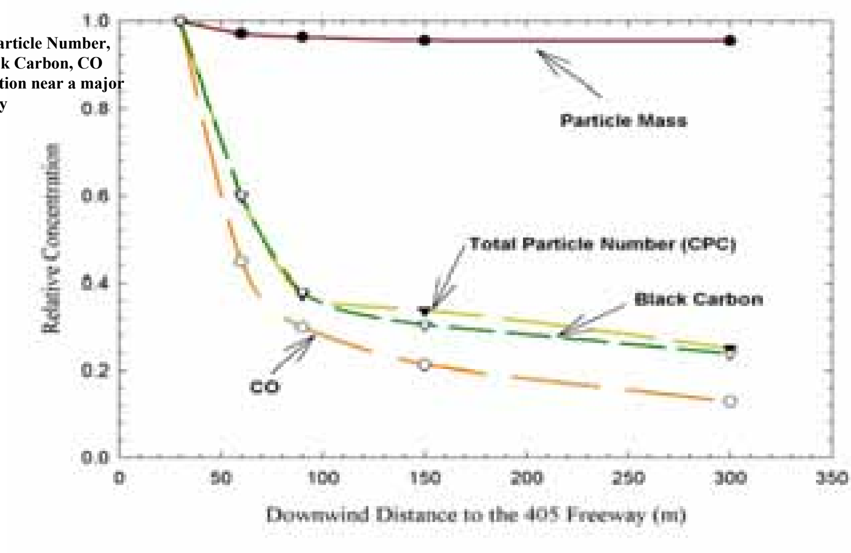
- Fire/burning is potentially an important contributor to noncancer risks
- Large decrease from 1990 to other years is primarily due to wildfires&prescribed burning due in part to methodology inconsistency
- Major source reductions larger for noncancer HAPs than total HAPs
- Area&other trend somewhat limited by methodology uncertainty
- Mobile source tox weighted trends closely follow total HAP trends

This is similar to previous slides, however the emissions have been "weighted" by their respective toxicity factors to depict inhalation noncancer effects. In other words a ton of Chromium VI would be depicted to be more (is much more toxic) than a ton of benzene. Current as well as future projections show reduction of noncancer-weight tons are greater than those expected for straight tons. Some of this reduction may be an artifact of the changes in the methodology between 1990 and future years.

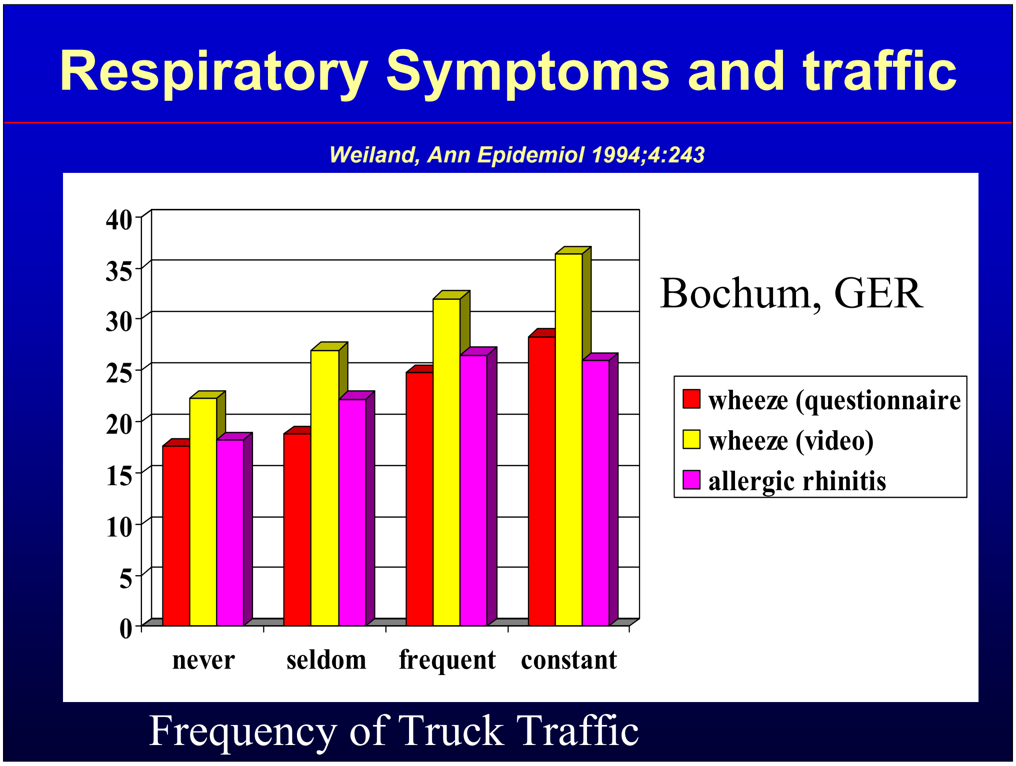
This figure provides a transition to a quick summary of a growing body of evidence that suggests both exposures and health effects of concern for populations who spend significant time on or near heavily traveled roadways. Some of these studies measure the distribution and composition of pollutants emitted and some look for health effects as a function of time spent in or near roadways. Our current NAAQS program tends to avoid placing monitors in microenvironments such as these. At this time, is not clear what current regulations and fleet turnover vs. growth in VMT will do to affect these emerging concerns, although it is reasonable to expect some benefits. This issue bears watching for air quality managers because of its potential significance to future air strategies, urban planning, and environmental justice.

Extreme exposure in near highway environment

Relative Particle Number, Mass, Black Carbon, CO Concentration near a major LA freeway

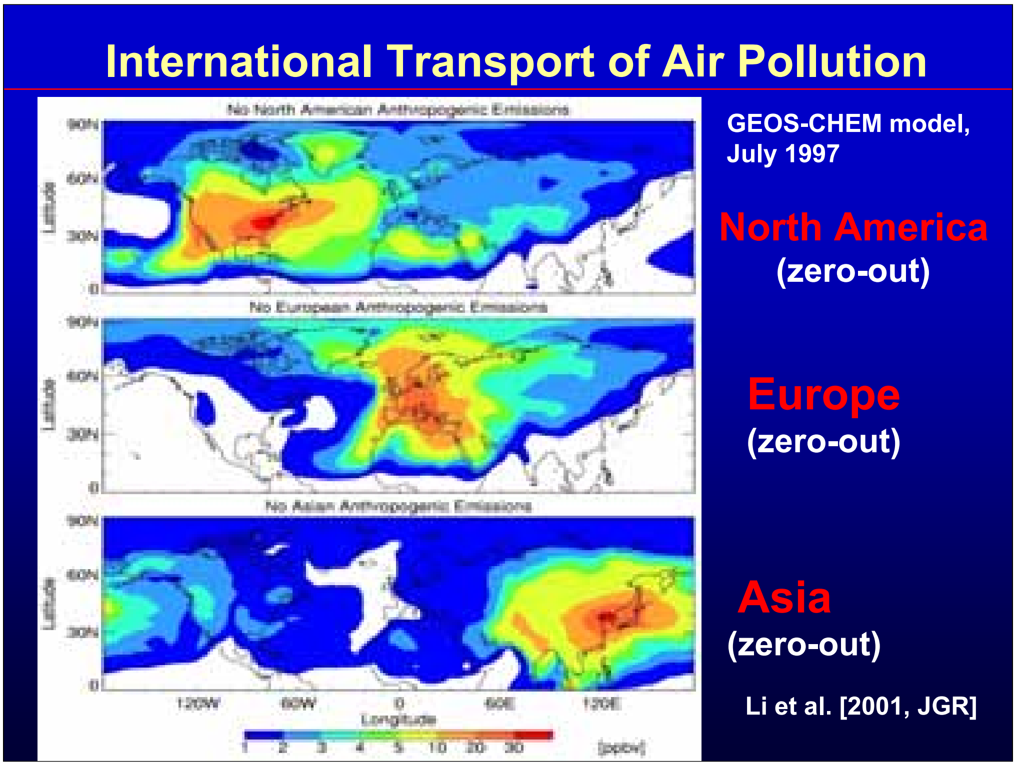


These are the results of monitoring by the Southern California PM research center sponsored by EPA. It reflects measurements near a heavily traveled freeway. It show that some indicators of traffic particles that are not well correlated with particle mass have very strong gradients near roads.



One of the earlier European studies shows a relation between respiratory symptoms in children and frequency of truck traffic. More recent studies have shown a variety of associations; long-term residence near roadways is associated with increased risk of mortality, and short-term exposure to traffic conditions (driving, cycling or mass transit) is associated with heart attacks.

This slide introduces a brief discussion of linkages between conventional air pollutants and regional to global scale transport issues, including climate. The NRC pointed out the issue of international transport of air pollutants as well as the potential need to adapt air quality planning to address the effect of climate change on air quality. In this portion of the briefing we note two additional related potential interactions: the effect of conventional air pollutants on regional climate and the possible need for air quality mangers to integrate conventional and non-conventional strategies that might address both climate and air quality concerns.



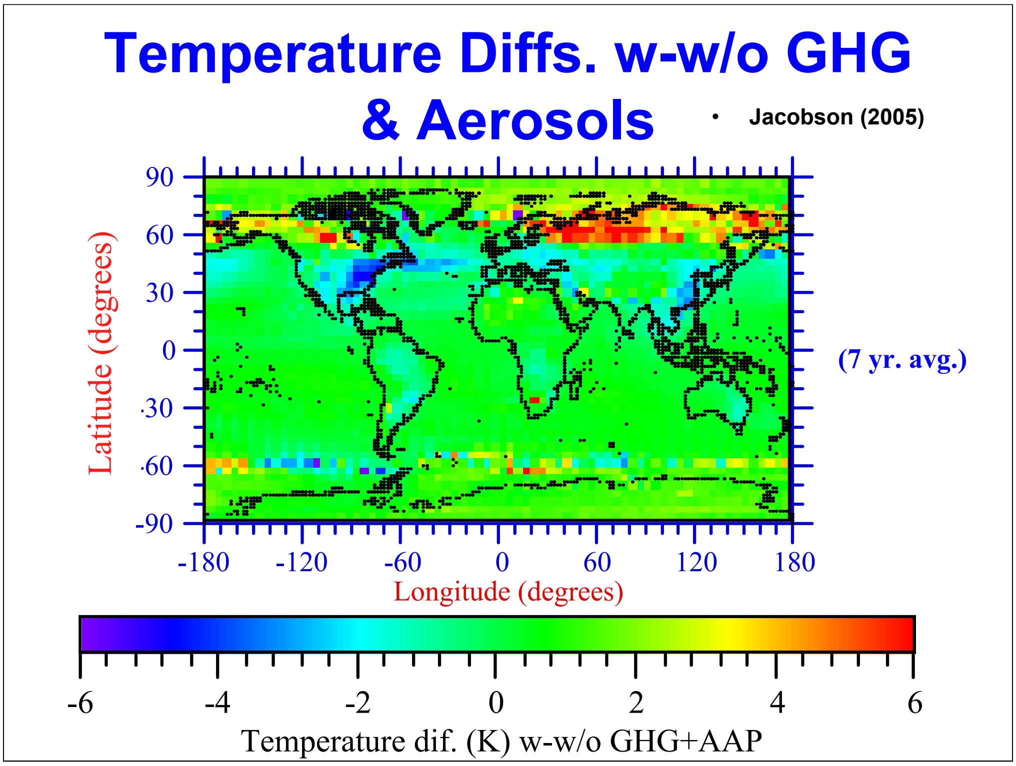
This slide summarizes the results of zeroing out emissions of key ozone precursors from anthropogenic sources in three Continents. It is intended to illustrate the extent of significant regional and intercontinental transport of ozone and its precursors. On this scale, methane gas is one of the most important contributors to ozone transport. Modeling and measurements suggest that background ozone has increased from 10 to 20 ppb in preindustrial times to 40 or more ppb today. The amount of transport may significantly affect our ability to attain air quality goals in the future. Because both methane and ozone are greenhouse gases, the air quality and climate interests clearly overlap on this scale.

Assessing indirect strategies: "cool" cities

- Trees aren't just good to look at – they remove air pollution (ozone and PM)
  - They also emit VOC's
  - And cool the environment reducing evaporative emissions from manmade sources
- Air Policy Issue
  - Credit for enhancing tree cover
  - Penalty for eliminating trees?

On a local scale, urban foresters and others are considering 'cool cities' as a means to reduce ozone and PM air pollution. This includes direct removal by increased vegetation and indirectly reducing emissions of VOC and NOx by cooling through trees and more reflective urban surfaces. These strategies raise issues for air quality managers regarding the need to consider credits for adopting such strategies, as well as what to do in areas where sprawl eliminates trees and increases urban heating. It is also an area in which the collective local implementation of potential programs related to climate change mitigation overlaps with air quality management.

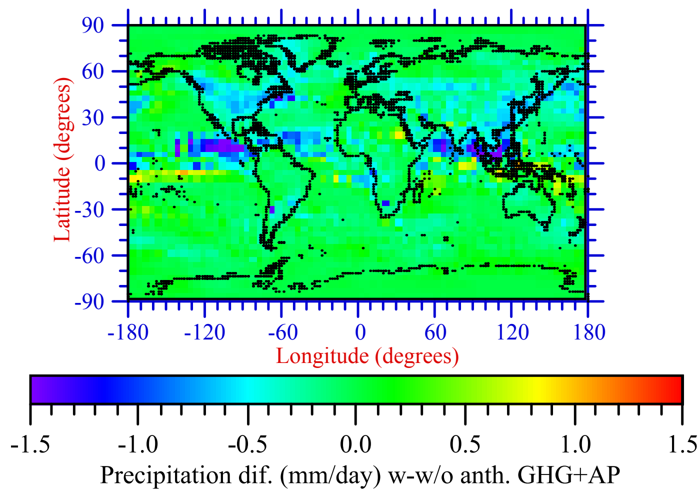
An example of related societal trends that may link with air quality considerations. A new movement in urban planning is attempting to redesign cities and buildings to promote healthier environment for people and ecosystems. A catch phrase is of this group is ‘active living by design.’ The recent roadway findings noted above suggest there may be additional health benefits of separating people from traffic. Smart growth advocates argue that greenways can protect water quality, preserve sensitive natural areas, reduce flood hazards, and provide important recreational opportunities. They also note the need to preserve the corridors that link greenspaces together.



This and the following figure present recent global simulation modeling conducted by Mark Jacobson of Stanford University. Such complex global modeling is obviously uncertain, and the results serve mainly to illustrate the complexity of the issues.

Together, the figures show the result of zeroing out manmade greenhouse gas (GHG) and aerosol particles (in this figure for temperature and in the following figure precipitation). Focusing on North America, the blue cooling suggests that the net effect of reducing the high regional background of fine particles in the East (a key feature in attaining the health based air quality standards) would be to produce warming – i.e. these particles are currently cooling that region. Looking only at temperature, the air quality management strategy might be viewed as aggravating potential warming. The cooling is due to increased cloud cover that reduces sunlight reaching the ground and increases that reflected into space.

Precipitation Diffs. w-w/o GHG & Aerosols

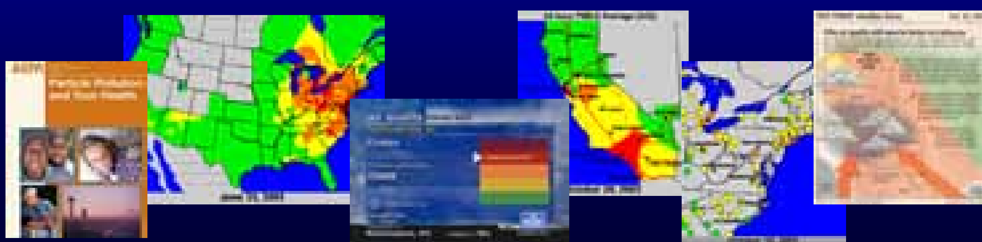


This figure shows the effects of the zero outs on precipitation. The increased cloudiness associated with the aerosol particles comes with a decrease in cloud droplet size which results in reduced precipitation. This illustrates an important potential regional effect of air pollution, namely that air pollution can affect climate on a regional scale, and some of the effects – reduced precipitation – may be problematic. Recent results from researchers at the Desert Research Institute suggest that atmospheric sulfates may be reducing the amount of snow pack accumulation in the Rocky Mountains, potentially aggravating drought conditions. These results illustrate the importance of examining the unexpected feedbacks between air pollution and climate.

The more obvious concern noted in the NRC report is the effect of climate change on air pollutant concentrations. EPA/ORD is conducting extensive modeling to assess some of these effects. The results will be available in 2006-7. Some of the possible effects range from increased ozone under warmer temperatures and increased emissions and stagnation to reduced heating related PM from warmer winters. Obviously, forecasting the timing, extent, and scale of these potential effects will be of importance to air quality managers in the future.

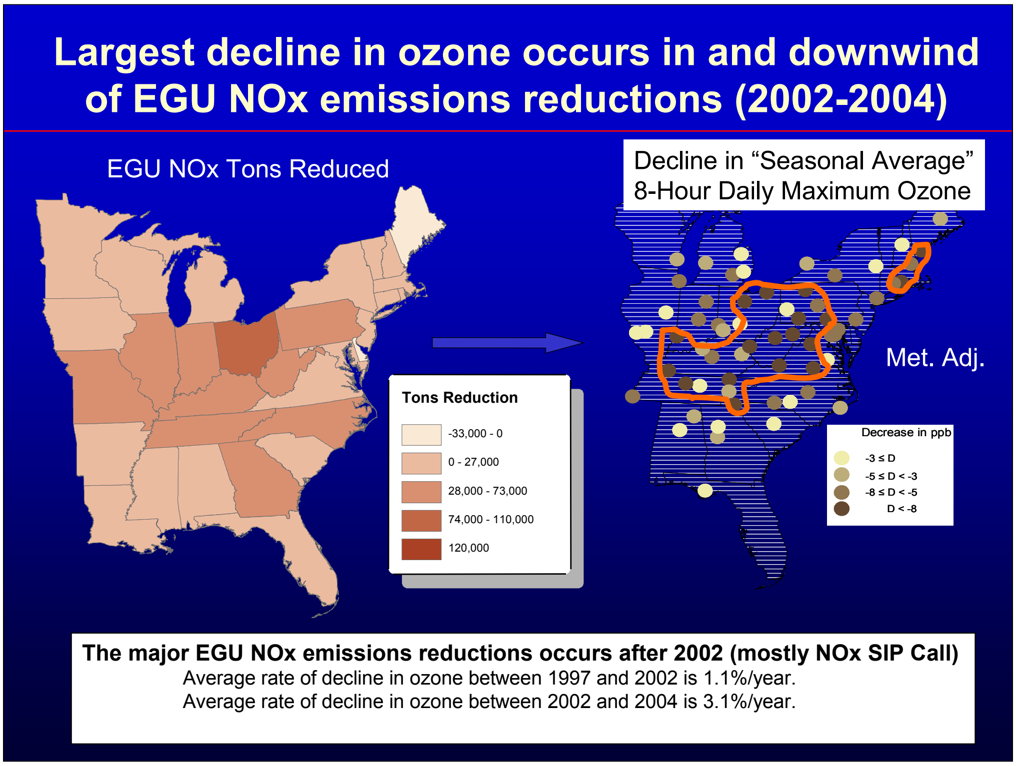
Communications: Air Quality Index

- Year Round 24/7 coverage/operations delivering real-time data (ozone & particles) for 46 States, 6 Canadian Provinces and all U.S. National Parks
- Next-day AQI forecasts for over 300 cities (summer) and over 150 cities (year-round)
- State-of-the-science information about air pollution health effects for the public, media and stakeholders
- Public/Private partnerships with The Weather Channel, USA Today, CNN, weather service providers, NOAA National Weather Service, EPA’s Office of Env. Information

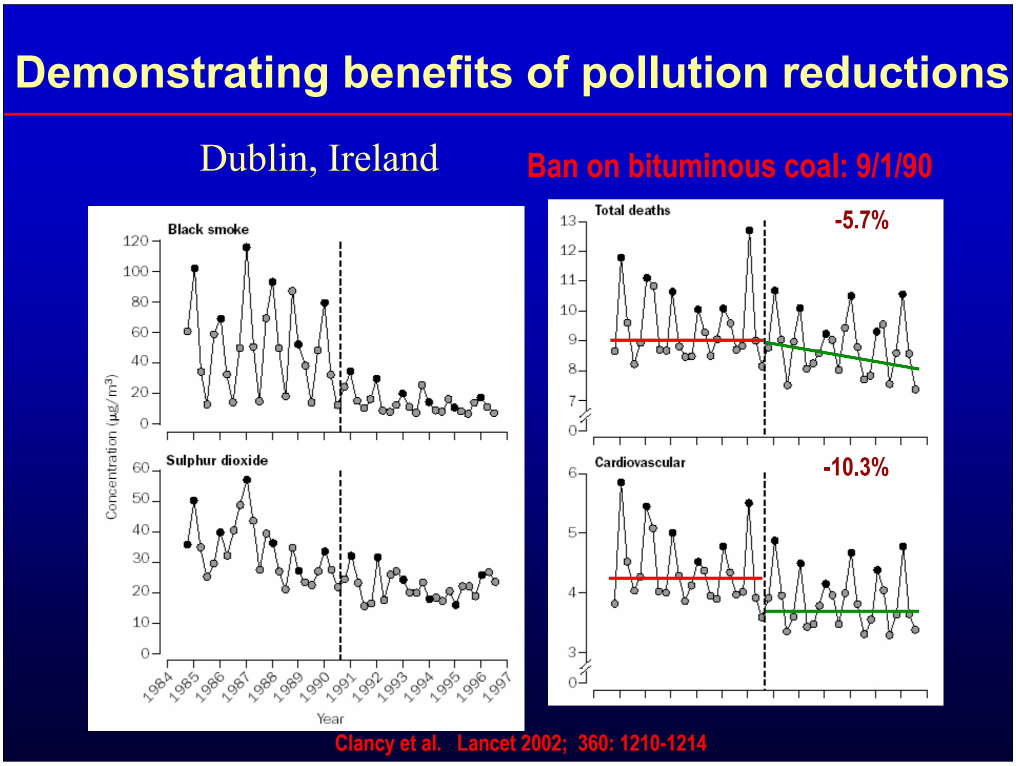


As NOAA and EPA cooperate to develop real time modeling forecasts of air quality comparable to weather forecasts, air quality managers will need to be concerned with communications and potential mitigation strategies that might flow from these advances.   It is also important to begin to consider accumulating these daily model runs for comparison to actual results.

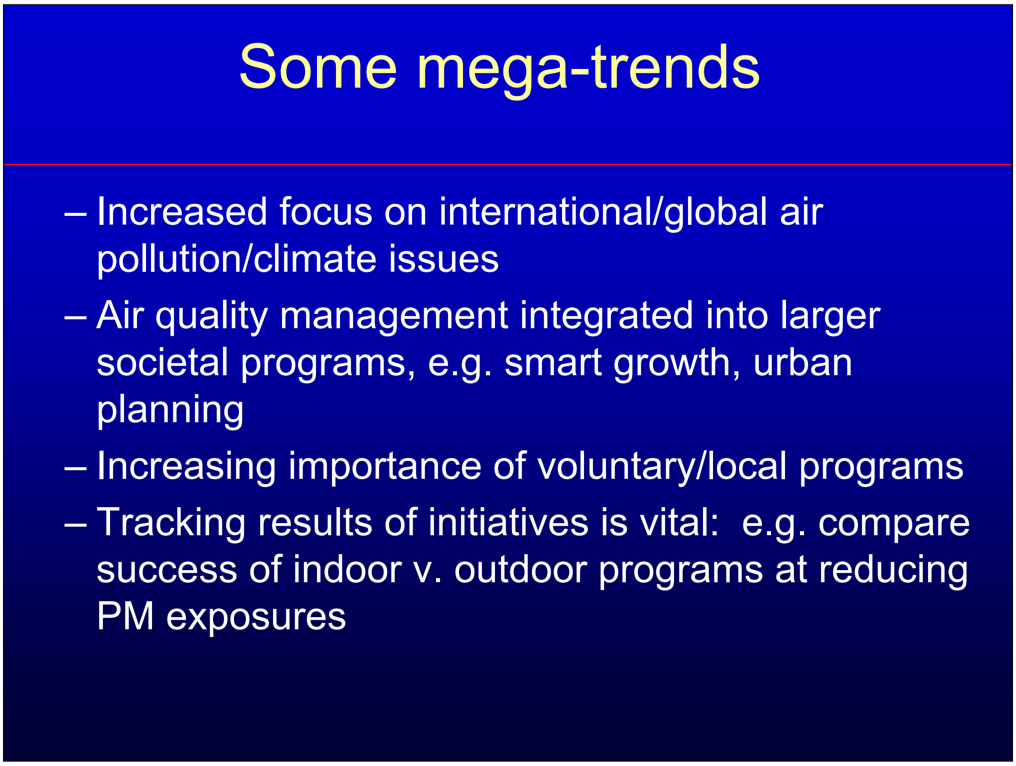
The first phase of the CAAAC work on the NRC recommendations dealt extensively with this topic. This slide is a reminder of the need to build accountability as an integral part of future air quality management programs.



This slide, from a recent EPA report, shows a preliminary analyses of the effectiveness of the NOx SIP call in reducing ozone. It is an example of an accountability analysis.



Another example of accountability research, in this case extending results beyond air quality to actually measuring the health benefits of a pollution control intervention, in Dublin, Ireland.



A recent CAAAC subcommittee discussion added a number of insights from members that should be reflected in the notes to this summary slide.