



Regional Approaches for Improving Air Quality

**Second US-China NO_x and SO₂
Control Workshop**

Dalian August 2-5, 2005

Dale Evarts, US EPA



Overview

- Why take a regional approach to managing air pollution?
- Regional approaches in the US
 - Acid Rain Program
 - Regional NO_x Reductions
 - Clean Air Interstate Rule (CAIR)
 - Regional Planning Organizations
- Illustrate impacts of regional pollution on Beijing
- Challenges for the power sector



Key Points

- Local reductions alone cannot achieve desired air quality management goals
 - Need to address regional sources at the same time
 - Not addressing regional sources can lead local areas to delay implementing controls (cleaning up their own sources) as they “blame” problems on external sources
- Use multi-pollutant approaches to addressing pollution from coal-fired power sector
 - Generally more cost-effective to address controls at once
- Need authority to force states to participate and to ensure compliance with regional approaches
 - Methods for verification (e.g., continuous emission monitors) and strong penalties for non-compliance
 - Result: high rate of compliance
- Set performance targets and allow flexibility in how to meet the targets
 - This encourages competition among technologies, fuels, etc.

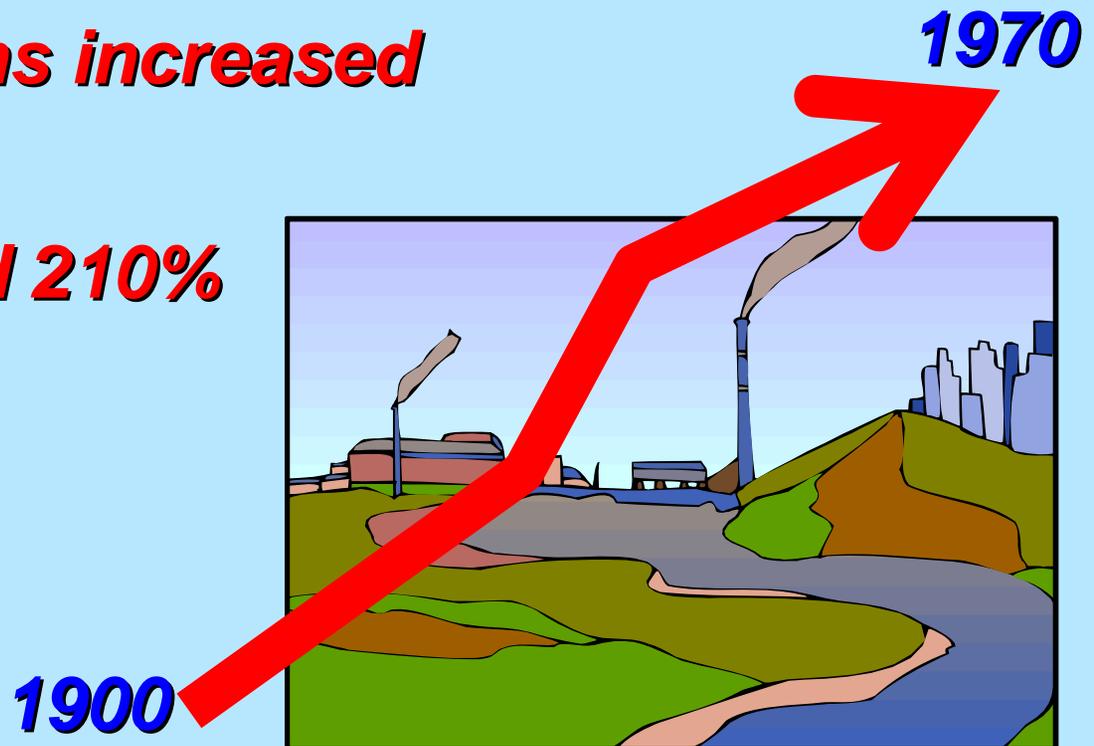
Progress Toward Clean Air

- **Before Clean Air Act (1970)**

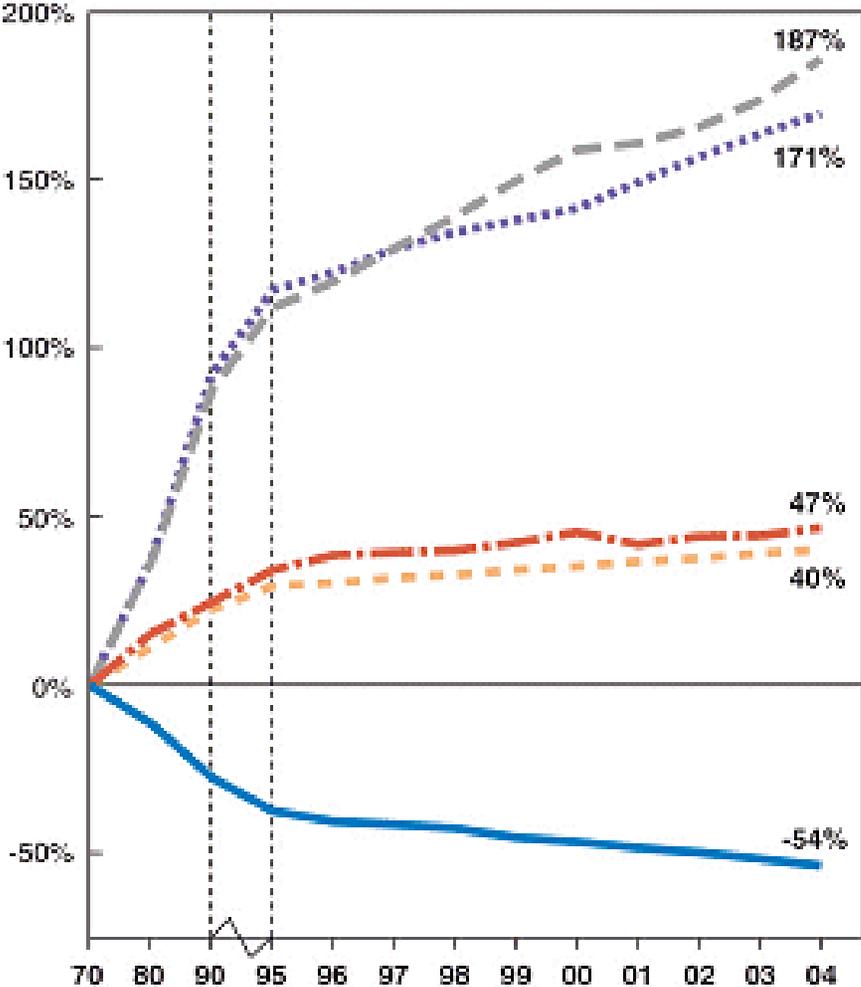
- ***NO_x emissions increased 690%***

- ***VOC emissions increased 260%***

- ***SO₂ increased 210%***



Comparison of Growth Areas and Emissions



- 

Gross Domestic Product
- 

Vehicle Miles Traveled
- 

Energy Consumption
- 

Population
- 

Aggregate Emissions (Six Principal Pollutants)



Why take a regional approach to managing air pollution?

- Air pollution travels
- We are all downwind (and upwind) of somebody
- Regional air pollution can overwhelm local efforts to control urban air pollution
- Regional controls can complement local air pollution reduction measures
 - And be more cost-effective too!
- We are capable of assessing the sources, transport, fate and effects of air pollution on a local, regional, national and international scale

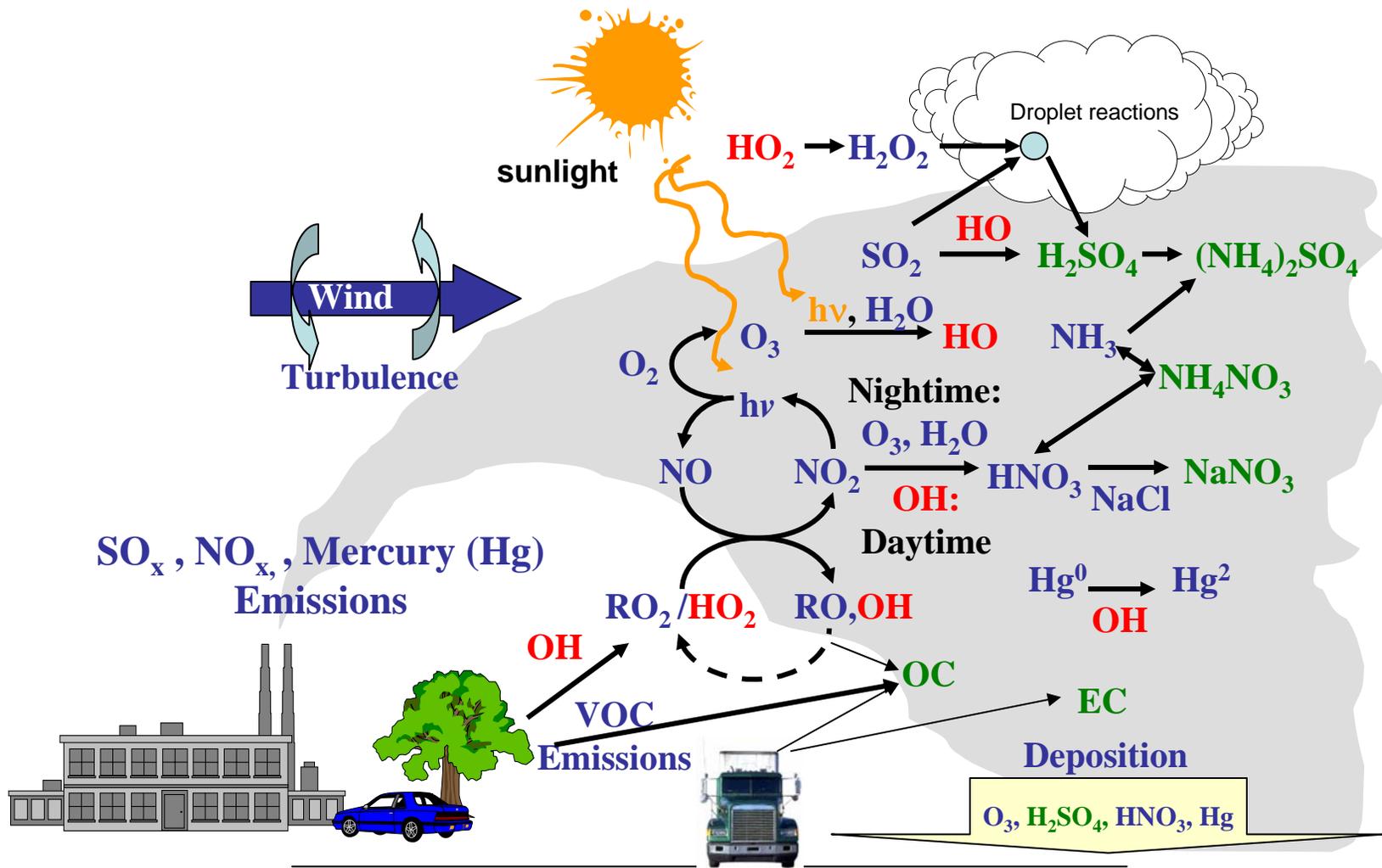


Figure: Schematic of the evolution and unified chemistry of urban ozone, particulate matter, acids, and mercury. Gas phase species are shown in blue and particulate matter in green. The OH and HO₂ radicals, which cycle from one to the other and back, are shown in red as they are central to the chemical transformation of virtually all species, and undergo rapid transformation. OH^{*} is formed primarily from the photolysis of ozone followed by reaction with water.

One-Atmosphere Approach



Mobile Sources

NO_x, VOC, PM, Toxics



Industrial Sources

NO_x, VOC, SO_x, PM, Toxics



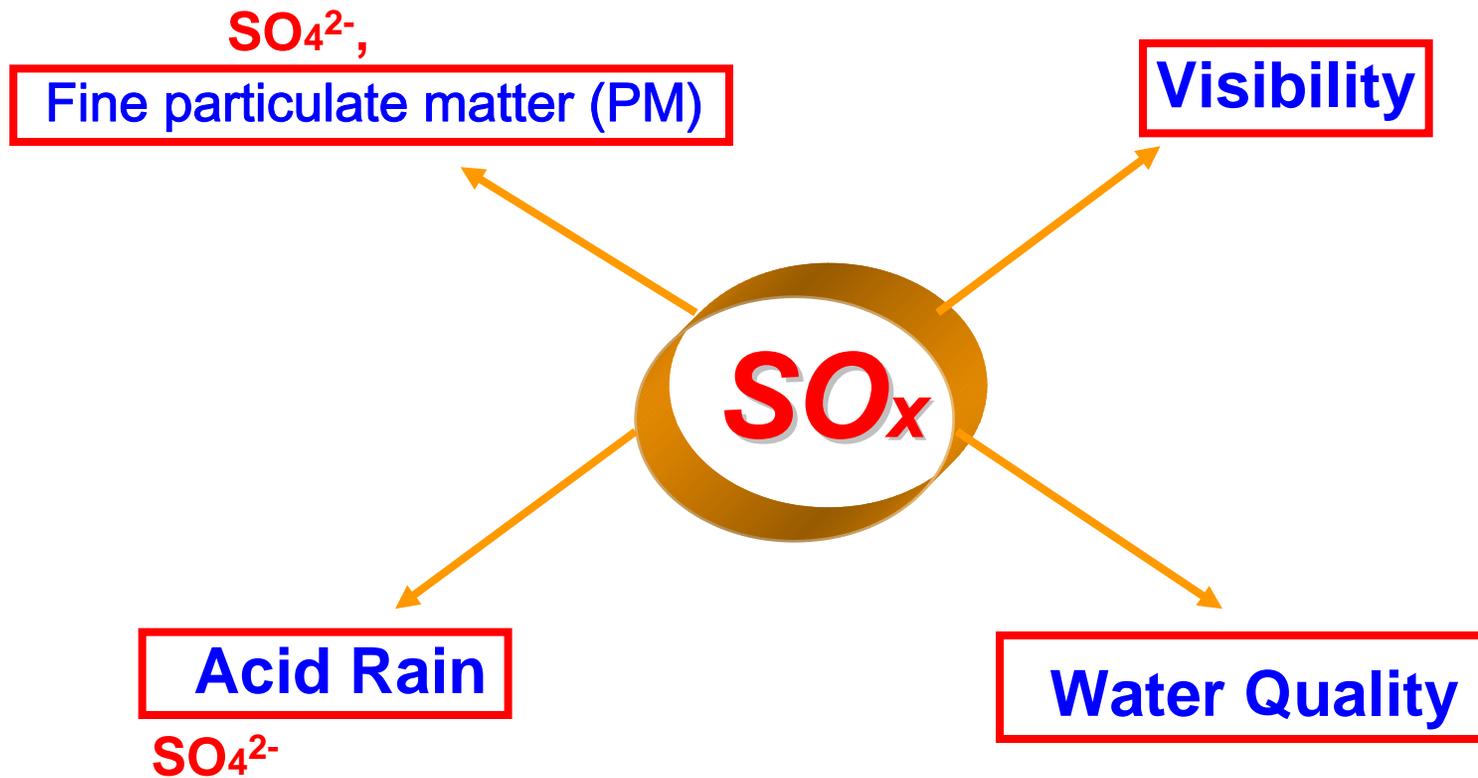
Area Sources

NO_x, VOC, PM, Toxics

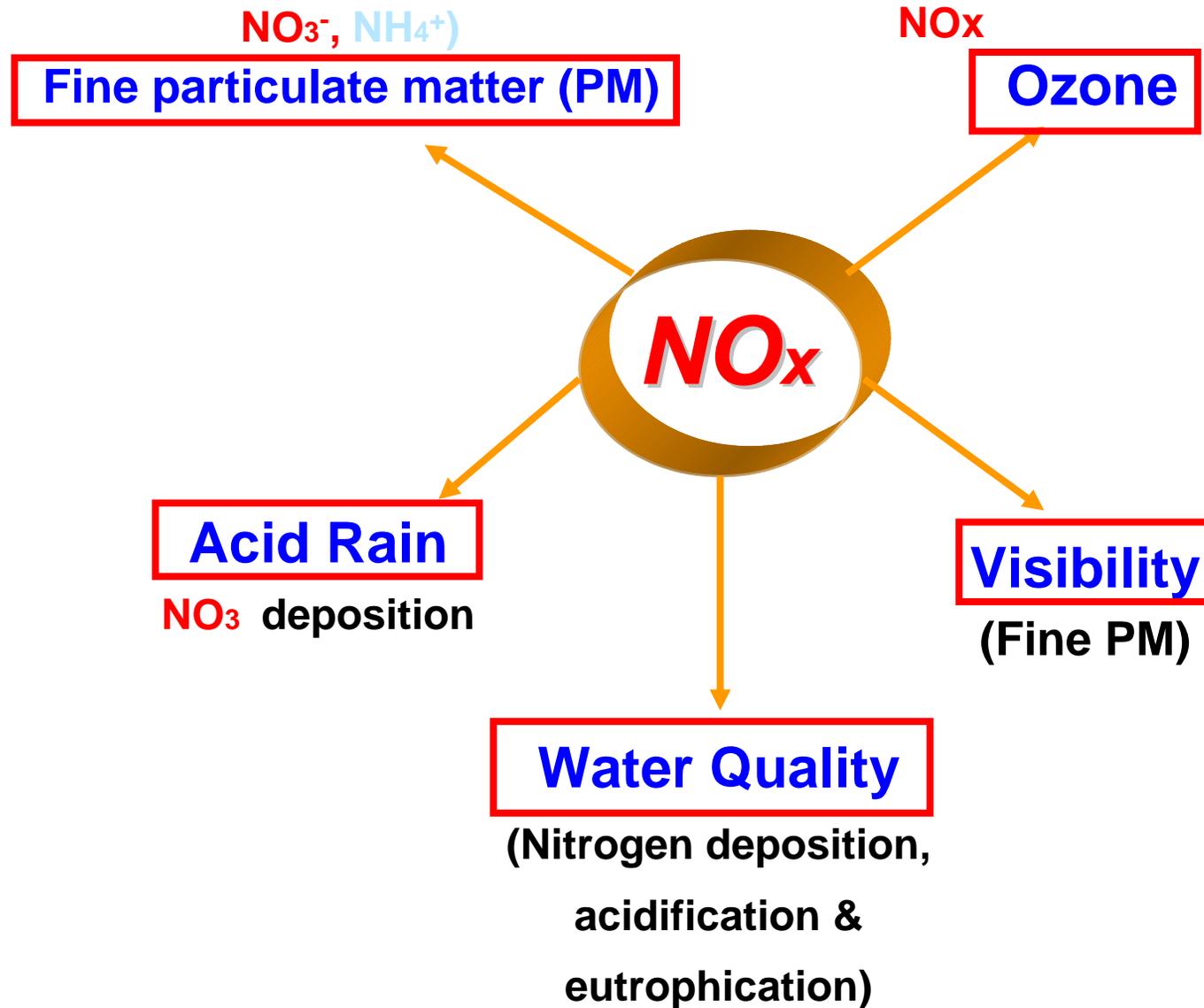
Chemistry
Meteorology



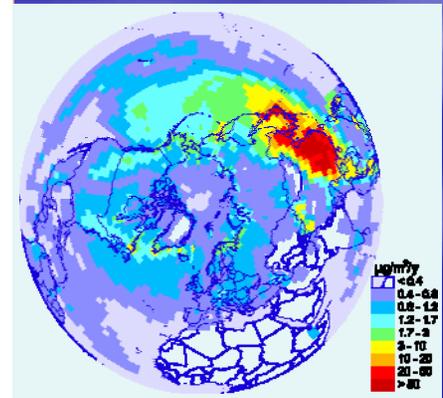
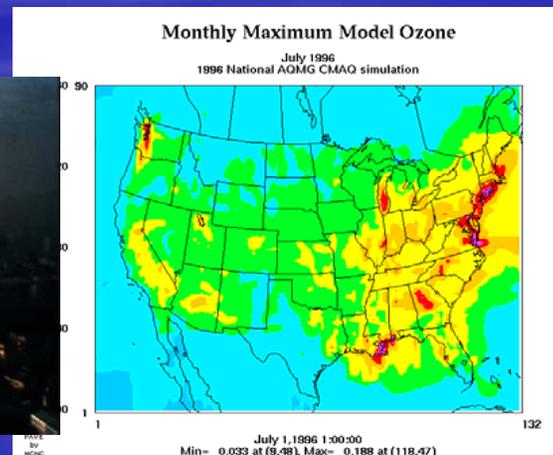
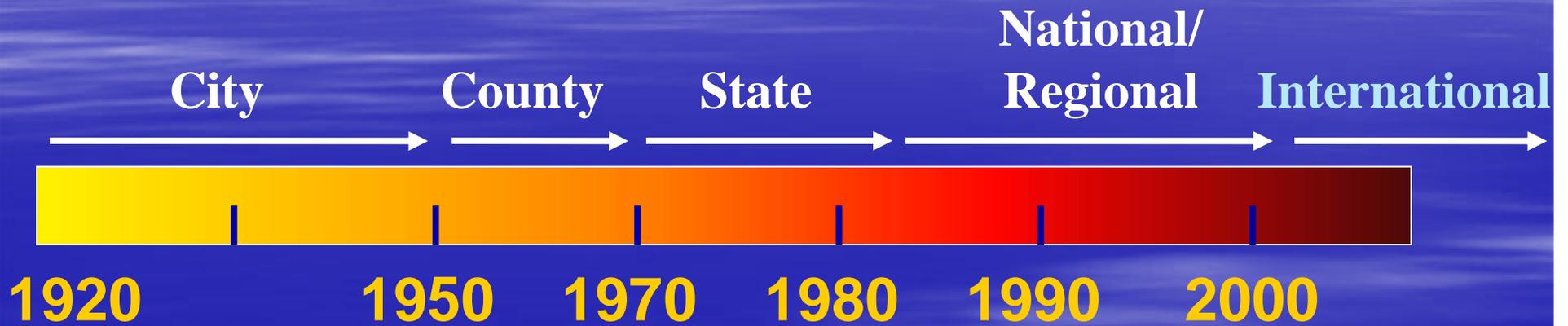
SO_x-Related Air Quality Issues



NO_x-Related Air Quality Issues

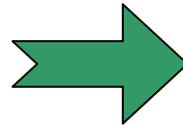


Air Pollution Control in 21st Century



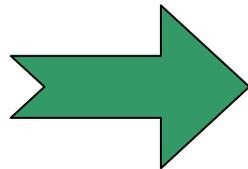
Different Views of China

Potential for Improved Quality of Life



2004 Average
Air Quality
(Beijing-Region)

$\text{SO}_2 \sim 55 \mu\text{g}/\text{m}^3$
 $\text{NO}_x \sim 120 \mu\text{g}/\text{m}^3$
 $\text{PM}_{10} \sim 150 \mu\text{g}/\text{m}^3$



China Class I
Air Quality Levels

$\text{SO}_2 = 20 \mu\text{g}/\text{m}^3$
 $\text{NO}_x = 50 \mu\text{g}/\text{m}^3$
 $\text{PM}_{10} = 40 \mu\text{g}/\text{m}^3$



Hundreds of Thousands
of Fewer Illnesses/Deaths
from Respiratory and
Cardiovascular Disease

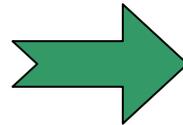
Higher Economic
Productivity, Greater GDP

Better Visibility, Tourism

Healthier Forests, Higher
Crop Yields

Large Regional Airsheds

Air Quality Management Goes Beyond Cities



Air pollution is regional, not just local.

It affects both urban and rural areas (public health, visibility, agriculture, forestry, lakes and rivers).

Improving air quality requires region-wide strategies.

US Approaches to Regional Air Quality Management



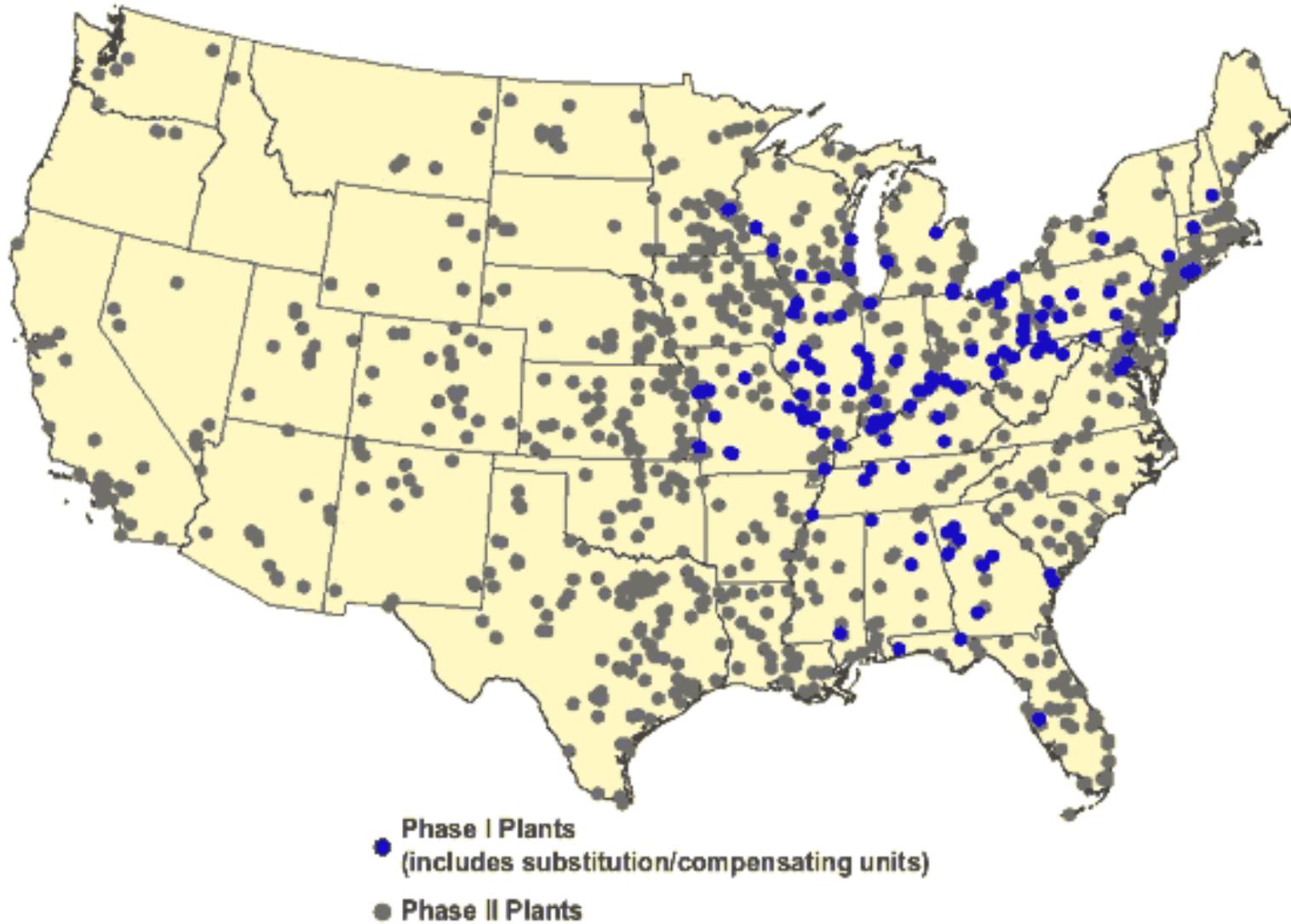
- Built step upon step over over more than 15 years
- Began with Acid Rain Program in 1990
 - Enacted with the Clean Air Act Amendments of 1990
 - Focused on SO₂, to a lesser degree NO_x
 - Implemented first cap and trade program
- Additional Regional NO_x reductions in late 1990's
- Clean Air Interstate Rule (CAIR) revisited SO₂ and NO_x for graduated reductions in 2010 and 2015
- Other Regional Planning efforts underway to address visibility impairment



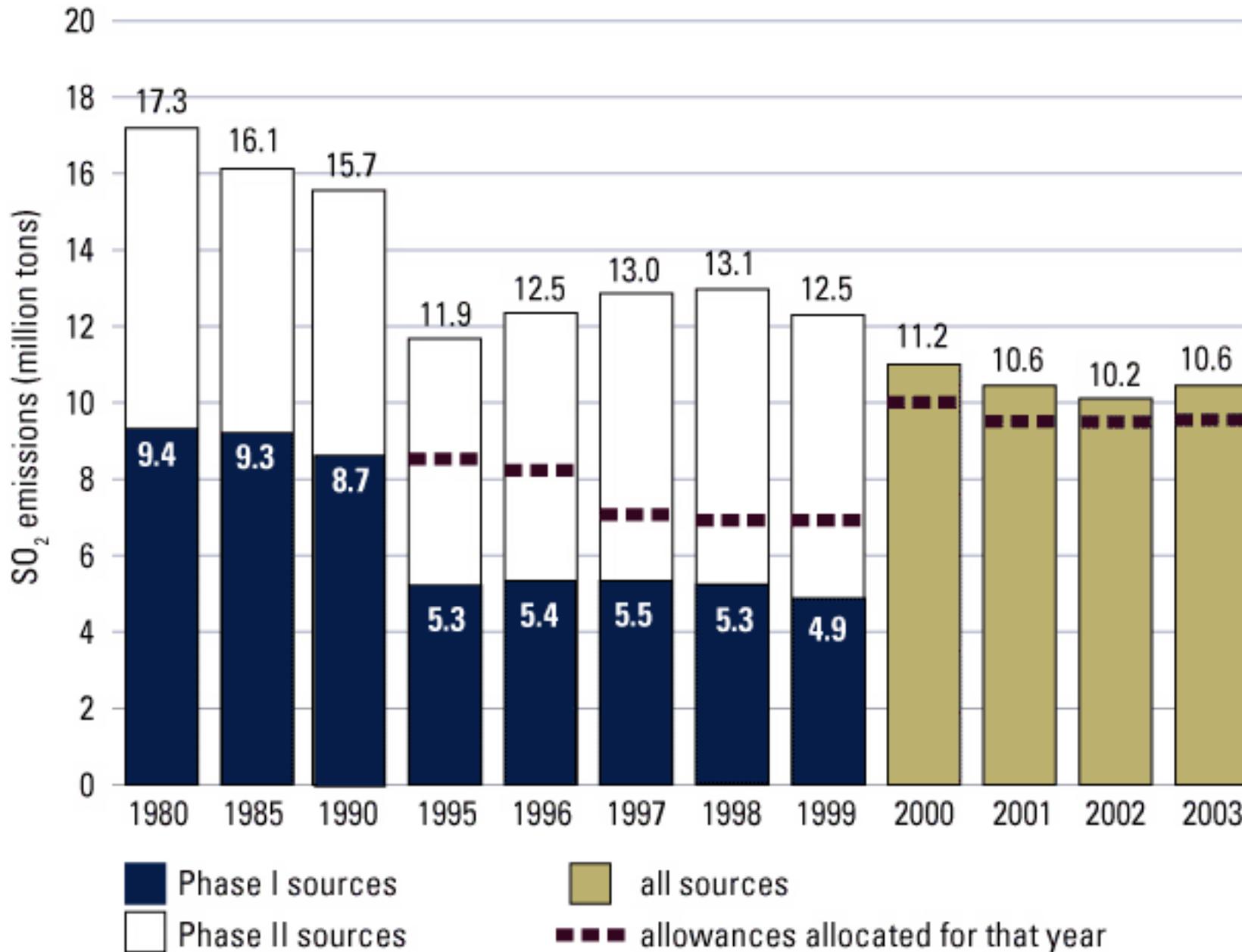
Acid Rain Program Goals

- Achieve environmental benefits through reductions in SO₂ and NO_x emissions.
- Facilitate active trading of allowances and use of other compliance options to:
 - minimize compliance costs,
 - maximize economic efficiency, and
 - allow strong economic growth.
- Promote pollution prevention and energy efficient strategies and technologies.

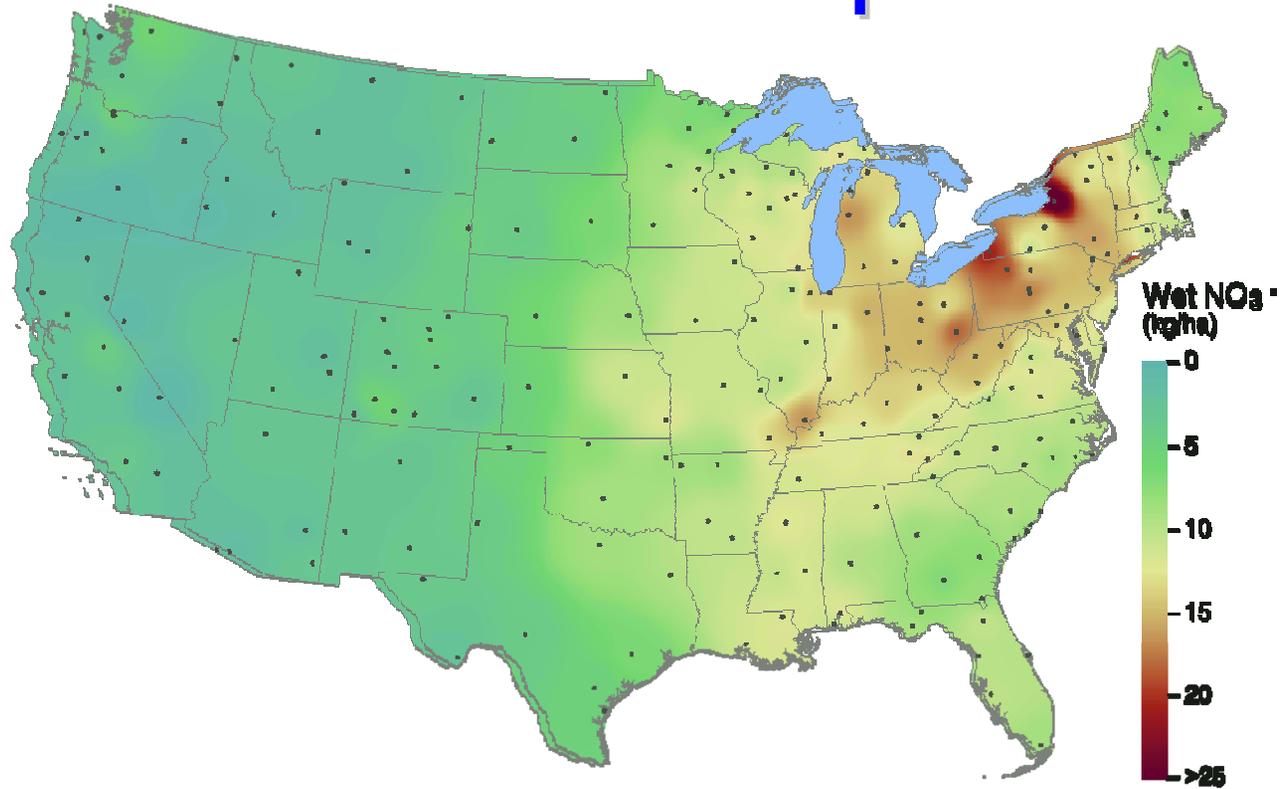
LOCATION OF ACID RAIN PROGRAM POWER PLANTS



ACID RAIN PROGRAM UNIT EMISSIONS (short tons)



Wet Nitrate Deposition



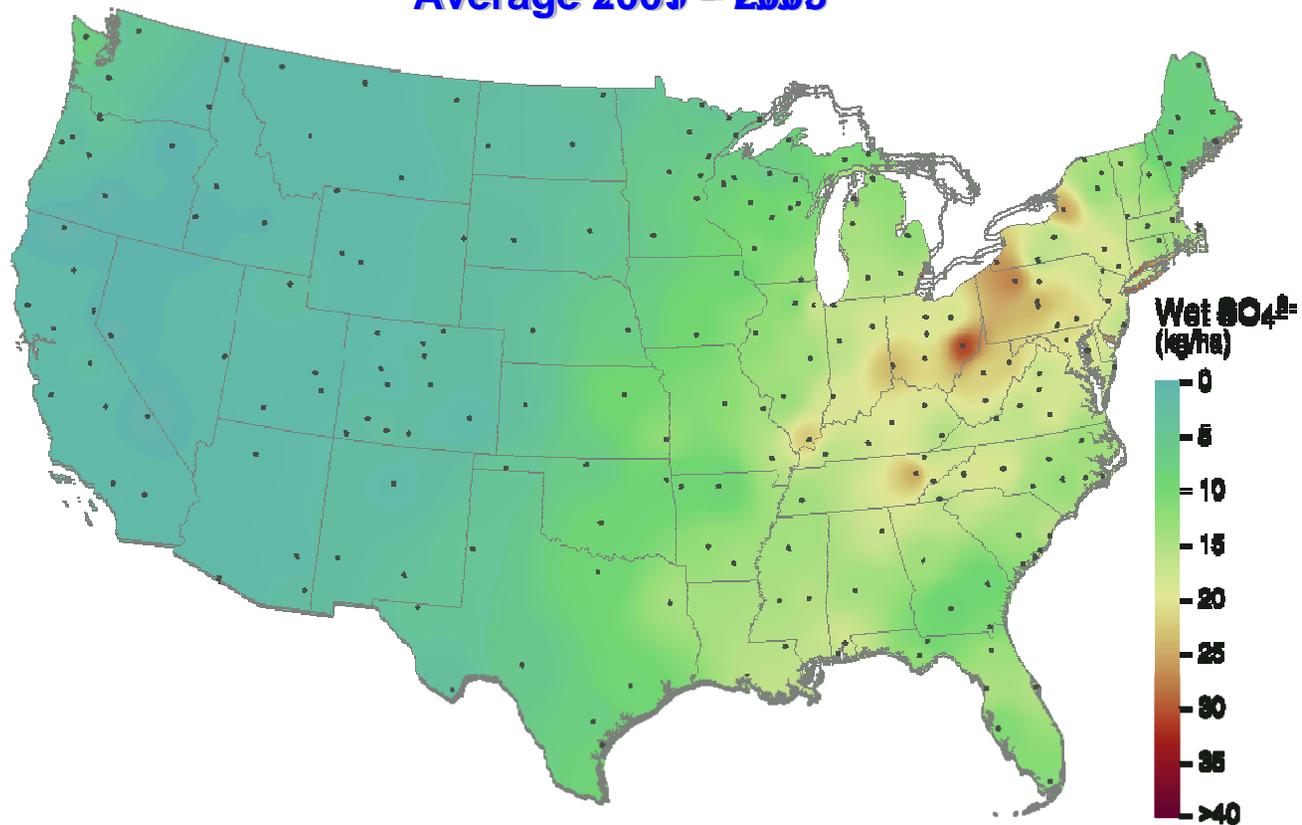
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USEPA/CAMD 09/03/04
Redesign/09/03/04

Average Wet Nitrate Deposition, 2008-2009

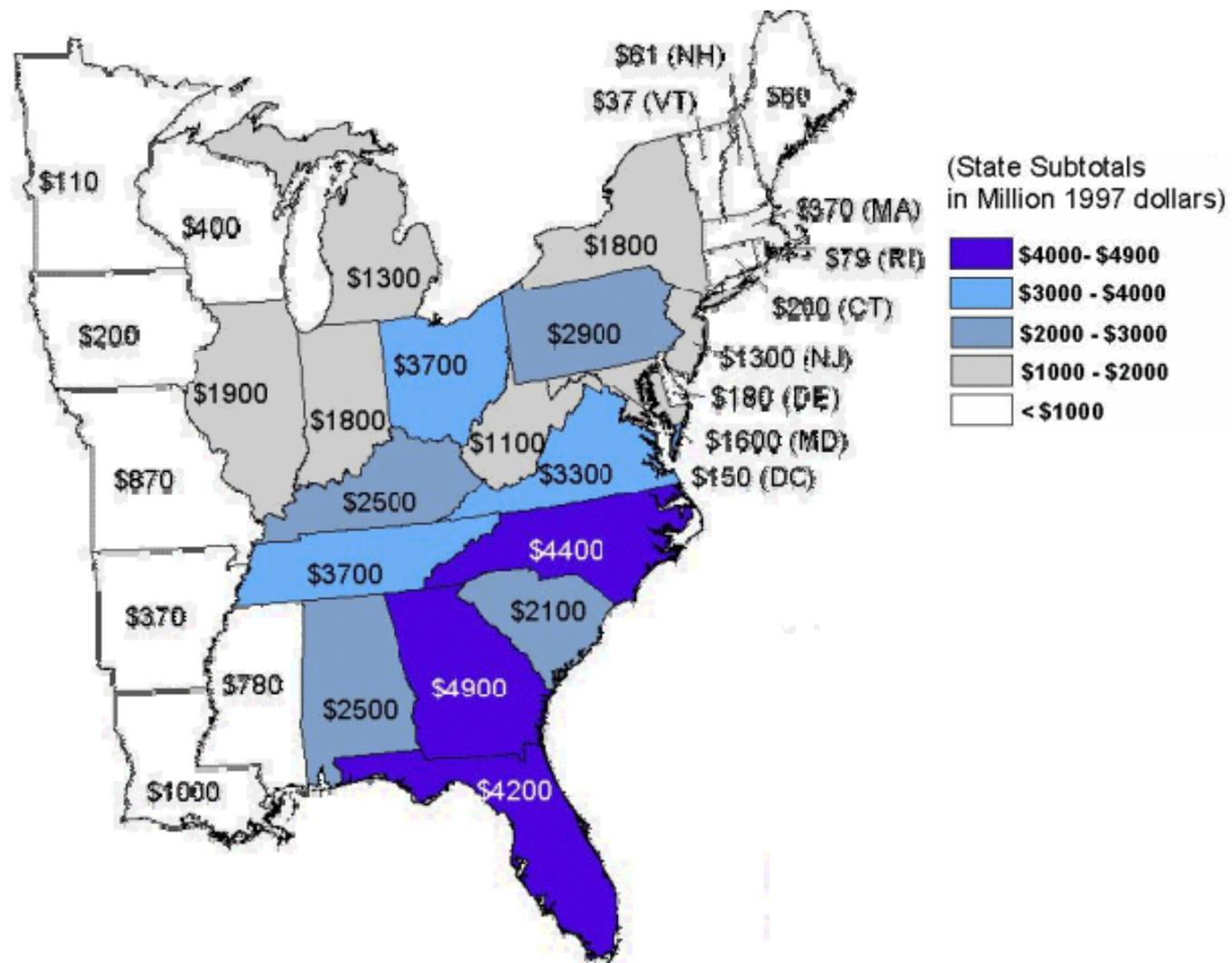
Wet Sulfate Deposition

Wet Sulfate Deposition
Average 2001 – 2003





Significant Health Benefits





Low Annual Compliance Costs





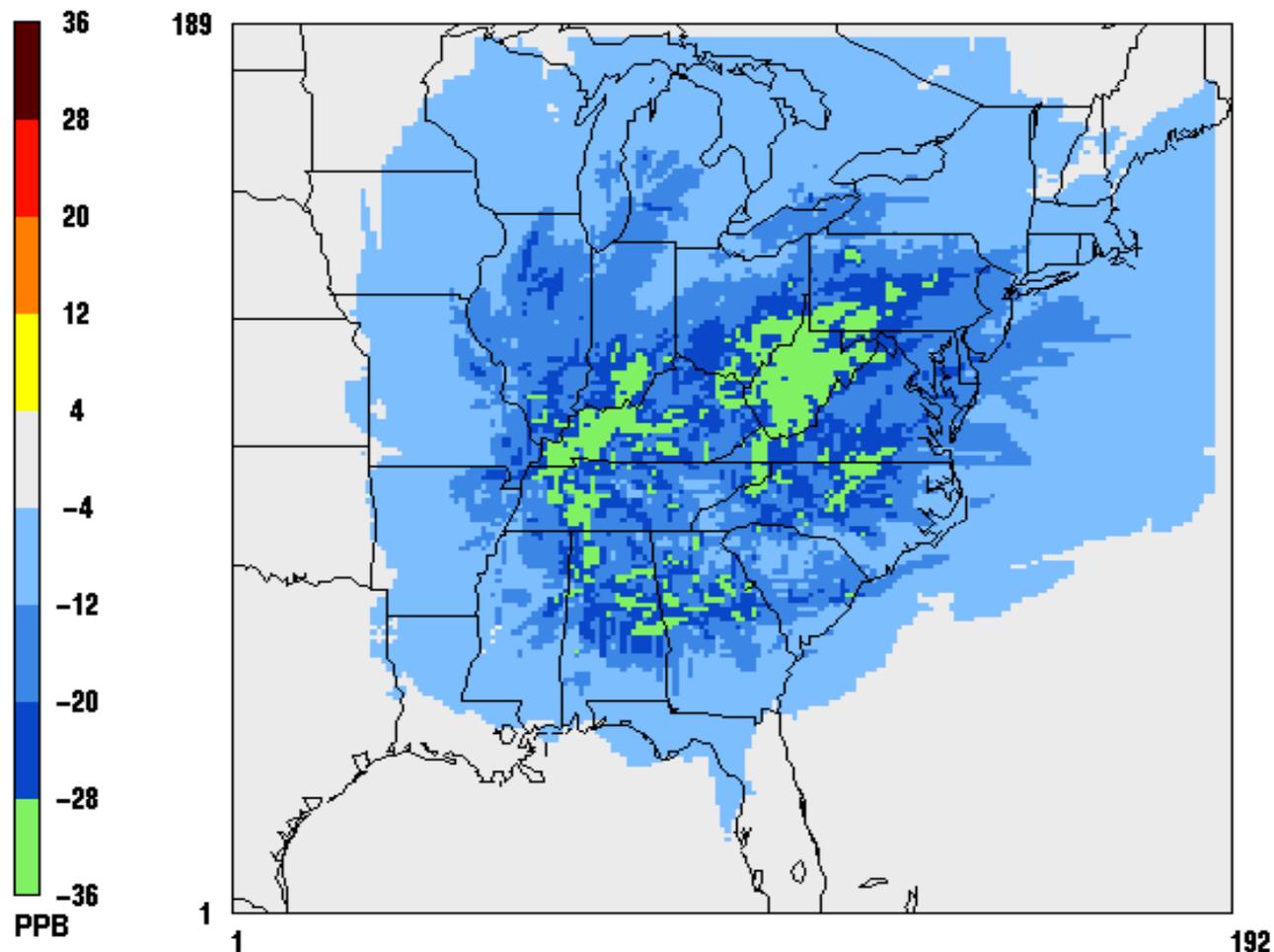
Regional NO_x Reduction Rule ("NO_x SIP Call")

- Addressed regional transport of ozone in the Eastern U.S. during the summertime ozone season
- Used existing legal authorities in the US Clean Air Act
- Required emission reduction measures to be in place by May 2004
- Established NO_x budgets for affected states and allowed trading of NO_x allowances between sources in these states
- Reduces summertime NO_x emissions by about 23% (approximately 900,000 tons) from 1996 levels (mostly from the power sector)

Maximum Air Quality Improvements With the NOx SIP call....

2007 SIP Call Budgets plus CAA

Largest Reduction Over Four OTAG Episodes



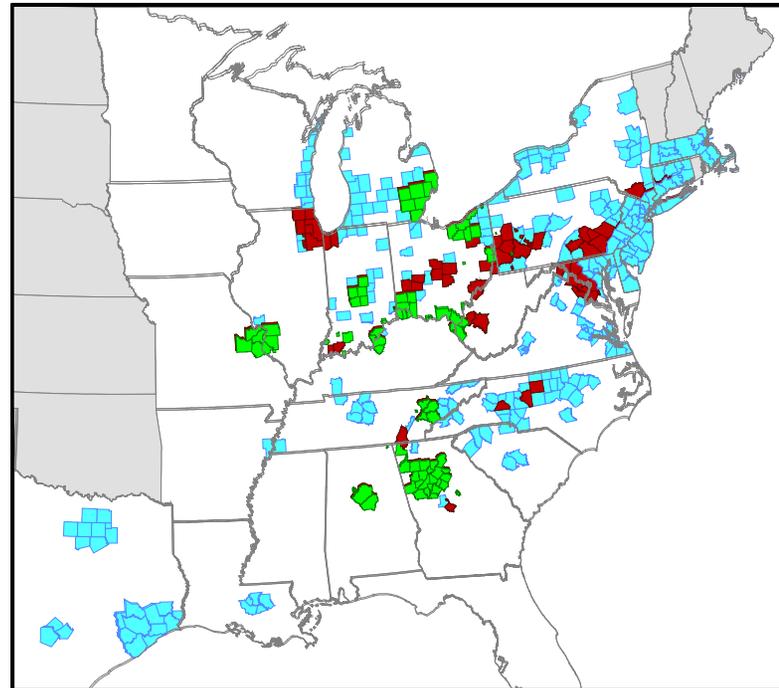


Clean Air Interstate Rule

- Clean Air Interstate Rule (CAIR) will significantly cut emissions of SO₂ and NO_x from power plants
- Helps cities and States in the East meet new, more stringent national ambient air quality standards (NAAQS) for ozone and fine particles
- Guarantees substantial benefits for public health and environment
- Achieves the largest reduction in air pollution in more than a decade
- Provides one of the largest investments in pollution control technology in history
- Serves as the single most important step to take now to improve air quality in the U.S.

Ozone and Particle Pollution: CAIR, together with other Clean Air Programs, Will Bring Cleaner Air to Areas in the East - 2015

Projected Nonattainment Areas in 2015 after Reductions from CAIR and Existing Clean Air Act Programs



104 ozone areas -- 118 M people

36 PM_{2.5} areas -- 71 M people

5 ozone areas -- 36 M people

14 PM_{2.5} areas -- 31 M people

-  Nonattainment areas for 8-hour ozone pollution only
-  Nonattainment areas for fine particle pollution only
-  Nonattainment areas for both 8-hour ozone and fine particle pollution

Projections concerning future levels of air pollution in specific geographic locations were estimated using the best scientific models available. They are estimations, however, and should be characterized as such in any description. Actual results may vary significantly if any of the factors that influence air quality differ from the assumed values used in the projections shown here.



The CAIR Approach

- Analyze sources of SO₂ (for PM_{2.5}) and NO_x (for PM_{2.5} and ozone).
- Determine projected impacts of individual states on ozone and PM nonattainment in 2010, to define geographic boundaries covered by the rule.
- Allow cost-effective approach for regional reductions, propose an optional cap-and-trade program similar to current Acid Rain Program for SO₂ (Title IV) and the NO_x SIP call.
- EPA develops an emissions budget for each state based on application of highly cost-effective controls on electric generating units (EGU) in a cap and trade program, that includes all affected states. States have discretion in deciding which sources to control to meet the budget.
- Provide the most timely reductions; propose a two-phase program with declining compliance caps for NO_x in 2009 and 2015, and for SO₂ in 2010 and 2015.



Key Elements of CAIR

- CAIR sets an emission reduction requirement for each State, based on capping power plant emissions collectively at levels that EPA believes are highly cost-effective to achieve.
- Provides an optional cap and trade program based on successful Acid Rain and NOx Budget Trading programs as a method to implement the necessary reductions.
- Includes a two-phase program with declining power plant emission caps:
 - **SO₂ annual caps: 3.6 million tons in 2010 and 2.5 million in 2015**
 - **NO_x annual caps: 1.5 million tons in 2009 and 1.3 million in 2015**
 - **NO_x ozone season caps: 580,000 tons in 2009 and 480,000 tons in 2015**
 - **Emission caps are divided into State SO₂ and NO_x budgets.**
- Allows States flexibility on how to achieve the required reductions, including which sources to control and whether to join the trading program.

Cap and Trade Mechanism: Allowance Allocation and Markets

EPA ROLE

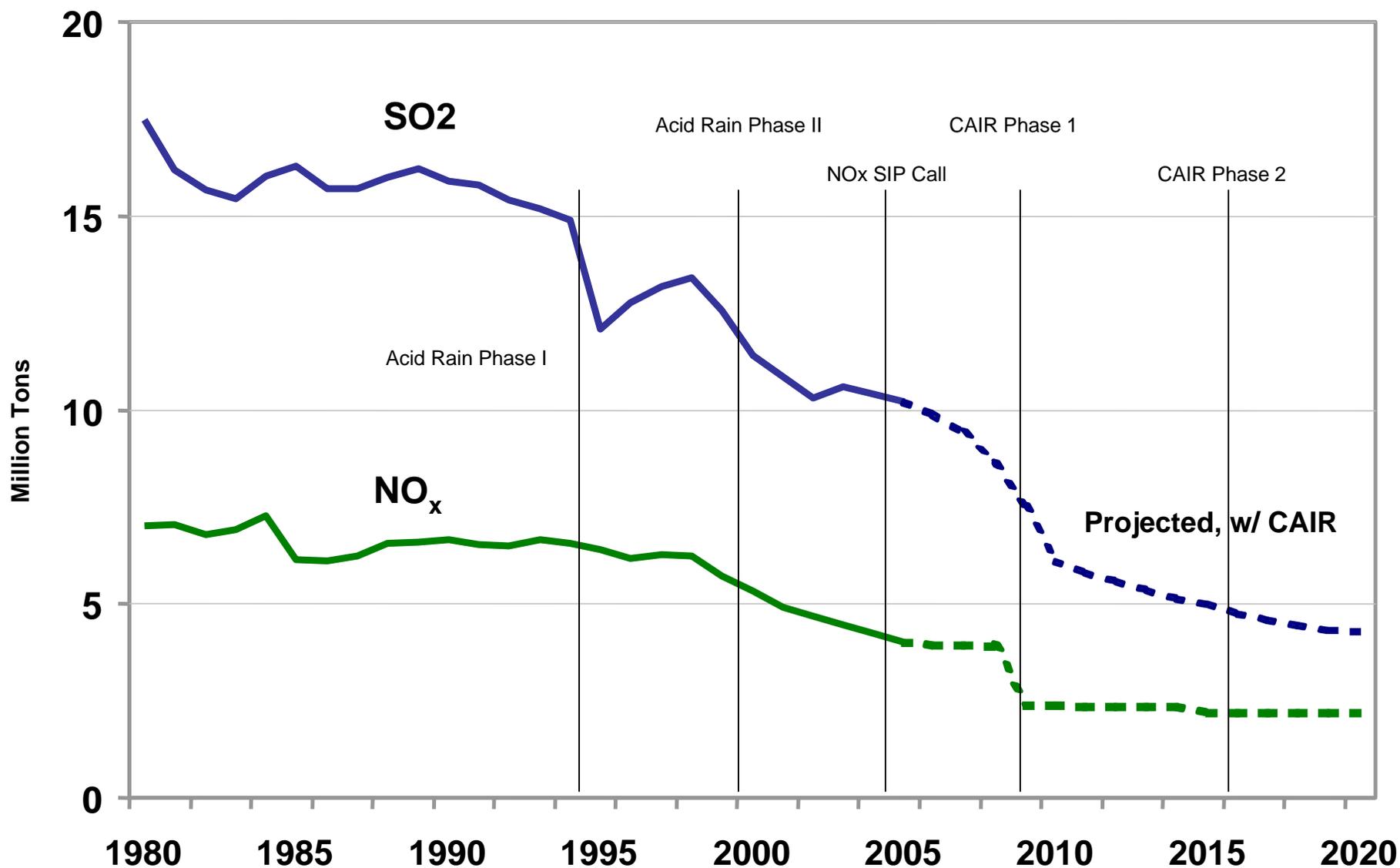
- Set state budgets
- Establish trading program and market procedures
- Administer tracking systems
- Define allowance allocation parameters

STATE ROLE

- Identify sources for reduction
- Voluntary trading program
 - Adopt EPA rules/program in 18 months
 - Determine trading program budget
 - Allocate NO_x allowances (SO₂ already allocated)

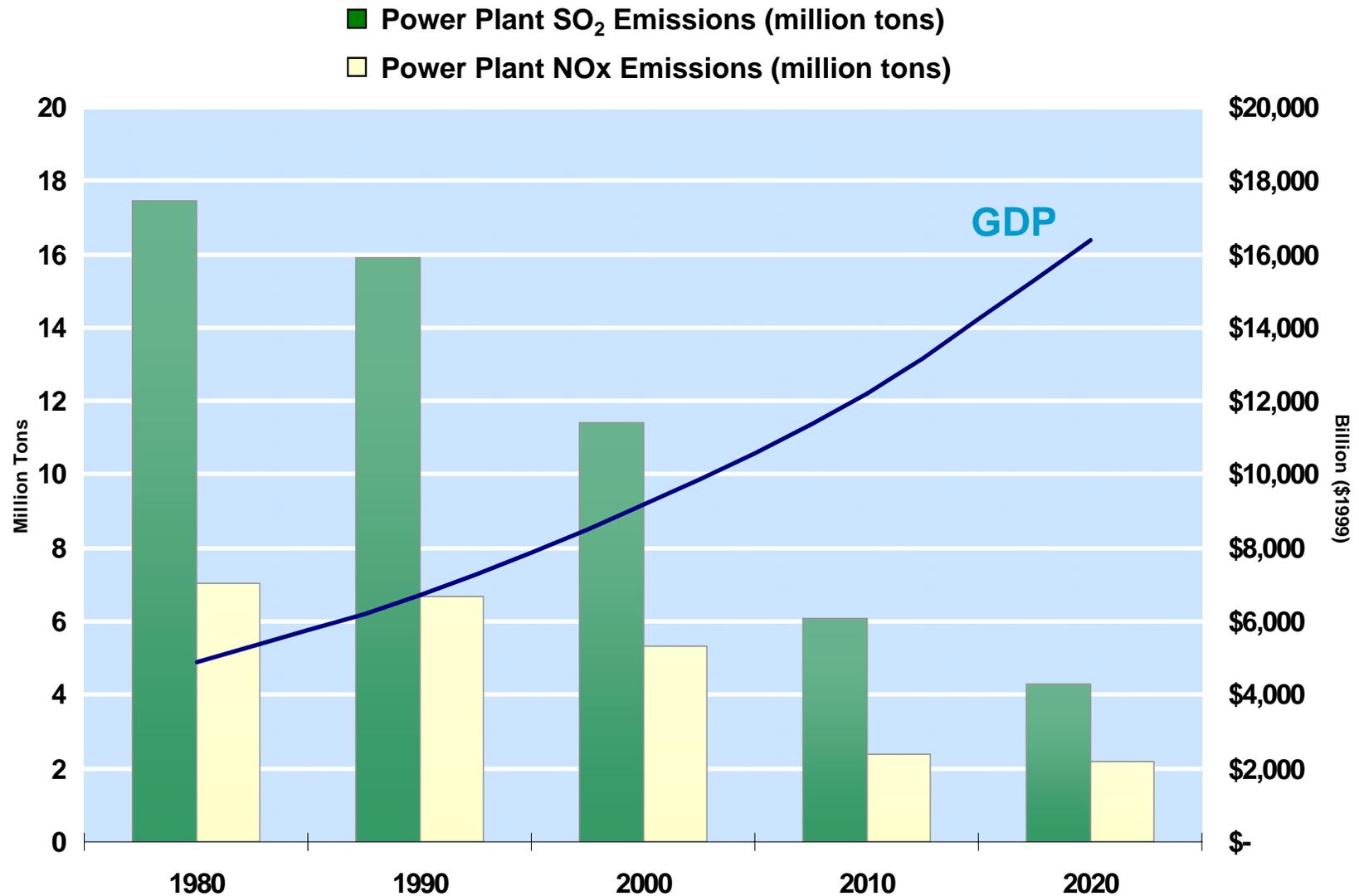
- **EPA expects a smooth transition to new trading program**
 - Designed with existing cap and trade programs in mind
 - Reasonable control costs available
 - High number of sources facing different control costs

National NO_x and SO₂ Power Plant Emissions: Historic and Projected with CAIR



Source: EPA

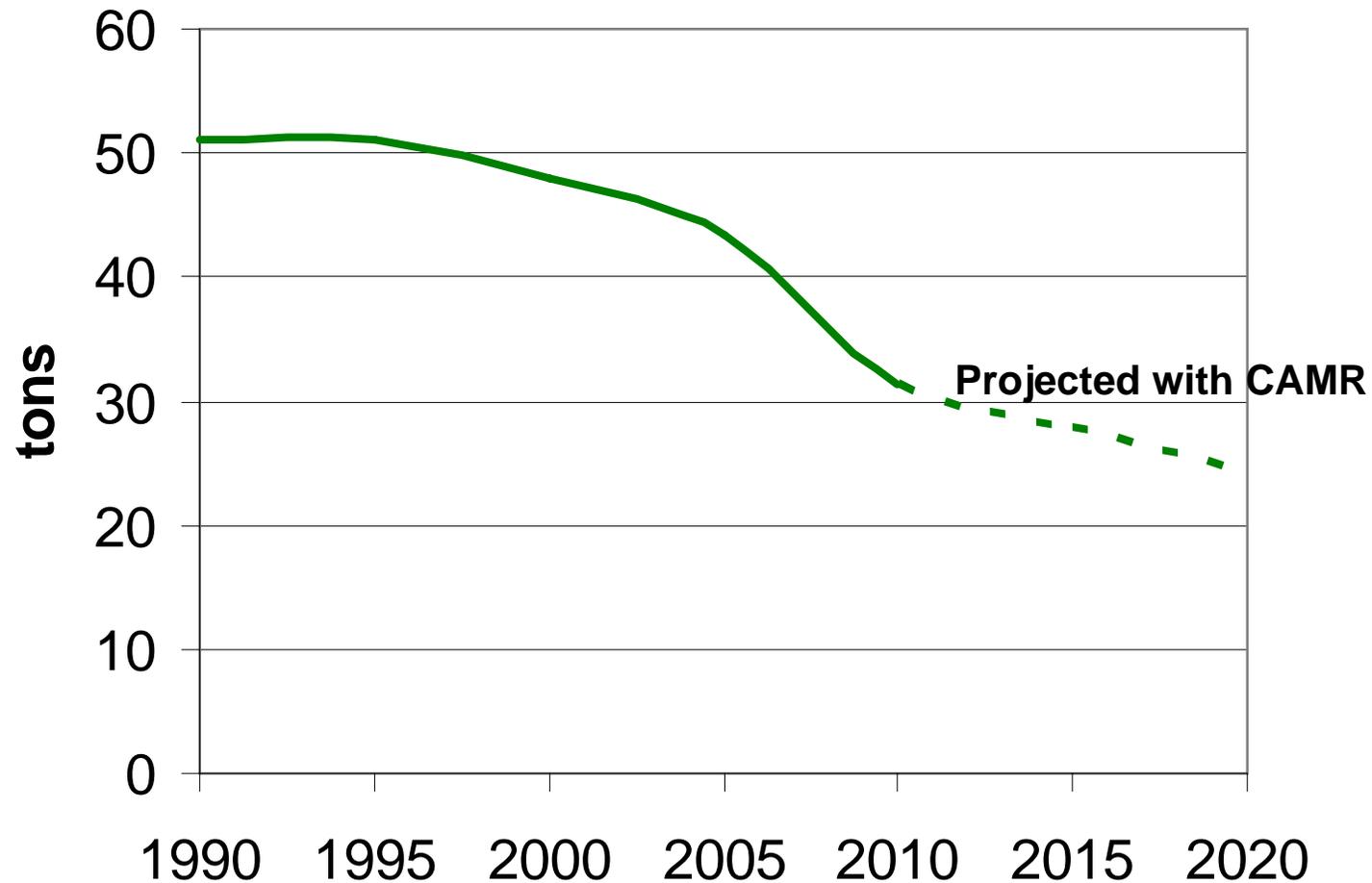
Economic Growth & Environmental Improvement



Sources: 1980 - 1999 emissions data are from the National Air Pollutant Emissions Trend Report (EPA, March 2000). Projections for SO₂, NO_x and mercury are derived from the Integrated Planning Model (IPM). GDP data for 1980 - 2000 is from the Bureau of Economic Analysis, U.S. Department of Commerce. The GDP projection for 2010 is from OMB's Analytical Perspectives Report for 2003, Table 2-1. The 2010 to 2020 projection follows EIA's assumptions in AEO 2001 of 3% growth per year.



National Mercury (Hg) Power Plant Emissions: Co-benefits from the Clean Air Interstate Rule



Source: EPA

Note: 1999 emission estimate for utility coal boilers is based on 1999 Information Collection Request (ICR); 1990 and 1996 are based on different methodology.



Regional Haze

- Regional haze can originate from sources located across broad geographic areas
- EPA has encouraged the States and Tribes across the U.S. to address visibility impairment from a regional perspective
- Regional Planning Organizations (RPO's):
 - Evaluate technical information to better understand how their States and Tribes impact national park and wilderness areas (Class I areas) across the country, and
 - Pursue the development of regional strategies to reduce emissions of particulate matter and other pollutants leading to regional haze

Visibility Impairment



Geographic Design





Impacts on Beijing from Regional Transport

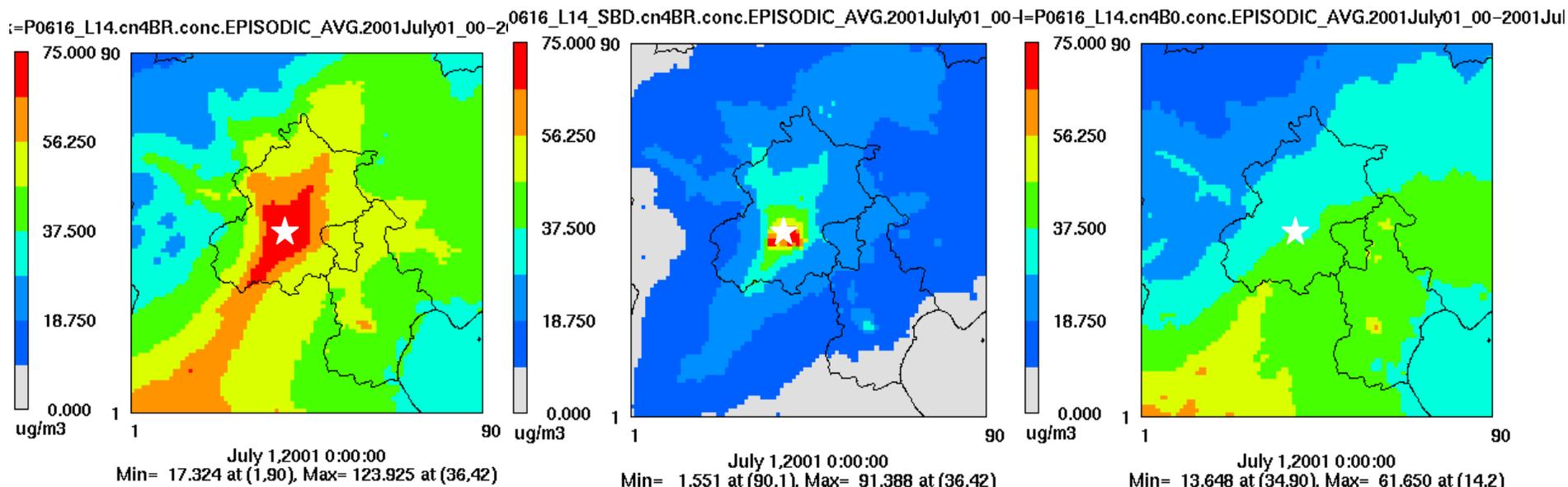
- Modeling analysis initiated in 2003
- Collaboration with Tsinghua University and DOE/Argonne National Lab
- Demonstrates significant regional transport contributions for PM_{2.5} and ozone
- Impact demonstrated by modeling and satellite imagery.

Modeled Impact of Local vs. Transported PM 2.5 in Beijing

Local Emissions +
Regional Transport

Local
Emissions

Regional
Transport



PM 2.5 Episodic Average (July 1-20, 2001)

(Insert Beijing air quality modeling simulation)

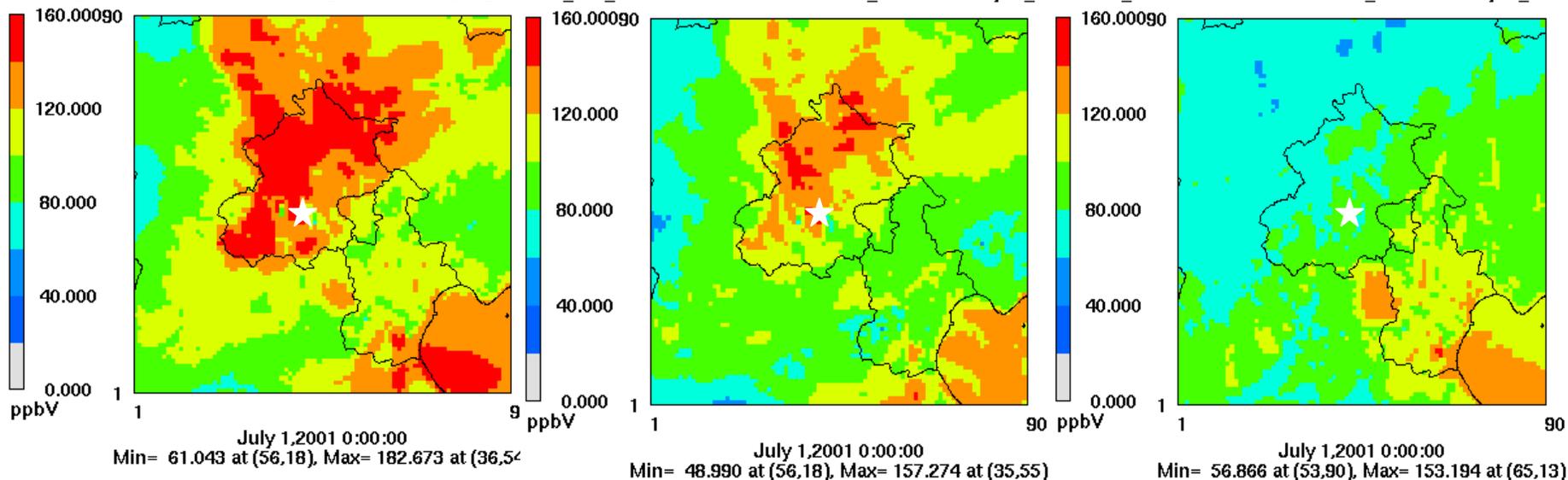
Modeled Impact of Local vs. Transported Ozone in Beijing

Local Emissions +
Regional Transport

Local
Emissions

Regional
Transport

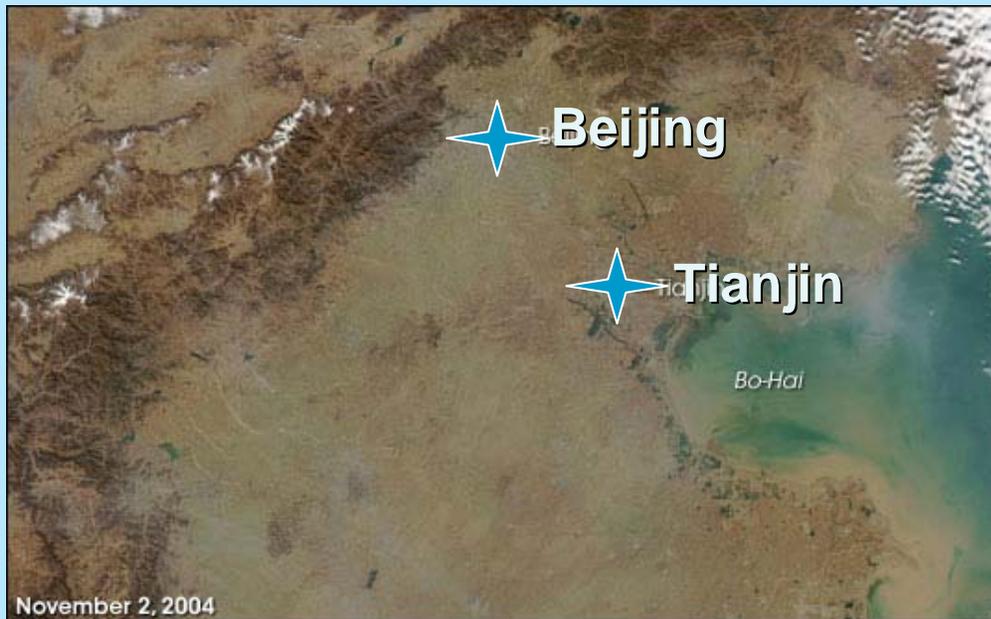
I=P0616_L14.cn4BR.conc.EPISODIC_MAX.2001July01_00-0616_L14_SBD.cn4BR.conc.EPISODIC_MAX.2001July01_00=P0616_L14.cn4B0.conc.EPISODIC_MAX.2001July01_00-2001Ju



O₃ Episodic Max (July 1-20, 2001)

MODIS (Aqua) Satellite Images

Nov. 2, 2004



Nov. 3, 2004



Between the afternoon of November 2 and November 3, 2004, a layer of haze built up in east-central China, and lingered until November 5th, causing significant visibility problems. By November 6th, a new cloud of haze had accumulated.



Final Points

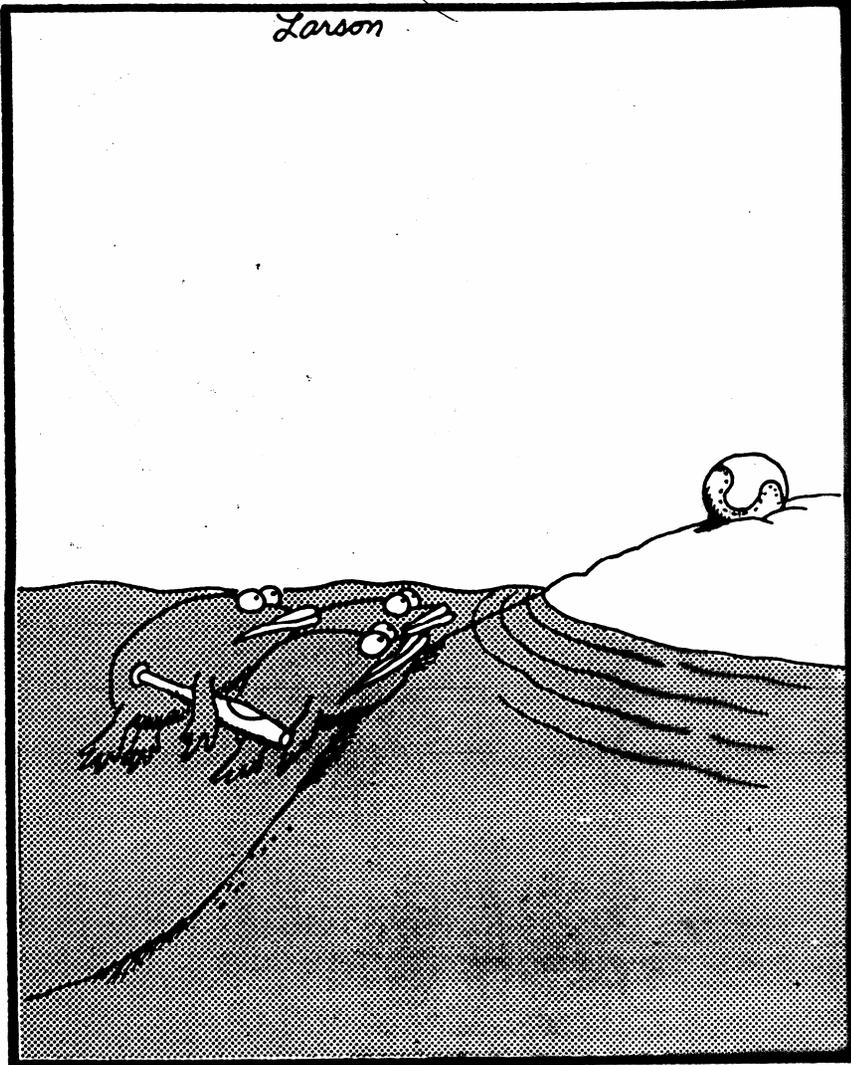
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For More Information

- Clean Air Interstate Rule:
www.epa.gov/cleanairinterstaterule/
- Acid Rain Program:
www.epa.gov/air/acidrain/index.html
- NO_x SIP Call:
www.epa.gov/airmarkets/fednox/
- Regional Planning Organizations
www.epa.gov/visibility/regional.html

Larson



Great moments in evolution



THANK YOU!

谢谢

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Second US-China NO_x and SO₂ Control Workshop