

# Science of Ozone and PM<sub>2.5</sub> Chemistry in the South Coast and San Joaquin Valley

Air Quality Planning and Science Division  
California Air Resources Board  
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# Goals of the Presentation

- Discuss scientific basis of SIP process
- Summarize ozone and PM<sub>2.5</sub> chemistry and atmospheric processes
- Provide overview of air quality modeling results for South Coast and San Joaquin Valley
- Describe how atmospheric science is used to guide SIP strategy development



# California's Investment in Science

- ARB has a long history of air quality research in collaboration with air districts
- Academic partnerships leverage ARB resources and expand scientific expertise in air pollution
- Field studies in the South Coast and San Joaquin Valley provide region-specific understanding of air quality problems

# California's History of NO<sub>x</sub> Control

- The 1990 Federal Clean Air Act emphasized control of VOC for ozone
- Early on, California recognized the importance of adding NO<sub>x</sub> control
- California's regulation of ozone forming pollutants has strongly relied on science with effective results
- New PM<sub>2.5</sub> standards in 1997 added further importance to NO<sub>x</sub> control

# Federal Air Quality Standards

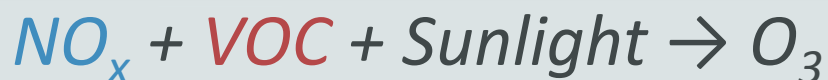
- Presentation focuses on standards addressed in 2016 SIPs:
  - 8-hour ozone: 75 ppb
  - Annual PM<sub>2.5</sub>: 12 µg/m<sup>3</sup>
- EPA evaluating need for more stringent ozone standard between 60 and 70 ppb
- Attainment deadlines established following promulgation of new standards



# Understanding Atmospheric Chemistry and Responses to Emissions Reductions

# The Basics: Chemistry of Ozone and PM<sub>2.5</sub> Formation

## Ozone Formation:



## PM<sub>2.5</sub> Formation:



# The Atmosphere: Complex Multi-Pollutant System

- Ozone and PM<sub>2.5</sub> air quality reflects multi-pollutant interactions among:
  - Emissions
  - Meteorology
  - Atmospheric chemistry
- Emissions of each precursor vary in space and time
- Meteorology causes transport and dispersion
- Chemical reactions occur with differing time scales and are highly nonlinear



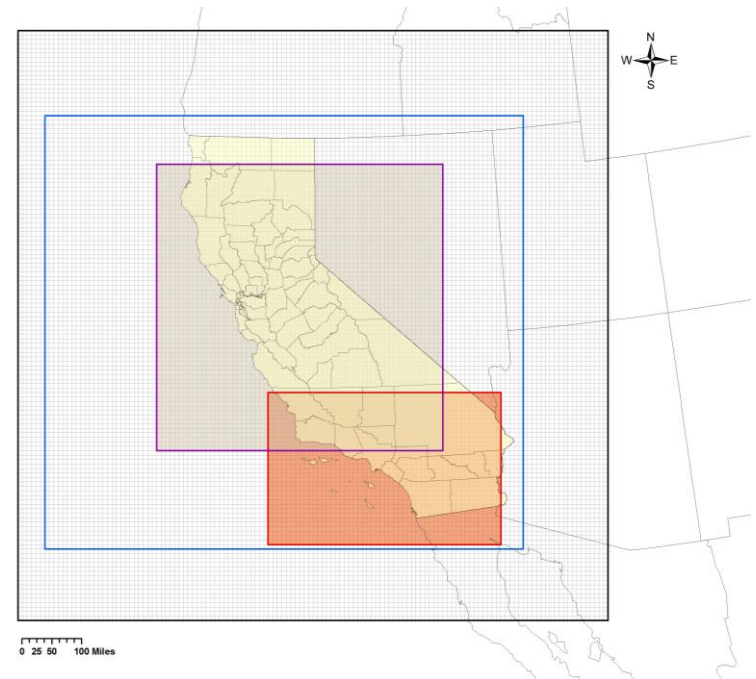


# Atmospheric Response to Emissions Controls Depends on Linked Processes

- Controlling common precursors is basis of an effective multi-pollutant control strategy
- Effectiveness of reductions may differ by region and by location within a region
- This relationship may also change over time due to relative pace of emission reductions

# Use of Models is Required for SIPs

- Air quality modeling integrates these complex atmospheric processes
- Provides tool to evaluate response to emissions changes
- System consists of:
  - Emissions model
  - Meteorological model
  - Air quality model




# Scientific Foundation of California Modeling

- Recent major field studies:
  - 2000 : CRPAQS/CCOS
  - 2000-2010: EPA/ARB Advanced Monitoring Initiative, MATES III, ARCTAS, CalNex
  - 2010+: MATES IV, Discover-AQ
- Annual science meetings:
  - International Conferences on Atmospheric Chemical Mechanisms, Aerosol Modeling Algorithms, and Meteorology Modeling
- Staff publications in peer-reviewed technical journals



# Using Models in SIP Strategy Development

- Assessing relative effectiveness of different precursors
- Identifying magnitude of precursor reductions needed to meet standards
- Evaluating impacts of reductions in different source sectors



# Overview of Modeling Results for South Coast and San Joaquin Valley

# California's Comprehensive Assessment of PM<sub>2.5</sub> Science

- Science documented in SIPs, workshops, and peer-reviewed publications
- NO<sub>x</sub> most effective on a regional basis
- PM<sub>2.5</sub> reductions effective for targeted attainment needs

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## California's Success in Reducing PM<sub>2.5</sub> Pollution

California has made remarkable progress in reducing fine particle pollution in the nation's most challenging nonattainment regions, the South Coast Air Basin and the San Joaquin Valley. This article outlines the state's success.

Since 2000, annual concentrations of fine particulate matter (i.e., particles less than 2.5 micrometers in diameter or PM<sub>2.5</sub>) have dropped approximately 50% in the South Coast Air Basin (SC) and the San Joaquin Valley (SJV) and both regions are expected to attain the annual standard of 15 µg/m<sup>3</sup> by the 2014 deadline. Compliance with the 24-hr standard of 35 µg/m<sup>3</sup> is projected in SJV by the 2019 deadline and in SC by 2014. The downward trend in the peak annual average PM<sub>2.5</sub> concentration in California's major urban areas is shown in Table 1.

atmospheric mix, and California's emission control programs have successfully targeted the most significant emission sources. While PM<sub>2.5</sub> attainment strategies have varied somewhat in different locations, the major strategies have included California's longstanding oxides of nitrogen (NO<sub>x</sub>) control programs; statewide fleet rules to reduce both NO<sub>x</sub> and PM from diesel engines; the phase-out of most open burning; and the implementation of episodic controls for residential wood-burning.

Implementation of the diesel fleet regulations adopted by the California Air Resources Board



# Ozone Modeling to Support Upcoming SIPs

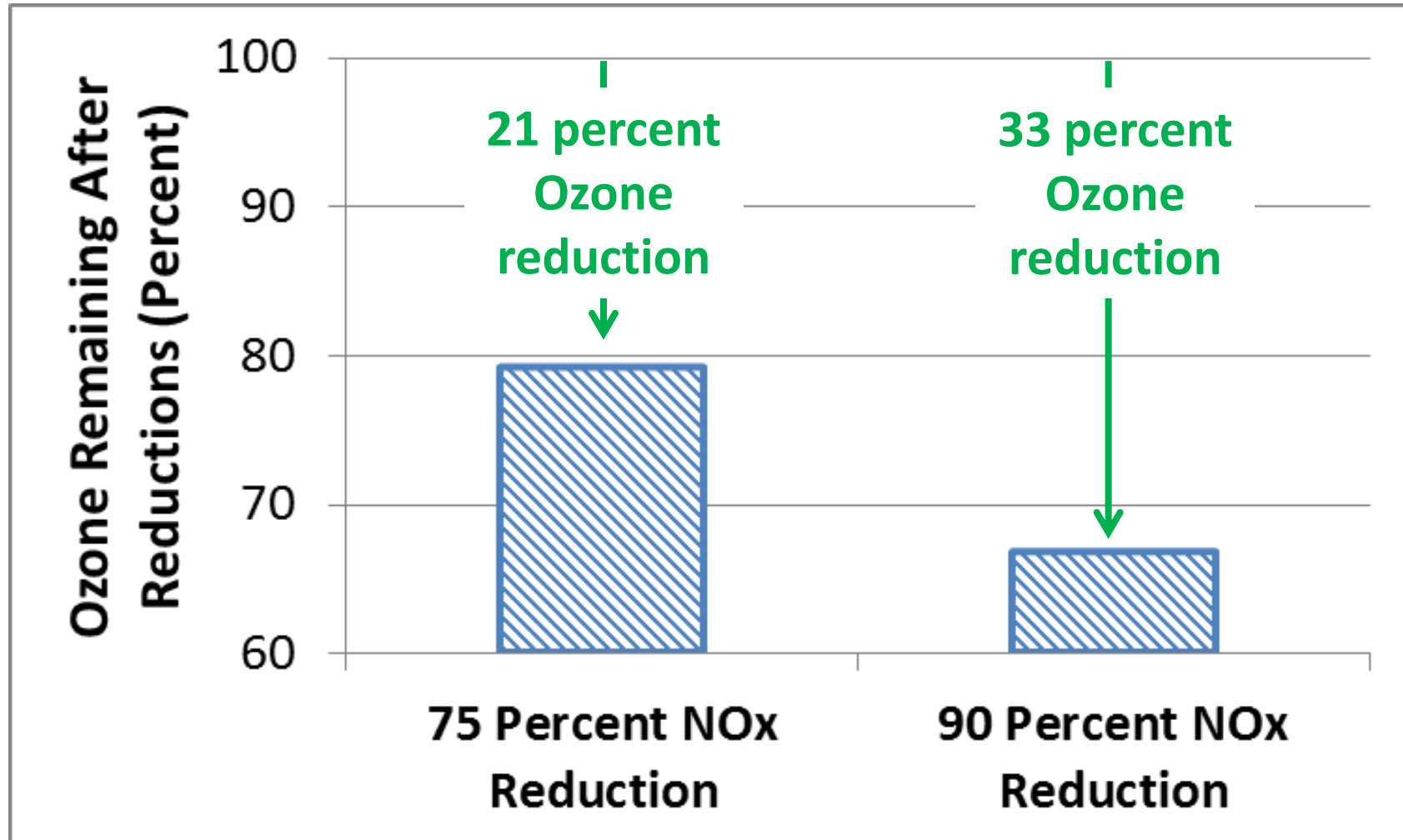
- Initial modeling for South Coast and San Joaquin Valley for 2016 SIPs underway
- Builds upon modeling conducted for prior ozone SIPs in these regions
- Early model runs focus on response to broad emissions reductions

# Nature of Modeling Evaluation

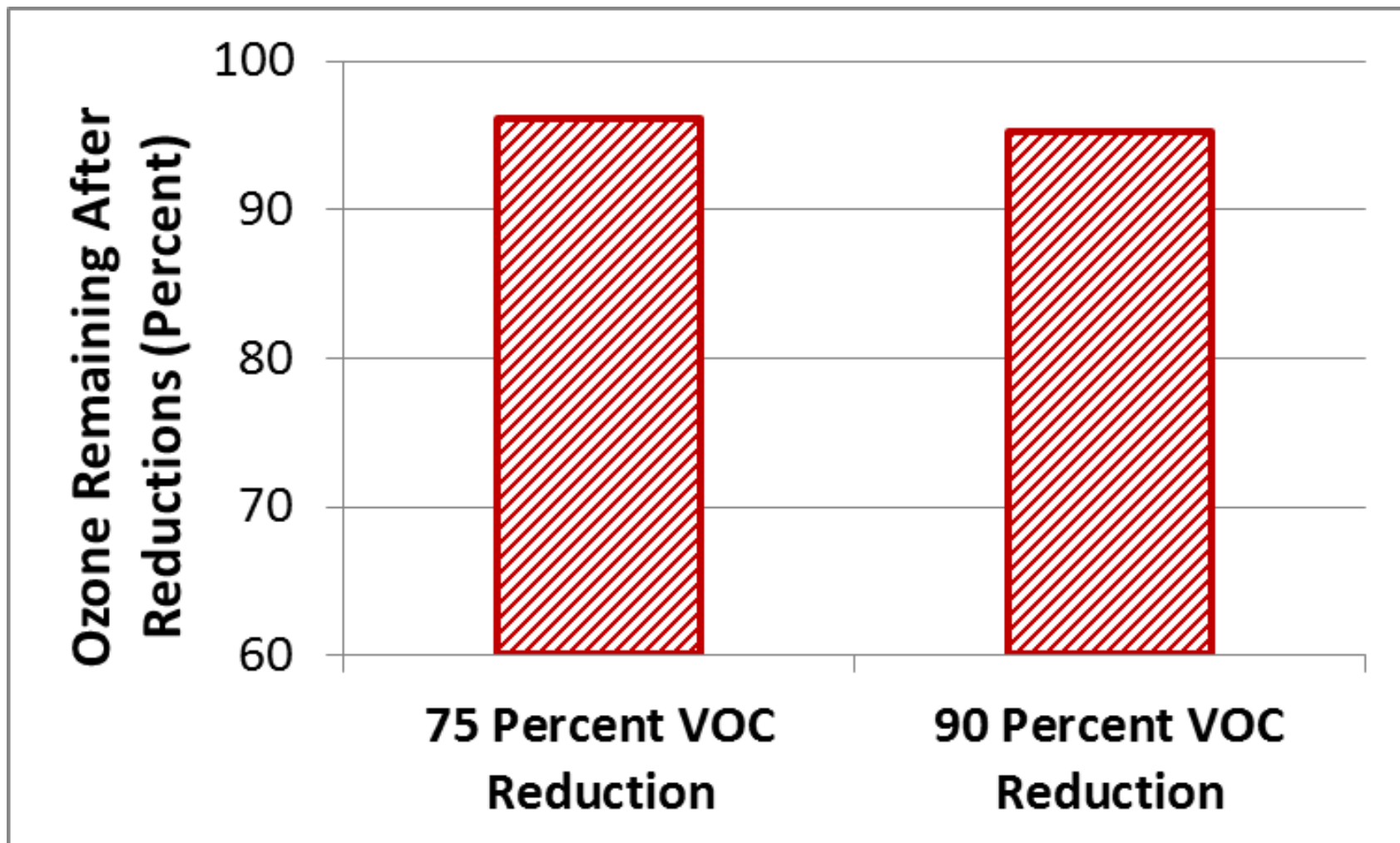
- Series of modeling runs evaluate benefits of reducing individual precursors
- Reflects percent reduction from today's emission levels
- Benefits shown as percent ozone remaining after reductions
- Modeling runs also evaluate combinations of VOC and NO<sub>x</sub> reductions



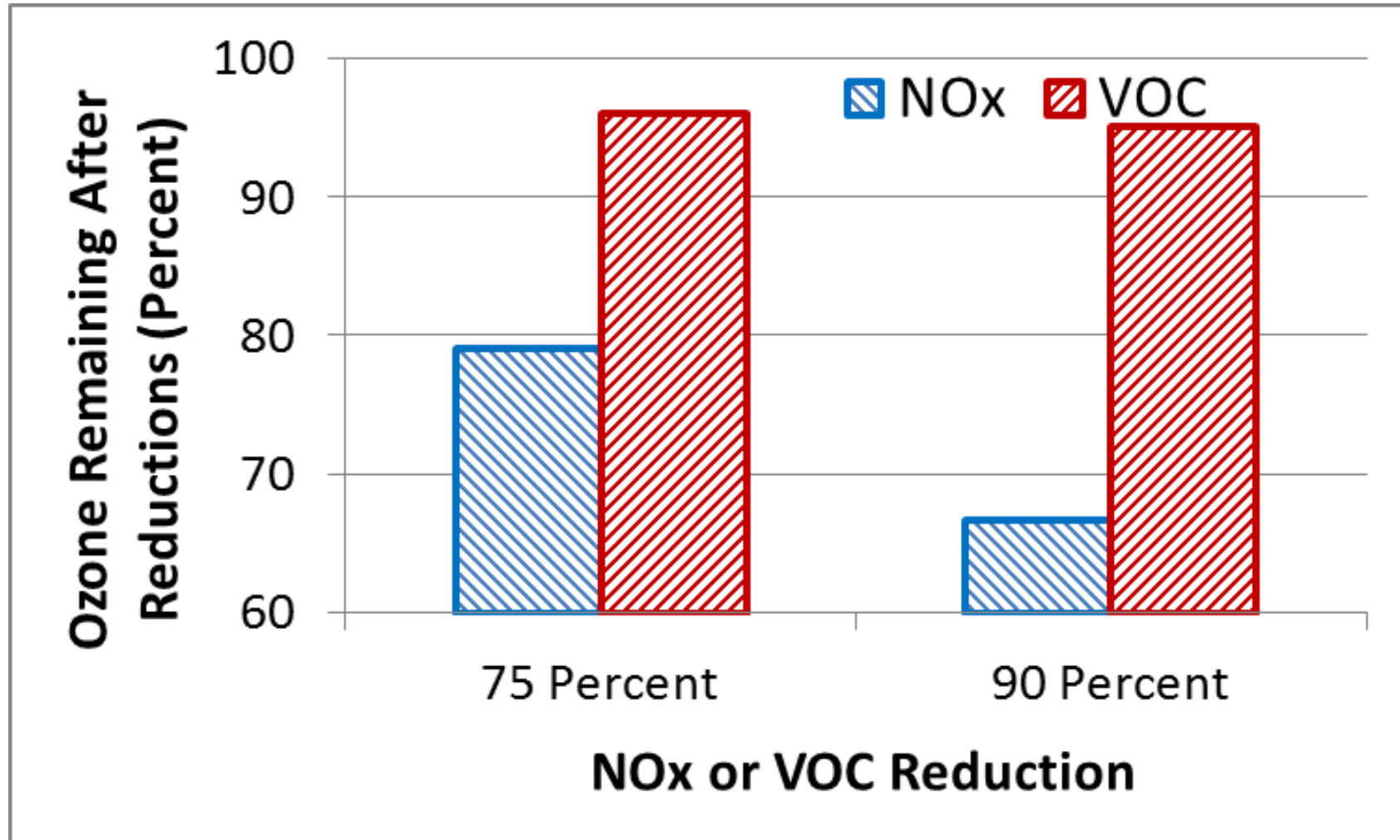
# Relative Effectiveness of NO<sub>x</sub> Reductions: San Joaquin Valley



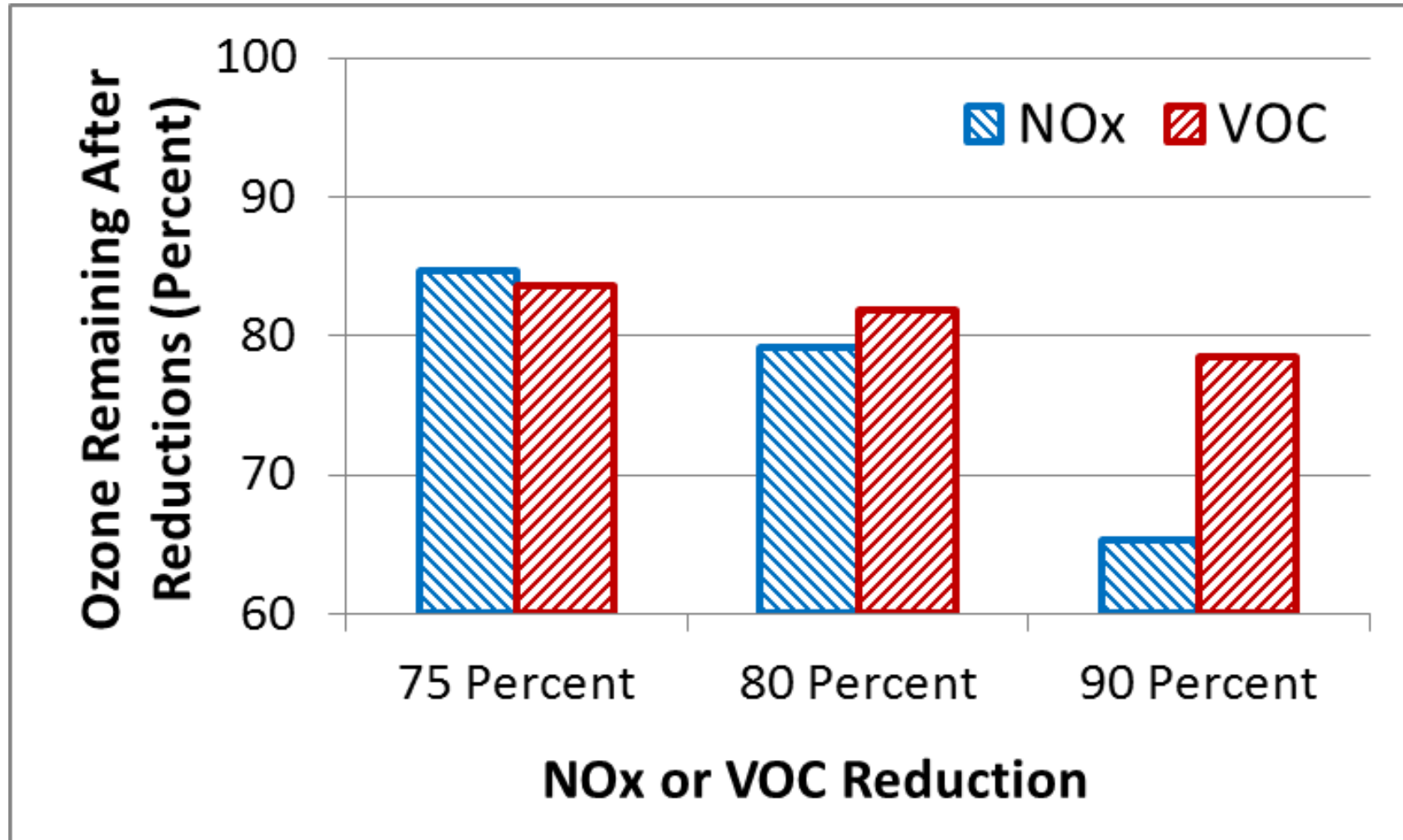
# Relative Effectiveness of VOC Reductions: San Joaquin Valley



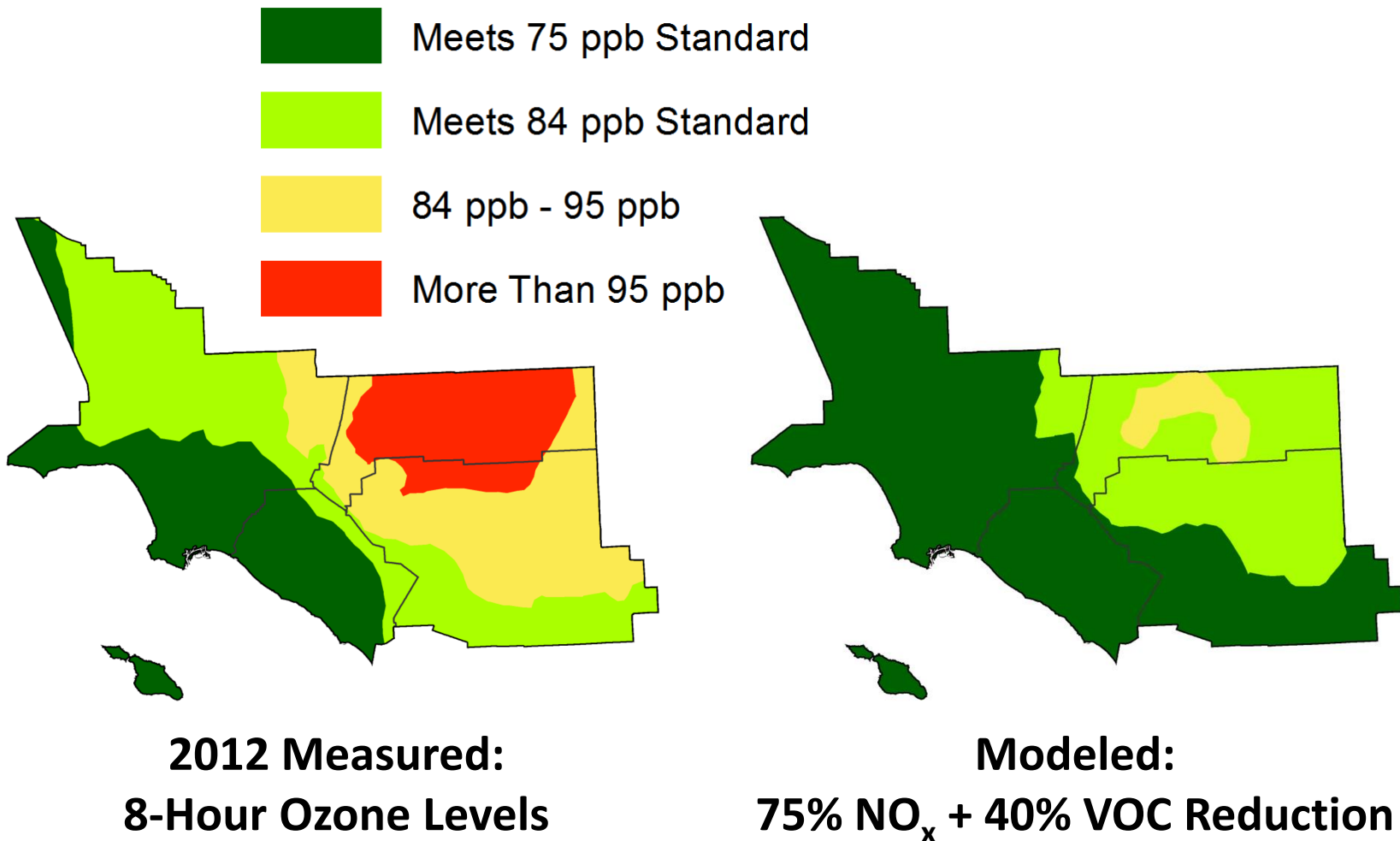
# Comparison of Precursor Effectiveness: San Joaquin Valley



# Comparison of Precursor Effectiveness: South Coast



# Benefits of Combined Strategy: South Coast Ozone

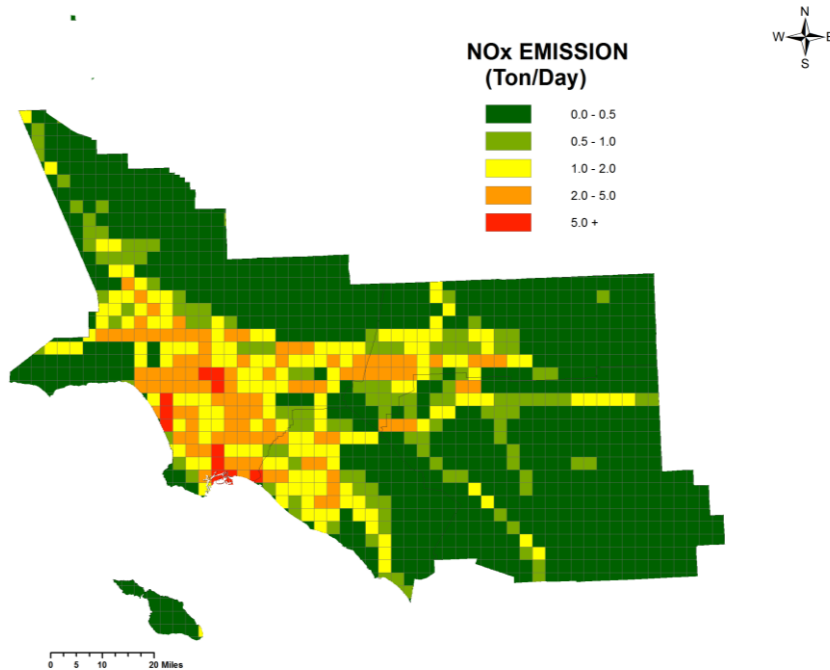




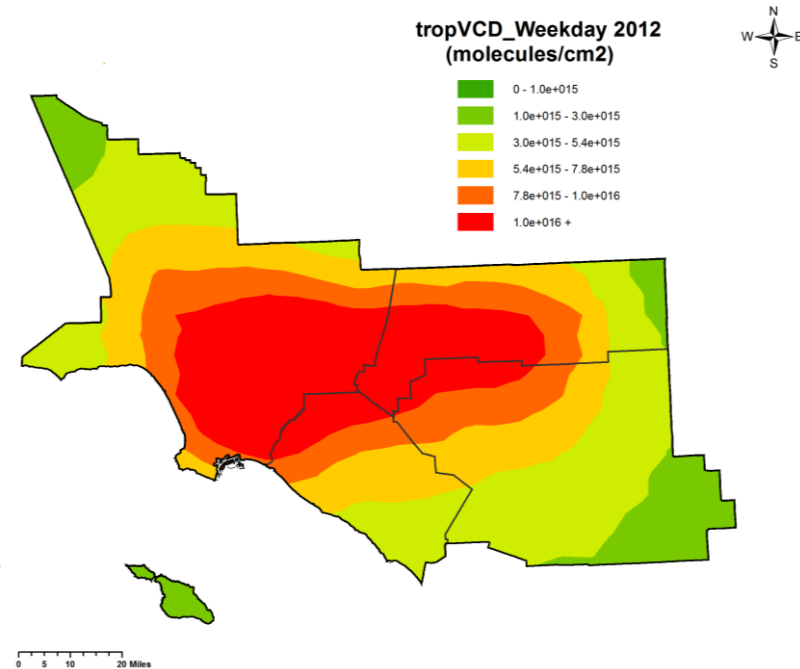
# Need for Regional NO<sub>x</sub> Reductions in South Coast

- Modeling indicates large NO<sub>x</sub> reductions needed for attainment
- Modeling can also assess benefits of reducing emissions from different source sectors or locations
- Emission inventories and satellite images indicate regional distribution of NO<sub>x</sub>

# Distribution of NO<sub>x</sub> in the South Coast



**Spatial distribution of summer  
2012 NO<sub>x</sub> emissions**



**Satellite image of summer  
2012 NO<sub>x</sub> concentrations**



# Modeling Next Steps

- Continued assessment of precursor relationships
- Evaluation of role of natural sources and transport
- Detailed modeling to assess benefits of reductions from individual source sectors and potential strategy scenarios





# From Science to Strategy

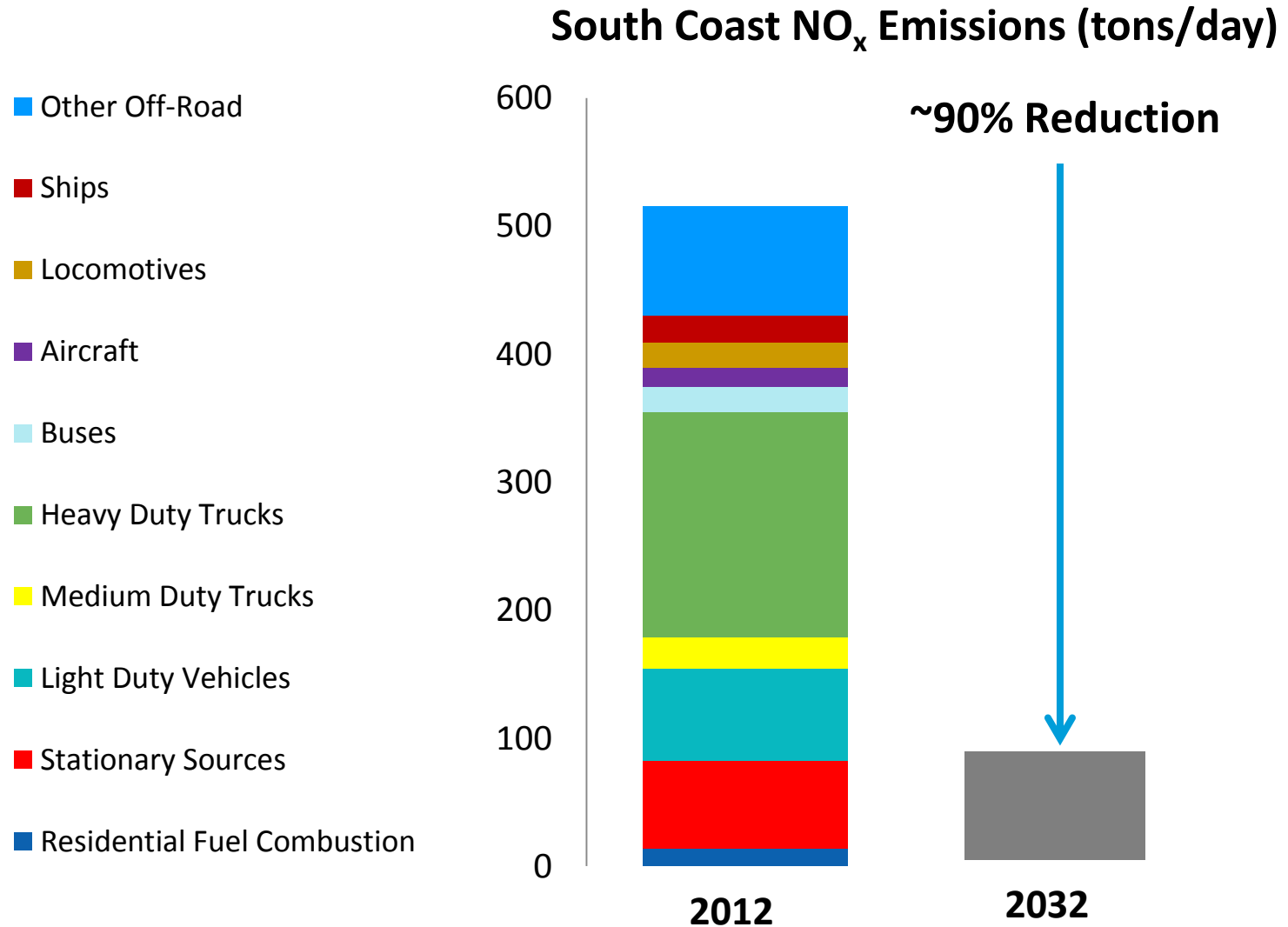
# Key Science Findings

- NO<sub>x</sub> reductions are key to ozone and PM<sub>2.5</sub> attainment
- Large NO<sub>x</sub> reductions needed, coming from many source sectors
- VOC reductions important for progress in South Coast, less effective in SJV
- Targeted reductions in other precursors beneficial for PM<sub>2.5</sub>

# Science to 2016 SIP Strategy

- Science identifies *what* reductions are needed for attainment
- Strategy development process:
  - Identifies from *where* reductions will come
  - Defines *how* reductions will be achieved through specific measures and actions
  - Considers *who* needs to take action through national, state, regional and local controls
  - Integrates *when* those reductions need to occur from multi-pollutant perspective, including climate

# Identifying Contributing Sources





# Identifying Strategies for 2016 SIP

- Requires long-term, comprehensive reductions across all sectors
- Encompasses improved technology, fuels, energy efficiency, planning, and infrastructure
- Planning scenarios integrate emission benefits of combined air quality and climate actions
- Modeling can then assess air quality benefits of specific scenarios

# SIP Planning: 2014-2016

- Ozone and PM<sub>2.5</sub> SIPs due in 2016
- Collaborative effort involving ARB, air districts, and U.S. EPA
- Air quality modeling has begun, with continuing feedback to strategy development
- SIP planning process will parallel development of the freight strategy

# Summary

- Air quality science provides strong foundation for SIPs
- NO<sub>x</sub> reductions needed for both ozone and PM<sub>2.5</sub>
- VOC reductions are important for progress in South Coast, less effective in SJV
- As standards become more stringent, role of science becomes increasingly important in SIP process



## Leading the Way

- California providing international air quality leadership
- Important to follow science-based process
- Most effective strategies will reflect specific nature of the region