Earth System Research Laboratory
SCIENCE, SERVICE & STEWARDSHIP

# Regional Air Quality

## Overview and Introduction

- *Why Air Quality? Why NOAA?*
- *The Air Quality Research Challenge*
- *Our Air Quality Research Strategy*
- *Our Capabilities and Platforms*
- *Our Approach and Findings*

FRED FEHSENFELD
Chemical Sciences Division

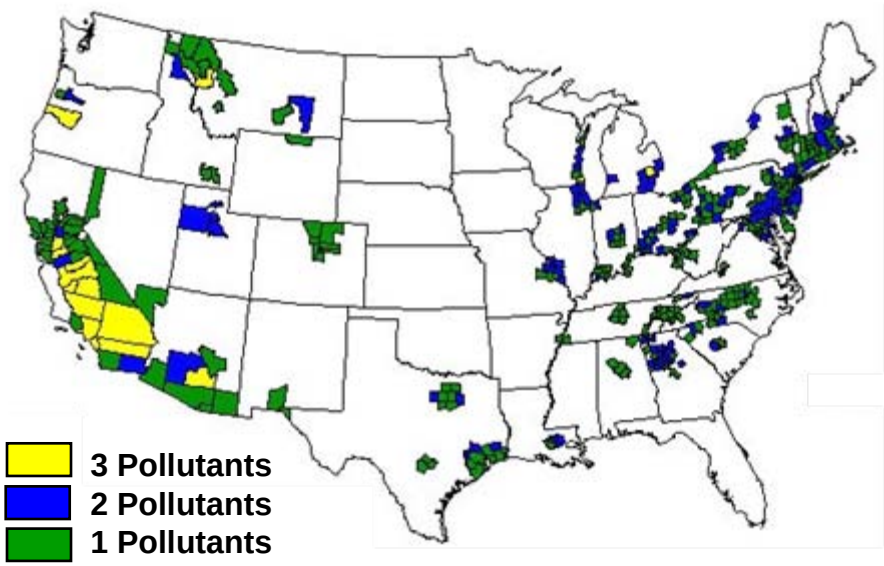
# NOAA's Role In Air Quality Research

## Why Air Quality?

### A Serious National Problem

- *Principal Pollutants: $O_3$ and PM.*
- *More than half the U.S. population lives in areas that do not meet the health-based air quality standards.*
- *Tens of thousands of deaths each year are are attributed to exposure to poor air quality.*
- *Estimated health costs are $14 - $55 billion annually*
- *Reduced crop yields cost an additional $3-$5 billion of losses each year.*

**Counties Designated as NAAQS "Nonattainment"**

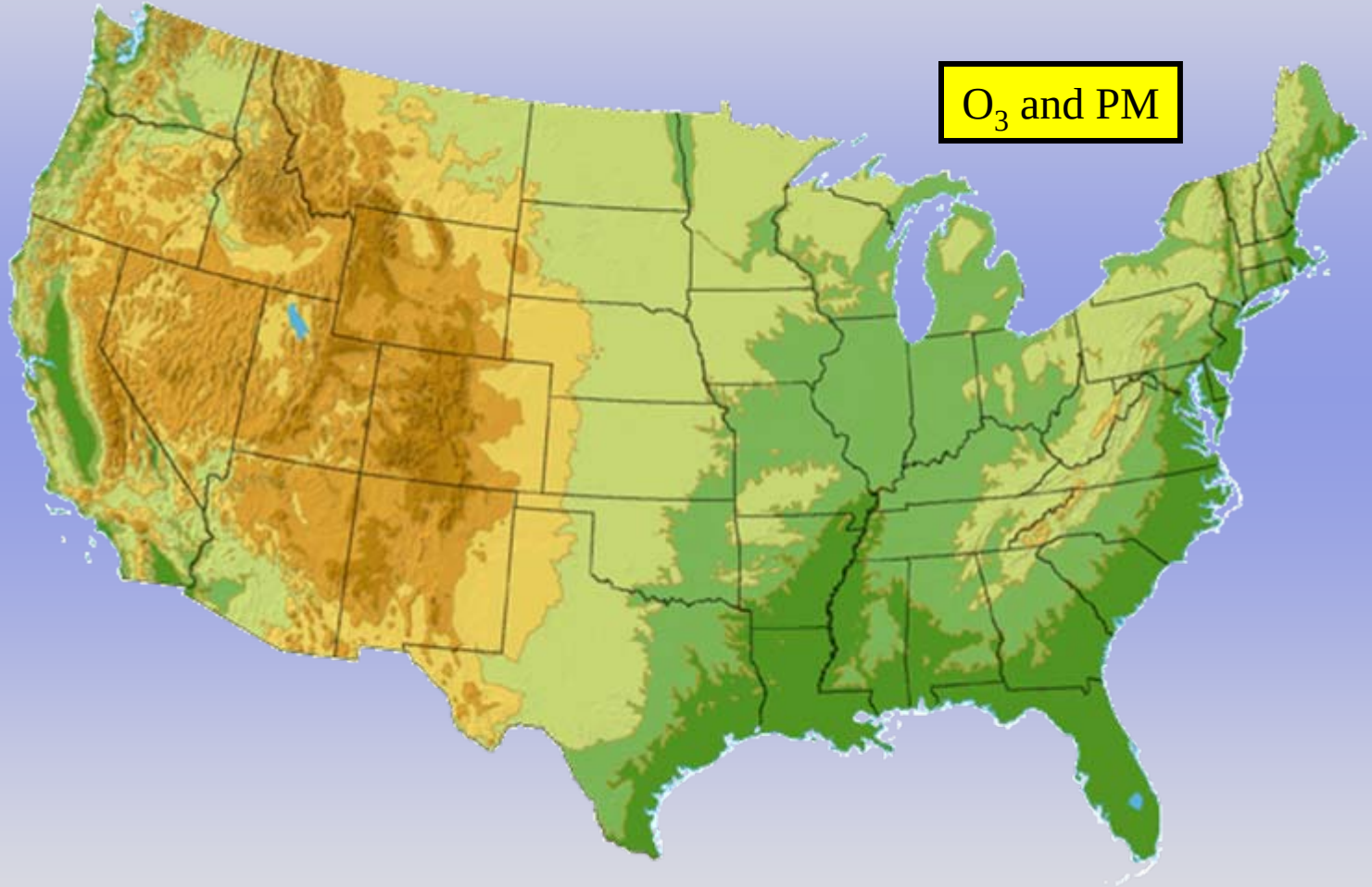



## Why NOAA?

- *High quality policy relevant research is critically needed now.*
- *Our research builds on NOAA's unique scientific competence and resources.*
- *An "Independent Broker" of scientific information.* Managed ←*NOAA*→ Management

***Understanding Air Quality in the US: A Challenge***

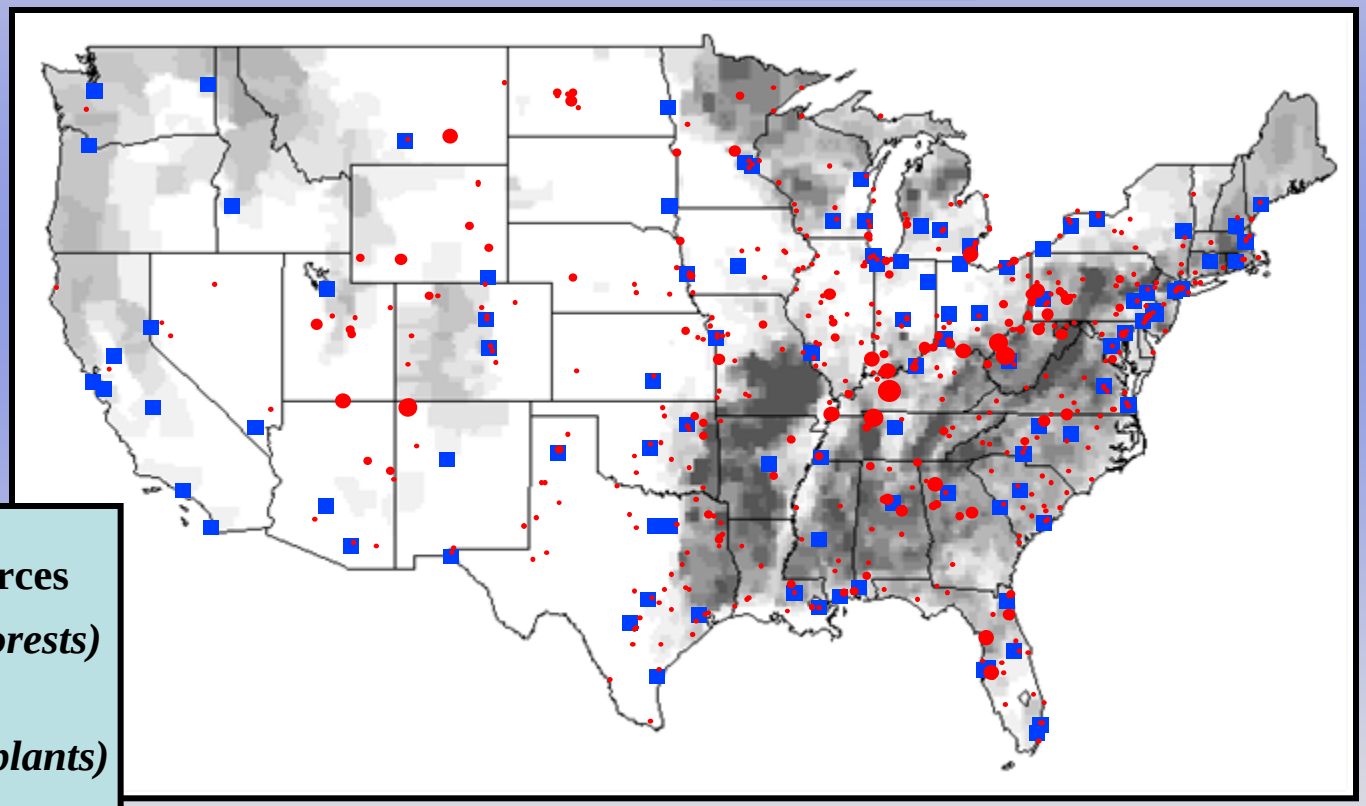
# Understanding Air Quality in the US: A Challenge




- Chemically and Meteorologically Diverse

# Understanding Air Quality in the US: A Challenge

$O_3$ and PM



**$O_3$ & PM Precursor Sources**

- ***Biogenic emissions (forests)***
- ***Cities***
- ***Point Sources (power plants)***

Air Quality Research: A Regional Strategy

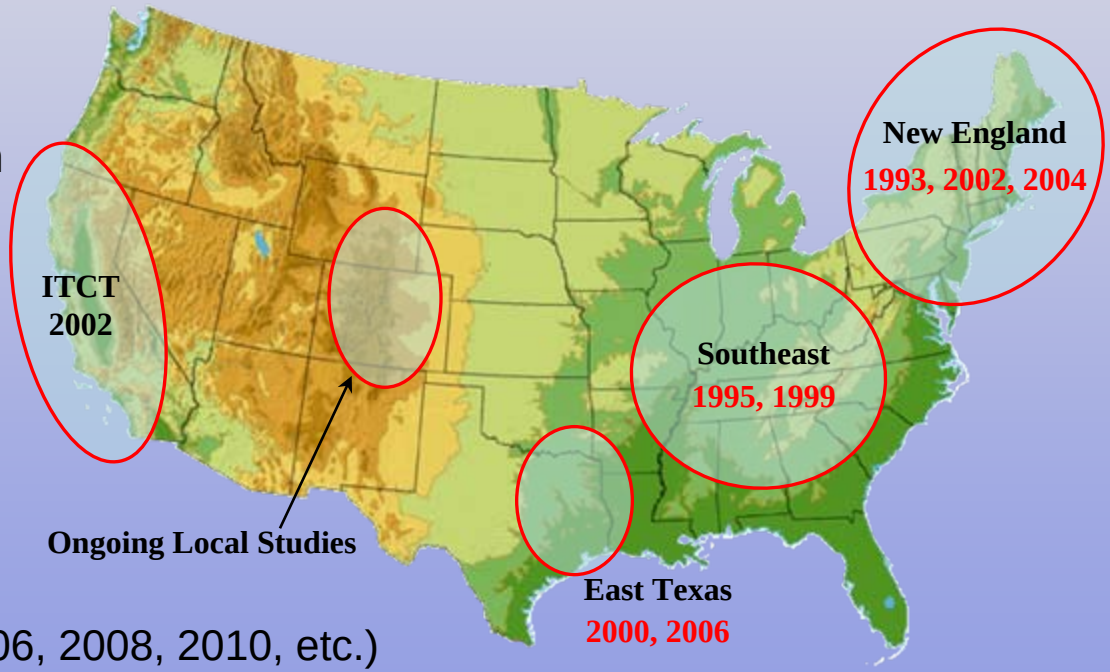
- Chemically and Meteorologically Diverse
- Air Quality Problems Not Only a Local Issue

# ESRL Regional Air Quality Research

## Strategy:

*A series of regional field measurements supported by laboratory studies and model analysis to help supply the Nation's air quality information needs.*

- ***Regional Selection Criteria***
  - Severity of the AQ problem
  - Emission mix
  - Meteorology / topography
  - Effect of regional transport
- ***Schedule***
  - Every two years (2004, 2006, 2008, 2010, etc.)
  - Repeat as needed (verity results, check emission changes)



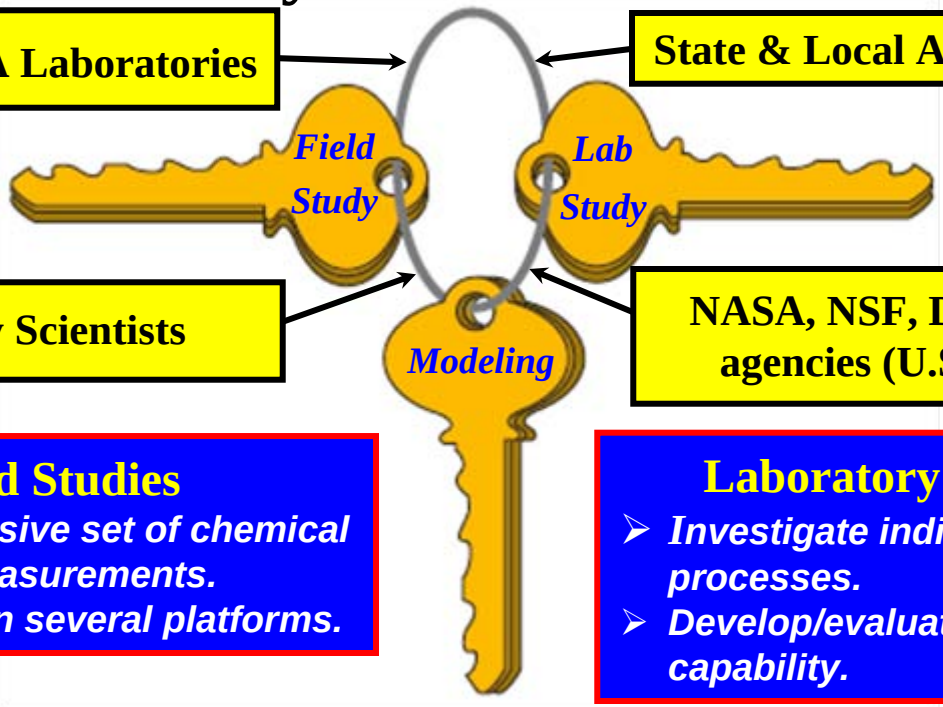

**Capabilities Required to Undertake Regional Research**

# ESRL: Scientific Competence and Resources

## Keys to Success

**Other NOAA Laboratories**

**State & Local AQ Managers**




**University Scientists**

**NASA, NSF, DOE, other agencies (U.S. & Int.)**

### Field Studies

- *Comprehensive set of chemical and met measurements.*
- *Deployed on several platforms.*

### Laboratory Studies

- *Investigate individual processes.*
- *Develop/evaluate instrument capability.*

### Model Analysis and Evaluation

- *Use models to evaluate emissions, assess process understanding.*
- *Use field and laboratory studies to help evaluate model capability.*

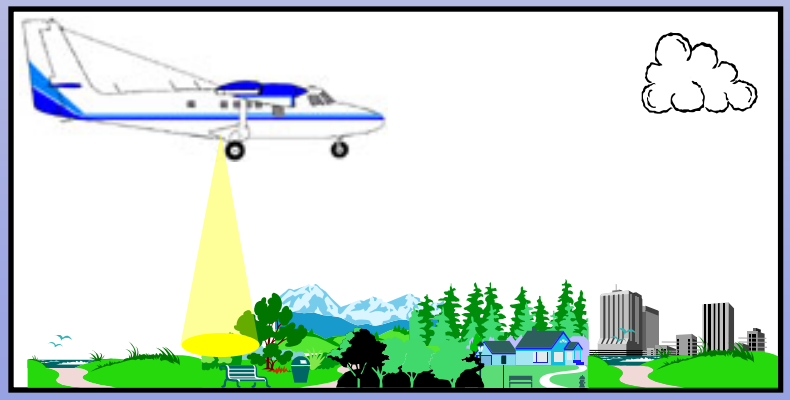
NOAA's Platforms

# NOAA's Platforms

**NOAA WP-3D Aircraft** - urban and power plant plume studies, emissions verification, regional and inter-regional transport, day/night $O_3$/PM chemistry, aerosol optics


**NOAA R/V Ronald H. Brown** - marine chemistry, marine emissions, coastal emissions, chemistry in the land/bay/sea breeze recirculation, aerosol - physics, - chemistry, - optics and satellite validation.

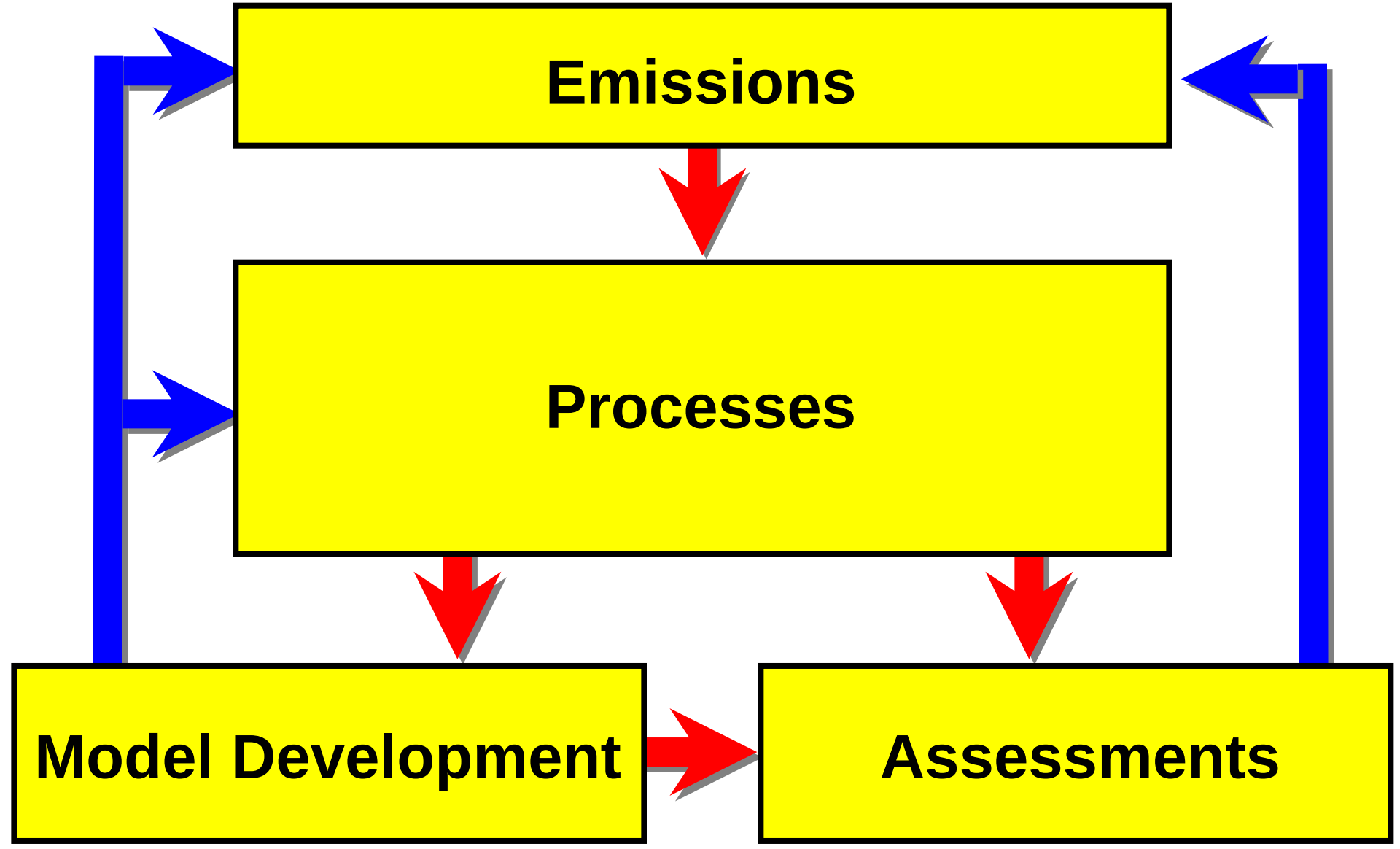
**NOAA LIDAR Aircraft** - regional distribution of $O_3$ and PM, urban and power plant plume studies, regional and inter-regional transport, boundary layer evolution and variability.



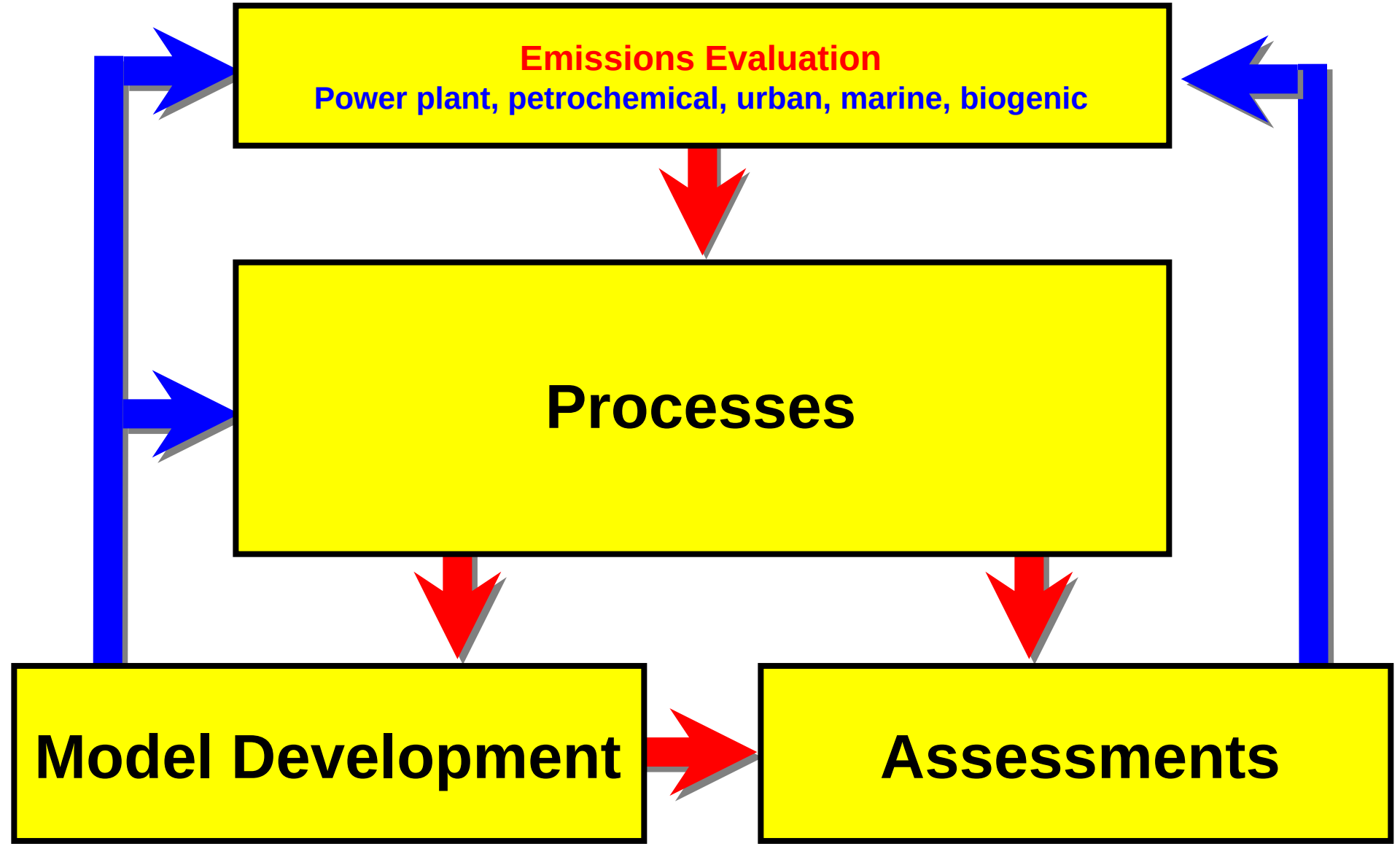
**In Addition:** Wind profiler network, Instrumented tall tower, flux towers

ESRL's Air Quality Research Approach and Findings

# ESRL Chemistry: Approach &Findings



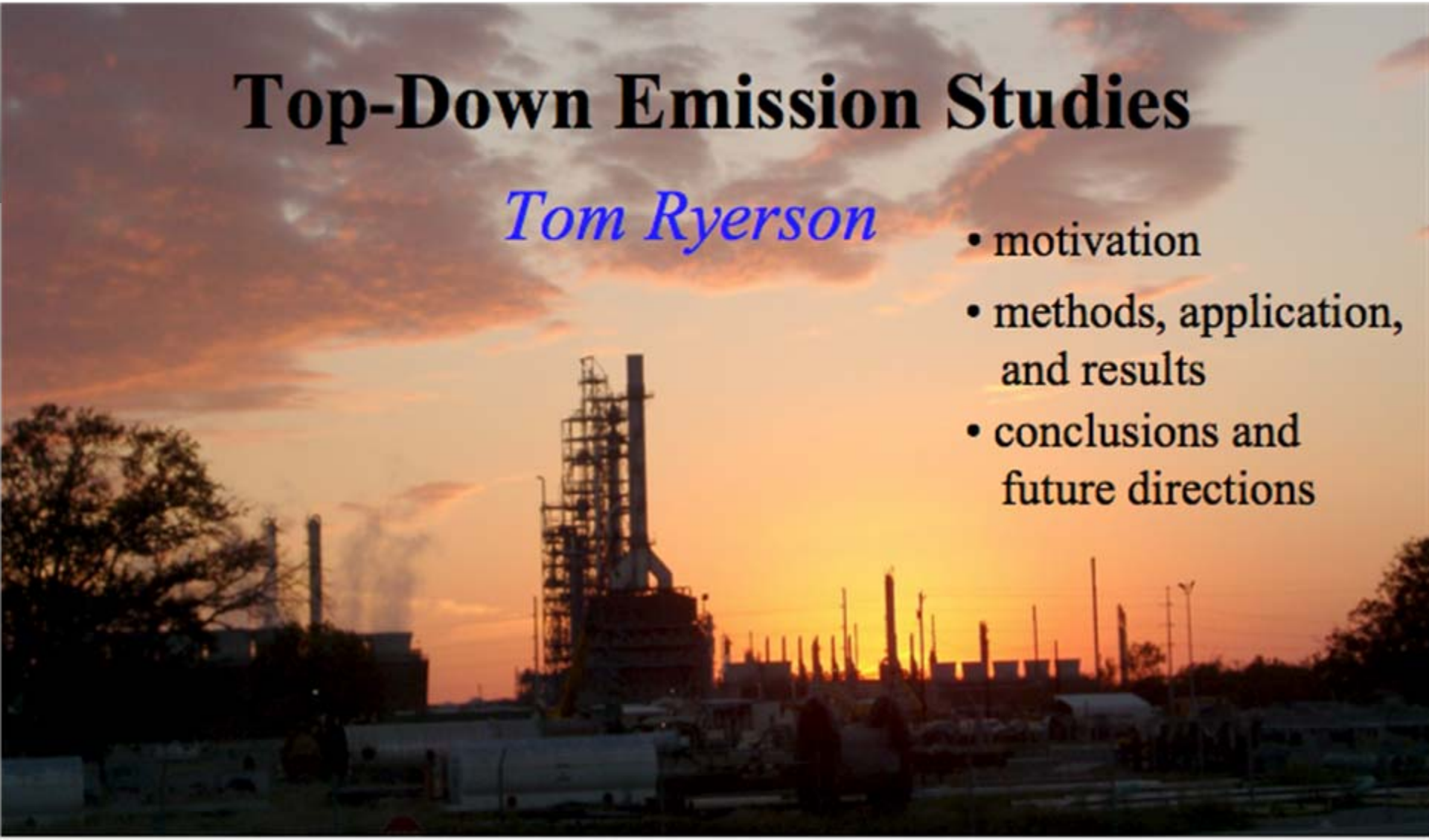
# ESRL Chemistry: Approach &Findings



# Top-Down Emission Studies

*Tom Ryerson*

- motivation
- methods, application, and results
- conclusions and future directions

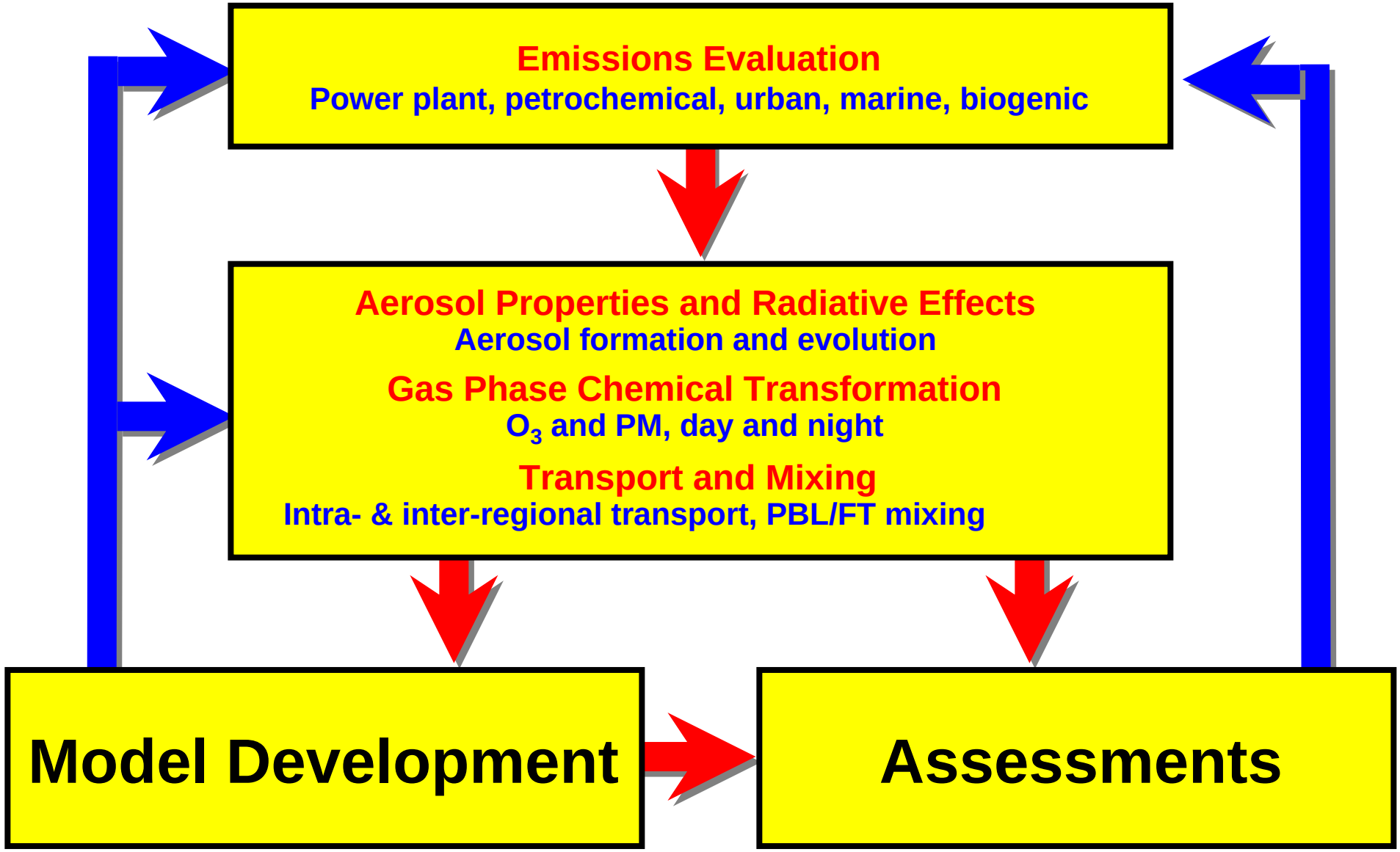


NOAA Earth System Research Laboratory

ESRL Atmospheric Chemistry Review

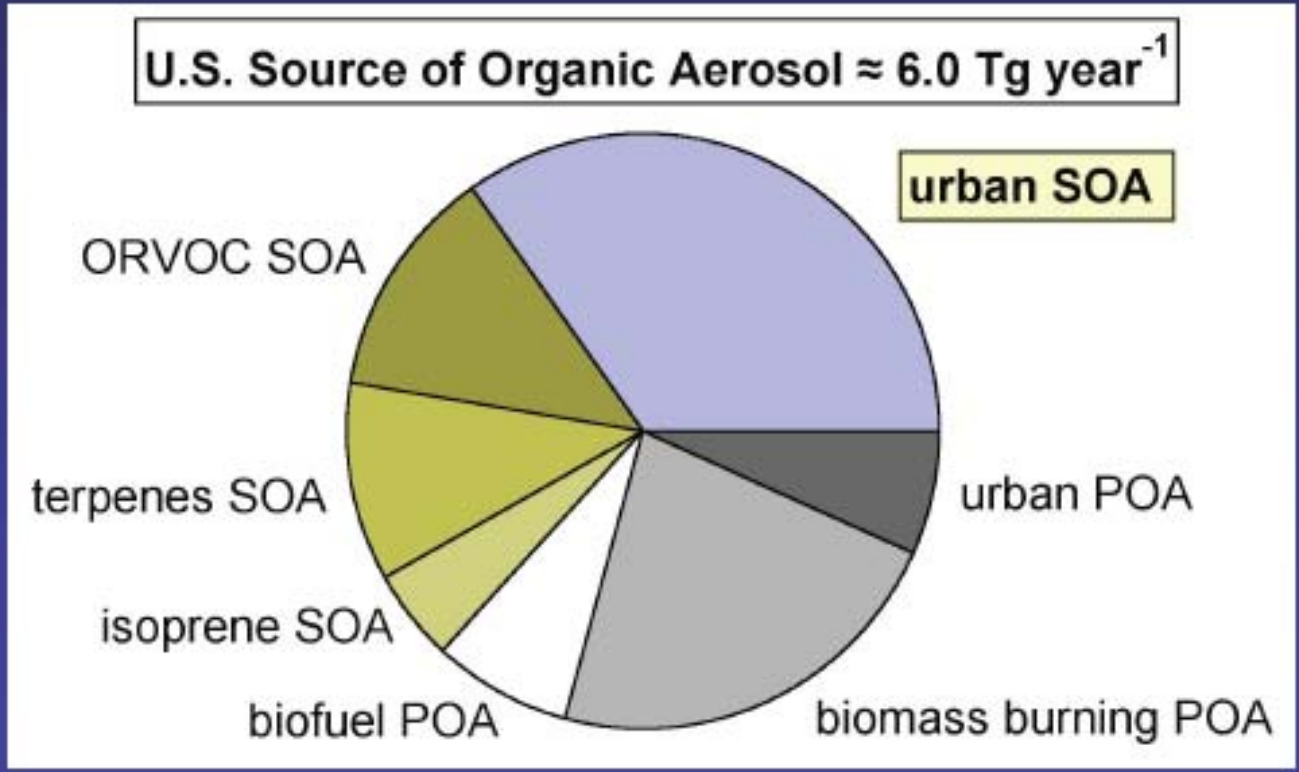
*January 29 - 31, Boulder, Colorado*

# ESRL Chemistry: Approach &Findings



# Secondary Organic Aerosol in Polluted Atmospheres: Large Underestimates by Current Models

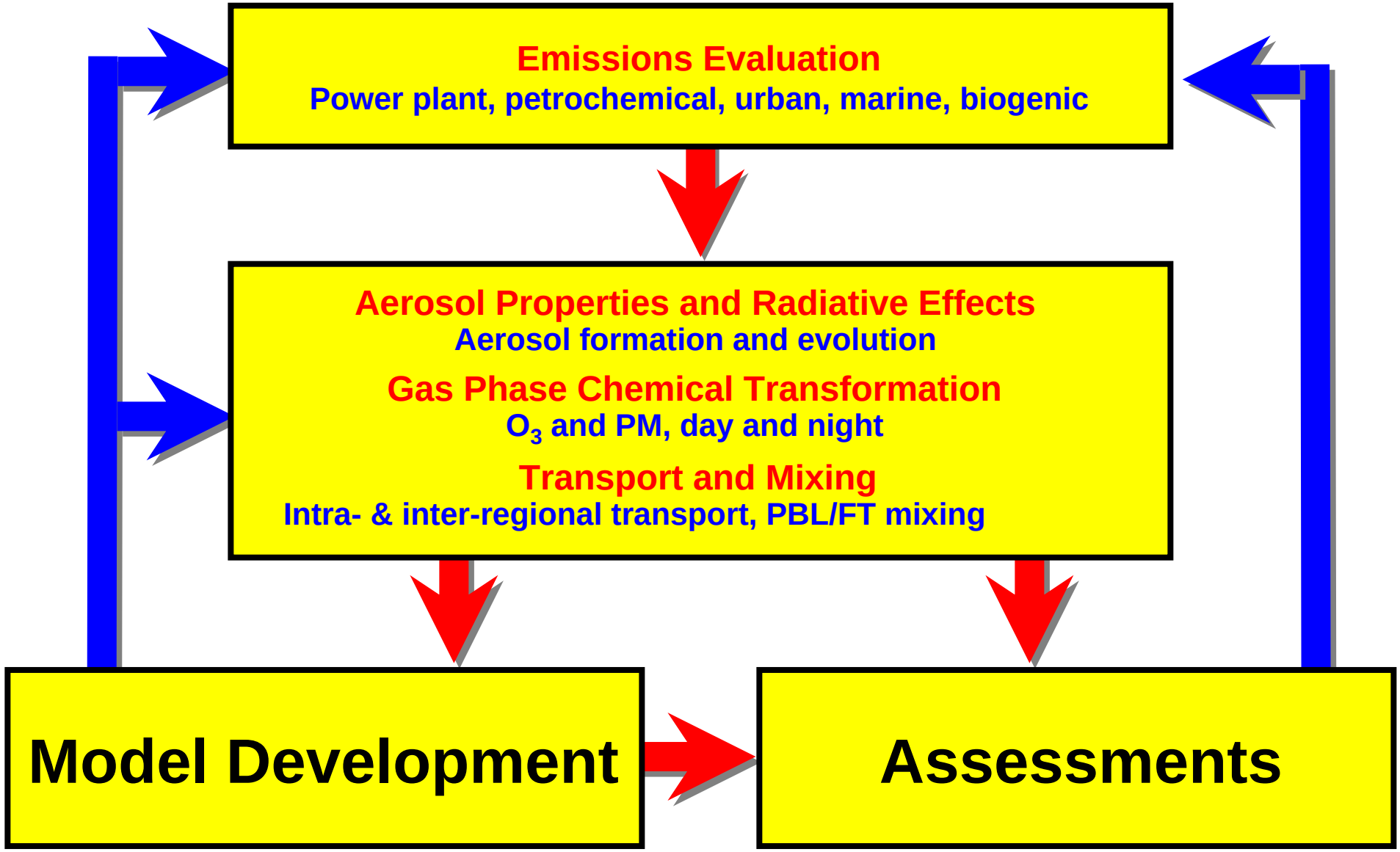
Joost de Gouw




Outline:

Urban SOA is underestimated
Potential explanations
Future directions: organic acids

# ESRL Chemistry: Approach &Findings



# Nighttime Tropospheric Chemistry

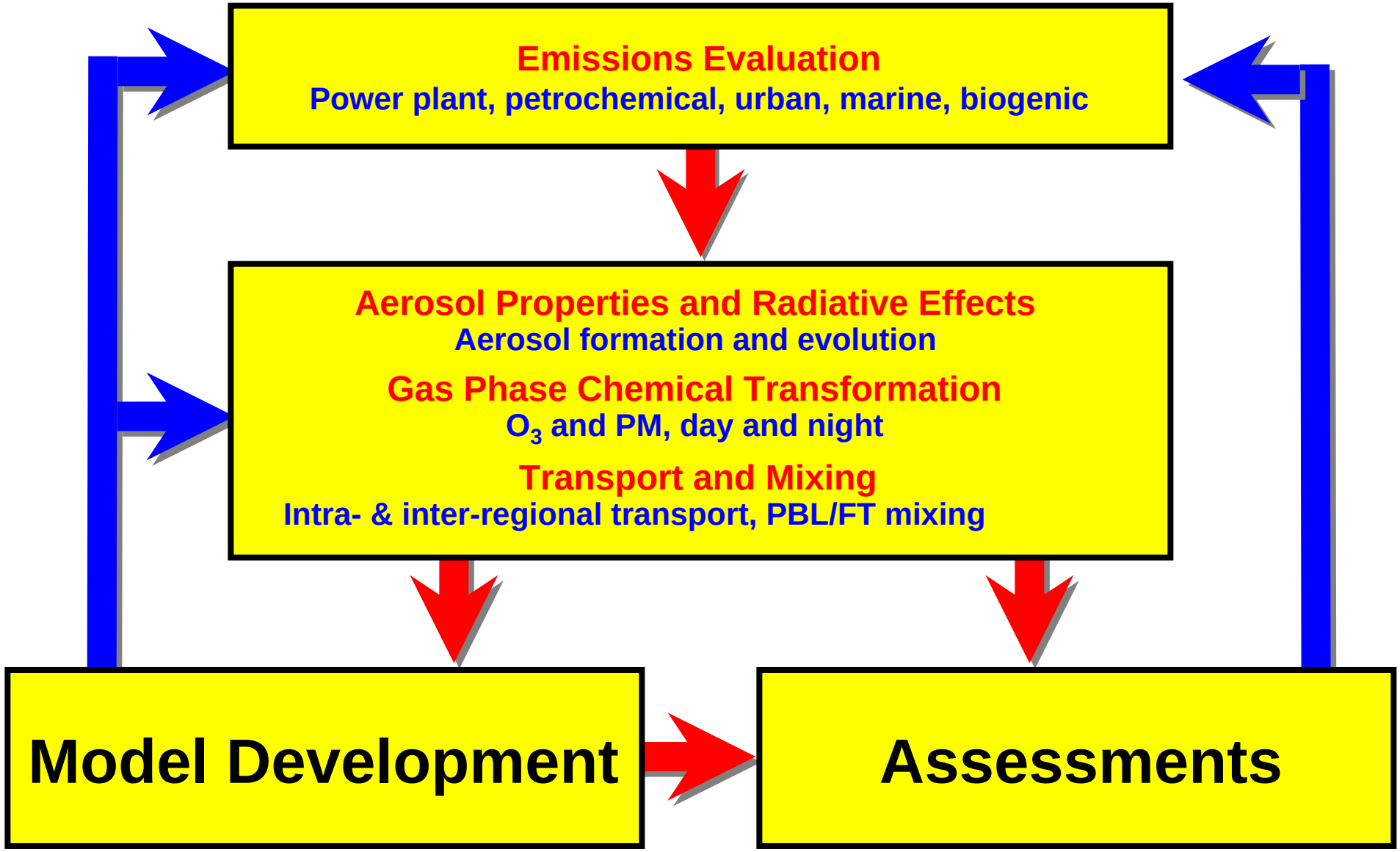
## Nocturnal Reactions of $NO_x$, $O_3$, VOC and Aerosol

Steven S. Brown

NOAA Earth System Research Laboratory

Atmospheric Chemistry Review
January 29-31, 2008, Boulder, CO

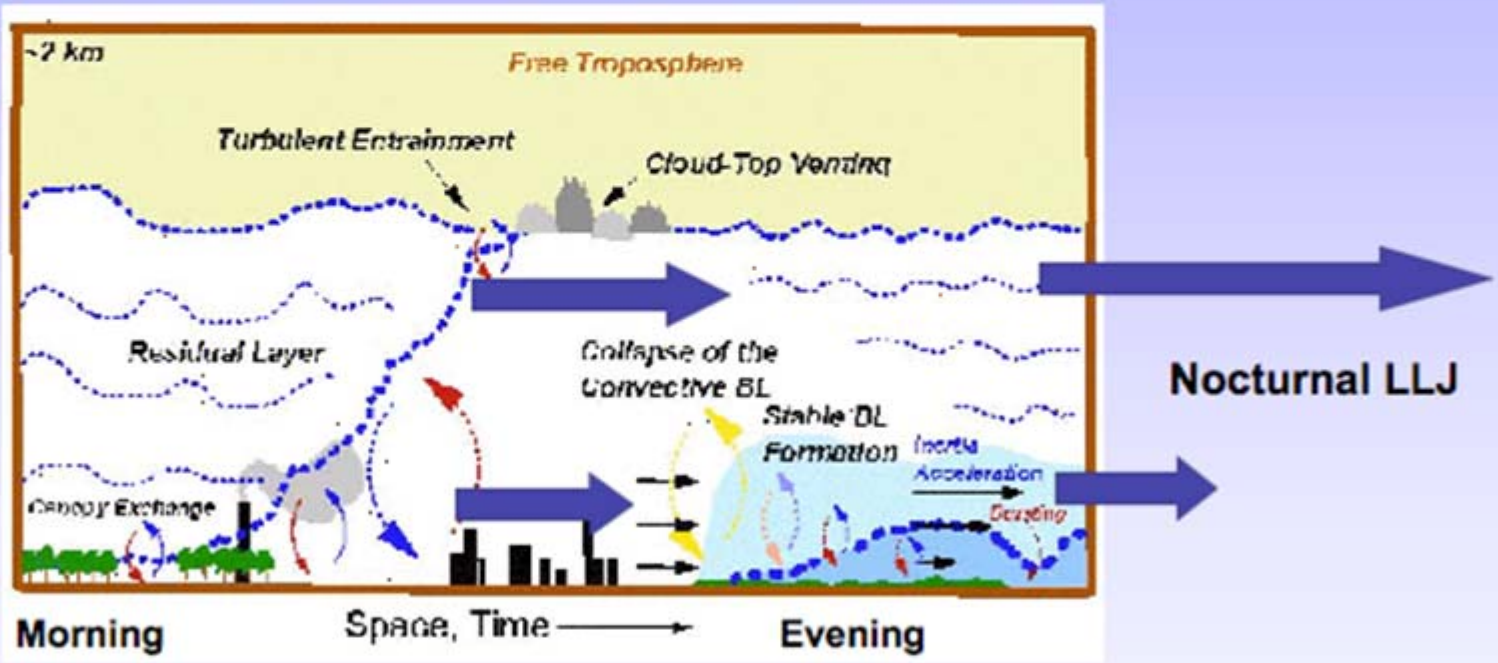
# ESRL Chemistry: Approach &Findings



# Ozone Transport and Mixing Processes

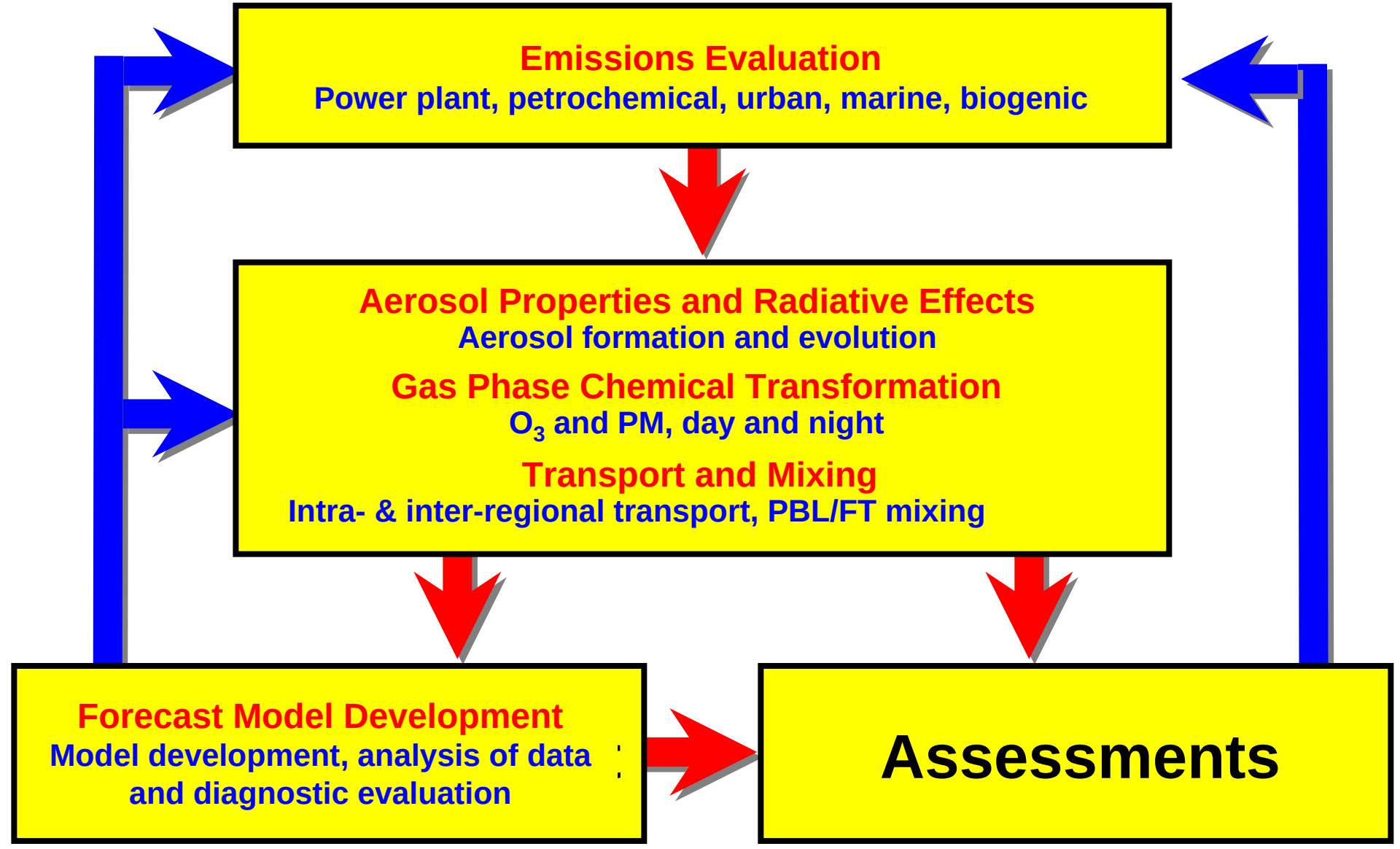
Mike Hardesty
ESRL Chemical Sciences Division

**Air Quality is not just chemistry!**




- Tighter standards → Increased local impact of transport
- Stagnant conditions → Smaller scale processes become important

# ESRL Chemistry: Approach &Findings

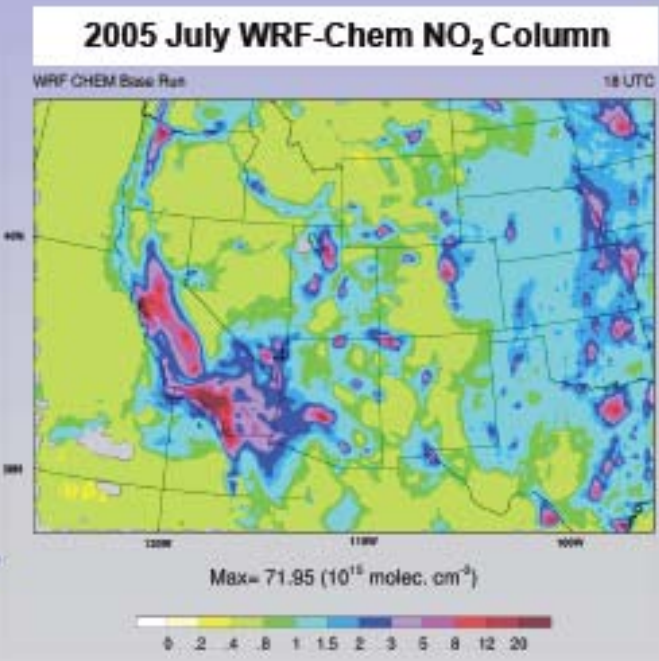


# Air Quality Research at ESRL

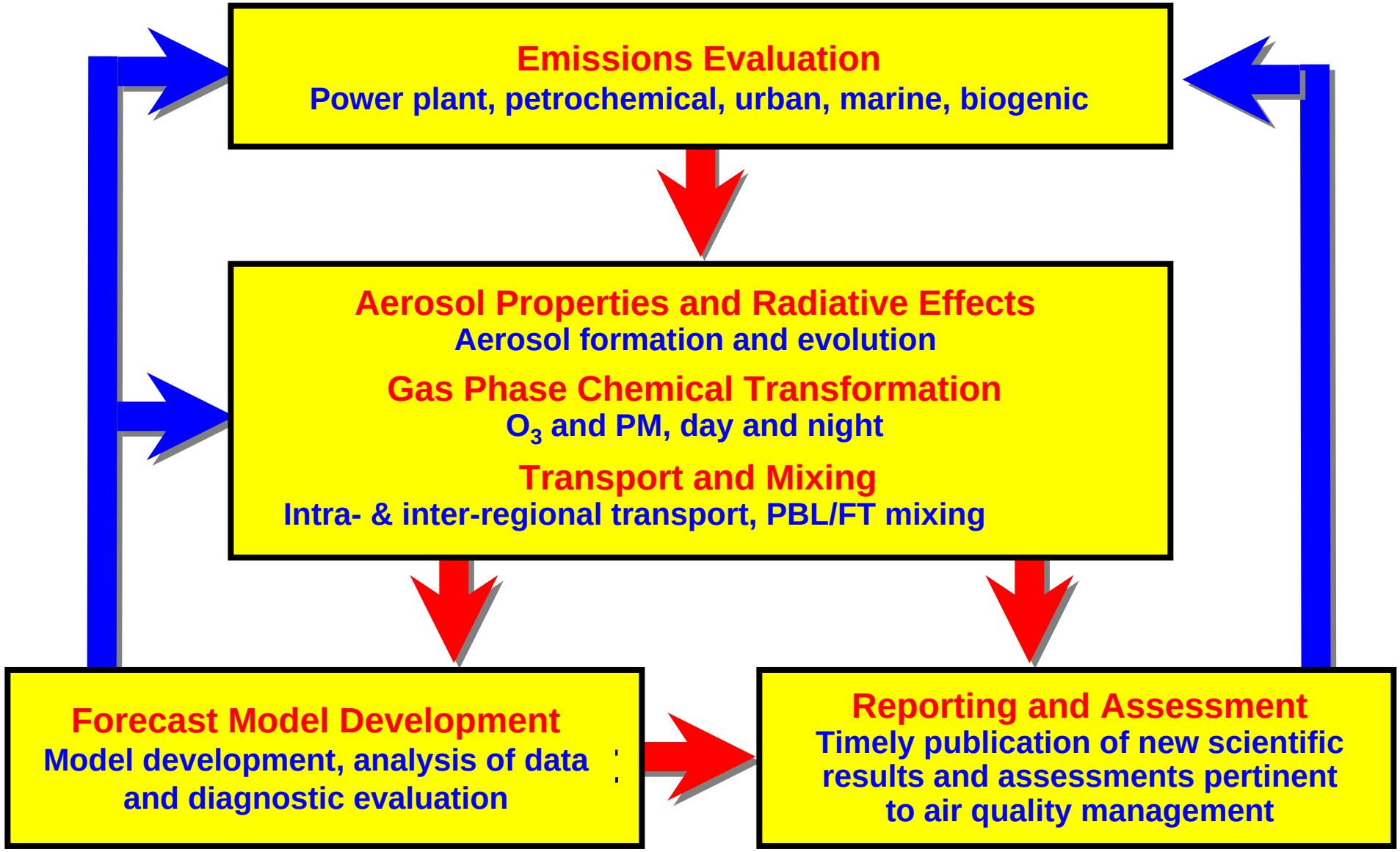
## Modeling

***Focus: Improved predictive capability for forecasting, research, and regulatory needs.***

- Model Development
  - ✓ WRF-Chem - online community model
- Analysis of data from field intensives (FLEXPART, WRF-Chem)
- Air quality forecast models
  - ✓ Diagnostic evaluation using data from intensive field studies
  - ✓ Post processing (ensembles, bias correction, etc.)
  - ✓ Chemical data assimilation ($O_3$, PM)

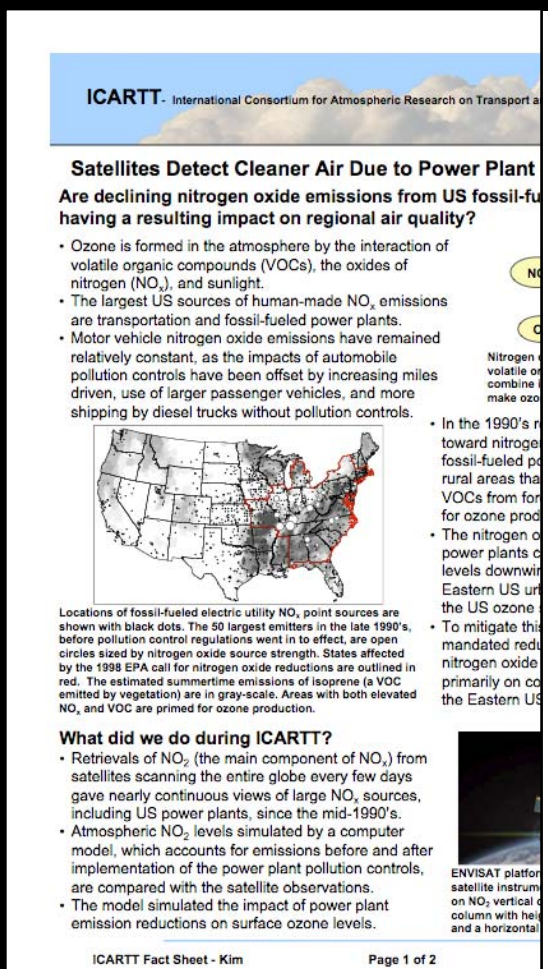


# ESRL Chemistry: Approach &Findings



# Reports and Assessments

- **Presentations and Seminars**
- **Fact Sheets**
- **Peer Reviewed Publications**
- **Policy Relevant Assessments**



ICARTT- International Consortium for Atmospheric Research on Transport a

**Satellites Detect Cleaner Air Due to Power Plant**

**Are declining nitrogen oxide emissions from US fossil-fu having a resulting impact on regional air quality?**

- Ozone is formed in the atmosphere by the interaction of volatile organic compounds (VOCs), the oxides of nitrogen ($NO_x$), and sunlight.
- The largest US sources of human-made $NO_x$ emissions are transportation and fossil-fueled power plants.
- Motor vehicle nitrogen oxide emissions have remained relatively constant, as the impacts of automobile pollution controls have been offset by increasing miles driven, use of larger passenger vehicles, and more shipping by diesel trucks without pollution controls.

Locations of fossil-fueled electric utility $NO_x$ point sources are shown with black dots. The 50 largest emitters in the late 1990's, before pollution control regulations went in to effect, are open circles sized by nitrogen oxide source strength. States affected by the 1998 EPA call for nitrogen oxide reductions are outlined in red. The estimated summertime emissions of isoprene (a VOC emitted by vegetation) are in gray-scale. Areas with both elevated $NO_x$ and VOC are primed for ozone production.

- In the 1990's r toward nitroge fossil-fueled p rural areas tha VOCs from for for ozone prod
- The nitrogen o power plants c levels downwir Eastern US ur the US ozone
- To mitigate thi mandated redu nitrogen oxide primarily on co the Eastern US

**What did we do during ICARTT?**

- Retrievals of $NO_2$ (the main component of $NO_x$) from satellites scanning the entire globe every few days gave nearly continuous views of large $NO_x$ sources, including US power plants, since the mid-1990's.
- Atmospheric $NO_2$ levels simulated by a computer model, which accounts for emissions before and after implementation of the power plant pollution controls, are compared with the satellite observations.
- The model simulated the impact of power plant emission reductions on surface ozone levels.

ENVISAT platfor satellite instrum on $NO_2$ vertical column with hei and a horizontal

ICARTT Fact Sheet - Kim Page 1 of 2

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 112, D10S47, doi:10.1029/2006

Click Here for Full Article

**Determination of urban volatile organic compound emission r and comparison with an emissions database**

C. Warneke,[1,2] S. A. McKeen,[1] J. A. de Gouw,[1,2] P. D. Goldan,[1] W. C. Kuster,[1] J. S. Holloway,[1,2] E. J. Williams,[1,2] B. M. Lerner,[1,2] D. D. Parrish,[1] M. Trainer,[1] F. C. Fehsenfeld,[1] S. Kato,[3] E. L. Atlas,[4] A. Baker,[5] and D. R. Blake[5]

Received 16 August 2006; revised 7 March 2007; accepted 27 March 2007; published 15 May 2007.

[1] During the NEAQS-ITCT2k4 campaign in New England, anthropogenic VOCs CO were measured downwind from New York City and Boston. The emission ratios of VOCs relative to CO and acetylene were calculated using a method in which the ratio of a VOC with acetylene is plotted versus the photochem age. The intercept at the photochemical age of zero gives the emission ratio. The so determined emission ratios were compared to other measurement sets, including data from the same location in 2002, canister samples collected insi New York City and Boston, aircraft measurements from Los Angeles in 2002, and average urban composition of 39 U.S. cities. All the measurements generally agree within a factor of two. The measured emission ratios also agree for most compo within a factor of two with vehicle exhaust data indicating that a major source of VOCs in urban areas is automobiles. A comparison with an anthropogenic emissio database shows less agreement. Especially large discrepancies were found for the $C_2$-$C_5$ alkanes and most oxygenated species. As an example, the database overestim toluene by almost a factor of three, which caused an air quality forecast model (WRF-CHEM) using this database to overpredict the toluene mixing ratio by a factor o as well. On the other hand, the overall reactivity of the measured species and the react of the same compounds in the emission database were found to agree within 30%.

**Citation:** Warneke, C., et al. (2007), Determination of urban volatile organic compound emission r emissions database, *J. Geophys. Res.*, *112*, D10S47, doi:10.1029/2006JD007930.

**1. Introduction**

[2] Volatile organic compounds (VOCs) are emitted into the atmosphere in large quantities from a variety of different natural and anthropogenic sources [*Brasseur et al.*, 1999; *Hewitt*, 1999]. VOCs are key ingredients in the formation of ozone and aerosols in polluted air, and play a significant role in determining regional air quality, in the chemistry of the global troposphere, and possibly in the global carbon cycle. On a global scale the biogenic VOC emissions, mainly isoprene, $\alpha$- and $\beta$-pinene and methanol [*Guenther et al.*, 1995, 2006], dominate over the anthropogenic sources. On a regional scale, in and around urban areas, the anthropogenic emissions, which are in large part caused by-production, storage and us more important.

[3] In July and August of 20 chemistry and transport study America and Europe within th collaboration (International C Research on Transport and the NOAA contribution to 2k4 (New England Air Qua Transport and Chemical Tran ducted, which involved airbo NOAA WP-3 research aircra New Hampshire and ship-bas NOAA research vessel *Rona* Maine. Research goals of th included a detailed characte emissions of gas phase and a American continent, including cities (Boston and New York point sources such as powe transformation leading to the f tants (ozone and aerosol); involved, including local a Europe; and (4) the evaluat models.

[1]Earth System Research Laboratory, NOAA, Boulder, Colorado, USA. [2]Also at Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, Colorado, USA. [3]Department of Chemistry, University of Colorado, Boulder, Colorado, USA. [4]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Florida, USA. [5]Department of Chemistry, University of California, Irvine, California, USA.

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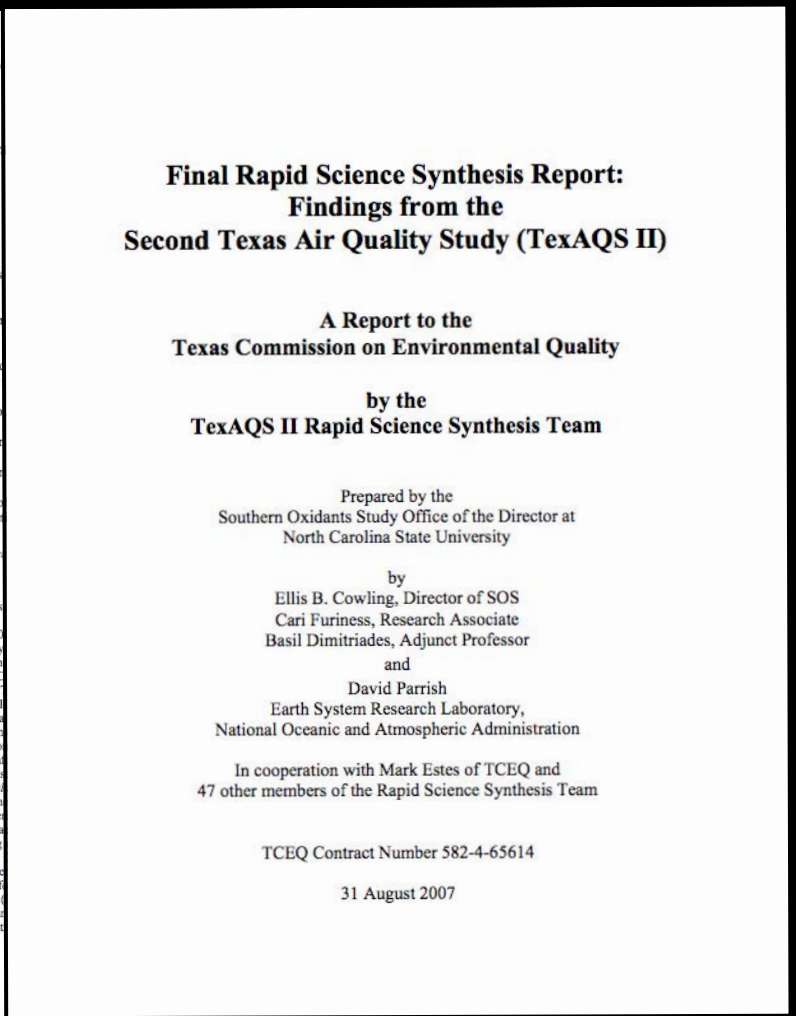
0148-0227/07/2006JD007930$09.00





**Final Rapid Science Synthesis Report: Findings from the Second Texas Air Quality Study (TexAQS II)**

**A Report to the Texas Commission on Environmental Quality**

**by the TexAQS II Rapid Science Synthesis Team**

Prepared by the
Southern Oxidants Study Office of the Director at
North Carolina State University

by
Ellis B. Cowling, Director of SOS
Cari Furiness, Research Associate
Basil Dimitriades, Adjunct Professor
and
David Parrish
Earth System Research Laboratory,
National Oceanic and Atmospheric Administration

In cooperation with Mark Estes of TCEQ and
47 other members of the Rapid Science Synthesis Team

TCEQ Contract Number 582-4-65614

31 August 2007

# ESRL Chemistry: Approach &Findings