#### Hot Science Cool Talks

UT Environmental Science Institute

# 25

#### **Big, Beautiful Sky:** The State and Future of Texas' Air

#### Dr. David Allen September 5, 2003

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Big, Beautiful Sky?



## Preserving air quality in Texas

#### **Professor David Allen**

Department of Chemical Engineering Center for Energy and Environmental Resources University of Texas

#### Every breath you take...

The Houston region has one of the highest national ozone levels. Asthma prevalence in inner-city Houston school children approaches twice the national average.

Fourteen Americans die every day from asthma, a rate three times greater than just 20 years ago. 673,076 adults and 401, 289 children suffer from asthma in Texas.

Ozone can cause coughing, throat irritation, reduced lung function, and pain when taking a deep breath.

## Breath of Life?

Scientists have estimated that the number of deaths in the United States associated with air pollution range from 50,000 to 100,000 per year.

While particulate matter is the form of air pollution most prominently linked to premature death, there is increasing evidence that ozone plays a role.



## Outline

- What are the components of air pollution and how is Texas doing?
- What is photochemical smog and how is it formed?
- A tale of two cities: Austin
- How do we understand air pollution and who sets air quality standards?
- A tale of tow cities: Houston
- What are scientists and officials doing so we can breath easier?
- What can all of us do?

## Air Quality in Texas cities

Houston, Dallas/Fort Worth and El Paso violate the current ozone standard and Austin, San Antonio and Longview would violate the new ozone standard.

El Paso violates the current particulate matter standard. Houston and possibly DFW would likely violate the new particulate matter standard.





Air pollutants of concern in Texas **PM<sub>10</sub> and PM<sub>2.5</sub> - Fine particulate matter suspended in** the atmosphere degrades visibility and has been associated with increased rates of mortality O<sub>3</sub> - Ozone at ground level is an irritant, and is associated with increased incidence of respiratory disease and decreased respiratory function Hazardous air pollutants – A variety of health impacts associated with exposure to HAPs

 Air pollutant formation
OZONE = Reactive Organic Compounds \* Oxides of Nitrogen \* Sunlight \* Stagnant Air

 PARTICULATE = Sulfur Oxides, Reactive Organic MATTER Compounds, Oxides of Nitrogen, Ammonia, Direct emissions + Sunlight + Stagnant Air

#### Ozone: Good Up High, Bad Nearby



#### Understanding atmospheric chemistry is crucial to understanding air pollution

Ozone is formed in the atmosphere by the reactions of volatile organic compounds (VOCs) and oxides of nitrogen (NOx) – Relative effectiveness of VOC and NOx emission reductions varies between cities Particulate matter is emitted directly and is formed in the atmosphere by the reactions of VOCs, NOx, SOx, and ammonia *Relative* effectiveness of emission reductions varies between cities

#### A Tale of Two Cities: Austin

Austin: Moderate ozone and fine particulate matter concentrations; air quality dependent on both local and regional sources

Houston: Sees some of the highest ozone concentrations in the United States but relatively moderate particulate matter concentrations; dominated by a mix of local emissions, industrial and urban

## Austin's status

All monitors meet the current National Ambient Air Quality Standards – no local regulations in place – only national initiatives (for example, cleaner cars)

The region would be in non-attainment for the new, more stringent NAAQS, due to be implemented in 2004

 An Early Action Compact has been initiated



#### What do we need to know to improve air quality?

Emission inventory development
Air quality modeling
Air quality modeling monitoring



# How do we improve air quality?



- National Ambient air Quality Standards (NAAQS) set the threshold for action for many air pollutants
- States prepare plans (State Implementation Plans or SIPs) for individual cities

#### Who sets air quality standards?



#### **Emission inventories**

Point sources





# Area sources

On-road and non-road mobile sources





**Biogenic** emissions

#### National sources of VOC and NOx





#### VOC emission inventory (tons/day) for the 5-county region



**Biogenics** dominate VOC emissions in the 5-county area, but in the urban areas where ozone formation is greatest, anthropogenic sources dominate

#### Anthropogenic VOC emissions (tons/day) for the 5-county region



Travis County dominates anthropogenic VOC emissions, and these emissions are equally divided among on-road, non-road and area sources

#### NOx emission inventory (tons/day) for the 5-county region



On-road and nonroad sources dominate NOx emissions

#### Anthropogenic NOx emissions (tons/day) for the 5-county region



Travis County dominates anthropogenic NOx emissions; on-road and non-road sources dominate

# Along with inventories we need to develop air quality models.



Photochemical Grid Modeling: Used in the development of air quality regulations



The Area to be Modeled

Specification of the Grid

#### Air quality modeling in Central Texas





Include both regional and local effects

 Identify strategies that will reduce peak ozone concentrations

#### A San Marcos airport station reading



9-3-98 Wind direction, Ozone, NOx concentrations vs. Time of Day San Marcos Airport site



9-17-99 Wind direction, Ozone, NOx concentrations vs. Time of Day San Marcos Airport site



#### What emission sources contribute to ozone formation?

Evolution of ozone concentrations at a monitor in Austin, over the course of a day, with sources attributed

#### O3 concentration by type at an Austin<sup>®</sup> Urban Luocation

VOC-limited



Sample back trajectories for high ozone episodes in Austin....



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# It's tempting to blame Houston, but.....





# Every city in eastern Texas has an impact on at least one other city



#### 32-Hour back trajectories for days with peak 8-hour ozone levels over 75 ppb. 1993-1999



#### So we understand the problem. What do we do?

- Main local source is due to vehicles and for onroad vehicles 10% of the vehicles give 50% of the emissions
- Regional benefits of emission reductions in other Texas cities
- What are the benefits?





## A Tale of Two Cities: Houston





 The Houston-Galveston area is a severe ozone nonattainment area

•The current State Implementation Plan (SIP) calls for significant NOx emission reductions (approximately 70% of the projected 2007 inventory; 90+% for point sources)

SIP also calls for VOC emission reductions (approximately 25% of the projected 2007 inventory)

Costs and benefits of controls have been estimated to be ~5 billion/yr

#### Ozone formation in Houston is qualitatively different than in most other urban areas



# Ozone formation in Houston is formed rapidly and efficiently



#### Rapid ozone formation can be localized, and narrow plumes/high ozone air parcels can persist for long distances.





#### What causes these events? Localized, high hydrocarbon concentrations



# Where do we find rapid ozone formation/high hydrocarbon concentrations?



# What are these hydrocarbons?

 low molecular weight alkenes (propene, ethene and butenes) are a major source of hydrocarbon reactivity for ozone formation.



## Why is Houston so different? Industrial emissions are variable.



#### Texas Air Quality Study -2000 (TEXAQS - 2000)

Provide scientific basis for air quality management strategies in southeast Texas



# TEXAQS - 2000 :(www.utexas.edu/research/<br/>ceer/texaqs/)Sampling Sites(www.utexas.edu/research/<br/>h/ceer/texaqsarchive)



TEXAQS and other research programs address key areas of uncertainty

Emission inventories.

Chemical and physical processes in the atmosphere.

Regional air quality modeling.

# TexAQS and other research programs indicate:

- Emission inventories: Data from TexAQS suggest that the VOC emission inventory is low by a factor of 3-10
- Emissions are variable: Daily variations can change emissions from any single facility by a factor of 100 or more

Air quality models, on which regulations are based, are unable to describe the spatial variability that we see Existing regulatory models have been unable to replicate critical observations How did our improved scientific understanding get incorporated into the regulations?

Accelerated Science Evaluation
TCEQ commissioners to decide whether to stay with existing plan or to craft a "mid-course correction"
For updates, see the web site: (www.utexas.edu/research/ceer/texaqsarchive)

#### ACCELERATED SCIENCE EVALUATION of OZONE FORMATION IN THE HOUSTON-GALVESTON AREA



Working Committee David Allen, University of Texas Mark Estes, Texas Natural Resource Conservation Commission James Smith, Texas Natural Resource Conservation Commission Harvey Jeffries, University of North Carolina

DRAFT-Work-in-progress.

September 27, 2001

#### Actions taken by the TCEQ

Based on the data from TexAQS, which indicate that VOC emissions from industrial facilities are underestimated, new rules have been proposed for emissions of reactive hydrocarbons from flares, cooling towers and fugitive sources Benefits of better scientific understanding to the State of Texas

More effective SIP More confidence by policy-makers in the decision making process Demonstration of the value of timely scientific analyses Demonstration of the value of federal/state scientific partnerships

#### What's next to understand and do?

Our cities are linked; we need to better understand regional ozone formation and transport – across cities and across borders



#### What's next...



Need to better understand fine particulate matter and regional haze





#### Second Texas Air Quality Study (STAQS) A New Strategic Texas Air Quality Study

Texas must begin now developing science base for control of 8-Hour ozone, fine particulate matter (PM<sub>2.5</sub>) and regional haze

STAQS is a five-year field investigation aimed at developing the underlying science for effective control policies

Study will utilize experienced TexAQS 2000 study team;

- Leadership provided by Texas universities, TNRCC, Texas Environmental Research Consortium, NARSTO and Southern Oxidants Study
- The UT-Austin Center for Energy and Environmental Resources will provide overall study coordination and administration.

#### Second Texas Air Quality Study (STAQS) A New Strategic Texas Air Quality Study



#### What can we do?

•Keep your automobile well tuned and maintained.

•Carpool, use mass transit, walk, bicycle, and/or reduce driving, especially on hot summer days.

•During the summer, fill your gas tank during the cooler evening hours.

Participate in your local utility's energy conservation programs.

Seal containers of household cleaners, workshop chemicals and solvents, and garden chemicals to prevent VOC from evaporating into the air. Dispose of them properly.

#### Questions?

David Allen Allen@che.utexas.edu www.utexas.edu/research/ceer/airquality www.utexas.edu/research/ceer/texaqs www.utexas.edu/research/ceer/texaqsarchive

## Dr. David Allen



Dr. David Allen is the Melvin H. Gertz Regents Chair in Chemical Engineering and the Director of the Center for Energy and Environmental Resources at the University of Texas at Austin. Dr. Allen's research addresses issues related to air quality in Texas. He was a lead investigator in one of the largest and most successful air quality studies ever undertaken: the Texas Air Quality Study (www.utexas.edu/research/ceer/texaqs).

His current work is focused on using the results from that study to provide a sound scientific basis for air quality management in Texas. Dr. Allen also serves as the Chair of the Texas Council on Environmental Technology(TCET), which was established by the 77th Legislature. TCET is charged with encouraging the development, demonstration, certification and deployment of novel technologies for cost-effectively reducing emissions to air, water and land in Texas. At the national level, Dr. Allen serves on the Science Advisory Board of the EPA, dealing with issues of air quality modeling and cost-benefit analysis of the Clean Air Act. He also serves on the National Research Council's Board on Environmental Studies and Toxicology.

Dr. Allen received his B.S. degree in Chemical Engineering, with distinction, from Cornell University in 1979. His M.S. and Ph.D. degrees in Chemical Engineering were awarded by the California Institute of Technology in 1981 and 1983. He is the author of4 books and more than 150 technical papers. He has held faculty appointments at UCLA and the California Institute of Technology; he joined the University of Texas in 1995.