VARIABLE EMISSIONS FROM POINT SOURCES
AND THEIR IMPACTS ON OZONE FORMATION

A CASE STUDY OF THE HOUSTON AREA

David Allen, University of Texas
Harvey Jeffries, University of North Carolina
Variable Point Source VOC Emissions

- Observational evidence indicating variability in point source VOC emissions
- Process data indicating variability in point source VOC emissions
- Modeling variability in point source VOC emissions
- Implications for ozone formation and air quality modeling
What observations do we have, indicating that point source VOC emissions are highly variable?

(Episodic high VOC concentrations)

- Ground based monitors show significant variability in hydrocarbon concentrations, much larger variations than can be explained by meteorology
What observations do we have, indicating that point source VOC emissions are highly variable?

- Variability in hydrocarbon concentrations is much greater in industrial source regions than in residential regions
- Concentrations of highly reactive VOCs in industrial source regions frequently (once per week per compound per site) exceed 100 ppbC
What observations do we have, indicating that point source VOC emissions are highly variable?

(Episodic high ozone concentrations)
What observations do we have, indicating that point source VOC emissions are highly variable?

(Episodic high ozone concentrations)
Conceptual Model for Point Source VOC Emissions

- Observational evidence indicating variability in point source VOC emissions
- Process data indicating variability in point source VOC emissions
- Modeling variability in point source VOC emissions
- Implications for ozone formation and air quality modeling
Sources of variable industrial emissions: what we know

- Sources are ubiquitous (all volatile compounds, all locations, all times of day)
- Sources are intermittent
- Ozone concentrations “only” reach 250 ppb
- Concentrate on HRVOCs – these represent a set of compounds that must be addressed, and a relatively small number of major sources are involved
Sources of HRVOCs in annual inventory

- Major sources include olefin manufacturing, olefin polymerization and refining
Emissions are variable

- Nearly Constant emissions
- Routinely Variable emissions
- Authorized Highly Variable emissions
- Unauthorized Variable emissions*

* Emissions events and scheduled maintenance, startup, and shutdown activities
Finding:
The overall magnitude and the variability in emissions of highly reactive volatile organic compounds (HRVOCs) from point sources are dominated by contributions from flares, cooling towers, various vents and sources of fugitive emissions.
Conceptual Model for Point Source VOC Emissions

• Overview of the point source VOC inventory
• Observational evidence indicating variability in point source VOC emissions
• Process data indicating variability in point source VOC emissions
• Modeling variability in point source VOC emissions
• Implications for ozone formation and air quality modeling
Modeling variability in point source VOC emissions

- Use a probability distribution function (PDF) to record a series of snapshots of emissions
Different process units have different variability.
Finding:
The magnitude and variability in HRVOC emissions from point sources can be effectively characterized using probability distribution functions.
Conceptual Model for Point Source VOC Emissions

- Overview of the point source VOC inventory
- Observational evidence indicating variability in point source VOC emissions
- Process data indicating variability in point source VOC emissions
- Modeling variability in point source VOC emissions
- Implications for ozone formation and air quality modeling
Conceptual issue
Air quality models for SIP development

- Historical episodes are emission snapshots
- Need to separate emissions that change from episode to episode from those that remain nearly constant
- In evaluating SIP effectiveness, need to consider an album of many emission snapshots
An album of emission snapshots

Numerous facilities/processes

Photochemical Process

Feedback?

Stochastic Ozone Level

Facility 1

Facility 2

Facility 3

... Facility n
What photochemical modeling tools do we use?

- Currently impossible (due to resource and computational constraints) to consider enough emission snapshots with the full regional photochemical model
- Episodic emissions are most important in industrial source region
- Consider many emission snapshots using a version of the full regional model that focuses on a smaller spatial area (industrial source regions)
- Examine most important snapshots with the full model
An emission snapshot for a sub-region

Harris, Galveston, Chambers, and Brazoria Counties
VOC Event Emissions
Events Starting: January 31, 2003 to January 30, 2004

- Event Emissions
- 2000 Annual Average

Event Emissions:
- January 2003: 53,983 lbs/hr
- February 2003: 25,096 lbs/hr
- June 2003: 86,557 lbs/hr
- October 2003: 64,860 lbs/hr

Total VOC Event Emissions = 4,131,738 lbs
An emission snapshot for a sub-region

Harris, Galveston, Chambers, and Brazoria Counties
HRVOC Event Emissions
Events Starting: January 31, 2003 to January 30, 2004

Total HRVOC Event Emissions = 1,701,964 lbs
An emission snapshot for a sub-region

August 30, 2000 16:00:00
Min = 0.0 at (1,1), Max = 149.9 at (39,40)

August 30, 2000 16:00:00
Min = 0.0 at (1,1), Max = 293.0 at (68,43)
An emission snapshot for a sub-region

Harris, Galveston, Chambers, and Brazoria Counties
HRVOC Event Emissions
Events Starting: January 31, 2003 to January 30, 2004

Total HRVOC Event Emissions = 1,701,964 lbs
Finding:
Only about 1% of emission events lead to >10 ppb increases in ozone concentrations. Variability in impact is due to time of day, magnitude and duration of releases; meteorology is also significant.

Routine process variability leads to smaller changes in predicted absolute ozone concentrations, but the effect of variability on the response to control strategies is larger than the response of absolute ozone concentrations.
Summary

• Point source VOC emissions are variable
• Variability is due to a ubiquitous group of source types – probably flares, fugitives, process vents and cooling towers
• Variability (not nearly constant emissions) leads to observations of HRVOC concentrations in excess of 100 ppbC on a weekly basis
• HRVOC concentrations in excess of 100 ppbC can, under commonly observed conditions, lead to extensive ozone formation
• Need to model an album of emission snapshots to adequately describe ozone formation
Citations


Emission variability not confined to VOCs or petrochemical facilities

Cement Kiln Daily Average NOx Emissions Variability
May 1, 2003 - March 31, 2004