

QUANTIFICATION OF OZONE IMPACTS OF VOLATILE ORGANIC COMPOUNDS

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Ozone in photochemical smog is formed from the gas-phase reactions of oxides of nitrogen (NO_x) and volatile organic compounds (VOCs). VOCs differ in their effects on ozone formation, and methods for quantifying these differences would aid in the development of cost-effective ozone control strategies. In this presentation, the role of VOCs and NO_x in ozone formation and the process of developing and evaluating chemical mechanisms for simulating these processes in the atmosphere will be summarized. Following that, the problems and recent progress in developing quantitative reactivity scales measuring ozone impacts of VOCs will be discussed.

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**QUANTIFICATION OF OZONE REACTIVITIES
OF VOLATILE ORGANIC COMPOUNDS**

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THE PHOTOCHEMICAL OZONE PROBLEM

OZONE IN PHOTOCHEMICAL SMOG IS FORMED FROM REACTIONS OF VOLATILE ORGANICS COMPOUNDS (VOCs) AND OXIDES OF NITROGEN (NO_x) IN SUNLIGHT.

LOS ANGELES HAS THE WORST OZONE PROBLEM IN THE UNITED STATES. BUT MANY OTHER URBAN AREAS ALSO EXCEED OZONE AIR QUALITY STANDARDS.

CONTROL OF BOTH VOC AND NO_x IS NEEDED TO REDUCE OZONE. BUT ALL THE "EASY" CONTROLS HAVE BEEN IMPLEMENTED. ADDITIONAL CONTROLS WILL BE COSTLY.

OZONE IS NOT THE ONLY POLLUTANT OF CONCERN IN PHOTOCHEMICAL SMOG. BUT IT IS THE FOCUS OF MOST CONTROL REGULATIONS FOR VOCs (OTHER THAN TOXICS).

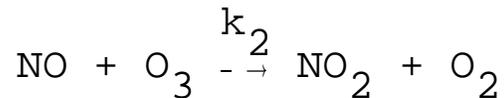
AN UNDERSTANDING OF THE PROCESSES RESPONSIBLE FOR OZONE FORMATION IS NECESSARY TO DETERMINE THE MOST COST EFFECTIVE OZONE CONTROL STRATEGY.

FORMATION OF O₃ IN PHOTOCHEMICAL SMOG

THE ONLY SIGNIFICANT CHEMICAL REACTION WHICH FORMS OZONE IN THE TROPOSPHERE IS THE PHOTOLYSIS OF NO₂



BUT THIS IS REVERSED BY THE RAPID REACTION OF O₃ WITH NO:



THESE PROCESSES RESULT IN A "PHOTOSTATIONARY STATE" BEING ESTABLISHED, WHERE O₃ IS PROPORTIONAL TO THE NO₂ TO NO RATIO

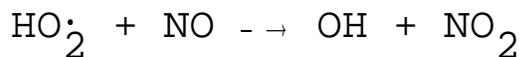
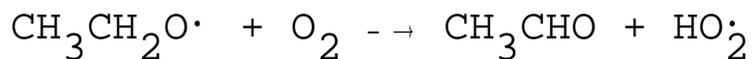
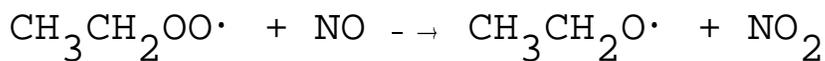
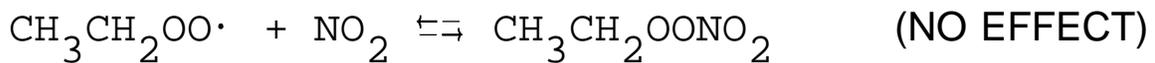
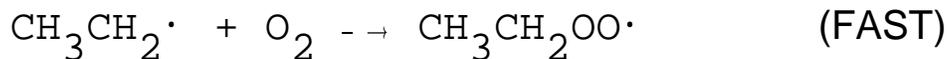
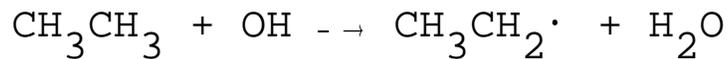
$$[\text{O}_3] \approx \frac{k_1}{k_2} \cdot \frac{[\text{NO}_2]}{[\text{NO}]}$$

IF OTHER REACTANTS ARE NOT PRESENT TO CONVERT NO TO NO₂, ONLY VERY LOW LEVELS OF OZONE ARE FORMED.

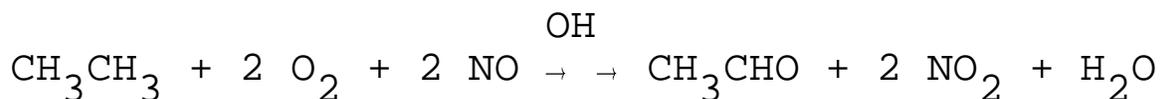
ROLE OF VOCs IN OZONE FORMATION

WHEN VOLATILE ORGANIC COMPOUNDS (VOCs) REACT
THEY FORM RADICALS WHICH CONVERT NO TO NO₂

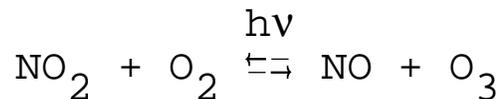
FOR EXAMPLE, **ETHANE**:



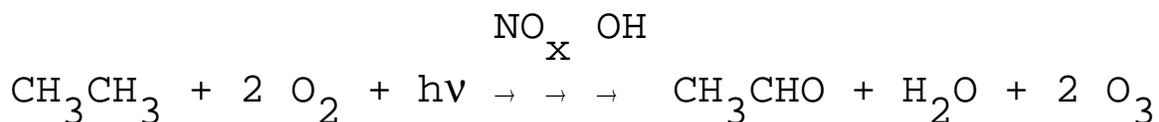
OVERALL PROCESS:



COMBINED WITH:



YIELDS:



OZONE FORMATION CONTINUES UNTIL NO_x IS REMOVED

MAJOR NO_x SINKS:

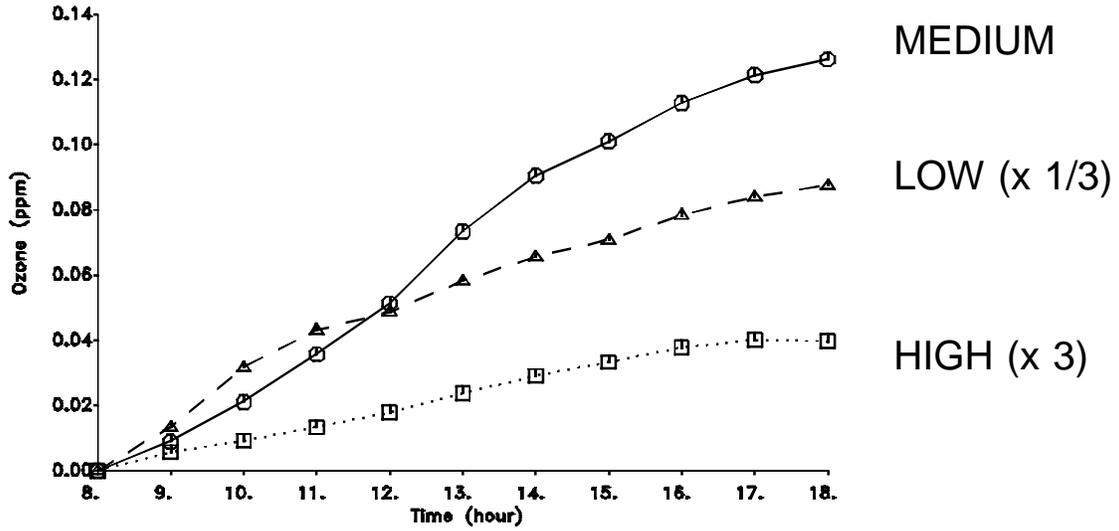
- $\text{OH} + \text{NO}_2 \longrightarrow \text{HNO}_3$
- $\text{NO}_2 + \text{O}_3 \longrightarrow \text{NO}_3 \xrightleftharpoons{\text{H}_2\text{O}} \text{N}_2\text{O}_5 \longrightarrow 2 \text{HNO}_3$ (NIGHTTIME SINK)
- ALDEHYDES $\xrightarrow{\text{OH}} \xrightarrow{\text{O}_2} \text{RCO-OO}\cdot \xrightarrow{\text{NO}_2} \text{RCO-OONO}_2$ (PANs)
- AROMATICS $\xrightarrow{\text{OH}} \xrightarrow{\text{O}_2}$ PHENOLS $\xrightarrow{\text{NO}_3, \text{NO}_2}$ NITROPHENOLS
- ALKANES $\xrightarrow{\text{OH}} \xrightarrow{\text{O}_2} \text{RO}_2 \xrightarrow{\text{NO}} \text{RONO}_3$

NO_x IS REMOVED IN THE ATMOSPHERE MORE RAPIDLY THAN VOCs.

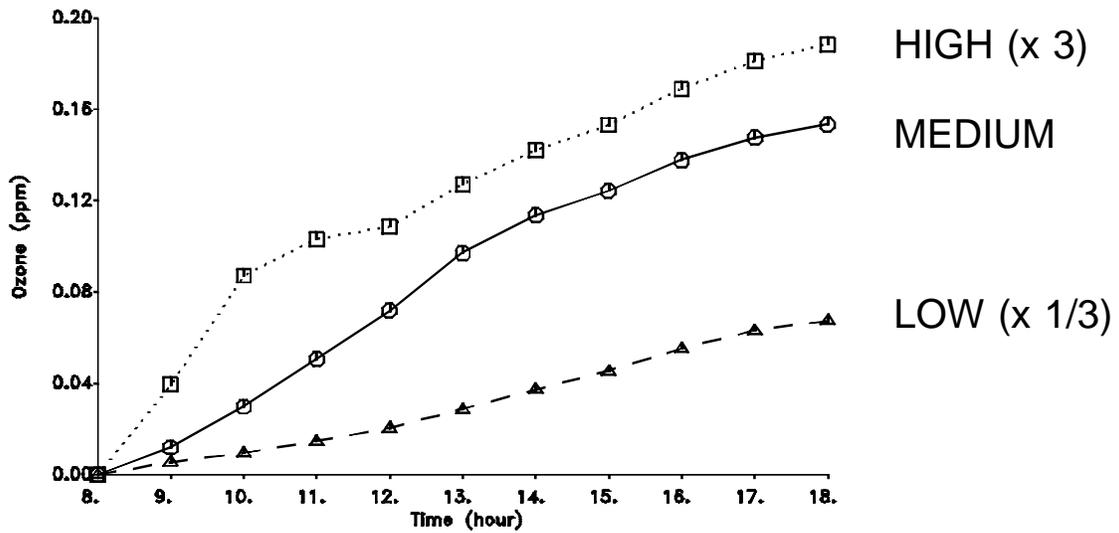
THEREFORE, NO_x AVAILABILITY ULTIMATELY LIMITS THE AMOUNT OF O₃ WHICH CAN BE FORMED.

EFFECT OF VOCs AND NO_x ON O₃ FORMATION

VARY NO_x EMISSIONS



VARY VOC EMISSIONS



IMPLICATIONS OF ATMOSPHERIC CHEMISTRY FOR OZONE CONTROL STRATEGIES

NO_x CONTROL:

- NO_x IS REQUIRED FOR OZONE FORMATION. IF NO_x WERE ABSENT, NO O₃ WOULD BE FORMED. WHEN NO_x IS CONSUMED, OZONE FORMATION ENDS.
- NO_x IS REMOVED MORE RAPIDLY THAN VOCs. THEREFORE, AVAILABILITY OF NO_x LIMITS HOW MUCH OZONE CAN ULTIMATELY BE FORMED.
- BUT NO_x ALSO REDUCES THE RATE OF OZONE FORMATION. THIS IS BECAUSE:
 - NO REACTS WITH O₃
 - NO₂ REACTS WITH RADICALS. LOWER RADICALS CAUSE LOWER VOC CONSUMPTION RATES

THEREFORE, NO_x CONTROL HAS THE GREATEST BENEFIT ON OZONE DOWNWIND, BUT CAN MAKE O₃ WORSE NEAR THE EMISSIONS SOURCE AREAS.

IMPLICATIONS OF ATMOSPHERIC CHEMISTRY FOR OZONE CONTROL STRATEGIES

VOC CONTROL:

- REACTIVE ORGANICS ENHANCE THE RATES OF OZONE FORMATION FROM NO_x . IF VOCs WERE ABSENT, OZONE WOULD BE LOW.
- VOC CONTROL HAS THE GREATEST EFFECT ON OZONE NEAR THE SOURCE AREAS.
- VOC CONTROL IS LESS EFFECTIVE IN AREAS WHERE OZONE IS NO_x -LIMITED. THIS INCLUDES DOWNWIND AND RURAL AREAS.
- NATURAL EMISSIONS OF VOCs ARE IMPORTANT IN MANY AREAS. THIS LIMITS MAXIMUM EXTENT OF VOC CONTROLS.

ANY COMPREHENSIVE OZONE CONTROL STRATEGY SHOULD TAKE BOTH VOC AND NO_x INTO ACCOUNT.

AIRSHED MODELS ARE REQUIRED FOR QUANTITATIVE PREDICTIONS OF EFFECTS OF VOC AND NO_x CONTROL ON OZONE.

CONCEPT OF VOC REACTIVITY

VOCs DIFFER IN THEIR EFFECTS ON OZONE FORMATION. THE TERM **REACTIVITY** IS USED TO REFER TO THIS.

SEVERAL DIFFERENT ASPECTS OF A VOCs ATMOSPHERIC REACTIONS AFFECT ITS REACTIVITY:

- HOW FAST THE VOC REACTS.
- HOW MANY MOLECULES OF NO ARE OXIDIZED WHEN THE VOC REACTS.
- EFFECTS OF THE VOC'S REACTIONS ON RADICAL LEVELS. THIS AFFECTS HOW MUCH O₃ IS FORMED FROM REACTIONS OF THE OTHER VOCs.
- EFFECTS ON RATES OF NO_x REMOVAL. O₃ FORMATION ENDS ONCE NO_x IS REMOVED. (IMPORTANT ONLY WHEN O₃ IS NO_x-LIMITED.)
- REACTIVITIES OF THE VOC'S MAJOR OXIDATION PRODUCTS.

QUANTIFICATION OF REACTIVITY

A USEFUL MEASURE OF THE EFFECT OF A VOC ON OZONE FORMATION IS ITS **INCREMENTAL REACTIVITY**:

$$\left[\begin{array}{l} \text{INCREMENTAL} \\ \text{REACTIVITY} \\ \text{OF A VOC IN} \\ \text{AN EPISODE} \end{array} \right] = \lim_{[\text{VOC}] \rightarrow 0} \frac{\left[\begin{array}{l} \text{OZONE} \\ \text{FORMED} \\ \text{WHEN VOC} \\ \text{ADDED TO} \\ \text{EPISODE} \end{array} \right] - \left[\begin{array}{l} \text{OZONE} \\ \text{FORMED} \\ \text{IN} \\ \text{EPISODE} \end{array} \right]}{[\text{VOC ADDED}]}$$

THIS CAN BE MEASURED EXPERIMENTALLY IN SMOG CHAMBERS OR CALCULATED FOR POLLUTION EPISODES USING AIRSHED MODELS.

IMPORTANT TO NOTE THAT THIS DEPENDS ON THE CONDITIONS OF THE EPISODE (OR THE EXPERIMENT) AS WELL AS ON THE VOC.

ENVIRONMENTAL FACTORS WHICH AFFECT REACTIVITY

AVAILABILITY OF NO_x

- THIS IS THE MOST IMPORTANT SINGLE FACTOR
- VOCs FORM THE MOST OZONE (REACTIVITIES ARE THE HIGHEST) WHEN NO_x IS ABUNDANT
- VOCs HAVE THE SMALLEST EFFECTS ON OZONE (REACTIVITIES LOWEST) WHEN NO_x IS LOW.
- THE ROG/NO_x RATIO IS COMMONLY USED TO MEASURE NO_x AVAILABILITY.

NATURE OF OTHER VOCs PRESENT.

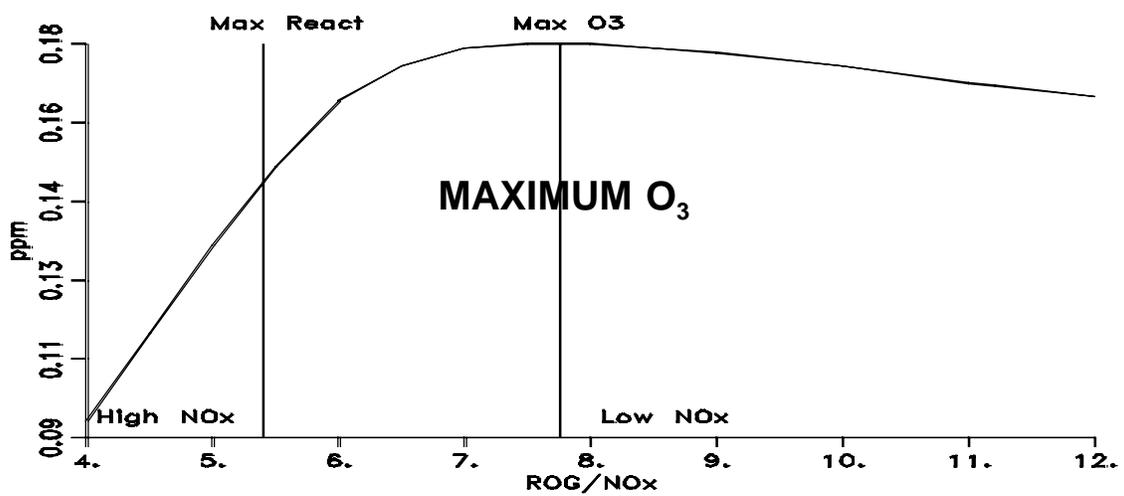
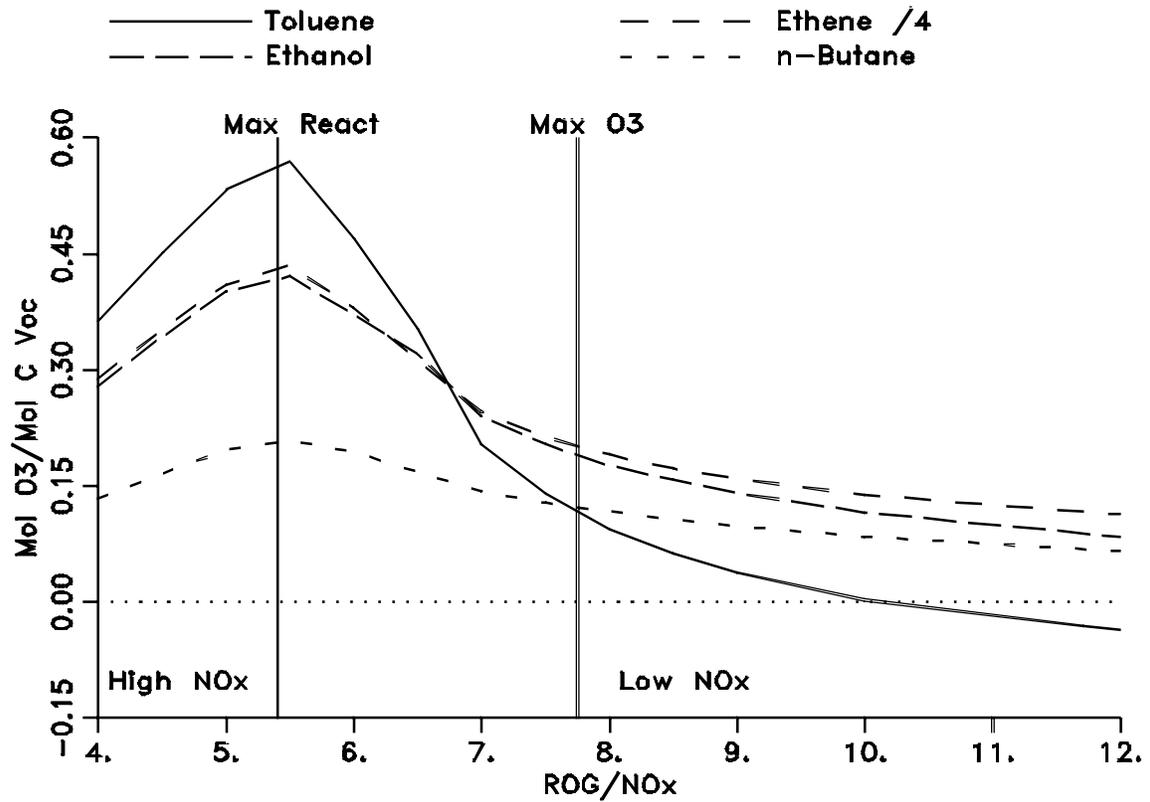
- VOCs WITH STRONG RADICAL SOURCES DECREASE THE IMPORTANCE OF RADICAL SOURCES OR SINKS IN AFFECTING A VOC's REACTIVITY.

AMOUNTS OF SUNLIGHT AND TEMPERATURE:

- AFFECTS OVERALL RATES OF REACTION.
- AFFECTS DEPENDENCE OF REACTIVITY ON ROG/NO_x RATIO. (MORE SUNLIGHT LIKE INCREASING ROG/NO_x)

TRANSPORT, ALOFT AND BACKGROUND POLLUTANTS, EMISSION SCHEDULES, AMOUNTS OF DILUTION, ALSO AFFECT REACTIVITY AND VOC/NO_x DEPENDENCIES

DEPENDENCE OF INCREMENTAL REACTIVITIES ON ROG/NO_x



MEASUREMENT OR CALCULATION OF ATMOSPHERIC REACTIVITY

ATMOSPHERIC REACTIVITY CANNOT BE MEASURED
EXPERIMENTALLY

- NOT PRACTICAL TO DUPLICATE IN AN EXPERIMENT ALL ENVIRONMENTAL CONDITIONS WHICH AFFECT REACTIVITY
- CHAMBER EXPERIMENTS HAVE WALL EFFECTS, USUALLY HIGHER NO_x LEVELS, STATIC CONDITIONS, HIGH AMOUNTS OF ADDED TEST VOC, ETC.

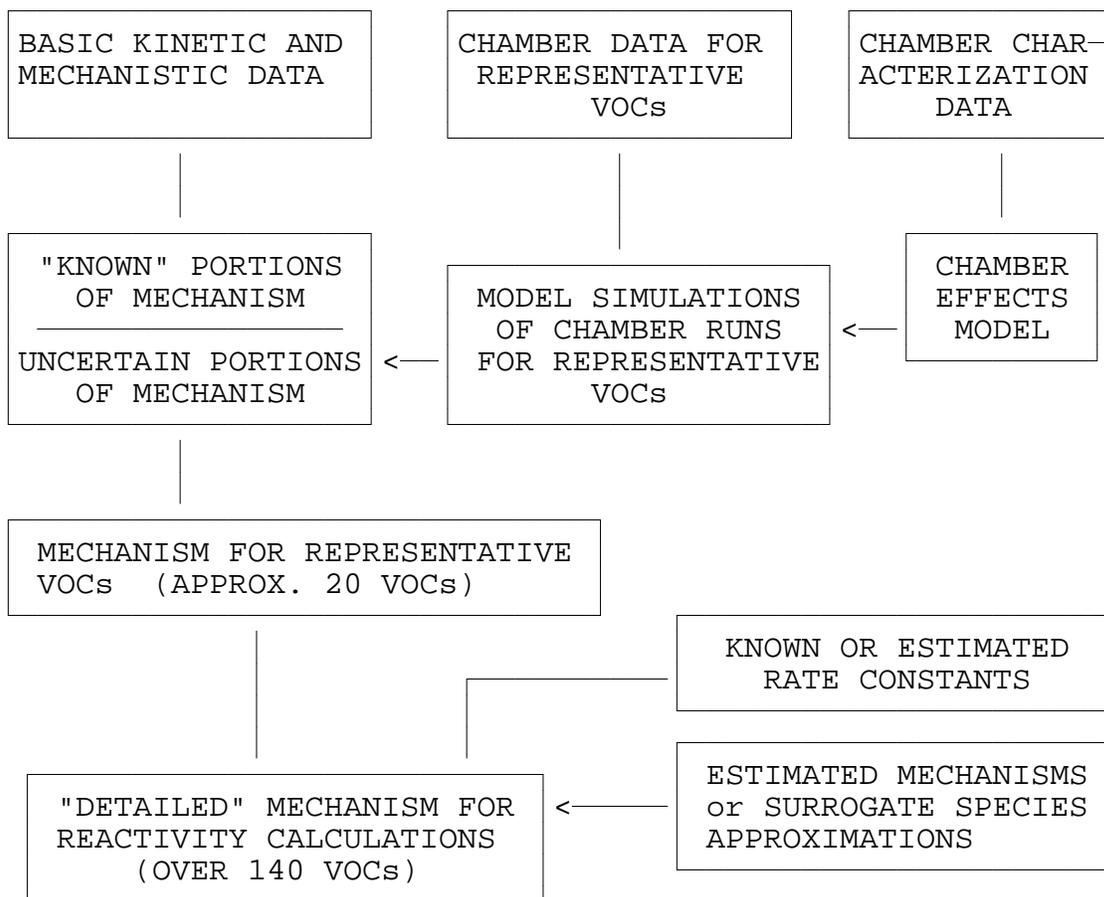
ATMOSPHERIC REACTIVITY CAN BE CALCULATED USING
COMPUTER AIRSHED MODELS, GIVEN:

- MODELS FOR AIRSHED CONDITIONS
- CHEMICAL MECHANISMS FOR THE VOC's
ATMOSPHERIC REACTIONS

MODEL CALCULATIONS OF ATMOSPHERIC REACTIVITY
CAN BE NO MORE RELIABLE THAN THE CHEMICAL
MECHANISM USED.

**EXPERIMENTAL MEASUREMENTS OF REACTIVITY
PROVIDE A MEANS TO TEST THE RELIABILITY OF A
MECHANISM TO PREDICT ATMOSPHERIC REACTIVITY.**

DEVELOPMENT OF A CHEMICAL MECHANISM TO CALCULATE VOC REACTIVITIES



TYPES OF ENVIRONMENTAL CHAMBER EXPERIMENTS TO TEST ATMOSPHERIC CHEMICAL MECHANISMS

SINGLE VOC-NO_x-AIR RUNS:

- MOST STRAIGHTFORWARD TEST OF A VOC'S MECHANISM
- USED FOR MECHANISM DEVELOPMENT
- NOT A "REALISTIC" ENVIRONMENT
- ONLY USEFUL FOR VOCs WITH RADICAL SOURCES.

COMPLEX MIXTURE-NO_x-AIR RUNS:

- TESTS MECHANISMS' ABILITY TO SIMULATE O₃ FORMATION UNDER REALISTIC CONDITIONS
- NOT USEFUL FOR MECHANISM DEVELOPMENT

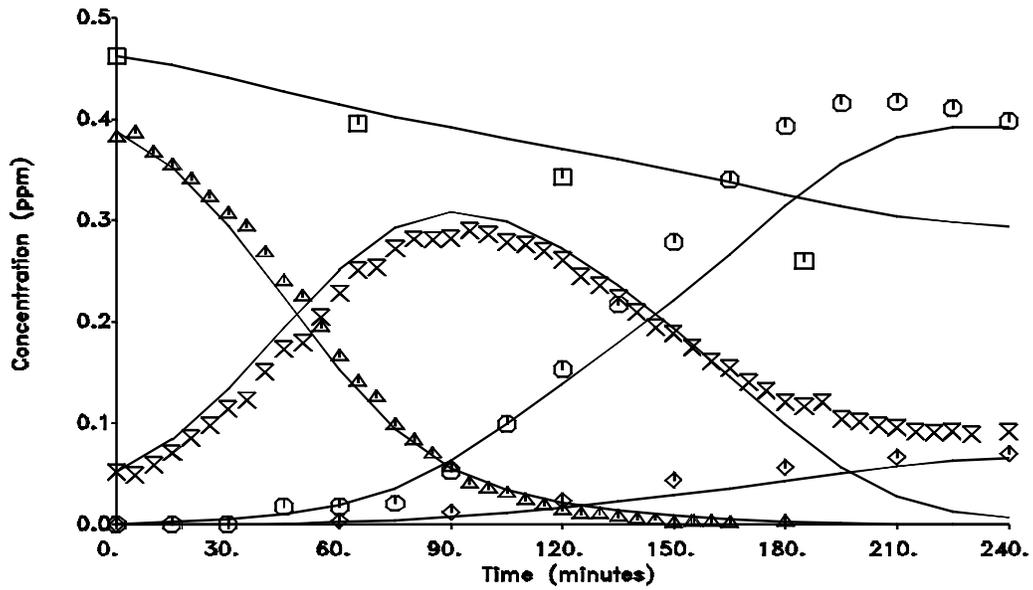
REACTIVITY EXPERIMENTS (MIXTURE-NO_x-AIR COMBINED WITH MIXTURE-NO_x-AIR RUNS WITH TEST VOC ADDED):

- CAN TEST MECHANISMS OF SINGLE VOCs UNDER REALISTIC CONDITIONS
- BEST TEST OF MECHANISM'S ABILITY TO PREDICT INCREMENTAL REACTIVITY
- NOT SAME AS ATMOSPHERIC REACTIVITY.

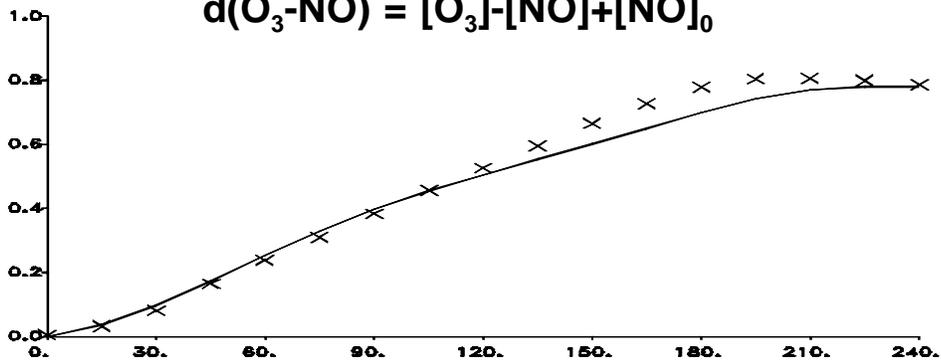
EXAMPLE OF SINGLE VOC-NO_x-AIR EXPERIMENT: FIT OF MODEL CALCULATION TO A TOLUENE - NO_x - AIR EXPERIMENT

EC-264 (Toluene - NO_x)

- Ozone
- × NO₂ + Nitrates
- Toluene x 0.4
- △ NO
- ◇ PAN
- Model Calculation

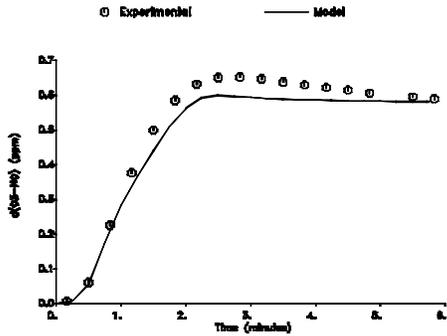


$$d(O_3-NO) = [O_3]-[NO]+[NO]_0$$

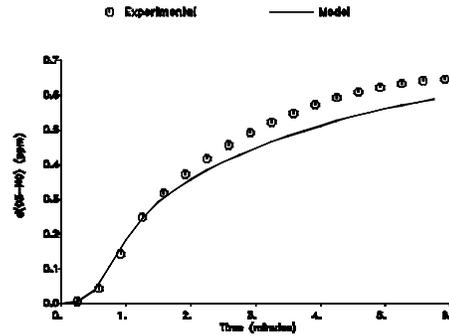


EXPERIMENTAL VS CALCULATED $d(O_3-NO)$ IN AROMATIC ISOMER - NO_x EXPERIMENTS

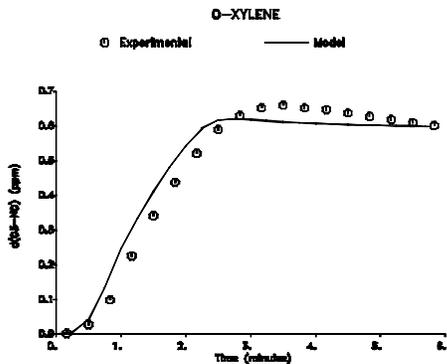
M-XYLENE



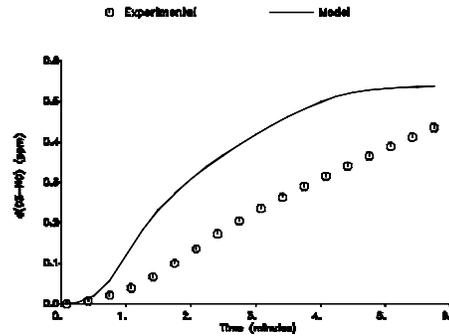
1,3,5-TRIMETHYLBENZENE



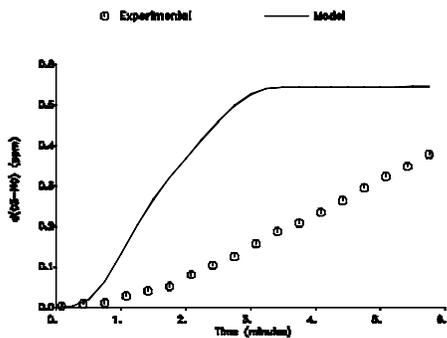
O-XYLENE



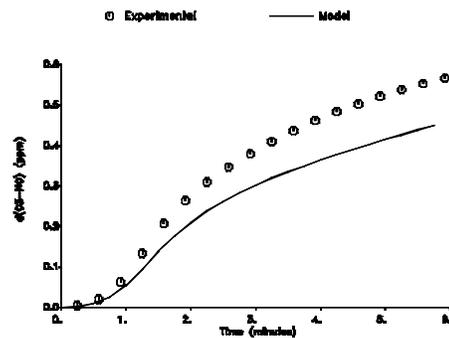
1,2,4-TRIMETHYLBENZENE



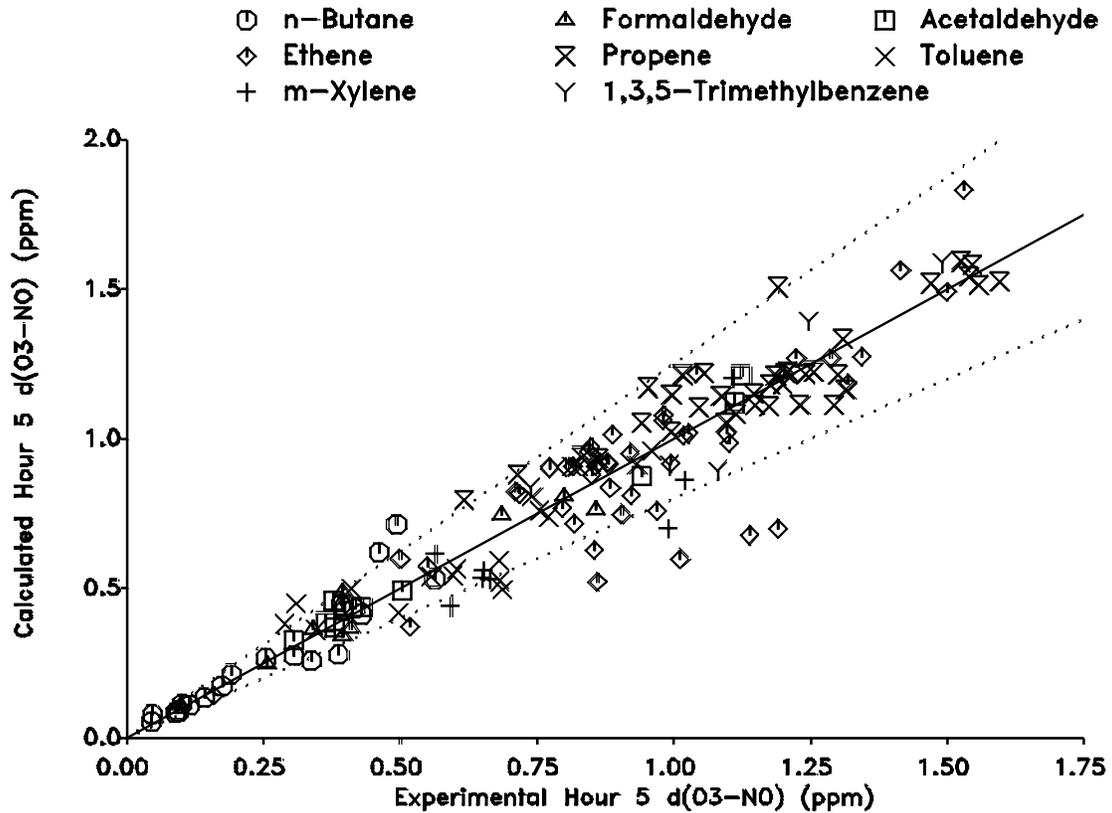
P-XYLENE



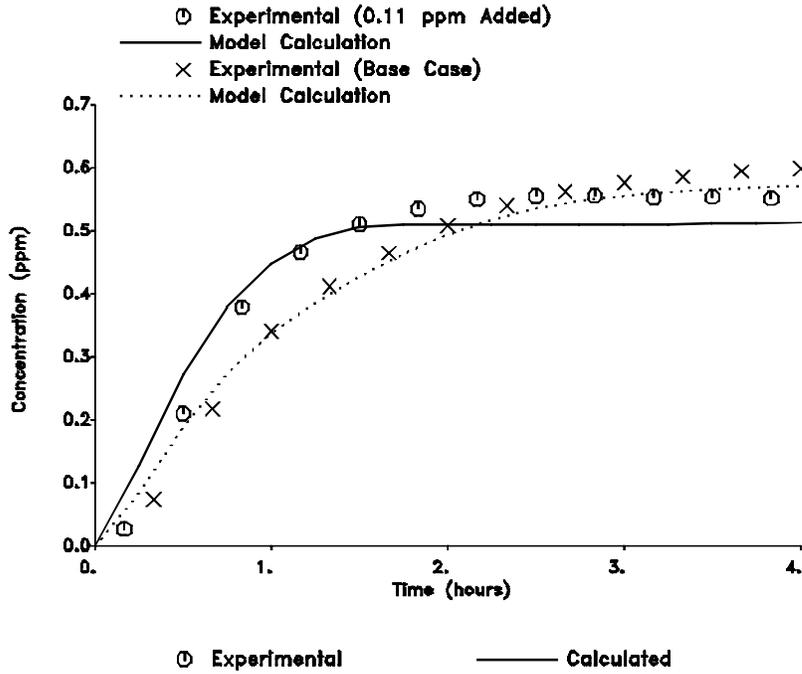
1,2,3-TRIMETHYLBENZENE



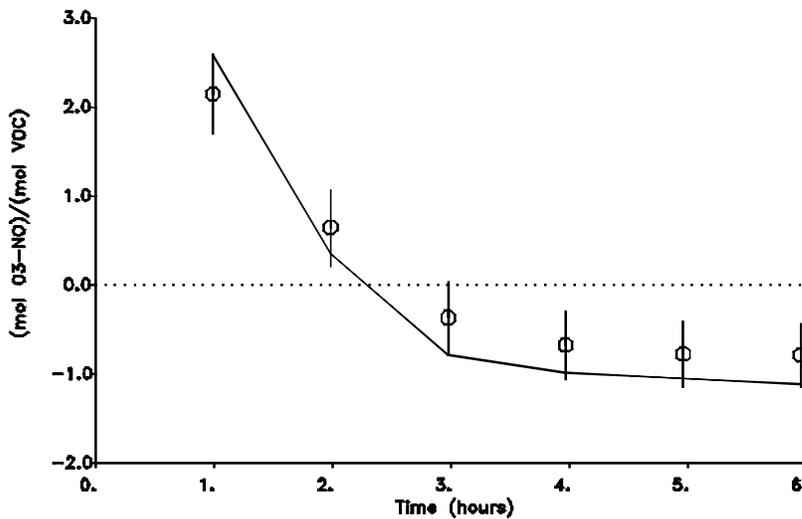
**PLOT OF EXPERIMENTAL VS CALCULATED
OZONE FORMED + NO OXIDIZED IN
SELECTED SINGLE COMPOUND - NO_x EXPERIMENTS**



EXAMPLE OF AN INCREMENTAL REACTIVITY EXPERIMENT: EFFECT OF M-XYLENE UNDER HIGH ROG/NO_x CONDITIONS

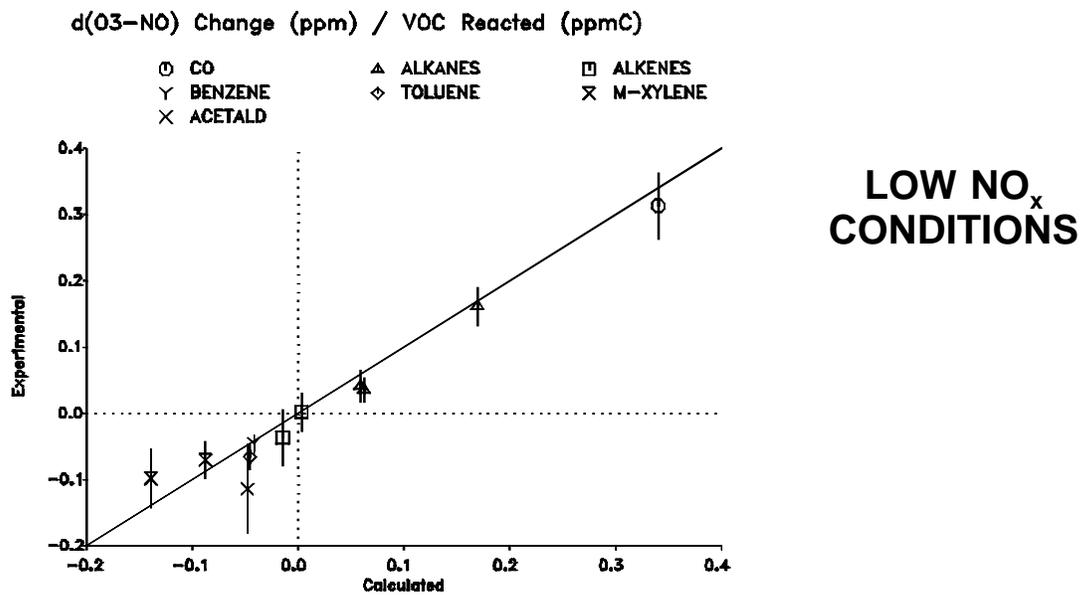
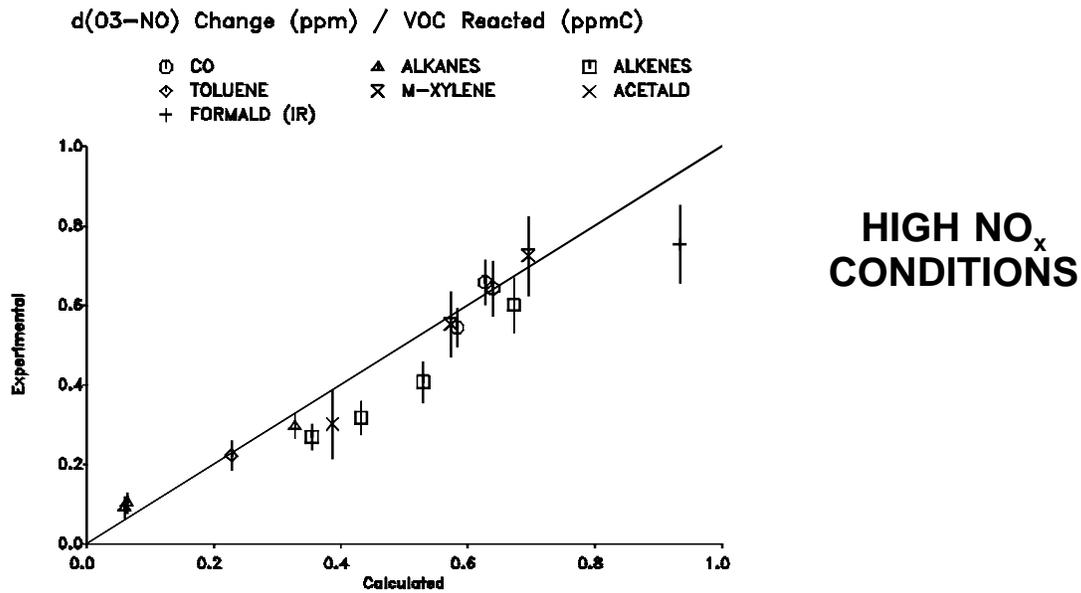


$\Delta([O_3]-[NO])$
vs TIME

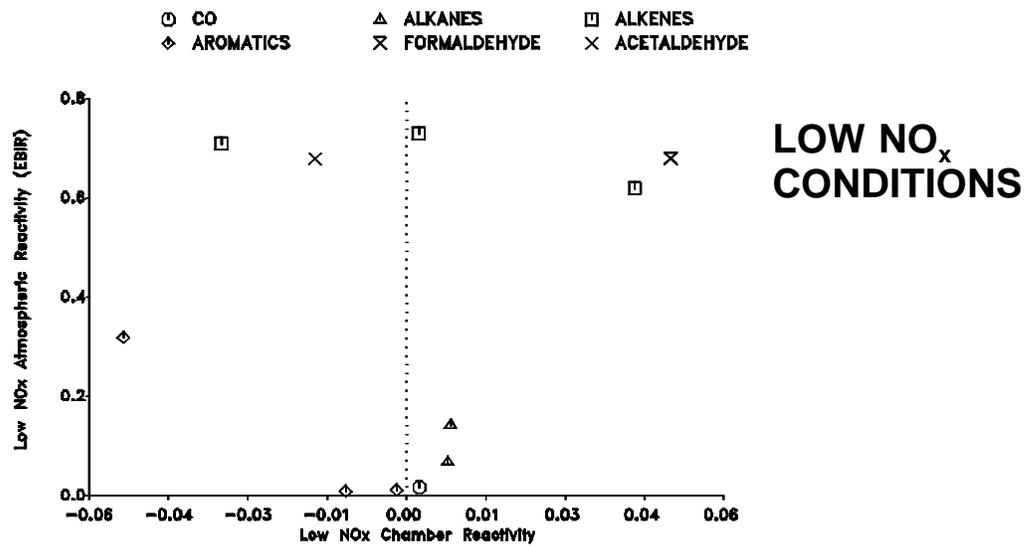
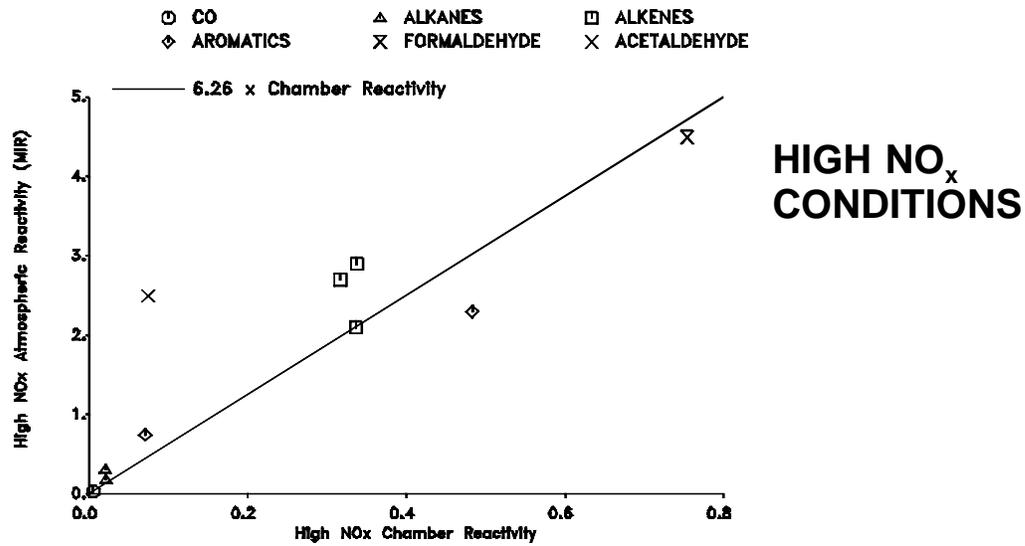


{CHANGE IN
 $\Delta([O_3]-[NO])$ } /
 (XYLENE REACTED)
 vs TIME

MODEL PERFORMANCE IN SIMULATING INCREMENTAL REACTIVITY EXPERIMENTS



CORRESPONDENCE BETWEEN ENVIRONMENTAL CHAMBER AND CALCULATED ATMOSPHERIC REACTIVITIES.



CURRENT STATUS OF THE CHEMICAL MECHANISMS USED TO PREDICT O₃ IMPACTS OF VOCs AND NO_x

MANY UNCERTAINTIES IN VOC REACTION MECHANISMS, ESPECIALLY FOR AROMATICS. PARAMETERIZED MODELS ADJUSTED TO FIT CHAMBER DATA.

MECHANISMS CAN SIMULATE O₃ AND NO IN MOST WELL-CHARACTERIZED EXPERIMENTS WITHIN $\pm 30\%$. SOME EXCEPTIONS AND INCONSISTENCIES.

- POOR REPRESENTATION OF SOME AROMATIC ISOMERS.
- UNEXPLAINED VARIABILITIES IN SIMULATIONS OF ETHENE RUNS
- POSSIBLE UNDERPREDICTION BIAS IN NEW OUTDOOR AND XENON ARC LIGHT EXPERIMENTS.

CHAMBER DATA BASE FOR MECHANISM EVALUATION IS NOT ADEQUATE FOR MANY VOCs.

CURRENT CHAMBERS DO NOT PROVIDE GOOD TESTS FOR MECHANISMS UNDER VERY LOW NO_x CONDITIONS.

EFFECTS OF CHEMICAL MECHANISM UNCERTAINTY ON AIRSHED MODEL PREDICTIONS HAVE NOT BEEN ADEQUATELY ASSESSED.

VOC REACTIVITY AND OZONE CONTROL STRATEGIES

CONTROL STRATEGIES AIMED AT REDUCING EMISSIONS OF MORE REACTIVE VOC'S WILL BE MORE EFFECTIVE THAN THOSE REDUCING ALL VOC'S EQUALLY.

IF A VOC IS SUFFICIENTLY UNREACTIVE TOWARDS OZONE FORMATION, IT DOES NOT MAKE SENSE TO REGULATE IT TO REDUCE OZONE.

REPLACING REACTIVE VOC EMISSIONS WITH EMISSIONS OF VOC'S WHICH ARE LESS REACTIVE IS PROPOSED AS A VOC CONTROL STRATEGY. EXAMPLES INCLUDE:

- ALTERNATIVE FUELS
- SOLVENT SUBSTITUTION
- REFORMULATION OF VOCs IN CONSUMER PRODUCTS

A GENERAL REACTIVITY RANKING SCALE WOULD AID IN DEVELOPING SUCH CONTROL STRATEGIES.

BUT REACTIVITIES DEPEND ON ENVIRONMENTAL CONDITIONS. THIS COMPLICATES DEVELOPMENT OF A GENERAL REACTIVITY SCALE.

EXAMPLES OF WAYS TO DEAL WITH THE DEPENDENCE OF REACTIVITY ON ENVIRONMENTAL CONDITIONS

BASE THE SCALE ON A "REPRESENTATIVE" OR "WORST CASE" EPISODE.

- MAY NOT BE OPTIMUM FOR ALL CONDITIONS.

BASE THE SCALE ON CONDITIONS WHERE VOCs HAVE MAXIMUM REACTIVITY REACTIVITIES (MIR SCALE).

- REFLECTS CONDITIONS WHERE VOC CONTROL IS THE MOST EFFECTIVE OZONE CONTROL STRATEGY.
- GIVES GOOD CORRELATIONS TO EFFECTS OF VOCs ON INTEGRATED OZONE EXPOSURE.
- BUT DOES NOT REPRESENT CONDITIONS WHERE HIGHEST OZONE CONCENTRATIONS ARE FORMED.

USE MULTIPLE SCALES REPRESENTING THE RANGE OF APPLICABLE CONDITIONS.

- ALLOWS AN ASSESSMENT OF EFFECTS OF VARIABILITY.
- BUT NOT USEFUL WHEN A SINGLE SCALE IS REQUIRED.

STEPS IN THE DEVELOPMENT OF GENERAL REACTIVITY SCALES

1. DEVELOP MODELS (MECHANISMS) FOR THE VOCs' ATMOSPHERIC REACTIONS. CONDUCT EXPERIMENTS WHICH TEST THEIR ABILITY TO PREDICT REACTIVITY
2. DEVELOP A SET OF MODEL SCENARIOS REPRESENTING THE RANGE OF AIRSHED CONDITIONS WHERE OZONE IS A PROBLEM.
3. DETERMINE APPROPRIATE METHOD(S) TO QUANTIFY OZONE IMPACTS IN AN AIRSHED SCENARIO.
4. DEVELOP APPROPRIATE METHODS TO DERIVE REACTIVITY SCALES FROM THE DISTRIBUTION OF REACTIVITIES IN THE SCENARIOS.
5. DETERMINE RANGES OF UNCERTAINTIES OR VARIABILITIES IN THE REACTIVITY SCALE(S).
6. DEVELOP APPROPRIATE CONTROL POLICIES GIVEN THE REACTIVITY SCALES AND THEIR UNCERTAINTIES.

CRITERIA FOR MODEL SCENARIOS FOR DEVELOPMENT OF REACTIVITY SCALES

MULTIPLE SCENARIOS SHOULD BE USED TO REPRESENT THE RANGE OF CONDITIONS WHERE THE SCALE WOULD BE APPLIED

REACTIVITY IS PRIMARILY A **CHEMICAL EFFECT**.
THEREFORE:

- REPRESENTATION OF AN APPROPRIATE DISTRIBUTION OF CHEMICAL CONDITIONS MOST IMPORTANT
- MODEL SHOULD USE MOST DETAILED CHEMICAL MECHANISM AVAILABLE, EVEN THOUGH THIS REQUIRES USE OF SIMPLER PHYSICAL MODELS.

ABILITY TO ACCURATELY SIMULATE ANY SPECIFIC EPISODE IS LESS IMPORTANT THAN USE OF AN APPROPRIATE DISTRIBUTION OF CONDITIONS

ALTERNATIVES FOR QUANTIFYING OZONE IMPACTS WHEN ASSESSING VOC REACTIVITY

OZONE YIELD REACTIVITY: EFFECT OF VOC ON MAXIMUM OZONE CONCENTRATION OR AMOUNT OF OZONE FORMED

$$\text{REACTIVITY} = \frac{\Delta \text{ Maximum } [O_3]}{\Delta \text{ VOC}}$$

INTEGRATED OZONE REACTIVITY: EFFECT OF VOC ON OZONE CONCENTRATION INTEGRATED OVER TIME, OR INTEGRATED OZONE OVER A STANDARD

$$\text{REACTIVITY} = \frac{\Delta \int [O_3] dt}{\Delta \text{ VOC}}$$

OR

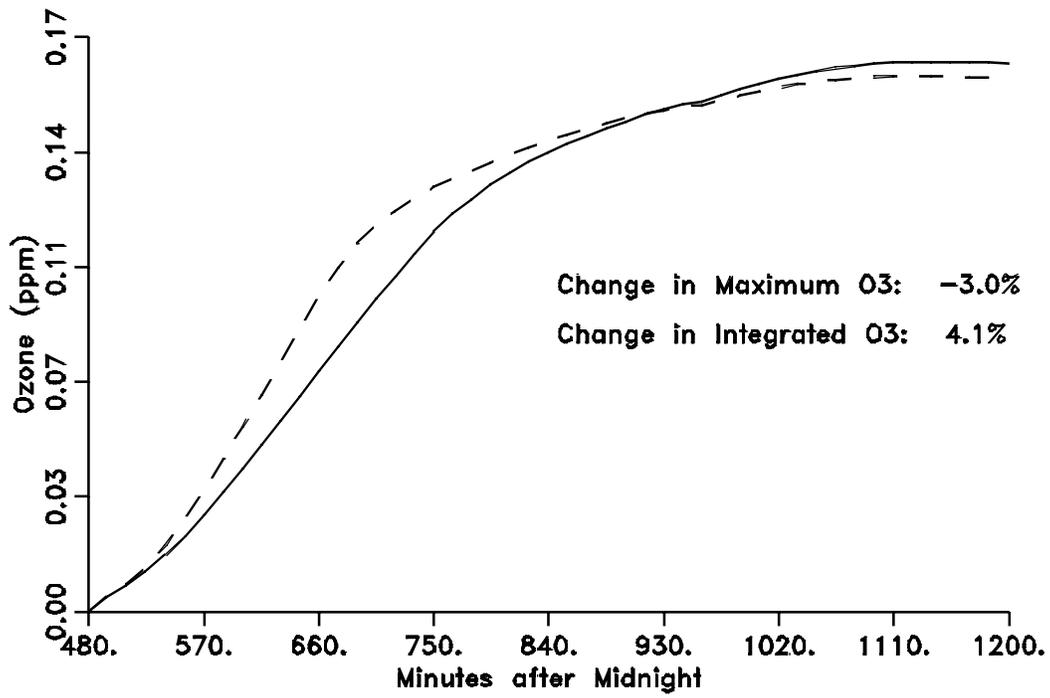
$$\text{REACTIVITY} = \frac{\Delta \int \max(0, [O_3] - [O_3]^{\text{std}}) dt}{\Delta \text{ VOC}}$$

OZONE EXPOSURE REACTIVITY: EFFECT OF THE VOC ON EXPOSURE OF THE POPULATION TO OZONE

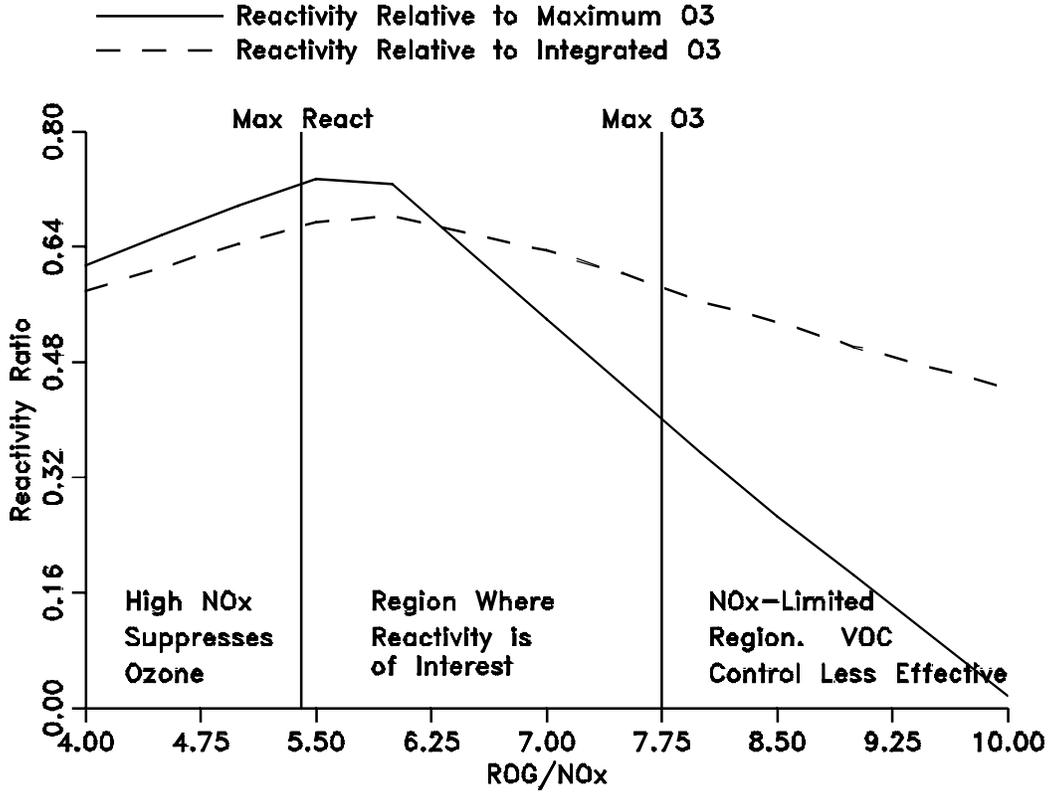
$$\text{REACTIVITY} = \frac{\text{PERSON-HOURS EXPOSED TO } O_3 \text{ OVER THE STANDARD}}{\Delta \text{ VOC}}$$

EFFECT OF TOLUENE ON O3 IN LOW NOx SCENARIO

- Base Case (ROG/NOx=12)
- - - Toluene added (10% of base ROG C's)



TOLUENE REACTIVITY / BASE ROG REACTIVITY



EXAMPLES OF REGULATORY POLICIES REGARDING VOC REACTIVITY

U.S. EPA

- PRESENT POLICY: A VOC IS EITHER **REACTIVE** OR **EXEMPT**. ISSUE IS WHAT TO EXEMPT.
- CANDIDATES FOR EXEMPTION EXAMINED ON A CASE BY CASE BASIS.
 - ETHANE REACTIVITY IS USED AS THE INFORMAL STANDARD
 - INCREMENTAL REACTIVITY IS NOW ONE OF THE FACTORS CONSIDERED
 - EPA PROPOSED EXEMPTING ACETONE BASED ON ITS CALCULATED INCREMENTAL REACTIVITY.
- CLEAN AIR ACT REQUIRES THE EPA TO CONSIDER VOC REACTIVITY IN CONTROLS OF CONSUMER PRODUCTS.

EXAMPLES OF REGULATORY POLICIES REGARDING VOC REACTIVITY

CALIFORNIA AIR RESOURCES BOARD

- REACTIVITY ADJUSTMENT FACTORS (RAF_s) ARE USED IN EXHAUST EMISSIONS STANDARDS IN THE "CLEAN FUELS/LOW EMISSIONS VEHICLE" REGULATIONS

$$\begin{array}{l} \text{ADJUSTED} \\ \text{EMISSIONS} \\ (\text{g/mi}) \end{array} = \mathbf{RAF} \times \begin{array}{l} \text{ACTUAL} \\ \text{EMISSIONS} \\ (\text{g/mi}) \end{array}$$

WHERE

$$\mathbf{RAF} = \frac{\begin{array}{l} \text{MAXIMUM INCREMENTAL REACTIVITY} \\ \text{(MIR) OF EXHAUST (g O}_3\text{/g VOC)} \end{array}}{\begin{array}{l} \text{MIR OF STANDARD EXHAUST} \\ \text{(g O}_3\text{/g VOC)} \end{array}}$$

- REACTIVITY NOT NOW CONSIDERED IN STATIONARY SOURCE REGULATIONS

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

- PROPOSED EMISSIONS TRADING PROGRAM (**RECLAIM**) WILL PERMIT TRADES OF ALL NON-EXEMPT VOCs REGARDLESS OF REACTIVITY. BUT RESULTING CHANGES IN REACTIVITY WILL BE TRACKED AND ASSESSED AS PART OF ASSESSMENT OF OVERALL PROGRAM.

SUMMARY OF RESEARCH NEEDS FOR DEVELOPING REACTIVITY SCALES

RESEARCH AREA

RESEARCH NEED

MECHANISMS FOR VOCs

- BASIC KINETIC AND MECHANISTIC STUDIES.
- CHAMBER EXPERIMENTS TO TEST MECHANISMS.

SCENARIOS FOR REACTIVITY ASSESSMENT

- IMPROVE EMISSIONS DATA.
- OBTAIN DATA TO TEST AIRSHED MODELS.
- DETERMINE DISTRIBUTION OF OZONE EPISODE CONDITIONS.
- DEVELOP MODELS FOR MORE EPISODES.

METHODS TO QUANTIFY OZONE IMPACTS

- HEALTH EFFECTS STUDIES.
- EXPOSURE MODEL DEVELOPMENT.

DERIVE REACTIVITY SCALE(S)

- DETERMINE WHAT CONSTITUTES AN "OPTIMUM" SCALE (POLICY ISSUE).
- DEVELOP ANALYSIS METHODS TO DERIVE "OPTIMUM" SCALE FROM RESULTS OF MULTI-SCENARIO CALCULATIONS.