EVALUATION OF ATMOSPHERIC OZONE IMPACTS OF COATINGS VOC EMISSIONS

BY

WILLIAM P. L. CARTER

COLLEGE OF ENGINEERING CENTER FOR
ENVIRONMENTAL RESEARCH AND TECHNOLOGY
UNIVERSITY OF CALIFORNIA, RIVERSIDE

September 25, 2003

OUTLINE

CHEMISTRY OF OZONE FORMATION

QUANTIFICATION OF REACTIVITY AND EXAMPLES

UNCERTAINTIES IN REACTIVITY SCALES

ONGOING REACTIVITY RESEARCH FOR ARCHITECTURAL COATINGS VOCs

ADDITIONAL INFORMATION AVAILABLE

THE PHOTOCHEMICAL OZONE PROBLEM

GROUND LEVEL OZONE IS FORMED WHEN SUNLIGHT REACTS WITH EMITTED OXIDES OF NITROGEN (NO_x) AND VOLATILE ORGANICS COMPOUNDS (VOCs).

THE PROCESS OF OZONE FORMATION FROM VOCs AND NO_x IS COMPLEX

- VOC AND NO_x CONTROL ARE NOT EQUALLY EFFECTIVE IN REDUCING OZONE.
- DIFFERENT TYPES OF VOCs HAVE DIFFERENT OZONE IMPACTS (REACTIVITIES).

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

CHEMISTRY OF O_3 FORMATION IN PHOTOCHEMICAL SMOG

THE ONLY SIGNIFICANT CHEMICAL REACTION WHICH FORMS OZONE IN THE TROPOSPHERE IS THE PHOTOLYSIS OF NO_2

$$NO_2 + h\nu \rightarrow NO + O^3P \qquad (1)$$

$$O^3P + O_2 + M \rightarrow O_3 + M$$

OR OVERALL

$$NO_2 + h\nu \rightarrow NO + O_3$$

BUT THIS IS REVERSED BY THE RAPID REACTION OF O_3 WITH NO:

$$O_3 + NO \rightarrow NO_2 + O_2 \qquad (2)$$

THIS RESULTS IN A "PHOTOSTATIONARY STATE" BEING ESTABLISHED, WHERE O_3 IS PROPORTIONAL TO THE NO_2 TO NO RATIO

$$[O_3] = \frac{k_1[NO_2]}{k_2[NO]}$$

IF OTHER REACTANTS ARE NOT PRESENT TO CONVERT NO TO NO_2, ONLY VERY LOW LEVELS OF OZONE ARE FORMED.

ROLE OF VOCs IN OZONE FORMATION

WHEN VOLATILE ORGANIC COMPOUNDS REACT THEY FORM RADICALS THAT CONVERT NO TO NO_2

SIMPLIFIED EXAMPLE:

$$VOC + OH \rightarrow R\cdot + H_2O$$
$$R\cdot + O_2 \rightarrow RO_2\cdot$$
$$RO_2 + NO \rightarrow RO\cdot + NO_2$$
$$RO\cdot + O_2 \rightarrow HO_2\cdot + RCHO$$
$$HO_2\cdot + NO \rightarrow OH + NO_2$$

<u>OVERALL</u>

$$VOC + 2\ O_2 + 2\ NO \rightarrow \xrightarrow{OH} \rightarrow RCHO + 2\ NO_2 + H_2O$$

<u>COMBINED WITH</u>

$$NO_2 + O_2 \overset{h\nu}{\rightleftarrows} NO + O_3$$

<u>YIELDS</u>

$$VOC + 2\ O_2 \rightarrow \xrightarrow{OH,\ NO_x} \rightarrow RCHO + H_2O + 2\ O_3$$

OZONE FORMATION CONTINUES UNTIL NO_x IS REMOVED

IMPLICATIONS OF ATMOSPHERIC CHEMISTRY FOR OZONE CONTROL STRATEGIES

NOx CONTROL:

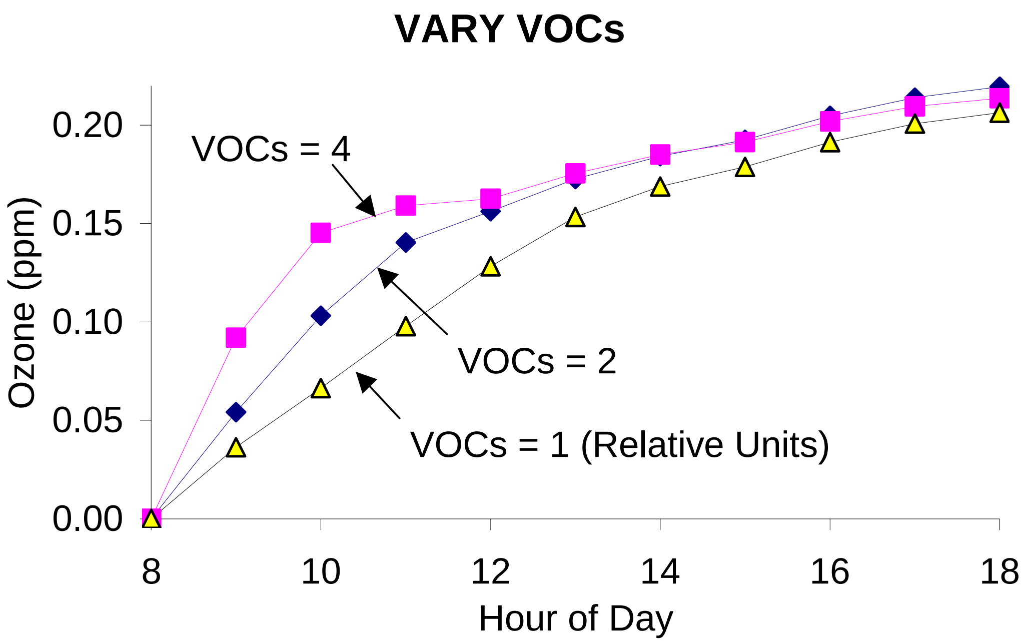
- NO_x IS REQUIRED FOR OZONE FORMATION AND LIMITS <u>HOW MUCH</u> O_3 CAN BE FORMED.
- BUT NOx REDUCES THE <u>RATE</u> OF O_3 FORMATION BECAUSE IT REACTS WITH O_3 AND RADICALS
- NOx CONTROL HAS GREATEST BENEFIT DOWNWIND, BUT CAN MAKE O_3 WORSE NEAR EMISSIONS SOURCE AREAS.

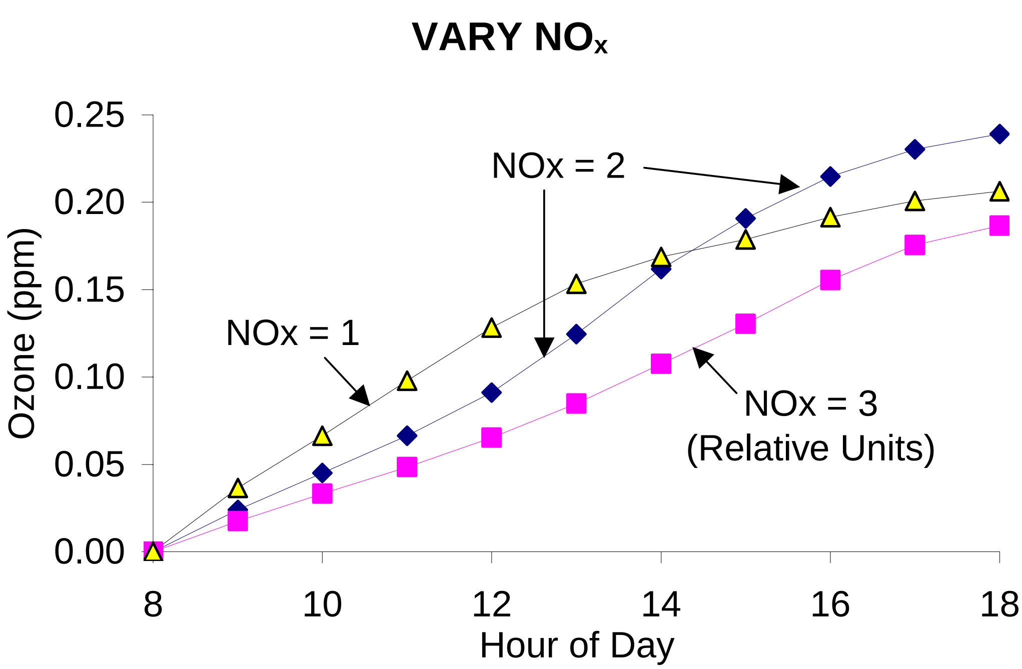
VOC CONTROL

- VOCs ENHANCE THE <u>RATE</u> OF O_3 FORMATION FROM NO_x
- VOC CONTROL IS MOST EFFECTIVE NEAR THE SOURCE AREAS WHERE NO_x IS HIGH.
- LESS EFFECTIVE IN NOx-LIMITED AREAS, SUCH AS DOWNWIND AND MOST RURAL AREAS.
- NATURAL EMISSIONS OF VOCs LIMITS THE MAXIMUM EXTENT OF VOC CONTROLS.

ANY COMPREHENSIVE OZONE CONTROL STRATEGY SHOULD TAKE ALL THESE FACTORS INTO ACCOUNT.

EFFECTS OF VOCs AND NO_x ON OZONE





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 IT REACTS.
- HOW MUCH O3 IS FORMED DIRECTLY FROM ITS REACTIONS AND THOSE OF ITS PRODUCTS.
- WHETHER IT ENHANCES OR INHIBITS RADICAL LEVELS. THIS AFFECTS HOW FAST O3 IS FORMED FROM ALL VOCs.
- WHETHER IT ENHANCES RATES NO_x REMOVAL. THIS AFFECTS ULTIMATE O3 YIELDS BECAUSE NOx IS REQUIRED FOR O3 TO BE FORMED.

A VOC's EFFECT ON O_3 ALSO DEPENDS ON THE NATURE OF THE ENVIRONMENT WHERE IT REACTS

QUANTIFICATION OF REACTIVITY

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

$$\begin{bmatrix}\text{INCREMENTAL}\\ \text{REACTIVITY}\\ \text{OF A VOC IN}\\ \text{AN EPISODE}\end{bmatrix} = \lim_{[\text{VOC}]\to 0} \frac{\begin{bmatrix}\text{OZONE}\\ \text{FORMED}\\ \text{WHEN VOC}\\ \text{ADDED TO}\\ \text{EPISODE}\end{bmatrix} - \begin{bmatrix}\text{OZONE}\\ \text{FORMED}\\ \text{IN AN}\\ \text{EPISODE}\end{bmatrix}}{\begin{bmatrix}\text{AMOUNT OF VOC}\\ \text{ADDED TO EMISSIONS}\\ \text{IN THE EPISODE}\end{bmatrix}}$$

THIS DEPENDS ON THE CONDITIONS OF THE EPISODE AS WELL AS ON THE VOC

MEASUREMENT OR CALCULATION OF ATMOSPHERIC REACTIVITY

REACTIVITY CAN BE MEASURED IN ENVIRONMENTAL CHAMBER EXPERIMENTS. BUT THE RESULTS ARE NOT THE SAME AS REACTIVITY IN THE ATMOSPHERE.

- IMPRACTICAL TO EXPERIMENTALLY DUPLICATE ALL CONDITIONS THAT AFFECT REACTIVITY
- CHAMBER EXPERIMENTS HAVE WALL EFFECTS, USUALLY HIGHER LEVELS OF NO_x AND ADDED TEST VOC, STATIC CONDITIONS, ETC.

ATMOSPHERIC REACTIVITY MUST BE CALCULATED USING **COMPUTER AIRSHED MODELS**, GIVEN:

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

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

- CHAMBER EXPERIMENTS ARE USED TO TEST THE RELIABILITY OF CHEMICAL MECHANISMS TO PREDICT ATMOSPHERIC REACTIVITY.

REACTIVITY CALCULATIONS ALSO REQUIRE APPROPRIATE MODELS FOR AIRSHED CONDITIONS

MODELS FOR AIRSHED CONDITIONS

BOX OR TRAJECTORY ("EKMA") MODELS

REPRESENTS AIR PARCELS AS WELL-MIXED BOXES WHERE EMISSIONS AND REACTIONS OCCUR

CAN REPRESENT VARIATION OF CONDITIONS WITH TIME AND POLLUTION FORMATION AT ONE LOCATION

ADVANTAGES

- PERMITS USE OF DETAILED MECHANISMS TO CALCULATE IMPACTS OF >500 TYPES OF VOCs
- USE OF MANY SCENARIOS CAN REPRESENT WIDE RANGE OF CONDITIONS THAT AFFECT REACTIVITY
- **USED TO DERIVE THE "MIR" REACTIVITY SCALE USED IN CALIFORNIA REGULATIONS**

DISADVANTAGES

- HIGHLY SIMPLIFIED REPRESENTATION OF ACTUAL AIRSHEDS.
- DOES NOT REPRESENT TRANSPORT OR HOW VOC IMPACTS VARY WITH LOCATION
- UNCERTAIN HOW COMPLEXITIES OF TRANSPORT AFFECT REACTIVITY
- BOX MODELS NOT CONSIDERED TO BE APPROPRIATE FOR SIP MODELING

MODELS FOR AIRSHED CONDITIONS

3-D URBAN OR REGIONAL MODELS

REPRESENTS AIRSHEDS AS 3-DIMENSIONAL GRIDS WITH THOUSANDS OF WELL-MIXED BOXES (CELLS) WITH EXCHANGE BETWEEN ADJACENT CELLS

REPRESENTS TRANSPORT AND SPATIAL VARIATIONS OF POLLUTANTS AS WELL AS EVOLUTION OVER TIME

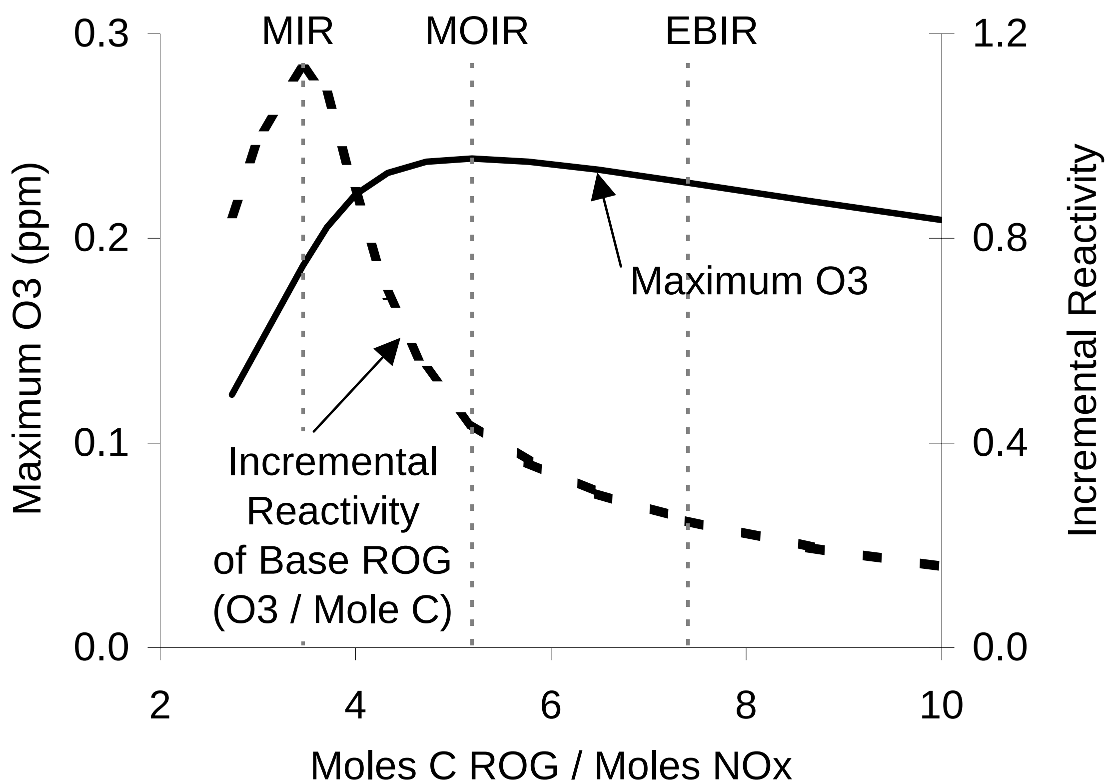
ADVANTAGES

- MOST REALISTIC PHYSICAL REPRESENTATION OF ACTUAL EPISODES
- CAN BE USED TO PREDICT HOW POLLUTION VARIES OVER LARGE REGIONS
- CAN REPRESENT HOW COMPLEXITIES OF TRANSPORT AFFECT CHEMICAL PROCESSES

DISADVANTAGES

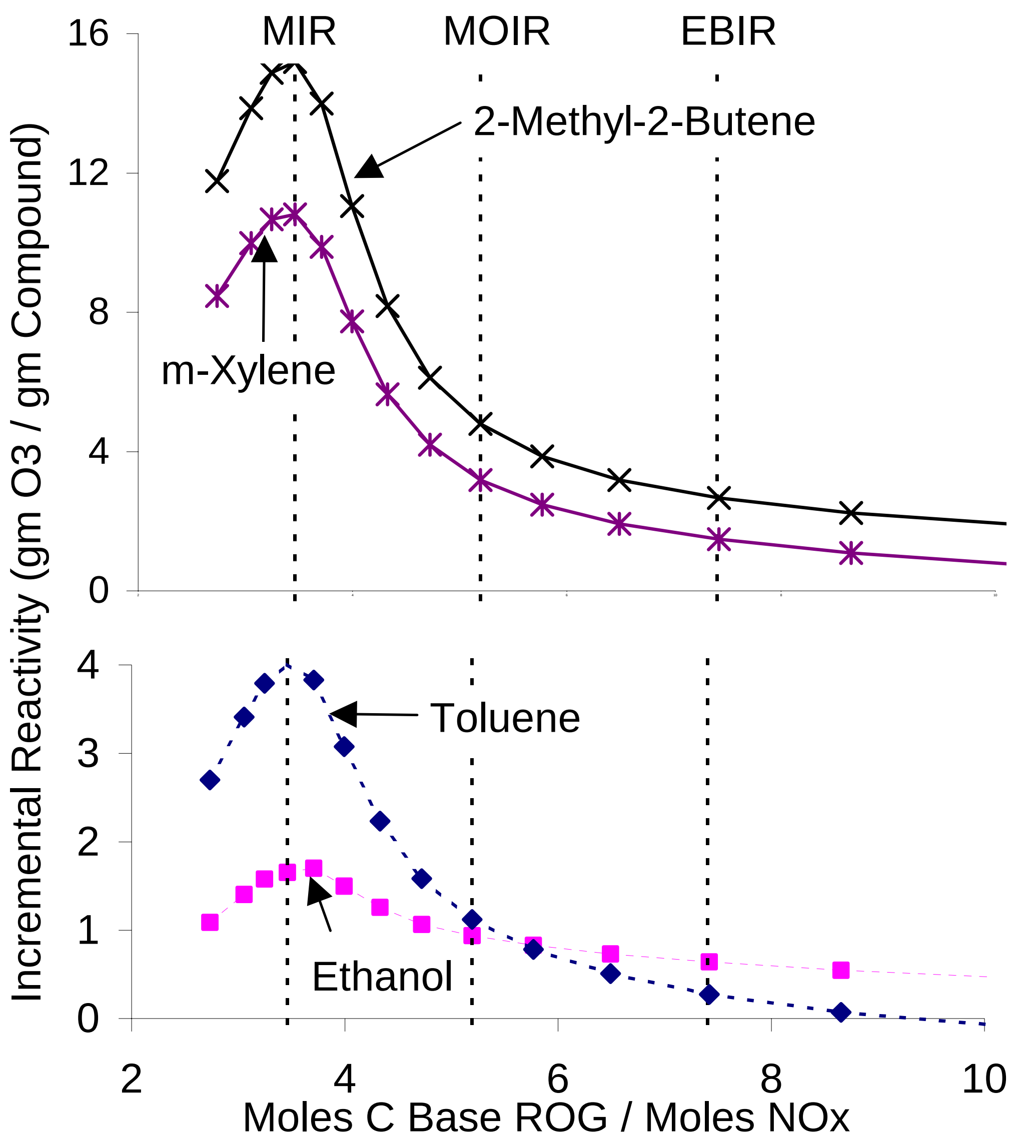
- EXPENSIVE TO RUN AND VERY EXPENSIVE TO PREPARE INPUTS FOR NEW SCENARIOS
- MUST USE CONDENSED MECHANISMS THAT LUMP MANY VOCs INTO A FEW GROUPS
- NOT OBVIOUS HOW BEST TO QUANTIFY O_3 IMPACTS FOR REACTIVITY ASSESSMENT.
- **NO COMPREHENSIVE VOC REACTIVITY SCALE HAS YET BEEN DEVELOPED USING SUCH MODELS**

- EXAMPLES OF BOX MODEL CALCULATIONS: DEPENDENCE OF INCREMENTAL REACTIVITIES ON ROG/NO_x



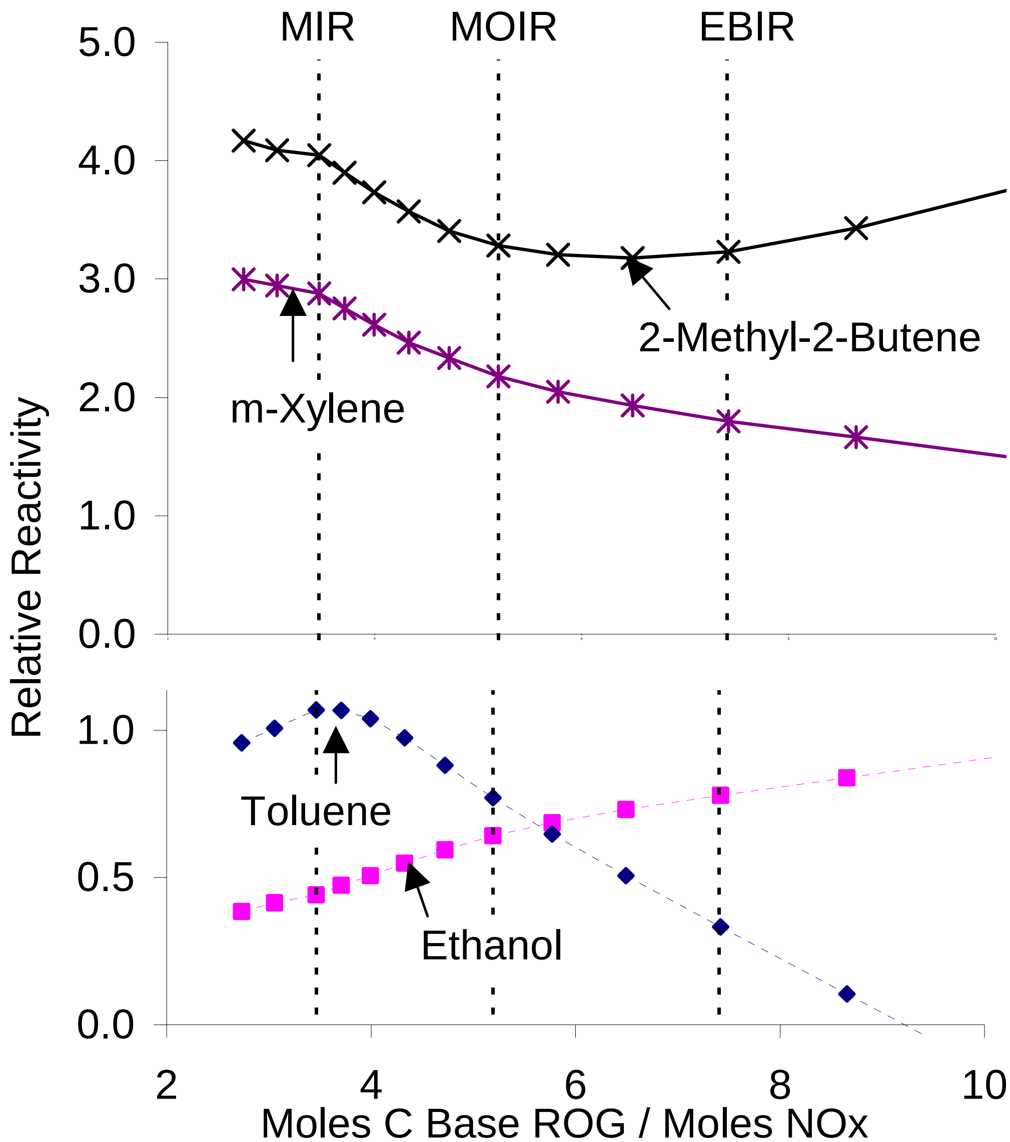
BASE ROG:	VOC MIXTURE USED TO REPRESENT VOCs FROM ALL SOURCES IN THE EPISODE
MIR:	ROG/NO_x WITH MAXIMUM INCREMENTAL REACTIVITY OF AMBIENT VOC MIXTURE
MOIR:	ROG/NO_x WITH MAXIMUM PEAK O_3 CONCENTRATION
EBIR:	ROG/NO_x WHERE VOC AND NO_x CONTROLS ARE EQUALLY EFFECTIVE IN REDUCING O_3

EXAMPLES OF BOX MODEL CALCULATIONS FOR INDIVIDUAL COMPOUNDS: DEPENDENCES OF INCREMENTAL REACTIVITIES ON ROG/NO_x



DEPENDENCES OF RELATIVE INCREMENTAL REACTIVITIES ON ROG/NO_x

INCREMENTAL REACTIVITIES RELATIVE TO THE BASE ROG MIXTURE (MASS BASIS)

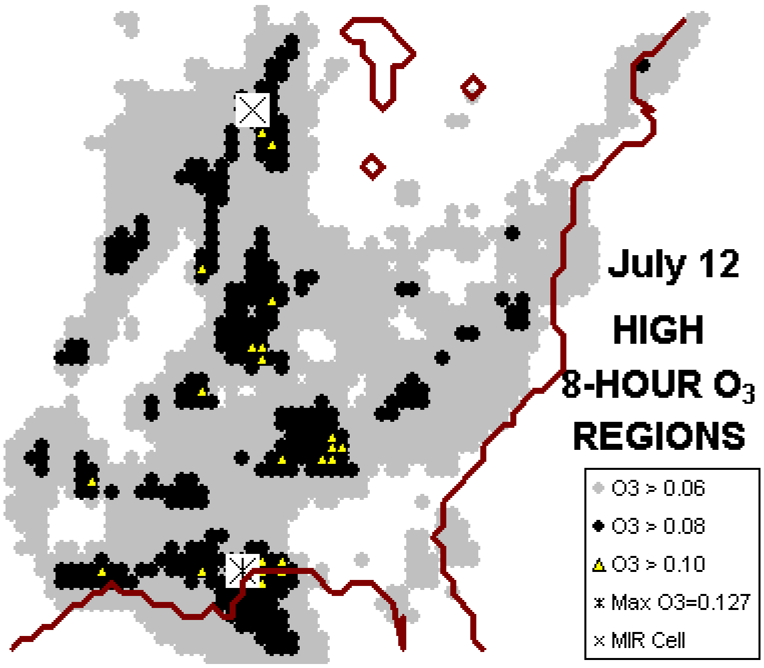


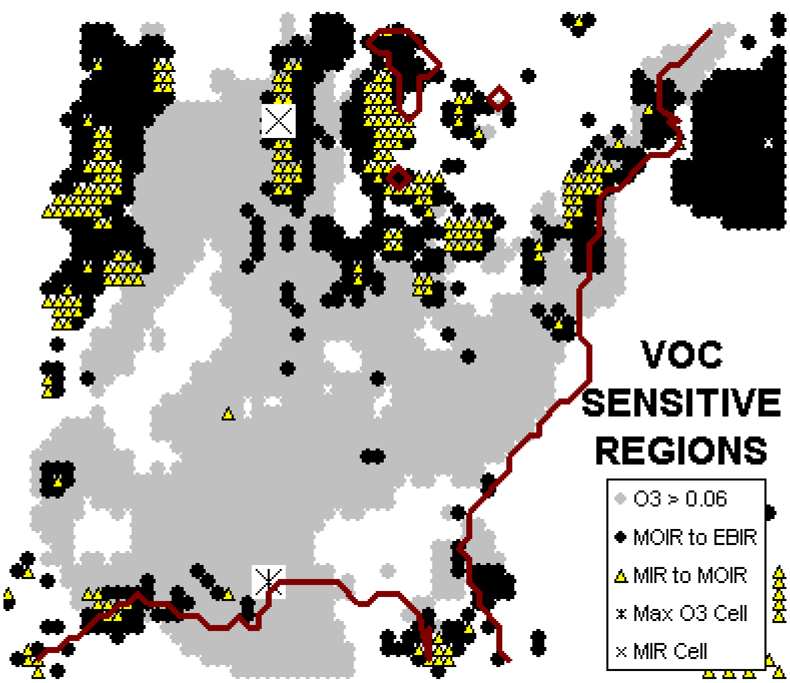
EXAMPLES OF RELATIVE REACTIVITIES OF COATINGS-RELATED AND OTHER SELECTED VOCs AT DIFFERENT NO_x LEVELS

OZONE IMPACTS PER GRAM OF EXAMPLE VOC
/ IMPACT PER GRAM OF AMBIENT VOC MIXTURE.

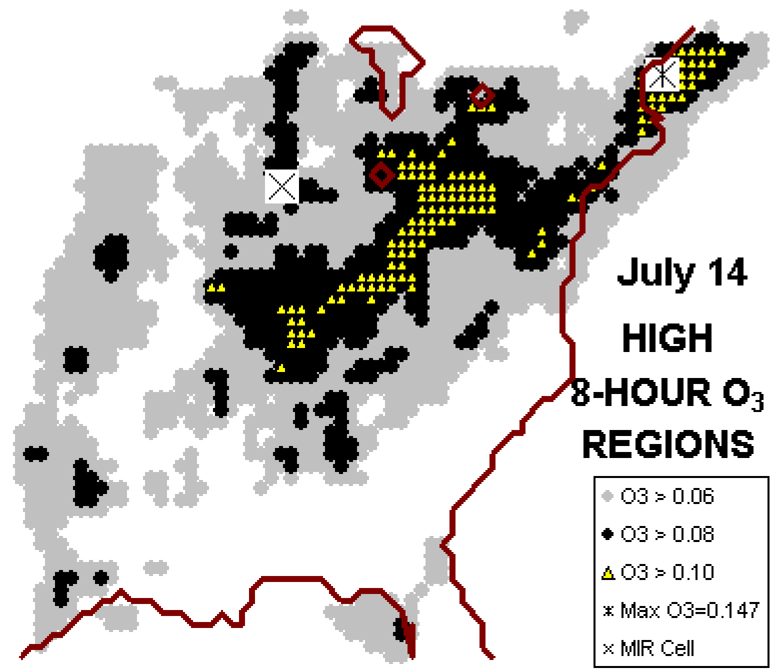
COMPOUND OR MIXTURE	MAX. VOC IMPACT (MIR) (HIGH NO_x)	NO_x GIVING MAXIMUM OZONE	NO_x & VOC IMPACTS EQUAL (LOW NO_x)
ETHANE (EPA'S "BORDERLINE EXEMPT" STANDARD)	0.08	0.14	0.17
ALL-ALKANE MINERAL SPIRITS	0.21	0.33	0.30
TEXANOL®	0.24	0.32	0.33
VMP-NAPHTHA	0.37	0.55	0.54
AROMATICS-100	2.0	1.6	1.3
AMBIENT VOC MIXTURE	1	1	1

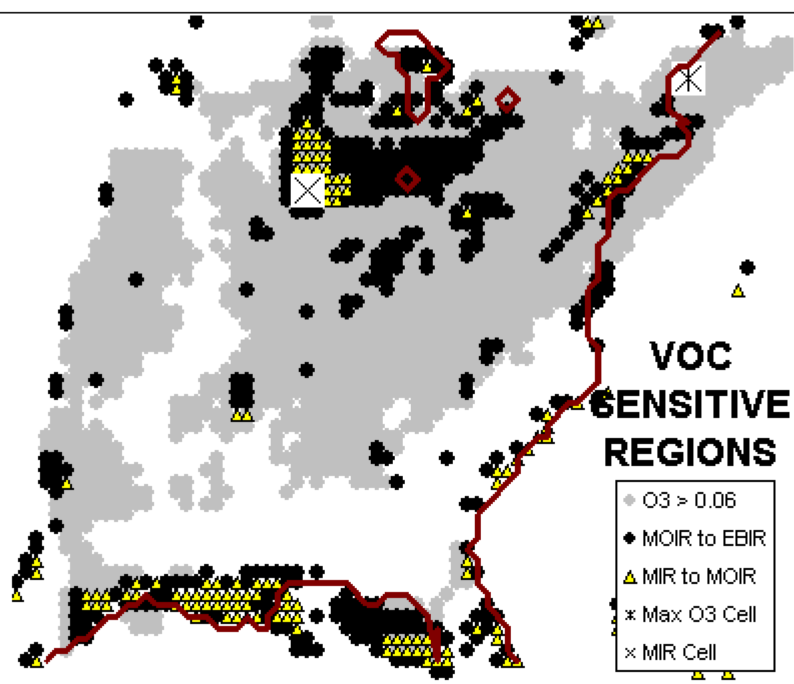
EXAMPLES OF 3-D MODEL CALCULATIONS: HIGH O_3 AND VOC SENSITIVE REGIONS



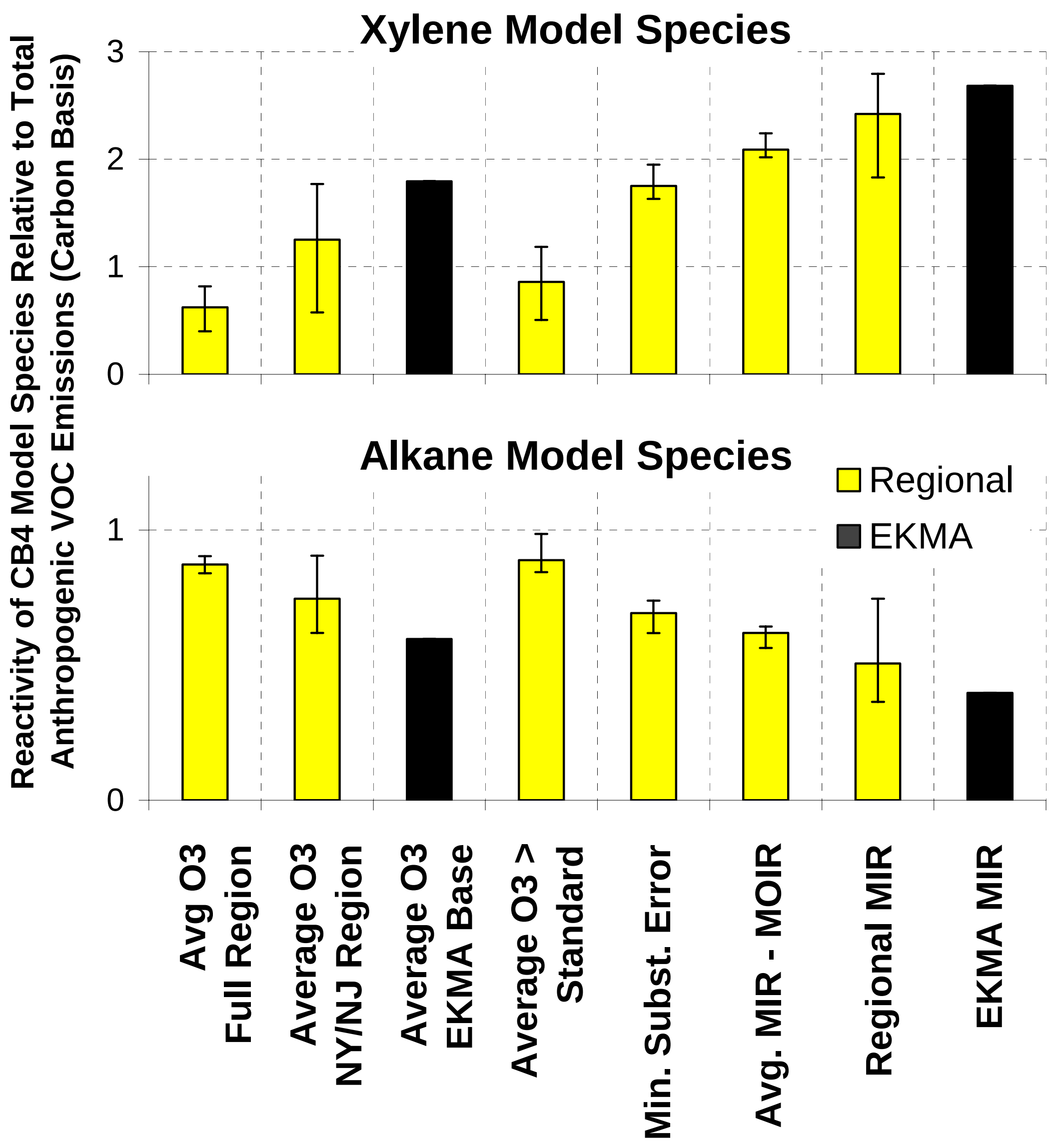


EXAMPLES OF 3-D MODEL CALCULATIONS: HIGH O_3 AND VOC SENSITIVE REGIONS





COMPARISON OF REGIONAL AND BOX MODEL RELATIVE REACTIVITIES FOR AROMATIC AND ALKANE MODEL SPECIES



CAMx MODEL WITH CB4 MECHANISM USED. ERROR BARS SHOW RANGE FOR DIFFERENT EPISODE DAYS.

VOC REACTIVITY AND OZONE CONTROL STRATEGIES

VOC CONTROLS AND CONTENT STANDARDS THAT CONSIDER REACTIVITY CAN BE MORE EFFECTIVE THAN THOSE THAT TREAT ALL VOC'S EQUALLY.

EXAMPLES INCLUDE:

- ENCOURAGING USE OF ALTERNATIVE FUELS
- ENCOURAGING USE OF LESS REACTIVE SOLVENTS

HOWEVER REACTIVITY-BASED CONTROLS AND STANDARDS REQUIRE USE OF A SINGLE SCALE TO QUANTIFY OZONE IMPACTS

BUT REACTIVITIES DEPEND ON CONDITIONS AND HOW O_3 IMPACTS ARE QUANTIFIED. THIS COMPLICATES DEVELOPMENT OF A GENERAL 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.

USE MULTIPLE SCALES REPRESENTING THE RANGE OF APPLICABLE CONDITIONS.

- ALLOWS ASSESSMENTS OF VARIABILITY.
- BUT NOT USEFUL WHEN SINGLE SCALE NEEDED

BASE THE SCALE ON CONDITIONS WHERE HIGHEST O_3 FORMED (**MOIR SCALE**).

- DOES NOT REFLECT CONDITIONS WHERE O_3 IS MOST SENSITIVE TO VOCs
- NOT WELL CORRELATED TO O_3 EXPOSURE IMPACTS

BASE SCALE ON CONDITIONS WHERE O_3 FORMATION IS MOST SENSITIVE TO VOCs (**MIR SCALE**).

- REFLECTS URBAN CONDITIONS WITH HIGHEST POPULATION EXPOSURE.
- **USED IN REACTIVITY-BASED REGULATIONS IN CALIFORNIA**
- BUT DOES NOT REPRESENT CONDITIONS WHERE HIGHEST OZONE LEVELS ARE FORMED.

EXAMPLES OF REGULATORY POLICIES REGARDING VOC REACTIVITY

CALIFORNIA AIR RESOURCES BOARD

THE **MIR SCALE** IS USED IN SEVERAL REGULATORY APPLICATIONS

- “REACTIVITY ADJUSTMENT FACTORS” ARE USED FOR EXHAUST STANDARDS FOR ALTERNATIVELY FUELED VEHICLES.
- REACTIVITY-BASED STANDARDS ARE USED IN THE NEW AEROSOL COATINGS REGULATIONS.
- REACTIVITY-BASED STANDARDS ARE BEING CONSIDERED FOR ARCHITECTURAL COATINGS.

UNITED STATES EPA

PRESENT POLICY: A VOC IS EITHER **REACTIVE** OR **EXEMPT**. ETHANE IS USED TO DEFINE BORDERLINE.

- EXEMPTION CANDIDATES ARE EXAMINED ON A CASE-BY-CASE BASIS
- INCREMENTAL REACTIVITIES ARE AMONG THE FACTORS CONSIDERED.

POLICIES REGARDING REACTIVITY ARE BEING RE-EXAMINED. MORE RESEARCH IS NEEDED.

THE EPA IS WORKING WITH **THE REACTIVITY RESEARCH WORKING GROUP** TO IDENTIFY AND SUPPORT POLICY-RELEVANT RESEARCH.

UNCERTAINTIES IN REACTIVITY SCALES

UNCERTAINTY IN THE GENERAL APPLICABILITY OF ANY SINGLE SCALE

- NO SCALE CAN REPRESENT ALL ENVIRONMENTS.
- NOT ALL EXPERTS AGREE ON THE MOST APPROPRIATE SCALE FOR REGULATIONS.
- CALIFORNIA HAS ADOPTED THE MIR SCALE. THE EPA WANTS MORE RESEARCH BEFORE ADOPTING A SCALE FOR REGULATIONS.

CHEMICAL MECHANISM UNCERTAINTY

- GENERAL MECHANISM UNCERTAINTIES CAUSE UNCERTAINTY FOR EVEN WELL-STUDIED VOCs.
- UNCERTAINTIES ARE MUCH GREATER FOR VOCs WITH NO DATA TO VERIFY THEIR MECHANISMS.

COMPOSITION UNCERTAINTY

- APPLICABLE TO COMPLEX MIXTURES SUCH AS EXHAUSTS AND PETROLEUM DISTILLATES

MECHANISM UNCERTAINTY CLASSIFICATION AND MINIMUM UNCERTAINTY ESTIMATES FOR RELATIVE MIR SCALE

NO.	DESCRIPTION	MIN. UNC'Y
1	MECHANISM NOT EXPECTED TO CHANGE SIGNIFICANTLY	15%
2	SOME UNCERTAINTIES BUT MECHANISM ADEQUATELY TESTED	15%
3	ESTIMATED MECHANISM BASED ON DATA FOR SIMILAR COMPOUNDS	30%
4	ESTIMATED MECHANISM BASED ON UNCERTAIN ASSUMPTIONS	75%
5,6	MECHANISM OR ESTIMATE IS HIGHLY SIMPLIFIED OR MAY BE INCORRECT	100%

NOTE:

- MINIMUM UNCERTAINTIES SHOWN ARE **HIGHLY APPROXIMATE AND SUBJECTIVE**
- UNCERTAINTIES SHOWN ARE FOR **RATIOS** OF MIRs
- UNCERTAINTIES IN **ABSOLUTE** OZONE IMPACTS ARE MUCH HIGHER

EXAMPLE SOLVENT VOCs WITH VARIOUS MECHANISM UNCERTAINTY ASSIGNMENTS

NO.	EXAMPLES	MIN. UNC'Y
1	METHANOL, ACETALDEHYDE[A], 1-METHOXY-2-PROPANOL[B]	15%
2	ETHYLENE GLYCOL, ETHYLBENZENE, 1-METHOXY-2-PROPYL ACETATE[C]	15%
3	C_{8+} ALKANES[D], MOST GLYCOLS, GLYCOL ETHERS, ESTERS, ETC.[E]	30%
4	C_{13} NAPHTHALENES, FURAN, C_{3+} ACETYLENES[D]	75%
5,6	AMINES, OXIMES, HALOGENATED COMPOUNDS, OXIMES, ETC.[E]	100%

NOTES:

[A] SIMPLE, WELL-ESTABLISHED MECHANISMS

[B] RELEVANT REACTION ROUTES WELL-ESTABLISHED BY LABORATORY STUDIES

[C] ENVIRONMENTAL CHAMBER DATA USED TO VERIFY OR DERIVE MECHANISMS

[D] MIRs SENSITIVE TO GENERAL MECHANISM UNCERTAINTIES

[E] MECHANISM UNKNOWN OR VERY UNCERTAIN

EXAMPLES OF COMPOSITIONAL UNCERTAINTY FOR COMPLEX MIXTURES

COMPONENT	MIR UNC'Y
ALL-ALKENE PETROEUM DISTILLATES	
• MINIMAL INFORMATION GIVEN	~33%
• CARBON NUMBER DISTRIBUTIONS KNOWN	~17%
• FRACTIONS OF NORMAL AND TOTAL BRANCHED AND CYCLIC ALSO KNOWN	0%
MIXTURES OF AROMATICS	
• MINIMAL INFORMATION GIVEN	~60%
• CARBON NUMBER DISTRIBUTIONS KNOWN	~55%
• FRACTIONS OF MONO-, DI-, AND POLY-SUBSTITUTED BENZENES AND NAPHTHALENES ALSO KNOWN	0%
OTHERS	
• UNSPECIFIED GLYCOL ETHERS	~30%
• PETROLEUM DISTILLATE WITH AROMATIC FRACTION NOT SPECIFIED	~100%

EXAMPLE WORKSHEET TO ESTIMATE OZONE IMPACTS OF A FORMULATION

COMPONENT	GM /LITER	MIR (GM O_3 / GM)	MIR UNC'Y COMP	MECH	O_3 FORM. (GM O_3 / LITER)
ALKANE MIX	100	0.85	15%	30%	85 ± 29
AROMATIC MIX	10	6.4	50%	30%	64 ± 37
TEXANOL®	20	0.89	0	30%	18 ± 5
AMINE	5	~7	0	100%	35 ± 35
UNIDENTIFIED VOCs	2	~4	200%		8 ± 16
WHOLE FORMULATION					210 ± 61

REACTIVITY RESEARCH NEEDS FOR VOCs FOR ARCHITECTURAL COATINGS

REACTIVITY DATA ARE ALREADY AVAILABLE FOR MANY TYPES OF VOCs USED IN COATINGS

- DATA AVAILABLE FOR REPRESENTATIVE ALKANES, AROMATICS, ALCOHOLS, GLYCOLS, ESTERS, ESTERS AND A FEW OTHERS.
- BUT NOT ALL ASPECTS OF MECHANISMS ARE ADEQUATELY EVALUATED.

REACTIVITY ESTIMATES ARE UNCERTAIN FOR SOME IMPORTANT TYPES OF COATINGS VOCs

- NO DATA FOR LOW VOLATILITY COMPOUNDS SUCH AS TEXANOL®
- PETROLEUM DISTILLATES HAVE LARGE COMPOSITIONAL UNCERTAINTY AND COMPONENTS INCLUDE UNSTUDIED VOCs
- AMINES AND ALCOHOL AMINES HAVE VERY LARGE MECHANISM UNCERTAINTY

NEED TO DEVELOP LOWER COST REACTIVITY SCREENING AND ENFORCEMENT METHODS

UNCERTAIN HOW MUCH DEPOSITION ON SURFACES AND OTHER NON-ATMOSPHERIC LOSS PROCESSES ARE AFFECTING ATMOSPHERIC AVAILABILITY

PRELIMINARY RESULTS OF SURVEY OF COATINGS EMISSIONS REACTIVITY

VOCs IN DRAFT COATINGS INVENTORY FOR WHICH REACTIVITY DATA ARE UNAVAILABLE

MIR x EMIT	TYPE OF VOC	MECH UNC'Y
	WATER BASED COATINGS	
~10%	Texanol®	3
~5%	Butyl Carbitol	3
~3%	Various Petroleum Distillates	-
~1%	Methyl Carbitol®	3
~0.5%	Diethylene Glycol	3
~0.5%	Di (propylene glycol) Methyl Ether	3
~0.5%	2-Amino-2-Methyl-1-Propanol	6
~25%	UNCERTAIN VOC TOTAL	
	SOLVENT BASED COATINGS	
~50%	Various Petroleum Distillates	-
~1%	n-Butyl Alcohol	3
~0.5%	Ethyl 3-Ethoxypropionate	3
~50%	UNCERTAIN VOC TOTAL	

DATA FROM CALIFORNIA ARB
1998 ARCHITECTURAL COATINGS SURVEY

COMPONENTS OF CE-CERT COATINGS PROJECT FOR THE CALIFORNIA ARB

CONDUCT EMISSIONS, REACTIVITY AND UNCERTAINTY SURVEY OF COATINGS VOCs TO PRIORITIZE RESEARCH

DEVELOP AND EVALUATE IMPROVED PROCEDURES TO QUANTIFY REACTIVITIES AND COMPOSITIONAL UNCERTAINTIES FOR PETROLEUM DISTILLATES

CONDUCT ENVIRONMENTAL CHAMBER STUDIES OF SELECTED COATINGS VOCs

- VOCs CHOSEN BY CARB'S REACTIVITY RESEARCH ADVISORY COMMITTEE BASED ON USAGE AND UNCERTAINTY
- TEXANOL® (MAJOR WATER-BASED COMPONENT)
- 6 TYPES OF PETROLEUM DISTILLATES

    VMP Naphtha
    ASTM Type IA "Regular Mineral Spirits"
    ASTM Type IB "Mineral Spirits 75 (<8% Aromatic)"
    ASTM Type IC "Low Aromatic Mineral Spirits"
    ASTM Type IIIC1 "Odorless Mineral Spirits"
    Aromatic 100

- MOST EXPERIMENTS CONSIST OF INCREMENTAL REACTIVITY MEASUREMENTS UNDER VARIOUS CONDITIONS

CHAMBER EXPERIMENTS WITH PETROLEUM DISTILLATES ARE NOW UNDERWAY

ADVANTAGES OF THE UCR-EPA ENVIRONMENTAL CHAMBER

INDOOR CHAMBER DESIGN FOR BEST CONTROL OF TEMPERATURE AND LIGHTING CONDITIONS

CURRENTLY THE LARGEST INDOOR CHAMBER AVAILABLE FOR MODEL EVALUATION

- MINIMIZES WALL EFFECTS
- MINIMIZES PM WALL LOSSES
- PROVIDES SAMPLE VOLUME NECESSARY FOR SPECIALIZED MEASUREMENTS.

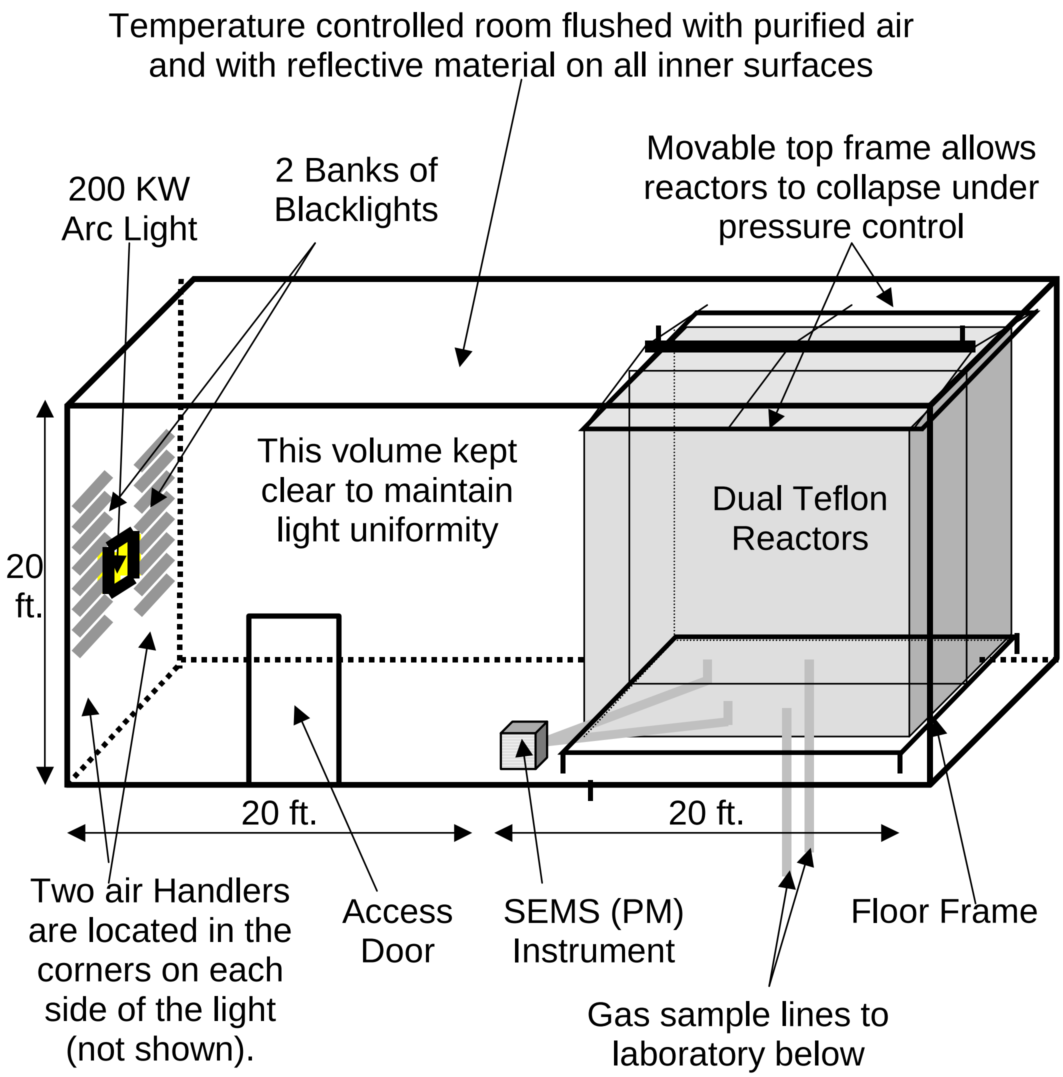
A 200 KW FILTERED ARGON ARC SIMULATES THE INTENSITY AND SPECTRUM OF SUNLIGHT BETTER THAN COMMONLY USED BLACKLIGHTS.

REPLACEABLE TEFLON® FILM REACTORS INSIDE A "CLEAN ROOM" PERMIT EXPERIMENTS AT LOWER CONCENTRATIONS THAN PREVIOUSLY POSSIBLE.

TEMPERATURE CONTROL TO $\pm 1^{o}C$ IN THE RANGE 5-45^{o}C ALLOWS SYSTEMATIC STUDIES OF TEMPERATURE AND HUMIDITY EFFECTS

A VARIETY OF ADVANCED GAS-PHASE AND PM INSTRUMENTATION AVAILABLE

DIAGRAM OF UCR-EPA ENVIRONMENTAL CHAMBER



- CONSTRUCTION COMPLETED EARLY 2002 AND EVALUATION COMPLETED LATE 2002
- MECHANISM EVALUATION AND VOC REACTIVITY ASSESSMENT EXPERIMENTS NOW UNDERWAY

CURRENT STATUS OF CARB COATINGS REACTIVITY STUDY

AN EVALUATION OF EMISSIONS, REACTIVITY, AND UNCERTAINTY WAS USED AS A BASIS FOR CHOICE OF COMPOUNDS TO STUDY IN THE CHAMBER

CARB'S "BINNING" METHOD FOR ESTIMATING REACTIVITIES OF PETROLEUM DISTILLATES WAS EVALUATED USING NEW COMPOSITIONAL DATA

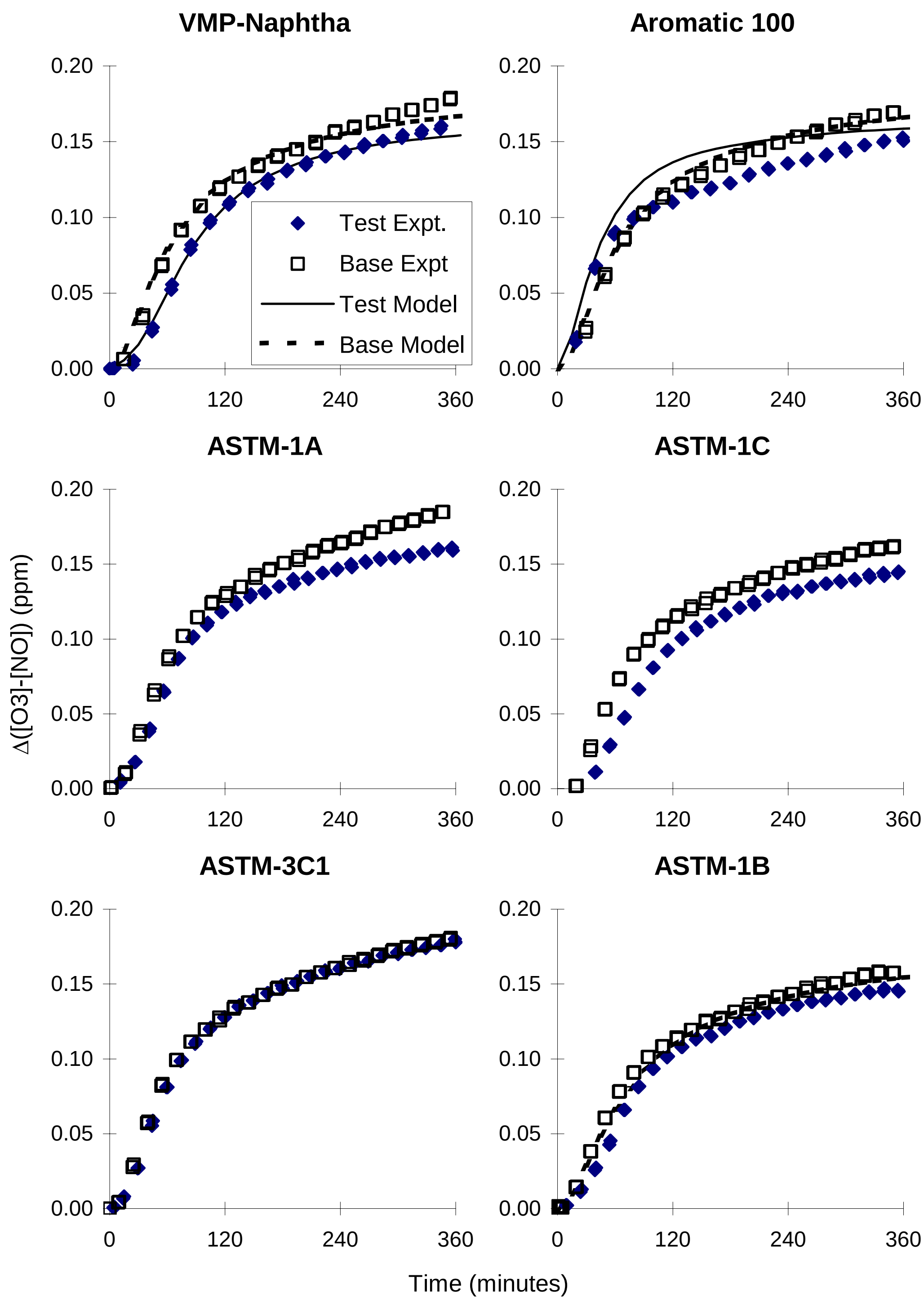
VARIOUS AMBIENT SURROGATE - NO_x EXPERIMENTS WERE CONDUCTED TO DETERMINE APPROPRIATE BASE CASES FOR REACTIVITY EXPERIMENTS

CHAMBER EXPERIMENTS WITH THE 6 PETROLEUM DISTILLATES WERE CONDUCTED AT 2 DIFFERENT ROG AND NO_x RATIOS. (ANALYSIS STILL UNDERWAY)

METHODS FOR INJECTING AND ANALYZING TEXANOL® FOR CHAMBER EXPERIMENTS ARE BEING EVALUATED.

NEW FUNDING OBTAINED FROM THE CALIFORNIA SCAQMD TO STUDY ADDITIONAL COATINGS VOCs AND TO OBTAIN PM DATA DURING EXPERIMENTS

EXAMPLE CHAMBER REACTIVITY RESULTS



ADDITIONAL INFORMATION AVAILABLE

REACTIVITY DATA AND DOCUMENTATION

http://www.cert.ucr.edu/~carter/reactdat.htm

- TABULATIONS OF REACTIVITY SCALES
- REPORT DOCUMENTING CHEMICAL MECHANISM AND METHODS USED TO CALCULATE SCALES

CE-CERT ARCHITECTURAL COATINGS PROJECT

http://www.cert.ucr.edu/~carter/coatings

- PROJECT SUMMARY AND PROPOSAL
- PROGRESS REPORTS AND PRESENTATIONS

UCR-EPA CHAMBER

http://www.cert.ucr.edu/~carter/epacham

- SUMMARY CURRENT STATUS
- PROGRESS REPORTS AND PRESENTATIONS
- DRAFT QUALITY ASSURANCE PLAN