DATA ANALYSIS COMPLEMENTING PROXIMATE MODELING OF WEEKDAY/WEEKEND OZONE DIFFERENCES IN SOUTHERN CALIFORNIA

SPONSORED BY:
COORDINATING RESEARCH COUNCIL
NATIONAL RENEWABLE ENERGY LABORATORY

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OVERVIEW

- OBJECTIVES
  - > DETERMINE IF WEEKEND/WEEKDAY OZONE DIFFERENCES ARE RELATED TO VOC OR NOx LIMITATION AS DETERMINED FROM ANALYSIS OF AMBIENT DATA
  - > COMPLEMENT CONCURRENT MODELING
- KEY ELEMENTS OF APPROACH
  - > AMBIENT CONCENTRATIONS OF PRECURSORS
  - > AMBIENT CONCENTRATIONS OF OZONE
    - - FOCUS ON HIGH OZONE DAYS
  - > EXTENT 0F REACTION
  - > COMPARE WITH MODELING

DATABASE

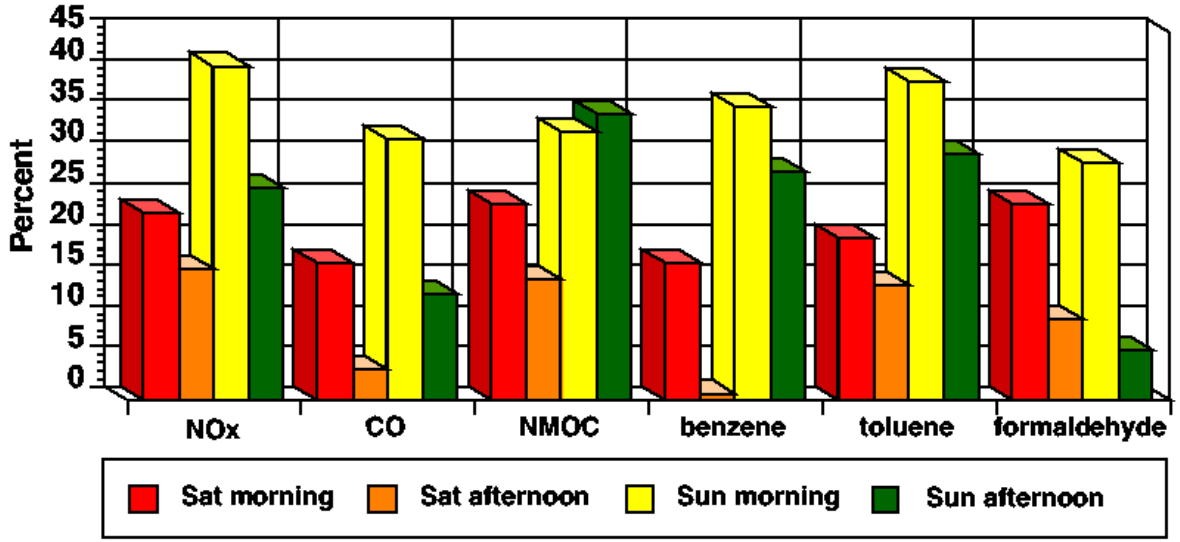
- FIVE AIR BASINS
  - > SOUTH COAST
  - > MOJAVE
  - > SALTON SEA
  - > SOUTH CENTRAL COAST
  - > SAN DIEGO
- FOUR TO EIGHT YEARS DATA
  - > 1991-97 OZONE
  - > 1994-97 OZONE AND VOC/NOx LIMITATION
  - > UPDATE TO 1998 OR 1999
- OZONE SEASON
  - > MARCH THROUGH OCTOBER
  - > AT LEAST 75 PERCENT OF ONE OZONE SEASON
  - > AT LEAST TWO YEARS DATA FOR SOME ANALYSES
- SPECIES
  - > 102 OZONE SITES
  - > 76 NOx
  - > 47 CO
  - > 3 NMOC, FORMALDEHYDE
  - > 8 BENZENE, TOLUENE

KEY FINDINGS

- BOTH NOx AND NMOC CONCENTRATIONS LOWER ON WEEKENDS THAN ON WEEKDAYS. EVIDENCE FOR LOWER NOx IS STRONGER THAN EVIDENCE FOR LOWER NMOC.
- PRECURSOR CONCENTRATIONS LOWER ON SUNDAYS THAN ON SATURDAYS.
- OZONE MAY BE LOWER OR HIGHER ON WEEKENDS THAN ON WEEKDAYS. NEARBY SITES HAVE SIMILAR PATTERNS.
- LIMITING OZONE PRECURSOR MAY BE VOC OR NOx. NEARBY SITES ARE SIMILAR.
- SPATIAL PATTERN OF DIFFERENCES BETWEEN WEEKEND AND WEEKDAY OZONE CORRELATES WITH LIMITING OZONE PRECURSOR.

Percentage Decreases in Mean Weekend Precursor Concentrations Compared With Mean Weekday Concentrations

(Averaged Over All Sites,1991-97)

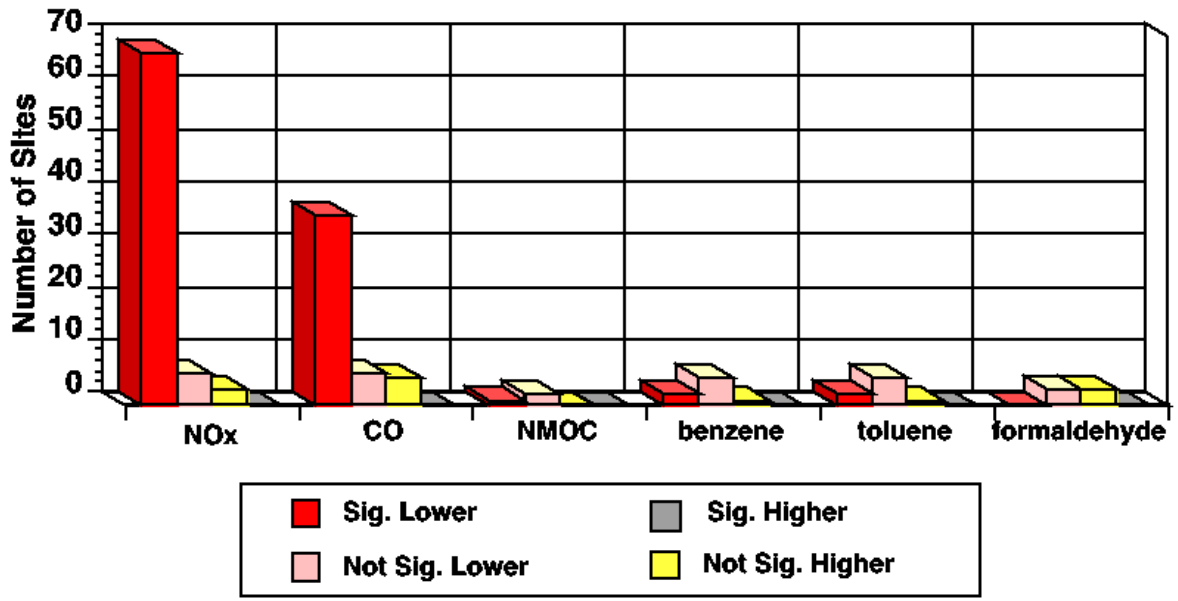


NOx	76 sites	Morning = 6-9 am	Afternoon = 12 - 3 pm
CO	47 sites	Morning = 6-9 am	Afternoon = 12 - 3 pm
NMOC	3 sites	Morning = 5-9 am	Afternoon = 12 - 5 pm
benzene	8 sites	Morning = 5-9 am	Afternoon = 12 - 5 pm
toluene	8 sites	Morning = 5-9 am	Afternoon = 12 - 5 pm
formaldehyde	3 sites	Morning = 5-9 am	Afternoon = 12 - 5 pm

The NMOC data are very limited (samples collected every third day, usually July-Oct; no data before 1994). Most NMOC differences are not statistically significant.

Statistical Significance of Comparisons of Saturday Morning Concentrations With Weekday Concentrations

(Tested by Site for All Sites, 1991-97)

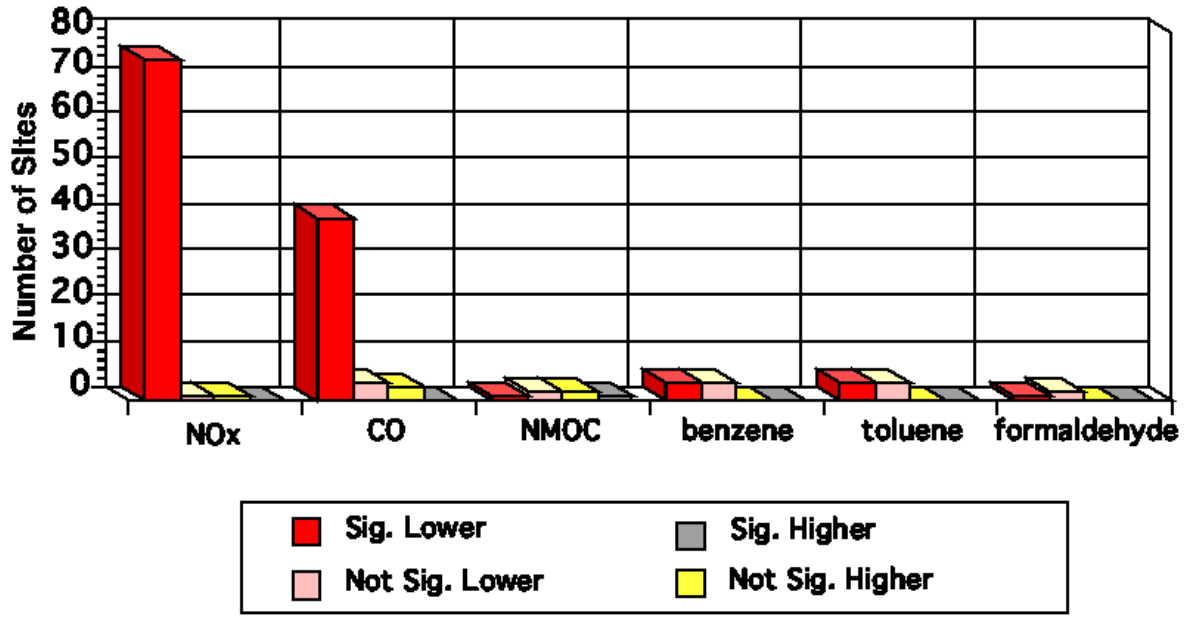


NOx and CO based on Wilcoxon Signed Rank Test
> paired nonparametric test appropriate for daily data with serial correlation

NMOC, benzene, toluene, and formaldehyde based on Two-Sample t-test
> unpaired test appropriate for every third day sampling schedule

Statistical Significance of Comparisons of Sunday Morning Concentrations With Weekday Concentrations

(Tested by Site for All Sites, 1991-97)



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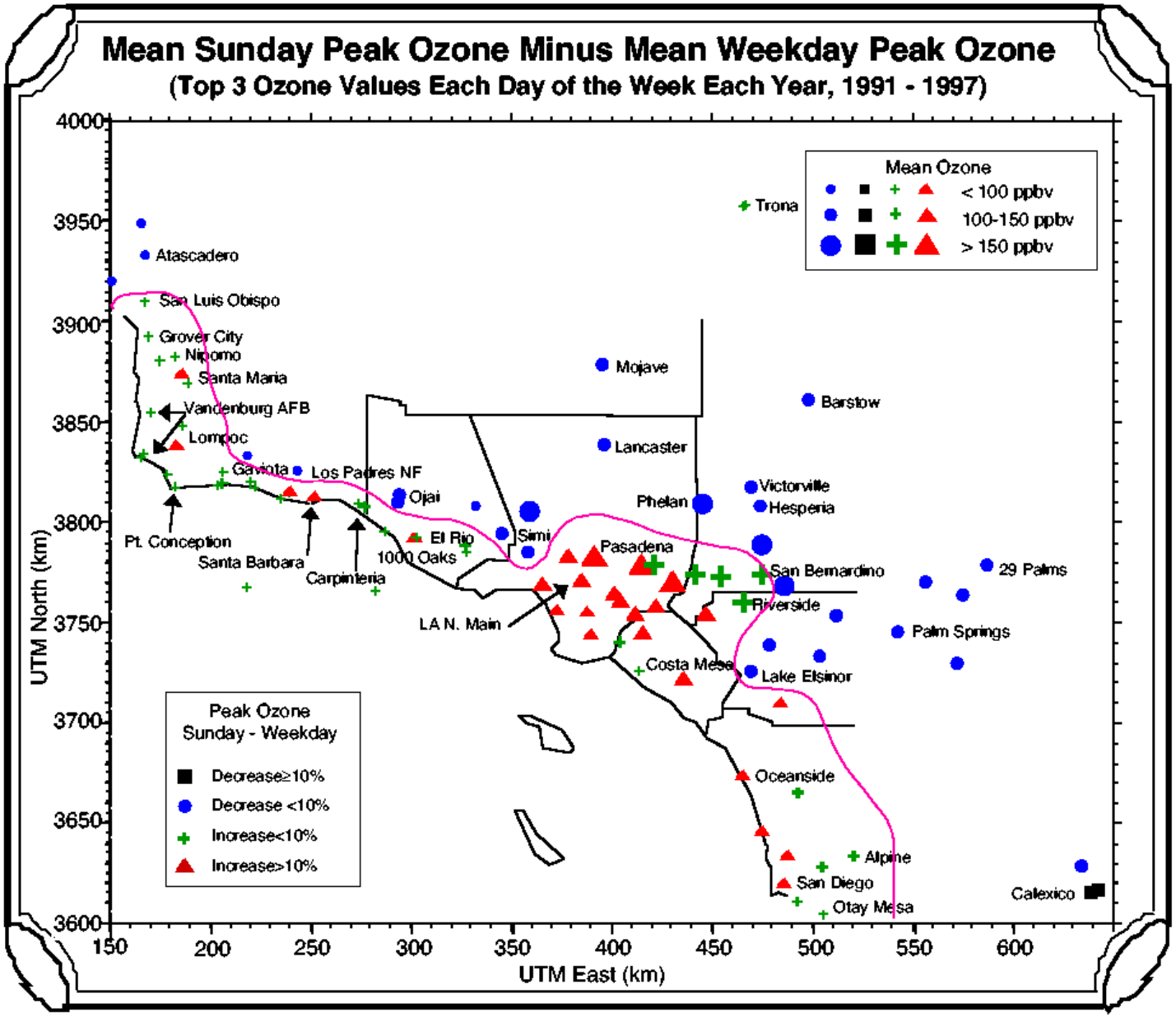
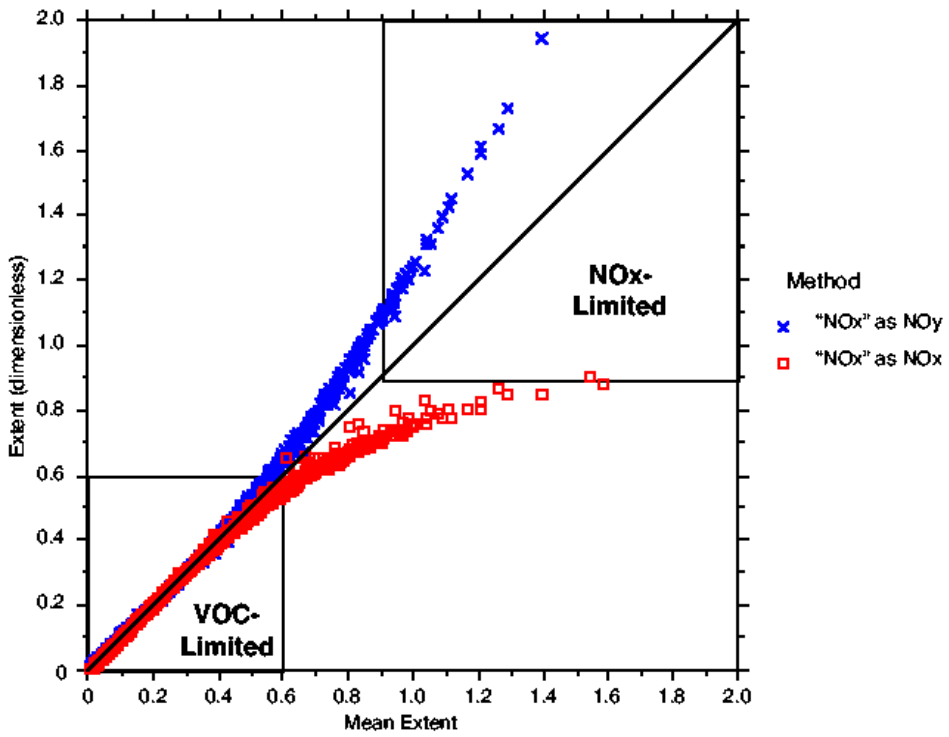
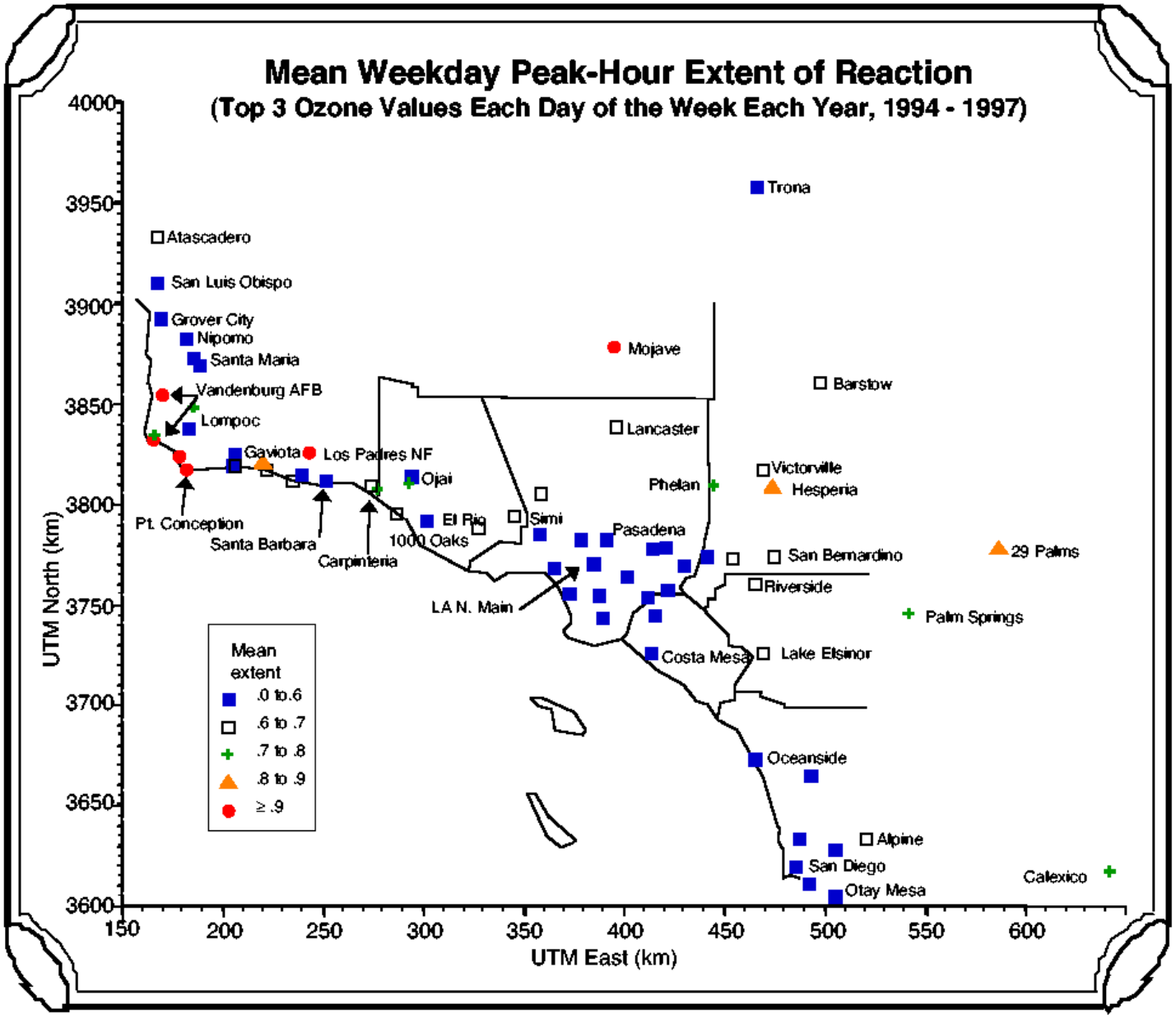

Mean Sunday Peak Ozone Minus Mean Weekday Peak Ozone
(Top 3 Ozone Values Each Day of the Week Each Year, 1991 - 1997)
Mean Ozone
< 100 ppbv
100-150 ppbv
> 150 ppbv
Peak Ozone
Sunday - Weekday
Decrease≥10%
Decrease <10%
Increase<10%
Increase>10%
Trona
Atascadero
San Luis Obispo
Grover City
Nipomo
Santa Maria
Vandenburg AFB
Lompoc
Gaviota
Los Padres NF
Pt. Conception
Santa Barbara
Carpinteria
Ojai
El Rio
1000 Oaks
Simi
LA N. Main
Mojave
Lancaster
Barstow
Phelan
Victorville
Hesperia
Pasadena
San Bernardino
Riverside
29 Palms
Palm Springs
Costa Mesa
Lake Elsinor
Oceanside
Alpine
San Diego
Otay Mesa
Calexico
UTM North (km)
UTM East (km)
4000
3950
3900
3850
3800
3750
3700
3650
3600
150
200
250
300
350
400
450
500
550
600

DELINEATING VOC vs NOx LIMITATION

- USE SMOG PRODUCTION (SP) ALGORITHM
  - > MEASUREMENTS OF O_3, NO, NO_x or NO_y
  - > EXTENT OF REACTION
    - ⇨ INDICATES WHICH PRECURSOR LIMITS INSTANTANEOUS RATE OF OZONE FORMATION AT SPECIFIC TIME AND PLACE
- CRITERIA
  - > VOC-LIMITED WHEN EXTENT < 0.6
  - > TRANSITIONAL WHEN $0.6 \leq$ EXTENT < 0.9
  - > NOx-LIMITED WHEN EXTENT ≥ 0.9

Bounding the Extent of Reaction Using Routine NOx Data




Mean Weekday Peak-Hour Extent of Reaction
(Top 3 Ozone Values Each Day of the Week Each Year, 1994 - 1997)
UTM North (km)
UTM East (km)
4000
3950
3900
3850
3800
3750
3700
3650
3600
150
200
250
300
350
400
450
500
550
600
Trona
Atascadero
San Luis Obispo
Grover City
Nipomo
Santa Maria
Vandenburg AFB
Lompoc
Mojave
Barstow
Lancaster
Gaviota
Los Padres NF
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Pt. Conception
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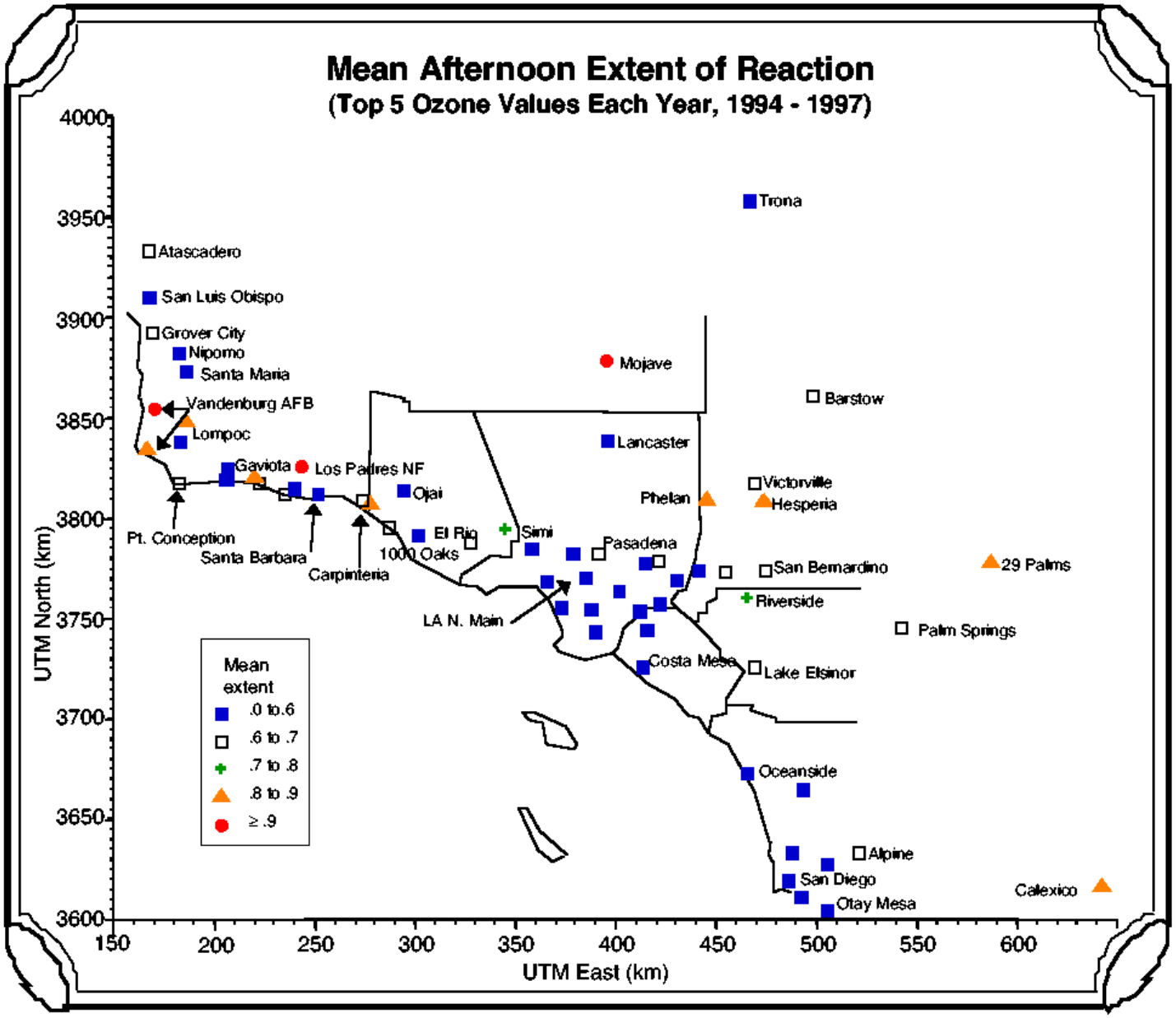
Simi
Pasadena
San Bernardino
29 Palms
Riverside
LA N. Main
Palm Springs
Costa Mesa
Lake Elsinor
Oceanside
Alpine
San Diego
Otay Mesa
Calexico
Mean extent
.0 to .6
.6 to .7
.7 to .8
.8 to .9
≥ .9


Mean Afternoon Extent of Reaction
(Top 5 Ozone Values Each Year, 1994 - 1997)
UTM North (km)
UTM East (km)
4000
3950
3900
3850
3800
3750
3700
3650
3600
150
200
250
300
350
400
450
500
550
600
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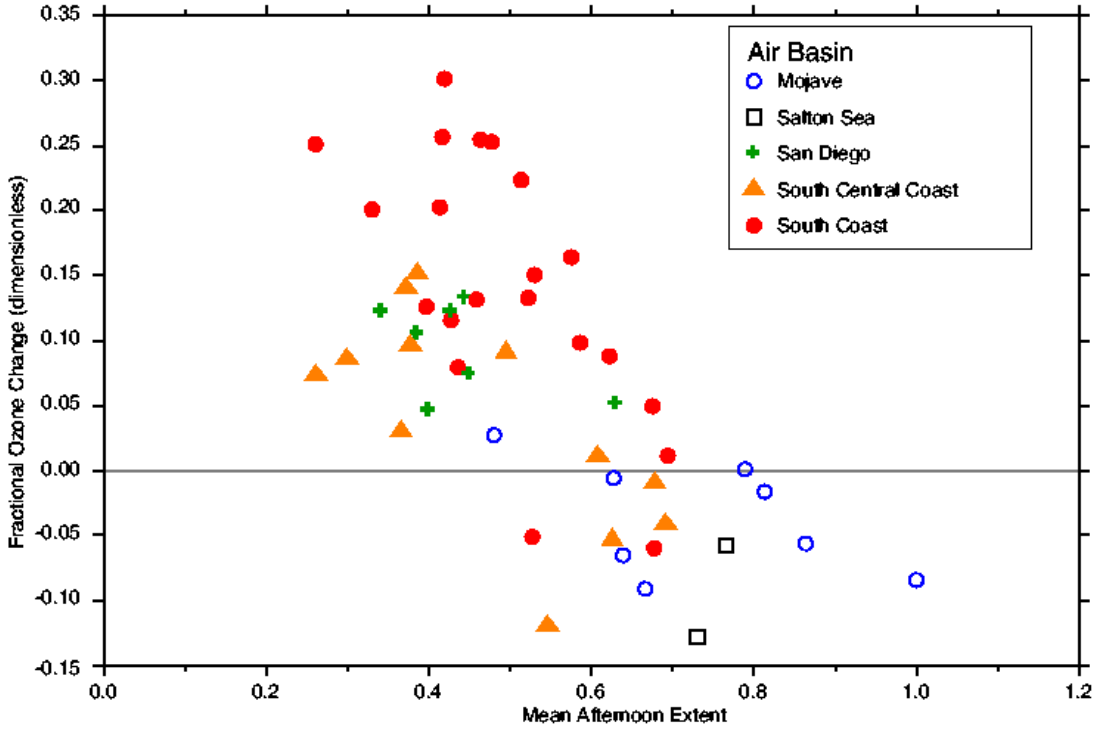
Mean extent
.0 to .6
.6 to .7
.7 to .8
.8 to .9
≥ .9

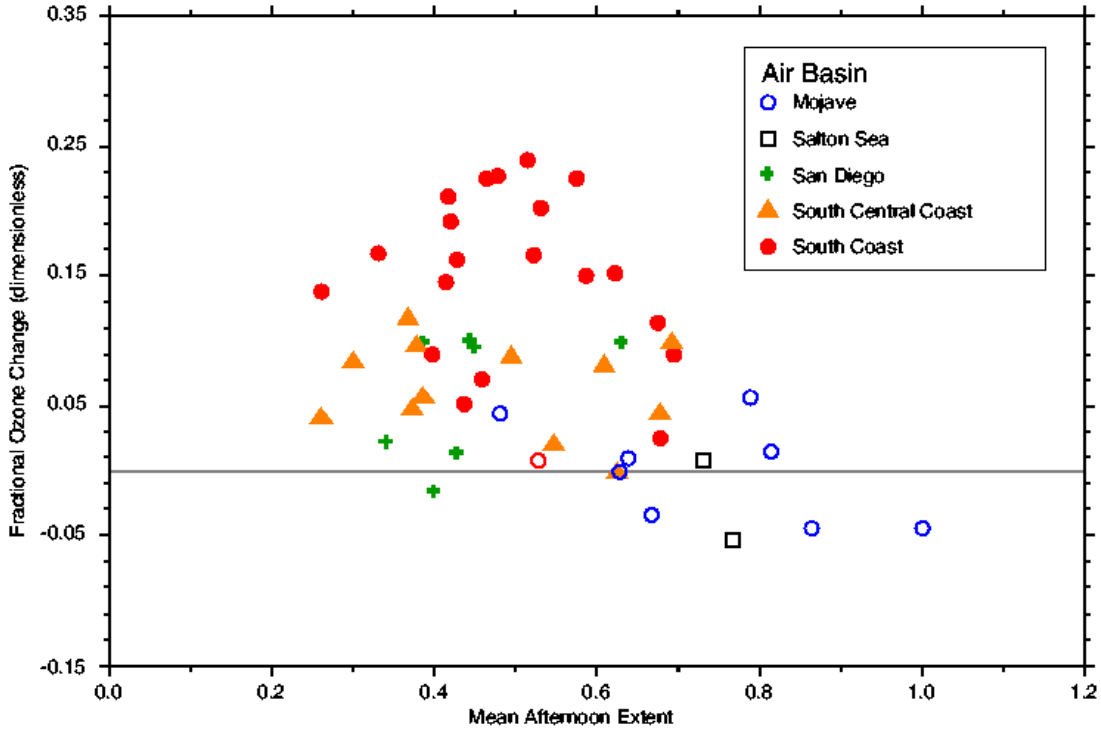
Mean Sunday Peak Ozone Minus Mean Weekday Peak Ozone versus Mean Extent of Reaction at the Time of the Peak Ozone

High-Ozone Days 1994 - 1997

(Top 3 Ozone Values for Each Day of the Week Each Year)



Mean Saturday Peak Ozone Minus Mean Weekday Peak Ozone
versus
Mean Extent of Reaction at the Time of the Peak Ozone
High-Ozone Days 1994 - 1997
(Top 3 Ozone Values for Each Day of the Week Each Year)



CONCLUSION

FINDINGS

- BOTH NOx AND NMOC CONCENTRATIONS LOWER ON WEEKENDS THAN ON WEEKDAYS. EVIDENCE FOR LOWER NOx IS STRONGER THAN EVIDENCE FOR LOWER NMOC.
- PRECURSOR CONCENTRATIONS LOWER ON SUNDAYS THAN ON SATURDAYS.
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- SPATIAL PATTERN OF DIFFERENCES BETWEEN WEEKEND AND WEEKDAY OZONE CORRELATES WITH LIMITING OZONE PRECURSOR.

WORK TO DO

- UPDATE THROUGH 1998
- STATISTICAL SIGNIFICANCE OF OZONE DIFFERENCES