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

SPONSORED BY:
COORDINATING RESEARCH COUNCIL
NATIONAL RENEWABLE ENERGY LABORATORY

PREPARED BY:
ENVAIR
CHARLES L. BLANCHARD
SHELLEY TANENBAUM
STEVE D. REYNOLDS

REVIEWED BY:
COORDINATING RESEARCH COUNCIL
NATIONAL RENEWABLE ENERGY LABORATORY

Envair

DATABASE

- FIVE AIR BASINS
  - > SOUTH COAST
  - > MOJAVE
  - > SALTON SEA
  - > SOUTH CENTRAL COAST
  - > SAN DIEGO

- THREE TO EIGHT YEARS DATA
  - > 1991-98 OZONE
  - > 1994-98 OZONE AND VOC/NOx LIMITATION
  - > 1996-98 POST-RFG

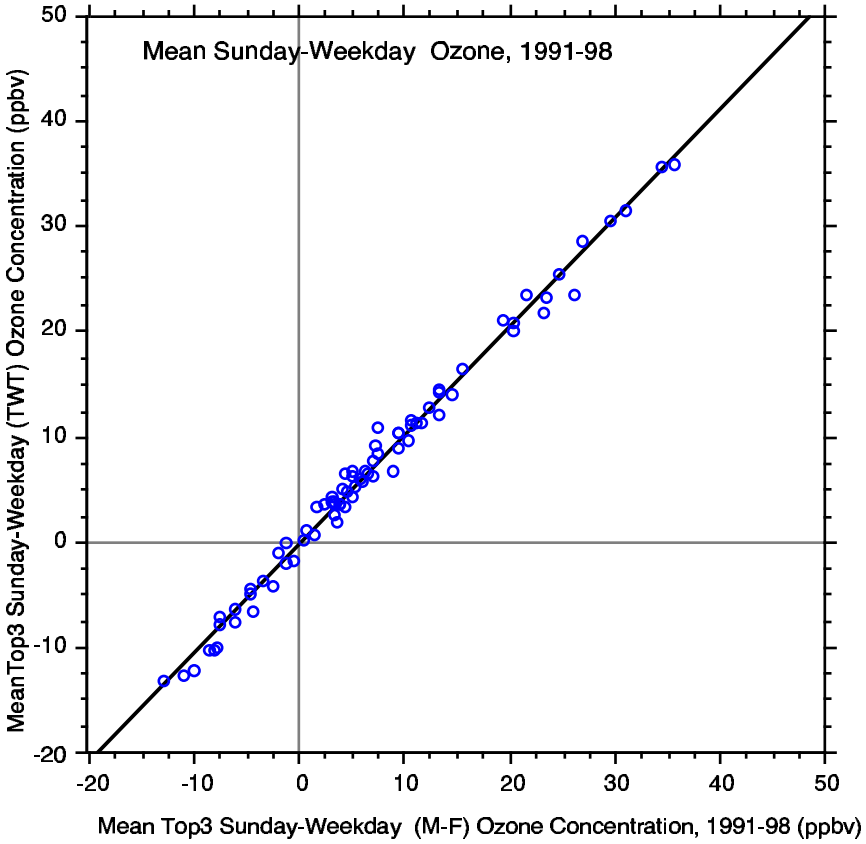
- OZONE SEASON
  - > MARCH THROUGH OCTOBER
  - > AT LEAST 75 PERCENT OF ONE OZONE SEASON
  - > AT LEAST ONE (THREE) YEARS DATA

- SPECIES
  - > 102 OZONE SITES
  - > 76 NOx
  - > 47 CO
  - > 9 NMHC
  - > 2 NMOC
  - > 5 FORMALDEHYDE
  - > 10 BENZENE, TOLUENE

DATA SUBSETS

- PERIODS
  - > 1991-98
  - > 1991-94
  - > 1996-98
  - > 1994-98
- WEEKDAYS
  - > MONDAY - FRIDAY
  - > TUESDAY - THURSDAY
- HIGH OZONE DAYS
  - > TOP 3 PER DAY OF WEEK PER YEAR (21 DAYS PER YEAR)
  - > TOP 5 PER DAY OF WEEK PER YEAR (35 DAYS PER YEAR)
  - > TOP 10 PER DAY OF WEEK PER YEAR (70 DAYS PER YEAR)
  - > TOP 2-11 PER DAY OF WEEK PER YEAR (70 DAYS PER YEAR)

COMPARISON OF MTWTF MEANS TO TWT MEANS

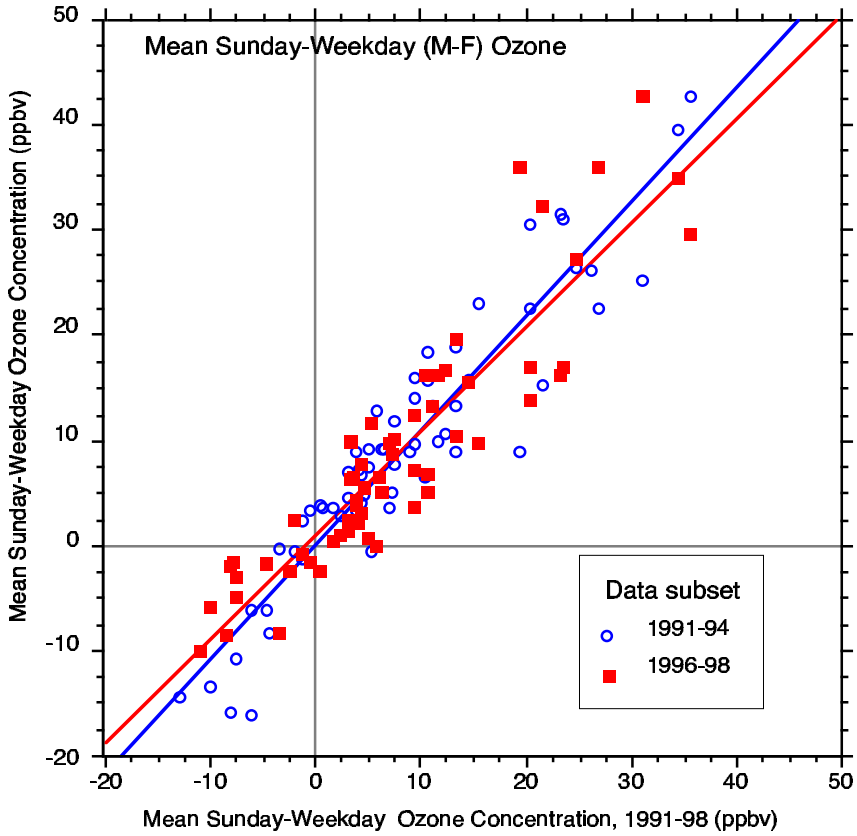


Regression relations

Top3 (TWT) = -0.17 + 1.03 * Top3 (M-F); R^2 = 0.99

COMPARISON OF THREE TIME PERIODS

Differences Between Sunday and Weekday Means, Top 3 Subset



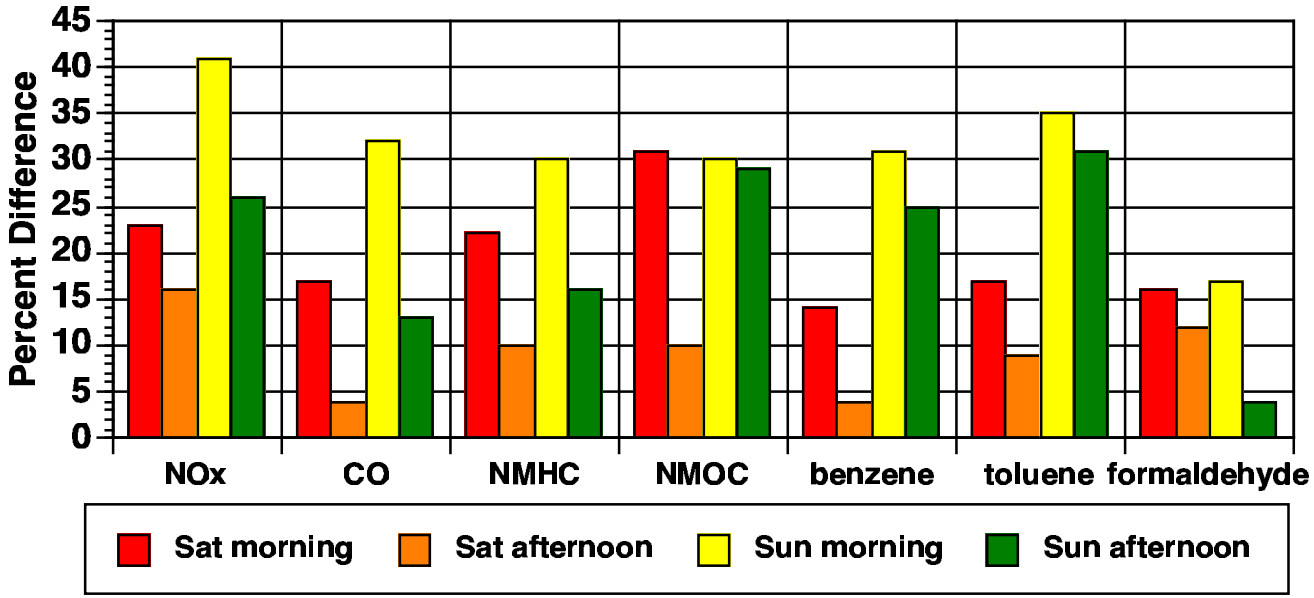
Regression relations

Top3(1991-94) = 0.28 + 1.09 * Top3(1991-98); R^2 = 0.88

Top3(1996-98) = 1.01 + 0.99 * Top3(1991-98); R^2 = 0.83

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

(Averaged Over All Sites,1991-98)

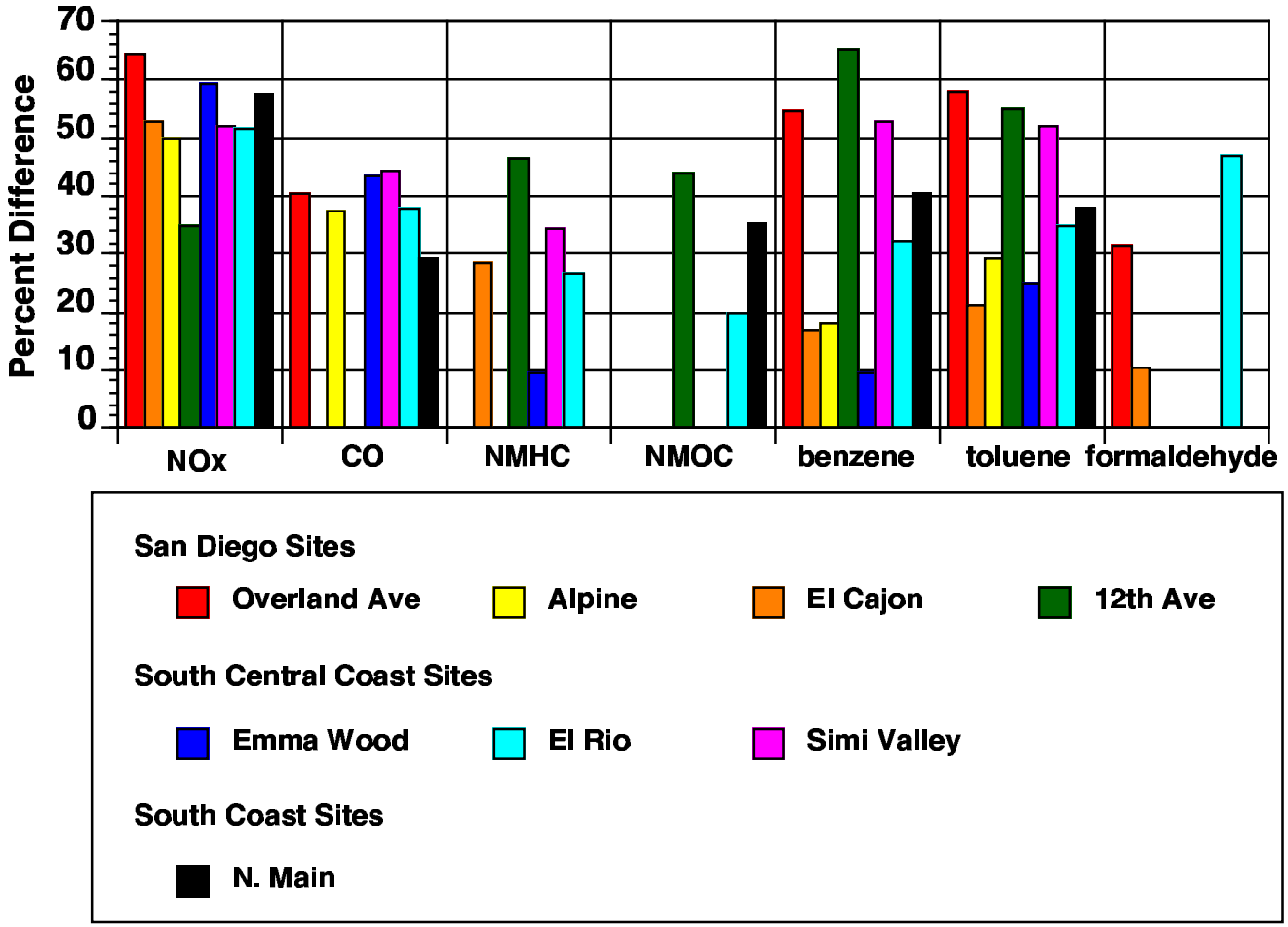


NOx	76 sites	Morning = 6-9 am	Afternoon = 12 - 3 pm
CO	47 sites	Morning = 6-9 am	Afternoon = 12 - 3 pm
NMOC	3 sites	Morning = 5-9 am	Afternoon = 12 - 5 pm
benzene	8 sites	Morning = 5-9 am	Afternoon = 12 - 5 pm
toluene	8 sites	Morning = 5-9 am	Afternoon = 12 - 5 pm
formaldehyde	3 sites	Morning = 5-9 am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

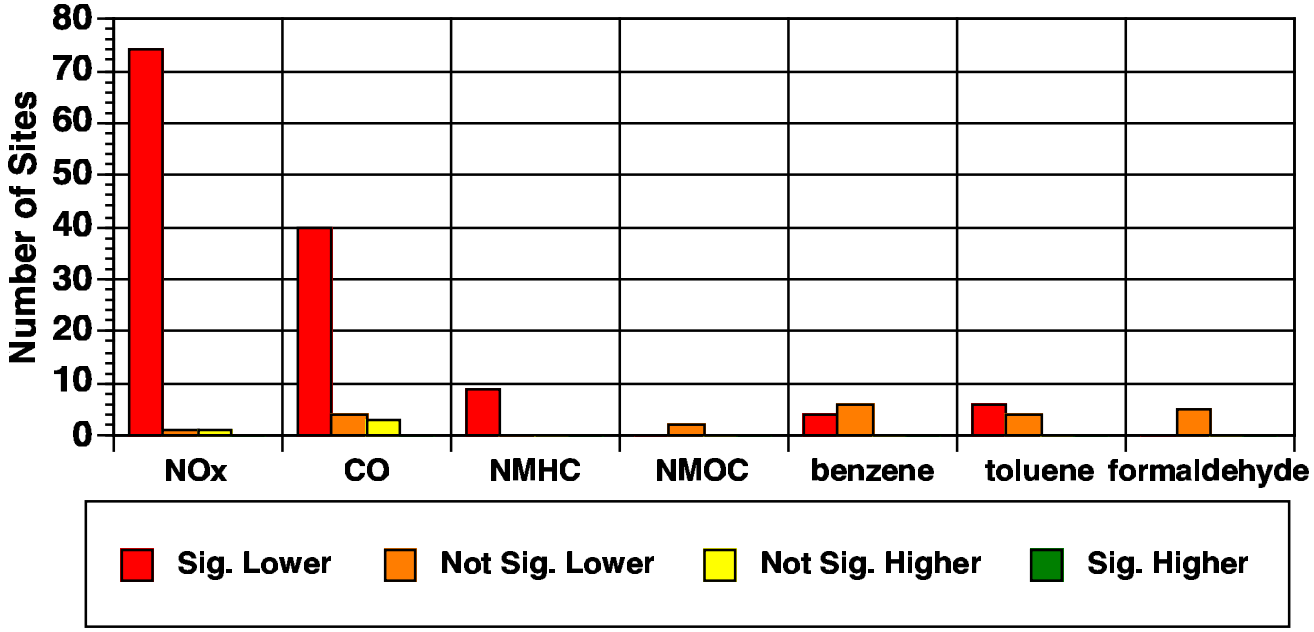
The NMOC data are very limited (samples collected every third day, usually July-Oct; no data before 1994). Many NMOC differences are not statistically significant.

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

(Sites With NMOC Measurements ,1994-97)



Statistical Significance of Comparisons of Sunday Morning Concentrations With Weekday Concentrations
(Tested by Site for All Sites, 1991-98)



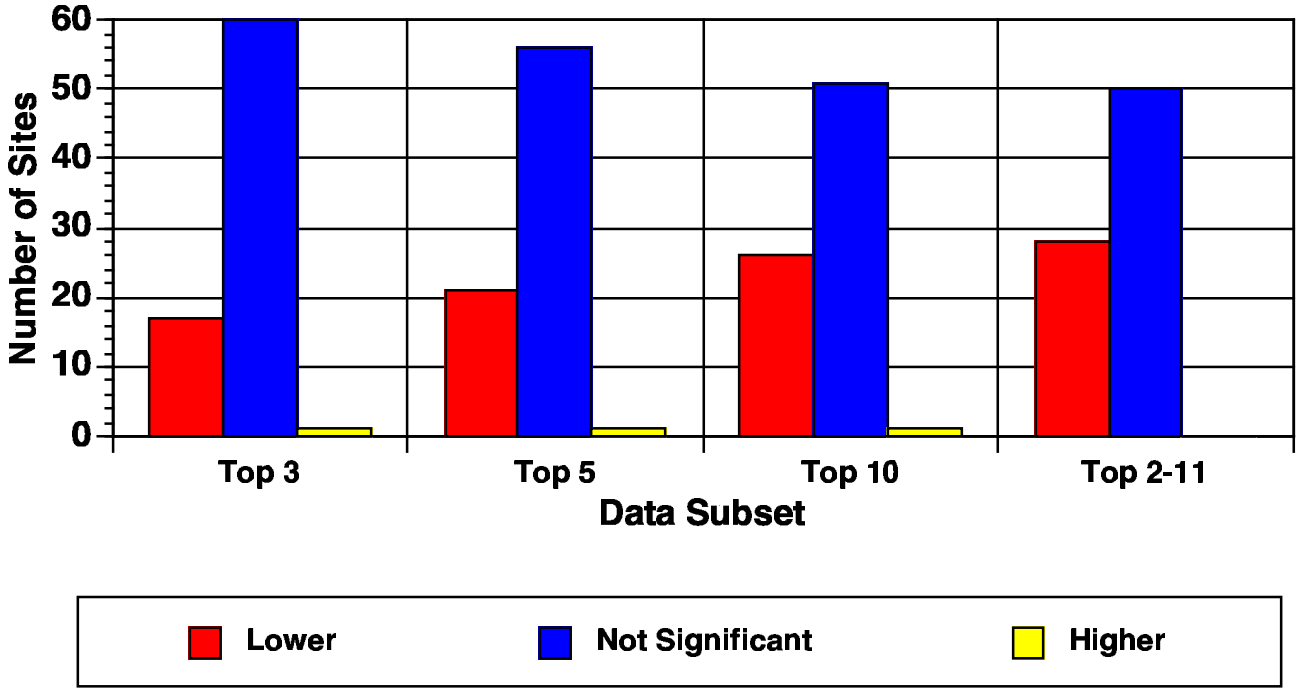
NOx, CO, and NMHC based on Wilcoxon Signed Rank Test
> paired nonparametric testappropriate for daily data with serial correlation

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

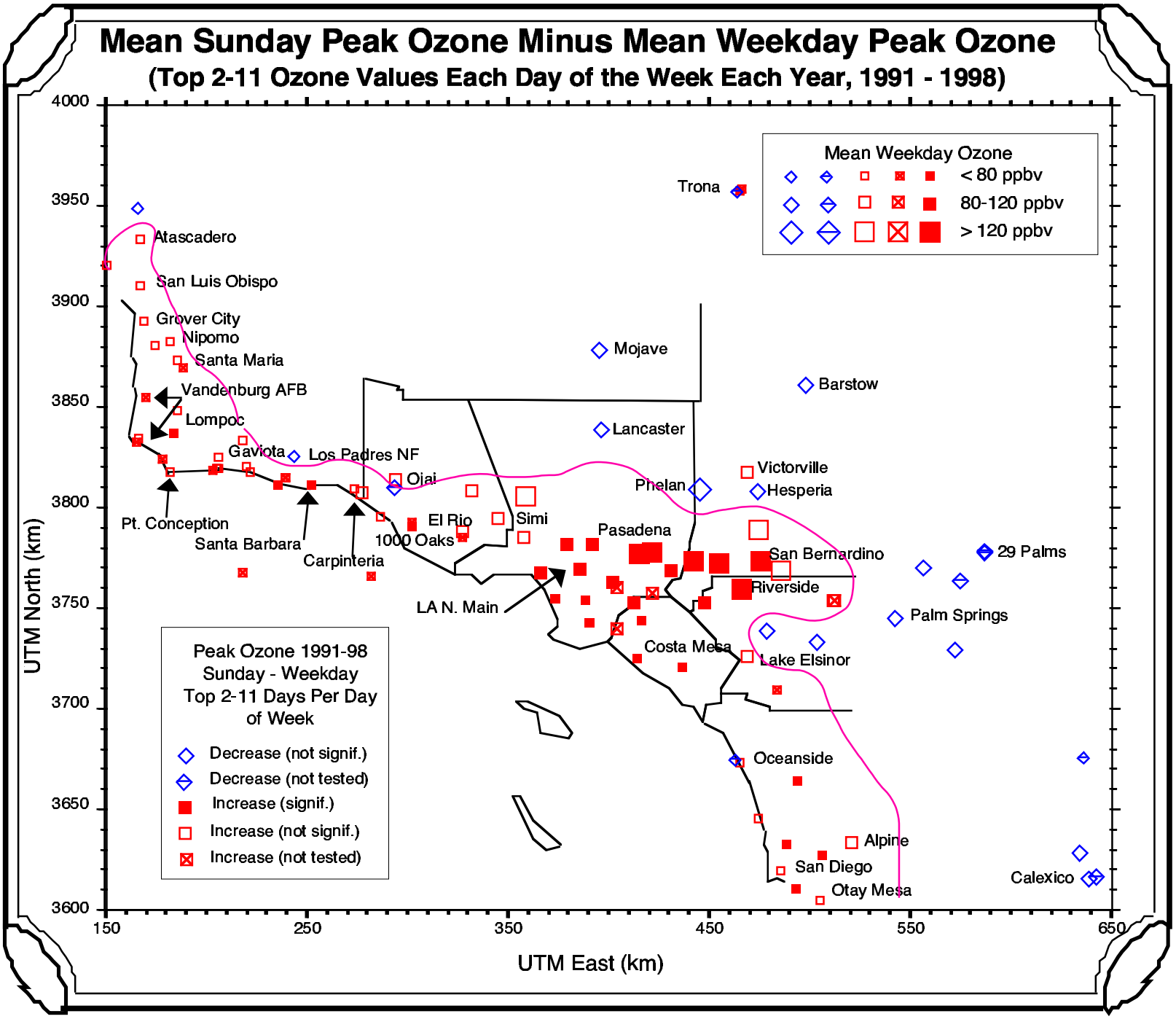
STATISTICAL TEST FOR OZONE DIFFERENCES

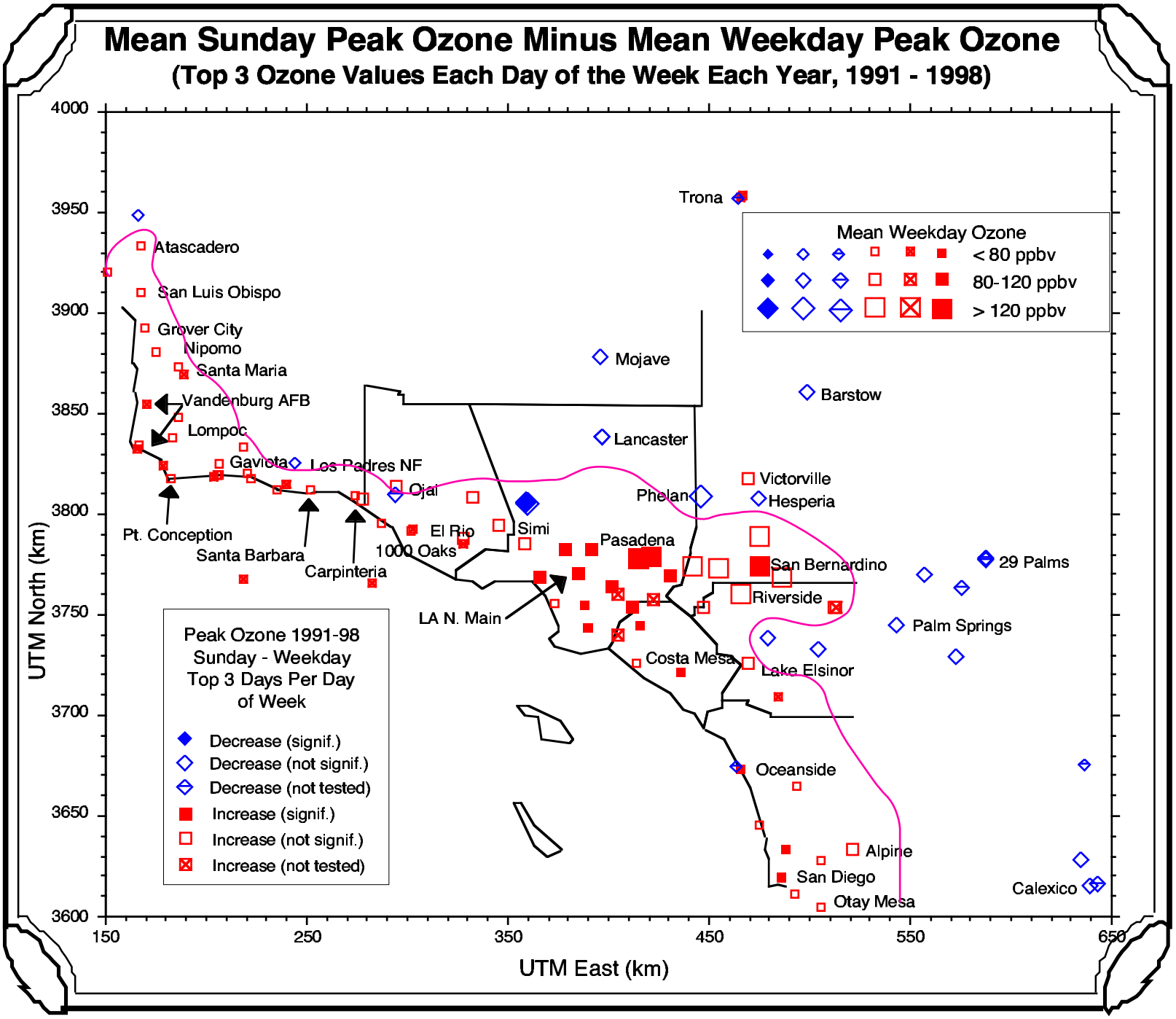
- Nonparametric test
- No assumption of normality or independence
- Carried out for each site with 6-8 years ozone data
- Each year rank Sunday - Friday daily means from 0 to 5
- Sum Sunday ranks over all years (6 to 8 years)
- For 8 years data:
  - > the possible sum of Sunday ranks ranges from 0 to 40
  - > attainable through a total of 6^8, or 1,679,620 ways
  - > sums < 9 or > 31 significant at $p < 0.01$

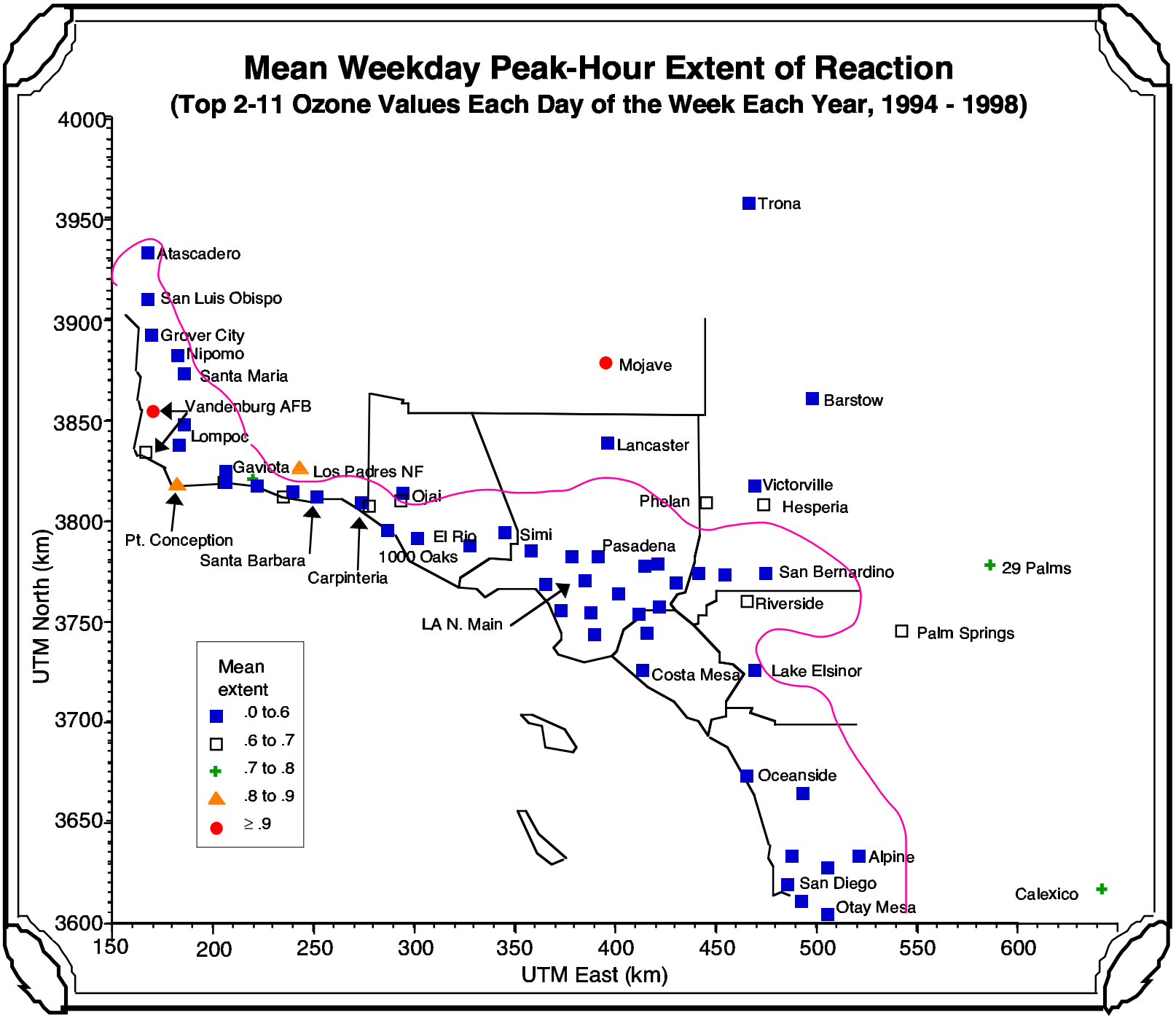
Statistical Significance of Differences Between Mean Sunday and Weekday Peak Ozone

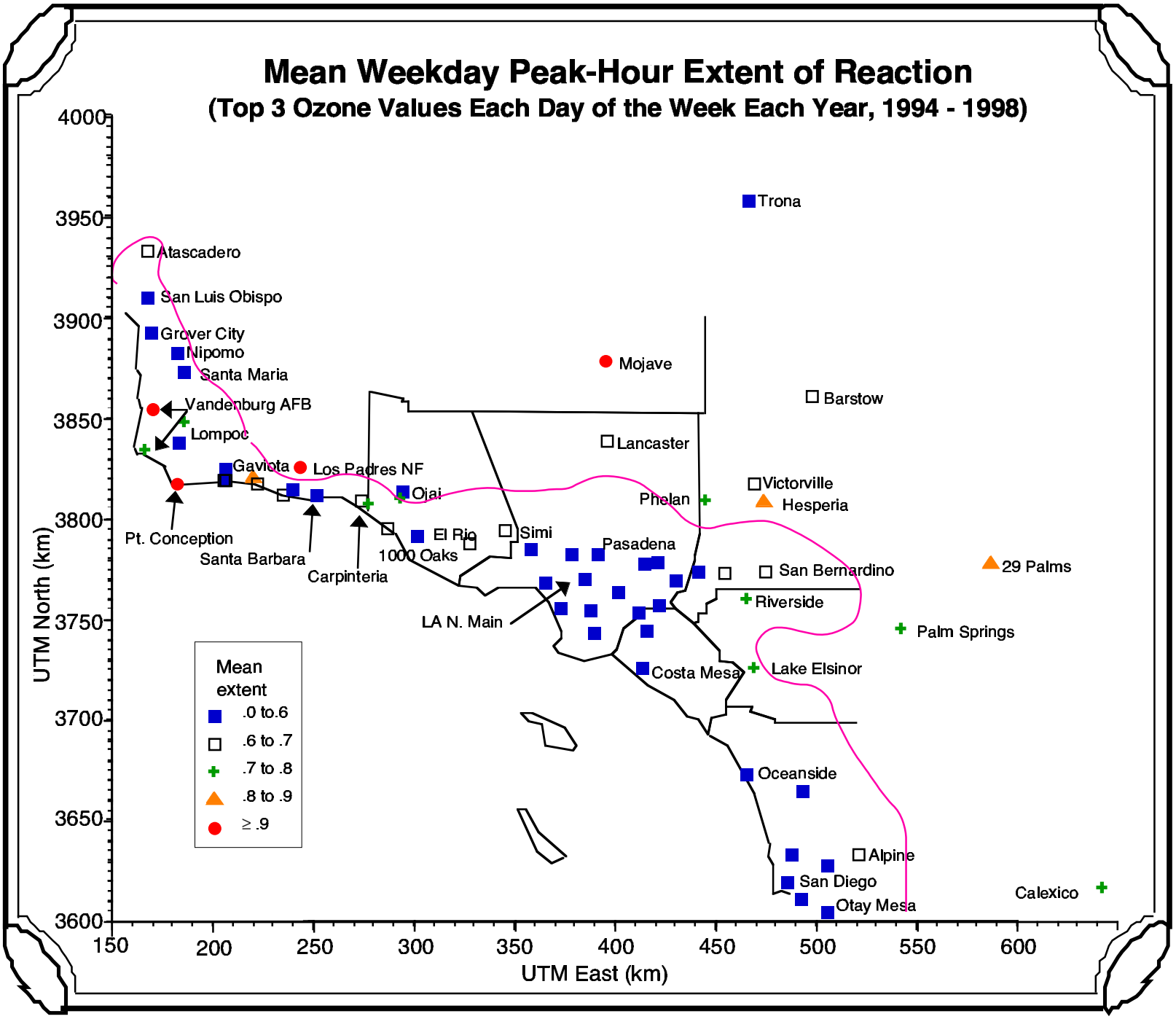


Singnificantly lower or higher at $p < 0.01$

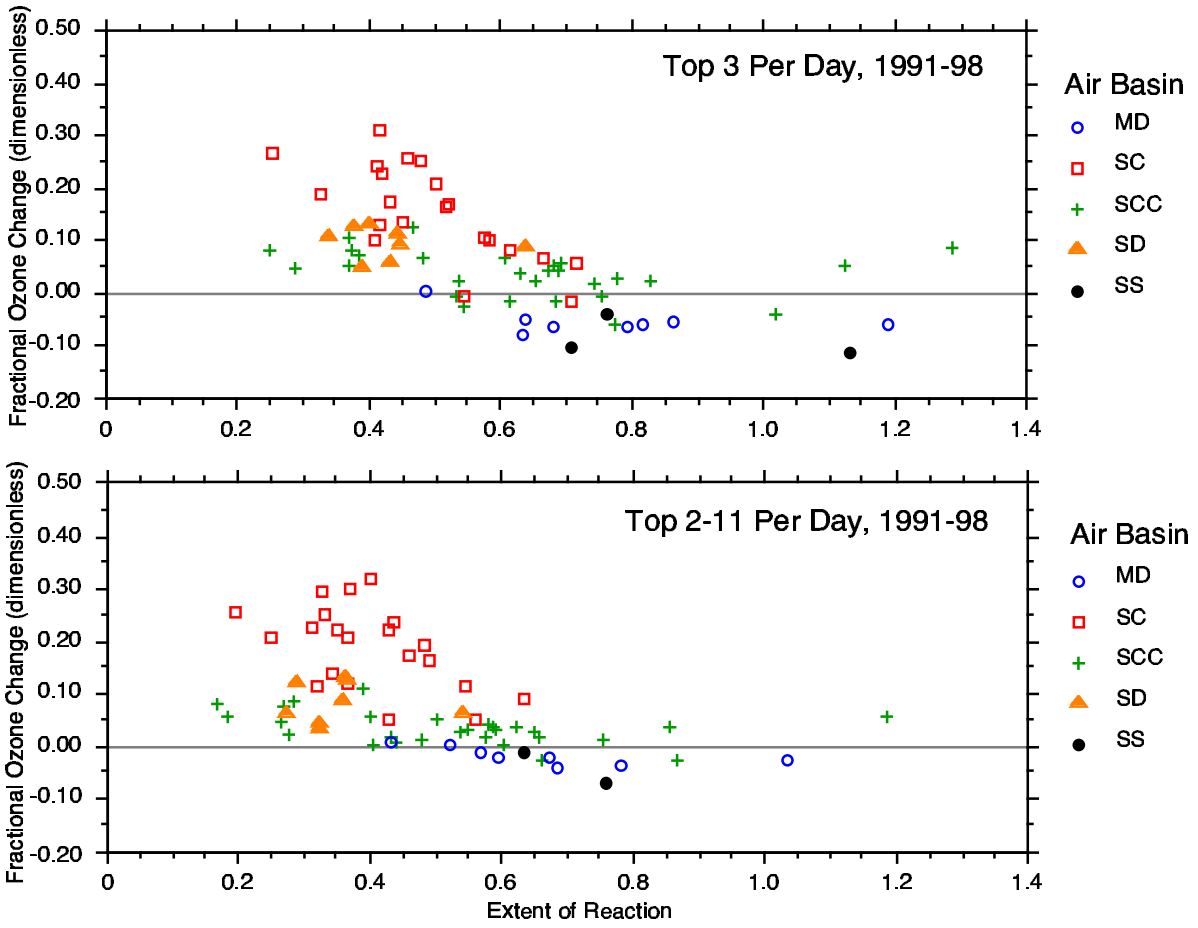

Mean Sunday Peak Ozone Minus Mean Weekday Peak Ozone
(Top 2-11 Ozone Values Each Day of the Week Each Year, 1991 - 1998)
Mean Weekday Ozone
< 80 ppbv
80-120 ppbv
> 120 ppbv
Peak Ozone 1991-98
Sunday - Weekday
Top 2-11 Days Per Day of Week
Decrease (not signif.)
Decrease (not tested)
Increase (signif.)
Increase (not signif.)
Increase (not tested)
Trona
Atascadero
San Luis Obispo
Grover City
Nipomo
Santa Maria
Vandenburg AFB
Lompoc
Gaviota
Los Padres NF
Ojai
Pt. Conception
Santa Barbara
Carpinteria
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
250
350
450
550
650


Mean Sunday Peak Ozone Minus Mean Weekday Peak Ozone
(Top 3 Ozone Values Each Day of the Week Each Year, 1991 - 1998)
UTM North (km)
UTM East (km)
4000
3950
3900
3850
3800
3750
3700
3650
3600
150
250
350
450
550
650
Mean Weekday Ozone
< 80 ppbv
80-120 ppbv
> 120 ppbv
Peak Ozone 1991-98
Sunday - Weekday
Top 3 Days Per Day
of Week
Decrease (signif.)
Decrease (not signif.)
Decrease (not tested)
Increase (signif.)
Increase (not signif.)
Increase (not tested)
Trona
Atascadero
San Luis Obispo
Grover City
Nipomo
Santa Maria
Vandenburg AFB
Lompoc
Gaviota
Los Padres NF
Ojai
Pt. Conception
Santa Barbara
Carpinteria
El Rio
1000 Oaks
Simi
LA N. Main
Mojave
Barstow
Lancaster
Phelan
Victorville
Hesperia
Pasadena
San Bernardino
Riverside
29 Palms
Palm Springs
Costa Mesa
Lake Elsinor
Oceanside
Alpine
San Diego
Otay Mesa
Calexico

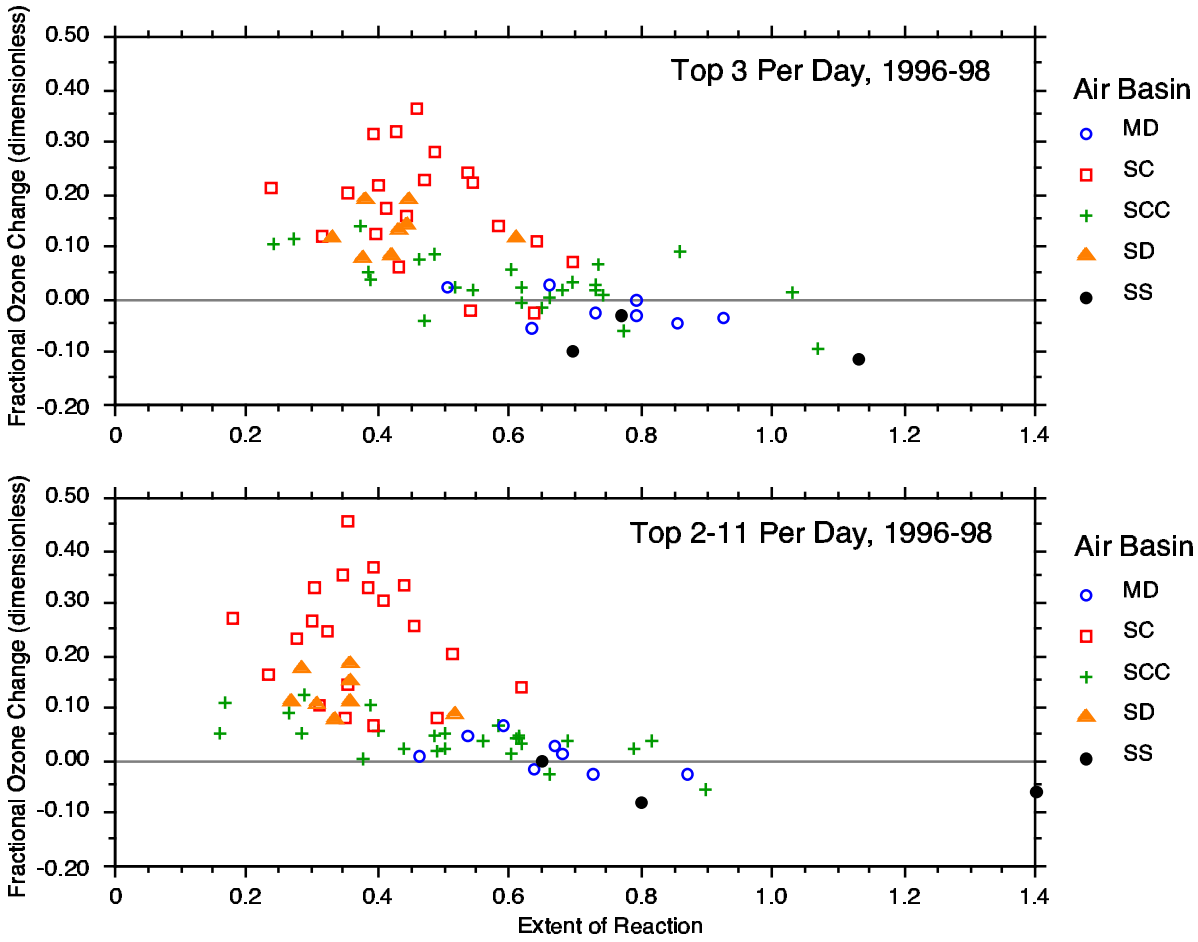

Mean Weekday Peak-Hour Extent of Reaction
(Top 2-11 Ozone Values Each Day of the Week Each Year, 1994 - 1998)
UTM North (km)
UTM East (km)
4000
3950
3900
3850
3800
3750
3700
3650
3600
150
200
250
300
350
400
450
500
550
600
Trona
Atascadero
San Luis Obispo
Grover City
Nipomo
Santa Maria
Vandenburg AFB
Lompoc
Mojave
Barstow
Lancaster
Gaviota
Los Padres NF
Ojai
Victorville
Phelan
Hesperia
Pt. Conception
Santa Barbara
Carpinteria
El Rio
1000 Oaks
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 Weekday Peak-Hour Extent of Reaction
(Top 3 Ozone Values Each Day of the Week Each Year, 1994 - 1998)
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
Gaviota
Los Padres NF
Ojai
Pt. Conception
Santa Barbara
Carpinteria
El Rio
1000 Oaks
Simi
Pasadena
LA N. Main
Mojave
Barstow
Lancaster
Phelan
Victorville
Hesperia
San Bernardino
29 Palms
Riverside
Palm Springs
Lake Elsinor
Costa Mesa
Oceanside
Alpine
San Diego
Otay Mesa
Calexico
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 1991 - 1998



Mean Sunday Peak Ozone Minus Mean Weekday Peak Ozone versus Mean Extent of Reaction at the Time of the Peak Ozone High-Ozone Days 1996 - 1998



CONCLUSION

- BOTH NOx AND NMOC CONCENTRATIONS LOWER ON WEEKENDS THAN ON WEEKDAYS. EVIDENCE FOR LOWER NOx IS STRONGER THAN EVIDENCE FOR LOWER NMOC.
- PRECURSOR CONCENTRATIONS AVERAGE ~15 - 40% LOWER ON SUNDAYS AND ~10 - 20% LOWER ON SATURDAYS THAN ON WEEKDAYS.
- OZONE MAY BE LOWER OR HIGHER ON WEEKENDS THAN ON WEEKDAYS. NEARBY SITES HAVE SIMILAR PATTERNS.
- HIGHER SUNDAY OZONE STATISTICALLY SIGNFICANT AT MOST SITES IN SOCAB (20 OF 28).
- 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.
- WEEKEND/WEEKDAY OZONE DIFFERENCES IN PART RELATED TO WHERE AND WHEN VOC OR NOx IS LIMITING.
- FINDINGS ARE CONSISTENT AMONG DATA SUBSETS.