

Understanding Relationships Between  
Changes in Ambient Ozone and  
Precursor Concentrations and Changes in  
VOC and NO<sub>x</sub> Emissions  
from 1990 to 2004 in Central California

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# Today's Topics

- I. Project overview
- II. Phase I: summary of results
- III. Phase II: objectives and schedule
- IV. Phase II: summary of results

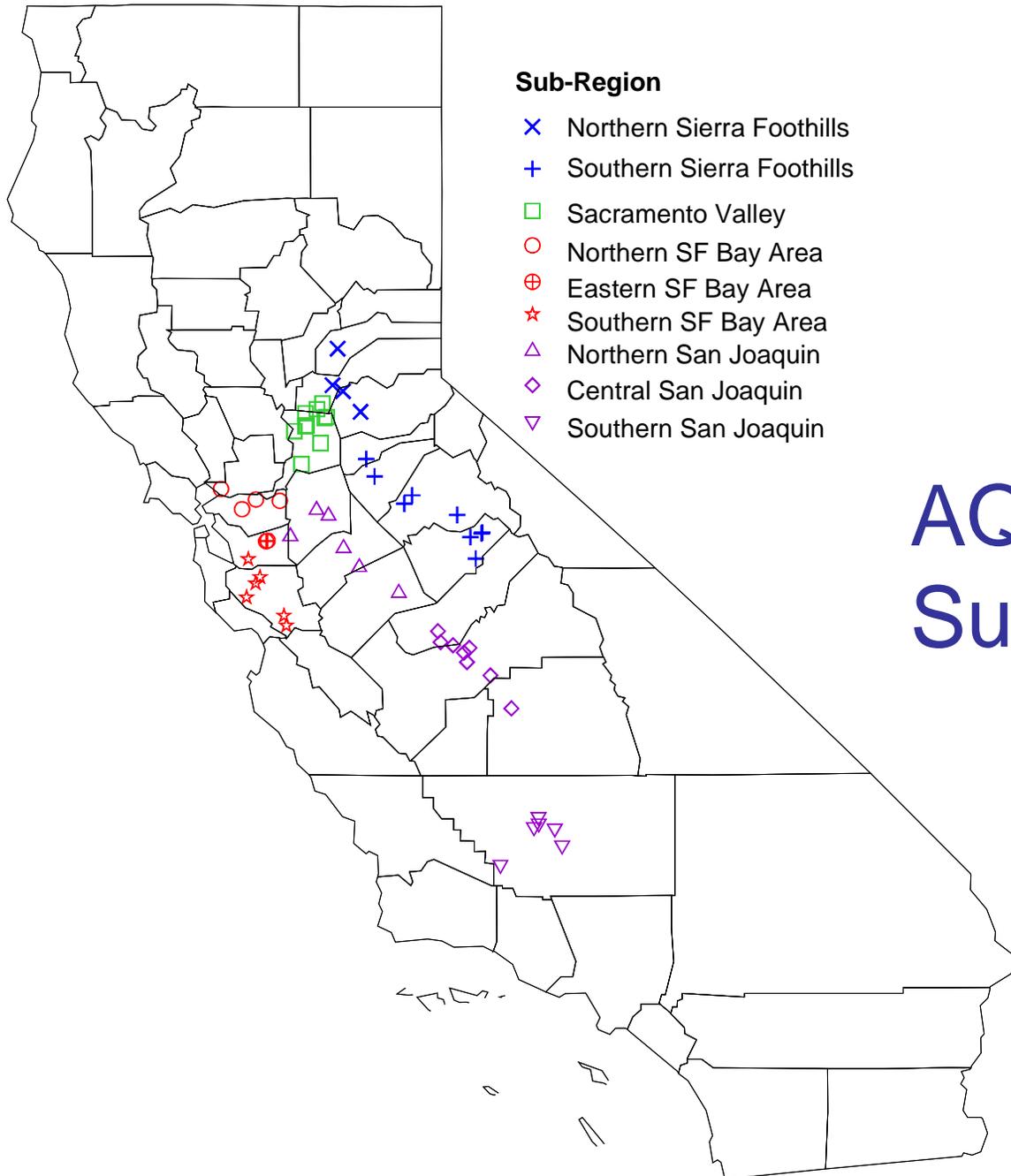
# I. Project Overview

- Phase I (completed)
  - Databases and methods
  - Ozone and precursor trends by site and by subregion
  - Precursor trends compared to county-level emission trends
  - Meteorological classifications
  - Ozone trends for all high-ozone days and by meteorological class

# I. Project Overview (continued)

- Phase II (in progress)
  - Grid emission inventories, 1990-2004
  - Relate ambient primary-pollutant trends to zone-of-influence emission trends
  - Relate ozone trends to ambient and emission trends of precursors, and to meteorological conditions
  - Submit final report

## II. Phase I: Summary of Results



**Sub-Region**

- × Northern Sierra Foothills
- + Southern Sierra Foothills
- Sacramento Valley
- Northern SF Bay Area
- ⊕ Eastern SF Bay Area
- ★ Southern SF Bay Area
- △ Northern San Joaquin
- ◇ Central San Joaquin
- ▽ Southern San Joaquin

# AQ Sites and Subregions

# 1990 – 2004 AQ Trends Summary

- No trends significantly upward\*
- NO<sub>x</sub> sig\* down at 22 of 28 sites\*\*
- CO sig\* down at 21 of 25 sites\*\*
- NMOC sig\* down at 5 of 7 sites\*\*\*
- Ozone sig\* down at 7 of 42 sites\*\*
- Annual mean top-60 ozone trends similar to trends in annual 4<sup>th</sup>-highest 8-hour max

\*  $p < 0.05$

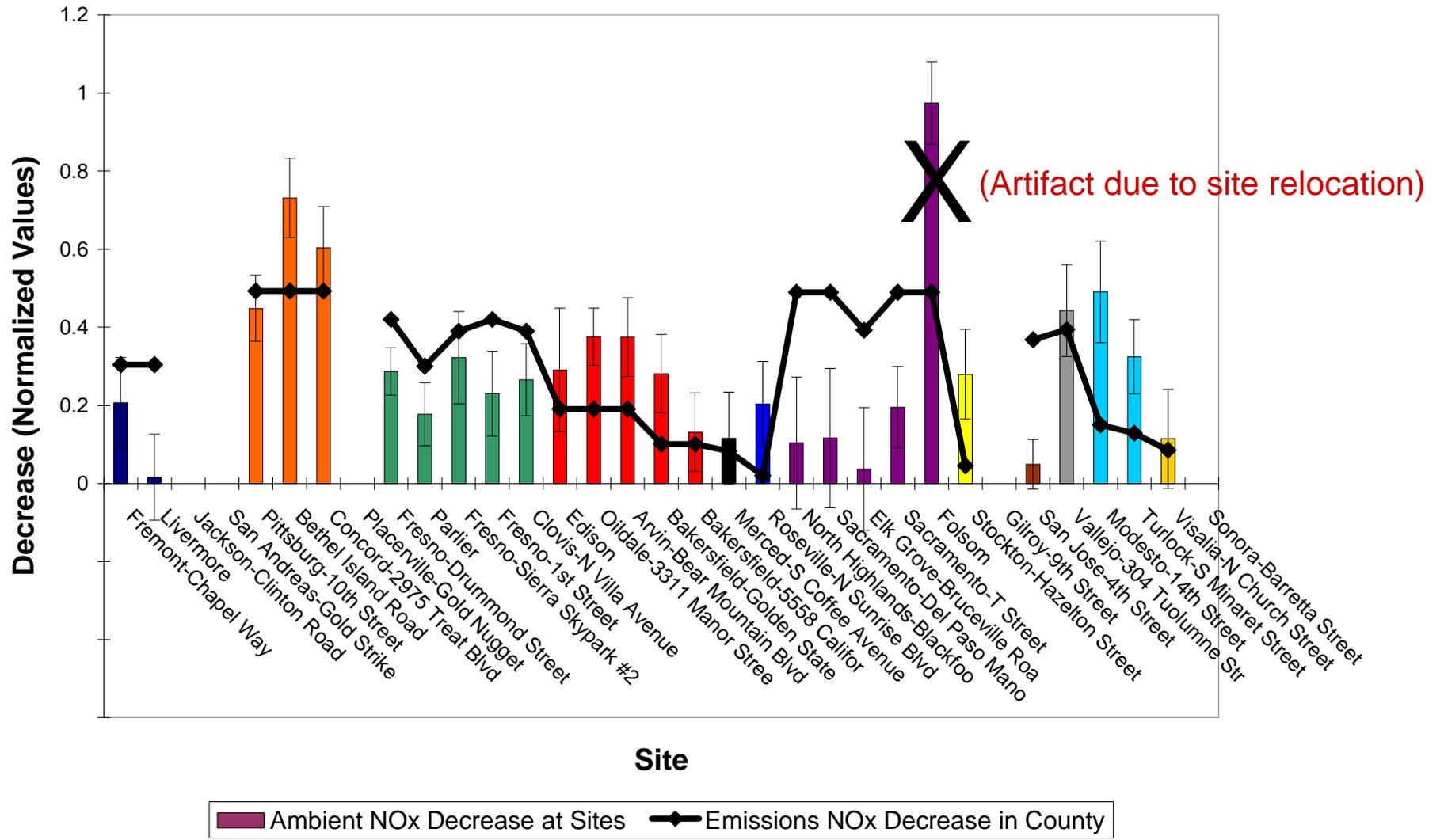
\*\* At least 10 years data. One or both metrics.

\*\*\* 7 - 10 years data

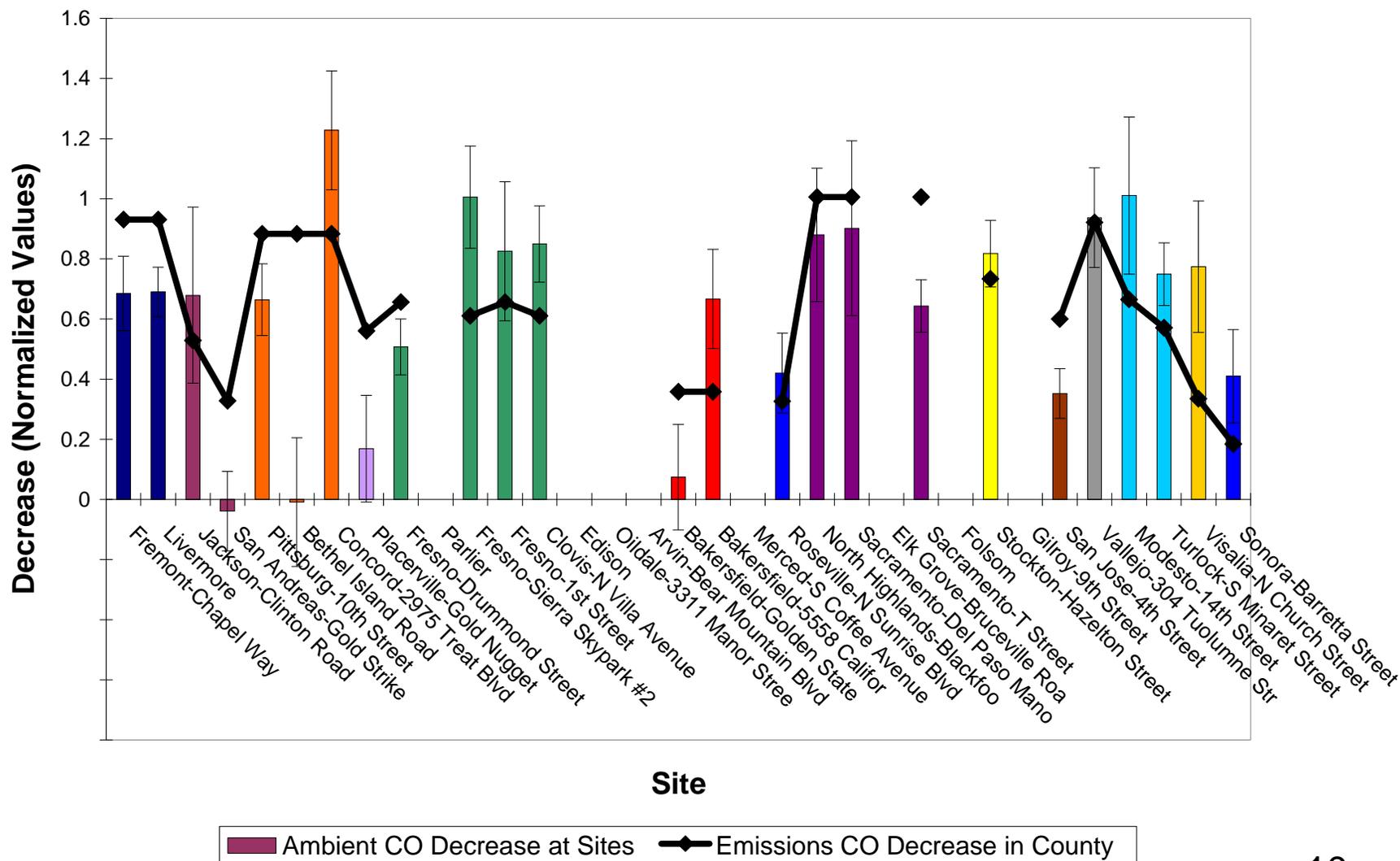
# Phase I Findings: Precursor Trends

- On average, ambient precursor decreases are comparable to county-level emissions decreases
- There is a possibility that emission decreases are overestimated or underestimated for some counties
- Confirmation requires comparison of site trends to spatially-resolved emission trends (Phase II)

## Ambient and Emissions Decreases for NOx



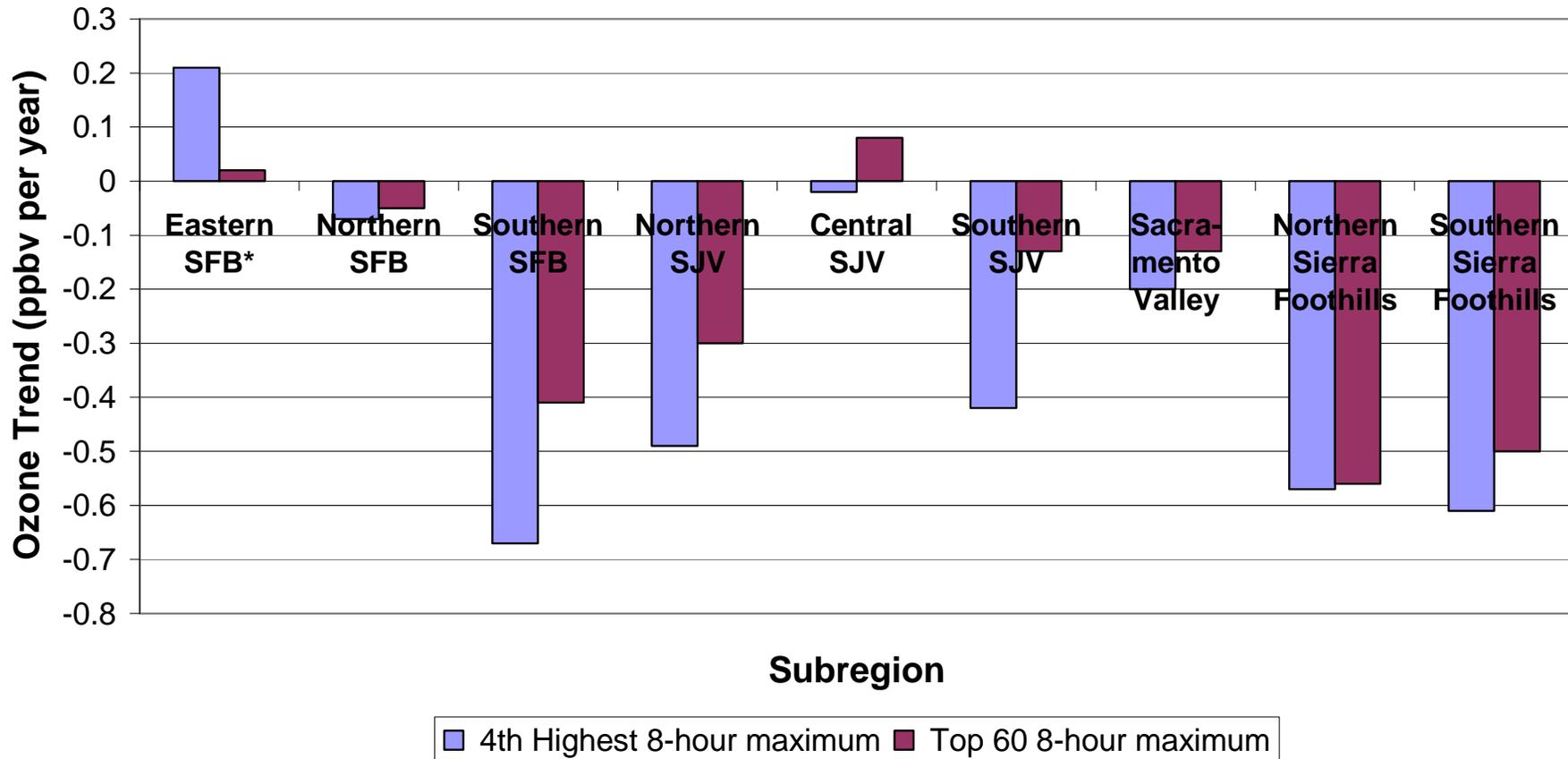
## Ambient and Emissions Decreases for CO



## Phase I Findings: Ozone Trends

- Phase I analyses demonstrate spatial variations of ozone concentrations and trends but do not explain them
- Site-to-site variations and directional variations of mean concentrations suggest importance of local ozone formation
- More detailed analyses in Phase II
- Potential limitation is signal-to-noise

## Ozone Trends in Subregions - Medians of Site Trends



\* Eastern SFB is Livermore Old 1<sup>st</sup> St 1990-2000 only

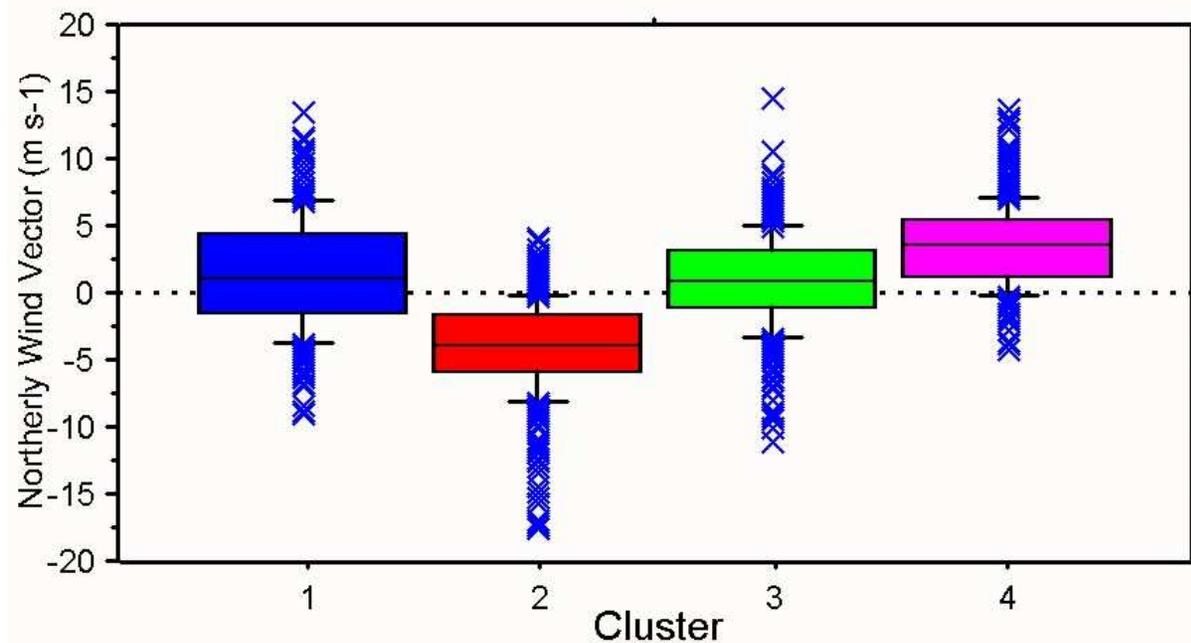
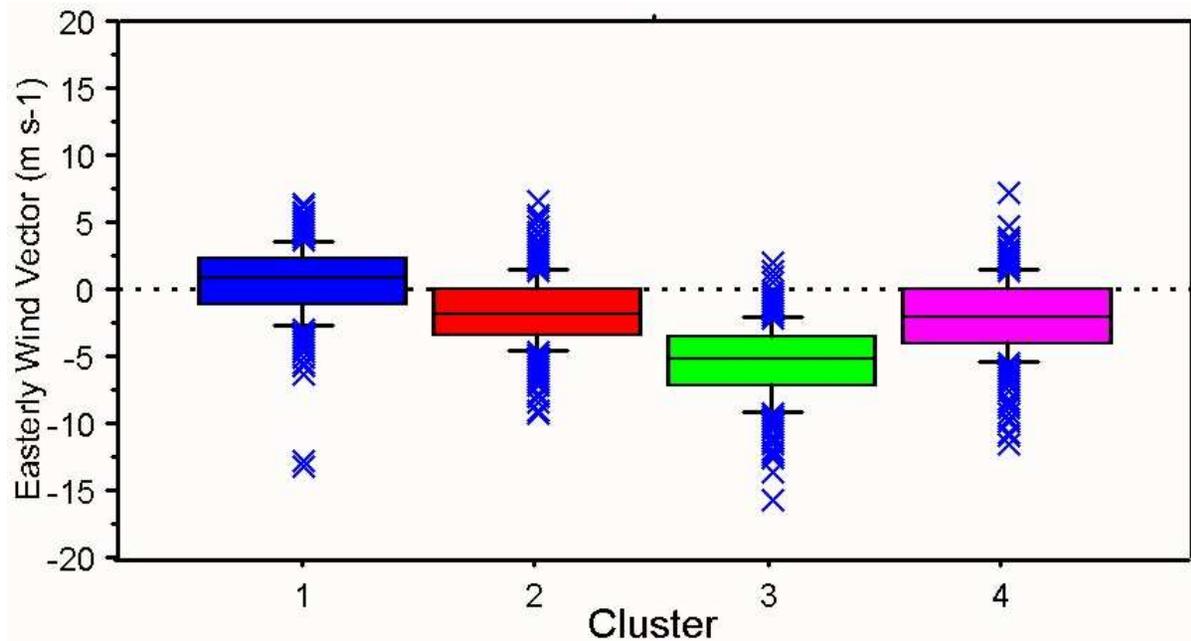
# Meteorological Classification

1. Principal component analysis (PCA) of regional-scale met variables
2. K-means clustering of PCs

PCA applied to all days of all years from 1990 to 2004  
(n = 5480\*\* days)

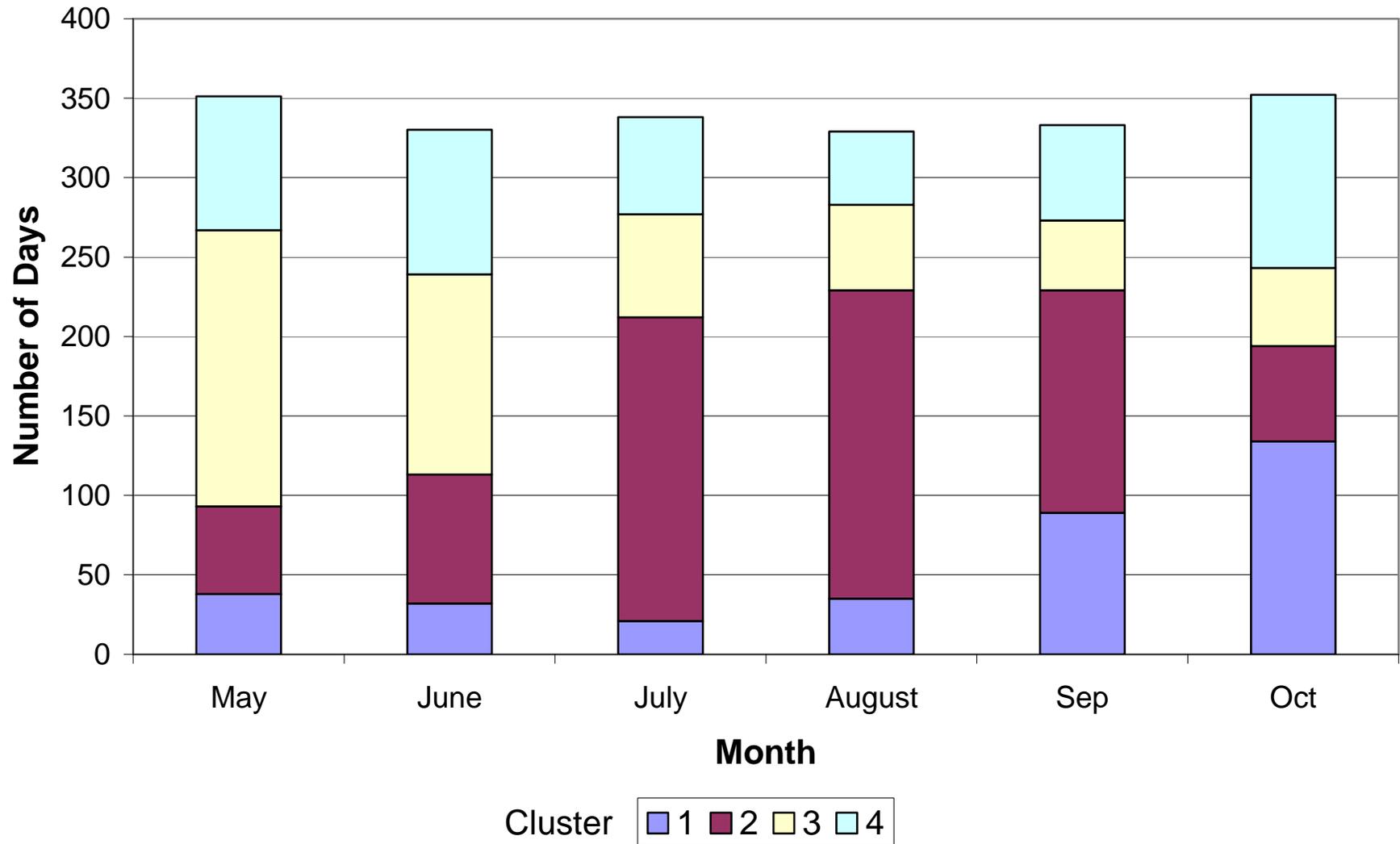
Clustering applied to all ozone-season days  
(n = 2790 days)

\*\* 5441 with pressure gradient data; 4202 with 850 mb data



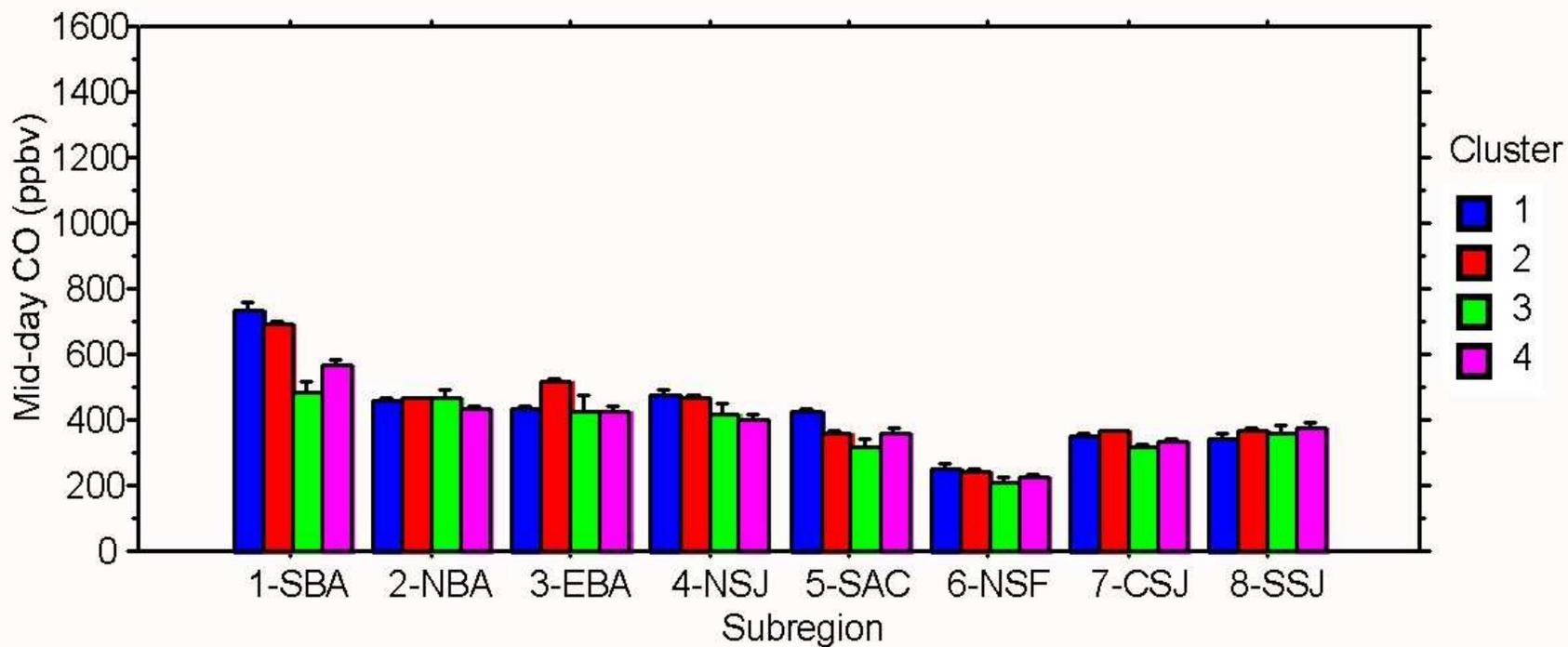
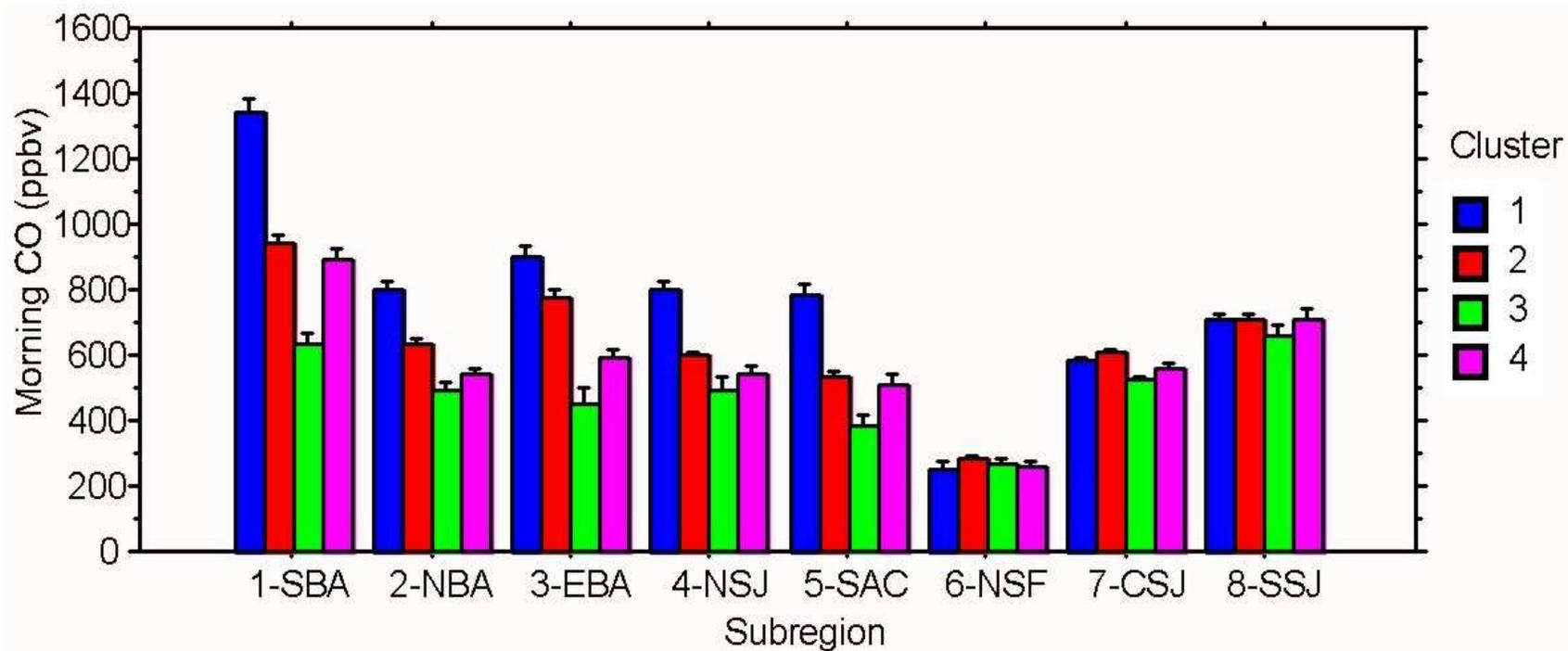
Clusters separate days into groups with different 850 mb wind directions

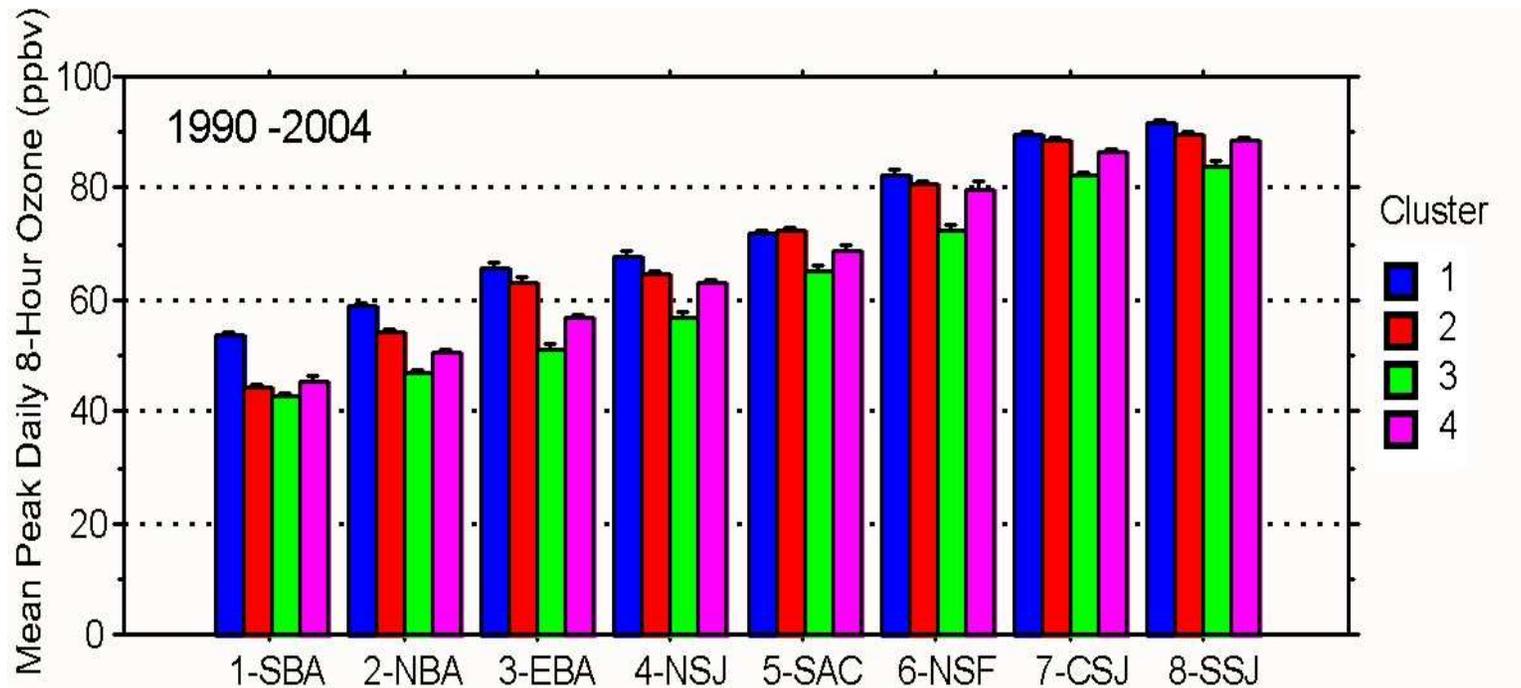
## Number of Days in Each Cluster, By Month



# Characteristics of Met Clusters

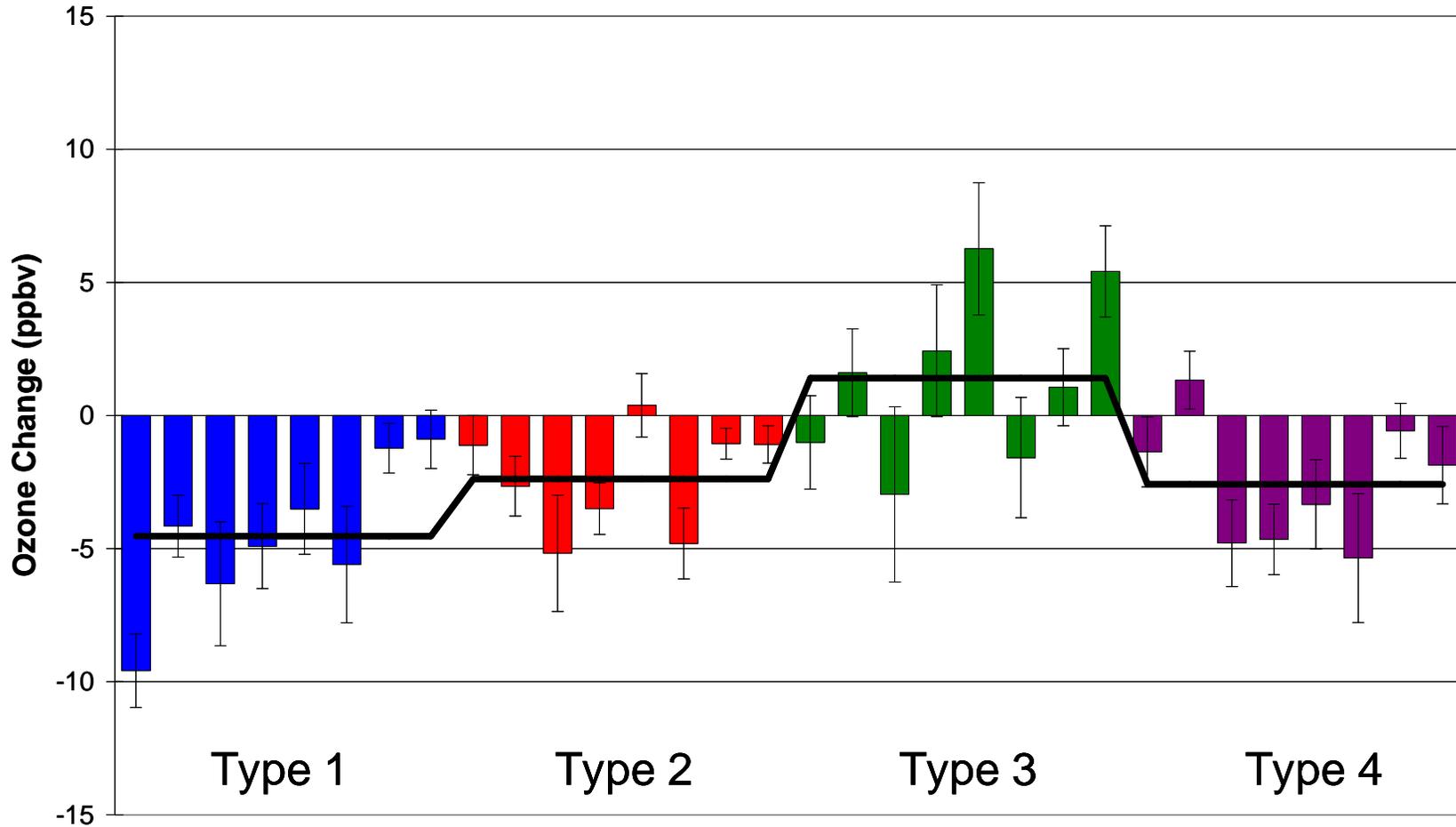
- Cluster 1: N and E 850 mb winds, lower surface pressure at San Francisco than elsewhere, and low surface wind speeds. Mean ozone and precursor concentrations are high due to generally poor ventilation.
- Cluster 2: SW 850 mb winds and higher surface wind speeds than in cluster 1.
- Cluster 3: more W 850 mb winds and higher surface wind speeds. Mean ozone ~ 5 to 15 ppbv lower than in cluster 1.
- Cluster 4: similar to cluster 1, but with better ventilation and 850 mb winds that are on average more N than for days in cluster 1.





Mean peak 8-hour ozone concentrations varied among sites, subregions, and met types – these days are all top-60 peak 8-hour days

**Change in Mean Peak Daily 8-Hour Ozone, 1995-99 to 2000-04  
(by Meteorological Class and Subregion)**



(Order is SBA, NBA, EBA, NSJ, SAC, NSF, CSJ, SSJ) 19

## III. Phase II: Objectives and Schedule

- Objectives
  - More accurate comparison of sites' AQ trends with “zone-of-influence” emission trends
  - Better understanding of ozone trends at sites within each subregion and the relation of ozone to precursor trends and meteorological variation
- Schedule – Complete by end of December

# Phase II Tasks

- Task 5: Prepare gridded emission inventories, 1990 – 2004
- Task 6:
  - (a) Compare “zone-of-influence” emission trends to ambient primary-pollutant trends.
  - (b) Relate ozone changes to precursor trends and meteorology.
- Task 7: Prepare final report and draft manuscript.
- Task 8: Provide data, documentation, and software
- Task 9: Present findings at meetings

## Task 5 Approach

- Generate gridded inventories from county-level inventories, 1990 - 2004
- Develop monitor-specific “zone-of-influence” emission trends using 3x3, 5x5, and 7x7 arrays of grid cells around each long-term monitor

## Task 5 Status

- Gridded inventories were generated from county-level inventories and year 2000 surrogate files prepared by STI
- Discrepancies identified and revisions made
- We created month and year “zone-of-influence” CO, NO<sub>x</sub>, and NMOC emissions using 3x3, 5x5, and 7x7 arrays of grid cells around each long-term monitor
- We are examining current and historical site photos for evidence of changes in land use

# Potential Biases in Gridded Emissions (Due to Not Using Historical Surrogates)

- Sites located in nonurban settings in 1990 becoming urban by 2000
  - Not problematic if site is still nonurban
  - Not too problematic for trends from 1994-2004 (year 2000 is approximate midpoint)
- Relocated sites – must match emissions
  - Livermore
  - Folsom
  - Madera

# Candidate Sites: Possible 1990-2004 New Urbanization Within 5 – 10 km

- Bethel Island 1990-2004
- Grass Valley 1994-2004
- Cool 1996-2004
- Auburn 1990-2004
- Fresno Sierra Skypark 1992-2004
- Edison 1990-2004

*Options: Limit trend comparisons to 1994-2004 and/or  
adjust gridded emissions on site-specific basis*

## Task 6 Status

- In progress: comparisons of “zone-of-influence” emission trends to ambient primary-pollutant trends
- Also in progress: analyses of ozone changes in relation to precursor trends
- Completed: analyses of met classes
- Completed: analyses of ozone trends at detailed temporal and spatial resolution

## IV. Phase II: Summary of Results

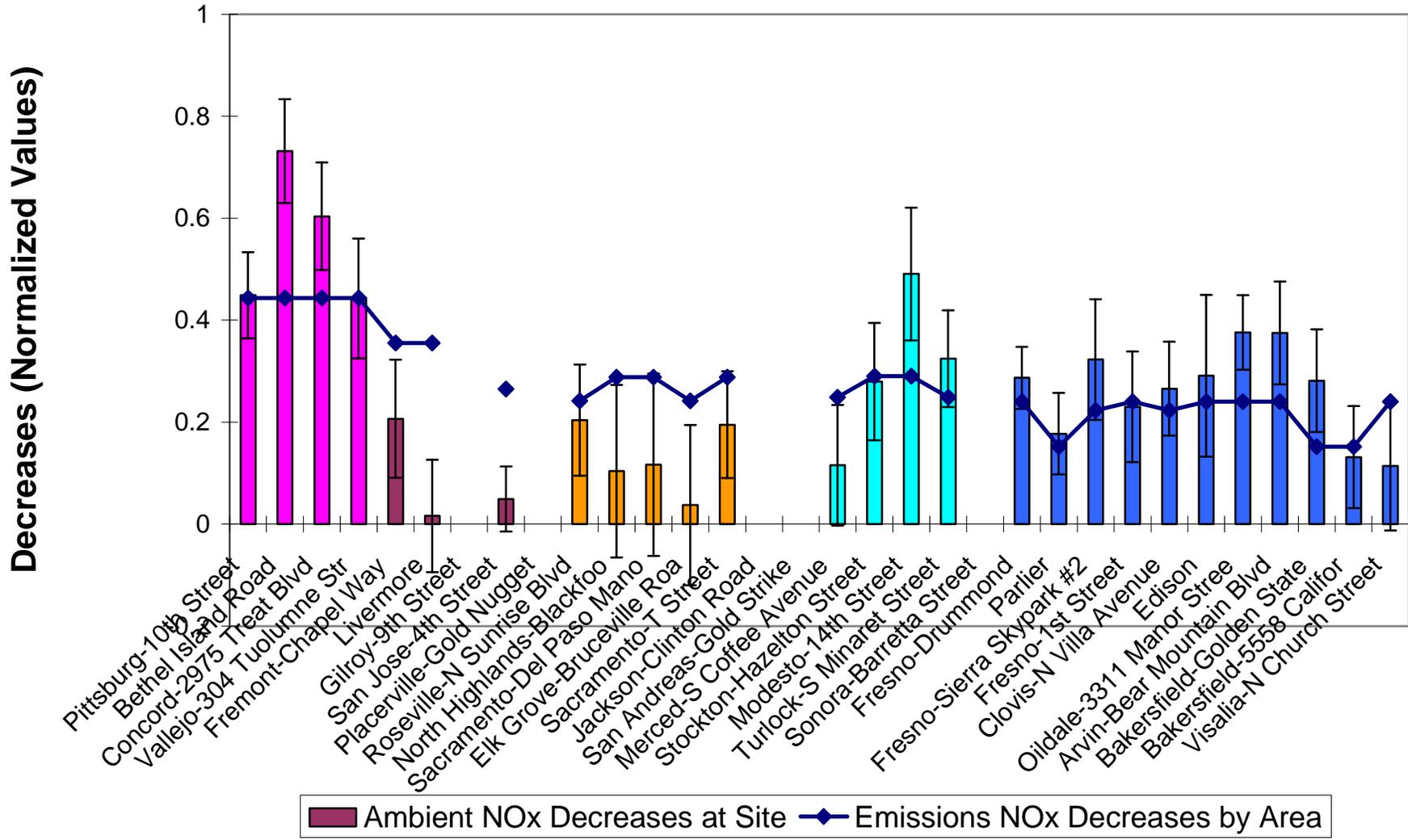
# Ambient and Emissions Trends for Ozone Precursors

- Ambient and emissions trends show discrepancies for NO<sub>x</sub> when emissions are quantified at county and regional scales
- Work in progress: comparisons at smaller spatial scales

## Precursor Trends: Regional Scale

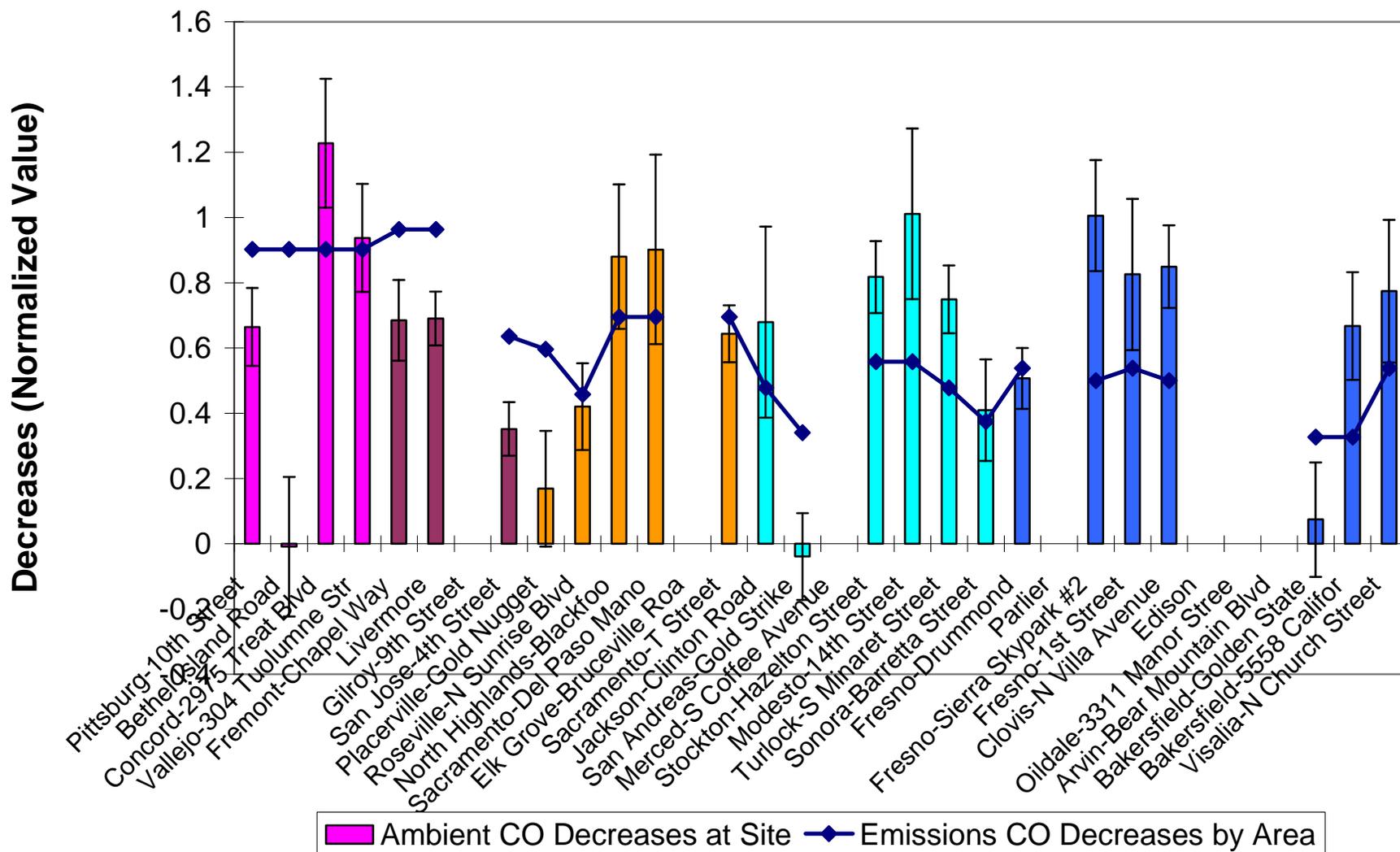
- We compared ambient precursor decreases to regional emissions decreases
- Combined subregions (2 to 6 counties):
  - Sacramento + N Sierra Foothills
  - East Bay + South Bay + SF (central Bay area)
  - N San Joaquin + S Sierra Foothills
  - Central San Joaquin + S San Joaquin

## Ambient and Emissions Decreases for NOx



Ambient-emissions NOx discrepancy exists for central Bay and Sacramento areas

## Ambient and Emissions Decreases for CO



Why aren't the ambient NOx trends at some sites as large as expected from the emission trends?

Working hypothesis:

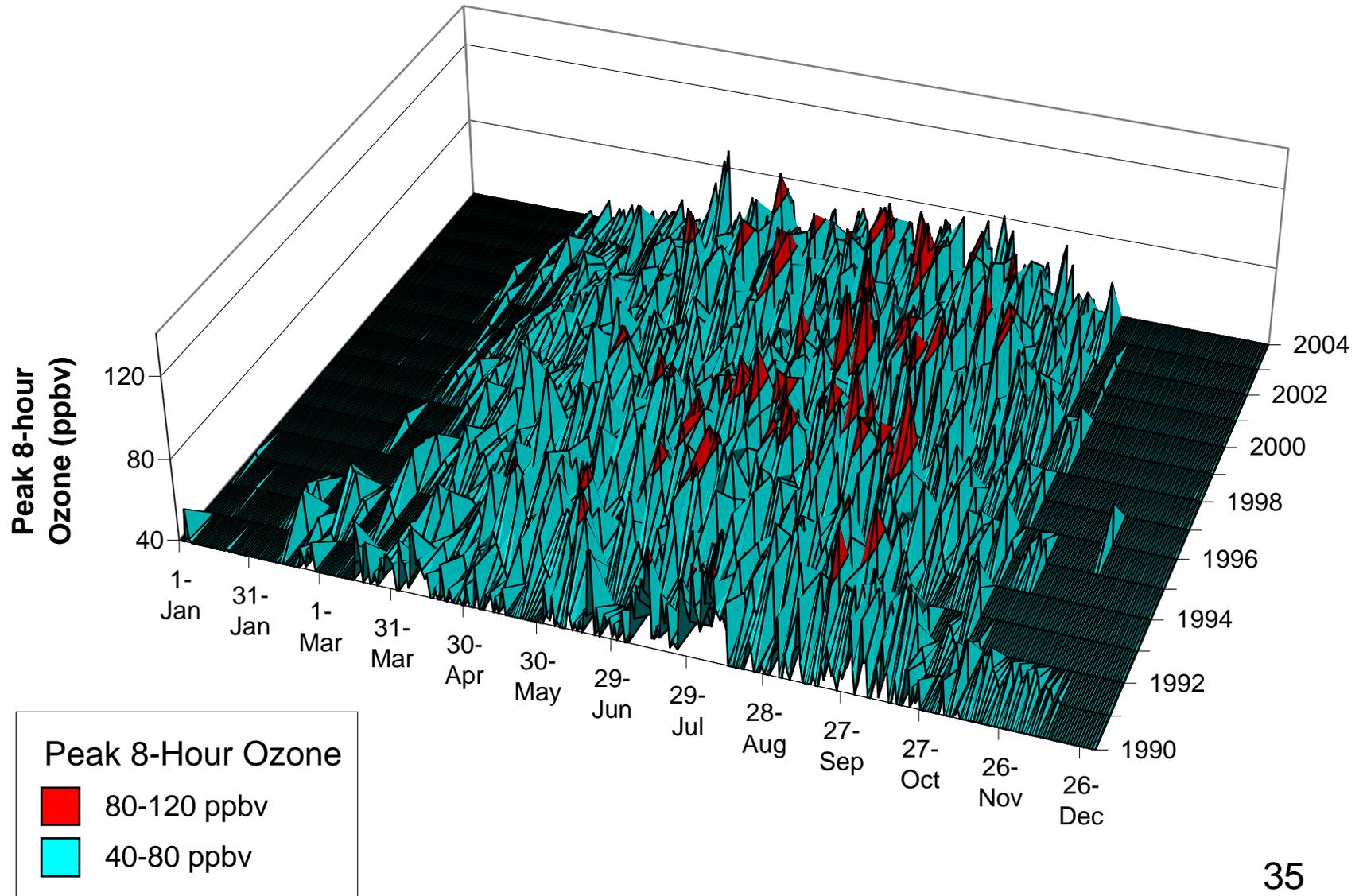
Diesel NOx emissions have not decreased

To be determined: are there discrepancies between ambient and near-site emissions trends?

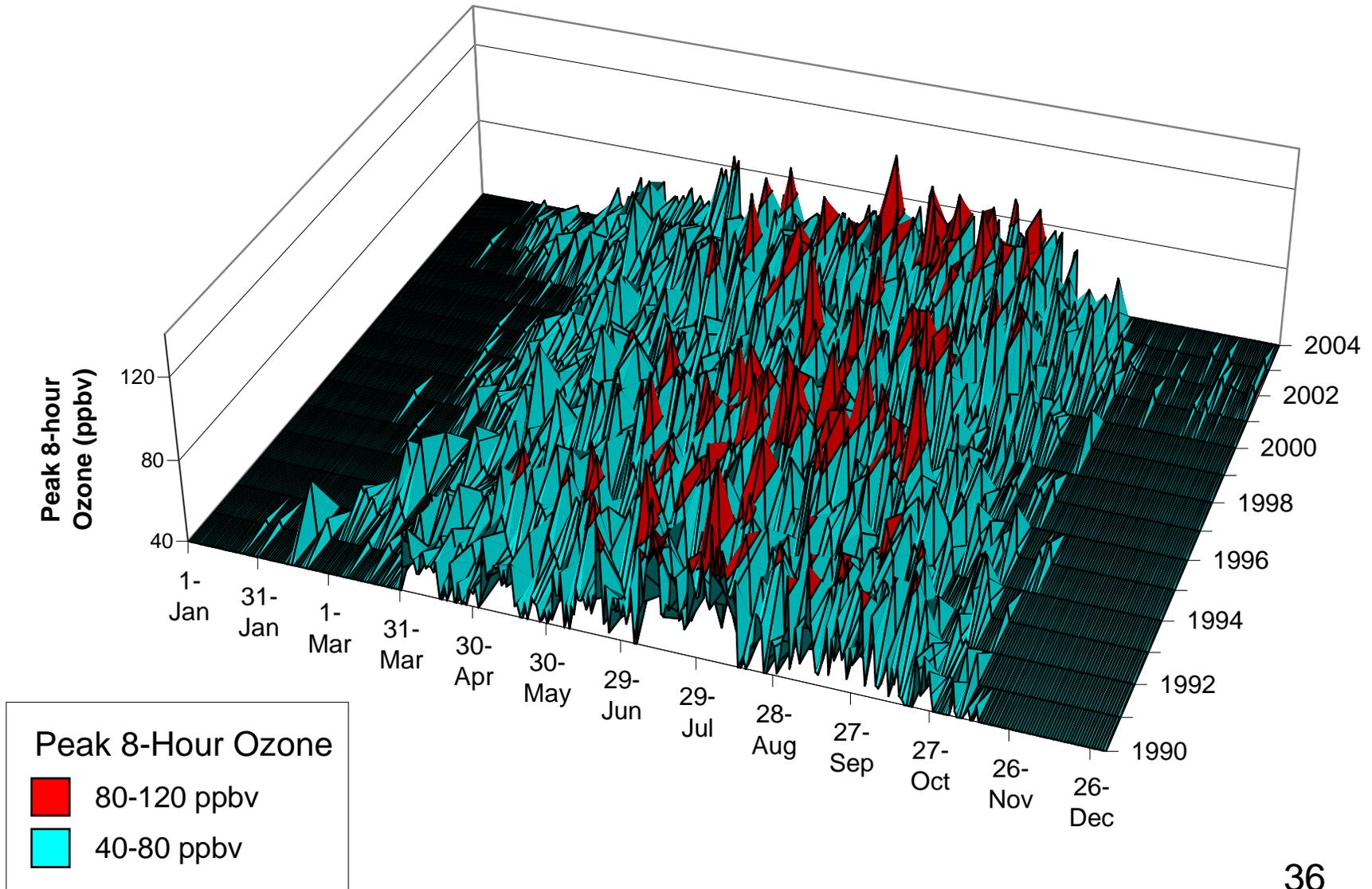
# Ozone Trends: Spatial and Temporal Patterns of Changes

Ozone concentration surfaces show changes in frequencies of high-ozone days over time – but some sites show more high-ozone days in later years

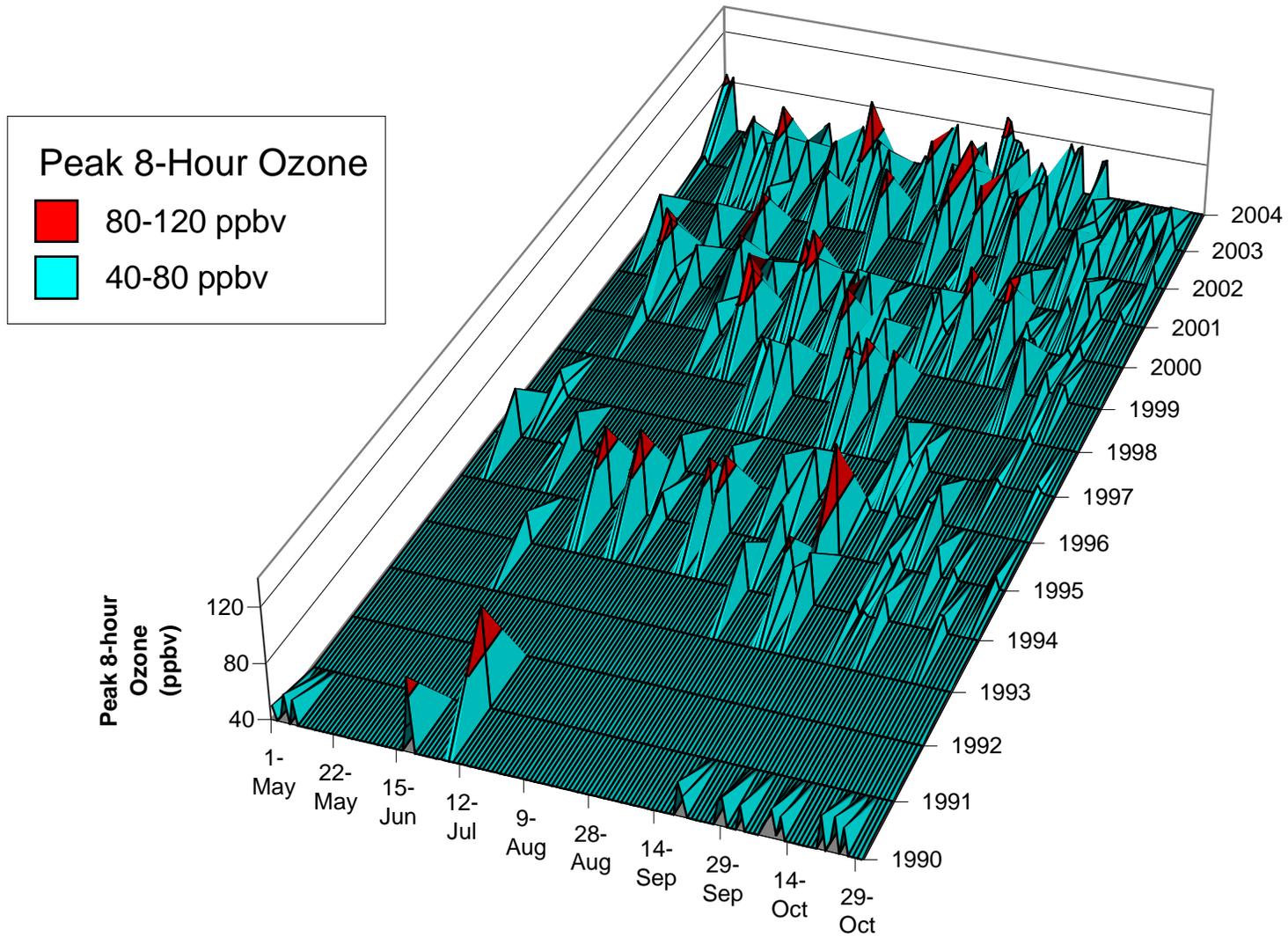
# North Highlands Ozone



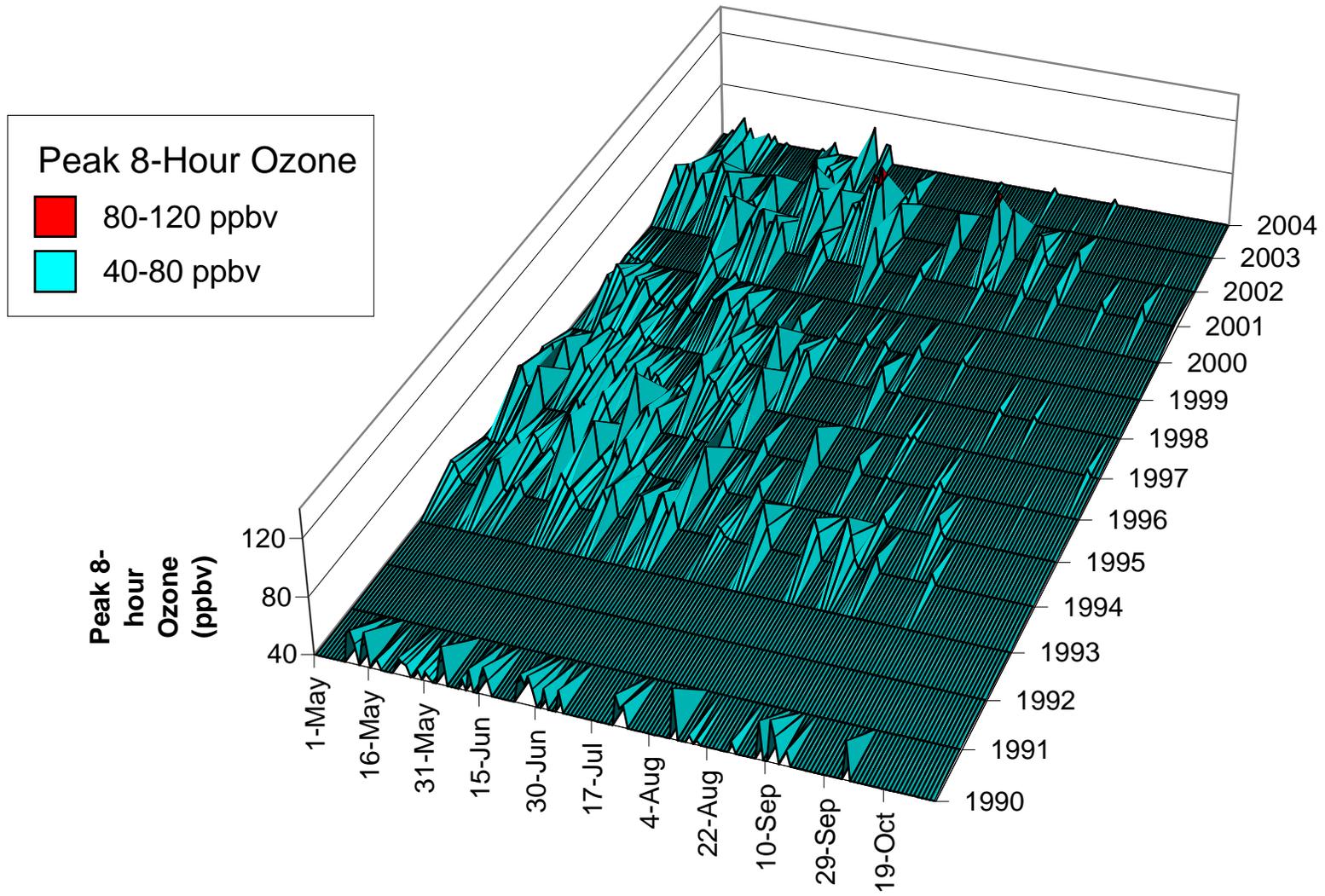
# Sacramento-Del Paso Ozone



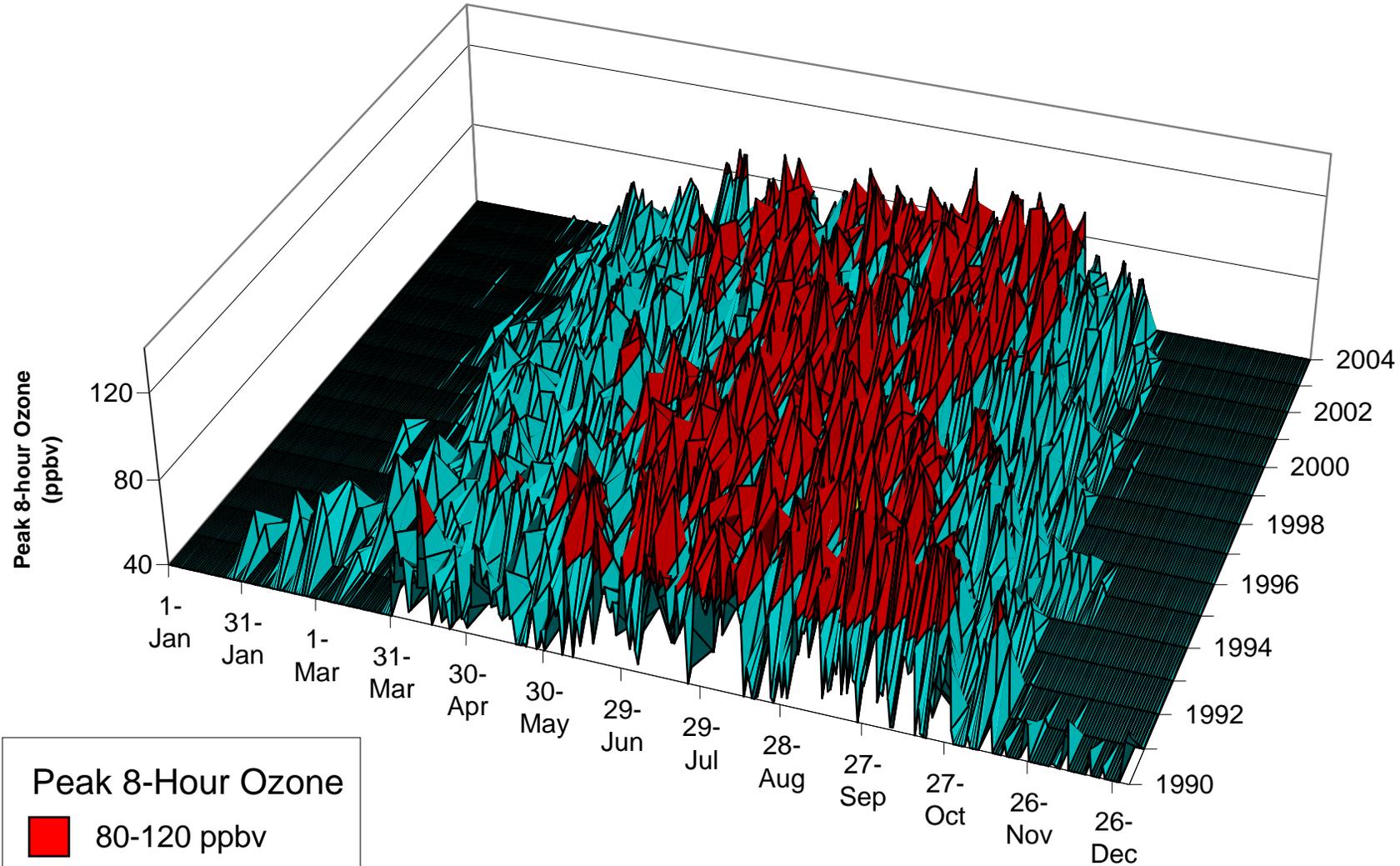
### Sacramento-Del Paso Ozone - Cluster 1



### Sacramento-Del Paso Ozone - Cluster 3



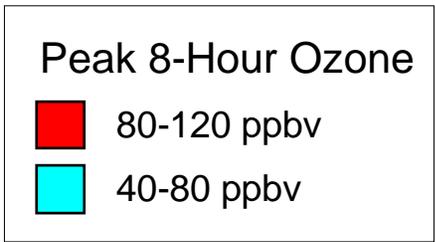
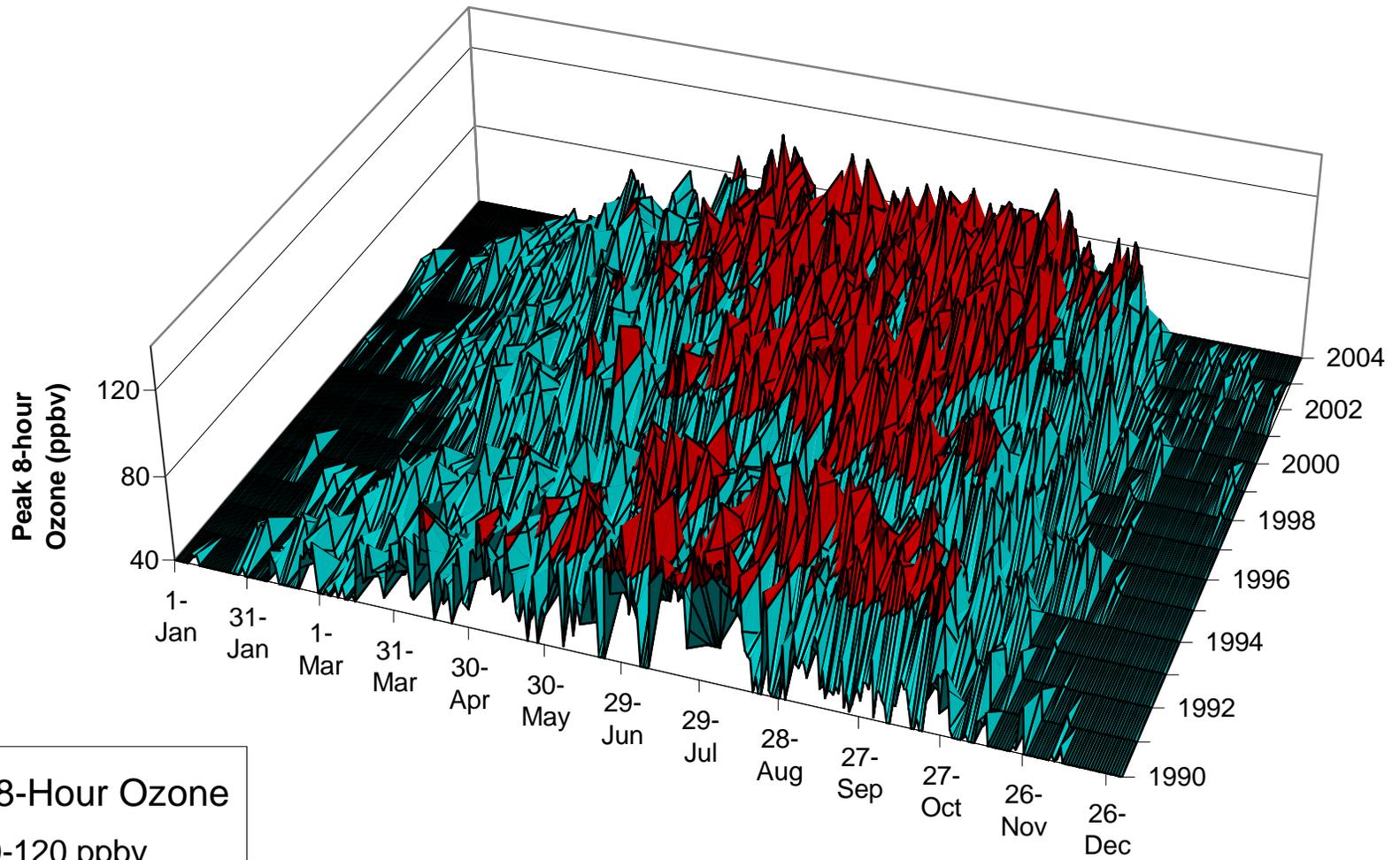
# Fresno 1st Street Ozone



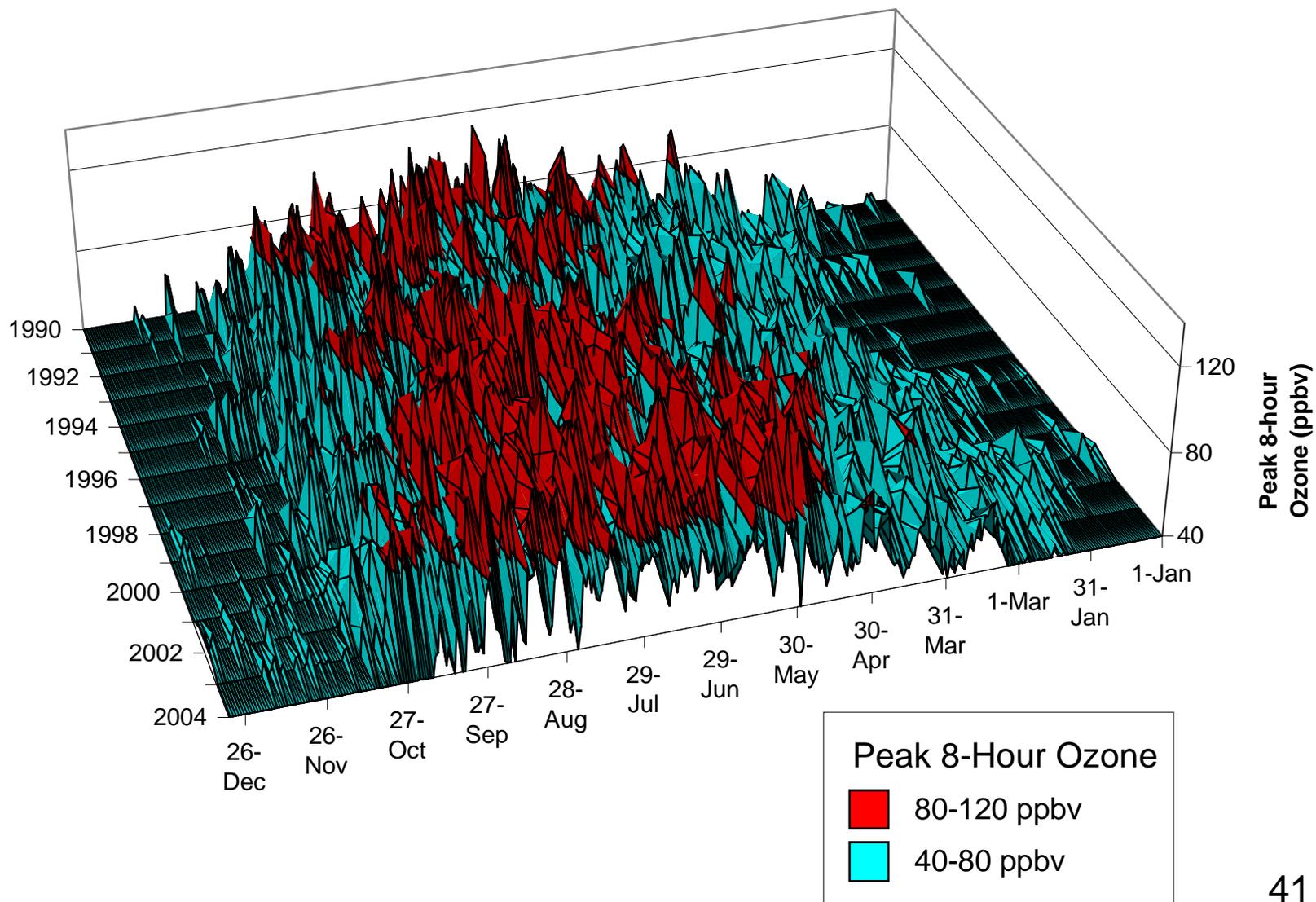
**Peak 8-Hour Ozone**

- 80-120 ppbv
- 40-80 ppbv

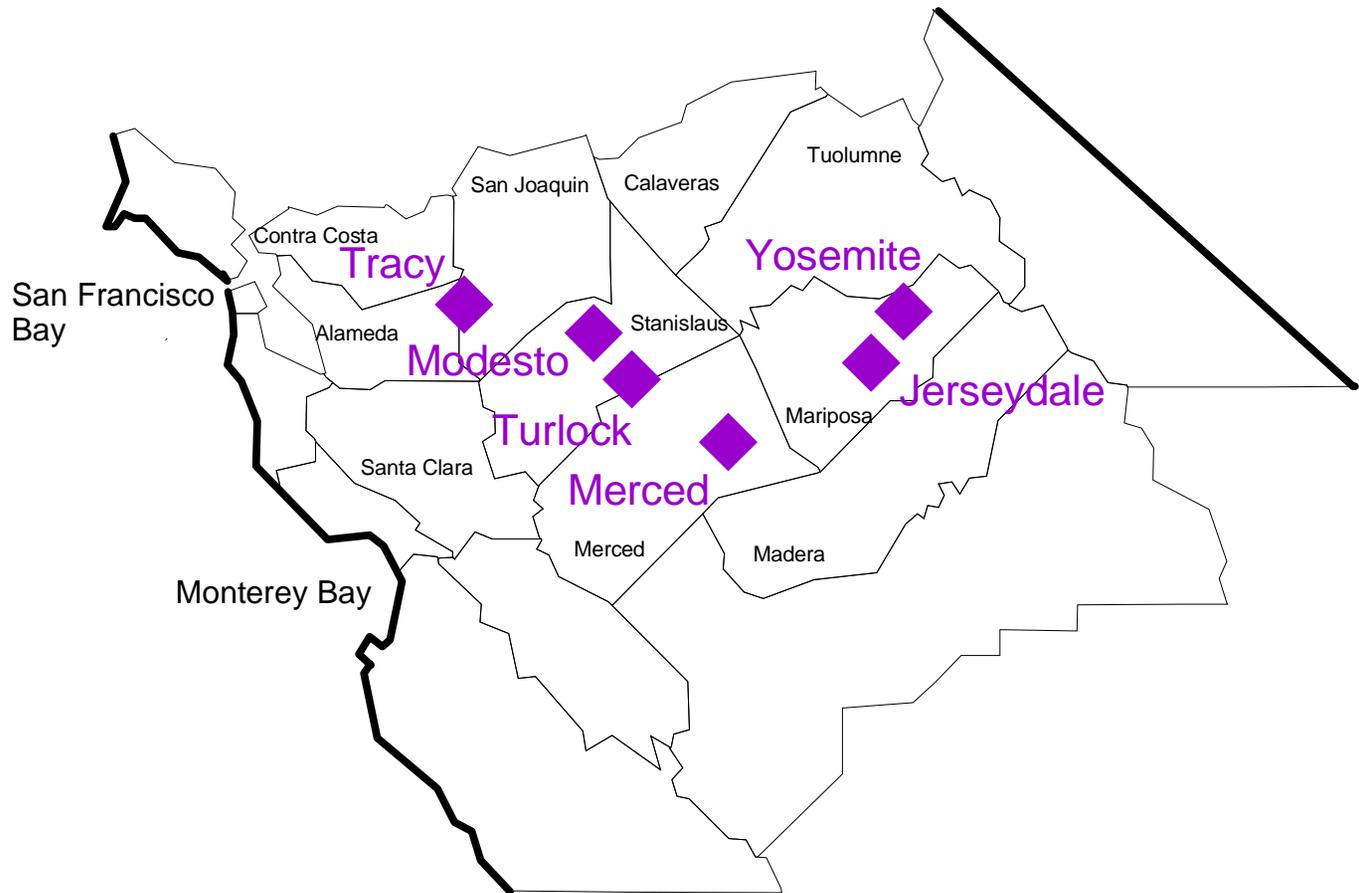
# Parlier Ozone



# Parlier Ozone



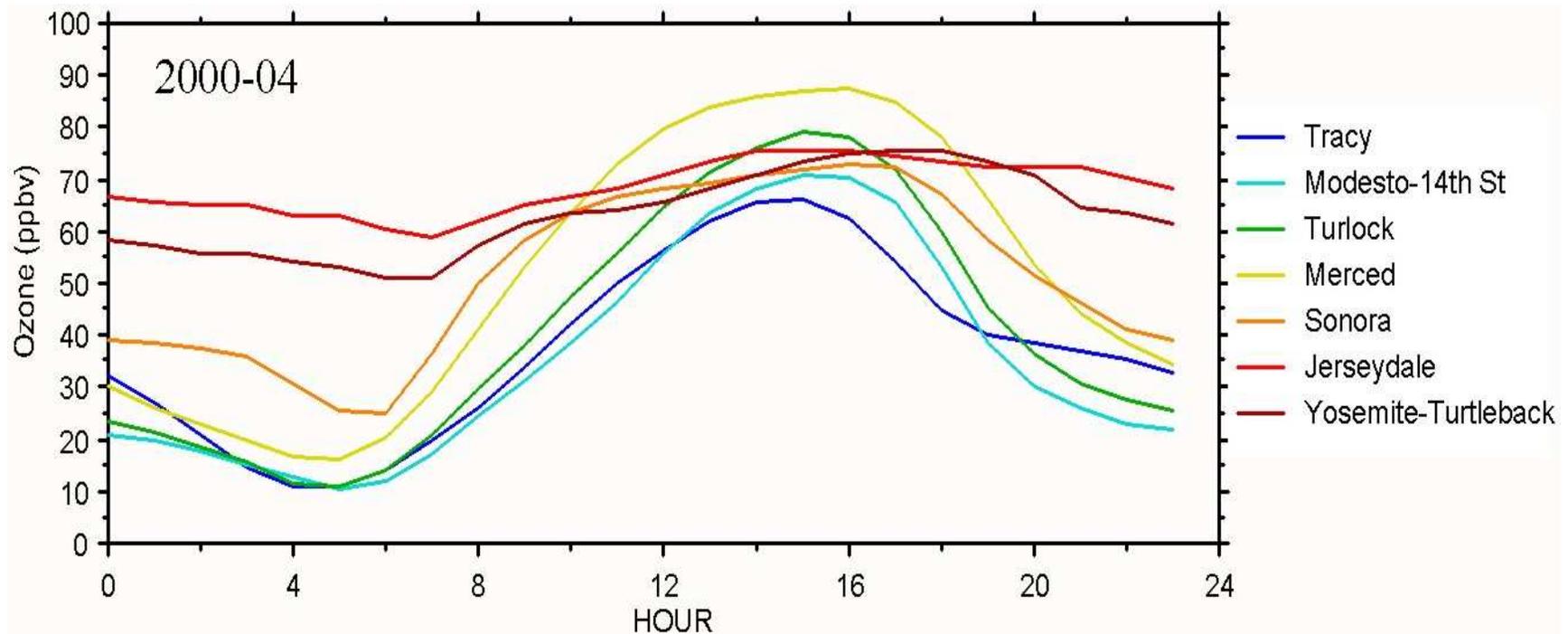
# From Tracy to Yosemite .....



.....a transect analysis

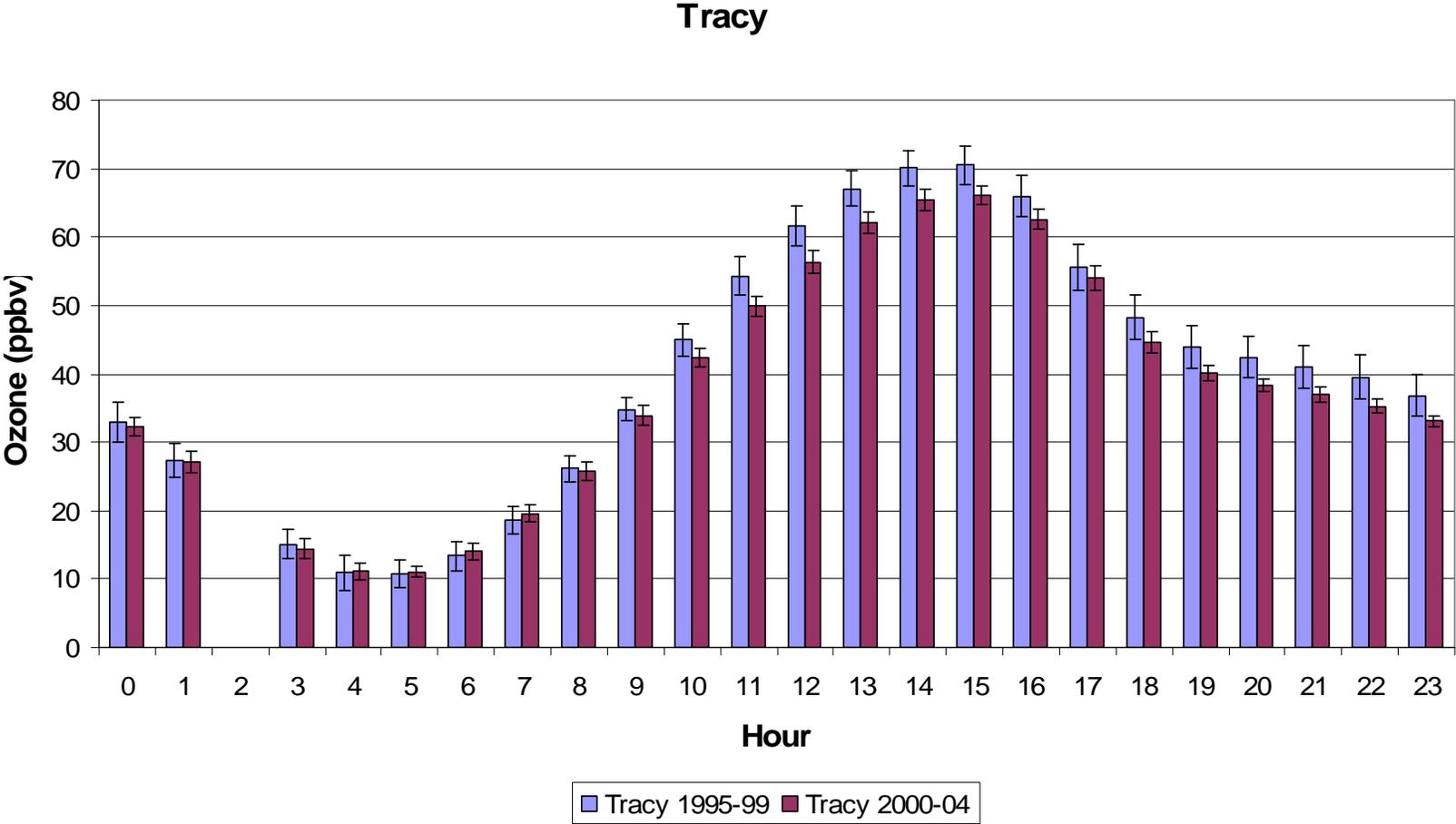
Peak ozone increases from Tracy to Merced, then declines ...

Jerseydale and Yosemite are less influenced by fresh emissions

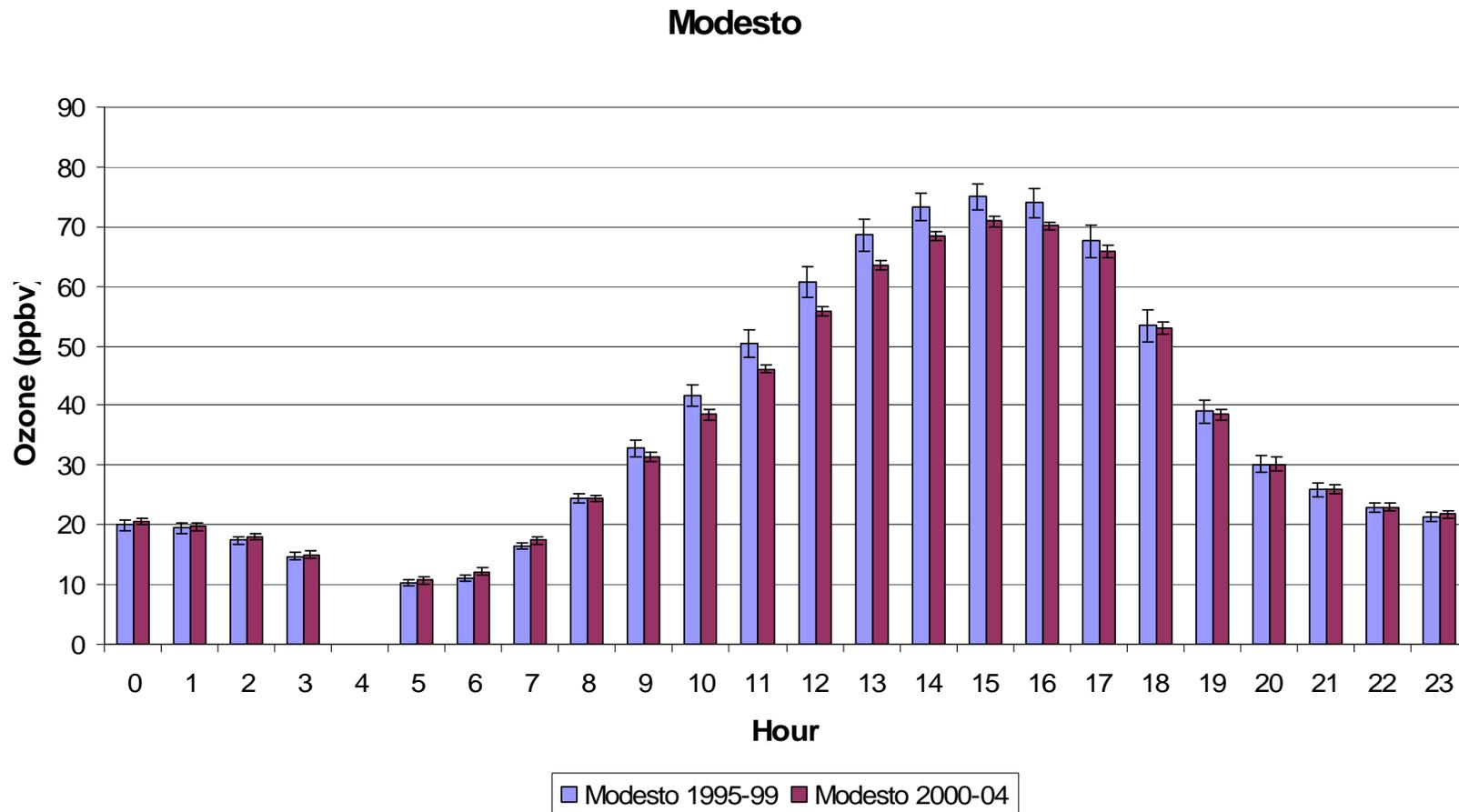


Means by hour, determined from top 60 peak ozone days

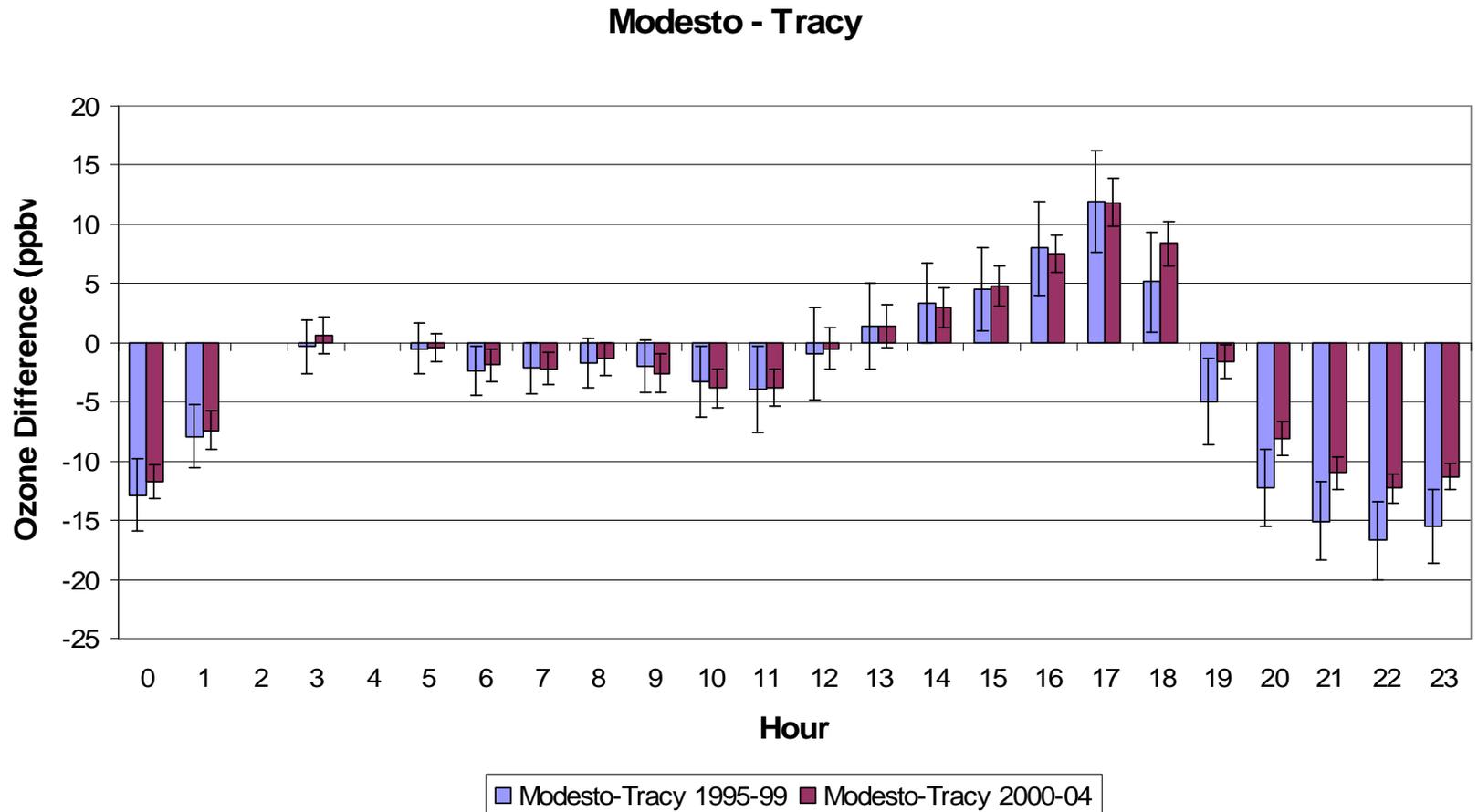
# Mean ozone at Tracy declines between 1995-99 and 2000-2004 during almost all hours



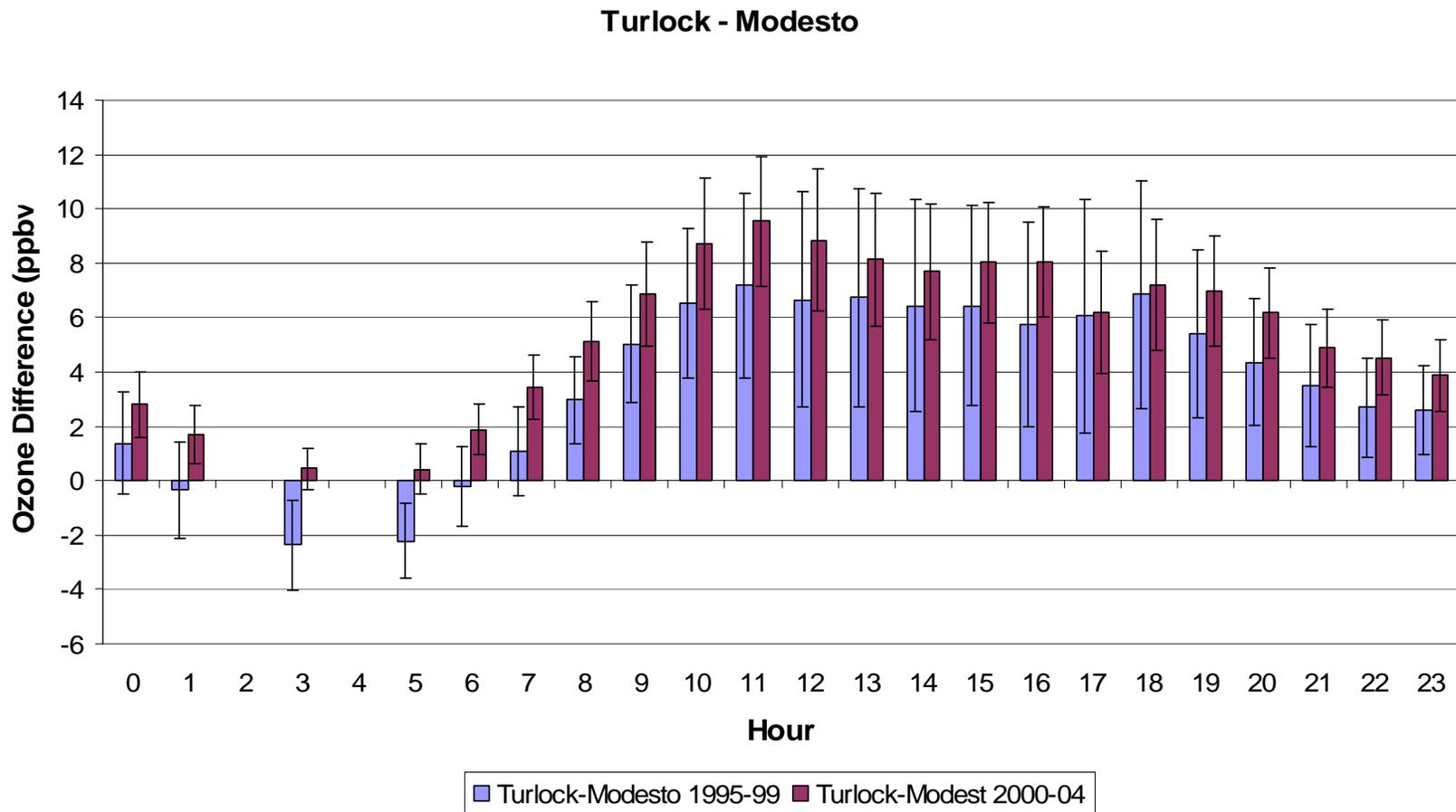
Also, mean ozone at Modesto declines between 1995-99 and 2000-2004 from 8 am through 7 pm



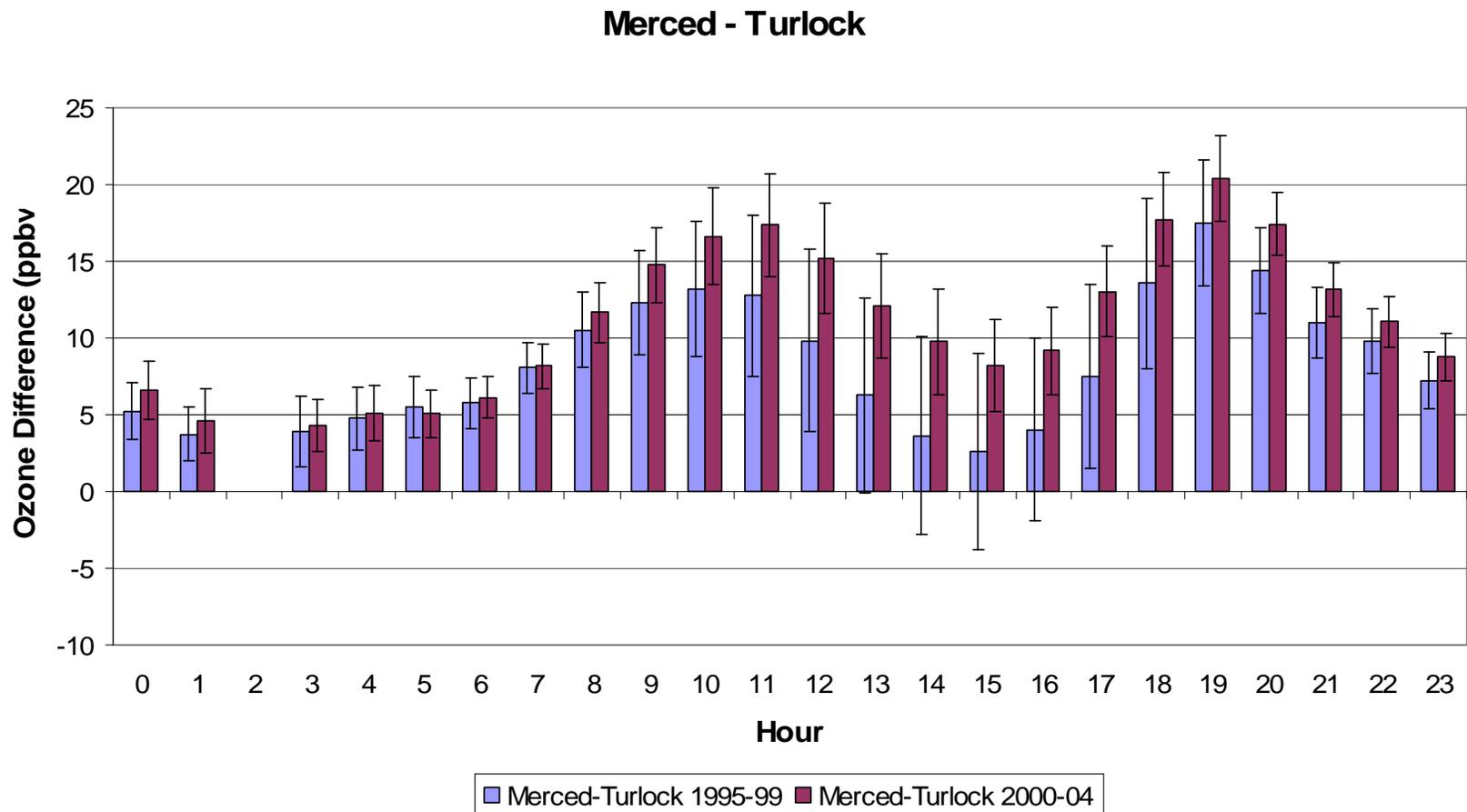
And ... Modesto-Tracy differences similar between 1995-99 and 2000-2004 (except from 6 am through 11 pm)



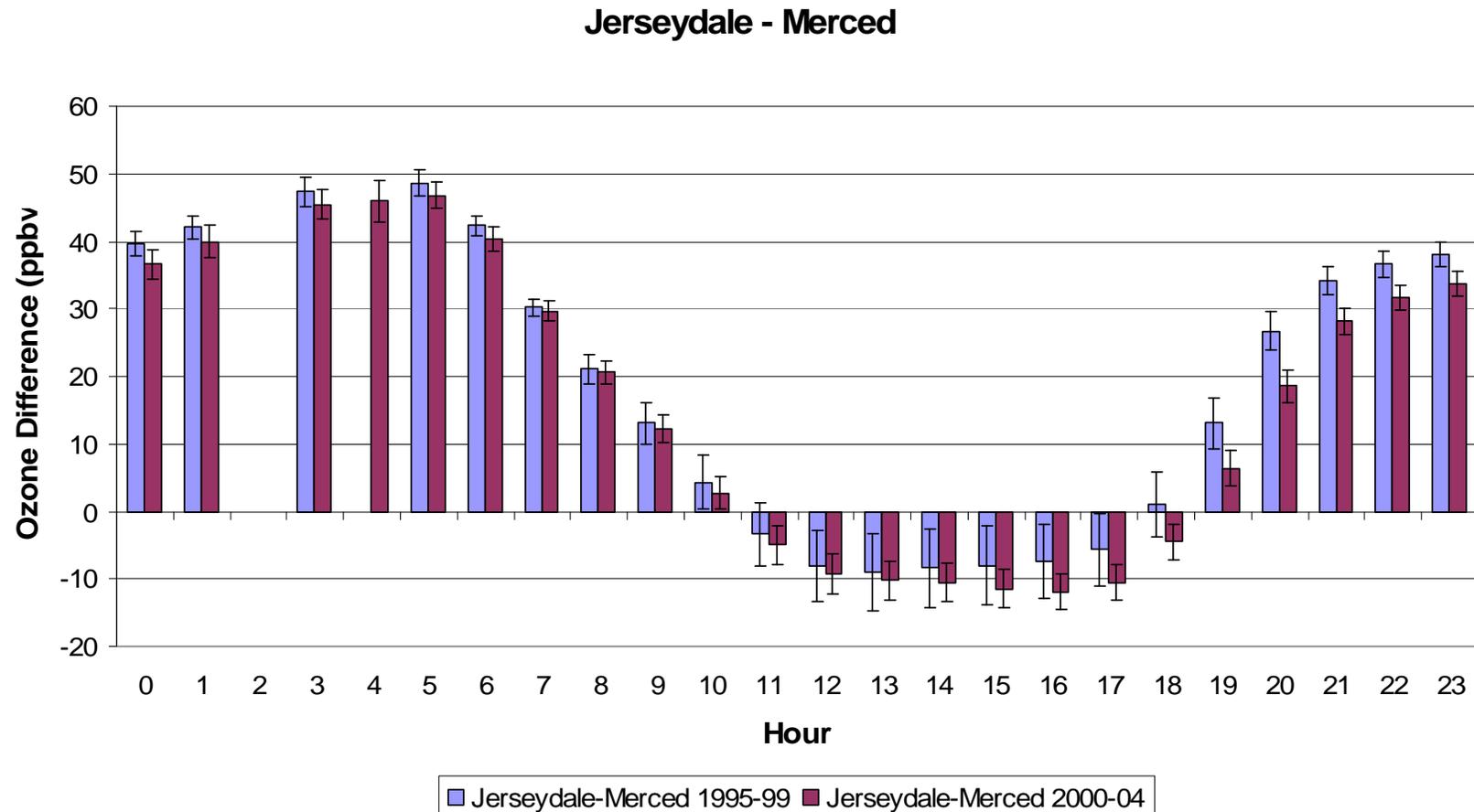
But ... the Turlock-Modesto difference increases between 1995-99 and 2000-2004 during all hours



And ... the Merced-Turlock difference increases between 1995-99 and 2000-2004 during almost all hours



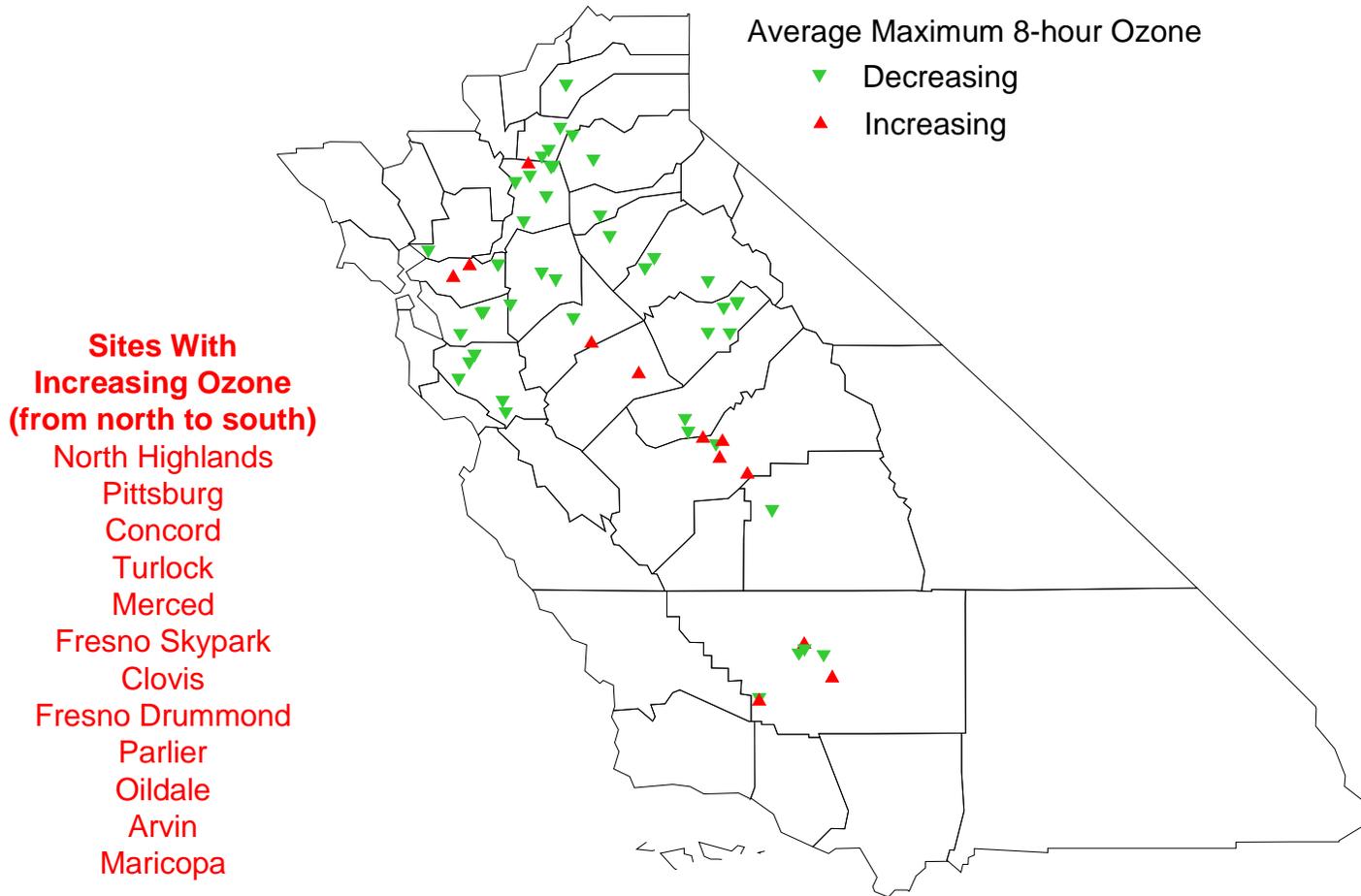
Yet ... the Jerseydale-Merced difference declines between 1995-99 and 2000-2004 during all hours



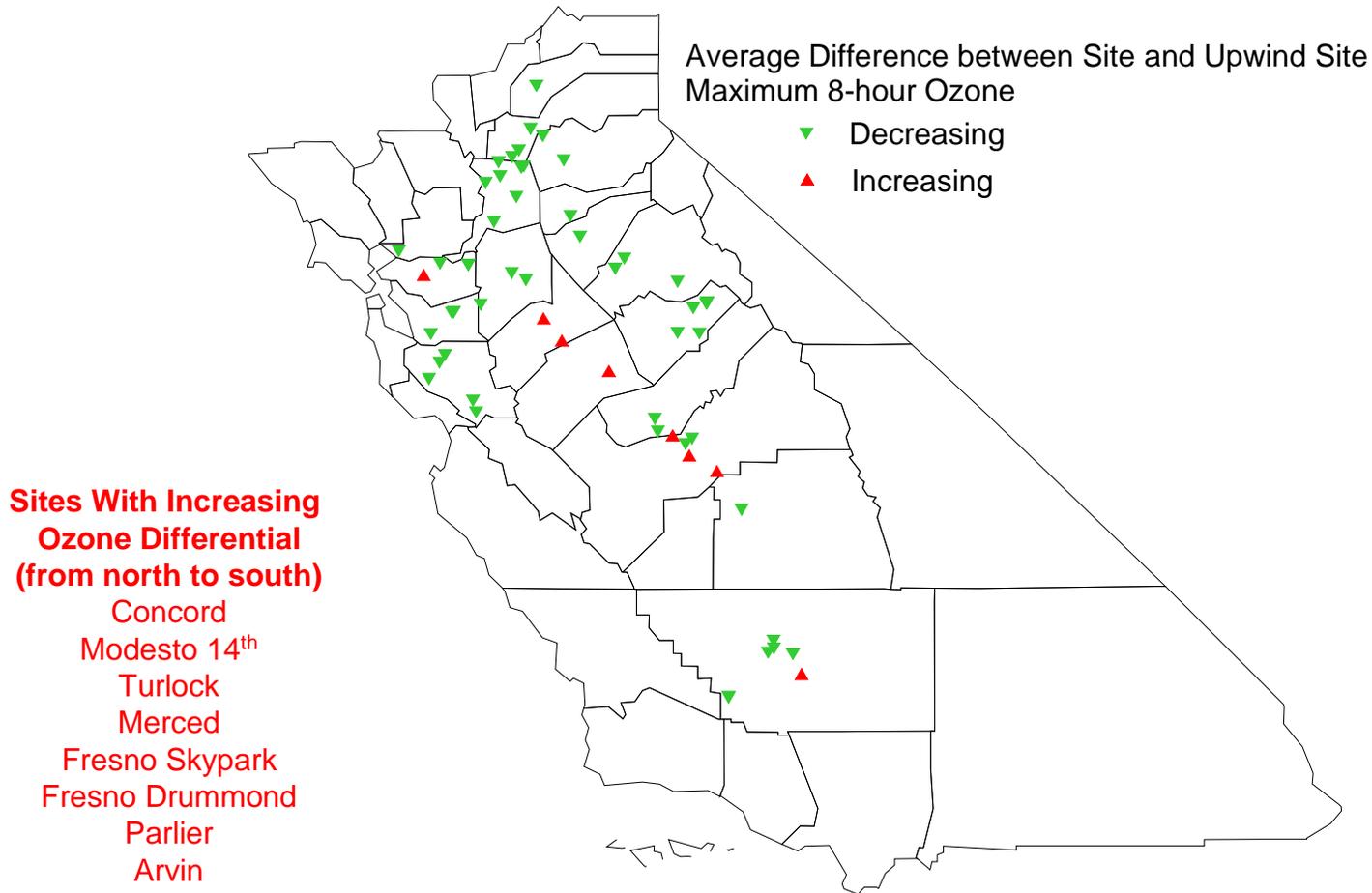
# How Does Northern SJV Ozone Formation In 2000-04 Compare With 1995-99?

- Lower at western boundary – ozone declined at Tracy and Modesto
- Decreased overall – indicated by declines at Jerseydale - reflect outflow and probably also aloft concentrations
- Increased within parts of the northern SJV – as shown by intersite differences that are larger in later years

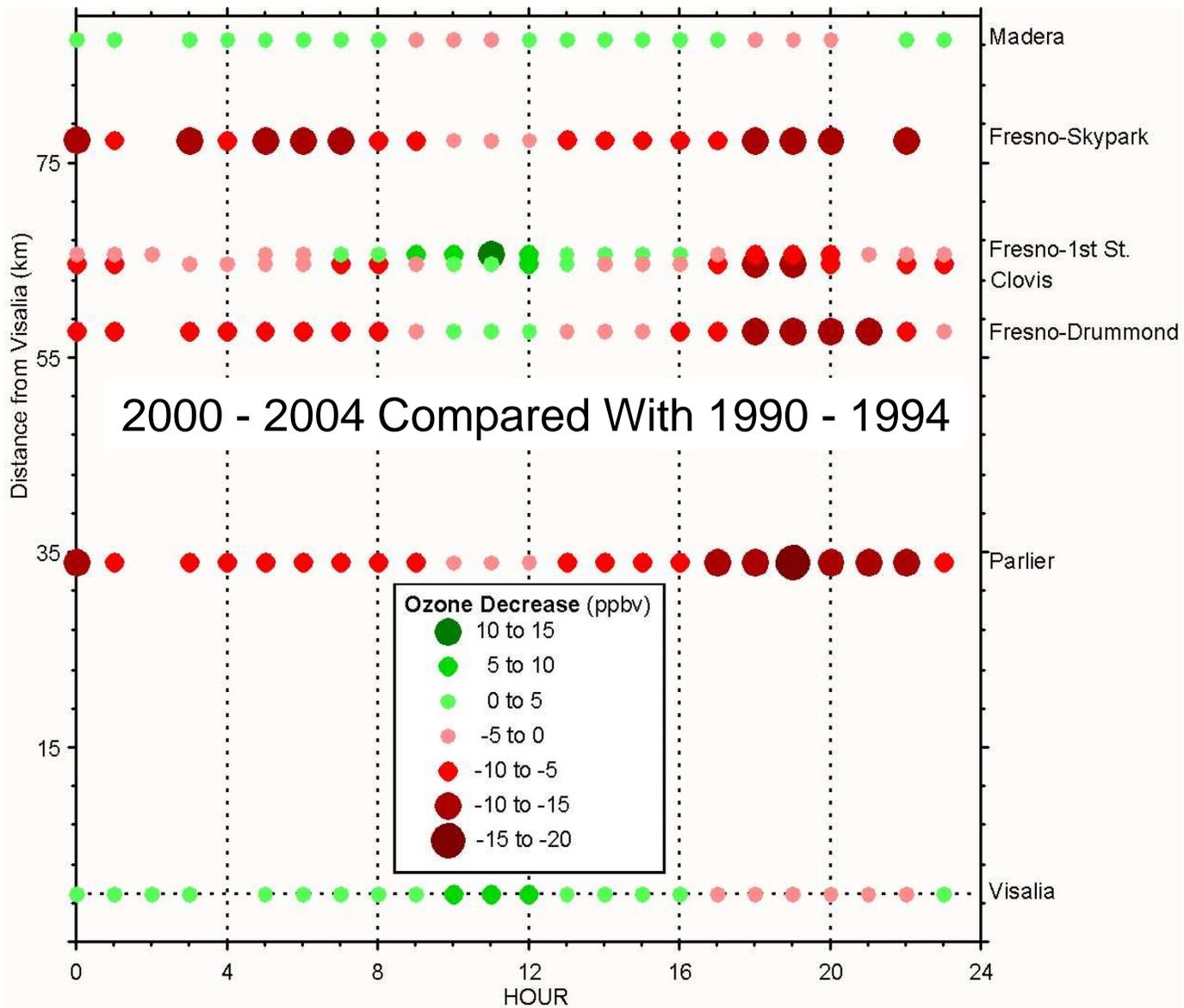
# Mean Peak Ozone In 2000-04 and 1990-94

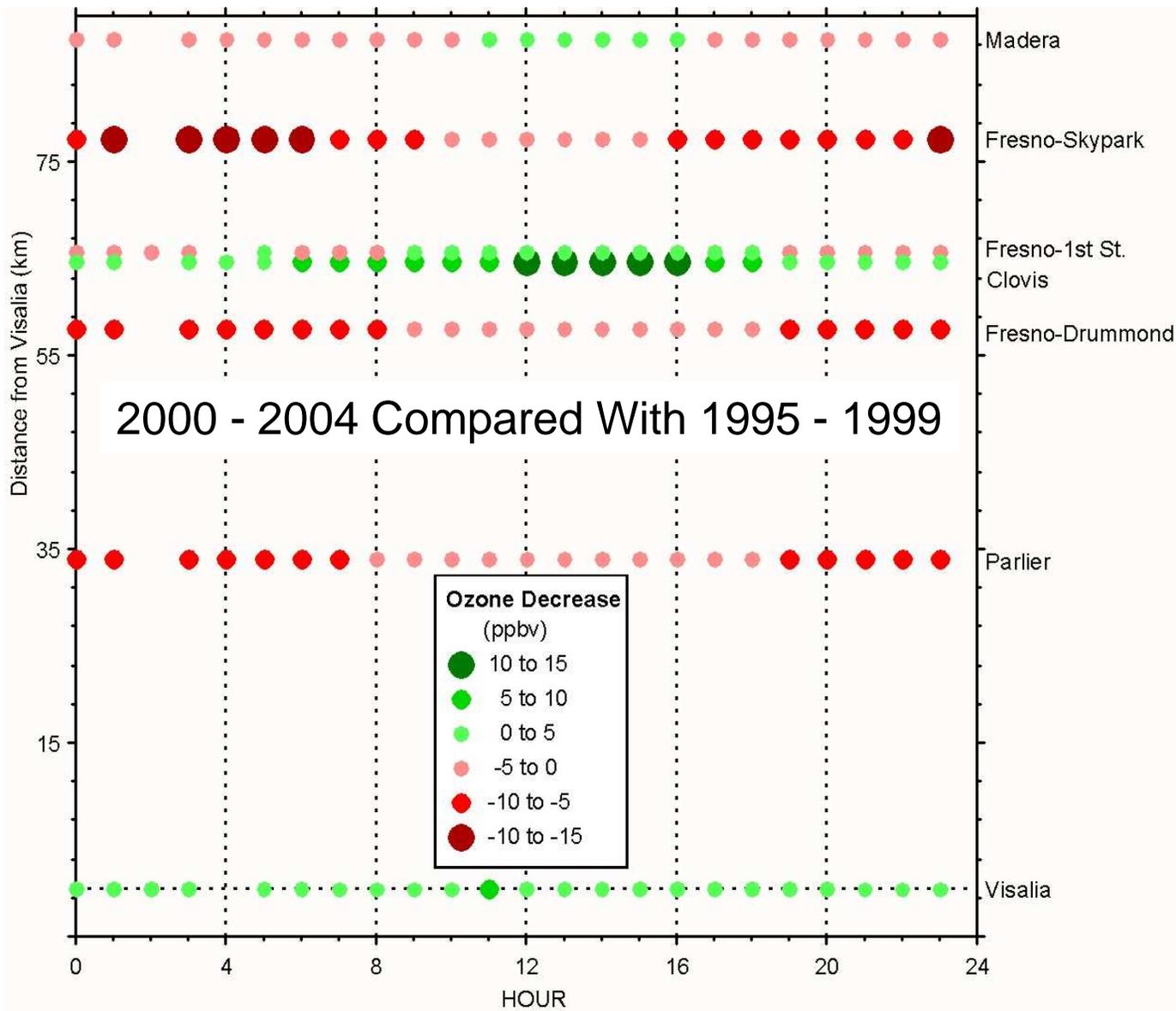


# A Double Difference: Mean Peak Ozone In 2000-04 and 1990-94 at Site and at Nearest Site

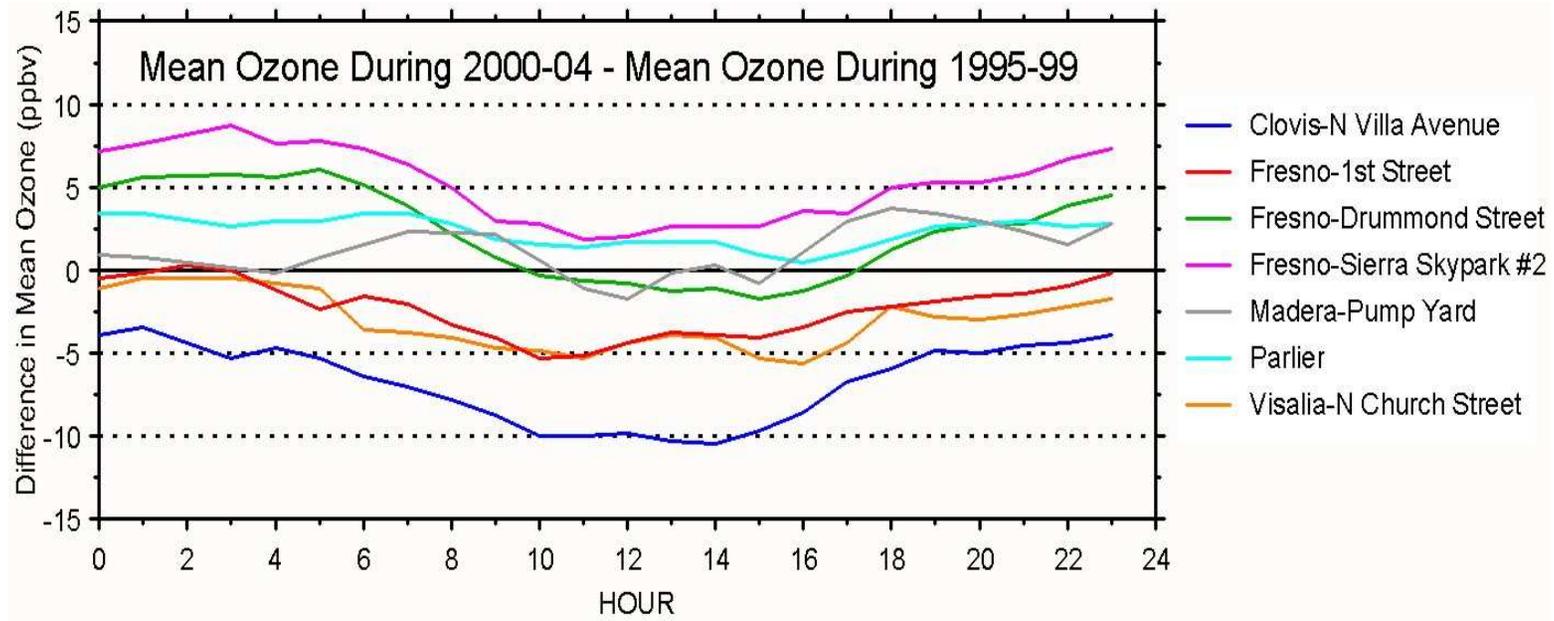


# Changes in Mean Diurnal Ozone Concentrations





# Despite localized effects, there is a subregional coherence of ozone trends



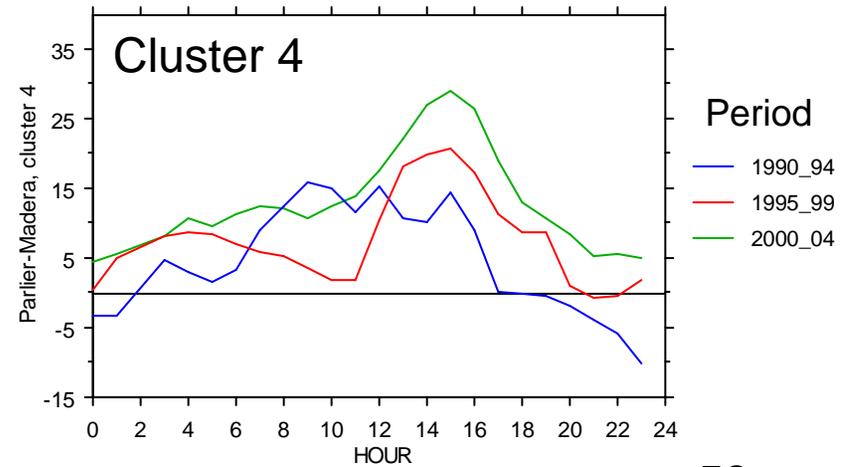
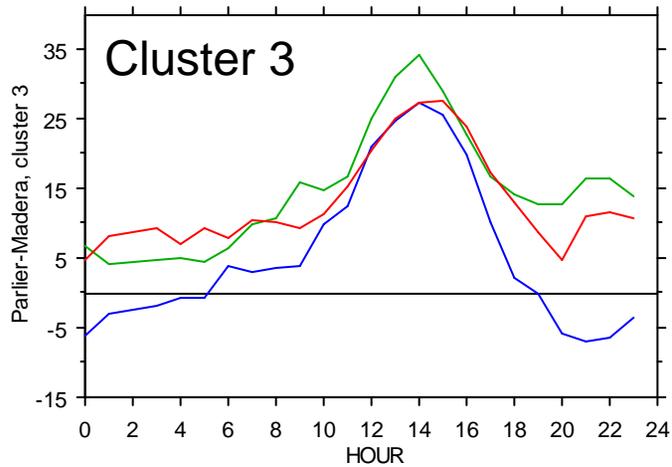
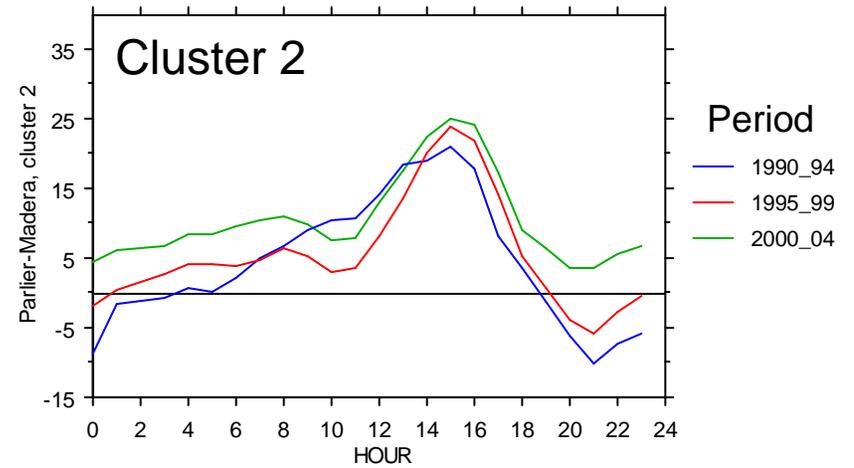
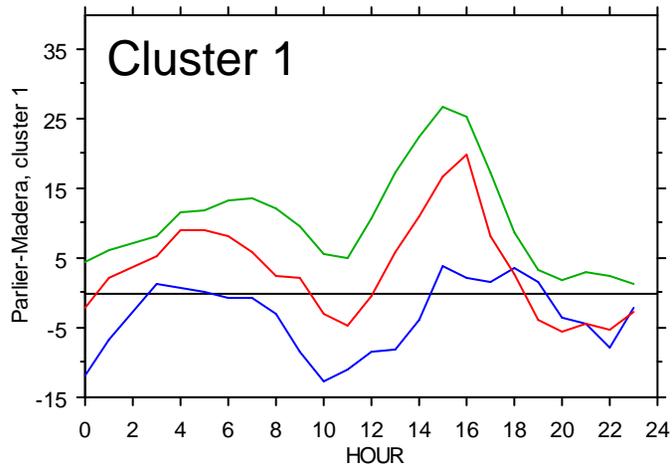
# Temporal Changes in Ozone

- Higher ozone concentrations at night during most recent years
- Higher daytime ozone concentrations at some sites interspersed between sites having lower daytime ozone
- Implies localized effects – but subregional coherence also exists

# Meteorological Variations

- Characterized ozone and precursor means by met cluster and subcluster
- Ozone trends are not explained by changes in meteorological conditions

# Differences Between Parlier and Madera Mean Ozone, By Time Period (Hourly Means, Top 60 Days)



# Ozone Trends – Preliminary Conclusions

- Overall ozone levels decreased
- Ozone formation increased in some portions of the Sacramento and central San Joaquin valleys
- These areas have experienced high growth and development
- To be continued .....

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you've seen too many slides