Understanding Relationships Between Changes in Ambient Ozone and Precursor Concentrations and Changes in VOC and NOx Emissions from 1990 to 2004 in Central California

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Today's Topics

- Project status and schedule
- AQ data acquisition and validation
- Trend analysis summary and examples
- Trends in AQ & county-level emissions
- Met data acquisition and validation
- Next steps

Project Status and Schedule

- Phase I
  - Delayed by compilation of meteorological databases
  - Databases and basic AQ trends complete
  - County emissions updated with EMFAC2007
  - Preliminary directional transport analysis completed May 2006 but needs to be rerun with current met database
- Phase II
  - Major effort will be in creating gridded emission inventories. Will allow directional disaggregation.*
  - Six-month schedule

~~* Trend adjustment~~ ~~*Forecasting~~

AQ Data Acquisition and Validation

- NMOC Concentration and Composition
  - Needed greater spatial and temporal coverage than available in validated databases
  - Started with EPA archives. Checked against CARB data. Added air toxics data
  - Compared canister and continuous NMOC
  - Flagged samples with sum/NMOC > 1 suspect
  - Compared NMOC & species to CO and NOx
  - Compiled species ratios and composition percentages
- NOx, CO, and Ozone
  - Main issue is data completeness
  - Some issues with rounding conventions

NMOC Data

PAMS in Central California
Years with at least 75% of VOC Data

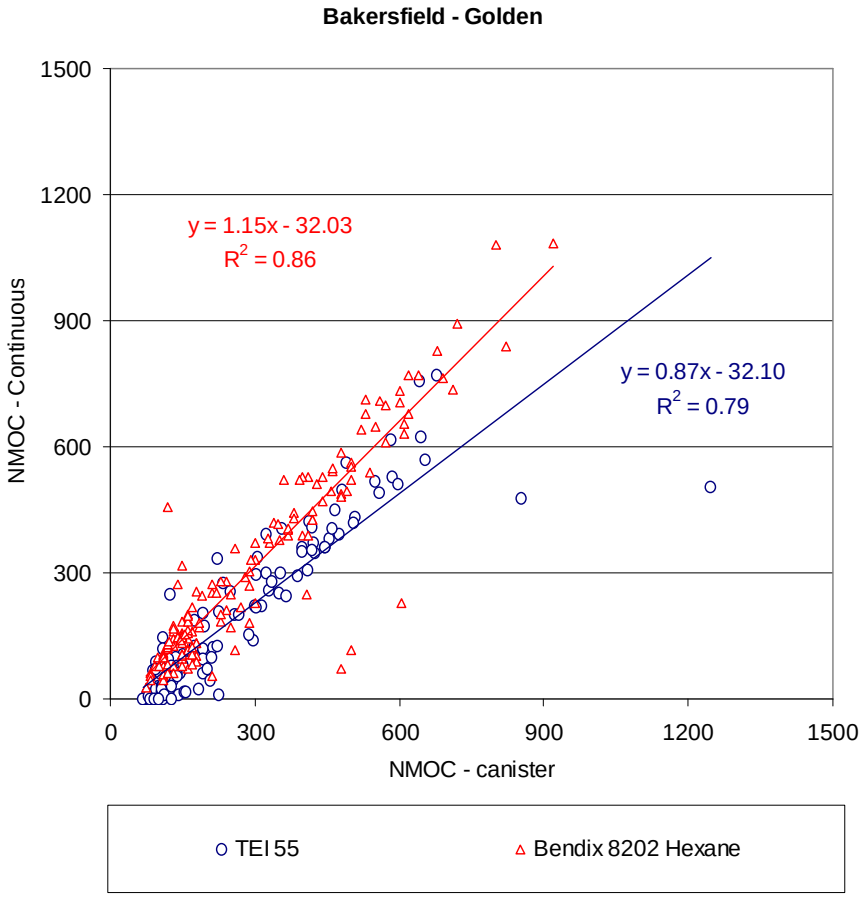
Site	Speciated Hydrocarbons [a]	Carbonyl Compounds [b]	Continuous NMOC [c]		
			Method 11	Method 160/161/162	Method 164
Sacramento					
Elk Grove-Bruceville	1996-2000		1996-2000		2000-04
Sacramento-Airport Rd.	1998-2000	1998-2000			
Sacramento-Del Paso	1994-2003	1998-2000	1996-98	1994-1998	2000-04
Folsom-50 Natoma Street	1996-2003		1996-99		2000-04
Fresno					
Madera	1997-2000		1998-99	1997-98	1999-2004
Clovis Villa	1994-2004	1994-2004	1995-96		1999-2004
Fresno-1st Street	1994-2000	1996-2000		1995-1997	1997-2004
Parlier	1995-2004		1999	1997-98	1999-2004
Bakersfield					
Bakersfield-Golden	1994-2004	1996-98, 2000-04	1995-96	1996-97	1998-2004
Arvin	1995-2004				2000-04
Shafter	1998-2000				1998-2004

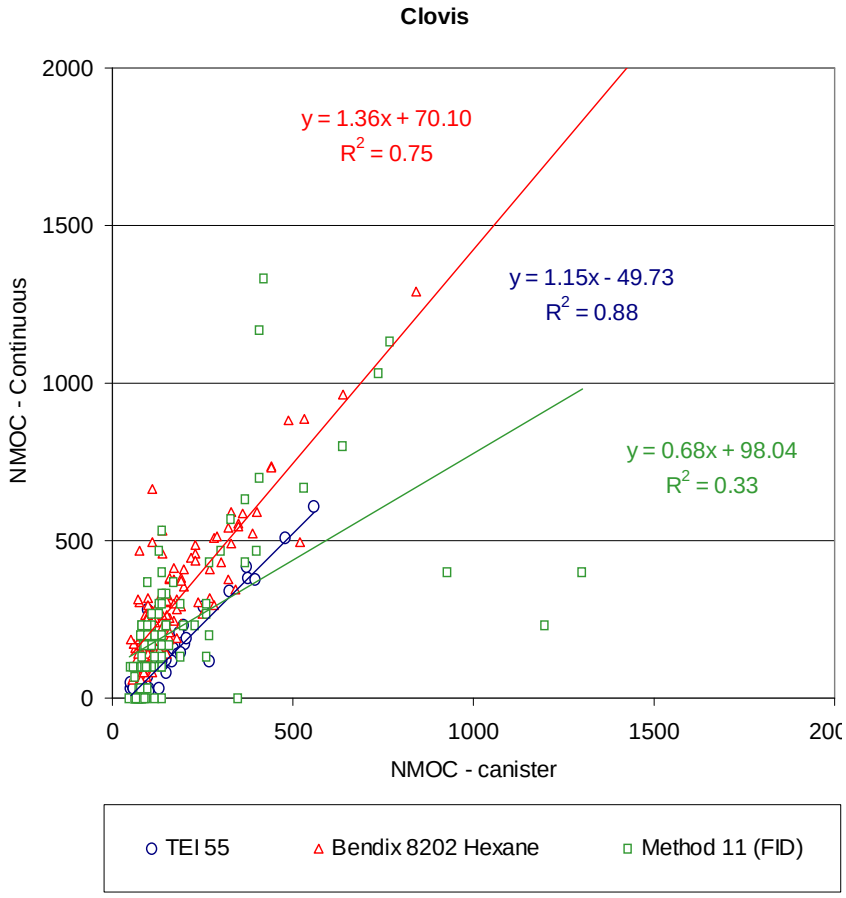
a - Canisters 3rd day (four 3-hr samples at 00, 06, 13, and 17, PDT) for PAMS species. Also TNMOC by PDFID through 2000.

b - DNPH cartridge 3rd day (four 3-hr samples at 00, 06, 13, and 17, PDT).

c - Method 11 - FID; Method 160, 61, 62 - Bendix 8202/8202A with methane, propane, or hexane calibration, respectively; Method 164 - TEI 55 (propane)

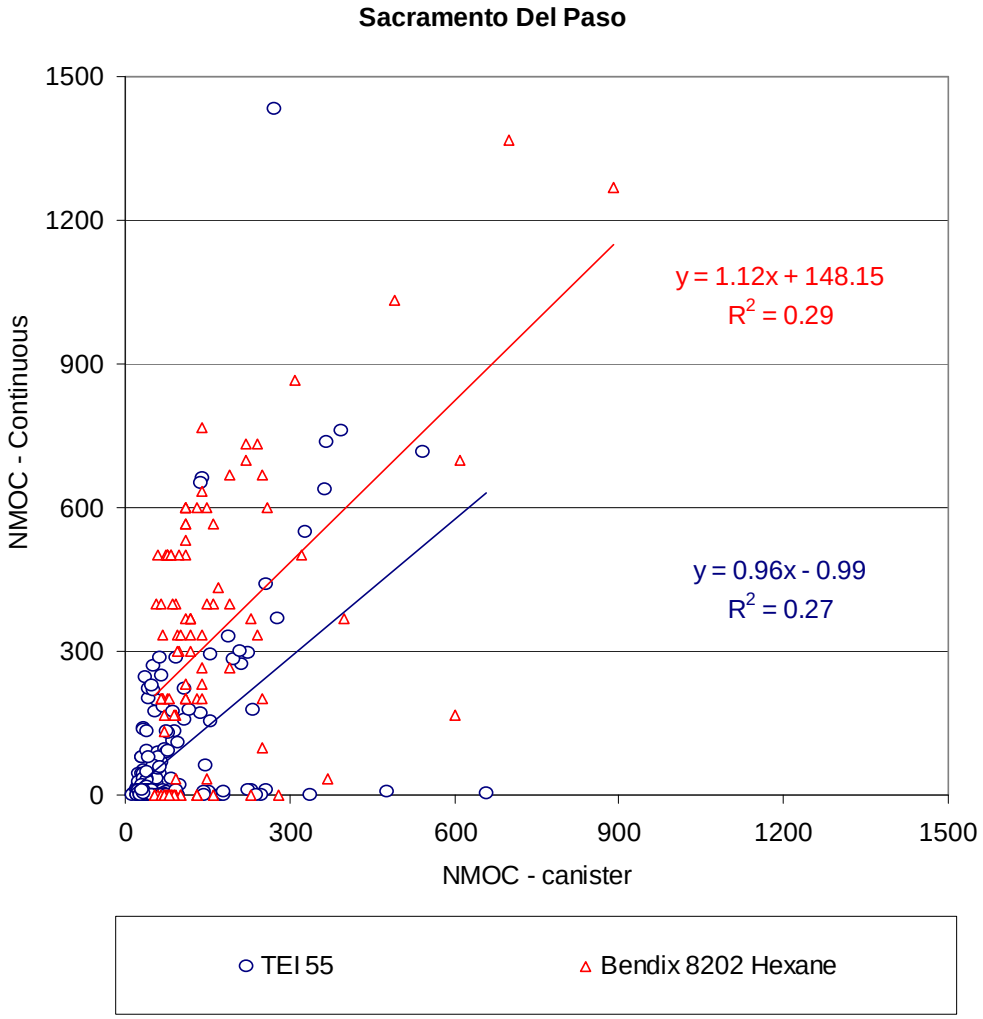
Correlations of Integrated and Continuous NMOC
Bakersfield Golden and Clovis



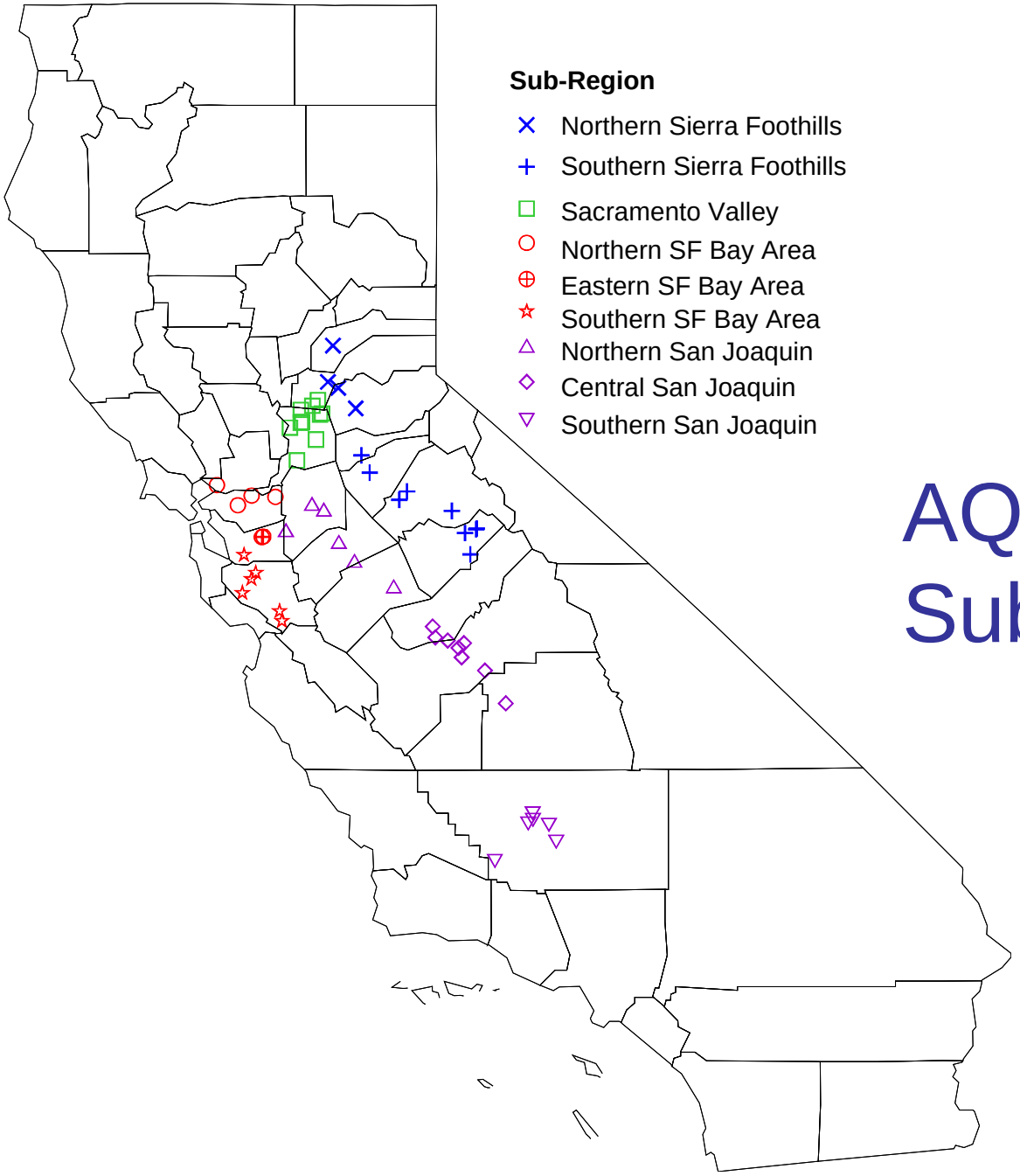


NMOC obtained by continuous methods (TEI 55) in San Joaquin Valley since 2001.

Correlations of Integrated and Continuous NMOC
Sacramento Del Paso



NMOC obtained by both integrated and continuous methods (TEI 55) in Sacramento up through 2003.



AQ Sites and Subregions

AQ Metrics

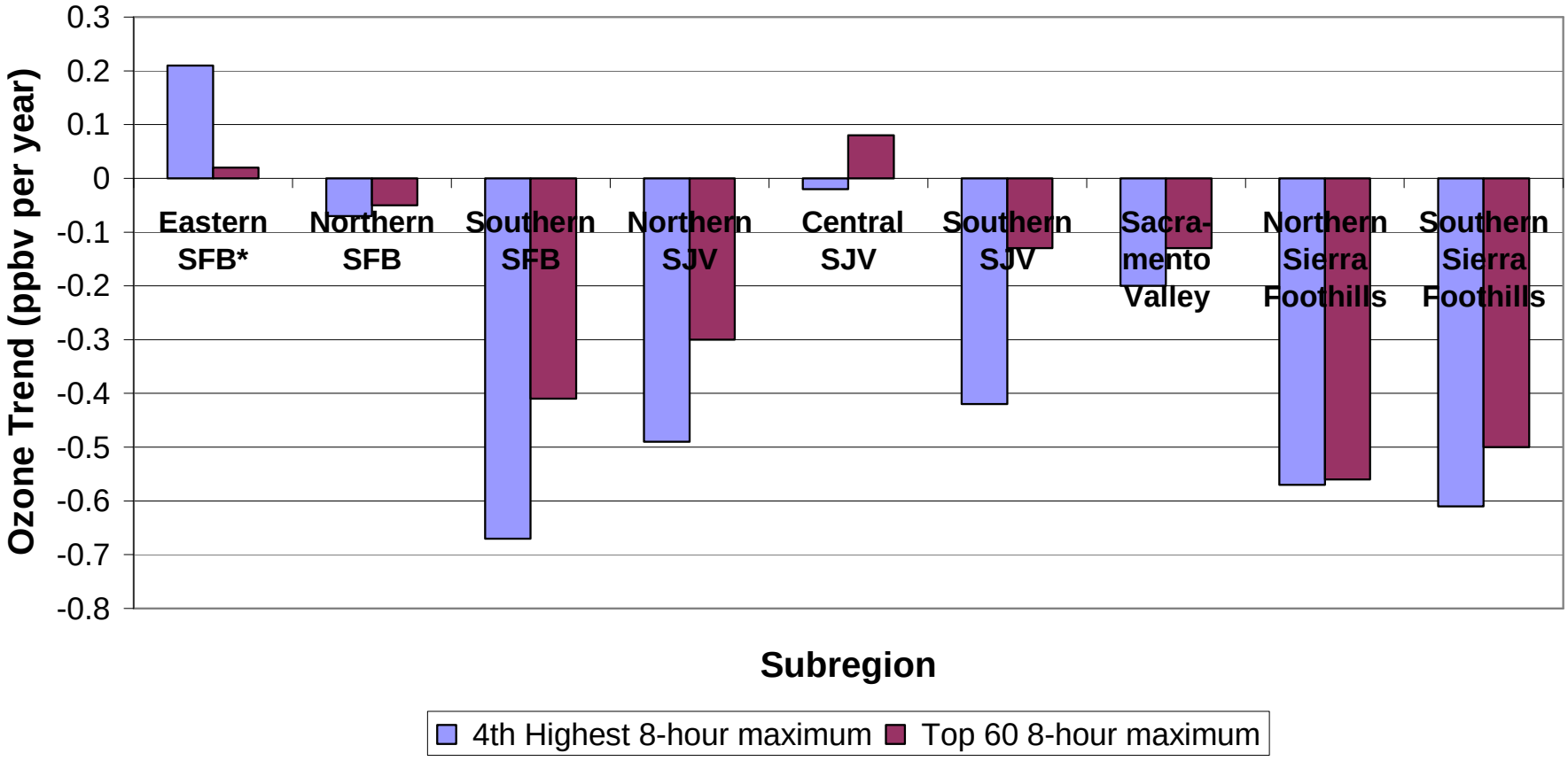
- Ozone
  - Annual 4th-highest daily 8-hour max, each site
  - Top 60 peak 8-hour days in each subregion, each year. Mean of 8-hour maxima, by site.
- CO and NOx
  - Means from Top 60 subregion days, each site
  - Morning (start hours 5 am – 10 am)
  - Time of peak 8-hour ozone maxima (“mid-day”)
- NMOC
  - Means from all days, by site and year
  - Early morning - 5 am PST - more complete sampling

AQ Trends – Summary Results

- NOx 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**
- Top 60 mean ozone trends similar to trends in annual 4th-highest 8-hour max

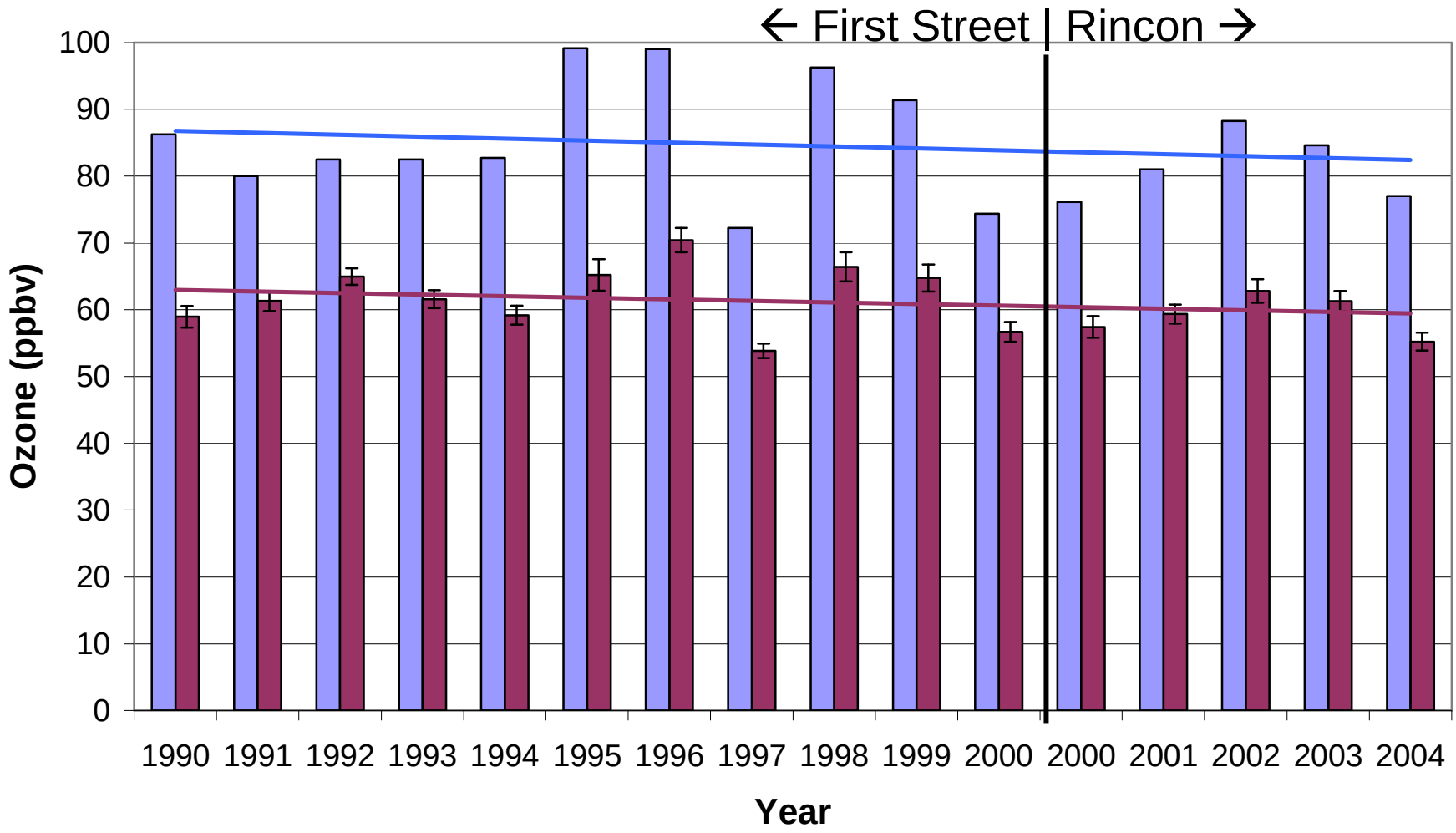
* $p < 0.05$
** At least 10 years data
*** 7 - 10 years data

Ozone Trends in Subregions - Medians of Site Trends

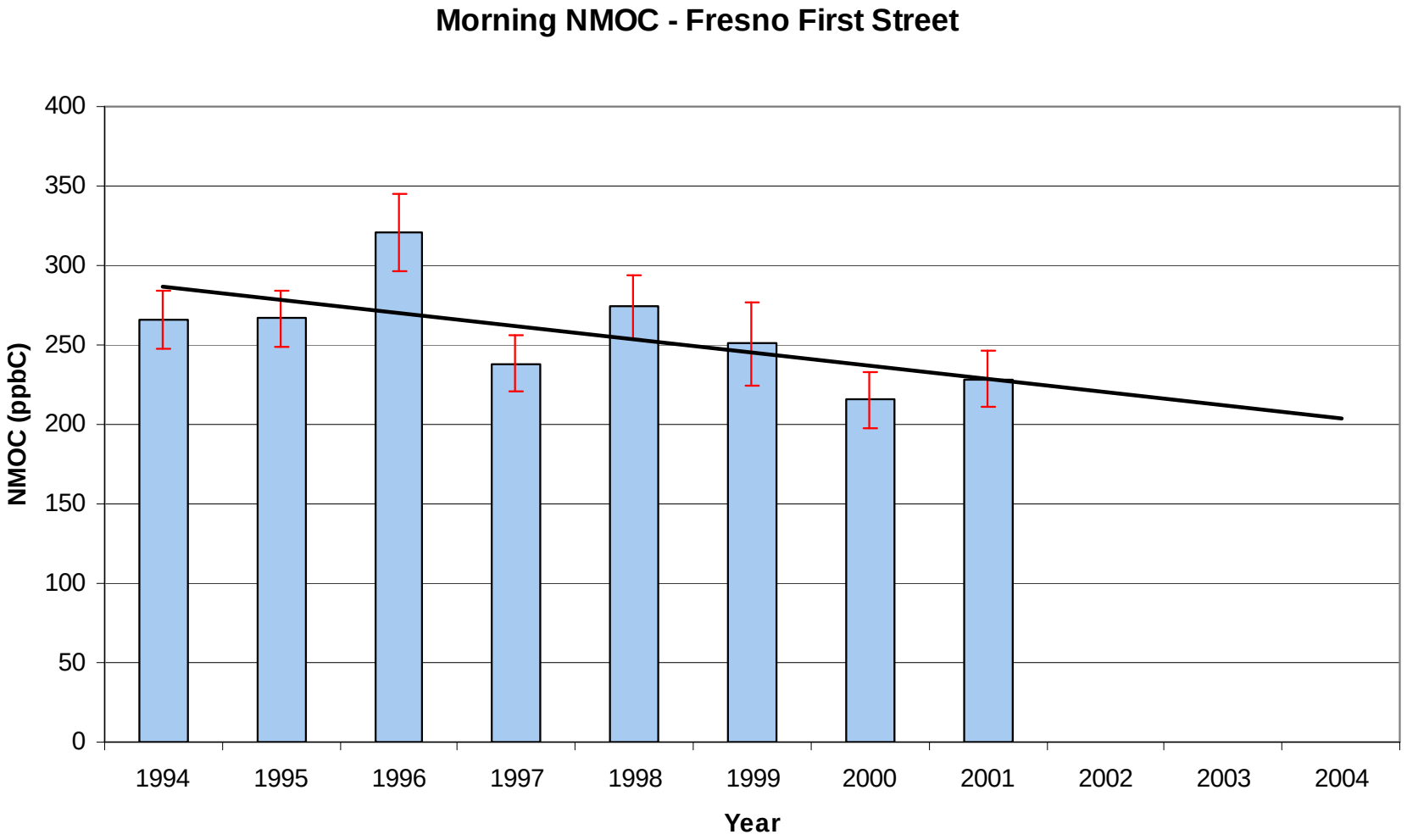


* Livermore 1st St only

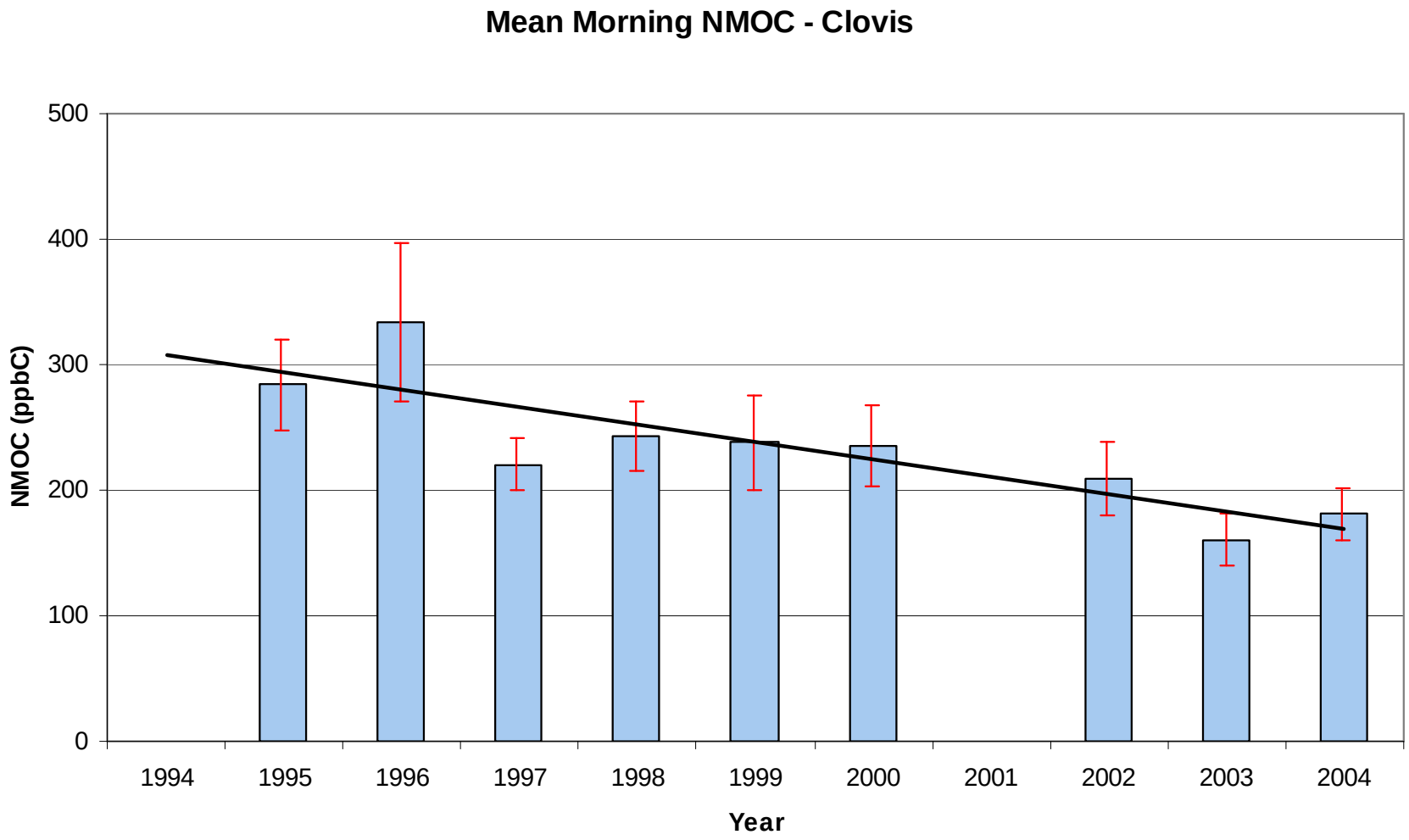
Livermore Annual 4th-Highest 8-Hour Ozone and Mean of Top 60 Subregional Days



AQ Trends at Fresno First Street and the Central SJV

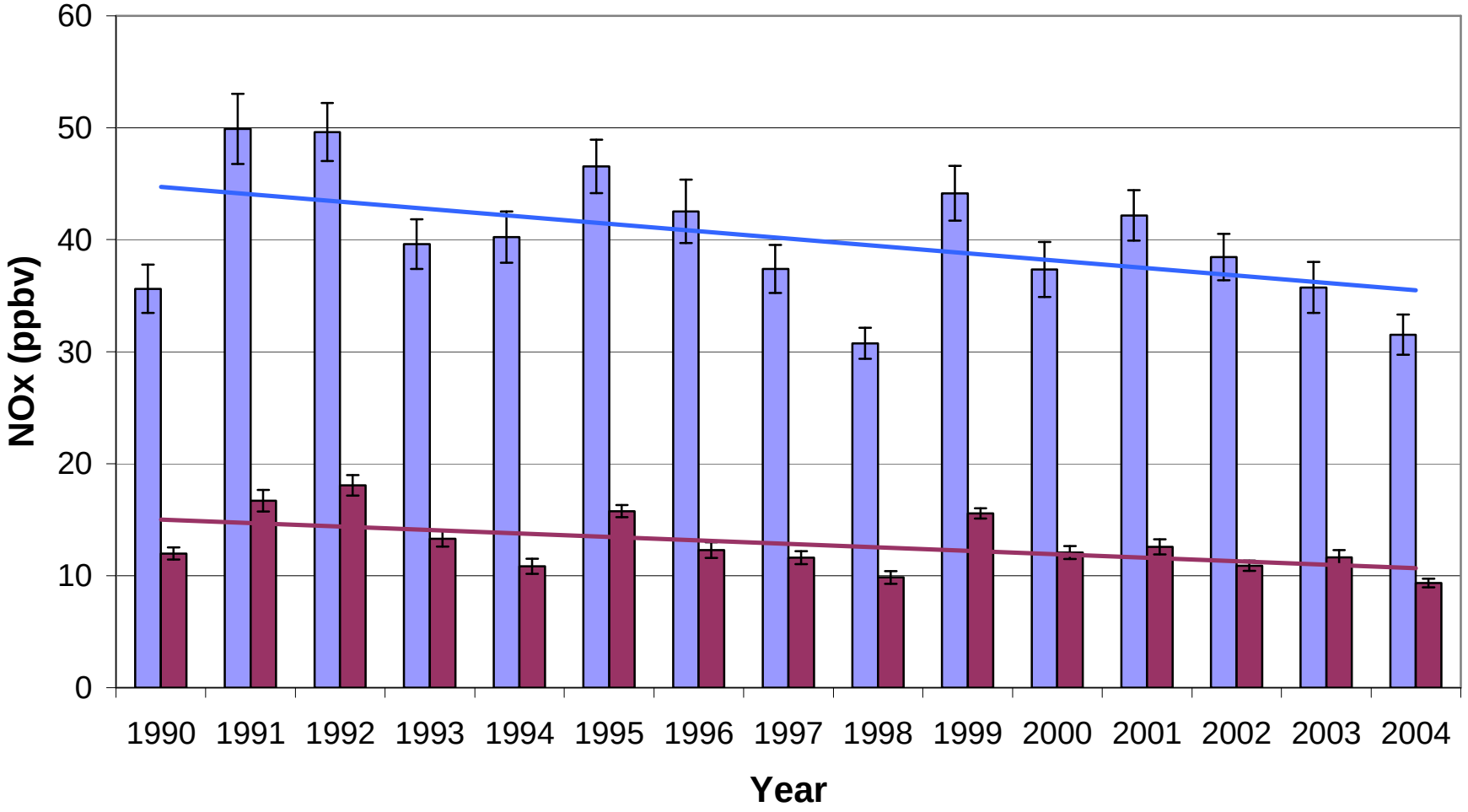


Morning NMOC decline: 8.2 ppbC/year (~66 ppbv over period)



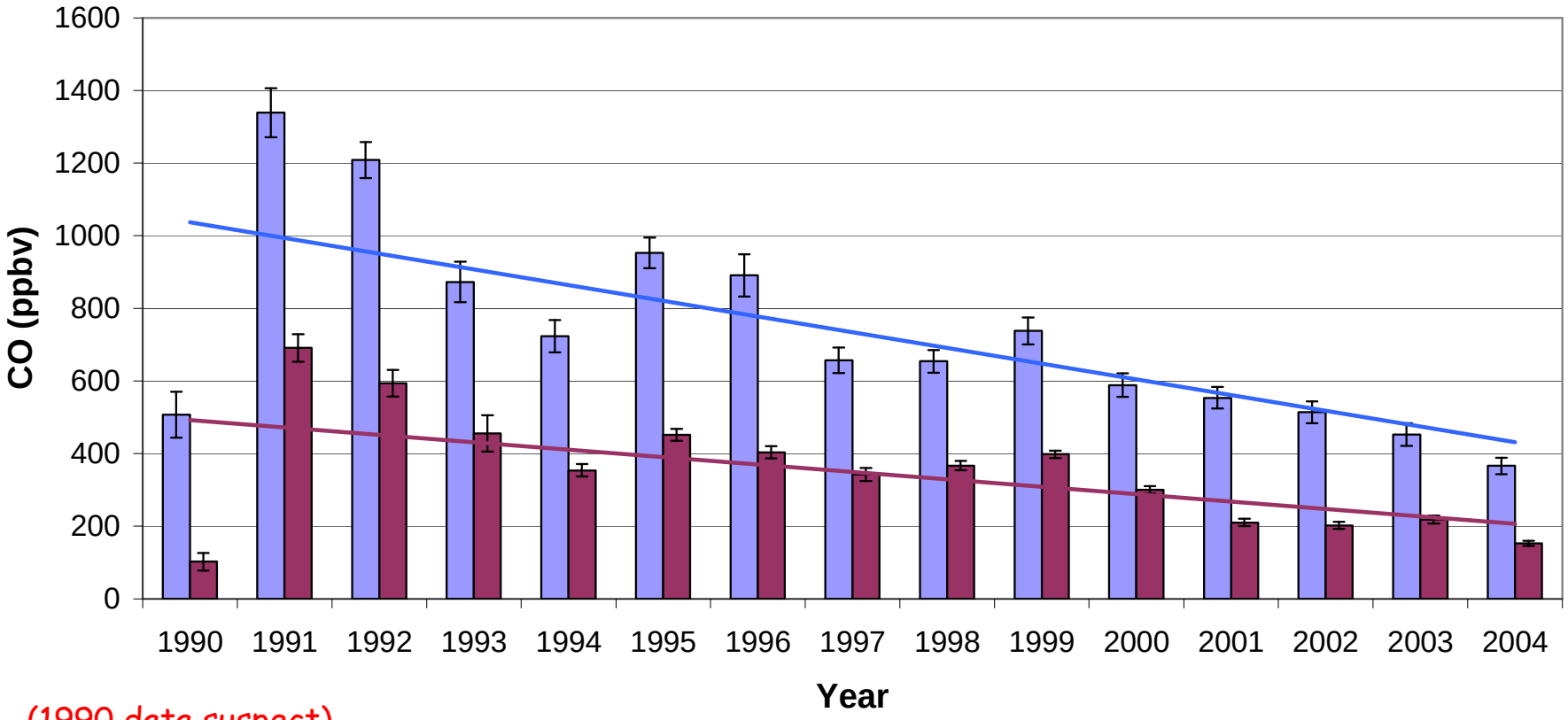
Morning NMOC decline: 11.5 ppbC/year (~115 ppbv over period)

Fresno First Street - Mean Morning (5 am - 11 am) and Mid-day (Time of 8-hour O_3 Max) NOx on Top 60 Subregional Days



Morning NOx decline: 0.66 ppbv/year (~10 ppbv over period)
Mid-day NOx decline: 0.31 ppbv/year (~5 ppbv over period)

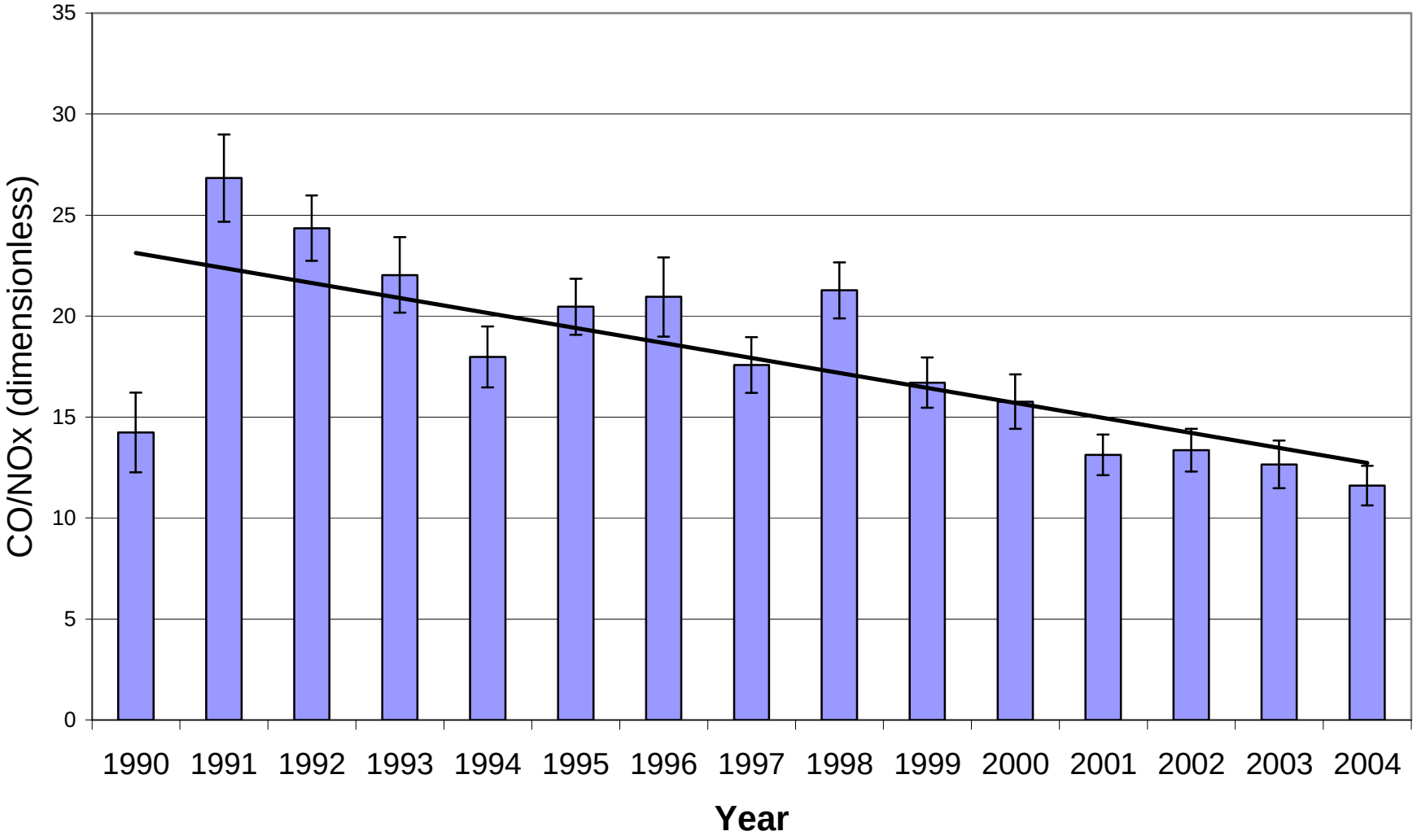
Fresno First Street - Mean CO on Top 60 Subregional High-Ozone Days
Morning (5 am - 11 am) and Mid-day (Time of 8-hour Ozone Max)



(1990 data suspect)

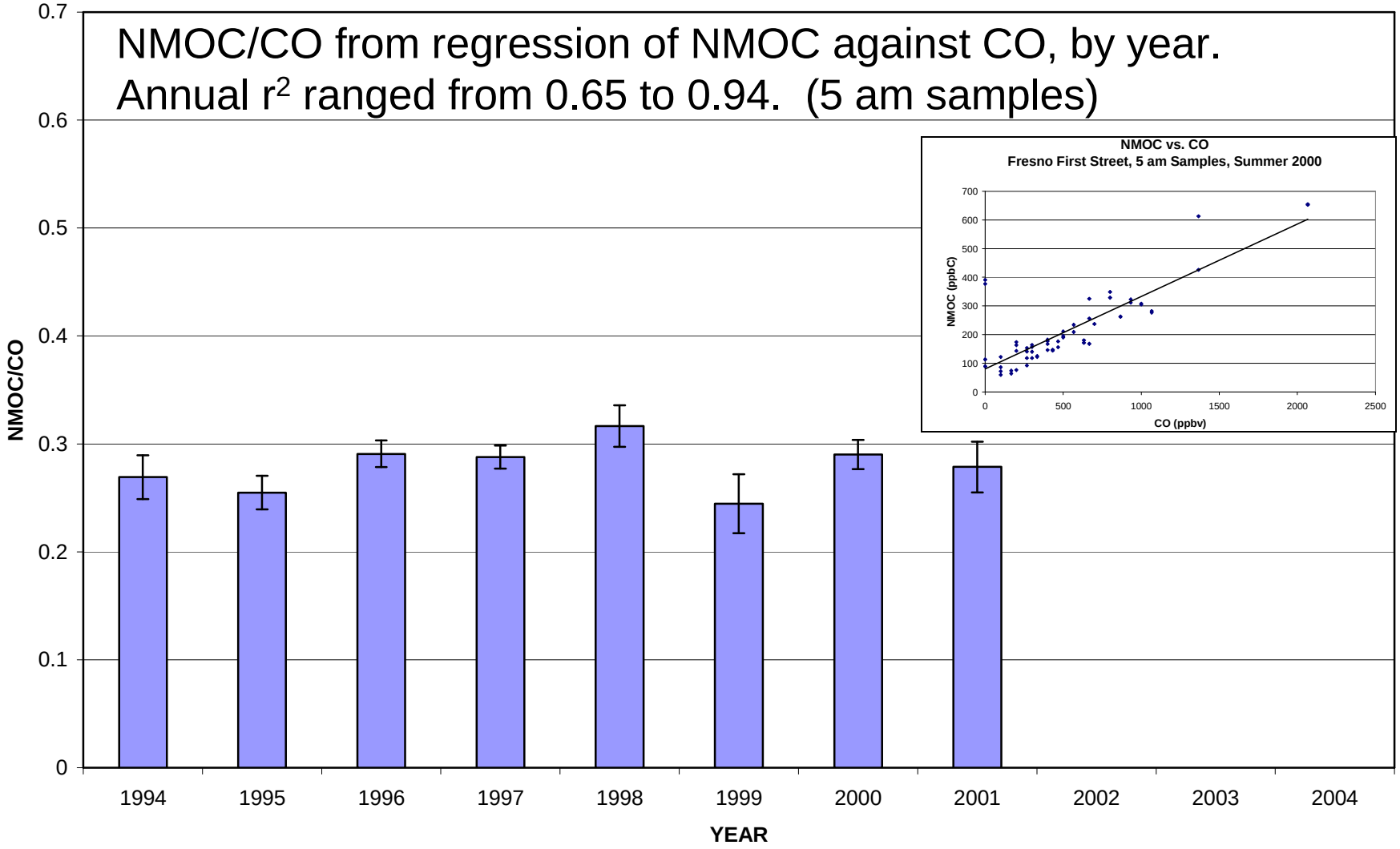
Morning CO decline: 43 ppbv/year (~650 ppbv over period)
Mid-day CO decline: 20 ppbv/year (~300 ppbv over period)

Fresno First Street Morning CO/NOx



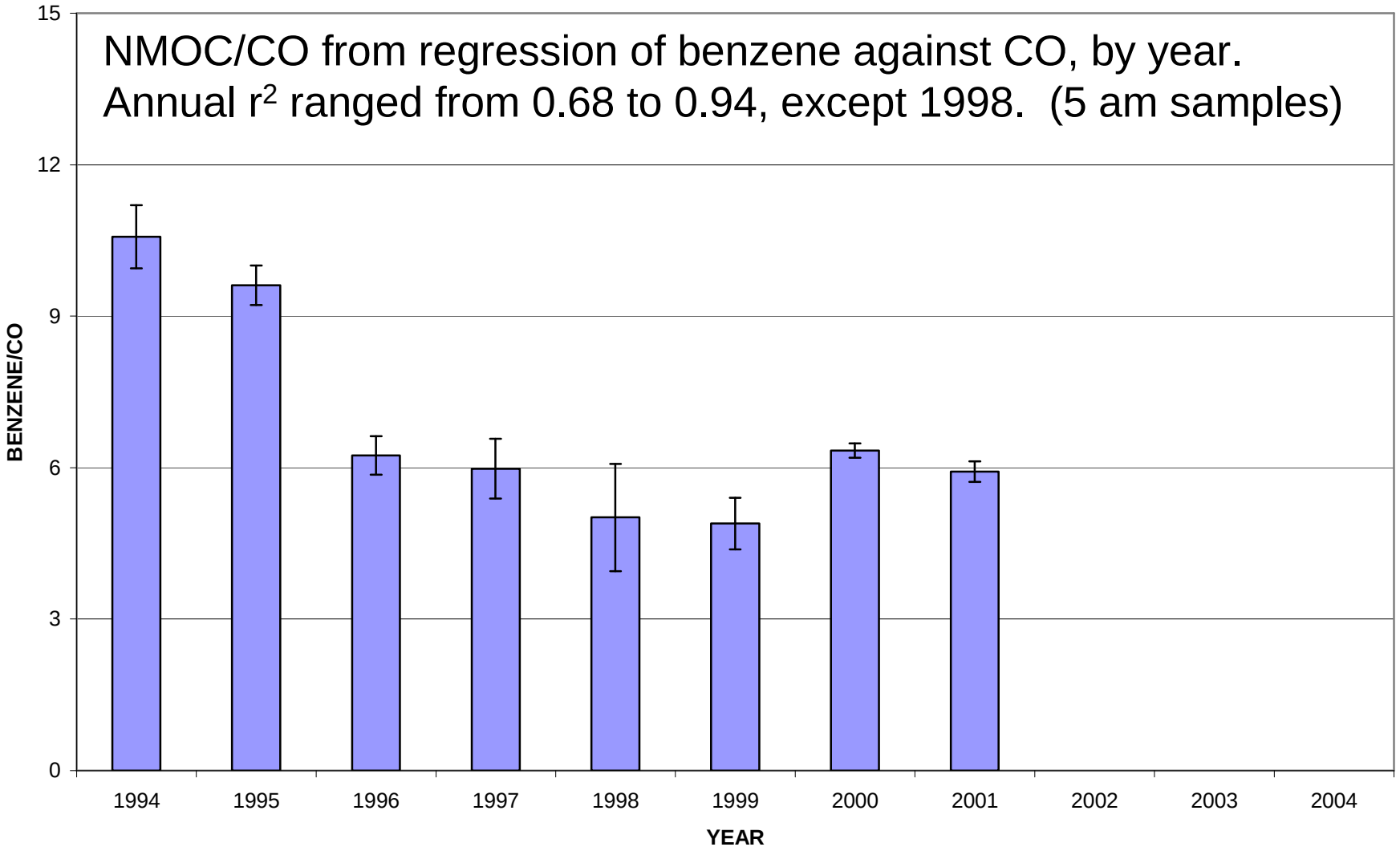
CO/NOx declines ➔ so does NMOC/NOx

FRESNO

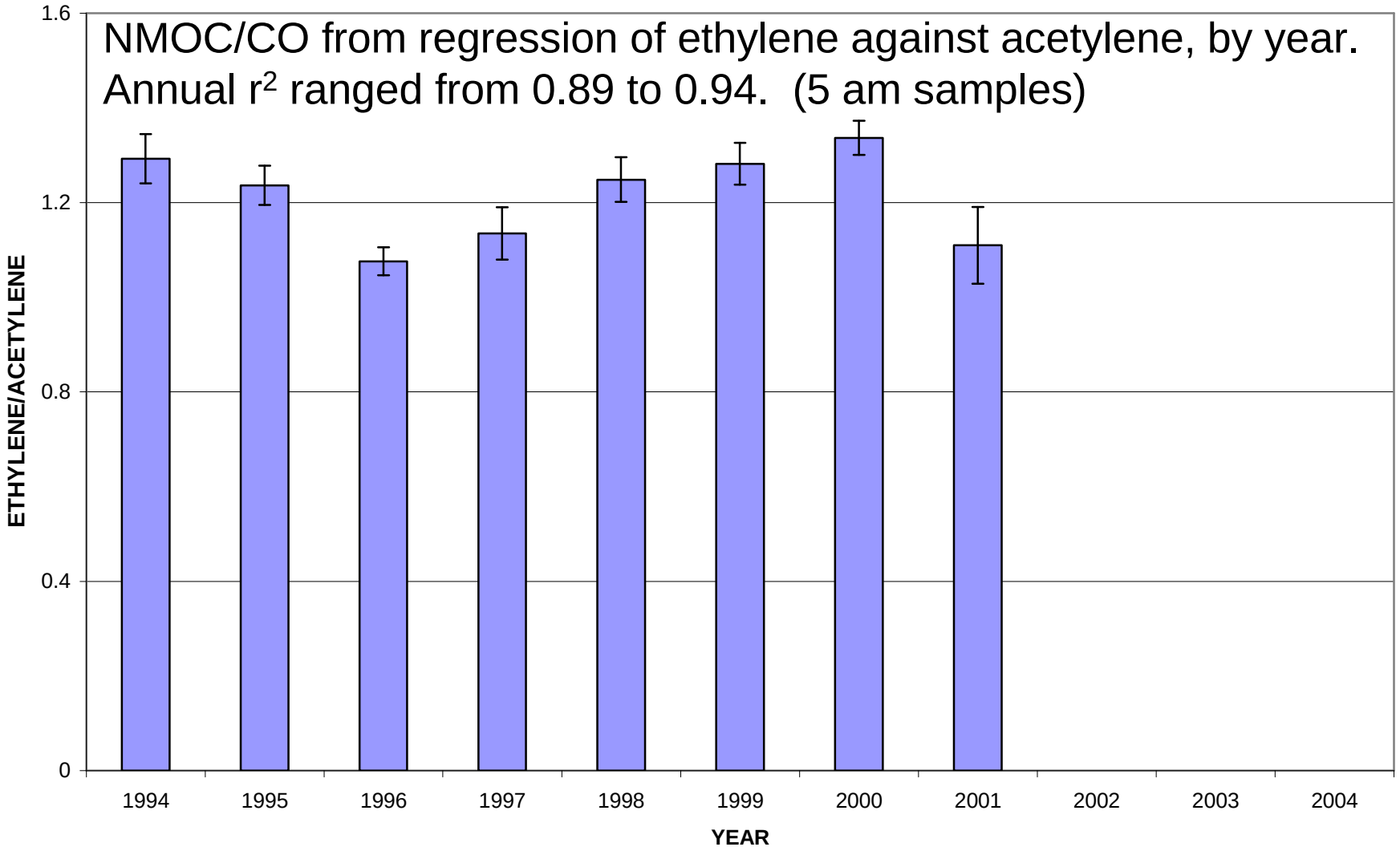


Similar results for Bakersfield and Sacramento Del Paso:
~0.3 ppbC NMOC per ppbv CO (some years differed)

FRESNO

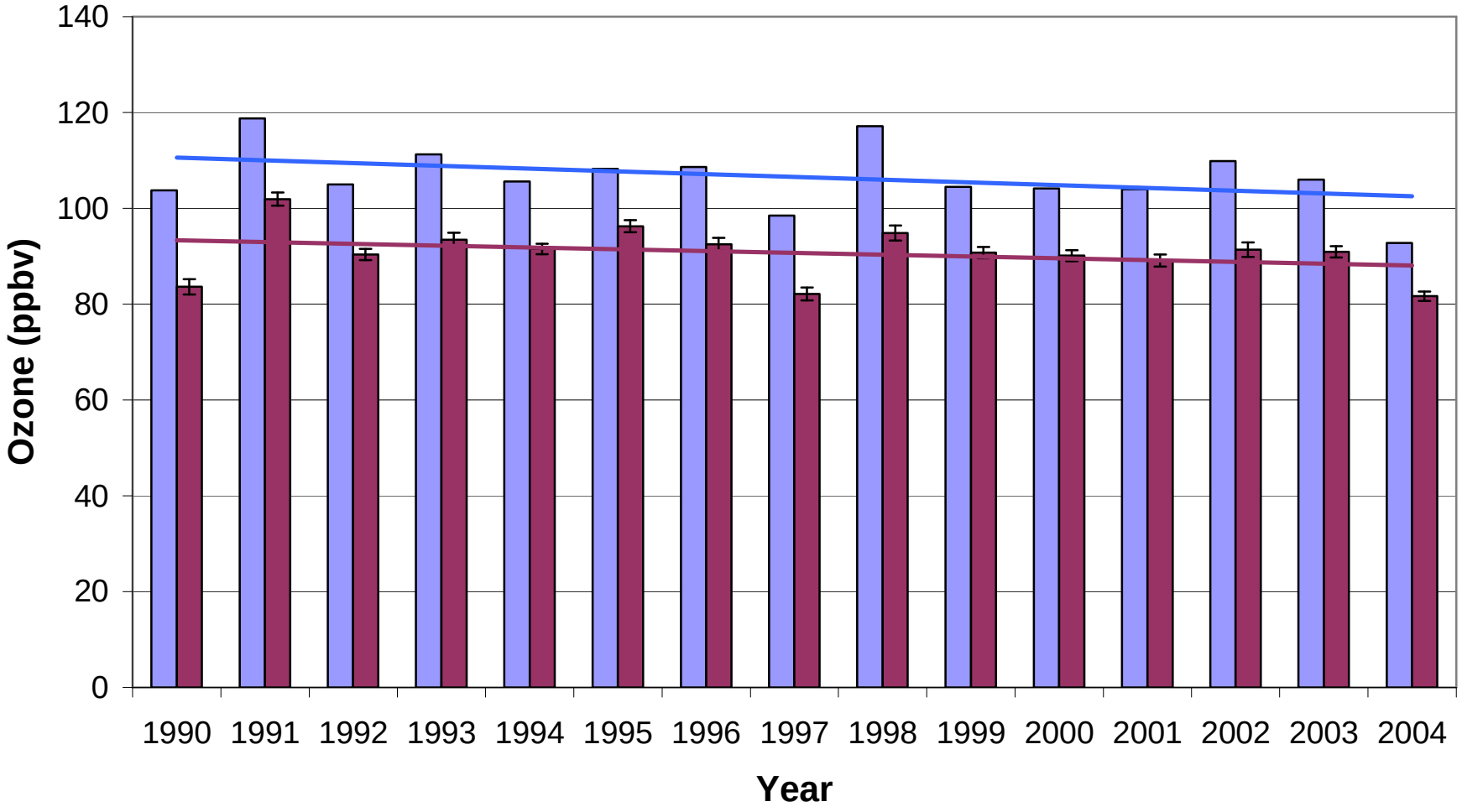

NMOC/CO from regression of benzene against CO, by year.
Annual r2 ranged from 0.68 to 0.94, except 1998. (5 am samples)
BENZENE/CO
15
12
9
6
3
0
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
YEAR

FRESNO


NMOC/CO from regression of ethylene against acetylene, by year.
Annual r2 ranged from 0.89 to 0.94. (5 am samples)
ETHYLENE/ACETYLENE
1.6
1.2
0.8
0.4
0
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
YEAR

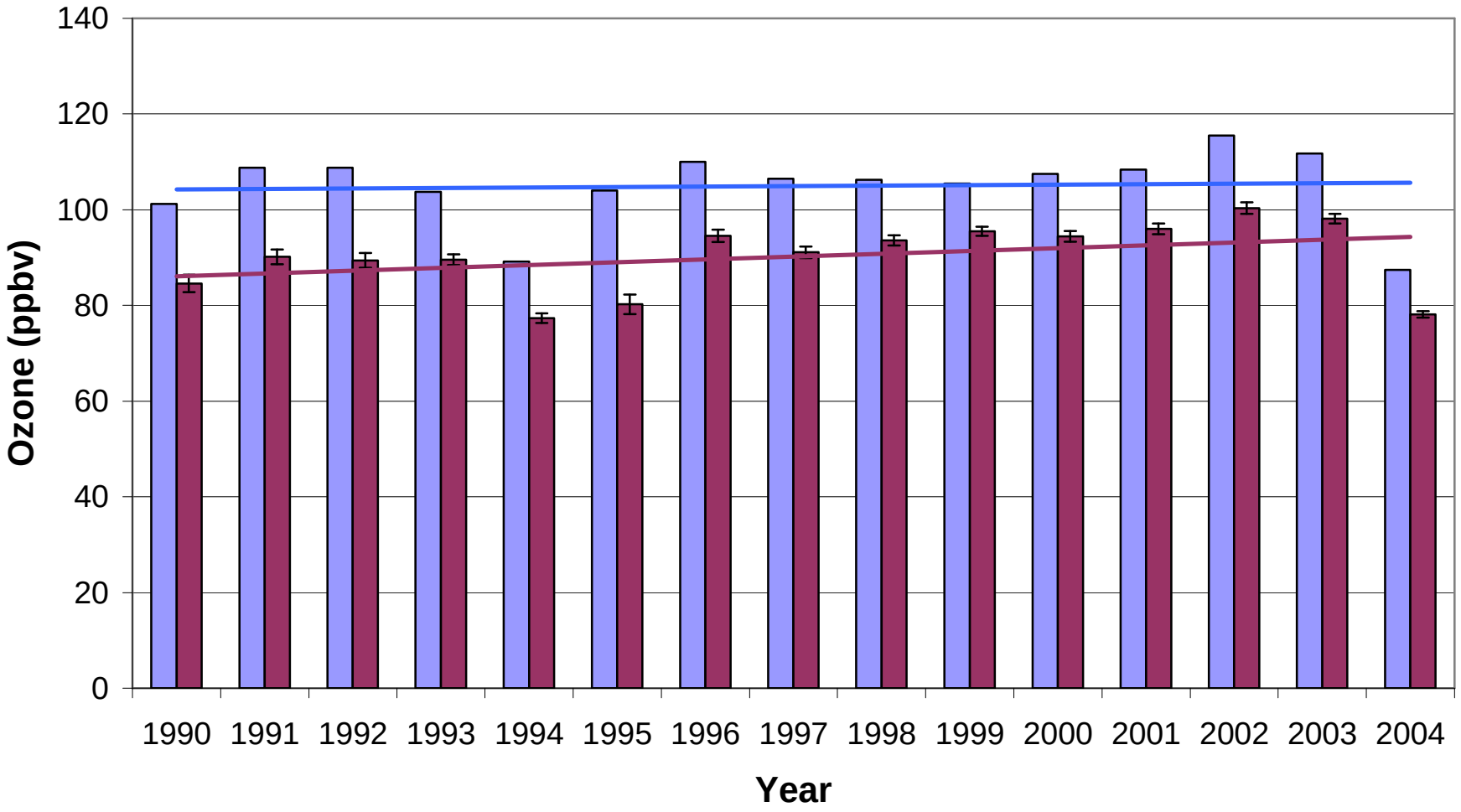
What are the ozone trends?

Fresno First Street -- Annual 4th-Highest 8-Hour Ozone and Mean of Top 60 Subregional Days



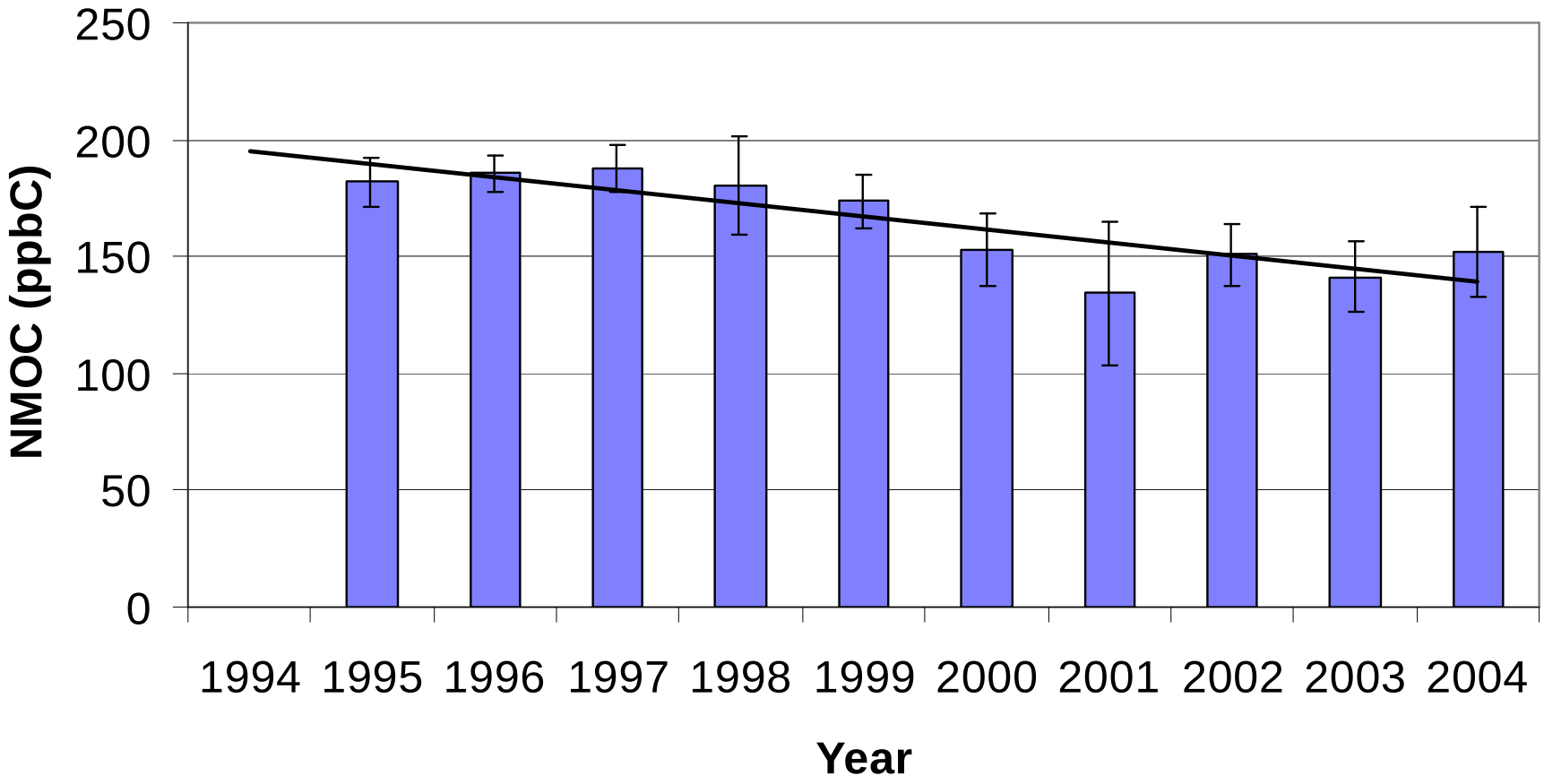
Annual 4th max decline: 0.58 ppbv/year (~9 ppbv over period)
Mean Top 60 decline: 0.38 ppbv/year (~6 ppbv over period)

Parlier -- Annual 4th-Highest 8-Hour Ozone and Mean of Top 60 Subregional Days



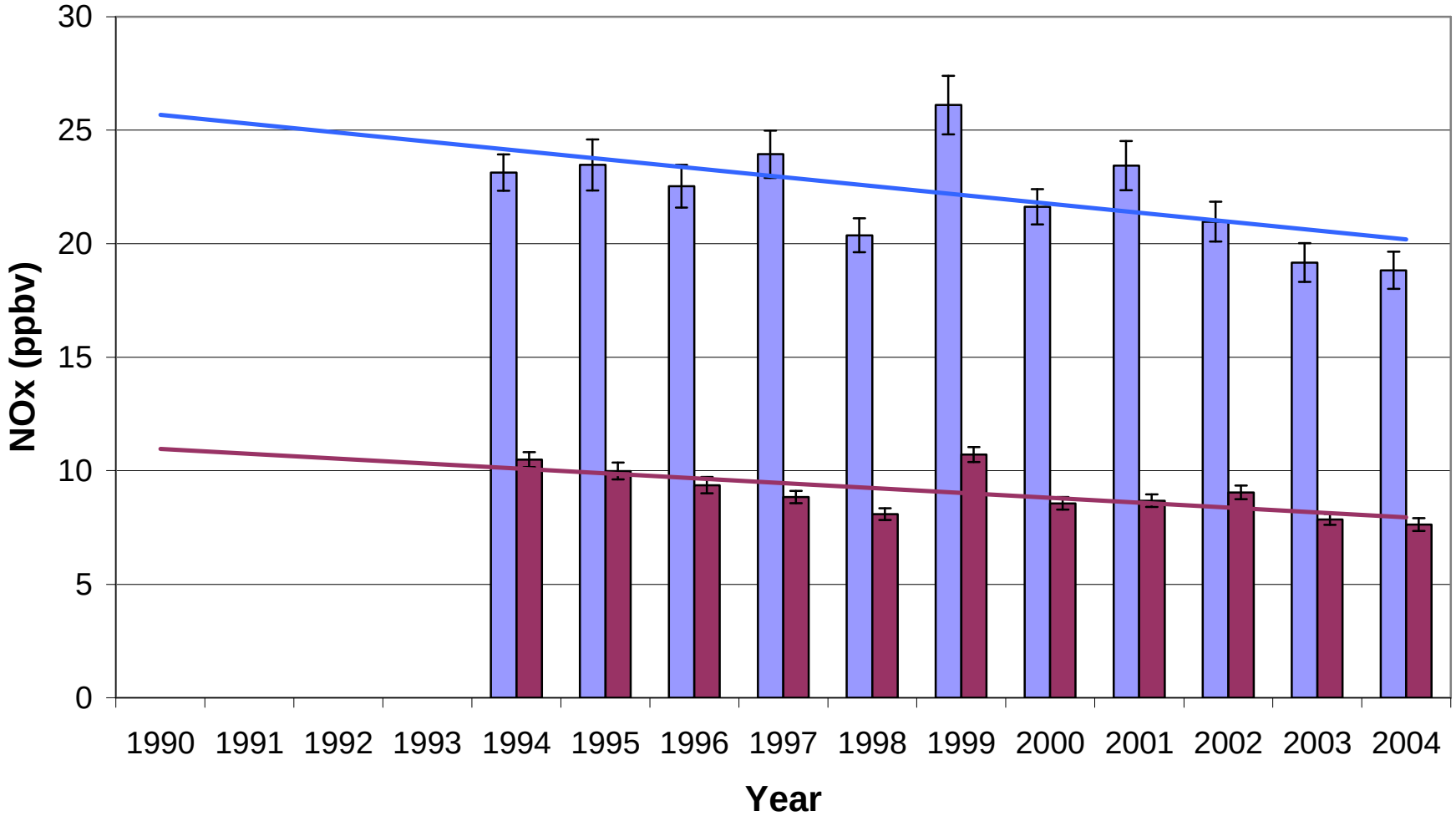
What are the precursor trends at Parlier?

Mean Morning NMOC Parlier



Morning NMOC decline: 5.1 ppbC/year (~51 ppbv over period)

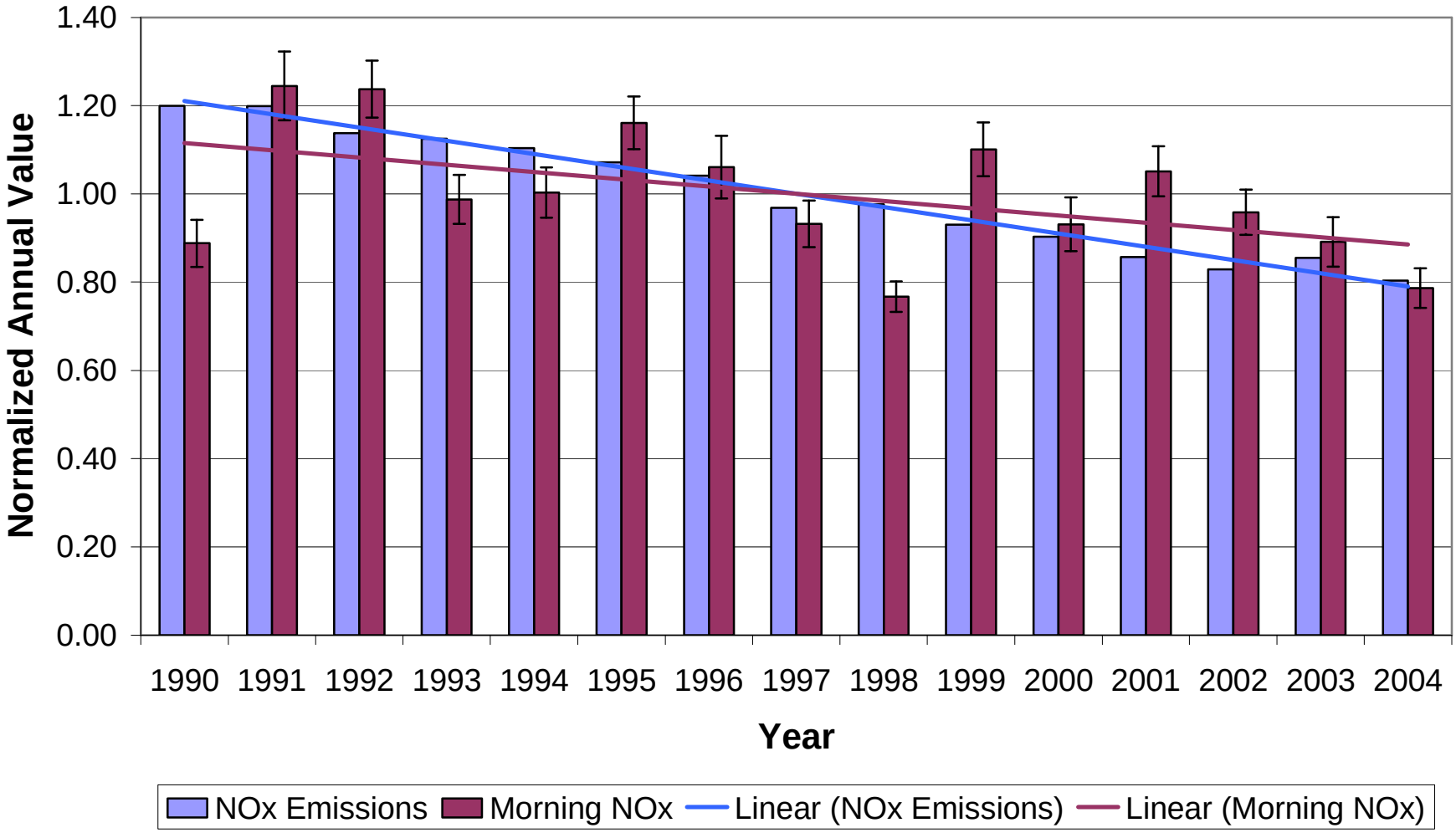
Parlier - Mean NOx on Top 60 Subregional High-Ozone Days
Morning (5 am - 11 am) and Mid-day (Time of 8-hour Ozone Max)



Morning NOx decline: 0.39 ppbv/year (~4 ppbv over period)
Mid-day NOx decline: 0.21 ppbv/year (~2 ppbv over period)

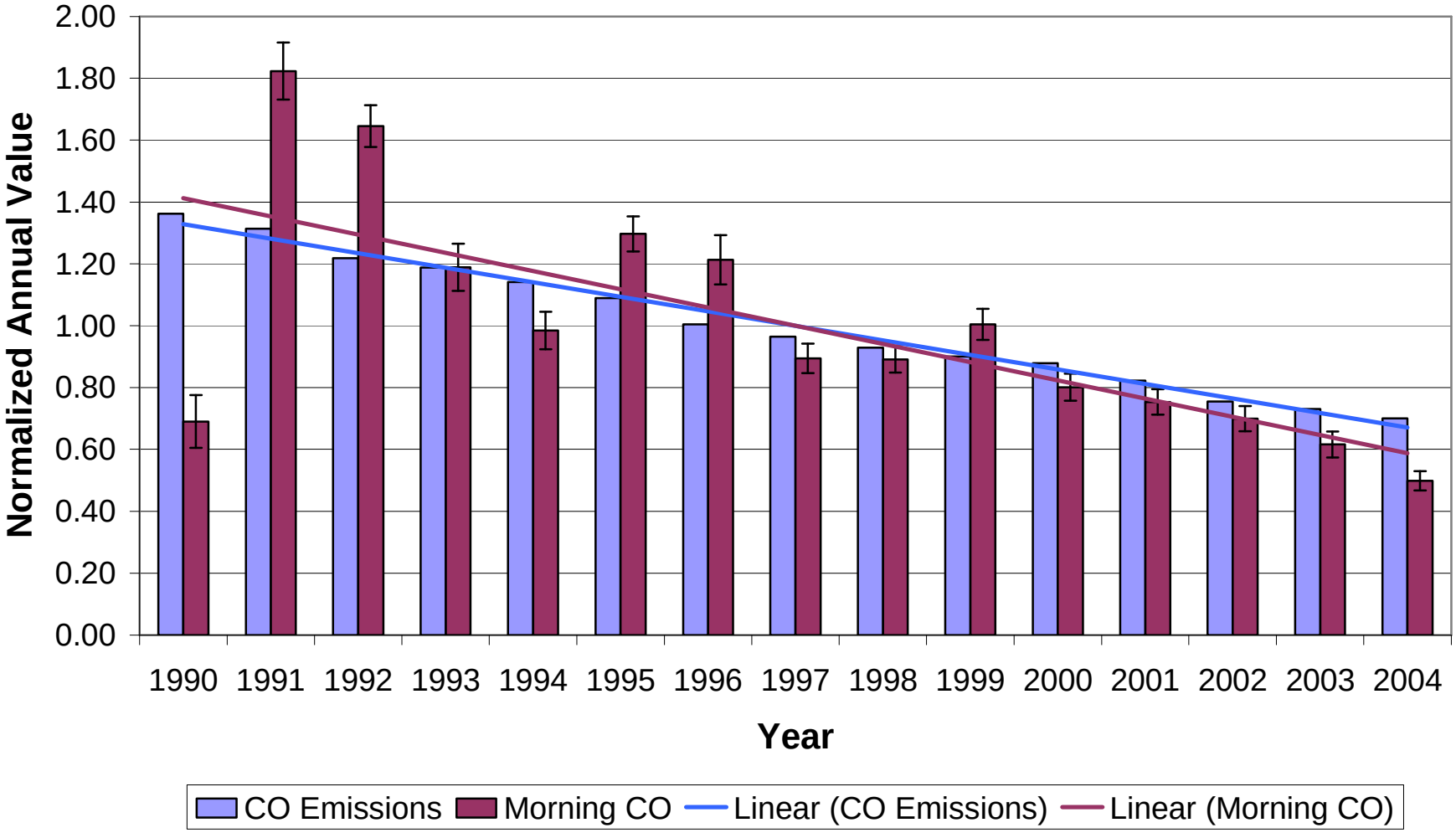
Comparison of AQ Trends to County-Level Emission Trends

Fresno County NOx Emissions Compared With Morning NOx Concentrations at Fresno First Street



Emission trend (Δ40) exceeds ambient trend (Δ20)

Fresno County CO Emissions Compared With Morning CO Concentrations at Fresno First Street



Ambient trend (Δ80) exceeds emission trend (Δ60)

Next Steps

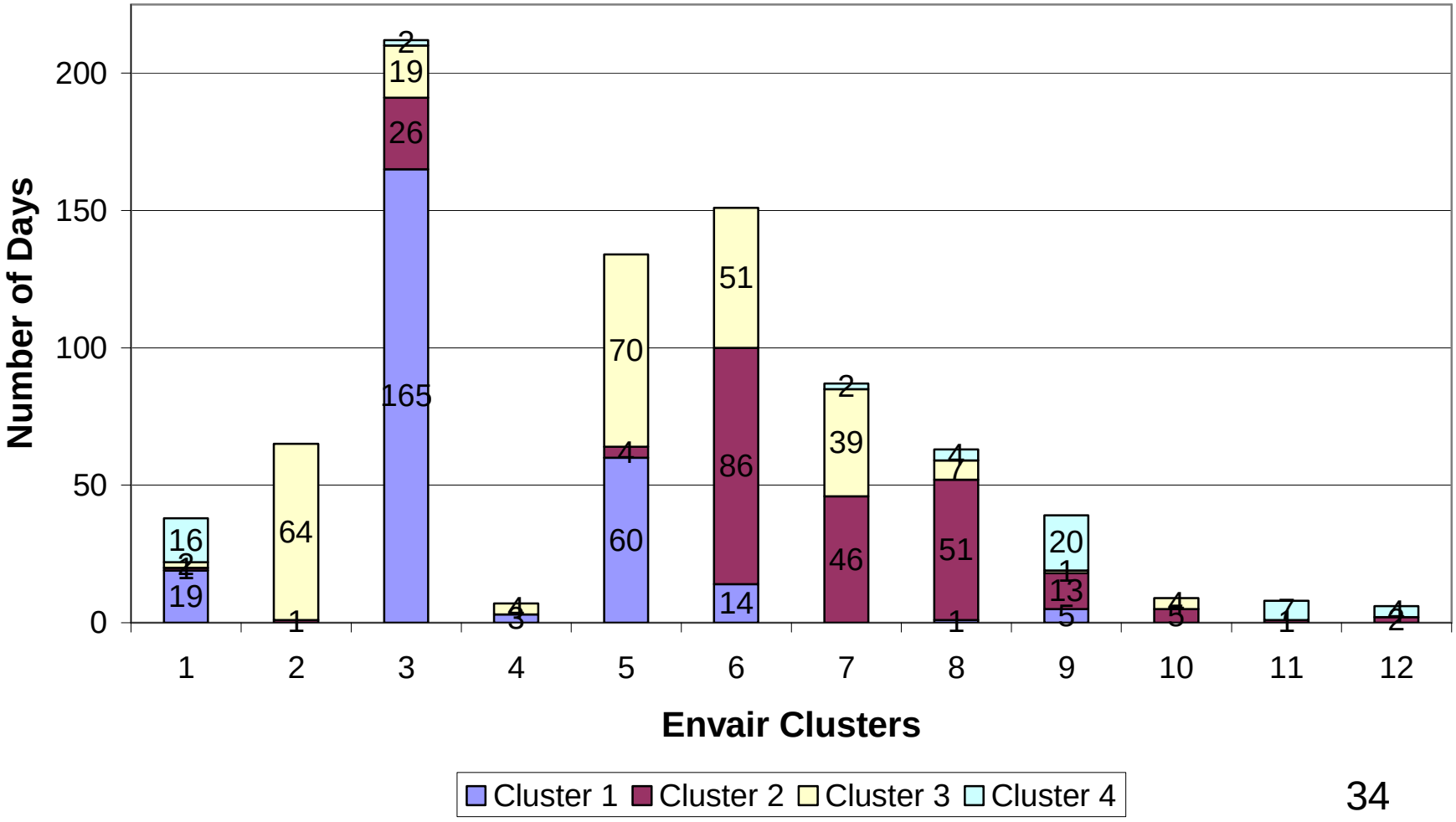
Directional information may permit more complete reconciliation of ambient AQ trends with emissions trends. What does this involve?

Phase I. Directional disaggregation of Top 60 days. Requires meteorological information to split days into groups with different transport patterns. Yields mean AQ metrics by transport direction.

Phase II. Directional disaggregation of emissions, obtained by gridding the annual inventories.

Cross-Check Previous Analysis With UC Davis Study

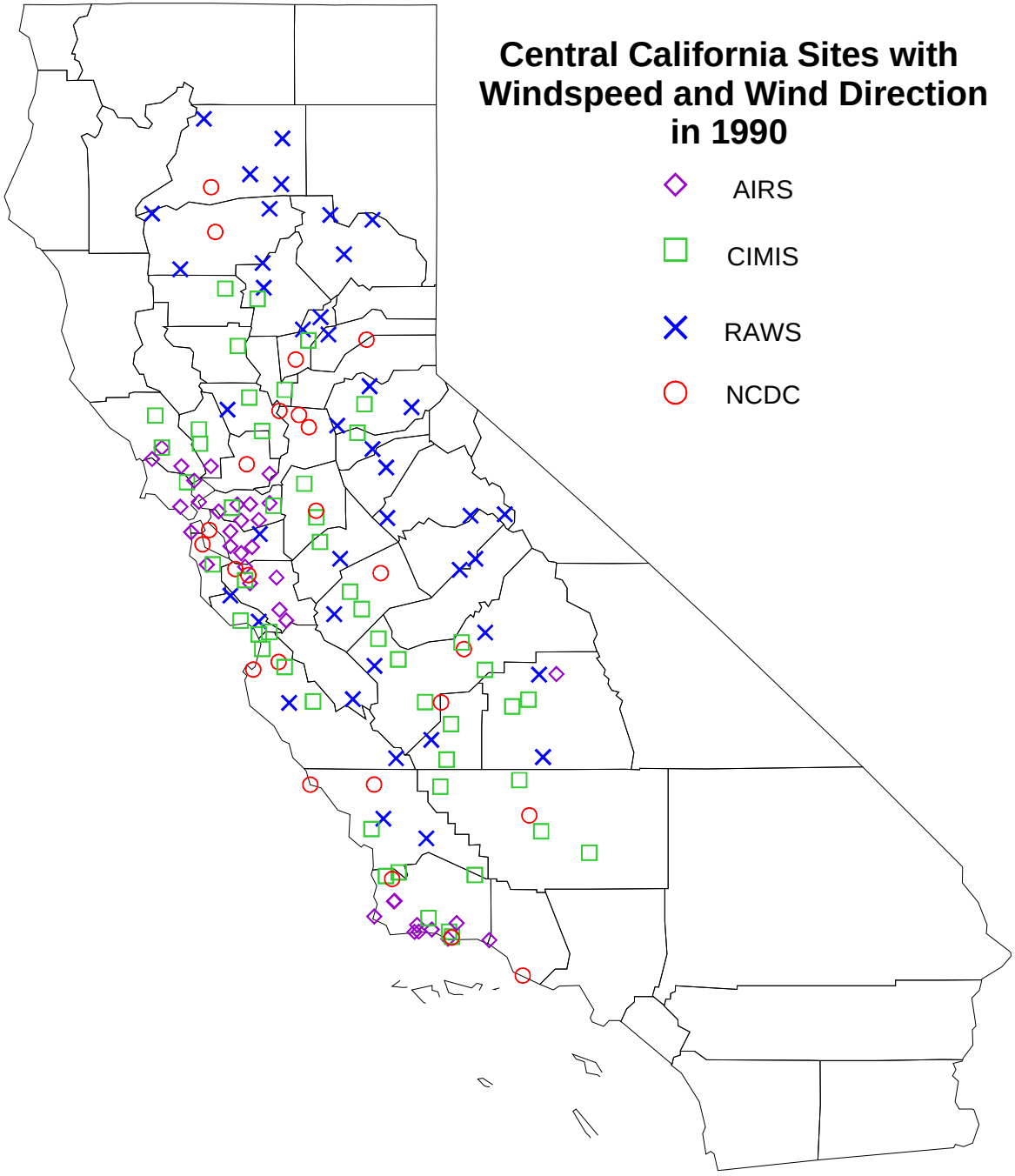
Comparison of UCD Clusters for SFBA to Envair Clusters
(Preliminary Classifications, May 2006)

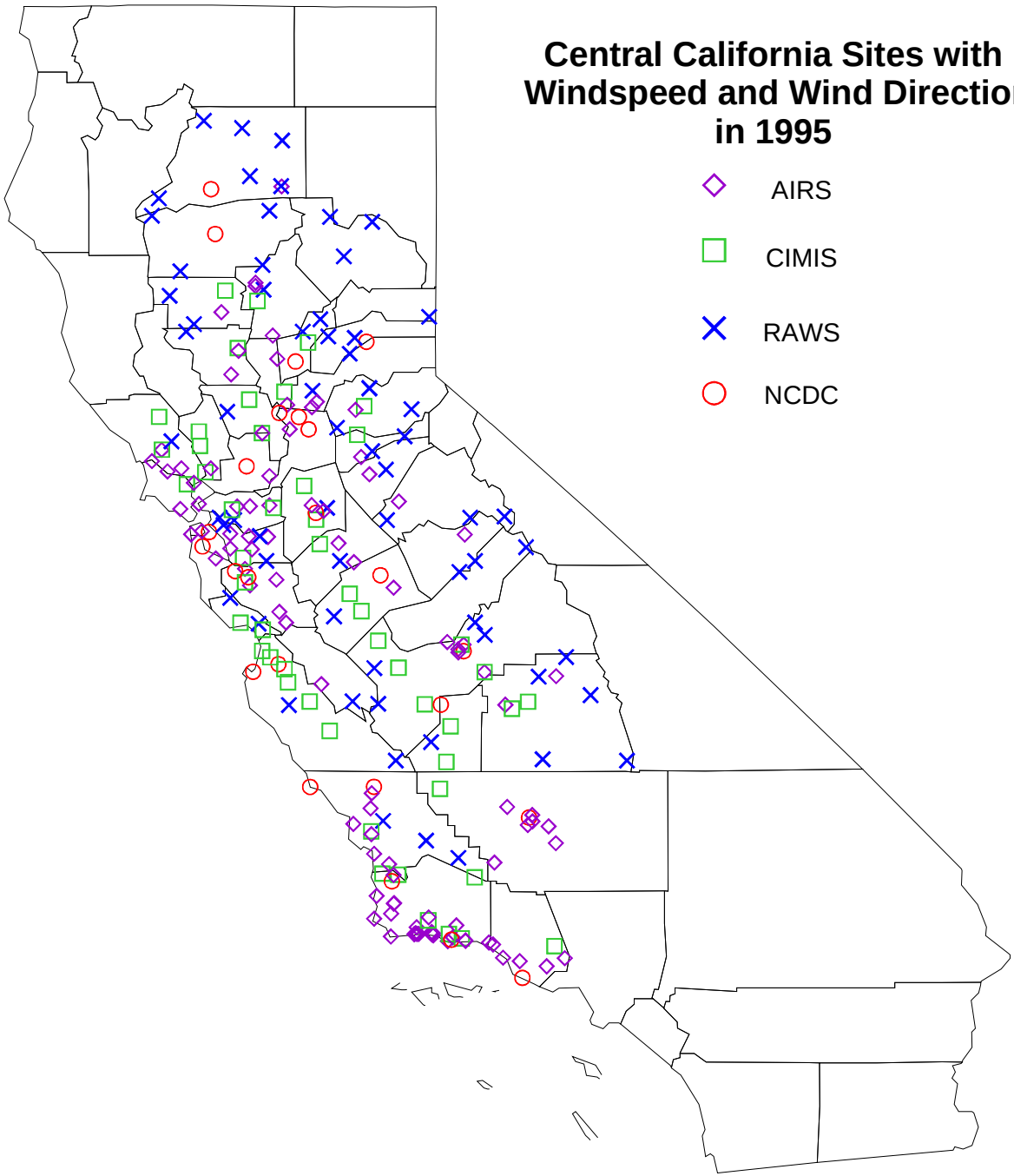


Surface Meteorological Data
Hourly WS and WD

147 Surface Sites Starting
1990-94 and Continuing to 2004

Suspect Hourly Data Eliminated


Central California Sites with Windspeed and Wind Direction in 1990
AIRS
CIMIS
RAWS
NCDC


Central California Sites with Windspeed and Wind Direction in 1995
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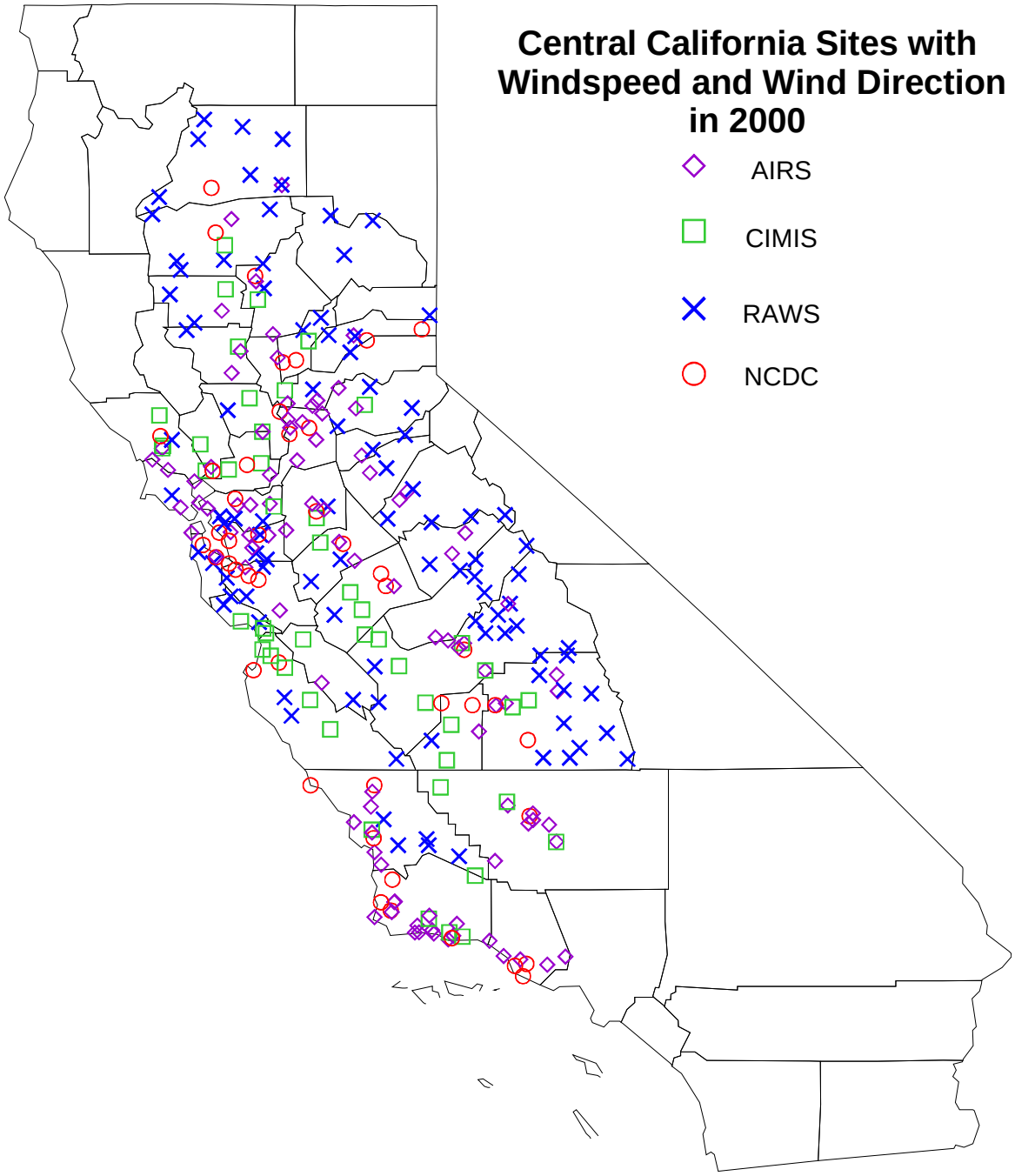
CIMIS
RAWS
NCDC


Central California Sites with Windspeed and Wind Direction in 2000
AIRS
CIMIS
RAWS
NCDC

Regional-Scale Meteorological Data

- Upper air: Oakland 850 mb soundings at 4 am & 4 pm local time
- Pressure gradients: San Francisco to Medford, Reno, Fresno, and Las Vegas

Preliminary Step for Directional Disaggregation*: Principal Component Analysis of Regional-Scale Variables and Surface WS and WD in Subregions

(Will help deal with redundant information and missing data)

~~* Trend adjustment Forecasting~~

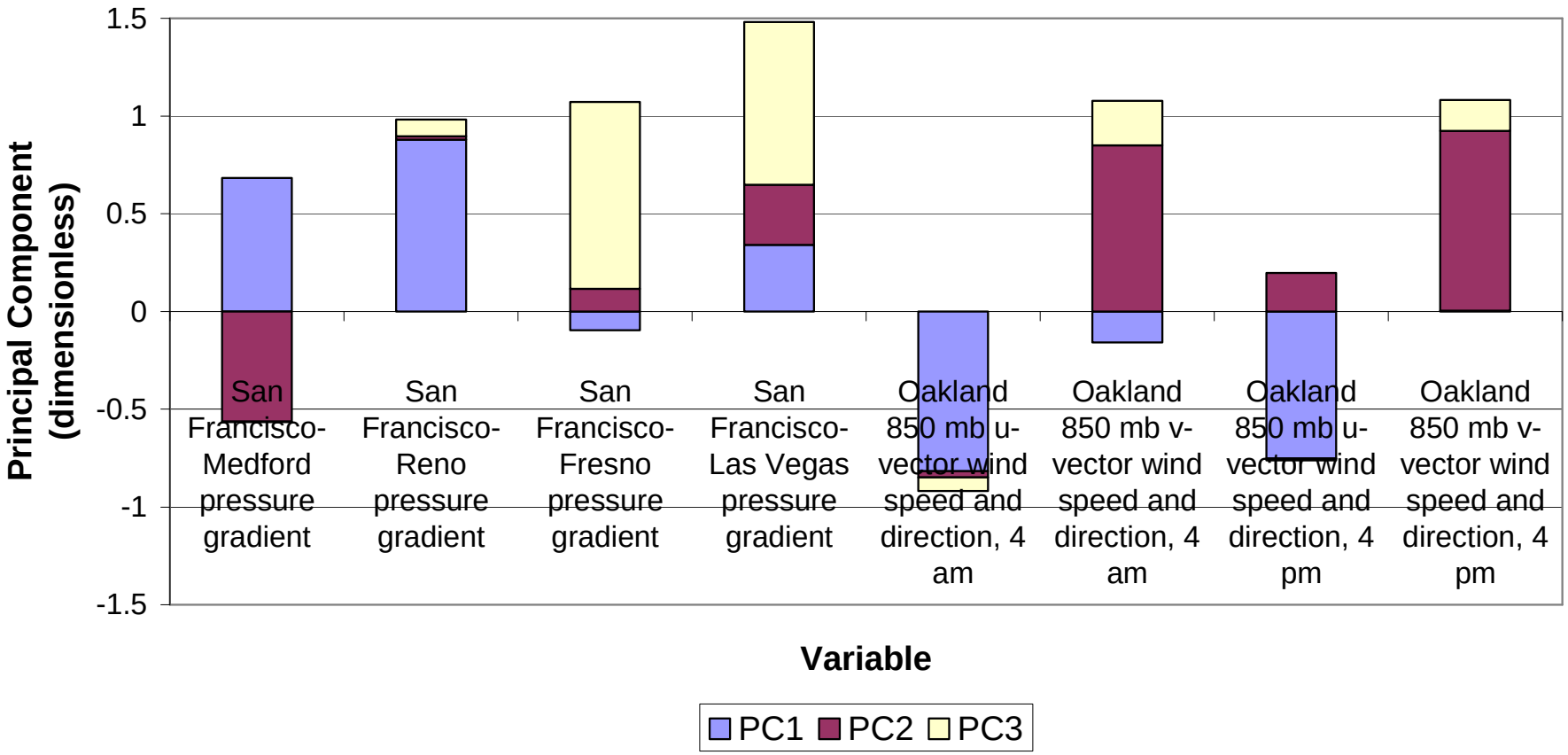
PCA of Regional-Scale Variables

San Francisco-to-Medford sea-level pressure gradient, daily average
San Francisco-to-Reno sea-level pressure gradient, daily average
San Francisco-to-Fresno sea-level pressure gradient, daily average
San Francisco-to-Las Vegas sea-level pressure gradient, daily average

Oakland 850 mb vector component (u) wind speed and direction at 4 am
Oakland 850 mb vector component (v) wind speed and direction at 4 am
Oakland 850 mb vector component (u) wind speed and direction at 4 pm
Oakland 850 mb vector component (v) wind speed and direction at 4 pm

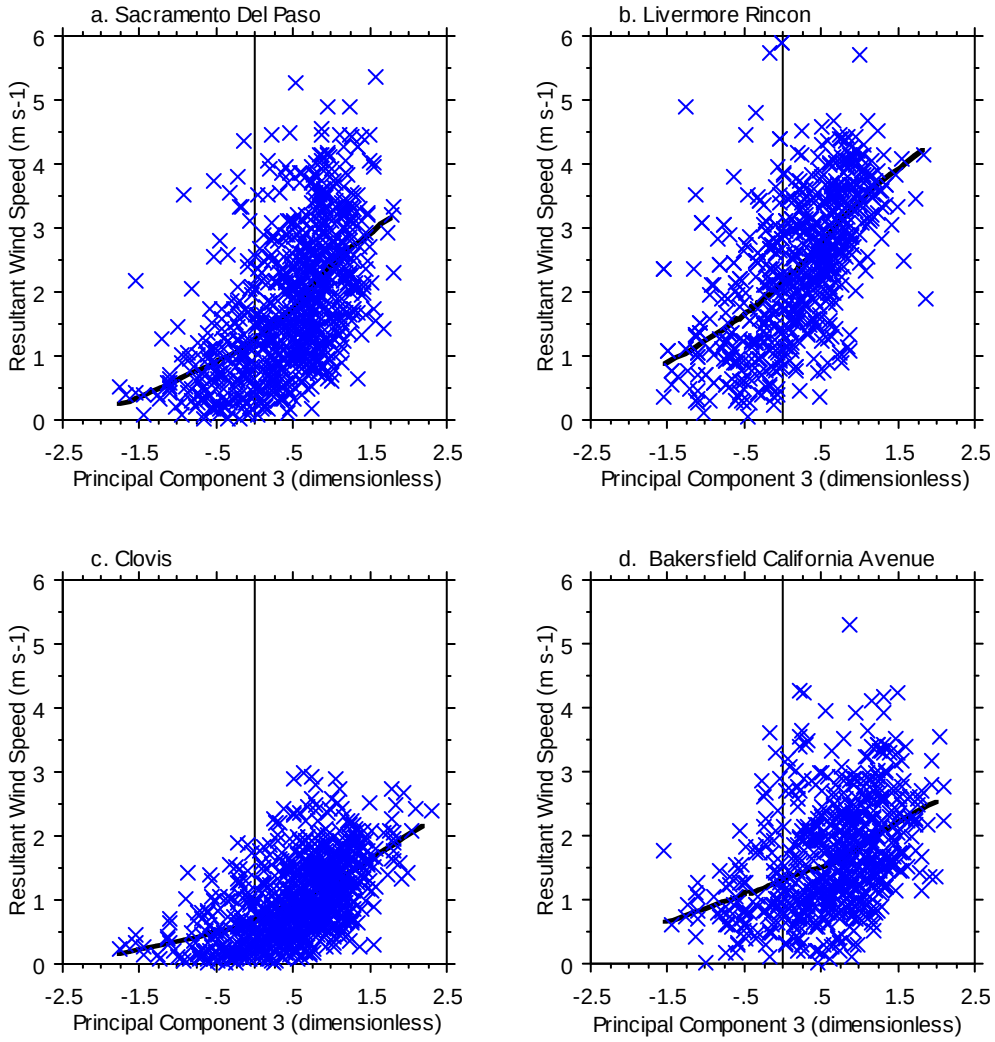
Oakland 850 mb temperature and height at 4 am
Oakland 850 mb temperature and height at 4 pm

PCA - Regional Scale Meteorological Variables



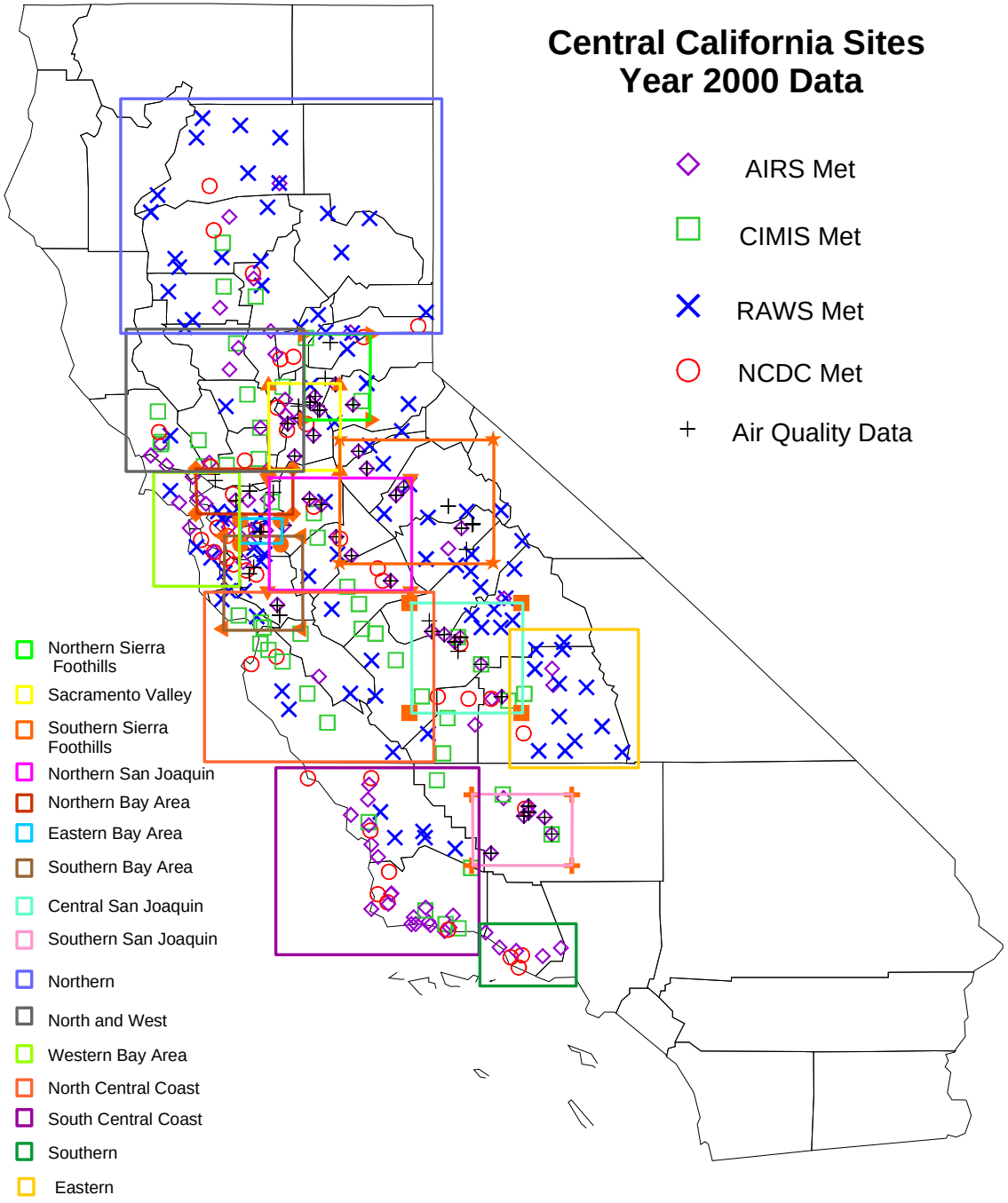
Three PCs explain 80% of variance of eight variables

PC1 is westerly wind – PC2 is northerly wind – what is PC3?

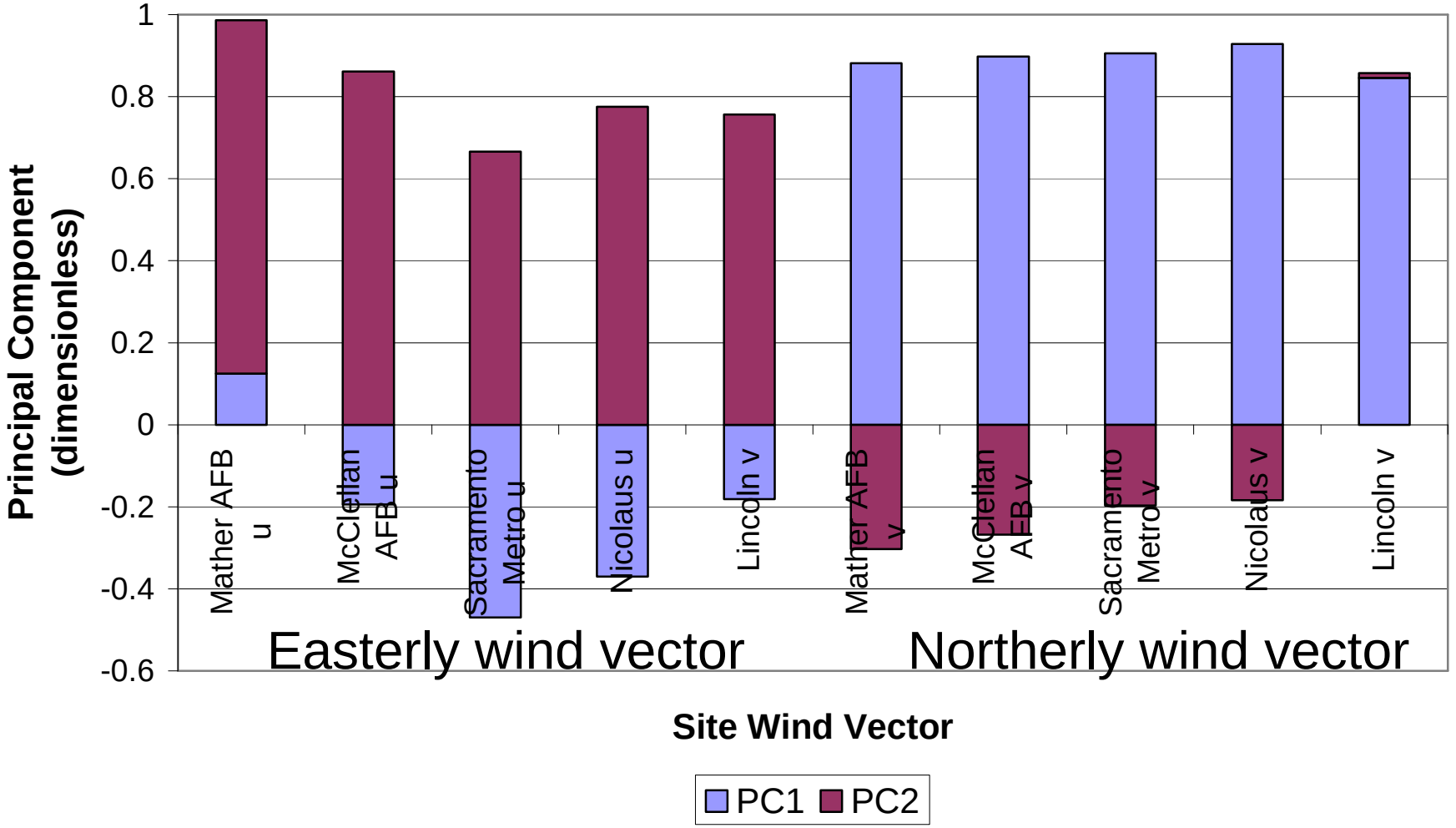


PC3 correlates with surface wind speeds – interpret as ventilation

Principal Component Analysis of Surface WS and WD in Subregions


Central California Sites
Year 2000 Data
AIRS Met
CIMIS Met
RAWS Met
NCDC Met
Air Quality Data
Northern Sierra Foothills
Sacramento Valley
Southern Sierra Foothills
Northern San Joaquin
Northern Bay Area
Eastern Bay Area
Southern Bay Area
Central San Joaquin
Southern San Joaquin
Northern
North and West
Western Bay Area
North Central Coast
South Central Coast
Southern
Eastern

Principal Component Analysis
Sacramento Subregion - Hourly Wind Vector



Other subregions are more complex!

On to Phase II?

- Not yet – complete Phase I first
- Finish comparison of sites' AQ trends to county emission trends
- Finish directional disaggregation
- Submit Phase I report
- Why would Phase II be useful?
  - Identify zones of emission influence - more accurate comparison of sites' AQ trends with emission trends
  - Better understanding of differences in ozone trends at sites within each subregion