Air Quality Forecasting and Trends

Presented by:
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Project Planner / Atmospheric Scientist
Air Pollution Meteorology and Trends in the San Joaquin Valley

- Air Monitoring Sites
- Dispersion, Transport, and Formation of Air Pollutants
- Meteorology during high Ozone and Particulate concentrations
- Large Scale and Middle Scale Weather Systems
- Forecasting Resources and Process
- Air Quality Trends
San Joaquin Valley Air Basin
Air Monitoring Sites

- Population Exposure
- Highest Concentration
- Source Apportionment
- Special Modeling and Air Quality Analyses
# San Joaquin Valley Air Monitoring Sites

<table>
<thead>
<tr>
<th>Monitoring Site</th>
<th>Ozone</th>
<th>PM10*</th>
<th>PM2.5*</th>
<th>Meteorology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stockton Wagner - Holt</td>
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<tr>
<td>Stockton Hazelton</td>
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<td>Tracy - Airport</td>
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<td>Modesto</td>
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<tr>
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<td>Fresno Sierra Sky Park</td>
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<td>Clovis</td>
<td>x</td>
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<td>Fresno - 1st</td>
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<td>Fresno Pacific Univ</td>
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<tr>
<td>Parlier</td>
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<tr>
<td>Visalia - Church</td>
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<td>x</td>
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<td>Visalia - Airport</td>
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<td>Ash Mountain</td>
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<td>Hanford</td>
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<tr>
<td>Corcoran</td>
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<td>Shafter</td>
<td>x</td>
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<tr>
<td>Oildale</td>
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<tr>
<td>Bakersfield - Golden</td>
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<td>Bakersfield - Calif.</td>
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<td>Bakersfield - Planz</td>
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<tr>
<td>Arvin</td>
<td>x</td>
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<tr>
<td>Edison</td>
<td>x</td>
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<tr>
<td>Maricopa</td>
<td>x</td>
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</tr>
</tbody>
</table>

Updated: 10/20/2006

# Includes SJVAPCD, CARB, and National Park Service Air Monitoring Sites

* Includes Filter Based and Real Time Data

** Includes Filter Based and Real Time Data

*** Planned Met. Tower installation next 6 months

New air monitoring sites at Huron and Tranquility to be installed within the next year.
Forecasting Air Quality

Need to predict changes in:
- Atmospheric Chemistry
- Weather
- Emissions
- Human Behavior
Atmospheric Chemistry

The forecaster predicts variations in:

- Ozone
- Particulate Matter
Ground Level Ozone

VOCs + NOx + Sunlight = Ground-level Ozone
Ozone Formation

NOx + VOC + Heat & Sunlight = Ozone

Ground-level or “bad” ozone is not emitted directly into the air, but is created by chemical reactions between NOx and VOCs in the presence of heat & sunlight.

Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of oxides of nitrogen (NOx) and volatile organic compounds (VOC).
Ozone Concentration Profile

Parlier Diurnal Ozone Profile - 5/28/03

Hours

Ozone (Parts Per Billion)

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

0 20 40 60 80 100 120 140 160
Ozone concentrations vary by time of day and location.
Particulate Matter

- Concentrations can gradually build during stagnant conditions
- Concentrations can increase rapidly during wind blown dust events and wildfires
- Concentrations can vary with time of day
Particulate Matter Comes From Many Sources

Natural
- Wind Blown Dust (Undisturbed Soil)
- Wildfires
- Wood Burning

Man Made
- Wind Blown Dust (Disturbed Soil)
- Industrial Sources
- Automobiles
- Disturbed Soil
Diurnal PM2.5 Profile

Fresno-First Street Diurnal PM2.5 Profile - 1/1/03

24-Hour Average is 60 micrograms per cubic meter
Weather Forecasting

What weather conditions influence air quality?
Weather Patterns Associated with Poor Air Quality

- Stagnant Conditions
- High Pressure
- Weak Pressure Gradients
- Weak Surface Winds
- Subsidence Aloft
- Temperatures Inversions
Temperature inversion during a period of high particulate concentrations

Atmospheric Temperature Profile at Fresno on November 9, 1993
Temperature Inversion
Plume Behavior and Lapse Rate
Stable Conditions
Multi-Layered Smoke

Paradise 2 fires

Up Kaweah Middle Fork
What weather conditions influence particulate matter concentrations?

- Long periods of stagnation
- Light winds
- Poor dispersion
- Temperature inversions
Winter Stagnation
What weather conditions influence ozone concentrations?

- Cloud cover
- Winds
- Poor dispersion
- Inversion strength
Forecasting Resources

- Weather Models
- Air Quality Models
- Satellite Images
- Web Cameras
- Local Observers (Fire Lookouts, Inspectors)
- Air Quality and Weather Data
- Regional Air Quality Studies
Data Sources to Assess Upper Air Transport and Dispersion

- Oakland and Vandenburg RAOB’s
- CARB Aircraft Sounding
- CARB Pibal
- Lower Air Profilers
- Satellite Sounding Data (GOES)
Synoptic Pattern for September 12, 2006 1 Hour Ozone Levels 131 ppb at Arvin
Synoptic Pattern of September 12, 2006 1 Hour Ozone Levels 131 ppb at Arvin
Wind Profile
Temperature Profile At Lost Hills on September 12, 2006, Ozone Episode

Environmental Technology Laboratory
Boundary Layer Wind Profiler Studies
Data provided by the NOAA Environmental Technology Laboratory
Wind Profile At Lost Hills on September 12, 2006, Ozone Episode
### Air Quality Model - Output

#### Ozone

<table>
<thead>
<tr>
<th>Site</th>
<th>1-hour</th>
<th>8-hour</th>
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</thead>
<tbody>
<tr>
<td>Merced</td>
<td>76</td>
<td>67</td>
</tr>
<tr>
<td>Modesto</td>
<td>80</td>
<td>64</td>
</tr>
<tr>
<td>Stockton</td>
<td>76</td>
<td>61</td>
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<td>Tracy</td>
<td>76</td>
<td>63</td>
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<tr>
<td>Turlock</td>
<td>37</td>
<td>72</td>
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<tr>
<td>Clovis</td>
<td>109</td>
<td>98</td>
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<tr>
<td>Fresno1st</td>
<td>106</td>
<td>89</td>
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<td>FresnoDrummond</td>
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<td>86</td>
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<td>FresnoSSP</td>
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<tr>
<td>Hanford</td>
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<td>93</td>
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<td>Madera</td>
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<td>75</td>
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<tr>
<td>Parlier</td>
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<td>93</td>
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<td>Arvin</td>
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<td>100</td>
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<tr>
<td>Bakersfield</td>
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<td>92</td>
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<tr>
<td>Edison</td>
<td>124</td>
<td>101</td>
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<tr>
<td>Maricopa</td>
<td>38</td>
<td>91</td>
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<tr>
<td>Oildale</td>
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<td>85</td>
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<td>Shafter</td>
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<td>71</td>
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<tr>
<td>Visalia</td>
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<td>85</td>
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<td>LowerKaweah</td>
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<td>85</td>
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<tr>
<td>AshMountain</td>
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<td>88</td>
</tr>
<tr>
<td>Shaver</td>
<td>95</td>
<td>73</td>
</tr>
</tbody>
</table>

#### PM10

- SanJoaquinPM: 38
- MercedStanislausPM: 50
- FresnoNaderaPM: 64
- TulareLakeBasinPM: 71
- EastValleyTularePM: 69
- EastValleyKernPM: 64
- WestValleyKernPM: 61

#### CO

- NorthCO: 0.6
- CentralCO: 0.9
- SouthCO: 0.9

*Note: S/J Simplified Title 17 Burn Status Estimate*
- North: No Burn Day
- Central/South (>3000ft): No Burn Day
- Central/South (<3000ft): Burn Day
Small Scale Weather Model
Specifically Designed for the San Joaquin Valley
Web Camera
Synoptic Weather Pattern Associated Poor Dispersion and High Ozone and Particulate Concentrations

- Pattern dominated by High Pressure
- Weak Easterly Winds Aloft Opposing Normal Thermally Driven Winds
- Large Scale Weak Pressure Gradients
- Subsidence
- Warmer Temperatures Aloft
- Warm Surface Temperatures (Ozone)
Wind Trajectories During High and Low Particulate Concentrations – Generated By Computer Models

Trajectory Start Time: 10/21/98 Hour: 1
Trajectory End Time: 10/21/98 Hour: 24
Ending Position

156 ug/m³

Trajectory Start Time: 10/25/98 Hour: 1
Trajectory End Time: 10/25/98 Hour: 24
Ending Position

13 ug/m³
Nighttime Wind Flow for $O_3$ Season
Daytime Wind Flow for $O_3$ Season
Emissions
The forecaster must predict:

- Large changes in emissions (fires, blowing dust)
- Changes in wind direction & speed during periods of high emissions
Emissions - Wildfire Smoke

Sept 18, 2006

Monterey
Modesto
Merced
Fresno
Hanford
Visalia
Bakersfield
Santa Clarita
Ventura
Human Behavior

• Variation in activities by day of week (Driving, Fireplace Use)

• Holidays (4th of July, Thanksgiving)

• Compliance with curtailment programs
Process

- Collect Air Quality Information
- Review Current Air Quality Data
- Run the Air Quality Model and analyze the output
- Verify Past Model Performance
- Weather Data and Map Analysis
- Document in Afternoon Forecast Discussion
- Publish and Distribute the Forecast
Products

- Air Quality Index Forecast and Discussion
- Smoke Management System - Agricultural Burn
- Prescribed and Hazard Reduction Burn Forecast
- Spare the Air and Residential Wood Burn Declaration
- Health Advisory Issuance
- Natural Events Action Plan (NEAP)
### Air Quality Index (AQI): 8-hr Ozone

<table>
<thead>
<tr>
<th>Descriptors Values</th>
<th>Ozone (ppb)</th>
<th>Cautionary Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good 0 - 50 GREEN</td>
<td>0 - 64</td>
<td>None</td>
</tr>
<tr>
<td>Moderate 51 - 100 YELLOW</td>
<td>65 - 84</td>
<td>Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors.</td>
</tr>
<tr>
<td>Unhealthy for Sensitive Groups 101 - 150 ORANGE</td>
<td>85 - 104</td>
<td>Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors.</td>
</tr>
<tr>
<td>Unhealthy 151 - 200 RED</td>
<td>105 - 124</td>
<td>Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.</td>
</tr>
<tr>
<td>Very Unhealthy 201 - 300 Purple</td>
<td>125 - 374</td>
<td>Active children and adults, and people with lung disease, such as asthma, should avoid all outdoor exertion. Everyone else, especially children, should avoid prolonged or heavy exertion outdoors.</td>
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<tr>
<td>Air Quality Flag Program</td>
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<tr>
<td>--------------------------</td>
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<tr>
<td><strong>GOOD</strong> 0-50</td>
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<td></td>
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<tr>
<td>No limitations.</td>
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<tr>
<td><strong>MODERATE</strong> 51-100</td>
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<tr>
<td>Extremely sensitive children and adults, especially those with respiratory diseases such as asthma, should consider limiting outdoor exertion.</td>
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<tr>
<td><strong>UNHEALTHY SENSITIVE GROUPS</strong> 101-150</td>
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<tr>
<td>Sensitive children and adults, especially those with respiratory diseases such as asthma, should limit prolonged outdoor exertion.</td>
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<td><strong>UNHEALTHY</strong> 151-200</td>
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<tr>
<td>Sensitive children and adults should avoid outdoor exertion, and everyone else should limit prolonged outdoor exertion during peak ozone periods.</td>
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## Fireplace and Woodstove Curtailment Program

### County Prohibited Discouraged

<table>
<thead>
<tr>
<th>County</th>
<th>2005-06 [04-05]</th>
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<tbody>
<tr>
<td>Fresno</td>
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<td>Kern (valley)</td>
<td>16 [2]</td>
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<td>Kings</td>
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<td>Madera</td>
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<td>Merced</td>
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<tr>
<td>Stanislaus</td>
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</table>
Summary

- Scientific studies are the basis for the forecast.
- Statistical models provide guidance.
- New tools continue to evolve.
- Products are utilized by over a 1,000 + San Joaquin Valley citizens.
- Daily forecast products distributed by 4:30 PM.
Air Quality Trends

- Ozone - 8 Hour
- PM2.5
- Ozone
State of Air Quality
Ambient Concentrations, 1990-2005

- 8-hour ozone
  - Large number of exceedance days
  - Design value has not significantly changed since 1990

- PM2.5
  - Most sites still violate annual PM2.5 standard
State of Air Quality - Ozone Ambient Concentrations, 1990-2005

- 1-hour ozone
  - Number of annual of exceedance days dropped 57% (3-yr average)
- 8-hour ozone
  - Number of annual of exceedance days dropped 16% (3-yr average)
Ozone Trends in SJV

Basin-Wide Year-To-Date (September 27) Ozone Exceedance Days

- O3-1
- O3-8
- Linear (O3-8)
8-Hour Ozone Design Value (2005)
Ozone 8-Hour Spatial Extent Reduced

Legend
Air Districts
Design Values
1995 Values
- < 85 ppb
- 86 - 95
- 96 - 105
- > 105

Legend
Air Districts
Design Values
2005 Values
- < 85 ppb
- 85 - 95
- 96 - 105
- > 105

1995

2005
One of seven improving sites in the SJVAB for 8-hour ozone air quality for the years 1990 to 2005.
One of the eleven sites with no clear trend for the years 1990 to 2005.
The only site where 8-hour ozone air quality is getting worse for the years 1990 to 2005.
Days Over 8-Hour Ozone Standard for Fresno-Sierra Sky Park (SSP) Site
Particulate Matter Measurements

- Particulate Matter
  - PM 10 attainment
  - Attainment of 24-hr PM2.5 standard
  - Annual average PM2.5 levels have improved since monitoring began in 1999

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2005</th>
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<tbody>
<tr>
<td>PM2.5 annual average, percent over standard</td>
<td>87%</td>
<td>33%</td>
</tr>
</tbody>
</table>
State of Air Quality - PM10
Ambient Concentrations, 1990-2005

- **1990-2005**
  - 24-hr design value dropped 56%
  - Highest annual average concentration dropped 39%

- **2003-2005**
  - No violations of the 24-hr and annual NAAQS
  - Attainment
Trend in the Number of Days Greater Than the PM2.5 24 Hour National Standard

Basin-Wide Days Over PM2.5 Standard

Days

Years

1999 2000 2001 2002 2003 2004 2005
PM2.5 Spatial Extent Reduced

2000 PM2.5 Annual Average

- 2003-2005 annual average all sites improved
- Modesto and Merced green
- Fresno yellow, like Corcoran
- Bakersfield and Visalia orange

Najita et al. 2005
Attainment of 24-hr PM2.5 Standard

3-year Average of 98th Percentile, Highest SJV site shown for each year

PM2.5 micrograms per cubic meter

NAAQS = 65
Vegetative Burning Controls

- Residential burning a significant contributor in the winter
- New markers for wood combustion helped identify impacts
- Controls include:
  - Residential wood combustion restrictions
  - Phase-out of agricultural burning
  - Smoke management program

Woodsmoke Contribution to PM2.5 at Fresno

Gorin et al. 2005
Air Quality Analysis, “Keeping a Watchful Eye on Your Air Quality.”
Questions?

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