Tasks 5.2 and 6.3: The Influence of Winds and Vertical Mixing on $PM_{2.5}$ Concentrations

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Task 5.2: Evaluation of Transport

- Winds
  - Transport pathways
  - Flows: nocturnal jet, eddy, terrain
  - Flux planes
  - Advection vs. diffusion
- Mixing heights
- Synoptic weather
  - Winds
  - Mixing

Task 6.3: Transport and the Regional Nature of Secondary PM

- Causes of the regional nature of PM
  - Transport
  - Diffusion
  - Emission source location
  - Aloft NO_x emissions

Approach

- CALMET modeling
  - Wind fields
  - Trajectories
  - Dispersion (CALPUFF)
- Data Analysis
  - Profiler winds
  - Mixing heights
  - PM data
- Case Studies
  - November 17 through 26, 2000
  - December 13 through 20, 2000
  - December 24 through 30, 2000
  - January 2 through 9, 2001

CALMET – Background

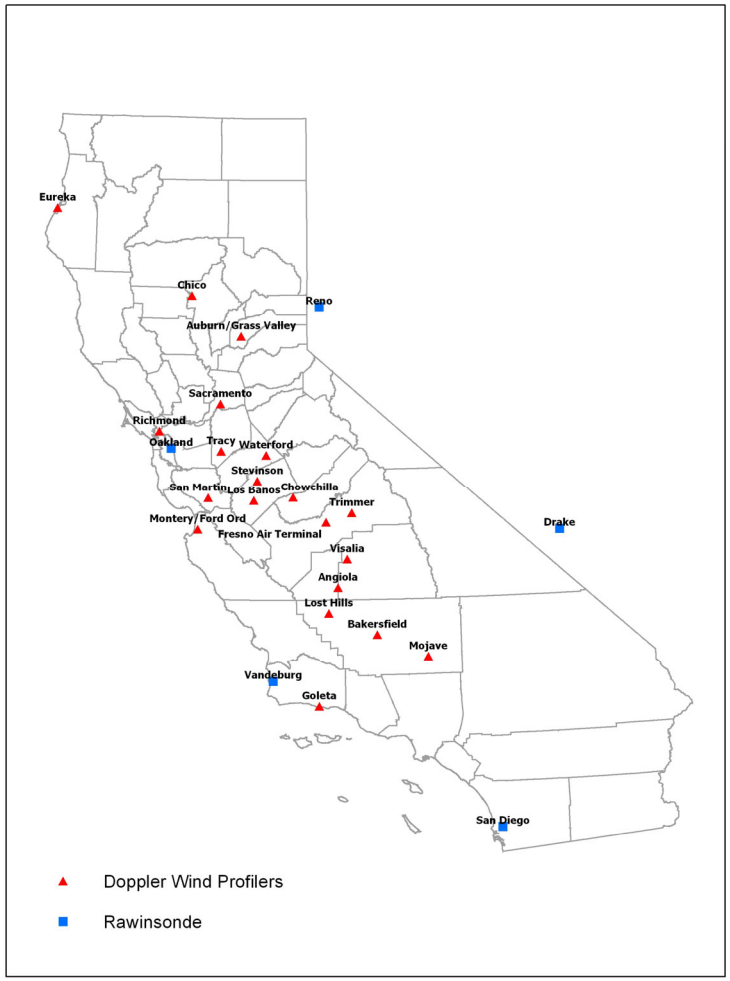
- What is CALMET?
  - A meteorological model that includes a diagnostic wind field generator containing objective analysis and parameterized treatments of slope flows, kinematic terrain effects, terrain-blocking effects, a divergence minimization procedure, and a micro-meteorological model for overland and overwater boundary layers
- Why use CALMET?
  - To resolve mesoscale and local-scale meteorological phenomena by blending observational data with synoptic-scale model results and analyses

CALMET – Data Sources

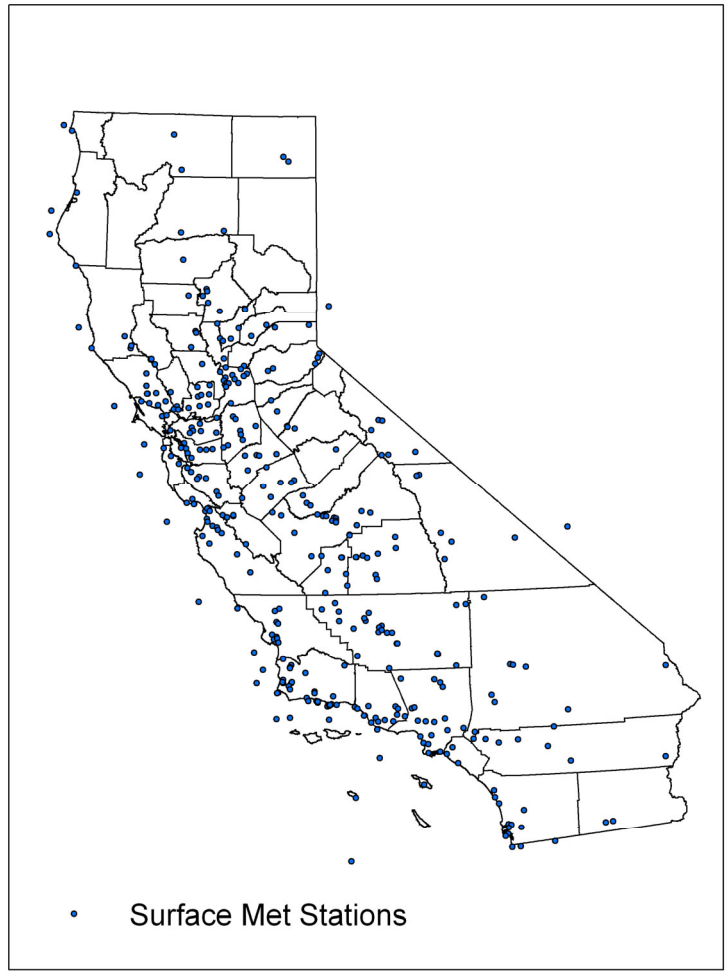
- Radar wind profiler wind and RASS virtual temperature data from 24+ sites, quality-controlled to Level 2
- Rawinsonde data from 5 sites
- Surface observations from 359 sites
- Eta Data Assimilation System (EDAS)
  - Regional-scale model data
  - Nudged by observations
- 0.9-km resolution terrain data
- 30-m resolution land use data

CALMET – Data sites

Upper-air



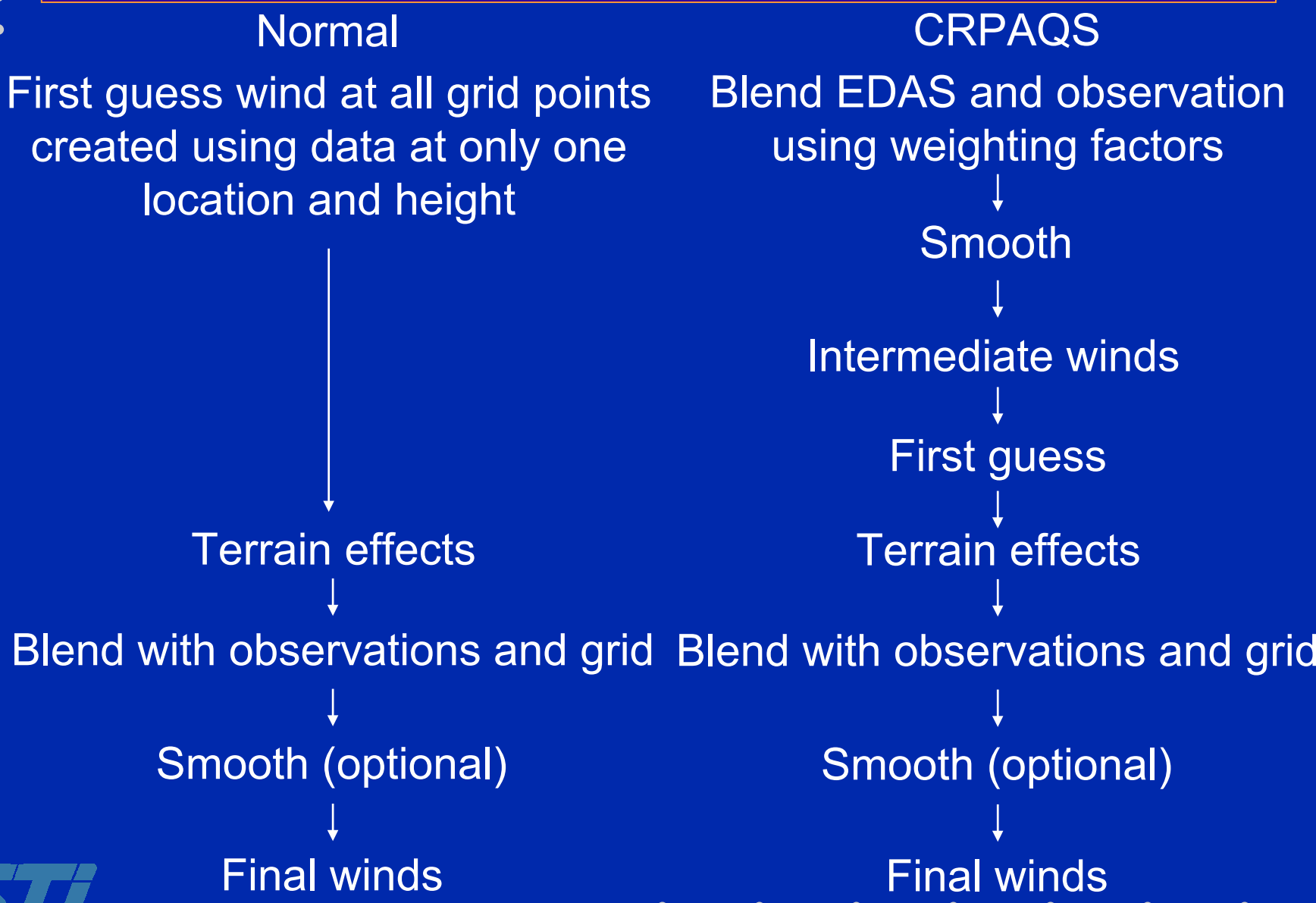
Surface



CALMET – Grid Resolution

- 20 vertical layers with interfaces at 0, 20, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1200, 1400, 1600, 1800, 2000, 2250, 2500, and 2750 m agl
- Horizontal resolution of 4 km
- Modeling grid 273 x 273 (1092 x 1092 km)

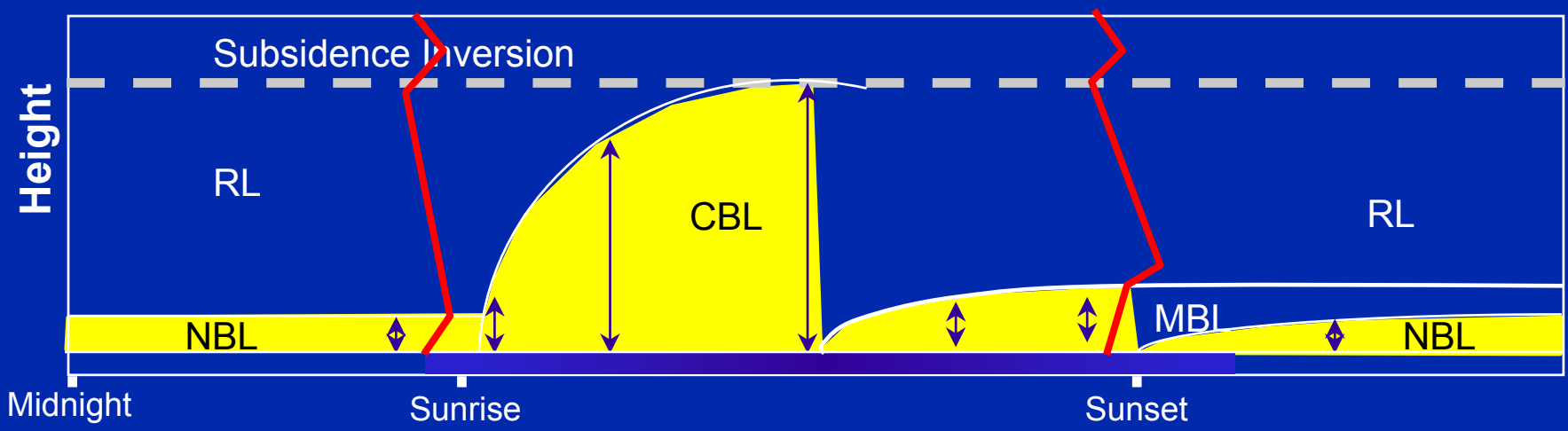
CALMET – Method



Data Analysis – Case Study: Focus on December 22-31, 2000

- Synoptic Weather
- Mixing Depth
  - Peak
  - Diurnal cycle
  - Spatial distribution
- Winds
  - Eddies
  - Jets
  - Terrain flows
- Transport
  - Distance, direction, speed

Mixing Depth – Definition

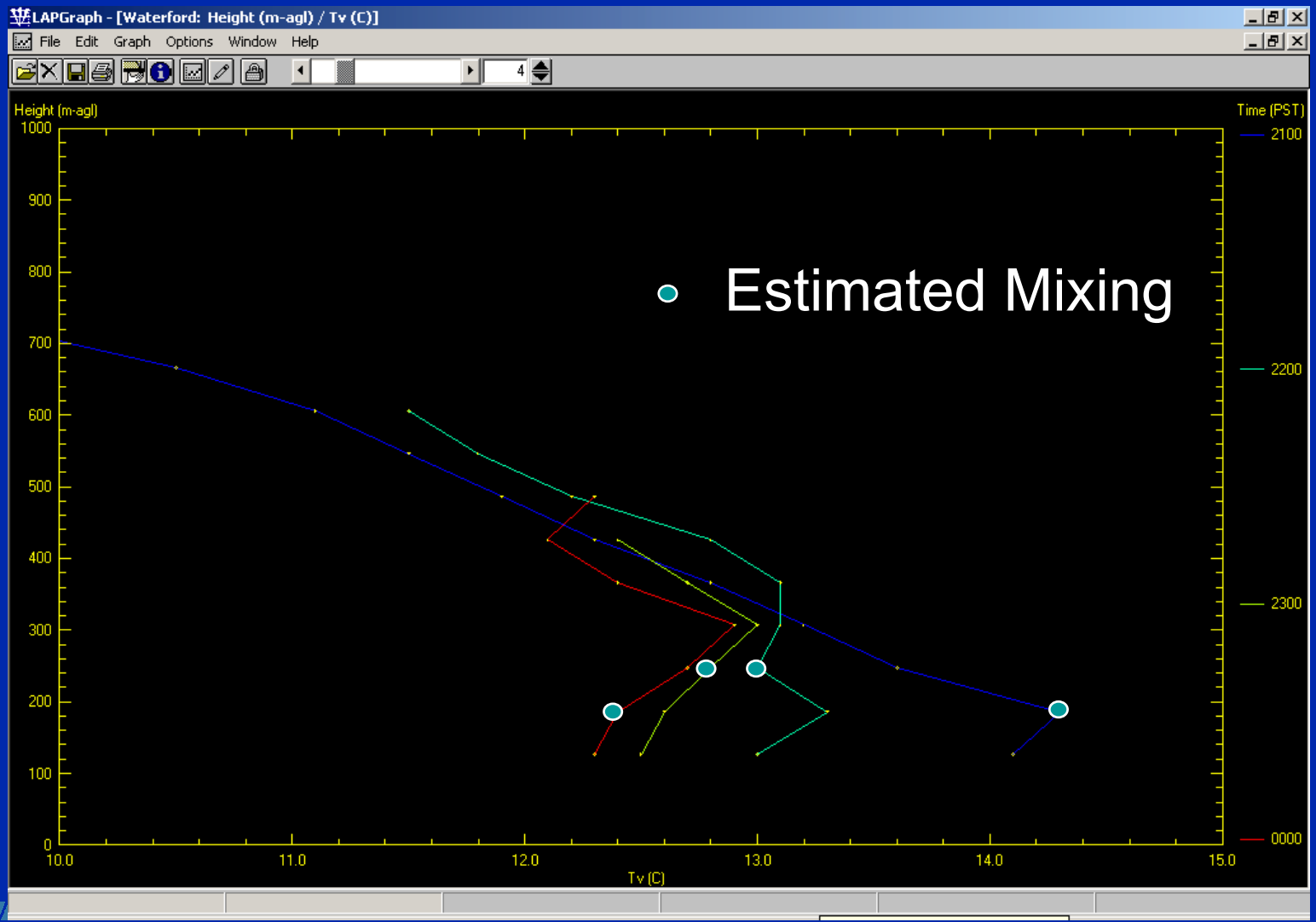


= **Surface-based mixing depth**

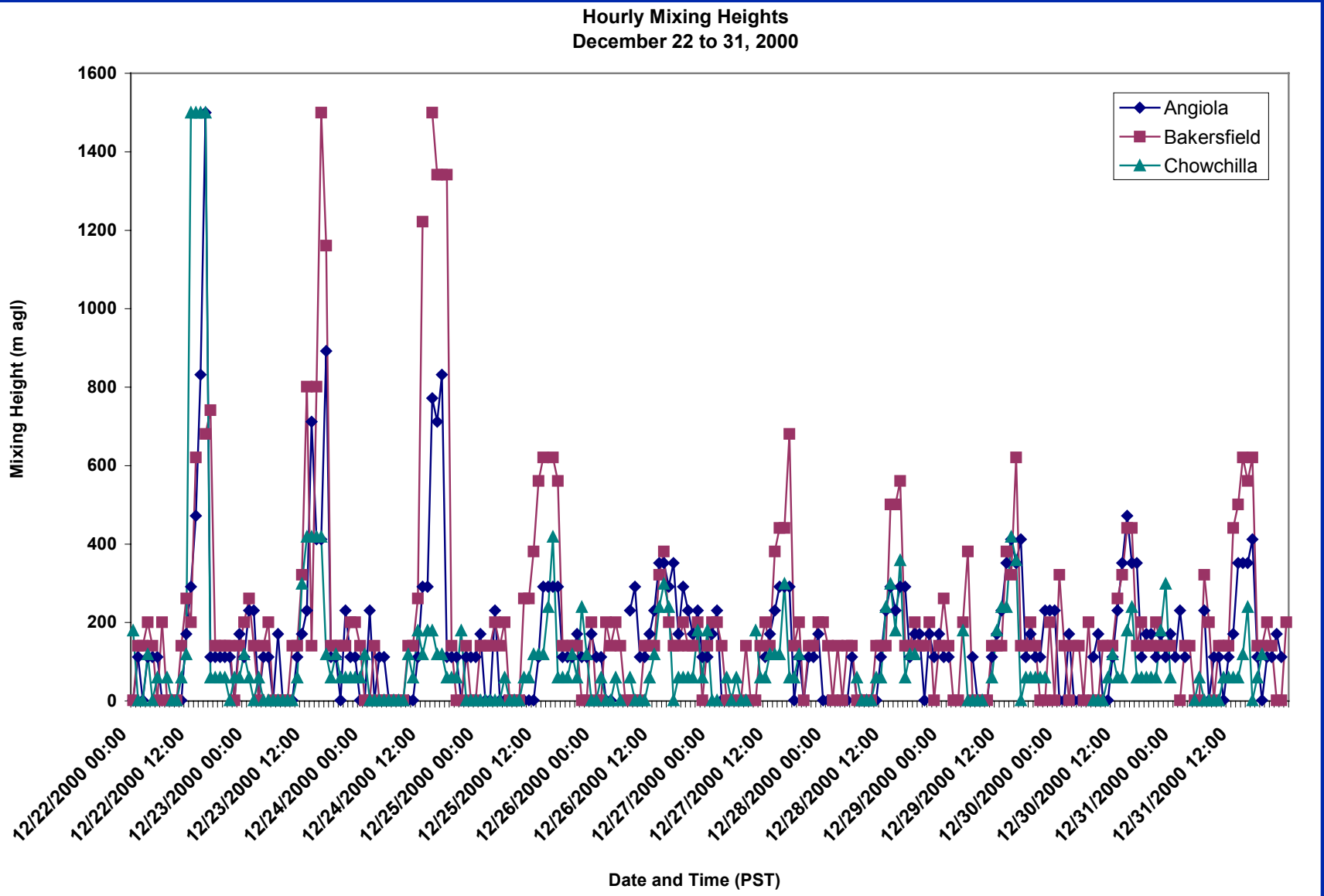
= **Surface-based vertical mixing**

RL = Residual Layer
CBL = Convective Boundary Layer
NBL = Nocturnal Boundary Layer
MBL = Marine Boundary Layer

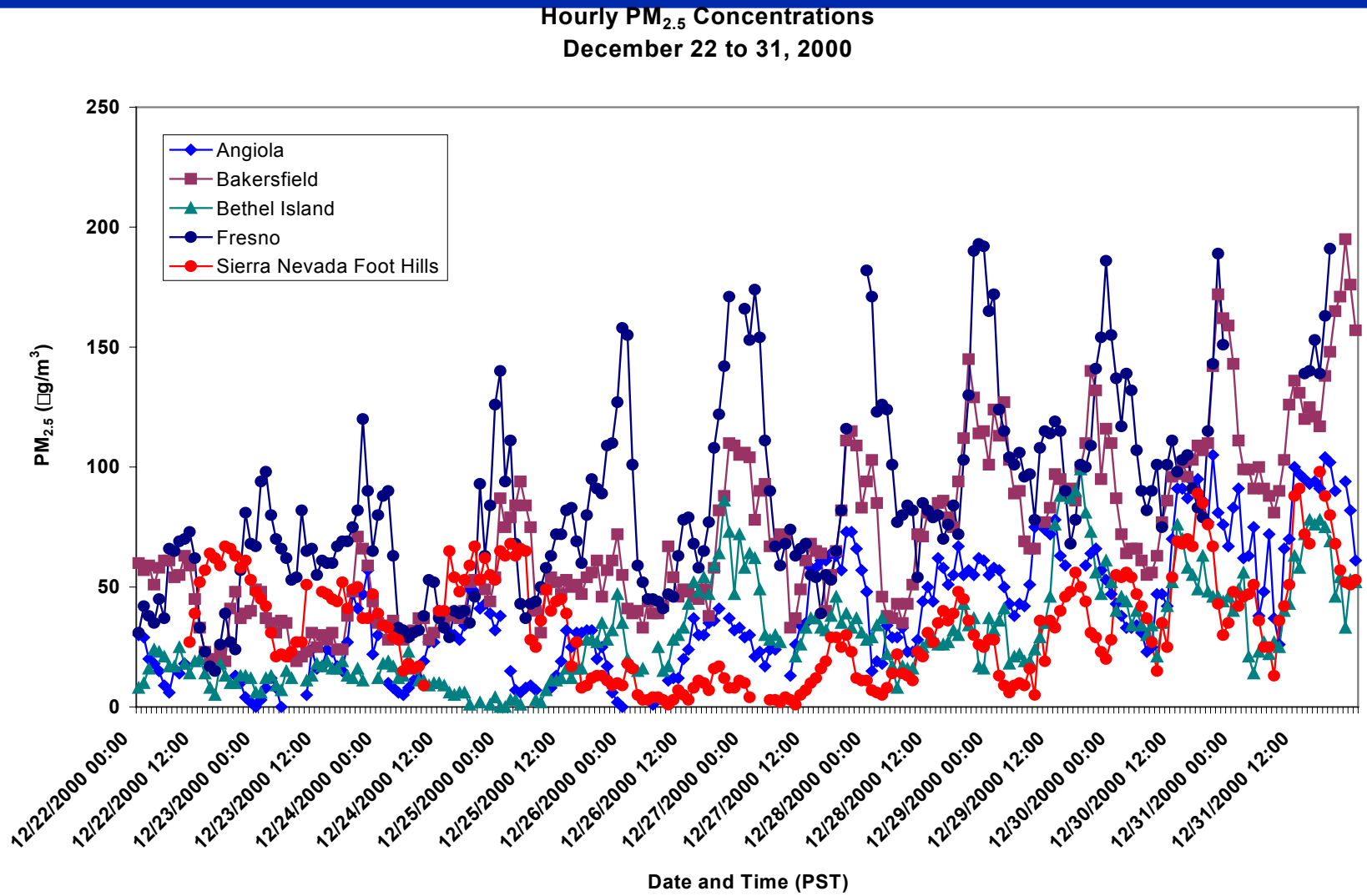
Mixing Depth – Time Continuity Analysis



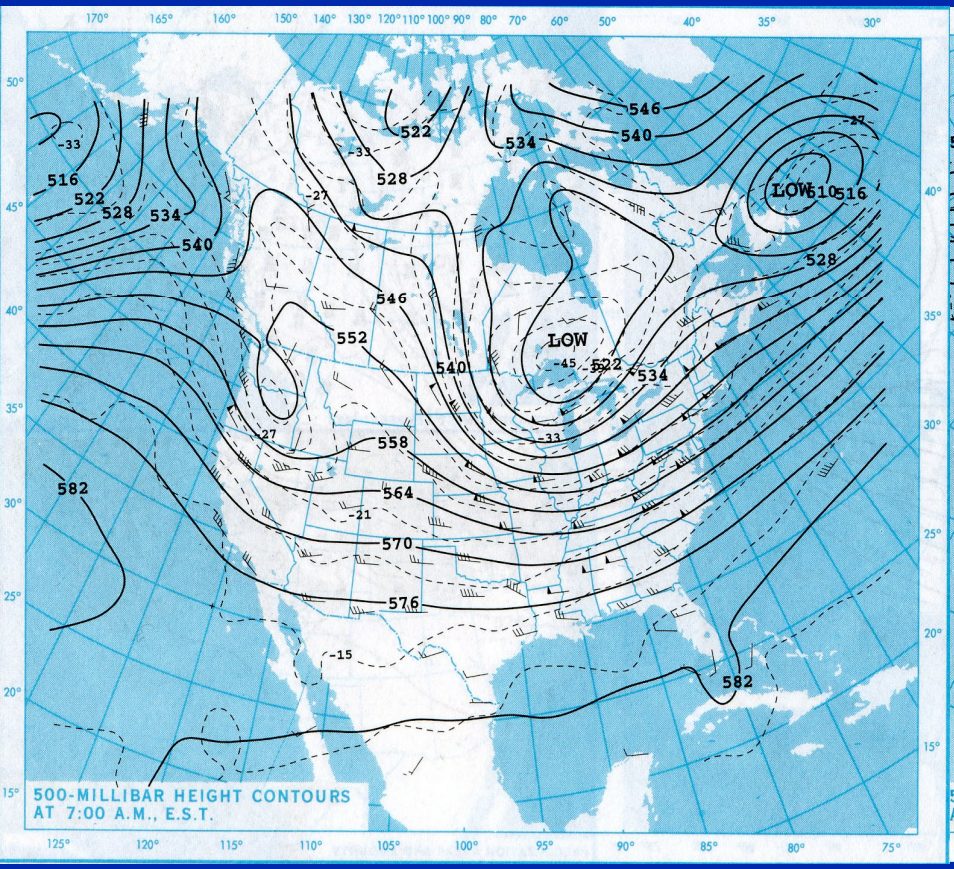
Mixing Depth – December 22-31, 2000



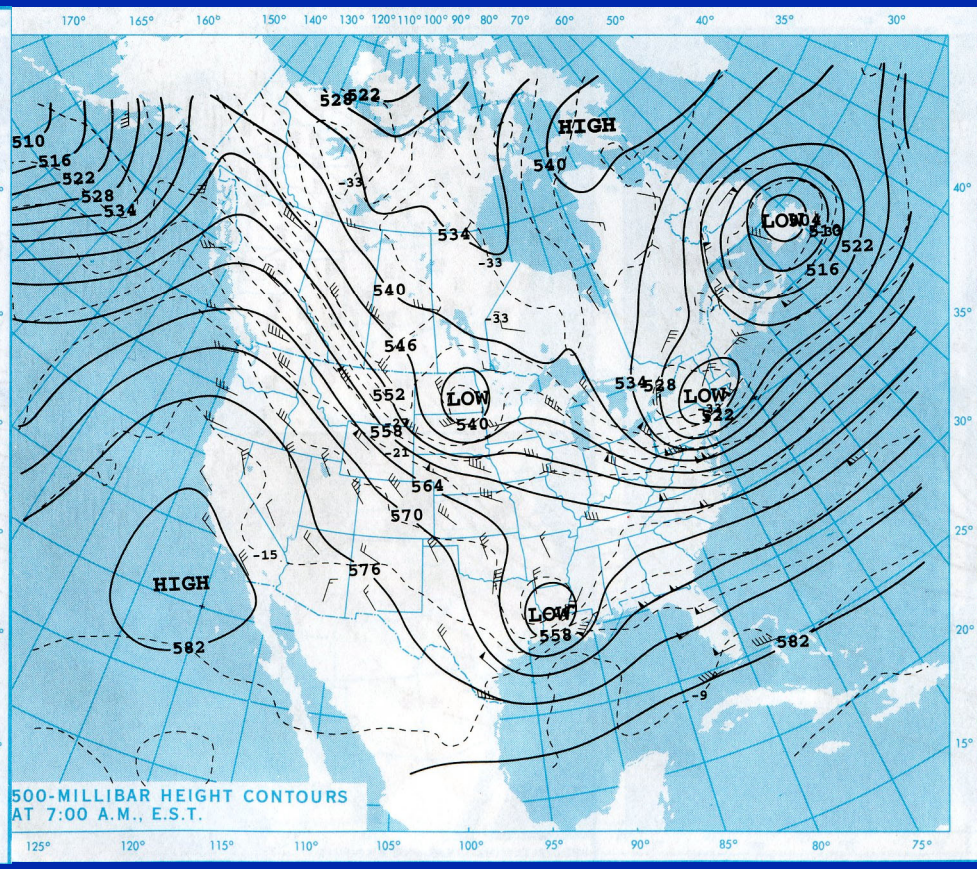
Hourly $PM_{2.5}$ Concentration – December 22-31, 2000



Synoptics – 500-mb Heights

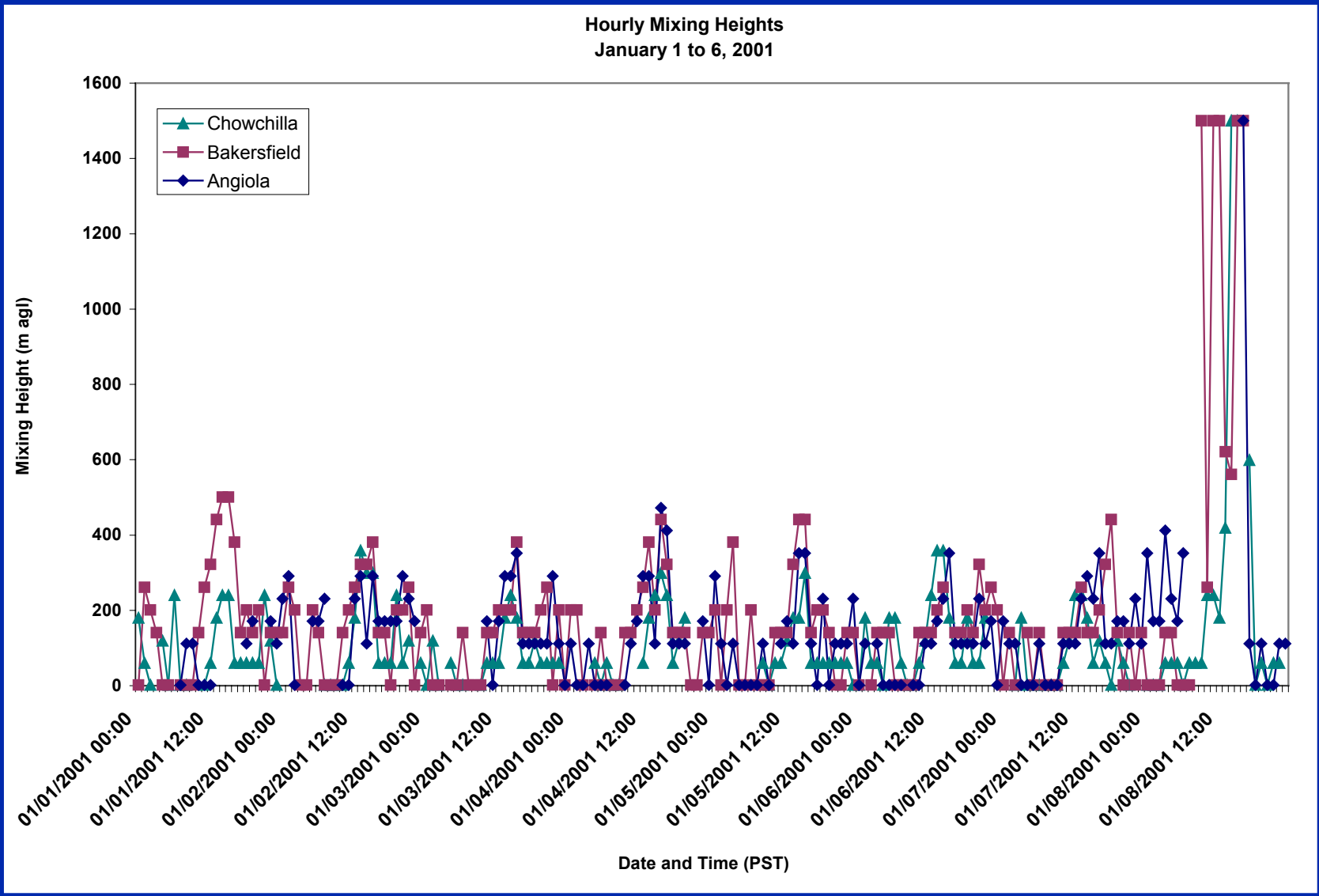


December 24, 2000

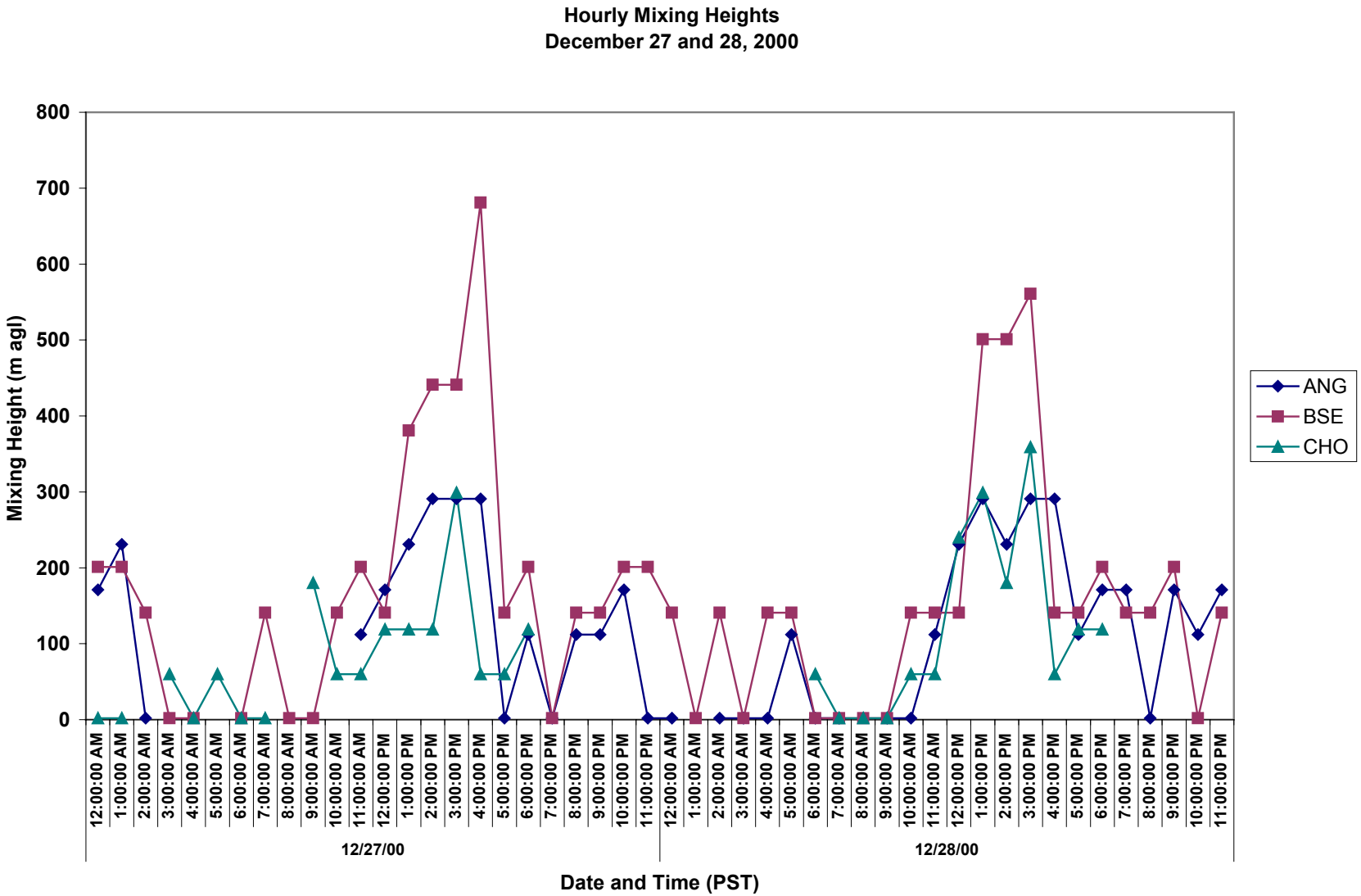


December 28, 2000

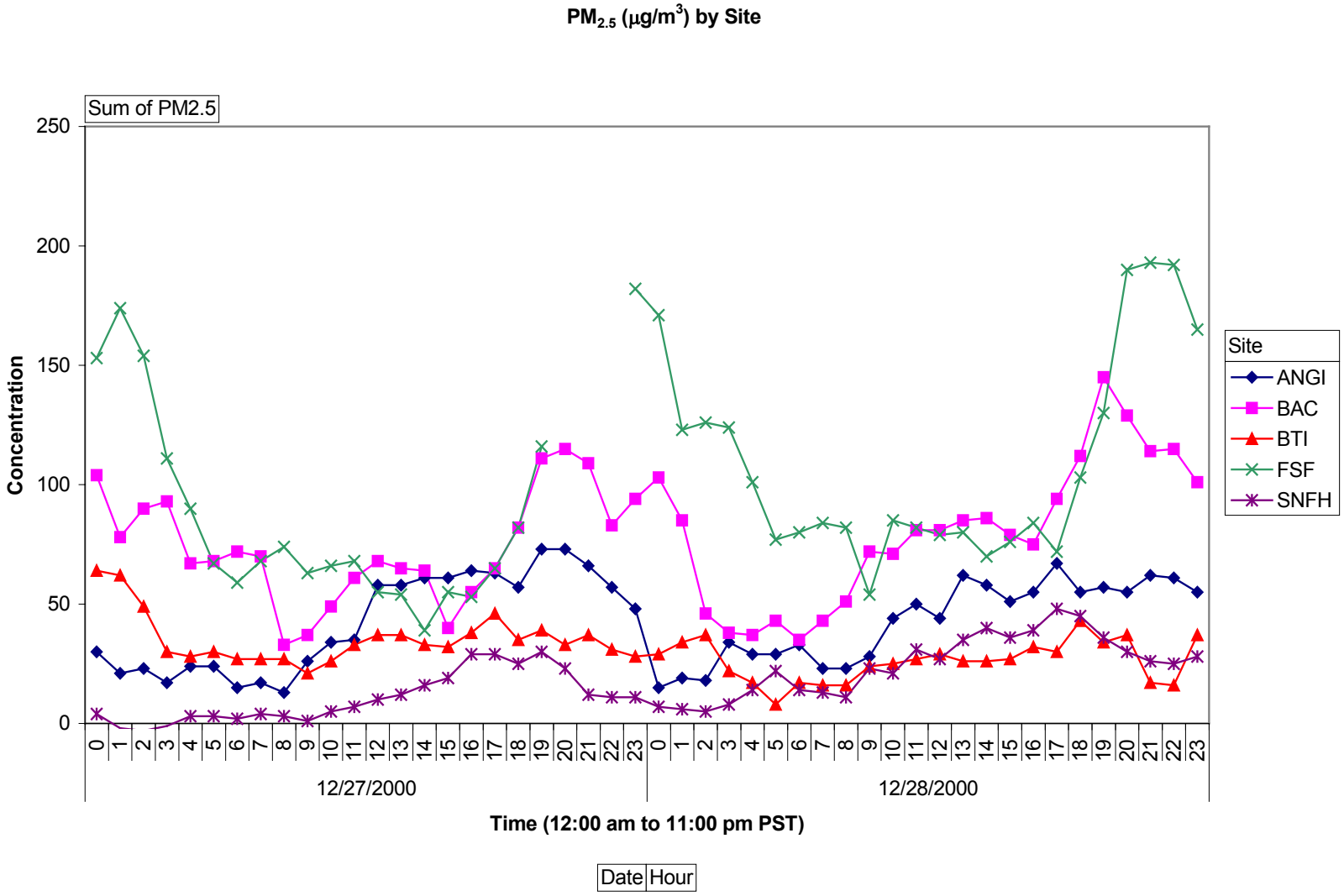
Mixing Depth – January 1-8, 2001



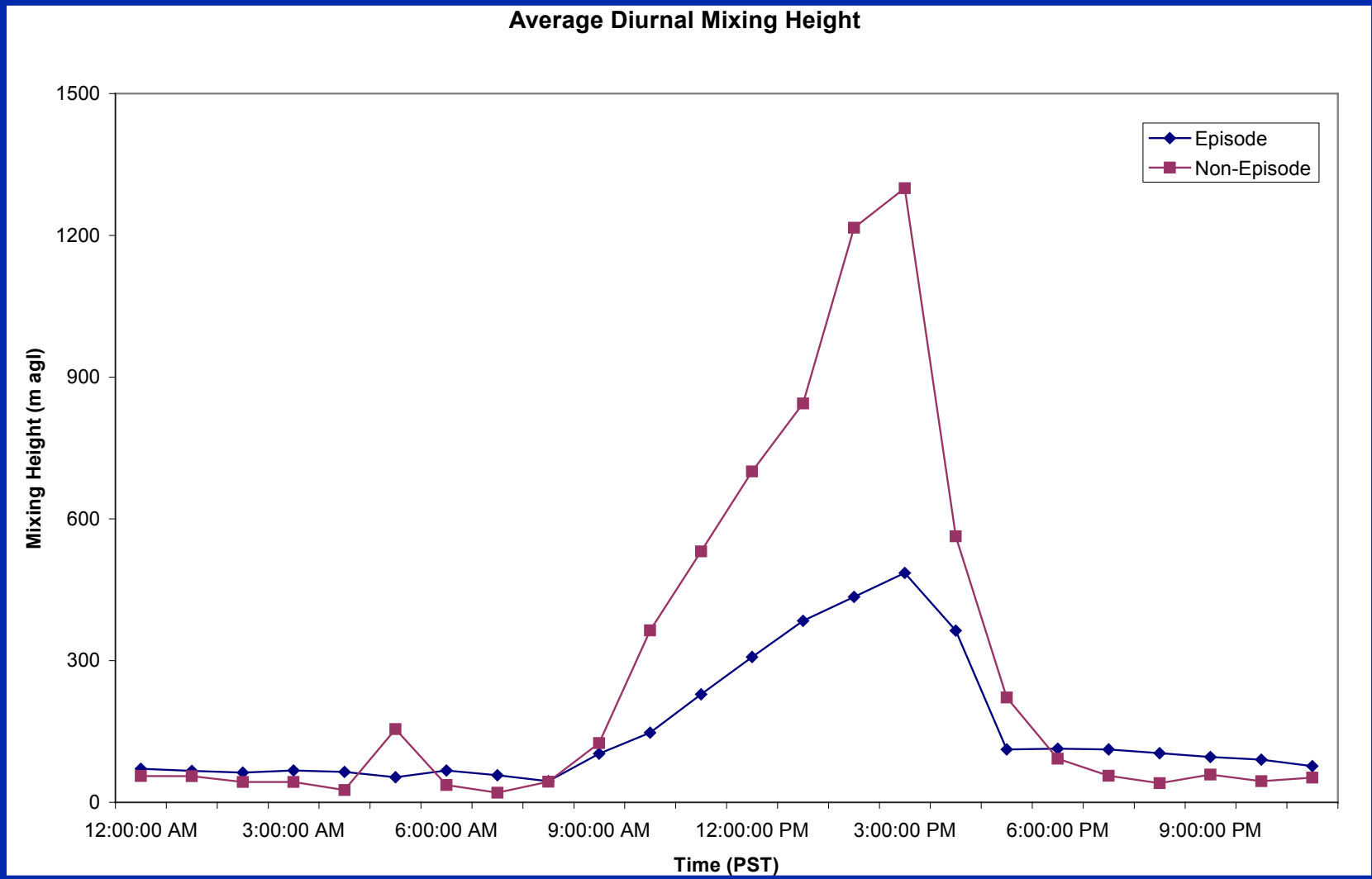
Mixing Depth – December 27 and 28, 2000



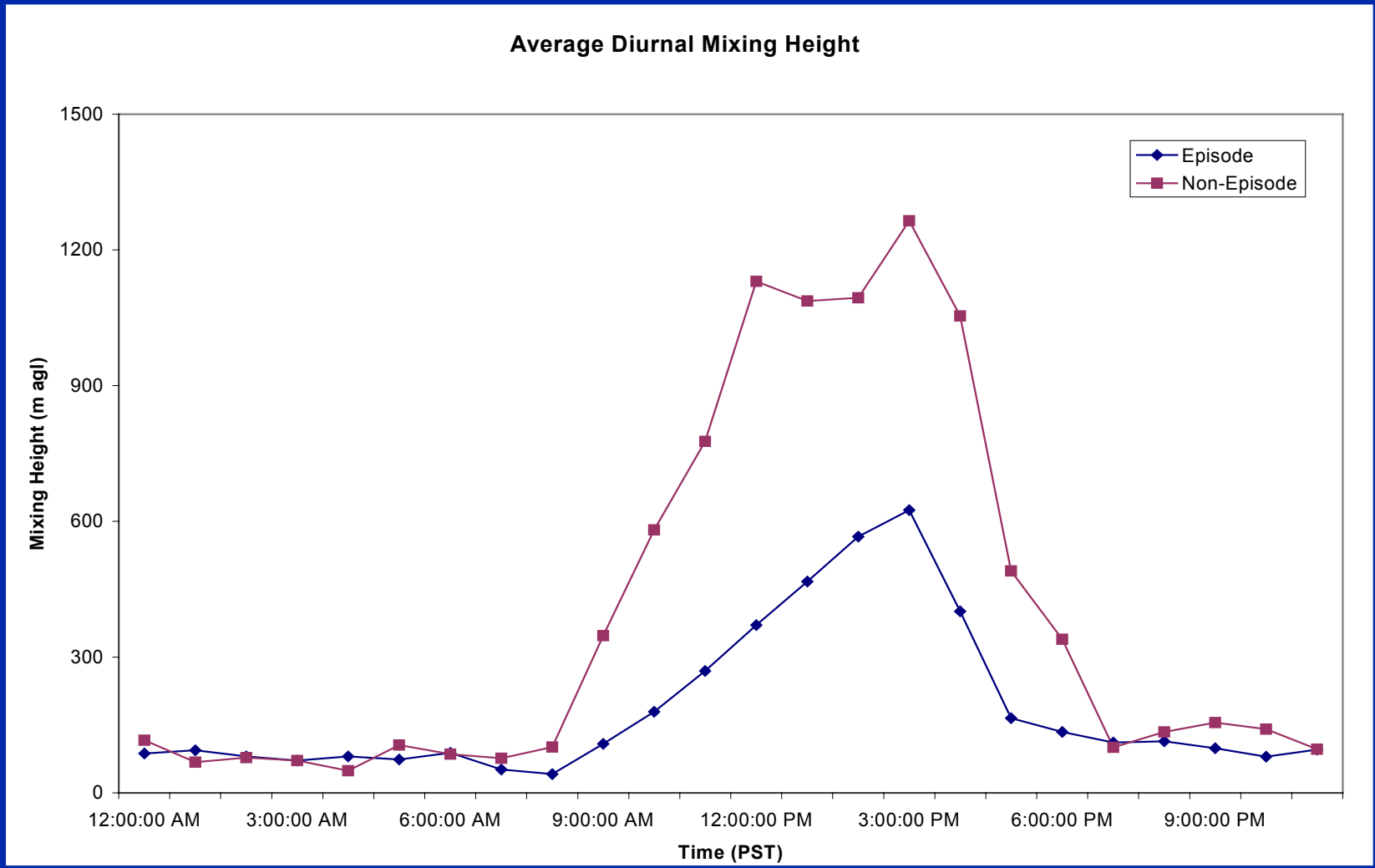
Hourly $PM_{2.5}$ – December 27 and 28, 2000



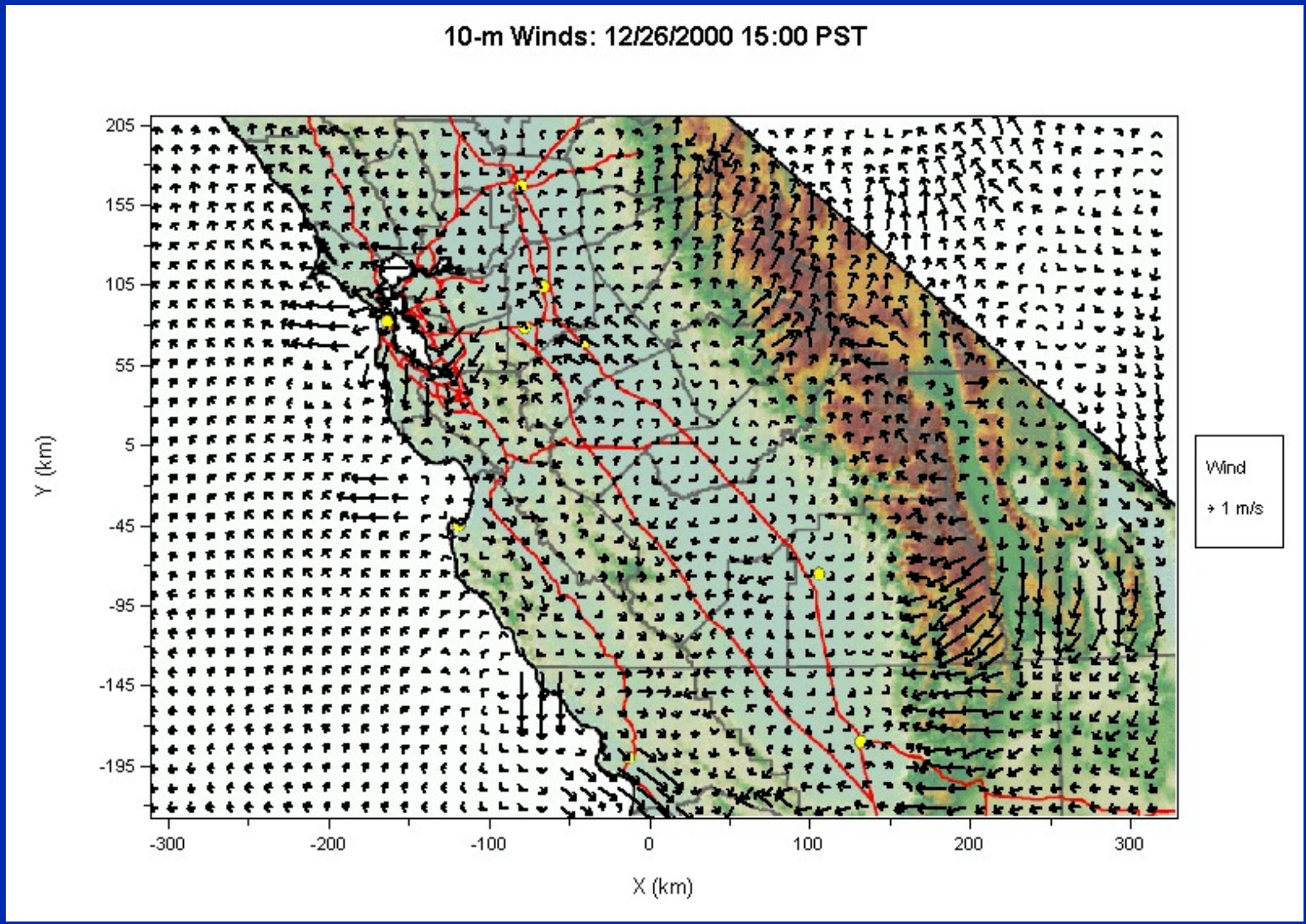
Mixing Depth – Average Mixing at Chowchilla



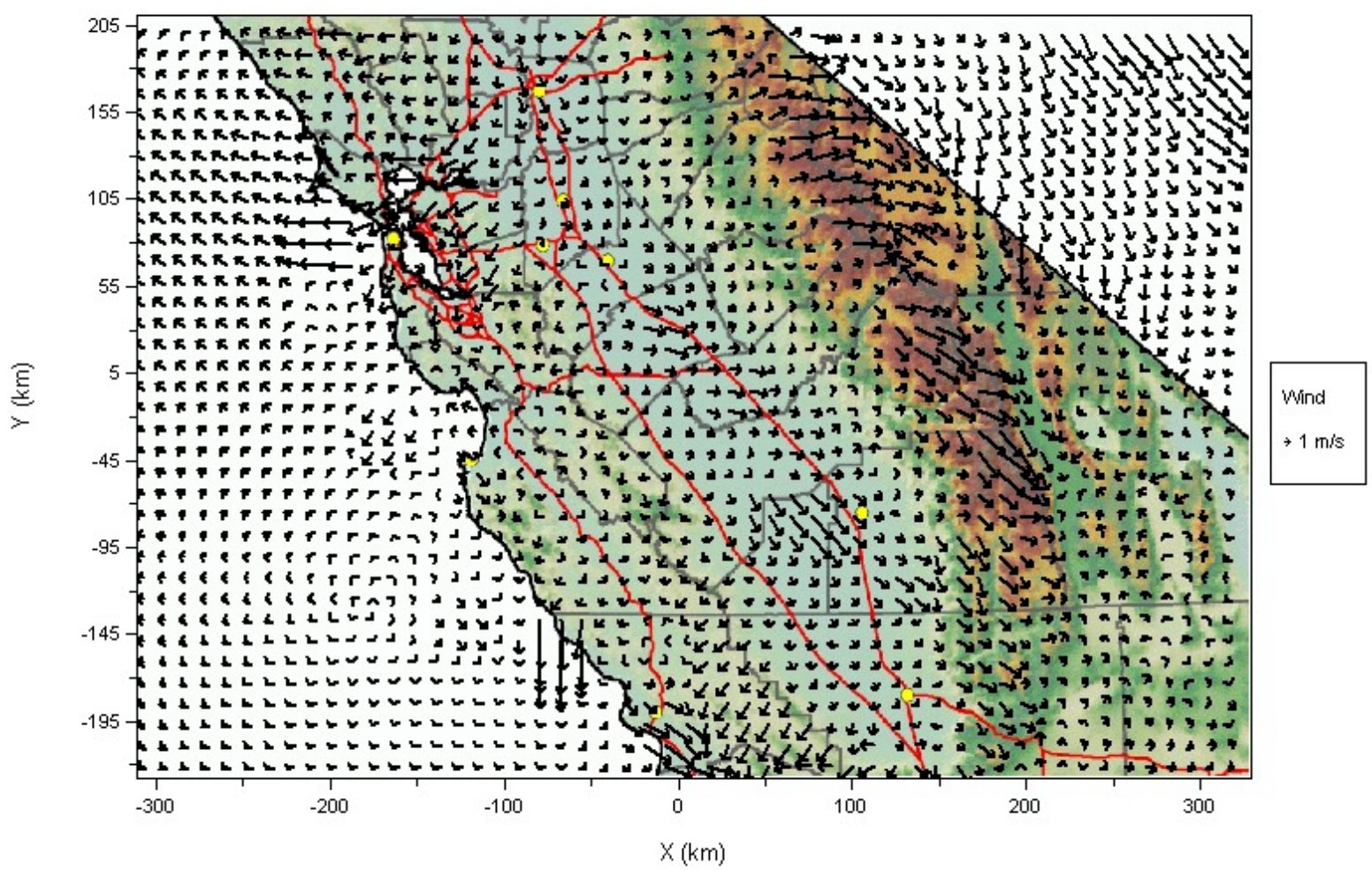
Mixing Depth – Average Mixing at Bakersfield



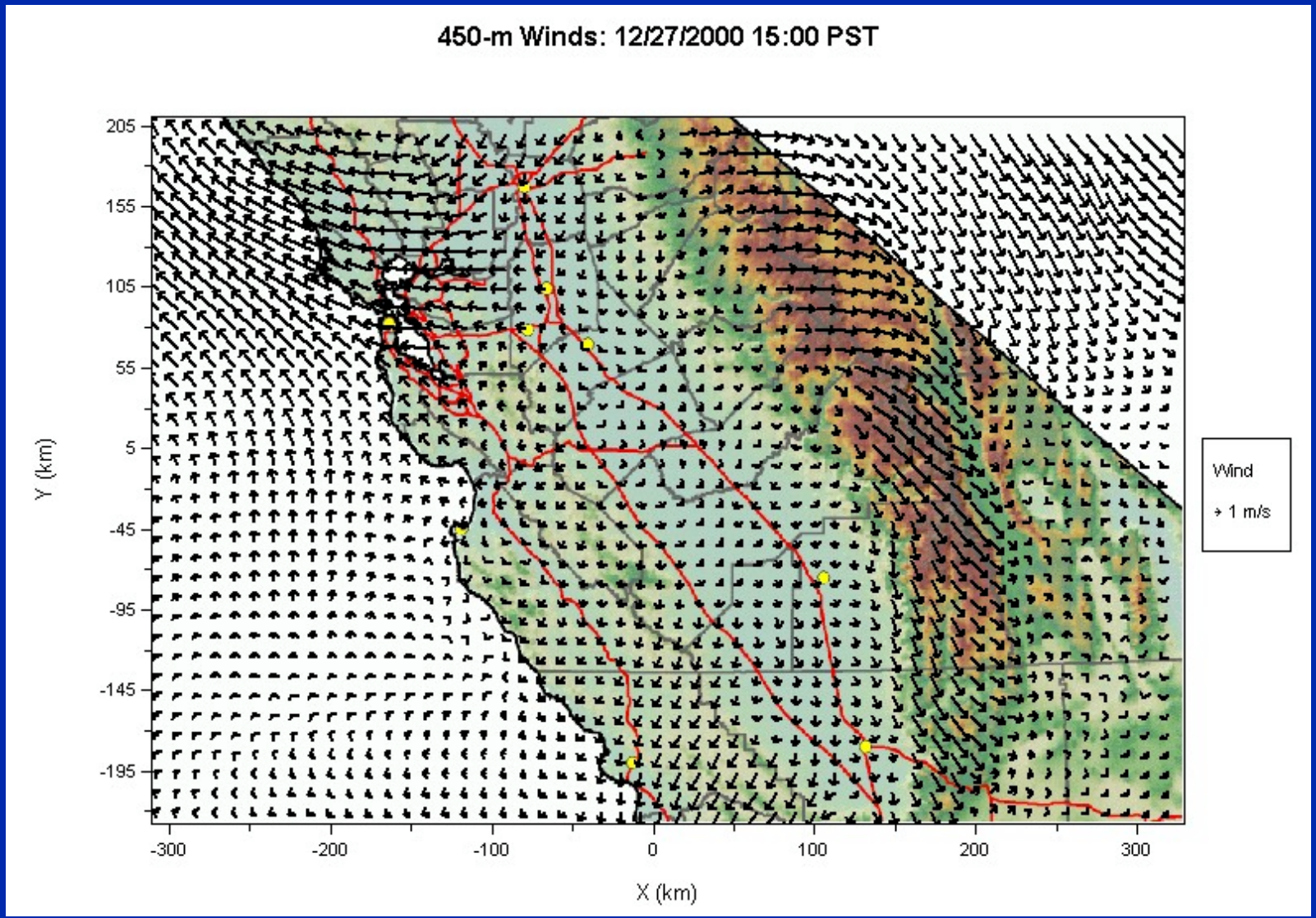
Winds – 10 m on December 26 at 1500 PST



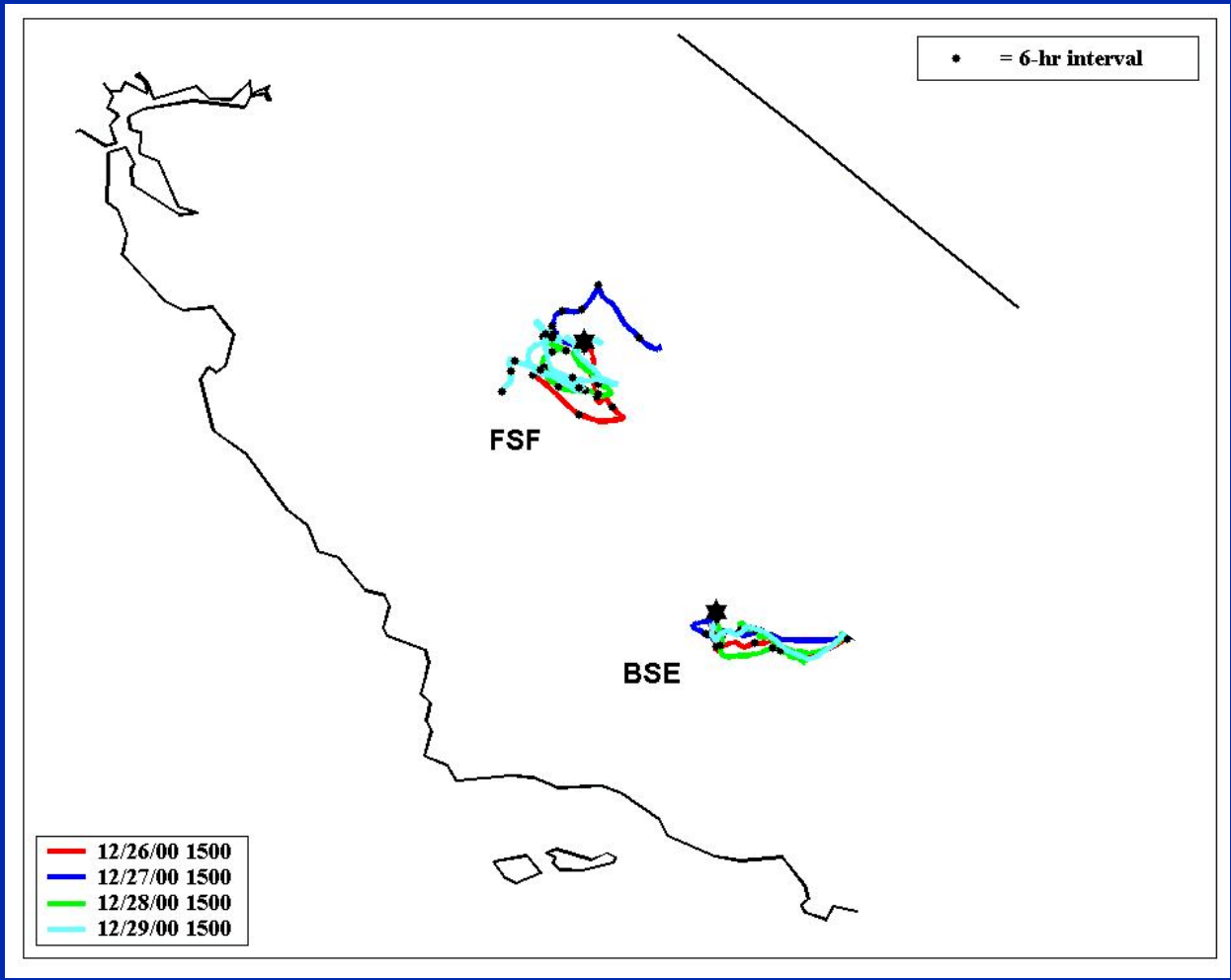
Winds – 10 m on December 27 at 1500 PST



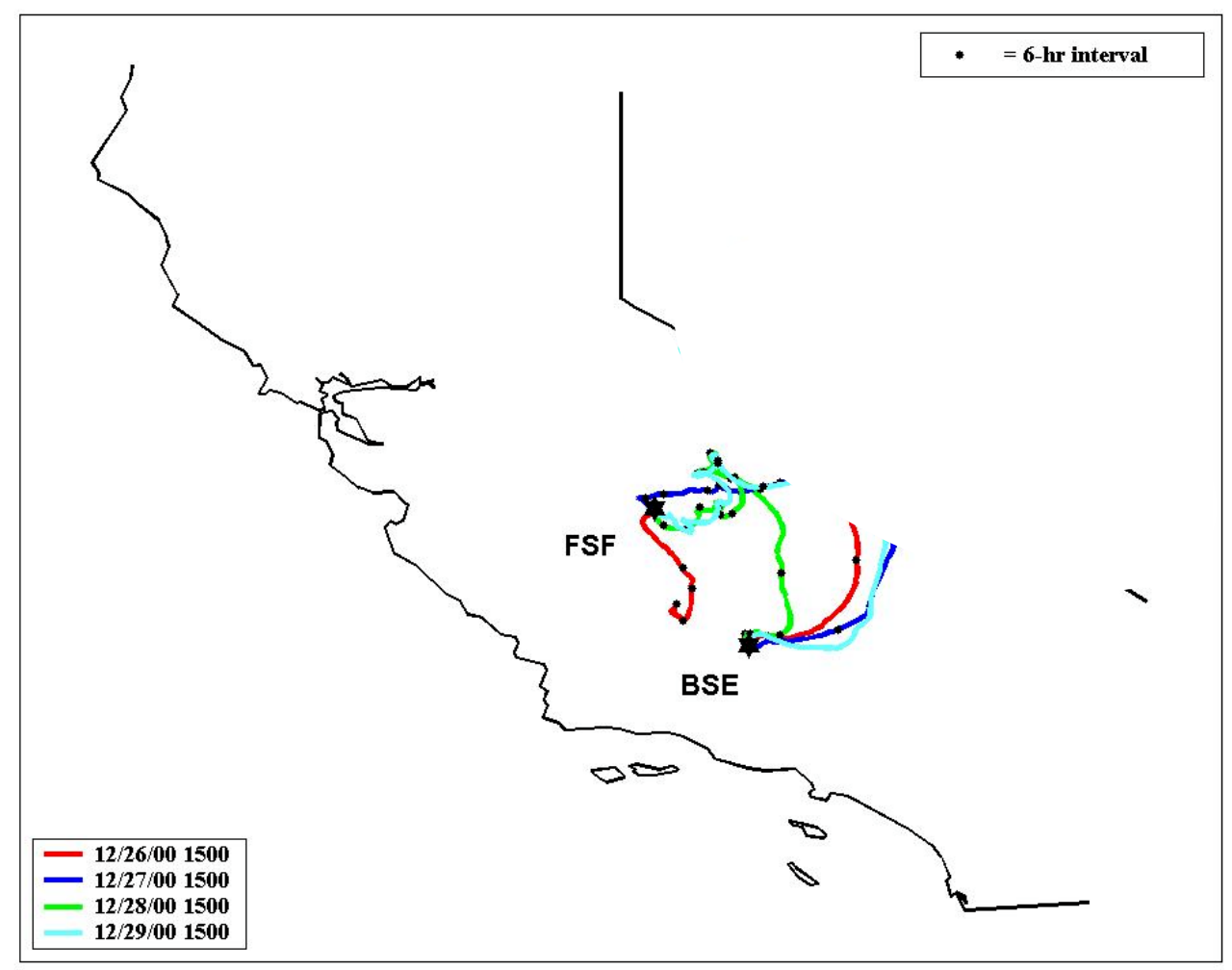
Winds – 450 m on December 27 at 1500 PST



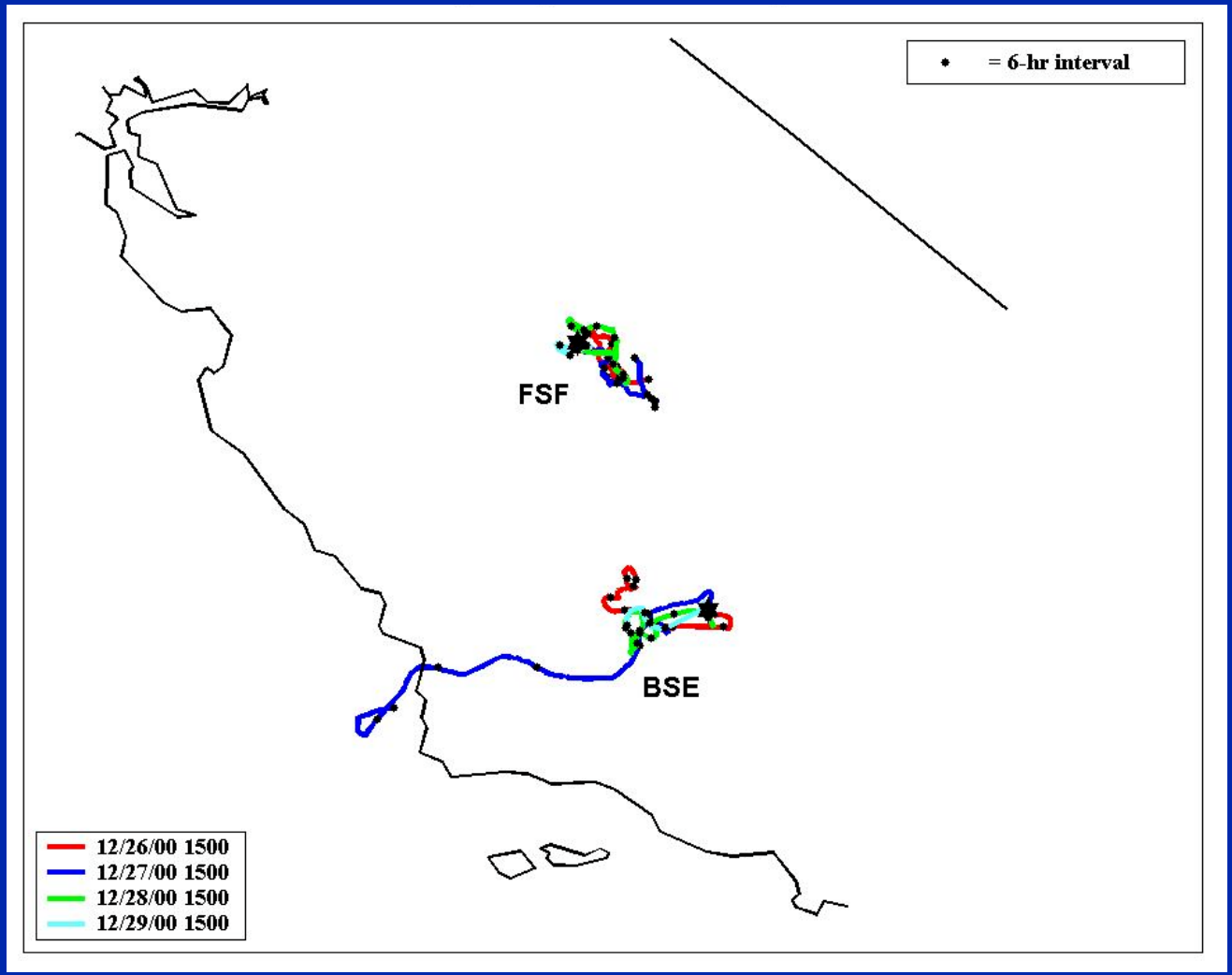
Transport – 48-hr Backward Trajectories at 10 m agl Arriving at Bakersfield and Fresno at 1500 PST on December 25-28, 2000



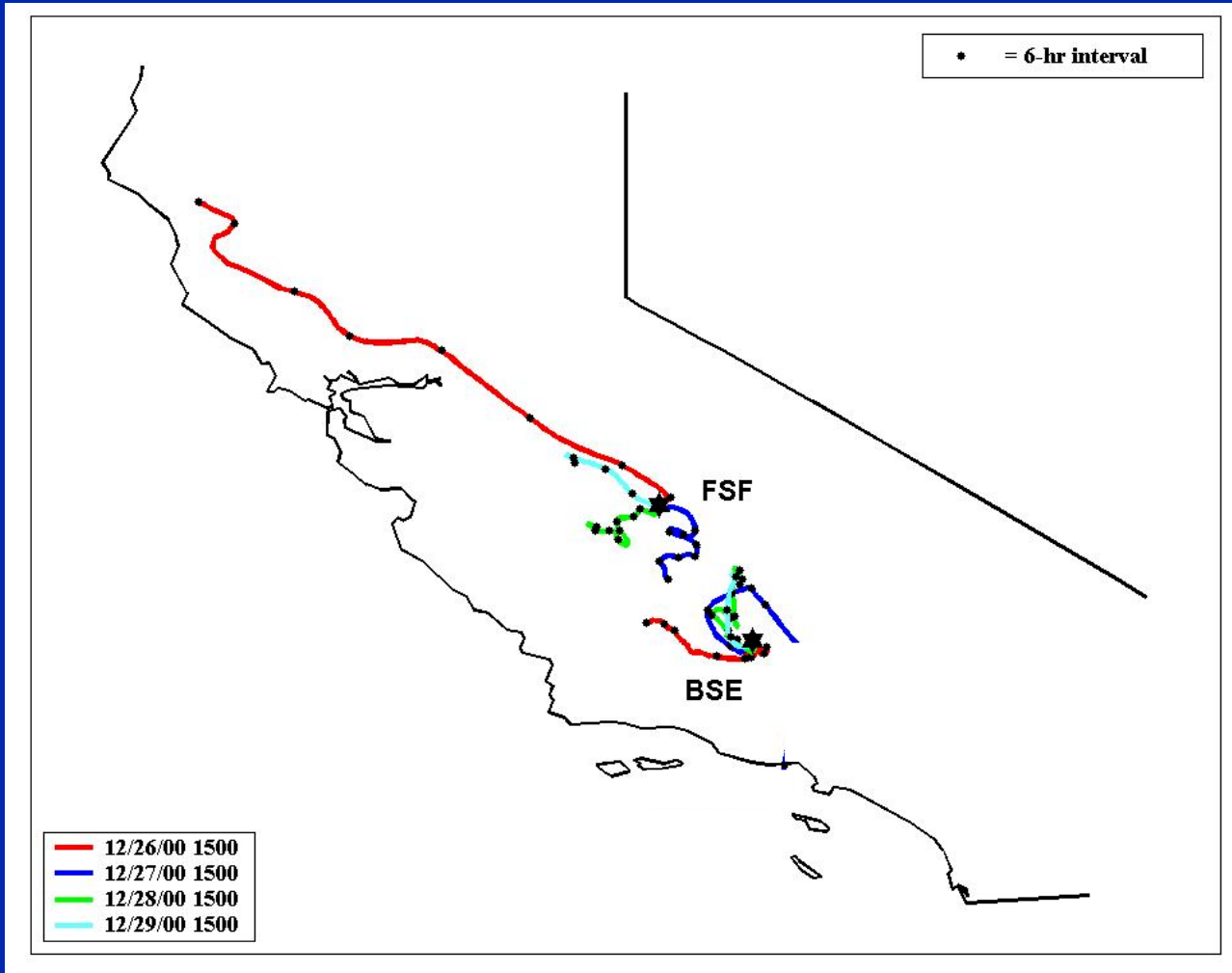
Transport – 48-hr Backward Trajectories at 450 m agl Arriving at Bakersfield and Fresno at 1500 PST on December 25-28, 2000



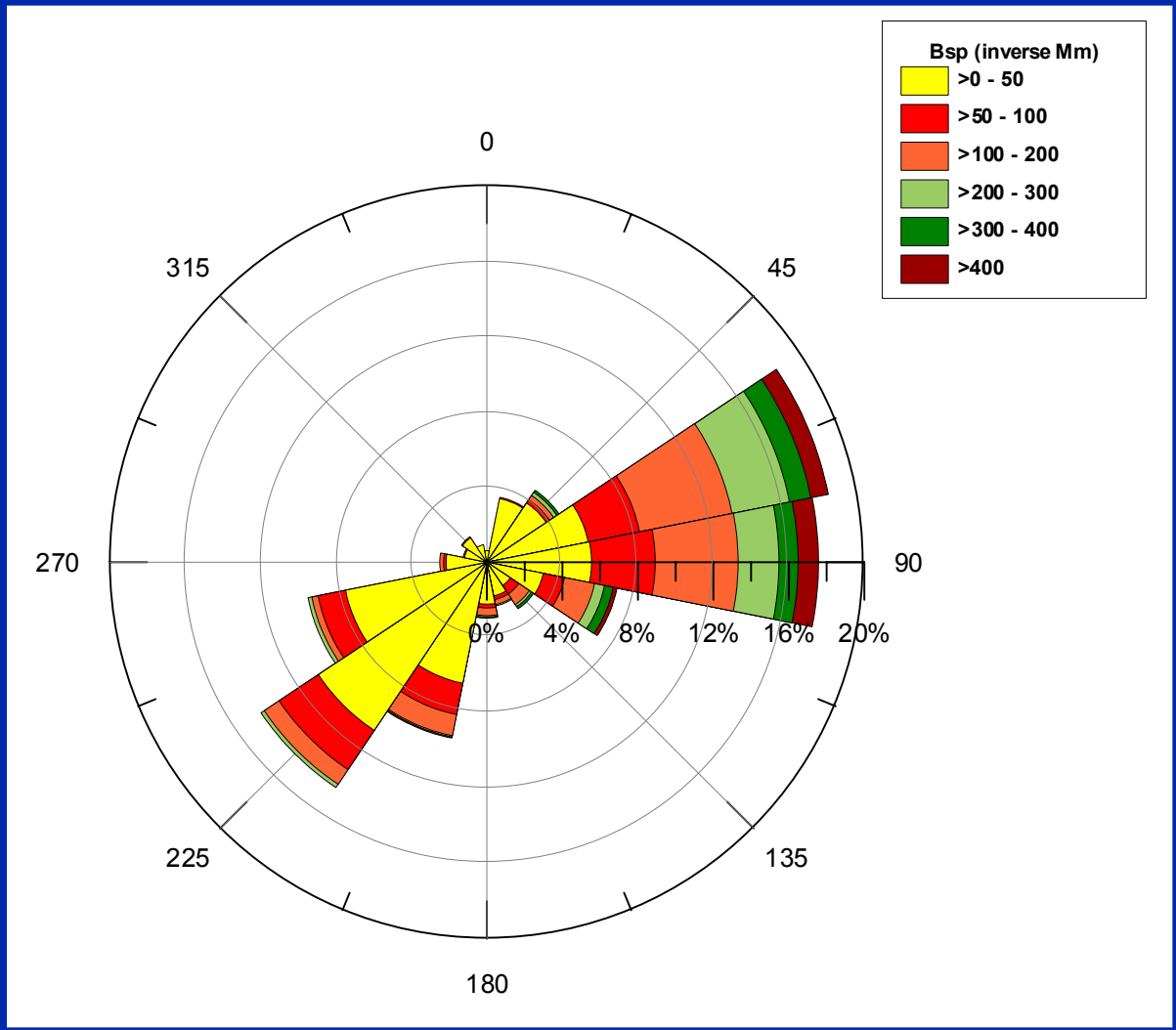
Transport –48-hour Forward Trajectories at 10 m agl Arriving at Bakersfield and Fresno at 1500 PST



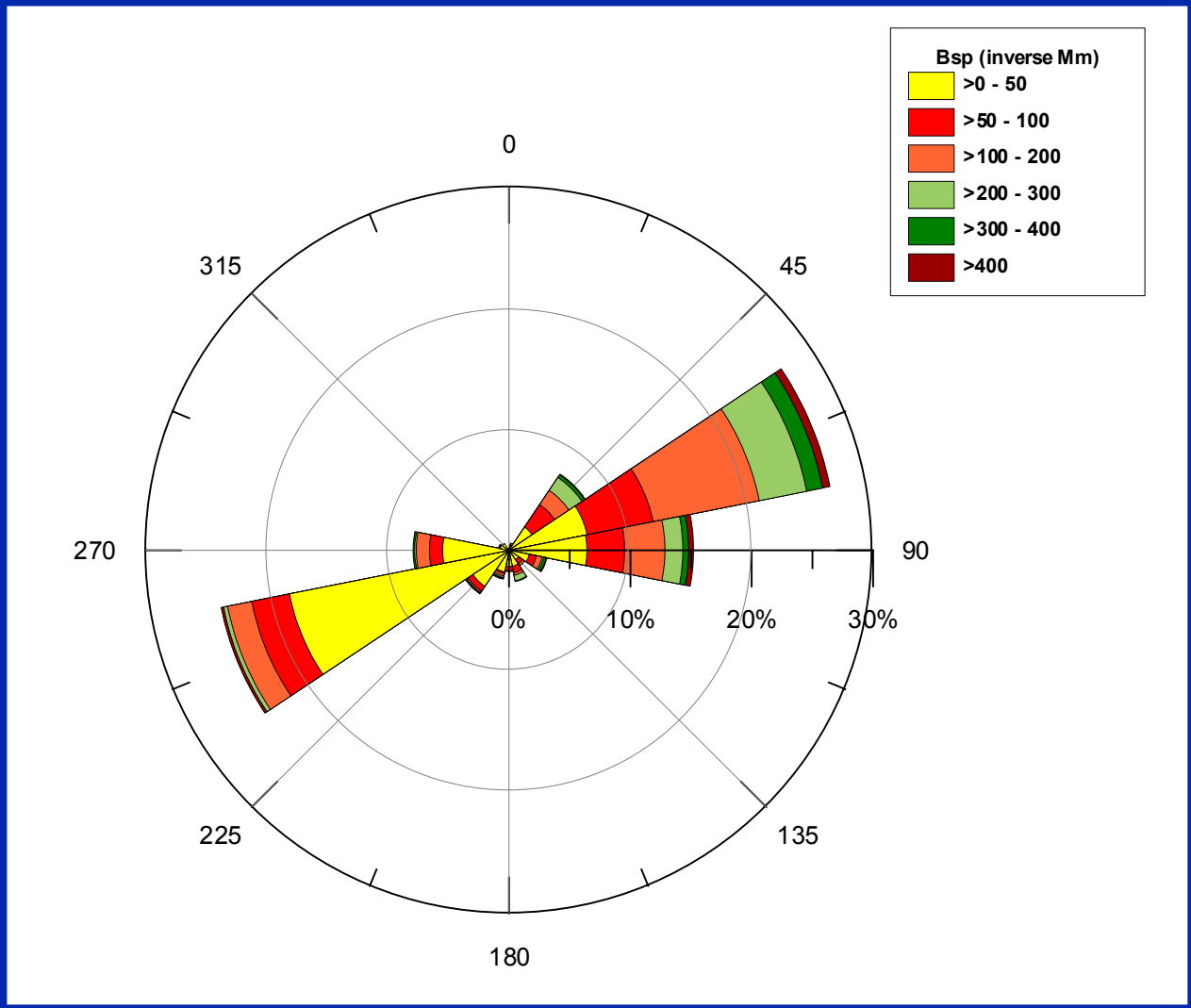
Transport: 48-hr Forward Trajectories at 450 m agl Arriving at BAK and FSF at 1500 PST



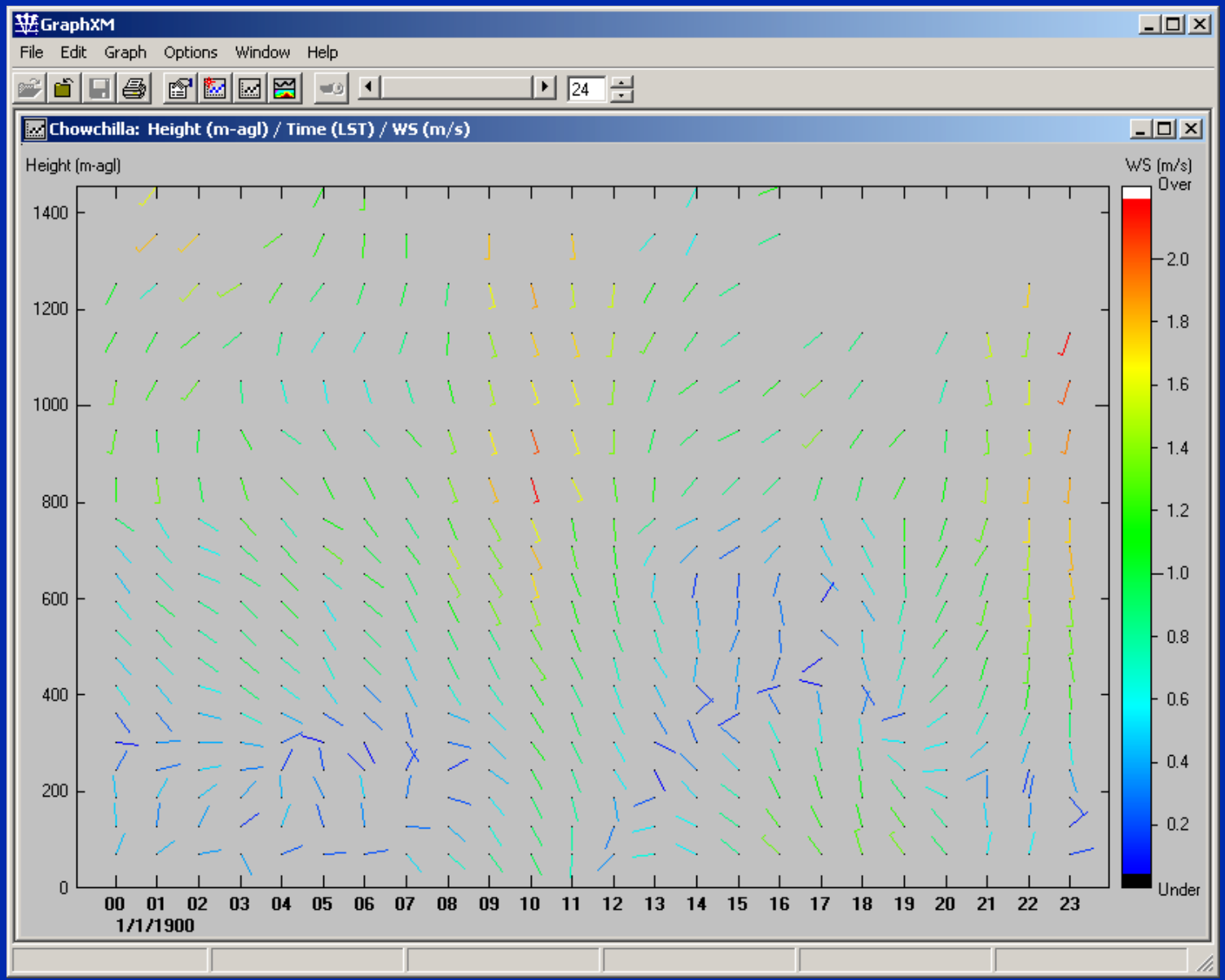
Transport – Pollution Rose at Altamont Pass



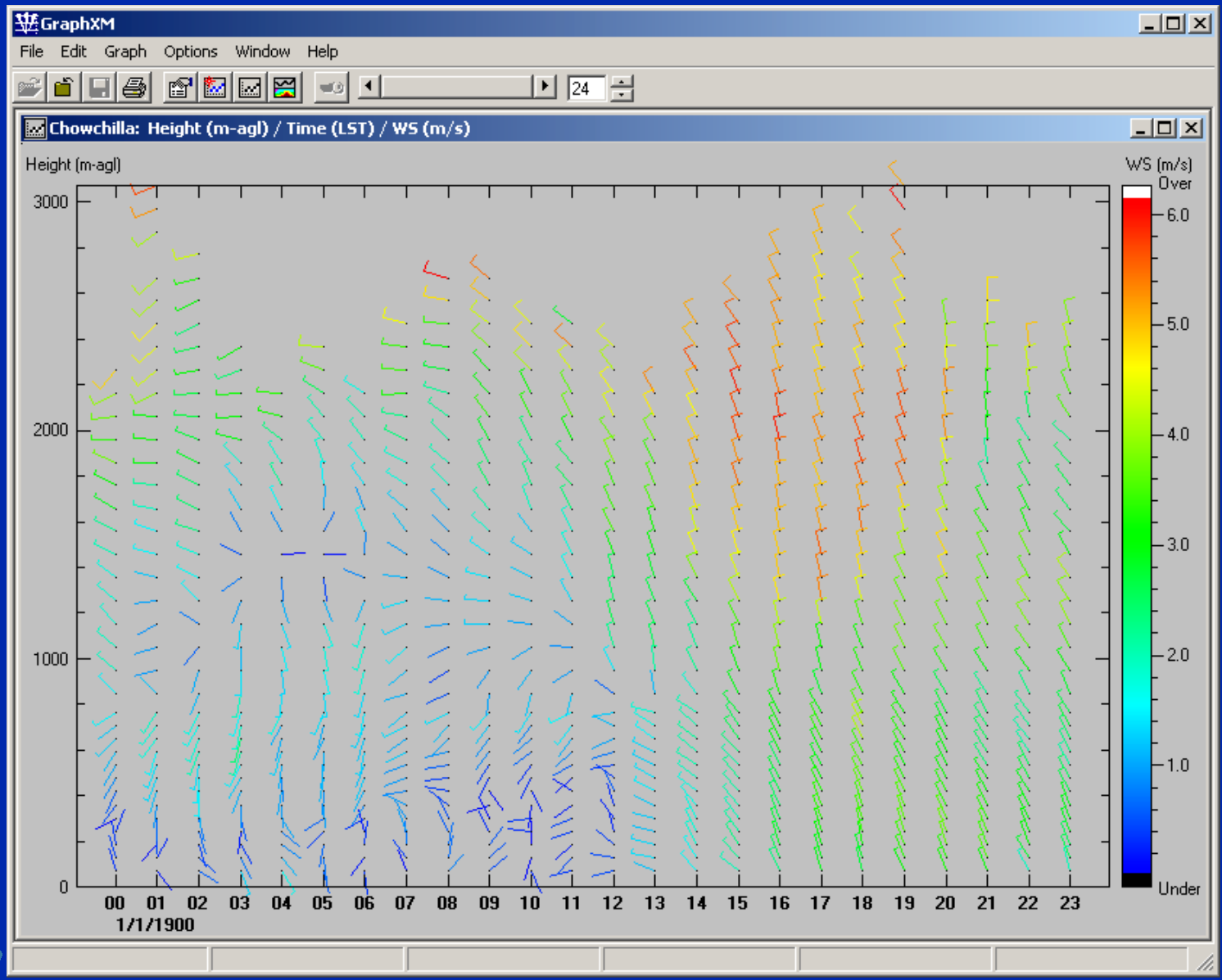
Transport – Pollution Rose at Pacheco Pass



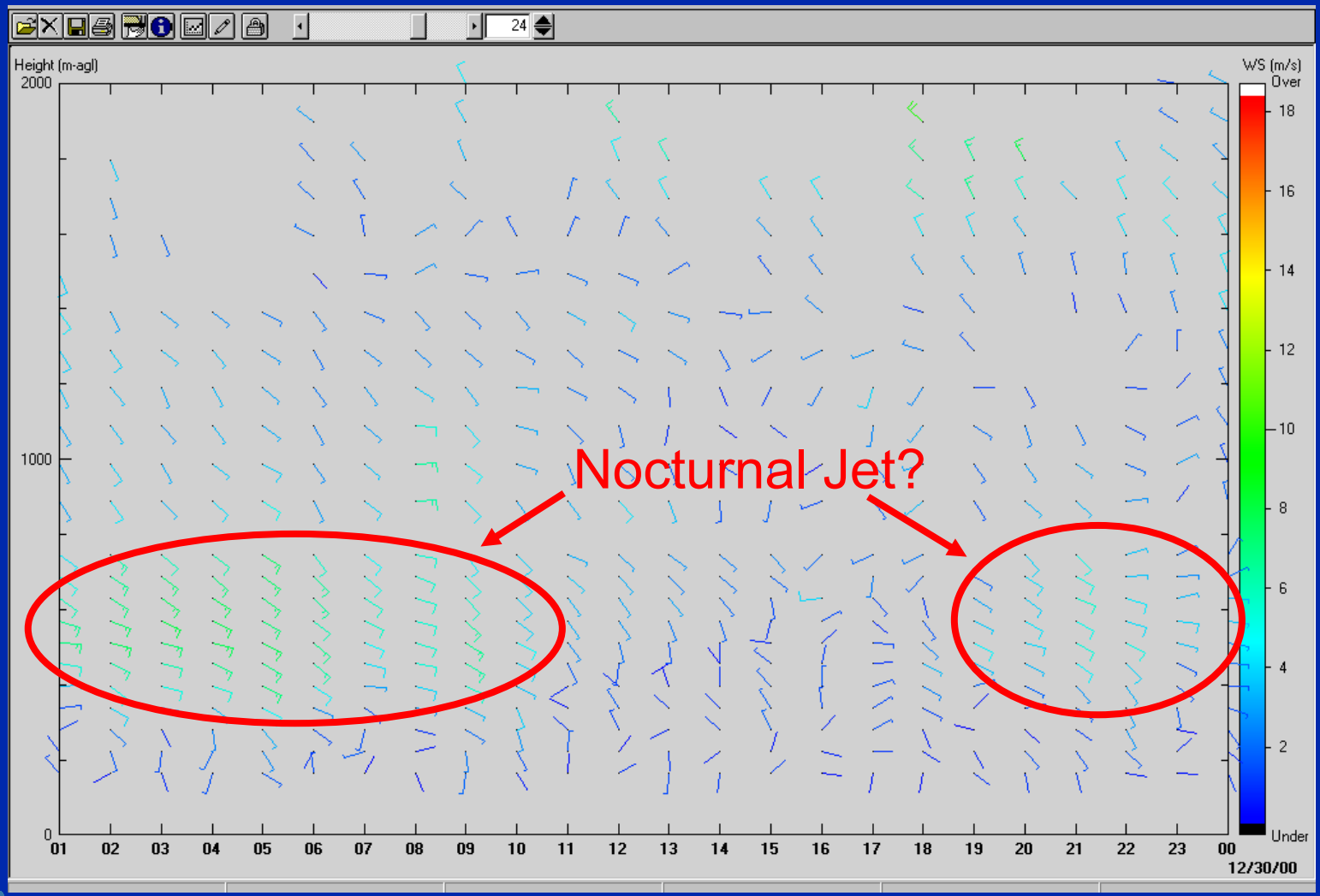
Chowchilla – Episode Days



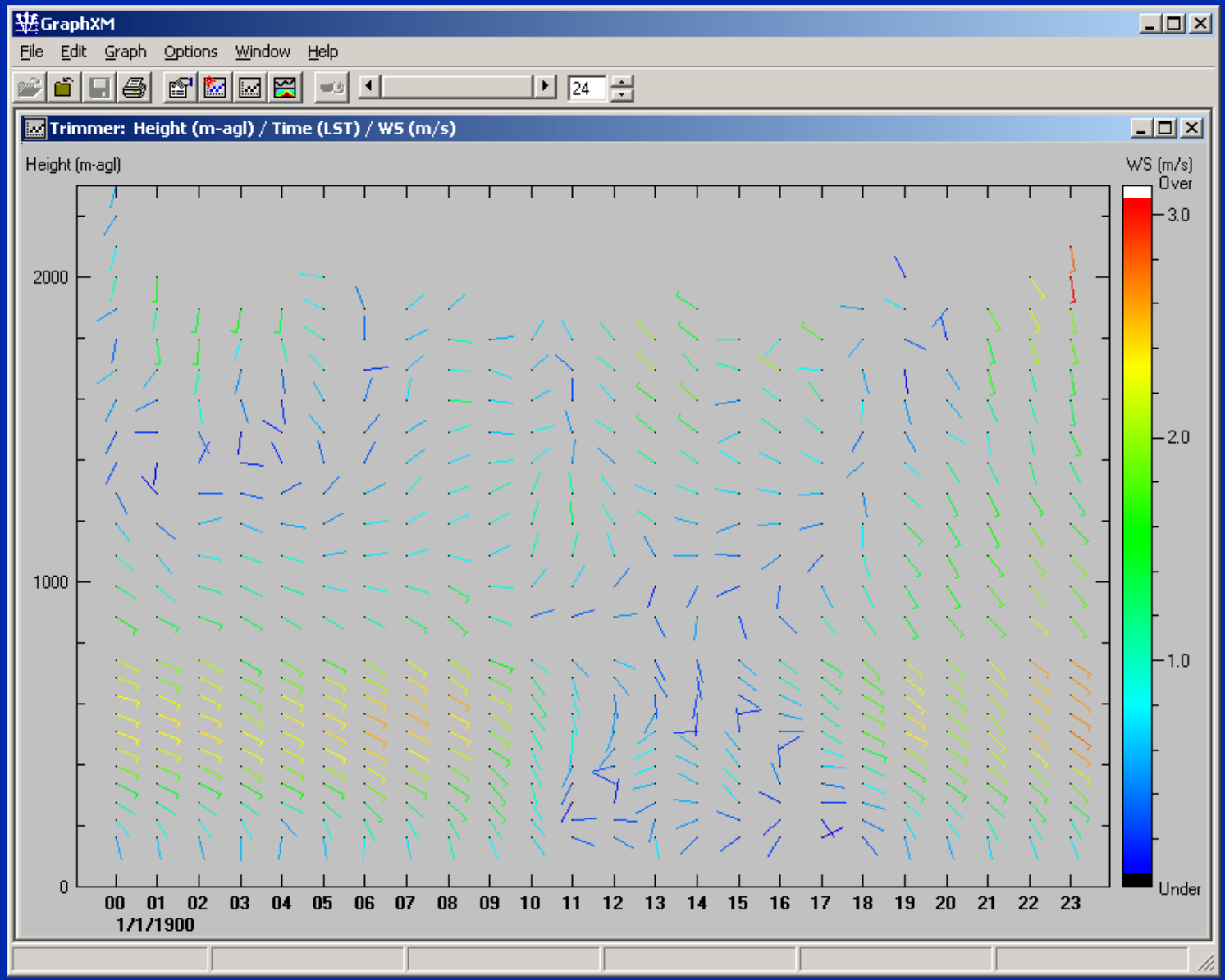
Chowchilla – Non-Episode Days



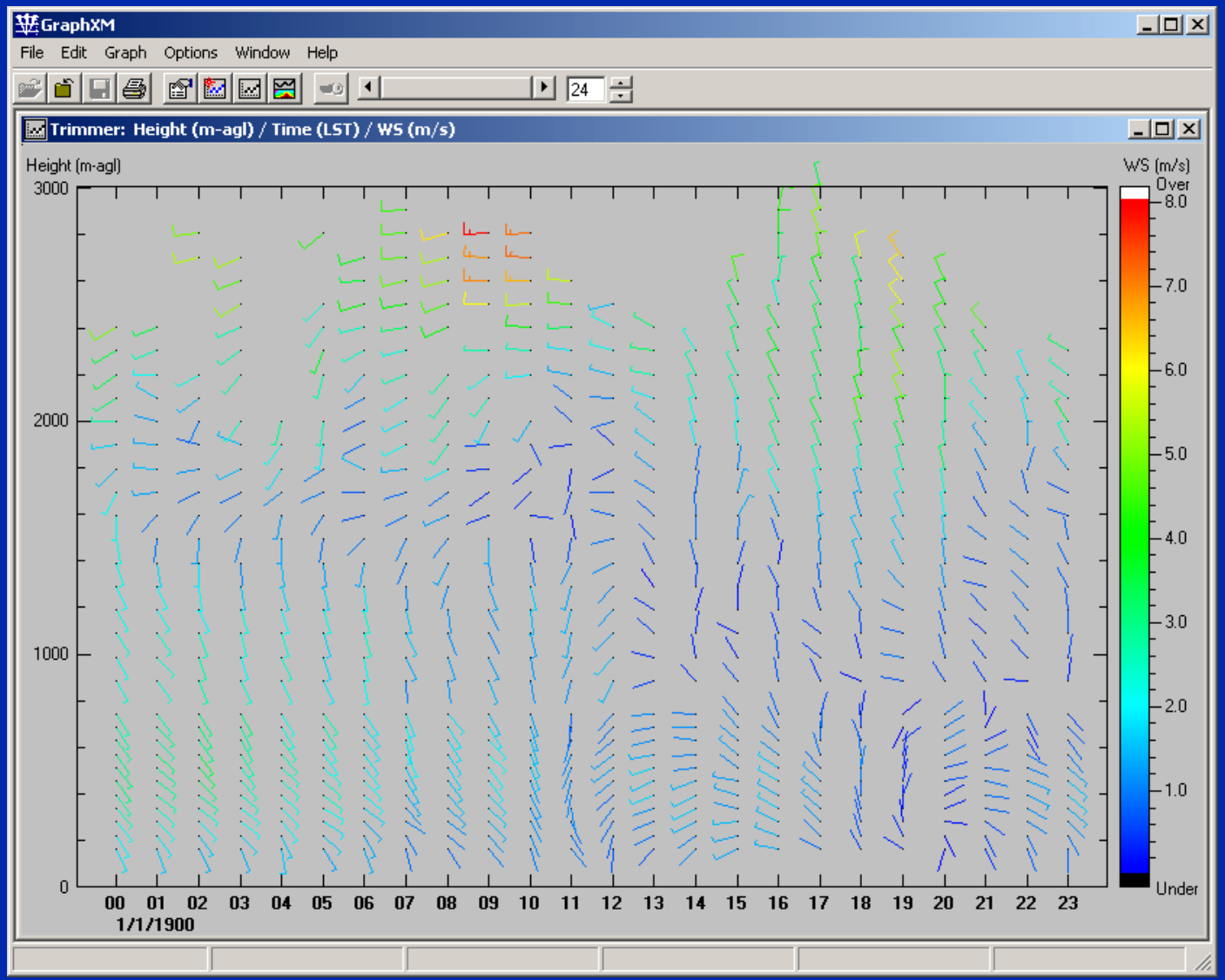
Winds – Trimmer on December 29, 2000



Trimmer – Episode Days



Trimmer – Non-Episode Days



Summary

- Mixing heights
  - As expected, upper-level synoptic weather patterns influenced mixing heights
    - Trough = high mixing height
    - Ridge = low mixing height
  - Distinct diurnal pattern
    - During episodes, mixing heights ranged from about 30 to 200 m at night to about 400 to 600 m agl during the day
    - During non-episodes, mixing heights ranged from about 30 to 200 m at night to 1000 m + agl during the day
  - PM concentration responded to mixing generally as expected, but the magnitude of variation is not explained by mixing alone
    - Low mixing = higher PM
    - High mixing = lower PM
    - Exception: mixing increased as did PM at Bakersfield on December 28 suggesting mixing down of PM and/or its precursors, or local sources

Summary

- Winds
  - Episodes had lighter winds during the day than did non-episodes
  - During episodes
    - Winds were variable in direction and were generally light from the surface to the maximum daytime mixing height of about 500 m agl, and at times much higher.
    - There is no evidence of transport from the San Francisco Bay Area (SFBA) into the San Joaquin Valley (SJV) during episodes
    - There is evidence of transport from the SJV into the SFBA.
    - We have not reached conclusions about transport from the Sacramento Valley into the SJV or visa versa.

Summary

- Trajectories
  - Trajectories on three of four episode days indicate that boundary layer air parcels generally circulated within a radius of 25 to 50 km over 48 hours
  - However, on one episode day, boundary layer air parcels traveled several hundred km in 48 hours
  - On most days, pollution from major SJV cities does not impact other major cities but does impact surrounding rural areas
  - However, occasionally pollution can be transported longer distances

What's Next

- Complete modeling of other episodes
- Run additional trajectories
- Perform CALPUFF dispersion modeling
- Integrate findings from other episodes into existing results
- Further analyze regional chemical characterization of secondary PM
- Deliver results for integration into other tasks