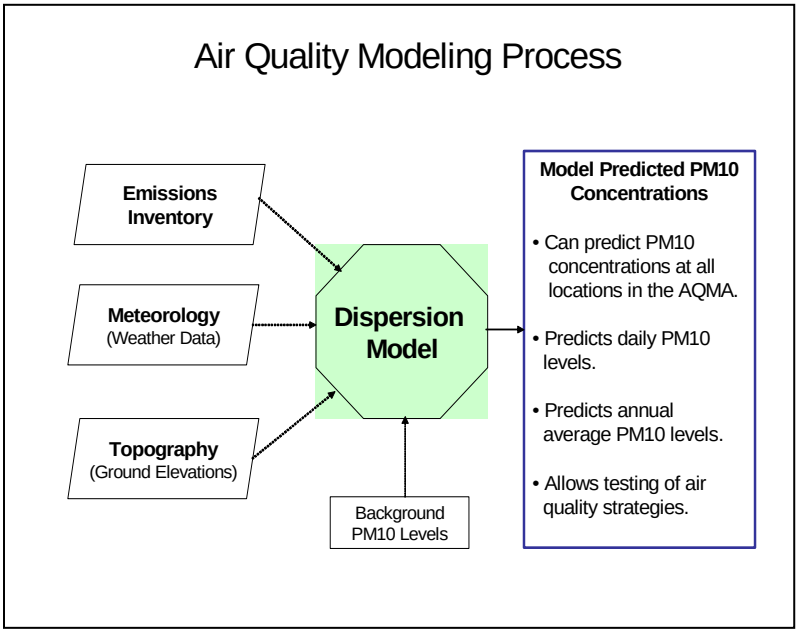
AIR QUALITY DISPERSION MODELING

4.14.5.0: Background

A *dispersion model* is a computer simulation that uses mathematical equations to predict air pollution concentrations based on *weather, topography, and emissions data*. In 2000, the Department and Medford-Ashland Advisory Committee agreed that new dispersion modeling technology would be developed for use in the PM_{10} attainment and maintenance plan. The Department evaluated several of the latest air dispersion models, looking for a modeling system that would: 1) better represent air movement within the Rogue Valley and reflect the effect of air stagnation conditions on particulate concentrations; and 2) better mimic the dispersion and deposition of road dust.

The Department selected the CalPuff dispersion model as the best tool for predicting PM_{10} concentrations in the AQMA. The modeling system also includes the CalMet wind field model to provide meteorological information for the modeling analysis. The adjacent Figure illustrates the three main information sources used by the model to estimate PM_{10} concentrations: 1) emissions information (gridded EI for area, mobile, non-road, and major industry), 2) weather data (wind speed, temperature inversion characteristics), and topographic information (land elevations and local terrain).



<u>Model Receptor Network</u>

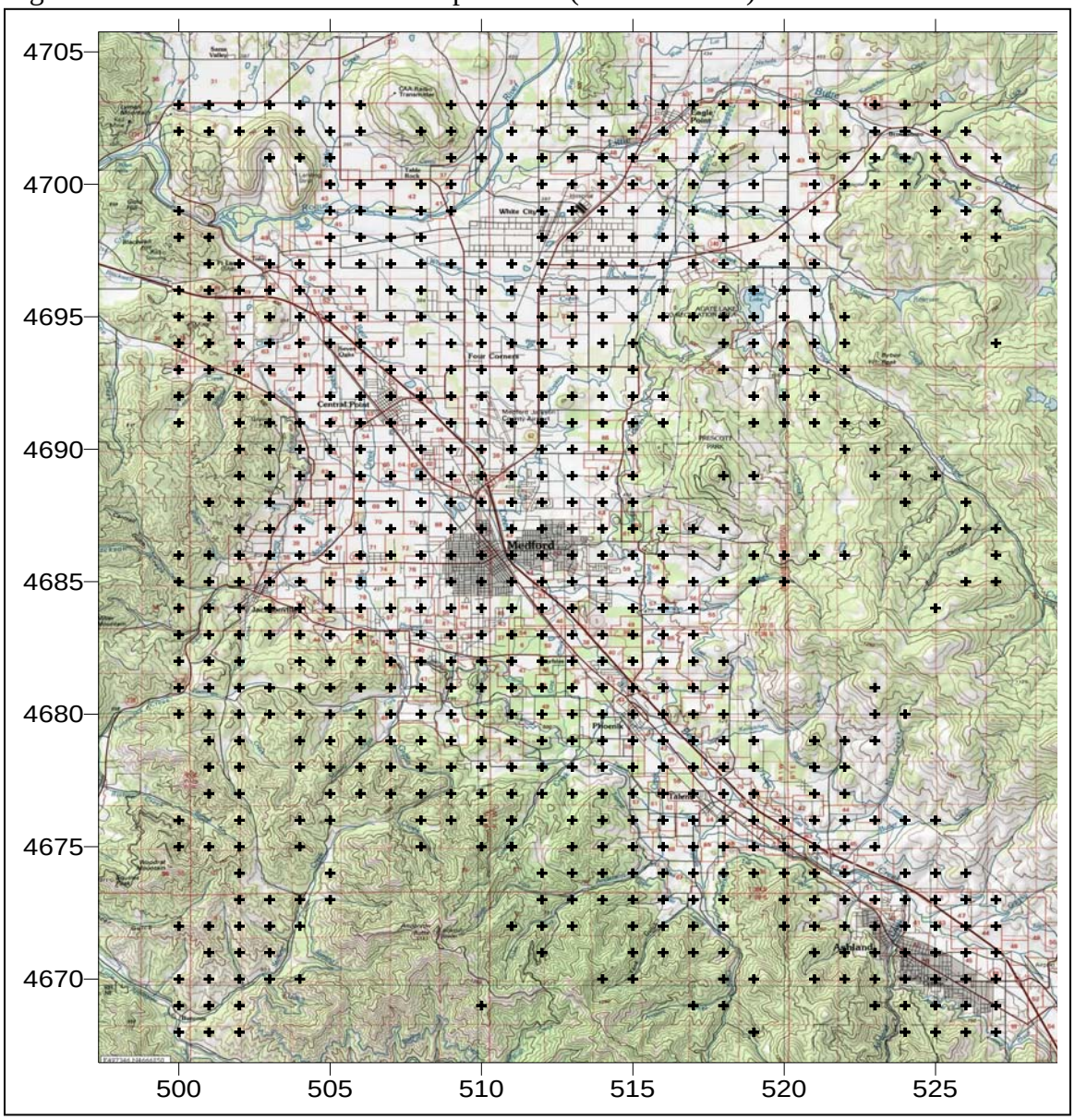
The CalPuff model can estimate ambient PM_{10} concentrations at any location in the AQMA. The modeling analysis begins by establishing a network of points throughout the AQMA (called receptors). The model then uses emissions and weather information to estimate ambient PM_{10} concentrations at each receptor location. Model receptors are typically placed near ground level to reflect the public's exposure to ambient PM_{10} concentrations.

The general modeling receptor network for the AQMA includes over 700 receptor locations, spaced 1-kilometer (0.62 miles) apart. It also includes a more closely spaced network of over 500 additional receptors in key areas of concern (Medford and White City). This higher resolution analysis is required under EPA modeling guidelines. The entire modeling receptor network estimates PM_{10} concentrations at over 1,200 locations throughout the AQMA.

Figures 45 and 46 show the receptor network used in the modeling analysis. Both the meteorological and dispersion modeling domains[1] are larger than the AQMA to account for the movement of air pollution in and out of the Valley. The meteorological domain covers an area of 100 x 110 km at a 1-km x 1-km mesh size. The meteorological domain extends from just west of Grants Pass to approximately 12 km east of Mt. McLoughlin, and from Crater Lake to about 10 kilometers into California.

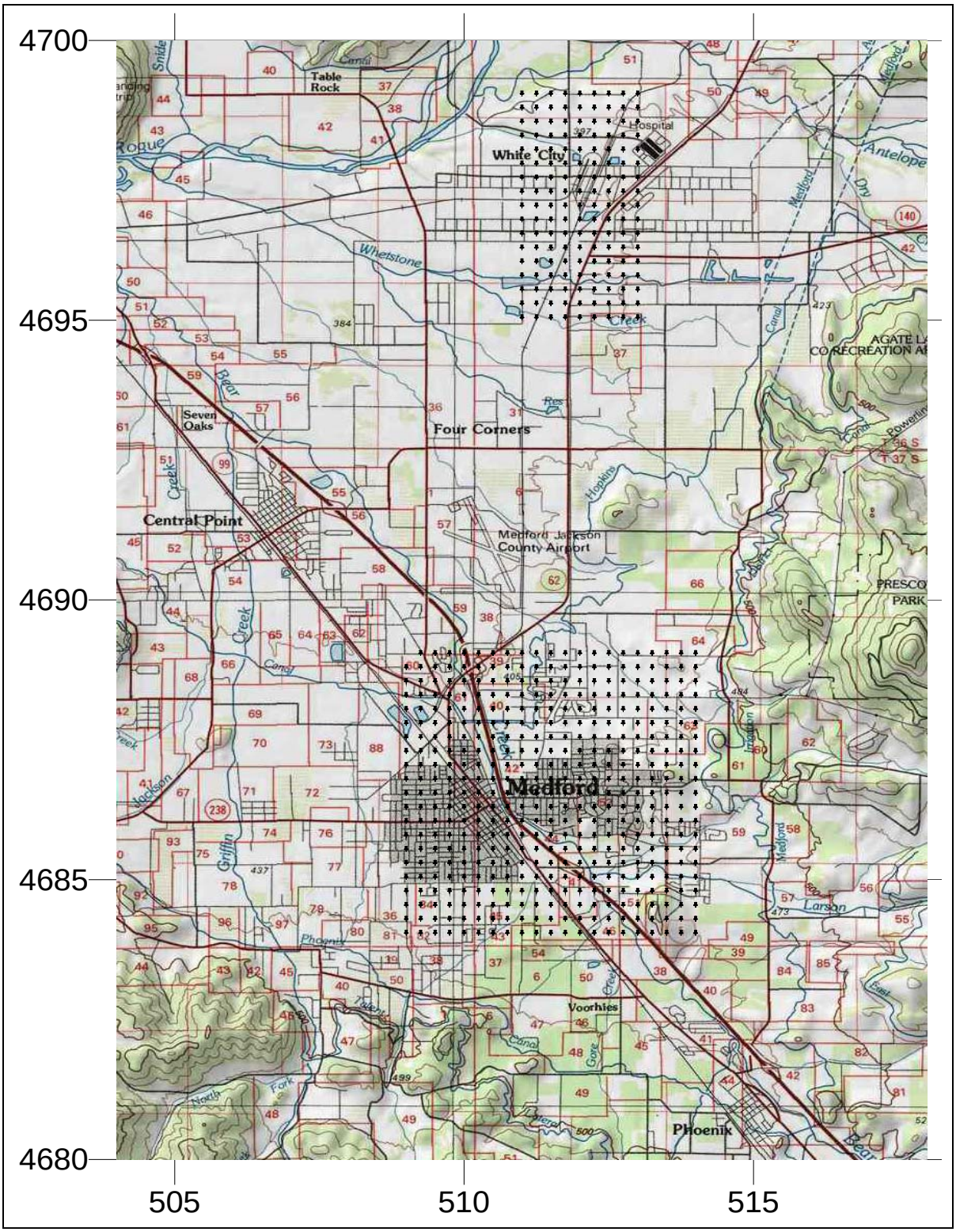
The model accounts for air movement vertically as well as horizontally. There are nine vertical levels used in the model to simulate three-dimensional air movement in the AQMA.

Figure 45: General-Scale Model Receptor Grid (1-Km x 1-Km)



[1] The model "domain" is the geographic area covered by the modeling analysis.

Figure 46: Refined Scale Model Receptor Grid (spaced every 250 meters)



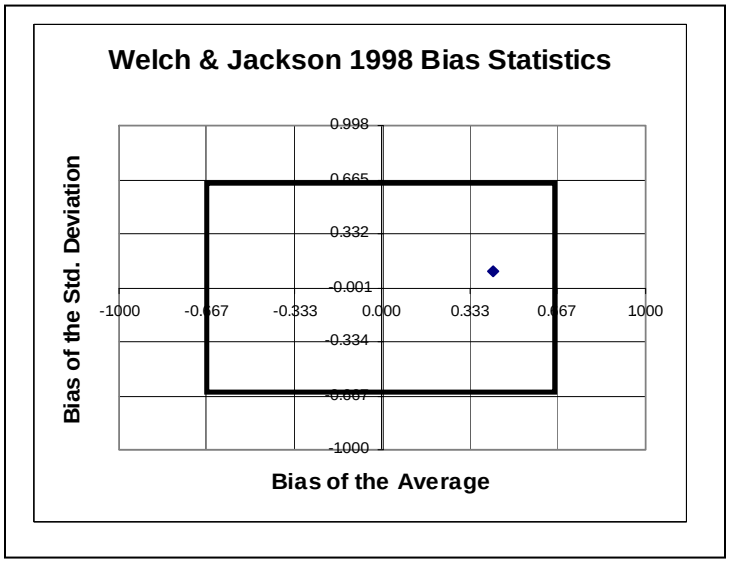
4.14.5.1: Model Performance Testing

Model performance testing involves comparing model predicted PM_{10} concentrations to actual measured PM_{10} values, to see how well the model can reproduce measured PM_{10}. The emissions inventory for 1998 (actual emission levels) and measured 1998 meteorology was used in the model to predict ambient PM_{10} concentrations that would occur at the Welch & Jackson and White City PM_{10} monitoring locations. Model predicted values were compared to actual measured PM_{10} levels at the Welch & Jackson and White City monitoring sites. A total of 181 daily PM_{10} measurements were available at each of the monitoring locations during 1998. This includes every-day sampling during the periods of January 1, 1998 - March 31, 1998 and November 15, 1998 - December 31, 1998. This is a far more complete data set than was available for previous model evaluation studies for the AQMA.

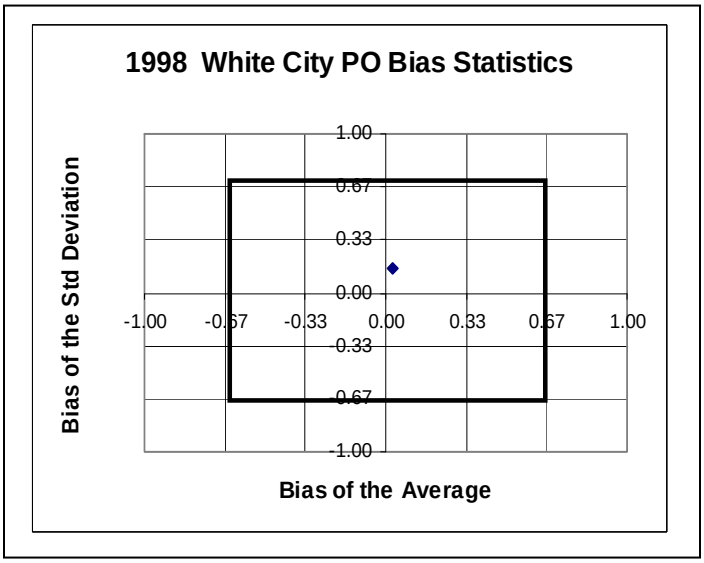
No model functions with 100% accuracy, however the performance of the CalPuff modeling system is well within EPA acceptability specifications. Figure 47 shows a statistical evaluation of the model's performance. The highlighted "target box" represents the statistical bounds of acceptable model performance. The closer the performance measures are to the center of the target (bias 0,0) the better the model performance. Figure 47 shows that the Calpuff predictions are well within EPA's criteria for acceptable performance at both monitoring locations. These statistics are based on the highest 25 predicted and highest 25 measured 24-hour PM_{10} concentrations.

Figure 47: Model Performance Statistics

(a) Welch & Jackson



(b) White City



After reviewing the results of the model performance analysis, the Advisory Committee approved the use of the CalPuff modeling system as the tool for developing the Medford-Ashland PM_{10} attainment and maintenance plan.

4.14.5.2: Worst-Case Meteorology in the AQMA

One important aspect of the attainment and maintenance analysis is to evaluate the PM_{10} impacts that could occur under the air stagnation conditions that routinely occur in the Rogue Valley. Previous modeling efforts in the early 1990's used meteorology from December 1985 to estimate worst-case PM_{10} concentrations. At that time, December 1985 meteorology reflected the best data record available of surface wind measurements for a prolonged and severe air stagnation event. The data record was however, very limited.

In 2001, the Department evaluated more recent meteorology, and selected calendar year 1998, and the winters of 1999 and 2000 to use in the attainment and maintenance analysis. The newer meteorology included several prolonged air stagnation periods. The newer meteorology has other benefits as well:

- The meteorological data record is much more complete for the 1998-2000 period that it is for December 1985.

- Meteorology from 1998-2000 can be used in conjunction with more current background PM_{10} data from the Dodge Rd. site, and reflects more contemporary regional PM_{10} influences on the AQMA. The Dodge Rd. PM_{10} data record is much more complete for the 1998-2000 period than it is for December 1985.

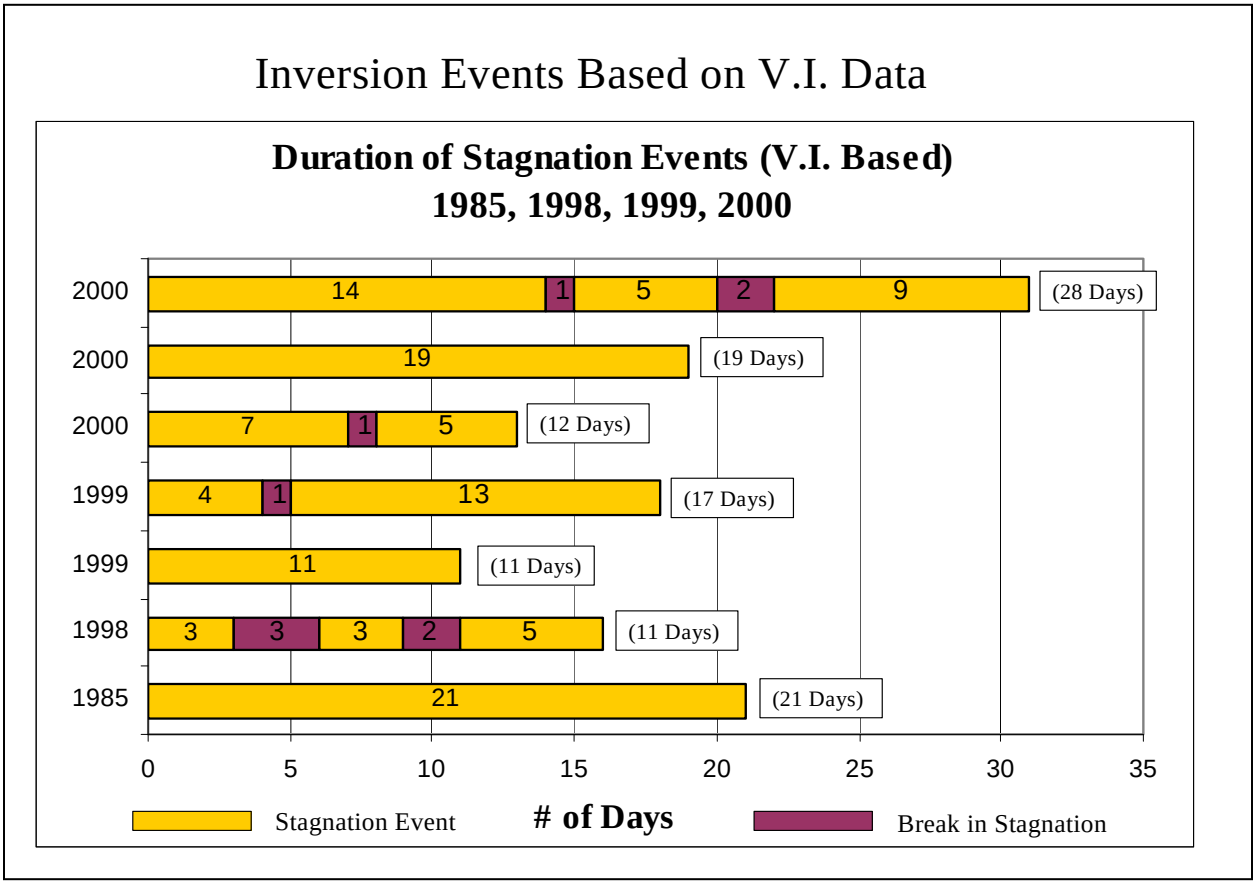
- Worst-case stagnation meteorology from 1998, 1999, and 2000 reflects a consecutive three-year period, and allows a better comparison with the daily PM_{10} standard than does the December 1985 period.

- The severity of the 1985 and (1998-2000) stagnation events are comparable.

There are several ways to compare the stagnation potential for the 1985 and (1998-2000) periods, including wind speeds, thermal inversion characteristics, duration of consecutive stagnation events, and precipitation (pollution washout effects). The Department compared all these parameters and found that while not identical, the stagnation intensity for the 1985 and (1998-2000) periods were comparable.

Figure 48. shows the duration of stagnation events for the time periods evaluated, using Ventilation Index as a basis for comparison. The Ventilation Index combines wind speed and inversion strength data. The lower the index, the more severe the stagnation event. Ventilation Index values below 200 reflect an air stagnation event.

Figure 48: Stagnation Events 1985, 1998, 1999, 2000

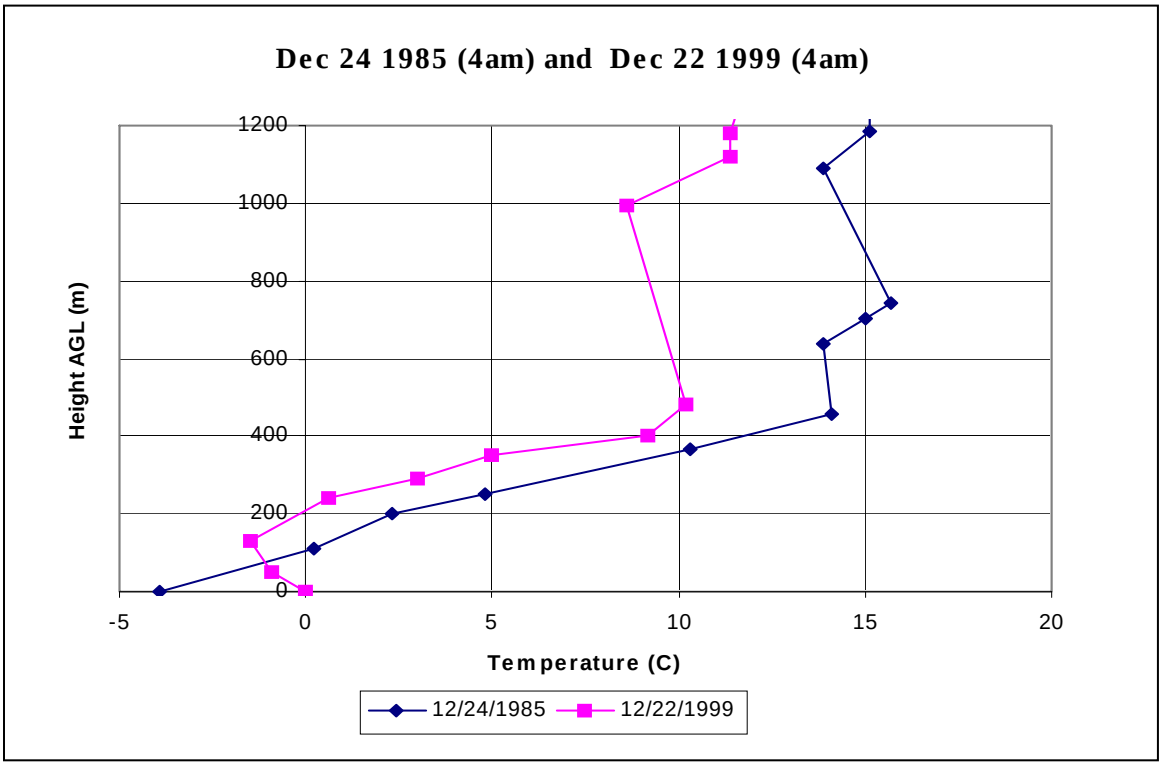


The frequency and duration of stagnation events in 1998-2000 are similar in many respects to those of 1985, and provide the potential for high PM_{10} concentrations to occur as air pollution levels build-up over several days. Often, PM_{10} concentrations will reach near peak levels within the first 3-4 days of a prolonged stagnation event.

Temperature inversions are also important considerations in air pollution build-up. In a normal atmosphere, temperatures should decrease with height above the ground. However, when there is an inversion, temperatures will increase rather than decrease with height. This reversal of the normal temperature profile restricts the upward movement of air, decreases ventilation, and can trap air pollution near the ground.

Figure 49 presents an example where two inversion events from 1985 and 2000 are compared. The temperature soundings show the change in air temperature as elevation above the ground increases. An inversion occurs when temperatures increase with height. While these inversion events are not identical, they both have comparable intensities and potential for the build-up of air pollution. The Department evaluated many such events in considering the use of 1998-2000 meteorology.

Figure 49: Temperature Inversion Profile Comparison.



After careful review, the Department concluded that more contemporary meteorology (1998-2000) offered comparable stagnation conditions to those of 1985, and would therefore provide an adequate worst-case test for the attainment and maintenance analysis. More recent meteorology would also reflect a more complete data record of weather information, and allow the use of up-to-date background data from the Dodge Road PM_{10} monitoring site. In 2001, the Air Quality Committee approved the use of 1998-2000 meteorology in the PM_{10} attainment and maintenance analysis.