

Comparison of Roadside Pollutant Concentration Modelling Using Local and Regional Meteorological Data

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1 Introduction

Traffic related air pollution is a major concern in many cities. As it is impossible to monitor all points of interest in large metropolitan areas, local authorities and regulatory bodies increasingly use atmospheric dispersion models to estimate pollutant concentrations. Reliable and accurate input data is an essential requirement of any mathematical model. In the case of dispersion models, a primary input is processed meteorological data, along with local topography and an emissions inventory. Local meteorological data will not be available for all areas and the nearest synoptic station may be a few kilometres away. Moreover, wind speed and direction data collected at such synoptic stations will not represent local street conditions. The paper describes the application of a pollutant dispersion model CALINE4R (Reynolds, 2000) to estimate local pollutant concentrations using both local and synoptic meteorological data. Calculated concentrations of carbon monoxide were compared to simultaneous measurements over the same period.

2 CALINE4R Pollutant Dispersion Model

The dispersion model employed in this study is a modified version of CALINE4 (Benson, 1992) renamed CALINE4R (Reynolds and Broderick, 1999). CALINE4 is one of the most commonly used pollutant dispersion models in the world. The current version of the model was developed by CALTRANS in the 1980s. However, a number of researchers/users have raised issues concerning the model such as treatment of modal emissions and calculation of vehicle heat flux factors. To this end, CALINE4 has been reprogrammed and restructured, and an enhanced version known as CALINE4R has been developed (Reynolds, 2000). CALINE4R has expanded capabilities (increased number of links and receptors) and flexible input/output. In addition, CALINE4R contains a number of new or improved algorithms, including the following, which are relevant for carbon monoxide prediction:

- Vehicle heat flux factors based on local fleet composition;
- Vehicle modal emissions at intersections;
- Treatment of calms (i.e. wind speed < 0.5 m/s);
- Incorporation of improved dispersion coefficients; and
- National Weather Service data allowing annual average concentrations to be computed.

3 Evaluation of CALINE4R

CALINE4R was successfully validated at a number of sites (Reynolds and Broderick, 1999). The first of these was located in a city centre at a heavy trafficked signalised controlled junction in Dublin (Reynolds and Broderick, 1999). The second site was located midway along a street canyon in Hannover, Germany (Reynolds, 2000). The third was located on an arterial suburban route at a traffic intersection in Melton Mowbray, UK (Reynolds, 2000). Traffic activity data and pollutant concentrations were measured at all three sites. In addition, meteorology was supplied or measured.

4 Study site

The survey site was at an arterial four-way signalised controlled junction in the heart of Dublin City, which is characterised by high local congestion. It is one of the busiest signalised intersections in the city, with in excess of 40,000 vehicles traversing the junction daily. The junction geometry is depicted in Figure 1, in which the direction of traffic flow through the junction is indicated, and the dashed lines represent bus lanes. Lombard Street consists of a one-way three-lane roadway, while Westland Row has one lane in either direction. Pearse Street has four lanes travelling in the same direction. The location of the air quality monitoring unit and the traffic count induction loops are depicted also. Carbon monoxide sampling took place 4m from the kerbside and at a height of 1.8m.

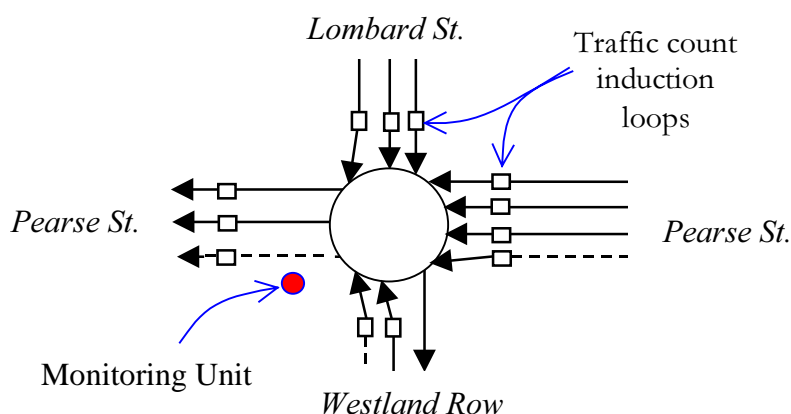


Figure 1 Schematic representation of intersection at survey site in Dublin.

5 Motor Vehicle Emissions Inventory Model

Traffic activity and fleet composition are obtained from video recordings and the SCAT (Sydney Co-ordinated Adaptive Traffic) urban-traffic-control-system (Sim and Dobinson, 1980). The emissions source strength for traffic traversing the study junction was computed by a Motor Vehicle Emission Inventory (MVEI) Model (Reynolds and Broderick, 2000). Composite emission factors are generated by the MVEI model on a lane-by-lane basis, with each lane being sub-divided into two segments reflecting the areas in which vehicles are in cruise or creep mode. The creep mode represents the movement of a vehicle queuing at an intersection or roundabout, whereby it progressively approaches the junction through a number of stop-starts. In this way the effects of congestion are taken into account explicitly, while vehicle acceleration and deceleration are taken into account implicitly through the use of speed-dependant emission factors.

6 Modelled and Measured Concentrations

CALINE4R was used to predict the running 8-hour mean for carbon monoxide using local and synoptic meteorological data. These predicted concentrations are compared to the observed running 8-hour mean for carbon monoxide. The results are presented in Table 1. As can be seen from Table 1, the observed and predicted pollutants concentrations using local meteorological data agree reasonably well. The local air quality standard (LAQS) for carbon monoxide is 10 ppm for a running 8-hour mean. This site exceeds the LAQS. However, when meteorological data from a synoptic station is employed, the site reaches attainment.

Table 1 Comparison of 8-hour rolling mean carbon monoxide concentrations using local and synoptic meteorological data.

Pollutant	Local Air Quality Standard -running 8h mean (ppm)	Observed (ppm)	Predicted using local meteorological data (ppm)	Predicted using synoptic meteorological data (ppm)
CO	10.0	11.82	12.15	8.43

7 Effects Of Weather Data

Meteorological data was measured at the monitoring site over one year, and this was compared to meteorological data measured at synoptic station located at Dublin Airport (approximately 5 km North of the study site).

As can be seen from Figure 2, the calculated carbon monoxide concentration does not reach attainment, when the wind speed was below 2.42 m/s. The local air quality standard for carbon monoxide in Dublin is 10 ppm.

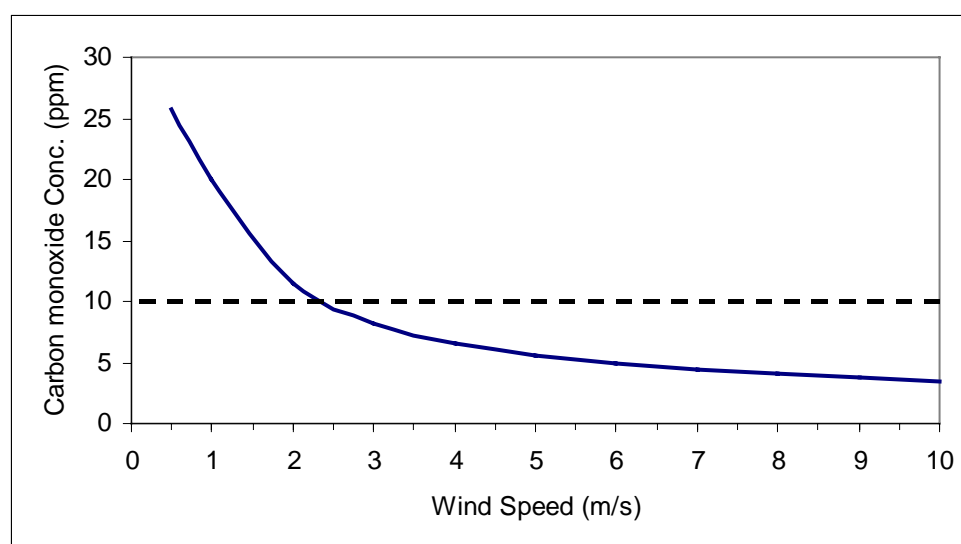
**Figure 2** Variation of predicted kerbside carbon monoxide concentration with wind speed.

Figure 3 presents the difference in wind speed (m/s) between the local and synoptic station. The average difference between the two sets of data was 3.54 m/s. As indicated in Figure 3, the wind speed at the synoptic station was always greater than that at the local station. This is expected, since the anemometer is located in open flat terrain at the synoptic station and is partially sheltered by buildings at the local station. The wind speed was the same at both stations on only 1.2% of occasions, while the difference between the two values lay between 3 and 4 m/s for 47.2% of the time.

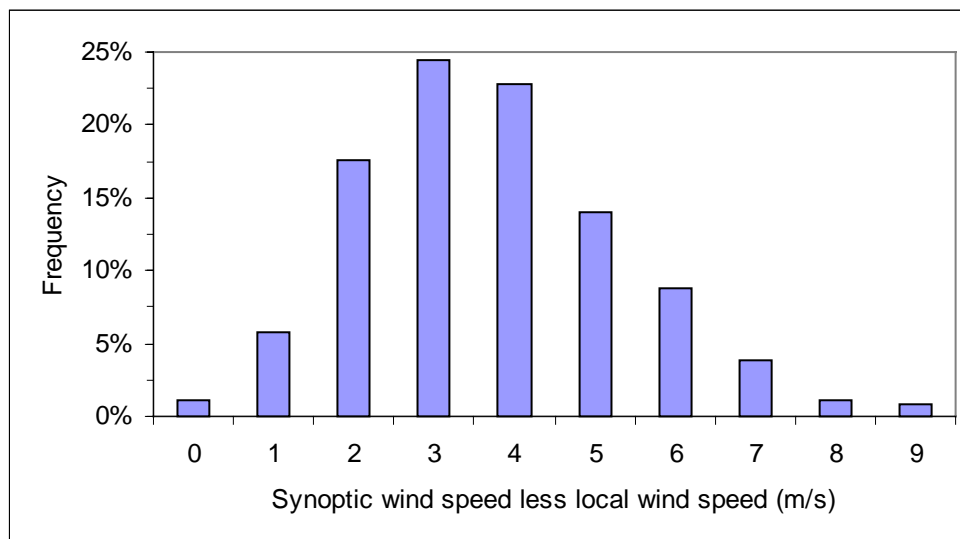


Figure 3 Difference between wind speed at local and synoptic stations.

Figure 4 presents the wind rose for both the local and synoptic meteorological stations. As can be seen from Figure 4, the local prevailing wind direction is offset by 50 degrees with the regional data. For kerbside concentrations, this can have a significant effect.

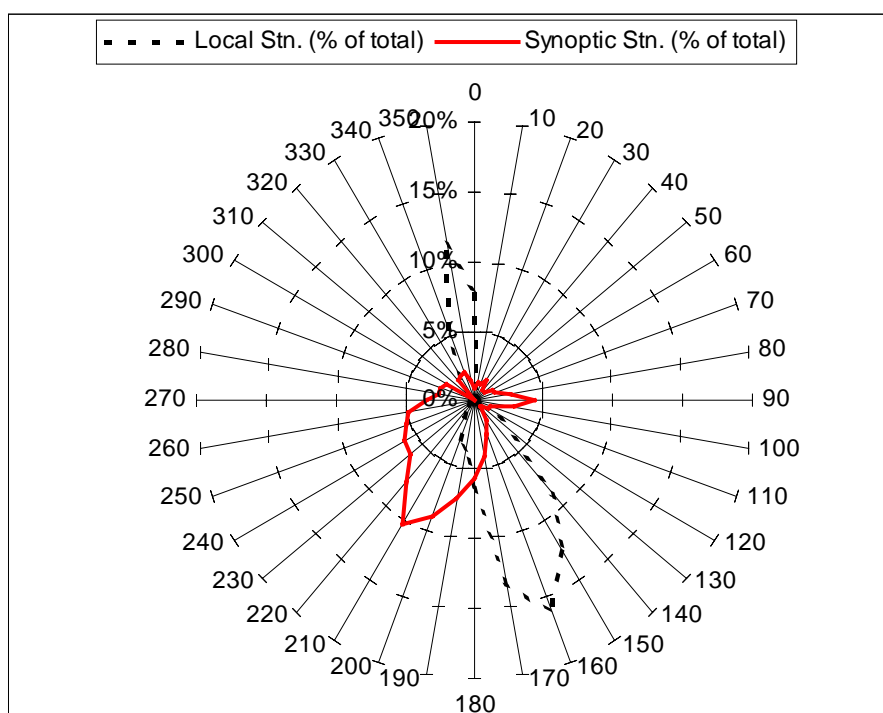


Figure 4 Comparison of local and synoptic wind roses for 1988.

Figure 5 presents the variation of carbon monoxide concentration with wind direction at the study site. Between 20 and 100 degrees, the local site will not reach air quality attainment (i.e. the pollutant concentration is greater than the air quality standard of 10 ppm). It must be remembered that the wind rose is averaged for the year.

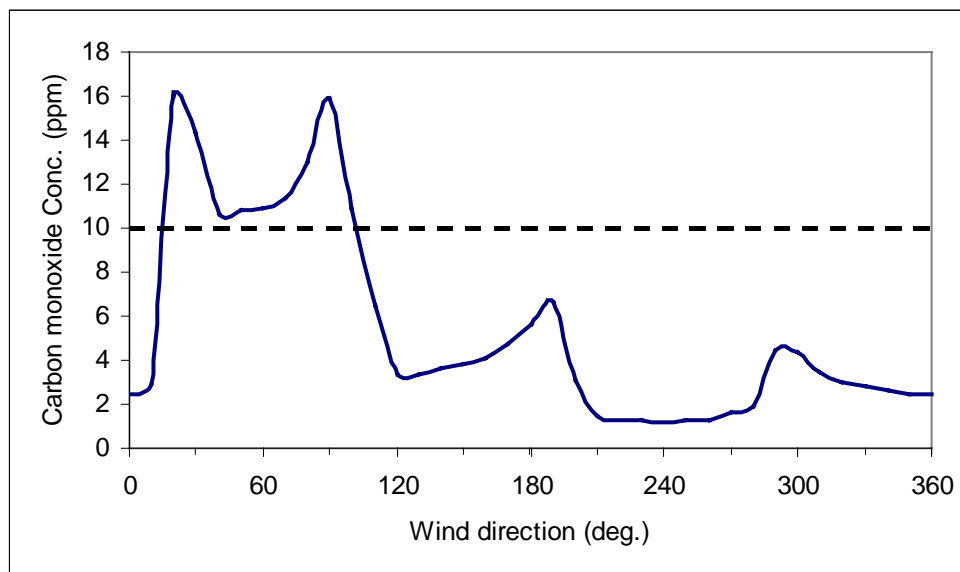


Figure 5 Variation of predicted kerbside carbon monoxide concentration with wind direction.

8 Conclusions

This paper has described the application of a pollutant dispersion model to estimate kerbside pollutant concentrations using both site-specific (local) and synoptic (regional) meteorological data. The study site did not reach air quality attainment for carbon monoxide. CALINE4R correctly predicted this using local meteorological data. However, when synoptic meteorological data was employed, the study-site reached local air quality attainment. As site-specific data is not available for every roadway and junction, care should be taken when using synoptic meteorological data.

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