COMPARISON OF A SIMPLE CORRELATION FOR POLLUTION DISPERSION PREDICTION IN URBAN AREAS WITH DAPPLE TRACER FIELD EXPERIMENTS

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1. Introduction

In this note, the measurements from the first DAPPLE tracer field experiment are interpreted in the context of a comparison with predictions from a simple empirical correlation for urban pollution dispersion, which was developed prior to the field campaign [1].

2. The simple correlation

The simple correlation is of the form

$$CUH_r^2/Q = K(x/H_r)^{-2} \quad \text{or} \quad CU/Q = Kx^{-2}$$

where C (kg/m^3) is the near field maximum concentration that would be measured at a ground-level receptor located on an arc a distance x (m) from the source. This is for a continuous source with release rate Q (kg/s) at, or near ground level and for a representative wind speed U (m/s). It is not clear at this stage what prescription of wind speed (U) would be most appropriate to represent plume advection in the urban topography. We anticipate that K will depend upon one or more dimensionless parameters that describe the urban topography. We take K to be in the range 10-20 as determined from [1].

The form of correlation above is one in which the building height disappears. This unusual result can be argued for by noting that for buildings very high compared with the plume height; the building height itself will not affect the dispersion process. The argument seems reasonable, however as the correlation appears to be applicable out to regions where σ_z/H_r is larger than unity there may be other explanations.

Though the correlation is presented in terms of the maximum concentration downwind of the source the result could be restated that the concentrations at any receptor a distance R from the source in any direction should be smaller than that provided by the correlation with R replacing x. This observation may be particularly useful for operational modelling.

3. The experimental data

The experiment provided a time series of sequential 3 minute averaged data over a 30 minute time period at 9 receptor sites (one of the 10 receptors failed, one was at elevation and the remaining 8 were close to ground level.). The release was for 15 minutes and at the short distances between source and receptor in the experiments it was anticipated that the release would appear as a continuous one. However a clear "constant" concentration was never apparent in the concentration records.

We have chosen the maximum of the 3 minute averaged data from each receptor for comparison. The receptor positions, along with the concentration data, are tabulated below and are also shown on the area map in Figure 1. The average building height *(H_{rT})* was estimated to be 22m [2]; the mean wind speed *(U)* and direction *(θ)* were taken from the meteorological measurements (at the reference station atop the Westminster City Council building) to be 3m/s and 200°; the source release rate *(Q)* was taken from the tracer experiment data set and was 1.27×10^{-7}kg/s.

Box Number #	**Distance from the source - *Direct, R (m)***	**Distance from the source *By road (m)***	**Angle with wind direction, φ (°)**	**Concentration *C(kg/m³)***	**Non-dimensional concentration *$CUHr^2/Q$***
1	200	200	67 (to the right)	1.14E-12	0.0131
2	200	250	38 (to the right)	-----	-----
3	120	160	28 (to the right)	9.58E-12	0.110
4	115	150	2 (to the left)	1.38E-11	0.158
5	115	150	2 (to the left)	1.20E-11	0.138
6	200	280	14 (to the right)	6.38E-12	0.0731
7	275	350	26 (to the right)	2.03E-12	0.0233
8	430	540	36 (to the right)	3.81E-13	0.00437
9	200	250	13 (to the left)	5.41E-12	0.0620
10	75	90	21 (to the left)	2.13E-11	0.244

4. Comparison and Interpretation

A comparison between model predictions and experimental measurements are shown in Figure 2. The model is seen to capture correctly the trend of the measurements, as all the model states is that any field measurements will be smaller than the predictions. The model "overpredicts" by about a factor of two (when using the minimum upper bound for the constant *K*). This may be partly because the measured maximum concentration need not necessarily be on the plume centre-line.

To consider this further and assuming a Gaussian plume structure for the measured plume, estimates of the maximum concentrations on an hypothesised plume center-line (given the recorded mean wind direction and a model estimate for σ_y and σ_z [3]) can be made and be compared with the corresponding predictions. These calculations were made and the results produced somewhat better agreement with the correlation particularly closer to the source. However further from the source the estimated concentrations turn out to be much larger than the model predictions. This suggests that (a) the width of the measured plume may be larger than that assumed from [3]. and/or (b) there is a preferred flow direction along the Marylebone Road with part of the the plume not diffusing/dispersing but rather being advected along long, large roads and establishing a preferred direction so that the center-line of the plume is off the mean wind direction

It also has to be noted that the DAPPLE measurements are 3-minute averages whereas the empirical correlation brings together measurements with averaging times ranging from 3-minutes (in one of the measurements at Birmingham City) up to 30 minutes (in the Salt Lake City measurements).

5. Conclusions

In this note, the DAPPLE field measurements were interpreted in the context of a comparison with predictions from a simple empirical correlation [1] that was derived before any DAPPLE (field or wind tunnel) measurements had been made. The model provides an upper bound for the measured concentrations downwind from the source. The DAPPLE measurements fell below the upper bound, supporting the arguments of this simple correlation.

References:

[1] Neophytou MK and Britter RE.(2004). A simple correlation for pollution dispersion prediction in urban areas. DAPPLE Cambridge Note 1, January 2004.

[2] Robins A. (2003). Decay of maximum concentrations in an urban area. DAPPLE Note –EnFlo03, November 2003.

[3] Hanna S, Britter R and Franzese P (2003). A baseline urban dispersion model evaluated with Salt Lake City and Los Angeles tracer data. *Atmospheric Environment*, 37, 5069-96.

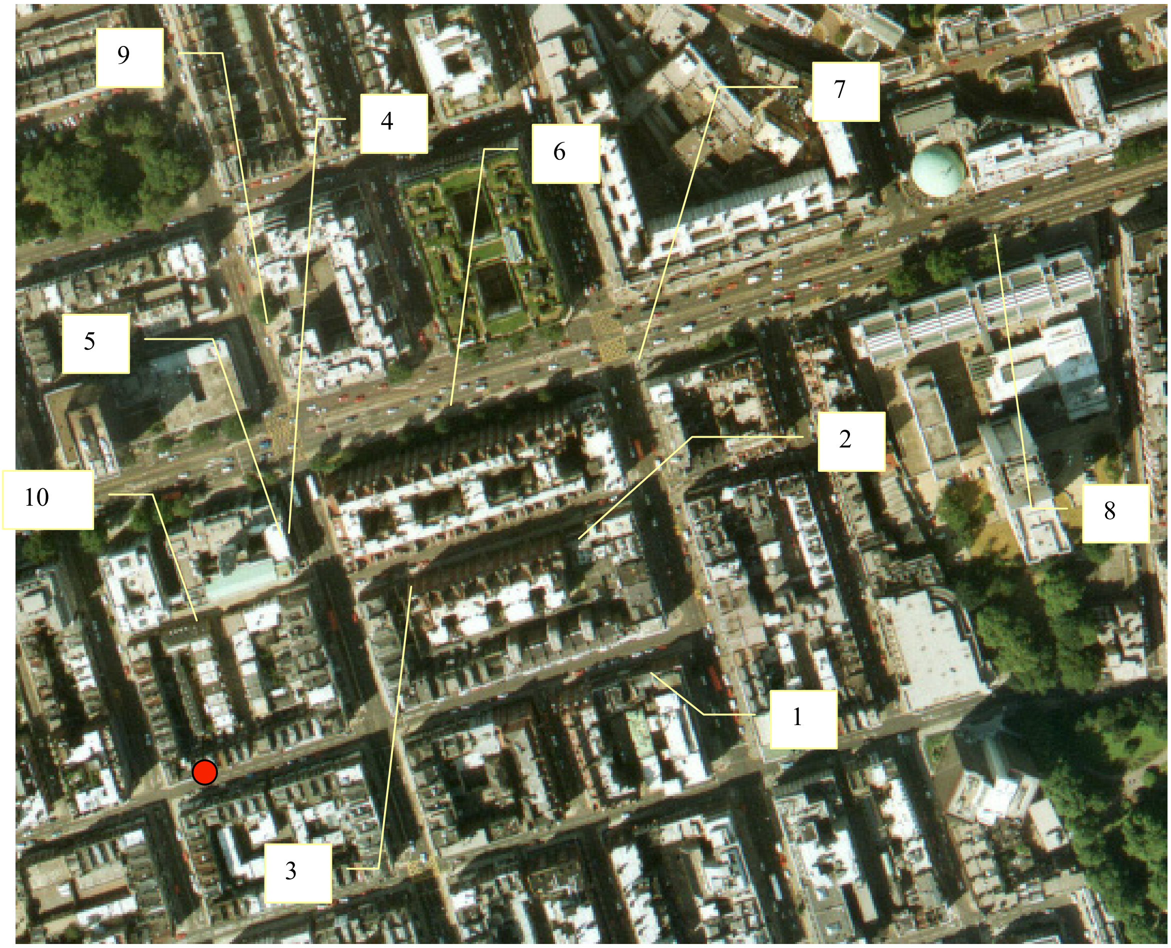

Figure 1: Area map of the tracer field study (Marylebone area) depicting source-receptor positions; source indicated by red the spot, and receptors are numbered and indicated by the yellow lines.

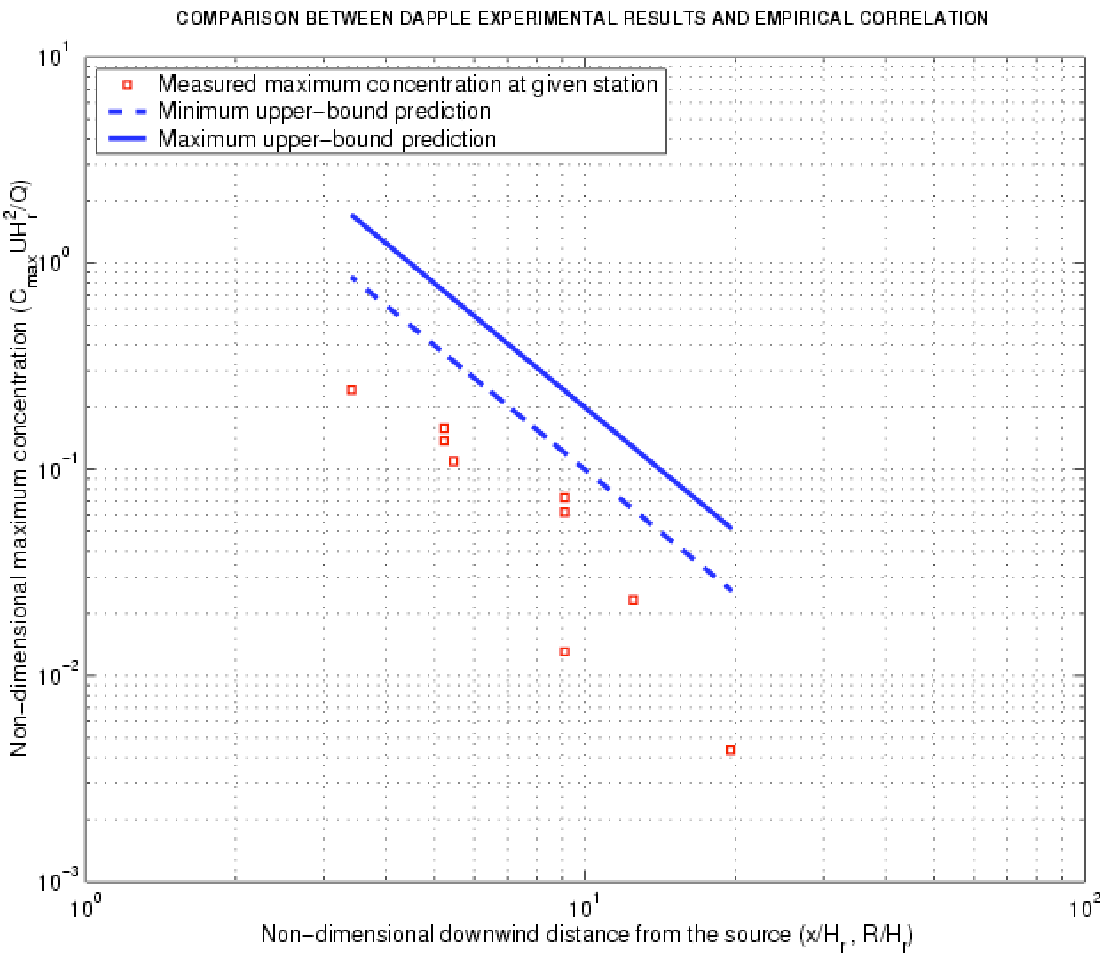

Figure 2: Comparison between DAPPLE field measurements and the Simple Correlation developed in [1].