

Interactive comment on “Tracer concentration profiles measured in central London as part of the REPARTEE campaign” by D. Martin et al.

D. Martin et al.

d.martin@bris.ac.uk

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General comments

We appreciate the insightful comments made by both referees and we hope the revised manuscript will be much improved. Each comment is followed by the relevant response.

Anonymous Referee # 1

It was encouraging that a dispersion experiment in a very complex urban situation was able to be analysed in a systematic way. References to earlier dispersion experiments and to DAPPLE put the work into perspective. Also it was good to see mention of the dependence of the vertical profile on the vertical wind profile (Section 3.2).

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1. However closer examination of Figure 7 show that there is a wide spread in concentrations. Low values, representing concentrations off the plume axis, are to be expected. Would it not be better, given that one was able to determine the crosswind profile to extract centre-line concentrations and do the analysis on these, hopefully reducing the scatter.

Response It is true that there is a fairly large spread that we get on those non-dimensionalized plots. It is likely that the spread is not really going to be much reduced, because most of the data are in the near-field (where we expect individual buildings and street canyons and their complex flow features to have a large impact on the flow and dispersion). The experiments had been designed with the intention of the BT tower samples being on the centre line of the plume given the meteorological conditions on the day. Repetition of experiments gives the highest probability of receptor concentrations of this being the case. Given the limited number of receptors used in these experiments the extrapolation of centreline concentrations may be subject to a large degree of error. Some of the source receptor angles are $\sim 50^\circ$ away from the mean BT tower direction and suggests that values may be close to centreline concentrations in any event and by implication the upper limit.

2. As mentioned in the paper the wind speed profile varies with height. Again would it not have been better to determine the friction velocity for each case, again reducing the variability? A non-dimensional plot using friction velocity and centreline concentrations might have less variability and would strengthen the case that channelling is less important at longer distances. There is therefore scope for further analysis which it is hoped will be presented in a later paper.

Response It is interesting the suggestion of using u^* instead of U as the normalization wind speed. This is rational, and indeed might reduce spread. However, a suitable estimate of friction velocity is not easy to come by. The rooftop site is rather heavily affected by specific buildings (it is within the canopy layer) and thus the u^* value might not be representative. The value of u^* at BT-top might be at a too high a level (within

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the mixed layer) to make sense as a surface-linked friction velocity value (especially since the boundary layer gets rather shallow later in the experimental period).

Minor details

1. A sentence explaining factors influencing the choice of source location would have been useful.

Response: A sentence explaining the locations of both sources and receptors will be added to the manuscript.

2. Figure 1 showing a plan of the experiment contains a lot of unnecessary detail.

Response: Unnecessary details will be removed from Figure 1 in the revised manuscript.

3. Although 10 times higher I was surprised that there was such a large ratio between the wind speed on the roof at Westminster and the BT Tower. Is the former sheltered in some way?

Response: There is indeed a ratio of around 4-6 of faster speeds at BT tower than rooftop. We should be reminded that the rooftop site is at 85% of mean building height (within about a square kilometre), and so it is no surprise that we get low wind speeds on this rooftop site.

4. The lidar results were not very useful except in confirming that the BT Tower was within the atmospheric boundary layer. Could more have been made of

Response: A more complete discussion of the Lidar measurements will be included in the revised manuscript which will give a more complete interpretation of these results in conjunction with anemometer turbulence parameters.

Anonymous Referee #2 Reply to Referee

1. The paper the experiments are sometimes referred to by year and sometimes as

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Repartee 1 and 2 – use one or the other, not both.

Response: All references within the manuscript will refer to REPARTEE 1 and 2.

2. Useful addition would be a tabulation of all the tracer concentration data and associated meteorological information (the latter probably only requiring that Repartee 1 is added to Table 3). A very nice paper should result with this added and following a careful revision of the text.

Response: A table will be added which collates all the tracer concentration data whilst all available meteorological data for REPARTEE 1 will be added to table 1.

3. Page 25246 Abstract, lines 5/6 – As written, this text doesn't mean anything – gradient of what?

Response: Text will be changed in the revised manuscript from 'The height of the tower gives a unique opportunity to study dispersion over a large vertical gradient' to read 'The height of the tower gives a unique opportunity to study vertical dispersion profiles in central London'

4. Introduction – there seems to be no acknowledgement of or reference to the large body of wind tunnel and small scale field studies of urban dispersion that have considerable bearing on some of the issues discussed in the paper.

Response: References which acknowledge the large body of wind tunnel and small scale field studies will be included in the final manuscript (e.g. Britter et al., 2003, Robins et al., 2001, Briggs et al., 2001)

5. page 25247 Rotach 2004, should be 2005 or vice versa;

Response: Rotach 2004 should actually be 2005 and this has been amended in the revised manuscript.

6. page 25247 Prairie Grass, 1956 isn't a reference

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Response: The prairie gas experiments are now referenced correctly in the revised manuscript.

7. Page 25247 There are numerous errors in the referencing throughout the paper. I'm not going to list any more, but the whole set needs careful checking. Allwine et al 2007 is listed but not referred to in the text.

Response: This reference has been removed and the whole set of references has been carefully checked in the revised manuscript.

8. Page 25247 Bottom – smoke and SO₂ are hardly exotic tracers.

Response: The term has been replaced in the final manuscript with 'disparate'.

9. Page 25248 I think it is a lattice tower, not an aerial, at the top of the BT Tower.

Response: The text has been changed to reflect the fact that it is indeed a lattice tower.

10. page 25250 Analysis, line 12/13 grammar

Response: Grammar will be corrected in the final manuscript.

11. Page 25250 Section 2.3.1 isn't it really an arc of 4 receptors and a vertical array of 3? This is not easy to follow as the map given as Fig 1 isn't relevant (I now realize).

Response: An arc of 4 receptors and a vertical array of 3 is probably a more accurate description of the experimental set up and the manuscript has been changed to reflect this.

12. Another map should be provided showing the location of the source and receptors. Why give a map for one case and not the other (ditto, but the other way around, for the detail in Table 1)?

Response: Originally only one map was displayed as it was felt that REPARTEE 2 was a slightly more complex experiment given the larger number of receptors and extra source. It is acknowledged that a separate map detailing source and receptor posi-

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tions for REPARTEE 1 would be a useful addition and will be included in the amended manuscript.

13. Page 25251 Section 2.3.2 – Present rather than past tense is used in places. Add the source letters and receptor numbers.

Response: The use of tenses has been corrected in the final manuscript. The source letters and receptor numbers will also be included in the final manuscript.

14. Page 25251 Section 2.4, line 1 – grammar

Response: The grammar in the final manuscript will be changed from 'Meteorological measurements on top of the BT Tower were taken from a lattice mast on the top of the BT Tower (51.521469_ N, 0.138881_ W) using a Gill ultrasonic anemometer (R3-100 with symmetric head) sampling at 20 Hz attached to the lattice mast.'

to

'Meteorological measurements from BT Tower were taken from a lattice mast at the top of the BT Tower (51.521469_ N, 0.138881_ W) using a Gill ultrasonic anemometer (R3-100 with symmetric head) sampling at 20 Hz attached to the lattice mast.'

15. Page 25252 line 3 ...sites at 1.5 m...There are numerous omissions of this kind (more commonly definite and indefinite articles) that need to be put right.

Response: Corrections to these omissions will be included in the final manuscript.

16. Page 25252 Section 3. There's 3.1.1 for REPARTEE 1 but no equivalent section for 2.

Response: The section heading for section for 3.1.2 for REPARTEE 2 has been added to the revised manuscript.

17. Page 25252 line 2 – Fig 2 shows 6 not 5 receptors and the plot is the sequence of 9 minutes averaged concentrations not time-resolved concentrations.

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Response: The text has been changed in the final manuscript to reflect the above comment.

18. Page 25253 line 2 – it doesn't suggest, it shows, but it should be no surprise as Briggs's urban vertical spread increases as $0.14x$ (140 m at 1 km).

Response: The word "suggest" will be exchanged for "shows" in the revised manuscript.

19. Page 25253 The discussion about travel times is confused. I think reference to and use of Chatwin's analysis of vertical dispersion and advection speeds is needed here.

Response: The section relating to travel times will be rewritten in the revised manuscript and will include reference and use of Chatwin's analysis of vertical dispersion and advection speeds.

20. Page 25253 paragraph 3 discusses sites 8, 9, 10 on Arc 1 (not mentioned before), which is Repartee 2 – make it clear which experiment is being discussed.

Response: A heading for section for 3.1.2 for REPARTEE 2 has been added.

21. Page 25253 I'm not sure what the final sentence is meant to convey – the plume will simply be wider.

Response: This statement will be omitted from the revised manuscript.

22. Page 25253 A general point about interpreting the vertical profiles in terms of s – even with much more Comprehensive data this is hard – ratios of concentrations from three heights (and two are not That far apart) are not good indicators of s .

Response: It is accepted that the determination and the interpretation of s is a difficult exercise. The access to BT Tower gave a unique opportunity to study vertical plume dispersion in urban given the tower's location and height. However, BT Tower is a restricted area and access was available to a few height levels.

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23. Page 25254 Top – there's no mystery here, vertical spread implies that at any position downwind, concentrations at some heights are increasing and at others decreasing.

Response: This sentence will be removed in the final manuscript.

24. Section 3.2. The discussion here about the value of s ignores all the wind tunnel results that clarify the matter for neutral conditions.

Response: References to previously reported wind tunnel measurements will be included in the final manuscript (e.g. Britter et al., 2003, Robins et al., 2001, Briggs et al., 2001).

25. Page 25255 Much of the theory discussed here is dated and not particularly helpful (e.g. the use of power law profiles) – Hunt and Weber is a good reference though. This section needs revising. Again, results from wind tunnel work have been ignored.

Response: This section will be revised and focus will be on the Hunt and Weber reference as suggested by the referee. Reference to previous wind tunnel measurements (e.g. Britter et al., 2003, Robins et al., 2001, Briggs et al., 2001) will be included in the final manuscript.

26. Figure 4 needs some explanation as there was 1 experiment in 2006 and six in 2007. Note in the legend which of the 2007 experiments has been plotted (presumably, those for which BT is in the plume centre, more or less). These results are effectively 15 minute averages, which is rather short and some variability should be expected between runs. Variability will be greater for the 2006 data, as these are 9 minute averages, though they could be combined to give a 1 hour average - but only some have been plotted. Say which in the legend and why in the text.

Response: It is true that the 2007 data represents in effect 15 minute averages while the 2006 data are 9 minute averages. These data could be averaged to give a 1 hour average but given that the wind direction was highly variable during this period

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with the plume missing the receptors on a number of occasions. Values plotted are those closest to the plume centreline. Figure 4 caption would be revised in the final manuscript to read ' Figure 4 Vertical gradient profiles for different source-receptor distances: 460m (Experiments 4 and 5, 2007 data), 980m (Experiments 1-5, 2007 data); 1270m (Samples 1-4, 2006 data).'

27. Page 25256 Section 3.3, line 4 – repetition (but not hesitation)

Response: Repetition will be removed in the final manuscript.

28. A normal lateral profile has been found in many urban dispersion studies, not just BUBBLE. Same comments as above regarding averaging times - lateral spread is likely to be more variable than vertical though Response: A number of references where a normal lateral profiles have been noted (Davidson et al, 1995 and Andr n 1985) will be added to the revised manuscript. Clarification regarding averaging times will also be made.

29. Page 25256 What values of sigma y and z were deduced?

Response: Sigma y and z were deduced from Briggs urban parameters as was done in the recent paper investigating vertical dispersion by Flaherty et al.

The values calculated were as follows:

Class D

For 1270m exp sigma y = 165 and sigma z = 151 m For 980m exp sigma y = 133 and sigma z = 121 m For 460m exp sigma y = 67 and sigma z = 60 m

Class C for 1270m exp sigma y = 228m and sigma z = 254m for 980m exp sigma y = 183m and sigma z = 196m for 460m exp sigma y = 93m and sigma z = 92m

30. Page 25257 Section 3.4.1 – some reference to DAPPLE is needed here.

Response: ANSWER References to DAPPLE have been added to the text.

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31. The final sentence needs to be expressed more clearly.

Response: Sentence has been changed to the following 'The values of BT Tower / WCC wind speed during the 2007 experiments are slightly higher than the annual average value but well within the range of measurements made and can be judged to be atypical conditions.'

32. Section 3.4.2 – not sure why agreement seems to be expected between the BT and street wind directions - explain the relationship in terms of the known behaviour of winds in street canyons, or omit the section.

Response: This section will be omitted in the revised manuscript.

33. Page 25258 line 2 – various variables? line 5 – grammar Explain the threshold criterion used with the Lidar turbulence data - para 3.

Response: Grammar will be corrected in the final manuscript An explanation of the threshold criteria associated with the LIDAR data will be included in the final manuscript.

34. Page 25258 Actually, I don't think there's any demonstration given that the boundary layers are convective – it's November and quite windy.

Response: In the revised manuscript measured lidar parameters will be reinterpreted in conjunction with the sonic anemometry z/l values to give a better description of the relevant meteorological parameters.

35. Page 25258 The neutral height scale, u^*/f , is about 1km. Some further discussion is called for.

Response: Further discussion with reference to the neutral scale height will be included in the revised manuscript.

36. Page 25259 Notation varies in (5) and (6).

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Response: The notation has been changed in equation 6 to achieve a degree of consistency.

37. Page 25259 Need to refer to Hanna's work here, testing (6) to quite large fetches.

Response: Hanna's work looking at larger fetches will be referred to in the final manuscript.

38. Page 25259 Final sentence – grammar

Response: 'This involved multiple source dosage experiments from multi-position sources over a number of different wind flow regimes.' will be changed to 'These experiments were multiple source dosage experiments from carried out over a number of different wind flow regimes'

39. Page 25260 Para 1 – refer to Wood et al (2009).

Response: Wood et al., 2009 will be referred to in the revise manuscript.

40. Conclusions – I don't think that the conclusion about vertical profiles is that definite. It would probably be different if all the studies of vertical dispersion had been taken into account.

Response: The conclusion regarding vertical profiles will be revised in the final manuscript.

41. Line 7 prefers to lateral spread. line 7-9 –

Response: This line will be revised so as highlight the fact that the conclusion here refers to the final manuscript.

42. grammar para 2, line 3 – variation, not variability.

Response: Variability will be changed to variation in the revised manuscript.

43. Hanna's work should be mentioned as he has extended the analysis of decay rate to greater distances.

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Response: Hanna's (Hanna et al., 2007) work looking at larger fetches will be referred to in the final manuscript.

44. Page 25261 DAPPLE should be acknowledged both for the source of data but also for the use of expertise and project time/funds.

Response: DAPPLE will be acknowledged as both the source of the data as well as for the use of expertise and project resources including time funds and personnel

45. References – check for accuracy.

Response: All references will be checked for accuracy in the final manuscript.

TABLES

Table 1: Distance above ground was not 0. Add release point and equivalent data for Repartee 2.

Response: The table will be amended to have the correct distance above ground. The equivalent data for REPARTEE 2 will be added

Table 3: Add Repartee 1. Correct grammar in caption.

Response: Caption grammar will be corrected in the revised manuscript and data from REPARTEE 1 will be added.

Any comment on 40% along wind turbulence in Epvt 1, 2 and 3?

Response: It is true that there is a relatively of along wind turbulence during these experiments and this turbulence may be reflected in increased variance in results.

Where's the anemometer relative to the flow and lattice tower?

Response: Location coordinates of the anemometer will be included in the revised manuscript.

Table 4: Rather too many Nottinghams in the caption. Are X and Y now velocity com-

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ponents? Explain notation. Data for wind speed are wrong, well perhaps missing a decimal point.

Response: The grammar has been corrected in the table caption. X and Y indicate the release positions and the table captions will be revised accordingly in the manuscript

FIGURES

Figure 1. Need the equivalent for Repartee 1. Receptor 3 was not at 0 m.

Response: The equivalent figure for REPARTEE 1 will be added to the revised manuscript and the Figure 2. Add source to caption and that the lower figure is an expanded version of the upper.

Response: Figure caption would be changed to the following 'Time series of concentrations for REPARTEE 1 (26 October 2006). The top panel shows the 9 minute integrated values at all off the receptors while the bottom panels show the values from the BT tower.' Figure 3. Simplest to refer to Table 2 for the timing. Response: Figure 3 will refer to table 2 for timings in the revised manuscript. Figure 4. Make data points larger and don't connect them. Add to Brigg's urban or rural (whichever is correct). Is the ground the appropriate origin for analysing the data? Probably not – I expect the zero-plane level (or roof level) is more sensible. Does that change anything?

Response: Data points will make larger and will be added to Briggs urban curves.

Figure 5. Curious units for y axis. Add the lateral spread assumed to give the 'black' profile, and the downwind distance of the observations. Show the data points, don't join them and remove coloured background.

Response: Y axis will be labelled in the revised manuscript. The lateral spread will be added as well as the downwind distance of the observations. Data points will be shown and the background will be removed.

Figure 6. Lidar measurements of what

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Response: The figure captions will be amended in the revised manuscript to indicate the relevant LIADAR parameters measured: Aerosol top layer, Boundary layer top, Convective mixing layer height, turbulent mixing layer height.

Comment #

We appreciate the insightful comments made and we hope the revised manuscript will be much improved.

The analysis of the vertical profiles is based on Equation (1), which appears to be incorrect. Its current form is

$$C(z)/C(0)=\exp(-bz\bar{E}_s) \quad (1)$$

In this equation, b has units and cannot be a constant. The correct form is

$$C(z)/C(0)=\exp(-b(z/z_{\bar{z}})\bar{E}_s) \quad (2)$$

where $z_{\bar{z}}$ is the mean height of the plume. See van Ulden (1978, Atmospheric Environment, 12, 2125-2129) for a discussion of the formulation.

Response: The correct form of this equation will be included in the revised manuscript

The authors have collected data that can provide insight into dispersion in urban areas. However, the interpretation of the data needs to be improved substantially before the paper can be published. The data needs to be interpreted using an up-to-date theoretical framework. The sonic anemometer and the Lidar provide boundary layer parameters that can be used to interpret the behaviour of the plume; Briggs stability classes date back to the 60s, and might be useful only if turbulence measurements are not available. They are rarely used in current literature.

Response: It is correct to say that the Briggs stability classes are quite dated and that they are not that much used in today's literature although recent examples exists (Flaherty et al. , 2007) Bearing in mind the above comments and those of the two reviewers a reanalysis of the BT anemometer data has been undertaken to give z/L values for

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relevant periods and these are analysed in conjunction with the LIDAR data to provide boundary layer parameters that in order to interpret the behaviour of the plume and these analyses will be included in the revised manuscript. Comments made by two reviewers will also provide a more up-to-date theoretical framework for data analysis. The dosage\distance correlation which included data for the DAPPLE experiments in central wind speed utilises reference wind speed to define upper dosage. The rationale behind this was to give a simple analysis for practical purposes which wouldn't rely on turbulence measurements and which might not be available in any case. Given that they are available in this case this will be reflected in the final manuscript.

References

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