

We thank the reviewer for taking the time to thoroughly review the paper and we regret that we did not spend sufficient time proof-reading each submission. We have made the 27 corrections and clarifications indicated by the reviewer and the co-authors have reviewed the paper for any further errors or poor phrasing.

We would also like to take the opportunity to thank all the reviewers for their very helpful and inciteful comments and corrections throughout the review process, which have substantially improved the paper and improved our understanding of plume rise.

Reviewer Comments:

I am pleased to see that the summation of plume rise due to buoyancy and plume rise due to momentum has been removed from the paper as the effects cannot be combined linearly. Consequently, I now have no objections to the publication of this paper. There are some minor points of clarification and typographical errors which should be corrected. Indeed, I found all iterations of this paper to be in need a thorough proofread. Please take time to do this before submission – it is not the role of the reviewer.

1. Line 23: “The parameterizations could be improved...”. This seems a little strong and I would suggest that “the agreement between the plume rise calculated from observations and the Briggs parameterizations could be improved...”

Modified as suggested.

2. Line 69: “Sharf et a., 1993” should be “Sharf et al., 1993

Corrected.

3. Line 86: “but we compare plume rise due to buoyancy and momentum with plume rise due to buoyancy only”. This is now only done for the neutral stability case.

We add “...for cases of neutral stability”.

4. Line 106: Perhaps add “plume rise” before parameterizations to clarify. There is also a typo: “there are not” should be “these are not”. To clarify, my suggestion is “While plume rise parameterisations for vertical plumes do exist, these are not...”

Modified as suggested.

5. My confusion over whether Fort McMurray is north or south of the Syncrude industrial complex (line 119) is due to the fact that there is no “Fort McMurray” marked in Figure 1, but there is a “Fort McKay”. Can Fort McMurray be marked on Figure 1?

The location of Fort McMurray has been added to the figure (left panel).

6. Line 214: typo “into our out of the image plane”

Corrected.

7. There is still some repetition in lines 210-211 and 216-217 as both refer to the horizontal distance from the camera to the stack measured by satellite.

We removed the second instance of “(measured from satellite imagery)”.

8. There seems to be some inconsistency with Δh being used to refer to both plume rise and “the plume cloud’s final height” (lines 257-258). I would suggest it should be plume rise with the final height being $h_s + \Delta h$. Similarly in Equation 9, is the final term plume rise or the final rise height? If you think it is plume rise, why would plume rise depend on h_s ?

In this instance (Section 2.3.1), we modify “plume height” to “plume height above the smokestack exit”.

To avoid confusion, we have replaced “plume height” with “plume rise height” in 17 instances throughout the manuscript.

For Equation 9, the original formula in Briggs (1984) is Equation 8.97. The formula depends on height above the ground because of the parameterization of the dissipation rate (which is a function of z). This makes the plume rise equation iterative as it includes $z = h_s + \Delta h$. In Byun et al., the equation is modified to replace Δh on the right-hand side with a simpler parameterization (as suggested by Briggs by personal communication to Byun et al.) so that the equation is no longer iterative. This is the formulation that is used in GEM-MACHv2.

9. Line 360: “assumes an entrainment rate of...”. I assume this should be “entrainment parameter” – if it is a rate, you should give units.

Changed to “parameter”.

10. Line 362: “to be affected by the boundary-layer height” should, I think, be the interface at the boundary-layer top (or the boundary-layer top).

Changed to “...boundary-layer top”.

11. I was wondering how p (line 365) is calculated, since Δh depends on p in Equation 12. Is it related to “the plume is assumed to have a vertical extent equal to Δh ” (i.e., $[h_s + 0.5\Delta h, h_s + 1.5\Delta h]$)? For a large plume rise, this vertical extent seems quite large.

We add a sentence after Eq. 12 as “Since p is a function of Δh , p is first estimated using the original Δh (Eqs. 9-11), and then this value is used to give a new Δh value from Eq. 12.”

The extent of $\pm 0.5\Delta h$ is from Briggs (1975) and Section 8-4.2.2 of Briggs (1984). The text states “...the plume is assumed to have vertical extent (i.e. the difference between the plume top and the plume bottom) equal to Δh , following Briggs (1975).”

12. Line 474: “Briggs slightly overpredicts on average”. I think this should be underpredicts.

Corrected.

13. Line 489: “60 image” should be “60 images”

Corrected.

14. Table 2 and lines 496 to 498: The figures quoted in the text for mean and standard deviation and correlation do not agree with the Table.

These errors have been corrected as “Neutral conditions had DCNN-analysed Δh of 137 ± 70 m while Briggs-predicted plume rise was 98 ± 31 m. In stable conditions, DCNN-analysed plume rise was 128 ± 34 m and Briggs-predicted plume rise was 123 ± 41 m.”

The final sentence of the paragraph is modified to “The correlations are similar or stronger compared to those determined for the final visible height method (especially for stable conditions, with $R^2 = 0.59$). This improved correlation could be due in part to the reduced number of samples (26 for the exponential method compared to 60 for the final visible height method).”

15. Line 526: “away from the mean”. Is this the mean of the plume rise of all the plumes?

Modified to “the mean of all the plume rise heights”.

16. Lines 564 onwards: These results are contrary to those for the manually selected cases so it might be worth acknowledging this.

We have removed this sentence and the following sentence as they repeat information from the previous paragraph. The contrary results are discussed in Section 3.5.3.

17. Lines 571-572: The sentence “For unstable atmospheric conditions, in which...” is not a proper sentence. I think it either needs to go on and say something else (i.e. For..., in which..., something else) or perhaps the “in which” needs removing?

“in which” is deleted.

18. Line 593: Should “64.4%” be “45.2%”?

Yes. This is corrected.

19. Line 670: “the mean value”. The mean value of what? Is it plume rise (i.e. 180 m)?

Changed to “the mean plume rise value”.

20. Lines 675 & 684: “a negative exponential curve”. I do not understand the reference to “negative”. Negative exponential curves are used for decay modelling, values decrease with downwind distance and tend to zero at large values and I think you will find that they are not the correct shape for plume rise.

In the first instance, we modify this to “the exponential curve described by Equation 1”. In the second instance “negative” is removed and it is described as “an exponential curve”. For clarification, in Section 2.2, Equation 1 is described as “a negative exponential decay curve (with an upper asymptote).” The shape is demonstrated in Fig. 2(e,f).

21. Line 678: “there is no turbulence”. I’m not sure this is true in reality. Do you mean a “constant wind speed gradient” or do you mean a uniform wind speed (i.e. zero wind speed gradient)? What about mechanical turbulence generated when there is (non-zero) wind and a rough surface? Or convective turbulence? Or plume rise induced turbulence / turbulence in the plume?

We rewrite this as “Notably, in strongly stable conditions, the plume may not entrain with the surrounding air or exchange heat with the surrounding air, in which case it could travel in the shape of an underdamped sine wave.”

22. Lines 695 – 696: “The final visible height...”. This sentence only applies for Table 2 and not for Table 3. However, the previous sentence indicates both: “based on the results of Tables 2 and 3”.

The start of this paragraph is modified (red text added) as “The analysis in which the exponential fitting is applied to the ensemble image set is expected to return higher plume rise compared to the final midpoint location, as the exponential fitting may be extrapolating above the observable plume for plumes that are not strongly curved. This is the case for all the stability classes (Table 3 and Fig. 9), except for stable conditions, where the average plume rise is equal within uncertainty for both methods.”

The sentence that mentions Table 2 (and the following sentence) are modified as “However, based on the results of Table 2, this is in fact not the case. The final visible height method predicts higher plume rise in all cases (although the differences are within uncertainties).” The incorrect reference to Table 3 here is removed.

23. Lines 717-719. Is this for the ensemble image set? It doesn’t say but the manual selection does not have any images in unstable conditions so I think it must be. Furthermore, for lines 726 onwards, the reported changes in “plume rise” are presumably changes in the mean plume rise over all the images?

For clarification, we have added the text “For the ensemble data set,...” to the second sentence of this section. For the second paragraph in the section, we changed “plume rise” to “average plume rise” in the 6 instances that it occurs.

24. Line 731: “much be” should be “must be”.

Corrected.

25. Figure 10 caption: “including plume rise due to momentum”. This should now state “for neutral stability cases only”. Have the authors updated this figure since removing the calculation of plume rise due to momentum and buoyancy effects by addition of the individual components?

In the figure caption, we have deleted “including plume rise due to momentum”. We confirm here that the figure in the previously submitted revision was for buoyancy only and did not include plume rise due to momentum. The text was left in due to an oversight and should have been deleted.

26. Lines 782-783: “with slightly lower plume rise through the evening and nighttime hours”. The plume rise does not look lower during these hours. Do you mean that the predictions of plume rise by the Briggs formulae are lower than the observations during these hours?

“...with Briggs parameterized plume rise slightly lower than observed (DCNN) plume rise through the evening and nighttime hours”

27. Lines 824-825: “resulting increase in momentum”. There is no increase in momentum. Perhaps the authors mean “increase in plume rise due to momentum

“Results demonstrated that the resulting increase in plume rise due to momentum was not significant.”