Referee#2 (anonymous)

Referee#2 General Comments

- *I would like them to provide more justification of the form of their entrainment coefficient. This seems to be based on the similarity drift observed by Kaminski et al. (2005) (and later by Carazzo et al. 2006, 2008). However, the veracity of this similarity drift is inconclusive: it was not observed by Wang and Law (JFM, 2002) in their experiments nor has it been seen in DNS or LES of buoyant plumes (see papers by van Reeuwijk and co-workers especially JFM 2015). It may simply be an artefact of Kaminski et al.'s experiments and for this reason I am somewhat sceptical of its adoption in volcanic plume models.*

We agree with the referee. We have highlighted that FPLUME can consider different options, in particular user-defined constant coefficients or the parameterization based on the local Richardson number. We have also add the sentence "However, the veracity of the empirical parameterization in Eq. (18) was not observed by Wang and Wing-Keung Lawin (2002) in their experiments nor has it been seen in DNS or LES simulations of buoyant plumes (Craske et al., 2015)". In addition, we have also added a paragraph at the end of section 2.2.

Referee#2 detailed Comments

- *p. 8010, l. 26. Buoyancy drives the plume upwards below the NBL; above the NBL the buoyancy is negative. I would delete the sentence from `above' onwards; you also need to insert `to' after `leads'.*

  ok
- *p. 8011, l. 2 Momentum reaches a maximum at the NBL and carries the plume upwards above the NBL for all plumes regardless of eruption strength.*

  The sentence now reads "Excess of momentum above the NBL (overshooting) can drive the mixture higher forming the umbrella region, where tephra disperses horizontally first as a…"
- *p. 8011, l. 5+ I didn't understand the sentence beginning `Depending on the balance...'*

  Sentence has been removed.

- *p. 8011, l. 10 I didn't understand what is meant by `characterization trough observations'*

  The sentence now reads “Quantitative observations and models of volcanic plumes are…”
- *p. 8011, l. 14 `build' ! `built'*

  ok
- *p. 8011, l. 18 `its' ! `their'*

  ok
- *p. 8011, l. 28 Woods (1988) does not include moisture.*

  Right, reference removed.
- *p. 8012, l. 14+ Can the authors substantiate their claim that atmospheric dispersion models without aggregation over predict ash concentrations in the far field? While this seems plausible, aggregation may reduce fall speeds by increasing the drag (more irregular shapes) and reducing the effective density (relative to a single particle of the same size). I think one needs to be careful with what is being compared with what, and what is being kept fixed as the reference point. I would make the statement less strong.*

  Yes, aggregation reduces effective density and hence fall speeds (relative to a single particle of the same size). However, this effect is highly counterbalanced by the velocity increase due to the size of aggregates compared to the primary particles given the d^2 dependency.
- *p. 8012, l. 24 `bent' ! `bending'*

  ok
- *p. 8013, l. 10 `specie' ! `species'*

  ok
- *p. 8013, l. 23 I didn't understand `univocally'.*

  Word removed
- *p. 8016, l. 6 `in' ! `on'*

  ok
- *p. 8023, l. 4 `than' ! `as'*

  ok

- *p. 8023, l. 8+ Do the authors have any evidence that there is no entrainment in the umbrella region? The dynamics of the region are clearly complicated but the flow is turbulent which suggests entrainment has at least the potential to take place.*
  We have added the reference Costa et al. (2015) as support. See also the changes in section 2.3 with respect to the original version.
- *p. 8025, Eq. (28) I'm assuming that the sum over all Aj has index k? Is this correct?*
  Yes, equation corrected
- *p. 8025, l. 16 `where' ! `were'*
  ok
- *p. 8027, l. 1 `to' ! `in'*
  ok
- *p. 8027, l. 11 Insert `a' after `as'*
  ok
- *p. 8028, l. 6 Insert `to' after `respect'*
  ok
- *p. 8030, l. 8 `meet' ! `met'*
  ok
- *pp 8032-8034 Regarding Fig.7, could the authors comment on why the model and observations agree better for small and large values of but not intermediate values?*
  These are not "observations" but comparison with a parameterization (Cornell) based on observations. Comparison makes sense only for ϕ larger that that of aggregates.
- *p. 8034, l. 3 `allows to' is not grammatically correct. Something like `... is that it allows estimation of the fraction ...'*
  ok
- *p. 8034, l.17 Remove `a'*
  ok
- *p. 8034, l. 18 `on' ! `in'*
  ok
- *p. 8034, l. 19 `along' ! `during'*
  ok