Referee#3 (anonymous)

Referee#3 detailed Comments

- *Title: maybe the present title can be misunderstood; it could explicitly states that the model is accounting for other important phenomena rather than only ash aggregation. I admit it might be quite long then...*

  We modified already the title as suggested by reviewer #1 but we prefer to keep the emphasis on ash aggregation as, although the code is very general and account for several processes, it is the new feature among 1D plume models.
- *Abstract: as the 1.0 version of the model is presented here, it would be nice to end by a sentence announcing future/potential improvements.*

  We added the sentence: "The modular structure of the code facilitates the implementation in the future code versions of more quantitative ash aggregation parameterization as further observations and experiments data will be available for better constraining ash aggregation processes."
- *p8010-l19: maybe state that volcanic plume are turbulent flows*

  OK
- *p8010-l23: "negatively buoyant basal thrust region"*

  OK
- *p8011-l09: you may wish to add a couple of references here, e.g. Carazzo et al. 2014 (Laboratory experiments of forced plumes in a density, stratified crossflow and implications for volcanic plumes, Geophysical Research Letters 41 (24), 8759-8766)*

  OK
- *p8011-l17: I would add that sophisticated 3D multiphase models have problems on their own related to the accurate description of the physical processes their are taking into account (e.g., closure equations, impact of spatial resolution, etc).*

  OK, a sentence added
- *p8012-l5: the upcoming special issue of the Journal of volcanological and geothermal research might be cited (if time has come).*

  Done
- *p8013-l2: for sure the TGSD is also depleted in large particles related to the source due to sedimentation.*

This fact is not relevant for ash aggregation that involves fine ash only.

- *p8014-l5: I suggest to define the mass, momentum, energy fluxes as well as s before giving the equations of conservation that will give their evolution with z. The parameters related to aggregation in the equations should be defined in the main text here (rather than in page 8016) as they are key in the paper (I mean not only in the table at that stage), as well as the rate of entrainment.*

  OK, done
- *p8015-l25: this is a detail, but one may note that buoyancy main become positive in the basal gas-thrust region (i.e. before the source momentum has become negligible).*

  We added "generally" in the revised version
- *p8016-l18: is rho_p independent of the size of the particles?*

  Yes, is the weighted average of all particle classes. We clarified this point.
- *p8019-equ(5): is this formula equivalent e.g. to the ones used in Girault et al. 2014 (The effect of total grain-size distribution on the dynamics of turbulent volcanic plumes, Earth and Planetary Science Letters 394, 124-134)? If not, what are the implications of the choice made here?*

  On pag 8019 there is no eq. (5) but eq. (15) that refers to a well-known experimental parameterization describing settling velocity of non-spherical particles. Eq. 5 is the definition of the partial pressure of water vapour.
- *p8021&8022: variable entrainment. I have two questions on that part: - for sure a volcanic plume is a forced jet in the basal gas-thrust region. Hence I do not see why it is necessary to propose a function for A_plume(zs) for zs<10. I wonder also why A_jet(zs<10) cannot be taken as A_jet(zs=10) rather than proposing an unconstrained function. Does that choice really affect the results? I guess it does not, but if it is the case this as to be discussed as the model would then appear open-ended.*

  This choice was made to have a general formulation with reasonable limit conditions that can be extended even outside of the values characterizing volcanic plumes. However in the new version of the plots we used as well zs as variable so it is easier to see typical ranges of volcanic plumes.
- *I am not sure I understand why a sin(theta) is added in equation (19). Could you add a few sentences to explain that point in more details?*

We added the original references were this correction was firstly proposed.

- *p8023-equ(23): isn't there more recent ways to determine H_t? I think there is at least one paper by Koyaguchi and Suzuki that compare the evolution of Ht and Hb with the eruptive flow rate. This part of the model appears less convincing than the previous one adressing the dynamics of the plume below the NBL. Is there a way to show that the approach (i.e., the prediction of the total height Ht) is consistent with some results from 3D numerical models or lab-scale experiments?*

  OK. We added the following sentence at the end of the section: "Although the proposed empirical parameterization of the region above the NBL is qualitatively consistent with the trends predicted by 3D numerical models (Costa et al., 2015), a more rigorous description requires further research."

- *p8024-l10: Plume wet aggregation model. This part is the most difficult to read as many equations are presented that involved a large number of parameters. I wonder if it is possible to have an idea on the dependence of the model results on these various parameters. I understand that Df0 is the key parameter here, but it will be good to illustrate more its importance relative to other parameters. It will be good also to show a figure with the evolutions of the predictions of the model when starting from a model with no aggregation and then adding the different processes ending to the full variation of n_tot (equ 34).*

  Yes, unfortunately the physics of particle aggregation are controlled by several variables in a nonlinear way and a simple study as the one the reviewer suggested will be very partial anyway. The model we used is described and discussed in Costa et al. (2010) and Folch et al (2010).

- *p8034-l15: Eyjafjoll eruption: did you consider the possible presence of meteoritic water in the plume, and will this affect the results (aggregation made easier)?*

  This is a good point and the meteoric water can enhance aggregation. Unfortunately we have not considered this effect, as reliable data are not available for the day of the eruption. In the revised version we clearly stated this point adding: "moreover the presence of meteoritic water in the plume (not considered here) could significantly enhance aggregation."