

Interactive comment on “ASHEE: a compressible, Equilibrium–Eulerian model for volcanic ash plumes” by M. Cerminara et al.

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Comments on “ASHEE: a compressible, Equilibrium–Eulerian model for volcanic ash plumes” by Cerminara et al.

This paper describes a new Eulerian model for non-equilibrium dynamics of gas-particle mixtures valid for low concentration regimes and particle Stokes number. However, it describes gas-particle non-equilibrium effects including clustering of particles by turbulence. The model has been implemented to openFOAM and applied to LES simulations of volcanic plumes in a stratified atmosphere, describing important features such as air entrainment, buoyancy reversal (i.e. transition from jet to buoyant plume or generation of PDCs), or maximum plume height. The modelling of first-order non-equilibrium effects (Equilibrium Eulerian approach) supposes an improvement with

C2848

respect to a 3D dusty gas model or relaxations of it (e.g. ATHAM model), but without the higher computational cost associated to full N-phase models. This is a really nice and rigorous paper that certainly deserves publication. I only have some suggestions requiring minor to moderate revision.

1) A Table compiling all the symbols appearing in the equations is necessary.

2) Section 2 presents first the full multiphase equations (2.1), the equilibrium-Eulerian approach (2.2) and finally its LES version (2.3). This makes the section very long and not easy to follow. My suggestions would be: i) remove section 2.1 (equations are actually not new and can be found elsewhere, e.g. Cerminara 2015), ii) start by presenting directly the set of eq. (29) and then explain the meaning of variables and approaches, and iii) write down the LES equations (38) directly and, if necessary, move its derivation to an appendix. These changes would shorten the section and prevent some readers to get lost before reaching section 3. . .

3) A similar argument applies to Section 4, where up to 4 validation examples are presented. Results are very nice, but devoting up to 14 pages and 7 figures seems excessive. I agree that all these model validation tests have to be mentioned but the degree of detail may deviate attention. I suggest to largely simplifying (or removing) 4.1 and 4.2, which are not essential for the application focus of the paper. In contrast, section 4.3 is wonderful in terms of volcanic plumes. The parts regarding HPC model performance and strong scalability analysis (e.g. Fig 1) could be moved to Section 3.

4) Section 5 is also very nice. I found particularly interesting the use of ASHEE to “calibrate” much simpler 1D plume models. Further work on this would be very welcomed by the community.

5) The conclusions end up as “(the model) reproduce the non-equilibrium behavior of gas-particle mixtures with a limited computational cost”. This statement contrasts with the 25 days required to simulate 720s using 1024 CPUs (section 5)! Some discussion on mesh refinement versus accuracy (and convergence) would be worth.

C2849

Minor comments and typing:

Pg 8897, Line 7. "...by the brittle fragmentation of..." → "...by fragmentation of..."

Pg 8897, Line 12. "exceed" → "exceeds"

Pg 8897, Line 15. "forming" → "formed"

Pg 8897, Line 16. "ash" → "tephra"?

Pg 8897, Line 23. "volcano, understanding..." → "volcano. Understanding..."

Pg 8899, Line 29. Add also wet aggregation (e.g. Folch et al., 2015; doi:10.5194/gmdd-8-8009-2015).

Pg 8901, Lines 1-5. Re-write...

Pg 8901, Line 6. "has" → "have"

Pg 8901, Line 24. "Sect." → "Sec.". Check this throughout the text.

Pg 8902, Line 5. Remove "here".

Pg 8902, Line 8. "to a particle" → "for a particle"?

Pg 8902, Line 14. "coefficient"??

Pg 8903, Lines 14-15. Order references chronologically.

Pg 8904, Line 2. This point is important. Stress (in the introduction) that the model considers volcanic ash only, not tephra in general.

Pg 8904, Line 4. Remove "formula"

Pg 8904, Line 7. "bigger" → "stronger"

Pg 8906, Line 5. "«" → "»"

Pg 8906, Line 23. Remove comma

C2850

Pg 8907, Line 9. Citation parenthesis

Pg 8912, Line 23. "by" → "in"

Pg 8913, Line 22. "species" → "bins"?

Pg 8920, Lines 8-11. Why stabilization of convection is unnecessary in your formulation?

Pg 8922, Line 16. Words

Pg 8923, Line 9. "error" → "errors"

Pg 8923, Lines 13-15. Order references chronologically.

Figure 21. Insets too small. Cannot distinguish.

Interactive comment on Geosci. Model Dev. Discuss., 8, 8895, 2015.

C2851