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Interactive comment on "An Adaptive Semi-Lagrangian Advection Model for Transport of Volcanic Emissions in the Atmosphere" *by* Elena Gerwing et al.

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The paper presents simulations of the dispersion of the Pinatubo ash cloud using a transport model with adaptive mesh und prescribed winds. The application of adaptive grid methods to tracer transport problems is not new, however, the application of the chosen semi-Lagrangian method to a volcanic plume and the inclusion of particle sedimentation has – to my knowledge - not been done before. As such the paper warrants publication. However, there are number of issues that need to be addressed before publication.

The biggest issue is the model initialization and forcing. It is said (page 7, line 6-8)

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Discussion paper

that the initial concentration is derived by dividing the eruption rate by the injection volume. However, this results in a flux of ash mass per unit volume and time, not a concentration. This flux should have been maintained over the duration of the corresponding eruption phase. However, it seems that an initial perturbation/concentration was used instead. If this is true, then this is a major flaw of the paper. Only adding the ash emitted within one second underestimates the erupted ash mass by many orders of magnitude. Releasing all ash erupted during each phase (as listed in table 1) instantaneously at the beginning of an eruption phase is equally unrealistic. This issue needs to be addressed, simulations repeated if needed before the manuscript can be published.

Also, the total amount of ash should not depend on the choice of the grid. If the forced volume is different, then the ash flux into that volume should be (slightly) different to compensate.

In the abstract (page 1, line 3) and conclusions (page 18, line 5) the authors state that adaptive meshes are useful to resolve filament structures of volcanic emissions. However, in the chosen example and in the presented results no filaments are present. The authors need to better justify and motivate the selection of the Pinatubo eruption as a case study.

The model description (chapter 2) does not describe the semi-Lagrangian transport model in any detail. The reference (Behrens, 1996) is given but it is not clear from the text that the transport model is described in there. More details at least about the model concept are needed with a proper reference to the Behrens (1996) paper for further details.

Add in the last paragraph of page 4 that ash is treated as a passive tracer.

Particle deposition (page 4, line 28) was not monitored. It is unclear why, when it would have been as easy to implement as suggested in the conclusions (page 18, line 14-15). Since deposited ash is the main source of information for historical eruptions it would have been good to test the resolution dependence of that deposition.

The mass eruption rate in table 1 has wrong units. I would assume it is kg per second instead. In table 2 add ‘refinement’ to the word level to avoid confusion with vertical levels. A cloud radius in degrees is an odd choice since this means an elliptical shape in physical space. This is inconsistent with the stated initial radial expansion of the plume on page 5. Discuss and clarify.

I disagree that results are converged for fine mesh levels larger than 16 (page 9, line 1-2). According to figure 3, ash concentrations in the centre of the plume to the south west of the volcano increase significantly from fine mesh levels 17 to 20 and to 23. Quantify the differences and discuss convergence or non-convergence in greater detail.

Other minor issues include:

Page 1, line 17: fall **out** of tephra

Page 1, line 18: tephra fall(s) **out** can lead...

Page 2, line 2-3: add: ...warmer winters and colder summer on the Northern hemisphere continents through dynamical feedbacks and radiative forcing, respectively (Robock, 2000).

Page 2, line 4-6: timescales of minutes don’t influence the diurnal cycle

Page 5, line 3: remove ‘one of’ since it has been said before that Pinatubo was the largest eruption in the 20th century.

Page 6, line 5: what is ‘atypical’ about the winds?

Page 7, line 20: say already here that 7 times means refinement level 8 (in table 2). Write ‘in the initial model domain before refinement’.

Page 10, figure 3: increase font of colour bar and text.

Page 11, figure 4: use identical and more meaningful colour bar. There are no yellow or red colours visible. What defines the surface of the ash cloud? If it is a threshold concentration the figure should show an iso-surface. Explain.

Page 12, figure 5: use same colour bar for both panels to enable comparison.

Page 12, line 15: delete 'however'.

Page 12, line 11-17: use information from table 3 for superposition of different ash sizes. Ideally, this should give the best fit and allow for a more independent validation.

Page 13, figure 6: use identical and more meaningful colour bars. Yellow and red colours not visible.

Page 15, line 16: 'since non**e** of our (model) simulations'

Page 16, line 3-4: write: will (not might) be underestimated

Page 17, line 5-7 and page 18, figure 11: it is not obvious to me that the shape is recovered well in all calculations. Quantify differences, in particular, discuss differences between top right and bottom right panels (identical fine resolution). Label for bottom right panel: shouldn't it read 'coarse=8'?

Page 17, line 8-12: this is the common way to calculate performance gains due to adaptation. However, a transport model written and optimized for constant resolution can be significantly faster than an adaptive grid code run at constant grid resolution. Discuss to which extend this issue might apply here.

Page 17, line 12: unresolved reference

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