Response to Reviewers #2

August 23, 2026

- Reviewer comment in black.
- Authors reply in red.
- Change in the manuscript in blue.

1 Answer to referee

The referee writes The paper "Triggering volcanic eruptions by gas bubbles accumulations in the magma chamber" by Godano et al. develops a sophisticated semi-analytical model for Strombolian eruptions in terms of probabilities of erupted volumes and characteristic times of eruption supported by the comparison with volcanological data on the occurrences of eruptions over the whole interval of possible erupted volumes. The model is quite well described from the mathematical point of view, but it lacks of the physical justification for the mathematical assumptions. The authors clearly state that the model hypothesis are simply mathematical, but a wider perspective of what this mathematics implies would improve the quality of the paper.

Answer We thank the referee for appreciating our work and for the very useful suggestions. We hope that the new version of the manuscript can be accepted for publication on GMD.

The referee writes Also some assumptions, like the neglect of the downward buoyancy of dense blobs, could be assessed by dimensional analysis.

Answer The friction caused by the high viscosity is a force as well as the gravitational force pushing downward the dense blob. This implies that the values of the two quantities are the same. This is testified, in the old version of the manuscript, by the Archimedes number being ≈ 1.

The referee writes Line 44: "the result seems to be applicable to a broader range of eruptive styles". It is not demonstrated in the followings that the model may be applied to more volcanic cases. I would suggest to use a more prudent sentence.

Answer Done

The referee writes Lines 116-177: "Within this overall scenario, it is reasonable to hypothesize that the friction, generated by the viscosity, can contrast the sedimentation of the blobs due to gravity." This hypothesis should be supported with a dimensional analysis. The same comment applies to line 208.

Answer See the answer #1

The referee writes Lines 120-122: "Admittedly, large-scale convective motion can occur within magma chambers; however, this does not preclude the diffusive behavior of the blobs". Convection and diffusion can coexist, but the strength of convection and diffusion should be compared in some way, particularly because in Conclusions it is written "small local convective motion" (line288).

Answer We thank the Referee for this interesting observation. The integration of our model with large scale convective motion in the magma chambers requires a lot of efforts and deserves to be published in a forthcoming paper. We are already at work for this generalization of the model. However, in the new version of the manuscript we added a sentence clarifying that the velocities of convection and diffusion should be of the same order of magnitude.

The referee writes Line 133: "For simplicity, we assume that the force pushing the blobs upwards increases linearly in time with constant rate λ". This is a crucial assumption. The authors could provide a sensitivity analysis on other possible dependency on time as they do for the α coefficient.

Answer We thank the referee for this important observation. We made a mistake, the constants λ and α are the same. In the new version of the manuscript we correct our mistake.

The referee writes Line 152: "the exponential decay becomes dominant, with respect to the power law term, at $2 \cdot 10$ 3 Mm3 ." Write "about $2 \cdot 103$ Mm3 ", this is only indicative, not exact.

Answer It is true. In the new version of the manuscript we refer to the articles of Papale and Papale et al. for a more precise estimated value.

The referee writes Line 171: "At the same time a new blob is positioned at a random location in the box". The creation of a new blob is needed to maintain the total number of blobs constant, but it should be also justified physically. Also the need to have constant N should be discussed.

Answer The introduction of a new blob at a random position serves as a computational simplification. Without it, an overly rapid coalescence process would cause the number of moving (and erupting) blobs to decrease over simulation time. However, it is worth noting that N only affects the exponential cutoff at large volumes (Figure 4). Consequently, the total number of blobs has a negligible impact on the physics of the process. We are thus constrained only by upper and lower bounds, representing the physical states where the magma chamber is either saturated with blobs or entirely empty.

The referee writes Line 192: "For simplicity, we assume a linear time trend $V_{v,i}(t) = \alpha(t\tau_{V,i})$". The authors consider in details the bubble nucleation law (Section 2.2.1). If possible, they could extend this analysis to the growth of bubbles below the dense magma blobs to physically justify the assumed linear growth.

Answer The phenomenon is controlled by many factors as stated at line 135 of the old version and the time dependence of the force increases could be described by a very complex function. However,we can assume, without any loss of generality, that the function increases smoothly with t and that an expansion, truncated at the linear term, well approximate the function. In the new version of the manuscript we added a sentence explaining such an aspect.

The referee writes Line 195: which is the rationale for the choice of the exponential distribution for $\tau_{V,i}$? Further, τ_s is not defined.

Answer This implies a Poissonian process. In the new version of the manuscript we introduce this explanation and define τ_s which is the average $\tau_{V,i}$

The referee writes Section 4.2: all reduced units employed for computations and map into physical units has to be clearly explained, possibly with a table.

Answer We tank the referee for this suggestion. In the revised version of the manuscript we have made more explicit the conversion from simulation units to physical ones, adding a table for the quantities of interest.

The referee writes Line 227: please clarify how is defined a stationary thermalized state.

Answer A stationary thermalized state is a state for which the macroscopic properties of the system do not change in time and thermal equilibrium is reached. In the new version of the manuscript we report such a definition.

The referee writes Line 239: how is it justified that the Boltzmann constant is taken equal to one?

Answer We tank the referee for enlightening this point. Actually the equation 13 and 14 were written for a colloidal particle diffusing in a fluid. Since in our case fluctuations have not a simple thermal origin, but are generated by different fast and small scale mechanisms as discussed in the text, in the revised version of the manuscript we have changed $k_B T$ with ϵ, fixing the energy scale for the fluctuation amplitude.

The referee writes Line 247: "Concerning instead the right tail, ..." Refer again to Figure 4, writing this after the comment to Figure 5 is misleading.

Answer In the new version of the manuscript we moved the comments to Figure 5 before the comment to Figure 6.

The referee writes Line 186: $\Delta\rho_{dm}$ is not defined.

Answer In the new version of the manuscript we defined $\Delta\rho_{dm}$.

The referee writes Caption of Figure 6: τ_r should be τ_{er}

Answer Done