Reply to Reviews on "G&M3D 1.0: an Interactive Framework for 3D Model Construction and Forward Calculation of Potential Fields" by Wang et al.

We thank two Reviewers for their careful reviews and comments on our manuscript entitled "**G&M3D 1.0: an Interactive Framework for 3D Model Construction and Forward Calculation of Potential Fields**" (ID: egusphere-2025-5357). All of these comments are addressed in this document. For clarity, the original reviewer comments are reproduced below in *italics*, and our responses are provided in regular font.

 # RC1:
The manuscript by Wang and co-authors presents G&M3D, a software package with a graphical user interface to create a set of three-dimensional subsurface bodies. The bodies are either based on basic geometric shapes or freely drawn with the mouse on individual profiles and then combined into a 3D volume. The software furthermore allows the user to assign density differences and magnetic properties to the bodies and forward model the resulting gravity anomalies and magnetic intensity as well as their gradients. The authors demonstrate the software's capabilities in an application to the gravity anomaly caused by a real salt dome. The manuscript is well written, the text is clear in most places, and the content fits the scope of GMD. The Figures nicely illustrate how the graphical user interface looks and can be used.

There are some concerns/open questions regarding the flexibility and efficiency of the method, the accessibility of the software, and the clarity of the text. These can be addressed with moderate revisions. Please see the attached PDF for my comments.

Major comments:
1) The authors often stress how efficient/fast computation is, but they are not using parallel approaches. I would like the authors to comment on the potential of further speed-up through parallelization. Did they deem it unnecessary with the current speed of the code? Would the implementation be problematic?

Reply: Thanks for this valuable suggestion. Although the current BCE implementation is already efficient for moderate model sizes, we agree that parallelization is beneficial for larger and more finely discretized models. In the BCE algorithm, the forward responses are computed layer by layer along the z-direction, and the contribution from each layer can be evaluated independently before summation. Therefore, the algorithm is naturally suitable for parallelization, and the implementation is not problematic.
In the revised manuscript, we implement this capability in G&M3D 1.0 through task-based multithreading in standard C++, where layer-wise forward responses are launched asynchronously and collected after completion. To assess its practical effect, we test the same synthetic model discretized into 200 × 200 × 200 prisms under vertical magnetization conditions using 8 threads. The total computation time is reduced from 19.83 s in serial mode to 5.75 s in parallel mode, corresponding to an approximately

3.45-fold speed-up. These results confirm that parallelization is feasible in the present framework and can further improve computational efficiency for larger forward-modelling problems. (page 8, lines 243-245; page 9, lines 246-248)

2) The authors mention inversion a few times but as far as I can see, an inversion would have to be done one model at a time and all by hand. That is not feasible. For inversion, it would be necessary to be able to automatically change properties without the GUI. Good studies to look at would be Galley et al., 2020, Spang et al., 2022 or de la Varga et al., 2019.

Galley, C. G., Lelièvre, P. G., & Farquharson, C. G. (2020). Geophysical inversion for 3D contact surface geometry. Geophysics, 85(6), K27-K45. https://doi.org/10.1190/geo2019-0614.1

Spang, A., Baumann, T. S., & Kaus, B. J. (2022). Geodynamic modeling with uncertain initial geometries. Geochemistry, Geophysics, Geosystems, 23(6), e2021GC010265. https://doi.org/10.1029/2021GC010265

de la Varga, M., Schaaf, A., and Wellmann, F. (2019) open-source stochastic geological modeling and inversion, Geosci. Model Dev., 12, 1–32, https://doi.org/10.5194/gmd-12-1-2019.

Reply: Thanks. We agree that the original wording may have overstated the role of G&M3D 1.0 in inversion. The current version of G&M3D 1.0 is designed exclusively for 3D body construction and forward modelling; it currently lacks inversion capabilities and does not support automated model updates independent of the GUI. We mention inversion mainly because forward modelling is a fundamental component of any geophysical inversion and because the models created by G&M3D 1.0 can serve as robust initial models or synthetic benchmarks for inversion studies. In the revised manuscript, we have updated the relevant statements to clarify that G&M3D 1.0 is not intended as an inversion framework. (page 15, lines 378-379)

3) If I understand correctly, the algorithm saves time by skipping layers that don't have any anomalous bodies, but as soon as a single anomalous prism is detected, the entire layer is computed. Would it not be more efficient to only compute anomalous prisms? The way I imagine the current implementation, a vertical needle (1x1x100 prisms) would take much longer to compute than a horizontal one (100x1x1 prisms). Can individual prims not be skipped because of the matrix approach? Some clarification about this would help.

Reply: Thanks. We agree that a vertically elongated body (e.g., 1×1×100) requires more computation time than a horizontally distributed body (e.g., 100×1×1) in the present implementation. This is because the BCE calculation is performed layer by layer along the z-direction: all empty layers are bypassed, whereas any layer containing anomalous prisms must undergo a complete 2D convolution. Consequently, skipping empty layers is only a procedural optimization rather than the core algorithmic innovation. In the current matrix-based formulation, individual anomalous prisms within an active layer cannot be skipped independently.

To clarify this point, we have added a synthetic example in the revised manuscript. For a 100 × 100 × 100 case under vertical magnetization, two bodies with the same volume but different spatial distributions 1 × 1 × 100 prisms and 100 × 1 × 1 prisms require approximately **2.65 s** and **0.04 s**, respectively, for calculating gravity, magnetic, and gradient components. Although the vertically elongated case is less favorable for this layer-wise implementation, the absolute computation time remains highly acceptable due to the intrinsic efficiency of the BCE-framework. (page 8, lines 238-241)

4) In section 2.2 and Figure 2, it is stated that the model domain and observation points are doubled in x- and y-direction but it is unclear what purpose this serves. Is it necessary for the computational method? Can other methods avoid this? How does this affect the computational performance.

Reply: Thanks. We have clarified this point in the revised manuscript. In the BCE formulation, Eq. (21) is essentially a 2D linear convolution between the layer-wise model parameters and the kernel. Since the FFT-based approach inherently computes circular convolution, the model domain and observation points must be padded to twice their original dimensions in the x- and y-directions. This extension embeds the linear convolution into a circulant form, thereby eliminating wrap-around boundary artifacts. While this extension increases the size of the FFT arrays from $N \times M$ to $2N \times 2M$ (resulting in a fourfold increase in memory and per-layer computational cost), this overhead is negligible compared to the computational intensity of direct spatial domain summation. The BCE method thus retains a decisive advantage over non-FFT-based strategies. (page 6, lines 163-166; Figure 2)

5) For both gravity anomalies and magnetic field anomalies, there are analytical solutions for buried spheres (e.g., Lowrie and Fichtner, 2020, p. 349). While the salt dome is a great example to highlight the capabilities of the irregular tool, a benchmark against these analytical solutions would be more convincing for the validation of the computational accuracy of the software. A setup with a few buried spheres could be used to test both gravity anomaly and magnetic field anomaly.

Reply: Thanks. We agree that a benchmark against analytical solutions provides a more rigorous validation of the computational accuracy of G&M3D 1.0. In the revised manuscript, we have incorporated a new synthetic benchmark consisting of three buried spheres. Their centers are located at (50 m, 55 m, 50 m), (140 m, 75 m, 65 m), and (110 m, 155 m, 80 m), with radii of 20 m, 30 m, and 35 m, respectively. The computational domain (200 m × 200 m × 200 m) is discretized into a high-resolution 800 × 800 × 800 grid. The resulting gravity and magnetic anomalies are compared against their respective analytical solutions, as shown in Figure R1. The maximum absolute residuals are 7.5×10^{-6} mGal for gravity and 5.4×10^{-3} nT for magnetic anomalies. These extremely low error levels confirm the high numerical precision of G&M3D 1.0. (page

9, lines 253-260; Figure 3)

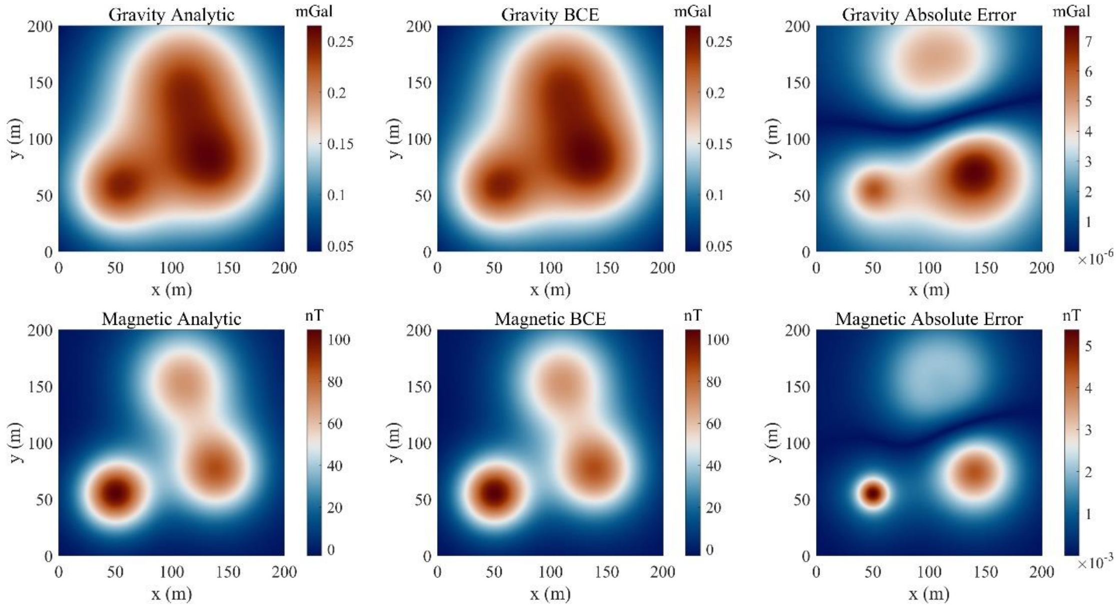

Figure R1: Comparison between analytical solutions and BCE results for gravity and magnetic anomalies produced by a synthetic model of three buried spheres.

6) The manuscript makes no statement if and how the software can handle the existence of topography.

Reply: Thanks for this practical suggestion. In the revised version, we have integrated topography-related functionality into G&M3D 1.0. The software now supports topographic model construction and 3D visualization (Figure R2), with a built-in constraint ensuring that anomalous bodies are correctly positioned beneath the topographic surface.

Furthermore, we have added a dedicated forward modelling module for topographic scenarios, enabling the calculation of gravity and magnetic anomalies, and their gradients at observation points with variable elevations (non-planar surfaces), as shown in Figure R3. The manuscript and figures have been updated to demonstrate these new topographic modelling capabilities. (page 9, lines 270-272; page 10, lines 283-285; page 13, lines 345-346; page 14, line 364; Figure 9; Figure 10)

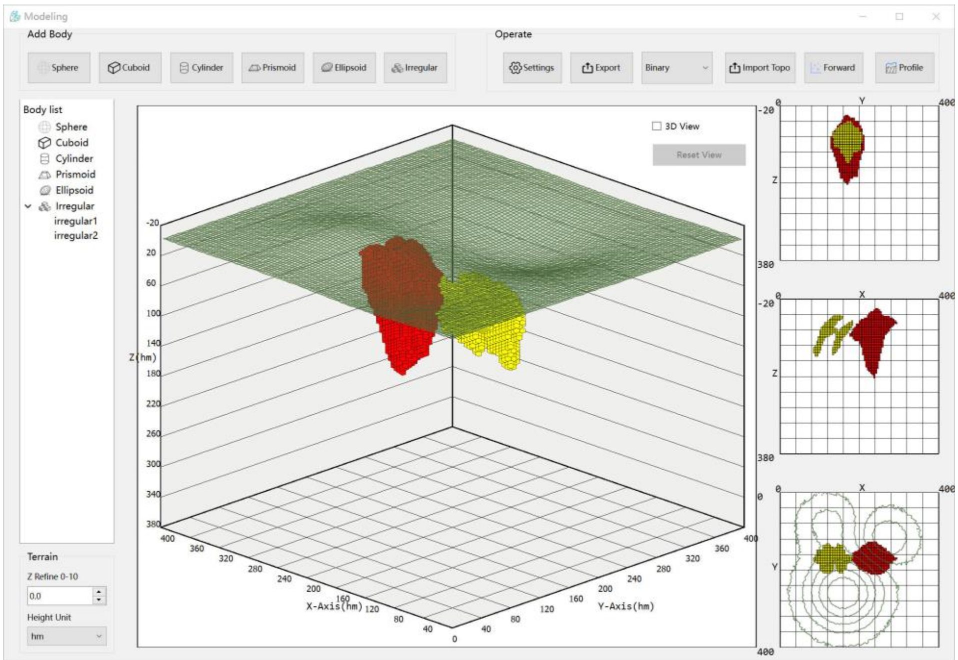

Figure R2: An irregular sulphide deposit model constructed using the Irregular tool.

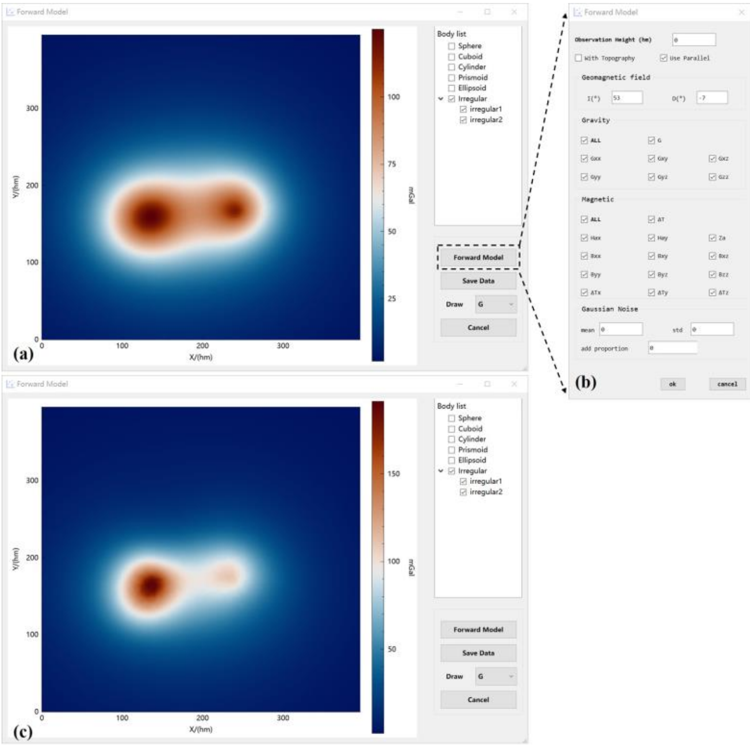

Figure R3: (c) Results calculated over undulating topography.

7) Another complication would be two anomalous bodies overlapping. For instance, a basaltic dike intruding into an older solidified granite intrusion. Can one body overwrite the properties of parts of another body?

Reply: Thanks. G&M3D 1.0 fully supports overlapping anomalous bodies. In cases of spatial overlap, the physical properties of the most recently created body will override the properties assigned to the prisms in that region. This sequential overriding logic has been explicitly clarified in the revised manuscript to ensure the model construction process is well-defined and unambiguous. (page 11, lines 294-295)

8) In the zenodo repository, the authors provide a Windows executable and source code, but there are no instructions on how to use the software on Linux or Mac. A Readme with clear instructions on how to compile and launch the software on all 3 systems would greatly improve the accessibility of the software. Without such instructions, it cannot fill the role of a community software as advertised in the manuscript.

Reply: Thanks. Since Qt supports cross-platform development, we have expanded the software's accessibility in the updated release. We now provide a Linux-compatible version along with a comprehensive README file that outlines the compilation and deployment procedures for different environments. These resources are now available in the updated Zenodo repository (https://zenodo.org/records/19674359). While G&M3D 1.0 has not yet been bundled as a native macOS installer, macOS users can successfully build and run the software from source using the Qt framework. We have updated the repository documentation to explicitly state the supported platforms and provide clear build instructions, ensuring G&M3D 1.0 better serves the broader research community.

9) The authors state that open-source options for gravity and magnetic forward modelling are rare. But they do exist and should be cited and discussed in line 67. Options include: simpeg (Cocket et al., 2015), geomIO (Bauville and Baumann, 2019), eventhough it depends on matlab, SRBF_Soft (Ulug & Karslıoglu, 2022), Hogue et al., 2020, cited elsewhere in the manuscript, also Matlab. There seem to be more. Even if these don't exactly provide what the authors present, they are close enough to warrant acknowledgement and highlighting what advantages/disadvantages G&M3D has in comparison.

Cockett, R., Kang, S., Heagy, L. J., Pidlisecky, A., & Oldenburg, D. W. (2015). SimPEG: An open source framework for simulation and gradient based parameter estimation in geophysical applications. Computers & Geosciences. https://doi.org/10.1016/j.cageo.2015.09.015

Bauville, A., & Baumann, T. S. (2019). geomIO: An open-source MATLAB toolbox to create the initial configuration of 2-D/3-D thermo-mechanical simulations from 2-D vector drawings.

Ulug, R., & Karslıoglu, M. O. (2022). SRBF_Soft: a Python-based open-source software for regional gravity field modeling using spherical radial basis functions based on the data-adaptive network design methodology. Earth Science Informatics, 15(2), 1341-1353. https://doi.org/10.1007/s12145-022-00790-y

Reply: Thanks. In the revised manuscript, we have included the suggested references and expanded our literature review to provide a more comprehensive context. We now acknowledge existing open-source tools such as SimPEG (Cockett et al., 2015), geomIO (Bauville and Baumann, 2019), SRBF_Soft (Ulug and Karslıoğlu, 2022), and the MATLAB-based software by Hogue et al. (2020). We have clarified that the distinctive contribution of G&M3D 1.0 lies in its seamless integration of interactive 3D body construction, gravity and magnetic forward calculation, and real-time visualization within a standalone GUI framework, specifically designed for users without programming expertise.

In addition, we conducted a head-to-head performance benchmark with SimPEG on a desktop equipped with an AMD Ryzen 7 3700X CPU (8 cores) and 32 GB RAM. For a 200 × 200 × 200 grid, G&M3D 1.0 completed the forward calculation in approximately **2.52 s**, whereas SimPEG required **1606.62 s**. Notably, when the resolution increased to 800 × 800 × 800, SimPEG encountered a memory bottleneck and failed to complete the task, while G&M3D 1.0 maintained robust performance. This substantial performance gap further demonstrates the superiority of G&M3D 1.0 as a highly efficient tool for large-scale forward-modeling problems. (page 2, lines 67-74; page 9, lines 249-252)

10) There is an inconsistency with the term density/density contrast. Equations 1-7 use rho for density contrast. Delta rho would be more appropriate. In the remainder of the text, the authors only use the term "density" while it should always be density contrast.

Reply: Thanks. We agree and have standardized the terminology throughout the manuscript. Specifically, we now use \Delta \rho in Eqs. (1)-(7) and consistently apply the term "density contrast" throughout the text to ensure mathematical and conceptual accuracy. (page 3, Eqs. 1-7)

11) A great feature for the Irregular tool would be the possibility to load semi-transparent images into the background of the drawing domain (Figure 7). This would allow the user to match results of imaging surveys much more effectively. I don't know how feasible this is from the software point of view, but it would be a great addition.

Reply: Thanks for this excellent suggestion. We have successfully implemented the requested functionality in G&M3D 1.0. To facilitate reference-guided modeling, the Irregular tool also allows users to digitize geological bodies directly over geophysical or geological cross-sections, significantly improving modeling accuracy (Figure R4). (page 13, lines 329-330; Figure 8)

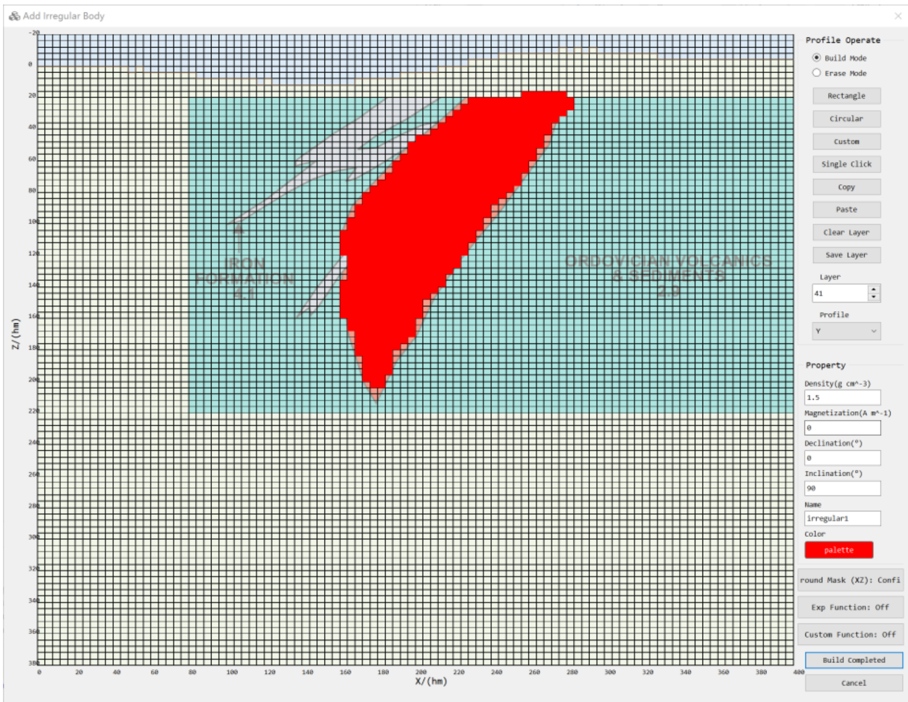

Figure R4: In this example, a screenshot adapted from Thomas (1997) is used as a semi-transparent background template to construct an irregular sulphide deposit with a density contrast of 1.5 g·cm^{-3}.

12) The colormap used in Figures 9, 11, and 12 is not appropriate for scientific results. It is journal policy to use colormaps that allow readers with color deficiencies to interpret them. There are a number of perceptually uniform and deficiency friendly maps available in Matplotlib or at https://www.fabiocrameri.ch/colourmaps/.

Reply: Thanks. In the revised manuscript, we have replaced the original colormap with the perceptually uniform and color-deficiency-friendly "vik" colormap (Crameri, 2018) from https://www.fabiocrameri.ch/colourmaps/. Figures 9 and 11 (now Figures 10 and 12) have been redrawn to ensure scientific accessibility. (Figure 10; Figure 12)

Crameri, F. (2018). Scientific colour maps. Zenodo. https://doi.org/10.5281/zenodo.1243862

13) Starting in line 164, the anomalous bodies are often referred to as models which is confusing as the whole domain should be the model in my opinion. Please stick with the term "body" or "anomalous body". This also affects the list of bodies in the GUI.

Reply: Thanks. We have strictly distinguished "model" from "body" throughout the revised manuscript. The terminology and associated labels within the GUI have been updated accordingly to ensure consistency.

14) Please make sure that all units are given with positive or negative exponents instead of forward slash (i.e., g cm^-3 instead of g/cm^3).

Reply: Thanks. We have standardized all units across the manuscript to use negative exponents instead of forward slashes.

Minor comments:
G&M3D is an intuitive name, but the text should still state once what it stands for.

Reply: Thanks. We have defined G&M3D at its first occurrence as “Gravity and Magnetic 3D modeling”.

L. 12-13: Rephrase: However, open-source tools that allow for both the flexible and interactive construction of source models and potential-field forward calculations are rare.

Reply: Revised as suggested.

L. 14: “3D” has to be defined somewhere once.

Reply: “3D” has now been defined at its first occurrence as “three-dimensional (3D)”.

L. 16-19: First sentence is unclear and confusing considering the following sentence. I think what the authors want to say is that the domain is divided into rectangular prisms and the 3D shapes mentioned in the second sentence are approximated by a collection of angular prisms. Please clarify.

Reply: Thanks. In the revised manuscript, we now explicitly state that G&M3D 1.0 facilitates the construction of complex 3D anomalous bodies, which are internally discretized into an assembly of rectangular prisms for high-efficiency forward calculation.

L. 30: Give some examples of other less efficient techniques.

Reply: Thanks. Revised as suggested.
“Compared with more logistically demanding methods, such as seismic reflection surveys and electrical surveys requiring dense electrode deployment, gravity and magnetic surveys generally offer simpler field procedures, lower acquisition costs, and greater efficiency for large-area data collection.”

L. 66: Rephrase: Nonetheless, open-source options that …. are rare.

Reply: Revised as suggested.

L. 69: It’s debatable whether C++ is considered a high-level programming language.

Reply: Thanks.

"C++ is a widely used general-purpose programming language with strong computational performance and portability, making it well suited for numerical computing and scientific software development."

L. 70: Please provide a link and ideally a citation for Qt.

Reply: Revised as suggested. "Qt (https://wiki.qt.io)"

L. 74: I assume that the mentioned software is based on Qt. Express that explicitly.

Reply: Revised as suggested.
"For instance, … using standard C++ with the Qt library for gravity data interpretation."

L. 81: The sentence is a repetition of the previous one.

Reply: Thanks. We have revised this part to avoid repetition.

L. 88: Unclear what "mass volume" means.

Reply: Thanks. We have revised this expression for clarity.
"the volume of an anomalous body"

L. 92: Change to in-text citation, then colon, then equations. Same for magnetic equations.

Reply: Thanks. Revised accordingly.

Eq. 1: z should be z_0? Same for other equations.

Reply: Thanks. We have corrected this notation.

Eq. 2-7: I guess "V" are the gradients. Please add clarification. Also, "\Delta \rho" would be more appropriate for density anomaly.

Reply: Thanks. We have clarified that the terms V denote the components of the gradients. We have also replaced "\rho" with "\Delta \rho" to consistently represent density contrast.

Eq. 8-10: arctan should not be in Italics.

Reply: Revised as suggested.

Fig. 1: Observation point should be capital P.

Reply: Revised as suggested.

L. 101: sin and cos should not be in Italics. Same in equations 17-20.

Reply: Revised as suggested.

L. 102: "main magnetic field" appears to refer to the Earth's magnetic field. Please clarify.

Reply: Thanks. We have clarified that the "main magnetic field" refers to the Earth's main magnetic field.

L. 102: Then the scalar…

Reply: Revised as suggested.

L. 112: Should be P(x_n, y_m, z_0) for consistency.

Reply: Revised as suggested.

Eq. 21: Why semicolon instead of comma here?

Reply: Thanks. We have revised Eq. (21) and the related text for clarity. The semicolon has been removed.

L. 116: Does function t describe distance or decay of signal with distance? Please elaborate more.

Reply: Thanks. Equation (21) is a unified and compact representation of Eqs. (1) to (16), where t denotes the kernel response at the observation point produced by a prism with unit density contrast or unit magnetization.
"Therefore, t represents the kernel (or sensitivity) coefficient, which can be evaluated using any of Eqs. (1) to (16), rather than a simple distance-dependent decay term."

L. 117: observation point P(...).

Reply: Revised as suggested.

L. 130: it is unclear what this extension is for.

Reply: Thanks. We have clarified that this extension is required because Eq. (21) is a linear convolution, while the FFT corresponds to circular convolution. The BCE extension is therefore used to avoid wrap-around errors.
"This extension is necessary because Eq. (21) represents a linear convolution, whereas

the FFT inherently evaluates a circular convolution. By embedding the original problem into an extended domain, the linear convolution can be reformulated in a circulant form and computed efficiently without introducing wrap-around boundary errors at the boundaries."

L. 133/134: it is also unclear why the field effects are computed in the extended area.

Reply: Thanks. We have clarified that the extended area is only used as an auxiliary computational domain for the FFT-based implementation. The final results used in practice remain those within the original observation area.
"Note that the extended area serves only as an auxiliary computational domain; only the results within the original observation region are retained."

Fig. 2 caption: clarify that the extended observation points are red and source region observation points are black.

Reply: Thanks. We have clarified this in the figure caption.

L. 152: two strategies, not several.

Reply: Revised as suggested.

L. 159: explain what "vertical magnetization" means. Also, how does this affect gravity?

Reply: Thanks. "vertical magnetization" refers to the case with a magnetization inclination of I'=90°, for which the magnetization vector is parallel to the z-axis. In this case, k_{1} and k_{2} in Eqs. (8) to (16) are zero, and only k_{3} remains.
"vertical magnetization" does not affect gravity itself, because gravity depends only on density contrast. Rather, the gravity case and the magnetic case under vertical magnetization both admit simplified symmetric kernel structures, which improves computational efficiency. By contrast, this simplification is generally not available for non-vertical magnetization. In practice, magnetic data may also be transformed to a reduction to the pole (RTP) form to approximate the vertical-magnetization case.

L. 169: I suggest using m or km instead of hm throughout the text. Hectometer is not a commonly used unit.

Reply: Thanks. We have replaced hm with km.

L. 173: I guess this is number of cells/prisms. Please clarify.

Reply: Thanks. We have clarified that these values refer to the numbers of prisms in the x-, y-, and z-directions.

Table 1, caption: I suggest replacing "grid numbers" with "numerical resolution".

Reply: Revised as suggested.

Table 1: I assume that number of observation points did not change in this test. Please clarify.

Reply: Thanks. In this test, the number of observation points scales with the numerical resolution, as they are defined at the horizontal centres of the prisms within the BCE-framework. We have clarified this in the revised manuscript. It is worth noting that user-defined observation locations can be accommodated via interpolation.

Table 1: Please demonstrate that the scaling of the code holds for larger numbers of prisms. At least until 800^3.

Reply: Thanks. Following the reviewer's suggestion, we have conducted additional benchmarks to demonstrate that G&M3D 1.0 maintains its performance scaling for larger models. These new results, including a 800^3 resolution case, have been added to Table 1.

L. 180: "Table 1 shows…"

Reply: Revised as suggested.

L. 185: These numbers are in seconds?

Reply: Thanks. Yes, these values are in seconds. We have clarified this in the revised manuscript.

Fig. 4: Button in the GUI says "Setting" instead of "Settings".

Reply: Revised as suggested.

Fig. 4, caption: missing space after (a). Also, last sentence is unclear.

Reply: Thanks. We have corrected the missing space and revised the caption for clarity.

L. 218: Ellipsoids would also be good.

Reply: Following the reviewer's suggestion, we have developed and integrated an Ellipsoid tool into G&M3D 1.0. A corresponding description of this feature and its implementation has been incorporated into Section 3 of the revised manuscript.

Fig. 6: The 3 panels on the right don't seem to align with what is in the main panel. At the very least the x-coordinates of the dark blue prismoid are not correct.

Reply: Thanks. We apologize for the misalignment in the original figure. We have corrected the coordinates in Fig. 6. In addition, to enhance spatial clarity and reduce visual ambiguity, we have added a 3D rotation function in the GUI.

Fig. 9: "Forwarding Model" should be "Forward Model". "Heigh" should be "Height".

Reply: Revised as suggested.

Fig. 9, caption: No space after (a) and (b).

Reply: Thanks. Revised accordingly.

L. 301: include year of publication or replace "Ennen's" with "the author's".

Reply: Thanks. Revised accordingly.

L. 326: unit?

Reply: Thanks. We have added the unit "mGal" for gravity anomalies and the unit "E" for gravity-gradient components in the revised manuscript.

L. 327-328: This sentence is unnecessary in this context.

Reply: Thanks. We have removed it from the revised manuscript.

Fig. 11: What is the unit of V_ij?

Reply: Thanks. We have clarified the units in Figure 11. Specifically, mGal is used for the gravity field V_z (milligal), whereas E is used for the gradient components V_{ij} (Eötvös). We have also added the definitions (1mGal = 10^-5 m s^-2 and 1 E = 10^-9 s^-2) in the text for completeness.

Fig. 12: label of colorbar is overlapping with "x10^-3"

Reply: Thanks. We have removed this figure from the revised manuscript. We find that the original difference map mainly reflected the limited precision of the gravitational constant used in the software. After updating the gravitational constant from two to four decimal places, the absolute differences decrease to the order of 10^{-12}.
"The maximum absolute difference is 1.2×10^{-12} mGal for the gravity anomaly and 1.3×10^{-12} E for the gravity-gradient components."

L. 340: remove "and" at the end of the line.

Reply: Revised as suggested.

References: Please provide DOIs for all references. This is journal policy.

Reply: Thanks. We have checked the references and added DOIs where available.

RC2:

I have read and reviewed the manuscript entitled "G&M3D 1.0: an Interactive Framework for 3D Model Construction and Forward Calculation of Potential Fields." The paper addresses an important and practical challenge in the potential-field community, namely the construction of realistic and geologically meaningful 3-D synthetic models. From both technical and implementation perspectives, the manuscript is generally well structured and in good shape. I therefore recommend minor revision. My moderate-level comments are listed below.

1. Software design philosophy and architectural principles
As the manuscript presents a scientific software framework, it would be beneficial to more clearly describe the underlying software design philosophy and architectural principles adopted in the development of G&M3D. For example, discussing aspects such as modularity, low coupling and high cohesion, extensibility, and the separation between data structures and computational kernels would help readers better understand the robustness, scalability, and long-term maintainability of the framework.

Reply: Thanks. We have added a detailed description of the software's architectural principles in the revised manuscript. In particular, G&M3D 1.0 follows a modular design pattern that high cohesion and low coupling. There is a strict separation between the graphical user interface (GUI), model data management, and the high-performance forward-calculation kernels. This decoupled architecture not only enhances the framework's robustness but also facilitates the integration of new features and future maintenance. (page 9, lines 269-270; page 18, 427-429)

2. Input/output specifications and data interoperability
The paper would benefit from a clearer description of input and output requirements. In particular, it would be useful to specify supported data formats, model parameterization conventions (e.g., coordinate systems and right-hand rule definitions. A brief discussion on interoperability with existing modelling or inversion workflows (e.g., UBC-GIF formats, SEG standards, Oasis Montaj, etc) would further enhance the practical value and adoption potential of the framework.

Reply: Thanks for this valuable suggestion. In the revised manuscript, we have explicitly defined the input/output specifications and data interoperability of G&M3D 1.0. The software adopts a standard right-handed Cartesian coordinate system. It supports various inputs, including topographic digital elevation models (DEMs), predefined model files (.bin), and user-defined dynamic link libraries (.dll or .so) for modeling continuously varying physical properties. For output, G&M3D 1.0 supports an extensible data-export module, allowing users to save results in multiple formats (e.g., standard text and binary formats) via a dedicated Export tool. We have also expanded the discussion on interoperability, emphasizing that the architecture can be easily adapted to support industry-standard formats (such as UBC-GIF or SEG) to seamlessly integrate with existing inversion workflows. (page 10, line 273; page 14, lines 349-351)

3. Representation of heterogeneous physical properties
In the current implementation, each geological body appears to be assigned a constant physical property. The authors are encouraged to discuss the spatially varying physical properties, for example, Gaussian distribution.

Reply: Thanks for this helpful suggestion. In the original version, each geological body was assigned a constant physical property. In the revised version, we have significantly upgraded the property-assignment module to support spatially heterogeneous physical properties. Specifically, G&M3D 1.0 now facilitates analytically defined property variations, including built-in exponential models and flexible user-defined functional interfaces. This enhancement allows for the flexible representation of complex density contrast or magnetization distributions, such as Gaussian-type variations or depth-dependent density compaction. As an open-source framework, G&M3D 1.0 will undergo continuous refinement to support additional forms of continuous property variation in future releases. (page 11, lines 299-301)

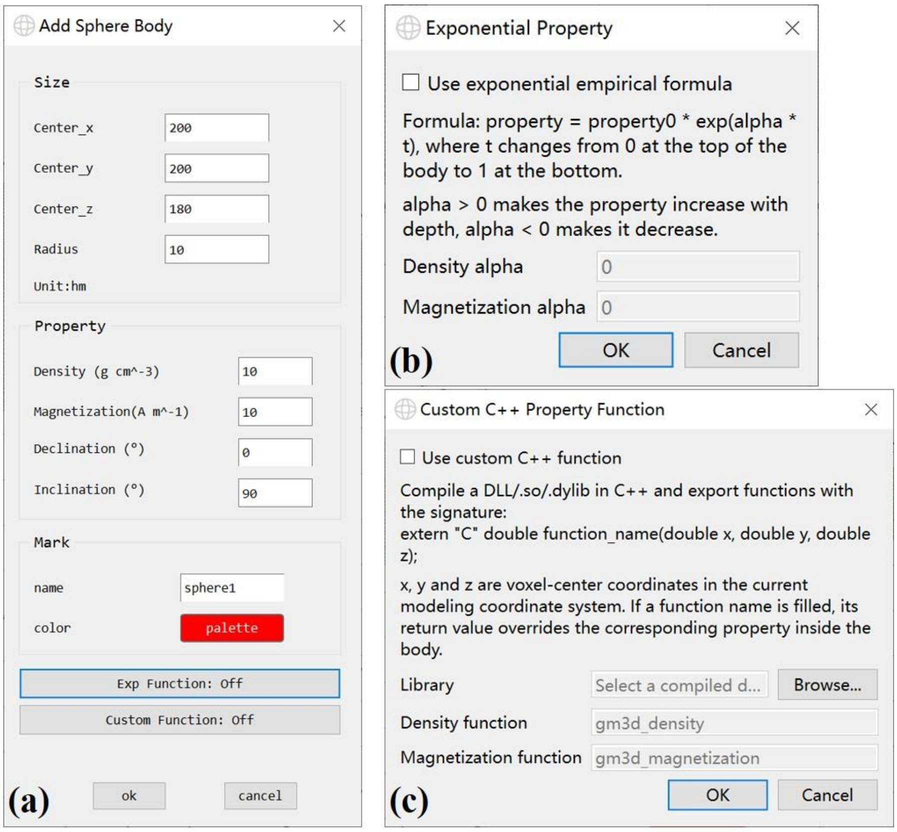

Figure R5: (a) The property-setting interface with two newly added buttons for continuous physical-property parameterization, (b) The built-in interface for defining exponential functions, (c) a flexible interface for implementing user-defined functions.

page 11, lines 299-301: "Spatially heterogeneous physical-property distributions within a single body can be represented in G&M3D 1.0 through continuously varying functions. In particular, the software supports user-defined functional forms, which allow flexible construction of bodies with spatially variable density contrast or magnetization."