Dear Prof. Hergarten,

We thank you for handling our manuscript, for securing two expert reviews, and for your frank summary of the main concerns. We particularly appreciate your direct question about the origin of the topography problems, which we address in detail below. Separate documents contain our responses to the two reviewers.

1 Positioning of the contribution

We agree that LaScape is best described as a coupling plugin for LaMEM rather than an independent model. We will revise the title. We also agree that the coupling concept follows the previous research (i. e., ASPECT-FastScape coupling (Neuharth et al., 2022)). However, we wish to declare several methodological innovations in our implementation. First, this represents the first comprehensive documentation of an open-source, finite-difference-based coupling framework. We offer a verified, well-documented, and publicly available implementation of this capability within LaMEM, along with a clear explanation of its limitations. Second, our work explores various coupling methods. For geodynamics-to-surface coupling, we demonstrate that interpolating velocities (rather than topography) from the coarser geodynamic grid to the finer erosional grid results in higher stability. This is due to the inherent smoothness of velocity fields. The landscape model retains its own topography and evolves it based on the velocity fields. The combination of different solution algorithms and mesh processing methods can lead to varying levels of accuracy in geomorphic evolution across specific scenarios, a point worth discussing and comparing.

The manuscript has been restructured accordingly. The description of the two component codes has been condensed relative to that of the coupling module, Section 2.3 has been substantially expanded (grid generation, data collection across ranks, interpolation in both directions, timestep subdivision, marker phase conversion, and mass conservation are each described explicitly), Figure 1 has been completely redrawn, and the broad geodynamic claims of the original version have been removed throughout.

2 Topography problems

We agree that the river patterns shown in the original manuscript were not acceptable, and your comments and those of the declining reviewer prompted us to investigate their origin systematically. We found three separate contributing factors and isolated each with dedicated tests.

(a) **The random noise**. In the original runs we had deliberately switched off the random seeding of the initial topography so that models with and without surface processes would start from strictly identical surfaces. On a laterally uniform surface, the stream-power law has no mechanism to break the symmetry, and the drainage organizes into regular, closely spaced, straight channels. All revised models seed the initial topography with small-amplitude white noise using a fixed random seed, so that paired runs remain directly comparable.

(b) **Insufficient landscape resolution**. Resolution tests with the revised 2D coupled plume configuration (Fig. A1a-d) show that grid spacings coarser than about 0.5 km produce overly dense and straight rivers, whereas a spacing of 0.26 km yields well-organized dendritic networks. High uplift rates produce a similar visual impression by increasing the drainage density (Fig. A1e-h). This is now documented as an explicit limitation, with the recommendation that users verify that their surface grid resolves the expected valley spacing (Section 4.4 of the revised manuscript).

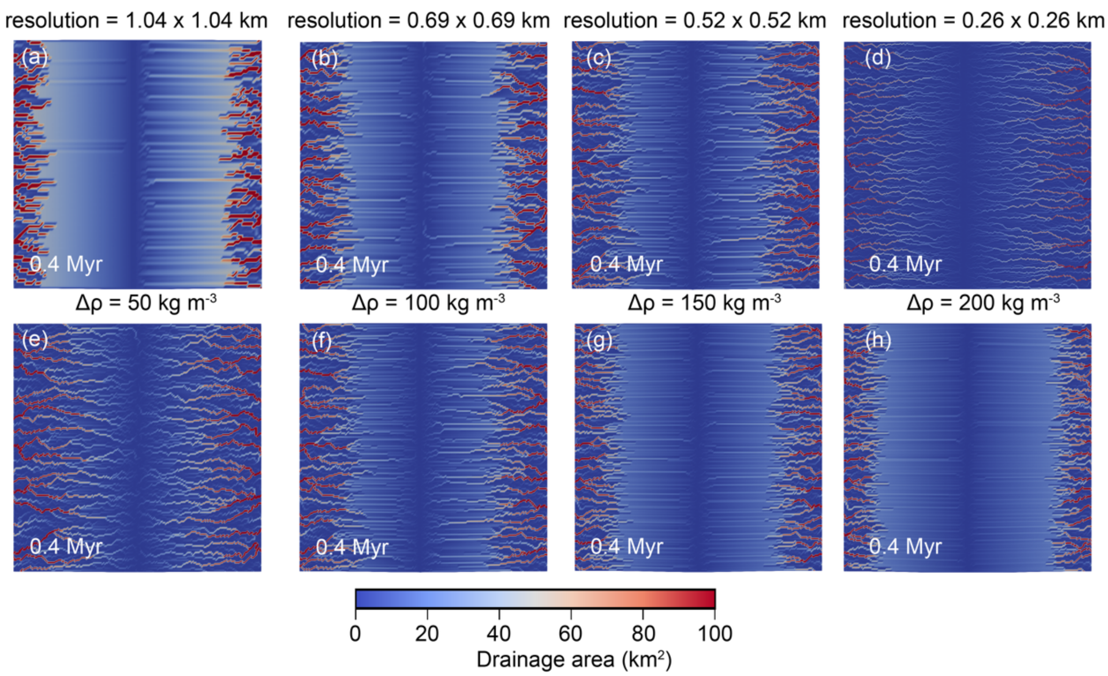

Figure A1. Parameter sensitivity tests of the 2D coupled plume model. (a-d) FastScape grid spacings of 1.04, 0.69, 0.52, and 0.26 km. (e-h) Density contrasts of 50 to 200 kg m^{-3}, controlling the uplift rate. Colors show drainage area. Grid spacings coarser than about 0.5 km and high uplift rates produce dense, straight river patterns.

(c) **The horizontal advection in the Eulerian frame**. To test your hypothesis directly, we ran standalone FastScape models, without LaMEM and without the coupling module, applying uniform uplift and an increasing horizontal advection velocity (Fig. A2). With no advection the landscape is dendritic. At advection velocities of about 0.2 cm yr^{-1} and above (at 0.26 km grid spacing, over 10 Myr), straight rivers aligned with the transport direction develop. Because the coupling module is not involved in these runs at all, we conclude that this artifact is inherent to the Eulerian advection treatment of the landscape evolution model itself, which is consistent with your diagnosis.

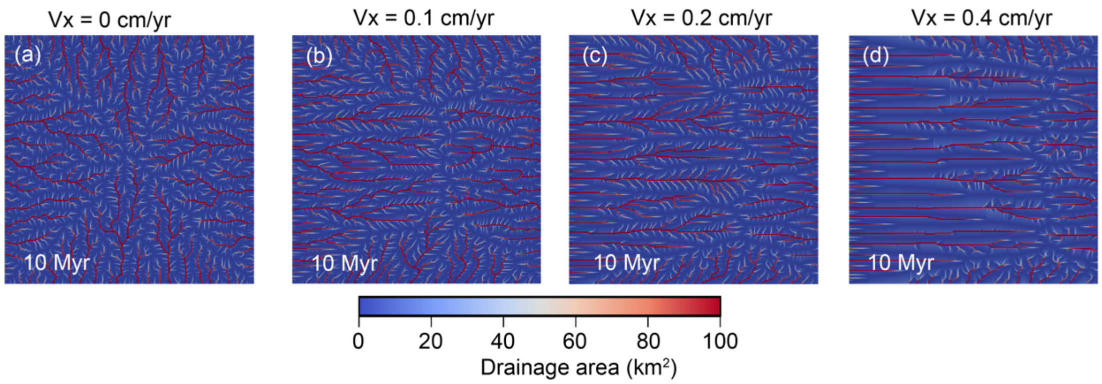

Figure A2. Standalone FastScape test of horizontal advection (no coupling involved). Uniform uplift with horizontal advection velocities of 0, 0.1, 0.2, and 0.4 cm yr^{-1} after 10 Myr. Straight rivers aligned with the transport direction develop at and above about 0.2 cm yr^{-1}.

These findings also explain our decision to replace the original example models. The continental extension model additionally used LaMEM's dynamic grid, in which the model size changes under the background strain rate. This requires stretching or rebuilding the landscape grid, which artificially disrupts the drainage organization, whose response time can span millions of years. We concluded that such setups should not be used with the coupling at all, and the revised manuscript states this prohibition explicitly (Sections 2 and 4.4). The revised examples comprise two decoupled end-member verification tests, a comparison between a 2D-coupled and a fully 3D plume configuration with parameter sensitivity tests, and a 3D subduction model with an oceanic plateau that introduces along-strike variability.

3 Verification and applications

Following the reviewers' remarks on the missing verification, the revised manuscript now distinguishes verification from evaluation, as requested by the GMD manuscript guidelines. Two decoupled end-member tests verify the implementation at the interface level. A coupled run with a negligible erosion rate reproduces the standalone LaMEM solution to within 1 m of topography (Fig. A3), and a coupled run with disabled data transfer and prescribed uplift reproduces the standalone FastScape solution to within 1 cm of topography and 10^{-3} km^2 of drainage area (Fig. A4). Parameter sensitivity tests across buoyancy, erodibility, and diffusivity ranges confirm stable operation and physically consistent responses. The computational overhead of the coupling module is now quantified (13.7% of the total solution time in a small 3D plume model, 2.1% in the larger 3D subduction model, decreasing with problem size). The comparison between the 2D-coupled and the fully 3D configuration (Fig. A5) substantiates the statement that fully 3D coupling is required wherever the surface response to laterally varying tectonics is of interest. A more detailed user manual will be prepared and accompanies the code in an updated Zenodo release.

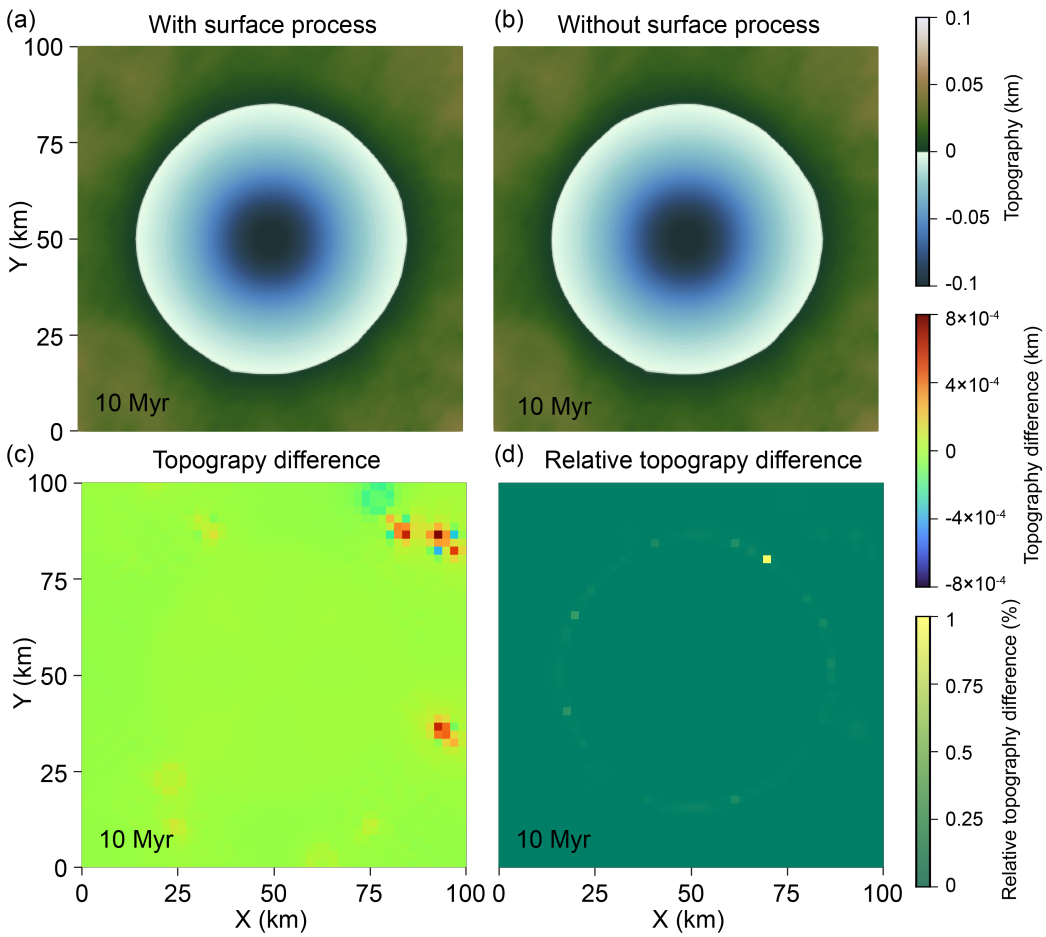

Figure A3. Verification test NoFSModel. Comparison of the coupled falling-block model with a negligible erosion rate (a) against the standalone LaMEM run (b). The maximum absolute topography difference is below 1 m (c), and relative differences above 1% occur only where the absolute topography is close to zero (d).

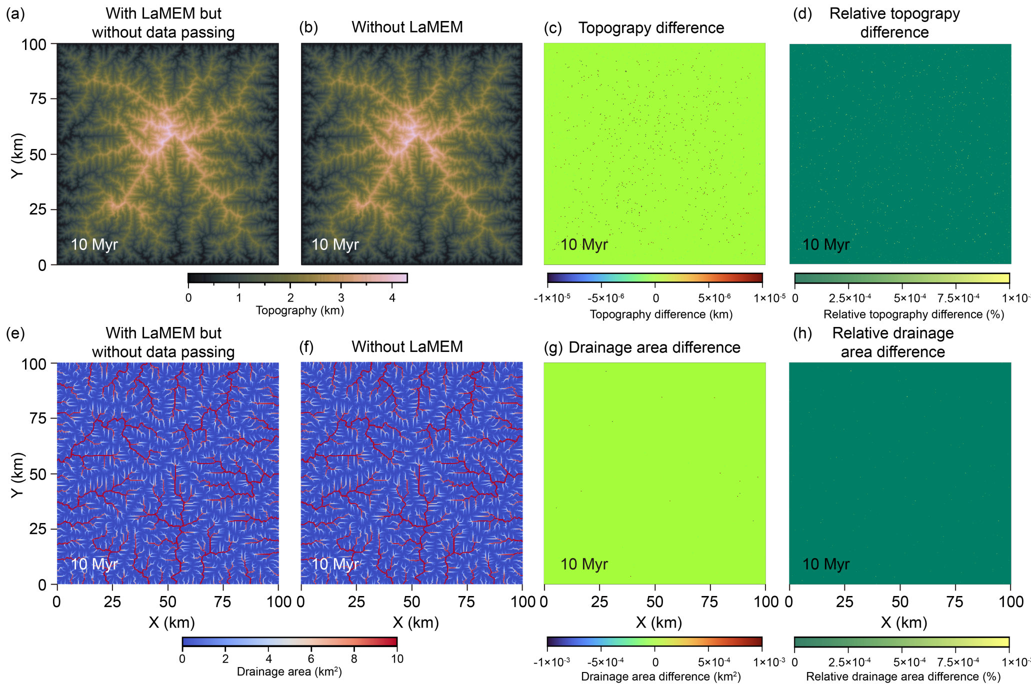

Figure A4. Verification test NoLMModel. Comparison of the coupled run with disabled data transfer and prescribed uplift against the standalone FastScape run. Topography and drainage area agree to within 1 cm and 10^{-3} km^2, respectively.

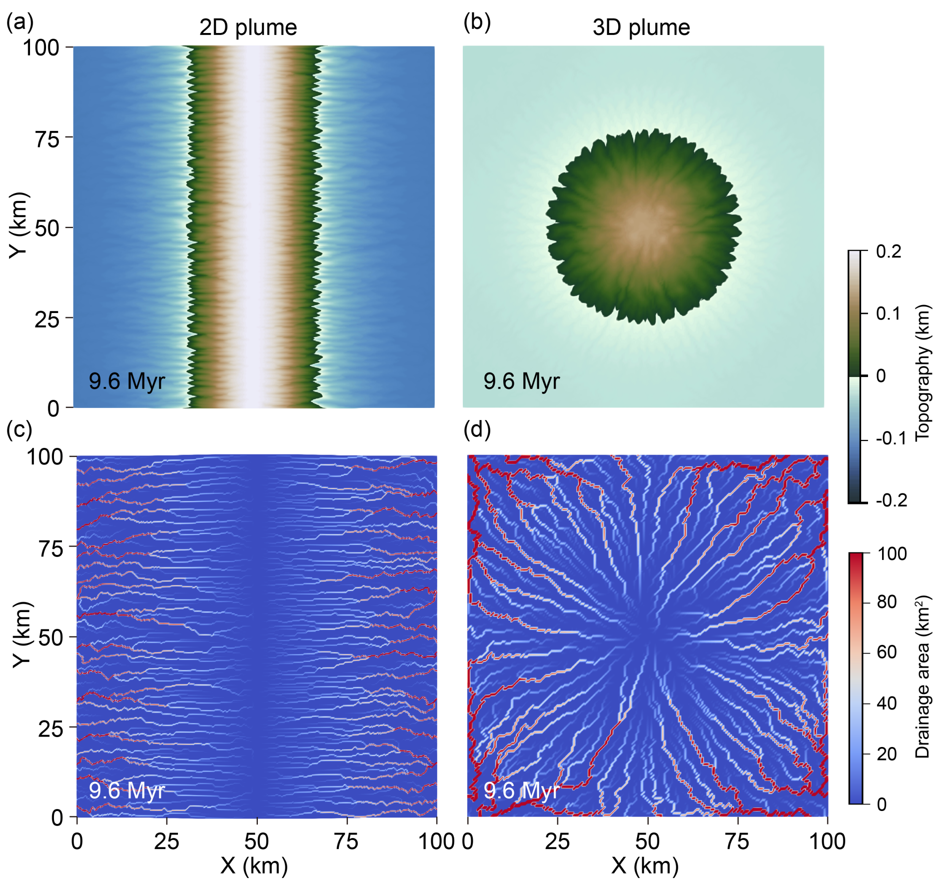

Figure A5. Comparison of the 2D-coupled (T-coupled) and fully 3D plume configurations. The T-coupled model exaggerates the topographic amplitude and forces parallel drainage, whereas the fully 3D model captures the dome-shaped uplift and its radial drainage.

We will provide more detailed clarifications in our revised manuscript (almost done).