

Review Evaluation Report

Referee #1 (anonymous) — how the revised manuscript addresses each comment

Manuscript: "Mobility of dry granular flows over erodible beds: Experimental insights into the influence of flow–bed density contrasts" (originally submitted as "Mobility of dry granular debris flows over erodible beds: Experimental insights into the influence of flow–bed inertia", egusphere-2026-1235).

Journal: Natural Hazards and Earth System Sciences (NHESS)

Recommendation: Accepted

This report compares the original preprint (v1), Referee #1's review comments [C1]–[C12], the authors' point-by-point response [A1]–[A12], and the revised manuscript (v2) to assess how each comment was addressed. Comments and responses concerning Dr. Hervé Vicari's review are not evaluated individually here, per Referee #1's instruction; they are noted only where they overlap with the general reframing of the paper (see the Overall Evaluation section).

[C1] Language / long sentences / noun-heavy phrasing / paragraph structure

Status: **Partially addressed**

The authors committed generally to revising sentence structure, phrasing, and paragraph organization (A1). The Introduction and Results in v2 are visibly shorter and more segmented than v1, many of the sprawling, citation-dense paragraphs have been cut or split, largely as a side effect of the terminology/framework overhaul prompted by Referee #2. For example, Section 3.1.2 now alternates short descriptive paragraphs with short interpretive ones rather than one long block. Some Discussion paragraphs (e.g., Sect. 4.1.1–4.1.2) remain dense with subordinate clauses, so the revision is a clear improvement but not a systematic rewrite of every long sentence flagged.

[C2] Terminology: "debris flow" vs. "dry granular flow" (Takahashi framework)

Status: **Addressed**

The title itself was changed, and "debris flow" has been replaced by "dry granular flow(s)" essentially throughout the manuscript:

"we conducted dry granular flow experiments to investigate how contrasts in solid particle density between a moving mass and an erodible bed affect erosion, flow evolution, and deposition"

This directly implements A2 and aligns with what the authors told Referee #2 they would do.

[C3] Comment of Mr. Vicari — validity of Pudasaini & Krautblatter (2021)

Status: **Addressed**

Handled through the parallel discussion with Referee #2 / Dr. Vicari rather than as a standalone change for Referee #1. In the finished manuscript this shows up as: removal of P&K as the interpretive backbone, a much more balanced/limited citation of P&K alongside Issler et al. (2024), and a discussion built instead around established mechanical entrainment theory (Iverson, 2012; Iverson and Ouyang, 2015; Farin et al., 2014; Crosta et al., 2009). Dr. Vicari's individual points were not evaluated here; this reframing is confirmed to be carried through consistently in v2's Introduction, Section 2.1, and Discussion.

[C4] Unrealistic density contrasts vs. natural bed materials — relevance/transferability

Status: **Addressed**

New explicit statement in Sect. 2.1:

"The experiments were performed at a consistent laboratory scale and were not intended as dynamically scaled reproductions of natural flows. Accordingly, the imposed solid-particle-density

contrasts were deliberately larger than those typically expected in natural torrent or hillslope materials in order to produce measurable differences in flow response."

The new Sect. 4.3 ("Deposit geometry and mobility scaling") goes further, placing the experiments against the Baselt et al. (2022) compilation and the Pudasaini & Miller (2013) volume–area relation (Fig. 7) to discuss where the lab data sit relative to natural-scale mobility, directly responding to the transferability concern.

[C5] Steep slope (37°) unrepresentative of torrent debris flows

Status: Addressed

Sect. 2.2 now justifies the slope in terms of the dry-material requirement rather than claiming torrent representativeness:

"A flume inclination of 37° was used for all dry granular flow experiments to ensure sufficiently high sliding velocities and erosive potential... This inclination was required to mobilize the dry material solely by gravity and to prevent early deposition before or on the erodible bed."

This matches A5 and is consistent with the broader "dry granular flow" reframing (C2).

[C6] Missing roughness information for the plywood bed

Status: Addressed

Sect. 2.2 now gives quantitative roughness values for all flume surfaces, including:

"the rigid bed sections were made of rough plywood ($k_s \approx 0.27$ mm; Fig. 1d). Surface roughness was measured using a Keyence VK-X3000 3D laser scanning microscope based on focus variation (<3 μ m accuracy)."

[C7] "Flow-front velocity" is actually an average, not an instantaneous, velocity

Status: Addressed

Terminology was changed throughout to "average flow-front velocity," and the method now explicitly justifies the choice:

"Average flow-front velocity was calculated from the traveled distance from reservoir flap to each sensor... divided by the corresponding flow-front arrival time. Cumulative average velocities were preferred over section-wise velocities between adjacent sensors."

A short justification for not reporting section-wise (more "instantaneous") velocities is also included, a small overshoot beyond what A7 promised, but it fully resolves the concern.

[C8] Chapter 3 needs a brief introductory paragraph

Status: Addressed

New opening paragraph of Sect. 3:

"The results are presented in two parts. The first part describes the spatiotemporal evolution of the dry granular flows in the channel... The second part analyses the resulting deposits on the runout area..."

[C9] Sect. 3.1.2 too purely descriptive; forces reader to jump between Results and Discussion

Status: Addressed

The authors said they would add "short guiding sentences" while preserving the Results/Discussion split in practice they went a bit further. Sect. 3.1.2 in v2 now includes fairly substantial interpretive paragraphs embedded directly in Results, e.g.:

"The contrasting erosion patterns reflect fundamentally different flow–bed interactions at us4. In the Glass experiments, the initial drop in flow height suggests rapid erosion of the upper Glass bed..."

This gives the reader a mechanistic thread without waiting for Sect. 4, resolving the core complaint (though it does blur the Results/Discussion boundary slightly more than the authors originally proposed).

[C10] Same front-velocity terminology point, restated

Status: Addressed

Addressed — see C7 above.

[C11] Missing introductory text for Sect. 3.2

Status: Addressed

New lead-in:

"The 3D surface scans and lateral cross sections of the final deposits characterize deposition in the runout area... We first present the deposit geometry and runout metrics for all scenarios and then describe the internal material distribution of the mixed Qtz–Glass and Qtz–Mag deposits."

[C12] Discussion needs comparative/non-dimensional diagrams and a statistical summary across repetitions

Status: Addressed

Two new, substantial subsections were added:

- Sect. 4.2 "Collision- and friction-dominated flow regimes", introduces the Savage number as the relevant dimensionless parameter for dry granular flow (fluid-based numbers being inapplicable, as the authors note themselves) and reports quantitative ranges, e.g.:

"All fine-particle experiments yield $0.0015 \leq NSav \leq 0.0269$... the non-erosive coarse-particle reference yields values between 0.023 and 0.25."

- Sect. 4.3 "Deposit geometry and mobility scaling", new Figure 7 compares the experiments' inundated area vs. volume and L/H mobility ratio against the Baselt et al. (2022) compilation of small-scale, large-scale, and natural events, plus the Pudasaini & Miller (2013) volume–area model.

Reproducibility/variability across repetitions was already present in v1's Table 2/Fig. 5 and Supplement Table S1 ($\pm 4\%$, max $\sim 8\%$ runout variation); this is retained and referenced again in v2. Both halves of C12 are covered, largely in line with A12.

Overall Evaluation

All 12 of Referee #1's comments are addressed in the revised manuscript, ranging from fully implemented (C2, C4–C8, C10–C12) to substantially implemented with some residual density in the prose (C1).

The reframing driven by the overlapping terminology/theoretical-framework concerns raised independently by Referee #1 (C2) and Dr. Vicari (C3) is carried through consistently across the revised manuscript: a new title, consistent "dry granular flow" terminology, a deemphasized Pudasaini & Krautblatter (2021) framework, and a mechanistic discussion re-centered on bed internal friction and particle shape. The authors' responses to Dr. Vicari's detailed comments were considered in reaching this overall assessment but were not evaluated point-by-point in this report.