Review Report for

Sediment continuity: historical development and misconceptions of a core concept of geomorphology

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Round 1 Review

Comments by reviewer 1 (anonymous)

Completed: 2025-09-17 07:12 AM

Recommendation: Minor revisions

Reviewer Comments

For author and editor

I provide my review as a pdf.

Round 1: Reviewer 1

Review of paper Sediment continuity: historical development and misconceptions of a core concept of geomorphology September 17, 2025 The objective of the authors is to explain the origin and evolution of the concept of mass conservation as used in (river) morphodynamics, which they do by reviewing the concept from a historical perspective. The paper is well written, clear, interesting, and certainly contributes to increasing our understanding. The historical overview helps the reader understand why we think how we think, how concepts evolve, and how important it is to challenge the ideas and concepts that we now take for granted. I must highlight that I cannot judge the paper from the philosophical or historical perspective, as this is not my field of expertise. Hence, I rely on the opinion of other reviewers on these topics and I focus on the physical topics. I congratulate the authors and, in my (limited) view, the manuscript is acceptable for publication provided some issues are addressed. The main issue I encounter is in the first part of the discussion (Section 5.1). It is a value judgment against the dredging industry that may need nuance and a broader perspective. For instance, consider the sentence: “In addition, the history of dredging and extraction technology suggests opportunism and laxness on behalf of the governments at the cost of society and the riparian ecosystems, to the benefit of one specific industry.” I would reflect on the fact that there was a need for dredging for, not only providing material for construction, but also for allowing sufficient navigational depth for ever increasing ships. The necessary technology appeared, making it possible at scale. I wonder why the authors describe this as opportunistic, or whether it is something more general against making business and capitalism. According to the authors, dredging was done “at the cost of the society”, failing to acknowledge that the state (i.e., the society) benefited from roads, train tracks, and houses as well as from making the Port of Rotterdam the most important in Europe thanks to the connection to the hinterland. These benefits to society are neglected by the authors. Consider the sentence: “but also because it [the dredging industry] globally sells so-called nature-based solutions with dredged and disposed sediment. All this continues to happen with Dutch state support.” I agree that the term “nature-based solution” is not properly defined. Everything can be considered a nature-based solution. E.g., one can argue that for increasing the navigational depth, constructing groynes is to let nature do the deepening for you. Nevertheless, the authors attack the industry (by defining their intervention as “so-called” nature-based solutions) without clearly explaining why these are not true (what is true?) nature-based solutions. I would definitely not encourage the authors to define here what is a nature-based solution, or the review process will extend to infinity. In my view, there are beneficial and unfavorable interventions with dredged and disposed sediment, and criminalizing all interventions is unfair. Finally, the attack to the government policy is unfounded. If the authors think 1 that the government policy is inadequate, they must provide a substantial amount of evidence, while not a single reference is given. Consider the sentence: “Yet one of the geomorphic absurdities of the 20th and 21st century arguably is the sheer volume of earth materials that are displaced and extracted by machine.” Defining it as an absurdity is again a value judgment without any reference supporting the statement. In retrospective, it is simple to conclude that an intervention had negative impacts that were not properly foreseen. Yet this does not make the intervention absurd (according to the Cambridge dictionary, ”stupid and unreasonable, or silly in a humorous way”). Apart from the discussion section, it strikes me that the authors do not mention three references. Considering them may strengthen the paper. First is the (in)famous diagram by Hjulstr¨om (1935) showing that transport, deposition, or erosion is to be expected as a function of the grain size and the flow speed (it even has a Wikipedia page 1). This is after Exner (1925) published his work, and to my despair, it can still be found in presentations at conferences and reports around the world. Second is

Tulla (1854), who justified the “normalization” of the Rhine River in Germany, stressing the importance of having one single channel. This landmark study is of great historical importance for understanding the changes that the Rhine has undergone. Third is the role of the Pannerdensch Kanaal as a defensive element. I was expecting this point to be discussed too. Some minor issues follow. Line 33. “for a particular section, the amount of mass that transports into it, is equal to the mass that is transported out ”. Not a section but a control volume. No mass can be transported into a section (area), but across a section. It is transported into a volume. Line 49 (Equation 3). I think the sign on the right-hand side is wrong. If I am not mistaken it should be D − E. If deposition is larger than erosion, the bed level increases. Line 62. “an knowledge”. Typo. Line 67. “This is generally incorrect in morphological settings where the concurrent upstream flow acceleration also increases the sediment input which may balance the output. ”. It is unclear to me what the authors want to say here. If the flow is accelerated in a control volume, the output of sediment is larger than the input and the bed level will decrease. Line 82 “alongrivers”. Typo. Line 110. “To Newton, on the other hand, deriving laws from metaphysical principles was unacceptable (‘hypotheses non fingo’ ...)”. Nice quote. I am not sure (and again, I am not a philosopher) if the point of Newton was that it was unacceptable for him to derive laws from metaphysical principles or simply that he derived them from experience and refused to offer speculative or conjectural causal explanations for phenomena. It is just a tiny nuance for my curiosity maybe. Also, maybe a translation from Latin could be useful to some readers. Line 191. “The history of the flow continuity concept thus sheds some light on how and why it took three centuries to apply this well-known “law” to other substances than water, is na¨ıve: the conceptions of law, of matter and of flow continuity were quite different from what they are now.”. Check grammar. Line 219. “. At the end of the 18th century, as in many other rivers in Europe, the focus of management shifted to international navigation (1831 Mainz treaty), fishing (1885 salmon treaty) and sediment mining for large-scale road and railway construction. ” This text looks out of context. Check coherence with previous sentences. 1https://en.wikipedia.org/wiki/Hjulstr\%C3\%B6m_curve 2 Line 271. “Anonymous 2026).”. There seems to be a citation to the future. Line 371. “Holland,together ”. Typo. Line 333. “They importance ”. Typo. Line 337. “We now know that both notions are not wrong under uniform steady flow conditions. ” I do not follow which notions and why uniform flow matters. If flow is uniform there are no gradients in transport and if the boundary condition is at equilibrium, no changes in the channel occur. Line 338. “However, they cannot be generalized for a natural river with meanders, bars and bifurcations.”. Similar to previous line. I do not follow argumentation. Line 354. “First, continuity of flow means that, given a constant discharge and river width, local deepening leads to lower local flow velocity, that is, unless the situation changes upstream, too. ”. Unfinished sentence. Line 356. “Second, if faster flow is not strictly local,”. Faster than what? I think these lines need to be reviewed. Line 362. “decreasing cross-section surfaces”. If it is a cross-section surface, it must be the hydraulic area. Indeed, if the width is reduced, for the same discharge the velocity increases and the area reduces ($A = Q/u$, where A [m/s] is the area, Q [m3/s] is the discharge, and u [m/s] the velocity), but I am not sure if this is the point you want to make because, what is the implication of the decreasing area? I think you only want to stress the reducing width. Line 442. “It is perhaps ironic that the removal of such cohesive, early Holocene layers, together with the now ubiquitous use of simulation models that rely on the principle of sediment continuity, made the rediscovery of such hard layers in the early 21st century an antipodal surprise to river experts who, a century earlier, did not see evidence for sediment continuity (see for review Pierik et al. 2022).”. Sorry, I cannot follow this reasoning. I do not understand what you want to convey. Line 475. “met international”. met [at?] international. Line 600. “railways;another one”. Typo. Line 603. “, when the adverse effects to bank stability and to riparian ecosystems ”. Also channel erosion? Or was it not acknowledged? Line 607. “with incision still continuing (both in the

Netherlands and in Germany);". Are you certain that incision is still continuing in Germany? Stabilization works have occurred for decades. Please add reference. Line 608. "and the bed sediment caliber has increased considerably and armored in the upstream reaches". Upstream reached of the Netherlands or Germany? Line 617. "not only because of its importance for navigation of container ships, which are rapidly increasing in size (Cox et al. 2022), ". Is this reference adequate to point to the increase in the ship size? Line 641. "the context of it use, ". Typo. Line 660. "and that sediment does not abrade or dissolve (e.g., Paola & Voller 2005)." Check the last term in their Equation (15) for dissolution. Abrasion does not change mass. 3 References Exner, F. M. (1925), Uber die Wechselwirkung zwischen Wasser und Geschiebe in Fl¨ussen, ¨ Akad. Wiss. Wien Math. Naturwiss, 134(2a), 165–203, (in German). Hjulstr¨om, F. (1935), Studies of the morphological activity of rivers as illustrated by the River Fyris, Bulletin of the Geological Institute of Uppsala, 25, 221–527. Tulla, J. G. (1854), Der Rhein von Basel bis Mannheim mit Begr¨undung der Nothwendigkeit, diesen Strom zu regulieren, Carlsruhe.

- ***Comments by reviewer 2 (anonymous)***

Completed: 2025-10-15 09:26 PM

Recommendation: Major revisions

Round 1: Reviewer 2

The submitted manuscript offers an interesting history of the concept of sediment continuity and a case study of the problems when continuity is neglected. I thought that the paper offers some nice historical context about the Exner equation that would be generally useful to the fluvial geomorphology community. I have a few major comments but mostly minor editorial changes for clarity. Major comments A study site map with the reaches being discussed would be very helpful in understanding this section 3.1, the problems of sediment continuity here and the later sections that further discuss these site specific problems. Someone without detailed knowledge of this river will have some difficulty envisioning the problems without such a map that shows the problem areas. I think the discussion section would benefit from a review of current literature or river restoration practice to discuss whether sediment continuity is still being neglected in some river science. I think this problem is much larger than a few undergraduates and is a mistake that some practicing engineers/ecologists/geologists still make. It is also a misconception in some recently published papers (see my minor comment below). I think broadening the discussion to mention some current case studies or examples of river design failure without sediment continuity would provide present day context to your reader and possibly help make the case that this is still an important issue today. See for example, these papers (https://www.jstor.org/stable/26266029 https://doi.org/10.1111/j.1752-1688.2007.00091.x) that highlight the problem of not addressing sediment continuity properly and the fact that channel planform and sediment supply are linked. Minor comments by line number 14 Although undergrads make this mistake, I know graduate students, faculty, and consultants who also sometimes make this mistake. I realize that you have a citation for undergraduates below, but I think this statement needs to be broadened to represent the fact that this mistake is not uncommon outside (and sometimes even inside) the field of geomorphology. 35-36 I am unclear what 'dragged out by the flow' means exactly, I think more technical language could be beneficial here? 36-37 Shear stress technically doesn't cause form drag on sediment particles, pressure variations around grains cause drag, which is then simplified into the drag force equation that uses velocity; can you clarify here? I am also a little confused because particle suspension is being discussed but in many rivers, sediment mass balance changes are also caused by bedload? I am also not fully clear why a balance between drag force and gravity is being described here, there are other forces such as lift that are also important for sediment motion in river systems? 66-67 Please see comment above, there are recent publications that also make this mistake. For example, https://doi.org/10.1029/2024WR038282 implies in the introduction that sediment deposition cannot locally occur where the applied shear stress exceeds the critical shear stress. This neglects the sediment mass balance that could occur where sediment is mobile at a location but receives more sediment than can be transported out of that location. I think (?) there are also published papers in which sediment transport rates are inferred from differencing repeat measurements of bed topographies (DEM of difference) within an area. This method ignores the upstream sediment supply and the fact that zero difference in bed topography doesn't imply zero transport, just zero scour/deposition. 165-166 I don't fully understand this statement, do you mean the cross-sectional area and the flow velocity (not the amount of water) are inversely proportional? 191-193 I don't fully understand the structure of this sentence? What is naïve? I am a little confused because this seems like a bit of a straw man; are there published papers that say that it is surprising that sediment continuity took so long to develop after flow continuity? What naïve argument (has this been published somewhere?) are you refuting? 306, 309 I am not sure 'corrosion' is the correct word here given it means the deterioration of substances through processes like oxidation? 336-339: I am not fully following this argument. "Notably, cause and effect

were switched to argue that faster flow in the channel would erode and deepen the river. We now know that both notions are not wrong under uniform steady flow conditions. However, they cannot be generalized for a natural river with meanders, bars and bifurcations." Are you saying that if they temporally changed the flow velocity to be uniformly faster throughout the entire reach compared to the original flow velocity, then the channel would erode? Or are you saying if they locally (spatially) increased the flow velocity, then the channel would erode? If the former, I am not completely following how this argument is 'not wrong' because it still neglects sediment supply or are you trying to say that the assumption is the supply is temporally constant? If the latter, this would technically violate the 'uniform' flow assumption that is mentioned as being part of this notion? I also don't fully understand the linkage to more complex river morphology systems and how this relates to the previous sentence. 340-342 "particularly far off from steady flow, due to the strong backwater effect of the tidal estuary and sea, a strong downstream fining trend with gravel coming from the upstream location we discuss next, and the locus of fine sand sedimentation at this location". I am not following how this relates to steady flow, this seems to be nonuniform flow at least in terms of the backwater and I am not clear how downstream fining shows the existence of unsteady or nonuniform flow? 362-364 "He also wanted to remove floodplain vegetation to allow sediment suspended from the channel to deposit on the banks, further deepening the channel." Why would this occur, it seems like the opposite would happen; vegetation would cause deposition? Or are you implying that he was incorrect? If so, I think this needs to be stated explicitly? 559-561 "sediment transportation depending on slope, flow velocity and the caliber of the sediment. The last variable he used to infer the cause of downstream fining, which is one of the possible causes for a nonlinear slope profile." The last variable is the caliber of the sediment and I am not clear how that explains downstream fining because it is downstream fining?

Recommendation by Associate Editor 2 (Matthieu Giaime)

Completed: 2025-10-22 01:44 PM

Recommendation: Minor revisions

Reviewer Comments

For author and editor

Dear Authors,

I read your manuscript, entitled “Sediment Continuity: Historical Development and Misconceptions of a Core Concept of Geomorphology,” with great interest, along with the insightful reviews from two anonymous referees. Both reviewers highlight the significance and relevance of your work in elucidating the origin and evolution of the concept of sediment continuity in river studies.

The reviewers concur that some key references are missing from the current version. Reviewer 1 suggests strengthening the dredging section with additional references to avoid conveying value judgments rather than sound scientific reasoning. Reviewer 2 also suggests including a study site map. Given the absence of figures in the manuscript, a map illustrating all the sites mentioned, particularly a detailed map of the Rhine River, would enhance the manuscript’s clarity. Additionally, they recommend strengthening the discussion by incorporating a review of the current literature or river restoration practices, to evaluate whether the concept of sediment continuity remains overlooked in certain areas of river science.

Based on my own assessment of your manuscript and the reviewers’ constructive feedback, I am pleased to recommend that your manuscript be accepted after minor revisions. I encourage you to ddress the reviewers’ suggestions thoroughly, particularly those aimed at improving the clarity of the discussion, to further amplify the impact of your valuable study.

I look forward to receiving your revised manuscript.

Best regards,

Anonymous Associate Editor

EiC decision round 1

2025-10-25 Decision: Moderate revisions

We would like you to undertake a moderate revision of your manuscript. As this is a moderate revision decision, after you revise your manuscript, AE1 will assess your answer to the reviewers comment and decide if it needs to be sent back to one of the reviewers.

AE1 would also like to recommend for you to have a look at "The History of the Study of Landforms - or the Development of Geomorphology: Volume 1 Geomorphology before Davis (Chorley, Dunn and Beckinsale, 1964). In this book, Chapter 8 discusses Guglielmini's contributions in some detail, which he thinks would add more specific information to your framing of the sediment continuity problem.

Response to reviewers of 'Sediment Continuity'

Our responses are given in blue text.

Editor evaluation

Thank you for your steer and the fast review process. We also thank the reviewers in our acknowledgement paragraph. We have conducted a moderate revision as requested.
As suggested by the AE, we have looked at "The History of the Study of Landforms - Volume 1 by Chorley, Dunn and Beckinsale and its discussion of Guglielmini in chapter 8, p. 87. We have noted that it is based on secondary literature and does not refer to the original. As such, we do not think it has much to add to our paper, which is based on the much more elaborate discussion in Maffioli (1994), Bertoloni Meli (2006) and on our own reading of the original. We could elaborate on Guglielmini's theory, if you think this is of interest, but the paper is rather long as it is already and Guglielmini's theory is possibly more of interest for a historic analysis of the development of 'grade' that the Chorley et al book focusses on. (We found another relevant reference in Chorley et al. that we cite now: Oldham).

Associate Editor recommendation

The reviewers concur that some key references are missing from the current version.
We have considered the suggestions and read the proposed works.
Reviewer 1 suggests strengthening the dredging section with additional references to avoid conveying value judgments rather than sound scientific reasoning.
We have rewritten part of this section. Our arguments were outcomes of a broader perspective, that are as much value judgements as statements that there are benefits to society from past and present practices. See our more detailed response to reviewer 1.
Reviewer 2 also suggests including a study site map. Given the absence of figures in the manuscript, a map illustrating all the sites mentioned, particularly a detailed map of the Rhine River, would enhance the manuscript's clarity.
We have added a relevant historic map.
Additionally, they recommend strengthening the discussion by incorporating a review of the current literature or river restoration practices, to evaluate whether the concept of sediment continuity remains overlooked in certain areas of river science.
This, and the added map, meant lengthening the paper slightly.
Based on my own assessment of your manuscript and the reviewers' constructive feedback, I am pleased to recommend that you do some moderate revisions on your manuscript. I encourage you to address the reviewers' suggestions thoroughly, particularly those aimed at improving the clarity of the discussion, to further amplify the impact of your valuable study.
Thank you. We also corrected slight inaccuracies in language and content. All are included in the document with tracked changes.

Reviewer 1

I congratulate the authors and, in my (limited) view, the manuscript is acceptable for publication provided some issues are addressed.
Thank you!

Discussion issue

The main issue I encounter is in the first part of the discussion (Section 5.1). It is a value judgment against the dredging industry that may need nuance and a broader perspective. For instance, consider the sentence: “In addition, the history of dredging and extraction technology suggests opportunism and laxness on behalf of the governments at the cost of society and the riparian ecosystems, to the benefit of one specific industry.”
I would reflect on the fact that there was a need for dredging for, not only providing material for construction, but also for allowing sufficient navigational depth for ever increasing ships. The necessary technology appeared, making it possible at scale. I wonder why the authors describe this as opportunistic, or whether it is something more general against making business and capitalism.
According to the authors, dredging was done “at the cost of the society”, failing to acknowledge that the state (i.e., the society) benefited from roads, train tracks, and houses as well as from making the Port of Rotterdam the most important in Europe thanks to the connection to the hinterland. These benefits to society are neglected by the authors.
In hindsight, adding this matter was too much for the available space. We agree that some toning down, or much more text is needed, but we respectfully disagree that a broader perspective is needed. We believe that our perspective is in fact broader than the generally accepted view (with which the statements of the reviewer appear to resonate) and there are good reasons to doubt that the technology was ‘necessary’ and that being the most important port in Europe, with 60% of its cargo tonnage directly linked to fossil fuels, is a benefit to society. However, the space in this paper is too limited to develop a critique of extractivism. We suggest an interesting reference to the reviewer from social science: Hajer, M. A., & Oomen, J. (2025). Captured Futures: Rethinking the Drama of Environmental Politics. Oxford University Press, https://doi.org/10.1093/9780198955382.001.0001
Consider the sentence: “but also because it [the dredging industry] globally sells so-called nature-based solutions with dredged and disposed sediment. All this continues to happen with Dutch state support.”
I agree that the term “nature-based solution” is not properly defined. Everything can be considered a nature-based solution. E.g., one can argue that for increasing the navigational depth, constructing groynes is to let nature do the deepening for you. Nevertheless, the authors attack the industry (by defining their intervention as “so-called” nature-based solutions) without clearly explaining why these are not true (what is true?) nature-based solutions. I would definitely not encourage the authors to define here what is a nature-based solution, or the review process will extend to infinity. In my view, there are beneficial and unfavorable interventions with dredged and disposed sediment, and criminalizing all interventions is unfair. Finally, the attack to the government policy is unfounded. If the authors think that the government policy is inadequate, they must provide a substantial amount of evidence, while not a single reference is given.
Consider the sentence: “Yet one of the geomorphic absurdities of the 20th and 21st century arguably is the sheer volume of earth materials that are displaced and extracted by machine.” Defining it as an absurdity is again a value judgment without any reference supporting the statement. In retrospective, it is simple to conclude that an intervention had negative impacts that were not properly foreseen. Yet this does not make the intervention absurd (according to the Cambridge dictionary, ”stupid and unreasonable, or silly in a humorous way”).

See our response above. We can make both cases with substantial referencing if we had more space, but we toned down our formulation because it distracts from the main points we wish to make here. We have dropped the use of 'absurdity' but remark here that it is not simply a value judgement but the outcome of taking a broader perspective that looks beyond the ecomodernist frame. We used it in the same manner as Hajer and Oomen (2025).

Relevant references

Apart from the discussion section, it strikes me that the authors do not mention three references. Considering them may strengthen the paper. First is the (in)famous diagram by Hjulström (1935) showing that transport, deposition, or erosion is to be expected as a function of the grain size and the flow speed (it even has a Wikipedia page 1). This is after Exner (1925) published his work, and to my despair, it can still be found in presentations at conferences and reports around the world.

We recognize the issue, and to make things worse it is also found in geology textbooks. It is quite interesting that Hjulström received so much attention despite earlier works showing its errors. In view of the length of this manuscript, we only refer to it briefly. A more general history of how thinking about river sedimentation developed is outside the scope of this paper.

Second is Tulla (1854), who justified the "normalization" of the Rhine River in Germany, stressing the importance of having one single channel. This landmark study is of great historical importance for understanding the changes that the Rhine has undergone.

We are aware of the importance of Tulla and have again studied the original German text. We added this reference, because Tulla holds very similar (and partly misconceived) views as his contemporaries did. He writes (translated from German 1822 edition, p 73) "straight, gently curved and properly closed river beds silt up less than those that are not; the reason for this lies in the greater speed of the water and the smaller amount of debris, gravel and sand that the rivers have to carry away, because there is no erosion of the banks and the movement of gravel and sand banks is eliminated." In other words, there is no general sediment transport except where river banks are collapsing.

Third is the role of the Pannerdensch Kanaal as a defensive element. I was expecting this point to be discussed too.

On the military importance of the Pannerden Canal, we agree that this is important to mention, as it helps to explain the scale of expenditure. We have added a few sentences on the matter in section 3.1. The Canal's strategic importance is discussed at length in the literature we cite (e.g., the seminal PhD thesis of van de Ven (1976).

Some minor issues follow.

We have corrected typos and errors and clarified where needed. Comments requiring a response are:

- Line 33. "for a particular section, the amount of mass that transports into it, is equal to the mass that is transported out ". Not a section but a control volume. No mass can be transported into a section (area), but across a section. It is transported into a volume.

Agreed, now changed into river reach.

- Line 49 (Equation 3). I think the sign on the right-hand side is wrong. If I am not mistaken it should be D − E. If deposition is larger than erosion, the bed level increases.

Corrected, thanks.

- Line 67. "This is generally incorrect in morphological settings where the concurrent upstream flow acceleration also increases the sediment input which may balance the output. ". It is unclear to me

what the authors want to say here. If the flow is accelerated in a control volume, the output of sediment is larger than the input and the bed level will decrease.
We have removed the word acceleration and reworded what the problem is (Exner in words really): an increase of velocity does not cause erosion at that location, because erosion is caused by a gradient in sediment transport, and the increase of velocity, for instance due to a flood, also happens upstream such that more sediment enters the location of interest.

- Line 110. "To Newton, on the other hand, deriving laws from metaphysical principles was unacceptable ('hypotheses non fingo' ...)". Nice quote. I am not sure (and again, I am not a philosopher) if the point of Newton was that it was unacceptable for him to derive laws from metaphysical principles or simply that he derived them from experience and refused to offer speculative or conjectural causal explanations for phenomena. It is just a tiny nuance for my curiosity maybe. Also, maybe a translation from Latin could be useful to some readers.

We added a translation of Newton's quote but have left the point about his arguments against deriving laws from metaphysical principles as it stood, as it was indeed Newton's point that this should not be done. The literature cited backs this. If needed, we can cite the literature more precisely.

- Line 219. ". At the end of the 18th century, as in many other rivers in Europe, the focus of management shifted to international navigation (1831 Mainz treaty), fishing (1885 salmon treaty) and sediment mining for large-scale road and railway construction. " This text looks out of context. Check coherence with previous sentences.

We have changed the phrasing to make our point about the shift after 1800 clear here.

- Line 337. "We now know that both notions are not wrong under uniform steady flow conditions. " I do not follow which notions and why uniform flow matters. If flow is uniform there are no gradients in transport and if the boundary condition is at equilibrium, no changes in the channel occur.

Line 338. "However, they cannot be generalized for a natural river with meanders, bars and bifurcations.". Similar to previous line. I do not follow argumentation.
Line 354. "First, continuity of flow means that, given a constant discharge and river width, local deepening leads to lower local flow velocity, that is, unless the situation changes upstream, too. ". Unfinished sentence.
Line 356. "Second, if faster flow is not strictly local,". Faster than what? I think these lines need to be reviewed.

We have reviewed the sections around these lines. We have changed the text substantially around these points in order to clarify our points about eighteenth-century failures to take upstream flow conditions and sediment supply into account. They basically amount to not taking into account sediment continuity.

- Line 362. "decreasing cross-section surfaces". If it is a cross-section surface, it must be the hydraulic area. Indeed, if the width is reduced, for the same discharge the velocity increases and the area reduces (A = Q/u, where A [m/s] is the area, Q [m3/s] is the discharge, and u [m/s] the velocity), but I am not sure if this is the point you want to make because, what is the implication of the decreasing area? I think you only want to stress the reducing width.

We reformulated this to clarify our point how they did not consider sediment continuity.

- Line 442. "It is perhaps ironic that the removal of such cohesive, early Holocene layers, together with the now ubiquitous use of simulation models that rely on the principle of sediment continuity, made the rediscovery of such hard layers in the early 21st century an antipodal surprise to river experts who, a century earlier, did not see evidence for sediment continuity (see for review Pierik et al. 2022).". Sorry, I cannot follow this reasoning. I do not understand what you want to convey.

We have elaborated on what is relevant about recent research on these Holocene layers. The point is that hard layers used to be considered normal, then, when sediment continuity became important in numerical modelling they were mostly forgotten in the literature, and now they are a surprise again (and a complicating factor for numerical morphological models).

- Line 603. “, when the adverse effects to bank stability and to riparian ecosystems ”. Also channel erosion? Or was it not acknowledged?

We have no investigated whether they observed such erosion in relation to the bank stability but it is plausible.

- Line 607. “with incision still continuing (both in the Netherlands and in Germany);”. Are you certain that incision is still continuing in Germany? Stabilization works have occurred for decades. Please add reference.

We removed Germany here because we are not certain (Roy Frings, who developed the sediment balance for the Niederrhein for a decade ago, is not certain in part due to the unknown contribution of subsidence).

- Line 608. “and the bed sediment caliber has increased considerably and armored in the upstream reaches”. Upstream reached of the Netherlands or Germany?

Clarified: the upstream reaches in the Netherlands. (These are outside the tidal influence and have a steeper gradient than the downstream branches so they are usually distinguished in the Dutch context.)

- Line 617. “not only because of its importance for navigation of container ships, which are rapidly increasing in size (Cox et al. 2022), ”. Is this reference adequate to point to the increase in the ship size?

Yes, the paper cited contains a discussion and a figure of increasing ship size throughout the 20C, so we think it is adequate. However, this is part of a section now removed, mentioned above.

- Line 660. “and that sediment does not abrade or dissolve (e.g., Paola & Voller 2005).” Check the last term in their Equation (15) for dissolution. Abrasion does not change mass.

Agreed, changed formulation.

Reviewer 2

The submitted manuscript offers an interesting history of the concept of sediment continuity and a case study of the problems when continuity is neglected. I thought that the paper offers some nice historical context about the Exner equation that would be generally useful to the fluvial geomorphology community. I have a few major comments but mostly minor editorial changes for clarity.
Thank you, in particular for your suggestions that confirm that misconception of sediment continuity continues to plague present-day practices and education.

Major comments

A study site map with the reaches being discussed would be very helpful in understanding this section 3.1, the problems of sediment continuity here and the later sections that further discuss these site specific problems. Someone without detailed knowledge of this river will have some difficulty envisioning the problems without such a map that shows the problem areas.
We have added an annotated map showing the relevant locations and rivers on an (open access) historic map of 1809; within the period of interest.
I think the discussion section would benefit from a review of current literature or river restoration practice to discuss whether sediment continuity is still being neglected in some river science. I think this problem is much larger than a few undergraduates and is a mistake that some practicing engineers/ecologists/geologists still make. It is also a misconception in some recently published papers (see my minor comment below). I think broadening the discussion to mention some current case studies or examples of river design failure without sediment continuity would provide present day context to your reader and possibly help make the case that this is still an important issue today. See for example, these papers (https://www.jstor.org/stable/26266029 https://doi.org/10.1111/j.1752-1688.2007.00091.x) that highlight the problem of not addressing sediment continuity properly and the fact that channel planform and sediment supply are linked.
Thank you for these two suggestions, they were unknown to us but quite relevant for our paper (I wish I knew them when one of us wrote a review on river meandering (2024, not cited here).
Simon et al. rightly argue that a complex systems approach to river patterns, including consideration of river bed and bank by different but linked physical / morphological concepts (quite familiar to one of us), is more effective than Rosgen's influential concepts for stream restoration. They were influential mainly outside geomorphology in the practices of stream restoration in North America (not so much in Europe), where communication is improved with simplified concepts, though in Rosgen's case, we agree they had fatal errors despite Rosgen citing relevant geomorphological literature. However, sediment continuity plays a relatively minor role in the critical evaluation of Rosgen. The Simon et al. paper also refers to Lane's balance, which we also avoided on purpose as not to overcrowd this paper with twentieth century work on sediment transport.
The Kondolf paper we now cite, because, while also in part about the Rosgen problem, it centralizes the notion of stable gently meandering rivers that emerged from Farque's work, among others, and argues for a cultural preference for serpentine forms, including rivers, in the century before Farque.

Minor comments by line number

We have corrected typos and errors and clarified where needed. Comments requiring a response are:
14 Although undergrads make this mistake, I know graduate students, faculty, and consultants who also sometimes make this mistake. I realize that you have a citation for undergraduates below, but I think this

statement needs to be broadened to represent the fact that this mistake is not uncommon outside (and sometimes even inside) the field of geomorphology.
This agrees with our experience, but despite frantic searching we found no references to work that investigated this, and a systematic search through present-day literature and governmental reports to pinpoint such mistakes is well beyond the scope of this paper. Also, one benefit of exposing students to history of science is to illustrate such mistakes with historical cases of people who can no longer be offended.
36-37 Shear stress technically doesn't cause form drag on sediment particles, pressure variations around grains cause drag, which is then simplified into the drag force equation that uses velocity; can you clarify here? I am also a little confused because particle suspension is being discussed but in many rivers, sediment mass balance changes are also caused by bedload? I am also not fully clear why a balance between drag force and gravity is being described here, there are other forces such as lift that are also important for sediment motion in river systems?
The reviewer is correct, we agree, and we clarified the text.
66-67 Please see comment above, there are recent publications that also make this mistake. For example, https://doi.org/10.1029/2024WR038282 implies in the introduction that sediment deposition cannot locally occur where the applied shear stress exceeds the critical shear stress. This neglects the sediment mass balance that could occur where sediment is mobile at a location but receives more sediment than can be transported out of that location. I think (?) there are also published papers in which sediment transport rates are inferred from differencing repeat measurements of bed topographies (DEM of difference) within an area. This method ignores the upstream sediment supply and the fact that zero difference in bed topography doesn't imply zero transport, just zero scour/deposition.
In general we agree (see general response to main comment), but we think that the paper cited above is actually poorly formulated, and implicitly applicable to shallow flow in gravel bed rivers which are close to incipient sediment transport anyway. A search for recent literature is beyond the scope of our paper but of course we hope that it will be widely read and help to avoid such mistakes. See reply to minor comment line 14.
165-166 I don't fully understand this statement, do you mean the cross-sectional area and the flow velocity (not the amount of water) are inversely proportional?
We indeed formulated unclearly here and used the occasion to add clarifications, in the following paragraph, on the use of velocity, conservation laws and acceleration in eighteenth-century fluid dynamics. We make clear that these were not, initially, the parameters measured.
191-193 I don't fully understand the structure of this sentence? What is naïve? I am a little confused because this seems like a bit of a straw man; are there published papers that say that it is surprising that sediment continuity took so long to develop after flow continuity? What naïve argument (has this been published somewhere?) are you refuting?
We are anticipating that a present-day reader, unaware of the history of conceptual shifts in terminology, could ask this question—whether the same principle of continuity could have been applied to sediment. This is a type of question that we encounter often, and to which the reply can only be: they might in principle have done so but the important fact is that they did not. We clarified the text to make clear that we are here trying to separate productive and unproductive ways to ask questions about the historical development of a knowledge concept.
306, 309 I am not sure 'corrosion' is the correct word here given it means the deterioration of substances through processes like oxidation?
Correct today, but the author that we are citing meant something different. We clarified this in the text.

336-339: I am not fully following this argument. “Notably, cause and effect were switched to argue that faster flow in the channel would erode and deepen the river. We now know that both notions are not wrong under uniform steady flow conditions. However, they cannot be generalized for a natural river with meanders, bars and bifurcations.” Are you saying that if they temporally changed the flow velocity to be uniformly faster throughout the entire reach compared to the original flow velocity, then the channel would erode? Or are you saying if they locally (spatially) increased the flow velocity, then the channel would erode? If the former, I am not completely following how this argument is ‘not wrong’ because it still neglects sediment supply or are you trying to say that the assumption is the supply is temporally constant? If the latter, this would technically violate the ‘uniform’ flow assumption that is mentioned as being part of this notion? I also don’t fully understand the linkage to more complex river morphology systems and how this relates to the previous sentence.
We have changed the text substantially around these points in order to clarify our points about eighteenth-century failures to take upstream flow conditions and sediment supply into account. They basically amount to not taking into account sediment continuity. R1 made similar points and we have reviewed this entire section and reformulated the matters to make our points clearer.
340-342 “particularly far off from steady flow, due to the strong backwater effect of the tidal estuary and sea, a strong downstream fining trend with gravel coming from the upstream location we discuss next, and the locus of fine sand sedimentation at this location”. I am not following how this relates to steady flow, this seems to be nonuniform flow at least in terms of the backwater and I am not clear how downstream fining shows the existence of unsteady or nonuniform flow?
See the comments above, in response to R1: we have reviewed this entire section and reformulated the matters to make our points clearer. The reviewer is correct, but the historic authors made the implicit assumption of steady flow and were unaware of the backwater effect.
362-364 “He also wanted to remove floodplain vegetation to allow sediment suspended from the channel to deposit on the banks, further deepening the channel.” Why would this occur, it seems like the opposite would happen; vegetation would cause deposition? Or are you implying that he was incorrect? If so, I think this needs to be stated explicitly?
Same as in response to R1: we have reviewed this entire section and reformulated the matters to make our points clearer. Their assumption here is that vegetation on a narrow embanked floodplain would raise water levels and slow down flow in general, which would, by their notion of river sedimentation and erosion, not result in the erosion they wanted, so they propose to remove vegetation. We suspect their point that overbank sedimentation would happen rests on speculation but our sources are not specific enough on this point to be sure.
559-561 “sediment transportation depending on slope, flow velocity and the caliber of the sediment. The last variable he used to infer the cause of downstream fining, which is one of the possible causes for a nonlinear slope profile.” The last variable is the caliber of the sediment and I am not clear how that explains downstream fining because it is downstream fining?
Downstream fining as a component of grade is beyond the scope of this paper so we have removed the cryptically short explanation.

Round 2 Review

Comments by reviewer 2 (Anonymous)

Completed: 2026-02-09 07:02 PM

Recommendation: Accept

Recommendation by Associate Editor 2 (Matthieu Giaime)

Completed: 2026-02-10 09:02 AM

Recommendation: Accept

Reviewer Comments

For author and editor

Dear authors,

I read with interest your manuscript entitled “Sediment continuity: historical development and misconceptions of a core concept of geomorphology”. Based on my reading of your precise and detailed responses to the reviewers' comments and reviewer 2's positive opinion of your resubmission, I would like to recommand for the manuscript to be accepted.

EiC decision Round 2

2026-02-11 Decision Accept

Congratulations! I am pleased to inform you that your manuscript entitled "Sediment continuity: historical development and misconceptions of a core concept of geomorphology" has been accepted for publication in Geomorphica.