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Referee comment on the technical note:

A double-Manning approach to compute robust rating curves and hydraulic geometries

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General comments

This paper introduces a "double-Manning" approach to construct physically informed river stage–discharge rating curves, promoting the practical importance of simple methods that maintain physical realism. The approach is based on the separation of in-channel and overbank flows, allowing for flexible and improved calibration and extrapolation of rating curves, even in dynamic or data-sparse river systems. It seeks to bridge empirical power-law methods and more complex hydraulic models, offering a practical tool for hydrologists to build or refine stage-discharge rating curves using accessible field and remote-sensing data, supporting flexible, and better-informed river monitoring and prediction. The double-Manning formulation, implemented as open-source software, facilitates straightforward application while allowing adjustments based on direct measurements, reasonable assumptions or estimates, and/or observable geomorphic changes. By replacing traditional lumped parameters with field-measurable river hydraulic and geometric properties, the approach aims to contribute to enhancing operational monitoring, flood prediction, and hydro-geomorphic research.

While the fundamental concept of modelling in-channel and overbank flows separately using hydraulic principles (e.g., Manning's equation) is not novel (e.g., Ven Te Chow, 1959; Sellin, 1964; Henderson, 1966; Posey, C.J., 1967; Knight, D.W., Shiono, K., 1990; Knight, D.W. and Abril, B., 1996; Smart, 1999; Mietton et al., 2000; Knight et al., 2009; Fenton, 2015; Kiang et al., 2018; Manasanarez et al., 2019; IWA Publishing, 2024) the double-Manning approach presented in this technical note introduces a specific implementation that is distinct in its simplicity and focus on data-sparse environments. In particular, it builds on a recognized foundation of Manning-based rating-curve research (Leonard et al., 2001; Kean and Smith, 2005; Price, 2009; Frontiers in Water, 2023). Existing methods, including Bayesian rating-curve frameworks and compound channel modelling, have explored multi-stage rating curves and the separation of channel and floodplain roughness using Manning's equation to enhance physical interpretability (Le Coz et al., 2014; Pappenberger et al., 2006). However, I find that the specific formulation and implementation presented in this technical note, while building upon this body of research, still contributes meaningfully by combining novel structural modelling, dynamic geomorphic responsiveness, and practical software integration. This represents an advance over previous empirical or single-zone Manning adaptations by providing a ready-to-use, physics-based, dual-zone framework operationalized in open-source tools, facilitating practical adoption by the hydrological community.

High-quality and technically sound hydrological (discharge) observations are recognized as largely lacking at both national and global scales (WMO, 2010; WMO, 2022). The World Meteorological Organization has repeatedly highlighted in its State of Global Water Resources reports and Hydrological Observing System initiatives the critical need for reliable discharge data to support water management, flood forecasting, and climate adaptation, with many regions facing data scarcity (WMO, 2022). Recent reviews in the scientific literature (Alfieri et al., 2020; Blöschl et al., 2019) similarly underscore the limitations in discharge data availability and the need for innovative yet practical methods to improve monitoring capacities globally. This context provides clear merit to contributions like this technical note, which offers conceptual and practical, easy-to-use tools to address the operational challenges of maximizing the use of available discharge measurements and developing rating-curves easily. The open-source software implementation, makes this Manning-based dual-zone rating-curve tool publicly available, representing a valuable addition to the technical literature and practice of operational hydrology.

Additionally, I find merit in the technical note's provision of diverse solution strategies under different scenarios of data availability, which is particularly useful for practicing hydrologists and researchers, especially in data-poor settings. The extract provided by the authors clarifies the positioning of the double-Manning approach as a pragmatic middle ground: it offers a simpler, operationally accessible alternative to distributed hydraulic models while providing greater physical relevance and extrapolation capability than straightforward empirical power-law fits. This simplicity, paired with its physical basis and ready-to-use numerical implementation, underlines the utility of the approach for operational river monitoring and prediction, aligning well with the needs of agencies and practitioners seeking robust yet practical solutions.

In think the title of this technical note might better reflect the sound approach to developing rating-curves that maximize measured hydrologic data and direct field observations of river hydraulics. Furthermore, the indication that the method computes "hydraulic geometries" is unclear (how about instead saying that it provides estimates of geometric hydraulic parameters?).

This note addresses relevant scientific questions within the scope of HESS by focusing on operational hydrology, river monitoring, and methods to improve stage–discharge rating curves using physically informed, practical approaches for dynamic and data-sparse conditions. It presents a novel combination of concepts, practical tools, and implementation/solution strategies, reaching substantial and applicable conclusions. The methods and assumptions are valid, clearly outlined, and sufficient to support the interpretations and conclusions provided. The description of the numerical implementation and conceptual framework is complete and precise enough to allow reproduction by fellow scientists, ensuring traceability of results. The authors give proper credit to related work while clearly indicating their new contributions, which are explicitly differentiated from existing studies.

The paper is very well written, and while I will provide minor recommendations in my specific and technical comments to further improve the text, figures, and tables, it already presents a concise and complete abstract summarizing the work effectively. The overall presentation is well-structured and clear, with fluent and precise language throughout. Mathematical formulae, symbols, abbreviations, and units are correctly defined and used consistently. The number and quality of references are appropriate and sufficient to support the context and contributions of the work, and the supplementary material provided is of adequate quality and quantity to complement the technical note without redundancy.

In conclusion, I recommend that the technical note be accepted for final publication, subject to further clarifications and technical corrections.

Specific comments

L.68: noting that h is flow (i.e., water) depth and h_β is the height of the channel banks, and $\wedge$ indicates that the smaller of the two numbers be taken

L.102: In the statement "Furthermore, we posit that the inundation width and depth distributions can be described with power-law functions.", what do you mean by the term "distribution"? Is the (frequency?) distribution what you really want to describe with this function? On what grounds do you propose power-law functions for this? (Perhaps you could include some reference(s) here).

L.106: In "…and therefore rewrite Equation 8 as…", are you actually rewriting Eq. 8, or are you just directly applying Manning's equation (as you did in Eqs 6 and 7), which has a similar structure to Eq. 8?

L.108: since the definition of B (the width of the valley bottom) is relative arbitrary, some recommendations or guides on how it could be determined in the field or by remote sensing, for use within the framework of this methodology, could be of great value and use.

L.117-118: In "Therefore, we consider the wide-rectangular floodplain approximation to be reasonable even when not formally defensible based on Equation 3 alone.", could you expand/explain this further, for example by mentioning which principles or assumptions necessary to apply Eq. 3 might not be defensible?

L.136-137: In "…Geometric and velocity data are measured directly,…", do you really need velocity to estimate any of the parameters in Table 1?

L.141-142: Could you please explain in more detail the statement "Therefore, the approximate "rectangular-channel" values for both width and depth should be selected with flow mechanics in mind (e.g., Naito and Parker, 2019)."?

L.144-145: In "Therefore, the effective channel depth for the double-Manning approach will be less than the distance from the floodplain surface to the thalweg.", can you introduce first the concept of "effective channel depth" in your explanation? Since the thalweg is the lowest point of the cross section this necessarily implies the main rectangular channel, however, could you explain why such effective channel depth excludes the floodplain? Finally, can you explain why the effective channel depth is less than the distance from the floodplain surface to the thalweg?

L.154-155: Can you further explain the statement "(Although R_h also includes dependence on b, most channels are wide relative to their depth, making R_h much more sensitive to h than to b.)".

L.158: In “Similarly straightforward measurements can provide slope (*S*) for Equation 6. This can be done with digital elevation models,…”, again, is a DEM-based estimate good enough, given that *S* is the channel-bed (not surface) slope?

L.175-177: In this statement “Although channel-bank height may be solved for as a free parameter using a large amount of stage–discharge data (Section 5.1),…”, if you already have a large amount of stage–discharge observations, why would you want to estimate the channel-bank height? From a practical perspective, you could simply fit an empirical rating curve based on your good-quality observations.

L.209-210: “Equation 12 involves four field-measurable parameters: channel width (*b*), bank height (h_β), channel-bed elevation (z_b), and in-channel Manning’s n (n_{ch}). It also includes two free parameters requiring selection or calibration, the power-law coefficient (k_{fp}) and exponent (P_{fp}) for flows across the floodplain, which relate to floodplain topography and roughness.” I think we could also consider the slope *S* and valley-bottom width *B* (present in Eqs 6 and 9, which contribute to Eq. 12) as field-measurable parameters, and n_{fp} (from Eq. 9) as a free parameter requiring selection or calibration. Also, note that in Eqs 8 and 9 the channel-bed elevation is presented as the height of the channel banks h_β. Using different symbols for the same physical concept can be confusing, so please consider using only one or the other throughout the document.

L.214: In “Users can specify values for width (*b*), depth (h_β), and/or slope (*S*); they may also specify bounds for in-channel Manning’s *n* (n_{ch}), the floodplain coefficient (k_{fp}) and/or exponent (P_{fp}), and the offset between flow depth and river stage (z_b).”, please consider including *B* and n_{fp} in this list, in case Eq. 9 is required.

L.280-281: I do not think the statement, “These values bracket our computed Manning’s *n* on this mixed-land-cover floodplain and provide some confidence in our results.” Is justified for a value of $n_{fp} = 0.079$, especially when compared to the criterion of $n < 0.025$.

L.303-304: In “We computed the slope of the Cannon River from the site of the gauge at Welch to the mouth of Belle Creek, ∼3.5 km downstream”, wouldn't this distance be too great to provide an accurate river channel-bed slope for the gauging site?

L323.324: I suggest reviewing the statement “…, but here simply accept this based on the lack of available data alongside the good visual and quantitative fit (Figure 3).” In this situation, I would rather refer to the fact that it is better to have an estimate that provides a good visual and quantitative fit than to rely on a purely theoretical solution.

L.328-329: Could you further explain the statement “Therefore, they represent a likely upper bound on the grain-induced in-channel roughness.”

L.375-376: In “Second, it permits links to and tests against field data that (a) augment the standard paired stage–discharge measurements”, what do you mean by " augment"?

Figure 1:

- It might be worthwhile to also indicate in the title of this figure that both z_s and z_b are measured with respect to a common datum.

Table 1:

- Why is the valley-bottom width *B* excluded? This is one of the parameters required to apply equation 9.

- I would change the title of the "Variable" column to "Symbol" instead.

- Is using a DEM a valid option to estimate *S* (channel-bed slope) and h_β (bank height), considering that estimating both parameters requires bottom/underwater measurement?

- The description of the observation method for the floodplain discharge coefficient k_{fp} should mention that n_{fp} is first estimated through insight obtained from field surveys or Manning's *n* tables or photos and then entered into Eq. 9 to calculate k_{fp}.

Table 2:

- Perhaps the rows on grain size D_{50} and D_{84} could be regrouped under a subsection entitled "Inputs for n_{ch}"

- In the "Solved" description of the row about k_{fp}, since Eq. 8 is empirical, I don't think either k_{fp} or P_{fp} should be assigned any units (I would remove these [m^{3-fp} s^{-1}] units).

- It would be helpful if the table clearly distinguished between the values of observed variables/parameters (obtained through direct measurement or field-based estimation) and those estimated or optimized using the "doublemanning" software. One option could be to present observed values in bold, with the corresponding estimated values shown in parentheses and in regular font next to them. This would improve the table's readability and help avoid confusion in rows under the "Solved" section, such as "Channel depth (h_β)", for which observed values are available, and "Stage Offset (z_b)", which section 4.2 of this manuscript identifies as a field-measurable parameter.

- I would not include the row "Channel width (*b*)" under the "Solved" section at all. This would simplify the table and perhaps eliminate footnote *d* (to be checked).

- I recommend that footnotes *c* and *d* be better explained, especially when applied to fixing P_{fp}.

Technical corrections

Below I recommend technical and typographical corrections to this manuscript, and some typing suggestions.

L.74: "Most natural channels and floodplains satisfy this criterion …"

L.116-117: "However, many floodplains contain such significant internal bottom roughness (e.g., from vegetation) that the additional drag against their side walls is small in comparison."

L.136: "The third factor indicates how directly the parameter ~~variable~~ in question may be measured or calculated."

Eq. 14: I would present the units of the equation separately, leaving the equation clean as just: $nch \approx 0.049\ D_{84}^{1/6}$. The way it is currently presented is confusing, as the units (s $m^{-1/2}$) appear to be variables or parameters of the equation.

L.181-182: "…these in fact amplify the overall trend towards wider flow horizontal occupation as water rises…."

L.187-188: "…may be ~~extracted from~~ used to compute the bulk coefficient, k_{fp} (Equation 10)."

L.209: "…channel width (b)…"

L.232: "We applied~~y~~ this double-Manning approach to three rivers (Table 2) to demonstrate its applicability across a ~~wide~~ range of settings and quantities of available data.…" (I wouldn't talk about a wide range of settings. A "fair" range of settings, maybe).

L.262-263: "To ensure that we do not over constrain the problem, we extend our Manning's n search range to $0.025 \leqslant nch \leqslant 0.060$."

L.356-357: "..., and estimates ~~replaces~~ the lumped k_{fp} parameter using ~~with~~ a field-approximated n_{fp} and measured valley-bottom width (B) and slope (S) (Equation 10)"

L.361-362: "Combining this n_{fp} with our estimated valley-bottom width (Figure 4) and slope, we use Equation 10 to solve for k_{fp}."

L.367-368: "After entering the field-observed channel geometry and slope (b, h_β, S), floodplain width (B), and floodplain roughness (n_{fp}) into equation 9,…"

L.388-389: "Second, it separates the effects of channel–overbank-region (often, channel–floodplain) form and flow resistance from the power-law exponent (Equation 1)"

L.398: "Although the double-Manning formulation involves eight ~~seven~~ parameters (Table 1)"

L.422-423: "Changes in the balance of sediment and water supply to a river can alter its slope, though large to medium-sized rivers are typically large enough that this takes hundreds to thousands of years (Mackin, 1948; Wickert and Schildgen, 2019)."

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