Corrigendum to Earth Surf. Dynam., 7, 17–43, 2019
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Corrigendum to "Long-profile evolution of transport-limited gravel-bed rivers" published in Earth Surf. Dynam., 7, 17–43, 2019

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We (Wickert and Schildgen, 2019) derived Eq. (1), the valley-width-resolving Exner equation, by erroneously keeping the width term, B, within the derivative (by analogy to the one-dimensional channel solution). This incorrectly implies that a river may aggrade or incise based on changes in the valley width. The correct equation omits the far right-hand term of our original Eq. (1):

$$\frac{\partial z}{\partial t} = -\frac{1}{B(1-\lambda_p)}\frac{\partial Q_\mathrm{s}}{\partial x}. \tag{1}$$

By making a mistake in Eq. (1), we optimized opportunities to propagate this error throughout the paper. Fortunately, the propagated mistakes can be rectified by removing all terms related to downstream changes in valley width. Although this is straightforward, we provide corrections to the equations that we believe are most likely to be applied.

Equations (2)–(19) in the core derivation are correct, as they do not include any reference to the Exner equation (1). Equation (20) combines Eqs. (1)–(19) with the Exner mass balance framework and must therefore be changed to remove its valley-width derivative term:

$$\frac{\partial z}{\partial t} = \frac{k_{Q_\mathrm{s}} I}{\mathbb{S}^{7/6}(1-\lambda_p)}\left[\frac{7}{6}\frac{1}{\left(\frac{\partial z}{\partial x}\right)}\frac{\partial^2 z}{\partial x^2} + \frac{1}{Q}\frac{\partial Q}{\partial x}\right] \frac{Q}{B}\frac{\partial z}{\partial x}\left|\frac{\mathrm{d}z}{\mathrm{d}x}\right|^{1/6} + U. \tag{20}$$

The $P_{x,B}$ term within the brackets in Eq. (36) must be removed, along with the $P_{x,B}$ terms in Eqs. (39) and (40). This simplifies the analytical solution in Eq. (40) to

$$z = (z_1 - z_0)\left(\frac{x^{(1-6P_{x,Q}/7)} - x_0^{(1-6P_{x,Q}/7)}}{x_1^{(1-6P_{x,Q}/7)} - x_0^{(1-6P_{x,Q}/7)}}\right) + z_0. \tag{40}$$

Similarly, $P_{x,B}$ and all terms directly multiplied by it should be removed from Eqs. (52)–(54). This invalidates the premise of Sect. 5.3, whose equations no longer predict that valley widening may produce concave-up long profiles. Revising Eq. (54), while also converting x_0 to A_0 via Eq. (32) to make the mathematical expression more straightforward, provides the corrected slope–area relationship:

$$S = S_0\left(\frac{A_0}{A}\right)^{(6/7)P_{A,Q}}. \tag{54}$$

In this revised Eqs. (54), the concavity index $\theta = (6/7)P_{A,Q}$ and the steepness index $k_s = S_0 A_0^\theta$.

Removing the valley-width dependence of Eqs. (40) and (54) in these corrections permits straightforward comparisons with topographic data and straightforward derivative products, namely slope and drainage area.

Figures 2, 3, 5, 6, and 8 include spatially varying valley width, but they remain qualitatively – and nearly quantitatively – identical after incorporating the corrections. Figure 4 is now valid only along the x axis, meaning that the drainage-area–discharge exponent ($P_{A,Q}$) alone sets channel concavity. The corrected version of Fig. 7 given here remains qualitatively the same, but its axes are shifted by a factor of 100 due to an unrelated programming error. In addition, the caption of the original Fig. 7 stated that $P_{xB} = 1$ when in fact $P_{xB} = 0.1$.

Appendix B1 incorrectly notes that "Explicit inclusion of channel width, b, provides a space to substitute the valley width, B". This is at the heart of the problem. A widening valley and an expanding flow are fundamentally different: the latter includes areas of no sediment transport. Equation (B1) is no longer relevant, and Eq. (B2) should read

$$\frac{\partial z}{\partial t} = -\frac{1}{B(1-\lambda_p)} \frac{\partial Q_{\mathrm{s},\hat{x}}}{\partial x}. \tag{B2}$$

Correcting this error also requires that the numerical solutions (Appendix D) omit the valley-width derivatives. First, we distribute terms in the corrected Eq. (20):

$$\frac{\partial z}{\partial t} = \frac{k_{Q_\mathrm{s}} I}{\mathbb{S}^{7/6}(1-\lambda_p)} \left| \frac{\mathrm{d}z}{\mathrm{d}x} \right|^{1/6} \left[\frac{7}{6} \frac{Q}{B} \frac{\partial^2 z}{\partial x^2} + \frac{1}{B} \frac{\partial Q}{\partial x} \frac{\partial z}{\partial x} \right] + U. \tag{D1}$$

Therefore, the full discretized equation becomes

$$\begin{aligned} z_{i,l} = & -\frac{\Delta t}{4(\Delta x)^2} \frac{k_{Q_\mathrm{s}} I}{\mathbb{S}^{7/6}\left(1-\lambda_p\right)} \left| \frac{z_{i+1,l^*} - z_{i-1,l^*}}{2\Delta x} \right|^{1/6} \\ & \left[\frac{14}{3} \left(\frac{Q_{i,l} + Q_{i,l+1}}{B_{i,l}(z_{i,l}) + B_{i,l+1}(z_{i,l^*})} \right) \right. \\ & \left(z_{i+1,l+1} - 2z_{i,l+1} + z_{i-1,l+1} \right) + \\ & \left(\frac{(Q_{i+1,l} + Q_{i+1,l+1}) - (Q_{i-1,l} + Q_{i-1,l+1})}{B_{i,l}(z_{i,l}) + B_{i,l+1}(z_{i,l^*})} \right) \\ & \left. \left(z_{i+1,l+1} - z_{i-1,l+1} \right) \right] + z_{i,l+1} - U\Delta t. \end{aligned} \tag{D2}$$

When we redefine these terms to include time averaging, the resultant discretized equation becomes cleaner:

$$\begin{aligned} z_{i,l} = & -\frac{\Delta t}{4(\Delta x)^2} \frac{k_{Q_\mathrm{s}} I}{\mathbb{S}^{7/6}\left(1-\lambda_p\right)} \left| \frac{z_{i+1,l^*} - z_{i-1,l^*}}{2\Delta x} \right|^{1/6} \\ & \left[\frac{14}{3} \frac{Q_i}{B_i} \left(z_{i+1,l+1} - 2z_{i,l+1} + z_{i-1,l+1} \right) \right. \\ & \left. + \frac{Q_{i+1} - Q_{i-1}}{B_i} \left(z_{i+1,l+1} - z_{i-1,l+1} \right) \right] \\ & + z_{i,l+1} - U\Delta t \end{aligned} \tag{D3}$$

In addition to the valley-width correction, we now include an accidentally omitted 7/6 power applied to the sinuosity term, $\mathbb{S}$, within the numerical solutions.

Finally, we correct our prior sloppy and direction-agnostic notation for the upstream Neumann boundary condition:

$$\left. \frac{\mathrm{d}z}{\mathrm{d}x} \right|_{x_0} = -\mathrm{sgn}(Q_\mathrm{s}) \mathbb{S} \left(\frac{1}{k_{Q_\mathrm{s}} I} \frac{Q_\mathrm{s}}{Q} \right)^{6/7}. \tag{D4}$$

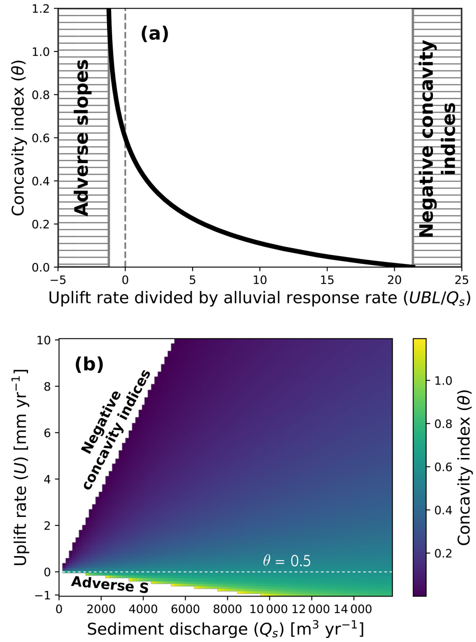

Figure 7. Relative importance of sediment discharge versus tectonic addition or removal of material in setting channel concavity.

Equation (D5) in the original paper should be qualified as true when sinuosity $\mathbb{S} = 0$ and not require a domain beginning at 0. Updating this equation to a more general form,

$$-\left. \frac{\mathrm{d}z}{\mathrm{d}x} \right|_{x_0} \approx \frac{z_{i+1} - z_{i-1}}{2\Delta x}. \tag{D5}$$

Prior to the publication of these corrections, Grau Galofre et al. (2020) nondimensionalized and generalized our analytical solution (Eq. 40). The changes within these corrections do not alter the form of Eq. (40). Therefore, their generalized dimensionless form and the similarities that they drew between it and detachment-limited long-profile evolution remain unaffected.

Code availability. The updated source code, GRLP v1.4.1, is available from GitHub (https://github.com/awickert/GRLP, last access: 26 October 2020), Zenodo (Wickert, 2020), and PyPI (https://pypi.org/project/GRLP/, last access: 26 October 2020).

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