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Interactive comment on "State of the Art Study of Influence of Bed Roughness and Alluvial Cover on Bedrock Channels and Comparisons of Existing Models with Laboratory Scale Experiments" *by* Jagriti Mishra and Takuya Inoue

Jagriti Mishra and Takuya Inoue

jagritimp@gmail.com

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We thank you for the positive consideration of our manuscript and for constructive feedback and comments on our manuscript. The Author comments are written italics.

1) Objectives and physical rationale of the various models: the various cover models treat different aspects of cover distribution and dynamics, they use different approaches with respect to their assumptions and modelled details, and only partially overlap in their objectives. For example, the Johnson 2014 model is mainly concerned

with the feedback between cover and roughness, while the Turowski and Hodge paper is concerned with the description of the distribution of sediment on the bed, and the transformation between a point of view considering masses and one considering fluxes. As a result, Turowski and Hodge did not treat roughness feedbacks at all, while Johnson used a generic flux-based approach. Can the models then be meaningfully compared? Likewise, the Aubert et al. 2015 model includes hydraulic details that the reach-scale approaches of most of the other models do not treat explicitly. It seems important to me that the authors clearly work out the different focus of the various models, including the relevant assumptions and approaches. This means that a brief description of the physical and conceptual rationale of the models should be included in the paper. I agree with reviewer #1 that the key differences in model predictions should be worked out before comparing them to data. This gives the necessary background information to decide what kind of data are necessary to test the models.

We have revised and restructured the introduction part as suggested by you and other reviewers.

Except for the Lagrangian description models that track individual particles (i.e., Hodge and Hoey, 2012; Aubert et al., 2016), the Eulerian description models are roughly classified into four categories; the linear model proposed by Sklar and Dietrich (1998, 2004), the exponential model proposed by Turowski et al. (2007), the probabilistic model proposed by Turowski and Hodge (2017) and the roughness models proposed by Inoue et al. (2014), Johnson (2014), Nelson and Seminara (2012) and Zhang et al. (2015). In this study, we focus on a detailed study of the similarities and differences among the Eulerian description models proposed by Sklar and Dietrich (2004), Turowski et al. (2007), Inoue et al. (2014), Johnson (2014) and Turowski and Hodge (2017). We compare the efficacy of these models from comparisons with our experimental results. In addition, we apply the roughness models (Inoue et al., 2014; Johnson, 2014) to the experiments conducted by Chatanantavet and Parker (2008) in order to analyse the effect of bedrock roughness on alluvial cover in a mixed bedrock - alluvial river with alternate bars.

2) Scales of observations, and field vs. lab work: The cover effect has been studied on a variety of spatial and temporal scales. Within the overview in the introduction, these scales are mixed and the conclusions drawn from the observations are not put in the correct context. For example, the authors cite the study of Cowie et al., 2008 (catchment scale, geological time scale, use of proxies for relevant variables) together with the study of Mishra et al., 2018 (scaled down lab experiments, channel scale, single meander bend), drawing a singular conclusion from two very different approaches. I think there is a need to make the reader aware of these differences. We have tried to incorporate more literature review and modify the manuscript as suggested by reviewers and editors. We have also mentioned the scale of study for each study in the new manuscript.

1 Introduction Economic growth worldwide has fuelled the demand for the construction of straightened river channels, sabo dams, the collection of gravel samples for various research, etc., leading to a decline in sediment availability and alluvial bed cover. Sumner et al. (2019) reported that the straightening of the Yubari River, which was carried out to improve the drainage of farmland, caused the bedrock to be exposed and the knickpoint to migrate upstream. In addition, construction of a dam in the upstream section of Toyohira river in Hokkaido – Japan, decreased the sediment availability to the downstream section contributing to the formation of a knickpoint (Yamaguchi et al. 2017 in Japanease). Sediment availability plays a very important role in controlling the landscape evolution and determining the morphology of the river over geologic time (Moore 1926; Shepherd 1972). Various field-scale (Gilbert, 1877; Shepherd, 1972; Turowski et al., 2008b; Turowski and Rickenmann, 2009; Johnson et al., 2010; Jansen et al., 2011; Cook et al., 2013; Inoue et al., 2014; Beer and Turowski, 2015; Beer et al., 2017), laboratory-scale (Sklar and Dietrich, 1998, 2001; Chatanantavet and Parker, 2008; Finnegan et al., 2007; Johnson and Whipple, 2010, 2007; Hodge and Hoey, 2016a, 2016b; Hodge et al., 2016; Turowski and Bloem, 2016; Inoue et al., 2017b,

Mishra et al., 2018; Fernandez et al., 2019; Inoue and Nelson, 2020), and theoretical and numerical studies (Hancock and Anderson, 2002; Sklar and Dietrich, 2004, 2006; Lague, 2010; Hobley et al., 2011; Nelson and Seminara, 2011, 2012; Johnson, 2014; Nelson et al., 2014; Zhang et al., 2015; Inoue et al. 2016, 2017a; Turowski and Hodge 2017; Turowski, 2018) have suggested that sediment availability has two contradicting effects on the river bed, known as Tools and Cover effect. It acts as a tool and erodes the bedrock bed, known as tools effect. As sediment availability increases, the sediment starts settling down on the river bed providing a cover for the bed underneath from further erosion, known as the cover effect. Sklar and Dietrich (2001) and Scheingross et al., (2014) performed rotary-abrasion mill experiments showing the importance of cover in controlling incision rates in bedrock channels. Reach scale studies of Erlenbach performed by Turowski et al. (2013) showed how extreme flood events can contribute to incision by ripping off the channel's alluvial cover. Cook et al. (2013) suggested that bedrock incision rates were dominantly controlled by the availability of bedload. Their field surveys of bedrock gorge cut by Daán River in Taiwan showed that the channel bed merely eroded for years, despite floods and available suspended sediment. Channel incision occurred only when bedload tools became available. Yanites et al. (2011) studied the changes in the Peikang River in central Taiwan triggered by the thick sediment cover introduced by landslides and typhoons during the 1999 Chi-Chi earthquake. Their results show slowed or no incision in high transport capacity and low transport capacity channels. Mishra et al. (2018) showed that incision rate increased when the sediment supply rate of the laboratory-scale channel became considerably smaller than the sediment carrying capacity of the channel. Laboratory scale experiments performed by Shepherd and Schumm (1974), Wohl and Ikeda (1997) and Inoue and Nelson (2020) showed formation of several longitudinal grooves at low sediment supply to capacity ratio. As the sediment supply increases, one of the grooves attracts more sediment supply and progresses into a comparatively straight, wide and shallow inner channel which further progresses into a narrower, more sinuous, deeper inner channel (Wohl and Ikeda, 1997; Inoue et al., 2016). Channels with higher sediment supply to capacity ratio are expected to be wider as alluvial cover shifts erosion from bed to banks of the channel (Beer et al. 2016; Turowski et al., 2008a and Whitbread et al., 2015). These findings show the ratio of sediment supply to capacity controls alluvial cover ratio, bedrock incision rate and morphodynamics in bedrock rivers. Finnegan et al. (2007) conducted laboratory-scale experiments and studied the interdependence among incision, bed roughness and alluvial cover. Their results indicated that alluvial deposition on the bed shifted bed erosion to higher regions of the channel or bank of the channel. Similar findings were noted in flume studies conducted by Wohl and Ikeda (1997) and Johnson and Whipple (2010). They have shown the importance of alluvial cover in regulating the roughness of bedrock bed by providing a cover for the local lows and thereby inhibiting the erosion and focusing erosion on local highs. Inoue et al. (2014) conducted experiments by excavating channel into natural bedrocks in Ishikari River, Asahikawa, Hokkaido – Japan. They conducted experiments with different combinations of flow discharge, sediment supply rate, grain size and roughness. Their experiments advocated that the dimensionless critical shear stress for sediment movement on bedrock is related to the roughness of the channel. Their experiments also suggested that with an increase in alluvial cover, the relative roughness (i.e., the ratio of bedrock hydraulic roughness to moving sediment size) decreases, also, erosion in areas with an exposed bed is proportionate to sediment flux. Fuller et al. (2016) performed laboratory scale experiments and established the importance of bed-roughness in determining the incision and lateral erosion rates. Chatanantavet and Parker (2008) conducted laboratory-scale experiments in straight concrete bedrock channels with varying bedrock roughness and evaluated bedrock exposure with respect to sediment availability. In their experiments, alluvial cover increased linearly with increasing sediment supply in case of higher bed roughness, whereas in case of lower bed roughness and higher slopes, the bed shifted abruptly from being completely exposed to being completely covered. This process of the bedrock bed suddenly becoming completely alluvial from being completely exposed is known as rapid alluviation. Rapid alluviation was also observed in the laboratory scale experiment conducted by Hodge and Hoey

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(2016a; 2016b) in a 3D printed flume of natural stream Trout Beck, North Pennies-U.K. Their first set of experiments focused on quantifying hydraulic change with varying discharge, suggesting that hydraulic properties fluctuate more during higher discharge. Their second set of experiments (Hodge and Hoey, 2016b) concentrated on quantifying the sediment dynamics for varying discharge and sediment supply. They supplied 4 kg and 8 kg of sediment pulse to the channel and observed a similar alluvial pattern in both cases suggesting that the deposition of sediment on the bed may not only depend on the amount of sediment supplied, but may be strongly influenced by the bed topography and roughness. The latest studies of alluvial cover in bedrock rivers have entered the next stage, which includes not only the effect of sediment supply-capacity ratio but also the effect of bed roughness. A majority of traditional bed-erosion models are classified as the stream power and shear stress family of models (cf. Shobe et al., 2017; Turowski, 2018) (e.g., Howard, 1994; Whipple and Tucker, 1999), in which bed erosion is a function of discharge and bed-slope. These models however cannot describe the role of sediment in controlling the bed dynamics. Several models remedy this shortcoming by considering the tools and cover effect of sediment supply (Sklar and Dietrich, 1998, 2004; Turowski et al., 2007; Chatanantavet and Parker, 2009; Hobley et al., 2011; Inoue et al., 2017b). In section 1.1, we introduce previous theoretical and numerical models that take into account sediment cover in bedrock channel. In sections 1.2 to 1.6, we describe in detail the governing equations of the five models dealt with in this study.

3) Missing literature: For a comprehensive, state-of-the-art review that the authors intended to deliver (line 9 in the abstract), too much literature has been overlooked. Scanning through the reference list, more than a dozen missing publications immediately sprang to my mind (see below; the list is not comprehensive and the authors should conduct an additional research). The literature on the cover effect is not so extensive that it cannot be cited completely within a paper intended to review the field, so I suggest that the authors conduct a comprehensive literature research. As an alternative, they could limit their review to a process perspective (short time scales, small

spatial scales), or even experiments, and omit work dealing with long-term channel dynamics, and morphodynamic adjustment. Establishing a clear description of the scope and focus of the article would help to delineate the literature that needs to be included.

We have tried to incorporate more literature review and modify the manuscript as suggested by reviewers and editors. Please see Comment 2

4) Methods: the descriptions of the methods and of the experimental set up are often incomplete. Please rewrite, bearing in mind that a reader should have all necessary information to reproduce your work.

We have included infortmations as suggested by RC2. 2 Experimental Method 2.1 Experimental Flume The experiments were conducted in a straight channel at the Civil Engineering Research Institute for Cold Region, Sapporo, Hokkaido, Japan. The experimental channel was 22m long, 0.5m wide and had a slope of 0.01. The width-depth ratio was chosen to achieve no-sandbar condition (i.e., small width-depth ratio, 6.1 to 8.3 in our experiments). Chatanantavet and Parker (2008) conducted several flume experiments with sandbar condition (i.e., large width-depth ratio, 11 to 30 in their experiments) and suggested that the alluvial cover increases linearly to the ratio of sediment supply and transport capacity of the channel when the slope is less than 0.015. The formation of bars strongly depends on the width – depth ratio (e.g., Kuroki and Kishi, 1984; Colombini et al., 1987). Generally, neither alternate bars nor double-row bars are formed under conditions with width-depth ratio < 15. In this study, we investigated the influence of bedrock roughness on the alluvial cover under conditions where the slope and width - depth ratio were small compared to the experiments of Chatanantavet and Parker (2008). 2.2 Bed characteristics and conditions The channel bed consisted of hard mortar. In order to achieve different roughness conditions, the beds in Gravel30, Gravel50 and Gravel5 were embedded with gravel of different sizes. In Gravel30, the embedded particle size is 30 mm, in Gravel50 particle size of 50 mm is embedded and in Gravel5, 5 mm particle size is embedded. We performed an additional 2 cases with net-installation on the riverbed. The net was made of plastic. An installed net on the riverbed can trap sediment during high flow, eventually protecting the bed from further erosion from abrading sediment (Kazuaki et al.,2015, in Japanese). A net of mesh size 30 mm X 30 mm was installed on the bed in Net4 and Net2. The height of the net was 4mm and 2 mm respectively. Figure 1 shows the experimental channel bed of all 5 runs. For each bed roughness (example: Gravel50 series), a group of experiments with varying sediment supply were performed for different time durations. 2.3 Measurement of observed bedrock roughness In order to measure the initial bed roughness (before supplying sand), a water discharge of 0.03 m3/s was supplied, and the water level was measured longitudinally at every 1 m at the centre of the channel. The hydraulic roughness height for bedrock (ksb) was calculated using Manning – Strickler relation and Manning's velocity formula. k_sb=(7.66n_m √g)ˆ6 (14a) n_m=1/U Dˆ(2/3) ãĂŰS_eãĂŮˆ(1/2) (14b) where n_m is the Manning's roughness coefficient and U is the average velocity (U=Q/wD where U is the water discharge, w is the channel width, D is the water depth), S_e is the energy gradient. In order to compare the hydraulic roughness height and the riverbed-surface unevenness height, the riverbed height before water flow was measured with a laser sand gauge. The measurements were taken longitudinally at every 5 mm. The measurements were taken at three points: 0.15 m away from the right wall, the centre of the channel, and 0.15 m away from the left wall. The standard deviation representing the topographic roughness σ_br was obtained by subtracting the mean slope from the riverbed elevation (Johnson and Whipple; 2010). 2.4 Measurement of dimensionless critical shear stress on bedrock To measure the dimensionless critical shear stress of grains on completely bedrock portion, i.e. τ_(*cb), 30 gravels of 5mm diameter each, were placed on the flume floor at intervals of 10 cm or more to make sure that there was no shielding effect between the gravels (there was shielding effect due to unevenness of the bedrock). Next, water flow was supplied at a flow discharge that no gravel moved, and was slowly increased to a flow discharge at which all the gravels moved. The water level and the number of gravels displaced were measured and recorded for each flow discharge. These measurements were performed for all the 5 bedrock surfaces. We calculated the dimensionless shear stress

τ_* (=(DS_e)/Rd), here R is the specific gravity of the submerged sediment (1.65). We defined the critical shear stress was τ_(*cb) is the weight average of τ_* using the number of displaced gravels. 2.5 Validation of alluvial cover Different amounts of gravel (5mm, hereafter called as sediment) was supplied manually while the flow rate was kept constant at 0.03 m3/s. The alluvial cover ratio was measured once equilibrium state was achieved. Once the areal fraction became stable in qualitative observations and the variation of hydraulic roughness of mixed alluvial – bedrock bed k_s calculated from the observed water depth was decreased despite sediment being supplied, we considered that the experiment has reached its equilibrium state. The sediment supply amounts and other experimental conditions for various cases are provided in Table 1. Each run has multiple cases, each with different sediment supply and time duration. Each case was performed unless the P_c became constant. The gravels were supplied from Run-0 of no sediment to Run-4∼5 of completely alluvial cover. The Run-0 with no sediment supply in each run represents the bedrock-roughness measurement experiment explained in section 2.3. For each roughness condition, initially, we supplied sediment at the rate of 3.73x10-5m2/s and observed the evolution of Pc. If Pc≈1, the sediment supply was approximately reduced by 1.5 times in the subsequent run, and then the sediment supply was further reduced to 2 times and 4 times in subsequent runs (example: Gravel30, Gravel50 and Net4). In roughness conditions where sediment supply of 3.73x10-5m2/s resulted in Pc≈0, the sediment supply was increased by 1.25 or 1.5 times and 2 times in the subsequent runs (example: Gravel5 and Net2). However, for ease of understanding, we will present each experimental run in ascending order of sediment supply rate. Equilibrium conditions were achieved after 2-4 hours of sediment supply. The alluvial cover was calculated at the end of the experiment, using black and white photographs of the flume by taking the ratio of the number of pixels. The water level was measured and recorded every hour at the centre of the channel, to calculate the hydraulic roughness during and at the end of the experiment. Bedrock topography with alluvial cover was also measured with a laser sand gauge. Since bedrock topography without alluvial cover has been measured in section 2.3, we can calculate the alluvial thickness from the difference of the two data.

Comments by line

9 The stated aims in lines 79-82 say something different. Note that the abstract is not part of the article, but a summary of it. As a consequence, it should be possible to read abstract and article independently. We have tried to change the abstract.

26 It does not make sense to mention Cowie et al. and Mishra et al. in the same breath as is done here; they worked at fundamentally different scales. Line 42: We have made the changes. Please see comment 2

27 Cowie et al. did not show this, they used plotted incision rates against the ratio of incised and total drainage area! Line 42: We removed Cowie et al. from this line . Please see comment 2

30 See also Wohl and Ikeda 1997. Line 44: Added in new manuscript. . Please see comment 2

32 There are plenty of other field studies working at a similar scale that are omitted here. Section 1: We have included several new literatures. . Please see comment 2

38 The linear model was actually first proposed by Sklar and Dietrich 1998 (cited elsewhere). Line 85: We have included the reference for Sklar and Dietrich 1998. . Please see comment 2

40 It would be good to explain the rationale behind the function: it is the most simple connection between the end points of no cover at no supply and full cover at supply equal or exceeding the transport capacity. Line 85: We included this . Please see comment 2

45 These papers give a more differentiated view then reported here. We have deleted the papers from this line, and have explained in detail in 3rd paragraph in Introduction. . Please see comment 2

57 It would be good to explain the rationale here. The exponential equation was actually derived for a mass ratio using a probabilistic argument, and equation (2) was obtained by assuming that the mass ratio is equal to the ratio of supply to capacity. The latter assumption was demonstrated to be incorrect by the analysis of Turowski and Hodge 2017. Line 89, Line 145: We have revised accordingly.

1.1 Previous Models for Sediment Cover One of the simplest and first models to incorporate effects of sediment availability and transport capacity of the channel was introduced by Sklar and Dietrich (1998; 2004). According to saltation-abrasion model proposed by Sklar and Dietrich (1998; 2004), the alluvial cover P_c increases linearly with the ratio of sediment supply to sediment transport capacity q_bs/q_bc , i.e. in absence of sediment supply, the alluvial cover is absent. However, when sediment supply becomes equal to or exceeds the transport capacity of the channel, the channel bed is fully covered. In order to express the non-linear relationship between P_c and q_bs/q_bc , Turowski et al. (2007) proposed a model that considered the cover effect as an exponential function of the ratio of sediment flux to sediment transport capacity. The model uses a probabilistic argument i.e., when sediment supply is less than the capacity of the channel, grains have an equal probability of settling down over any part of the bed. Also, the deposited grains can be static or mobile. These models however lack the statement of sediment mass conservation. A group of models utilise entrainment/deposition flux or Exner equation for sediment mass conservation (Turowski, 2009; Lague, 2010; Inoue et al., 2014;2016;2017; Nelson and Seminara, 2012; Hodge and Hoey, 2012; Johnson, 2014; Zhang, 2015; Turowski and Hodge, 2017). Turowski and Hodge (2017) generalized the arguments presented by Turowski et al. (2007) and Turowski (2009), and proposed a reach- scale probability-based model that can deal with the evolution of cover residing on the bed and the exposed bedrock. Turowski (2018) proposed a model and linked availability of cover in regulating the sinuosity of the channel. Lague (2010) employed Exner equation to calculate alluvial thickness with respect to average grain size d. Their model however lacks the tools effect for bed erosion. Recently, Johnson (2014) and Inoue et al. (2014) proposed

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reach-scale physically-based models that could encompass the effects of bed roughness in addition to alluvial thickness. Inoue et al. (2014) also conceptualised 'Clast Rough' and 'Clast Smooth' bedrock surfaces. A bedrock surface is clast-rough when bedrock hydraulic roughness is greater than the alluvial bed hydraulic roughness (supplied sediment), otherwise, a surface is clast-smooth i.e. when the bedrock roughness is lower than the alluvial roughness. Inoue et al. (2014) and Johnson (2014) clarified that the areal fraction of alluvial cover exhibits a hysteresis with respect to the sediment supply and transport ratio in a clast smooth bedrock channel. They described that along with rapid alluviation, perturbations in sediment supply can also lead to rapid entrainment. Whether the bed undergoes rapid alluviation or rapid entrainment is determined by the bed condition when perturbations in sediment supply occur. If the perturbations occur on an exposed bed, it undergoes rapid alluviation, conversely, when perturbations happen on an alluviated bed, it undergoes rapid entrainment. Zhang et al. (2015) proposed macro-roughness saltation-abrasion model (MRSA) in which cover is a function of alluvial thickness and macro-roughness height. Nelson and Seminara (2012) proposed a linear stability analysis model for the formation of alternate bars on bedrock bed. Inoue et al. (2016) expanded Inoue et al. (2014) to allow variations in the depth and width of alluvial thickness in the channel cross-section. They further modified the numerical model (Inoue et al., 2017a) and implemented the model to observe changes in a meander bend. Hodge and Hoey (2012) introduced reach-scale Cellular Automaton Model that assigned an entrainment probability to each grain. The assigned probability of each grain was decided by the number of neighbouring cells containing a grain. If five or more of total eight neighbouring cells contained grain, the grain was considered to be a part of the cover, otherwise, it was considered an isolated grain. They suggested that rapid alluviation occurred only in cases when isolated grains were more than the cover on the bed. Also, they advised a sigmoidal relationship between q_bs/q_bc and 1-P_c. Aubert et al. (2016) proposed a Discrete-Element Model where they determined P_c from the velocity distribution of the grains. If the velocity of a grain is 1/10th or lower than the maximum velocity, the grain settles as cover on the bedrock surface. The model, however, cannot deal with non-uniform velocity fields and hence cannot predict results for varying alluvial cover. Except for the Lagrangian description models that track individual particles (i.e., Hodge and Hoey, 2012; Aubert et al., 2016), the Eulerian description models are roughly classified into four categories; the linear model proposed by Sklar and Dietrich (1998, 2004), the exponential model proposed by Turowski et al. (2007), the probabilistic model proposed by Turowski and Hodge (2017) and the roughness models proposed by Inoue et al. (2014), Johnson (2014), Nelson and Seminara (2012) and Zhang et al. (2015). In this study, we focus on a detailed study of the similarities and differences among the Eulerian description models proposed by Sklar and Dietrich (2004), Turowski et al. (2007), Inoue et al. (2014), Johnson (2014) and Turowski and Hodge (2017). We compare the efficacy of these models from comparisons with our experimental results. In addition, we apply the roughness models (Inoue et al., 2014; Johnson, 2014) to the experiments conducted by Chatanantavet and Parker (2008) in order to analyse the effect of bedrock roughness on alluvial cover in a mixed bedrock - alluvial river with alternate bars.

77 The Turowski and Hodge model is a generalized version of the arguments presented by Turowski et al. 2007 and Turowski 2009. Line 96: Turowski and Hodge (2017) proposed a reach- scale probability-based model that can deal with the evolution of cover residing on the bed and the exposed bedrock. Turowski 2018 proposed a model and linked availability of cover in regulating the sinuosity of the channel.

79-82 Here, you need to lay out the objectives and aims of the paper. Note that the statements here do not agree with the statements made in the abstract (line 9). Line 123-131 “Except for the Lagrangian description models that track individual particles (i.e., Hodge and Hoey, 2012; Aubert et al., 2016), the Eulerian description models are roughly classified into four; the linear model proposed by Sklar and Dietrich (1998, 2004), the exponential model proposed by Turowski et al. (2007), the probabilistic model proposed by Turowski and Hodge (2017) and the roughness models proposed by Inoue et al. (2014), Johnson (2014), Nelson and Seminara (2012) and Zhang et

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al. (2015). In this study, we focus on a detailed study of the similarities and differences among the Eulerian description models proposed by Sklar and Dietrich (2004), Turowski et al. (2007), Inoue et al. (2014), Johnson (2014) and Turowski and Hodge (2017). We compare the efficacy of these models from comparisons with our experimental results. In addition, we apply the roughness models (Inoue et al., 2014; Johnson, 2014) to the experiments conducted by Chatanantavet and Parker (2008) in order to analyse the effect of bedrock roughness on alluvial cover in a mixed bedrock - alluvial river with alternate bars."

137 This is only one out of a family of equations that they derive. Three analytical examples, using different assumptions for their P-function, are given in their eqs. 30-32 (the one presented here is eq. 30). Other options (for example, parameterizing the P-function using the cumulative beta distribution) cannot be expressed in a closed form, but may also be interesting to test. Obviously, the authors can make a sub-selection of the family of models proposed by Turowski and Hodge, but they should justify their choice.

Line 217: Their model also provides two other analytical solutions (Equation 30,31 in Turowski and Hodge, 2017), however we are employing Equation 12 in this study as the equation does not contain any parameter with obscure physical meaning and all the parameters can be calculated in laboratory or analytically.

140 Not quite accurate, this depends on the circumstances. Line 217: We removed this statement.

141 The channel adjustment is not relevant for the present paper. Line 217: We removed this sentence

239 Lague, 2010, also used gravel layer thickness in a slightly different formulation. Additional literature on the cover effect is listed below. I have not included literature where cover-dependent erosion models were implemented in landscape evolution models. You are welcome to contact me if you have trouble locating any of the articles: We

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have tried to include the suggested literature and other literature that we found suitable.

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