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Interactive comment on "Alluvial cover controlling the width, slope and sinuosity of bedrock channels" *by* Jens Martin Turowski

Anonymous Referee #1

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Overall summary:

'Alluvial cover controlling the width, slope and sinuosity of bedrock channels' by J.M. Turowski proposes a new, process-physics based, model for the erosion, morphology, and scaling of bedrock river channels at steady-state conditions. It is a well-written, detailed, and innovative piece of research that fits strongly within the realms of Earth Surface Dynamics and I believe would make an excellent contribution to the fluvial geomorphology community. The manuscript is the first, to my knowledge, to develop a model that considers the physics of the processes that generate meandering and sinusoity in bedrock, and the manuscript essentially has two parts: model development (section 2) and model testing against field observations (section 3). A comprehensive review (Lague, 2014) set out the fundamental requirements for any successful bedrock

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river modelling approach and the author here tests his new model against these requirements, as well as two additional relations specifically for channel sinuosity observed in the field. The new model performs well, with the scaling exponents of the new model for slope and width matching the relatively broad range found in field data (Table 1). The model also finds a scaling of sinuosity that agrees with observations of discharge variability and erodibility in previous work.

In the discussion, the advantages of the new modelling approach are highlighted against existing approaches, and some implications of the new method for one of key applications of bedrock river erosion modelling; stream-profile inversion to determine the history of tectonic uplift or fluvial erosion rates. These aspects of the manuscript are important, demonstrating the implications of the new model for the fluvial geomorphology community rather than simply presenting the new model.

While I do not have any problems with the proposed model itself, and definitely think the work is appropriate for publication in Earth-Surface Dynamics, there are several relatively minor details related to the presentation of the work that I believe the author should address in order to help the reader engage with the work and to maximise the potential impact. These are discussed below, followed by some minor detailed comments (e.g. typographical errors).

Detailed points:

I feel that the manuscript would benefit from some additional figures and visual representation of the work, particularly in the introductory and model development sections. The text of the manuscript does a good job in explaining the proposed framework of the model, but I think it would help the reader if this was also represented in a conceptual figure in order to visualise the main aims of the proposed modelling approach, the definition of the important parameters (i.e. d).

For example, a top view of a channel showing an idealised bedrock meander showing the development of sinuosity through the path of bedload detaching from flow lines to

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impact the outer bank would make a nice simple addition to the Introduction (Section 1). Immediately the reader would understand the potential importance of bedload sediment transport in driving sinuosity, and help give further justification for developing the new model with bedrock cover as the key parameter (Page 4, Line 6). Another example of a potential new figure could explain the conditions required for steady-state width to develop (in section 2). On Page 5, Line 9, the text even states 'for the purposes of illustration', but there is no visual illustration. There could, for example, be one panel of a figure where d < W, and the channel is actively widening, one where d $\sim$ W and one where d > W, and bedload impacts have reduced and channel widening ceased. Such figures would help the reader visualise the background to the proposed modelling approach, and complement the description of the processes currently explained purely in the text (and equations).

The other main point is associated with the structure of the manuscript; in particular, the location of the section where the new modelling approach is compared to existing approaches (Section 4.1). Section 4.1 does a good job of identifying the gaps and weaknesses associated with existing approaches, and how there remains a need to develop and use an approach that is purely physics-based, without assumptions. I think some of these elements could be moved to the introduction, as additional justification for the development of a new model. The current introduction mainly focuses on the sinuosity problem, yet this is just one of three parts of the model (alongside more general scaling of width and slope). A suggestion to the author could be to take elements from the initial part of the discussion and integrate it into the introduction, providing a more comprehensive discussion of the bedrock modelling problem that the new approach goes on to tackle.

Developing from this last point, due to the current structure of the paper, it feels like section 4.3 is tagged on at the end of the manuscript. This section is really important and interesting, and potentially of wide interest to readers beyond the immediate field of bedrock erosion modelling, towards wider landscape evolution applications. If the

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paper introduces the current issues with existing modelling approaches (current section 4.1) earlier, it could also discuss the potential issues associated with the selection of the scaling exponents m and n for applications of bedrock modelling in landscape evolution studies (i.e. stream profile inversion). This could then potentially give section 4.3 in the discussion more impact, as the reader is already aware of the importance of need to accurately constrain the values of m and n, and the discussion can highlight the differences between those commonly used in landscape evolution studies and the values identified using the new modelling approach. This is just a suggestion to potentially help develop the implications of the new modelling approach for wider landscape evolution problems.

Specific points (typographical errors etc).

Page 5, Line 10: Insert ‘to’ between ‘Due’ and ‘frequent’.

P6, L22: ‘river’ should be ‘rivers’

Figure 2: Typo of ‘section’ in bottom panel label.

P13, L9: ‘adjust’ should be ’adjusts’

P23, L17: space should be inserted to ‘Ferguson,2007’

P25, L14: ‘Storm strike frequency’

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