Responses to Reviewers' Comments

From the editor,

You are kindly asked to respond to the contributions of the discussion, in particular to the referee comments (RCs), by posting author comments (ACs). Thereby, it is sufficient to post one AC only by starting a new discussion thread. If you would like to reply to more than one comment, please reply to the first one and you will then have the option to either post additional ACs or to co-list your AC in response to other comments.

Anonymous Referee #1

Received and published: 16 January 2019

The paper reports some qualitative aspects of anabranch confluence kinetics in braided rivers based on a computational morpho-dynamic model. This approach to describing and analyzing confluence dynamics is new and I am not aware of any similar published work. This topic has been approached previously using field observations and physical modeling. The paper contains 5 itemized conclusions. None of them are new and some have been well known in the literature for 20 years or more, including from some of the papers cited in the manuscript. For that reason alone I cannot support publication of the paper. However, the fact that the dynamics can be reproduced in a computational model is very useful, in which case the paper could be re-written to focus on the ways in which the model reproduces known aspects of confluence morphology and dynamics, and perhaps any observed differences for the sand bed case.

Anonymous Referee #2

Received and published: 4 February 2019

This manuscript describes the set-up and execution of a numerical model to simulate the morphodynamics of a sand-bed river. The model parameters are based upon a river sand-bed river. The model is run for 48 days of simulation time. The subsequent bed topography predictions are used to analyse confluence dynamics. Page 4 Line 14 states that “the main objectives of the study are to quantitatively analyse changes in flow field, sediment concentration and bed elevation at typical confluences, compare them with those observed in natural rivers, and investigate evolution processes at confluences and the controlling factors.” Sections 3 and 4, which describe and discuss the results, are written in a fairly general style; the data presentation and analysis lacks the rigor that is necessary to investigate the manuscript’s objectives. There is a dearth of quantitative comparison to natural rivers and the single simulation does not provide.

Anonymous Referee #3

Received and published: 15 February 2019

The manuscript presents an investigation on confluence dynamics in braided rivers using a 2D model. The confluence evolution is one key process in braided rivers, and the 2D numerical model is a kind of useful tool to investigate the confluence dynamics. However, less novelty can be found regarding both modelling and mechanics of confluence process. For the model, in which six fractions are used for sediments with size from 0.0025 to 0.25mm, the interaction among fractions should be significant, but it is not clear how to deal with them and whether the cohesive is taken into account. For the results and discussion, outputs of simulation are just given directly with very limited contribution to the related knowledge.

Responses from the author

Thanks for the suggestions. We added a brief discussion section to the manuscript to state the contributions of the present work and discuss the way how the model reproduces the confluence morphology and dynamics. Please see page 18, line 5 to page 19, line 17 in the revised manuscript, also as follows.

“It is still not clear what processes are essential for a model to produce a braided pattern. The key elements in our model includes basic hydrodynamic and sediment transport principles, a multiple fractional method for graded sediments, a multiple layer arrangement for vertical sorting process, and deposition dominated process. Nicholas

(2013) proposed that the parameterizations of secondary circulation and local bed slope effects on sediment transport are key controls on bar and bifurcation evolution, but in our model these effects are not included, though both models concentrate on large braided rivers with sand-bed and include bank erosion scheme and momentum conserving hydrodynamic model. Nonetheless, it is acknowledged that graded sediment division into multiple fractions is essential for models to represent the non-uniform sediment transport in real rivers, because sediment entrainment and transport are non-linearly related to bed shear stress (Mosselman, 2012; Iwasaki et al., 2016). This is certificated in our model which produced a more realistic braided river with confluence showing similar dynamics and geomorphology to natural rivers, and recent study also includes this effect in delft 3D, illustrating its important role in predicting bed sediment deposition and erosion in braided rivers (Williams et al., 2016).

The present work studies the confluence dynamics with model simulation, and illustrates the potential to investigate morphodynamic processes with models by analyzing interaction between hydraulic condition, sediment transport and bed morphologic changes. Existing braided river models usually include the spatially explicit predictions of water depth, flow velocity, sediment transport rate and bed topography with varying water surface elevation. However, most works are focused on analyzing morphologic changes and statistical characteristics of the braided pattern or local units (e.g. Schuurman and Kleinhans, 2015), or on predicting the multiple flow routines in real rivers (Williams et al., 2016; Schuurman et al., 2018), mainly because the model ability is still considered to be limited in representing the complicated processes in natural rivers. Nevertheless, river simulation works have benefited from discussing morphodynamics based on hydraulic interactions between flow and floodplain. For example, Harrison et al (2015) quantified the flow exchanges between the river channel and its floodplain in the process of a chute formation with a morphodynamic model, and Wu (2007) well predicted the flow field in the lower braided reaches of the Yellow River. As the representation of models in physical processes that are critical to channel morphodynamics is improved, it is be possible for future research work to seek to investigate morphodynamics in braided rivers by numerical simulation.”

The purpose of this paper is to discuss the confluence dynamics based on quantitative data provided by the numerical simulation. We changed the objective to "Based on quantitative data provided by the numerical simulation, the main objectives of the study are to analyse changes in flow field, sediment concentration and bed elevation at typical confluences, compare them with those observed in natural rivers, and investigate evolution processes at confluences and the controlling factors", see lines 14 to 18, page 4. The result sections provide some comparisons with natural rivers relating to the processes and general morphology at confluences. More quantitative comparisons with natural rivers can be found in Yang et al (2015). The scour depth pattern at confluences compared to natural rivers is given as an example in Figure 1r. In Figure 1r, a state-space approach was used to assess the spatial characteristics in the river confluences with scour depths. The state-space pattern was reconstructed using a series of values of scour depth by plotting each value versus the previous value at its neighbourhood upstream cross section (Doeschl et al., 2006). When the state plot moves from one point to the successive points and eventually forms a closed loop, it records the information on spatial ordering. The smoothly stretched long loops shown in this plot indicate the deterministic downstream effect, i.e. sedimentation zones with relatively shallow flow are often separated by reaches with flow deeper and more confined.

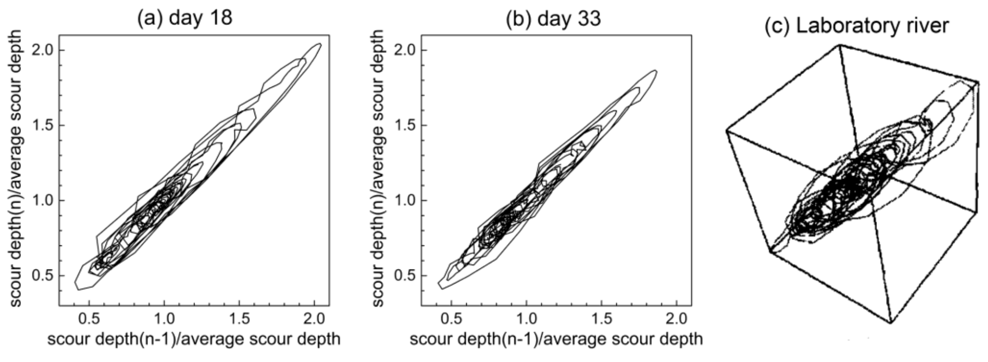

Figure 1r State-space plots of scour depth series for days (a) 18 and (b) 33; (c) 3-D state-space plots of a laboratory river

In the model, sediments were divided into six fractions, with the particle size ranging from 0.0025 to 0.25mm. Considering the hydraulic condition and the actual situation in the lower reaches of the Yellow River, only suspended sediment load is considered in the model. Cohesion effect between sediments is not included in the model. To consider the influence of bed sediment composition on the overall transport process, the riverbed is divided into multiple layers to represent the spatial and temporal variations of sediment gradations of the loose layers at the sediment water surface. Except the two equations listed in the manuscript, key equations describing the sediment transport are listed as follows, with more details of the model can be found in Zhou and Lin (2006), Zhou and Lin (2008), Yang et al (2015) and Yang (2013). The simplified formula for calculating the total transport capacity for the existing suspended sediment, $\Phi(\omega_s)$, is given as:

$$\Phi(\omega_s) = K_1 \frac{\gamma_m}{\gamma_s - \gamma_m} \frac{\bar{u}^3}{gH\omega_s} \tag{3}$$

where K_1 is a coefficient; γ_m = specific weight of water mixed with sediment; $\bar{u}$ = depth-averaged flow velocity; $\omega_s = \sum p_k \omega_k$ = average fall velocity of suspended load, with p_k = percentage of the kth size fraction of suspended load. The transport capacity in equation (2) for size fraction k, ϕ_k, can be calculated by

$$\phi_k = \sigma p_k \Phi(\omega_s) + (1-\sigma) p_{bk}^e \Phi(\omega_k) \tag{4}$$

where σ = min($S/\Phi(\omega_s)$,1); $S = \sum s_k$; $p_k = s_k / S$; and p_{bk}^e is the effective percentage of the kth size fraction sediment in bed layer to be suspended.

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