Answer to Dr.Kieran Dunne

Text in black is the comments from referees

Text in blue is the author's response

General comments:

This manuscript presents a novel, potentially quite powerful methodology to extract the formative discharges of ungauged, alluvial rivers, utilizing a combination of an innovative remote sensing technique coupled with a mechanistically-based relationship be-tween river channel width and water discharge from threshold channel theory. Overall,I like this paper. I think it demonstrates a strong linkage between analysis of remotely sensed data and mechanistic theory, allowing for improved understanding of the processes at play in environment where it might be more difficult to employ the standard suite of direct empirical measurements - fluvial geomorphologists working on Martian channels has been doing this for years quite successfully. I find this manuscript to be in good shape overall. I have do have a few minor questions/clarifications that I have outlined below

Specific comments:

Line 98: When you are defining your variables, you set your threshold Shields parameter equal to 0.3. This is an order of magnitude greater that the more standard range(0.03-0.05) that is usually observed for grains/channels under the flow conditions found in your typical natural river. I am not criticizing the usage of this value in the model, but I believe that it would be beneficial to readers to clarify this discrepancy. The first two authors have published papers where they employed the same threshold model on rivers on the Kosi Megafan and rivers in the Bayanbulak Grassland (this reviewer is incredibly envious of their field sites!), but have used threshold Shields parameter values of 0.3and 0.04, respectively. Given that the critical shear stress/shields stress is a physical parameter that can be either measured directly or calculated based upon measurable grain size data, I believe that it would be worth explaining departure from the more commonly used 0.03-0.05 values, or at least stating that the usage of this offset 0.3 value has been shown to be effective for explaining the geometry of the category of rivers that the ones used in this study fall under.

We agree that the value we use is large and acknowledge that there is a misunderstanding here. We have clarified this in section 3 in the revised manuscript. The sediment is in the fine sand-silt range and thus one expects values of the critical shields stress to be much higher then the 0.03-0.04, value commonly used for gravel bed rivers. We propose to add the following paragraph to explain our choice of value.

"Typical grain size of the sediments of the Himalayan Foreland rivers is order of $d_s = 100 - 300 \mu m$. Thus the dimensionless grain size reads;

$$D^* = \left(\frac{d_s^3 g \rho_s^2}{\eta^2} \right)^{1/3} \simeq 1 - 6$$

where $g = 9.81\ m/s^2$ is the acceleration of gravity, $\rho_s = 2650\ kg/m^3$ is the sediment density, and $\eta = 10^{-3}\ Pa.s$ is the dynamic viscosity of water. In this range of values the critical shields number θ_t is on order of $\theta_t \sim 0.1$ with a maximum around 0.3 (Julien, 1995; Selim Yalin, 1992). Delorme et al. (2017) recently obtained an experimental value of $\theta_t \sim 0.25$ for silica sands of size 150 μm. We therefore took the upper value of 0.3 as a conservative estimate. Taking lower values of θ_t such as the classical 0.1 would lead to a slightly better match between the theoretical prediction and the data but does not lead to any significant change in our conclusions."
Figure 4: The panes that should show both the binary and raw images are empty, am I missing something? Maybe just my computer acting up, but I tried downloading the PDF a few times with no effect.

This is probably an issue of image format. In the revised manuscript, we have replaced this image with an appropriate format.

Line 200: How are the histograms skewed? Is the skewness a result of natural variation in thread width or error in the cross-section selection?

To address this we have modified section (5.2) in the revised manuscript to explain skewness of the width histogram. This skewness mainly results from the natural variability of width along the threads and also due to the error in the cross-section extracted from images, particularly at the location where curvature of a threads is high. We have also included a histogram (Figure 1) in the manuscript (Fig.8) to show the distribution of threads width in a braided river.

Line 201: What is meant by "post probable?" Median? Modal?

Since the width of threads varies significantly along its course, their probability distributions are skewed. To take this skewness into account, we use the most probable width (W_m) as a representative value of the width. This value corresponds to a geometric mean of the distribution. To illustrate this we have included a figure (1) in the revised manuscript (Fig.8) to illustrate the probability distribution of width in a braided river. Red vertical line shows the geometrical mean of thread's width.

Line 210: Could you explain a bit more how you got from equation 4 to equation 6,even if you put it in the appendices? Where does the sqrt(gd) come from?

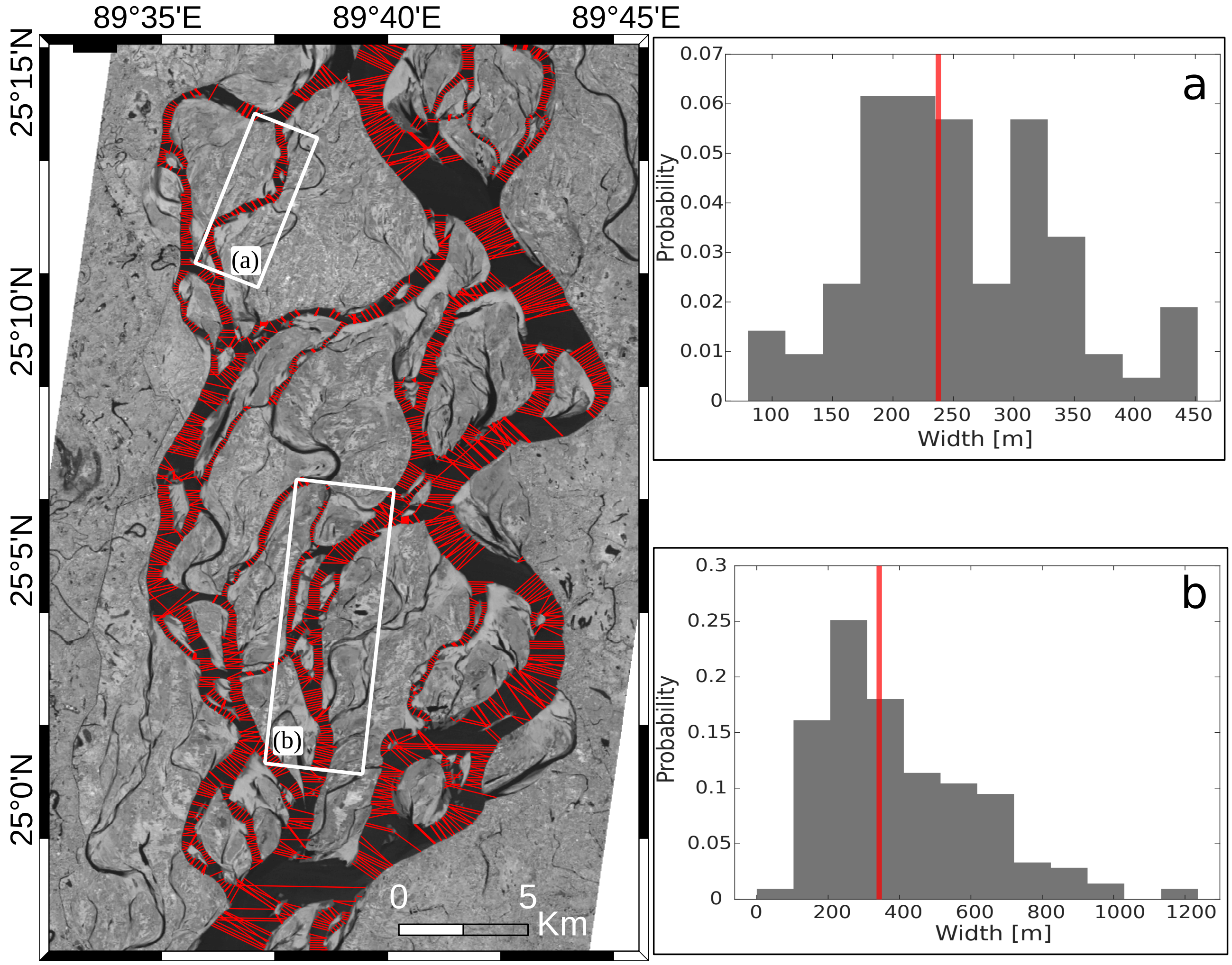

Figure 1: Distribution of thread's width measured across two different reaches in a braided river. Vertical line in red shows the most representative width that corresponds to geometric mean.

Thank you for highlighting this. We have rewritten the equation 4 in the dimensionless form as given below. This clarifies how equation 6 is obtained from equation 4.

$$\frac{W}{d_s} = \left[\frac{\pi}{\mu} \left(\frac{\theta_t (\rho_s - \rho_f)}{\rho_f} \right)^{0.25} \sqrt{\frac{3C_f}{2^{3/2} \mathcal{K}\left[1/2\right]}} \right] Q_*^{0.5} \tag{1}$$

where $Q_* = Q_w / (d_s^2 \sqrt{g d_s})$ is the dimensionless water discharge, d_s is the grain size, $\rho_f \approx 1000\,\mathrm{kg\,m^{-3}}$ is the density of water, $\rho_s \approx 2650\,\mathrm{kg\,m^{-3}}$ is the density of quartz, $g \approx 9.81\,\mathrm{m\,s^{-2}}$ is the acceleration of gravity, $C_f \approx 0.1$ is the Chézy friction factor, $\mu \approx 0.7$ is the Coulomb's coefficient of friction, $\mathcal{K}(1/2) \approx 1.85$ is the elliptic integral of the first kind, and $\theta_t \approx 0.3$ is the threshold Shield's parameter.

Line 230: Okay so here is where I start to reflect and have a few structural problems with the paper. I think a lot of this material discussing the formative discharge and its control on channel morphology needs to be made earlier on in the paper, either in the introduction or at the point where the authors introduce equation 4. I found myself a bit confused when I was reading the results section (specifically Fig. 8) where estimates of monthly discharge were being made within a threshold channel geometry theoretical framework that isn't really meant to reflect the month to month flow width-discharge relationship, and it took me a while to realize that the main point is that the model does a good job at recognizing formative discharges, but does not do so well when it comes to recognizing discharges below that. I think that the clarity of the manuscript could be improved if the authors clearly introduced earlier on that the goal of the remote sensing analysis coupling with theory would be to identify the formative discharge of the channels. I think this might clarify to the reader exactly what their coupling of threshold theory and satellite imagery analysis is capable of producing.

Thank you for the suggestion. We have added a paragraph in section 3 (morphology of alluvial rivers) to bring more clarity on the research problem we are addressing. In this section, we have briefly introduced the concept of formative discharge that forms the geometry of natural alluvial rivers. Further we have highlighted how our knowledge of the morphology of a threshold channel can lead us to assess discharge that sets the geometry of natural alluvial channels by using thread's width derived from remote sensing images.

References

Delorme, P., Voller, V., Paola, C., Devauchelle, O., Lajeunesse, É., Barrier, L., and Métivier, F. (2017). Self-similar growth of a bimodal laboratory fan.

Julien, P. (1995). *Erosion and sedimentation.* Cambridge university press.

Selim Yalin, M. (1992). *River mechanics.* Pergamon.