Text in black is the comments from referees

Text in blue is the author's response

Answer to the reviewer

Summary. The authors utilize hydrograph records and satellite imagery to develop algorithms where discharge can be predicted based on the formative width of the river channel.

General comments: Overall, I have few comments as the paper is well written and conveys its results in a straightforward manner. I believe with very minor revisions this manuscript would be suitable for publication within Earth Surface Dynamics. The details provided on additional data and the methodology within the appendix are welcome.

We are thankful to the reviewer for finding this manuscript suitable for publication in Earth Surface Dynamics.

There are a few points throughout that may not be well established. Namely, that the extracted width during the wet season is a good proxy for the formative discharge. The idea that the formative discharge occurs at annual timescales has always felt like a misinterpretation of Leopold and Maddock and Wolman and Miller. It occurs at annual to multiple year timescales in temperate regions based on the frequency of events. Arid regions flood considerably less. The reasonable match between discharge from Equation 4 & 6 suggests that the flow is likely close to the formative value, but some discussion on the recurrence of formative flows within this system would be welcome.

In order to clarify our analysis we added the following paragraph in the discussion section.

"Formative discharge in the Himalayan Rivers occurs during the monsoon period at annual time scale (Roy and Sinha, 2014). This clearly reflects in the discharge hydrographs estimated from the measurement of channel's width from the satellite images. Furthermore, Métivier et al. (2017) have recently shown that non cohesive streams laden with sediments cannot have a width much larger than the width of a threshold stream before they start to braid. They also showed that, for experimental braided rivers, threads are always formed at bankfull flow, and at the limit of stability. Our hypothesis is thus that the formative discharge of threads in the Ganga plain is the bankfull discharge."

Another point of concern, though fairly noted by the authors, that could use more discussion is the non overlapping satellite images and discharge records. For some rivers they are fairly close, but others like the Chenab and Teesta have discharge records from the 1970s and images from 2014 and 2018, respectively. It is not clear that averages taken from the 1970s should be compared with measurements from current times with-out significant effort to establish that the underlying time series is non-stationary. The acknowledgement of the changes to flow due to anthropogenic modification is a step in this direction, however the step from width to discharge relies on the idea that the river is self-forming, which may not be the case in many managed and modified large rivers. If the timescale of river adjustment is relatively quick then the formative discharge always matches the width, however if adjustment to modification of the flow or climate change is slow the formative width concept estimates will lag the actual discharge. I would greatly appreciate the authors providing more insight into these issues within the discussion.

We agree with the reviewer. To address this, we plot the time series of monthly discharge recorded at the gauge station (1973-1979) and estimated from satellite images (2014-2018) for the Indus, Chenab, and Teesta rivers (Figures 1 & 2, 3 and 4). Despite a large variability, the discharge time series of Indus and Chenab rivers show a strong declining trend during the monsoon period (June-September). Whereas discharge during the non-monsoon period appears to remain constant around the mean. Figures (1 & 2) clearly show that discharge estimated from satellite images plot within the variability of the observed trend. The estimated discharge of the Teesta River also plot within the noise of observed trends (Figures 3 and 4).

Further, alluvial rivers adjust their width at relatively short time scale in response to the formative discharge. Métivier et al. (2017) suggested a "limit-channel width", a largest possible width of a stable alluvial channel. Beyond this value, channel destabilizes into a braid and readjusts the width until they reach the "limit-width". On an average this process occurs at the annual time scale in the Himalayan Foreland rivers. In the revised manuscript we have added a paragraph in discussion section to explain the monthly discharge time series of the Indus, Chenab and Teesta rivers. We have also included the figures (C1 and C2) of discharge time series in the appendix C.

A note on time series here. Is the monthly mean value representative of the actual hydrograph? The rivers are relatively large and that may be the case, however I would feel more at ease with the methodology if I knew that the hydrographs were not being under sampled to a degree that they may not adequately represent the flow in the system anymore.

For most of our rivers we could only access the monthly discharge recorded at the ground station. This is why we have considered the average monthly discharge to compare the discharge estimated from satellite images. To test whether this value is a representative of the actual hydrograph, we explore the daily in-situ discharge data of the Kosi River for years 2011, 2013, and 2014. Figure 5 shows the probability distribution of the discharge values recorded in different months. The vertical lines in red and blue are the mean and median values. Figure 5

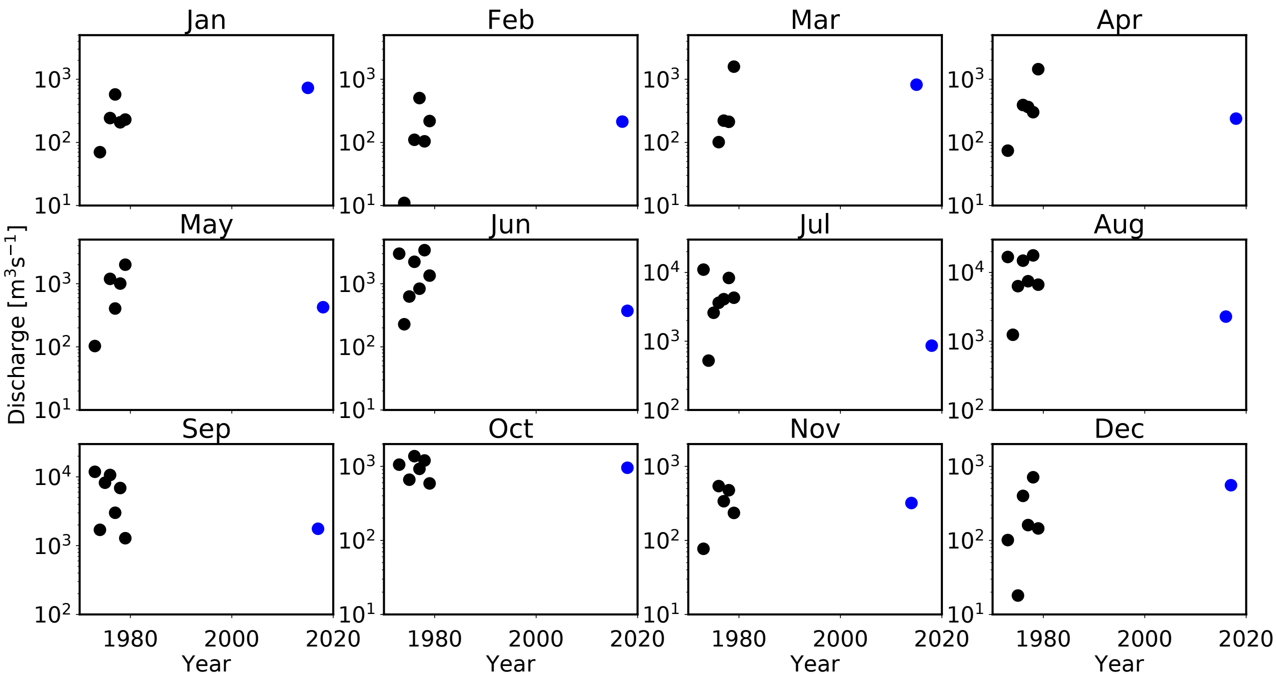

Figure 1: Time series of discharge of the Indus River (circle in black) measured at the ground station (Kotri). Circle in blue is the discharge estimated from satellite images.

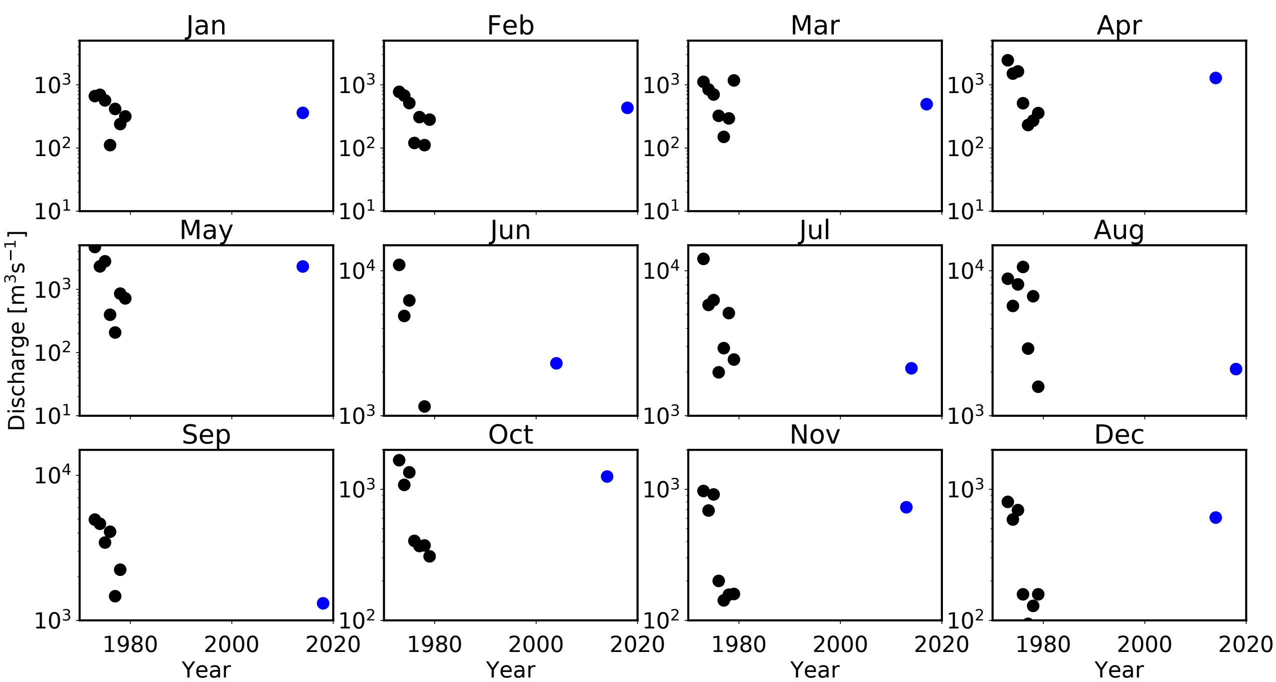

Figure 2: Time series of discharge of the Chenab River (circle in black) measured at the ground station (Panjnad). Circle in blue is the discharge estimated from satellite images.

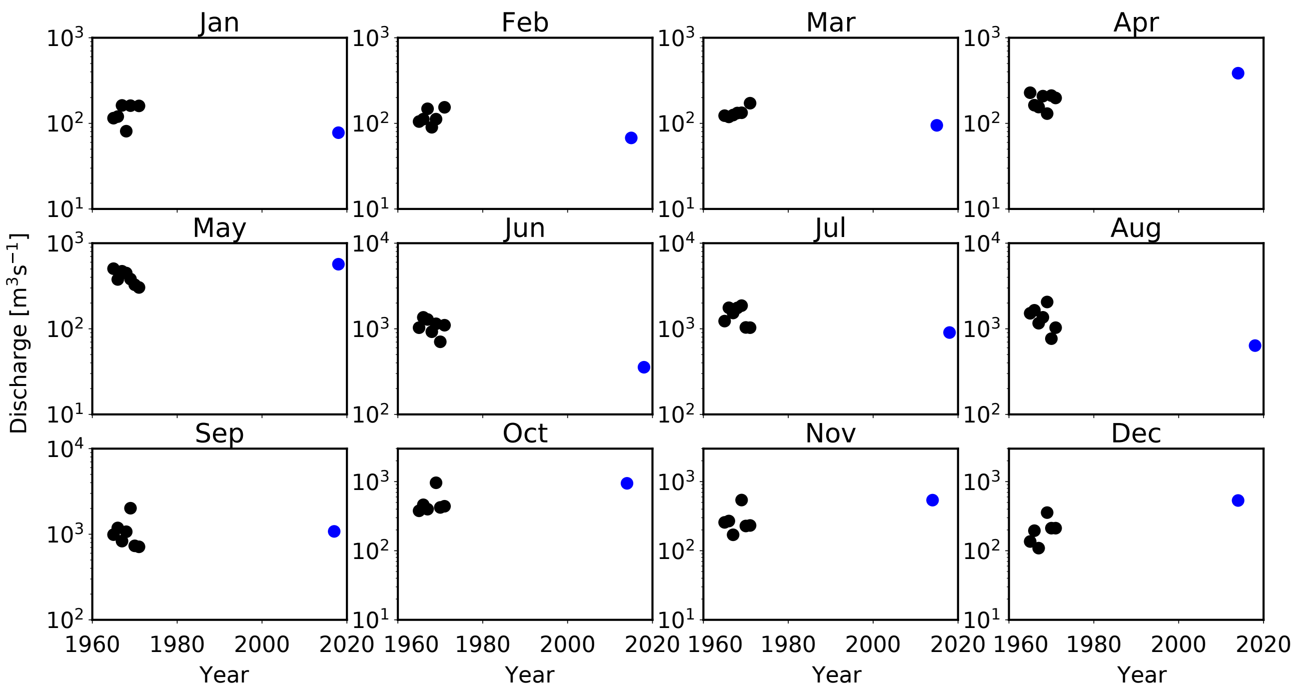

Figure 3: Time series of discharge of the Teesta River (circle in black) measured at the ground station (Anderson bridge). Circle in blue is the discharge estimated from satellite images.

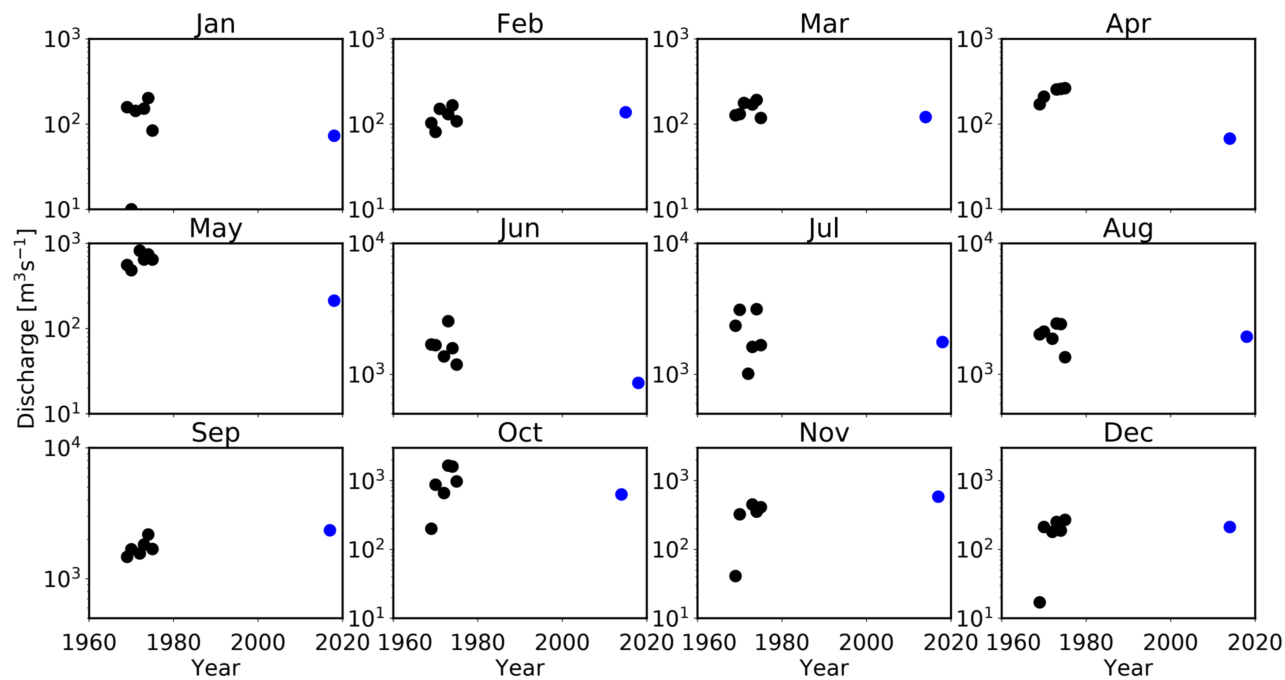

Figure 4: Time series of discharge of the Teesta River (circle in black) measured at the ground station (Kaunia). Circle in blue is the discharge estimated from satellite images.

clearly shows that the mean and median of the distribution of discharge are closely placed. This suggests monthly average discharge of the Himalayan Foreland can be used as a representative value actual hydrograph.

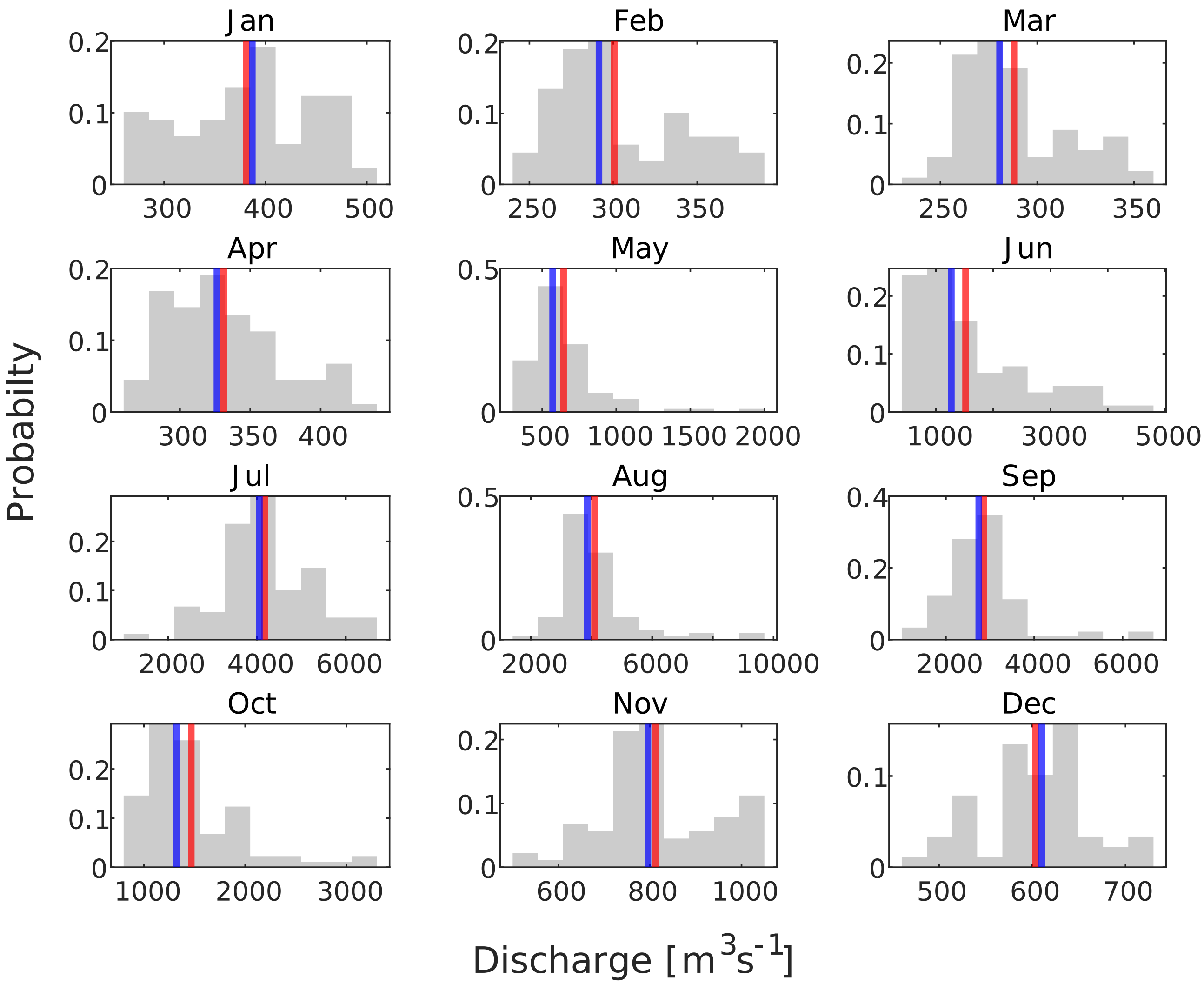

Figure 5: Histogram of daily discharge of the Kosi River measured at the Bhimnagar barrage in 2011, 2013, and 2014. Vertical lines in red and blue are the mean and median values of the probability distribution.

To better understand the utility of this method relative to other existing methods the authors should consider a comparison with the data available from Allen and Pavelsky which presumably covers many of the same rivers. Their method and the authors have similar data limitations and therefore would inspire more confidence in the current assessment and indicate potential broader applicability of the methods developed here.

In order to address this, in the revised manuscript we have included the following analysis in the discussion section. Allen and Pavelsky (2018) measured the width of the global rivers from Landsat images for the month when they commonly flow near mean discharge. In their database, Global River Width from Landsat (GRWL), for braided river they have reported the aggregated width of all the active threads. This width can not be used to estimate discharge from our regime curve that we established for the Himalayan Rivers. Our regime curve relates to the measurement of hydraulic geometry of individual threads of braided and meandering rivers (Gaurav et al., 2015, 2017), therefore it is applicable only at the thread scale. Since the resulting regime curve is non linear, estimating discharge across a transect in a braided river from the aggregated width will be different from the discharge obtained from the summation of discharge of the individual threads.

To overcome this, we have used binary water mask images from GRWL database to extract width of the individual threads. We then use these threads to estimate their discharge using our regime curve (equations. 4 and 6 in the manuscript). We observed for most of our rivers, discharge estimated from threads width extracted from the GRWL database falls within the same order of magnitude to the yearly average discharge measured at the corresponding gauge stations (Table 1). This suggests that water mask from GRWL database can be used as a first order approximation of the mean discharge of the Himalayan Foreland rivers. Also we noticed that the discharge estimated from GRWL database appears to occur during early monsoon period in June and July. Also We have we have included the (Table 1) in appendix C (Table C1) in the revised manuscript.

River	Station	$\langle Q_{\mathrm{insitu}} \rangle$ $\mathrm{m^3 s^{-1}}$	$\langle Q_{\mathrm{sat.}} \rangle$ $\mathrm{m^3 s^{-1}}$	$\langle Q_{\mathrm{GRWL}} \rangle$ $\mathrm{m^3 s^{-1}}$
Teesta	Anderson	605 ± 109	638 ± 165	408 ± 177
Teesta	Kaunia	924 ± 144	745 ± 155	400 ± 110
Kosi	Bhimnagar	1559 ± 313	1810 ± 380	2936 ± 625
Chenab	Panjnad	2500 ± 961	1275 ± 268	937 ± 344
Indus	Kotri	3745 ± 825	794 ± 162	218 ± 102
Ganga	Farakka	11477 ± 2279	10593 ± 2225	15959 ± 9616
Ganga	Paksay	12080 ± 2403	11605 ± 2438	5679 ± 3310
Brahmaputra	Bahadurabad	21751 ± 2942	21717 ± 4740	11149 ± 5122

Table 1: Annual average discharge measured at the gauge station and estimated from satellite images. $\langle Q_{GRWL} \rangle$ is the discharge estimated from binary water mask from GRWL database from Allen and Pavelsky (2018)

Specific comments: Ln. 65- A few lines explaining what the 'threshold theory' entails would be welcome here. What does the threshold theory say about rivers that allows this method to progress?

We have added a paragraph on threshold theory and its applicability in explaining the morphology of a sandy bed alluvial rivers.

Table A2-Could you add a column listing the years of satellite images on the right.These data are in table A1 as a list, but a summary would be welcome here.

Done.

References

Allen, G. H. and Pavelsky, T. M. (2018). Global extent of rivers and streams. *Science*, 361(6402):585–588.

Gaurav, K., Métivier, F., Devauchelle, O., Sinha, R., Chauvet, H., Houssais, M., and Bouquerel, H. (2015). Morphology of the kosi megafan channels.

Gaurav, K., Tandon, S., Devauchelle, O., Sinha, R., and Métivier, F. (2017). A single width–discharge regime relationship for individual threads of braided and meandering rivers from the himalayan foreland. *Geomorphology*, 295:126–133.

Métivier, F., Lajeunesse, E., and Devauchelle, O. (2017). Laboratory rivers: Lacey's law, threshold theory, and channel stability.

Roy, N. and Sinha, R. (2014). Effective discharge for suspended sediment transport of the ganga river and its geomorphic implication. *Geomorphology*, 227:18–30.