

Gewalt et al. present an impressive dataset of historical and modern drone imagery compared with nearby weather station for alluvial fans from a lithologically comparable, Dolomitic, region in the Alps (Plansee and Friedergries). What I especially found interesting, explained in further detail below, was the volumetric analysis and the consideration of precipitation intensity thresholds to initiate transport. I appreciated the author's ability to assess and discuss autogenic dynamics, often less considered, and their consideration of the upstream catchment sediment storage and connectivity to the fans. The work contains quite a lot of information where it became sometimes easy to lose the main threads/story upon the first read. Additionally, it raised a few questions for me, which I will address below section by section. I do think that it is novel, and a significant contribution in the field of fan response, especially relevant to alpine communities, that warrants publication.

Introduction:

-The author's did an excellent job succinctly summarizing a breadth of relevant literature and examples, especially focussed on the alluvial alpine fans and fluvial response to heavy precipitation. However, the introduction would benefit a lot from being broken into more paragraphs rather than a large block of text. Additionally, I think a few highly relevant and overarching fundamental concepts in the field were missing for me to better tie everything together. I think some key fluvial concepts missing that could strengthen the work (no need to use all of them, but maybe a few) would be system sensitivity and buffering, geomorphic effectiveness, effective discharge and discharge intermittency, and magnitude-frequency relationships and their impact on fluvial systems (including and beyond alluvial fans). For example, Wolman and Miller (1960), Rossi et al. (2016), Magilligan et al. (1998), or Nash (1994) discuss differences in rainfall magnitude, frequency, and how runoff translates to geomorphic work done on the landscape. A sentence or two with appropriate citations and further explanation of what can be considered as an internal/autogenic dynamic would also be beneficial to tie in better your work (e.g. Scheingross et al. 2020; Romans et al. 2016...).

Study Area:

I think that the work would benefit from including a zoomin subset or stand alone map of all of the Plansee fans at least in the appendix if not in the main text. I am aware that they are not the main focus, and that the general area is shown. Still, it was a bit surprising later as a reader when the $n=69$ or 67 (in figure 3) as there are quite a lot of catchments that were compared (not just one single or a few systems!). Realizing this actually makes the arguments and statistics much stronger than if the work was only considering the Friedergries system alone.

Methods and Data Preparation:

I found this section quite well detailed and clear. It is clear the the methodological approach was sound, well cited, and well thought out.

Results:

Figure 3: You could consider mentioning that the open circles are outliers from Plansee in the caption, but it does become evident from the text since that is the only other area you compare. It might also be worth mentioning if the data is normally distributed or skewed in some way. The box plots look very symmetrical, but mean channel slope might have a slight skewness that is a bit difficult to see upon first read in the box plots.

It seems a bit strange to me to present the figure 5 using the thresholds without first describing the intensity threshold selection and R^2 (figure 6). It could just as well go at the end of the methods or in the appendix. Yet, it wasn't a major concern for me since it is interesting and important to the confidence and understanding of figure 5. I think it would be easier to argue about including it in the results if it also included the return interval increments/estimates on the top of figure. That way the reader can visualize how the different precipitation intensity threshold's relate to the return intervals.

Figure 5: It appears that Friedergries has more peaks (e.g. 1983) in it's normalized active area than the Plansee curve? Is this truly a correlation to the higher precipitation threshold and less frequent activation or is it that more Plansee fans are being averaged together causing the lose of some details/peaks in their final plotted normalized active area?

Figure 5: The liquid sum above 30mm/d would still include the 85mm/d events, so it is interesting that including many of the lower threshold events in the 30 mm/d threshold extreme rainfall curve averages out the 1983 peak visible in the 85mm/d extreme rainfall curve. Could you address this a bit more in the discussion?

Line 319: Please refer to Figure two when mentioning Nudelgraben so that the reader can quickly know where to look to confirm where this is.

Figure 6: For Friedergries, after a threshold value of 70, the R2 appear to plateau/reach an asymptote. The 85 value may be slightly higher, but not by very much compared to the clear peak observed in the Plansee curve. Does using a threshold that produces the first adequate (e.g. $R^2=0.8$) threshold of 70 (that is a bit closer to Plansee than the 85 value) make a significant difference to the results?

Figure 9: I think this figure would benefit from listing the dates or at least the seasons above the figures. Otherwise the reader has to flip back and forth to find out what figures are associated with summer or winter. I ended up just writing it on the figure anyway.

Discussion:

General: The discussion could benefit from a little bit of restructuring to make a few main points even clearer to the reader. Referring a bit more to the result figures would also be helpful.

Section 5.1: I think the author could benefit from referring back to the figures and sub-figures more specifically during the descriptions in lines 420 to the end of the paragraph. It was difficult to know where we can visualize this. Is this visible within figure 9 or is it referring to a period outside of that plotted window? It is a bit difficult to remember what event you are referring to here since no dates were provided on many of the figures.

Section 5.2.1

Lines 429-onwards: I actually think that you describe the Plansee and Friedergries fan response to the precipitation better in section 5.5. At this point in the paper, it is still unclear what you mean by “higher susceptibility to high rainfall”. It would be clearer to disentangle frequency and magnitude a little bit more in this case. It is true that you have identified in the results that the threshold is lower, but it has not yet been fully discussed ultimately what the net effect on the fan response and stream bed are. It has also been well studied that areas that are hit and responding more frequently by moderate rainfall events, doing most of the transport work throughout a given year, can actually be less shaped at the stream bed by the most extreme events compared to a system only hit by very extreme events and no other events doing geomorphic work. Thus, an area hit by more extreme events can still be less impacted by the largest events in terms of shaping the stream bed and deposits. (see concepts from Wolman and Miller (1960), Rossi et al. (2016), Magilligan et al. (1998), or Nash (1994) suggestions from the introduction). Thus, the “higher susceptibility to high rainfall” is a bit unclear if you mean just a more frequent response to rainfall above a certain minimum threshold (clear) or more susceptible to the highest magnitude rainfall events (likely untrue whereby figure 5 1983 appears not to show this for the Plansee, lower threshold curve).

Additionally, the jump to sensitivity to supra regional and local precipitation seems to come without enough of an explanation or reference to the results to fully follow the author to this conclusion. It is not that it isn't a potentially valid statement, but rather the reader hasn't fully been guided through the discussion or tied back to the results and figures to also reach this conclusion. I recommend incorporating more of a tie in to the results and literature for further explanation for this section or combining sections 5.2.1 with 5.5 where the system is discussed in greater detail. Later, in section 5.5, you explain more specifically, that the steepness of the slopes in Plansee catchments leads to more activation of the system with a lower runoff allowing for activation with a lower threshold. After this description, then this susceptibility statement becomes clearer.

Section 5.2.2

Lines 435-436: “linear models” -please refer back to the figure 5 in the results to help the reader.
Lines 435-436: “We interpret the linear models as representing the influence of the runoff component under conditions of low or constant background sediment input.” I think that I

understand what you mean, but the phrasing is a bit problematic. As far as I understand, you could not remove or only control for periods of low or constant background sediment input. This your figure 5 figures could still include (perhaps as outliers) sediment input fluctuations as well as runoff activating the surfaces. You also follow up by discussing the impact of sediment input fluxes so you don't just purely assume that it is simply constant within your discussion. Wouldn't it be clearer to state something like: we isolated the relationship between precipitation and active area using linear models (figure 5). We primarily, interpret the potential effects on precipitation on runoff to activate the fans. In addition, precipitation can impact sediment input, which we discuss below...

Lines 440-446: Could you also discuss a bit what the difference transport lengths of Friedergries vs the Plansee fan-catchment systems could mean for the buffering and lag times between the systems? Would you have any general estimates if the response time of the two different systems are comparable or quite different?

Section 5.3:

I think Clarke et al. 2010's laboratory alluvial fan work is highly relevant to describing the incision and backfill sediment waves that you observe. Clarke et al. (2010) also describe this phenomenon as autogenic and could potentially strengthen your interpretation since the concept to sediment waves in autogenic dynamics is still somewhat new/under-described.

Section 5.4: This is more of a suggestion rather than a concern. Although it is important to clearly state limitations and concerns in the work, this section disrupted the flow for me. My favorite section was section 5.5 where I felt like a lot of concepts and conclusions from previous sections came together in your discussion. I worry that some readers may not get to that point after reading through a paragraph of limitations. I recommend that you move key sentences from the limitations to be mentioned directly at the base of sections where they are most relevant (as a sentence near the end or at most a short paragraph at the end of a given section). That way some discussion on the limitations are sprinkled into the discussion rather than disrupting the flow before the end of the discussion section 5.5. Alternatively, the limitation section could be shortened or moved to after section 5.5.

Section 5.5:

This was a very well structured discussion section and I found the discussion on connectivity and sediment storage in the catchment very relevant and interesting to understand the full dynamics in context.

Line 514: What is long-term for you? Please roughly define.

Line 520: In this case, sediment input would make more sense than sediment import.

Lines 542-560: Do you expect that the Plansee fans will also be actively responding in the summer as well in addition to the shift of activity towards the spring and autumn? (two signals regional and local on top of one another)? Or is that the shift in activity to the spring and autumn would inherently reduce activity during the summer (overprinting)? Is it just a question of scale that the large catchment is more buffered, storing sediment and only responding to the regional events and that the smaller, steep catchments respond more rapidly, but could also potentially respond to the larger regional events as well? If the Plansee fans are less responsive in the summer, why is that the case exactly when the Plansee fans are also being hit by the larger summer events as well? Could it be that the shorter response (steep slopes, shorter lengths) in Plansee fans means that they are activated more frequently and lose out on some of the impacts of the extreme events unless the extreme events exceed the threshold of the total amount of material moved at the bed by the sum of the smaller events?

Conclusions:

Thank you for your extensive body of work and I hope that these review comments are constructive and helpful for you.

References:

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- Magilligan, F. J., Phillips, J. D., James, L. A., & Gomez, B. (1998). Geomorphic and sedimentological controls on the effectiveness of an extreme flood. *The Journal of geology*, 106(1), 87-96.
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- Scheingross, J. S., Limaye, A. B., McCoy, S. W., & Whittaker, A. C. (2020). The shaping of erosional landscapes by internal dynamics. *Nature Reviews Earth & Environment*, 1(12), 661-676.
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- Wolman, M. G., & Miller, J. P. (1960). Magnitude and frequency of forces in geomorphic processes. *The Journal of geology*, 68(1), 54-74.