Response to George Allen's comments

(Responses *italicized and blue*.)

Overall:

Schwenk et al. presents a method to assign steady-state flow directions to channel links of delta and braided rivers with complex river morphologies. This information is useful for a range of biogeochemical and hydrological flux processes. The manuscript is generally well written and I find the manuscript easy to understand. I think it was a high-quality study and I appreciate that the code and datasets were made freely available. The one major problem I found with this study is that, it might be submitted to the wrong journal. It is a methods study, essentially explaining the RivGraph Python package (https://github.com/jonschwenk/RivGraph), which may not be suitable for ESD, at least according to the aims and scope of the journal. In my opinion this study is probably most appropriate for a journal like IEEE Geoscience and Remote Sensing Letters. However, that being said, if the Editor wishes to continue with the review process, I think Schwenk et al. is a nice contribution.

We thank George for the positive and constructive comments. Maarten Kleinhans (other reviewer) had the same concern: that this paper is too methods-y for Earth Surface Dynamics (ESD). We submitted this work to ESD because we believed that the ESD community is most likely to contain researchers who would find both the method and its implications interesting, although we acknowledge it is an atypical ESD submission. Accordingly, we corresponded with the Associate Editor both before and after reviews to ensure its suitability here and received a supportive response. We have also made additional efforts to appeal to a broader readership by contextualizing this research through comparisons with other work (L50-54, L60-62, L102-105), explaining the theoretical basis for DPAs when applicable (L109-119, L151-154, L170-173, L201-205, L218-223, L246-247, L253-255), and adding discussion about the implications of our results to process-form relationships across CNs (L21, L64-66, L70-71, L413-414, L437-444, L494-497).

We would also like to emphasize that this is not an overview of the RivGraph package. This manuscript represents only one piece of RivGraph, albeit one of the more complicated pieces. We intended this paper to be independent of RivGraph as the recipes described herein are only examples of possible recipes—optimized for the deltas and braided rivers we took as example cases, but hopefully generally applicable.

Major comments:

1. I think the manuscript would benefit from a paragraph in the introduction discussing other channel vectorization algorithms to provide additional context and motivation (e.g. RivaMap, RivWidth, RivWidthCloud, MERIT Hydro, etc.).

We appreciate the suggestion. As mentioned above, this paper is not intended to be a presentation of RivGraph, and therefore we prefer not to discuss in-detail the many tools available for pre-processing data. However, we do agree that it would be beneficial to the reader to be aware of available tools for preparing their channel network, so we have added some text mentioning these. We note, however, that (as far as we know), none of these tools "do it all," including resolving centerlines, network structure (links, nodes, and connectivity), and morphologic properties (width, length). L102-105.

2. Include in the intro and/or abstract that RivGraph determines the steady-state, or mean long-term flow direction. Deltaic systems are often bidirectional flow and this point was only acknowledged in pass in the Conclusions.
We have addressed this by adding a paragraph to the introduction. L36-42.

3. I think a very large potential improvement of this approach would be automatic identification of inlets and outlets and this should either be implemented into the code or acknowledged in the "Improvements and Speed" section.
This is a great suggestion and one we have spent considerable time achieving. For the methods described herein, however, we did not want to confound the thrust of this paper—automatically setting channel directions—with other pre-processing steps one may use to implement these techniques. For this same reason we have neglected to include methods of generating channel masks. However, the RivGraph package does indeed automatically find inlet and outlet nodes for braided rivers. For deltas, the lack of a linear overall flow direction (compared with a valley direction of braided rivers) and the wide range of possible delta configurations renders an automatic solution intractable. However, outlet nodes for deltas are automatically determined by providing a shoreline.

4. It appears that lakes and other non-channelized water bodies are not included in the Delta river masks. Were these removed? These features can be some of the most difficult to skeletonize and I am curious how the authors handled these features.
The methods of mask generation are described in the cited Piliouras and Rowland work. Separate masks were created for the channels and lakes, such that we could isolate the different types of water bodies for various metric calculations and inter-delta comparisons. This was done by classifying water bodies by size, such that the largest connected water body represents the channel network. We then resegmented the channel network by shape to remove lakes that were structurally connected to the channels. The non-channelized water bodies were therefore not 'removed' from the analysis in the present manuscript, but rather the masks presented here represent only the channel class. Future work includes plans to add structurally connected lakes to the network/topology, but as you point out, these features are difficult to skeletonize, and that is beyond the scope of this paper.

5. While the authors may have captured all the major sources of errors for their sample data set, applying these algorithms worldwide will likely cause a number of currently unidentified errors to be identified. I recommend noting this point somewhere in the manuscript main text (e.g. end of section)
We have added text explicitly mentioning that global application might require some recipe modification in the final paragraph of the conclusions. L502-503.

Minor comments:
1. Add how the authors identified inlets and outlets. Was this done manually? Could it be automated?
Please see the response to Major comment 3.

2. Figures:
a. Panels should be in the same order as they are referred to in the main text.
This has been fixed.
b. Figures would benefit from having labeled panels (e.g. "a","b","c", etc..).

Done.

c. Figures are sometimes mislabeled (e.g. Figure 5 is referred to as Figure 6 several times).

Corrected.

d. Figures with maps: Add North arrow(s) to maps that are not oriented North as up.

Added to Figure 1. We did not add arrows to Figure 4, as it is not intended to be a "map" figure, but rather display results.

3. If the authors wish to add an additional end-member sample, the braided section of the Congo River has a very distinct planform geomorphology and could be an additional case to test RivGraph. This idea is just a gentle suggestion, not a demand.

Thank you for the suggestion! Due to the relative similarity of large braided river morphology, we only analyzed two braided river CNs, but we expect very similar results for the Congo River as those achieved for the Brahmaputra and Indus Rivers.

L76: Islands of size 20 pixels or less were removed (filled) from all channel networks. Please justify this action.

We have added a line stating that this island-filling procedure is not strictly necessary, but reduces some of the noise by eliminating smaller channels that are relatively unimportant to the network topology. L90-91.

L87: Replace "GISs" with "GIS software packages"

We ended up removing the reference to GIS in favor of citing specific community-developed tools. L102-105.

L269: "the shortest link is selected as the one to be fixed (flipped), as DPAs are generally more certain about longer links." I probably don't completely understand but why not just flip the link with the lowest direction certainty?

The problem is that while we have certainty estimates for various DPAs, we don't know their degree of certainty relative to each other. Because of this, we can't simply select the highest-certainty prediction. Instead, we resort to link length, as we have empirically observed that the final flow direction prediction is generally more reliable for longer links. Note that this only refers to (a very small number of) cases where there are multiple options for flipping links to fix an interior source/sink.

L283: change "informations" to "information"

Done.

L421: "one second" Is this on one core or is this code paralllelized?

Added some text to clarify this is unparallelized and run on a typical desktop computer. As a side note, the recipes are generally not (easily) parallelizable because they require sequential setting of flow directions. However, the computational expense is minor enough that parallelization would not be needed, even if more complex recipes were created. L471.