

Authors response to comments from Reviewer #1

We thank Reviewer #1 for the constructive suggestions and positive comments. Our paper has two main aims: i) to describe the database and its development for existing and potential users and ii) to introduce the innovative aspects of our approach and suggest a template for database development that might be applied to other continents. Reviewer # 1 in particular responded to the second of these aims, recognizing the novel aspects of our methods that enabled us to successfully accommodate characteristic features of the Australian continent, notably the large number of endorheic drainage basins and extensive distributary drainage structures. This, reviewer #1 notes, will be of interest to readers considering similar issues elsewhere.

Specific comments

We welcome the specific comments and suggestions of reviewer #1 and respond as follows:

RC:Page 15436, line 23 to page 15437, line 1: I find the description of the global databases HYDRO1k and HydroSHEDS to be somewhat misleading. It is true that both databases offer only certain pre-defined stream networks and basin boundaries. But the mentioned limitations, in particular the fact that the available products only include stream delineations for catchments larger than 1000 or 20 square kilometers, respectively, are simply due to arbitrary thresholds that were applied by the producers. It is a rather straight-forward task to extract other stream networks or catchment subdivisions as desired by a user. Furthermore, the HydroSHEDS database offers a seamless drainage direction map, i.e. the basis for stream delineation, at 3 arc-second resolution, not 15 arc-second as mentioned in the manuscript. I suggest that these explanations are clarified accordingly. I believe, however, that this comment does not contradict the authors' general conclusion that the global databases cannot (and are not intended to) achieve the quality of the applied national data for the Australian continent.

AC: We readily acknowledge the great value of the HYDRO1K and HydroSHEDS global databases and the opportunity they provides users to derive a finer resolution stream network. We will clarify (and correct) the description of the Hydro1K and HydroSHEDS databases as suggested, noting key limitations that prompted the development of a new database for Australia. These include the lack of recognition of anabranching stream systems and the difficulties involved in identifying suitable contributory area thresholds for stream network delineation across a continent with highly variable drainage density.

RC:Pg. 15437, l. 14, and elsewhere: The reference of "Stein and Hutchinson 2014" should really be "Stein and Hutchinson in prep." and should be changed accordingly. Obviously, it is rather unfortunate that this publication describing the applied new methodology is not yet available. The same reference is used in section 3.1, and here the unavailability of the publication is even more critical. From what I understand, the described processes are designed to derive a DEM-based stream network that matches (as good as possible) the stream network of 1:250K maps, and then these two sets of stream networks are interlinked (via IDs). This is all very interesting, but without the mentioned reference it is somewhat hard to follow or verify. Maybe a few more explanations would be useful here?

AC: Stein and Hutchinson 2014 is "in prep." but this method of citation is not permitted in HESSD so it was suggested we use Stein and Hutchinson , 2014. As explained above, one of the main aims of this paper is to provide a broad overview of the methods to guide readers interested in developing a similar database elsewhere. To assist readers requiring greater explanation of the more novel aspects of our methods we will replace the reference to Stein and Hutchinson (2014) with a statement that notes that the methods employed in this manuscript significantly extend those presented in earlier material that is available online (Stein (2006) and Stein and Hutchinson (2009)) and that a full technical description of these methods is in preparation.

RC:Pg. 15438, l. 3: The authors mention that the automated procedures were combined with manual editing, and in chapter 3.1 they state that corrections were applied "as far as possible" (pg. 15439, l. 19). These diversions from fully automated procedures deserve some special attention as they make the applied methodology difficult to replicate or interpret. Maybe some additional comments can be added in the discussion section? Are manual edits unavoidable?

AC: We have recently enhanced the drainage analysis software to fully automate the procedures to remove many of the anomalies in the flow direction grid. Improvements in the ANUDEM elevation gridding program have also reduced the number of such anomalies and hence the need for corrections to the flow direction grid. We will add an additional comment to indicate that the drainage analysis procedures are now fully automated and thus more easily replicated and interpreted.

Line 19 pg 15439 We applied fully automated procedures to correct the stream network attribution where it contradicted usual conventions, for example, where a stream segment was unnamed downstream of a named stream or a 'minor' hierarchy segment was downstream of one attributed as 'major'. We will clarify this sentence and remove the phrase "as far as possible" so that it does not imply that additional manual edits were applied.

RC:Pg. 15440: The last sentence is not entirely clear to me (semantically).

AC: We will rework this sentence to try to make its meaning clearer, breaking the long sentence into two, the first describing the sub-division of the drainage basin, the second the application of the coding scheme.

RC:Pg. 15442: This page provides quite detailed regional information and explanations that are very specific for Australia. I believe this level of detail is not necessary to understand the manuscript. Is it possible to condense this section a bit? The same comment goes for pg. 15450.

AC: We will try to reduce the regionally specific information where possible. However, to describe the database for users and potential users, one of the principal aims of our paper, we think that it is important that we explain some of the key differences with the widely used AWRC River Basins.

The section on pg.15450 illustrates the range of planning and assessment tasks to which the new database, and similar databases that could be developed elsewhere, might be applied. We attempted to provide enough detail in our description of the application that a reader may understand the critical role of the database but did not present the outcomes that by necessity would be Australian focused.

RC: Pg. 15443, l. 15-16: The authors use “a modelled estimate of runoff volume rather than contributing area to discriminate the tributary and main stem” in their Pfafstetter coding. They also mention this method (“surrogate of river flow”) as an advantage in the discussion section (page 15452, line 29). On the one hand, I agree that this is an elegant solution to avoid that dry rivers with large contributing areas are (incorrectly) coded as the main stem rivers. On the other hand, this method introduces an ambiguous threshold: if the modeled runoff has any errors and requires updates in the future, it would necessitate that the entire Australian stream network is recreated and recoded. Can the authors comment on this problem in the discussion section? Can they also clarify where these runoff estimates are coming from (also in the caption of Figure 7)?

AC: We will expand the discussion to include a comment on the potential disadvantage of this method for discriminating the main stem and tributary. Any change in the model used to derive the runoff estimates, or indeed in the time period over which they were calculated, does not require that the stream network be recreated as the network delineation process depends only on the surface flow pathways determined from the DEM and the location of the channel heads. However, we agree that changes in the modelled runoff could require re-assignment of some of the Pfafstetter codings and hence the delineation of the levels of the nested catchments in some drainage basins. As suggested we will clarify the origin of the runoff estimates in section 3.2.3 and in the caption of Figure 7

RC:Pg. 15444, l. 13: The authors acknowledge that the catchment size within Pfafstetter levels (below level 9) can vary significantly. This may lead to significant inconsistencies in subsequent applications. Can the authors briefly comment on this shortcoming? Do they think it is an intrinsic problem of the Pfafstetter coding that cannot be solved?

AC: We will comment on this issue as suggested and suggest opportunities to overcome it for subsequent applications. We believe that the variable catchment size is largely a consequence of the natural variation in drainage density and basin size that occurs at a continental scale and hence is more an intrinsic characteristic of drainage basins than of any particular coding scheme *per se*.

RC:Pg. 15448, l. 8: I suggest “up- or down-stream” instead of “up or down stream”

AC: Accepted

RC:Pg. 15451, Section 4.3 (Limitations and uncertainties): I would expect that the delineation and assignment of inland sinks is highly problematic due to their ephemeral nature and the potential of bifurcations (if flooded, the sinks may overflow in different directions). I understand that there is no real solution to this problem, but can the authors mention this issue as another source of uncertainty?

AC: We will comment on the additional uncertainty due to the reliance on the ANUDEM diagnostics to locate inland sinks rather than employing a comprehensive search. However, while we may have missed some smaller sinks we are confident that those that were retained after verification are reasonably permanent features of the landscape – certainly over the time frame of years in which the database is likely to be used. We will also note that the elevation difference between alternate pour-points may be small in some cases and thus there is additional uncertainty as to which neighbouring basin a sink basin would overflow. Nevertheless, we believe the broader scale (Level 1

and 2) boundaries are robust as was evidenced by the comparison with similarly derived boundaries from other data sources.

We will also comment on the uncertainty around the location of the sub-catchment boundaries of individual stream links within the more dynamic braided and anastomosed channel networks but note that we expect that the broader scale catchment boundaries containing the stream valley will be similarly robust.

RC: Pg. 15452, l.1-11: I am not sure I understand this argument correctly. Even if streams are burned into the DEMs of the US and European databases, this does not prevent the calculation of topographic descriptors from the original DEMs (i.e. before burning). So I do not really see an important difference or advantage here.

AC: The original DEMs employed for the US and European databases do not accurately represent the location of the stream valley hence the need for stream burning. The significantly altered DEM heights in the grid cells that comprise the DEM derived stream network after stream burning, will thus produce errors in the terrain parameters that are critically dependent on the elevation values e.g stream segment slope, catchment relief, terrain curvature, etc. We will explain this issue more fully.