

NR	Comment	Response (refers to hess-2022-408-manuscript-version2.pdf)	change (in updated MS)
	<b>Reviewer1</b>		
1	the main framework that was being described was a GIS overlay, but how the different features were weighted is unclear, or I must have missed this	We describe in lines 186 to 187 (hess-2022-408-manuscript-version2.pdf): "Existing spatial data for each region forms the basis for categorising the landscape features using a rule-set based on attribute features within the spatial datasets" and lines 195-196 state: "Our approach uses a defined rule-set and priorities, which we apply to regionally available data sets to achieve a landscape classification for each of our regions. " and we then detail the rule sets in lines 200ff in the remainder of the methodology section. The resulting rule set we present in the Results as figures 2,4,5 for each of the regions. There is no weighing as such, it is a prioritisation process, which we outline in lines 215 - 221	changed to: "The classification employs a geographical information system to overlay existing spatial data for each region. The spatial data are the basis for categorising the landscape features using a rule-set to prioritise the spatial data based on attribute features within the datasets" (lines 254 - 257, updated MS).
2	refers to other papers in the methods and the result without explaining how exactly this was integrated in the current paper and was used in the framework. As a result, it is not clear how the results were actually derived. From a reproducibility perspective, I think it would be hard to replicate the results.	Citation in the <b>Methods</b> are supporting information for example to point to further details regarding the study areas, and the example datasets for the spatial data. They are not needed to understand the methods, but would be helpful for replicating the results. Citations in the <b>Results</b> are only datasets, which are needed for reproducing the work.	After first sentence starting at l266 added: "Tables 1 to 3 provide a list of citations for example datasets used in this process." for in-text clarification
3	how decisions were made about different classes, where these simply in the original data, or were those classes decided on in this study	The classes come from the data, that is they are broad statements summarising data elements. For example, Floodplain and Non-Floodplain are deliniation of floodplain areas, Groundwater dependent and non-groundwater dependent are deliniation of vegetation based on their groundwater dependency from the data.	inserted in line 294: "This resulted in a classification where the landscape classes have their origin in the spatial data sets, and included the water dependency, which was a pre-requisite of the prioritisation"
4	this study was the culmination of a series of other studies, but these studies (while referenced) are not discussed in the paper	I think we have a confusion here. Our landscape classification provided the means for the other works/studies to proceed. We refer to those studies in the <b>Discussion</b> to exemplify how our work was used. That is what section " <b>Landscape classification based impact assessment</b> " (lines 355) describes. In lines 324-327 we clearly state: "However, the bioregional assessment program needed to assess impacts of coal resource extraction on ecological systems via a water pathway. Hence, we needed to develop an ecological landscape classification for this purpose that could service the different regions of the assessment." and lines 328-330 state: "While our spatially explicit landscape classification provided experts with the ability to readily identify cause and effect relationships between landscape elements and landscape hydrology, there are obvious differences between the landscape classifications in the three regions."	Inserted a second sentence into first paragraph under heading "Landscape classification based impact assessment" (l458 updated MS): "The purpose of developing the landscape classification was to assess the risk of coal resource development on the ecology of a region via a water pathway. Our landscape classification provided the spatial canvas on which experts can base their assessment of risk from coal resource development on the ecology of a region via a water pathway. "
5	much clearer methodology and workflow to be able to reproduce the results and to make the paper easier to read and understand	I think this is a good suggestion when taking together with the previous comments. I will endeavour to provide a "visual" workflow in the introduction that outlines how the sections of this paper align with the methods/results/discussion and their purpose.	Workflow figure and description added to introduction.
6	Here is an example of some of the unclear discussion (l408 and further):  "The modelling of risk to ecosystems at regional scale focuses on recognising which parts of the region are potentially impacted and which parts are unlikely to experience harm. Using our landscape classification as a crucial input, the modelling delineated impacted areas within each region, based on a zone of potential hydrological change."  From this, I fail to understand how the classification was aa "crucial input" and how this assisted in delineating the impacted areas	In lines 371 to 407 we provide details on how the landscape classification is the input for the modelling in 3 steps. I am unsure how more specific I would need to be than "Nevertheless, each landscape classification provides a typology with an explicit connection of water to the landscape class. This connection enables a causal linkage between hydrological change in one part of the landscape and impact to ecosystems represented by landscape classes." (lines 335 - 337).	No change

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7	There is an earlier reference to Hosack et al., is this the paper that describes the modelling? It would still be useful to help the reader understand what the modelling was (Summarising the earlier study) and highlighting how it was shown that the classification was a “crucial input”	Yes, Hosack et al 2018 is the work where experts rely on the landscape classification. We have summarised this work under the three steps in step 1 and 2. Hosack et al 2017 details the Bayesian methodology for incorporating and updating expert information via elicitation into risk assessments.	No change. This paper is about developing the landscape classification, which is a pre-requisite for the subsequent expert modelling. We provide a brief description of the approach on qualitative and quantitative modelling under the subheading "Landscape classification based impact assessment". It is outside the scope of this paper to describe in more details the process and method of Bayesian expert modelling. Details of expert elicitation methods and further references are available from the references cited in-text.
8	Another example from the start of the methodology, where essentially the overall approach is summarised (1184.):  “The purpose of this ecohydrological landscape classification is to characterise the landscape based on patterns in land use, ecology, geomorphology and hydrology, and from these, develop landscape classes of water-dependent, remnant and human-modified features. Existing spatial data for each region forms the basis for categorising the landscape features using a rule-set based on attribute features within the spatial datasets.”  The first problem I have is that why landscape classes of “water-dependent, remnant and human-modified features” are chosen doesn’t seem to be explained. I can see that this is a useful classification, but at least some rationale for the choice (and why no other classes) should be presented	This is outlined in section "Landform classification" (line 227ff). I think Willem is confusing landscape classes with landform classification; here landscape classes are the result of the classification, while landform classification is part of the processes to broadly divide the landscape into non-overlapping elements. Landform classification is a high level classification that describes the earth surface elements with a hydrological lens, that is three elements. We clearly justify our choices in lines 229 - 230: "Relatively intact areas are more likely to contain ecological assets such as species and ecological communities, than highly modified areas"; and lines 232 to 234: Landform classification determines "areas that are subjected to flooding, or that have persistent water, assists in identifying landscapes that support water-dependent habitat and vegetation, and aquatic ecosystems".	No change
9	The second problem is the references to a “rule-set”. I presumed this was going to be discussed later in the paper, but either I have totally missed it, or it is never discussed	Figures 2,4,5 summarise the resulting rule sets. Details for the rule sets are in lines 266 (updated manuscript) onwards.	I have added "The rule-set emanating from the classification and prioritisation is the main outcome of our approach and we present the rule-set as a decision pathway visually below. For example, for the Namoi region, the rule-set includes: identify the habitat. If the habitat is a stream, select by topography and decide on upland or lowland. For upland areas, identify the groundwater associations as GDE or non-GDE and so on until one derives at the final landclass level (see Figure 3)." to the last paragraph under Results, before the subsection "Landscape classes in the Namoi region"
10	There is further reference to the “rule-set” in I200 with no further explanation, simply a listing of the features (and again no explanation why these features were chosen)	Section 2.2 provides the rules set reasoning.	clarified as per response to comment 9
11	There is subsequently mention of a “hierarchical approach, where hydrological features have priority...” (I215) but again no explanation how this priority is incorporated.	Hmmm, what am I missing here? Lines 218 to 221 (hess-2022-408-manuscript-version2.pdf) clearly state the priorities.	No change
12	Comments in Manuscript		see below under 15
13	In my opinion the methodology is not well described and it is unclear how decisions were made for different classes	This is an interesting comment given that 2 previous reviewers stated (1) "In general, it is well written and clear structured, the reasons why it was developed were given and three aims were defined: characterize the system at regional level, develop the system and ensure that the new developed system is able to fulfil its purpose (aiding in formulating conceptual models and patterns of water dependency across the landscape)", and "The paper is clear about what has been done and why, and the outcomes". See also the AC1 response.	improved as per response to comment 9. , comment 2,3.

## 15 In-text comments in main document

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Page 3, C1	These are quite complex statements and I think a more detailed example would be useful. Why are aquatic organisms and environmental flows not useful indicators for "waters and the wider landscape". This might be crystal clear to you, but is not intuitive. This is a major part of your argument.	clarification added:	While both these elements are part of the immediate landscape surrounding water bodies, they do not in themselves provide conceptual and direct linkages between changes in water and ecosystem responses in the wider landscape. Therefore, a standardised approach to formulating classifications that combine these two aspects, ecosystems and their water sources, is lacking
Page 3, C2	This is again a very dense conceptual statement and it would be worth explaining this in more detail. What do you mean by "surface water and groundwater regimes"? And why do they need to be incorporated into the "spatial demarcation"? How does this relate to catchments/watersheds?	clarification added. Note, here we do not focus on catchments and watershed division of the landscape. Instead we take a more integrated view and landscape elements, regions and regional boundaries. We would like to avoid any discussion of the discrepancies between administrative/socio-cultural boundaries and the NRM/biophysical boundaries. Issues are well known and discussed elsewhere (see eg. Herr, A. 2007. Data Integration Issues in Research Supporting Sustainable Natural Resource Management. November 2007 Geographical Research 45(4):376 - 386. DOI: 10.1111/j.1745-5871.2007.00476.x. Such discussion is beyond the scope of this paper.	Including surface and groundwater regimes will provide the establishing of conceptual connection between impacts from developments on ground water and surface water within the classification, and the classification must be spatially explicit, to enable a landscape wide analysis of those impacts so that one can link changes in water at one part of the landscape to ecological responses at another part of the landscape.
Page 3, C3,3 Page 7,C1 Page 7, C2	testing missing figure b)	no response required adjusted adjusted. Added:	no response required adjusted We chose these features because these three terms represent a generally applicable delineation used in most spatial dataset: In Australia the word remnant vegetation (our remnant features) practically describes all vegetation where there was no clearing or regrowth of (semi-) native vegetation has resulted in a vegetation community that resembles its predecessor's structure. It represents areas with low to very minimal human interference. This is opposed to human-modified, where human activities are the defining features of the area, such as urban areas or other infrastructure. Water dependency is essential for establishing a conceptual linkage of water across landscape elements.
Page 7 C3 Page 8 C1	What is the reason for choosing these three classes? I think this needs to be clarified. Why would these be "distinct" in the landscape and why are they important or relevant? I cannot see any comment to address Where does these originate from. Why were these exactly chosen? For example, why just upland/lowland? Basically all these are qualitative choices, probably linked to your final map that you would like. Therefore this should be clarified. Unless these classifications have no influence on the framework development.	We provide our choices and reasoning in the methods section. Yes all these choices are qualitative. They are based on conceptual understanding and the available data (ie. the attributes of the spatial data). The focus on the selection of choice is the prioritisation for hydrological features and landscape elements from which we can infer ecological impacts via water.	no change. See also response to comments #3 and #4.
Page 8 C2	Can you explain this more? Why specifically is hydrological connectivity the main reason, and how do you define "hydrological connectivity"		I have changed the sentence to: "For our work, which was to assess the potential impact of coal resource developments on the landscape via a water pathway, the hydrological connectivity is the main reason for developing a new classification, and therefore the most important characteristics are the hydrological features. The work here is about describing the conceptual understanding of how water connects the landscape elements, so that we can identify where in the landscape impacts are likely, given a location from the impact on water emanates.. "
Page 8 C3	This needs some evidence to support why this qualitative choice is important	I am unsure what the Willem means by "evidence". The work here is about the conceptual connection of water between the landscape elements, so we can identify where in the landscape impacts are likely, given a location from the the impact on water emanates. In the subsequent part we provide an example of how the (region-data dependent) prioritisation works.	See changes under response to Page 8 C2 above
Page 8 C4	an you explain what you mean by "spatially complete"?	explanation provided.	Changed to : "This resulted in a spatially complete in the landscape classification, that is there are no gaps in the mapping data"
Page 8 C5	I am assuming you will explain this further	Yes. We do address this in the discussion	

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Page 8 C6	What is "dominant": > 50%? And what is the uncertainty around this?	This is based on the Australian Land Use Mapping (ALUM), which we list as a dataset. It is beyond the scope of this paper to go into the details of the ALUM classification (and any of the other publicly available datasets). The advantage of our approach is that we make use publicly available data, instead of having to create new data. The reader can readily access the data (and their metadata information about for example uncertainties inherent in the data). It suffices to say that for a broad scale regional landscape impact assessment, the data is sufficiently accurate to gain a conceptual understanding of the hydrological connectivity and for experts to develop an impact model, as we outline in the discussion.	no change
Page 9 C1	am unsure how this actually worked? did you look at long term data? Or was this simply determined from the existing classifications? What do you exactly mean by "stream position"?	clarification added. This is a region dependend classification that only applies where there are uplands and lowlands and where the appropriate data is available.	added clarification in-text
P9 C2	o this is again simply based on the original data.	Conceptually, spring defintions need to identify where the water is coming from, because this is necessary to understand connectivity to where the chnages to water originate. So your statetment is correct in so far that the datasets do provide the information on the source waters for the springs.	no change needed
P 11 C1	am unclear the methodology. Are we simply talking about GIS overlays? Or is there actually some sort of decision making?	It is both. The GIS overlay (and GIS overlay in general) do need a decision making on how to overlay/combine the data. We have clarified as per comment #1	change implemented as per comment # 1
P 11 C2	How? Please indicate the rules, as this needs to be reproducible	addressed in comment #9	addressed in comment #9
P11 C3	Please specify, again, reproducibility is important	addressed in comment #9	addressed in comment #9
P12 C1	Please outline this consistent rule set and prioritisation	addressed in comment #9	addressed in comment #9
P12 C2	So this was simply a GIS operation?	addressed in comment #1	addressed in comment #1
P12 C3	In the original data?	Yes, all this work is about using original data, overlaying these and applying the rule-set to create the final landscape classification. So while this is using the original data, these data are now embedded and conceptually connected within the landscape classification	no change needed
P13 C1	I can't really see the "criteria", what makes something an "upland" topography compared to a "lowland" topography?	as per comment P12 C3, the data provides the information and we have outlined the rule-set in the methods.	no change needed
P20 C1	Can you explain why exactly your classification system does provide this?	as per comments # 1,2,3,4	as per comments # 1,2,3,4
P20 C2	It is not clear to me how this impact was included, what specific criteria were used to identify this impact?	as per comment # 4	as per comment # 4
P20.C3	how exactly?	This we describe briefle under "Landscape classification based impact assessment" and the references provided therein provide the descriptions of the process if the reader wants more details	To clarify, we have changed the last sentence in the first para of this subsection to: "We describe this in a 3 step process briefly below. For details we direct the reader to above references" and adjusted to subsquent's paragraph starting sentence for brevity.
P20 C4	Please indicate examples of these differences and how this reflects the region?	Methods section and figures 2,4,5 indicated in text already provide this. It would lengthen the paper unnecessarily and mean repeating what the study area descriptions already provide.	no change
P21 C1	How is this causal linkage tested? It is one thing to link these things, but what is this based on?	The experts "tested" the causal linkages and their resulting output provided clear evidence that the landscape classification was "fit-for-purpose", otherwise they would not have been able to complete their task to assign a risk to ecosystems. We already provide an example how this was "tested" in the sentence at the end of the para: "For example, spatially modelling groundwater level drawdown enables a prediction on which landscape elements classified as springs may be experiencing impacts from water extraction and, with additional ecological modelling, by how much and when.	no change
P21 C2	Are there published results from this? Where is this modelling?	In lines 392-394 we clearly state: "In the remainder of this section we show an application of the approach in more detail to substantiate our claim for the general useability of our classification approach in water mitigated regional impact assessment of human developments." This following section also provides the references.	no change

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P21 C3	What demonstrates that this is an "essential" framework	It was essential for the experts to have a landscape classification with hydrological connectivity to do their impact modelling. Hence this is an essential framework for the experts.	no change
P21 C4	I think a solid concise summary of the main findings of these earlier papers should be included here.	Hmmm, what am I missing here? Lines 364 onwards state that we briefly explain the process in the following. But see also response to comment #5	no change. But see response to comment #5
P21 C5	I assume you will explain how they did this?	yes. That is what the following section and references are about	
P22 C1	OK, is this because the conceptual model is based on the earlier studies or has this been developed independently?	The expert developed the qualitative model, which also includes a conceptualisation intrinsically. It is beyond the scope of this brief summary to explain the qualitative modelling approach. Hence we referred to reader to the reference provided at the end of this paragraph.	no change
P22 C2	Where is this shown? Or explained?	It is beyond the scope of this brief summary to explain the qualitative modelling approach. Hence we referred to reader to the reference provided at the end of this paragraph.	no change
P22 C3	More detail and a short summary will strengthen the explanation	Hmmm. What am I missing here? We already referred to Table 7, in line 392 which gives a brief summary of the variable	I have changed the last sentence of this para to: "Table 7 provides a brief summary of these variables; specific details of the variable definitions are in Ickowicz et al. (2018)", which will hopefully clarify this better.
P24 C1	And the methodology and results of this are where in the paper? Otherwise a summary is needed to help the reader. It also would assist with reproducibility	They are not in this paper. Hosack et al 2017 provides the methods and details.	No change, but see also response to comment #5
P24 C2	How? Can you please outline this in more detail?	The landscape classification was crucial for experts to do their work.	Please refer to our response to comment P21 C1
P27 C1	Also, where all the spatial datasets at the same resolution?	They were not all at the same resolution. However, this is not a limitation in modern GIS applications, as aggregation/dissagregation and automated scaling enable mixing of different scales. Please see also RC2 response, item Scale	No change
P27 C2	this questions the value of the final map? If the original data is questionable, how can the combined modelling be correct?	No it does not detract from the value. This is an intrinsic feature of assessing risk, which is a combination of probability (including uncertainty) and consequence/harm. The map provides risk levels, so where there is a lack of knowledge (or higher uncertainty) the risk is higher. This is what the expert analysis incorporates and why we use experts. If there would be data about all aspects, we could address risks readily and there would be no need for complex interdisciplinary projects to address NRM issues.	no change

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	<b>Reviewer2</b>		
1	line 17, and 109: "at the landscape level" What does this mean?	We have provided definition of landscape level at the end of the 4th para in the introduction	clarification provided
2	line 105: "It places the landscape classification within a common framework" I don't understand this. Common with what?	I have added a definition of common framework to lin 105	clarification provided
3	line 108: "conceptually describe" How is this different from "describe"?	I have rephrased to "the classification also provides the ability develop a conceptual understanding of". In this context a conceptual understanding allow for the building of a conceptual model. I presume that I do not have to define conceptual understanding here as it is intrinsic to scientific work in that it provides the understanding of core principles, functions and relationships.	explained the meaning of concepts/conceptualisation in the context of gaining a system understanding
4	line 217 "spatially complete". I don't understand this.	Changed to : "This resulted in a spatially complete in the landscape classification, that is there are no gaps in the mapping data"	clarified
5	line 347: "conceptual understanding". How is different from "understanding"?	see my response to comment 3	clarified
6	line 371: "to conceptualise and prioritise" Could be replaced with "of".	Shortening this would detract from the main tasks in this step, which is to conceptualise the landscape in terms of its ecohydrological causal linkages, and prioritise means to identify the most important spatial features that link ecology with hydrology	no change
7	line 380: "digraphs" I assume that you are referring to directed graphs, but a definition would help.	I have rephrased to sign directed graphs to make it clearer. The references after this provide the details on the method.	adjusted
8	Confusing, which was probably due in part to the nature of the work which spans hydrological and ecological modelling, but it was also because of the style of writing, which is wordy and vague	I have provided more clarifications as outlined in comments 1-7. While we already have attempted to make this paper as clear as possible, it is difficult to reduce explanatory context wording. Please also refer to our response to comment #5 and #13 for Reviewer1.	adjusted
9	I don't think that what the authors have proposed is wrong, but I'm not sure that it is necessarily very new. I'm also concerned that it's not really tested.	please see our RC2 response on points 2. Validation and 3. Novelty. Please also refer to Reviewer1 response to comments P21C1	NA
10	How have they established this for their classification system which appears to be ad-hoc? They state that their method differs from those that "apply statistical dimensionality reduction and classifications such as proximity analysis". So how can we assess their methodology?	We provide the methodology in the method section. The classification system is outlined in the methods and presented in figures 2,4,5. I am unsure how else to present the approach that would make it clearer.	NA
11	There is virtually no discussion of scale in the paper, which is concerning, given the importance to hydrological processes. I appreciate that the data sets that the authors have used have many differing scales, but it was not clear from the writing what the authors' scale objectives were	please see our RC2 response on points 1. Scale	I have added more context to scale under section "Study area" to the end of the para: "For this paper, we content that there is no one scale appropriate for a subsequent analysis of ecological impacts. Here we use scale in a more fluid context, that is, we work at scales ranges relevant for ecological impacts of water changes from coal resource developments when using an expert assessment approach."
12	They refer to the "landscape level" and a "regional level landscape" (line 98), without explaining what these mean.	please see our RC2 response on points 1. Scale	landscape level clarified as per comment 1
13	What are the scales of the landscape groups plotted in Fig 3, and the landscape classes plotted in Figs 6a and 6b? How will the scales of their groups and classes affect the hydrological models to be developed?	please see our RC2 response on points 1. Scale. Note that we do not develop hydrological models. We use hydrological models as input for the expert elicitation of ecological impacts of the landscape classes/groups.	We have provided additional context around the workflow (including Figure 1) and with the discussion to clarify that hydrological modelling was an input to the expert analysis (see para starting at line 549).

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14	very little discussion of the hydrological processes that will be modelled, other than their association with landscape units	This is because the paper is not a hydrological paper, but an integration paper that focusses on developing and applying an ecohydrological landscape classification. Hydrological processes come into play during the expert analysis.	We have provided additional context around the workflow (including Figure 1) and with the discussion to clarify that hydrological modelling was an input to the expert analysis.
15	understand the effects of the classification system on the development of the quantitative models. For example, it's interesting not to see vegetation used as a classifier for the stream uplands in Figure 2. I suppose that the authors are using a single vegetation type for these four classes	There seems to be a misconception of the classifications purpose. The stream classification is focussed on in-stream ecology, and it is not used for developing hydrological models. It is however used for analysing ecological impacts based on hydrological models. The streams are embedded within the Remnant Vegetation Habitat. The vegetation classes surrounding the streams are related to the Remnant Vegetation Habitat in figure 2.	We have provided additional context around the workflow (including Figure 1) and with the discussion to clarify that hydrological modelling was an input to the expert analysis.
16	I would also assume that the resulting hydrological model would use the same parameters for the topography and vegetation for quantitative hydrological models of all landscape units in these classes, is that correct?	No this is not correct. The hydrological models are not directly related to the landscape classes. We refer to the hydrological changes, which are outlined in Post et al 2020 (Line 358). Landscape classes and hydrological model outputs form the inputs for the expert assessment.	We have provided additional context around the workflow (including Figure 1) and with the discussion to clarify that hydrological modelling was an input to the expert analysis.
17	"The purpose of the landscape groups was to combine non-water dependent landscape classes and relate water dependent landscape classes to region specific aspects of their water dependency, which enabled conceptualisation of the landscape for modelling purposes." Again, this is vague. What type of modelling are they referring to?	I have rephrased to: "The purpose of the landscape groups was to combine non-water dependent landscape classes and relate water dependent landscape classes to region specific aspects of their water dependency. This enabled experts to develop a conceptualisation of the landscape for developing their ecological impact models"	clarified
18	In Figure 2, the "Non-floodplain or upland riverine" group is comprised of 8 different classes, which have very different vegetation types. Are the authors proposing to use their groups as a basis for their quantitative model, despite their having such great variation in the hydrological process parameters within each group? Wouldn't the use of these groups in <i>any</i> form of modelling violate the requirement that "the characteristics within the components are more similar than the characteristics between the components"?	No. The experts use this grouping to develop impact models and they decide on the scale and detail they require. For example, if they assess upland riverine components, they will look at where in the upland riverine landscape hydrological modelling identified impacts. They then use this to prioritise/identify which landscape classes they need to develop a qualitative and subsequent quantitative model.	We have provided clarifications in the discussion under "Landscape classification based impact assessment". Please see also our response to Reviewer 1 comments #4,7.
19	Most importantly, there does not appear to be any attempt to validate the general approach. The authors provide examples of the use of their classification system and state that it "works" (line 471), but how do we know this? How would the approach work in a region with very different topography and/or hydrological processes, such as an alpine region, where local slope, aspect and elevation will likely dominate the hydrology, and where the hydrological processes (snow accumulation and melt, glaciers) will be very different?	Please see our response AC2 to RC2 comments, specifically section 3. Validity	no change