Response to discussion by Ertsen on Westerberg et al. "Perceptual models of uncertainty for socio-hydrological systems"

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Abstract

Ertsen discusses the representation of reality and uncertainty in our paper, raising three critical points. In response to the first, we agree that discussion of different interpretations of the concept of uncertainty is important when developing perceptual models – making different uncertainty interpretations explicit was a key motivation behind our method. Secondly, we do not, as Ertsen suggests, deny anyone who is not a "certified" scientist to have relevant knowledge. The elicitation of diverse views by discussing perceptual models is a basis for open discussion and decision-making. Thirdly, Ertsen suggests that it is not useful to treat socio-hydrological systems as if they exist. We argue that we act as "pragmatic realists" in most practical applications by treating socio-hydrological systems as an external reality that can be known. But the uncertainty that arises from our knowledge limitations needs to be recognised, as it may impact on practical decision-making and associated costs.

Response

We appreciate the comments by Maurits Ertsen (2018) and the opportunity to clarify our philosophical position, which is indeed important when working across disciplines and with policy, industry and civil society. Maurits Ertsen raises some interesting issues about reality and its representation, and questions whether uncertainty exists at all other than in the interpretation of those involved in an analysis or decision situation. He recognises that he does not have the answers to these profound questions. As we see it, there is no commonality of views amongst professional philosophers on these issues either, but a discussion of different interpretations of the concept of uncertainty and how these differences might influence our analyses are useful (and challenging) components of the type of analysis we suggested. This was a key motivation behind the paper and we highlighted the perceptual nature of interpretations of uncertainty in the title and introduction of the article onwards. In agreement with Ertsen (2018) on the need for discussion of this second-order philosophical uncertainty, we suggest that this can be explicitly added as one of the questions to be addressed in Table 1 (in Westerberg et al., 2017) under Step 1 about the framing of the problem, e.g. "Is the interpretation of the concept of uncertainty itself different among different researchers and stakeholders, and how can this influence the analysis?".

Our elicitation of diverse views on uncertainty as the basis for open discussion and decision-making should reassure the careful reader that we are not (as Ertsen (2018) suggests) denying anyone who is not a "certified" scientist to have relevant knowledge of a matter of concern, as much as we acknowledge that scientists do not stand removed from those matters (Krueger et al., 2012). Where the terms scientist and stakeholder were juxtaposed in our paper this was done as shorthand for certified scientists vis-à-vis people who are not certified scientists but otherwise affected or in a position to affect the issues at stake. Since publication of the original paper, we have applied our methodology to a real world example. Comparisons and discussion of everyone's perceptual models (developed individually) showed that no one, neither scientists nor stakeholder, had an exhaustive perceptual understanding of the uncertainties involved and that the exercise thus improved everyone's prior knowledge.

Stakeholders will agree that we make socio-hydrological analyses for a purpose, often to assess the potential impact of decisions into a future of unknown boundary conditions using predictive methods of limited accuracy, especially when cascades of model components are required (e.g. Grames et al., 2016; Beck and Krueger, 2016; Beven and Lamb, 2014). In these circumstances, it is a useful strategy to try to understand and assess the uncertainties associated with such predictions in a structured and explicit way, since taking account of the uncertainties can make a difference to the decision that is made. This will be the case for the type of cost-benefit analysis mentioned by Ertsen (2018), when the costs are highly sensitive to uncertainties in the analysis. McMillan et al. (2017), for example, quantify the costs of errors in the stage–discharge relationship for Norwegian hydropower industry when maintaining minimum environmental flows. When costs are highly sensitive to uncertainties we might decide either to be more risk averse or to make the decision in a totally different way. In essence we (and we believe many others involved in such practical applications, however often unthinkingly) act as "pragmatic realists", i.e. we treat the socio-hydrological systems we analyse *as if* they are an external reality that can be known while recognising the uncertainty arising from the limitations of our knowledge of them (Beven, 2002).

For example, for hydrologists the concept of discharge is quite important, but as soon as we start to think carefully about a flood discharge it becomes a rather nebulous quantity. We can watch a (real) flood going past in a river and can appreciate that it might represent a (real) danger to life and property. We cannot, however, easily measure it with any accuracy, or properly represent the effects of the 3-dimensional turbulent flow structure in all its complexity, or the impacts of momentum losses on the flows at different scales. Flood discharge can therefore be considered as an uncertain quantity (e.g. Beven et al., 2012; Clarke, 1999), but when the water level rises to enter houses and causes damage and other socio-hydrological impacts, then few of us would doubt the realism of such events (and the water levels are, of course, much easier to measure with a degree of accuracy). Similar considerations will apply to many aspects of the human response to flooding where some variables will be more conceptual and constructed than others.

We acknowledge that assessing the characteristics of uncertainty may be challenging and that there are certainly limitations of classical risk-based decision analysis in dealing with unknowns (see for example Rougier and Beven, 2013; Zeitoun et al., 2016). Any assessment of uncertainty is necessarily a construct; effectively based on a perceptual model. The critical question in this context is whether an assessment of uncertainty (with all the assumptions it requires) will lead to better, more robust, decision making or whether this can be achieved in some other way (e.g. by considering the information content of the available data more directly, Nearing and Gupta, 2017). After all, it is in decision making where science really matters. And here, in agreement with Ertsen (2018) and as suggested in Westerberg et al. (2017), the question comes down to who frames, produces and reproduces pieces of scientific information or scientific uncertainty that gain traction and lead to real benefits for some and real losses for others. We hope that our approach of explicating and contrasting our perceptual models of uncertainty is one step towards confronting the political economy surrounding our socio-hydrological research.

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