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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Developing predictive insight into changing water systems: use-inspired hydrologic science for the Anthropocene" *by* S. E. Thompson et al.

S. E. Thompson et al.

sally.thompson@berkeley.edu

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The author team would like to thank Reviewer 1 for their thoughtful and constructive comments. Our responses to them are provided below, along with an indication of how we propose to revise the paper to clarify our meaning and, where appropriate, to incorporate the reviewer's suggestions. We have addressed the 3 points the reviewer made independently.

1. Predictive insight

The reviewer is correct that this manuscript does not attempt to address deep uncer-

tainty in the context of planning for and predicting the behavior of water resources. Instead, we have attempted to walk a "middle path" between two extremes, one of which is a highly deterministic view of water resources and water systems – which we consider to be untenable given the role of human agents and the inherent challenges associated with complex systems; the other of which would suggest that predictive efforts in systems which are influenced by people are necessarily futile.

In between these extremes, we argue, lies a domain within which knowledge about the interactions between human and water systems offers scope for understanding and, in a broad sense, some predictability. We argue that given a suite of dominant governing factors and initial conditions, the dynamics of interaction between physical, ecological and social systems constrain the possible temporal trajectories that these coupled systems can take. Understanding these constraints provides insight into possible futures which has a predictive value for visualizing, planning, and nudging systems towards desired future outcomes. This type of prediction does not aim for rigorous quantification – it is not about being able to predict the flow on a given day 100 years from now – but rather for the elucidation of potential future states.

The predictive insights obtained in this way are of course dependent on stationarity in the description of the factors that govern a system. One goal of these modeling efforts is to identify those factors that are likely to change on the relevant timescales and to incorporate a description of their dynamics into the problem formulation.

Some changes, however, are likely to defy endogenous description. These changes are exogenous to the initial description of the system, leading to a new problem statement, with new initial conditions, and new potential future trajectories. Since such large changes could, in principle, occur in any given system on the timescales of relevance to the "100 year prediction horizon," this timescale - while potentially tractable from the point of view of exploring system trajectories – should be viewed as aspirational in any specific system.

To account for the effects of changes that are not forseen or forseeable, the "data-model learning" section of the paper focuses on techniques to identify unforeseen changes in system behavior, to dynamically adapt short-time predictive frameworks, and guide changes in longer-term thinking about system trajectories.

Acknowledging that deep uncertainty is likely to remain as a potential influence in all water systems, we nonetheless consider the successes made in learning from coupled system dynamics, and the importance for hydrology in focusing on the outcomes of such dynamics on timescales relevant to physical, ecological and social change in systems (as opposed to e.g. the timescales relevant to a flood or an annual runoff projection) and conclude that developing "predictive insights" by identifying plausible system trajectories on decadal – century timescales is a achievable and useful scientific goal.

Proposed revisions: While the current version of the manuscript expresses caution about the feasibility of long-term predictions, and the potential for human-influenced systems to be genuinely unpredictable, it does not frame the idea of predictive insight in terms of identification and constraint of possible trajectories for coupled systems. In a revision, we will explain the nature of these predictive insights in terms of system trajectories in the introduction to the paper.

2. Place based learning and implementation We completely agree with the reviewer that both bottom-up and top-down approaches are necessary for learning about water systems and for implementing water management. Indeed, the entire premise of "comparative hydrology" is to provide a research mechanism that is (in the reviewer's language) "bottom-up" in nature, allowing commonalities and generalizations to be observed and to emerge from observation, rather than being imposed. Fundamentally, we view values, norms, policy and institutions as components that would help to inform this "bottom-up" approach.

We also agree that imposing a "one-size-fits-all" approach to water management is

inappropriate, particularly if such an approach were blind to the differences in values and norms between systems.

Aside: Please note that the language of "bottom-up" versus "top-down" is somewhat problematic, as the grass-roots, place-based approach the reviewer advocates as a "bottom up" approach is commensurate with the notion of "top-down" modeling as promoted by Sivapalan (2003) ("Downward approach to hydrological prediction"). For this reason we have attempted to avoid these terms in the manuscript, as the vocabulary is fundamentally confused across disciplines.

Proposed revisions: There are several places in the manuscript (e.g. discussion of sociohydrology in Section 2, discussion of comparative hydrology in Section 3) where we have made broad reference to 'social' factors without specifying that these factors include not only structural and institutional aspects, but cultural and normative aspects which influence the relationship between people and water. We will clarify that cultural and normative factors must be considered in these sections, and highlight that despite the value of learning by making generalizations across places, interventions and decisions made in any one place must be tailored to the needs, norms and values of the people living in a given water system.

We will similarly emphasize the importance of place-based decision-making and management when discussing links between management and research in the Implementation section.

3. Construction of knowledge between science and communities

We found this point to be valuable, and we acknowledge that it was overlooked in the original manuscript. The reviewer brings up a fundamental question with respect to use-inspired science, namely: "how can the 'real world problems' that inspire scientific effort be identified, and, given resource constraints, prioritized and selected as targets of inquiry?"

The answer, as suggested by the reviewer, and which we support as a valuable and important path forwards, is that to maximize the value of use-inspired science for communities, the process of problem identification, prioritization and investigation should involve a collaboration between the impacted communities (stakeholders) and scientific researchers. Identification of a problem without such a collaboration risks being counterproductive, redundant, or irrelevant. There is also long-term value in maintaining collaboration and communication between researchers and communities on multiple fronts: communities hold knowledge that might be inaccessible to researchers, the details of research can be refined with community participation to maximize the usefulness of knowledge generated, ongoing interaction can improve trust and respect between researchers and communities, increasing the likelihood of research being mutually beneficial.

Despite our broad support of these suggestions, we do not wish to make the bald statement that use inspired science fundamentally requires a collaborative, co-production of knowledge approach. There are examples of use-inspired science (indeed, examples presented in this special issue, e.g. see papers by di Baldassarre et al.) which have not involved stakeholder engagement, but nonetheless identify pervasive water-related social problems, and use these to inspire fundamental scientific research. Clearly this research is not as "ready" for translation and application as research efforts that are embedded in the translational activities that the reviewer suggests. It may nonetheless provide valuable insights into the operation of water systems. Thus, we prefer to remain inclusive of multiple methods of implementing use-inspired science, while highlighting that there is a wide realm of techniques available for identifying problems and shaping research collaboratively between communities and researchers, and that these should form part of the toolkit of use-inspired science implementation.

Proposed revisions: We intend to amend the section on use-inspired science to discuss this issue, and to discuss translational and two-way activities in the implementation section.

In the review we will identify some interesting and potentially valuable models for engaging in two-way communication that use-inspired science can draw on, such as collaborative learning (Daniels and Walker, 2001) and collaborative modeling approaches (Tidwell and van der Brink, 2008).

We will also highlight that the identification of research targets as a collaborative process between communities and researchers is an arena where there is a clear and essential role for engagement between hydrologists and social scientists. Hydrologists, as a generalization, are poorly trained and equipped to mediate such collaborative processes, while the field and participant-based research aspects of social science provide a broad set of methods and approaches that could be used productively.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 7897, 2013.