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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Develop a coupled agent-based modeling approach for uncertain water management decisions" *by* Jin-Young Hyun et al.

Andres Baeza (Referee)

andres.baeza@gmail.com

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General Comments

In this work the authors developed an agent-based model to simulate agents that make decisions related to irrigation management. The agents consider climate and social information to update risk perception and cost of operations, to decide whether to increase or reduce water consumption for irrigation. The agents are located in a river network with a man-made structure that controls water flow. The results show that by considering this environmental and social information along with the perception of risk, agents can replicate water consumption patterns observed in the San Juan river

basin. I think this is a very interesting work that provides great methodological tools to develop a coupled hydrological, agent-based model. The introduction is clear and well supported by the literature. While some points could be made even clearer, the authors did a good job introducing the objectives and the methods proposed. I considered the method section to be the most interesting part of this paper. The Bayesian inference (BI) rule provides a great tool that combines robust math and easy applicability to develop the agents' decision-making framework. My main concern with the BI is the assumption or presumption of risk. In the model, when agents ignore incoming information, these agents are labeled as "risk-averse". I do not understand why, by not considering previous information, these agents would be considered risk-averse. My understanding is that risk-averse individuals pay more attention to not have great losses vs. a risk-seeking agent, who would give more importance or weight to potential large gains, thereby discounting loses. I think the authors need to clarify this point. Finally, for the methods, a sub-section containing the estimation and calibration methods, and the comparison with real data, is needed. Some aspects of these methods are described when the results were described later in the manuscript, and this created some confusion about the methods that were used.

The case study is quite interesting and well supported by time-series data. My main comment in this section is about the kind of agents their model is trying to simulate. It is not clear to me who are the "irrigated" and/or "ditch object" -agents. Are these infrastructure operators, managers, or a group of farmers with influence on the decision made to obtain water? The authors can do better explaining these agents. Another point that I think needs an explanation is how the social and climate factors that each agent considers as important were elicited. Some agents consider extreme precipitation, while others consider "animas precipitation". I also suggest that the authors differentiate between climate vs. social factors in Table 1. This would make the different socio-ecological factors that influence each agents' decisions clearer to the readers. I suggest looking at the ODD+D protocol, instead of ODD, to describe the model, because the ODD+D includes the decision-making aspect of the model (Müller et al.,

2013). The authors cited this study, but they have not used it. I consider the discussion to be somewhat weak and not in line with the aim of the study, nor the results. The discussion starts with a reflection about the policies implemented in the study area, but it was only loosely connected to the decisions of the agents, the information these agents considered, and the risk. There is no discussion or reflection about implementing theory-planned behavior, which I think would be a great step to incorporate real theories of human behavior into agent-based models. The authors should highlight this effort. Perhaps the discussion can be constructed around the following question: How do the risk perception, information flow, and costs influence policy outcomes in not only the San Juan river basin, but also in other basins? The discussion should start with a broader statement about the generality of the method and its applicability to other rivers. Then, it should include the implications of the results for policy outcomes, first for the example of the San Juan river, and then for other irrigated areas. Finally, the authors stated in 5.2 that they will discuss future research, yet no specific ideas were provided. In any case, these future directions should be included in the conclusion, rather than the discussion. At a minimum, a real discussion about these ideas, including what would be needed and other considerations, should be included.

Specific comments

Abstract I do not consider risk perception and uncertainty to be the same, as the author clearly described in the introduction (Line 107). On line 22, the authors should be more careful when introducing these terms in the abstract. Introduction Line 59: Why do the authors start with the word “therefore” to introduce planned behavior? Line 73: Need to introduce the low-cost rule. Line 89-100. In the abstract, the authors suggest that risk perception is included in the BI rule. They then introduce risk perception when discussing the CL rule. This causes some trouble understanding the model. Line 128: A line or two is needed stating what “two-way” coupling means. I think they refer to feedback between decisions, perception, and water dynamics. Is this correct?

Methods Line 229: A definition of subscripts i and j is needed.

Case Study Line 313: What does “cfs” stand for? What is this unit? Line 385: What does “matching” the time series mean? Is it based on Least Squares as a Maximum Likelihood? In other words, an explanation is needed on how the comparison between real data and simulated data was carried out. Line 418: An explanation for the Nash-Sutcliffe Efficiency is needed. Line 457: The phase including “. . .multi-objective calibration. . .” is not a result. This should be in the methods. Line 585: The statement beginning “The BC-ABM results . . .” is also not a result. The fact that agents react to climate and socio-economic factors is part of the rules imposed by the model, but it is not a result per se. Line 624: I do not understand why the authors introduce multi-criteria decision analysis vs. other decision-making tools. It is an important tool, but it is hard to see the connection.

Figure 1: In ABM process 3, what is the question that leads to yes or no? It is related to the opportunity cost, but it needs to be stated in the figure. Figure 2: Perhaps a better name for “irrigated agents” is needed.

I hope these comments are useful to the authors.

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