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Earth System Dynamics
Discussions

Interactive comment on "On the social dynamics of moisture recycling" *by* Patrick W. Keys and Lan Wang-Erlandsson

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Reviewer Comment = RC Author Comment = AC

RC: This study examines the social dimensions of moisture recycling taking the case of three countries: Mongolia, Niger, and Bolivia. The characteristics of sources and sinks of moisture are examined to understand the heterogeneity of moisture recycling socialecological systems. A moisture tracking model called the Water Accounting Model2layers (WAM-2layers) is used to track the sources and sinks of moisture starting from the moisture entering a grid cell as evaporation. The study finds that sources and sinks of moisture can experience different levels of human well-being and highlights the need to include power discontinuities in the description of moisture

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Discussion paper

recycling socialecological systems, and aims to contribute to the ongoing discussion about the emerging discipline of socio-hydrology. The paper is well written and is a good fit for Earth System Dynamics, but significant revisions should be made before the manuscript can be considered for publication. Please find my comments below.

AC. We appreciate the careful consideration the Reviewer has given to the manuscript. We hope that our revised manuscript merits further consideration for publication in ESD.
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RC1. The abstract is not fully representative of the paper. First, there is no mention about what model/tool is used to carry out the analysis. And second, the abstract is too qualitative. I suggest (a) adding some information about the model; (b) adding some quantitative information about the key findings; and (c) providing some take-home message about the differences in the coupled social-hydrological systems among the three selected regions in relation to the archetypes discussed in the paper.

AC1: Thank you for these comments. We have made the suggested changes, adding brief information about the analysis, some quantitative results, and more clearly articulated key messages contrasting the different MRSES.

RC2. Page 2, Line 28: It is not clear of how this paper provides information for land-water managers; I didn't find any discussion in the remainder of the paper. It is important to add this information because it has been highlighted as one of the major contributions of the paper.

AC2. Thank you for the comment. We recognize that we were unclear where this text appears. We now explicitly direct the reader to the sections "4.2 Guidelines

for constructing MRSES", "4.3 Advancing human-water systems understanding", "4.4 Systems may be reinforced in unexpected ways", and "4.5 Power must be considered carefully".These four sections contain the information we originally referred to that could help land-water managers.

RC3. Section 2.1: The selection of the three countries for case studies is justified based on the authors' prior work and the global regions that receive significant precipitation from upwind evaporation. Given that the goal of the paper is to examine the connections between moisture recycling dynamics and social-ecological systems, wouldn't it be interesting to conduct the study in regions where there is an ongoing intensification of human activities and where hydrological-social systems are more tightly coupled and are fast evolving? In South America, the Cerrado Biome is one of such regions that is undergoing rapid land use/land cover change due to agriculture expansion. Studies have shown that the changes in land use in the Cerrado region have decreased the amount of water recycled to the atmosphere via evapotranspiration (Spera et al. 2016). There are also other regions where rainfall patterns and ET have been altered by human activities, especially land use change and irrigation (e.g., High Plains, Northwest India, Eastern China). Some of these regions also coincide with the regions of strong land-atmosphere coupling identified by Koster et al. (2004). Finally, from hydrologic point of view it would be more meaningful to conduct such a study over a river basin.

AC3. Thank you for these reflections. We were careful about the regions we selected, in that we wanted to ensure that we picked regions that were experiencing significant vegetation-regulated moisture recycling, which we used as a proxy for potential impacts from land-use change. Likewise, the countries are all quite similar in national area, providing a reasonable control on the spatial scale of the corresponding precipitationsheds. Also, for our purposes of emphasizing social

dynamics, countries are more suitable than hydrologic basins. This is because: (a) Many regions experience limited runoff, suggesting the most meaningful hydrological flows are not river basins but sources and sinks of atmospheric moisture (for more on this see Weiskel et al. 2014); and (b) Countries provide a lens for evaluating social dynamics, especially land-use policies, since governance institutions (e.g. regulatory frameworks, transboundary legal arrangements, etc) are typically based on political or administrative units, such as countries, rather than hydrologic basins.

RC4. Page 4, Line 11: What are the necessary inputs for WAM model? What is the spatial resolution? Please provide detailed information about the model, data, and experiment settings.

AC4. We agree that it is important for the reader to have this information available. The inputs are described in Section 2.3 "As input to the WAM-2layers, we use ERA-Interim Reanalysis data, from the European Center for Mesoscale Weather Forecasting (Dee et al., 2011). We downloaded global, model-level data at the 1.5 deg. by 1.5 deg. Resolution. The WAM-2layers uses 6-hourly data for horizontal and vertical wind, humidity, and surface pressure; and it uses 3-hourly data for evaporation and precipitation."

There are no experiments, as such, since we use the WAM-2layers to calculate how moisture moves around the planet. However, we do explain how the WAM-2layers calculates this movement of moisture in Section 2.2. We hope that this explanation eliminates any confusion regarding the functioning of the WAM-2layers.

Additionally, one of the other Reviewers commented on the need for more detail on the land-use change simulations/experiments. This is clearly a failing in our (the authors)

communication, since there were no such experiments. In this regard, we have added clarification text in Section 2.2 of the revised manuscript to clear up this confusion:

"We emphasize that the WAM-2layers is a moisture tracking scheme, and not a simulation. It is possible to couple the WAM-2layers with dynamic simulations of land-surface hydrology, including vegetation (e.g. Wang-Erlandsson et al., 2014; Keys et al., 2016), but that is not what we have done in this research. Thus, the results that we present are purely based on the implicit hydrological information contained within the ERA-Interim Reanalysis data."

RC5. Page 5, Line 19: ". . .coarsest grid resolution": Please specify the resolution/grid size?

AC5. Thank you for the comment, you and the other Reviewers requested this. We have included a table that summarizes the different datasets, including variable name, description of variable, source resolution, units, time period of analysis, and source reference. This table is found in the Methods section.

RC6. Section 3.3: This short section about the integration of moisture recycling and social features doesn't provide much information about such integration. The authors present a figure from their previous study and refer to the literature review section for further context. In the current form, I don't see this section providing any new information. I suggest the author to revise this section and make a strong case about this important integration.

AC6. Thank you for the comment, and we agree that this section needs to be revised. We have changed the format of the results presentation, based on Reviewer

2's suggestion of reporting each individual case study in its entirety. Thus, when we now present each case study, they are more coherent, with the results for the precipitationshed, social characteristics, and literature review of social dynamics presented in sequence.
Additionally,, we have removed Fig 4 since it did not substantially improve the paper, and apparently led to confusion among the other Reviewers.

RC7. Section 3.4: This is related to the previous comment. This rather lengthy and descriptive section provides a good literature review but it is purely qualitative and doesn't provide a good linkage with the quantitative analysis provided in other sections. A better integration of the "quantitative" and "qualitative" parts is needed.

AC7. Thank you for this suggestion. We agree that better integration among the different threads of each cast study is necessary. With the new format of each case study presented in its entirety, we hope this addresses this issue.

RC8. Sections 3.1 and 3.5: How is land use change considered in the model? What data is used and at what resolution? Is deforestation and agricultural and irrigation expansion considered? If so, does the model account for the changes in ET because of such land use changes? Please provide these details. I also suggest that the author strengthen Section 3.1 (the quantitative analysis) by including more results from the model (e.g., results of changes in land use and the impacts on moisture recycling). Currently, this section is too brief and focuses mostly on the precipitationsheds shown in Figure 2. Please also see comment 6 on better integration.

AC8. We apologize for the confusion on this issue, since it was clearly a failure in communication. As we stated in response to comment 4, there were no land-use

change simulations in this analysis. We ran a single analysis of moisture recycling, using ERA-Interim data, which is output from the European Center for Mesoscale Weather Forecasting (ECMWF) forecast model. Thus, our analysis examines the observed record, with implicitly historical land-cover (i.e. inferred from various observational datasets).

RC9. Section 3.8: Please consider expanding the discussion by adding information about studying human-water interface using hydrological modeling, in line with the discussion provided by Wada et al. (2017).

AC9.Thank you for this suggestion, and this is discussed in detail in section 4.3 “Advancing human-water systems understanding”

RC10. Figure 2: This is a minor issue, but I suggest changing the unit to mm.

AC10. Thank you, we have made this change.

RC11. Page 8, Line 23: reference needed after “malnourished rangeland systems”.

AC11. There is no reference for this, because it is based on our own analysis within this paper. Results from our case study analysis, including the analysis of land-uses and social characteristics of the sources and sinks of moisture, are more comprehensively reported in the results section. Likewise, we have re-written much of the literature review text so our statements ought to be much clearer to the reader.

RC12. Page 12, Line 21: change “lead” to “led”

AC12. Thanks for this suggestion. We have identified all past tense forms of “lead” and changed them to “led”.

RC13. Page 12, Line 31: reference needed after “corrupt leaders”.

AC13. Thanks, the corresponding reference has been added.

RC14. Page 14, Line 31: MRSES has already been defined.

AC14. We recognize that we already defined this, but given that it was defined much earlier in the manuscript, we decided to remind the reader here (at the beginning of the actual MRSES discussion) to ensure the reader does not now need to hunt through the paper for the definition.

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