

## ***Interactive comment on “Rain or Snow: Hydrologic Processes, Observations, Prediction, and Research Needs” by A. A. Harpold et al.***

**Anonymous Referee #2**

Received and published: 17 October 2016

### 1 General comments

#### 1.1 Summary of goals, approaches and conclusions

Harpold et al. wrote a review manuscript on precipitation phase methods (PPM) to show the diversity of available approaches and the advances needed to improve predictions in complex terrain. They reviewed (1) the processes determining the precipitation phase (PP), (2) observation possibilities of the PP and (3) available PPMs. Finally, they formulated research gaps and recommendations on how to improve PPMs. For the second item they concluded that for complex terrain robust observation networks are missing and that for remotely sensed indirect observations of the PP field validations are needed. For different available PPMs they found in their review that accuracy generally increased when humidity is included and when the model is applied on

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smaller time steps. They formulated also recommendations for future research based on found research gaps.

#### 1.2 Conceptual overview

Up to now most hydrological models are applying primitive PPMs despite the knowledge of atmospheric processes influencing the PP. Thus, this review paper is interesting since it shows the hydrological community the need of future research on this topic. A special emphasis is on the potential on remotely sensed observations. However, especially for the remote sensing part I would like to see a clearer synopsis on how useful these products are for observing the PP in general, additionally to the large amount details listed for each sub method. I would also like to see thoughts and ideas on how the authors would approach their formulated research gaps conceptually, for example on how to include atmospheric models in PPMs. In a review paper I would like to see that the authors are able to create something new with the gathered information. Both mentioned points may be a chance on how to include this aspect. I also suggest that the authors include more details in the manuscript referring to their emphasis on complex terrain in the abstract. There are some formality issues, for example when citing literature. Since this is a review paper, I gave special attention to this aspect. In general, I think that the authors can address my comments with minor revisions. Please find in the following sections details to my above mentioned critics.

### 2 Specific comments

#### 2.1 Synopsis of remotely sensed information

Section 3.2 and 3.3 are quite long indicating an emphasis on remotely sensed observations. After reading the two sections I feel that a synopsis is missing with general information about the applicability of those observations for PPM, which seems a bit lost in the detailed description in these long sections. I would suggest a summarizing paragraph, or an overview table with the following items, for example: description, coverage, availability, resolution, validated, references. The remotely sensed observations

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do also hardly appear in section 5 (Research Gaps), while the need to validate these products, was mentioned in the abstract. This synopsis can also be placed in the very short Conclusion section, in which the remotely sensed observations are also only very briefly mentioned (line 800).

## 2.2 Incorporation of atmospheric information

The authors describe well in section 4.2 the problematic scale issue between kilometer-scaled atmospheric models and processes influencing PP which act on a finer resolution. They emphasize that "...grid cells are averages requiring hydrological modellers to consider effects of elevation, aspect, etc. in resolving precipitation phase fractions for finer-scaled models." (l588ff). I think this is a very relevant topic and I would like to see this topic further discussed in the research gap section, maybe even with some conceptual ideas and/or reference to existing work, or – if not existent – references to similar work done by the downscaling community to represent unresolved variability on the sub-grid scale.

The authors also promote in section 5.5 (Develop spatially resolved products) the benefit of gridded products. Since these products probably suffer the same scale problems as mentioned in l588 for atmospheric models, the authors may discuss this aspect of including sub-grid variability here as well.

## 2.3 Specific conclusions for complex terrain

The authors mention in the abstract that the manuscript "...conveys the advancements needed to improve predictions in complex terrain..." (l22f) and that in complex terrain robust observation networks are missing (l26f). I cannot find many details in the manuscript which allow formulating such a focus on complex terrain in the abstract. I suggest adding a paragraph in the research gap section summarizing specific issues in complex terrain.

## 2.4 Formality issues

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I would in general like to see page numbers to relevant sections when citing a book (or similar). One prominent example is the book authored by the U.S. Army Corps of Engineers, which regularly is available as a non-searchable pdf document or as a hardcopy. It contains various topics relevant to snow hydrology. To find the cited paragraph without mentioning page numbers is nearly impossible. I think this example shows that the standard of including page numbers when citing books and similar long references should be used. Similarly, the authors have not included access dates for all cited URL (e.g. line 200, line 1077 and others). Some cited references appear different than others (sometimes white spaces between "," sometimes italic "et al.", sometimes with square brackets). More importantly, there are a few citations which do not appear in the reference list. These points are mentioned in my section "Comments line by line" below.

## 2.5 Motivate Figures in the text

Figure 1 and Figure 4 are hardly described in the text, although containing important information. I would suggest that the authors link their text closer to those Figures, especially to Figure 1 which shows the consequences of wrong PP in a hydrological model.

## 2.6 Explain abbreviations and lines in Figure 2

It is not clear to me what the blue dotted line is (probably the mixing ratio). I would also suggest to add the used abbreviations for H, LE, f(sat), r etc in the caption. The arrow after H or LE should probably indicate that the energy of the hydrometeor is increasing because of a sensible heat transfer? Please clarify these uncertainties.

## 3 Comments line-by-line

Line 33ff: This sentence is the same as the previous.

Line 200/208: Please use access dates with URLs. I suggest putting the links in the reference list.

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Line 231: Lejeune not in reference list.

Line 265. Not clear which the comparison study is.

Line 354. The cited study is called Arkin and Ardanuy (1998).

Line 411 and elsewhere: Kulie and Bennartz (2003) not in reference list

Line 539: Froidurot wrongly spelled.

Line 945: no page numbers

Line 973: Krug (1995) and Bergström (1995) refer to the same document

Line 978: Missing page numbers

Line 1037/1040: Please use McCabe and Wollock (1999a) and (1999b)

Line 1213: two times YE et al. (2013) in reference list

Line 1178: delete "publication info" and add page numbers

Table 1: McCabe and Wollock (2009) not in reference list.

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