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The Cryosphere Discussions

Interactive comment on "Snow Ensemble Uncertainty Project (SEUP): Quantification of snow water equivalent uncertainty across North America via ensemble land surface modeling" *by* Rhae Sung Kim et al.

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Dear Referee,

Thank you for your valuable comments. Below we have provided a response to each of the comments provided by the referee.

Anonymous Referee 3's comments: The authors present a highly interesting and relevant study assessing snow modelling uncertainties across the North American region with (among others) the goal of providing information about global snow observation

needs. The study comprises four different land surface models and three forcing data sets, resulting in an ensemble of twelve members. The results show that the uncertainty represented by the ensemble spread varies across the study domain, with for instance high uncertainty in the simulation results for mountainous and forested regions. The authors conclude that for these regions high-resolution observations are needed to capture the high spatial variability in snow water equivalent. Overall, the article is very well written, easy to follow and from the technical perspective ready for publication in my opinion. Nonetheless, the current manuscript only provide rather shallow information about what snow observations are required in order to reduce the uncertainty seen in the simulation results. What variables should be measured and on which spatial and temporal resolution? For example, the need for high-resolution observations in mountains to capture the high spatial snow water equivalent variability has been recognized a long time ago. However, for very large domains, we still lack observations with sufficient quality as well as high enough spatial and temporal resolution, and this may not change soon either. Providing some more details, foremost more quantitative, about the observational needs to constrain the model uncertainties would make the paper even more interesting to read.

We agree with these excellent points that more detailed requirements of snow observations would be a nice outcome of this study. In fact, the SEUP efforts are designed with this quantification in mind, and this paper represents the initial phase that establishes a baseline of the snow modeling uncertainty over the continental scales. In this paper, we focus on providing guidance on when and where the snow modeling uncertainties are highest. Following-up on this effort, our group has been working on SEUP Phase II, to conduct observation system simulation experiments (OSSEs) that systematically quantifies the worth of the existing data and data yet be collected, and recently, these techniques have been applied to snow modeling studies. The snow OSSE derives the utility from a multitude of observations by exploring the interaction between different observation types and observation sampling methods (e.g., using different spatial and temporal resolutions). The results from this effort will be evaluated across a suite

of metrics that capture the information of the observations and uncertainty and are expected to help in the choice and refinement of sensors for the accurate characterization of global, terrestrial snow mass.

We have added the following sentence in lines 509-513 on pages 16-17 to acknowledge the focus of future efforts:

“More detailed requirements of snow observations (e.g., choice of observation types and sampling methods) will be focused in future efforts by conducting observation system simulation experiments (OSSEs) that systematically quantify the worth of the existing data and data yet to be collected. The results from this future effort are expected to help in the choice and refinement of sensors for the accurate characterization of global, terrestrial snow mass.”

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