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Hydrology and Earth System Sciences Discussions

Interactive comment on "A Bayesian spatial assimilation scheme for snow coverage observations in a gridded snow model" *by* S. Kolberg et al.

Anonymous Referee #2

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The authors present a methodology allowing the assimilation of satellite snow cover data into a gridded hydrological model. The proposed assimilation scheme applies Bayesian updating of the snow depletion curve (SDC) parameters. The information content of the snow cover data is enhanced by normalisation of maps of snow storage and accumulated melt depth (removing the elevation gradients). The methodology is illustrated using a 2400 km2 mountain region in Norway.

The authors attempt to solve the very difficult problem of estimating the snow water equivalent (SWE) using the snow covered area (SCA) satellite observations. While the observations of SCA are very accurate, the information content of these observations is limited.

The main innovation of the article lies in the application of the transformation of the SWE fields in order to enhance the information contained in the SCA data. The transformation consists of the normalisation of the spatial images of average snow storage and degree-day sum by the elevation data.

Unfortunately, the explanation of the methodology is far from clear. In particular, there is the absence of a clear statement of the problem and the authors do not explain how the transformation of the data may help in the process of assimilation of SCA satellite images. As the results are not very good (see Table 4), it is hard to say if all the effort is worthwhile.

The transformation of data is a powerful tool in statistics but should be handled with care (Box and Cox, 1964). The authors show that the removing of elevation gradients provides much smoother maps of snow storage and accumulated melt depth. However, the authors do not explore different methods of smoothing the spatial data (see for example Huang and Cressie, 1996).

Selected specific comments:

1. page 1187, line 25 with a general accuracy of around 7%

It is not clear what the authors mean by "accuracy" here.

2. page 1188, lines 5-12. The authors write about dynamically updated states that suggests a dynamic model. However, such model is not presented in the paper. It also seems that the authors use the expression dynamic for time varying, which is misleading.

3. Page 1189: lines 4-10. The authors state that variance describes the uncertainty of estimates - does that imply that the authors assume Gaussian distributions for these estimates?

4. Page 1189, end of the second section. The authors should mention also the work of Huang and Cressie (1996), who developed a prototype of a temporally dynamic and

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spatially descriptive model and showed how to use the Kalman filter algorithm to obtain snow water equivalent predictions at locations where no observations are taken.

5. Page 1190, line 10 and Figure 1-please correct the figure captions (bare ground fraction? Ěthe accumulated melt depth ) Does this function relate to average over the grid, or point variables? Guessing from the context, the authors use the expression 'dynamic' to describe time variability. In general, the expression "dynamic" is used to describe the time dependence of a variable on its previous values. The authors state that the accumulated depth is the only time varying (i.e. dynamic in the authors' notation) variable. From figure 1 it is clear that y is also varying in time. The whole sentence (line 11-13) is not clear and should be re-written.

Page 1192, eq. 5-6. Again notation is confusing: y should depend on time, and y' might suggest differentiation rather than integral: The authors should correct notation if they want to be understood correctly.

Page 1193, line 4: do the authors mean time varying rather than dynamic? Line 26: the authors introduce Gaussian Markov Random Field; it is not clear if the Markov property relates to time or to space.

Pages 1194-5: The transformation is not clearly explained (see the general comments).

Page 1196: The authors introduce the likelihood function as the distribution of observations conditioned on the model parameters. However, the determination of the parameters of this distribution is not clear.

Page 1197. Discharge-based likelihood requires the estimate of an internal water storage. The authors should explain how it is estimated.

Pages 1199-1200. The analysis of the results indicates that the updating scheme is affecting the posterior distributions, which is a positive outcome. The authors should give a more detailed comparison of the approach without transformation to illustrate better the advantages of the new methodology.

References

Box, G.E.P. and D.R.Cox, An analysis of transformations, 1964, J. Roy. Stat. Soc. Series B (Methodological), 26, 211-252. Huang, H.-C. and Cressie, N., 1996, Spatio-Temporal Prediction of Snow Water Equivalent Using the Kalman Filter, Computational Statistics and Data Analysis, 22, 159–175.

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