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Interactive comment on "Assessment of the uncertainty of snowpack simulations based on variance decomposition" *by* T. Sauter and F. Obleitner

Anonymous Referee #1

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This paper presents how Global Sensitivity Analysis (GSA) can be used to discuss snowpack model sensitivity and to identify factors affecting model results in terms of snow depth and surface energy balance (SEB). The authors apply the GSA method to punctual snowpack simulations carried out a high Arctic glacier (Kongsvegen Glacier).

The topic of this paper is important for scientists involved in snowpack modelling since it proposes a technique to quantify model sensitivity including interactions between parameters. This method can be extended to other geophysical models. The results are really interesting and should be published in GMD. Prior to publication, major revisions should be made to better illustrate the reliability of the results obtained with the GSA. The description of the reference simulation should also be improved. They are listed below (General comments) followed by more specific and technical comments.

General comments

1- The conclusions of the authors in terms of model's sensitivity rely on the parameters uncertainties and their distribution used to generate the ensemble and described in Table 2. The authors should evaluate if their ensemble represents correctly the model uncertainty. This could be achieved comparing the ensemble dispersion (the standard deviation of the members relatively to their average) to the model RMSE (computed using observations and the ensemble average). The error can be computed for snow depth but also for other measured parameters such as albedo and surface temperature. The ensemble dispersion is expected to be of the same magnitude as the error. If the ensemble dispersion is too large compare to the error, this would mean that one or several error distributions are too large and not appropriate.

This comparison requires having a reliable estimation of the model error. One year of simulation at KNG8 may be not sufficient. Therefore, the authors should consider extending their analysis to other years. If the data are not available at KNG8, a good alternative would be to use meteorological data available at KNG6 (Karner et al, 2013). The differences between their conclusion and those of Karner et al (2013) are mentioned several times in the paper (P 2826 l 2-3, P2828 l 3-5). Applying the GSA method at KNG6 would also allow the authors to discuss more in details these differences. Extending the GSA method to other years will probably require reducing the number of members of the ensemble. The authors could follow a two-step approach. They could first present the results of the analysis of the original version of the paper (one year at KNG8 with 16000 members) and then extend the analysis to other years at KNG8 or KNG6 using an ensemble with a restricted number of members.

2 - The authors include the aerodynamic roughness length, z0, in the sensitivity analysis (Tab. 2). As mentioned in Tab 1, this corresponds to the roughness length for momentum. In land surface models, the roughness length for heat exchanges z0H is

generally deduced from z0 following z0H=z0/K. K is a constant equal to 10 by default in SURFEX (Mascart et al, 1995). This is the case in the reference run (Tab. 1). The authors should explicitly mention if z0H is modified or not when generating the ensemble members using the uniform distribution for z0. If not, it probably reduces the mean sensitivity measures for z0 in the GSA. In this case, it would be really interesting to account for the dependency of z0H on z0 in the GSA. Note that this general comment may be not relevant if this dependency is already taken into account in the numerical experiments described in the paper. In any case, z0H should be mentioned in Tab. 2 with the type of distribution and the range of values.

3- Section 3.1 contains the description of the results of the reference simulation. For this simulation, the authors do not consider using a spin up to generate the initial profile of snowpack properties (especially temperature) contrary to the method followed by Karner et al (2013). Are meteorological data from previous years available at KNG8 and could they be used to improve the initial snowpack following the same method as Karner et al (2013)? What would be the impact on the simulations, at least for the reference run?

The description of the results (P2819 l 25 to P 2820 l 15) is rather short and could be more clearly identified using separated paragraphs for example. Then, the authors should discussed more in details the physical processes behind the model results. For example, the difference of snow temperature close to the surface may also be due to higher snowpack thermal conductivity because of the higher snowpack density close to the surface. On contrary, the sentence P 2820 l10-11 suggesting a “surprisingly” direct link between surface albedo and snow surface density should be explained.

Specific comments

Title The title should better reflect the content of the article. In particular, it should be mentioned that the GSA method was applied at one high Arctic site, which somewhat reduces the generality of the title.

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Abstract The Abstract is too vague and does not allow the reader to extract the method followed by the authors and the main findings of this study. For example, it should clearly mention where the study has been carried out (the current version only mentions “in a high Arctic environment”) and which factors affect the results. It would also be useful to state the name of the snowpack model in the abstract

P2813, l 5, the sentence “measured input except of outgoing infrared” is not clear. Indeed, when using a detailed snowpack model such as Crocus, incoming shortwave and longwave radiations are provided as atmospheric forcing. They can be measured values such as in this study. However outgoing shortwave radiation is not a measured value suggested by this sentence.

P2813, l 12, the terms P and M of Eq. 3 should be defined. In Armstrong and Brun (2008), the term E of Eq 3 has a different definition than the one used in this study. In Armstrong and Brun (2008), E is defined as the sublimation and evaporation rate at the surface.

P 2814, l 12-13, the term “roughness length for fresh snow” is not precise enough. Please specify which roughness length (see general comment 2).

P 2815, l 20, adaptations of Crocus’s parameterisation for fresh snow density have been already proposed in polar environment (Dang et al, 1997, Libois et al, 2014) and could be compared to the modification proposed by the authors.

P 2820, l 16-29, precise the time period considered as the “ablation season” and the “accumulation season”.

P 2821, l 1-2, Karner et al. (2013) give the 10-year average surplus as KNG6. It would be interesting to give the inter-annual range of surplus so that the reader can better realize the differences between KNG6 and KNG8.

P2821 l 25, P 2822, l 19-20, it would be useful if the authors could precise how the ensemble members are generated. For a given member, are the perturbations of the parameters fixed for the whole duration for the simulation (for example, RH is always increased by 2

P2827, l 25, the impact of PVOL on Crocus simulations has been previously discussed in Gascon et al. (2014) and could be mentioned in this discussion part.

Conclusion The conclusion is written as a single paragraph and would be more clear if the authors could divide it into several paragraphs.

Table 1: The definitions of ALB0.3, ALB0.8 and ALB1.5 are erroneous. These 3 parameters refers to the spectral albedo for surface ice for 3 spectral bands and not to the absorption coefficient for 3 spectral bands. These parameters are not used to compute snowpack albedo (see Vionnet et al (2012) for more details concerning the computation of snowpack albedo in Crocus). They are only used to compute albedo when the snow density is above the ice density threshold (830 kg m-3 in this study).

Technical comments

Text

P2810, l 19, (and after), the authors use sometimes “snowpack model” or “snow model”. Please be consistent. I personally recommend “snowpack model” to avoid confusions with the modelling of snow in the atmosphere as a microphysical specie.

P2810, l 19, (and after), use Crocus instead of CROCUS.

P2812, l 4, remove “of” between “the” and “snow grains”

P2816, l 10, use “snow depth variations smaller than . . .” rather than “snow depth smaller than . . .”

P2817, l 7, define SD

P2818, l 6, the sum goes from “i to k” rather than from “i to r”

P 2819, l 20, “shortwave radiation” is not used to evaluate the reference simulation

P2819, l 23, the date of the snow pit profile is 6 April "2011" instead of "2010".

P2820, l 4-5, Fig. 3 shows the vertical profile of temperature and not the "vertical temperature gradient".

P 2820, l 18 (and after), energy fluxes are in W m-2

P2181, l1, close the bracket after Fig. 1

Tables

Table 2: remove "%" after the range of values for PVOL (0.03-0.05).

References

Dang, H., C. Genthon, and E. Martin (1997), Numerical modeling of snow cover over polar ice sheets, Ann. Glaciol., 25, 170–176.

Gascon, G., Sharp, M., Burgess, D., Bezeau, P., Bush, A. B., Morin, S., and Lafaysse, M., How well is firn densification represented by a physically-based multilayer model? Model evaluation for the Devon Ice Cap, Nunavut, Canada, J. Glaciol., 60(222), 694 - 704, doi: 10.3189/2014JoG13J209, 2014.

Karner, F., Obleitner, F., Krismer, T., Kohler, J., and Greuell, W.: A decade of energy and mass balance investigations on the glacier Kongsvegen, Svalbard, J. Geophys. Res.-Atmos., 118, 3986–4000

Libois, Q., G. Picard, L. Arnaud, S. Morin, and E. Brun (2014), Modeling the impact of snow drift on the decameter-scale variability of snow properties on the Antarctic Plateau, J. Geophys. Res. Atmos., 119, 11,662–11,681, doi:10.1002/2014JD022361.

Mascart, P., J. Noilhan and H. Giordani. 1995. A modified parameterization of flux-profile relationships in the surface layer using different roughness length values for heat and momentum. Bound.-Layer Meteorol., 72(4), 331–344.

Vionnet, V., Brun, E., Morin, S., Boone, A., Faroux, S., Le Moigne, P., Martin, E., and Willemet, J.-M.: The detailed snowpack scheme Crocus and its implementation in SURFEXv7.2, Geosci. Model Dev., 5, 773–791, doi:10.5194/gmd-5-773-2012

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