Response to reviewer #2 to «A model for the spatial distribution of snow water equivalent parameterised from the spatial variability of precipitation" by T. Skaugen and I.H. Weltzien.

Let us first express our gratitude for the reviewers who spend their precious time securing the quality of our research, it is very appreciated.

General comments:
1. At the first time it sounds contradictory, that an improved SWE simulation does not improve the model performance in runoff. As this is one major results it needs to be clearer evaluated.

Response: R#1 had a similar comment (general comment #5), please see the response and suggested change.

2. The main novelty of this study is the implementation of SD_G to the rainfall runoff model and testing for large catchments. I would suggest including an analysis to answer some of the following research questions: In which catchments is the model performance best? Large or small catchments? High or low elevated catchments? Catchments in the south or in the north?

Response: R#1 had a similar comment (general comment #4), please see the response and suggested change.

3. What would happen if the simulations using SD_LN were restarted each year in autumn with no snow? This would solve the problem of the "snow towers". For me it is not clear why this is not considered? At least, it should be discussed in more detail.

Response: Such a procedure would solve the immediate problem of the snow towers, but we would still be left with a routine for the spatial snow distribution that did not work properly and/or is conceptually wrong. The coming and going of snow in a catchment is a process governed by the climate. Sometimes, in Norwegian catchments, snow survives the summer and other times it does not. Our ambition must be to have models that simulates this behavior without relying on manually updating the snow reservoir (which is not a trivial task since the other reservoirs/states in the hydrological model have to be updated as well). **Change**: No suggested change, we have already discussed this in some detail at p.22,l.12-p.21,l.11)

4. The quality of the figures needs to be improved. References in the text should be ordered first chronologically and then alphabetically. Also the reference list at the end of the manuscript needs to be revised because the format is not consistent (e.g. page 31 line 7-8 vs. page 31 line 10-11 vs. page 32 line 37-38).

Response: Noted
Change: We will improve figures as suggested below and edit the references in the text and check the format in the reference list.

Introduction: The introduction is very technical e.g. page 6 line 4-18 belongs more to the methods. The introduction does not have a clear story. It is not clear how you get the information of the spatial variability of the precipitation in order to estimate the parameters for SD_G.

Response: R#1 had a similar comment (general comment #1), please see the response and suggested change.
Change: We will make sure that the information on how the spatial variability of precipitation is obtained is clearly explained.

Methods: The methods part is very detailed with a lot of formulas. For the reader it is very difficult to follow and it is not clear for which parts in the results all these formulas are necessary. You should include the period of simulation in the methods and also your runoff measurements. Where are the data from? The description of the MODIS satellite (page 20 line 20 – page 21 line 3) belongs also to the methods and not to the results part.

Response: R#1 had a similar comment (general comment #3), please see the response and suggested change. The results are obtained by, at all times, having estimates of the spatial moments (the spatial mean and variance of SWE) in order to estimate the spatial PDF, so all the formulas are necessary. The precipitation data are from the Norwegian meteorological institute, whereas the runoff data are from Norwegian water resources and Energy Directorate (NVE).

Change: We will start this section with have an introduction, an overview, where the different steps for estimating the spatial PDF of SWE is outlined. This will help the reader to get an overall understanding of the method without detailed study of the equations. We will include the description of the MODIS data in the methods.

Results: This part is very short compared to the methods. The authors need to evaluate runoff, SCA and SCA with respect to different characteristics (size, elevation,. . .) of the 71 catchments.

Response: R#1 had a similar comment (general comment #4), please see the response and suggested change.

Specific comments:

Commas are sometimes missing after an equation (e.g. equation 7), also a colon before the equation (e.g. page 13 line 11).

Response :Noted
Change: It will be changed

The correct spelling is "i.e." instead of "i.e"

Response :Noted
Change: It will be changed

Page 2 line 11: ..in the already existing parameter . . ..?

Response: Noted
Change: perhaps just delete "already"

Page 6 line 6: You should define the SD_LN here and not later on page 7 line 1.

Response :Noted
Change: It will be changed

Page 8 line 3-5: Include log-normal distribution, gamma distribution. . ..

Response :Noted
Change: It will be changed

Page 8 line 9: should be "changed its shape"

Response :Noted
Change: It will be changed

Page 8 line 13: Skaugen and Randen (2013)

Response :Noted
Change: It will be changed

Page 8 line 21: include the parameter for shape and scale in the text.

Response :Noted
Change: It will be changed

Page 9 line 3: "reminder"

Response :Noted
Change: It will be changed

Page 9 line 6: Γ is not defined.

Response: Noted
Change: The gamma function will be defined

Page 9 line 11: space is missing in equation 3.

Response :Noted
Change: It will be changed

Page 10 line 16: spatial mean

Response :Noted
Change: It will be changed

Page 10 line 18: There is no straight line in Fig 1b)

Response: Agreed
Change: We will replace "does" with "will".

Page 12 line 15: Do "units" have the same meaning as pixels or area in this context?

Response: No, a unit is an amount of SWE (it is later defined as 0.1 mm)
Change: We will include the notation [mm], when the units are first mentioned (p.9,l.4)

Page 13 line 7: delete the comma

Response :Noted
Change: It will be changed

Page 14 line 6: bracket is not closed

Response :Noted
Change: It will be changed

Page 14 line 15: I would suggest to use f_m instead of f_s for the abbreviation of snowmelt in order to be consistent with f_a (accumulation).

Response: A good idea
Change: It will be changed, also in the Figure 2.

Page 14 line 16: delete "the same"

Response :Noted
Change: It will be changed

Page 15 line 3: "with respect to"

Response :Noted
Change: It will be changed

Page 15 line 10: why is "spatial" written in italic?

Response: Just to emphasize that it is spatial frequency distributions such that the frequencies and their integral can be seen as areas.
Change: It can be removed

Page 15 line 13: why "left"?

Response: They will become snowfree
Change: We will reformulate

Page 16 line 21: How is the correction be applied? Can you provide more details?

Response: Precipitation is increased or decreased by multiplying the amount with a constant.
Change: we will reformulate the sentence

Page 17 line 4: I would suggest to name the cited literature. ("is found in Skaugen. . .")

Response :Noted
Change: It will be changed

Page 17 line 6: From Table 1 only 5 instead of 11 model parameter are bold. The explanation of the reduction of the calibrated parameter is written in the discussion of the manuscript.

Response: 11 parameters can potentially be calibrated. In this study only 5 parameters are calibrated either using V1 or V2 (parameters in bold in Table 1).
Change: The explanation of the reduction of the calibrated parameters is written in the methods section (Sub sect. 2.5 (should be 2.6)). We will change the table caption of Table 1 to emphasize that in this study only 5 parameters are calibrated.

Page 17 line 9: "2.6" instead of 2.5

Response :Noted
Change: It will be changed

Page 17 line 11: delete "from"

Response :Noted
Change: It will be changed

Page 17 line 18: The following procedure was conducted:

Response :Noted
Change: It will be changed

Page 18 line 20: delete "for"

Response :Noted
Change: It will be changed

Page 19 line 11: delete ")."

Response :Noted
Change: It will be changed

Page 20 line 2: What do you mean with "most catchments"? How many catchments have these "snow towers"? Is this phenomenon only observed for high elevated catchments?

Response: We agree that the term "most catchments" is not very precise. The high mean annual slope of SWE using SD_LN was the cause of such a statement.

Change: In the stratified analysis of the catchments with respect to efficiency for runoff simulation SWE and SCA we will include a quantification of such behavior and see if it is related to mean elevation, catchment size etc. (see response and change to R#1, general comment #4)

Page 20 line 18: You wrote that you found 150 estimates for SCA for each catchment. In page 21 line 4 you wrote that 69 catchments have values for SCA and 2 have no SCA observations. Also why did you write in line 7 70 catchments? Please correct these inconsistencies or explain better!

Response: Sorry, a typo. There are 71 catchments. Only 69 catchments have estimated SCA
Change: We will change the numbers in P.20,l.17 and on P.21,L.7.

Page 21 line 5: delete "for"

Response :Noted
Change: It will be changed

Table 1: On page 16 line 18 you wrote that you use temperature and precipitation lapse rates, but why are they 0 in Table 1? Additionally, I would suggest shortening the table to the most relevant parameters, because you do not use the most of the parameters in the following. Include a space between Table and 1 (page 34 line 1) Also correct "Mean elevation of catchment"

Response: They are set to zero since they are not used. Unless the editor wishes otherwise, we would like to keep the table as it is since it is complete for the DDD model. Just having a subset of the table would demand an additional paragraph explaining the other parameters.
Change: Space will be inserted and also the correct spelling of "catchment".

Table 2: Where does this 1.02 value come from? You wrote in the table caption, that 1 is the ideal value.

Response: 1 is indeed the ideal value but the variability error is allowed to be more than 1 (signifies higher variability than the observed series), see Kling et al. (2012), full reference is found in the paper.
Change: No change.

Figure 1: "Spatial mean and standard deviation of observed precip." I would additionally suggest including the parameter values of the fitted line and rename "m" on the x-axis to "mean".

Response :Noted
Change: It will be changed

Figure 2: This figure is very hard to understand. Where comes the 0.1 on the x-axis label come from?

Response:R#1 had the same comment (specific commet #7). Since we deal with spatial frequency distributions, one must think of the frequencies as number of locations with a given SWE value. The x-axis shows the number of units, so we have to multiply with the unit value (0.1 mm) in order to have mm.
Change: we will make a new Figure 2 and elaborate on the explanation (see response to R#1, specific comment #7)

Figure 5: Why do you include a running average over the catchments? Are they sorted by size, mean elevation,..?

Response: The running mean was included to improve readability. They are not sorted by size, elevation but geographically, starting with central southern Norway, moving along the coast to the north.
Change: A new analysis of the results will be conducted and the figure will be replaced (see response and change to R#1, general comment #4).

Figure 6: Is your time unit days? It would be better to choose years! What does the "16.75" in the figure caption mean?

Response: Yes. "16.75 " is the identification of the catchment"

Change: We can add proper axis labels and remove "16.75"

Figure 7: I would suggest changing the y limits in the figures a and b to clearer see the differences between the log-normal and gamma distribution. Is the unit of slope of regression "mm" and "C"? I think it should be mm/time and _C/time (_C/year; mm/year)

Response: Agreed, to both comments
Change: We will change the y limits, and have proper units (mm/year and °C/year)

Figure 8: include the unit of the RMSE. Does this mean that the model is around 15% wrong in estimating the SCA? Do the models underestimate or overestimate the SCA? Where are the largest errors observed?

Response: We can include the unit and yes, the models are around 15% wrong in estimating SCA.
Change: In a more stratified analysis of the results we will answer the questions posed by the reviewer.(see response and change to R#1, general comment #4)

Figure 9: It is very difficult to see anything from this figure.

Response: The figure should have proper labels, but we do not see why it is so difficult to read the figure. Red and blue are simulated values of SCA and the green circles represents observed SCA, just as the figure captions says.
Change: We will add proper labels with units to the figure