

Interactive comment on “Precipitation and snow cover in the Himalaya: from reanalysis to regional climate simulations” by M. Ménégoz et al.

Anonymous Referee #1

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Overview:

The research article aims on the added value of a regional climate model to provide a first regional description of snow cover and snowfall in the remote mountainous region of Nepalese Himalaya, which is characterized by sparse dense observation network. In order to examine the precipitation and snow cover conditions in the Himalayan region, simulations with the regional climate model MAR including improved cloud microphysics and surface snow schemes have been carried out from March 2000 to December 2003. The evaluation of the model performance shows that due to its higher spatial resolution, the RCM is able to better capture the spatial variability of precipitation and wind fields in monsoon and extra-monsoon season compared to the driving ERA-Interim data. Uncertainties in the different rainfall products (satellite observa-

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tions, reanalysis and rain gauge networks) lead to pronounced biases between model and data. The authors highlight, that the RCM is able to simulate the precipitation in high altitudes more realistic since the density of rain gauge stations is less in these regions. This induces a more precise model reproduction of snow cover extent and duration. The impact of summer monsoon and extra-tropical Westerlies determines the large spatiotemporal variability of snowfall in the Himalayas as well as on the Tibetan Plateau. Finally, the authors suggest the performance of longer simulations to analyze the interannual snowfall variations in the Himalayas and the reduction of the model biases by optimizing the physical parameterization in the model.

The study addresses to an interesting and highly up-to-date research topic since the realistic resembling of the precipitation and snow cover conditions in remote mountainous areas as Himalayas with sparse dense observation network are currently of special focus in particular with respect to the feedbacks between Himalayan snow cover and the Indian summer monsoon under global warming. In this context, RCM studies are a useful tool to better resolve the regional patterns in high elevated areas with regard to existing uncertainties and errors in the few available observation data. The manuscript represents a substantial contribution to scientific progress and the results are presented in a well-structured way. However, the English language (especially the style) has to be improved significantly throughout the paper (see my comments below). Besides there are only some few clarifications and typesetting errors (see my comments below). If these minor comments are addressed appropriately, the paper is recommended for publication in “Hydrology and Earth System Sciences”.

Specific comments:

1. A proofreading for the English grammar and style (maybe by a native speaker) should be done for the entire paper. In particular, you should avoid using the same words (repetition) but rather apply more sophisticated words and phrases. In the following there are some examples, which have to be changed and/or modified.

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- p. 7652, line 8: “Eastern” – Please use a common format for the geographical orientation (also “Western”) in the entire manuscript (either small or capital letters).
- p. 7652, line 9: “brings” – Please replace this word with a more appropriate verb in the entire document. The same has to be done for words as “give”, “take” and “find”. Don’t use them when it’s not really necessary.
- p. 7652, line 9: Please delete “interesting” and try to avoid non-essential emphases.
- p. 7652, line 11: “We found are model to simulate quite accurately the snow cover extent and duration for the two years of simulation in these areas”. Please change the sentence order and style! Better would be: “During the two years of simulation, the model resembles the snow cover extent and duration quite accurately in these areas.”
- p. 7652, line 15: “Tibetan Plateau”. Please use always capital letter for “Plateau”.
- p. 7652, line 16: “marked”. Please replace it with “pronounced” or “dominant” or “significant” and avoid repetitions.
- p. 7654, line 26: “. . . boundary conditions . . .” better: “lateral boundaries”.
- p. 7655, line 8: Please use only “recently” instead of “very recently”.
- p. 7655, line 21: Please use “setup” instead of “protocol”.
- p. 7656, line 15: “Originally conceived for polar regions. . .” better: “Originally integrated over polar regions. . .”.
- p. 7658, line 15: “On a general view. . .” better: “In general. . .”. Please check this phrase in the entire paper.
- p. 7659, line 12: “. . . when going in the South and in the East of the domain. . .”. Please simplify the sentence and use another sentence order.
- p. 7659, line 24: “. . . reproduces better than the ERA-INTERIM . . .”. Please change the sentence order.

p. 7659, line 26: “This is particularly true over the Himalaya, ...”. Please don’t use “true” and rewrite the sentence regarding the style.

p. 7665, line 3: “As an example, ...”. Please change the sentence order.

2. p. 7655, line 11: What do you mean with “even event”? Should it be “local”?

3. Several times, the high computational costs are highlighted and used as major explanation for the short simulation period (e.g., p. 7655, line 16). Since it is obvious and known in science community, I wouldn’t recommend doing this so often but rather focusing on the main aim of the study. Further, for a better comparison with MODIS data, you have chosen this legitimate 3-yr simulation period. In the outlook you sufficiently emphasize on future work (longer simulations), which underlines the importance of an extension of this study. In this context, I highly recommend to analyze the interactions between snow cover extent in Himalayas and Tibetan Plateau and the Indian and/or East Asian Summer Monsoon intensity on interannual time scale since these feedbacks are still poorly understood especially with respect to the local response of soil moisture anomalies in spring due to snow melting and the rainfall in summer. In addition, the impact of remote acting extra-tropical variability modes as AO and NAO including the strength of the Siberian High on the large-scale monsoon circulation is of special interest.

4. In this paper, many observation and reanalysis data sets are used to compare them with the model results. I would suggest summarizing the data set descriptions in a single chapter after the model is presented.

5. How realistic is the cumulus convection parameterization scheme implemented in MAR regarding the realistic simulation of summer rainfall in your domain (especially in the most affected areas) compared to other studies? Do you see any advantages or disadvantages of this scheme by validating the monsoon rainfall with respect to the large differences between model and observations? Please add some comments and references.

6. Since the simulation period is too short, it is not possible to calculate the statistical significance for your differences, which would be interesting to see. However, some statistical parameters (BIAS, RMSE and pattern correlation) would be useful for a better quantification.

7. Please provide one or two references for the sparse dense meteorological observation network in mountainous regions (p. 7660, line 9).

8. For analyzing the seasonal snow cover extent, the conditions in the winter (DJF) and spring (MAM) seasons have to be considered since the most part of snow extent can be found within these seasons. I am wondering, whether the focus on the entire extra-monsoon period or the winter and spring season is more realistic. Did you check the winter and spring conditions? How well does the model represent the other main seasons? Are there any reasons in the different definition of winter (JFMA; p. 7667, line 7) and (DJFM; p. 7668, line 20)? Is this related to regional differences in the Himalayas? Please check the literature about the winter definition in these regions.

9. Figures:

Fig.1: okay

Fig.2: Please add the unit at the colorbar and use always headlines for the figure caption (a), (b) and so on as done in Fig.1.

Fig.3: Same as Fig.2 and use a larger size for the caption of the isolines.

Fig.4: Same as Fig.3

Fig.5: Same as Fig.2

Fig.6: Same as Fig.2

Fig.7: Same as Fig.2

Fig.8: okay

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Technical corrections (typesetting errors):

1. p. 7652, line 3: "... between March 2000 to December 2002". Please change it to "... between March 2000 and December 2002".
2. p. 7652, line 13: "... snowfall can occur during the whole year Western Himalaya. . ." I think a preposition is missing after year.
3. p. 7653, line 15: "Precipitations. . ." Please remove the "s" in the end.
4. p. 7654, line 4: Please remove "and better".
5. p. 7656, line 22: I assume it must be "79° E".
6. p. 7659, line 22: Please replace "toward" with "by".
7. p. 7661, line 8: "Similar like during the monsoon period, . . .". Please change it to "Similar to the monsoon period, . . .".
8. p. 7662, line 15: "... with regions with SCE . . .". Please use "of SCE" instead of "with SCE".
9. p. 7663, line 25: Please use "central" instead of "centre".
10. p. 7669, line 3: ", . . . observational data is . . .". Please change it to ", . . . observational data are . . .".

Please check also your reference list of spelling errors (especially the correct usage of small and capital letters in the titles).

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