

Interactive comment on “Snow cover data derived from MODIS for water balance applications” by A. Gafurov and A. Bárdossy

A. Gafurov and A. Bárdossy

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We are very grateful to Mr. M. Braun for his review of the paper. Following are statements to his comments:

The paper is revised with many changes commented by all reviewers. Several comments that can not be answered here directly because of length of texts will be answered in the final revised paper.

1. General Comments

M. Braun: While presenting a very interesting approach the presentation of the study should be substantially improved prior to publication. Technical and Linguistic review of the manuscript and precision of expression would substantially improve the paper.

A.Gafurov et. al.: The content of paper was changed in many places and the final re-

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vised paper will hopefully meet the requirements meant in the comments by Mr. Braun.

2. Specific comments

1)

M.Braun: - while the paper focuses on the single issue of cloud covered pixel removal in the data, the title and abstract are misleading as they suggest the derivation of snow cover and the application of snow cover in water balance application. The actual topic of the paper should be more clearly stated and the results should be addressed in the abstract.

A.Gafurov et. al.: The title and the abstract of the paper are fully revised in the final revision of publication.

M.Braun: - clarify that the presented methods are used as a sequence of steps of which each removes more cloud cover; consider a more thorough comparison of the performance of the approaches. Which are essential / most effective? What are advantages and drawbacks?

A.Gafurov et. al.: A small extension to methodology section is included where the sequence of steps is discussed. Evaluation of approaches and their advantages are also discussed in the results part of the study. Final revised paper contains all these changes.

M.Braun: - expand upon why daily retrieval is required? Is daily change in snow cover substantial enough to make it necessary to derive daily snow cover? Does the applied method provide substantially better information than updating snow cover on pixels whenever cloud free MODIS observations are available?

A.Gafurov et. al. Using proposed methodology, it is possible to obtain daily snow cover information which is very important for hydrological modeling purposes, especially when considering daily time step. Taking only cloud free MODIS snow information could lead to water balance estimation errors since: 1) it is possible that a single pixel is

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cloud covered for several continuous days when satellite observations take place and 2) the snowmelt amount when pixel is cloud covered can not be obtained because of continuous cloud cover and this may contribute to water balance in considerable order. The discussion according to this comment is included in final revised paper as well.

M.Braun: p 793 line 2: please cite examples of the mentioned studies

A.Gafurov et. al.: The importance of snow and glacier in mountainous areas for lowlands has been studied by several researchers in the past. Kling et al. [2006] carried out a study in whole Austria and came up with the runoff coefficient of snowmelt for alpine parts of Austria to be greater than 80 % and for lowlands less than 50 %. The study by Singh et al. [2006] in Himalayan basin reported 87 % glacier melt contribution in total runoff. This is included in the introduction part of final revised paper as well.

M.Braun: p. 793 line 12: At the latitude of the study area, more than 1 daily overpass of each MODIS will take place on most dates. This is most probably utilized in the production of MOD10.

A.Gafurov et. al.: Yes, more than 1 daily overpass of each MODIS will take place on most dates. But for snow cover data only daytime signals are used in the production of MOD10. The text on in final manuscript will be changed accordingly.

M.Braun: - p. 793 line 13: clarify global data; (this refers to the operational MODIS products?)

A.Gafurov et. al.: Yes, this refers to MODIS data products. 44 Variables are estimated using 36 spectral bands. The text in final revised paper is changed accordingly.

M.Braun: - p. 793 line 15: MODIS can not observe earth coverage through clouds = trivial for optical sensors.

A.Gafurov et. al.: As for my knowledge, the limitation of MODIS products is that no information is obtained for cloud covered areas. The text in the final revised paper is changed to: The main limitation for the direct usage of MODIS snow cover data in

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environmental studies is the extent of cloud covered pixels

M.Braun: - p. 794 line 4: % of what?

A.Gafurov et. al.: % cloud removal. Text in final paper is changed to They came up with 9-21% and 6-13% cloud removal for the first two methods, respectively, and varying accuracies for the third method according to the temporal step.

M.Braun: - p 794 line 20: please clarify source of climatological information

A.Gafurov et. al.: The source is specified and the text in final paper is changed to: The climate is characterized by semi-arid to arid with hot summers and cold winters (Kimura et. al., 2002)

M.Braun: - p. 795 line 1: over 40_C: certainly not a value for the basin. Refers to where?

A.Gafurov et. al.: From personal experience in the location close to Kokcha, over 40 °C refers to the region where also Kokcha is located. The value (over 40 °C) has been removed in the final paper.

M.Braun: - p. 795, Data section: MODIS tiles are NOT 2330km x 2030km! Please clarify the difference between MODIS Swath and Tiled Data products. In the context of the work Swath data is irrelevant as only tile H23V05 is used.

A.Gafurov et. al.: The text is changed to: MODIS snow cover product is partly distributed as tiles of about 10° by 10 ° worldwide. There are in total 36 horizontal (H) and 18 vertical (V) tiles covering the entire globe.

M.Braun: - p. 798: Method 4: Not clear: three direct neighboring pixels; which neighbors are chosen and why?

A.Gafurov et. al.: The text is changed to: Four direct side-bordering neighbouring pixels of the cloudy pixel are examined. If at least three pixels are defined as snow, then the cloudy pixel is also assigned to be a snow covered pixel as well. It is possible

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that this assumption is not always true, but the probability of a pixel having the same cover as at least three of its direct neighboring cells is higher than the middle pixel having the opposite cover.

M.Braun: - p. 798 Eq (7): The equation does not reflect the use of 8 neighboring pixels.

A.Gafurov et. al.: The equation in the final paper is changed according to the comment:

M.Braun: - p. 798: Figures 3a and b are used to illustrate the method; (really?) AND show a pixel cover time series. Please expand upon this; what do the values (200, 50, 25...) stand for? Do they have a specific meaning as numbers? If not consider replacing them by descriptive terms as is done later in the text on page 800. Consider also putting these terms in the figures.

A.Gafurov et. al.: The meaning of values (200, 50, 25) are given in the figure (next to the values) and also added to text in the final revision paper.

M.Braun: - p. 801 line 11: If it is not visible, why plot it?

A.Gafurov et. al.: This was removed in the final revised paper

M.Braun: - p. 802 Validation: First paragraph is very fuzzy. Please clarify.

A.Gafurov et. al.: Continuing sentences in final paper clarifies more the paragraph 1 of the validation section.

M.Braun: - it appear that if you apply approach 6 as approach 1 you're done. Clarify why approach 6 is used. Generally the order of the sequence of approaches should be explained.

A.Gafurov et. al.: Yes, if I apply approach 6 as approach 1 I am done. The processing technique of step 6 is applied at the end because its results are usually at the highest disagreement comparing to other steps. The sequence of approaches is explained more in detail in the final revised paper.

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M.Braun: - it would be interesting to address the advantage of the approach when compared to the 8-day composite snow cover product MOD10A2

A.Gafurov et. al.: This is included in the discussion part of the final paper.

M.Braun: - The validation of the approach using 2 days out of 1 year of data seems not to be very robust

A.Gafurov et. al.: The performance of methodology is calculated for 16 days in the results section and for 6 days in the validation section and these will be included in the final revised paper.

M.Braun: - consider combining the maps in fewer figures. The size of the snow cover maps is larger than necessary. Smaller maps next to each other could also make comparison easier.

A.Gafurov et. al.: The maps are combined into fewer figures and will be demonstrated in the final revised paper.

3. Technical comments.

All technical comments will be considered and corrected in the final revised version of the paper.

Thank you for your detailed comments!

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 791, 2009.

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