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Hydrology and Earth System Sciences Discussions

Interactive comment on "Validation of MODIS snow cover images over Austria" *by* J. Parajka and G. Blöschl

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We would like to thank Dr. Essery for his insightful comments on the manuscript. Although some of his interesting remarks go beyond the scope of this paper, they will be addressed in our future research. We have addressed his comments as follows:

General comments:
We agree with the reviewer that additional cloud information may help assess the accuracy of the MODIS cloud classification. Unfortunately, the available data set (measurements at the climate stations) did not include the relevant information about cloud cover and thus it was not possible to perform such an analysis. An analysis of the snow mapping accuracy using the last available cloud-free observation is interesting and could also be examined. A similar topic was addressed in the study

of Tekeli et al. (2005), who found that allowing for a 2-day time shift between MODIS and ground data increased the MODIS accuracy from 62% to 82%. We have added a relevant comment to the Introduction section to highlight such possibilities.

Specific comments:

p. 1575:

1) We have added information on the "others" category: "...we reclassified the MODIS snow cover maps from originally 16 pixel classes to four classes: snow, no snow (land), clouds and others (mostly representing missing or erroneous data)."

2) The details of the CORINE land cover mapping approach, minimal mapping units, spatial resolution, legend nomenclature etc. are provided in the guidelines published by the European Environmental Agency (EEA) which are referred to in the paper. There is no need for duplication and we hence prefer to retain the brief description of the data set as it is.

3) We provided more detail on the ground measurements: "The snow depth readings are taken from permanent staff gauges and are hence point measurements. They are performed daily at 7:00 ...".

p. 1576: As indicated in the paper, it is difficult to assign representative land cover classes for the climate station locations (pixels) because, following WMO standards, all climate stations are located at open grassy sites. In this study we have therefore examined the larger scale effects of vegetation and evaluated the MODIS accuracy especially in forested areas. As is demonstrated by the results, the largest misclassification errors were found for the pasture and shrub classes rather than for the forest. This was also a reason why we grouped the remaining land cover classes into one category. The classes grouped into the "others" category are given in the discussion on potential sources of misclassification (p. 1581) and include the urban fabric, industrial units, open spaces, permanent crops, heterogeneous agricultural areas

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and inland wetlands classes. Application of the NDVI may help shed more light on the MODIS accuracy for different land cover units and is on our future research agenda.

p. 1577: Again, an analysis of the sensitivity of the validation accuracy to snow depth thresholds is interesting but beyond the scope of this paper.

p. 1578: Yes, there are days with no snow-free land apparent but cloud cover implies that snow coverage is less than 100

p. 1579: The validation accuracies presented in Tables 2 and 3 are not identical. In order to improve the clarity we have changed the paragraph as follows: "Out of a total of 77168 cloud-free station-days for which snow was measured at the climate stations, 84

p. 1580: We do not have sufficient information to compare the forest densities of Hall et al. (2001) and Simic et al. (2004) with those in Austria. The separation of underestimation (MU) and overestimation (MO) errors in relation to topography and land cover (as is given in Figure 7) did not exhibit any consistent relationship. We thus preferred to display the overall misclassification error in Figure 7.

p. 1582: We have added an explanation to the caption of Figure 9: "...captured in the afternoon. In this example, the in situ data indicated snow cover and the MODIS data indicated no snow."

p. 1585: We have added the following references to the Discussion and conclusions section: "...based on data assimilation techniques such as Ensemble Kalman Filtering (e.g. Rodell and Houser, 2004, Slater and Clark, 2006)."

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p. 1590: There are a number of possibilities for presenting the results. For clarity, we prefer to retain the table as is.

p. 1592: Again for clarity, we prefer to retain the layout of Figure 2 as it is.

Technical corrections:
1) We have made all technical corrections suggested by the reviewer.

References: Hall, D. K., Riggs, G. A., Salomonson, V. V., Barton, J. S., Casey, K., Chien, J. Y. L., DiGirolamo, N. E., Klein, A. G., Powell, H. W. and Tait, A. B.: Algorithm theoretical basis document (ATBD) for the MODIS snow and sea ice-mapping algorithms. Available at: http://www.modis-snow-ice.gsfc.nasa.gov/atbd01.html, 2001.

Rodell, M., and Houser, P. R.: Updating a land surface model with MODIS-derived snow cover. Journal ofHydrometeorology, 5, 1064-1075, 2004.

Slater, A. G., and Clark, M. P.: Snow data assimilation via an ensemble Kalman filter. Journal of Hydrometeorology, 7, 478-493, 2006.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 1569, 2006.