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Hydrology and Earth System Sciences
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Discussions

# *Interactive comment on* "Validation of the operational MSG-SEVIRI snow cover product over Austria" *by* S. Surer et al.

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Response to Reviewer #1: We would like to thank the anonymous reviewer for her/his helpful comments on the manuscript. We have addressed the comments as follows (listed in the sequence given by the referee):

1) Overall the paper is organized well, the objectives, the approach and conclusions are fairly clear. It provides a rather detailed characterization of the accuracy of SEVIRI based snow mapping with respect to the surface elevation and the season. It should be mentioned however that the validation approach used in the paper is not novel: in the last decade a couple of dozens of papers have been published where satellite-based snow products were either compared with in situ observations or matched to other



satellite-based maps. The novelty of the study concerns only the source of remote sensing data which is MSG SEVIRI.

We agree with the reviewer that there are already numerous validation studies published. In order to stress this information more clearly, we have revised the introduction as follows: "Recently, operational satellite products have become available that provide snow cover 10 information at different spatial and temporal resolutions (Table 1). Table 1 indicates that most of the current products provide daily snow cover information at spatial resolutions ranging from 500 m to 5 km. The numerous validation studies indicate that the satellite products have large snow mapping accuracy with respect to ground snow observations for cloud free conditions, which varies between 69% and 94% in the winter seasons. "

2) The discussion section of the paper could be substantially expanded. What are the sources of snow mapping errors, why the accuracy of MODIS and MSG is different, what can be done to improve the MSG snow mapping algorithm, does the accuracy and the spatial resolution of current SEVIRI snow maps satisfies local hydrological/ weather/climate models/applications: all these and many other questions can be covered in the discussion section.

One of the aims of EUMETSAT HSAF project is to investigate the impact of snow products developed within the project in hydrological studies. There have been several impact studies performed by using the snow products in hydrological modeling. Some of these studies will be published in coming months/years. In response to this comment we have extended the discussion section by adding following sections: a) a part related to hydrological modeling:

"The use of MSG-SEVIRI snow product in hydrological modeling is under study, calibration of a conceptual hydrological model by using MSG-SEVIRI snow cover product has been performed. It is observed that the multi-objective calibration, in which MSG-SEVIRI snow cover data is used besides the runoff data, improved the snow cover estimation of the hydrological model (Akyurek et al., 2013).

b) Some discussion on snow mapping errors (page 11 line 17):

"The comparison between MSG-SEVIRI and MODIS snow cover products shows a good overall agreement. The overestimation and underestimation errors of MSG-SEVIRI snow product is larger compared to MODIS-Terra snow product. In both of the products underestimation error is observed in winter months and overestimation error is observed in spring and summer months. The overestimation and underestimation are more pronounced for mountainous areas compared to flat lands for MSG-SEVIRI snow product. Besides the spatial resolution affecting the snow mapping accuracy, the difference in the viewing geometries of two sensors may have an effect on the snow mapping. The view geometry may be one of the major error sources in snow mapping algorithms. The influence of the varying MODIS view zenith angles on snow mapping algorithm must be investigated in detail. As view zenith angle increases, it is known that NDSI decreases (Xin et al., 2012). Since MODIS observes the surfaces at much smaller view zenith angle (VZA)s then the SEVIRI, it detects more snow cover area. That may be the reason to observe large underestimation errors for SEVIRI compared to MODIS in winter months. The narrow band width in Green and Mid. Infrared portion of the spectrum for MODIS makes the possibility to map more snow compared to SEVIRI. The over estimation for spring months is due to high percentage of fractional snow cover due to melting in these months. MSG-SEVIRI algorithm tends to map more snow for fractional snow covered areas. The effect of complex topography, and the shadows was not held in MSG-SEVIRI snow mapping algorithm. Therefore the MSG-SEVIRI algorithm can be modified with the use of a proper DEM in order to correct the topography effect."

3) It would be good to give a better justification for limiting the study to the territory of Austria. Since snow cover is one of the primary meteorological and hydrological factors, it would seem more reasonable to define the study region considering the location of local watersheds or the domain of regional weather models. The validation



studies of the snow products within HSAF project have been done and still being done in several mountainous areas within Europe. The lacking of ground observations at mountainous areas makes the validation studies difficult. The reason in selecting the Austria as a study area is the availability of ground observations at different altitudinal zones ranging from the lowland to the high Alpine environment. We believe, indeed, that the large variability of physiographic characteristics and relatively large density of ground snow observations make Austria an ideal test bed for such validation and also for extrapolation of results to similar conditions (i.e. Carpathians). In response to this comment, a new sentence is added in line 3 on page 3: "MSG SEVIRI snow product has been produced operationally within HSAF project funded by EUMETSAT. The validation studies composed of comparison of ground observations with satellite snow product have been performed on mountainous areas of Europe (HSAF, 2011). The idea in this study is to extend the test sites in order to evaluate the MSG SEVIRI snow product and perform detailed validation studies."

4) When describing the SEVIRI-based snow mapping technique it seems important to more clearly state that two different snow mapping algorithms are used with MSG data, one is applied in the plain areas whereas the other one is used in the mountains. We agree with the reviewer and revised the section as follows (Page 3 line 13): "The snow cover retreival algorithm differs for flat and mountainous regions. Considering different characteristics of snow for mountainous and flat areas, two different algorithms are used in producing the snow products for flat and mountainous areas, and then the products are merged to have a single snow product. In flat regions......"

5) The map in Figure 1 looks strange: Eastern Europe and Western part of Russia are shown as snow-free, whereas in February these areas should have at least some snow. Apparently only snow cover in the mountains is shown in the map. If this is the fact, it should be clearly stated in the text of the paper. Otherwise the map is misleading. We agree with the reviewer, so we changed the map, which now presents a merged (flat and mountainous) product. (Figure Attached)

6) The definition of mountainous areas on page 12157 is not quite clear, particularly its last clause ("range in mean altitude exceeded 800 m and mean altitude exceeds 500 m"), please reformulate. In response to this comment, we have changed the sentence as follows: "The area is defined to be mountainous if the mean altitude in the particular mesh exceeds 1000 m or the mean altitude in the mesh exceeds 700 m, and the standard deviation of the slope is greater than 2o or the mean altitude variation (the difference between the maximum and minimum altitude in the particular mesh) exceeds 800 m and the mean altitude exceeds 500m."

7) Page 12158: ": : :compares the sum of all correctly classified days with the presence of snow and no snow to the number of all cloud-free days at each meteorological station (station-days) in the selected period: : :" : generally understandable but sounds a little awkward. Please rephrase. We agree and have revised the sentence as follows: "The overall accuracy index kA is estimated at each meteorological station and it is used to compare the sum of all correctly classified days where snow and no snow have been observed to the number of all cloud-free days at each meteorological station (station-days) in the selected period."

8) Page 12159: ": : :relative frequency of MODIS pixels classified as clouds is less than 60 %": "fraction" sounds better than "frequency" in this context. The same applies to the two sentences that follow. Yes, we agree and in response to this comment we have changed the section as follows: "The comparison is performed at the coarser spatial resolution of the MSG-SEVIRI and for those MSG-SEVIRI pixel-days where the fraction of MODIS pixels classified as clouds is less than 60%. Our test simulations (not shown here) indicate that the results are insensitive to the selection of this threshold between 40 and 70%. In the mA and mM evaluation, the ground is considered as snow covered if the fraction of MODIS snow pixels within the MSG-SEVIRI pixel is at least 50% of the sum of MODIS pixels classified as snow and land. The presence of no snow (land class) is considered in the same way, i.e. the fraction of MODIS pixels classified as land is larger than the sum of snow and land pixels.



9) Page 12161: I do not think that it is legitimate considering clouds as the snow mapping error. Therefore the Kc index that combines real snow mapping errors and cloudy pixels seems quite confusing. To compare the effective daily area coverage by MODIS and SEVIRI it looks more reasonable to simply examine the total area of cloud-clear portions of the daily snow cover map. The Kc index is used to present the performance of the snow products for all days including the days with cloud cover. In order to present the cloud clearance property of MSG-SEVIRI snow product, we believe that all-days accuracy index is needed, as it is presented in Figure 6. On the other hand the reviewer is right that cloud classification performance is not related with the snow mapping accuracy evaluation. Therefore Ka and Km indices are used to present the performance of the products for cloud clear days, as it is presented in Figure 5.

10) Page 12165: Prior to discussing the difference between the MSG and MODIS snow identification algorithm and particular values of the spectral indices (NDSI and SI) used in the two algorithms these indices have to be introduced. In response to this comment, a new sentence describing SI is added on page 3 line 21, and sentence describing NDSI is added on page 5 line 1. "In the mountains, the snow recognition algorithm uses the snow index (SI) which relates 0.6$\mu$m (0.56-0.71 $\mu$m), and 1.6$\mu$m (1.5-1.78 $\mu$m) SEVIRI channels. The used snow index is obtained by dividing the bands NIR1.6 to VIS0.6. The pixels having NIR1.6/VIS0.6 values lower than a fixed threshold value of 0.6 were collected. The cloud. . ...."

"The spatial resolution of the products is 500m. Normalized difference snow index (NDSI) is a well-known snow index used in snow product generation from MODIS data. The NDSI takes advantage of the fact that snow reflectance is high in the visible (0.545–0.565 $\mu$m) wavelengths and low in the shortwave infrared (1.628–1.652 $\mu$m) wavelengths (Hall et al. 2006, 2007). For the validation. . .."

11) There is a number of other factors that apparently may affect the snow identification, the accuracy of snow maps and the agreement between MODIS and MSG snow products. In particular MSG mostly observes southern slopes of the mountains which

may have less snow especially in spring and summer, whereas MODIS scans the region primarily in the east-west direction. Do the authors observe any effect of the different geometry of observation of MODIS and MSG on the accuracy of snow mapping ? This is an interesting suggestion. In this study, however, we did not examine the effect of different viewing geometries of the sensors MODIS and SEVIRI on snow mapping performance. But we plan to investigate the effect of varying MODIS view zenith angles on snow mapping as well as the effect of band widths of the sensors on Green and MIR bands in the future. In response to this comment, following information is added to the discussion part on page 11 line 4: “The comparison between MSG-SEVIRI and MODIS snow cover products shows a good overall agreement. The overestimation and underestimation errors of MSG-SEVIRI snow product is larger compared to MODIS-Terra snow product. In both of the products underestimation error is observed in winter months and overestimation error is observed in spring and summer months. The overestimation and underestimation are more pronounced for mountainous areas compared to flat lands for MSG-SEVIRI snow product. Besides the spatial resolution affecting the snow mapping accuracy, the difference in the viewing geometries of two sensors may have an effect on the snow mapping. The view geometry may be one of the major error sources in snow mapping algorithms. The influence of the varying MODIS view zenith angles on snow mapping algorithm must be investigated in detail. As view zenith angle increases, it is known that NDSI decreases (Xin, 2012). Since MODIS observes the surfaces at much smaller view zenith angle (VZA)s then the SEVIRI, it detects more snow cover area. That may be the reason to observe large underestimation errors for SEVIRI compared to MODIS in winter months. The narrow band width in Green and mid. Infrared portion of the spectrum for MODIS makes the possibility to map more snow compared to SEVIRI. The over estimation for spring months is due to high percentage of fractional snow cover due to melting in these months. MSG-SEVIRI algorithm tends to map more snow for fractional snow covered areas. The effect of complex topography, and the shadows was not held in MSG-SEVIRI snow mapping algorithm. Therefore the MSG-SEVIRI algorithm can be



modified with the use of a proper DEM in order to correct the topography effect.”

12) MSG SEVIRI includes an HRV band. Can it be used to improve the spatial resolution of snow cover maps ? The better spatial resolution of HRV band, having spectral waveband 0.75 ïĄ■m, can be helpful in replacement of visible band having spectral waveband 0.635 ïĄ■m. As the visible waveband increases, the reflectance values are getting decrease so it is better to use 0.6 ïĄ■m waveband in detecting snow. It is also known that the main contribution in detecting snow comes from the difference between optical and IR bands. Therefore the use of HRV band would not create too much improvement in snow cover mapping.

13) Since the region involved in the analysis is not large, it would be good to discuss whether the results of the study are applicable to other mountainous regions in Europe. Would the accuracy be the same or different over Carpatians/Atlas/Pyrenees/Scandinavia etc. ? In response to this comment, a new sentence is added in line 3 on page 3: “MSG SEVIRI snow product has been produced operationally within HSAF project funded by EUMETSAT. The validation studies composed of comparison of ground observations with satellite snow product have been performed on mountainous areas of Europe (HSAF, 2011). The idea in this study is to extend the test sites in order to evaluate the MSG SEVIRI snow product and perform detailed validation studies.” âĂČ

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C6953/2013/hessd-10-C6953-2013-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 12153, 2013.

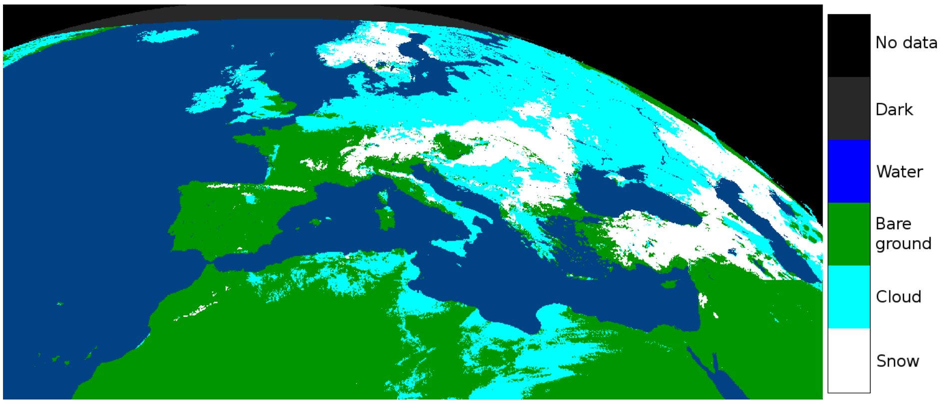


**Fig. 1.** Example of a MSG-SEVIRI snow cover map for February, 21st, 2012