



Snow cover dynamic in the Atlas Chain (Morocco) using daily MODIS products over the last decade

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Over semi-arid areas, snow cover in the mountains represents an important source of water for many people living downstream. This study evaluates the daily MODIS snow covered area products over the 7 catchments with a rain-snow functioning covering the Atlas chain in Morocco. To this objective, more than 4600 daily MODIS images from September 2000 to June 2013 have been processed based on a spatio-temporal filtering algorithm aiming at reducing the cloud coverage and the problem of discrimination between snow and cloud. The number of pixel identified as cloud is reduced by 96% from 22.6% to 0.8%. In a second step, the ability of the product to detect snow is tested against 5 stations of automatic snow depth measurements covering 22 complete seasons. The overall accuracy is equal to 90%. Although slightly lower than previously published validation studies, this is fairly good considering the highly varying dynamic of the snow cover in the region characterized by period of complete ablation even during the core of the winter due to high incoming radiation. The timing of the seasonal snow is also correctly detected with 11.4 days and 9.4 days of average errors with almost no bias for the onset date and the ablation date, respectively and 18.2 days on the snow cover duration. The processed fractional snow cover is also tested against a series of 19 clear images acquired by the FORMOSAT sensor at 8-m resolution from February to June 2009 in the Tensift catchment (Marrakech). The comparison of the two datasets results in a correlation coefficient of $r=0.94$ and an average low bias of 3.96 km^2 but some differences are observed during the very end of the ablation phase. Finally, the processed snow cover products provide insights into spatio-temporal variability of snow cover in the region which is analyzed through seasonal indicators including onset and melt-out date, the snow cover duration (SCD) and the maximum snow cover extent: (1) the dynamic is characterized by a very strong interannual signal with a variation coefficient of the maximum Snow covered extent reaching 77%; (2) there is no evidence of a statistically significant long term trend on none of the seasonal indicators although results point out that the snow cover duration has increased in winter and decreased in spring for the 2001-2013 period. The study concludes that the daily MODIS product can be used with a reasonable confidence to map snow cover in the South Mediterranean despite difficult detection conditions. This characterization of snow pack dynamic at seasonal and inter-annual scale is also an important and unique information in the region for water managers such as basin hydraulic agency to plan water management at the catchment scale.