Spatio-temporal variations of snow cover in the southern slope of central Alborz

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Extended Abstract

Introduction

Snow cover as one of the most important components of the Earth's surface plays an important role in the global hydro climate processes. Snow acts as a temporary reservoir of water and keeps the rivers flowing long time and recharges underground aquifers to provide water during the dry season for billions of consumer. Study of spatial and temporal variability of snow cover in arid and semiarid region such as Iran can indicate very high temporal and spatial variations of precipitation. In Iran, about 60% of surface water and 57% of groundwater is in snow covered areas. Hence, the purpose of this study is to evaluate the accuracy of MODIS snow products and combines remote sensing and terrestrial data to investigate the spatiotemporal changes of snow cover in South Central Alborz slopes. Eventually, this research assesses the relevance of this change with climatic elements.

Materials and Methods

In the present study, we have used data from 16 synoptic stations located in the study area and MODIS data. At first, the MOD10A and MOD10A2 products have been used to extract snow cover. Then, snow depth, precipitation and temperature (on a scale of hourly and monthly) data of the selected stations have been used to evaluate the accuracy of MODIS data and relationship between snow cover changes and climatic elements. MODIS images have also been used for the detection of snow cover by the NDSI index = (band4-band 6) / (band4 + band6). In this equation, Band4 is the spectral reflectance in the visible band (0.555 micrometers) and band6 is the spectral reflectance in the intermediate-infrared band (1.64 micrometers). Hence, in this sensor products addition to snow other phenomena is indivisible. Therefore, in order to separate and identify the pixels of different phenomena, the images have been processed in ArcGIS. For

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evaluation of the pictures, daily images (MOD10A1) for three years (2007-2009) winter (December to February) have been processed and accuracy assessment conducted by snow depth data. If the depth of snow at the station is one centimeter or more, the pixel located at the station is considered as snow cover and otherwise as no snow. The adaptation degree between the image and the station has been obtained by a coefficient divided by the number of days for the correct classification (snow-snow and no snow-no snow) divided to the total number of days in each month, as a percentage. Finally, the variability of snow cover has been evaluated by Mann-Kendall test. To examine the relationships of snow cover anomalies and climatic conditions, Z index has also been employed.

Results and discussion

The percentage of adaptation of the earth data and satellite images for three months of December, January, and February is 81, 67 and 75 percent, respectively. However, these results are the average of all the stations and in the snowy areas the average image precision is even reduced by 40%. The studies show that errors are often caused by clouds in the location pixel. Therefore, the second assessment has been performed by removing cloudy days. The results show that at this phase image accuracy and the adaption percentage is increased for each quarter to more than 95 percent. According to the movement of the clouds, the eight days product of this sensor has been used to monitor and evaluate changes in snow cover. The snowfall in the region began in October, with the fall in air temperature and increase in snow accumulation, reaching a maximum of 34 percent during the period ending January 9. The snow cover in January and February were 31.4 and 25.6 percent, respectively, with the highest monthly values. The highest and lowest snow cover values for these two months were 76.2% and 9.7%, respectively, in January 9, 2008, and February 2, 2015. The coefficient of snow cover variations is increased with decreasing height, and is extremely severe in less than 1500 m, while in the areas above 2500 m in autumn and winter, it is less than 20%. A survey of monthly snow cover changes shows that in October, November and March, the trend is increasing, although not significant. While in January, February, April, and especially in May most snow covers are declined over the last 15 years. This negative trend is significant in May with a score of -2.18. Comparison of the average rainfall, temperature and snow cover percentage indicate that most of the positive anomalies of snow cover with positive anomalies of rainfall and negative anomalies of temperature and its negative anomalies are consistent with the positive anomalies of temperature and negative rainfall.

Conclusion

The results of the satellite image accuracy estimation showed that the MODIS snow product has a good ability to estimate the snow cover area of the study area. But the cloud is one of the main limitations of MOD10A1. As in the present study, after removing cloudy days, the average accuracy of these images has risen from 67% to over 95% and even in snowflake stations to 100%. Since the clouds are changing rapidly and daily, but snow is gradual, it is recommended to use this sensor product (MOD10A2) to monitor the long-term snow cover. The monitoring results showed that the January and December have the highest snow cover area. In terms of spatial changes, the continuity and the extent of snow cover decreases from West to East in the study area. The percentage of snow covers in the Shahrood and Karaj river basins are more than the Semnan and Hablehrood basins. The results of the trend show that although snow cover

changes tend to be negative for most of the months and high altitude zones, rarely this decline is significant. The highest increase was observed in March with a score of 1and the most severe declining trend in May, with a score of -2.18, and a maximum reduction in peak space was also observed in the altitudes of 2500 to 3750 meters. In most of the years, the positive anomalies of the snow cover are coincided with the positive anomalies of rainfall and the negative anomalies temperature.

Keywords: southern Alborz, snow, remote sensing, MOD 10.