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Remote sensing based retrieval of snow cover properties Case study (Shirkooh Mountain Yazd, Iran)

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ABSTRACT

Snow cover area is one of the most important criteria to calculate snow melt runoff. This can have an effect on the biology of the plant and the environment of a region. Using the catchment basin physical characteristic to calculate snow cover area is a conventional method, though its accuracy is not good enough. Most of the useful methods in calculating snow cover area are based on satellite images and remote sensing methods. In this research, based on satellites images and Weather-station data, two methods have been used to calculate snow cover properties. As MODIS images have better spatial/spectral resolution in comparison with other similar Satellite images like NOAA/AVHRR, they are more suitable to distinguish snow from cloud. In this research, Normalized Difference Snow Index (NDSI), and threshold technique have been used to snow cover properties in Shirkooh Mountain. In first step, snow cover were separated based on NDSI. Then, optimum threshold was determined for three spectral bands (2, 4 and 6) to separate snow from clouds and other wet resources. Furthermore, ASTER images which have 15m spatial resolution, have been used as base images to check the accuracy of snow cover areas that extracted from MODIS images. The results show that correlation between the snow cover area extracted from ASTER and MODIS images is about 0.87. Also, since the correlation obtained from the snow pixels reflectance and snow Persistence is more than 0.5, by using these images, snow Persistence can be estimated.

Keywords: Snow cover; Shirkooh; NDSI; MODIS image; Remote Sensing.

INTRODUCTION

Snow covered area is a huge water resource on most part of the world and mountainous areas. Over 40 percent of the northern hemisphere is covered with seasonal snow (Klein, A.G., Hall, D.K. & Riggs, G.A., 1997) also Over 30 percent of the earth is covered with seasonal snow (Dozier, J., 2000). Snow-cover and its equivalent water, supplies 1/3 of the water requirements for farming and its land irrigation throughout the world (B. Rayganiand and et al).The high albedo of snow coupled with its large areal extent makes it a strong influence on the Earth’s radiation budget (Klein, A.G., Hall, D.K. & Riggs, G.A., 1997). Snow cover monitoring is necessary for climatologists. Therefore, continuous snow cover monitoring and survey of snow cover maps due to higher efficiency of snow cover in different studies is very necessary. A number of satellites and airborne remote sensing systems can contribute to snow monitoring from space. These systems include NOAA-AVHRR (National Oceanic and Atmospheric Administration’s Advanced Very High Resolution Radiometer) and Terra/Aqua-MODIS Polar-orbiting

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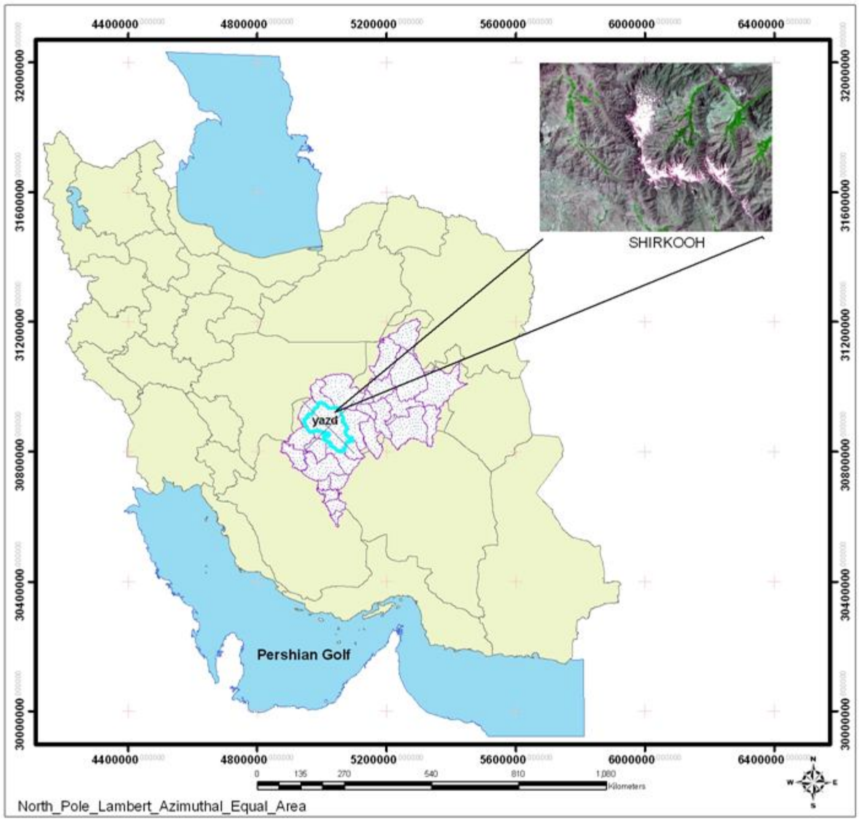
satellite systems have been extensively used to monitor the global distribution of snow. Algorithms have been developed to map snow using Moderate Resolution Imaging Spectroradiometer (MODIS) data. The snow-mapping algorithm employs a grouped-criteria technique using the Normalized Difference Snow Index (NDSI) and other spectral threshold tests to identify and classify snow to map snow cover in mountain region. The usefulness of the NDSI is based on the fact that snow is considerably more reflective in the visible than in the shortwave IR part of the spectrum, and the reflectance of most clouds remains high in the short-wave IR, while the reflectance of snow is low. In extracting snow area from MODIS satellite images, it was completely obvious that if we do the atmospheric corrections correctly, we can provide an image of snow covered area with NDSI with medium accuracy more than 80 percent (Lee & Over, 2001). It should be mentioned that the other two criteria on bands 2 and 4 are necessary for removing the shade and water (Zhang, 2003).validation of the MODIS snow maps is an on-going process. Landsat Enhanced Thematic Mapper Plus (ETM+) data, when available, have also been used for validation of the MODIS snow maps. Results show that the MODIS snow-mapping algorithm is very sensitive to mapping snow; however, the snow maps often show more snow than really exists. This is especially true in warm areas where no snow should exist. Additional criteria to screen false snow detection have been developed and integrated into the algorithm. MODIS compared with other images like NOAA has better spatial resolution and more bands and is better for survey. We prepared snow cover map by MODIS data in Shirkooh Mountain. In this research NDSI index and threshold technique have been used to detect snow cover changes in this region. In first step, snow areas were separated based on NDSI. Then optimum threshold was determined for three spectral bands (band number 2, 4 and 6) to separate snow from clouds and other wet resources. Furthermore, ASTER images which have 15m spatial resolution, have been used as base images to check the accuracy of snow cover areas that extracted from MODIS images. The results compared with snow cover map extract from ASTER images and showed higher precision. This comparison showed a high correspondence about 87% between them in this region.

The Area of Study

The study of area in this research is the mountains of Shirkooh in central of Iran. This mountains with the expansion of over 1000 Square Kilometer is located in 31º 23' to 31 ˚45' North and 53º 50' to 54 º20' East in Southern east of Yazd (Fig1). The mountains are covered by snow in some months of the year. These mountains which are located in Taft Shielding region are one of the important factors in balancing the weather and water supply. Although in these mountains because of its location in center of Iran and warm and dry climate there is a little seasonal snow, this little snow is the most important water supply source in this region, especially Yazd-Ardakan basin which the main population and state industrial centers are located in this area. With regard to the fact that these mountains are the main water supplying source in the region and the main snow is in these mountains, so it seems that a careful study for providing map of snow cover area in order to use in the hydrology, agriculture, environmental planning and natural sources is necessary.



Figur1: Study of Area in central of Iran.

MATERIALS AND METHODS

The data were used in this research is related to the two snow measuring stations in Shirkooh Mountains (Table1&2). (NIR Station with the altitude 2451m and Deh-bala Station with the altitude 2580m). The remote sensing data used in this paper are 13 MODIS images, so the images being used are selected according to the time in a way it was near snow time. The selected images are in table 3.

Table 1: This table shows snow thickness, snow water and density in Dehbala weather Station for selected date.

Date	Thickness (cm)	Snow Water (cm3)	Density (%)
11/27/2006	2.1	0.41	19.1
12/04/2006	5.2	0.68	13.1
12/13/2006	14.5	2.3	15.8
12/26/2006	13.8	4.1	29.7
01/24/2007	11	2.3	20.9
02/19/2007	6.5	0.9	13.9

Table 2: This table shows snow thickness, snow water and density in NIR weather Station for selected date.

Date	Thickness (cm)	SNOW_WATER (cm3)	Density (%)
11/28/2006	2.5	0.45	18.5
12/17/2006	15	4.25	28.3
12/30/2006	18.3	5.8	31.6
01/15/2007	16.8	5.2	31
01/28/2007	23.5	8.3	35.3
02/24/2007	18.5	6.8	36.8

Table3: The Selected MODIS images in area study.

Row	Date
1	12/10/2006
2	12/21/2006
3	12/26/2006
4	12/30/2006
5	01/09/2007
6	01/15/2007
7	01/20/2007
8	02/10/2007
9	03/04/2007
10	03/13/2007
11	03/26/2007
12	04/17/2007
13	04/30/2007

MODIS images from the Terra and Aqua with continuous near daily coverage are good candidates for monitoring snow. The moderate resolution imaging spectra-radiometer (MODIS) on board NASA’s Earth observing system (EOS) has been designed to include specific characteristics for snow. MODIS has 36 spectral channels between 0.4 and 14.3 m and spatial resolutions from 250 to 1000 meters. To calculate the snow surface the 1, 2, 4 and 6 bands were used. On these images atmospheric and radiometric corrections have been done then the selected bands Georeference selected coordinate system UTM 40 zone and used software's for processing images were ENVI 4.7 and ERDAS 9.2 version.

METHODOLOGY

MODIS bands covering the visible through the IR parts of the spectrum are used in the snow map algorithms. MODIS bands 4, 6, 7, 13, 16, 20, 26, 31, and 32 may be used as inputs. We used 2, 4 and 6 bands in this study. Much has been written about the MODIS sensor characteristics, and detailed information may be accessed by studying the information on the following Web site: http://modis.gsfc.nasa.gov. We use following methods for providing snow map.

A. NDSI Index

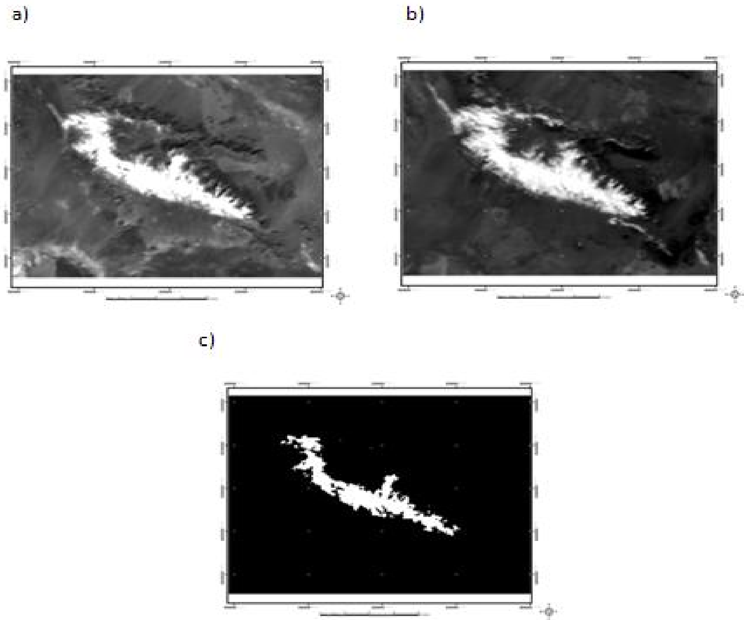
Snow has strong visible reflectance and strong short-wave IR absorbing characteristics. The Normalized Difference Snow Index (NDSI) is an effective way to distinguish snow from many other surface features. Both sunlit and some shadowed snow is mapped effectively. To calculate and separate snow from other phenomena we can get use of the two above mentioned properties and separate the snow covered surface .This can be done by NDSI. The index can be calculated from the following equation.

$$NDSI = \frac{band4 - band6}{band4 + band6} \qquad \textbf{(1)}$$

B. Threshold Method

One of the problems in monitoring the snow with remote sensing is the cloudy weather and it causes the impossibility to extract snow from the data (Klein & Barnett, 2003). In some cases, because of the cloudy weather and NDSI Index inability in separating the snow from other wet sources, identifying the threshold for bands 4 and 6, we used the threshold method. The method is one of the ways to increase the snow map accuracy. Doing this we can make some of the other parts of the images more visible. The base of using the threshold is the difference between various spectral values of images. According to the fact that snow has different reflectance in near and middle infrared (2.5 to 0.4 micrometer), it enables us the method is more accurate than other methods to distinguish this phenomenon from other surrounding covers.

Also can be used the reflection of band 4 to separate dark and shade areas from the snow and band 2 in separating the water. thus with recoding and changing the pixels values the pure reflection of band 2 is more than 11 percent of total reflection as the band 2, pure reflection of band 4 equal or more than 10 percent as band 4 that changes to zero and one and multiplied in the image of the NDSI Index and finally the resulting image is extracted from the snow covered surface. Figure 2 (a , b) show the results of the two methods.



Figur2: a) MODIS image for 15/01/2007 b) Extracting the Snowy Surface by NDSI Method c) Extracting the Snowy Surface by Threshold Method

According to the classified images and extracted snow surface in 13 images and table 4 is specified that in 21th of Dec with the area of 459/21 square km there was the most expanded area of snow on these region.

TABLE4: THE SNOW AREA FROM MODIS IMAGES

Row	Area(km2)	date
1	211/5	12/10/2006
2	459/21	12/21/2006
3	234/69	12/26/2006
4	237/66	12/30/2006
5	191/22	01/09/2007
6	293/22	01/15/2007
7	271/98	01/20/2007
8	280/64	02/10/2007
9	189/28	30/04/2007
10	113/6	03/13/2007
11	65/82	03/26/2007
12	51/67	04/17/2007
13	13/71	04/30/2007

Result and Analysis

In order to calculate and evaluate the accuracy of extracted area with 2 above mentioned methods we used the image of ASTER Satellite. We extracted the snow cover area from ASTER Satellite images with Maximum likelihood classification (MLC) (figure 4), Threshold and NDSI methods. Results for MLC methods are shown in Table 5.

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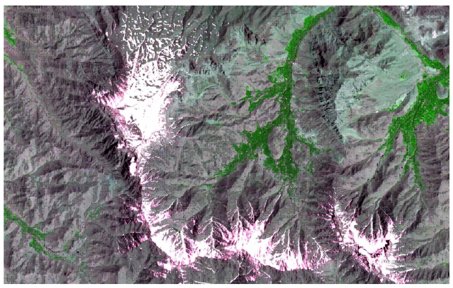


Fig. 3. ASTER images resolution (15m)

Fig. 4. Extracting the Snowy Surface by MCL Method

Fig. 5. MODIS images Spatial resolution (250m)

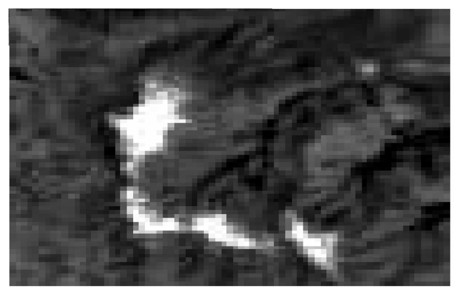


Fig. 6. Extracting the Snowy Surface by MCL Method

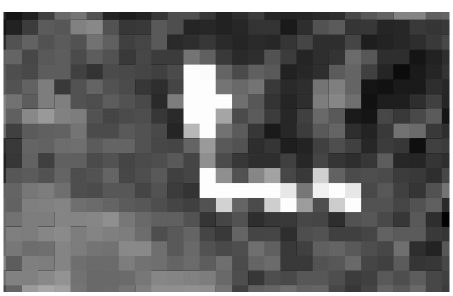


Fig. 7. MODIS images Spatial resolution (1km)

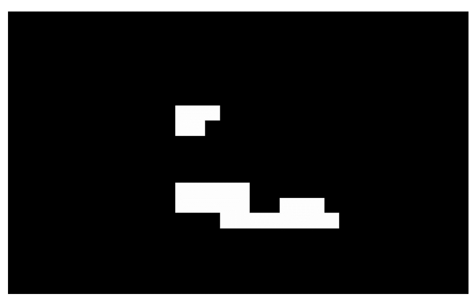


Fig. 8. Extracting the Snowy Surface by MCL Method

TABLE5: EXTRACTING THE SNOWY SURFACE AREA FROM TWO SAMPLE MODIS SELECTED IMAGES VERSES ASTER IMAGE.

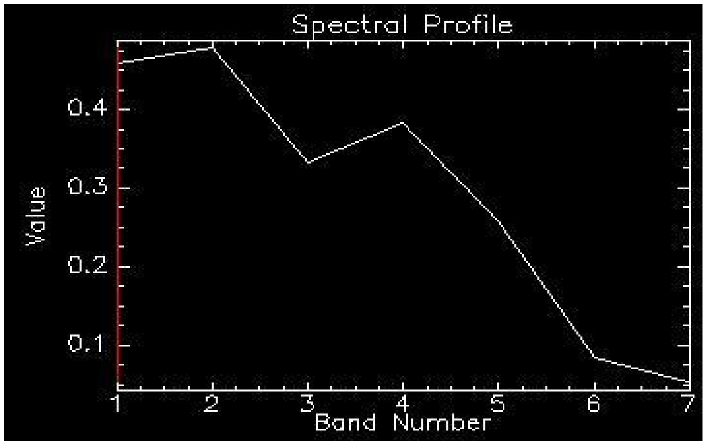
Row	Date	Type Image	Spatial resolution(m)	Area(km2)
1	04/21/2002	ASTER	15	10/5
2	04/21/2002	MODIS	1000,500,250	12/4
3	04/21/2002	MODIS	250	11/2

According to the fact that ASTER image is showing 15 m pixel size with high accuracy, the extracted snow area of this image shows a difference of 1867255 square meters in comparison with MODIS. It means that for a square meter of extracted snow from ASTER image there is 1.17 square meter snow in MODIS image. So in this step we can see an accuracy of 0.87 in comparison with ASTER images. This issue proves the accuracy of MODIS images in an acceptable way to detect the snow area changes. The obtained results are for a cold period of the year, from the end of Dec in 2006 to the mid of May in 2007, which completely shows the snow area changes in a snow fall and melting period.

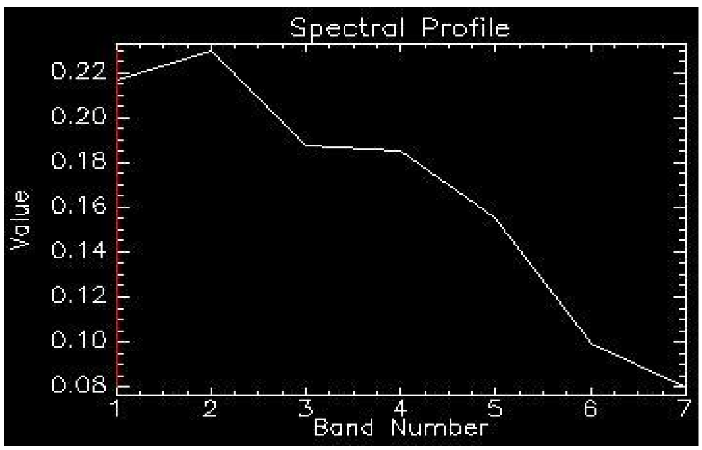
For estimating the lifetime of the snow (persistence) we have done some attempts, we separated snow pixels in images that were not cloudy in different times and compared the reflection amount of those pixels in different bands and estimated the correlation amount between reflection amounts of related pixels with the passed time from the snow using statistics. We get to an acceptable correlation in two snow monitoring station in the mountains, but because there was lack of image we didn't relied on the result. Also, since the correlation obtained from the snow pixels reflectance and snow persistence is more than 0.5, by using these images, snow Persistence can be estimated (Table 6).

TABLE6: EXTRACTING CORRELATION BETWEEN SNOW REFLECTANCE VALUE AND SNOW PERSISTENCE (BAND 1-7).

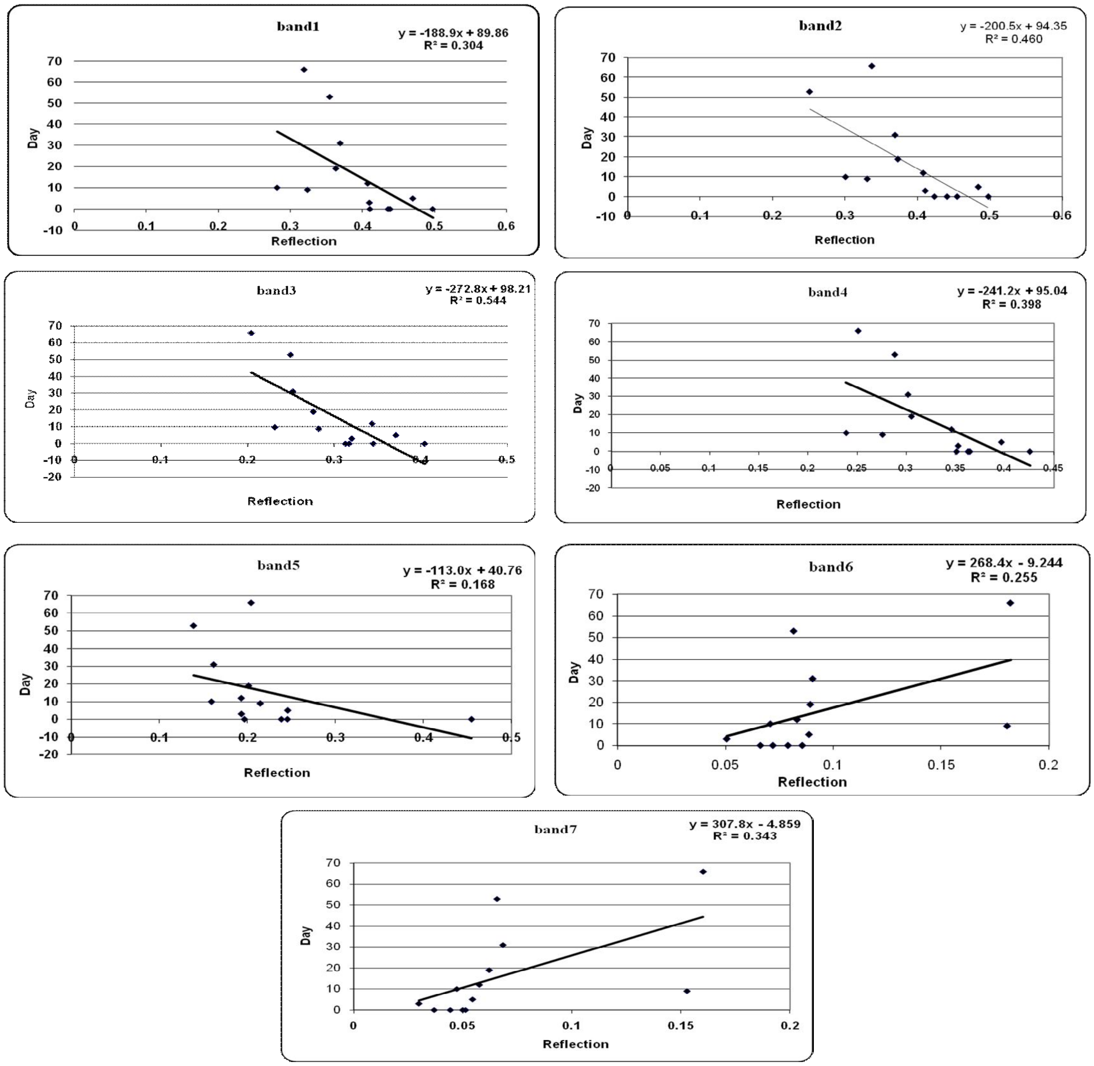
Number bands	Correlation
Band 1	-0.5701
Band 2	-0.6341
Band 3	-0.6967
Band 4	-0.6185
Band 5	-0.2264
Band 6	0.6444
Band 7	0.6777



Figur9: The snow area from MODIS images, this diagram show that more extended snow cover in 01/15/2007.



Figur10: The snow area from MODIS images, this diagram show that more extended snow cover in 01/09/2007.



Figur11: Correlation between snow reflectance and snow life time for (band 1-7)

Conclusion

The result shows that the calculated snow covered area with MODIS images; it can be accuracy is about 80 percent. We used ASTER images with 15 m resolution for Accuracy Assessment and it gave an acceptable result. The Using of the satellite images to monitor the snow according to the considerable decrease in costs and time consume is suggested. For snow monitoring we need the sensors with low temporal and spatial resolution. In this research we used MODIS images so that we can calculate snow line and its area in the places which don't have snow control stations. Also we understand that because of the spectral resolution (36 reflection bands), temporal (some images in a day) and spatial resolution (250 meter to 1000 meter); MODIS images are one of the suitable images to monitor the snow map, snow persistence and snow line. This shows that snow map extract from MODIS image, its accuracy is acceptable for some projects. We can get use of snow area maps in hydrology, agriculture, tourism, summer sports, natural sources, environmental planning, etc. Also, since the correlation obtained from the snow pixels reflectance and snow Persistence is more than 0.5, by using these images, snow Persistence can be determined.

References

A.G. Klein, D.K. Hall, & G.A (1997), "RiggsImproving the MODIS Global Snow-Mapping Algorithm," IEEE International Geoscience and Remote Sensing Symposium Proceedings (IGARSS'97), pp.619-621.

J. Dozier, (2000), "Remote Sensing of Alpine Snow Cover Invisible and Near-Infrared Wavelenghs," NASA Goddard Space Flight Center, USA.

B. Raygani, S. Soltani Koupayi, S. J. Khajeddin and S. Barati (2008).,"Journal of the Iranian Natural Res," Vol. 61, No.3, pp. 525-536.

E.T. Engman, and R.J. Gurney (1991) ,"Remote Sensing in Hydrology," Chapman and Hall. Cambridge, London.

D. Hall, G.Riggs, V. Salomonson, (2001)," Algorithm Theoretical Basis Document (ATBD) for the MODIS Snow and Sea Ice-Mapping Algorithms," Hydrological Science Branch NASA, September.

A.G. Klein, D.K. Hall, and G.A. Riggs, (1998), "Global Snow Cover Monitoring Using MODIS,"in: 27th International Symposium on Remote Sensing of Environment, pp, 363-366.

S. Lee, E.g. Klein, and T.M. Over, (2001),"A Comparison of MODIS and NOHRSC Snow cover products for simulating stream flow using the Snowmelt Runoff Model," in: http:// WWW. Modis- snow ice, Gsfc,NASA,Gov.

A.A. Matkan, P. Ziaiian, S. Dadashi, (2007),"Snow cover detection using Image processing algorithms in Karaj and latian Basins," Earth from space the most effective solutions," The Third International Conference ,Moscow December.

K.M. Poon, (2004), "Hydrological Modelling using Modis Data for Snow Coverd Area in the Northern," Master Science thesis, University of Calgary, January.

B. Rayegani, (2005),"Snow cover area evaluation using remote sensing in zayanderood ," Isfahan University of technology.

J. Sokol, T.J. Pultz, and A. E. Walker (1999)," Passive and Active Airborne Microwave Remote Sensing of Snow Cover," the Fourth International Airborn Remote Sensing Conference and Exhibition / 21 st Canadian, Symposium on Remote Sensing, Ottawa, Canada.

Y. Zhang, (2003)," Modis and Snow-cover Map," in: http: // WWW. Climate. Eas. Gatech. Edu / yzhang / MODIS snow. PDF.

Zobayri, A.majd, (1996)," Knowledge and application of remote sensing technology in natural resources," Tehran University.

A.G. Klein and A.C. Barnett, (2003),"Validation of MODIS Snow Cover Maps Of the Upper Rio Grande River Basin for the 2000-20001 snow year," Remote Sensing of Environment, Vol, 86, pp, 162-176.