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Research Article

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Assessment of Global Snow Cover Index to Study the Surface of Snow Cover and Preparation of Snow Map, Case Study: Birjand City, South Khorasan Province, Iran

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Abstract The exact estimating of snow cover surface and the corresponding equivalent volume of snow water is considered as one of the key and fundamental operations in the field of water resources management, especially in areas where snowfall has a large contribution to atmospheric precipitation. ARCGIS and ENVI4.8 software are used for image processing and analysis. In this study, MODIS images are recognized appropriate due to high temporal resolution (Imaging 2 times a day), proper spatial and spectral resolution and accessibility.
NDSI algorithm is used to extract the surface under the snow cover and the results show that the MODIS image and The NDVI index are suitable for preparation snow maps.

Keywords Snow Measurement, MODIS Sensor, NDSI, Birjand

Introduction

Iran is a land with low water that is located in the dry and semi-arid region of the Earth; thus, snowfall is the most important factor that influences the water reservoirs especially in the warm seasons of the year. Snow is one of the most important forms of precipitation in the mountainous hydrological cycle which plays a valuable role in drinking and agricultural water resource supply with delayed currents in the high water seasons and energy production. On the other hand, the coincidence of snowmelt runoff and spring rainfall cause the destructive floods that its flow volume is more than the capacity of the river. Some researchers believe that remote sensing data can provide a better assessment of the snow cover surface in the catchment area than traditional land survey methods. The MODIS sensor is more appropriate for this purpose than other sensors due to its temporal resolution (twice a day) and better spatial resolution (250.500.1000 m) and more spectral resolution. The snow surface is produced by the MODIS sensor using the snow map algorithm based on the NDSI index with the bandwidths radiation 4 and 6 of the sensor. The global index of snow cover can be useful for detecting snow from other phenomena because of the low reflection of the snow in the infrared band and the

high reflection in the visible bands. Fattahi and vazifedost are the persons that studied about snow survey and they estimate the snow surface temperature and the snow cover area with image of the MODIS sensor during the 9-year statistical period (2000-2008) in Golestan. The results showed that MODIS images are very suitable. Motajiyan et al. concluded from estimating the global snow cover index at the regional scale in Karaj and Latiyandam basin that the proposed threshold by NASA is not suitable for studying in the regional scale. In addition, Safari Shad concluded from his investigation about preparation of snow cover surface map using MODIS satellite imagery in Ghareh Chay watershed that the NDSI index can separate the pixels with snow by applying the thresholds mentioned. Shams et al. concluded that using the remote measurement techniques for survey of snow is necessary in these areas by searching about detection method of snow pixels' extraction in MODIS images. Salomonson and apple estimated the map of snow cover surface at sub pixel of MODIS and LANDSAT sensor images with the NDSI Index in Alaska, Siberia and Kanda in their paper and they concluded that the percent of their method is less than 2; thus, it can extend worldwide. Klein and Barnett investigated the satellite data of MODIS sensor snow cover map, the ground data and snow distribution factors in the Rio Gorand watershed; therefore, they found that the most error of this map is related to early and late snowfall period.

Materials and Methods

Birjand is located in the southern province of Khorasan, Iran. It is limited from the north to the Qaynat city, from the east to the Darmian and Sarbisheh cities, from the south to the Nehbandan and Kerman cities, and from to the west to the Saran and Tabes cities. The area of this city is 6888 Km^2 and its capital is Birjand, which is 59 degrees and 13 minutes' longitude and 32 degrees and 53 minutes' latitude and it is located at an altitude of 1470 meters above sea level. Its climate is desert and semi-desert. There is no major river in Birjand city and the rivers are known as Cal and they are generally seasonal.

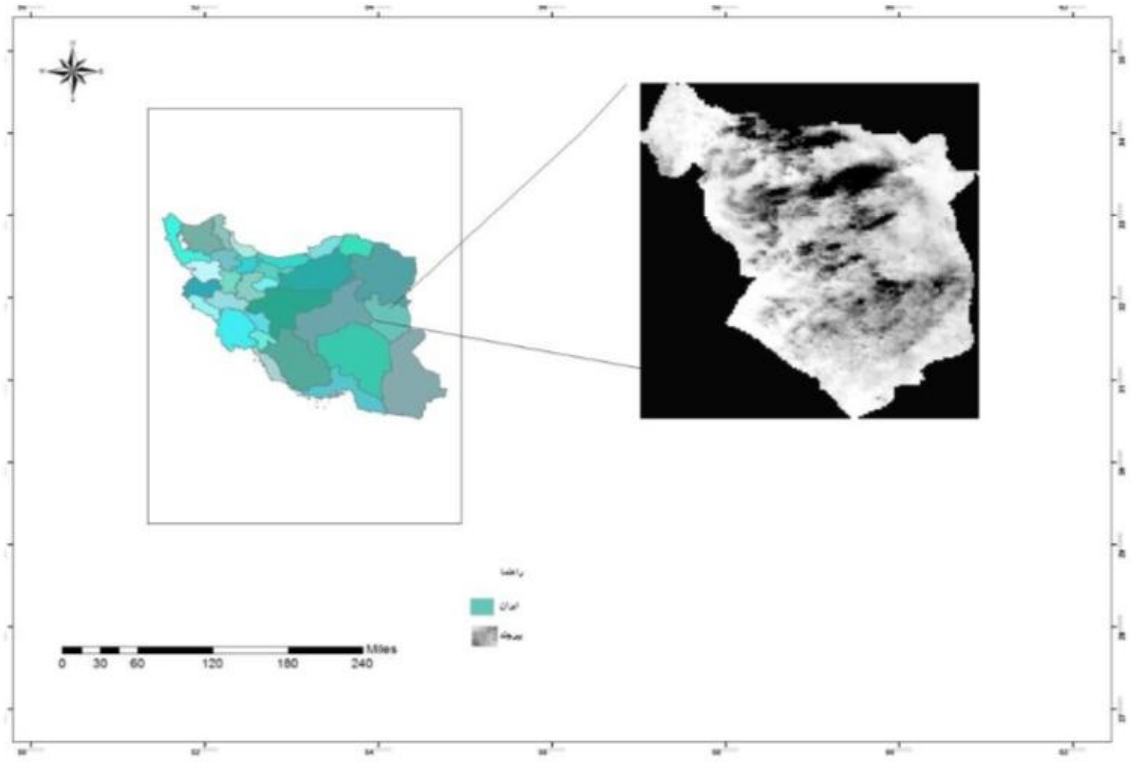

Figure 1: Location of the studied area

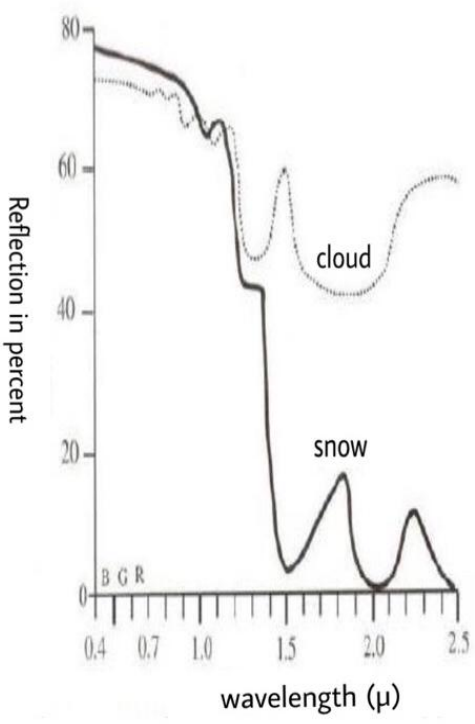

Figure 2: Spectral Reflection Curve of Snow and Cloud

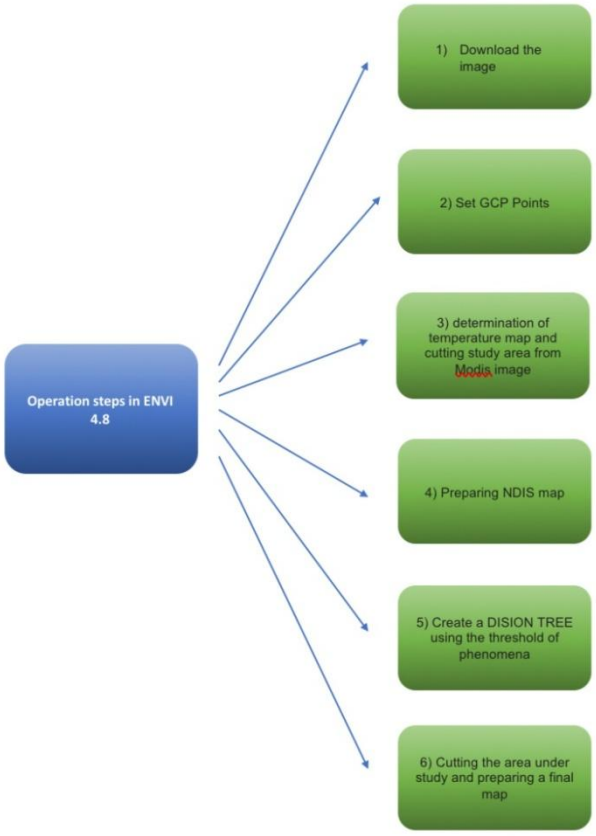

Figure 3: Steps in ENVI4 Software

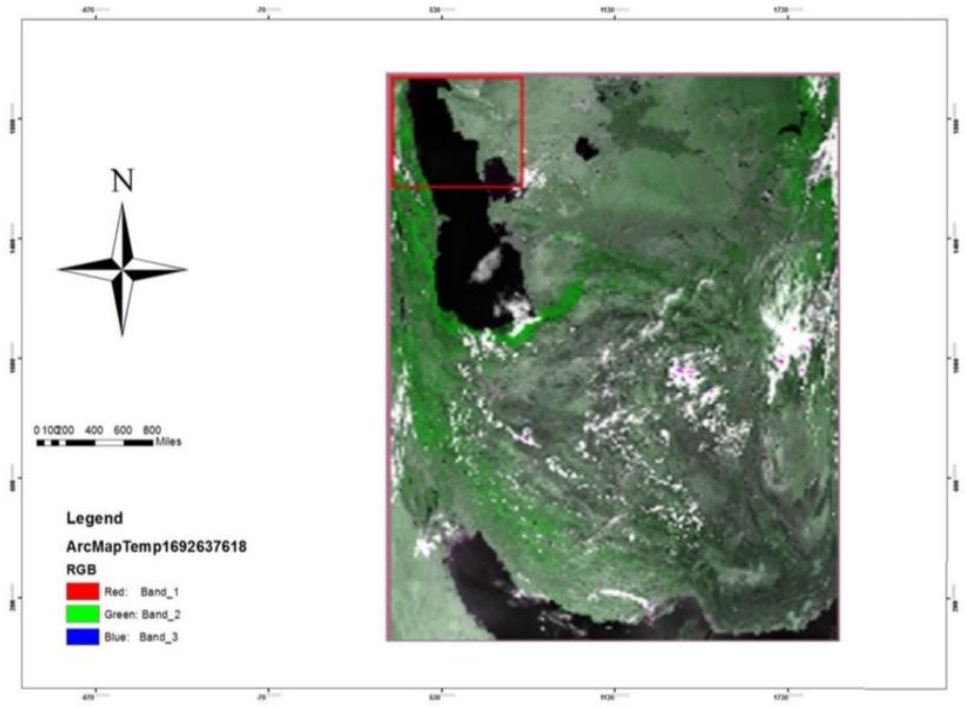

Figure 4: Georeferenced Image of MODIS

The images of the MODIS sensor were used from the NASA site to estimate the snow cover surface in this area. ENVI and ARCGIS software were used to prepare and analyze the data. At First, the images have been corrected geometrically by image to map. (Fig. 3) NDSI as an algorithm has automatic extraction snow with

groups of thresholds in pixels. A THERMAL image is required to calculate the threshold for the cloud. Fig. 4 is a thermal image and it is calculated in pixels (3).This index is based on the fact that snow has high reflectivity in the visible area and low reflectivity in the Mid-infrared wavelengths is used snow detection in places without Snow and cloud. The NDSI formula in the MODIS image is as follows .As seen in Fig. 2, snow has a large reflection in the visible part and low reflection in the infrared part.

NDSI=(BAND4-BAND6)/(BAND4+BAND6)

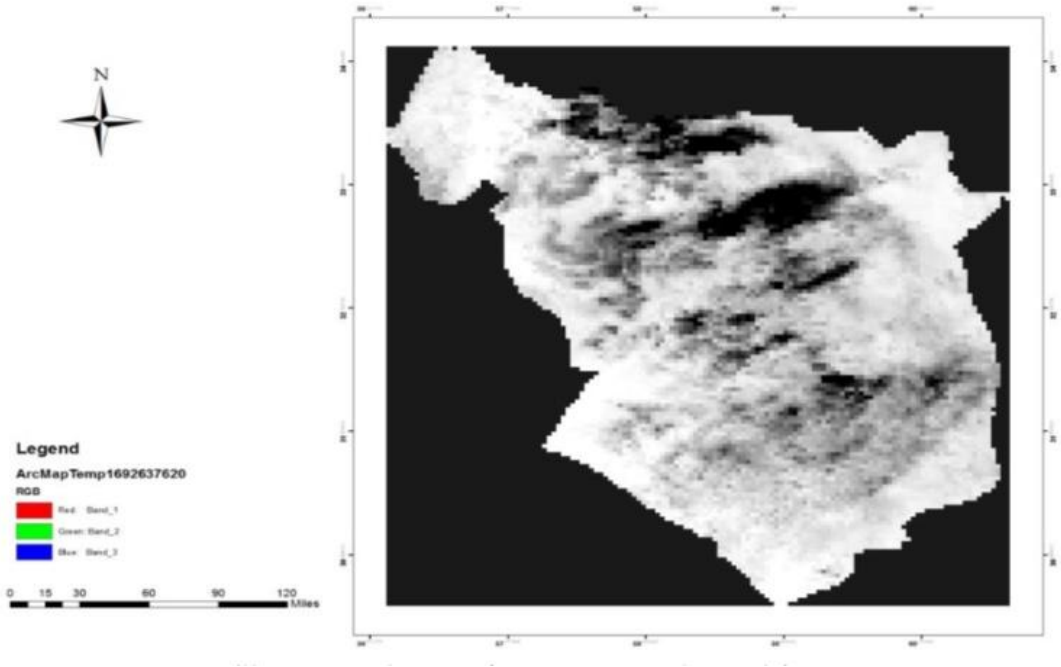

Figure 5: Thermal Image of the Study Area

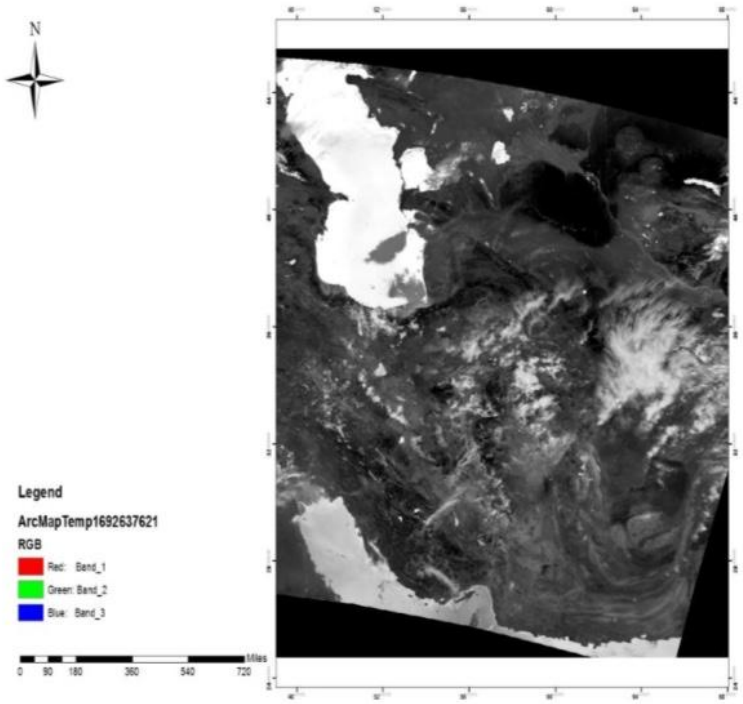

Figure 6: World Snow Cover Index in the Modis Picture

In preparing the snow map, NASA's proposed threshold is 0.4 for the NDSI. Fig. 4 is a NDSI map that is obtained from image that 0.4 is being employed for threshold in the regional scale. In preparing a snow map, when the pixel has a greater or equal NDSI than 0.4, it is considered as a snow pixel, and if it is less than 0.4, it is considered as the pixel without snow. In this index, Minimum NDSI of pixels that are covered approximately 50% or more by snow is 0.4. Another test is used for the separation of water from snow because water may also have a NDSI about 0.4. Water can be separated from snow because water reflection is less than 11% in the band 2; therefore, if the reflection of the band 2 be greater than 11% and the NDSI be more than 0.4, that pixel will be considered as snow but if the reflection of MODIS band 4 be less than 10%, pixels won't be considered as snow.

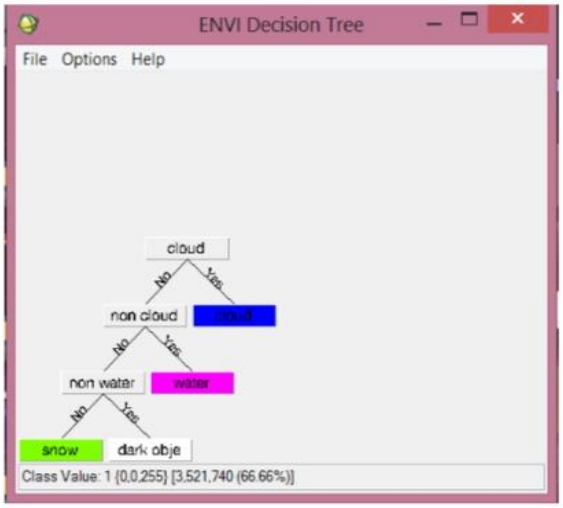

Figure 7: World Snow Cover Index in the Modis Picture

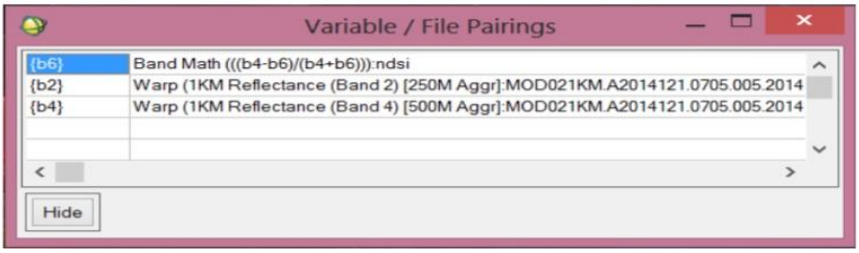

Figure 8: World Snow Cover Index in the Modis Picture

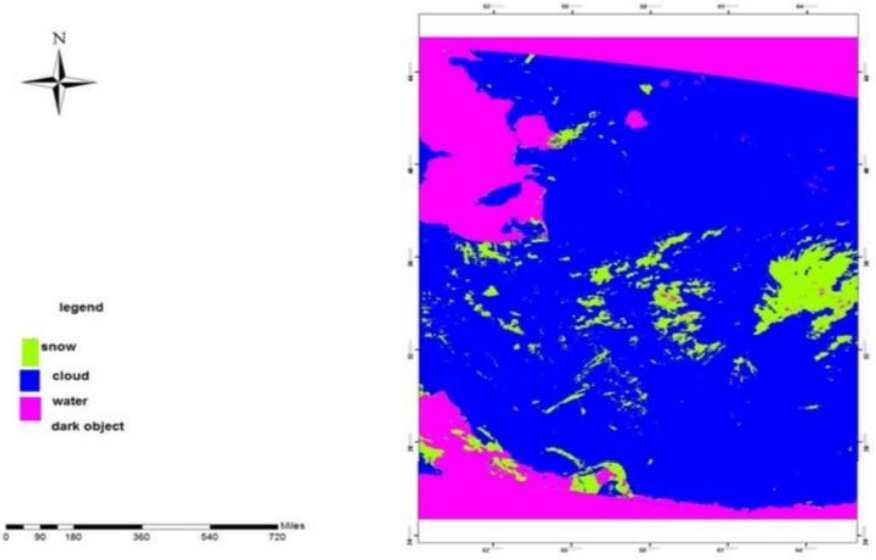

Figure 9: Calculates Threshold for Separating Snow, Cloud, and Water

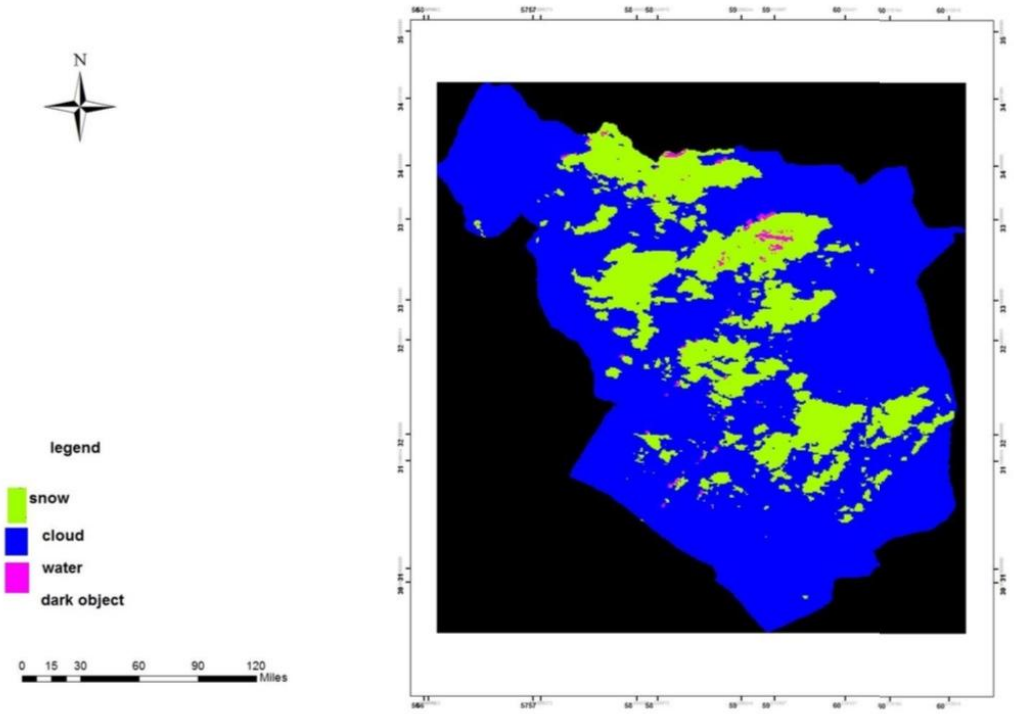

Figure 10: Snow Cover in Birjand City in 2014

Discussion and Conclusion

Snow cover products are very suitable for calculating of water balance sheet and flood forecasting and warning. Ground work is very difficult for calculating amount of snow cover. Snow cover surface can be calculated by satellite imagery. The results of this study showed that using the MODIS images is suitable for local and temporal snow monitoring. The advantages of this sensor are good resolution ability and easy access to the internet.Fig. 10 shows snow cover using the MODIS image and the NDSI index in Birjand city in 2014; thus, this formula is suitable for calculating the snow cover surface.

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