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ESTIMATION OF SNOW COVER OF PIRIN MOUNTAIN, BULGARIA, USING SATELLITE IMAGES (NOVEMBER 2001–JULY 2002)

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Ана Тенчова, Светослав Любенов, Гоце Тенчов. ОЦЕНКА НА СНЕЖНАТА ПОКРИВКА НА ПИРИН ПЛАНИНА, БЪЛГАРИЯ, ЧРЕЗ САТЕЛИТНИ СНИМКИ (НОЕМВРИ 2001 – ЮЛИ 2002)

Оценка на снежната покривка на Пирин планина, България, чрез сателитни снимки (ноември 2001 – юли 2002). Извършен е методичен тест на възможността за използване на сателитни снимки за оценка на снежната покривка на Пирин планина. Чрез съвместно използване на топографска карта и снимки от сателита TERRA е оценена динамиката на снежната покривка в четири зони на височини от 1000 до 2911 m. Изводът е, че практически в реално време, експресно и без влагането на значителни средства може да се оцени снежната покривка в планината. Също така могат да се набележат най-общите тенденции в снеготопенето. На това ниво на използване на сателитните данни остават нерешени въпросите, свързани с оценката на дебелината и плътността на снежната покривка.

Anna Tenchova, Svetoslav Lubenov, Gotze Tenchov. ESTIMATION OF SNOW COVER OF PIRIN MOUNTAIN, BULGARIA, USING SATELLITE IMAGES (NOVEMBER 2001–JULY 2002)

The use of satellite images for estimation of snow cover in the Pirin Mountain, Bulgaria is tested methodically. Using images from the TERRA satellite and topographic map of the area, the snow cover dynamics in four different zones within altitude from 1000 m to 2911 m is estimated. A winter–summer period of 2002 is used. The conclusion is that practically, in real time, in an express way and practically for low cost an information for the plain surface covered by the snow can be obtained. The tendency of snow melt dynamics can be outlined as well. The problems about thickness and density of snow remained unsolved.
Keywords: snow dynamics, montain area, Earth satellites
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The content of water in a snow of an area depends on its surface, thickness and density. It is a part of water dynamics forecast in the area. It is a part of a system for water run off and for flood forecast [1–3]. The estimation of these parameters in a mountain area is complicated and time-consuming process. Special groups are to travel across the mountain and outline the borders of snow and its properties. They can measure these data in separate and accessible points. In winter such information should be updated after every snowfall. This paper aims to test methodically and practically the use of satellite images in snow cover estimation. The investigated area is the Pirin Mountain. It is situated in the southwestern part of Bulgaria. The snow of the Pirin Mountain supports and feeds both rivers: Struma and Mesta. They flow into the Agean Sea. The estimation process runs as follows:

1. Specification of the Pirin Mountain topography; 2. Selection of satellite images; 3. Determination of the area covered by snow; and 4. Presentation of snow cover dynamics for the period from November 2001 to July 2002.

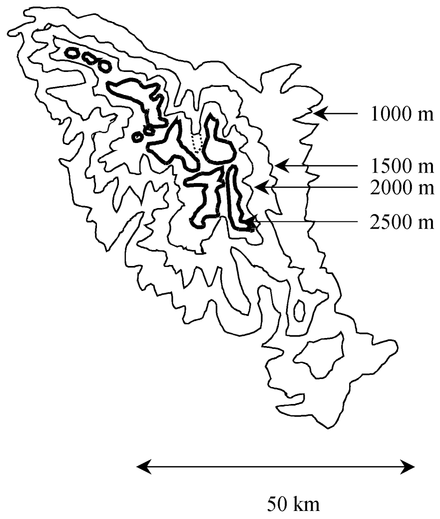

Fig. 1

Topography of the Pirin Mountain can be specified using radar data from the satellites. Data from ERS-1 and ERS-2 can be used. In the future the ENVISAT ASRIN system can be used as well. Radar data are not at our disposition. To estimate topographic properties of the investigated area a topographic map with a scale of 1:500 000 was used. It was digitized. The borders of the Pirin Mountain are conditionally accepted as a 1000 m isohypse. This assumption is accepted because in the spring time, snow is at altitudes higher than 1000 m. Four zones with an altitude difference of 500 m are outlined as follows: 1000–1500 m, 1500–2000 m, 2000–2500 m, and above 2500 m. The areas that these zones cover are approximately as follows: 470 km^2, 310 km^2, 180 km^2, and 65 km^2. Fig. 1 presents these four different level zones. The digitized data from topographic map are processed by the SURFER program and borders and areas of the four zones are

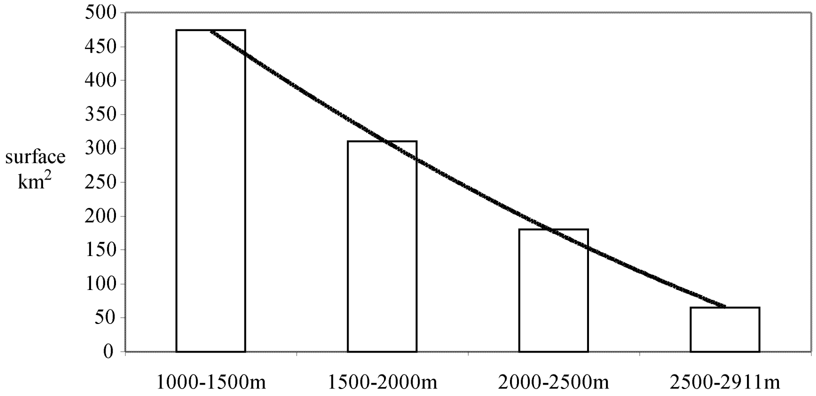

Fig. 2

obtained. The plain surface of the four areas is presented in Fig. 2. The total plane surface of the Pirin Mountain within 1000 to 2911 m is stated of about 1030 km^2.

The satellite images were of the same scale. The available images were taken by the TERRA satellite. It contains the instrument MODIS (Advanced Spaceborne Thermal Emission and Reflection Radiometer) that observe the entire surface of the Earth every 1–2 days with a scanning imaging radiometer. Its wide field of view

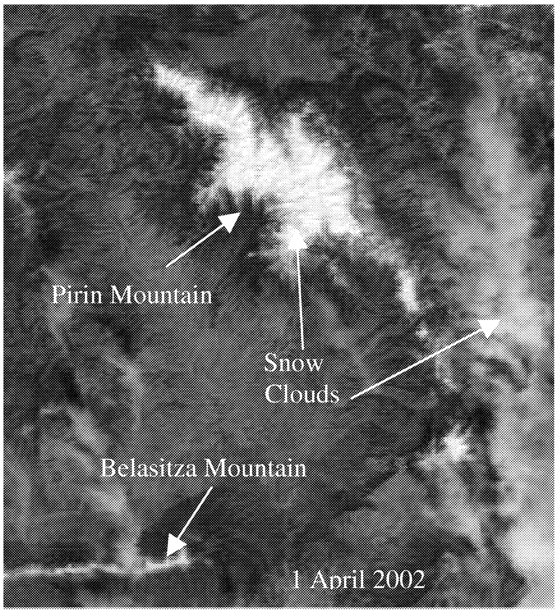

Fig. 3

(over 2300 km) provides images of daylight-reflected solar radiation over the entire globe. MODIS is able to see features as small as 250 m–1 km. MODIS operates continuously. The available free of charge images are with resolution of about 250 m/pixel. Practically that corresponds to scene with scale of about 1:500 000 to 1:1 000 000. They were in a true colors and in the visible optical band. TERRA passes about every 48 hours over the Pirin Mountain area. The images that can be used are to be taken in morning time and in cloudless weather. The use of optical images is limited by these factors. After obtaining an image, it must be scaled and matched according to the Pirin Mountain level scale shown in Fig. 1.

The next problem deals with the surface covered by snow. Fig. 3 presents an image taken by MODIS on April 1, 2002. The part of the Pirin Mountain covered by snow is clearly outlined. On the other hand the problem of differentiating the clouds from snow with available technique remained unsolved.

It is estimated the plain covered by the snow in each of the four level zones of the Pirin Mountain. The PAINTSHOP program is used to process the images and to compute the area covered by snow. It is selected the period of time covered from the late autumn of the 2001 to the summer of 2002. Fig. 4 shows the dynamics of the snow cover within the investigated period. The data are not distributed regularly within the time because of the poor weather. The autumn of 2001 was very hot and the first snow practically covered the Pirin Mountain at the end of December 2001. The early spring of 2002 was very hot as well. This is the reason that the area covered by the snow in altitudes lower than 2000 m is reduced. At the end of March and at the beginning of April, snowfalls occurred as well. As a result, the area covered by snow increases. The hot weather in May and June

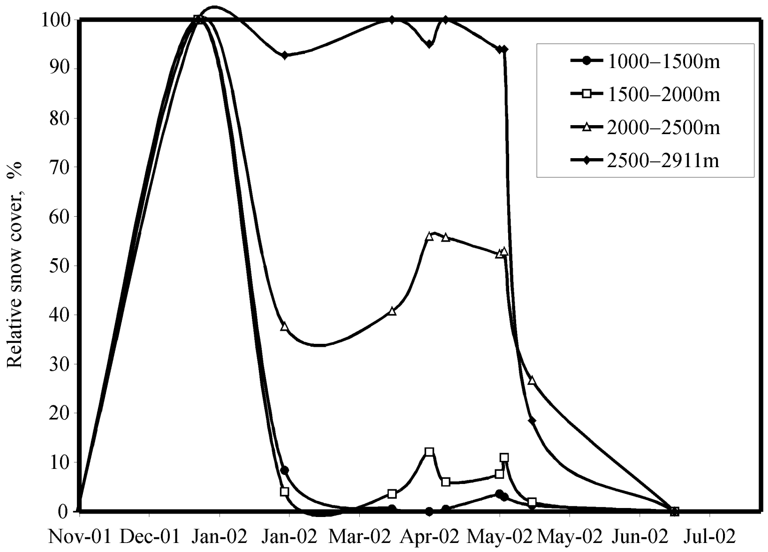

Fig. 4

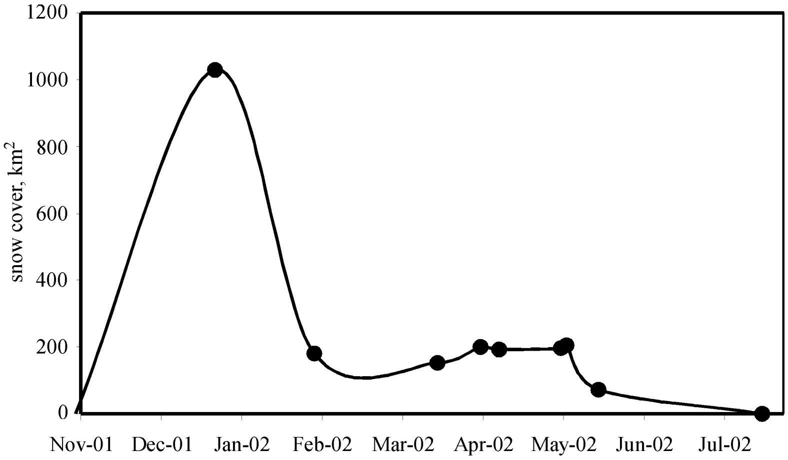

Fig. 5

reduced substantially the area covered by snow. Another peculiarity of the Pirin Mountain is that it is situated along the meridian. This is the reason the snow in the southern part of the mountain melt earlier that in the northern part.

Fig. 5 shows the plain area of the Pirin Mountain covered by snow. It is estimated with an relative error of about 10%.

CONCLUSION

Our experience shows that free of charge satellite image, taken from Terra satellite in clear weather can be processed for several hours and practically "in real time" (one or two days after satellite passage) the area covered by the snow can be outlined and its surface computed. The obtained data are approximate and can be used to forecast the tendency of snowmelt in a mountain region. Unsolved problems deal with: 1. Determination of the visible mountain area covered by snow and its outline from clouds. 2. Determination of the real surface covered by snow. For these purposes a 3–D map of the area must be used. 3. Determination of thickness and density of snow. To solve these problems is necessary to use radar and scaterometer data [4] and advanced programs for processing data taken by MODIS, ASTER, and other instrument on TERRA.

REFERENCES

1. Nagler, T., H. Rott. *EOQ*, **62**, 1999, 29.
2. Bach, H., G. Lampart, G. Strasser., W. Mauser. *EOQ*, **62**, 1999, 24.
3. Тенчова, А. Възможности на дистанционните изследвания при мониторинг и прогноза на наводненията. XXX Юбил. Конф. по въпросите на обучението по физика. Пловдив. 2002, 286.

4. Wismann, V., V. Winebrenner, K. Boehnke. In: Proc. of the International Geoscience and Remote Sensing Symposium IGARSS'97, Singapore, **IV**, 1997, 1823.

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