A DISCRIMINATIVE APPROACH BASED ON AEROSPACE MULTISPECTRAL BANDS DATA IN MONITORING OF SNOW COVER AND WATER

Roumen Nedkov, Temenuzhka Spasova, Deyan Gotchev

Abstract: The contemporary methods in aerospace-data-based monitoring require the use of combined images with different resolutions and electromagnetic spectral ranges. This is the core of the presented research for the creation of new approaches, data-processing methods and algorithms for analysis. Data from active and passive space-borne sensors are used. Results for quantitative changes of snow and water cover are obtained. Data with different polarization from the micro-wave band are combined with different composite images in the optical band. Results, based on satellite data, about the dynamic of the changes in the researched objects are commented.

Key words: snow cover, satellite data, microwave and optical bands

INTRODUCTION

The main aim is to investigate the possibilities for an application of a discriminative approach, based on the use of aerospace data from different sensors in the monitoring of the snow cover, water areas and wetness.

The topicality of this research originates from modern tendencies of remote sensing application in solving problems with different essence concerning environmental ecomonitoring. So the discriminative approach is crucial for the monitoring of floods, snow cover and surface humidity, which are directly connected with environment protection. [1, 2]. In order to interpret different, large scale environmental processes in difficult-to-be-reached regions, combinations of satellite images in optical and radio bands are of fundamental importance. In such cases satellite images in different spectral bands create the opportunity to reach a high objectivity and comprehensiveness for the received information about processes and phenomena, which influence the environment. [3, 4, 5].

The aim of the presented research is the creation and application of methods for a discriminative approach for the use of aerospace data received in different spectral bands. This is important for the research of the snow cover, water overflows and wetness variations.

DATA AND METHODS

Data use

Data from “Moderate Resolution Imaging Spectrum Radiometer” (MODIS) [6] and the European Space Agency (ESA) satellites “Sentinel-1-A”, “Sentinel-2-A” (Fig. 1) are used [4]. The “Sentinel-1-A” has a Synthetic Aperture Radar (SAR) [3]. Both the “Sentinel-2-A” Multi-Spectral Instrument (MSI) and the MODIS register data in the optical bands with different resolutions. For the MSI the 13 spectral bands span from the visible (VIS) and the near infra-red (NIR) spectrum regions to the short wave infra-red (SWIR) one. Their different spatial resolutions at the Earth surface range from 10 to 60 m [5]. For MODIS the 36 spectral bands span from the visible (VIS) and the near infra-red (NIR) spectrum regions to those in the short wave infra-red (SWIR), Middle infra-red (MIR) and Thermal infra-red (TIR) parts of the spectrum. Their different spatial resolutions at the Earth surface range from 250 to 1000 m [6]. (Table 1)

Image processing methods

For both types SAR and MSI MODIS optical sensors data the image processing methods are different. This is due to the different principles for registration of electro-magnetic energy from the two types of sensors.

Sometimes, images of one and the same area that are collected from different sources (SAR and the MSI images) must be used together. The MSI images are in the UTM, Zone 35N, WGS84 coordinate system. This requires to reproject the SAR images to an universal UTM, Zone 35N, WGS84.

After the reprojection is finished a SAR image coregistration is done in which the MSI image is used as a reference image [10, 11]. The next step newly generated composite images use SAR images from different time-series and with different polarization types. This creates a possibility to use pseudo-colors in order to increase the contrast and to sharpen the contours [7, 8, 9]. The result is a more precise selection of the identical points for the SAR images coregistration (Fig. 1c).
Table 1

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Date</th>
<th>Spectral Band, wavelength</th>
<th>GSD*, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentinel-1-A</td>
<td>24.12.2015</td>
<td>$\lambda = 5.6 \text{cm}$, Polarization: HV, VV</td>
<td>10x10**</td>
</tr>
<tr>
<td></td>
<td>17.01.2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>29.01.2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentinel-2-A</td>
<td>23.12.2015</td>
<td>2.19 $\mu m$, 1.61 $\mu m$, 0.865 $\mu m$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>01.02.2016</td>
<td>0.665 $\mu m$</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>11.02.2016</td>
<td>0.49 $\mu m$</td>
<td>10</td>
</tr>
<tr>
<td>MODIS</td>
<td>24.12.2015</td>
<td>2.13 $\mu m$</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>17.01.2016</td>
<td>0.850 $\mu m$</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>29.01.2016</td>
<td>0.650 $\mu m$</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.550 $\mu m$</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.470 $\mu m$</td>
<td>500</td>
</tr>
</tbody>
</table>

* Ground Sample Distance (GSD)
** Pixel Spacing Resolution (rg x az) [5]

The generated composite images are based on data received from Sentinel-2-A plus MSI from the visible (VIS) 234 spectral bands, the near infra-red (NIR) 8A spectral band and the MIR 11 spectral band (Fig. 1b). A composite image from MODIS (a combination between the VIS and NIR band for the 7, 2, 1 channels) is used (Fig. 1a). The latter gives the best results for snow cover and water areas [12].

The changes of environmental objects are shown with the SAR images with vertical (VV) polarization on Fig. 4 a, b. The former are detected after the division of three images from an one month time span. On Fig. 4a the first image is from division of a SAR image from 24.12.2014 with one from 17.01.2016. On Fig. 4b the result is from division of an image from 17.01.16 with one from 29.01.2016. The value 1 colored in orange means that there is no change for the object. A value bigger than 1 colored in green means that the existing old one has changed, or a new one has emerged. A value smaller than 1 colored in brown means lack of an object, or an abrupt decrease in the reflection from an object.

Composite SAR images generated from images with different (horizontal-vertical HV and vertical VV) polarizations are shown on Fig. 2. Different dates are used for one and the same combination R- VH, G- VV, B- VH/VV of the composite images. This is done so, in order, a better interpretation of the snow cover, water areas and wetness variations to be achieved.

The Normalized Difference Snow Index (NDSI) is used for the snow-cover research. For its calculation is used the formulae [13, 14]:

$$NDSI = \frac{P_{1.61 \mu m} - P_{0.55 \mu m}}{P_{1.61 \mu m} + P_{0.55 \mu m}}$$

where $P_{\lambda}$ is the reflection in the 1-st spectral channel, $P_{\lambda_{11}}$ is the reflection in the 11-th spectral channel.

The overflow zones from MODIS and SAR images are shown on Fig. 5 a, b. From MODIS is used the combination of the 7,2,1 channels which are most representative for the determination of snow cover, water areas and wetness (Fig. 5a). A generated composite image from two dates from two successive seasons is shown on Fig. 5b. For it the used combination is: R-VV from 10.05.2016 (a humid period), G- VV from 10.05.2016 (a humid period), B-VV from 10.02.2016 (a dry period). This emphasizes the overflow zones of territory where the flood has emerged. This combination necessitates the use of dry and humid periods. The overflow area is colored in blue, the water is in black, and the other territories are in yellow.

The NDSI values’ distribution is shown on Fig. 6. Both NDSI and SAR images are merged, in order to improve the visualization and verification of the received data.
RESULTS AND DISCUSSION

The SAR composite clearly and definitely registers changes in snow cover and water areas during the summer-winter transition. The clearest visualization of a snow-cover is shown on Fig. 3a, b. The lack of snow-cover is visualized on Fig. 3c, where the visualization of water areas is the best one. The division between SAR images visualizes in the best manner the changes in the reflection from Earth ground objects. When for the division are used images from different time-series, the interpretation changes comprehensiveness for the reflective characteristics is increased. (Fig. 4a, b). To research the snow cover, water areas and wetness variations are used composite SAR images, which are obtained from composite images with the following combinations R –HV polarization, G –VV, B – VH/VV (Fig. 2a, b, c, d, e, f).

When a cloud cover exists, SAR images are used in order to fix the floods dynamic through a clear determination of the overflows’ boundaries (Fig. 5b). NDSI combined with SAR VV-polarization-images provides the possibility correctly to determine the presence, or lack of a snow-cover. On the image from 01.02.0016 the NDSI has the biggest values (0.99), which is a clear indication for the presence of fresh snow. (Fig. 6)

CONCLUSION

In general, the offered discriminative approach for monitoring of snow cover, water areas and wetness is better than the classical ones. The combined use of satellite data in optical and radio bands increases the objectivity and comprehensiveness for the monitoring of snow cover, water areas and wetness. When a dense cloud cover exists images from optical sensors cannot be used, but the SAR images give the opportunity for monitoring of floods and snow-cover.

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ДИФЕРЕНЦИРАН ПОДХОД ПРИ МОНИТОРИНГ НА СНЕЖНА ПОКРИВКА И ВОДА НА БАЗАТА НА АЕРОКОСМИЧЕСКИ ДАННИ В РАЗЛИЧНИ СПЕКТРАЛНИ ДИАПАЗОНИ
Румен Недков, Теменужка Спасова, Деян Гочев

Резюме: Съвременните тенденции в мониторинга чрез аерокосмически данни налагат използването и комбинирането на изображения с различна разделятелна способност, различни диапазони на електромагнитния спектър, което е основната цел в изследването за разработването на нови подходи, методи за обработка и алгоритми за анализи.

Използвани са данни (сателитни изображения) от два вида сензори - активен и пасивен.

Получени са резултати за количествени изменения на снежна покривка и вода. Комбинирани са данни от микровълновия диапазон с различна поляризация, с данни от различни композитни изображения на канали от оптичен диапазон на електромагнитния спектър. Представени са резултати за динамиката на измененията на изследваните обекти на база спътникови данни.

Ключови думи: снежна покривка, спътникови данни, микровълнов и оптичен диапазон

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