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Studying Features of NDVI Dynamics for Vegetation Monitoring of the South of Central Siberia

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The work presents the results of studying NDVI (Normalized Difference Vegetation Index) for identification and mapping of ground vegetation using Terra/Modis satellite data. NDVI dynamics for various types of agricultural crops and lands at the south of Krasnoyarsk krai and Khakasia Republic was detected during the 2006 growth period and analyzed.

INTRODUCTION

Numerous experiments showed that NDVI (Normalized Difference Vegetation Index) is among the most reliable indicators [1]. Using the intensity of reflected light in the red and near infrared spectrum ranges, NDVI allows one to isolate green vegetation against other natural formations, especially soil and dry vegetation [2].

Using one-day NDVI values, it is possible to precisely isolate vegetative objects from other natural objects and analyze them, while identification and classification of various types of vegetation becomes complicated and inefficient. In this connection, it was decided to use these differences in NDVI dynamics during growth period as a basis for identification and classification of vegetative objects.

Used Data

In this work we used Terra/Modis and Landsat 7 ETM+ satellite data. Terra/Modis satellite data were used for calculation of NDVI. Landsat 7 ETM+ data, due to higher spatial resolution, are more suitable for geographical reference of the contours being studied. The task of monitoring of agricultural fields can successfully be solved by using daily average spatial resolution data (150-250 m) [1]. In this connection, we used satellite data obtained in the red (620-670 nm) and near infrared (841-876 nm) channels with a 250 m spatial resolution (MOD09GQK product) of Terra/Modis satellite. Satellite data of Terra/Modis satellite channels 1, 2, 3, 5, 6 with a 500 m spatial resolution were used for detection of territories covered with clouds and cloud shadows. To cover the whole growth period of agricultural fields at the Krasnoyarsk krai and the Khakasia Republic, Terra/Modis images for a period from May 10 to September 10 of 2006 were used. Information about the position of the satellite and the Sun was obtained from MODMGGAD products. Geographical reference of the studied contours was made with the help of the spatial data of the image taken on September 4, 2001 by Landsat7 ETM+ satellite with a 30 m spatial resolution.

Preprocessing Algorithm

Terra/Modis satellite images were processed by stages.

1. Using MODIS Reprojection Tool software, the projection of MOD09GQK images was transformed from Sinusoidal projection (ISIN) into Transverse Mercator projection. At the same time HDF format was converted into GeoTIFF format.

2. Using the possibilities of ENVI procedure of Band Math and decision-tree-type classification, the mask of unsuitable values was generated.

2.1. Observations made at a zenith angle more than 40º were excluded from the initial satellite data.

2.2. To make possible the analysis of vegetation development by satellite data, it is necessary to generate the time series of observation data free from the effect of negative factors such as cloud cover and shadows of clouds. Identification of clouds was based on spectral data of Terra/Modis channels 1, 2, 3, 5, 6. A decision-tree-type classification was developed in ENVI software environment for generation of cloud masks. The multi-level classification based on binary conditions related each pixel of an image to one or another class. The conditions (tree nodes) included: normalized differential snow index (NDSI) [3] and the values of the spectral data of Terra/Modis channels 1, 2, 5 [4].

Thematic Treatment of Satellite Data

An important indicator characterizing the physiological state, phytopigment dynamics and biological productivity of plants is Normalized Difference Vegetation Index. For Terra/Modis satellite data NDVI is calculated by the following formula:

$$NDVI = (\rho_{NIR} - \rho_{red}) / (\rho_{NIR} + \rho_{red}) \qquad (1)$$

where ρ_{NIR}, ρ_{red} are spectral reflectance in the near infrared (841 - 876 nm) and red (620 – 670 nm) zones.

Within the visible range (λ = 400÷700 нм) the reflection of plant radiation is connected with pigment concentration (mainly chlorophyll and carotenoids). Up to 95% of ρ value variations within the visible range are due to alteration of chlorophyll content. In the near infrared band (λ = 700÷1300 nm) radiation reflection is determined mainly by the inner structure of phytoelements [5, 6].

Studying of NDVI Dynamics of Plants during Vegetation Period

The process of growth and ripening of various types of plants has its own peculiarities connected with different distribution of green mass in time. That is why it is possible to distinguish between different types of vegetation studying vegetation indices at different growth periods on the basis of satellite images.

If the vegetation index dynamics of plants during growth period is displayed in a schematic form, as on Fig. 1, and if the following characteristics are chosen as parameters describing the form of the curve:

- slope of line during growth and development of vegetative organs (G),
- maximum value of NDVI during the whole growth period (M),
- slope of line during ripening and fruiting (R),

it will be possible to characterize the state of vegetative cover and, in particular, distinguish several types of vegetative cover.

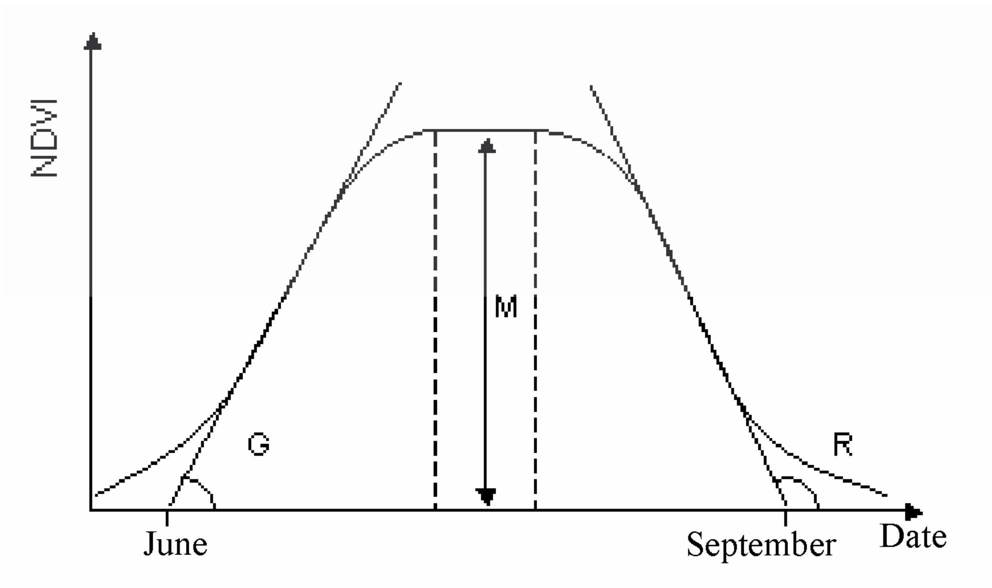

Fig. 1. Diagram of dependence of vegetative cover NDVI upon time

Calculation of parameters G and R at the indicated periods is based on finding slope of line that passes through the set of points of NDVI curve on a plane in the best way possible (using the least square method).

The first stage of thematic treatment was generation of daily NDVI maps by the data of the red and near infrared channels with a 250 m spatial resolution of Terra/Modis satellite. Next, the mask of values was superimposed on the daily NDVI maps, and the obtained data were exported to the special ENVI module developed in IDL that calculated the above mentioned parameters G, M, R.

RESULTS

To demonstrate the work of the above described algorithm, we processed the data of Terra/Modis satellite at the south of Krasnoyarsk krai and the Khakasia Republic during the 2006 growth period. A fragment of the composite image obtained by RGB synthesis of G, M, R parameter values is shown on Fig. 2.

Comparison of the obtained composite image with the field research data [7] and topographic maps of the same regions revealed the following classes of the earth surface:

- agricultural crops:
  - buckwheat (1),
  - oat (2),
  - wheat (3),
- bottomland meadows in complex with brushwood, willow coppice and poplar stands (4);
- pine forests (5);
- alfalfa and cereal communities (6);
- settlements (7);
- water surface (8).

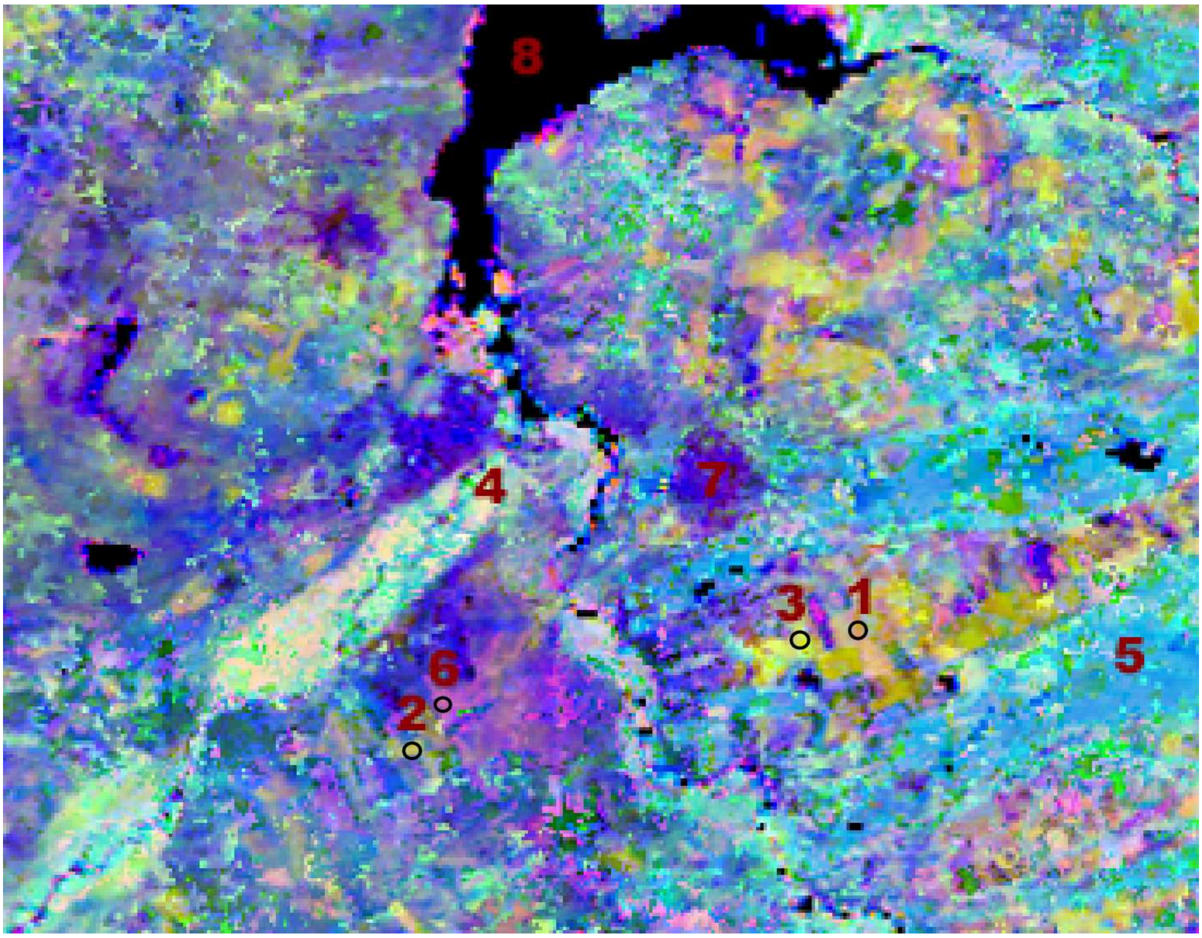

Fig. 2. A fragment of the composite image of the south of Krasnoyarsk krai and north-east part of the Khakasia Republic obtained by RGB synthesis (G: M: R)
(interpretation of numerical values is given in the text)

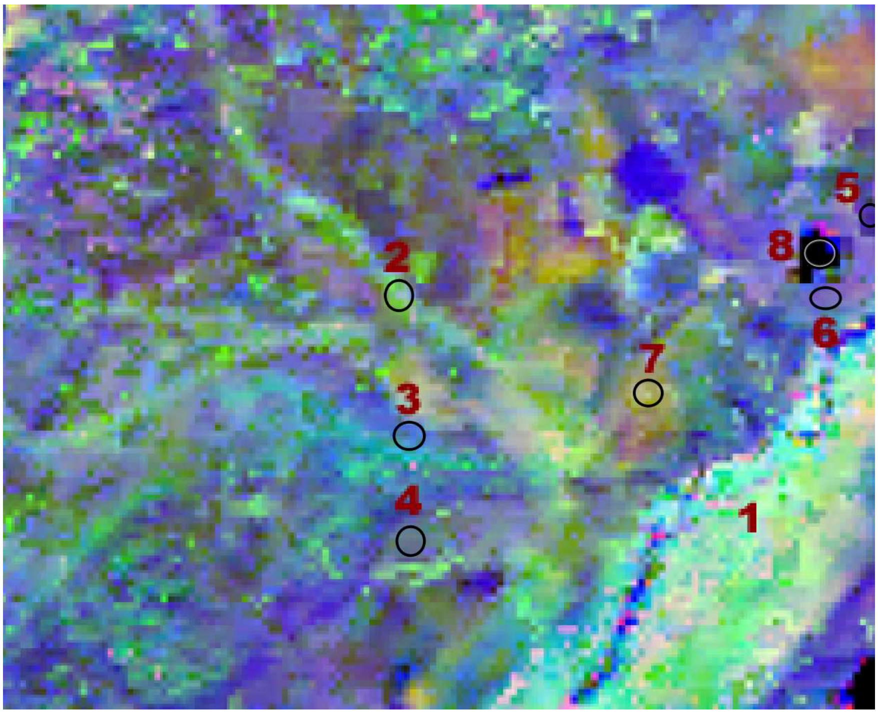

Fig. 3. A fragment of the composite image of lake Solenoye of Askiz Region of the Khakasia Republic obtained by RGB synthesis (G: M: R) (interpretation of numerical values is given in the text)

For a detailed analysis of the composite image a test area was chosen near Lake Solenoye located at the territory of Askiz Region of the Khakasia Republic. According to the field research data [7] and the data of the land use schematic map of Askiz Region of the Khakasia Republic, the following classes of the earth surface can be discerned on the composite image (Fig. 3):

- bottomland meadows in complex with brushwood, willow coppice and poplar stands (1);
- steppificated boggy areas (2);
- Stony steppes (3);
- Bunch grasses (4);
- Weed encroachment (5),
- Awnless brome (6),
- oat crops (7);
- water surface (8).

The results of the investigations show that the developed method makes possible the identification and classification of various types of vegetation on the basis of satellite images. This will reduce ground-based experimental work, opening possibilities for large-scale mapping of agricultural lands and other land plots.

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