

# Operational Monitoring of the Agricultural Production Based on the Observational MODIS Data as a Support for Improving Regional Planning

V. Povkh <sup>a</sup>, L. Shljakhova <sup>a</sup>, G. Garbuzov <sup>a</sup>, E. Vorobeychik <sup>b</sup>

<sup>a</sup> South Regional Information & Analytical Center (SRIA-Center) 27 Budeonovskiy, Rostov-on-Don, 3440082, RUSSIA - dzz@jeo.ru

<sup>b</sup> IT department, Rostov region administration 112 Sotcialisticheskaya, Rostov-on-Don, RUSSIA 344050 -rra@donpac.ru

**Abstract** - The SRIA-Centre supported by the Rostov-on-Don region administration is realizing a large-area change detection program using MODIS/TERRA data. This program is the initiative for gathering, storing and assessing environmental information for Rostov region on the base of remote sensing, local and common-used knowledge and science integration. The goal is to implement a long-term and high quality operational monitoring of environmental data as a support for improving regional planning and management in relevant decision-making communities. The MODIS imagery offers an opportunity for a daily coverage required for operational applications. The objective of this research is to assess the application of MODIS data for operation crop conditions and yields of the winter wheat as the major sources of the yield production in this region. Thematic analysis of MODIS radiometer data is made with use of supervised classification techniques which require to define training classes of vegetation condition prior to execution.

**Keywords:** Agriculture, observational data, crop production, MODIS

## 1. INTRODUCTION

There is a strong requirement in the agricultural business and administration for early crop inventory and determination of their status. That is why the Rostov-on-Don administration is supporting the project of SRIA-Center using MODIS/TERRA data for monitoring agricultural land use. Before realization of this project, the undertaken efforts have been in an integration of all usable remotely-sensed and other data collected for the Rostov-on-Don region during the past decade as well as data collected for ground truth verification of current satellite observations. The purpose of these efforts was to increase the use of remotely-sensed information for monitoring the status of this southern Russian province with highly affected by human agricultural activities (Kozoderov, Povkh, 1998; Povkh *et al.* 2004, Shljakhova *et al.*, 2000). The main goal of new study is to analyze observational MODIS data as a tool for agricultural crop monitoring because timely and accurate crop production forecasts and estimates are important inputs to effective crop production, processing, distribution and marketing decisions.

## 2. METHODS

The specificity of research area is that it serves as one of the major sources of the yield production having the winter wheat as its main crop. More than half of this territory in Rostov/Don region covering total area of 729 thousand hectares (ha) including 21 administrative agricultural districts was encompassed for this

study during winter - early spring season 2002. The MODIS radiometer data regular receiving from TERRA satellite in a pair of red and NIR spectral bands for the whole region with ground pixel resolution of the images approximately 250 m enable to give information for separate administrative agricultural units of the region.

Images from MODIS also offer the potential to precisely quantify crop health through an improved characterization of plant chlorophyll, photosynthesis, and biomass amount. The improved spectral resolution of MODIS serves also for creation of more precise vegetation indices (the ratio of near-infrared to red spectral components), which have been widely used to measure and predict crop yields. The specified spectral ranges are in accordance with well known remote sensing algorithms applied to estimate vegetation properties (Gitelson 2004a, Gitelson 2004b).

Remotely sensed and *in situ* data collected and archived by existing regional operational-scientific networks in Rostov have produced a large body knowledge and data that can be made available to support new research including assessment of methods for integration of these both types of observations. This data came from different sources such as ground-based observations, cartographic information, spatial data, table data, physical parameters of the area and others. All the data should be integrated in such a way that a database is available to researchers in a convenient, useful and timely manners. There are: historical data (i.e. data collected about the agriculture within the study region during past decades): yield production, winter wheat production, fertilizers applying, soil moisture estimates, fall crops as well as others; cartographic information about structure, square in agricultural land use (cultivation and grazing); operational information: the result of satellite imagery (from KFA-1000/Russian Space Photo System, MSS, MODIS, METEOR-3) processing, thematic maps; ground truth verification of current satellite observations: the result of biologists, vegetation studies and measurements, the completed maps of the land-use practices and other agricultural and ecological treatments. Additional sets of data for the interactive analysis of the MODIS images on our work station have included *in situ* assessments of selected winter wheat fields on 103 test sites of the region using the agricultural experience of the ground-truth observers. The selected test fields are proven to be representative for the region. The field measurements have been realized on each wheat site on particular dates of TERRA passages. Additional information about the targeted fields under study included meteorological conditions, soil moisture estimates, fertilizers applying, etc. The interactive analysis consisted in such MODIS data processing that could enable the complementary information to serve for better understanding the differences between the agricultural fields of

crop conditions for the region. These fields are maintained to be suitable to one of the group classified by crop reporting district of the official statistical data. Two test units (two groups) of the state parameters assessment, called by agro-meteorologists as “good” and “moderate” were used for the analysis within selected region in a way similar to that presented by Kozoderov, Povkh, 1998b, Shljakhova *et al* 2000.

Geographic data are complicated by the fact that they must include information about position, regional topographic peculiarities and links. The topological and spatial aspects of geographic data processing provide capabilities for transforming the original spatial data in order to answer particular queries. Global positioning system (GPS) satellites are able to provide digital coordinates and elevation information for any location on the Earth. This system is an efficient tool for data collection and data input in the field.

An important part of the agricultural GIS is in a vector map field representation over the entire Rostov region. The type of crops selected for the studies is due to the large size of individual fields of winter wheat. Thus, any losses of accuracy resulted from the low spatial resolution of MODIS radiometer data are diminished. Field boundaries were outlined within the GIS media as an initial step of evaluation of segments that belong to a particular field using the proposed technology based on the interpretation of high-resolution space photo images, where natural boundaries of field could be delineated (Povkh, 2004). The existence of detailed land division vector layers has allowed to register the MODIS images obtained at any earlier stage. A specified current mask was constructed in the proposed thematic analysis of the GIS vector layers for the winter wheat fields. Besides the geographical registration, data with detailed vector maps of the fields have allowed to automate the collection of basic information about conditions of test plots within the framework of GIS with uniform indexing of objects of the analysis. The digital version of the land division vector layers and multispectral MODIS imagery processing procedures are realized by ENVI 3.2/3.6 the software package.

The methods of the study spring cropping area in Rostov/Don region are divided into two parts. At first, preliminary materials of field surveys are used to estimate wheat conditions for identified areas of its potential production and to derive parameters for the remote sensing analysis. Afterwards, methods to detect possible sites for winter wheat growth via remote sensing data are applied.

We have developed various approaches in the current technology based on vegetation index (VI), simple combinations of two bands of MODIS radiometer data of known thematic significance.

The results of remote sensing of VI of the crop of winter wheat were obtained in early spring season 2002 and were regressed on the yield production identification by statement data based on ground observations using linear, quadratic and exponential models. A simple linear model would have given an excellent fit to the data.

### 3. RESULTS AND DISCUSSION

As a result of the MODIS imagery processing by VI created in the proposed manner, we obtained thematic maps of the winter wheat state identifying for the Rostov region as to the winter wheat

conditions on the dates of its this satellite surveying. MODIS data processed for VI for Masnikovsky district of the Rostov-Don region are shown in Figure1.

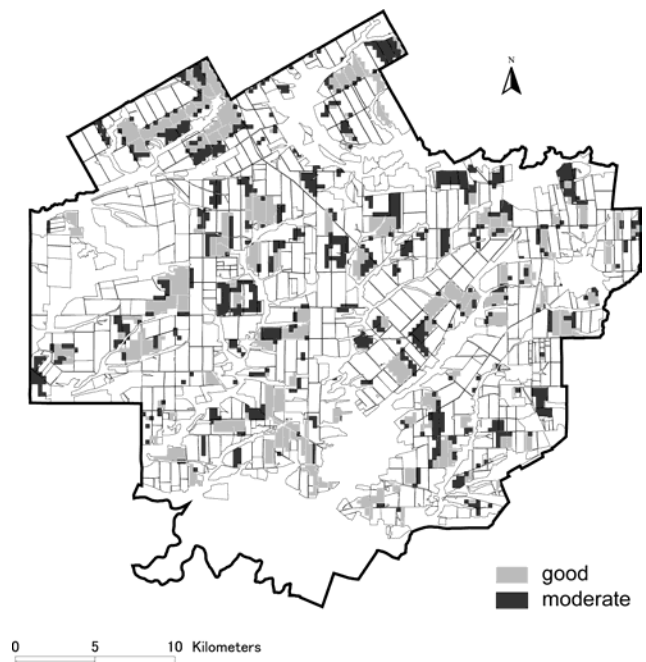


Figure 1. A two-category classification map of the winter wheat state (4 February 2002).

The results of operational remote sensing monitoring have been confirmed by ground observations of the studied area. The error between the compared data sets was relatively low. Approximately for 70% inspected fields the error was within 10%, and for 96% was within 20%.

Several activities have been focused on vegetation status monitoring and yield prediction (Figure 2).

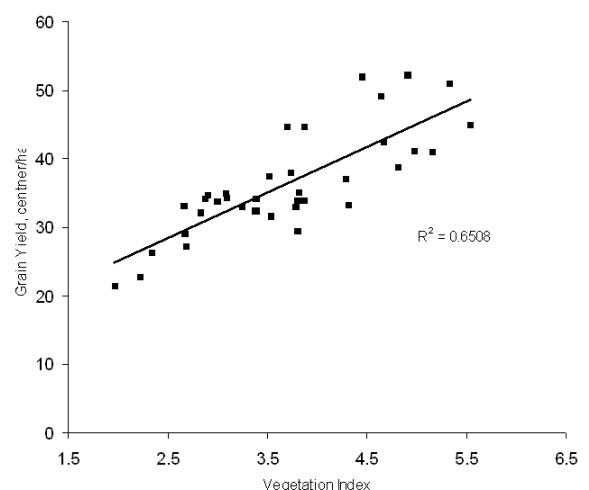


Figure 2. Regression model relating grain yield to vegetation index (VI) for Masnikovsky district of Rostov-Don region (2001 season).

A statistical regression analysis between vegetation index calculated as relation of red and NIR spectral bands by MODIS data and yield production as the official “statistical data” about 37 test fields crop area for one district of Rostov region were carried out. The best fitting were achieved with a linear regression, with determination coefficient varying  $R = 0,8616$ , STD 4,49 centner/ha ( Figure 2).

#### 4. CONCLUSIONS

Results of satellite and *in situ* data processing for the selected area of Rostov/Don region of Russia have shown prospects of the proposed technology of winter wheat crop condition assessment and yield production management. The relevant techniques are based on data set processing of satellite and ground-based data by GIS. Improved regional planning is the final goal of the proposed research.

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