Northern Kazakhstan Agriculture Monitoring by TERRA/MODIS

U. Sultangazin, N. Muratova, A. Terekhov

Space Research Institute, Shevchenko str., 15, Almaty, 480100, Kazakhstan – nmuratova@mail.kz

Abstract – Space monitoring experience of Northern Kazakhstan crop areas is highlighted. The purpose of 2002-2004 monitoring was crop production forecast. Some results of spring planting calendar dates fixing, spring-sown and fallow fields areas definition, weed infestation and crops state estimation are discussed. The basic approaches to thematic processing of TERRA/MODIS data are described.

Keywords: MODIS, crop rotation, fallowing, weed infestation, yield forecast.

1. INTRODUCTION

The Republic of Kazakhstan (RK) has the landmass about 2.7 million square kilometers. About 80% of the total area of Kazakhstan is used for agricultural purposes. Kazakhstan is a significant wheat exporter in Central Asia region. Spring crop (90% wheat and 10% barley) is basic cultures on the areas more that 12 million hectares. Most of the arable lands are located in the northern part of the country where typical landscapes are steppe and forest-steppe and most crop production is only rain fed. The average annual precipitation is about 400 mm with considerable spatial and inter-seasonal variations that result similar variation in crop yields. Average production is more than 14 million metric tons of grain. About 8 million tons is used for domestic consumption, and the rest is exported. So monitoring of agriculture areas and crop condition is very important for republic economics and grain market. Accurate and timely information about crop yield is critical data for the Ministry of Agriculture of RK.

At present time EOS/MODIS data is more operative source of information which use for agriculture monitoring (Sultangazin U., 2004). The set of tasks decided by MODIS data includes following ones: spring soil moisture estimation, spring sown areas evaluation, planting dates fixing, analysis of crop state and fields weed infestation levels, croppage forecast, control of harvested areas and monitoring of crop rotation system. All tasks are accompanied by current ground surveys. The basis requests to information received by satellite information are reliability and operative objectivity.

2. METHODS

Large sizes of cereal fields (2 x 2 km) allow efficiently use of TERRA/MODIS satellite data with middle resolution (1,2 channels, 250 m) (Doraiswamy P., 2002). Swath width about 2200 km of TERRA/MODIS system gives opportunity to monitor daily the agriculture territories. Only cloud cover creates some limits in periodicity of croplands spectral characteristics reception. Continental climate give opportunity to have a lot of cloudless satellite images.

Crop canopy spectral characteristics in red and near infrared channels and their changes during the vegetative period follow the certain laws, connected with the agrotechnical works and the features of wheat growth. There are critical key moments when canopy spectral characteristics are sense to different parameters, connected with tasks decision. Ground surveys are carried out in that time and the necessary information for satellite data calibration are collected. Solutions of above described tasks are based on regressive models and standard methods of classification.

3. RESULTS AND DISCUSSTION

3.1 Spring soil moisture estimation

Spring soil moisture estimation is based on information of calendar dates of spring snow melt registered by TERRA/MODIS and NOAA/AVHRR during February-April (fig. 1), ground measurements of soil moisture before sown season and soil mechanical structure (Terekhov, 2002a, Muratova, 2004a). Productive soil moisture stock in the ground points is calculated on the base of measurements and soil characteristics. Soil map and satellite information are used for extrapolation of point data and creation of oblast level map in 1:1000000 scale. In the case of summer precipitation deficit this map becomes important for yield forecast.

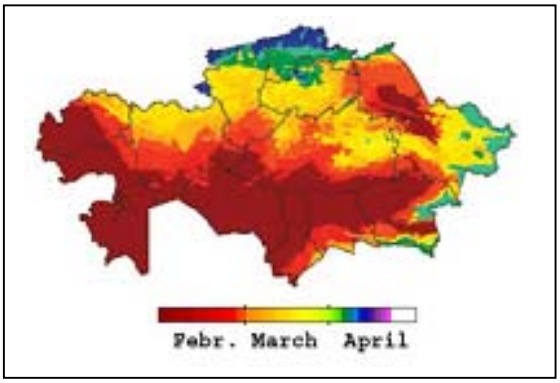

Figure 1. The map of 2002 spring snow melt calendar dates.

3.2 Spring sown areas evaluation

Spring sown areas evaluation is based on the crop mask (Terekhov, 2002b). Maximum spectral differences of spring crops, other landuse and nature grasses are registered during planting (from May to the beginning of June) and cereal earing-flowering (from second half of July to beginning of August). Cloudless TERRA/MODIS (band 2) data during these periods are used for recognition of planted fields by Supervise Maximum Likelyhood method, crop mask building and estimation of spring sown areas according of mask size.

3.3 Planting dates definition

Planting dates is important factor for wheat growth and correspondently productivity. Critical period of planting dates determination is started in the middle and continued till the end of June when plant cover areas and canopy reflectance depend strongly from planting terms (Muratova, 2004b). By linear regression between reflectance of MODIS band 2 and ground information from test fields the map of planting dates is built. Three classes of early, optimal and late planting periods are selected from the result of image processing. In Kazakhstan sowing campaign starts usually after 5 May and finished to 15 June. Weather features of vegetation period are capable to vary crop yield up to 30 % depending on sowing time.

3.4 Monitoring of crop rotation system

Monitoring of crop rotation system is curried out with help of multi-year information about land use. Fallow-crop rotation system is typical for Northern Kazakhstan. Fallow fields are mechanically processed 3-4 times and differed by low NIR reflectance values during vegetation season. The map of crop rotation (fig 2) was reconstructed on the base of landuse monitoring in last 4 years. The map includes four classes: 1st, 2nd, 3rt, 4th and more number of years after fallowing.

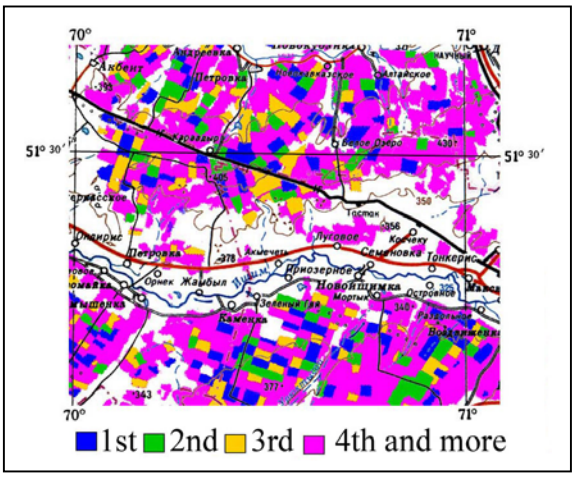

Figure 2. Fragment of crop rotation map.

3.5 Ground surveys

Ground surveys are important part of agriculture monitoring with using MODIS data. Calibration of satellite data is based on information from fields. Ground surveys are curried out three times during vegetation season as routing observation of crop fields located along roads. Information from 300-500 fields is collected during 10-14 days. The 3.2, 3.3 tasks request May-June data. Yield forecast corresponds with July-August characteristics. Harvest parameters estimates by September ground truth data. Field survey includes a description of crop and soil state and other biometrical parameters.

3.6 Weed infestation estimation

Weed infestation level is key factor for analysis of crop state in current year (Sultangazin U., 2003). Fields fallowing by tillage is the basic way of struggle with weeds in Kazakhstan. Parameters of fallow-crop rotation determinate the level of weed infestation. The technique of estimation of weed infestation degree was developed on the base of crop rotation map (fig 2). Ground survey in the period from end of July to start of August collects the information about crop conditions including level of field weed infestation in dependence of land use years after fallowing. Data about 500 fields per year is usually accumulated. All fields were divided on three classes (low, average, high) according weed infestation contents. The statistical information about weed infestation classes inside various land use years after fallowing was used. Weather condition during growing season has different influence (fig. 3) on weed population inside four classes described in 3.4. In 2003 the low level of weed infestation was less 10%, average 10-40 %, high more 40 % of weed population on fields.

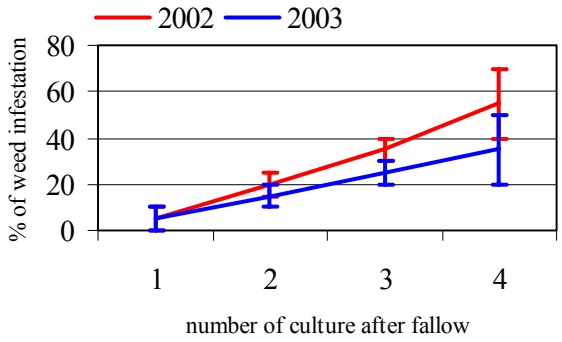

Figure 3. Weeds infestation (%) for four classes.

3.7 Yield forecast

Yield forecast is prepared in one month before harvest as expected volume of grain production. Three basic factors determine this volume. These are weather condition, weed infestation degree and planting time. The information from ground survey fields' database is selected and used for calibration of spectral characteristics. These fields, as rule, have a first culture after fallowing with low level of weed infestation and plant in optimal time. The average spectral characteristic and potential crop productivity of test fields defines the relation between TERRA/MODIS band 2 reflectance and yield in current year. The map of North Kazakhstan crop land potential productivity is built on the base of calibrating curve. Pass to real expected yield and estimation of total grain production is carried out after taking into account the decreasing factors such as weed infestation levels and their distribution according planting dates. In August 2002, 2003 and 2004 the differences of predicted grain production were about 7%, 10% and 3% in comparison with official values declared in the end of years.

4. CONCLUTIONS

MODIS 250 m resolution imagery could be used to monitor crop production in Northern Kazakhstan. The large area of cropland (more then 12 million hectares) has heterogeneous weather conditions and soil type. Good choice of images is highly required for any above described tasks. Weather condition, weed infestation degree and planting time influence

on crop productivity. Weed infestation degree depends strongly from the fallow-crop rotation system.

5. ACKNOWLEDGEMENTS

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