CROP STATE AND AREA ESTIMATION IN UKRAINE BASED ON REMOTE AND IN-SITU OBSERVATIONS

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Abstract: *This paper highlights the current state on establishing a network of test sites in Ukraine within the Joint Experiment for Crop Assessment and Monitoring (JECAM) project of the Global Earth Observation System of Systems (GEOSS). The results achieved so far on developing methods for crop state and area estimation using satellite and in situ observations are presented. The agromonitoring portal that provides access to geospatial products is described as well.*

Keywords: *Earth remote sensing, GEOSS, JECAM, satellite data processing, agriculture, area estimation.*

ACM Classification Keywords: *H.3.4 [Information Systems] Systems and Software - Distributed systems; I.5.1 [Computing Methodologies] Models –Neural nets; I.4.8 [Image Processing and Computer Vision] Scene Analysis - Sensor Fusion.*

Introduction

In the area of Earth observations one of the most powerful initiatives all over the world is the development of the Global Earth Observation System of Systems (GEOSS). This system is actively evolving during past ten years under the GEO Committee global activities. The main aim of the GEO Committee is availability and applicability increasing of space observations by means of coordination activities on the base of modern remote sensing possibilities for decision maker's support. Now, GEO has more than 80 country-level participants (including Ukraine), European Commission and 56 inter-governmental, international and regional organizations.

Agriculture is one of the 9 social benefit areas GEO Group. It can be mentioned that within this activities there are two global projects, Joint Experiment for Crop Assessment and Monitoring [JECAM, 2012] and, the most recent and ambitious, Global Agriculture Monitoring system (GLAM) [GLAM, 2010].

The overall goal of JECAM is to reach a convergence of approaches, develop monitoring and reporting protocols and best practices for a variety of global agricultural systems. JECAM will enable the global agricultural monitoring community to compare results based on disparate sources of data, using various methods, over a variety of global cropping systems. It is intended that the JECAM experiments should facilitate international standards for data products and reporting, eventually supporting the development of a global system of systems for agricultural crop assessment and monitoring. The JECAM initiative is developed in the framework of GEO Global Agricultural Monitoring (GEOSS Task AG0703 a) and Agricultural Risk Management (GEOSS Task AG0703 b).

To achieve the JECAM goals the initiative is bringing together the GEO Agricultural Monitoring Community of Practice to undertake an inter-comparison of monitoring and modeling methods, product accuracy assessments, and data fusion. JECAM is taking place on a finite set of regional pilot sites that are representative of a range of global agricultural systems. Data collected and shared are including time series datasets from a variety of Earth observing satellites and in-situ data with in-situ ground surveys results, in-situ soil moisture monitoring, meteorological data and other crop parameters estimation (measurement). The Community of Practice actively works with the Committee on Earth Observing Satellites (CEOS), the space-arm of GEO, and other data providers to facilitate the acquisition of Earth Observation data and ensure a coordinated approach to space based data acquisition.

Agriculture and Agri-Food Canada (AAFC) has taken on the secretariat role of the JECAM project on behalf the GEO Agricultural Monitoring Community of Practice. One of the responsibilities as secretariat is to develop and maintain this JECAM website where government, university and non-NGO researchers can investigate and collaborate on project objectives within JECAM. Current JECAM participants are presented in Fig. 1.

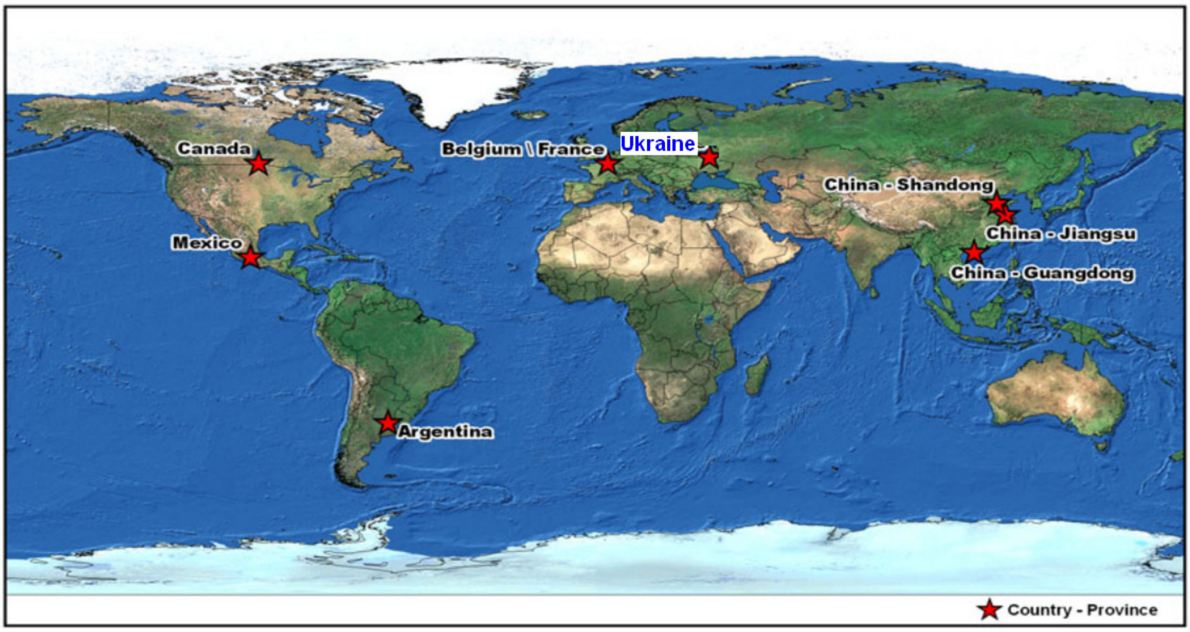

Fig. 1. International participants of the JECAM project

Last year a new global concept has been announced. (During Summit of Ministers of Agriculture G20, Paris, 22-23 June, 2011.) This initiative is related to the development of the Global Agricultural Monitoring (GLAM) for risk assessment all over the world and agrarian satellite services provision for developing countries.

Ukrainian specialists are actively involved in these international initiatives. In particular, Space Research Institute of the National Academy of Sciences and State Space Agency of Ukraine is the Ukrainian representative within the JECAM project, and holder of one of the test sites is the National University of Life and Environmental Sciences of Ukraine.

In this paper we outline the current state on establishing a network of test sites within the JECAM project and developing methods for crop state and area estimation using satellite and in situ observations [Gallego et al, 2012; Kussul et al, 2011a,b].

A Network of JECAM Test Sites in Ukraine

There are three test sites on the territory of Ukraine which are used within the JECAM project. Geographical positions, responsible organizations and scientific methodology are presented in the following sections.

As first and the most versatile test site is Kyivska oblast region (Fig. 2). Geographical location: 50°21'45.11" of north latitude and 30°26'40.43" of east longitude. On this area scientific investigations are provided by Space Research Institute NASU-NSAU.

The second test site has been chosen in Khmelnitsky oblast (Fig. 3). Geographical location of this agricultural region is 48°53'27.28" of north latitude и 26°50'58.50" of east longitude. The investigations on this test site were provided by Center of the Special Information Receiving and Processing, State Space Agency of Ukraine.

And, finally, third test site was countryside Pshenychne which belongs to branch of production of National University of Life and Environmental Sciences of Ukraine (Fig. 4). Geographical location: 50°7'42.99" of north latitude and 30°14'35.00" of east longitude.

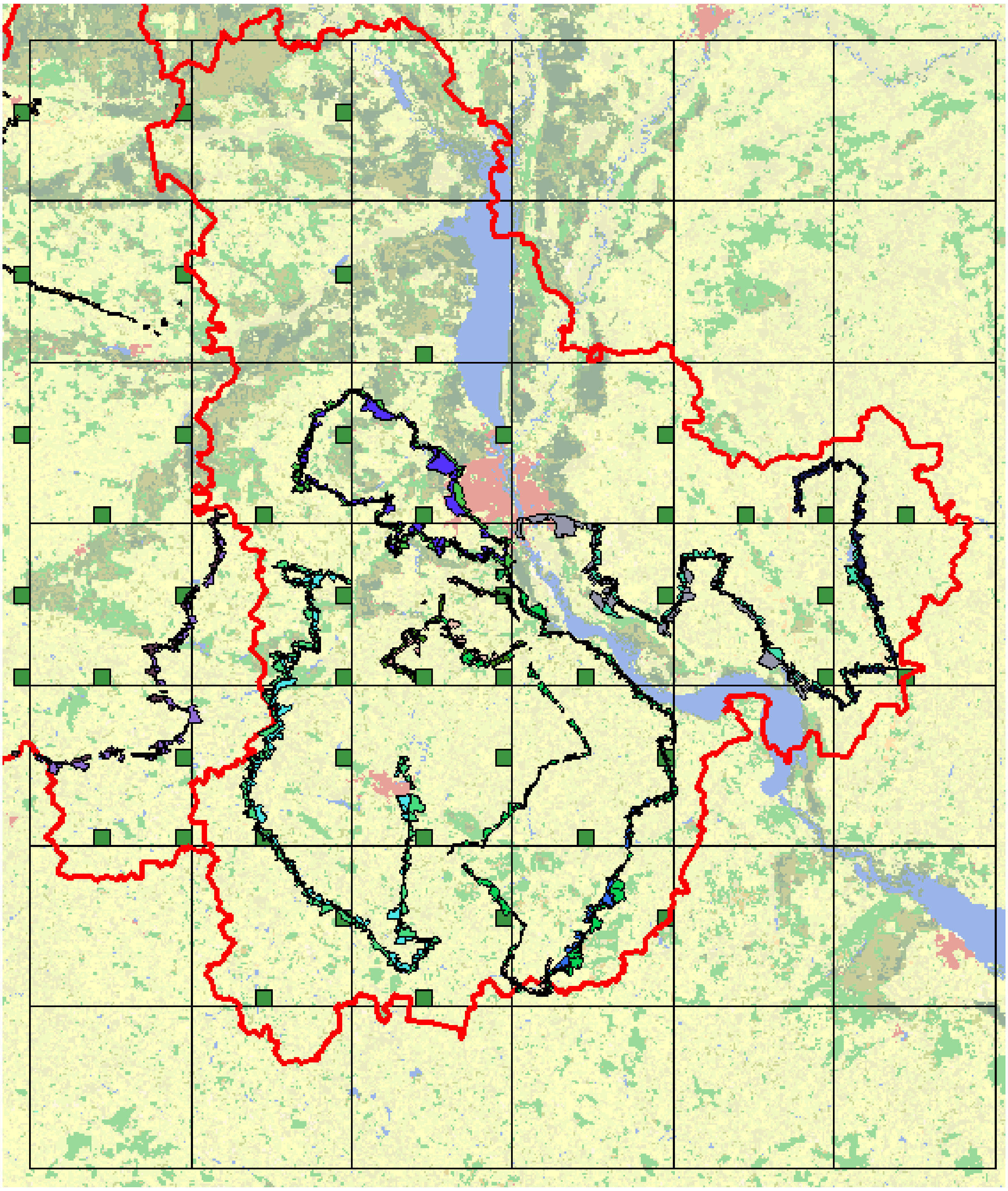

Fig. 2. Kievska oblast test site

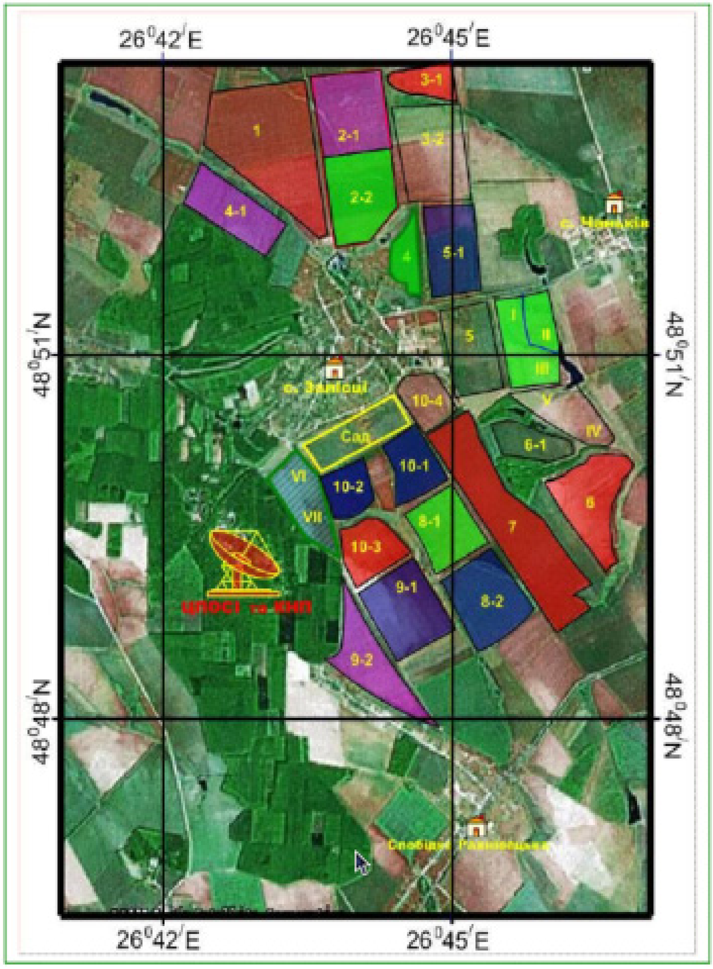

Fig. 3. Khmelnitsky oblast test site

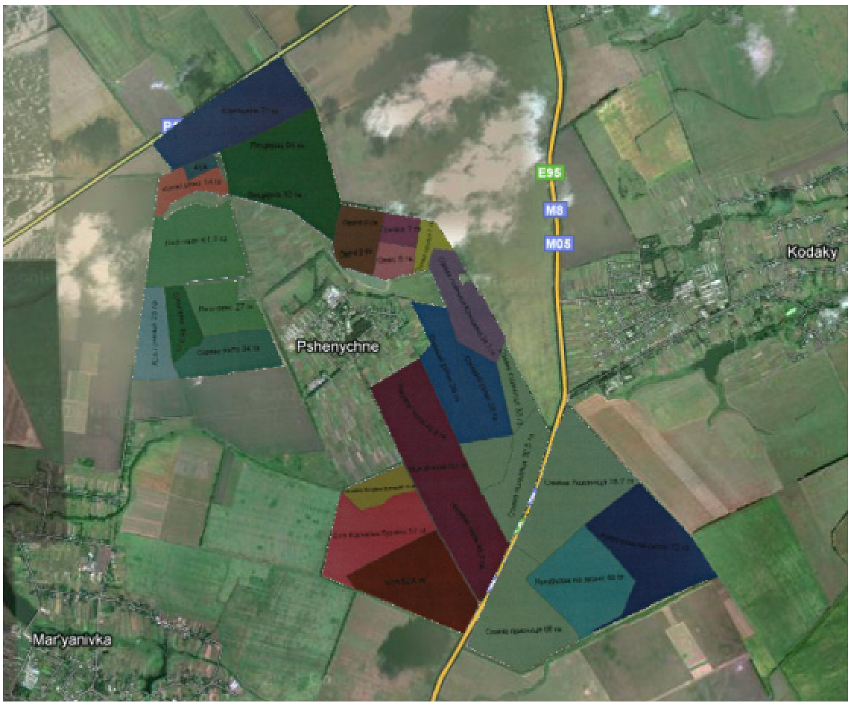

Fig. 4. Pshenychne countryside – third JECAM test site

Satellite Data

During last vegetation season (2011) the specialists of Space Research Institute NASU-SSAU have acquired a large amount of satellite images for target territory. This includes images that have been acquired by the following instruments.

1. **Mid-resolution Imaging Spectroradiometer (MODIS) on board Terra and Aqua satellites.** The MODIS dataset was obtained from the JRC Agri4Cast ImageServer (http://cidportal.jrc.ec.europa.eu/thematic-portals/agri4cast). The dataset contained orthorectified MODIS Normalized Difference Vegetation Index (NDVI) images. Data is stored in original Lambert Azimuthal Equal Area (LAEA) projection and cropped to the area of the selected three oblasts. Data is temporally aggregated to a decade period. The spatial resolution is 250 m. Data with heavy cloud contamination were excluded from the exercises.

2. **The Thematic Mapper (TM)** instrument onboard Landsat-5 satellite operates in 7 spectral bands with spatial resolution of 30 m and scene coverage is 185x185 km. Due to large amount of Landsat images which have been obtained during last year, this data source can be consider as main basis for agricultural monitoring.

3. **Earth Observer 1** data are provided by National Aeronautics and Space Agency of US and has 35 m spatial resolution in visible range. A couple of imageries were obtained by means of direct programming satellite via Web based informational system that is providing by NASA specialists.

4. **Ukrainian satellite Sich-2** was launched on 17th of August last year but nevertheless its data are very important for agricultural monitoring. The data have 5 spectral ranges and spatial resolution from 8 m (visible range) and 40 m (near infrared). Although Sich-2 data became available on autumn 2011 they have been used for some tasks solving.

Tasks and Scientific Methods

A number of applied agricultural monitoring tasks were solved by Space Research Institute specialists last year [Gallego et al, 2012; Kussul et al, 2011a,b; Kussul, 2011; Shelestov et al, 2011a,b]. The most important one were the crop area estimation, state vegetation estimation and winter crops area estimation, for example of winter rape beans.

Crop area estimation. For this task solving ground (in-situ) surveys were conducted when on the fields all crops were present. These included surveys along the roads and area frame sampling (AFS) surveys (segments surveys). During surveys along the roads it was collected information on crop types and geolocation data from GPS for further georeferencing of satellite images. During AFS surveys it was collected extensive information on the area being visited including land use, crop type, ground photos, type of observation, accessibility. For segment selection it has been used stratification technology from Joint Research Center of European Commission. Stratification was used to improve sampling efficiency. We followed an NASS-USDA approach where percentage of cropland area is considered as a main stratification factor. Stratification was done using ESA GLOBCOVER land cover map with resolution of 300 m. European LUCAS nomenclature was used in this investigation as a basis for land cover/land use types.

The following sampling strategy was used in the study. All the area was covered with a regular grid of sampling units of 40x40 km. Each sampling unit was further divided into segments of 4x4 km. As the field area in Ukraine is 50 to 150 ha we expected each segment to contain 15 to 20 fields in average. If some segments has more than 20 fields than area of segment was reduced up to 2x2 km.

During ground surveys surveyors were assisted with up-to-date satellite images (mostly Landsat-5, but not always). And, finally, on the base of ground measurements these satellite images were classified using different approaches such as neural networks and decision tree. Some classifications results are depicted in Fig. 5.

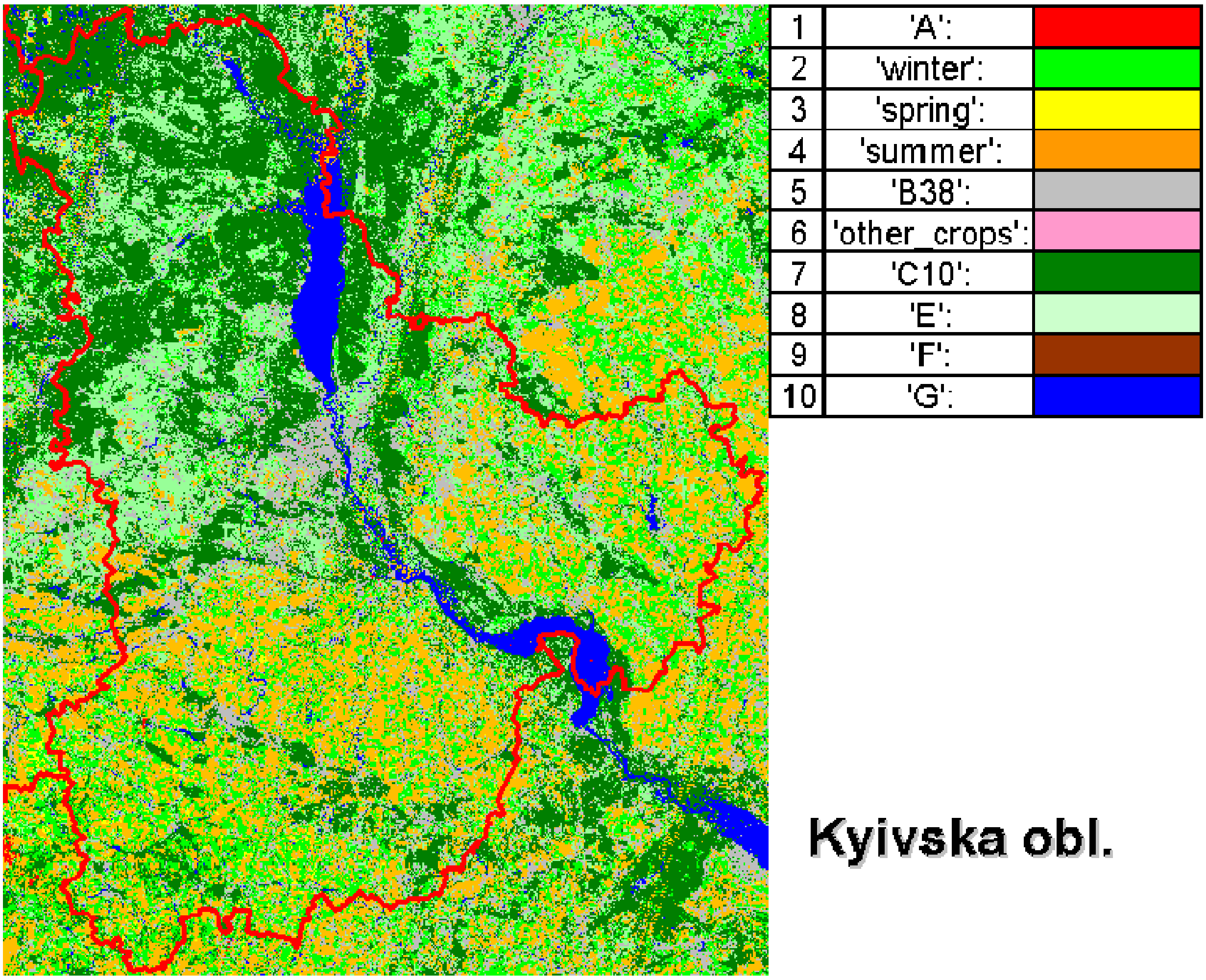

Fig. 5. Classified image for Kyivska oblast region

State vegetation estimation. During last year it was organized ground surveys in countryside Pshenychne region (another Ukrainian JECAM test site). During these in-situ observations it have been obtained a number of crop parameters such as crop height, projective cover, leaf area index, soil chemical analysis. Moreover, it were provided up-to-date satellite images. Since we have ground data as well as remote sensing data, efforts were directed to cross-validation and comparison these data. Thus, it has been estimated relationship between humus and satellite-derived biomass (Fig. 6), relationship between wheat height and biomass index (Fig. 7), relationship between crop height (ground observation) and biomass index (satellite estimation) (Fig. 8) and some other correlation dependencies.

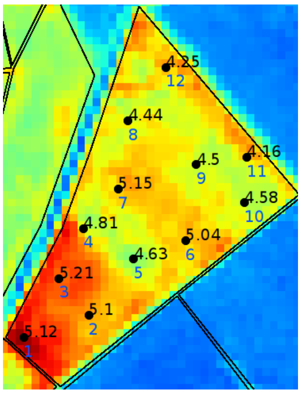

Fig. 6. Relationship between humus and satellite-derived biomass

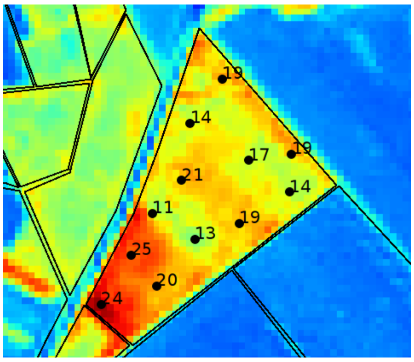

Fig. 7. Relationship between wheat height and biomass index

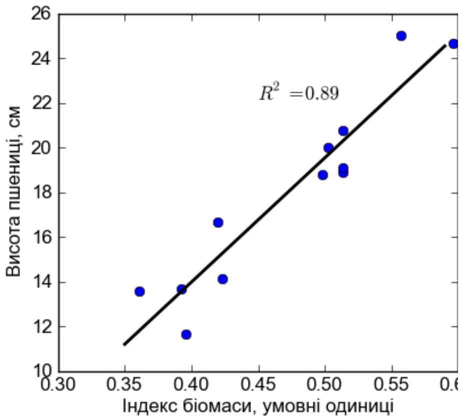

Fig. 8. Relationship between crop height and biomass index

Winter crops area estimation. European methodology of crop area estimation was used for winter crop area estimation on the base of SICH-2 data for Kyivska oblast. We used two images (1 of September and 10 of October), to distinguish winter rape and winter wheat, as well as Landsat data. These images were classified using MLP network architecture. For training set creation it were used surveys along the roads. Results are shown in Fig. 9.

Fig. 9 Classification map with winter rape fields

Information Technologies for Data Storage and Results Delivery

Since during more than 2 years we have collected a large amount of satellite images from different providers and a lot of in-situ measurements (on the fields, segments, roads etc.), including laboratory chemical soil analysis results, it was developed Web portal which provides possibilities to find, view and to do some other important GIS-operations on the multilayer basis. This set of information technologies are providing the standardized program interface for data retrieval and exchange. Portal main page is shown in Fig. 10.

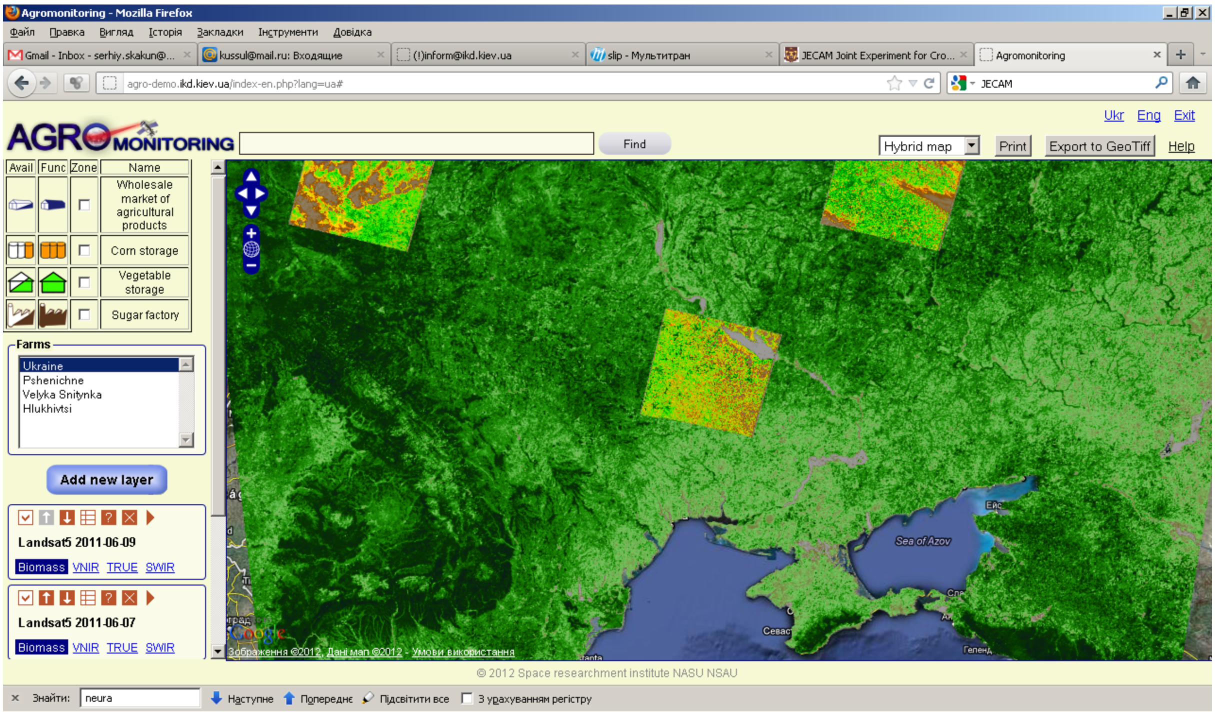

Fig. 10. Agromonitoring portal

Conclusion

In this paper we outlined the current state on establishing a network of test sites in Ukraine within the JECAM project. At present, there are 3 test sites in Kyivska and Khmelnitska oblasts. The following problems are solved using satellite and ground observation data: crop area estimation, state vegetation estimation and winter crops identification. A number of satellite images acquired by different instruments are used including MODIS, Landsat-5/TM, EO-1 and Sich-2. The satellite data and generated added value products are available at the agromonitoring portal.

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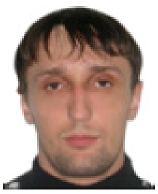

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