Regional Monitoring of the Black Sea Basin

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Main tasks and expected results of joint Russian-Bulgarian scientific collaboration and joint research are discussed. Investigations are planned to be carried out in a framework of the Project of joint Russian-Bulgarian activities on development of new technologies in the aerospace remote sensing of the Earth's surface.

Introduction

During the last years, destructive processes caused by natural disasters or anthropogenic activity are in the focus of scientific research and occupy the attention of state and government authorities. A great variety of multipurpose programs and projects on the environment study and control has been developed. In all of them the first and most essential step is land cover phenomena and processes monitoring at regional and global scale [1-4]. The necessary data can be provided by a complex of instruments installed on airborne and satellite platforms thus implementing the multiscale, multipurpose and multitemporal approach [2, 5]. On the other hand, the interrelated nature of many environmental problems predetermines the need of data integration and information sharing between different databases.

Since the environmental situation varies from site to site it is necessary to begin with regional monitoring and then to cover larger territory. In a framework of the Project of joint Russian-Bulgarian activities on development of new technologies in the aerospace remote sensing of the Earth surface we suggest the following scenario – for regional monitoring, to rely on well equipped small aircraft platforms in combination with ground-based measuring stations. Land cover state assessment will be performed and risk indices will be evaluated by using data in visible, infrared and microwave spectral bands. The Geo-Information Monitoring System, including on-ground and aerospace monitoring and modeling the Black See basin is supposed to be created in a framework of the Project of joint Russian-Bulgarian activities.

The results of aerospace observations will permit to work out the proposals and recommendations for forecasting the ecological catastrophes and their consequences, and to detect the ecological systems in a crucial state.

Scientific Equipment and Main Tasks

The compositions of possible scientific equipment and main tasks are presented below.

Visible Spectrometers

- Soil erosion, overmoistening, swamping, underflooding, soil fertility;
- Condition of inland waters (pollution, overgrowth with water-plants);
- Condition of vegetative canopy (volume of phytomass, changes in plant type, plant disease);
- Condition of agricultural crop fields (agricultural plant state, germination, vegetation phase, volume of phytomass);
- Chemical content of the air.

Infrared Spectrometers

- Condition of snow cover (pollution, boundaries);
- Soil and water surface pollution;
- Revealing fire sites (localization and boundaries);
- Areas with shallow water and flooding.

Microwave Radiometers

- Soil moisture, mineralization, overmoistening, swamping;
- Condition of irrigation and drainage constructions;
- Depth to water table;
- Land surface temperature contrasts;
- Condition of inland waters (pollution, mineralization, overgrowth with water-plants);
- Condition of vegetation (volume of biomass, changes in plant type, diseases);
- Condition of agricultural crop fields (agricultural plant state, germination, vegetation phase, volume of phytomass);
- Condition of snow cover (water equivalent, pollution, boundaries);
- Ice sheet on inland waters and road covers;
- Revealing fire sites (localization and boundaries);
- Shallow water and flooding;
- Underground irregularities detection (structure and localization of buried objects and industrial waste detection);
- Revealing geoecologically and epidemiologically dangerous zones and providing risk assessment.

Radars

- Soil erosion;
- Land surface topography (relief and sliding);
- Condition of forested areas (changes in tree types, glades and cuttings in a forest, plant diseases);
- Pollution and boundaries of inland waters;
- Ice sheet on inland waters;
- Boundaries of snow cover;
- Underground irregularities detection (structure and localization of communication network, buried objects and industrial waste detection).

Important note: There exists the instrumentation mentioned above and the software is available for resolving the tasks described above.

Examples of Data and of the Existing Collaboration

Below, the example is given of the soil moisture map (Fig. 1), obtained by microwave radiometer operating at the wavelength of 21 cm. The data have been received in 2005 in a framework of the Agreement on Collaboration between IRE RAS and NASA-AAMU Center for Hydrology, Soil Climatology and Remote Sensing (HSCaRS-AAMU), USA. The radiometer has been installed on board of "Rover" type mobile platform. The highest level of soil moisture content corresponds to dark blue color, minimum soil moisture content corresponds to red color. This map is obtained in on-line or run-time regime. The second hi-tech development is a compact system based on an unmanned helicopter with 6-cm microwave radiometer on board (Microwave Autonomous Copter System-MACS). Both, "Rover" and "MACS" systems have been developed for educational purposes as well as for research activities as related to "soil-vegetation", volcanic and aquatic systems studies and for practical applications of microwave radiometry in agriculture, hydrology, wetlands, water pollution, many others. A few examples of some other successful results of Collaborative Agreements are given below.

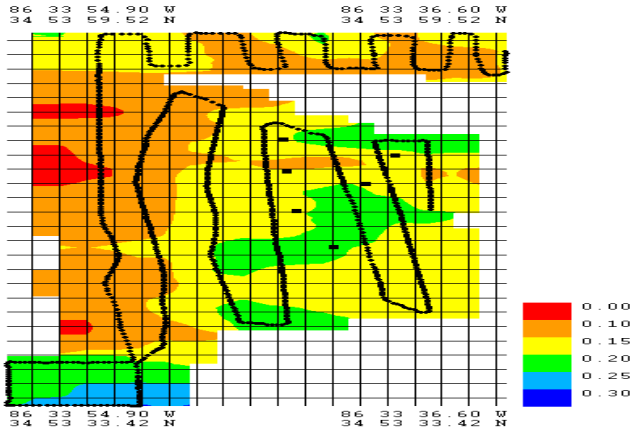

Fig. 1. Soil moisture map (moisture content is in g/cc).

IRE RAS - Microwave Radiometric Mapping Company (Miramap), European Space Agency, The Netherlands. The SkyMaster plane is equipped with IRE-VEGA scanning radiometers and Dutch optical spectrometers for levee/dykes condition detection.

STIL BAS - NASA-AAMU Center for Hydrology, Soil Climatology and Remote Sensing, USA. STIL BAS has developed a 128-channel optical spectrometer "TOMS" for HSCaRS-AAMU for installation on board of both "Rover" and "MACS" platforms for synchronous microwave and optical observations.

In general, that was a beneficial collaboration period of time that resulted in sensor, data acquisition system and software upgrade for providing effective scientific collaboration by developing technologies of trace and scanner data collection along with the in situ measurements, utilization of prior knowledge-based information, soil-vegetation and topographic maps, GPS positioning and mathematical modeling of the environment (GIMS for cartographic soil moisture mapping, shallow water table detection, revealing zones with water seepage through levees, above-water biomass determination, others).

The regional monitoring example of bioproductivity zones of the Black Sea is given on Fig. 2. The optical data were received in the frame of space experiment "Diatomeya" on the International Space Station (Yu.A. Gagarin Cosmonauts Center, IO RAS, IRE RAS). The main goal of this experiment is the obtaining of the satellite water color data to study the physical processes in the subsurface layer of sea and ocean, biological and ecological monitoring of sea and ocean, study of pollution circulation and dynamics.

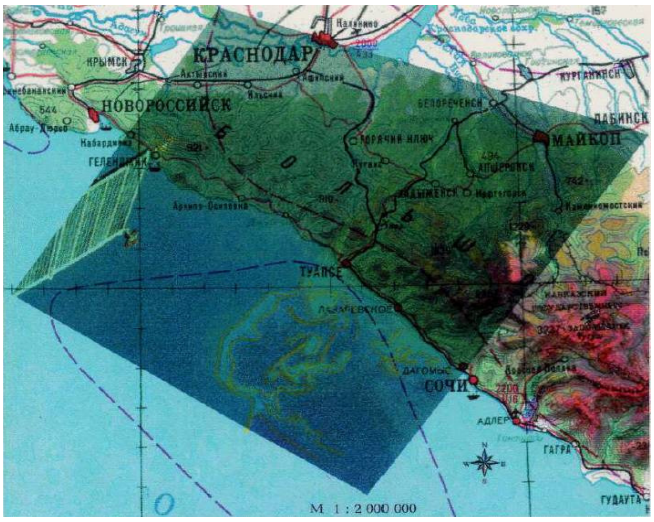

Fig. 2. Zone of bioproductivity of the Black Sea (near Tuapse).

For the remote sensing devices calibration and aerospace data validation it is necessary to perform accompanying to aerospace experiments the ground truth measurements of various parameters of observed objects. The example of ground truth observations of the Black Sea region near Gelendzhik, held together with IKI RAS [6] is given on Fig.3.

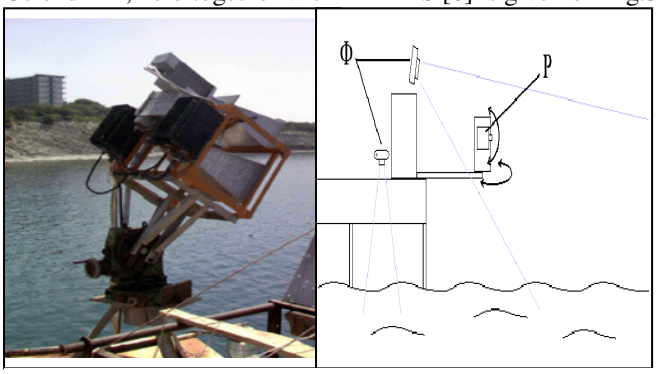

Fig. 3. Black Sea ground truth measurements

The measurements were carried out by microwave radiometers and polarimeters in wavelength range from 0.3 to 27 cm, and by 3 cm radar and 0.8 cm scatterometer. The objectives of experiments were: diagnostics of coastal area and atmosphere, processes of ocean- atmosphere interaction in a coastal area, ecological monitoring of a coastal area, etc. Remote measurements were accompanied by *in situ* measurements of meteorological and hydrological parameters.

Performing ground truth measurements enables to obtain the evaluation of accuracy of aerospace remote sensing data processing methods being worked out and developed, to study functional links between optical- biological fields and characteristics of radiation ascending from the water.

Russian-Bulgarian Project Goals

In the framework of the Project of joint Russian-Bulgarian activities on development of new technologies in the aerospace remote sensing of the Earth's surface it is planned the realization of works on the following main directions.

1. Development of proposals on the complex subject-oriented studies of selected objects on the Earth's surface.
2. Development of proposals on the instrumentation content and instrument parameters for research and detection of selected environmental objects condition.
3. Analysis of the effectiveness of joint use of Microwave, Infrared and Optical sensors for revealing the peculiarities of hydrological condition as well as of condition of vegetation.
4. Development of proposals on joint use of Microwave, Infrared and Optical sensors for revealing the peculiarities of hydrological condition as well as of condition of vegetation from ground-based and aircraft platforms.
5. Upgrade of the existing instrumentation for revealing the peculiarities of hydrological condition as well as of condition of vegetation from ground-based and aircraft platforms.
6. Analysis of the existing technologies and preparation of specific acts for conducting experiments, data processing, thematic interpretation, archiving and data exchange.
7. Conducting laboratory and out-door experimental studies, collecting/accumulating data banks.
8. Current experimental data critical analysis and developing recommendation on an increase in effectiveness of experimental studies.
9. Analysis of the results of processing the data collected in the laboratories, from on-ground and aerospace platforms in the frameworks of national and joint projects.
10. Creation of the distributed project related data banks.
11. Creation of an actively working scale-simulation model of the system for on-ground and aerospace monitoring of coastal zones related to Black Sea basin.
12. Generating proposals on future development of methodologies and means for on-ground and aerospace monitoring of the Earth's surface in the interests of science and economy.

Expected Results

The following results are expected in a framework of this project.

- Proposals on the main directions of the national and joint aerospace studies of the Earth's surface.
- Proposals on the complex subject-oriented studies of selected objects on the Earth's surface.
- Proposals on the instrumentation content and instrument parameters for research and detection of selected environmental objects condition.
- Technologies and task-specific acts/methodologies for conducting experiments, data processing, thematic interpretation, archiving and data exchange.
- The results of processing the data collected in the laboratories, from on-ground and aerospace platforms in the frameworks of national and joint projects.
- Creation of the distributed project related data banks.
- Creation of an actively working scale-simulation model of the system for on-ground and aerospace monitoring of coastal zones related to Black Sea basin.
- Proposals on future development of methodologies and means for on-ground and aerospace monitoring of the Earth's surface in the interests of science and economy.
- Joint publications.

Conclusions

Complex use of the remote sensing instruments operating in Optical, Infrared and Microwave bands will make it possible to develop an effective approach for determination of the impact of the following environment-related signatures on human habitat:

- Industrial activity;
- Urbanization;
- Mining activity;
- Ecocatastrophes/disaster of anthropogenic/man-made origin;
- Spontaneous disaster;
- Changes in climate and weather factors.

The proposals and recommendations for forecasting the ecological catastrophes and their consequences, as well as for detecting the ecological systems crucial state will be worked out.

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