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SPACE AND AVIATION TECHNOLOGIES OF MONITORING AND FORECASTING OF EMERGENCIES

The article describes the method of thematic processing of space images for operational detection of large-scale natural disaster and Express-assessment of their consequences. It provides the characteristic of the existing system of space monitoring in Russia, including the monitoring of flooding, floods and fires. It defines the basic directions of development of space monitoring.
Key words: emergency, remote sensing, space monitoring, fires, saturated zone.

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КОСМИЧЕСКИЕ И АВИАЦИОННЫЕ ТЕХНОЛОГИИ МОНИТОРИНГА И ПРОГНОЗИРОВАНИЯ ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ

В статье описаны методики тематической обработки космических снимков для оперативного выявления масштабных природных ЧС и экспресс-оценки их последствий. Даётся характеристика действующей системы космического мониторинга в России, включающей мониторинг паводковых вод, наводнений и пожаров. Определяются основные направления развития космического мониторинга.
Ключевые слова: чрезвычайная ситуация, дистанционное зондирование, космический мониторинг, очаги пожаров, зоны подтопления.

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1. Emergencies in Russia

The territory of Russia and numerous facilities are subject to destructive influences virtually of all known types of dangerous geological, hydro meteorological and biological processes. Almost on the 45 % of the Russian territory forest and other l fires the 34 % – of the territory the earthquake of 6 or more points (scale MSK-64), each time conditional on significant socio-economic losses in the cities and other settlements are also significant and increasing over time and space threat to socio-economic development of Russia. Floods, landslides and avalanches, man-caused go flooding areas, karst-suffusion and certain other hazardous natural and man-natural (human-induced) processes.

Prognostic assessment of the social and economic risks of losses of these processes on the territory of Russia was carried out for the period of 2001-2025, based on the most probable scenario at this time with the following assumptions.

1. The volume of the annual state budget financing and ongoing measures to prevent natural hazards and techno gene processes using methods of monitoring and engineering protection will remain at the level of the last decade of and will increase insignificantly.

2. Uncontrolled development of hazardous areas without preventing a fore cited process within them will continue.

3. Negative tendency of increasing of areas of development, frequency and intensity of natural hazards and Processes caused by increasing anthropogenic impacts on the environment and global change of climatic conditions will remain.

2. The use of space pictures for monitoring and forecasting of natural and man-made emergencies

Environmental monitoring – a system of surveillance and monitoring conducted regularly on a specific program for the environmental assessment, the analysis of the processes taking place in it and the timely identification of trends of change. When building a system of emergency monitoring the key of the system is regularity of observations, providing the rate of renovation information corresponding to the predicted frequency of occurrence of emergencies and their dynamics. Correspondence of the renovation of information the dynamics of the observed process is the basis for determining of the effectiveness of the monitoring system.

For ease of analysis it`s reasonable to divide the tasks of aerospace monitoring of emergency situations on the steps of:

- the medium-term forecast;
- short-term forecast;
- detection;
- monitoring, including short-term forecast of the situation;
- assessment of the consequences.

Aerospace monitoring of the environment is intended for improving the effectiveness of prevention and liquidation of emergency situations at all levels (federal, regional, local) to ensure the safety of the population and the objects of industrial and social purposes. Monitoring data are used to make recommendations to reduce the damage and making decisions in the process of liquidation of emergencies.

The following tasks are carried out by the monitoring:

a) control of emergencies or potentially dangerous situations;

b) monitoring of the states of territories and facilities.

For efficient monitoring of large areas the pictures of low and medium visibility obtained with a high frequency are the most suitable. The best quality of almost daily shooting photos is provided with radiometer MODIS (Moderate-resolution Imaging Spectroradiometer – Moderate Resolution Imaging Spectroradiometer) derived from U.S. satellites Terra and Aqua. The use of space pictures for monitoring and forecast natural emergencies greatly facilitates the possibility of prevention and liquidation of emergency situations, such as the spring floods, forest fires, for the mountain areas – mud flows and ice avalanches. With the help of software applications for the developing of satellite images, you can create a database of potentially dangerous objects, crucially significant objects for further organization of their address search, the coordination search, name, etc.

3. Creation of a complex space technology for early warning and monitoring of environmental changes of large-scale natural and man-made disasters

At its foundation SCM emergency was oriented on domestic spacecraft (SC) of the "Resource", "Meteor" and American satellites of the survey "NOAA". The work was being done in two ways :

collection and analysis of information data, the creation of databases of space data for designing and building of the complex space techniques and technologies for early warning and supervision of impact of environmental changes as a result of large-scale natural and man-made disasters;

development of a set of observations of environmental changes.

Analysis of information materials of the Federal Institute of Civil Defense (FC), Khrunichev, MV Khrunichev, NPO "Energia", Space Research Institute, Institute of Control Sciences, Russian Academy of Sciences IRE, VNIIEM and SEC "Skanex," IL SB RAS, Russian Ministry of Natural Resources GlavNIVTs made it possible to determine:

- types and scales of major natural disasters and determination of the scale and outcome. including:
  - wood, peat, prairie fires;
  - floods, flash floods;
  - oil spills;
  - earthquakes;
- kinds of large scale man-made disasters and their consequences:
  - hydraulic accidents;
  - product Pipeline accidents.

By increasing the number of spectral channels of remote sensing equipment, increasing the efficiency of obtaining the initial information and transferring of the results of its analysis it is possible to use additional SCM in the following ways:

- the rapid detection of dangerous natural phenomena (storms, squalls, a tsunami, the consequences of earthquakes);
- monitoring of potentially hazardous territories and facilities (observation of territories and objects where possible emergencies are possible, control of product lines);
- environmental monitoring (industrial pollution of land, rivers and waters of the seas);
- agricultural land monitoring (monitoring of soil, crops condition);
- forest monitoring (monitoring of forests and deforestation);
- assessment of the impacts of extreme natural situations.

Develop with the help of established techniques satellite data is transmitted to the management to decide on the liquidation of emergencies or reducing its risk.

Bank shots of Russian territory and potentially dangerous objects have been accumulated by Federal Institute of Civil Defense during all the years of SCM emergencies both by means of its own fund and purchase.

Currently, the bank has about 4,000 ranked by territories and types of emergencies images on 800's of laser disks in the server – for operational use.

4. Rapid assessment of earthquake damage using space imagery data

In order to eliminate the effects of earthquakes, you must have complex data. One of the most important components of this kind of data is an area of destroying destruction of infrastructure. The total area of destroying the infrastructure is necessary to plan the aftermath of the consequences of the earthquake. When knowing the area of destruction will be able to estimated approximate costs for debris clearing, recovery (if possible) partially destroyed objects, etc. In one word the total area of destruction is a necessary criterion to assess the damage from the earthquake and the development of measures to liquidate its consequences.

Usually, the total area of destructions before the liquidation events in the aftermath of disasters is a very approximate value.

As a result is very often due to misconceptions of the scale of damage (making it bigger or smaller) various incorrectness with material and human resources, involved in the elimination of the consequences.

To significantly improvement of ascertainment of the area of destruction, you can use remote sensing data of the Earth. When used properly, space pictures for the purpose of determination of the total area of destruction of the objects of infrastructure lead to more competent reallocation of funds.

In some cases, the data produced using satellites can give a more complete picture of the destruction in online mode, than the data of land research.

The aim is to assess the scale of destruction from earthquakes using remote the data of DSS.

To achieve the goal it is necessary to solve the following tasks:

to identify the infrastructure in space photographs;

produce a distinction on the basis of destroyed/undestroyed objects;

distinguish the destroyed objects in the general class and separate them from the rest of the information in the picture;

calculate the area of distinguished dedicated class of destroyed infrastructure.

5. Global Geographic Information System "Extremum"

Chief Designer GIS "Extremum" Academician MA Shahramanyan proposed and implemented a new approach to the problem of protection of the population from earthquakes – creation a system to mitigate the consequences of the devastating earthquake by operational prediction of the situation in the area of the seismic events, based on information received from the GIS "Extremum" which provides for the timely adoption of optimal solutions for carrying out rescue operations, without waiting for the results of investigation of the disaster zone. This allows for timely to begin rescue operations and reduce the number of victims to 50 %.

Regular tasks of GIS "Extremum" are:

- operational forecasting of the consequences of destructive earthquakes and secondary factors (radiation, chemical and hydrodynamic accidents at hazardous sites, gathering floods, etc.);
- creation of maps for certain types of risk and integrated risk and operational development of scenarios of reaction.

The basis of the effective functioning of the GIS "Extremum" is periodically scalable arrays of digital cartographic detail-oriented information (structure and character of housing development, population living in settlements of population, etc.).

Software tools for evaluating the consequences of destructive earthquakes include the environment, the means of organizing and conducting video conferences and programs for the calculation of the consequences of earthquakes as well as floods, fires and explosions.

At the same time, with the help of information of GIS "Extremum" fire and flood risk in the Russian Federation is predicted with an efficiency of 70 %.

Based on information received from the GIS "Extremum", manned round the clock, the Russian government knows about this event one of the first in the world (if not the first) to take action.

GIS "Extremum" is not only of scientific and practical importance. GIS "Extremum" formed the basis of established computer training program "GEO-extremum" used for the integrated teaching of Russian in schools a number of educational subjects in schools of Russia (basic life safety, geography, economics, physics, ecology, computer science, and others), thereby increasing level students' preparedness to for action in emergency situations reducing their risk of death from damaging factors of emergencies.

GIS "Extremum" is recognized the only system of forecasting earthquakes and of the consequences of it is to recommend setting it on duty around the globe.

6. Detection of forest fires using space imagery data

Identification and mapping of forest fires using data from satellite imagery is used for rapid detection of forest fires.

The technique allows to:

- identify areas of forest fires in the space pictures;
- determine the location of fires (Gridding);
- determine the nearest object of infrastructure that can suffer of fire.

The technique can be used by federal executive bodies, executive bodies of subjects of the Russian Federation and the Regional Centre for Civil Defense and Emergencies Russian Ministry of Emergency Situations to detect forest fires at the territorial, regional and federal levels.

The real scale of forest fires in Russia and the size of damage caused by fire has not yet been established. Regular monitoring of forest fires are conducted only in the zone of active protection of forests, covering two thirds of the total area of forest fund.

Satellite survey makes it possible to register fires both in protected and unprotected areas operatively and has a relatively low cost compared to aerial surveying. The data on the state of forests, obtained from space-based information have a higher reliability than the data obtained from the field due to incompleteness of the information.

The input data for the calculation are: space images within 1.1 km, which provide detection of fires and their location (geographical coordinates).

Identification and mapping of forest fires using data from space pictures can be used to detect forest fires at regional and global levels. This method may be used to solve problems of forest protection, selecting the optimal number of techniques for extinguishing the fires, etc.

7. Identification of flood situation according to imagery

Identification and mapping of flood situation according to satellite imagery is used to identify areas of water logging. The method allows to:

- carry out detection of floods on the rivers;
- to monitor the flood situation;
- identify areas of flooding and water logging discovery of location of settlements in flood zone;
- identify areas occupied only by floodwater (excluding riverbed).

The technique can be used by federal executive bodies, executive bodies of subjects of the Russian Federation and the Regional Centre for Civil Defense and Emergencies Russian Ministry to disclose the flood situation at the territorial, regional and federal levels.

To minimize human losses and reduce property damage from floods and floods require immediate assessment of the situation is needed. Therefore, the use of traditional means of observation (ground and aerial data) does not meet modern requirements to ensure the safety of the population in large areas, such as Russia. Similar problems can be solved by complex methods based on space monitoring areas.

Space monitoring of floods requires prompt detection of the spilling rivers, defection of a flood zones and monitoring the flood situation in flooded and waterlogged areas. Thus, efficiency is a key requirement for work methods.

Digital image processing is necessary for obtaining more rapid and objective results as this is the only way (as unlike to visual interpretation techniques) to calculate the flooded areas and settlements, communications, and other objects in the flood zone.

The aim of the method is rapid detection of early flood of waters, monitoring the flood situation, identifying flood zones and water logging areas, the detection of settlements, in the flood zone, the detection of areas occupied by only floodwater (excluding the riverbed), according to space pictures.

To achieve the goal to it is necessary to solve the following tasks:

1. To detect high water in the rivers:

- to discover the rivers, where the flooding began;
- visually to identify the area of the spill, put them on a picture or a map, to show settlements in the flood zone.

2. Monitoring of the flood situation:

- to process digital image of high or medium location, which map areas, located in flood zone;
- to recognize the water surface;
- to discover settlements, communications and often objects in the flood zone more accurately according to the space image;
- to map flood zones and water logging zones according to vectors.

3. Detection of areas and occupied only by floodwater:

- a joint digital processing of satellite images of high or medium location of two dates filming – during the flood and during the normal state of the river;
- detect only the surface of flood water overflow;
- calculate the area of the flood water.

8. Identification of oil spills according to satellite imagery

Detection and mapping of oil spills according to satellite imagery is used to identify areas of oil or oil products on spilled soil and water surfaces. The method allows to:

- carry out detection of oil spills;
- on the soil and the water surface;
- to monitor the development of an emergency (change in the area of contamination, etc.);
- to detect the zones of oil spill and their areas;
- to detect settlements, communication and other;
- infrastructure objects, trapped in the spill area.

The method can be used by federal executive bodies, executive bodies of subjects of the Russian Federation and the Regional Centre for Civil Defense and Emergencies Russian Emergencies Ministry to detect oil spills and their size at the territorial, regional and federal levels.

Spills of oil and oil products were and are emergencies, bringing great damage to nature and the economies of many countries. Strategical response and taking emergency measures to prevent the spread of contamination will significantly reduce the damage caused by oil spills.

The main reasons for such emergency situations are accidents on pipelines, oil wells, oil terminals, natural emissions of oil, as well as the accident at the tanker fleet, flushing their oil tanker vessels.

The results of the accident are the contamination of the area and the death of a huge number of flora and fauna. Wherein cleaning of the polluted by nature itself without inference of man will last for decades.

For effective elimination of the consequences of oil spills complex data are needed. One of the most important components of this kind of data are both the area of pollution as a result of oil spills on the water surface, and its configuration in case of a spill on the ground. These parameters are needed to plan the emergency response. Knowledge of the area of pollution makes possible to estimate the costs of collecting of the spilled oil, the rescue of flora and fauna in the contaminated area, the restoration (if possible) of polluted soil or water cleaning, etc. In a word the total area of contamination is a necessary criterion to evaluate the damage of emergency and the development of measures to eliminate its consequences.

9. Rapid assessment of damage from forest fires using data taken from space

The real extent of forest fires in Russia and the size of damage caused by fire have not yet been established. Regular monitoring of forest fires are conducted only in the zone of active protection of forests, covering two thirds of the total area of forest fund. It is believed that the area covered by the forest fire in the whole of Russia is about 2.0 million hectares per year. To improve the monitoring of forest conditions, getting more complete and accurate information about the losses of forest vegetation it is necessary to use satellite imagery data.

Space pictures make it possible to register the fires and burnt forest areas both on the developed and non-protected areas on-line and has a relatively low cost compared with air photography. Data on the state of forests, obtained from space information have a higher reliability than the data obtained from the field due to the incompleteness of its information. Therefore the value of the damage from the loss of the stand, calculated using satellite imagery is more reliable than that obtained by any other means.

The aim of the method is to obtain an urgent evaluation of damage from the loss of stand due to forest fires in both during and at the end of the fire season.

To achieve the goal it is necessary to solve the following the following problems:

- to identify forest burning space pictures;
- to determine the location of forest smell burning (coordinate gridding);
- to determine the areas of burned forests in the current year;
- assess the damage in physical indicators (Rubles).

Nowadays a great amount of information made by the Earth satellites can be used to assess the damage caused by forest fires. In particular, space images make it possible to obtain data on the coordinates of forest, burnt forest its area and type.

Algorithm of detection of the damage caused by forest fires consists of performing the following steps:

- locating forest burning according to space data;
- identifying of the contours of forest burning on the space images of the middle and high location;
- digital processing of satellite images to identify the circuits of forest burning;
- detection of geographical coordinates;
- counting the burned areas of the forest;
- characterization of the burned forest;
- determination of burnt wood;
- calculation of damage assessment in physical indicators;
- access the accuracy of methods of determination.

Flooding is a terrible and insidious damage and threaten almost three-quarters of the Earth's surface.

The main reasons are the intense rains, melting snow, wind, tides and surges at the mouths of rivers, ice jams, dam and dams. On the territory of Russia are the most devastating floods and the frequency of (35 % of the total frequency of occurrence of dangerous events) natural elements. The threat of flooding exists in Russia for more than 40 cities and thousands of other settlements. The total area of wetlands, periodically flooded by river and lake water is about 500 thousand square meters. Huge material damage is caused to farmland as a result of heavy rains, which washed away when, flooded, and as a result, dying crops.

Traditional methods of collecting information on the areas of crops, the victims of the floods do not meet modern requirements, as gathering the necessary information only ground-based data takes weeks and sometimes months. Efficient delivery of the required information can only be provided using satellite imagery data that allow you to get the necessary information within 1-3 days. Of great importance in the preparation of damage assessment of loss of crops by floods is the objectivity of this estimate, since it is known that local governments tend to either overstate this estimate or underestimate depending on the situation. Therefore, an objective assessment of the damage can only be obtained from independent sources, namely, according to satellite imagery. In addition, only the image space with a large coverage area, to provide a complete overview of the flood-affected areas, and thus obtain a more accurate assessment of the damage.

Digital image processing is necessary not only for the more rapid and objective the results, but also it is the only way (as opposed to visual interpretation techniques) to highlight areas of agricultural crops in the same state, and to provide a quantitative assessment of their condition, as well as highlight areas with the same degree of flooding and provide quantitative assessment of flooding.

The aim of the technique is getting rapid assessment of damage to agricultural land floods.

To achieve the goal to achieve the following objectives:

identify areas in satellite images, subjected to the action of floods;

to conduct a joint analysis of satellite images taken before and after the floods and to highlight areas in which there have been changes in the state of agricultural facilities;

assess the condition of crops to the flood and after the flood, to calculate the area of dead farm cultures;

assess the damage in physical terms.

Algorithm for identifying damage to crops floods is to perform the following steps:

identification of spatial data areas affected by floods;

selection of satellite images from the archive to the same territory, but received 1-2 weeks prior to the flood.

Digital processing of satellite images to identify the condition of crops to the flood, which died in the flood, calculate their areas.

10. Aerial reconnaissance and control of emergencies

Aerial reconnaissance and control of emergency Aircrafts are designed to provide first responders conduct search and rescue, transportation of people and goods, as a means of fire.

The IL-62 and Yak-42 is also used as a command post.

The functions of intelligence, the more monitoring on aviation Emergencies are imposed and the concept is not provided.

The aim of reducing the risk of emergency has three main stages: prevention of possible emergencies, intelligence disaster occurred and the elimination of its consequences. According to the monitoring PC also have three main components: monitoring of potentially dangerous objects and territories, intelligence and emergency control its development and elimination.

Spent the least at the present time and, accordingly, the most interesting is the problem of obtaining accurate and generalized information about the development of emergency in order to determine the optimal strategy and the adoption of specific management decisions on its localization and liquidation.

Carrier airborne surveillance emergencies can be helicopter capable hover over an object of observation.

The advantages of airships, providing priority in the monitoring of man-made emergencies, include the following:

- a very large load capacity and range of non-stop flights;
- achieved higher reliability and security than airplanes and helicopters;
- very long airship can stay aloft;
- the airship is not required runway (but requires mooring mast) – in fact, he may not land, but simply "hang" over the earth (which, incidentally, is only feasible when there is no wind).

The disadvantages include:

- the complexity of the landing;
- very large size of the required hangar/slipways, the complexity of storage and maintenance.

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