Use of the space segment of remote sensing for monitoring natural and anthropogenic emergencies in southern Russia

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Abstract. The article is devoted to the problem of remote sensing of the Earth. The article analyzes prospects for using the space segment of remote sensing for monitoring emergency situations of natural and man-made character in southern Russia (using the example of the Republic of Kalmykia) to predict and control emergency situations and eliminate their consequences. The use of a space monitoring system for identifying landscape fires in arid territories was suggested.

1. Introduction
The spatial aspect of information about emergencies is crucial. It is always important to know the nature, size and location of threats which can affect people in the vicinity, industries and the environment.

2. The fight against emergencies has much in common with military actions
There is also an enemy of natural or man-made origin. There is a need to protect the population, plan operations and allocate human and technical resources. Emergency management has a shorter history than military affairs due to the fact that people did not recognize the importance of systematic work with emergencies. The scale of man-made disasters forced people to consider them as enemies, aggressive states in the neighborhood. Accordingly, the role of space remote sensing in dealing with emergency situations is growing [1, 2].

When controlling emergency situations, GIS created on the basis of space remote sensing play an important role. Emergency situations threaten people throughout the national territory. There are floods, mudflows and avalanches, hazardous production. In order to predict and control emergency situations and eliminate their consequences, it is necessary to know local features [3]. Emergency situations sometimes develop even more rapidly than military operations. Computer technologies are needed to work with spatial information.

The main task of the space monitoring system used for emergency situations is to fight against large-scale forest, steppe, peat and oil fires. The reason for its creation is increased degradation of the natural environment and intensification of natural processes. One of the reasons for the aggravation of this situation is climate warming [4] accompanied by a sharp temperature instability, an increase in the number and strength of hurricanes and other emergency situations caused by natural phenomena. Natural emergencies develop rapidly. Their scales grow nonlinearly in time.

Therefore, the effectiveness of fight against emergencies and their consequences depends on efficiency of rescue operations and compliance of operation plans with the actual state of the object or...
territory.

3. Problem statement
The start time of rescue operations depends on how quickly the emergency will be detected. In the vast and sparsely populated territories of Russia, operational detection can be ensured by means of aviation patrols or spatial monitoring.

The Air forest protection service has shown that monitoring of Kalmykia can be carried out from space. For example, the scale of fires and the extent of damage are not comforting. Regular observations of landscape fires are carried out only in zones of active protection of territories (two thirds of the total area) [5]. In the northern and eastern districts of Kalmykia (one third of arid territories), firefighting and fire accounting measures are not implemented. In the zone of active protection of arid territories, 500–1000 landscape fires are recorded annually on the area of 0.5–2.1 thousand hectares. This circumstance and large unprotected territories indicate a low level of fire protection of arid territories. Satellite imagery [6] allows for recording fires in protected and non-protected areas in operational and semi-operational modes. It is less expensive than aerial surveys. The space data on the state of arid territories are accurate. The method for detecting landscape fires is based on the use of space images and interpretation of images containing landscape fires in arid territories of Kalmykia. The geographical reference of the foci of combustion is calculated automatically from the orbital data of the corresponding Earth remote sensing satellites.

The results are displayed on the vector GIS map. If necessary, the vector map can be replaced by a raster topographic one [7].

4. Materials and methods
Studies have shown that the problem can be partially solved by using the available space information (CI) from the spacecraft NOAA (USA) [8, 9], as well as the resource satellite of the Resource Ministry of Natural Resources [10]. However, high efficiency of obtaining high-resolution data is impossible to achieve since the space monitoring system was initially focused on information from the Meteor and NOAA (USA) and the resource spacecraft “Resource” created for other purposes.

The All-Russian Research Institute for Civil Defense and Emergencies (VNII GOES) (Federal Center for Science and High Technologies) of the Emergencies Ministry of Russia has developed and improved the space monitoring system. However, they are dealing with the ground component of the system.

Methods have been developed for the thematic processing of space information to identify fire and flood conditions, air and water pollution, oil spills. Methods have been developed for rapid assessment of consequences of emergency situations for agriculture and forestry, damage caused by earthquakes. The method was adopted to the new spacecraft. However, to resolve contradictions between the temporal and spatial resolution of remote sensing data within the existing system is impossible.

Most of the work was performed by the laboratory which receives and processes space information (Elista). The laboratory can receive and process high-quality space images from all free access spacecrafts.

The most characteristic (priority) tasks of the system and requirements for monitoring information are summarized in Table 1.

5. Conclusion
The functions of the spacecraft for monitoring natural and man-made emergencies by means of low resolution make it possible to solve the following tasks aimed at reducing risks and consequences of emergency situations:
- monitoring of occurrence and development of forest, peat and steppe fires;
- monitoring of pollution of water areas and earth surfaces with oil products;
- monitoring of territories of canal and reservoir infiltration;
- monitoring of occurrence and development of flooding;
- monitoring of ecologically unfavorable territories that are on the verge of escalation into emergencies;
- monitoring of the onset of droughts and dynamics of their development;
- assessment of the scale of natural emergencies;
- monitoring of areas exposed to mudflow and landslide hazards.

Table 1. Information requirements for solving monitoring priorities

| Priority problems, tasks                      | Information Requirements |
|----------------------------------------------|--------------------------|
| | Update frequency (t) | Update responsiveness (t) | Resolution (view / IR) |
| Identification of fires                     | 24 | 0.25–2 | 10–20 | 5–40 | 0.1–0.5 |
| destruction                                 | 24 | 0.25–2 | 10    | 5–40 | 0.1–0.5 |
| flooding                                    | 12 | 0.25–1 | 30–100| 5–40 | 0.1–0.5 |
| Assessment of the degree of damage caused by accidents and disasters | 3–6 | 1–3 | 1–2 | 5–40 | 0.1–0.5 |
| Determination of the aircraft crash site    | 3–6 | 1–2 | 1–2 | 5–40 | 0.1–0.5 |
| Determination of severity of accidents and the number of vehicles involved in the accident | 6–12 | 1–3 | 10–20 | 2–6 | 0.1–0.5 |
| Determination of the size of a pipeline accident zone | 6–12 | 1–3 | 2–10 | 5–40 | 0.1–0.5 |
| Pipeline Condition Monitoring               | 15 | 0.5–1 | 12    | 2–6  | 0.1–0.2 |

With regard to the identification of foci of landscape fires, the proposed method can be used in southern Russia. The results can be used to solve fire protection problems when firefighting equipment, etc. The technology for assessing landscape fire damage in arid territories of Kalmykia saved 3–5% of the republic’s budget.

It is necessary to expand the structure of the space monitoring system and include the atmospheric component as an additional element for remote sensing of the earth.

The Ministry of Emergency Situations uses systems created not on its order; when expanding the structure of the system, an order to create new media will be required. This requires investment.

At the present stage of development of SCM emergencies, its effectiveness was assessed only by the completeness and quality of the information received rather than by final results – prevented damage. The monitoring systems of other departments were assessed in accordance with the needs of these departments. To evaluate the options for the structure and composition of the aerospace monitoring system, it is necessary to create an apparatus for assessing their effectiveness. The creation of this device is a research issue.

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