

# FUNCTIONING OF FIRE AND FLOOD SPACE MONITORING SYSTEM IN KAZAKHSTAN

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## ABSTRACT:

The brief description of system of space monitoring of extreme situations in Kazakhstan, consisting of system of space monitoring of fires and system of space monitoring of flooding is given. Results of work of this system in several areas of Kazakhstan in an operational mode that includes operative mapping of passages of freshet waters and flooding, operative definition of the centers of fires and an estimation of the areas, which have suffered from fires, are described. The estimation of work of system of space monitoring of extreme situations is given, and features of its work last years are marked. Possible ways of its further development are outlined.

## 1. INTRODUCTION

Among natural and technogenic extreme situations, characteristic for Kazakhstan steppe fires have the greatest constancy. They annually cover significant territories. Last years the first fires begin in March, and the last come to an end at the beginning of November. They represent the big danger in the drought periods, which are characteristic for significant territory of republic, is especial in second half of summer, and in first half of September.

The significant part of the population of Kazakhstan lives on the banks of the rivers; therefore for some regions of republic constantly there is a potential danger of flooding. Thus danger can represent not only such greater rivers as Irtysh, Ural, Tobol, Ishim, Sir-Daria, but also the small rivers in the sizes. During spring thawing snow the volume of flow of these rivers can increase sometimes more than in 1000 times sharply. Last years in the region of Syr-Daria river there was very interesting a situation. On the one hand we observe the big shortage of water in Aral Sea, and with another – during the winter-spring period in middle stream of Syr-Daria is observed its overabundance.

Therefore since 2001 Space Research Institute of Kazakhstan (SRI) began actively to develop technologies of space monitoring of extreme situation which should provide the operative observation of republic territory, detection and mapping the real and potential centres of occurrence extreme situations of natural and technogenic character, the forecast of their development, a preliminary estimation of scales of disasters and them possible consequences.

Almost at once was started to carry out operative space monitoring of fires (since 2002) and high waters and flood (since 2003) for emergency departments of several regions of Kazakhstan. Now SRI carries out space monitoring in an operational mode in West-Kazakhstan and Karaganda (fires and high waters), East Kazakhstan and Aktyubinsk (fires), Kyzyl-Orda (high waters and control of filling Chardara reservoir) areas. With several areas negotiations are carried on for the beginning of works since 2008.

Principles of construction of systems of space monitoring of flooding and fires in Kazakhstan are stated in (Spivak L.F. et al, 2003-2005). In given paper we shall briefly describe technologies of work of these systems, and the basic attention we shall give practical application of these systems in operative work of Kazakhstan regional agencies of emergency situations.

## 2. SPACE MONITORING SYSTEM OF EXTREME SITUATIONS IN KAZAKHSTAN

Functional basis of work of space monitoring system of extreme situations in an operative mode are the SRI reception stations of remote sensing data located in Astana and Almaty. They carry out regular receiving of data from NOAA, EOS Terra and Aqua, Indian satellites IRS and from Canadian radar satellite RADARSAT-1. Zones of radio visibility of receiving stations cover a significant part of Russia and Asian region.

This space images are used for the decision of various applied tasks of extreme situations. The base complex of technologies includes technologies for the decision of the following applied tasks (very important for Kazakhstan): flood space monitoring and fire space monitoring. These technologies have already worked in a real time mode and they are described lower.

For an estimation of potential danger of extreme situations special GIS is used. It contains the information on settlements, a road and railway network, lines of the electric system, oil-and gas pipeline, large forests, especially important objects, etc. Combining these GIS layers and zones of flooding it is possible to define their location concerning the nearest settlements and especially important objects, and distance up to them.

Final maps of extreme situations zones are sending by e-mail in regional emergence agencies.

## 2.1 Operating flood space monitoring.

**2.1.1 Brief description of technology.** The technology of flood space monitoring is based on daily EOS-AM Terra MODIS images in infra-red band of river basin, including the parts located in the neighbor countries. It includes the decision a number of tasks. Main from them is mapping of flooding zones during passage of freshet waters and flooding. In previous and the initial stage of passage of a high water also we carry out mapping of destruction of a snow cover in territory of region, and recently mapping of destruction of an ice cover on large reservoirs. In view of worsening of flood situation in the middle stream of Syr-Daria in last years during the winter spring period the space monitoring of dynamics of filling of Chardara reservoir is allocated in a special task. Development of flood situation in this region depends from Chardara reservoir situation in many respects.

The special programs are devised for automation of process of mapping of snow, ice and water covers, which allow to carry out in the automated mode of procedure of transformation to a demanded projection, cutting of the necessary territory, calculation of various indexes (NDSI, NDVI, VI) and classification of images in MODIS data.

By results of space monitoring of destruction of a snow cover are the special maps indicative a current condition of a snow cover, dynamics and calendar terms of destruction a snow cover. This information is very interesting for the forecast of a freshet situation. It allows estimating terms of the beginning of thawing of a snow cover (early, normal, late), and also its rate (fast, normal, slow thawing).

Operating mapping of flooding zones during passage of floodwater is based on daily data Terra MODIS of territories for which there is a high risk of flooding.. In results on a basis of these images after thematic processing is created masks of flood areas. Zones of flooding are defined as a difference of water surfaces in normal conditions and during a high water. For exception of a cloudy cover and clouds shadows the cloud mask is used. For exception of wet soil the vegetation index NDVI is used. The operating situation is compared to maps for the previous day and the most dangerous territories with high dynamics of developing of increase water are identified (Figure 1).

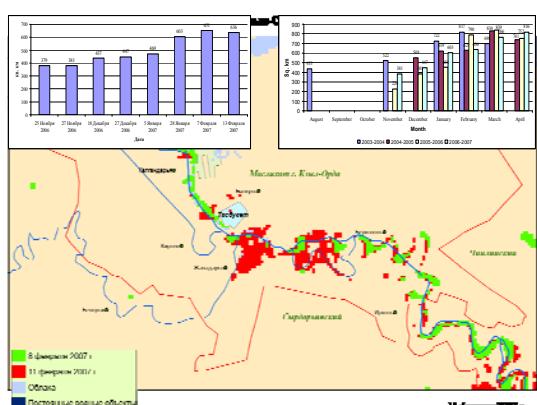


Figure 1. Operating mapping of flooding zones near Kzyl-Orda (green - 8 February, red - 11 February 2003) and diagrams of dynamic of filling of Chardara reservoir water surface in 2007 (left) and in 2003-2007 (right).

At space monitoring of dynamics of filling of water surface of Chardara reservoir is solved two primary tasks. The first consists in tracking a current situation (Figure 1, left diagram), and the second in comparison of this situation with dynamics of development of a situation for the last years (Figure 1, right diagram).

**2.1.2 Estimation of flood risk zones.** In process of accumulation of the information time series remote sensing data (seasonal and long-term) are formed. They allow characterizing of development of emergency situations in time during a current season and in comparison with the previous seasons. Also on the basis of the analysis of all long-term series of remote sensing data we can estimate risks of emergency situations (fires and high waters) on various territories. The territory is ranged on a degree of risk of flooding by freshet waters and floodwater. For this purpose available long-term series remote sensing data is analysed and frequency of hit of territory in zones of flooding is defined (Figure 2).

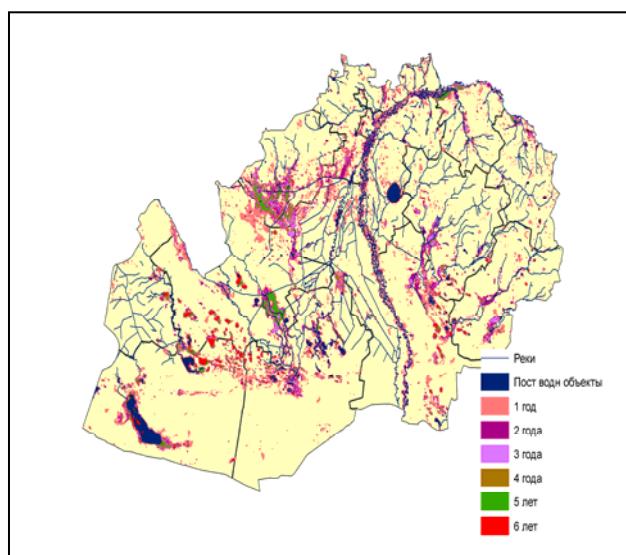


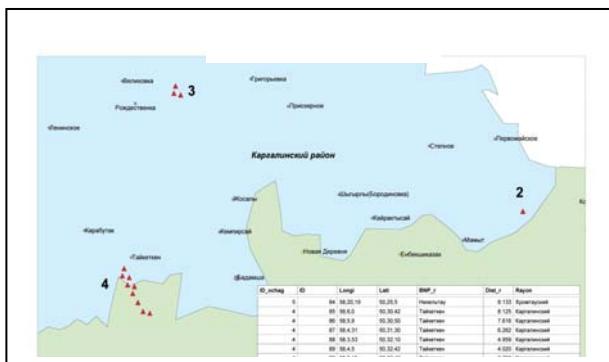
Figure 2. Estimation of flood risk zones for West-Kazakhstan oblast for 2001-2006.

Such information is very useful at planning economic activities. Besides they are useful at planning protective actions from repeating emergency situations and to the analysis of efficiency of the measures accepted by local authorities on struggle against high waters. Special meaning for flood risk estimation in the middle stream of Syr-Daria have space monitoring seasonal and long-term dynamic of filling Chardara reservoir in winter-spring period. Not all zones of flooding present danger to a life and the human economic activities. The some of them can be even useful. For example, places of gathering of freshet waters which in the further are used by the nature and the man.

**2.1.3 Modeling.** Recently emergency departments show interest to modeling of various extreme situations on water objects. There are modeling of zones of flooding as a result of flooding, high waters or break of dams; modeling of deformations of a river-bed; modeling of protective constructions. The decisions of these tasks are based on the software packages (BOR, RIVER, FLOOD) developed in Institute of Power Constructions (Russia) by Belikov V.V.

## 2.2 Operating fire space monitoring.

**2.2.1 Brief description of technology.** The technology of fire space monitoring is based NOAA AVHRR и EOS-AM terra MODIS data. Work of this technology in an operational mode includes transfer of operative data two times in day (maps of fire centers, tables with coordinates, nearest settlement, its distance and azimuth) in emergency departments in the morning (before 9 o'clock local time) by results of processing night images NOAA AVHRR, in the day (not later as 40 minutes after receiving) by results of processing daily data MODIS (Figure 3).



It is possible carry out zoning on the various periods of year. It can be all period of fixing of fires (May–October), and it can be characteristic time intervals. So for agricultural areas the additional information for the analysis can be received, considering three periods: before sowing, from sowing up to harvest, after harvest.

Results of zoning of territory on a degree of risk of emergency situations (fire and flood) can be useful at planning economic activities: at construction of the industrial enterprises, the gas-main pipeline, lines of electric transfer, etc. They can be used and for the decision of some other problems. So they allow defining farms which very often-burning stubble-fields, to this traditional way of increase of fertility of fields forbidden by the law.

### 3. FEATURES OF WORK OF SPACE MONITORING SYSTEM OF EXTREME SITUATIONS IN KAZAKHSTAN IN LAST YEARS

#### 3.1 Features of operating flood space monitoring.

For all observable regions, except for Syr-Daria, weak floods are observed last years. On the middle current Syr-Daria every year there are critical situations. In 2007 the critical situation has arisen in the end of the first decade of February and has led to flooding of the populated territories in area of Kzyl-Orda (Figure 1). For finding-out of the reasons of it we have given to regional authorities the information about the dynamics of filling of Chardara reservoir during this period (Figure 1). From Figure 1 it is visible, that, first, at this time there was a discharge of water from Chardara reservoir (left diagram), and, secondly, it has been filled on two third of maximal size that was fixed during many years supervision (right diagram). Whether there was it the reason of a critical situation, we cannot approve. The special commission found out this reason.

Flooding in the third decade of February 2008 had much more serious consequences both on number of flood victims, and on the destroyed houses. The reason of it was not Syr-Daria. The reasons were abnormal for this period storm rains and abnormal cold winter which has transformed the ground into an ice trench. Settlements which never flooding and were not ready to such situation have as a result suffered. Actually the high water on Syr-Daria has passed without special problems. Fix a critical situation during the peak period with help to MODIS data we could not owing to overcast, and use for these purposes data RADARSAT can't help in solving of this problem by virtue of some the objective and subjective reasons in particular owing to impossibility of the operative order.

It is necessary to note, that high overcast is a vital problem for carrying out of operative space monitoring of flooding last years, especially in the West Kazakhstan. So in 2005 for 45 days of development of a high water it was possible to receive 16 space images of territories of West Kazakhstan, suitable for mapping of flooding zones. For separate areas this value is even less. For example, for area of Uralsk of such images were only 9. In 2007 during development of a high water it was not possible to receive any space images this territory, suitable for mapping of flooding zones. In 2008 the situation was better, only the high water was not.

#### 3.2 Features of operating fire space monitoring.

In Figure 6 dynamics of the areas, which have suffered from fires, for three oblasts of Kazakhstan for all time of supervision is presented. It is visible, that it was the most least year on intensity of fires for Aktyubinsk (from 5 years) and Karaganda (from 3 years) oblasts and one of the least (second of 7 years) for West Kazakhstan. footnote on the same page.

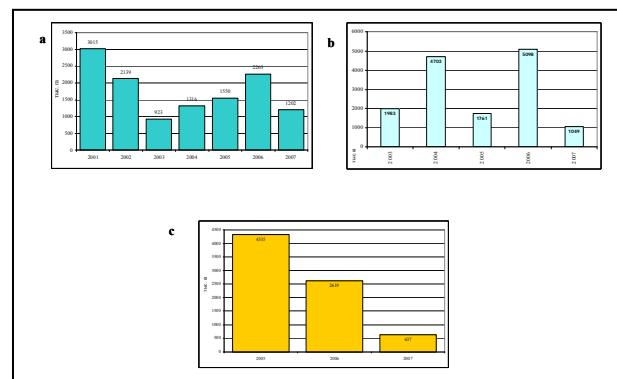


Figure 6. Dynamic of summary burnt areas in West-Kazakhstan oblast for 2001-2007 (a), Aktyubinsk oblast for 2003-2007 (b) and Karaganda oblast for 2005-2007 (c)

However characteristic feature of 2007 for West Kazakhstan is the long-term decade maximum of size of the areas, which have suffered from fires, in the third decade of July (Figure 7).

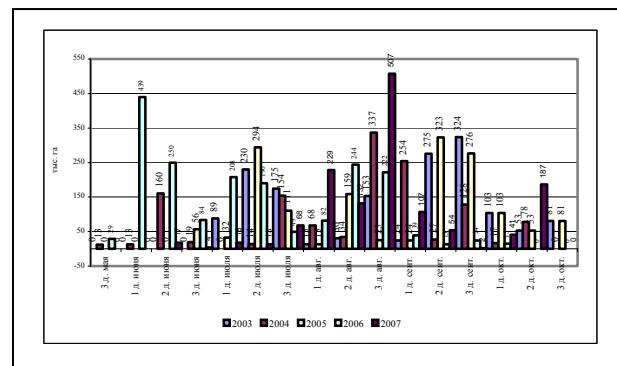


Figure 7. Decade dynamic of summary burnt areas in West-Kazakhstan oblast for 2003-2007.

The percent of the stationary centers resulting from thermal emissions of industrial targets, fixed by MODIS data in 2006 and 2007 is of interest. It is practically identical these two years; not looking that intensity of fires in 2006 was in 2 times above. It is caused by sharp decrease in number of the fixed stationary centers in the Aktyubinsk oblast. It is also interest we found out dust storms which basic centers are located on a territory of the Karaganda oblast that burnt out in the beginning of June 2005 (Figure 8).

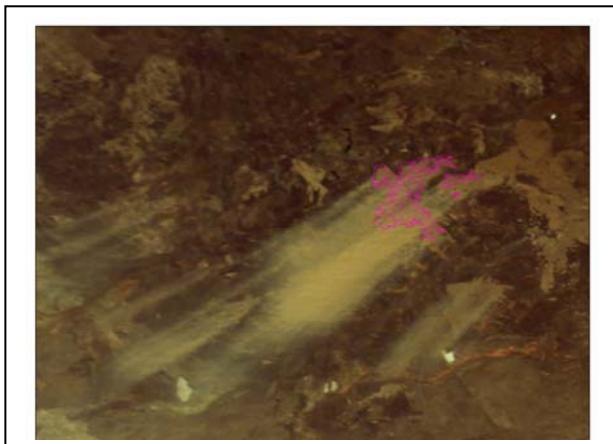


Figure 8. Dusty storm in territory of the Karaganda oblast fixed by Terra MODIS for August, 11th, 2005 with the indication burnt out in the beginning of June, 2005 areas (are noted by pink color)

#### 4. MAIN RESULTS AND WAYS OF DEVELOPMENT OF SPACE MONITORING OF EXTREME SITUATIONS IN KAZAKHSTAN

1. Space monitoring of fires became the effective tool which is actively used by regional and local bodies for carry out of operative measures on liquidation of fires, for finding-out guilty of the fires, caused large damage, and also at an estimation of a situation as a whole at meetings of authority both on regional, and on republican levels. Now regular space monitoring of fires is carrying out for four oblasts of Kazakhstan. In the near future their number will increase.

For more successful performance of the increasing amount of works the opportunity of use in system of fire space monitoring in Kazakhstan (mainly steppe) the automated algorithms of the Russian system of fire space monitoring, focused first of all on forest fires is considered.

2. Use of results of space monitoring of passage of freshet waters and flooding has basically information character. Efficiency of monitoring considerably rises at use of space images of the high resolution. However to wide application of

such images for operative space monitoring high waters and flooding prevent their high cost and complexities of the operative order.

Last years a vital problem for carrying out of operative space monitoring of high waters, especially in the West Kazakhstan, is high overcast during supervision. Use for the decision of this problem of radar data also is limited to their high cost and complexity of the operative order.

By virtue of told, one of mainstreams of development of space monitoring passage of freshet waters and flooding is search of optimum variants of use of data of the high resolution, including radar. Other direction of development of technologies of space monitoring of water objects in interests of regional emergency departments is use remote sensing data at modeling possible extreme situations (break of dams, washout of coast, etc.).

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