REMOTE SENSING FOR OPERATIONAL APPLICATIONS IN THE ENVIRONMENT OF THE MEGACITIES

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ABSTRACT

In the face of an nature and tecnogenious disasters the science community must provide Local Authorities with a methodology for the orientation of local policies, strategies, planning and interventions in the environmental field, giving way at the same time to an information tool to support the processes of analysis and evaluation aimed at the achievement of environmental aspects of urban planning. The focus of our paper is on the importance of assuring the ecomanagement in the area governed by the Municipal Administration that the satellite remote sensing techniques and new information technologies read the levels for the development environmental information system. We should work out common goal for reducing urbanism effects and ecological problems of megacities.

The Space Research Institute developed the system for megacity environmental monitoring based on space data from NOAA satellite series and from Russian RESURS satellites. Paper discussed the use of Remote Sensing, the access to satellite data and global communications technologies for Moscow Environmental Management. Currently space data after image processing are used by us for following purposes: detection of heat map of town and revealing of thermal anomalous, revealing of smoke traces from industrial plants; determination of type of cloudiness and observation of the dynamics of the atmospheric fronts; detection of strong fires in forest near city; detection and estimates of floods.

1. INTRODUCTION

In this paper we concentrate on the description of space monitoring system embracing the whole Russia. The system consists of the spatial data infrastructure and provides remote access to information resources of the monitoring and high rate transport of remote sensing data. Satellite environmental monitoring is considered as geoinformation distributed system based on Centers of information support, which receive and process space data from US meteorological satellite of the NOAA series and from Russian satellites of RESURS series. The ground station of the Space Research Institute in Moscow covers all the European part of Russia and a significant part of Western Siberia. Similar stations are installed also in Krasnoyarsk, Irkutsk, Vladivostok and other cities of Russia. Centers for receiving of satellite information perform demodulation of digital signals, carry out their processing and prepare the information for computers. Images of the Earth from NOAA satellites contain an information on cloudiness and on the Earth surface in visible and IR-bands, with resolution about 1 km, whereas RESURS satellites provide higher resolution.

Satellite data are used in support to a number of Space Environmental Projects: observation of cloud pattern and the dynamics of the atmospheric fronts; detection of the forest fires; observation of snow cover dynamics and forecast flood danger; estimate of technogenic influences at urban areas. Thus, Centers of information support might be helpful for local authorities in solving environmental problems and can form a basis for Natural Disaster mitigation. Centers of information support for space monitoring are linked by Russian Science Space Internet with Archive of Space Information, developed in frame of the international program PRIRODA-MIR (Armand, 1991). Archive infrastructure presented at Fig.1 (general architecture) possible to import data up to 6 Gb per day and provides interactive free access to Catalog data, as well as fast search and selection of experimental data. Potentials of information system make it prospective for large space projects support for processing, arhivation and distribution of remote sensing data. The arhive is characterized by high interoperability with data stores of NASA and ESA.

2. METEOROLOGICAL SATELLITES

To monitor large cities, it is appropriate to use, first of all, meteorological satellites, both domestic (of the RESURS type) and USA (of the NOAA series). Repetitive monitoring (several times a day) and highly developed meteorological and methodological data processing basis has led to the developing of a satellite subsystem of ecomonitoring of Moscow. The subsystem is capable to detect heat anomalies and industrial discharges (from power plants, large

industrial enterprises, and cooling ponds), to register smoke from factory chimneys and large forest and peat fires in the vicinity of the city (Kravtsov, Kudashev, 1984).

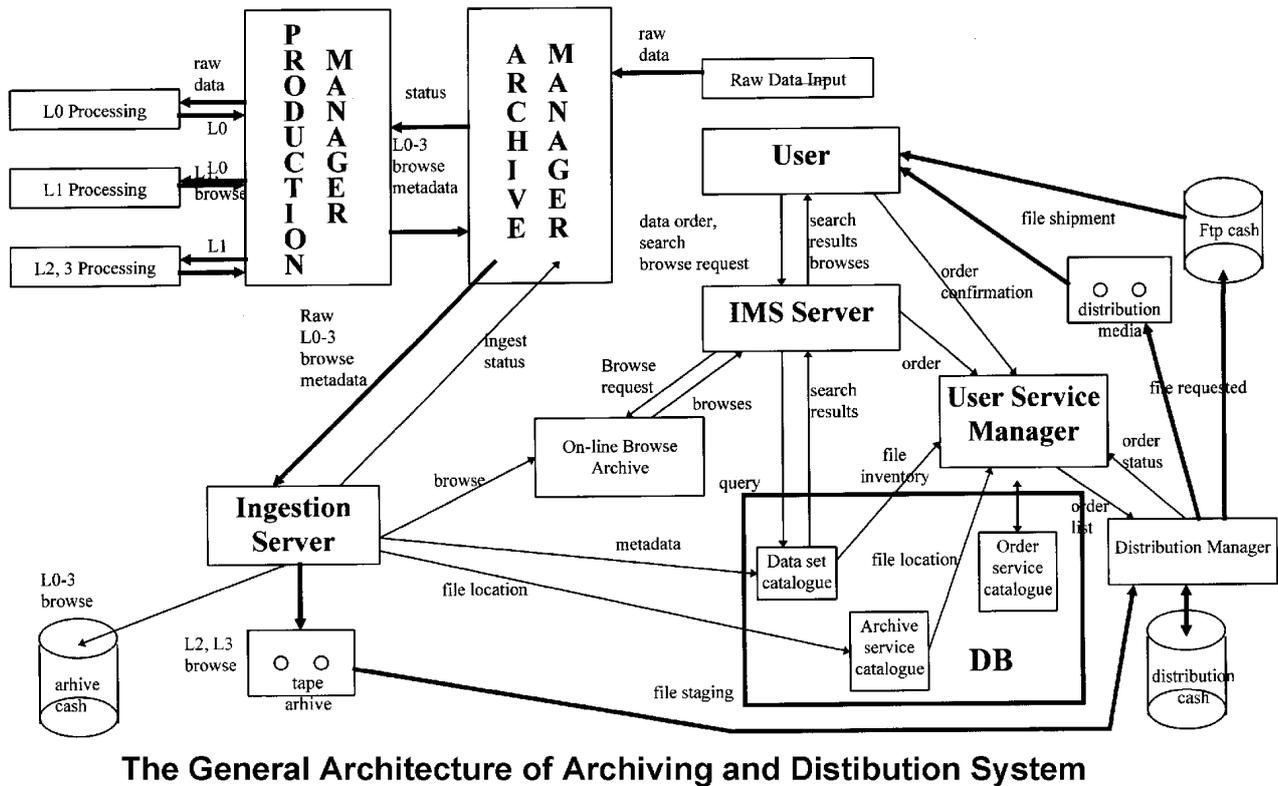## The General Architecture of Archiving and Distibution System

Figure 1.

A calibration is performed aboard RESURS and NOAA satellites with the purpose of farther transformation of combined heat energy registered from the Earth and the atmosphere into brightness temperatures according to certain technique.

3. DETECTION OF HEAT ANOMALIES AND INDUSTRIAL DISCHARGES

Detection of heat anomalies includes:

• classification of regions in images by brightness temperatures in conditions of noise and determination of anomalous sources of thermal radiation in the given image;
• determination of heat anomalies on the basis of time series with due consideration of noise.

Classification of regions in images by brightness temperatures 'and determination of anomalous sources of thermal radiation. Depending on the noise conditions, time of the day and nature and climate situation, different standard techniques revealing heat anomalies are used as well as techniques successfully tested for fire detection. Under no clouding, registration of heat anomalies using the temperature threshold technique is most appropriate. Heat anomaly processing technique is realized in the Fire Detection supplement to the ERDAS Imagine software package (Kravtsov et al., 1998,b, Kravtsov et al., 1999).

Operator sets temperature thresholds in the following intervals: T3p — 310-322K; T34p — 7-15K; T4p — 275-285K. For summertime default settings are T3 = 312K; T34 = 15K; T4 = 276K. Fig.2 displays an example of detection of heat radiation sources corresponding to power plants in the territory of Moscow (December 14, 1997).
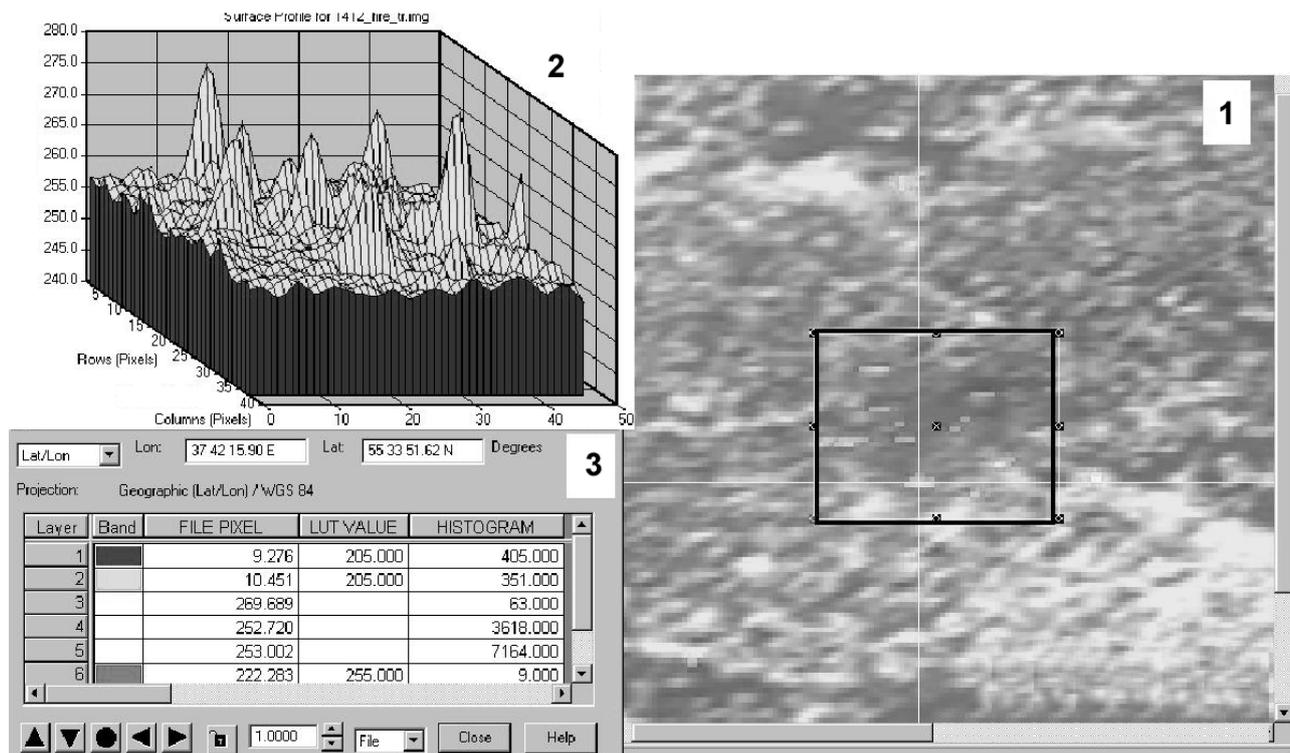
Figure 2. Localization of Moscow power plants. (1) — Image of Moscow obtained on Dec. 14, 1997 by NOAA-12 and processed by Fire Detection; (2) — Surface temperature profile (spectrum channel 3.93 mcm); (3) — coordinates of points and pixel values.
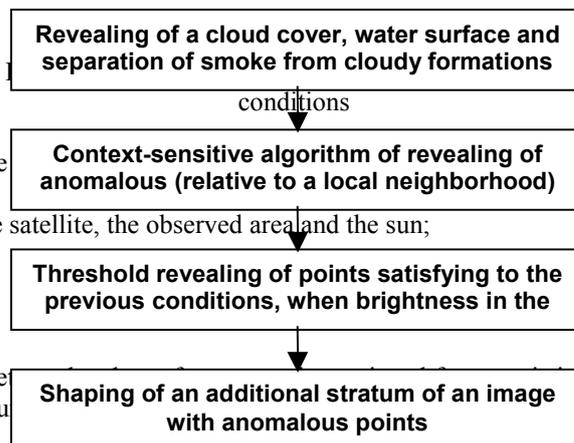
In conditions of ragged clouding and big zenith angle of the sun, "spekles" in channel 3 from clouds, water surfaces and open ground spaces drastically increase probability of false sources. In this case, good results have been obtained for a combined technique used in the ERDAS Imagine software.

The heat anomaly detection scheme for cases of high noise is presented in the following diagram (Fig.3).

Heat anomaly detection based on time series analysis with noise condition taken into account. The following factors have their impact on absolute values of self-radiation temperature

• time of the day, zenith angle of the sun, relative positions of the satellite, the observed area and the sun;
• meteorological conditions (clouds, precipitation, wind);
• the area building and infrastructure development;
• daily changes in population activity.

In order to distinguish between random and regular noise parameters, it is necessary to have additional observations. This task should be performed using data from ground

Revealing of a cloud cover, water surface and separation of smoke from cloudy formations
conditions
Context-sensitive algorithm of revealing of anomalous (relative to a local neighborhood)
Threshold revealing of points satisfying to the previous conditions, when brightness in the
Shaping of an additional stratum of an image with anomalous points

4. SATELLITE MONITORING OF INDUSTRIAL HEAT DISCHARGES

If sizes of heat radiation sources are available, for instance, sizes of power plant chimneys, cooling ponds, buildings of steel productions and like objects, it is possible to obtain absolute temperature values. Since the territory is surveyed by

NOAA satellites several times a day, the monitoring permits not only to detect heat pollution but also to exercise prompt control over the state of industrial objects.

Fig.4 presents an image from NOAA-15 featuring temperature anomalies revealed by the above technique.

Separation of smoke plumes, localization of smoke sources and estimation of plume boundaries within the city territory.

The problem of separation of smoke plumes has much in common with the problem of detection and analysis of heat anomalies. Unfortunately, at present, there are no ways to localize non-heat sources of pollution from the data of satellite optical and thermal channels (close IR and ordinary IR). The solution of the problem requires more subtle analysis techniques such as using wider range of spectral channels, employing special methods of processing and separation of boundaries of non-uniform plume regions and their recognition against the background of natural phenomena, in particular, separation of plumes from clouds. For the moment, a narrower problem can be solved such as the detection of heat plumes and smoke zones produced by localized sources i.e. from sources, which can be identified from data of the 3,5-3,9 □m spectral channel. There are such channels both on RESURS-O (channel 5 MSU-SK) and on NOAA satellites.

The use of multi-channel (optical and thermal) spectral systems as well as combined data from satellites of different series seems promising for the solution of such problem. An example of combination of images from RESURS-O1 (MSU-SK) and NOAA-12 December 14, 1997 satellite over 5 reference points within the territory of Moscow is presented in Fig.5. Sources of heat anomalies appear to completely coincide with sources of smoke plumes.
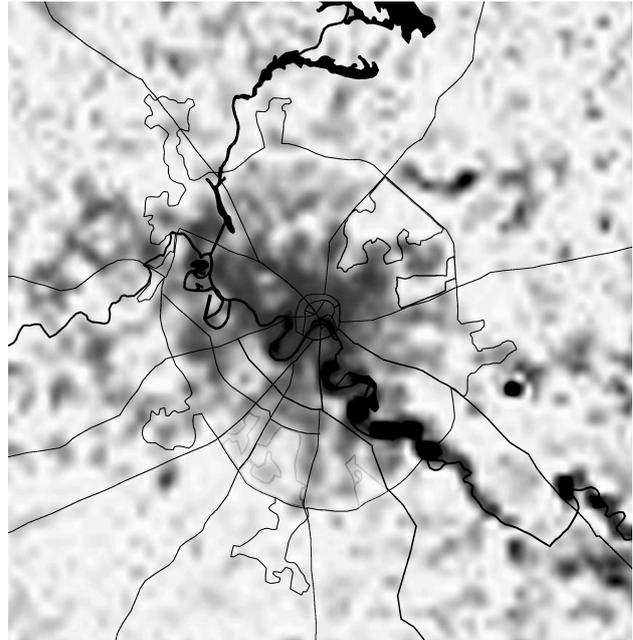

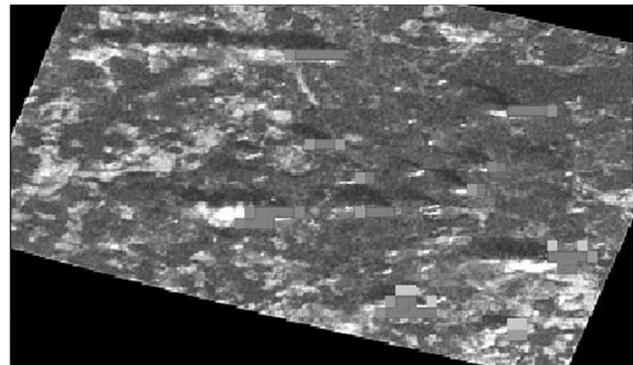Figure 4. Temperature anomalies in Moscow on March 9, 1999, 8:45 MSK, NOAA-15

Figure 5. Combination of sources of heat anomalies and smoke plumes

5. ASSESSMENT OF SITUATION DURING LARGE FOREST, PEAT AN INDUSTRIAL FIRES

Fires occurring in the vicinity of the city can dramatically affect ecological situation due to the input of carbonic acid and products of burning and, in certain cases, they can provoke acute shortage of oxygen. Examples are peat fires near Moscow in 1972 (Fig.7). Smoke plumes extended for 100-200 km.

Software developed for the needs of emergence revealing in Russia makes it possible to detect sources of fire (for peat fires, before the appearance of smoke plumes), to localize them geographically and employ up to date geoinformation systems in decision taking. In cases of large industrial fires within the city, NOAA observations permit to visualize the region polluted by dangerous chemical substances.

Thus, satellite system of environmental monitoring helps to solve a number of certain problems, in particular, to detect heat anomalies and discharges of power plants and large productions as well as to distinguish smoke plumes from power plant chimneys.
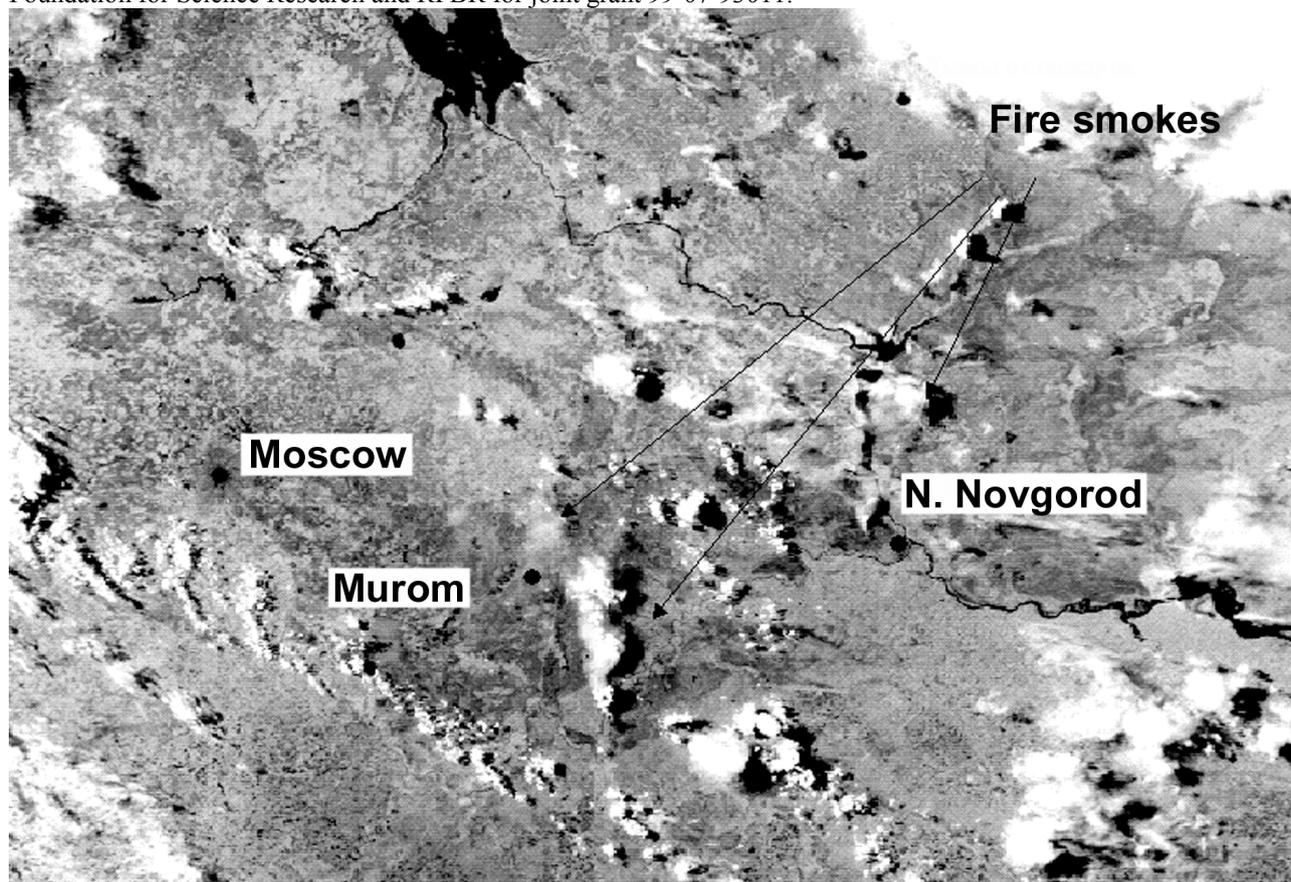
Figure 7. Fires in Central Russia, June 15, 1998

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