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Geophysics

Peculiarities of the Use of Satellite Information for Early Warning of Natural Meteorological and Hydrological Disasters in Georgia

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ABSTRACT. The peculiarities of the use of the information of the satellites for early warning of disasters of meteorological and hydrological origin for the territory of Georgia are investigated. The various characteristics of modern satellites and sensors installed are reviewed. The spheres of their implementation are indicated. The disasters that are typical of Georgia and to which the application of satellite information is effective are considered. *© 2009 Bull. Georg. Natl. Acad. Sci.*

Key words: *satellite, sensor, natural meteorological and hydrological disaster, early warning.*

According to the Strategic Plan of the World Meteorological Organization (WMO), in the operational activities and scientific-research work of its member National Meteorological Hydrological Services (NMHS) the use of information received from Earth Artificial Satellites assumes growing significance. It is preconditioned by the following factors:

- Satellites give a possibility to receive meteorological & hydrological information from regions uncovered by the observations (such as oceans and hardly accessible areas of the land);
- Satellite information is especially appropriate for the quick identification of natural disasters, enabling early warning and mitigation.

It is proved that in Georgia, due to the modern climate change, the frequency of natural disasters has increased 4 times and intensity has grown approximately 2 times over the last ten years.

It is established that 80% of natural disasters, 70% of human casualties and 65% of economic losses fall to the share of meteorological & hydrological hazards [1]. Most natural disasters are characterized by a large spatial spread, which determines the effectiveness of satellite monitoring for their assessment.

The Earth observation satellite system is of two types: polar orbiting and geostationary, namely:

- Polar orbiting satellites transmit information while flying along the orbit, from the area of their visibility. The anisochronism of this information with meteorological stations data creates definite difficulties, but polar orbiting satellites ensure reception of regular, global-scale information for fixed moments of time.
- Geostationary satellites, unlike polar orbiting ones, enable getting information at any moment of time. They move around the equator at 36 000 km elevation, synchronized with the Earth's rotation. They are nearly suspended at a given point, providing observations from 70^0 of the north latitude to 70^0 of the south latitude.

As a rule, the polar orbiting satellites move around on low - approximately several hundred km orbits - and transmit high spatial resolution images in comparison with geostationary ones with different frequency (from several measures per day, up to one measure in some days).

Regardless of the fact that none of the existing satellites and their sensors have been designed exclusively for the monitoring of meteorological & hydrological natural disasters, the accessed information from different, visible, near infrared, infrared, short wave, thermal infrared and short wave bands of electromagnetic scale gives an opportunity of early warning of the mentioned hazards and mitigation of their impact.

Each sensor can collect various types of unique information on the Earth's surface and coastal waters. For example, long wave, infrared range data are used for the assessment of fires; the relatively short wave range information of infrared spectrum can be used to study floods. Microwave sensors are used for monitoring of underlying surface (water, soil, snow).

Due to high accuracy, multi-temporal character, spatial-temporal continuity and complete coverage of affected regions, the satellite information is effectively used for decision-making of the following types:

- Rapidly identifying most impacted regions;
- Quickly assessing the scale of damage and intensity of some natural hazards, such as floods, fires, earthquakes, sea water pollution;
- Calculating the population density in disaster impacted areas; and
- Creating databases and their updating.

Continued development of remote sensing methods promotes the creation of new technologies. Combination of Earth observation satellite systems and GIS methods effectively assists corresponding services for early warning.

For the mitigation of consequences of meteorological & hydrological disasters the use of satellite technologies enables to create and apply databases, conduct: situation monitoring, exact modeling of various complex natural phenomena and on this basis to forecast anticipated developing conditions. The foregoing gives a chance to arrive at necessary conclusions and deliver them to policy-makers in time.

From the great number of Earth artificial satellites reviewed were such satellites and sensors on board, the use of which is advisable for the early warning of disasters that are characteristic of Georgia.

The analysis conducted in the present investigation revealed that these systems are: NOAA, TERRA, AQUA, LANDSAT, SPOT, ERS and RADARSAT.

NOAA satellites are equipped with AVHRR sensor. This sensor is Advanced High Resolution Radiometer, with resolution of 1.1 km and large coverage zone embracing 2 253 km. Scanning Radiometer works in five spectral areas, from visible to thermal infrared. These characteristics allow conducting monitoring of wide territories of the Earth.

TERRA and AQUA satellites are equipped with MODIS sensors. This sensor includes Middle Resolution Spectrometer and Spectrophotometer that observe the Earth surface in 36 various diapasons of spectrum. The resolution of the first two channels is equal to 250 m, resolution of the following five channels is 500 m and the others -100 m. The coverage area of equipment is 2 330 km.

LANDSAT satellite with MSS and TM Sensors on board performs scanning of the Earth's surface at seven spectral channels. The resolution of six of them is 30 m and the resolution of the last one – 120 m. Fig. 1 shows the image of the discharge of the River Chorokhi in the Black Sea from LANDSAT/TM Satellite.

Satellite SPOT is equipped with HRV and XS high spatial resolution sensors. Their characteristics are similar to MSS and TM sensors. These multispectral sensors are scanning Earth surface from visible green to near infrared range, in three spectral channels, but have higher resolution (20 m) than MSS and TM sensors. The coverage area of both sensors is 60 km. These sensors provide the composition of stereo photos and scanning of the same place. The satellite flies around the Earth for 100 min, covering its whole surface in 35 hours.

By successful combination of the middle and high resolution sensors it is possible to observe large areas of the Earth's surface, separation of especially interesting objects and their detailed examination. For example, it is possible to program SPOT sensors for the fire observation purpose.

The above mentioned satellites can not observe the Earth's surface in cloudy situation. The synthetic aperture radars, so-called "SAR systems", are used (RADARSAT and ERS satellites) for the observation in

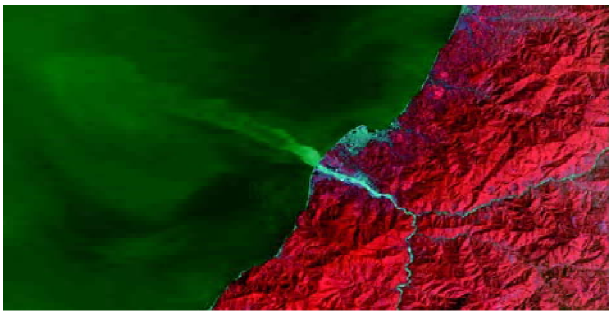

Fig. 1. The Image of the Discharge of the River Chorokhi in the Black Sea from LANDSAT/TM Satellite. July 15, 2002.

case of clouds. They collect data in the microwave area of electromagnetic spectrum under any climatic conditions, cloudy or clear situation and at any time (day or night).

The analyses of the above discussed satellite data show that the use of satellite information for Georgian territory from a wide range of hydrometeorological hazards is most effective for early warning of floods, snow cover, environmental accidents (among them oil spills) and forest fires and the provision of shipping safety on the Black Sea.

Among the hydrometeorological disasters flooding is the most widespread phenomenon. The satellite images are effective for flood management in the following cases:

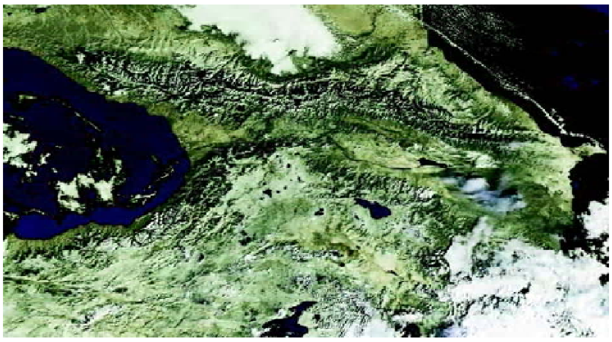

Fig. 2. Snow Cover Image from NOAA/AVHRR Satellite. November 1, 2008.

- detailed mapping that is required for the assessment of hazard maps and for the provision of input for various types of hydrological models;
- Quantitative assessment of the soil state, using satellite information;
- Modeling of large scale flooding for the identification of the areas of high risk and providing early warning.

Remote sensing flood and post-flood peaks images are used for identification of flood prone areas and flood forecasting based on hydrological models [2].

For the flood assessment it is necessary to use the snow cover information. At present Georgian-Finnish joint researches have been realized for the River Rioni basin using satellite information for snow cover assessment and flood forecasting [3].

Snow cover examination is prospective using radar radiometer, which practically does not depend on the atmosphere state and day-night time. Snow cover image from NOAA / AVHRR satellite is presented in Fig. 2.

The following problems have been identified for Georgia:

- The resolution of microwave radiometer (from 25 km – to 5 km) is insufficient for mountainous regions of Georgia;
- The determination of snow cover height is possible from 0 to 80 cm, which is insufficient for Georgian conditions (in some regions snow cover height is more than 2 m).

In the future it may become possible to overcome this problem by the use of a high resolution and low frequency (6-10 GHZ) radiometer [4].

To ensure a shipping safety system on the Black Sea operational determination of sea surface temperature is required. In the Georgian case the observational network consists of oceanographic stations in Batumi, Kobuleti and Poti, which is insufficient for the determination of the spatial distribution of the sea surface temperature.

For this purpose the use of satellite data is most prospective [5]. The investigation showed that the application of the above-discussed AVHRR and MODIS sensors data would be effective. It should be noted that the Black Sea surface and coastal zone temperature data received from these sensors requires definite corrections and the determination of corresponding errors that is the subject of further research.

Besides the quantitative growth of Black Sea pollution, its qualitative composition has also changed over the last years. In the past the main springs of inflows were sewages. Now the leading position is held by industrial wastes, which contain oil products and some organic substances synthesized by human activity. Their main sources are ships, oil spills and oil refining industry. The oil spills became dominant at the Georgian coastal zone, because oil transportation has increased through Batumi harbor and newly constructed Supsa and Qulevi terminals. As a result the monitoring of Black Sea pollution becomes ever more important.

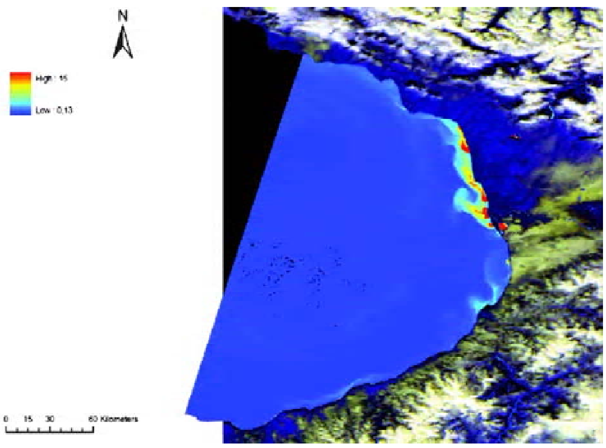

Fig. 3. TERRA/MODIS Satellite Image of the Black Sea Coastal Zone Pollution. July 9, 2008.

Fig. 4. TERRA/MODIS Image of Borjomi-Kharagauli Reservation Forest Fire, August 16, 2008.

To create an early warning system for hot spots carrying out satellite monitoring is very effective. In the Fig. 3 TERRA/MODIS satellite image of the Black Sea coastal zone pollution is given.

Satellite monitoring is also efficient for the forest fire early warning. In Fig. 4 TERRA/MODIS Satellite Image is given that shows Borjomi-Kharagauli Reservation Forest Fire on August 16, 2008. The satellite data are processed by UNOSAT "Satellite solutions for all" and published.

The images for several days are needed to show forest fire dynamics, but here, is presented only one image due to the restrictions of the article size. According to initial data the damaged area is equal to 450 ha for 17 August but this issue needs additional investigation.

On the basis of the above-mentioned the following may be concluded:

- For the purpose of early warning of hydrometeorological disasters on Georgian territory from the wide range of Earth Observation Satellites the use of NOAA, AQUA, TERRA LANDSAT and SPOT satellites and ERS and RADARSAT radar satellite systems is appropriate.
- Of the various hydrometeorological natural events charactering Georgian territory the use of satellite data is most effective for early warning of floods, hot spots (including oil spills), forest fires and for the provision of transportation safety on the Black Sea.

გეოფიზიკა

საქართველოს ტერიტორიაზე ჰიდრომეტეოროლოგიური კატასტროფების ადრეული შეტყობინებისათვის თანამგზავრული ინფორმაციის გამოყენება

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ნაშრომში განხილულია საქართველოს ტერიტორიისათვის ჰიდრომეტეოროლოგიური სტიქიური მოვლენების ადრეული შეტყობინებისათვის დედამიწის ხელოვნური თანამგზავრებიდან მიღებული ინფორმაციის გამოყენების თავისებურებანი. მოყვანილია თანამედროვე თანამგზავრების და მათზე არსებული სენსორების სხვადასხვა მახასიათებლები. მითითებულია მათი გამოყენების არეალი. განხილულია საქართველოსათვის მნიშვნელოვანი სტიქიური მოვლენები, რომელთა ადრეული გაფრთხილებებისათვის თანამგზავრებიდან მიღებული ინფორმაციის გამოყენება ეფექტურია.

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