Available online at www.sciencedirect.com

ScienceDirect

Procedia Social and Behavioral Sciences 19 (2011) 532–536

Procedia Social and Behavioral Sciences

The 2nd International Geography Symposium GEOMED2010

Remote sensing for early warning of natural meteorological and hydrological disasters and provision of transportation safety over the Black Sea in Georgia

G. Kordzakhia[a]*, L.Shengelia[a], G. Tvauri[b], M. Tatishvili[a], I. Mkurnalidze[a]

[a] *Institute of Hydrometeorology of Georgia, 150 D. Agmashenebeli Av., Tbilisi, 0112, Georgia*
[b] *M. Nodia Geophysical Institute of Georgia, 1 Alesdidze St., Tbilisi, 0193, Georgia*

Abstract

The effectiveness of the use of satellite information for the early warning of meteorological and hydrological disasters and provision of transportation safety on the Black Sea in Georgia were investigated. The research of determination of Sea Surface Temperatures by means of satellite information, verification of the obtained results based on quality control/quality assessment procedures were carried out.

Keywords: Disasters; transportation; safety, remote sensing; satellites, Black Sea

1. Introduction

Frequency and intensity of natural disasters has significantly increased in Georgia due to the modern climate change 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 disasters related to weather and water [1]. Hence, the identification of the natural disasters related to weather and water and their forecast is extremely important.

According to the Strategic Plan of the World Meteorological Organization (WMO) the use of Satellite technologies, in the operational activities and research work of its members National Meteorological Hydrological Services (NMHS) is of great importance, as:

- Satellites give possibility to receive meteorological & hydrological information from the regions uncovered by the observations (such as oceans and hardly accessible areas of the land);
- Satellites provide quick identification of natural meteorological and hydrological disasters for early warning and their timely delivery to policy-makers.

Regardless of the fact that none of the existing satellites and their sensors have been designed exclusively for the monitoring of natural disasters related to weather and water, the accessed information from different visible, near infrared, infrared, short wave, thermal infrared and short wave bands of electromagnetic scale gives opportunity of gathering necessary information and timely identification of the mentioned hazards [2].

2. Possibilities of Satellite Monitoring

The Earth observation satellite system is of two types: geostationary and polar orbiting. Polar orbiting satellites are more effective than geostationary ones for monitoring of natural meteorological and

*Corresponding author. Tel.: +99-59-914-5656; fax: +99-53-243-9550.
E-mail address: giakordzakhia@gmail.com

doi:10.1016/j.sbspro.2011.05.166

hydrological disasters, as they ensure reception of global scale information. Each sensor of such satellites can collect various types of unique information on the Earth surface and coastal waters. For example, long wave sensors, infrared range data are used for the detection 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).

From a great number of polar orbiting satellites were reviewed the satellites and sensors on board that are effective for the early warning of disasters characteristic of Georgia. The obtained analysis showed that those systems are: NOAA, TERRA, AQUA, LANDSAT, SPOT, ERS and RADARSAT [3]. The synthetic aperture radars, the so called "SAR systems", are used for the observation in case of clouds (RADARSAT and ERS satellites). They collect data in the microwave range 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 the wide range of disasters related to weather and water is the most effective for early warning of floods, inundation, environmental accidents (among them oil spills) and forest fires and provision of shipping safety on the Black Sea.

Among the natural meteorological and hydrological disasters flooding is the most widespread phenomenon. The remote sensing information is effective for flood management and it gives possibilities for:

- Detailed mapping that is required for preparation of hazard assessment maps;
- Provision of hydrological models with initial data;
- Quantitative assessment of soil state;
- Modeling of large scale flooding for identification of the areas of high risk; and
- Providing early warning.

Generally, remote sensed images are used for identification of flood prone areas and flood forecasting based on hydrological models. For proper forecasting of the flooding the snow cover data are needed. Snow cover examination is perspective using radar radiometer [4] that practically does not depend on the atmosphere state and day-night time. Land cover images with and without snow cover from TERRA/MODIS Satellite are presented in Fig.1. The following problems were identified while studying snow cover using satellite information for Georgia:

- The resolution of microwave radiometer (from 25 km – to 5 km) was not enough for mountainous regions of Georgia;
- The determination of snow cover height was possible from 0 to 80 cm, which was insufficient for Georgian conditions (in some regions snow cover height was more than 2 m).

In future this problem may be solved employing high resolution and low frequency (6-10 GHZ) radiometer [5].

In Fig. 2 TERRA/MODIS satellite image showing Borjomi-Kharagauli nature reserve (Georgia) forest fire in August 15, 2008 is presented. The satellite data are processed by UNOSAT „Satellite solutions for all" [6]. Initial treatment shows that damaged area is equal to 450 ha for 17 August but this result needs additional investigation.

3. Methodology of determination of the Black Sea surface temperatures from remote sensing

One of the measures for the provision of transportation safety over the marine area is to obtain high accuracy forecasts especially in case of disaster developed conditions. Achievement of successful forecasts depends on initial data, namely initial data of the sea surface temperature (SST). For determination of the Black Sea (BS) SST proper observational net is needed. In case of Georgia such net consists of hydrometeorlogical (oceanographic) stations located in Batumi, Kobuleti and Poti, which is rather rare for defining qualitative BS SST values in the points of regular grid. The use of satellite information for this purpose is the most valuable [3]. The investigation showed that the use of AVHRR and MODIS sensors was the most efficient, but the received BS SST data needed some adjustment and correction to minimize corresponding errors in satellite data.

The progress can be made by applying special quality control /quality assessment (QC/QA) procedures step by step. At the first stage QC/QA was carried for the pixel level and at the second stage – for the net level. The main element of analysis was the identification of anomalies and their withdrawal aiming to disable wiping the result (net product). QC/QA for satellite information was carried by means of hydrometeorological data of the stations - Qobuleti and Poti.

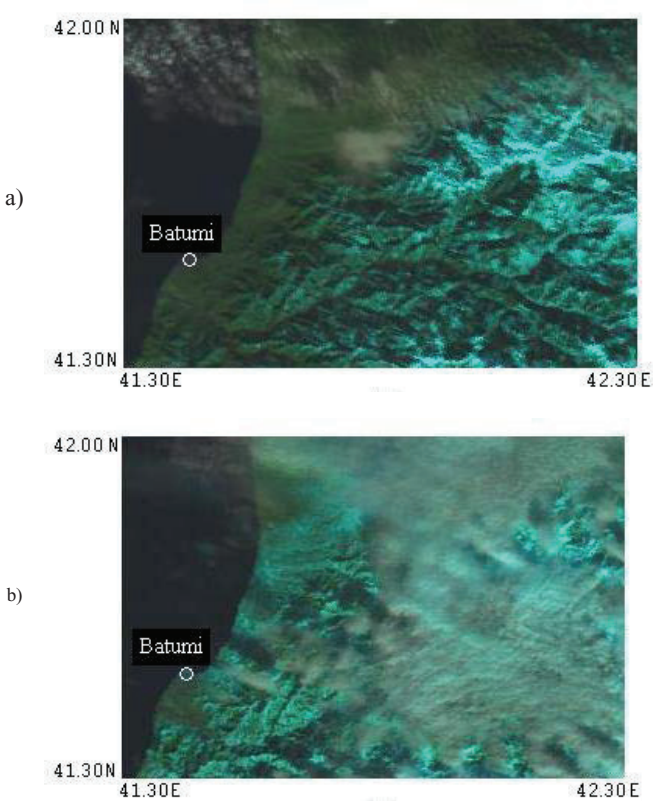

Fig.1. TERRA/MODIS satellite images. Batumi and adjacent area (Black Sea coastal zone) are presented: a) without snow cover (January 7, 2010, 08:27 GMT); b) with snow cover (January 29, 2010, 07:51 GMT).

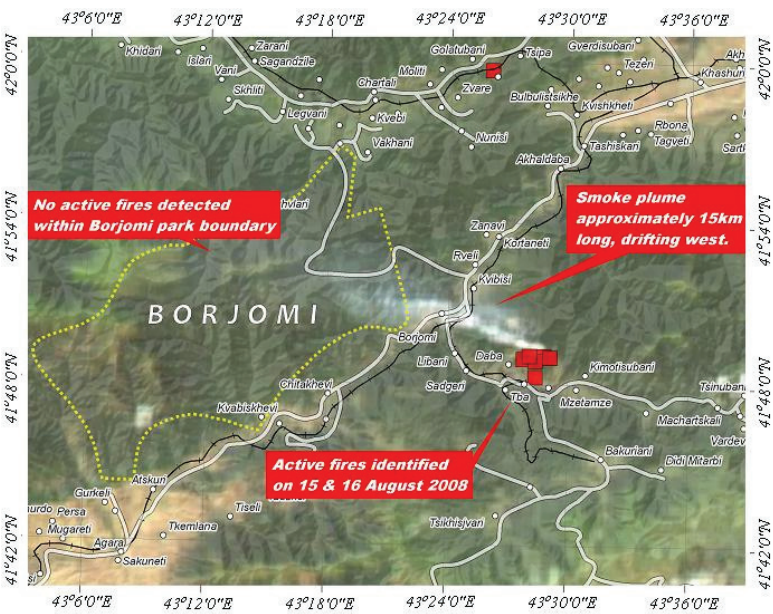

Fig. 2. TERRA/MODIS satellite image of Forest Fire in Borjomi-Kharagauli Nature Reserve (Georgia), August 15, 2008

Location accuracy is crucial for success of QC/QA of satellite information. For the refinement of the outline of the Georgian Black Sea coastal zone the Landsat/ETM archive images are used. These images are utilized as the data are transferred as location view i.e. the coordinate of any point is given with high accuracy. The determined outline of the Georgian Black Sea coastal zone is shown in Fig.3.

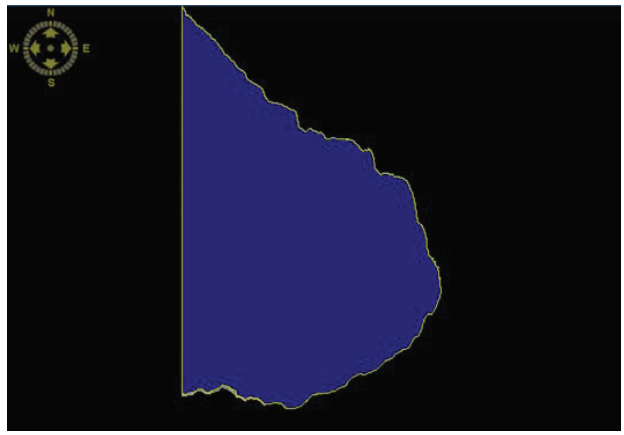

Fig. 3. The Outline of the Georgian Black Sea Coastal Zone Determined by Satellite data.

Based on the research the QC/QA methodology is summarized as follows:

1. During calculations those pixels have to be excluded for which:
- satellite zenith angle exceeds 530;
- the Sun zenith angle is less than 10;
2. BS SST is calculated by night algorithm, if the Sun zenith angle exceeds 75^0, and consequently - by day algorithm if the Sun zenith angle is less than 75^0;
3. Calculated values of BS SST are representative and used for those pixels for which cloudy indexes are equal to 0;
4. The Black Sea outline should be of the type as presented on Fig.3 for achieving high location accuracy for satellites with resolution of 30 m or less;
5. Checking information the satellite data is treated as inadequate if satellite observation deviation from hydrometeorological data is more than 3^0C;
6. BS SST of Georgian coast have to be calculated by multichannel method for the corresponding pixels of c. Kobuleti (east longitude $41{,}76399^0$, north latitude $41{,}82869^0$) and c. Poti (east longitude $41^0{,}75873^0$, north latitude $42{,}10637^0$).

The QC/QA procedures implementation for satellite information is more effective to carry out based on drifter information. It would be noted that the quality of observational data is crucial for the success of calculations of BS circulation models [7].That clearly shows necessity to implement such a QC/QA having enough statistics about drifter BS SST data sets (http://www.argo.ucsd.edu/index.html.). At present such a works are carried out.

Assuming above mentioned the following may be concluded:

- For the purpose of early warning of disasters of meteorological & hydrological origin local observable on the Georgian territory from the wide range of Earth Observational Satellites the use of NOAA, AQUA, TERRA, LANDSAT and SPOT satellites & RADARSAT and ERS radar satellite systems is appropriate;
- From the natural disasters related to weather and water charactering Georgian territory the use of satellite data is most effective for early warning of floods, forest fires and for the provision of transportation safety on the Black Sea;
- Established procedures of QC/QA are effective for the adjustment and correction of BS SST satellite data.

4. Conclusions

From above mentioned the following may be concluded:

From the wide range of Earth Observational Satellites the use of NOAA, AQUA, TERRA, LANDSAT and SPOT satellites & RADARSAT and ERS radar satellite systems are the most appropriate for the purpose of early warning of meteorological and hydrological disasters locally observable on the Georgian territory;

Out of all the weather and water related natural disasters peculiar for Georgian territory the use of satellite data is the most effective for early warning of floods, forest fires and for the provision of transportation safety on the Black Sea;

Established procedures of QC/QA are effective for the adjustment and correction of BS SST satellite data.

Acknowledgement

The research is fulfilled in the frames of the governmental scientific grant #GSH/ SHT08/5-432 “Creation of the System of Implementation of Satellite Information for the Provision of Safety of Marine Transportation and Ecology in Georgia” of Georgian National Foundation.

References

[1] Assessment of Economic Effectiveness of Hydrometeorological provision. Georgia. The International Bank of Reconstruction and Development. The Hydrometeorological Department of the Center of Monitoring and Prognostication of the Ministry of the Environment Protection and Natural Resources of Georgia.Tbilisi, Chapter 1.1.2 (In Russian), 2006.

[2] Nirupama PS. Role of Remote Sensing in Disaster ManagementInstitute for Catastrophic Losses Reduction. Research Paper Series - No 21. 2002.

[3] Shengelia L, Kordzakhia G, Tvauri G, Tatishvili M, Mkurnalidze I. Peculiarities of the Use of Satellite Information for Early Warning of Natural Meteorological and Hydrological Disasters in Georgia. Bulletin of the Georgian National Academy of Sciences 2009, 3-1: 79-83.

[4] Sari J, Metsamaki M, Saku T, Huttunen J, Jenni M, Versalainen C. A Feasible Method for Fractional Snow Cover Mapping in Boreal Zone Based on a Reflectance Model. Remote Sensing of Environment, 2005, 95: 77-95.

[5] Brubaker KL, Jasinsky M, Chang AT, Josberger E. Interpolating Sparse Surface Measurements for Calibration and Validation of Satellite-derived Snow Water Equivalent in Russian Siberia // Remote Sensing and Hydrology. (Proceedings of a Symposium held at Santa Fe, New Mexico, USA, April 2000), IAHS Publ., #267. 2001.

[6] Review of Active Fire Locations Threatening. Borjomi Natural Reserve, Georgia (15-20 August 2008), http://unosat.web.cern.ch/unosat/asp/prod_free.asp?id=101.

[7] Kordzadze A, Demetrashvili D. Numerical modeling of inner-annual variability of the hydrological regime of the Black Sea with taking into account alternation of different types of the wind above its surface. Proceed. of Intern. Conference: “A year after Johannesburg-Ocean Governance and Sustainable Development: Ocean and coasts- a Glimpse into the future”. Kiev/Ukraine, Oct.27-30. 2003.