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MULTISENSOR EARTH OBSERVATION SYSTEM

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Abstract: *Satellite Earth observation systems mark the high rates of growth and today provide a huge volume with a wide variety of data regarding the spectral, spatial and temporal characteristics of observed objects. Notwithstanding these achievements, due to the particularities of the remote observation technology, it is not possible in many practical cases to define precisely certain characteristics of the monitored objects. Therefore, in order to make full use of this variety of multispectral high spatial resolution data is also required obtaining and using multisensor and multitemporal data from observation.*

In the proposed work, the authors discuss a multisensor Earth observation system focusing primarily on the place and role of these systems in today's Earth exploration phase. The examples presented show both the advantages of its use and the particularities of the functioning of such systems. The location and role of a multisensor system in sync with existing global observation systems is outlined, a set of tools and systems that could be included in the exemplary implementation of such a system is shown. The accompanying difficulties and challenges that need to be solved for sharing and merging data from a multisensor system are outlined.

МУЛТИСЕНЗОРНА СИСТЕМА ЗА НАБЛЮДЕНИЕ НА ЗЕМЯТА

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Ключови думи: *дистанционни изследвания, хиперспектрални прибори, приложения*

Резюме: *Непрекъснатият напредък на съвременните технологии доведе след себе си до бурно развитие на сателитните системи за наблюдение на Земята . Множеството от сателитни системи за наблюдение осигурява събиране на огромни по обем, с голямо разнообразие, данни по отношение на спектрални, пространствени и времеви характеристики на наблюдавани обекти. Същевременно в много практически случаи, поради спецификата на дистанционните изследвания, не е възможно еднозначно да бъдат дефинирани определени , представляващи интерес , характеристики на наблюдавани обекти. Следователно, за да може да бъде пълноценно използвано това разнообразие от мултиспектрални, с висока пространствена разделителна способност данни, се изисква и получаване и използването на мултизензорни и мултитемпоралнии данни от наблюдение.*

В предложената работата авторите дискутират мултисензорна система за наблюдение на Земята, като основно се акцентира на необходимостта от използването и, както и на предимствата и особеностите, произтичащи от функционирането на подобна система. Посочено е примерно изпълнение на такава система. Посочени са и съпътстващите трудности и предизвикателства, които трябва да бъдат разрешени за съвместно използване и сливане на данните от мултисензорна система.

Introduction

Earth observation (EO) is the gathering of information about planet Earth's physical, chemical and biological systems via remote sensing technologies. Many satellite systems provide a high volume of high-quality surveillance data [1–4]. In most cases, however, these systems work separately from one another which make it difficult to accurately identify important features of the observed objects. In order to reach new levels of knowledge, it is required to improve the quality of the data used through the preprocess of data acquisition and improvement of remote sensing observation systems [5,6], as well as the sharing of data from different sensor systems (so call procedure "Data fusion") with different parameters (such as number of spectral channels, radiometric sensitivity, spatial geometry, etc.) by the developing of a Local or Regional Earth Observation Systems (L/R EOS) [7].

Earth Observation systems

Earth Observation systems (EOS) consist of instruments and models designed to measure, monitor and predict the physical, chemical and biological status of the Earth system. Most of high-tech environmental satellites scan the planet from space (Table 1a, Table 1b).

Table 1a. Modern Earth Observation systems

Instrument	**CartoSat - 3**	**EnMAP**	**HISUI**	**Shalom**	**FLORIS**	**HYPXIM-P**	**HyspIRI**	**Sentinel - 2**
Platform name	**CartoSat - 3**	**EnMAP**	**ALOS - 3**	**Shalom**	**FLEX**	**HYPXIM-P**	**HyspIRI**	**Sentinel - 2**
Spectral range (nm)	400 - 2400	420 – 2450	440 - 2500	400 - 2500	500 – 780	400 – 12000	380 – 12000	443 - 2190
Swath width (km)	15	30	30	10	105 – 150	16	150 – 600	290
Spectral bands	200	98	185	241		250	218	13
Resolution Spectral (nm) Spatial (m) Temporal (day)	12	6.5±1.25–10±2.50 30 ≤ 4 - ≤21	10 – 12.5 30 60	~ 10 2.5 – 10 2	0.3 – 3 300 – 500 19	10 – 150 2-100 3-19	7-54 30-60 5-19	15 – 180 10, 20, 60 5-10
Objective	Agriculture, geology, water observation	Environment observation	EO	Environment quality, crisis monitoring	Global data of chlorophyll	Water ecosystem	Investigation of ecosystem and natural disasters	Land management monitoring
Country	India	Germany	Japan	Italy/Israel	UK	France	USA	ESA

Table 1b. Modern Earth Observation systems

Instrument	**Hyperion**	**CHRIS**	**HJ – 1A**	**FY – 3A**	**HySI**	**TG - 1**	**Resurs-P No.1**	**Resurs-P No.2**
Platform name	**EO-1**	**PROBA**	**HJ – 1A**	**MERSI**	**IMS - 1**	**TG - 1**	**Resurs-P No.1**	**Resurs-P No.2**
Spectral range (nm)	355 - 2577	400 - 1050	450 - 950	400 - 12500	400 - 950	400 - 2500	400 - 1100	400 - 1100
Swath width (km)	7.5	14	50		128		30	38
Spectral bands	242	117	115	20	64	128	256	216
Resolution Spectral (nm) Spatial (m) Temporal (day)	10 30 16	1.3 – 12 36 7	2 - 8 100 4 to 31	20 – 50 250 - 1000 5	15 550 22	10 - 23	5 – 10 30 3 - 6	5 – 10 30
Objective	EO	EO	EO	EO	EO	Land monitoring	EO	EO
Country	USA	UK	China	China	India	China	Russia	Russia

The use of new technologies allows huge volume s of Earth observation data to be collected in near (quasi) real time and with high spatial and spectral resolution. For example the Sentinel missions are developed specifically for the European Union's Copernicus programme – the largest environmental monitoring programme in the world. By providing a set of key information services for a wide range of practical applications, the programme is making a step change in the way we manage the environment, understand and tackle the effects of climate change, and safeguard everyday lives [8, 9].

Earth Observation systems

The main purpose of building and using a multi-sensor surveillance system is to increase the accuracy of observation. The basic hypotheses behind the achievement of the goal are:

• The establishment of a multisensor Earth Observation System enables the sharing of data from different observation systems and thus provides additional information on the objects to be explored, which can be used to solve the tasks facing the core set of systems;

• In situ obtained data from the multisensor observation system can be used to validate algorithms and methodologies for joint use and comparability of the results of different systems;

• Integrating data usage makes it possible to verify remote spectral data and images from space based global Earth observation systems (EOS);

• Hyperspectral devices that produce in situ spectral data and spectral images of the objects studied can serve to simulate the characteristics of current and forthcoming global Earth observation systems (EOS).

Another but no less important objective to establish multisensor Earth observation systems is that through them the information from the whole set of existing monitoring systems is reached in the most accurate way and in the most appropriate way to the end users (Fig. 1).

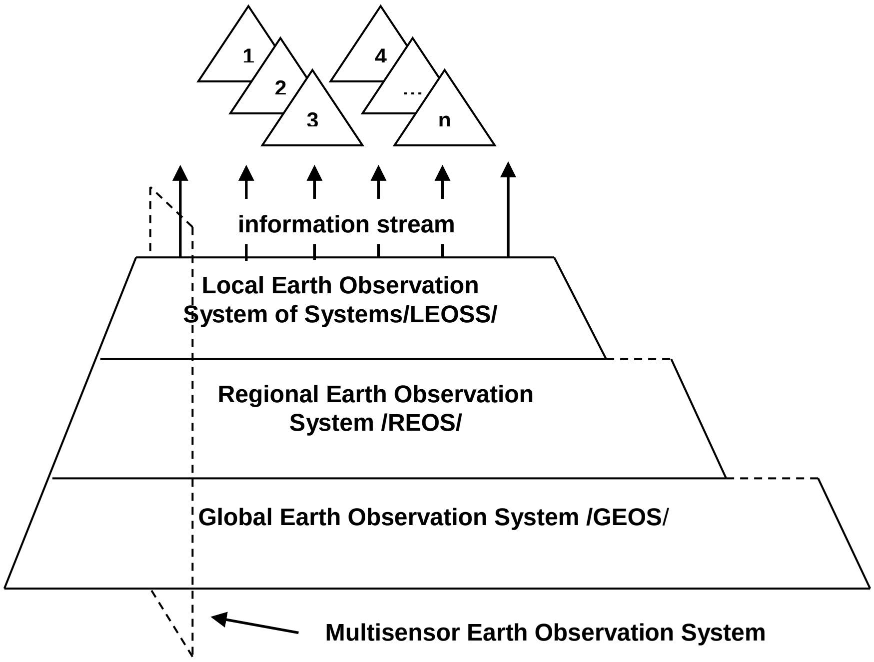


Fig. 1. Earth observation systems – a structure diagram

The author's time of the proposed article has the advanced remote sensing equipment available to meet the objectives of a local observation system, which may include, as appropriate, the following equipment:

- Spectrometers:

Model	**Resolution FWHM**	**Wavelength Range**
NIRQuest512-2.5	6.3 nm	900-2500 nm (IR)
USB4000-FL	10.0 nm	360-1100 nm (Vis-NIR)
USB2000	1.5 nm	350-1000 nm (Vis-NIR)
HR4000	0.75 nm	200-1100 nm (UV-Vis-NIR)

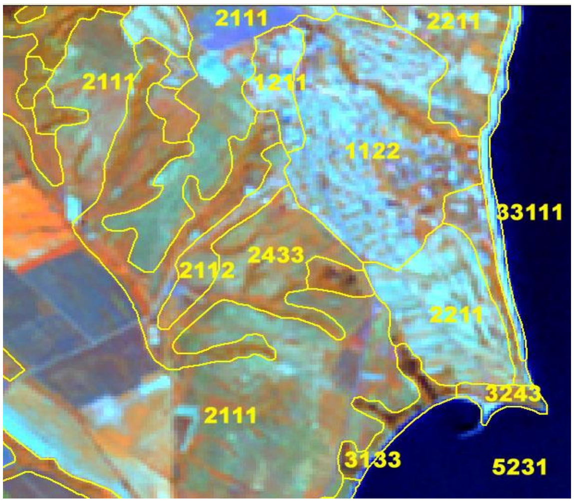
- Imaging Spectrometer:

Model	**Resolution FWHM**	**Wavelength Range**
Hyperspec VNIR Imaging Spectrometer	3.8 nm	380-1000 (Vis-NIR)

- Automated field network with distributed parameters for environmental data collection.

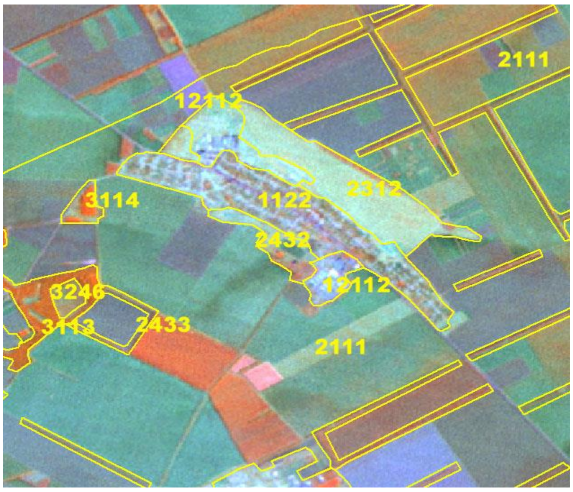
At the same time, the use of a multisensor Earth observation system also introduces multisource, multispectral and multispatial, multitemporal (multidimensional) differences in the obtained data and thus generates a series of tasks that must be solved. Integration and sharing of data (data fusion) from multiple sensor systems will require data to be co-registered and geometrically and radiometrically corrected. Fusion method could be performed at the signal, pixel, and feature or decision level of representation [9–11]. One of the most common applications is for image pixel-based fusion, which increase the spatial resolution of an image. The most frequent use of this approach is pansharpening when a high-resolution panchromatic image is fused with a lower resolution multispectral image (multisensor image fusion). Images with improved detail in false colours are generated Black Sea coastal zone are shown in the Fig. 2 [12].

- multisensor images:



Landsat 7 fragment with improved detail - vineyard with blurred texture in the image (2211)

Picture of the same plot of field inspection - establishment of vineyards southeast of Byala



Landsat 7 fragment with improved detail (12112)

Photo of the same field inspection area in Sokolovo

Fig. 2. Fragments of Landsat 7 images with outlined boundaries of grades 4th and 5th level and field photos from the Bulgarian Black Sea coastal zone 11 [12]

- multisensor multispectral data:

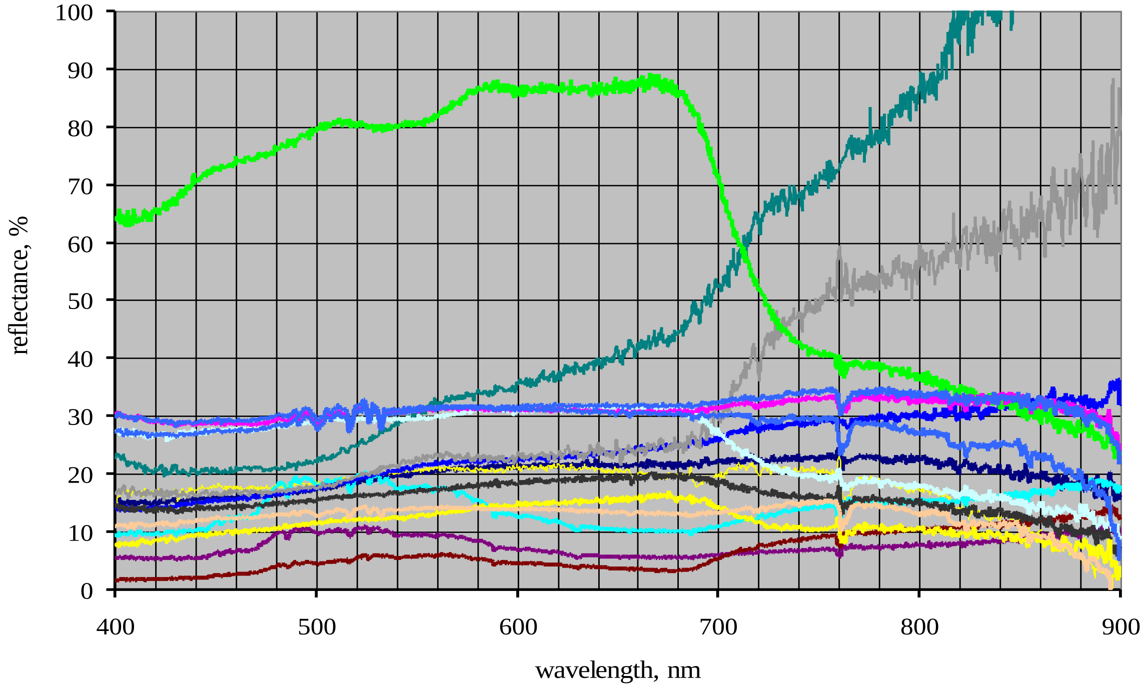


Fig. 3. Spectral data from terrain measurements using Thematically Oriented Multichannel Spectrometer of pure granites (5–30 %) and granites covered by soils and lichens (20–90 %) in the region of Sredna gora Mountains

- multisensor multitemporal data:

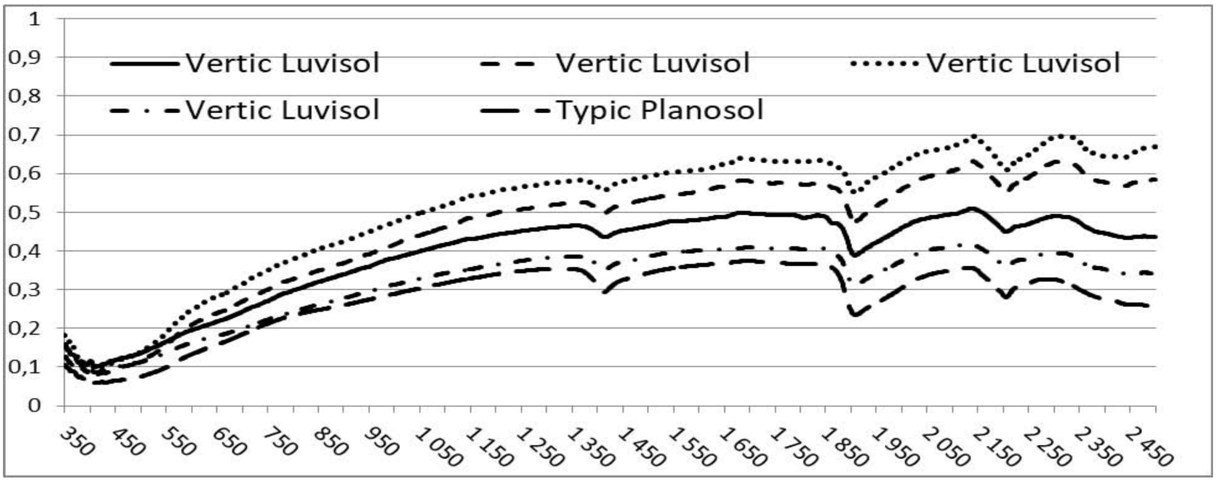


Fig. 4. Spectral reflectance of five types of studied soils

Table 2. Spectral data - in situ measurements: carbon content, organic matter, clay, sediment, sand and pH in water

OC	OM	CaCO3	Clay_Fraction	Silt_Fraction	Sand_Fraction	pH_H2O
0.28	0.48272	NA	44.1	19.3	36.5	4.3
1.5	2.586	NA	46.8	36.2	17	6.1
1.32	2.27568	NA	57	21.9	21.06	6.5
1.15	1.9826	NA	58.7	19.2	22	6.9
1.05	1.8102	NA	50.1	33.3	16.5	5.7

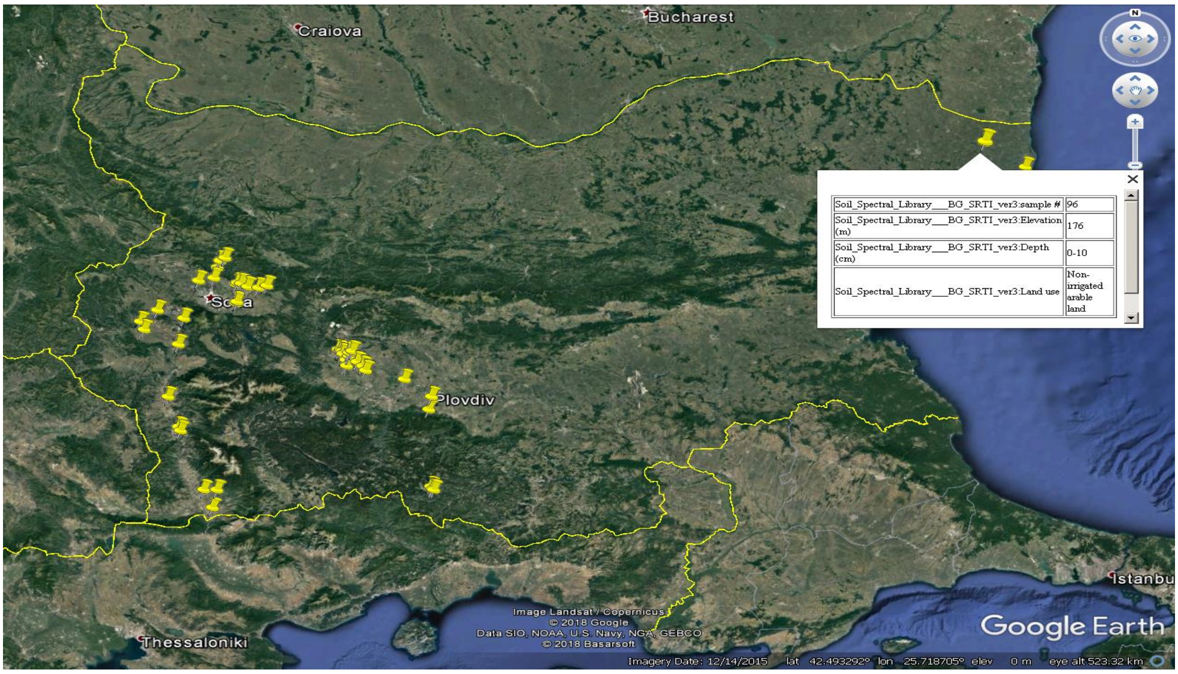


Fig. 5. Sampling sites for soil samples

- multitemporal image:

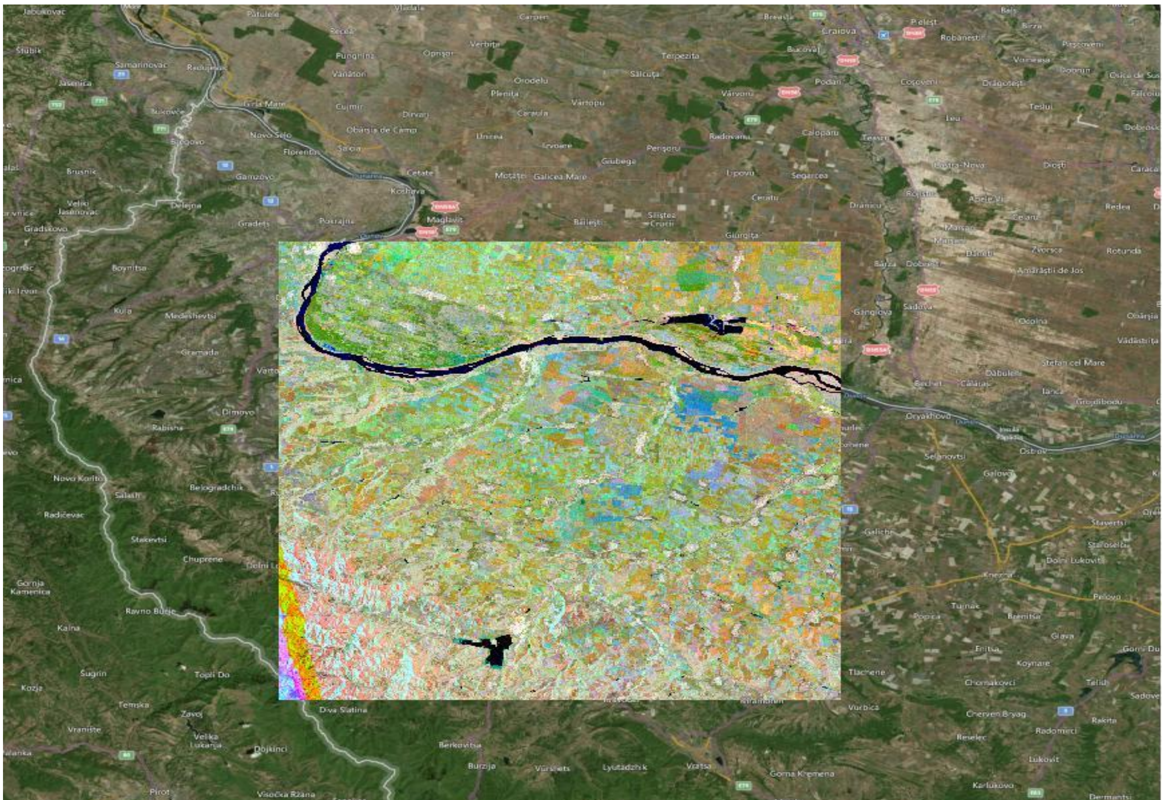


Fig. 6. Four-channel composite image of part of northwest Bulgaria composed of SAR images for four different months for years 2016 and 2017

Conclusions

Multisensor Earth observation systems allows the integration of data from multiple sensor systems and their fusion into the processing system, which improves the accuracy of the object's classification in the images.

Multisensor systems incorporating local Earth monitoring systems provide a prerequisite for obtaining timely and accurate thematic information for users that may be critical for practical application.

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