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Test Site/*In-Situ* Data for Earth Observation in Case of Limited Field Data Access

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Abstract

Remote sensing (RS) is the method making possible of observing, recording and collecting of objects or features on the Earth from distant places. There is no direct contact with the investigated objects. It is reflecting radiation scattering from the Earth surface content information in the form of wavelengths in different range of spectrum. Main source of the information comes from satellites forming as space image. A further step of the analyses of space image and interpretation is required in order to extract the useful information from the image. The goal of a remote sensing method is to extract the information that is directly related to a management process creating opportunity efficiently adapted to the data ultimately interested purpose. It provides an impact in wide areas of time management as well as cost and financial resources coordination in the stages of development and implementation. A success of this achievement depends on a successful use of the multilevel data collected from space-borne and the field observation systems. It is necessary to optimize the infrastructure for the data acquisition and analyzing, effectively data processing and integration with further use for decision making. The option of optimization contains adequate instrumentation and better timing and coordination in information collecting and management. There is a limitation in some cases for the investigated area for the field data access. It makes necessary to embrace the need for the field data using indirect way for satisfaction of the space image processing needs. General approach is to use the test site data integrated into the space data for processing. The main purpose of the paper is to recommend how to cover existing gap and limitation in the field data. For this reason, the use of the Test Site/*In situ* data for fitting of the field data limitation in the space image processing oriented for the Earth observation is demonstrated in this paper. There is one more advantage of offered approach is to use the Test Site/*In situ* for multilevel data access. The use of a country area with features contenting the main land cover/land use needs for the field data required in the space image processing is recommended. The method of the data collection process with further integration into space data which is necessary part of the space information processing as an evidence of reliability of used technology is described in this paper. The result of offered approach demonstrates the philosophy of using of the Test Site/*In situ* data which is a vital problem in space data processing. Conclusion of suggested way of problem solving demonstrates exclusion not only lack of field data as well as creating the environment of multilevel data access which makes the increase accuracy of the data processing.

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Keywords

Earth Observation, Remote Sensing, Test Site, Data Processing, Space Image and Integration

Subject Areas: **Aerospace Engineering, Image Processing**

1. Introduction

The Earth observation is used to monitor and assess the status and changes in the natural environment and to its protection if required. Currently the Earth observation has become technologically more and more sophisticated.

Accurate, timely, and reliable data are a precursor for analyzing and studying several aspects of the integrated Earth system. Remote sensing observations have catalyzed several aspects of the Earth system science by providing panoptic views and time-series measurements of the Earth study in ways nearly impossible to replicate by traditional ground-based methods. One of the primary goals of remote sensing method application is to study and understand all interacting and interfacing components of the Earth as a dynamic system impacting on the Earth condition. The use of RS method also becomes more important due to the significant influence of modern human civilization on the Earth planet and highly needs to minimize negative impacts along with the opportunities of the Earth observation which provides and creates a success in study and improvement of the social and economic aspects of human life.

It is necessary application of offered approach in the future providing investigation in the use of Test Site/*In situ* data. For this reason, it is intended to use the space image processing at least for neighboring countries to integrate into the local Test Site/*In situ* data in order to discover applicability of the method.

2. Multilevel Data Collection for Solving of Data Lack Weaknesses

There is no doubt that space technology plays an important role in our daily life. A big number of the Earth observing satellites are rotating in orbit. It is required to enhance the observing capability of satellites. Up-to-date space science and technology advances make a possible an accurate integration of different information incoming into one data which is highly important in the implementation of the global observation systems targets. Remote sensing information technologies have passed different stages within the development processes from sensor design to observation missions and data application. Approaches have been changed during these stages on the importance of the various links of the information chain. Today it is unambiguously recognized that the multilevel data collection is not only an integral part but also the backbone of a spatial data information system. In conjunction with the space component it forms a common information structure which creates affirmative approach to the data processing assurance. An adequate obtaining and deploying information, substantial improvement are required in space technology application in multilevel surveys, observing systems and networks together with the development of global monitoring systems oriented information services.

It is necessary to calibrate the used instrumentations for validation including applied software systems (providing required quality data inputs) for increasing and enhancing of processed data accuracy through geo-reference and integrated ground-based field data "R. Kancheva, D. Borisova1, G. Georgiev, Yu. Tishchenko, Test-Sites in Remote Sensing Studies and Earth Observations, Journal Fundamental Space Research, 2009; Main Report Socio-Economic Benefits Analysis of GMES, GMES Benefits and Impacts Report, Prepared by Price Water House Coopers, ESA Contract Number 18868/05, October 2006; Official Journal of the European Union, 22.2.2007, L 54/30-80, Corrigendum to Council Decision 2006/971/EC of 19 December 2006 concerning the specific programme 'Cooperation' implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007 to 2013), (Official Journal of the European Union L 400 of 30 December 2006)" [1]-[3]. One of the segments of data processing quality is data sharing and its integration from different level (ground-based and remote sensing) sources, at different scales needed to increase the frame of the observations as well as make sure of cross level and cross-thematic consistency of the acquired data "R. Kancheva, H. Nikolov, D. Borisova, 2005, Modeling and verification in vegetation spectral studies. Annual of UMG 'St. Ivan Rilski', Part I: Geology and Geophysics, vol. 48, Sofia, Publishing House 'St. Ivan Rilski', 221-224" [4].

The circumstances of data collection and processing are those high quality and timely delivery, successful integration and adequately adaptation into the ground-based field data, limitation and protection of definition during the development stage. It is highly desirable the use of the multilevel information system based on the remote sensing data combined with the ground-based field information and availability of other sources data are the way of the best outcomes of the expected production in the data processing. It creates a very strong environment in high accuracy and reliability of processed database making easy the decision achievements.

How space technology can be effectively applied in multilevel implementations—space, test site and ground measurements? How can be benefited when there is a lack of access into the test site or ground measurements?

An approach of use indirect ways of data collection instead of a test site or ground data where have obstacles in access to the ground data for some reasons which are the inherent part of the space data processing.

3. Data Lack Weaknesses Problem Solving

The stages of space technology application demand required developments and implementations for a final product. The space image with ground-based data merged to the topographical map with appropriate map-scale depending on task solving has to be integrated.

There is an importance of detailed elements and consequences needed to be undertaken within a frame of the space technology data processing. One of the important issues of space data processing is data validation. In regard with this there are existing gaps limiting the applications in the area:

- Obviously there is a big success in sensor technology but at the same time existing technological obstacles eliminate a possibility of their proper use;
- The lack of satisfied information for acquired data processing based on the field data with further remotely sensed data integration;
- Recognition and identification of the space data and the field data combination;
- Complication of information integration from different sources;
- Interface problem between users and applications.

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It is obvious that in some cases it is not possible to have appropriate data for processing, for instance, the ground-based which is limited space technology application in task implementations. It makes necessary to find out sources which can embrace the lack of such information during the stage of the space data processing.

4. The Test Site/*In-Situ* Data Access Area Selection in Space Technology Applications

As the general way TS/*In-situ* is the artificially developed area which allows the use of the area as the ground-based field measurements with further purpose of the integration into the space data processing. It is required to use or develop if necessary such areas with the similar Land Use/Land Cover features of the investigated area in order to be able to merge the ground-based field data into satellite data. It is the demand of remote sensing methods applications in data processing. Obviously the task of artificial TS/*In-situ* development is complicated and limited issue for several reasons:

1) to embrace the main Land Cover/Land Use features of investigated area for classification;

2) required time for the TS/*In-situ* development with the main Land Cover/Land Use classification reflecting investigated area;

3) necessity of a huge number of artificial test sites development around the World.

How the problem can be solved with the comprehensively approach in order to eliminate obstacles while limited access to the ground-based field for data collection from the investigated area exists?

There is no doubt that it has to be developed or selected areas for the TS/*In-situ* use purposes with a large variety of Land Use/Land Cover features for classification which can be integrated into the space data as a main part of the data processing.

For this aim we are describing and offering below suitable way of natural the TS/*In-situ* use. It is important to emphasize that there is not a big number of papers dedicated to the test site studies and investigations. So far we have limited information in the indicated area. The main reason is limitations in use of existing traditional methods. An approach of use of the Test Site/*In situ* data access in selected areas contenting a wide natural features which make possible the solving of the problem standing on big obstacles in the field data.

4.1. Azerbaijan's Natural Features for Test Site/*In-Situ* Data Purposes

Azerbaijan is situated on the Western Caspian coast, in the South Caucasus's east. The nine of the main eleven climatic types of the Earth, from subtropics to alpine meadows, are represented in Azerbaijan. Four seasons can be watched simultaneously. There is a splendid flora of humid sub-tropics and everlasting snow and glaciers of Shahdagh and Murovdagh, Gabala forests, full of spring flavors, and hot steppes of Mil, Mugan, and Shirvan, and mist and rains over tea and citrus plantations in the foothills of the Talish Mountain Range and warm "Moryana" (a shore-to-sea breeze) and the Absheron Peninsula's gusty "Khazri" (the Caspian north wind), all neighboring each other.

The territory of Azerbaijan is densely cut through by numerous mainly highlands, rivers, most of which have noisy mountain-echoing waterfalls such as Afurji, Ghirintov and Sariguney, Mighi. Azerbaijan's nature represented by deserts and woods. Flora of Azerbaijan is rich and versatile.

Highland and plain lakes which total number approximately equals to 250 such as Tufan (the Caucasus Major), Alagellar, Gey-Gel, Maralgel, Zeligel, Karagel (the Caucasus Minor) truly adorn Azerbaijan.

Azerbaijan's fauna is notable for the same richness and variety: more than 12,000 species populate the country. Goitered gazelles, wild boars, wolves, foxes, hares, coypu rats, pheasants, ducks, bald-coots ("kashkaldak"), and Sultan chickens inhabit the area. Deer, roe deer, wild boars, brown Caucasian bears, lynxes, and wolves and, somewhere, leopards are typical for lowland and midland. The Bezoar, mouflon, ibex and others populate the highland, the birds being represented by pheasants, partridges, stone partridges, francolins, Caspian snow cocks and Caucasian blackcocks.

The country appears to decline towards the Caspian Sea, where all rivers of Azerbaijan flow into. Some of them enter the Kura, the country's main one, while others do into the Araks, which is the Kura's largest tributary. The largest lake in the world (about 370,886 square kilometers of water surface) the Caspian Sea is unique in terms of its origins, natural and biological resources.

The sturgeon, stellate sturgeon, beluga, salmon, kutum, shemaya, herring, lamprey, sheatfish, pike, chub and some others populate in the Caspian Sea and rivers inflowing deltas.

Climate: Borrowing rather small territory, Azerbaijan has unique natural-climatic features. From eleven existing climatic zones of nine are presented in the territory of Azerbaijan: from subtropics up to the high-mountainous Alpine meadows. Mid-annual temperature is +13.7˚C, average temperature in January is +1.7˚C, average temperature in July is +27.9˚C. Climate is passing from temperate to subtropical. Strong northern winds mainly are common in autumn.

Relief: It is possible to allocate 4 basic parts in relief of Azerbaijan: the Big Caucasus (a part of the Main Caucasian Ridge), the Small Caucasian Ridge, Nakhichevan and the Kura-Araz lowlands, Talish Mountains and Lenkoran lowland.

The rivers and lakes: More than 1000 rivers are proceeding in the territory of the country. The largest river is Kura. Azerbaijan is famous for numerous sources of mineral waters. Most known are Istisu, Turshsu, and Badamli. There are no large fresh lakes in Azerbaijan, but many small lakes are present. Their number amounts to 250.

Flora: More than 4200 kinds of plants are counted in the territory of republic. Some of them are unique and also typical only for Azerbaijan: Eldar's pine, a silk acacia, lignum vitae. Mountain woods are attractive for rest and tourism.

Fauna: The fauna of Azerbaijan is rich and sundry. More than 12,000 kinds of animals and birds live here. There are bears, turs, wild boars, goitered gazelle (jeyran), wolves, foxes are found here etc. The world of birds is also various in the territory of the country. More than 250 kinds of birds live only in Kyzyl-Agaj reserve.

Existing nine climate zones from eleven, rich relief, fauna and flora features make territory of Azerbaijan attractive for the Test Site/*In-situ* (TS/*In-situ*) area in data collection where limited the ground-based filed data access with different reasons. The data accessed from the TS/*In-situ* area can be used for identification and classification of different segments and features of the Earth surface which are not available directly from investigated area as an important element of reliability and confidence of the space data processing.

The lack of the ground-based field data can be embraced using the territory of the country dividing into six TS/*In-situ* regions making available the use of data measuring and collecting appropriate remotely sensed data for further integration into the space data processing stage. The exceptions of the Azerbaijan territory consists of a rich features of the Earth surface classification. **Figure 1** shows the TS/*In-situ* areas with a rich content of the Land Cover/Land Use features.

There are Earth features in Azerbaijan territory divided into six country regions which can be described as following:

TS/In-situ 1 (*Baku region*)—The Absheron Peninsula is located 29 m below World Ocean level. The climate of Baku and Absheron is of temperate warm semideserts and steppes with Absheron-specific winds. Oil, gas, building stone, salt, sand are the mineral deposits of Absheron Peninsula. Salt lakes at the Absheron include Masazir, Gala, Beyuk-Shor and Hodzhasan. There are some of the oldest oil wells in the world where people would draw oil from with buckets and the first industrial oil wells on the Absheron.

Azerbaijan is the first among the world's countries by quantity and diversity of mud volcanoes. Among 800 mud volcanoes known in different countries on the Earth 400 are located within the boundaries of the South Caucasus oil-and-gas basins and among the latter 300 are located on the land of Azerbaijan, within its Caspian area of water and on numerous islands.

All known types of mud volcanoes on the world are represented in Azerbaijan. This is a genuine natural stock and laboratory of mud volcanoes. Due to this, in the last years Baku, capital of the country has become a center of international scientific forums on mud volcanism, geodynamics and seismicity.

TS/In-situ 2 (*Northeastern Azerbaijan*)—it is the closest mountainous area to Baku, capital of country, among all the other mountainous areas of Azerbaijan. A visit to this region will give you the opportunity to see various types of forests with different kinds of trees, famous Chirag-gala fortress and Khinalig settlement, home of to indigenous tribes. In one of the districts you will discover a cascade of waterfalls on the Gudialchay River in Tangaalti Gorge. http://www.azerbaijan.orexca.com/azerbaijan_regions.shtml.

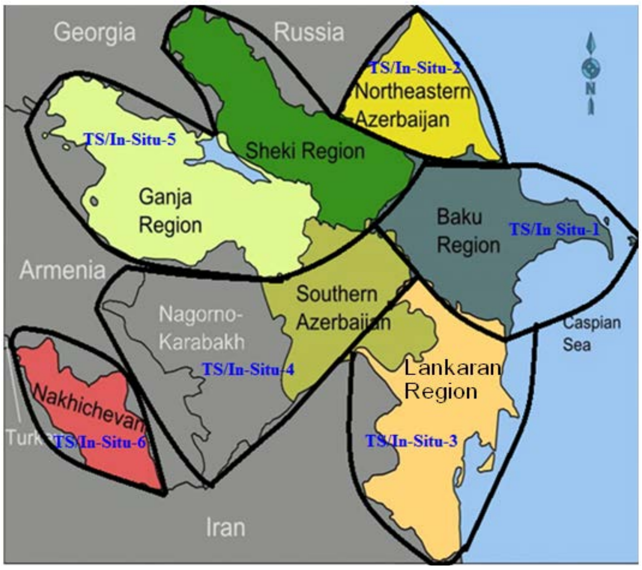


Figure 1. TS/*In-situ* data areas in Azerbaijan.

TS/In-situ 3 (*Lankaran region*)—The region is known as a sub-tropical area with extremely picturesque scenery and rich flora and fauna. For good reasons, the Hirkan National Park and Gizilagaj Reserve have been created here. The gulf at the mouth of the Kura River, surrounded by cane thickets, attracts migratory birds, transiting in spring and autumn.

TS/In-situ 4 (*Nagorno-Karabakh/Southern Azerbaijan region*)—Excursions to the mountains and valleys with babbling brooks and granite blocks of varying and unusual shapes, which are scattered everywhere like the toys of a giant. Every opportunity for active vacations is present in this region: from casual walks to extreme ascents of mountains and climbing frozen waterfalls... Thanks to its lakes and mountains the region is considered to be one of the most naturally reach places in Azerbaijan. There are mighty forests, snowy peaks, noisy waterfalls, medicinal mineral spas, crystal-clear water, sprawling sub-alpine and alpine meadows.

TS/In-situ 5 (*Nakhchevan region*)—While traveling along the mountain ridge in the Nakhchievan Republic, we admire the stunning nature and historical monuments; and even drop in on settlements hidden in the valleys below. The cities of this land differ from the rest of Azerbaijan in their historical and artistic values, cozy side streets and squares.

4.2. Method of Measurement

It is important to understand how to use and what method is required to apply for the TS/*In-situ* data instead of the ground-based information in the space image processing. For full stages of information processing product based on the space technology application implementation of data acquisition and data configuring from the integration of remotely systems and the ground-based field data is required when available. But the the TS/*In-situ* data required to be used when the ground-based field data isn't available.

A content of the TS/*In-situ* systems for data acquisition are following:

1) geo-referencing for data merging and data calibration and validation;

2) spectrometric and other sensors for data acquisition;

3) remote sensing data gathering platforms development; and

4) the ground-based field data gathering facilities.

Azerbaijan territory can be used as TS/*In-situ* area instead of the ground-based filed data source when such data is not available. The scale of application of the territory would be successfully covered within the worldwide framework. It is not necessary to spend financial, technical, technological or other required expenses for the purpose of the ground-based filed data access developing the number of the TS/*In-situ* areas around the World. The territory of Azerbaijan can be commonly used and satisfied with technical and technological needs in the ground-based filed data for any countries involved on the Earth studies with the use of the space technology or other applications.

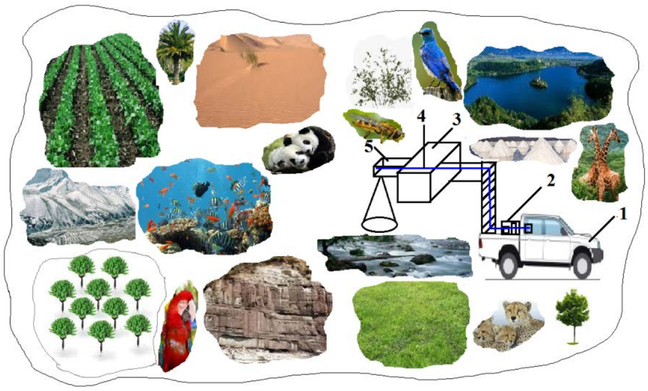
Figure 2 reflects the stages and the method of data collection starting from monitored TS/*In-situ* area up to input into the system as an initial phase of information collection with further integration into the space data. It is based on TS/*In-situ* receiving, collecting, primary mobile monitoring and processing system (RCPMMPS).

Description of the method: It can be used a mobile operation system in each of selected TS/*In-situ* for the Earth monitoring purpose depending on the features of the area which intended to be investigated. The data TS/*In-situ* contents RCPMMPS and the ground-based information should be almost the same nature as the studied area for some reasons cannot be reached for ground-based data collection. The selection of appropriate TS/*In-situ* area from appropriate Azerbaijan regions gives an opportunity to achieve multilevel data collection—space image, RCPMMPS and ground-based. It makes available to complete and properly cover integration and processing stages of the space technology application in the Earth observation and monitoring purposes.

5. Conclusions

An accuracy of the space data processing consists of the stages of data collection coming from successful merging and suiting of the space information and data taken directly from investigated area. Honestly the use of remote sensing method requires the confidence of the space image processed data with the ground-based measurements.

In this paper it is demonstrated how to use of RCPMMPS from TS/*In-situ* instead of the data when access to the ground-based information limited for some reasons for instance geographically or some other reasons of inaccessibility of area.



1. Vehicle with equipment
2. Equipment for data collection
3. Platform for data collection
4. Cable connecting data from monitored TS/In-situ to the data collection system
5. Optical and receiving system for data collection from TS/In-situ

Figure 2. Data collection from TS/*In-situ* area.

Six regional areas of Azerbaijan can be mainly covered with the lack of the ground-based data and offered RCPMMPS opens a wide opportunity for application of multilevel the Earth observation and monitoring system in the space data processing technologies.

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