

Review

Exceptional importance of the test site/*in-situ* data integrated into satellite information in earth observation

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Space information transferred into spatial data (data referenced to the known coordinate system in the selected geographic area titled as monument) has a significant contribution in Earth observation. It creates a possibility of collected information to be integrated from different sources and disciplines for a variety of applications. The main problem of an appropriate information collection relates to the data gaps and absence making incompatible data sets due to varying data needs, standards, undefined quality and barriers to sharing, accessing and using of data. For instance, data gap can arise for the reason of existing eliminations of the access to the investigated area. It makes impossible to conduct field investigations and measurements for further data integration which is necessary in data processing stage of space technology application. Remote sensing is an important source of information for a large number of Earth sciences and application fields. Data acquisition technologies and information extraction methods are pushed to give shift to user-oriented approaches where quantitative and reliable assessments, trend evaluations and forecasts are demanded. Success of this achievement depends on successful use of multilevel data collected from space-borne and field observation systems. It is necessary to optimize the infrastructure for data acquisition and analyzing, effective data processing and integration with further use for decision making. There should be an option of optimization contents of adequate instrumentation and better timing and coordination in information collection and management.

Key words: Space technology, test site, ground-based measurement.

INTRODUCTION

There is no doubt that space technology plays an important role in our daily life. A big number of Earth observing satellites are rotating in the orbit. It demands the enhancement of observing capability of satellites. Up-to-date space science and technology advances make possible the accurate integration of different information into one data which is highly important in the implementation of the global observation system targets. Remote sensing information technologies have passed different stages within the development processes from sensor design to observation missions and data application. Approaches have 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 the backbone of a spatial data information system. In conjunction with the space component, it forms a common information structure which creates an affirmative approach to the data processing assurance.

Adequately obtained and deployed information, with substantial improvement is required in space technology application in multilevel surveys, observing systems and networks together with the development of global monitoring systems in oriented information services. demands to select right way in data collection and its management which depend what instrument and time control process uses for this purpose (Main Report Socio-Economic Benefits Analysis of GMES 2006, Official Journal of the European Union 2006).

How can space technology be effectively applied in multilevel implementations – space, test site and ground measurements? How can benefits be derived from it when there is lack of access into the test site or ground measurements?

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The approach to be used is indirect ways of data collection instead of test site or ground data when there are obstacles in the access to the ground data for some reason which is the inherent part of space data processing.

DATA COLLECTION AND PROBLEM SOLVING

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

There are important detailed elements that need to be undertaken within the frame of space technology data processing. One of the important issues of space data processing is data validation. As regards this, there is existing gaps limitation for applications in the area:

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

It is necessary to calibrate used instrumentations for validation including applied software systems (providing required quality data inputs) to increase and enhance the processed data accuracy through geo-reference and integrated ground-based field data. One of the segments of data processing quality is data sharing and its integration from different levels (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 (Kancheva et al. 2009).

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

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

stage of space data processing.

INTEGRATION OF THE GROUND-BASED FIELD AND REMOTE SENSING DATA

The ground-based field information plays a major role in the elaboration of information extraction methods and validation of algorithms and models. An existing limitation of the ground-based field information access is that it makes impossible the proper execution and implementation of space data processing related to any investigated area. In particular, satellite imagery is a necessary source of data for use of remote sensing devices measuring different spectral characteristics of land cover/land use based on the methods of reflectance, emittance, and fluorescence of Earth segments operating in a wide range of electromagnetic wavelengths such as optical, thermal and radio, depending on the applications' necessity. The spectral reflection of land features are associated and depended on the investigated types of vegetation, soils, rocks, water and its biophysical and chemical properties, physiological and morphological state like biomass, leaf area index, chlorophyll, water content, mineral composition, organic matter, etc.

In conformity with the general way of space data processing, this study identified two stages of the processes:

1. Data collection and validation of the ground-based field data.
2. Space data selection with further integration into the ground-based field data.

Figure 1 shows space data processing stages integrated into ground-based field data as the evidence of the processing validation. It is possible that there is limitation to access of the ground-based field data in some cases for some reasons (complicated geographical location, political issues, etc). On the other hand, the lack of ground-based field information makes impossible the validation of space information processing stage.

How can the earth observation segments with its features be defined and interpreted on the earth surface with regards to the above indicated circumstance?

It is obvious that it cannot be interpreted in the case of lack of ground-based field information with space data using appropriate methods and software technology processing. Comparison and verification of the retrieved land cover reflectance by ground-based reflectance measurements are essential for accurate information content extraction from remotely sensed data. In other reliable predictive equations of land cover parameters obtained from spectral data, the predictive ability of the established relationships has to be verified and integrated into the ground-based field measurements, correlated to the atmospheric impacts made on the remote sensing data. Besides the indicated issues, ground-based information accessed from field measurements has a significant position in calibration purposes and analysis of remotely sensed data. With the exception of the control and calibration of measurements, ground based field

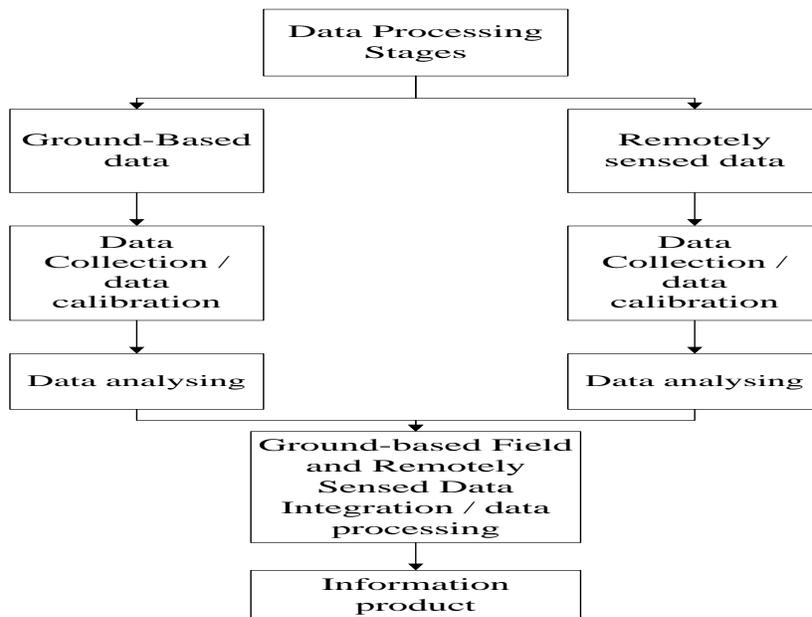


Figure 1. Integration stages of remotely sensed and ground-based field data.

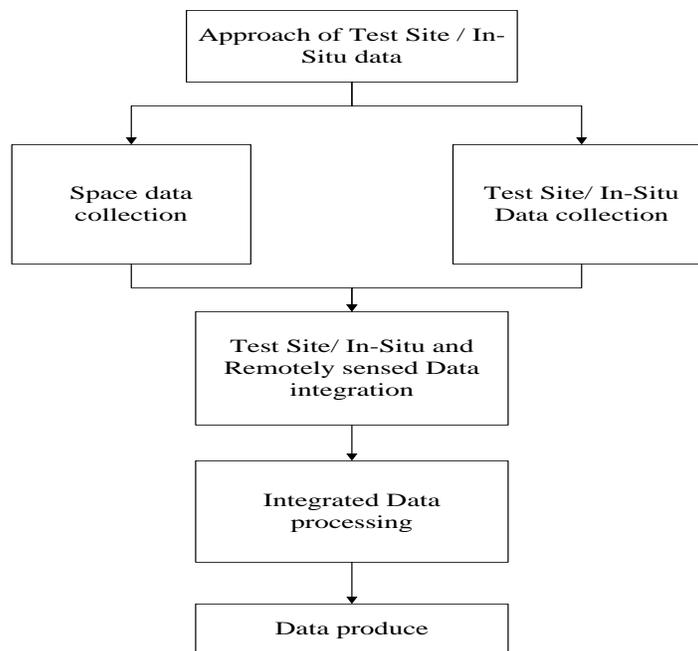


Figure 2. The stages of the space data processing integrated into TS/*in-situ* data.

information is required for checking the performance of remote sensing systems. It makes available the use of instruments in proper classification and data interpretation analysis.

Data classification for land cover/land use in the case of the lack of ground-based field data can be embraced by the use of selected Test Site/*in-situ* (TS/*in-situ*) data containing a similar nature of the Earth features in the investigated area. For implementation of the undertaken

task, the facilities used in the first stage of processing make accessible the expected data from TS/*in-situ* area. It is required to facilitate the condition of remotely sensed data collection from TS/*in-situ* area instead of ground data as ground-based field source. The structure of the data processed with the use of TS/*in-situ* involvement is shown in Figure 2.

Undoubtedly, it is necessary to consider TS/*in-situ* measurements to provide processing support of satellite

data and imagery in terms of the following aspects:

- (i) Spectroradiometric calibration of remote sensing instruments;
- (ii) Radiometric data corrections for the atmospheric effects;
- (iii) Transferring image data to target spectral response;
- (iv) Referencing remotely sensed data to ground-truth spectral characteristics;
- (v) Enhancement of data accuracy;
- (vi) Elaboration of data processing algorithms;
- (vii) Integration and fusion of data from different sources and levels (platforms);
- (viii) Development of models describing land cover state, trends and forecasts;
- (ix) Ground- truth feedbacks and methods for validation of spectral-biophysical models;
- (x) Verification of information extraction techniques.

SELECTION OF TEST SITE/*IN-SITU* DATA ACCESS AREA IN SPACE TECHNOLOGY APPLICATIONS

As the general way, *TS/in-situ* is the artificially developed area which allows the area to use ground-based field measurements with further purpose of integration into 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 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 a limited issue for several reasons:

- (i) To embrace main land cover/land use features of the investigated area for classification.
- (ii) Required time for *TS/in-situ* development with the main land cover/land use classification reflecting the investigated area.
- (iii) The necessity of a huge number of artificial test sites to be developed around the world.

How can the problem be solved with the comprehensive approach in order to eliminate obstacles when there is existing limited access to the ground-based field data collected from the investigated area?

There is no doubt that the selected areas for *TS/in-situ* purposes have to be developed with the large land use/land cover features for classification which can be integrated into the space data as a main part of data processing. This study describes and offers the most suitable way of developing natural *TS/in-situ* data access. It is important to emphasize that there are only few papers dedicated to the test site studies and investigations.

Azerbaijan and its natural features

Climate

Although Azerbaijan is a small territory, it has unique

natural-climatic features. From eleven existing climatic zones, 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, and average temperature in July is +27.9°C. The climate ranges from temperate to subtropical, though strong northern winds are mainly 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, and Talish Mountains and Lenkoran lowland.

The rivers and lakes

More than 1000 rivers flow 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 and their number amounts to 250.

Flora

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

Fauna

The fauna of Azerbaijan is rich and sundry. More than 12000 kinds of animals and birds live here. Bears, turs, wild boars, goitered gazelle (jeyran), wolves, foxes, etc., are found here. The world of birds also varies in the territory of the country. More than 250 kinds of birds live only in Kyzyl-Agaj reserve.

Azerbaijan territory as the *TS/in-situ* data source

The nine zones from the eleven existing climate zones, having rich relief, and fauna and flora features make the territory of Azerbaijan attractive for the *TS/in-situ* area used in data collection where there is limited ground-based field data access due to different reasons. The data accessed from *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 the investigated area as an important element of reliability and confidence of space data processing.

The lack of ground-based field data can prompt the division of the country's territory into six *TS/in-situ* regions making available the use of data measurement and collection of appropriate remote sensed data for further

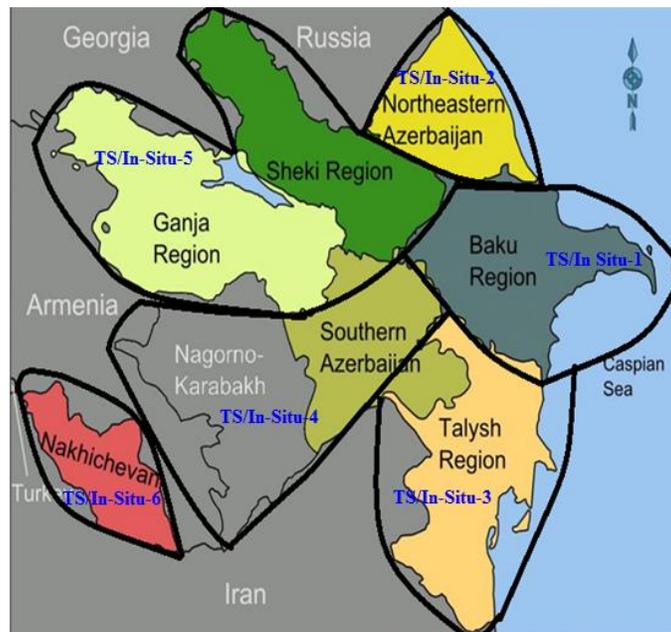


Figure 3. TS/*in-situ* data areas in Azerbaijan.

integration into space data processing stage. The exception of the Azerbaijan territory is as a result of the large space classifications of the Earth's surface, thanks to the existing natural features. Figure 3 shows TS/*in-situ* areas with a rich content of the land cover/land use requirements.

For the full stages of the information product based on space technology application, it is required that there should be an implementation of data acquisition and data configuration from the integration of remote systems and ground-based field data when available, or is to use TS/*in-situ* data when ground-based field data are not available.

A content of TS/*in-situ* systems for data acquisition is as follows:

- (i) Geo-referencing for data merging and data calibration and validation.
- (ii) Spectrometric and other sensors for data acquisition.
- (iii) Remote sensing data gathering platforms development; and
- (iv) Ground-based field data gathering facilities.

Azerbaijan territory can be used as TS/*in-situ* area as an additional level merged between remote sensing and ground-based filed data source. The scale of application of the territory would be successfully covered within the worldwide framework. It opens an opportunity for the purpose of multilevel data access – remotes sensing, ground-based filed data and TS/*in-situ* areas around the World for a full stage of space technology application. It is not necessary to establish a big number of artificially TS/*in-situ* areas for use in space data processing. The territory of Azerbaijan can be commonly used to satisfy

the technical and technological needs of TS/*in-situ* data for any countries involved on Earth studies with space technology or other applications as an interim stage of multilevel measurements as it is seen above in the given description.

CONCLUSION

The use of remote sensing method demands confidence of space image processed data with ground-based measurements. An integration of multilevel data based on satellite image, TS/*in-situ* and ground-based field measurements are evidencing accuracy of the conducted investigations. It has to be considered as the important stages of space technology applications in obvious circumstances.

It is not always possible to have an access into ground-based information (for instance geographically, politically or some other reasons of inaccessibility of investigated area) which creates a significant complications for the information products reached by application of space technology. Therefore this data gap needed to be embraced by artificially developed areas with the similar land cover/land use features for further classification. In general, the area is developed as a field data source attracting the test site which uses one of the level in remote sensing data processing.

This paper demonstrates the possibility of using Azerbaijan territory as TS/*in-situ* area, thereby opening an excellent environment for the multilevel data access in space image processing. The motley natural segments, with large geographical and geological representatives and other very important options of Azerbaijan territory make attractive its use as TS/*in-situ* area. An advantage

of such application is that it covers huge demands and requirements of data access in space image processing based on remote sensing methods. This approach eliminates development of a big number of artificial test sites around the world with obstacles of limited use due to technical, technological, economical and political reasons. The whole territory of the country can be successfully used for TS/*in-situ* purposes in a global world scale of Earth monitoring in land cover/land use classification with space technology application.

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