REMOTE SENSING IN EUROPE: STATUS ANALYSIS AND TRENDS FOCUSING ON ENVIRONMENT AND AGRICULTURE

Ioannis MANAKOS

Dr. & EARSeL Chairman, Center for Research and Technology Hellas, Institute of Information Technologies, Thessaloniki, 57001, Greece, imanakos@iti.gr

ABSTRACT

Target of the European policy is to safeguard and improve, wherever possible, through directives and regulations the quality of life of the citizens. High priority is set to the protection of the environment through the rational usage of the resources, the food security, and the reduction of risks and threats. Tackling the challenge, Information Services, based on the combination, analysis and modeling of data received from Earth Observation satellites as well as ground-based networks, operate or are planned to operate in an integrated manner to provide wide-area and cross border harmonized geo-information products. To this end, Remote Sensing is a key element for registering the surface status near real time, monitoring changes, and supporting and testing scenaria by projecting the validated trends in the present and past to delineate possible situations in the future.
This article attempts to provide a brief overview of European initiatives, potentials and limitations of existing approaches, existing service specifications and operation requirements, and an update regarding on-going projects, fostering Remote Sensing incorporation in the Decision Support and Policy Implementation chain.

Keywords: Europe, Remote Sensing, Environment, Agriculture

1. CONSIDERATIONS

Major goal of States' policies is the preservetion and, wherever possible, the improvemnet of the quality of life of their citizens. Challenges remain in relation with food security, conservation of natural resources, reduction of risks and threats, and sustainable urban and rural development. The human - environment interaction surface shall be managed in four (4) dimensions (spatial and time ones). Multifold perspectives of the human footprint shall be taken into consideration, and tackled in next decisions to be taken: the governmental, societal, economical, and environmental pillars of sustainability require decision taker's attention. Towards this direction studies like the Millenium Ecosystem Assessment (Hassan et al., 2005) pave the way introducing and combining the ecosystem services (supporting, provisioning, regulating, and cultural ones) to the human's constituents of well-being (security, basic material for good life, health, good social relations, leading to freedom of choice and action). Indirect drivers are identified: a) Demographic, b) Economic, c) Sociopolitical, d) Science & Technology, and e) Cultural & Religious. Direct ones, as well: a) Changes in Local Land Use & Land Cover, b) Species introduction or removal, c) Technology Adaptation and Use, d) External Inputs, e) Harvest and Resources consumption, f) Climate Change, and g) other natural, physical, and biological drivers.
Recognition and quantification of processes and impacts require a reply to the key questions of where something is happening, what is its extent, which is the reason, is this in compliance with a reference line of sustainability, is this reversable, are there interrelations to be considered, and in which geographical extent. All aforementioned require the engagement of remote sensing analysis and geospatial information update products and procedures.
Strategic areas of intervention are recognized by the European Environmental Agency (EEA) (Dufourmont, 2011), and consider a) environmental topics, such as air quality, air pollutant emissions, biodiversity, greenhouse gas emissions, freshwater, b) cross-cutting topics, such as climate change impacts, vulnerability and adaptation of ecosystems, environment and health, maritime issues, sustainable consumption and production and waste, land use, agriculture and forestry, energy, transport, c) integrated environmental assessment topics, such as integrated environmental assessment, regional and global assessment, decision support, economics, strategic design, and d) information services and communication topics, such as shared environmental information system, and communications.
European Union (EU) issues policies driven by aforementioned considerations. Policies are supported and iteratively improved based on projects' results of directed research, according to EU's funding frameworks. Target is the operationalization of the research results, which is supported by developmental and capacity building projects, in addition to dissemination and awareness raising campaigns. Feedback from beneficiaries and end users across the member countries is sought, and the whole aforementioned circle runs another time.

2. SUPPORTERS

Supporters in Europe’s policy consultancy and implentation towards geospatial data retrieving and handling issues are a) the EEA, b) the European Space Agency (ESA), c) the Global Monitoring for Environment and Security Programme (GMES), d) networks of excellence and associations and organized scientific and researcher societies acting either on European or National levels (like the European Association of Remote Sensing Laboratories (EARSeL), the European environment and information network (EIONET), the Remote Sensing and Photgrammetry Society (RSPSoc), the European Association of Remote Sensing Companies (EARSC), etc.). Their task is to safeguard Europe’s future, competence, adoptability, and excellence within a changing world.
Activities are related a) with the space infrastructure development in such a way that core services addressing the strategic areas of intervention (see chapter 1.) are covered, b) with the methodologies advancement in a way that standardized, objective, and near real time information may be provided, c) with the definition and expansion of the downstream services to create added value products for the end users, d) with the training and capacity building of the citizens in a life long learning perception, e) with the dissemination and promotion of data and techniques, and f) with the support of development of commercial inititiaves towards sophisticated products for every day life out of the spaceborne ones.
Especially the scientific audience, following and supporting policy developments, is organized in Activity Groups (Special Interest Groups), initiating series of Workshops and Symposia, on an ever growing rate and topic specialization, bringing actors together in brain storming events. First initiatives were triggered by the need of the European politicians to receive support on the potential and usage of the new spaceborne products in the 1970s (taken from Godefroy et al., 2008 as is): In 1971 the Parliamentary Assembly of the Council of Europe launched the so-called “Exercise on Scientific Cooperation” under the responsibility of the Parliamentary Committee on Science and Technology. It was directed by the European Joint Committee for Scientific Cooperation with two objectives:

a) to contribute to the strengthening of European scientific cooperation through the setting up of European scientific working parties in specific areas, and
b) to help the Parliamentary Assembly in its political decision-making through the organisation of European parliamentary hearings.

As a result the EARSeL emerged in 1976 with a view to creating an association between European remote sensing laboratories and institutions to work on problems in remote sensing of general interest to such bodies as the Council of Europe and ESA. Principal focus was and still remains to:

- stimulate and promote education and training related to remote sensing and Earth observation,
- form a bridge between technology and applications of interest to the wide user community,
- assist the sponsoring agencies in the development of new sensors and systems and in any technical matters of relevance,
- provide a network of experts for the agencies in Europe,
- carry out joint research projects on the use of remote sensing for research, monitoring and education,
- promote co-operation between remote sensing experts and the environmental managers and decision-makers.

EARSeL has the unique opportunity and utilized it to go over political and country barriers with the flag of Europe and scientific cooperation, as the case of former “East-West” division was.

3. STATUS

Internationally, one may witness more and more initiatives taken by Agencies acting on a National, Regional, Continental or Global level in an effort to establish a benchmark for assessing land cover changes, to quantify the reliability of the information received, and to enhance the potential of space applications by improving hardware and software towards the new findings of scientists and end user requirements. Target is the provision of at most accurate information in a form that it is of use to the decision makers and policy implementing bodies. The EEA, the ESA, and the GMES funded with many millions of Euros last decade’s projects (like the geoland, geoland2, and BOSS4GMES series) leading to this end (http://www.land.eu/ on 15.10.12), followed up this year by the implementation and streamlining of the GIO (GMES Initial Operation) lots throughout Europe (EEA, 2011). Asian and American Organizations acting together under common initiatives as the Group on Earth Observation (GEO), and the International Society of Digital Earth (ISDE) or UNESCO Natural and Cultural Heritage Programmes are seeking partnerships and solutions, forming a “striking force” in an effort to generate land cover products with highest possible precision (i.e. GEO, 2011). Questions arising in Land Cover Special Interest Groups (SIGs), like the one the EARSeL is leading, or the ones the International Society of Photogrammetry and Remote Sensing (ISPRS) is operating, are always around same keywords: precision of information retrieved, homogenization of the result production efficiency at most biogeographical regions of the Earth, methodology improvement, model adaptation and adjustment to most regions taking into account the specificities of each area, while at the same time being able to keep as possible standardized data assessment procedures. A series of satellites are being prepared (Sentinel series, PROBA-V, ZY-3 from China launched this year, etc.) to guarantee continuation of the data

provision to decision takers, while the International Users Community is setting along with the scientists its requirements, guiding together with the sponsors the sensors' development.
Within the aforementioned framework one may notice from the literature and own experience that systematic acquired ground truth data are missing, while spaceborne generated datasets being utilized in numerous projects around the globe are mistrusted for their reliability and applicability. There are big debates in the scientific community about the quantification of accuracy assessment rules and the influencing factors of topography, projection systems, and category and rule set definition for land cover and change detection mapping. The final outcome of all discussions is that there are more than enough data, and enough methodologies. Coordination and homogenization of the results in meaningful products, the users around the globe may use and trust, is missing. The INSPIRE directive (INSPIRE, 2007) supports this endeavor and Europe's Societies are closely following. Copyright issues are also a "hot" debate topic, addressed also within the new EU Framework Programme for Research and Innovation (Horizon 2020).

4. CHALLENGES

Remote Sensing activities face challenges driven by the recent research and technology developments in:
a) imagery classification: the new generation of very high resolution (VHR) and hyperspectral sensors require the development of a new generation of classification techniques. Active and semisupervised learning are examples of approaches suitable to the analysis of the expected data. Two main different operational scenarios are suggested: a) definition of training sets by interactive labeling of unlabeled samples carried out by photointerpretation, and b) definition of training set by using active learning techniques for driving in-situ data collection campaigns. New strategies, which integrate semi-supervised learning with active learning shall be investigated (Bruzzone, 2009).
b) change detection (CD) analysis: from the simple post classification comparison in the 1970s up to the complex algebra transformations and classifications of the 2000s, like Texture-based Algebra, Robust Change Vector Analysis (CVA), Multilevel CVA, Cross-Correlation Analysis, Object-based Image Differencing, Robust Image Differencing (LCM), Transformation Kernel Principal Component Analysis (PCA), Fast Fourier Transform, Object-based Multivariate Alteration Detection (MAD), Kernel Maximum Autocorrelation Factor (MAF), Object-based Post-Classification Comparison (PCC), Multisource PCC Support Vector Machines (SVMs), the challenges remain: preprocessing issues (geometry & radiometry), the influence of CD algorithm, the segmentation approach and threshold selection, the accuracy of the change mask, the influence of number and type of sensors, and the influence of surface features.
c) data fusion from optical, radar, and thermal infrared sensors, operated at various heights: the abundance of various sources of information and the information retrieval potential lying on the synergy and complementarity of their combined usage is an ever existing and intensified exercise for all actors in the field. Main objective remains the performance improvement in capturing the spatio- temporal variation of surface elements.
d) accuracy assessment: Ground data quality is of major importance on estimating the accuracy of land cover change detection and land cover change extent. Quality impacts vary with nature of errors and often with prevalence. Challenges may be identified in the genuine difficulty in discriminating classes (definition), technical problems, such as mis-registration, pre-processing, use of inappropriate reference targets (i.e. leading to spatial autocorrelation that violates the assumption of sample independence and spatial variability of spectral signatures of land covers), use of misleading measures of accuracy, and use of a biased approach to accuracy assessment. In addition, one has to recognize that sources of error and uncertainty originate also from error in the ground data (Foody, 2010). Ground data are not a gold standard reference, they contain error and are not always as truth. Recently there is an effort to find ways to utilize the plethora of available increasing amount of in situ images from citizen sensors acquired for arbitrary reasons to increase the training capacity of the classifier, and accuracy of the derived products.

5. TRENDS AND OUTLOOK

Having a record of more than four decades of innovation, developments, and achievements in Remote Sensing technologies, methodologies, and applications, Europe proceeds from the pure research on island topics and solutions towards multi-modal and –source data assessment, processes automation and data harmonization, web downstreaming service development, and tailor made solutions. Land cover/ land use change, disaster response, detailed mapping for monitoring purposes, 3D mapping, are among the applications connected with environment and agriculture that show the way forward. Expectations are directed towards the combination of observations from diverse instruments (radars, lidars, radiometers, optical sensors, etc.) in intelligent ways (Freeman, A., 2012).
Europe raise high expectations for data acquisition and abundance from the upcoming fleet of Sentinels, which together with the existing and upcoming TerraSAR-X, Pleiades, DMCii, JPSS missions in the US, the GCOM series in Japan, and other third party ones, are supposed to cover the demand from and for most earth observation applications. Completed (geoland, BOSS4GMES, MS MONINA, PROBA-V Preparatory Program, SEOS, other GMES and GEO related projects), and on going (geoland2, BIO_SOS, GMES4REGIONS, GEO related projects, and others not mentioned here) projects, have paved the way towards GMES Initial Operations and Pan-European

coverages' production, been promoting capacity building, and enhancing member states' engagement. With the new call for FP7 Space related proposals, closed two weeks ago (21st November 2012), EU agencies expect to establish a basis for the development of innovative new GMES products or improving the performance of applications and services combining in a novel manner existing and upcoming sensor data with in-situ ones. The results are expected in return to feed in the decision support for the technical features that the new observation techniques in the next generation of observation satellites shall carry on board.

In relation with the content of research one must look at the latest developments and advances of human activities to undestand what will be the future request from the remote sensing community for environment and agriculture: Today the land is covered in general by artificially sealed and urban areas, arabale and permanent crops, forests and wetlands, semi-natural and altered landscapes, open and bare soils, and pastures. Tomorrow urban sprawl, bio-fuel crops, food crops, soil degradation, rehabilitation and reforestation efforts comprise parts of a new picture of the landscape. The water resources shall increasingly be worrying the scientific community and the society, and, in addition, climate change impacts shall be identified, confronted and mitigated. Biodiversity, food security, natural resources depletion, deforestation, soil degradation, disaster management, and urban sprawl are among the most important keywords for the future remote sensing activities and applications.

Still, whatever the developments will be, main issues that remain are:

i) Research direction, its documentation, and promotion to the wider public of actors and policy implementers.
ii) Budget and the quality of the produced product: It is expected that funding will be increased for the Operational Program of the EU and reduced for the research and develpment sector.
iii) Harmonization and usability of the service: There is an urge and a strategy to address it, to produce thematic layer products in a strandardized, homogenized way, for which quality and credibility remain stable across wider areas, so that administrative and projects' areas implementation borders, will not hinder their joint utilization.
iv) Engagement of the Member States and adoption of research and technology achievements: Member states, funders of the policy making and implementation, shall remain interested and aware of the potential of remote sensing products usage for the security and enhancement of the quality of life of their citizens. They shall be supported to promote the assimilation of the new advancements in states' and everyday life functions, once their value is proven.

REFERENCES

Bruzzone, L., Marconcini, M., 2009, Toward an Automatic Updating of Land-Cover Maps by a Domain Adapatation SVM Classifier and a Circular Validation Strategy, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 47, No. 4, pp. 1108-1122.

Dufourmont, H., 2011, Requirements in LULC monitoring in Europe, EEA keynote presentation at the 4th EARSeL SIG WS on LU/LC in Prague.

EEA, 2011, DK-Copenhagen: GMES initial operations 2011–2013 — land monitoring services: high resolution land cover characteristics of 5 main land cover types — 6 lots, 2011/S 149-247068, *Contract Notice*, Services, http://ted.europa.eu/udl?uri=TED:NOTICE:247068-2011:TEXT:en:HTML&src=0, (15.10.12).

GEO, 2011, *GEO 2012-2015 WORK PLAN*, Revision 1, p.82.

Godefroy, M., Østrem, G., Vaughan, R., 2008, *EARSeL'S HISTORY: The First 30 Years of the European Association of Remote Sensing Laboratories*, Motala Grafiska AB, Sweden, p.115.

Foody, G. M., 2010, Assessing the accuracy of land cover change with imperfect ground reference data, *Remote Sensing of Environment,* Volume 114(No 10), pp. 2271-2285.

Freeman, A., 2012, How we will view the Earth from Space in 2025, *Delegate Handbook of RSPSoc 2012 Conference*, pp. 29-31.

Hassan, R., Scholes, R., Ash, N. (eds.), 2005, *Ecosystems and Human Well-being: A Framework for Assessment - Current State and Trends*, Volume 1, Island Press, pp. 1–25.

INSPIRE, 2007, Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), p.14.