

IEEE

GEOSCIENCE *and* REMOTE SENSING

Newsletter



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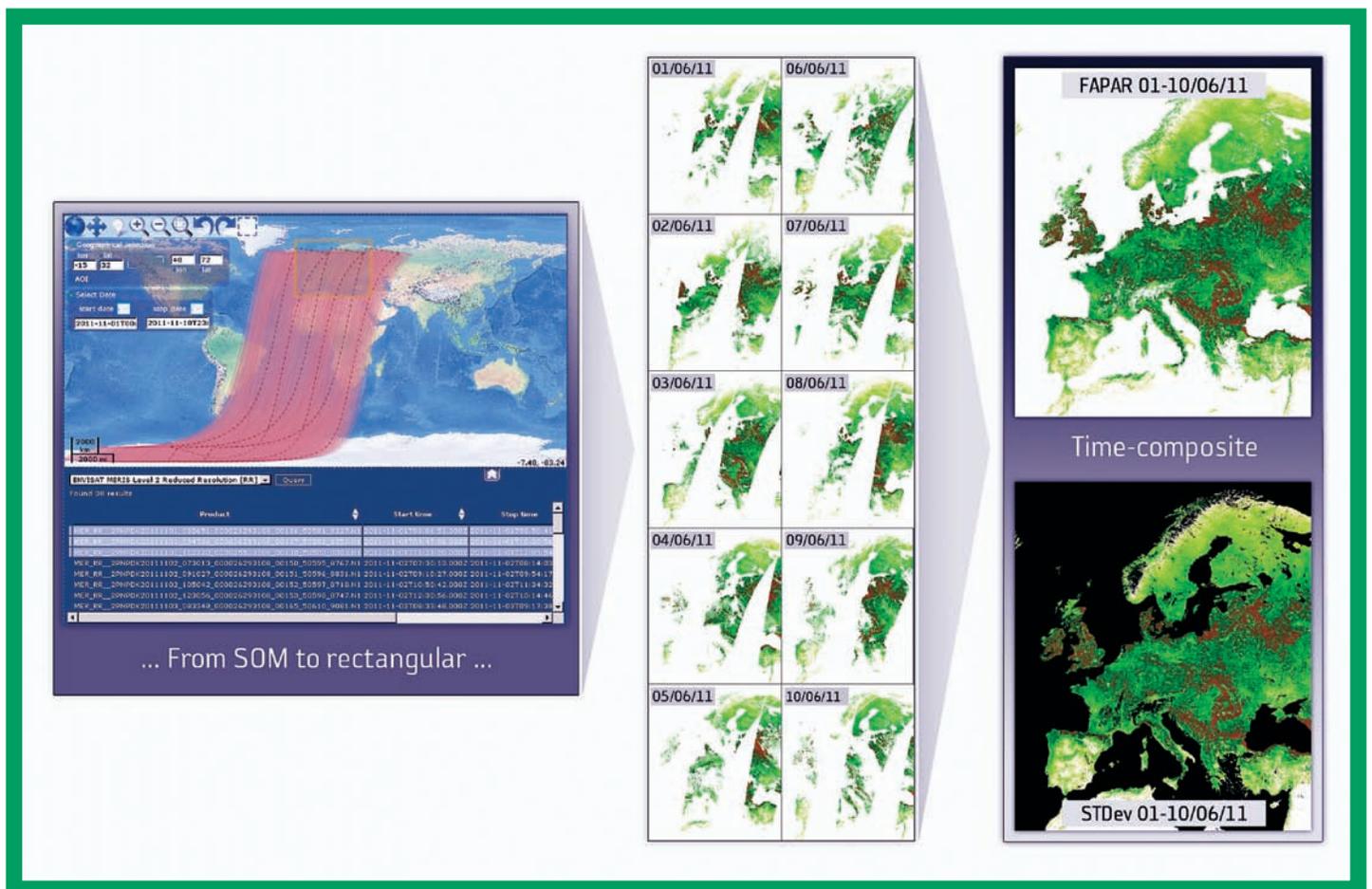


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Input	April 15	July 15	Oct 15	Jan 15

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This first issue of the IEEE Geoscience and Remote Sensing Newsletter in 2012 contains many interesting articles on various technical areas of remote sensing, as well as contributions on the activities of the IEEE Geoscience and Remote Sensing Society (GRSS). Starting from this issue, we will publish in the *Education Column* a section in which we inform the community of the recently completed Ph.D. dissertations in the fields of activity of our society. We will print the title of the dissertations, the student's and advisor's names and the dates of the theses defenses. The electronic version of each thesis will then be available for download at the indicated link. This is an important opportunity for beginning researchers to increase the visibility and impact of their work. It is also a useful initiative for our community to increase the awareness of the most recent research work accomplished by

a new generation of engineers and scientists. I strongly encourage you to contact me or Dr. Antonio Plaza, Director of Education for IEEE GRSS, for information on submitting recent Ph.D. dissertations defended and published in the technical areas of GRSS.

This issue of the Newsletter contains three main articles in the *Features* section. The first is a paper that presents a model for the scientific exploitation of Earth Observation missions. This paper describes the "European Space Agency Research and Service Support" model, which has been successfully experimented in the Envisat era, and is the foundation for supporting Earth Observation research in the coming Sentinel era. The second main feature article addresses the problem of hyperspectral unmixing for vegetation monitoring. The article points out the importance of the upcoming new hyperspectral satellites (e.g. PRISMA and EnMAP) for many applications related to vegetation, and describes the challenges associated with the extraction of the land-cover information at a spatial resolution on the order of tens of meters. This resolution necessitates the development of effective solutions to the problem of spectral unmixing. The article presents the activities carried out on this topic in two research projects. The third feature article addresses the situation in Japan one year after the earthquake, tsunami and nuclear accident, focusing on Sendai

(continued on page 4)

President's Message



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The year 2012 is a milestone year for the Geoscience and Remote Sensing Society (GRSS), the fiftieth anniversary of the GRSS, which started as the Group on Geoscience and Electronics (G-GE) in 1962 and evolved later into the society we know today. To celebrate the anniversary, the GRSS will publish a commemorative book which will appear in July.

Many additional important activities are on the agenda of the GRSS in 2012, including our annual premier conference, IGARSS, which will be held in Munich, Germany July 22 through July 27. The Technical Program Committee (TPC) meeting for this year's conference was held in Frascati, Italy on March 2. The task of the TPC this year was quite challenging because the volume of received abstracts received exceeded by far the number of abstracts received for prior conferences. The IGARSS 2012 team has done an excellent job in preparing for the conference.

The GRSS Administrative Committee (AdCom) meets three times a year; in the winter, in the summer (just prior to IGARSS) and in the fall. These meetings always run for two days, and the agenda is full of important reports, discussion items and new initiatives. The GRSS held its 2012 Winter AdCom meeting in Frascati on March 3–4. Among

(continued on page 9)

Cover Information: Example of production of 10-day FAPAR from the ENVISAT MERIS using G-POD environment.



Newsletter Editorial Board Members:

(Editor's Comments continued from page 3)

and Tsukuba, Japan. Sendai was the host city of IGARSS 2011 before it had to be moved to Vancouver, chaired by Prof. Motoyuki Sato of Tohoku University in Sendai. Tsukuba will host APSAR 2013 next September. Akira Hirose of the University of Tokyo will serve as General Chair of APSAR.

The *Book Review* column presents an overview of *Hyperspectral Remote Sensing of Vegetation*, edited by Prasad S. Thenkabail, John G. Lyon and Alfredo Huete. The review of this interesting book was written by Francesca Bovolo, researcher at the University of Trento, Italy.

The *Technical Committee Corner* column provides an overview of the upcoming 2012 Data Fusion Contest. This year the contest is designed to investigate the potential of multi-modal/multi-temporal fusion of very high spatial resolution imagery. I encourage you to take part in this challenging and interesting contest.

The *Chapters Corner* column presents the 2012 GRSS Distinguished Speakers Program. After the revitalization of this program completed in 2011, the article shows in detail the process to be followed for booking a Distinguished Speaker and for obtaining financial support provided by the GRSS to its local chapters in order to cover travel expenses of inviting a speaker. In addition, the article provides bios and topics addressed by the 2012 GRSS Distinguished Speakers. I welcome the new speakers, and I strongly encourage chapters to take advantage of this important and beneficial program.

The *Education Corner* column contains two main contributions. The first is a paper that describes the education-oriented activities carried out in the framework of the Hyperspectral Imaging network (Hyper-I-net) Marie Curie Research Training Network. This project was designed to build an interdisciplinary European research community focusing on hyperspectral imaging. The second contribution refers to the section mentioned at begin of these comments in in which we inform the community of the recently completed Ph.D. dissertations in the remote sensing and geoscience fields.

I would also like to draw your attention to the various calls for nominations reported in this issue. Once again, I would emphasize the call for applications for elevation to IEEE senior member. There are many engineers and scientists among our Society members who meet the eligibility criteria but are not yet IEEE Senior Members. I encourage them all to apply and all IEEE Senior Members to nominate eligible colleagues for this valuable recognition.

I wish everyone an enjoyable and productive spring season.

Lorenzo Bruzzone
Editor, IEEE GRSS Newsletter



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INCOMING AE

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Antonio Plaza received the M.S. and Ph.D. degrees in computer engineering from the University of Extremadura, Caceres, Spain. He was a Visiting Researcher with the Remote Sensing Signal and Image Processing Laboratory, University of Maryland Baltimore County, Baltimore, with the Applied Information Sciences Branch, Goddard Space Flight Center, Greenbelt, MD, and with the AVIRIS Data Facility, Jet Propulsion Laboratory, Pasadena, CA. He is currently an Associate Professor with the Department of Technology of Computers and Communications, University of Extremadura, Caceres, Spain, where he is the Head of the Hyperspectral Computing Laboratory (HyperComp). He was the Coordinator of the Hyperspectral Imaging Network (Hyper-I-Net), a European project designed to build an interdisciplinary research community focused on hyperspectral imaging activities. He has been a Proposal Reviewer with the European Commission, the European Space Agency, and the Spanish Government. He is the author or coauthor of around 300 publications on remotely sensed hyperspectral imaging, including around 70 Journal Citation Report papers, 20 book chapters, and over 200 conference proceeding papers. His research interests include remotely sensed hyperspectral imaging, pattern recognition, signal and image processing,

and efficient implementation of large-scale scientific problems on parallel and distributed computer architectures.

Dr. Plaza has coedited a book on high-performance computing in remote sensing and guest edited seven special issues on hyperspectral imaging for different journals, including the IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING (for which he serves as Associate Editor on hyperspectral image analysis and signal processing since 2007), the IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING (for which he serves as a member of the steering committee since 2011), the International Journal of High Performance Computing Applications, and the Journal of Real-Time Image Processing. He also serves as an Associate Editor on Education for the IEEE GEOSCIENCE AND REMOTE SENSING NEWSLETTER. He has served as a reviewer for over 300 manuscripts submitted to more than 50 different journals, including more than 150 manuscripts reviewed for the IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING. He has served as a Chair for the IEEE Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing in 2011. He has also been serving as a Chair for the SPIE Conference on Satellite Data Compression, Communications, and Processing since 2009, and for the SPIE Remote Sensing Europe Conference on High Performance Computing in Remote Sensing since 2011. Dr. Plaza is a recipient of the recognition of Best Reviewers of the IEEE GEOSCIENCE AND REMOTE SENSING LETTERS in 2009 and a recipient of the recognition of Best Reviewers of the IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING in 2010. He is currently serving as Director of Education activities and member of the Administrative Committee of the IEEE GEOSCIENCE AND REMOTE SENSING SOCIETY.



GRSS MEMBER HIGHLIGHTS

GRSS MEMBERS ELEVATED TO THE GRADE OF IEEE FELLOW FOR 2012

Jocelyn Chanussot “for contributions to data fusion and image processing for remote sensing”

Steven Durden “for contributions to microwave remote sensing and radar systems, including spaceborne cloud radar”

John Mathews “for contributions to radar observations of meteors”

Eric Miller “for contributions to inverse problems and physics-based signal and image processing”

Simonetta Paloscia “for contributions to active and passive microwave remote sensing of vegetation and land surfaces”

Scott Tyo “for contributions to transient electromagnetics ultra-wideband antennas, and mesoband radiating systems”

Malcolm Heron “for contributions to the application of radio science to oceanic and terrestrial remote sensing”

GRSS MEMBERS ELEVATED TO THE GRADE OF SENIOR MEMBER DURING THE PERIOD NOVEMBER 2011–FEBRUARY 2012

November:

Joseph
Helmut
Paul
Michael
Fred
Sivakumar

Buckley
Essen
Fieguth
Inggs
Kruse
Venkataraman

Kingston Section
Germany Section
Kitchener-Waterloo Section
South Africa Section
Denver Section
South Africa Section

February

Yuliya
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Maeda
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Nanjing Section
Tokyo Section
Tokyo Section

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You can also visit the GRSS website: <http://www.grss-ieee.org>



CALL FOR NOMINATIONS FOR THE GRSS ADMINISTRATIVE COMMITTEE

The Nominations Committee calls upon our membership to nominate members to serve on the GRSS Administrative Committee (AdCom). A nominating petition carrying a minimum of 2% of the names of eligible Society members (~60), excluding students, shall automatically place that nominee on the slate. Such nominations must be made by May 25, 2012. The Nominations Committee may choose to include a name on the slate regardless of the number of names generated by the nominating petition process. Prior to submission of a nomination petition, the petitioner shall have determined that the nominee named in the petition is willing to serve if elected; and evidence of such willingness to serve shall be submitted with the petition. Candidates must be current members of the IEEE and the GRSS.

Petition signatures can be submitted electronically through the Society website, or by signing, scanning and electronically mailing the pdf file of the paper petition. The name of each member signing the paper petition shall be clearly printed or typed. For identification purposes of signatures on paper petitions, membership numbers or addresses as listed in the official IEEE membership records shall be included. Only signatures submitted electronically through the Society website or original signatures on paper petitions shall be accepted.

A brief biography of the nominee, similar to that used for TGARS authors, but not to exceed one page, will be required and should be submitted with the nominating petition by May 25, 2012 to the GRSS Nominations Committee, c/o Dr. David G. Goodenough, IEEE GRSS Nominations Chair, Computer Science Department, University of Victoria, PO Box 3055, STN CSC, Victoria, BC, V8W 3P6, Canada. E-mail: dggooden@uvic.ca.

The slate derived by the Nominations Committee shall be presented to the Society membership at large via electronic ballot, and the three candidates receiving the greatest number of votes shall be elected. The Administrative Committee shall hold an Annual Meeting in November, 2012 after results of this vote are known, at which time elections will be held to fill the remaining three regular vacancies in the Administrative Committee, with all successful candidates to start on January 1, 2013.

Our AdCom consists of 18 elected persons, each of whom serves for three years. Their terms are overlapping to ensure continuity. Additional information on the society and the AdCom is available at <http://www.grss-ieee.org/>. We thank all candidates for their willingness to serve and support the IEEE Geoscience and Remote Sensing Society.

(President's Message continued from page 3)

items discussed at the meeting I am happy to highlight that a Phase 1 proposal for a GRSS magazine has been approved by the IEEE Technical Activities Board (TAB) and a Phase 2 proposal is in preparation. The Phase 2 proposal will be submitted to TAB in a couple of months, and if successful, the GRSS magazine will be launched in January 2013. Another item of interest from the meeting is that the GRSS will offer its first Summer School in Munich, just prior to IGARSS 2012. Current information on the summer school is available at <http://www.igarss2012.tum.de/>. It will run for two to three days. Outstanding speakers have been selected to give lectures at the summer school. A third item I would like to mention from the AdCom meeting is that the GRSS will offer scholarships to Masters and Ph.D. students starting later this year. Please watch our website <http://www.grss-ieee.org/> for updates.

The GRSS has recently started participating in two important IEEE activities. One such activity is the IEEE Women in Engineering (WIE) working group. Our representative is new AdCom member Gail Skoforonik Jackson. The other activity is the IEEE Life Sciences New Initiative (LSNI). Former *IEEE Trans. on Geoscience and Remote Sensing* (TGRS) Edi-

tor James A. Smith is the GRSS representative in LSNI. If you are interested in these two activities, please do not hesitate to be in touch with us.

I am very happy to announce that a paper which appeared in GRSS journal was selected as the 2012 recipient of the IEEE W.R.G. Baker Award. The IEEE W.R.G. Baker Award was established in 1956 and is presented by the IEEE Board of Directors for the most outstanding paper reporting original work published in any IEEE archival publication (such as Transactions, Journals and Letters), Magazines, or Proceedings. The paper must have been published during a three- to five-year window prior to the presentation year of the award on the fundamentals of electrical engineering, electronics, computing, and related arts and sciences as represented by IEEE. No more than one award may be given in any year. This year's recipients are Gerhard Krieger, Alberto Moreira, Hauke Fielder, Irena Hajnsek, Marian Werner, Marwan Younis and Manfred Zink for their paper "TanDEM-X: A Satellite Formation for High-Resolution SAR Interferometry," which appeared in *IEEE TGRS*, Vol. 45, Issue 11, Part 1, November 2007, pp. 3317–3341. I congratulate all of the authors on this outstanding recognition.

(continued on page 33)



FEATURE

A MODEL FOR THE SCIENTIFIC EXPLOITATION OF EARTH OBSERVATION MISSIONS: THE ESA RESEARCH AND SERVICE SUPPORT

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1. Overview

The European Space Agency (ESA) is developing five new missions called Sentinels specifically for the operational needs of the joint European Commission-ESA Global Monitoring for Environment and Security (GMES) programme [1]. In the coming Sentinel era, Earth Observation community will be challenged by the significant increase of storage and processing capacity needs. Whilst the yearly growth rate of the data archives of ESA's largest Earth Observation mission, ENVISAT, has been in the range of some hundreds of terabytes, the growth rate for the Sentinel missions' data will be one order of magnitude higher.

The Sentinel missions' measurements have a scientific potential which goes well beyond the products offered by operational services. In order to foster the realization of such scientific potential, straight access to data and adequate processing resources shall be made available to the Earth Observation community. In this paper we propose the "ESA Research and Service Support" model, successfully experimented in the Envisat era, as foundation for supporting the Earth Observation research in the Sentinel data exploitation era. Starting from the theoretical basis of the Research and Service Support model, the paper provides some concrete examples of support to science, introduces tools and services that can support EO scientists in developing applications on the basis of identified science product requirements, and the integration of information from the Sentinel type missions with existing and planned science missions.

The idea behind the proposed model is that the realization of the scientific potential of future EO operational missions can be nurtured by selectively extending approach, technical environments and tools that cover different aspects of the science data exploitation, given that the generation of scientific value-added products requires several pre-conditions and follows a number of steps which are not necessarily sequential. Being this paper an introduction to the proposed "Research and Service Support" model it focuses on two high level scientific needs: the capability to generate and test algorithms;

and the capability to perform near real time processing of multi-source Earth Observation mission data.

2. Motivation

Generating and testing algorithms relying on a cooperative environment where scientists can share and benefit from each other's work, find already published algorithms, combine, modify and exploit them, whilst maintaining full control and intellectual property rights of their work, would ease the productivity of any scientific community.

In particular, for the Earth Observation (EO) community, the requirement to perform near real-time processing of multi-source EO mission data entails the capability to access resources able to run the processing of large amounts of Earth Observation data.

The availability of a service providing support tools and environments enabling the possibility to generate scientific products designed around specific requirements is an important element for successful exploitation of the scientific potential of Sentinel missions.

The ESA Research and Service Support (RSS) service introduced in this paper, has been designed to the aim of providing on one hand the resources said above, and on the other hand ensuring that the research process is effectively and efficiently followed.

In order to clarify the scope of RSS, it is worth to compare it with the one of another significant service aimed at supporting the EO scientific process: the NASA's Giovanni (see <http://disc.sci.gsfc.nasa.gov/giovanni>). Giovanni is a web based application oriented to data visualization and statistical analysis over a number of large Earth Observation datasets; hence aiming at an end-to-end tool for supporting scientific work.

RSS has a different ambition, offering a front-end for data access and processing, relying on software tools made available by ESA for local data analysis at the user desk. ESA provided EO software toolboxes are available at <http://earth>.



esa.int/resources/softwaretools/. This approach is particularly adequate for those users who have started their work locally on their workstations with some data samples and want to “scale up” to massive data processing or wide service exposure. Also, many users rely on the RSS for the pre-processing of large data amounts, leaving their experimental tasks to run locally at their own labs.

3. Challenges and Support Models

After the launch of the European Remote Sensing satellites ERS-1 and ERS-2 in the nineties, the large growth of Earth Observation data availability, started less than a decade ago with the launch of the Environmental Satellite—ENVISAT and more recently with the Earth Explorer science and research missions [2], has opened new great opportunities for performing Earth Observation science. The plans of new ESA missions indicate 5-10 times more data to be acquired and archived in next 10-15 years. On the other side since 2004 the total number of ESA approved EO research projects, has been strongly growing. Such trends suggest that EO researchers’ capability might be challenged by the possible limitation of infrastructural resources available within their research centres. The demand on research centres to follow the growth in storage and processing capacity might represent one of the major barriers for EO scientists to perform high quality research with the large amounts of data which the new missions will make available in the coming years. The Sentinel missions planned within the European global monitoring for environment and security programme—GMES, will be operational from 2013 onwards [1], [3]. The exploitation of the scientific potential of these new types of missions would imply significant investments on research infrastructures, which may be a huge challenge for performing EO research.

Identifying challenges and removing barriers have already been demonstrated to be effective ways to make easier EO research. In the last few years, indeed, EO data online availability and simplified EO data user registration have undoubtedly sustained the growth in the number of EO research projects performed on ESA missions. Such results suggest that removing the challenge of a fast growing storage and processing capability from the scientists’ owned research infrastructure might enable a growing number of EO research projects and an enhanced capability to perform science over a large scale of geospatial and Earth Observation data and global phenomena.

In addition it is recognised that holding regular EO workshops and symposia not only stimulates the networking and exchange of ideas, but is a key driver for stimulating research. Such activities on one hand enable scientists to access relevant information and resources, and on the other hand reinforce the sense of EO research community, consequently activating new research initiatives and the exploration of possible cooperation and other synergies.

Therefore, it can be said that an effective and efficient service of support to EO researchers should provide them with adequate processing capability and allow users to be part of a community with access to information and resources.

We have designed the Research and Service Support (RSS) service architecture to empower scientists with solutions to the two challenges above identified. As part of ESA’s Earth Observation Ground Segment Department, the RSS service has the mission to provide tools and services that support the EO community in exploiting EO data, the researchers in developing applications and the service providers in generating value-added information.

The service makes available to EO researchers (from research centres, universities, or even industry) resources for their EO research. “Resources” means processing capacity, such as a Grid environment (with online access to EO data from ESA and non-ESA missions) [4] where RSS users can test a new algorithm on large datasets, improve and validate it, re-iterating this process until the scientific goal is achieved. RSS processing environment and other RSS resources available for supporting EO researchers is described in the following sections.

The approach used to tailor the RSS service is to follow the scientist’s viewpoint within a generic scientific research process and to provide support where data access, storage and processing may hinder the scientific research process. For the purpose of describing the RSS service, the scientific research process can be conveniently separated in different sub-processes or steps. The effort related to some of such steps can be drawn from other sources, when available.

We base our model for the generic scientific research process on the high level requirement that science needs to grow and progress. For that purposes theories need to be tested - as indicated in the classical work of Popper about the growth of scientific knowledge [5]. Popper makes reference to the method of learning by trial and error. He places it in the context of the progress of science, seen as the possibility to test a theory, to refute it, and even to know before a theory has ever undergone an empirical test, to say whether, provided it passes certain specified tests, it would be an improvement on other theories.

What is important to remark here is that for a theory the criterion of potential satisfactoriness is the *testability of the theory*. This means that is possible in general to compare the severity of the tests and even to define a measure of the severity of the tests.

As a matter of fact in our work we address only one of the “three requirements for the growth of knowledge” [5], pp.326. We disregard here the aspect of theory unification (e.g. Newton’s theory superseding and unifying Kepler’s and Galileo’s theories) as we support the development of theories within the EO domain. For the sake of completeness we must say that we therefore disregard here Popper’s formalisation of the link

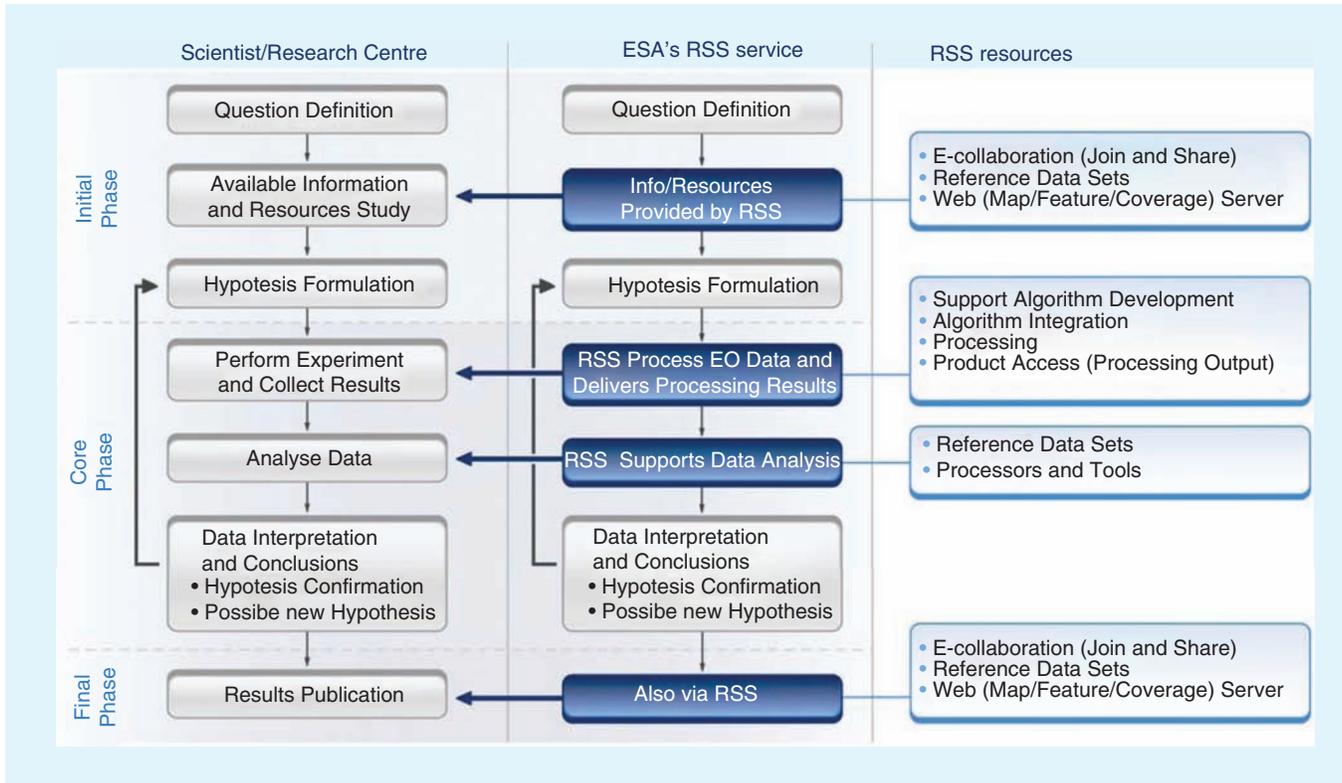


Figure 1. Research Process and RSS service.

between probability and content of a theory, which is useful in particular to address the theory unification, as well as to describe the probability of a theory being corroborated on the base of previous knowledge. We are in fact interested in the day to day work of scientists in the EO domain where small improvements to existing theories are as well important.

Popper defines (ibid. page 548) a high level process for the evolution of the theories:

$$P_1 \rightarrow TT \rightarrow EE \rightarrow P_2 \quad (1)$$

on which we base our EO research support model visualised in figure 1 above.

In the above process (1): P_1 is the problem from which we start, TT are the tentative theories by which we try to solve the problem, EE is the process (critical analysis, experiment or test) which we use to verify the theories, and P_2 is the new problem which emerges as consequence of the knowledge growth sustained by the process of scientific discovery. Our research support model—described below—supports another important requirement from Popper's work that is that new theories should be *independently testable*.

So expanding from the high level process (1) described above, a generic research process could be schematized as in the left panel of Figure 1.

In the central panel we highlight the sub-processes where RSS can have a support role by providing resources to EO scientists. Three phases can be distinguished.

The first phase of the research process is composed of three steps going from open questions to hypothesis formulation. The first step, addressing the selection and definition of the scientific question to deal with, initiates the process. The second step represents the sub-process aiming at gathering, organizing and evaluating available information, in order for the scientist to formulate the hypothesis in the successive third step. In this phase, RSS can contribute playing the role of information/resources provider.

The core phase is composed by steps four to six. In the fourth and fifth sub-processes, experiment and data analysis, respectively, RSS can provide a very significant support. The experiment, that in the case of EO research means data processing, can be supported by RSS not only by means of the mentioned Grid processing environment, but also, above all, by making available resources and services such as support to algorithm development, algorithm integration, product access and delivery. The data analysis step can be also supported by RSS by providing specific reference data sets, processors and tools, in order for the researcher to confirm or re-formulate the hypothesis in the successive sixth step.



Finally, the third phase regards the results publication. The concept of publication of results may go well beyond the publishing of scientific paper. It is linked to the networking need identified above. This sub-process can also benefit from RSS resources such as the Join&Share environment for e-collaboration, the Reference Data Sets (RDS) and the map and raster data publishing environments.

Such environments allow the scientist to network, communicate and publish the results, in addition to the usual channels, sharing knowledge, information and data within the EO community.

Considering the near future EO research scenario, it can be said that the process of furthering science will more and more require access to terabytes of data that will be produced daily by the Sentinel type missions and to petabytes of data accumulated in the long run. The issue of moving around terabytes or petabytes of data, has been the subject of a wide effort in information technology leading to developments in Grid and cloud computing. The basis for such approaches is the goal of exploiting computing resources such that the processing capability of each computing node is always utilized and computing resources are optimised. Making science in the Earth Observation domain in the Sentinel era will require moving and storing terabytes or petabytes of data that will imply significant cost, often unaffordable for small research centres. This is the reason why models of data processing which minimise the data access issue have shown to be successful.

4. The Current Research and Service Support

The recent history of the RSS service support via the Grid Processing On Demand (G-POD) [6], lists a lot of examples of algorithms developed by principal investigators for their science purposes, which have reached a much wider use beyond the initial community and use case. Examples based on MERIS products from the medium-spectral resolution, imaging spectrometer on board of the ENVISAT Satellite are:

- The MERIS Global Vegetation Index (MGVI), on demand, i.e. the Photosynthetically Active Radiation algorithm over a user-defined aggregation period of time and with 1 km resolution area of interest [7];
- The AeroMeris product, designed to extract all the information provided by MERIS Level 2 for a small area in an easily accessible format. To this end the user can specify area and time of interest, and obtain several files with all the information available in the Level 2 MERIS product;
- MERIS Level 3 water, land and atmosphere products like e.g.
- Chlorophyll Concentration for the open ocean [8];
- The aerosol optical thickness at 443 nm and the angstrom coefficient;
- Albedo 16-days averaged maps of spectral and broadband albedos at a spatial resolution of $0.05^\circ \times 0.05^\circ$;
- Water vapour over clear sky.

As an example of the general process of algorithm development, test and deployment over processing on demand environment, the MGVI case is reported in the following section.

4.1 MERIS Global Vegetation Index: A Success Story

The contribution of the Research and Service Support to the exploitation of EO missions' scientific potential is demonstrated via the success story of the development of MERIS derived products based on the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) algorithm, developed and owned by the Joint Research Centre, which expresses the fraction of incoming solar radiation useful for photosynthesis that is actually absorbed by vegetation. RSS supported the process of algorithm development, test and deployment over a general purpose processing on demand environment dedicated to the scientific exploitation of EO data generated by ESA missions, as well as the provision of tools and environments in support to that process.

The FAPAR value is estimated from daily MERIS spectral measurements in the blue, red and near-infrared bands acquired at the top of the atmosphere using a physically based approach [7] and [9].

The MERIS land Level 2 product is operationally provided in the Space Oblique Mercator (SOM) projection at the reduced resolution, i.e. at 1.2 km spatial resolution. Establishing long term time series of remote sensing geophysical products, that are relevant for environmental applications at regional or global scale, allows the production of Level 3 products. These latter correspond to lower temporal composite, e.g. 10-day or monthly period, and/or at a lower spatial resolution relevant for carbon or climate modelling communities. The spatially aggregated land products are therefore produced to be directly used for regional or global scale land analysis.

The time composite algorithm is based on the selection of the day over the time compositing period (10 consecutive days or 1 month) that corresponds to the most representative value of FAPAR, [10]. In order to make such temporal composite, a code has been developed and its executable implemented in the G-POD facility to produce daily products in a rectangular grid which are then used to make either 10-day or monthly products. Figure 2 shows an example of results over Europe from daily to 10-day products. The products are systematically produced and delivered via FTP at the Service Support Environment portal (<http://services.eoportal.org/>) on near real time.

The lower resolution products like the global ones at 0.5×0.5 degrees are produced by spatially aggregating 1.2 km products over a low spatial resolution window (the same or a different geographical window). The code searches for all pixels (e.g. the input pixels at 1.2 km) that are located in each grid cell of the new geographical region (output window). These pixels are then combined together by applying an operator to their values.

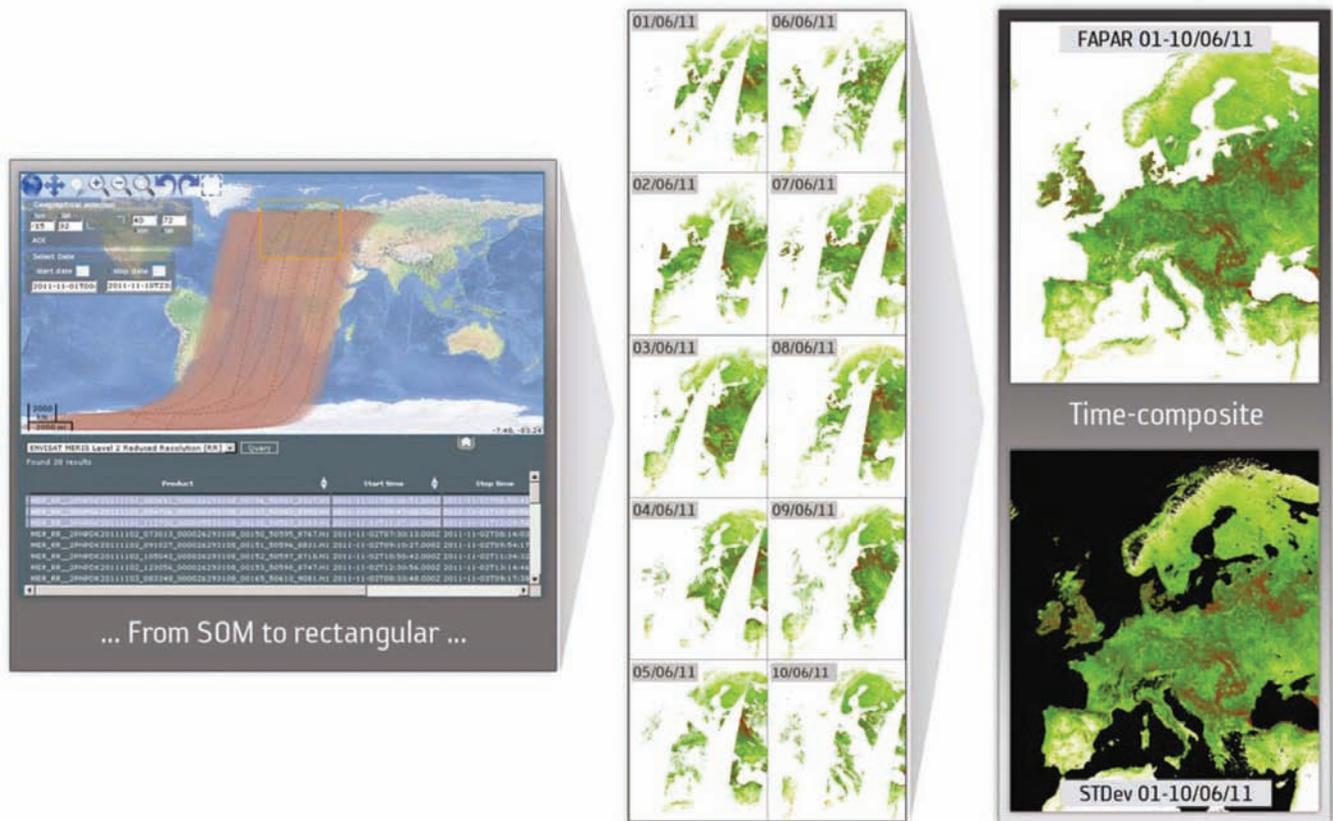


Figure 2. Example of production of 10-day FAPAR using G-POD environment.

The algorithm of aggregation implements two operators:

- computation of the mean, standard deviation, number of samples and
- computation of the median;

The averaged values refer mostly to the geophysical measurements, like the FAPAR and associated values and the median values are used when the geometry of measurements (such as the sun and observation zenith and azimuth angles) are reported. These global products correspond to the demo level 3 products that are automatically published at <http://earth.eo.esa.int/level3/meris-level3/> and have been used in the scientific community for monitoring the state of land surfaces, see [11] and [12].

Similarly to the MGVI, other projects which have been supported and hosted by G-POD are: Flood Monitoring [13]; Aerosol Properties [14]; Volcano Monitoring [15]; Fire detection [16] and many other fields like Land Surface Temperature, Aerosol Optical Depth, Land cover classification and Alga Monitoring.

5. Use Cases

5.1 Research and Science Use Case

Within this use case a scientist principal investigator has the objective of performing scientific activity along the

lines of the process modelled by Figure 1. We will concentrate here on a subset of high level requirements where RSS support can help to maximise the results, reducing the effort at the researcher side. They can be summarised in following needs:

- to be able to concentrate on algorithm development;
- to access (or easily create) a validation data set (possibly with heterogeneous data, as well as with many and very diverse data takes);
- to perform several processing runs against the validation data set in order to tune and validate the algorithm;
- to get continuous feedback on the ongoing work and issues encountered by the community of peers.

Once these steps are completed and the algorithm validated, the scientist would like to see the result of the work systematically applied on past data (bulk data access) and / or fresh data.

In support to the above mentioned scientific needs a 5-level service model has been defined, ranging from Basic Science Support Services up to support to Product Validation, and further to Production and Service Support. A detailed description of the proposed support is provided in section 7. Such model is implemented via the Research and Service Support service introduced in section 4.



5.2 New Scientific and Collaborative Product Development and Validation Use Case

The GMES Space Component [3] addresses the Sentinel data exploitation within a GMES Contributing Mission ground segment consisting of two elements:

- the Core Ground Segment providing Sentinel missions products generally up to Level 1B or 1C, data products from the Contributing Missions, coverages or ‘time series’ composed of products from multiple satellites and
- the Collaborative Ground Segment, providing supplementary functions to Sentinel Missions data, e.g. either through specific data acquisition, processing, dissemination, or specific data products (the access to GMES Contributing Missions is supported within the GMES Space Component).

The Core and Collaborative Ground Segment concept is illustrated in Figure 3.

The process of developing new scientific and/or collaborative products may need adaptations and validation which may entail additional processing steps to be performed within the same environments supporting the science use case.

The RSS service in support to scientists offers a model on how to complement the payload data ground segment scenario, which foresees a dedicated service to data users, enabling their data processors to run in the ground segment processing environment. The RSS model allows the development of additional (scientific) products to complement the base product list provided through the core ground segment services.

The goal of the proposed RSS service model is to foster the scientific use of EO operational missions data and the development of new derived products, by enabling remote access to and processing of ground segment core products according to user-provided algorithm implementations. Through collaborations with scientific research the service providers will be able to define and develop new and complementary value-added products (e.g. Level-2, 3), validate them on large datasets, and finally swiftly transfer the products to sustainable operations for global usage.

6. The Research and Service Support Architecture and Environments

Research and Service Support has developed environments targeting different steps in the research process and defined a support model [17]. Besides making available specialised data, e-collaboration environments and related expertise for application development, as well as bulk data access and processing for higher level products’ generation and provision, RSS has also the framework for the development of advanced technology and tools in various ground segment areas like resource identification and access, chaining of processors and services, information/feature extraction, interactive data analysis. Further information can be found at <http://rssportal.esa.int>

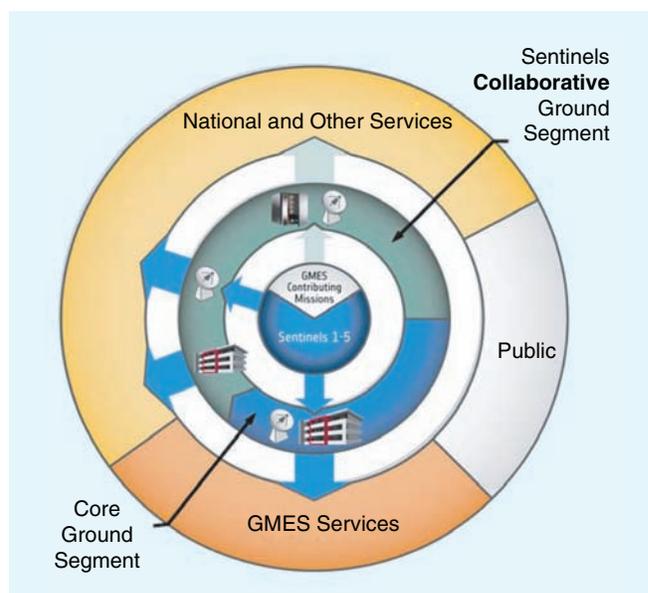


Figure 3. Core and collaborative ground segment concept.

The increase in EO data use within more and more applications is making available also other resources useful for feature/information extraction, such as chainable services and processing components. Therefore the key resources are now data (products archived in repositories and described through catalogues’ metadata), processors and services. Because of their proliferation, methods for their easy and semantic (in application terms) identification are necessary.

RSS is working through technology projects on new methodologies, based on ontology/semantics, for the identification and use/activation of resources. Examples of these activities are:

- harmonised enhancement of catalogue metadata standards for the inclusion of semantic search terms (describing the features/information contained in a product);
- semantic product search (identification of products with a specific content);
- resources’ registry and discovery;
- automated chaining of resources.

Our model of scientific research described in section 3 concentrated in an objective or logical view of the scientific knowledge and of the research process having as reference the work of Popper [5]. We have to note that in order to take into account the actual direct exploitation of EO data in particular in image analysis and image information mining a subjective or psychological view based on user’s conjecture is needed as outlined in [18]. Additional work is still needed to cover the link between user conjectures, perception and semantics, see [19] (note this reference does not cover the EO domain). In particular when analysing an EO product the user is expressing the conjecture that a feature relates to a particular object (e.g. this feature denotes an urban settlement) both

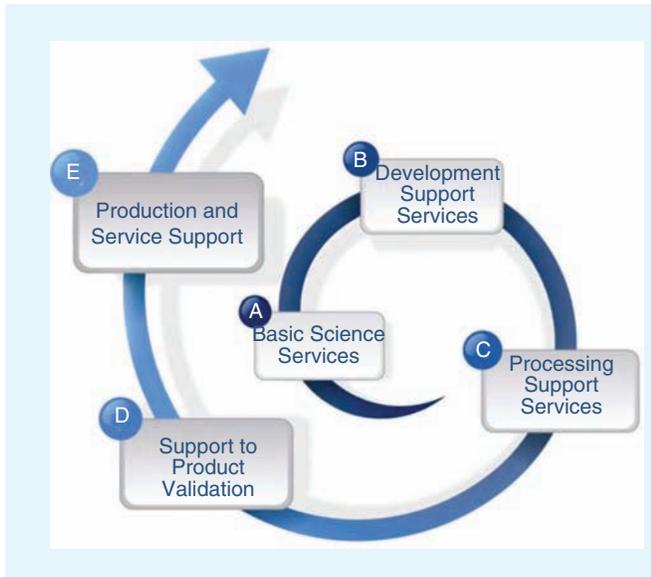


Figure 4. The 5-level RSS research process support model.

the subjective perception and classification aspects play a role. Such approach falls within the scope of knowledge-based information mining.

The possibility to interactively analyse entire image collections for searching features to be defined by the user interactively, is relevant from an application point of view and scientifically very attractive. Research has been performed and prototypes developed aimed at permitting to interactively search and tag (label) large or well characterised areas (features) within an entire collection of images.

A knowledge-based information mining approach is therefore substantially different from the model we propose in section 3, as it includes an ingestion phase (unsupervised), during which all the images of the collections are processed to automatically extract Primitive Features (like spectral, texture or geometric information) [18], and an interactive phase (supervised), where the user can train the system through positive or negative feedbacks on sample images, apply the trained “feature label” to the entire collection. The user can as well define (label) the semantic image content which is linked (e.g. by Bayesian networks [20]) to a completely unsupervised content-index. Based on this stochastic link, the user can query the archive for relevant images and obtain a probabilistic classification of the entire image archive as an intuitive information representation.

7. Support Model for the Defined Use-Cases

From our point of view, in order to support the two use cases described in sections 5.1 and 5.2, we have as well to take into account the need to ensure that:

- the routine production of EO products for operational services is not affected by research and science activi-

ties, nor by the development of new or higher level products;

- the objectives long term archiving and data preservation of EO data are fulfilled within the context of a cost effective architecture, and in particular that the data access and processing for scientific purposes is efficient.

The consequences of the above high level requirements and objectives are that:

- algorithm development is made easy and validation is supported;
- reference datasets are available to the communities;
- a dedicated processing and re-processing environment shall be available to the science users and the service developers.

In order to implement these statements RSS has developed a specific service model. Such model, intended for supporting the research process described in Figure 1 in its different steps and phases, is schematized in the following Figure 4.

The model is organized in 5 levels, from A to E: Basic Science Services, Development Support Services, and Processing Support Services, Support to Product Validation, and Production and Service Support.

The first level, or A, Production and Service Support, encompasses the access to EO Data through standard Query-Order services and to free Toolboxes for EO Data Processing. These services are used over the full research process from the first step Available Information Study (see Figure 1).

The second level, Development Support Services, covers the access to EO resources and toolboxes/processing components for algorithm development and test. These services are employed during the Hypotheses Formulation step for the preparatory work leading to the Perform Experiment and Collect Data step. This type of service is provided through specialized facilities and applications supporting software development and re-use, data management, processor testing.

The third level, Processing Support Services, includes the access to Grid and/or Cloud Computing resources [21], enabling mass data processing and collection of results. These services are required during the Perform Experiment and Collect Data step. Processing and data handling needs are typically very high and concentrated in time; hence the service model foresees the use of a shared (and scalable) facility.

Level D, Support to Product Validation, foresees the provision of reference data like ground truth or independently produced products and related processing resources required to conduct the validation. These services are essential to establish the quality of the processing and a pre-requisite for any collaborative product.

The last level, or level E, Production and Service Support, covers the configuration of new services allowing the systematic data processing in near real time and/or on long time series. Also covers the management of user access to the new services and the possibility of service orchestration. These



services are linked to the Publish Results activity, when the research has been concluded and the results are made available to the community.

Although ESA already provides Research and Service Support for most of the activities/levels described above, these services will need to evolve in line with the future needs. In particular, the following challenges should be addressed:

- Enhance Data Management and Processing capabilities by one order of magnitude in line with Sentinel data volumes;
- Cover activities of the research process which are little supported like the product validation;
- Support innovative technologies such as efficient data base technology for product time series, very large parallel computing devices, etc.

8. Research and Service Support: Future Evolution

The RSS model described above has been successfully experimented in the ENVISAT era. A fundamental question to answer is: how shall RSS evolve to confirm and if possible increase its value for science in the Sentinel era? To answer this question it needs to be considered that Sentinel type missions pose three important challenges to RSS service:

i. Large Data Volumes in the Order of 2TeraBytes a Day

Data Management at RSS is critical to a good service and requires fast access to (almost) all the data products generated. This is currently achieved by three sourcing modalities: copying rolling archives, caching data from on-line archives and moving off-line data on-line. Nowadays, the proportion is roughly 70-10-20 for the three modalities. Considering the data volumes from future EO operational missions, the proportion is expected to evolve towards a 20-70-10. That is, off-line archives will tend to be replaced by on-line archives and, due to the data volumes involved, copy from other archives will not be affordable. Instead, intelligent caching over large on-line archives is to be foreseen. Therefore topics currently under research and development are:

- Optimization of data circulation for caching purposes: data granularity, network configuration, seeding strategy;
- Caching strategies based on use-patterns, trying to “guess” which data will be requested next.

Simple precursors have been developed to bridge the ESA Grid Processing On-Demand (G-POD) environment with MERIS Catalogue and Inventory data source and various FTP repositories at ESA facilities.

ii. Growing Importance of Multi-Temporal Analysis

As a result of the systematic data acquisitions over long time periods (>20 years) and with high revisiting rates (<5 days), demands on time-series analysis will grow.

Optimizing data organization and retrieval/access to EO archive for such usage will be a challenge. Database techniques associated with Services for publishing raster data are being introduced in RSS for this purpose.

iii. Very Large Processing Requirements

Current processing architecture is based on a private Grid-processing paradigm.

This architecture has provided sufficient processing power over many years with very significant scalability and versatility. However, compelled by the very large processing requirements and, at the same time, by the advent of large cloud computing facilities, the architecture has recently evolved in the following direction:

- Virtualization of all local hosting infrastructures, in particular Grid working nodes;
- Deployment of cloud computing resources on the Grid;
- Location of large storing services for dissemination purposes.

This trend will lead in the coming years to the hosting of RSS environments over cloud computing facilities which will provide global scalability potential.

9. Conclusions

The ESA RSS service presented in this paper has successfully supported EO research and applications development during the last years, by making available processing capacity on online data and ensuring that the research process is effectively and efficiently followed.

As a matter of fact, RSS has over time acquired the expertise required to develop advanced environments in support to science and research - also included e-collaboration - in the development of applications, using not only EO products. These operational environments permit cost and time reduction for the design and implementation of new algorithmic solutions. Moreover, algorithms can also be run noticeably faster than at the researcher site (e.g. hours versus days) using huge data sets available online.

RSS environments permit to support the key phases in the research process also through the competence of the operational team, with scientific background and large experience both in the infrastructure and in the interaction with researchers.

Passing from the Envisat era to the Sentinel era will pose three main challenges to RSS: increased data volumes, growing importance of multi-temporal analysis and increased processing requirements. In response to each of these challenges RSS is defining adequate solutions, such as new storage strategy, new environments covering emerging needs and new processing strategy (e.g. based on virtualization, cloud computing).

ESA is willing to continue, and expand this support also to the Sentinel era, where scientific and collaborative products



are a challenge and at the same time an opportunity for a more complete utilisation of the huge amount of data becoming available.

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HYPERSPECTRAL UNMIXING FOR VEGETATION MONITORING: THE SPATIO-TEMPORAL DIMENSION

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1. Introduction

One of the earth's most critical challenges for the coming decades is to secure its ecosystem services in face of global environmental change and increasing human population [1] [2]. Whereas sustainable agricultural production is crucial to meet the world's future food security [2], the role of forests as providers of ecosystem services also cannot be overestimated [3]. To secure the ecosystem services (ES) provided by forests and agroecosystems, it is critical to understand the impact of global change so that ecosystem management can adapt accordingly. The *Millennium Ecosystem Assessment* [4], however, has indicated major gaps in global and regional monitoring systems, resulting in a lack of well-documented and standardized time-series information on various ecosystem features, significantly imposing barriers on assessing the status and trends of the provided ecosystem services.

For 30 years now, remote sensing capacity has been available that could enable rigorous global monitoring of key ecosystem features [5]. Yet, to date, the full potential of remote sensing data is still not fully exploited where it concerns the monitoring of dynamic vegetative systems. In forest and agro-ecosystems image interpretation is complicated by the high spectral similarity between different co-occurring plant species which is strengthened by the composite nature of the reflectance signals obtained by the remote sensing sensor [6] [7]. Diagnostic ecosystem characteristics, often linked to the presence or abundance of one specific plant species/type, are as such masked, and image interpretation is severely hampered [8].

In this perspective, the ongoing development of hyperspectral spaceborne sensors is promising. The high spectral detail provided by such sensors allows making a better discrimination between subtle physiological changes among plant species while the systematic revisits allow for a continuous monitoring of ecosystem changes [9]. Space-borne hyperspectral sensing inevitably comes with a decreased spatial detail though. This trade-off is the result of the large observation height of satellite sensors – roughly ranging between 650 and 800 km - in combination with the high spectral resolution. For all currently available (e.g., Hyperion) and currently

constructed hyperspectral satellites (e.g. EnMap, Prisma), the sensors' instantaneous field of view is at least 900 m² (i.e. pixel size is 30 m) [10]. In heterogeneous ecosystems this implies that the images capture not only the species of interest but also other components such as untargeted plants and surface soils. Consequently the spectral signal of a pixel is the integrated result of the spectral contributions of the different elements within that pixel which considerably constrains the accuracy of object-specific spectral analysis [11].

A number of fuzzy classification techniques accommodating mixing problems have been proposed with Spectral Mixture Analysis (SMA) being one of the most common techniques [11]. By modeling a mixed (satellite) spectrum as a combination of its constituent spectral components weighted

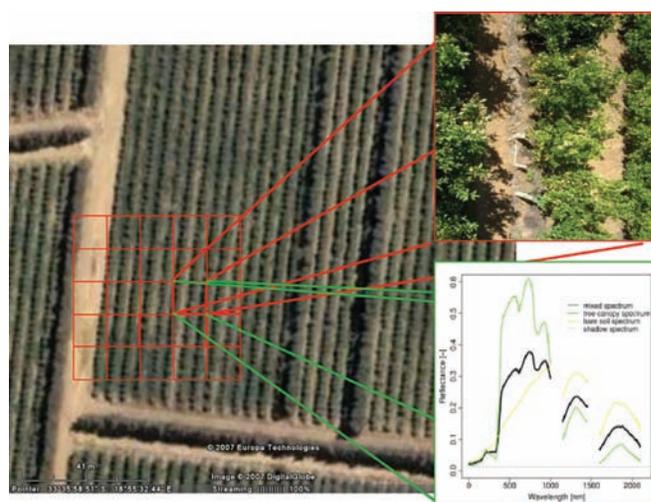


Figure 1. A bird's eye view of an orange orchard in Wellington, South-Africa. The image was extracted from Google™ Earth. A raster of twenty-five 10 × 10 m pixels is superimposed to illustrate the mixed pixel problem as experienced by the currently available and upcoming hyperspectral satellite sensors. The enlarged pixel (red cutout) clearly shows that crops, soil and shadows are all present within the pixel. The specific spectral characteristics of all the components contribute to the (mixed) pixel reflectance (green cutout).



by their fractional cover in the pixel, SMA allows, through model inversion, to estimate sub-pixel fractions for each component. Basically, the technique allows to say “*what is in a pixel*” thereby strongly facilitating image interpretation. Although the technique was shown effective in many applications, its utility in the context of monitoring ecosystem features in complex/mixed (semi-)natural ecosystems remains rather limited. The current unmixing algorithms are generally not capable to account for the high spectral similarity among vegetation spectra which severely hampers the implementation of SMA for steering management practices in forests and agro-ecosystems [12].

Yet, if this issue of spectral mixing can properly be circumvented hyperspectral satellite sensors can become a mainstream diagnostic tool to support ecosystem monitoring research, management and policies. The technique allows to upscale existing knowledge to ecosystem, regional and even global scales which obviously could significantly enhance the ability of a process like the *Millennium Ecosystem Assessment* to answer policy-relevant questions.

Spectral unmixing has been a very active research area in recent years as evident from some recently published review reports [11] [12] [13] as well as the high number of contributions in last year’s IEEE Transactions on GeoSciences and Remote Sensing Special Issue on Spectral Unmixing of Remotely Sensed Data [7]. Yet, effective spectral unmixing still remains an elusive exploitation goal with many remaining challenges [7] [12]. This is especially true for unmixing efforts in mixed vegetation systems. In this contribution we want to highlight the potential benefits of two relatively underexplored or underexploited aspects of spectral unmixing which we believe can become increasingly important when accurate unmixing is aimed for in complex natural ecosystems such as forests and agro-ecosystems, i.e. unmixing based data fusion [14] and temporal unmixing of hyperspectral data [15]. The first approach exploits the fact that an increasing number of very high resolution satellite imagery are becoming operational (e.g. Worldview2, Quickbird, IKONOS). These high resolution data obviously contain high spatial detail but most often (if not always) lack the spectral detail needed for accurate vegetation mapping. By combining the best of both worlds a data fusion approach for spectral unmixing can improve both the spatial as well as spectral detail of the images.

With the second approach we want to exploit the benefits of a temporal dimension in spectral unmixing. With the planned hyperspectral missions like EnMap and Prisma hyperspectral time series will become readily available [10]. Yet, effective hyperspectral time series analysis techniques are not widely spread. We anticipate major improvements for species specific vegetation mapping when concepts of time series analysis are implemented in spectral unmixing. In what follows we will introduce two recently initiated projects at the Hyperspectral Research Group of the Flemish Institute of Technological Research (VITO), Mol, Belgium. The two projects, funded under the STEREO program of the Belgian Science Policy Office¹, focus specifically on the development of new spectral unmixing algorithms for improved vegetation mapping. While the VegeMix project exploits the potential of multitemporal unmixing in an invasive species mapping context, the HyperMix project focuses on unmixing based data fusion for agricultural production monitoring.

2. VegeMix – Multitemporal unmixing for invasive species mapping

Biological invasions are now considered second only to habitat loss as a threat to biodiversity and ecosystem processes and integrity [16]. Remote sensing is crucial for inventory, assessment, and monitoring of invasive species and thus a vital component of conservation and management efforts. Despite its potential, reliable methods for the detection of invaders over large areas have not been widely established. Recently, airborne hyperspectral sensors have demonstrated potential for invasive species mapping across different types of communities and ecosystems (review by [17]), yet its relatively high cost and consequent lack of year round monitoring are known bottlenecks for setting up a continuous monitoring program over large areas. Despite a reduced spatial resolution, spaceborne hyperspectral sensors such as the Earth Observing-1 Hyperion sensor, have the capability to cover large areas multiple times during a growing season. This temporal repeatability not only allows for a continuous monitoring but furthermore allows capturing species specific phenology enhancing as such the spectral separability among vegetation types or plant species. Based on this premise the goal of the VegeMix project is to explore the potential of multi-temporal spectral mixture analysis for invasive species mapping in rainforests. The study is conducted in Hawaii Volcanoes National Park (HAVO) on the Island of Hawaii (Figure 2), a 1500 ha rainforest area dominated by the native *Metrosideros polymorpha* and *Acacia koa* tree species (Figure 2). Boosted by human activities these native forests have been subject to large, sprawling infestations of highly invasive tree species such as *Morella faya* and *Psidium cattleianum* (Figure 2). The invasive species drastically changes the native forest structure and nutrient balance and are therefore seen as a major threat to the native biodiversity [18].

¹ Since 2001 the Belgian Science Policy Office (BELSPO) STEREO program supports the exploitation and research in Earth Observation data. The main objective of the program is to make continuous progress in remote sensing analysis and to ensure the position of Belgium as an international centre of competence in remote sensing. The program is strongly focused towards the analysis and application of satellite imagery.

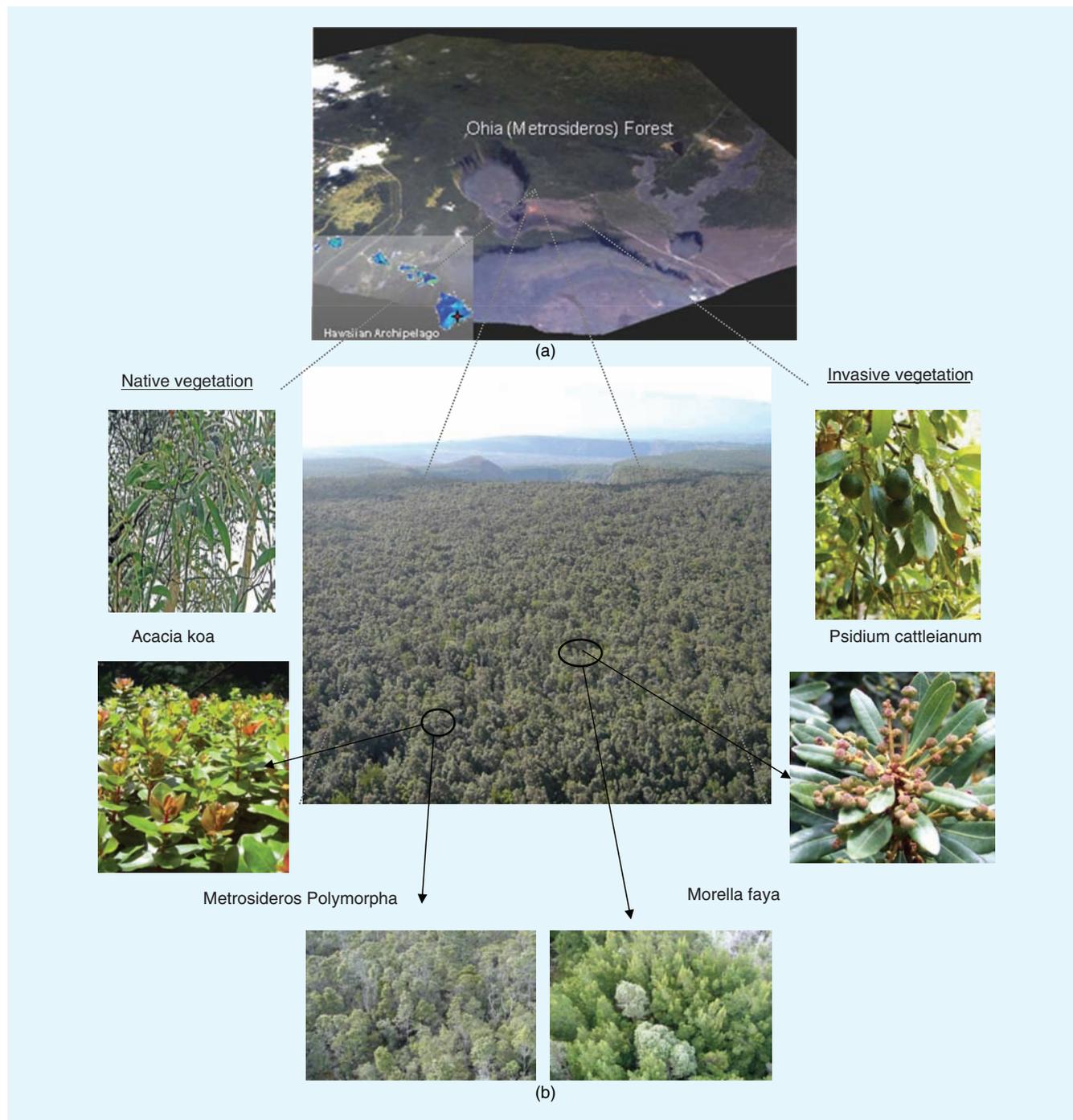


Figure 2. a) Hawaii Volcanoes National Park on the Island of Hawaii (imagery from the Carnegie Airborne Observatory; [27]); (b) detail of the native ohia (*Metrosideros*) forests and details of the most common native and invasive forest canopy species. Although most of this area is under protection by the U.S. National Park Service, it has experienced a number of biological invasions predominantly by *Morella faya* and *Psidium cattleianum* (adapted from [28]).

A time series of Hyperion imagery (collecting spectra in 220 wavebands ranging from 400 to 2500 nm at a spatial resolution of 30m), accompanied by a set of field observations of tree species locations is available for this study. The research team of Dr.

Gregory P. Asner of the *Carnegie Institution for Science*, Stanford, California, a scientific partner in this project, started the Hyperion tasking in July 2004 on approximately a weekly basis over the study area. As the tasking uninterruptedly continued



until December 2007, we now have a very unique hyperspectral time series covering our rainforest study area. Preliminary results already demonstrated the potential benefits of a multi-temporal unmixing approach for the detection and mapping of the invasive tree species in our study area. By combining information from multiple acquisition dates in the Multiple Endmember Spectral Mixture Analysis [6] - a commonly used sub-pixel classification technique - invasive species patches which were not detected by any of the single date approaches could now successfully be detected using the multi-temporal unmixing approach, as illustrated for a subset of the study area in Figure 3.

Current research efforts are now geared towards nonlinear mixture modeling [19], automated endmember bundles extraction [20] and feature selection for spectral unmixing [21], all in a multi-temporal hyperspectral context. The project aims at developing multi-temporal unmixing algorithms providing high fidelity maps of the spread of invasive species which on its turn will be used to support ecological interpretation assessments of the dynamics of invasive species in Hawaii. This work could eventually support the Hawaiian Ecosystems at Risk (HEAR) project, a government-funded project to provide technology, methods and information to decision-makers and resource managers to help support effective science-based management of harmful non-native species in Hawaii and the Pacific Rim (www.hear.org).

3. HyperMix - Unmixing based data fusion for agricultural production monitoring

Even in commercially exploited agricultural areas the potential yield is seldom attained due to physiological limitations, impacts

of pathogens (biotic stress) and abiotic stress factors (e.g., extreme temperature, drought, salinity). These stress factors can affect physical, biochemical and physiological leaf parameters. As such, any opportunity to monitor these factors in a continuous or periodic manner offers the potential to model plant processes, and therefore also to steer the process by means of adapted management measures, thereby reducing environmental impact of agricultural practices while optimizing production.

While the very high spatial resolution (<1m) sensors such as Ikonos and Quickbird lack the required spectral detail to detect the subtle spectral difference in vegetation reflectance patterns, the current and new hyperspectral spaceborne missions, yet meeting the spectral requirements for crop production monitoring, have a limited spatial resolution. This technology driven trade-off between spectral and spatial resolution is inevitable and therefore data fusion approaches are an intelligent way to make optimal use of the available spaceborne sensor data.

In the HyperMix project, we therefore aim at developing and optimizing both data and decision fusion approaches in order to improve agricultural ecosystem management. In the field of data fusion, we specifically work on the further optimization of spatial unmixing algorithms [22], [23]. As such the high resolution image is characterized by assigning sub-pixel fractions of the high spectral resolution image to the pixels of the high spatial resolution. Or in other words the spectral mixture of a hyperspectral pixel is linked to the spatial information of the underlying hyperspatial pixels. On the other hand, a lot of effort is put in the optimization of spatial and spectral feature extraction algorithms. For this, contextual

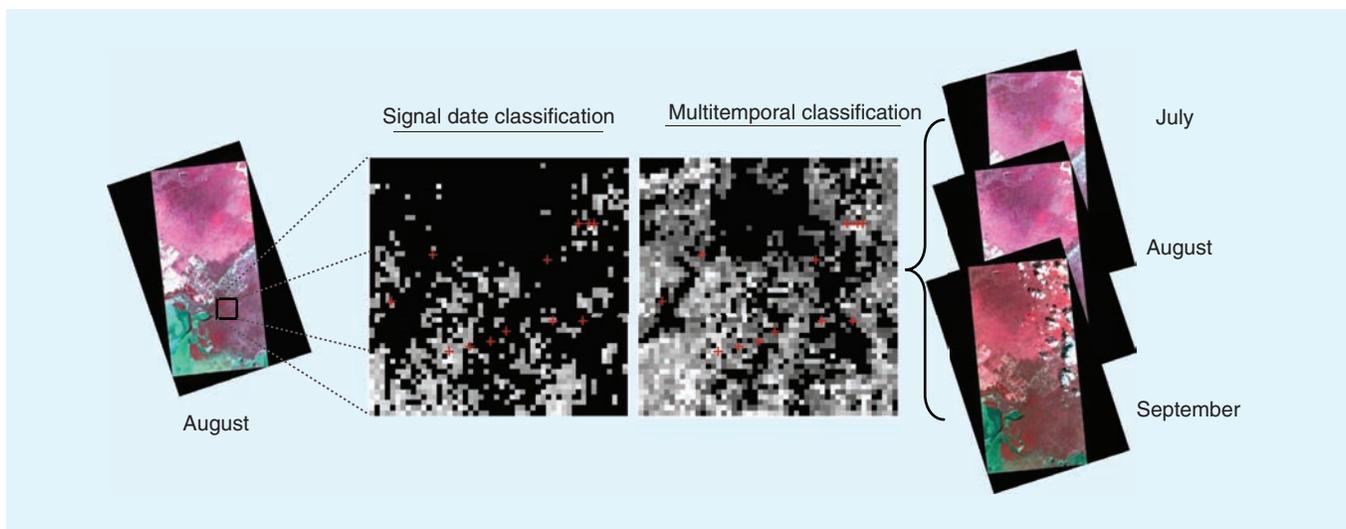


Figure 3. Comparison between the traditional single date and multitemporal Multiple Endmember Spectral Mixture Analysis (MESMA). In the centre panels the *Morella faya* cover fraction maps as provided by MESMA are shown for a small subset of the image (see black box in left Hyperion image). Only the pixels indicating a significant cover of the invasive species, i.e. >50%, are highlighted. The field observations of *Morella faya* are indicated as red crosses. On the left and right side of the figure, false color representations of Hyperion images acquired over HAVO are shown. These results clearly show that the multi-temporal approach is better suited to detect the patches of *Morella faya*.

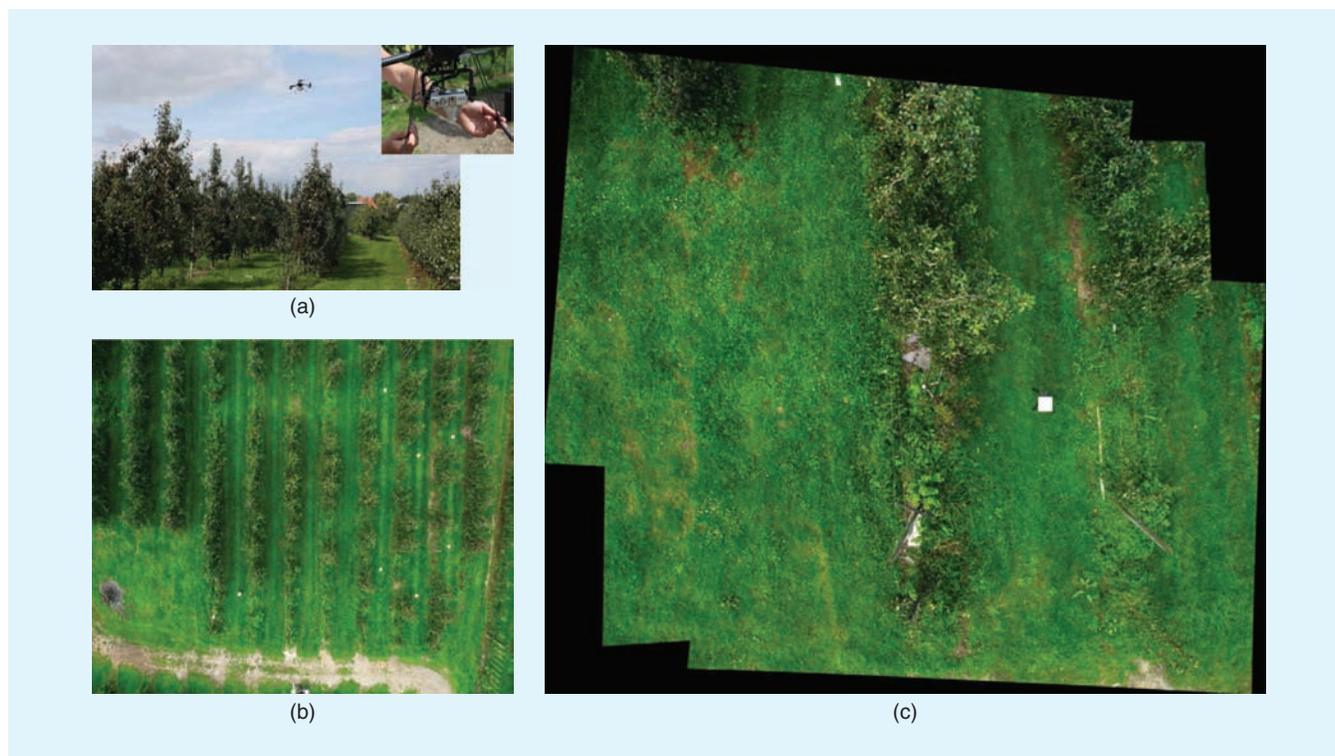


Figure 4. View of a UAV image acquisition over a fruit orchard with the Panasonic LX3 camera mounted on the UAV (cutout); (b) Colour image obtained by a UAV. (c) Stitched high spatial colour images obtained by a UAV.

features are extracted from the hyperspatial image, while spectral features are extracted from the hyperspectral image. State-of-the-art decision fusion strategies to combine both feature sets for classification are employed and adapted. This way we aim at obtaining vegetation maps that are spatially more detailed than the original hyperspectral images.

In order not to be tied to a specific satellite sensor, we start from the most detailed information available both spectrally and spatially. Hyperspatial (cm) images were gathered by a highly flexible micro unmanned aerial vehicle (micro-UAV, Figure 4), while hyperspectral data were acquired with the airborne APEX sensor (Figure 5). The airborne measurements were accompanied with field and lab measurements for calibration and validation purposes. These datasets provide a perfect starting point from which minimum spatial and spectral requirements can be specified. Later on we will upscale our methodologies by applying them on spaceborne sensor data.

The advanced fusion techniques are tested on their ability to detect biotic stresses in fruit orchards. The agricultural setting with gradual transitions of healthy and stressed vegetation, herbs and soil patches will certainly derive benefit from the fusion of high spectral and high spatial images. In Figure 6, a UAV colour image was classified to detect infected plant material in a fruit tree. The UAV imagery was collected with the Draganfly

X6 helicopter, owned and operated by VITO. The digital camera mounted on the UAV was a Panasonic LX3 with 10.1MP resolution. Several flights were undertaken at different altitudes, providing different spatial resolutions (Figures 4b and 4c).



Figure 5. Airborne hyperspectral APEX image of the fruit orchards.



Figure 6. (left) UAV colour image of a pear tree infected with fire blight. (right) Classification of the image on the left in the following classes: stone (white), infected brown-red coloured leaves (purple), yellow leaves (yellow), shadow (grey), dead plant material (black), grass (light green), healthy leaves (dark green).

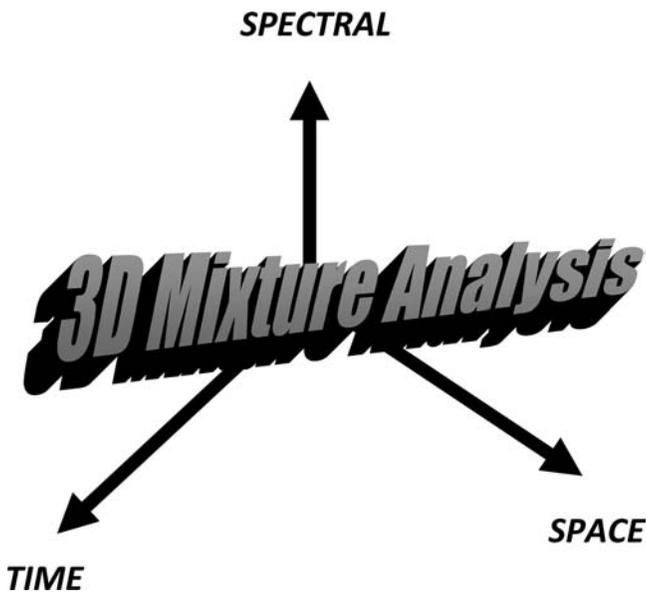


Figure 7. The 3D Mixture Analysis concept.

Due to the limited spectral bands, it can be seen that infected brown-red coloured leaves (classified as purple pixels) were difficult to distinguish from soil pixels. Twigs and dead leaves (classified as black) were also difficult to separate. It is clear that by adding spectral information, much more precise detection of stressed leaves should become possible.

4. Conclusions

In an era of fast global change it is of utmost importance being able to monitor (agro-) ecosystems at large spatial and

temporal scales. Despite the obvious potential for remote sensing, we pointed to the fact that additional research to increase the sampling resolution, in order to broaden the applicability of remote sensing for the management of natural ecosystems and agro-ecosystems, is critical. In other words, if optical remote sensing wants to become a mainstream diagnostic tool to support ecosystem monitoring research, management and policies, issues that currently still deteriorate image quality such as spectral mixing, should be properly addressed. In natural ecosystems, it is well acknowledged that the mixing problem is often aggravated by the high spectral similarity among co-occurring vegetation types and plant species. Additional advances in spectral unmixing are as such crucial if we want to be able to monitor the dynamics of target plant species in a heterogeneous or mixed canopy over large areas. In this light we initiated two conceptual approaches which we believe need further attention as they potentially open new opportunities for significant improvements in vegetation mapping. First we pointed to the benefits that can come from implementing hyperspectral time series analysis in spectral unmixing. With the new wave of spaceborne missions ahead of us, the availability of hyperspectral time series will exponentially increase in the coming years. This new data stream holds major potential for vegetation mapping. By combining spectral information from different moments throughout the growing season, plant phenology can be accounted for and spectral similarity issues can be diminished. On the other hand we point to the benefits that can come from data fusion and decision fusion techniques in unmixing. Combining the spectral and spatial information of different sensor data might allow to further increase the information detail required for rigorous vegetation monitoring. In the end we anticipate that an integrated approach combining the traditional spectral unmixing techniques with data fusion algorithms in a temporal context might result in unprecedented levels of unmixing accuracy in vegetated areas. We believe it is time to explore the 3D mixture analysis concept, i.e. simultaneously exploiting the spectral, spatial and temporal dimension of spectral data-cubes (Figure 7).

Acknowledgements

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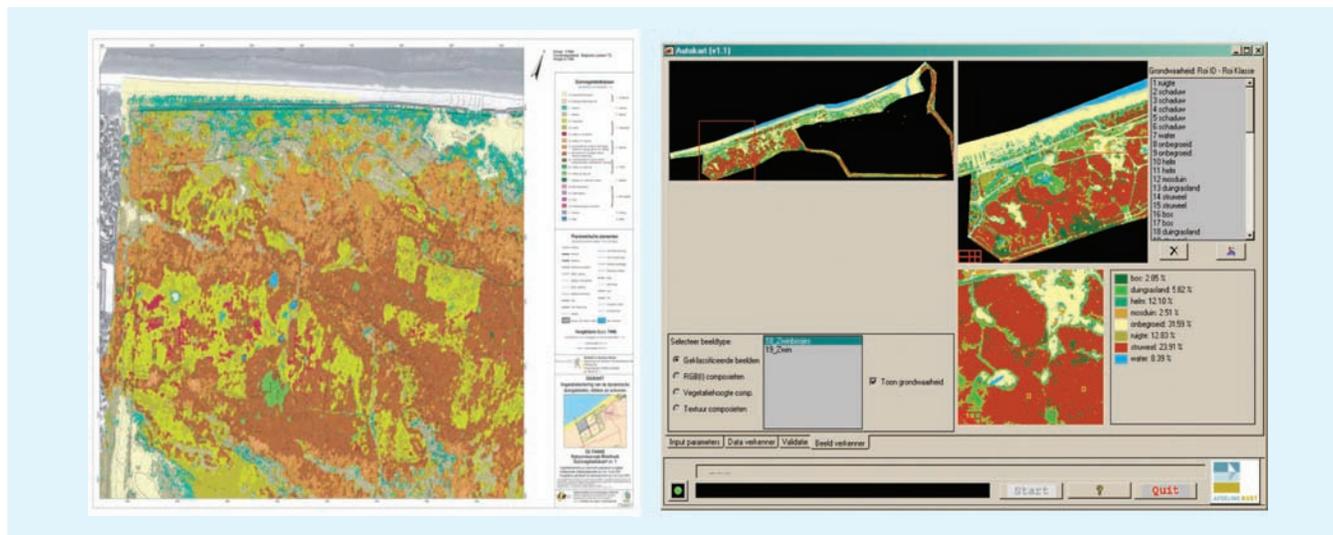


Figure 8. (left) Classification of the Belgian dune vegetation based on airborne hyperspectral imagery; (right) Autokart GUI: dune vegetation mapping based on DigiCam images.

Vegetation monitoring research @ VITO's Hyperspectral Research Group

The *Flemish Institute for Technological Research (VITO)* is a leading independent European research and consulting centre for the development of sustainable technologies in the area of energy, environment, materials and remote sensing (www.vito.be). Remote sensing activities at VITO started in the early nineties and for the last 10 years can be allocated to three main research fields: (i) space borne low resolution image processing for global vegetation monitoring; (ii) application development based upon low, medium and high resolution airborne and space borne images; (iii) the development of new remote sensing systems, platforms and instruments.

The *VITO Centre for Remote Sensing and Earth Observation Processes (TAP)* (currently including 1 professor, 14 postdocs, 4 PhD students and 37 scientists) nowadays has obtained regional, national and international respect with regard to global vegetation monitoring (VITO TAP is the coordinator of the SPOT VEGETATION Production Entity), high resolution imaging spectroscopy (VITO TAP is the APEX operator for ESA), and the development of innovative earth observation solutions (VITO TAP is the owner and operator of several unmanned airborne systems (UAS)). VITO TAP has a strong team of researchers experienced in conducting projects in the three research fields mentioned and a wide network of partners from previously performed projects for both Industrial and Governmental purpose.

As part of VITO TAP our *Hyperspectral Research Group* (<http://publications.vgt.vito.be/>) develops several applications based on imaging spectroscopy. The activities are mainly concentrated on vegetation mapping, on coastal and aquatic applications and on the development and operational implementation

of classification and unmixing techniques. Over the years, researchers within our group also built valuable expertise in calibration, atmospheric and geometric corrections of hyperspectral data. In collaboration with the technology group a processing chain for airborne data, referred to as CDPC or Central Data Processing Centre, was built. Currently the CDPC is able to process data from video, hyperspectral pushbroom, whiskbroom (i.e., APEX, CASI, AISA, Hymap, Hyspex) and frame cameras.

Our research results are often used to support management and policy of the different divisions within the Flemish government. Algorithms are as such often implemented into the CDPC or developed as stand alone software packages. An example of this latter is the Autokart software, an automated classification software package, currently installed at the Flemish Geographic Agency and used for monitoring the Flemish dune belt in the context of the European coastal defense policy. This stand alone application was an operational extension of the classification technique developed in [24] (Figure 8).

Our algorithms, although initially developed for hyperspectral data applications, are developed based on generic principles so that they can be used in a wide range of applications and applied on different sensor data. A nice example of this is the adjacency correction method SIMEC [25] that was originally developed for airborne data, but is currently also used for the correction of MERIS satellite imagery [26].

To support our activities and for calibration and validation purposes a laboratory with field instrumentation is available including a wide variety of handheld and experimental optical devices such as spectrometers, Microtops and CIMEL sunphotometers. The laboratory is maintained by a technician and instruments are calibrated regularly.



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JAPAN ONE YEAR AFTER THE EARTHQUAKE AND TSUNAMI ON THE TOHOKU COAST

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On March 11, 2011, at 2:46 pm local time, a 9.0-magnitude earthquake occurred 80 miles (129 km) east of Sendai, Japan at 30 km depth [1]. It resulted in a tsunami with waves as high as 45 ft (13.7 m) at the Tokoku (literally “north-east”) coast of Japan and was large enough to cause a small amount of damage on the other side of the Pacific Ocean in coastal California and on islands off Ecuador and Chile [1]. In Japan, the earthquake and tsunami killed just over 19,000 people and initiated a nuclear accident at the Fukushima Daiichi nuclear plant 100 km south of Sendai [2]. Remote sensing imagery from Japanese satellites and those of many other nations played a key role in observing tsunami-affected areas for disaster mitigation after the “3.11” earthquake.

Nearly one year after the disaster, in February 2012, I was invited by the Japanese government to visit Japan. On February 18, I visited the University of Tokyo, hosted by Prof. Akira Hirose, Head of the Department of Electrical Engineering and Information Systems. Akira Hirose-sensei and his graduate students welcomed me to the University of Tokyo at the Akamon, or Red Gate, as shown in Figure 1. In addition to being the Associate Editor for Asian Affairs of the GRSS Newsletter, Prof. Hirose will serve as the General Chair of APSAR 2013, to be held in Tsukuba, Japan, on September 23–27, 2013. Up to 300 attendees are expected to travel to Tsukuba and attend APSAR 2013. Current information on the meeting is available online at www.apsar2013.org.

On February 19, I took the Shinkansen, or bullet train, from Tokyo station to Sendai station, a very comfortable ride of only 113 minutes to travel a distance of 189 miles (304 km). My visit to Sendai was hosted by Prof. Motoyuki Sato, Professor and Director of the Center for Northeast Asian Studies at Tohoku University in Sendai. He is an IEEE Fellow “for contributions to radar remote sensing technologies in environmental and humanitarian applications” and is well known for his work in humanitarian demining in east Asia. He told me that on the fastest Shinkansen, one can travel from Tokyo to Sendai in only 93 minutes. Motoyuki Sato-sensei served as the General Chair for



Figure 1. Akira Hirose (left) and his graduate students welcoming Steve Reising at the Akamon, or Red Gate, of the University of Tokyo, Japan.

IGARSS 2011 Sendai-Vancouver, which was fully planned for Sendai but had to be moved to Vancouver after the March 2011 earthquake and tsunami. IGARSS 2011 was extremely successful in Vancouver, Canada, thanks to Motoyuki Sato-sensei and his excellent team, ably assisted by Conference Management Services and local participants in Vancouver.

In downtown Sendai, only a small number of buildings were seriously damaged by the earthquake, and no one was killed in downtown Sendai City due to the earthquake or tsunami. However, only 10 km to the east on the Pacific coast, entire villages were wiped away. I visited one such village that had a population of 3,000 before March 11, 2011. Today only the foundations of the houses remain, and a makeshift memorial and flowers were there to remember those who lost their lives there one year ago. The former residents of the town are in the process of petitioning Miyagi Prefecture so that they may rebuild their town on the same site where they and their ancestors lived for centuries and made their living from fishing in the Pacific Ocean. This and similar new towns will be built to withstand large earthquakes and tsunamis. Remote



Figure 2. Steve Reising visiting Sendai, Japan, with a view of downtown Sendai from the Sendai Castle park. The Westin Hotel is housed in the tallest building on the right side.

sensing technologies and information are needed to facilitate disaster mitigation, early warning and damage minimization through detection of areas damaged by natural disasters, including earthquakes, tsunamis, volcanoes, typhoons and floods.

Sendai City has about one million inhabitants, and it has grown significantly, both in population and employment, since the earthquake and tsunami one year ago. Some people have moved to Sendai after being evacuated from other prefectures after the disaster. Others have come to work on reconstruction after the devastation of properties. As shown in Figure 2, I experienced Sendai as a vibrant city that is functioning just as any other city of its size in the world. In terms of safety after the nuclear accident, Sendai is 100 km



Figure 3. Steve Reising visiting the historical site of Zuihōden in Sendai, Japan.

from the Fukushima-Daiichi nuclear power plants. Radiation levels in the air measured during January 2012 were only 0.06 microSieverts per hour, less than those in New York, Berlin, Beijing, Singapore and Hong Kong, measured during a similar period. In terms of visiting Sendai, for example the (always conservative) U.S. State Department's last Travel Advisory for Japan issued in October 2011 states, "The U.S. government believes the health and safety risks to temporary visitors to [non-evacuation areas within 80 km of the Fukushima-Daiichi nuclear power plant] are low and exposure does not pose significant risks to U.S. citizens making visits of less than one year."

Sendai has been known for many decades as The City of Trees, and it has many beautiful natural and historical sites. One of the most famous historical sites of Sendai is Zuihōden, the mausoleum of Date Masamune and his heirs in the Date family, who served as Lords of Sendai during the 17th Century, as shown in Figure 3. Zuihōden was destroyed by bombing and fire in 1945, rebuilt and restored for historical accuracy to its current state in 2001. During my visit to Sendai on February 19–20, I met with representatives of the Sendai Chamber of Commerce, toured meeting facilities at the Westin Sendai and the Kokusai Hotel across the street. The Westin Sendai is located in a 37-story office tower in downtown Sendai, within 10 minutes walking distance of the train station, and one of the most earthquake-safe buildings in the area. Along with two representatives of the Sendai Chamber of Commerce, Motoyuki Sato-sensei and I toured the meeting facilities in the Sendai International Center and discussed at length the new convention facility to be added on an adjacent property, to be completed by 2015. My favorite room in the Sendai International Center was a traditional Japanese tatami room, where guests can try on a kimono and attend a traditional tea ceremony. While riding around Sendai, I saw a great deal of construction to add new subway stations for a new subway line connecting the Sendai railway station, downtown Sendai and the Sendai International Center. This new subway line is planned to open by 2015. Motoyuki Sato-sensei and I had a meeting with the Associate Director of the Sendai City Museum and his staff. The museum has a beautiful setting, distinctive sculpture and a great deal of archaeological and historical information on Sendai and the Miyagi Prefecture.

On February 21, I took the Shinkansen back to Tokyo to visit Tsukuba, home to the Japanese Aerospace Exploration Agency (JAXA). Tsukuba is about 31 miles (50 km) from Tokyo, in the Ibaraki Prefecture. In contrast to Sendai's long history, so-called Tsukuba Science City is a planned city, envisioned in the 1960s, constructed in the 1970s and became operational by the 1980s. With a population of only 207,000 in 2008, Tsukuba is home to 60 national research centers and two universities. It is perhaps one of the world's largest-scale attempts to accelerate the pace of and improve



Figure 4. Steve Reising and Masanobu Shimada at the new museum in JAXA's Tsukuba Space Center in Tsukuba, Japan.

the quality of scientific discovery [3]. In 2005, the Tsukuba Express train began service, connecting Tokyo's Akihabara station, a center of consumer electronics, to Tsukuba in only 45 minutes.

My host in Tsukuba was Dr. Masanobu Shimada, who serves as the Science Manager of the Advanced Land Observation Satellite (ALOS) at JAXA. He is an IEEE Fellow "for contributions to radar remote sensing technologies." He has worked in Tsukuba for more than 30 years but still keeps his home in a different area of Japan and is there during the weekends. Masanobu Shimada-san and I toured the Epochal Tsukuba International Conference Center, where APSAR

2013 will be held next September. The Epochal Tsukuba's director is Dr. Leo Esaki, who shared the Nobel Laureate in Physics for the discovery of electron tunneling. Finally, Masanobu Shimada-san invited me to JAXA's Tsukuba Space Center to learn about their exciting research and many land applications of ALOS SAR data as well as preparations for the launch of ALOS-2 (see Figure 4).

In summary, one year ago Japan suffered an unprecedented triple disaster of earthquake, tsunami and nuclear accident. I witnessed the strength and resilience of the Japanese people as they have already cleaned up from 3.11 and are now beginning to rebuild the Tohoku coast. The city of Sendai is 100 km from the Fukushima-Daiichi nuclear power plant where the accident occurred and is currently at least as safe to visit as any other

city of its size in the world.

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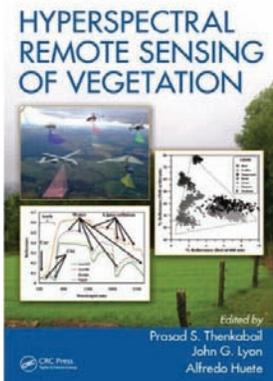


BOOK REVIEW

HYPERSPECTRAL REMOTE SENSING OF VEGETATION

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Hyperspectral Remote Sensing images of Vegetation is the first book fully devoted to hyperspectral remote sensing (or imaging spectroscopy) of vegetation. The book covers a wide range of topics in 700 pages and 28 chapters. A variety of both applications and methods are treated. Among applications we find biophysical and biochemical modeling; cropland, forest type and species detection and classification; carbon flux and light use analysis; precision farming; heavy metals effects analysis; wetland mapping; pasture characterization; invasive species separation; plant stress analysis; plant litter detection; vegetation water content analysis; soil mapping; cross-sensor calibration; and other planets applications. Concerning methodologies the book covers the whole processing chain from raw data to final product: pre-processing for hyperspectral data analysis, such as feature selection methods for dimension reduction; two- and multiple-band indices calculation (e.g., vegetation indices, cellulose absorption index, leaf area index); narrowbands selection; data analysis by support vector machines, principal components analysis, calibration, linear discriminant analysis, production efficiency models, spectral unmixing, etc. For each mentioned topic solutions have been proposed, which are peculiar for the use in hyperspectral image processing.

Almost all available hyperspectral sensors are involved in this book: ground, airborne, and spaceborne sensors. Tables are present that list hyperspectral instruments from past and future missions (more than 30 are documented), for both Earth and other Planets investigation along with their characteristics. Such tables are partially overlapping and a larger and more complete one would have been desirable.

The book includes 28 chapters grouped in XII parts. The first and the last are devoted to Introduction and Conclusions and are written by the Editors. Introduction gives an excellent overview on narrowbands for vegetation and agricultural crops applications. The chapter is completed by broad tables listing: i) narrowbands with their importance in vegetation and agricultural studies; and ii) Earth Observation Hyperspectral missions. This chapter gives a very good overview on methods and approaches. Conclusions chapter effectively summarizes the outcomes of the book. A highly useful table on optimal hyperspectral narrowbands has been built by the Editors according to the research and discussion in the chapters. This table is an interesting key to the reading of the book. The remaining 10 parts are written by a total of 72 contributors experts in hyperspectral data processing.

Part II is built of 2 chapters concentrated on the hyperspectral sensors physical properties and possible operational modes, as well as on common methods applied to hyperspectral data processing. The constraints of Global change applications are considered and challenges and feature directions sketched. The two chapters perform a critical and comparative analysis of advantages, disadvantages and challenges of airborne, ground-based, truck-mounted and space-borne hyperspectral sensors. Despite they partially overlap Chapter 1, this two chapters give different perspectives of hyperspectral data, approaches to hyperspectral data processing, and challenges.

Part III includes two chapters as well. They are devoted to relevant theoretical issues and perform an analysis of available methods for hyperspectral data mining and processing. Dealing with the high amount of data acquired by hyperspectral sensors, one of the most critical aspects is handling the high dimensionality and redundancy of data. To this end several data mining methods have been developed both supervised and unsupervised. Data mining includes both feature and information extraction steps. Chapter 4 effectively reviews state of the art on data mining, whereas Chapter 5 focuses on methods for data classification and unmixing.

Parts IV to X are devoted to various applications. Each chapter properly introduces the considered problem, identifies the hyperspectral narrowbands, features (see Chapter 4) and methods (see Chapter 5) most suitable for the solution of the considered problem. Part IV and V are mainly devoted to leaf, plant and vegetation biophysical and biochemical properties analysis based on hyperspectral data. Contributions are given on the estimation of chlorophylls, carotenoids and



anthocyanin content; leaf nitrogen concentration; pastures characterization; vegetation water content estimation; and vegetation stress. The effectiveness of several indices (simple ratio, normalized and enhanced vegetation indices) as well as multivariate statistics have been investigated. Parts VI and VII are devoted to vegetation litter; species identification and discrimination; canopy species in tropical forests; and invasive species according to the Normalized Difference Vegetation Index (NDVI), cellulose absorption index and proper band combinations. Parts VII and IX investigate forest and crop management, wetland vegetation properties, plant stress and disease related to heavy metals effects. Finally, Part X is devoted to global change analysis on the bases of long-term vegetation indexes.

These studies show how depending on the considered application both narrowband and broadband indices may be useful and point out that several different indices can be investigated to achieve the desired results. A very good summary is given in table 28.1 at the end of the book. An important issue that is analyzed through chapters is that the availability of remote sensing hyperspectral data gave to scientists the possibility of performing non-destructive spectroscopy analyses. This is a valuable advantage with respect to standard destructive methods.

The last part before conclusions, Part XI, is devoted to the use of hyperspectral data for the investigation of other planets. In this field hyperspectral data are used for the study of geological, mineralogical properties as well as for historical analyses. Nowadays many of the Solar system planets have been investigated by means of hyperspectral data: Mercury, Mars, Jupiter and Saturn. Moreover, the Earth Moon, and the moons of Jupiter and Saturn have been also analyzed. As an example, Mercury exosphere, Mars minerals and ice, Jupiter atmosphere and volcanoes have been studied. What is emphasized is that the methods used for other Planets are similar to the ones developed for Earth analysis.

Before concluding, it is worth to note that the scientists, students, and professionals have been waiting for a long time a book on hyperspectral remote sensing data documenting the unique opportunities given by them. Time is finally ripe for

such a book. The acknowledge goes to Editors for twiggging the opportunity and covering the gap, and to Authors for the excellent job in covering a wide range of topics. The final product is a book that effectively concentrates the main knowledge advances in hyperspectral data processing. Thanks to this property there is a wide range of potentially interested readers.



Francesca Bovolo received the “Laurea” (B.S.), the “Laurea Specialistica” (M.S.) degrees in telecommunication engineering (*summa cum laude*) and the Ph.D. in Communication and Information Technologies from the University of Trento, Italy, in 2001, 2003 and 2006, respectively.

She is presently a research fellow at the Remote Sensing Laboratory of the Department of Information Engineering and Computer Science, University of Trento. Her main research activity is in the area of remote-sensing image processing. In particular, her interests are related to multitemporal remote sensing image analysis (classification and change detection) in multispectral, hyperspectral and SAR data. She conducts research on these topics within the frameworks of several national and international projects. She is a referee for many *IEEE* and other international journals. Francesca Bovolo ranked first place in the Student Prize Paper Competition of the 2006 *IEEE International Geoscience and Remote Sensing Symposium* (Denver, August 2006). Since January 2011 she is an associate editor of the *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* and Guest Editor of the Special Issue on “*Analysis of Multitemporal Remote Sensing Data*” of the *IEEE Transaction on Geoscience and Remote Sensing*. She has been the Technical Chair of the Sixth International Workshop on the Analysis of Multitemporal Remote-Sensing Images (MultiTemp 2011). Since 2006, she has served on the Scientific Committee of the SPIE International Conference on “Signal and Image Processing for Remote Sensing”. She has served on the Scientific Committee of the *IEEE Fourth and Fifth International Workshop on the Analysis of Multi-Temporal Remote Sensing Images (Multi-Temp 2007 and 2009)*.



TECHNICAL COMMITTEES CORNER

2012 IEEE GRSS DATA FUSION CONTEST: MULTI-MODAL/MULTI-TEMPORAL FUSION

Fabio Pacifici¹ and Qian Du²
¹DigitalGlobe, U.S.A.
²Mississippi State University, U.S.A.

1. Introduction

The 2012 IEEE GRSS Data Fusion Contest is designed to investigate the potential of multi-modal/multi-temporal fusion of very high spatial resolution imagery. This year, participants will download three different sets of images (optical, SAR, and LIDAR) over the downtown of San Francisco and each participant will get to choose their own research topic to work with. Proposals should describe in detail the addressed problem, the method used, and the end result.

Participants will receive a collection of images provided by DigitalGlobe, Astrium Services, and USGS that includes very-high spatial resolution QuickBird, WorldView-2, TerraSAR-X, and LIDAR data, as shown in Figure 1. The optical and SAR data sets will be composed of a total of eight images from two acquisition times in 2007 and 2011 as shown in the Table I.

2. How to Get the Data and Enter the Contest

The data can be downloaded from: <http://www.grss-ieee.org/community/technical-committees/data-fusion/data-fusion-contest/>

Participants must read and accept the Contest Terms and Conditions, and the DigitalGlobe and Astrium Services/Infoterra GmbH End User License Agreement in order to download the data.



Participants are required to submit a manuscript to enter the Contest. The deadline for the submission is May 1st, 2012. The proposal must be formatted in accordance with the IEEE International Geoscience and Remote Sensing Symposium template (available at <http://www.igarss12.org/Papers/PaperKit.html>). The document must be in English and should be four pages maximum, including figures and references, and submitted in PDF format. Make

sure to include the following:

- Title
- Name
- Affiliation
- Email

Submit your proposal to: dftc-at-ieee.org

Table I. Data sets used for 2012 Contest

Sensor	Acquisition 1	Acquisition 2
QuickBird/ WorldView-2	11 November 2007	9 October 2011
TerraSAR-X	5 December 2007	2 October 2011
	16 December 2007	13 October 2011
	27 December 2007	24 October 2011
LIDAR	June 2010	



Figure 1. Composition of the optical, SAR, and LIDAR data sets over the downtown of San Francisco.



3. Award Committee

Each paper will be automatically modified to hide names and affiliations of the authors to favor the neutrality and impartiality of all reviews. Papers are judged in terms of sound scientific reasoning, problem definition, methodology, validation, and presentation. Eight independent judges will evaluate the proposals:

- Jocelyn Chanussot, Grenoble Institute of Technology, France
- Curt Davis, University of Missouri, USA
- Jenny Q. Du, Mississippi State University, USA
- Paolo Gamba, University of Pavia, Italy
- Karl Heidemann, USGS, USA
- Oliver Lang, Astrium Services, Germany
- Fabio Pacifici, DigitalGlobe, Inc., USA
- Uwe Sörgel, Leibniz Universität Hannover, Germany

4. Results and Prizes

Final results will be announced at the 2012 IEEE International Geoscience and Remote Sensing Symposium in Munich, Germany, in July 2012. The winning teams will be awarded with an IEEE Certificate of Recognition during the Chapters and Technical Committees Luncheon.

Additionally, the Data Fusion Technical Committee is pleased to announce that the winning teams will receive monetary prize as follows:

- First Place: \$800
- Second Place: \$500
- Third Place: \$300

The Data Fusion Technical Committee will also cover the cost of the Chapters and Technical Committees Luncheon for the three winning teams.

Finally, as tradition, a manuscript summarizing the contest outcomes will be submitted to a GRSS Journal. To further enhance its impact in the community, the Data Fusion Technical Committee will support its open-access publication cost.

Funding will be provided by the IEEE Geoscience and Remote Sensing Society and DigitalGlobe, Inc.

5. Discussion Forum

Questions, technical or otherwise, should be submitted to the IEEE GRSS Data Fusion Discussion Forum at <http://www.linkedin.com/groups/IEEE-GRSS-Data-Fusion-Discussion-3678437>

You can contact the Committee Chairs by email at: [dftc -at- ieee.org](mailto:dftc-at-ieee.org)

If you are interested in joining the Data Fusion Technical Committee, please send an email with:

- **Your Name**
- **Your Institution/Company**
- **Country**
- **Email**

Members receive information regarding Data Fusion research and applications, and update on the annual Data Fusion Contest. The subscription to the Data Fusion Technical Committee is free!

Join the LinkedIn IEEE GRSS Data Fusion Discussion Forum:
<http://www.linkedin.com/groups/IEEE-GRSS-Data-Fusion-Discussion-3678437>

(President's Message continued from page 9)

Finally, I would like to congratulate the five new IEEE Fellows (Class of 2012) that were nominated through the GRSS: Jocelyn Chanussot, Steven Durden, John Mathews, Eric Miller and Simonetta Paloscia. In addition, two other GRSS members were elected to IEEE Fellow through nominations submitted by other IEEE societies: Malcolm Heron (Ocean Engineering Society) and Scott Tyo (Antennas and Propagation Society). Congratulations to all new IEEE Fellow members for this most distinguished recognition!

We are certainly looking forward to an exciting 50th Anniversary of our society and hope you will participate in our activities this year.

With my best wishes,

*Jón Atli Benediktsson
President IEEE Geoscience and
Remote Sensing Society, benedikt@hi.is*



CHAPTERS CORNER

2012 GRSS DISTINGUISHED SPEAKERS PROGRAM

*David M. Le Vine, NASA Goddard Space Flight Center, Maryland, USA
Distinguished Speakers Committee Chair*

1. Introduction

The IEEE GRSS Distinguished Lecturer Program provides GRSS Chapters with talks by experts on topics of interest and importance to the Geoscience and Remote Sensing community. The purpose of the program is to provide our members with an opportunity to learn about some of the exciting work being done in our discipline and to meet some of the prominent members of our Society. Information about the speakers and how to take advantage of the program, including an application form, are available at the GRSS website (look for Distinguished Lecturer under the “Education” tab). Further information including a manual with instructions can be obtained by emailing the program chair, David Le Vine at d.levine@ieee.com

The program has been structured so that Chapters will incur little or no cost in making use of this program. Briefly a chapter contacts a lecturer from the list of available speakers, and once the initial details of the visit have been worked out (e.g. date and a rough budget) the chapter fills out the application form. Currently, the Society will reimburse Distinguished Lecturers up to \$1,250 for presentations to Chapters located inside the DL’s IEEE geographic region. Travelling outside the DL’s geographic region is reimbursable up to \$2,500. Canada and the U.S. are considered to be one region for reimbursement purposes. Reimbursement is directly to the lecturer from IEEE/GRSS.

New in 2012 is the addition of three new topics and lecturers:

- L. Bruzzone: Current Scenario and Challenges in the Analysis of Multitemporal Remote Sensing Images
- M. Crawford: Advanced Methods for Classification of Hyperspectral Data
- Y. Kerr: SMOS First Successes and Related Issues: The First Global Soil Moisture and Sea Salinity Maps are Coming

The full list of speakers and abstracts for the talks and background information for each Lecturer are available on the GRSS website: www.grss-ieee.org

Suggestions on ways to improve the program or ideas for topics and/or speakers are always welcome. Please send your comments or questions to the program chair at d.levine@ieee.org. We would greatly appreciate your suggestions.

2. Distinguished Speakers for 2012

1) **Lorenzo Bruzzone:** Department of Information Engineering and Computer Science, University of Trento, Italy. Email: Lorenzo.bruzzone@ing.unitn.it



Lorenzo Bruzzone (S’95–M’98–SM’03–F’10) received the laurea (M.S.) degree in electronic engineering (summa cum laude) and the Ph.D. degree in telecommunications from the University of Genoa, Italy, in 1993 and 1998, respectively. He is currently a Full Professor of telecommunications at the University of Trento, Italy, where he teaches remote sensing, pattern recognition, radar, and electrical communications.

Dr. Bruzzone is the founder and the head of the Remote Sensing Laboratory in the Department of Information Engineering and Computer Science, University of Trento. His current research interests are in the areas of remote sensing, radar and SAR, signal processing, machine learning and pattern recognition. He promotes and supervises research on these topics within the frameworks of several national and international projects. He is the author (or coauthor) of 114 scientific publications in referred international journals (76 in IEEE journals), more than 170 papers in conference proceedings, and 16 book chapters. He is editor/co-editor of 11 conference proceedings and 1 scientific book. He has served on the Scientific Committees of several international conferences and he was invited as keynote speaker in more than 20 international conferences and workshops. He is a member of the Managing Committee of the Italian Inter-University Consortium on Telecommunications. Since 2009 he is a member of the Administrative Committee of the IEEE Geoscience and Remote Sensing Society.

Dr. Bruzzone ranked first place in the Student Prize Paper Competition of the 1998 IEEE International Geoscience and Remote Sensing Symposium (Seattle, July 1998). He was a recipient of the Recognition of IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING (TGRS) Best Reviewers in 1999 and was a Guest Co-Editor of different Special Issues of international journals. In the past years joint papers presented



by his students at international symposia and master theses that he supervised have received international and national awards. He was the General Chair/Co-chair of the First, Second and Sixth IEEE International Workshop on the Analysis of Multi-temporal Remote-Sensing Images (MultiTemp), and is currently a member of the Permanent Steering Committee of this series of workshops. Since 2003, he has been the Chair of the SPIE Conference on Image and Signal Processing for Remote Sensing. From 2004 to 2006 he served as an Associated Editor of the IEEE GEOSCIENCE AND REMOTE SENSING LETTERS, and currently is an Associate Editor for the IEEE TGRS and the CANADIAN JOURNAL OF REMOTE SENSING. Since April 2010 he has been the Editor-in-Chief of the IEEE GEOSCIENCE AND REMOTE SENSING NEWSLETTER. In 2008 he has been appointed as a member of the joint NASA/ESA Science Definition Team for the radar instruments for OUTER PLANET FLAGSHIP MISSIONS. He is a member of the Italian Association for Remote Sensing (AIT).

Talk Abstract - Current Challenges in the Analysis of MultiTemporal Remote Sensing Images

In the last decade a large number of new satellite remote sensing missions have been launched resulting in a dramatic improvement in the capabilities of acquiring images of the Earth surface. This involves an enhanced possibility to acquire multitemporal images of large areas of the Earth surface, with improved temporal and spatial resolution with respect to traditional satellite data. Such new scenario significantly increases the interest of the remote sensing community in the multitemporal domain, requiring the development of novel data processing techniques and making it possible to address new important and challenging applications. The potentials of the technological development are strengthened from the increased awareness of the importance of monitoring the Earth surface at local, regional and global scale. Assessing, monitoring and predicting the dynamics of land covers and of anthropic processes is at the basis of both the understanding of the problems related to climate changes and the definition of politics for a sustainable development. Nonetheless, the properties of the images acquired by the last generation sensors pose new methodological problems that require the development of a new generation of methods for the analysis of multitemporal images and temporal series of data.

After a general overview of the problems related to the analysis of multitemporal images and time series of data, this talk will focus on the very important problem of automatic change detection between multitemporal images. The development and the use of effective automatic techniques for change detection are of major importance in many of the above-mentioned application scenarios. The increased geometrical resolution of multispectral and SAR sensors, the increased revisit time of high resolution systems, and the expected availability of time series of hyperspectral images in the near future result in many

different methodological problems as well as in very important new possible applications. The talk will address these problems by pointing out the state of the art and the most promising methodologies for change detection on images acquired by the last generation of satellite sensors. Examples of the use of change-detection approaches in operative scenarios will be provided. The presentation can be tuned on request on different kinds of target audience: 1) students; 2) remote sensing scientists; 3) scientists expert in data analysis.

2) Melba M. Crawford: Associate Dean of Engineering for Research, Purdue University, W. Lafayette, Indiana: Email: mcrawford@purdue.edu



Melba Crawford is a Professor of Engineering and Agriculture at Purdue University, where she is Director of the Laboratory for Applications of Remote Sensing and the Chair of Excellence in Earth Observation. She also serves as the Associate Dean for Research of the College of Engineering. Previously, she was a faculty member at the University of Texas at Austin, where she founded an interdisciplinary research and applications development program in space-based and airborne remote sensing. Dr. Crawford received the B.S. and M.S. degrees in Civil Engineering from the University of Illinois, Urbana, and the Ph.D. degree in Systems Engineering from Ohio State University, Columbus.

Dr. Crawford's research focuses on methods for analysis of hyperspectral and LIDAR data, including classification, active learning, and knowledge transfer, and in the application of these methodologies. Her research includes collaborative studies in land cover mapping and monitoring, topographic mapping, hydrologic modeling, and characterization of vegetation structure. She has more than 150 publications in scientific journals, conference proceedings, and technical reports.

Dr. Crawford's professional activities include service to the IEEE Geoscience and Remote Sensing Society, where she is an elected member of the Administrative Committee. As Education Director (1998–2000), she had responsibility for K-12, undergraduate, graduate, and professional educational outreach programs. She served as Vice President for Professional Activities (1999–2001) and Vice President for Meetings and Symposia (2002–2011), and is currently the Executive Vice President of the GRSS Society. Dr. Crawford is an Associate Editor of the IEEE Transactions on Geoscience and Remote Sensing. She was also a member of the NASA Earth System Science and Applications Advisory Committee (ESSAAC), the NASA EO-1 Science Validation team for the Advanced Land Imager and Hyperion, and the advisory committee to



the NASA Socioeconomic Applications and Data Center (SE-DAC). In 2004–2005, Dr. Crawford was a Jefferson Senior Science Fellow at the U.S. Department of State, where she coordinated Science Sector activities within the U.S. National Commission to UNESCO and served as an advisor to the U.S. Ambassador to UNESCO.

Talk Abstract - Advanced Methods for Classification of Hyperspectral Data

Accurate land cover classification that ensures robust mapping under diverse conditions is important in environmental studies where the identification of the land cover changes and its quantification have critical implications for management practices, ecosystem health, and the impact of climate. Hyperspectral data provide enhanced capability for more accurate discrimination of land cover, but significant challenges remain for classification, including highly correlated spectral bands, high dimensionality, and nonlinear spectral response in nonstationary environments. Advanced methods in machine learning, including nonlinear manifold learning, semi-supervised learning, and active learning are promising for classification of hyperspectral data.

Nonlinear global and local manifold learning methods provide natural capability to both accommodate nonlinear scattering and practical, robust feature extraction methods in dynamic environments. Adaptive semi-supervised approaches train the classifier with labeled samples in one location/time and adapt supervised classifiers to samples in spatially disjoint areas or at different times where samples exhibit significantly different distributions [Kim and Crawford 2010]. Active learning techniques that focus on developing informative training sets with minimal redundancy have been demonstrated to promote greater exploitation of the information in both labeled and unlabeled data, while significantly reducing the cost of data collection [Di and Crawford 2011]. New developments for feature extraction via manifold learning, semi-supervised classification, and active learning of hyperspectral data are outlined and demonstrated using airborne and space-based hyperspectral data.

3) Dr. David Goodenough: 3355 Haida Drive, Victoria, B.C. V9C 3P2, CANADA E-mail: dgoodeno@nrcan.gc.ca



David Goodenough has been a senior Research Scientist at Pacific Forestry Centre in Victoria, BC, of the Canadian Forest Service, Natural Resources Canada. He is also an Adjunct Professor of Computer Science at the University of Victoria where he has graduate students and is a NSERC recipient. He is a Fellow of the IEEE (1997). He is a recipient of the IEEE Third

Millennium Medal (2000). He was President of the IEEE Geoscience and Remote Sensing Society (1992–1993) and served as Past-President (1994–1996). Dr. Goodenough holds the following degrees: Ph.D. and M.Sc. (University of Toronto), M. Sc. and B.Sc. (University of British Columbia). He was an Assistant Professor of Astronomy at Wheaton College in Norton, MA (1970–1973). He was an Adjunct Professor of Electrical Engineering at the University of Ottawa (1979–1996). Dr. Goodenough worked at the Canada Centre for Remote Sensing (1973–99), where he was a Chief Research Scientist and Head of the Knowledge-Based Methods and Systems Section. He has published extensively (>200 papers). He has received the following awards: Government of Canada's Award of Excellence; the IEEE GRS-S Distinguished Achievement Award; the Canadian Remote Sensing Society's Gold Medal Award; the IEEE GRSS Outstanding Service Award; a Natural Resources Canada Departmental Merit Award; an Energy, Mines, and Resources Merit Award; and NASA Group Achievement Awards. Dr. Goodenough is Principal Investigator of a Radarsat-2 Forest Applications Project, a Hyperspectral Forest Applications Project, and a Co-I of a Scientific GRID Computing and Data Project for producing Above-Ground Forest Carbon Maps. Dr. Goodenough was Principal Investigator (PI) of the NASA project, Evaluation and Validation of EO- for Sustainable Development (EVEOSD) of forests. He is also PI of a CHRIS project, EVC, with the European Space Agency. Dr. Goodenough was the PI of the System of Experts for Intelligent Data Management (SEIDAM) Project with NASA. He was PI of a project for monitoring Canada's above ground carbon in its forests. He is a member of a USAF / DND hyperspectral team for a new hyperspectral sensor, ARTEMIS. Dr. Goodenough's current research interests focus on methods and algorithms for forest information from hyperspectral and polarimetric radar systems in order to create geospatial products for forest species, forest health, and forest carbon. He has provided consultation on remote sensing methods and systems for civilian and defense applications. Dr. Goodenough has participated in national and international large satellite missions, serving on Phase A teams, User and Science Teams, and Evaluation Teams.

Talk Abstract - Methods and Systems for Applications

In order to monitor the resources and environment of the planet, it is necessary to use remote sensing from multiple sensors and integrate these data with historical information contained within geographical information systems (GIS). Multiple sensors are required to identify attributes of interest. In forestry, resource managers want to know the amount of the resource by species, area, timber volume, etc., the spatial distribution, the health (chemistry) of the forests, and the temporal changes of the resource, both past and predicted for the future. The technologies of the IEEE Geoscience and Remote Sensing Society are used to create information



systems to support resource and environmental management. In this presentation we describe hyperspectral and radar methods and systems to obtain valuable forest information, such as chemistry, above-ground carbon, species, and biomass. Models of forests are used to predict remote sensing results. The inversion of these results can lead to the estimation of forest parameters. National and global monitoring requires systems for distributed data management. We have created a system (www.saforah.org) using GRID architecture, optical light paths, and a petabyte data store at the University of Victoria. SAFORAH serves out to the public and research community remotely sensed data of Canada and forest information products for land cover, biomass, and change. Hyperspectral sensing is used to obtain species distribution and forest chemistry. Examples of this work for forest applications and the generation of Kyoto Protocol products are presented.

4) Professor Ya-Qiu Jin: Fudan University, 220 Handan Road, Shanghai 200433, China Email: yqjin@fudan.edu.cn



Ya-Qiu Jin graduated from Peking University, Beijing, China in 1970, and received the M.S., E.E., and Ph.D. degrees from the Massachusetts Institute of Technology, Cambridge, USA in 1982, 1983 and 1985, respectively. All the degrees are from electrical engineering. He was a Research Scientist with the Atmospheric and Environmental Research, Inc., Cambridge MA,

USA (1985); a Research Associate with the City University of New York (1986–1987); a Visiting Professor with the University of York, U.K. (1993–1994) sponsored by the U.K. Royal Society; a Visiting Professor with the City University of Hong Kong (2000); and a Visiting Professor with Tohoku University, Japan (2005). He held the Senior Research Associateship at NOAA/NESDIS awarded by the USA National Research Council (1996). He is currently a Chair Professor of Fudan University, Shanghai, China, and the founder Director of the Key Laboratory of Wave Scattering and Remote Sensing Information (Ministry of Education). He has been appointed as the Principal Scientist for the China State Key Basic Research Project (2001–2006) by the Ministry of National Science and Technology of China to lead the remote sensing program in China. He has published more than 620 papers in refereed journals and conference proceedings and eleven books, three of which are in English [*Electromagnetic Scattering Modeling for Quantitative Remote Sensing* (World Scientific, 1994), *Information of Electromagnetic Scattering and Radiative Transfer in Natural Media* (Science Press, 2000), *Theory and*

Approach for Information Retrieval from Electromagnetic Scattering and Remote Sensing (Springer, 2005)]. He is co-editors of *Selected Papers on Chinese Chang'E-1 Microwave Lunar Exploration* (Science Press, 2010) and SPIE Volume 3503 *Microwave Remote Sensing of the Atmosphere and Environment*, and the book *Wave Propagation, Scattering and Emission in Complex Media* (World Scientific and Science Press, 2004). His main research interests include scattering and radiative transfer in complex natural media, microwave remote sensing, as well as theoretical modeling, information retrieval and applications in atmosphere, ocean, and Earth surfaces, and computational electromagnetics. Dr. Jin is the member of IEEE GRSS AdCom, Chair of IEEE fellow Evaluation Committee (GRSS), the Associate Editor of IEEE Transactions on Geoscience and Remote Sensing (TGRS), and IEEE GRSS Distinguished Speaker, Co-Chair of Technical Committee of IGARSS2011, and Chairmen of several international conferences. He is the Founder and Chairman of IEEE GRSS Beijing Chapter (1998-2003) and received the appreciation for his notable service and contributions toward the advancement of IEEE professions from IEEE GRSS. He received IEEE GRSS Education Award in 2010, the China National Science Prize in 1993, the first-grade MoE Science Prizes in 1992, 1996 and 2009, and the first-grade Guang-Hua Science Prize in 1993 among many other prizes.

Talk Abstract - Modeling, Simulation, Inversion and Chang'E data Validation for Microwave Observation in China's Lunar Project

In China's first lunar exploration project, Chang'E-1(CE-1), a multi-channel microwave radiometer in passive microwave remote sensing, was first aboard the satellite, with the purpose of measuring microwave brightness temperature from lunar surface and surveying the global distribution of lunar regolith layer thickness. In this lecture, the multi-layered model of lunar surface media is presented, and numerical simulations of multi-channel brightness temperature (Tb) from global lunar surface are obtained. It is applied to study of retrieving the regolith layer thickness and evaluation of global distribution of ^3He content in regolith media. Multi-channel Tb measurements by CE- microwave radiometers are displayed, and applied to inversion of the regolith layer thickness, which are verified and validated by the Apollo *in situ* measurements. It is the first time to retrieve the regolith thickness and ^3He content using microwave remote sensing technology.

In active microwave remote sensing, based on the statistics of the lunar cratered terrain, e.g. population, dimension and shape of craters, the terrain feature of cratered lunar surface is numerically generated. Electromagnetic scattering is simulated, and SAR (synthetic aperture radar) image is then numerically generated, e.g. making use of the digital elevation and Clementine UVVIS data at Apollo 15 landing site as the ground truth, an SAR image



at Apollo 15 landing site is simulated. Utilizing the nadir echoes time delay and intensity difference from the surface and subsurface, high frequency (HF) radar sounder is an effective tool for investigation of lunar subsurface structure in lunar exploration. Making use of rough surface scattering and ray tracing of geometric optics, a numerical simulation of radar echoes from lunar layering structures with surface feature, the topography of mare and highland surfaces is developed. Radar echoes and its range images are numerically simulated, and their dependence on the parameters of lunar layering interfaces are described.

5) Yann Kerr: CESBIO(CNES CNRS UPS IRD), Toulouse France Email : Yann.Kerr@cesbio.cnes.fr



Yann H. Kerr (M '88, SM '01), received the engineering degree from Ecole Nationale Supérieure de l'Aéronautique et de l'Espace (ENSAE), the M.Sc. from Glasgow University in E&EE, and Ph.D from Université Paul Sabatier. From 1980 to 1985 he was employed by CNES. In 1985 he joined LERTS; for which he was director in 1993–1994. He spent 19 months at JPL, Pasadena

in 1987–88. He has been working at CESBIO since 1995 (deputy director and director since 2007). His fields of interest are in the theory and techniques for microwave and thermal infrared remote sensing of the Earth, with emphasis on hydrology, water resources management and vegetation monitoring. He has been involved with many space missions. He was an EOS principal investigator (interdisciplinary investigations) and PI and precursor of the use of the SCAT over land. In 1989 he started to work on the interferometric concept applied to passive microwave earth observation and was subsequently the science lead on the MIRAS project for ESA with MMS and OMP. He was also a Co-investigator on IRIS, OSIRIS and HYDROS for NASA. He was science advisor for MIMR and Co-I on AMSR. He is a member of the SMAP Science Definition Team.

In 1997 he first proposed the natural outcome of the previous MIRAS work with what was to become the SMOS Mission to CNES, proposal which was selected by ESA in 1999 with him as the SMOS mission Lead-Investigator and Chair of the Science Advisory Group. He is also in charge of the SMOS science activities coordination in France. He has organised all the SMOS workshops, and was guest editor on three IEEE Special issues. He is currently involved in the exploitation of SMOS data, in the Cal Val activities and related level 2 soil moisture and level 3 and 4 development. He is also working on the SMOS next concept.

Talk Abstract - SMOS First Successes and Related Issues: The First Global Soil Moisture and Sea Salinity Maps are Coming

SMOS, an L-Band radiometer using aperture synthesis to achieve a good spatial resolution, was successfully launched on November 2, 2009. It was developed and made under the leadership of the European Space Agency (ESA) as an Earth Explorer Opportunity mission. It is a joint program with the Centre National d'Etudes Spatiales (CNES) in France and the Centro para el Desarrollo Tecnológico Industrial (CDTI) in Spain.

SMOS carries a single payload, an L band 2D interferometric, radiometer in the 1400-1427 MHz h protected band. This wavelength penetrates well through the vegetation and the atmosphere is almost transparent enabling to infer both soil moisture and vegetation water content over land and sea surface salinity over the oceans. SMOS achieves an unprecedented spatial resolution of 50 km at L-band maximum (43 km on average) with multi angular-fully polarised brightness temperatures over the globe and with a revisit time smaller than 3 days.

SMOS as been now acquiring data for over two years. The data quality exceeds what was expected, showing very good sensitivity and stability. The data is however very much impaired by man made emission in the protected band, leading to degraded measurements in several areas including parts of Europe and of China. However, many different international teams are now addressing cal val activities in various parts of the world, with notably large field campaigns either on the long time scale or over specific targets to address the specific issues. These campaigns take place in various parts of the world, in different environments from the Antarctic plateau to the deserts, from rain forests to deep oceans. Actually SMOS is a new sensor making new measurements paving the way to new applications. However, it also requires a very fine analysis of the data so as to validate both the approach and the retrieval quality, as well as for monitoring the evolution of the sensor. To achieve such goals it is very important to link efficiently ground measurement to satellite measurements through field campaigns and related airborne acquisitions as well as with other existing sensors. This lecture thus gives an overview of the science goals of the SMOS mission, a description of the main mission elements, and a foretaste of the first results including performances at brightness temperature as well as at geophysical parameters. It will include how the ground campaigns were elaborated to address the main cal Val activities accounting for SMOS specificities, in what context they were organized as well as the most significant results.

6) Dr. Ricardo Lanari: IREA-CNR, via Diocleziano 328 8024 Napoli, Italy E-mail: lanari.r@irea.cnr.it

Ricardo Lanari was born in Napoli, Italy, in 1964 and graduated in 1989, summa cum laude, in Electronic Engineering at the University of Napoli, Federico II. In the same year, following



a short experience at ITALTEL SISTEMI SPA, he joined IRECE and after IREA, a Research Institute of CNR (the Italian National Council of Research), where he currently occupies the position of senior researcher. His main research activities are in the Synthetic Aperture Radar (SAR) data processing field as well as in SAR interferometry techniques; on this topic he holds two patents,

has authored more than 60 international journal papers and, in 1999, the book entitled “Synthetic Aperture Radar Processing”, written in collaboration with prof. Giorgio Franceschetti and edited by CRC-PRESS. Riccardo Lanari has been a visiting scientist at different foreign research institutes, including the Institute of Space and Astronautical Science (ISAS), Japan (1993), the German Aerospace Research Establishment (DLR), Germany (1999 and 1994) and the Jet Propulsion Laboratory (JPL), USA (1997, 2004 and 2008), where he received a NASA recognition for the technical developments related to the SRTM mission. Riccardo Lanari is a senior member of the IEEE society and he has served as chairman and technical program committee member at several international conferences. Moreover, he acts as reviewer of several peer reviewed international journals. Riccardo Lanari has lectured in several national and foreign universities and research centers; he has been adjunct professor of Electrical Communication at the l’Università del Sannio (Benevento) from 2000 to 2003 and, from 2000 to 2008, lecturer of the SAR module course of the International Master in Airbone Photogrammetry and Remote Sensing, offered by the Institute of Geomatics in Barcelona (Spain).

Talk Abstract - Differential SAR Interferometry: Basic Principles, key Applications and New Advance

Differential SAR Interferometry (DInSAR) is a microwave imaging technique that permits to investigate earth surface deformation occurring in an area of interest with a centimetre (in some cases millimetre) accuracy. In particular, the DInSAR technique exploits the phase difference (interferogram) of temporally separated SAR images relative to the investigated zone and has already shown its capability in detecting surface deformation caused by different natural and anthropogenic phenomena. The aim of this talk is to introduce the basic concepts involved in the DInSAR technique, summarize the key applications of this method and present its new advance. In particular, a discussion on the rationale of the DInSAR approach will be given first, highlighting the key points and the main limitations. Several examples will be presented for underlining the capability of the technique to analyze the displacements caused by different phenomena such as volcano deformation, earthquakes and urban subsidence. Subsequently, the talk will be

focused on the advanced DInSAR techniques allowing to analyze the temporal evolution of the detected displacements through the generation of deformation time-series computed from a data set of temporarily separated SAR images. Finally, the advance brought in by the new generation X-band spaceborne SAR sensors, characterized by higher spatial resolution and shorter revisit times with respect to the earlier C-band systems, will be discussed, emphasizing the new investigation possibilities for fast varying deformation phenomena.

7) Dr. Keith Raney: Principal Professional Staff, Applied Physics Laboratory, Laurel, MD, 20723
Email: Keith.Raney@jhuapl.edu



Dr. Raney received a BS (with honors) in physics from Harvard University (1960), a MSEE from Purdue University (1962), and a PhD in Computer Information and Control from the University of Michigan (1968). He contributed to the design of NASA’s Venus radars Pioneer and Magellan, the ERS-SAR of the European Space Agency (ESA), and the Shuttle Imaging Radar SIR-C. While with

the Canada Centre for Remote Sensing (1976-1994) Dr. Raney was scientific authority for the world’s first digital processor for satellite SAR data, and responsible for the conceptual design of the RADARSAT synthetic aperture radar (SAR). These and other contributions in radar remote sensing systems, theory, and applications are documented in more than 350 professional publications. Dr. Raney was on NASA’s Instrument Definition Teams for the Europa Orbiter and several Mars missions, the IDTs and Science Teams for Magellan and Pioneer Venus, and advisory teams for ESA’s ERS radars. He was on the Science Advisory Group for ESA’s CryoSat radar altimeter, whose design is based on his original concept. He holds several United States and international patents, and two patents on polarimetric radar architectures, including the conceptual design of the Mini-RF radars for which he was the radar architect. He served for more than 20 years as an Associate Editor (radar) for the IEEE Transactions on Geoscience and Remote Sensing, and was the Society’s President for two terms (1988–9). He has served on numerous advisory committees for the Office of Naval Research, the U.S. National Academy of Sciences, Germany’s Helmholtz Society, and the Danish Technical Research Council, among others. He is a Life Fellow of the IEEE, a Fellow of the Electromagnetics Academy, and an Associate Fellow of the Canadian Aeronautics and Space Institute. Dr. Raney is a recipient of numerous awards, including the 1999 Gold Medal of the Canadian Remote Sensing Society, the IEEE Geoscience and Remote Sensing Society Transactions Prize Paper for 1998, the IEEE Millennium Medal 2000, and the



IEEE Dennis J. Picard Medal for radar technologies and applications for 2007.

Talk Abstract - Two Hybrid-Polarimetric Imaging Radars at the Moon: Their Design, Build, and Results

The two Mini-RF radars flown in near-polar lunar orbits (on Chandrayaan-1 and the Lunar Reconnaissance Orbiter) were the first of their kind, hybrid-polarimetric. This new paradigm transmits circular polarization, and receives coherently on orthogonal linear polarizations. The resulting data support calculation of the 2×2 covariance matrix of the backscattered field, from which follow the four Stokes parameters. These are the basis of science products from the observations, which include images that are traditional in radar astronomy, as well as polarimetric decompositions. The instruments each have mass less than 15 kg, antenna areas of about 1 m^2 , and modest power and spacecraft accommodation requirements. Data quality and instrument characteristics suggest that hybrid polarity is highly desirable for future exploratory radar missions in the Solar system.

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Werner Wiesbeck received the Dipl.-Ing. (M.S.E.E.) and the Dr.-Ing. (Ph.D.E.E.) degrees from the Technical University Munich in 1969 and 1972, respectively. From 1972 to 1983 he was with AEG-Telefunken in various positions including that of head of R&D of the Microwave Division in Flensburg and marketing director Receiver and Direction Finder Division, Ulm. During this period

he had product responsibility for mm-wave radars, receivers, direction finders and electronic warfare systems. From 1983 to 2007 he was the Director of the Institut für Höchstfrequenztechnik und Elektronik (IHE) at the University of Karlsruhe (TH) and he is now Distinguished Scientist at the Karlsruhe Institute of Technology (KIT). Research topics include antennas, wave propagation, Radar, remote sensing, wireless communication and Ultra Wideband technologies. In 1989 and 1994, respectively, he spent a six months sabbatical at the Jet Propulsion Laboratory, Pasadena. He is a member of the IEEE GRSS AdCom (1992–2000), Chairman of the GRSS Awards Committee (1994–1998, 2002–present), Executive Vice President IEEE GRSS (1998–1999), President IEEE GRSS (2000–2001), Associate Editor IEEE-AP Transactions (1996–1999), past Treasurer of the IEEE German Section (1987–1996,

2003–2007). He has been General Chairman of the '88 Heinrich Hertz Centennial Symposium, the '93 Conference on Microwaves and Optics (MIOP '93), the Technical Chairman of International mm-Wave and Infrared Conference 2004, Chairman of the German Microwave Conference GeMIC 2006 and he has been a member of the scientific committees and TPCs of many conferences. For the Carl Cranz Series for Scientific Education he serves as a permanent lecturer for Radar systems engineering, wave propagation and mobile communication network planning. He is a member of an Advisory Committee of the EU - Joint Research Centre (Ispra/Italy), and he is an advisor to the German Research Council (DFG), to the Federal German Ministry for Research (BMBF) and to industry in Germany. He is the recipient of a number of awards, lately the IEEE Millennium Award, the IEEE GRS Distinguished Achievement Award, the Honorary Doctorate (Dr. h.c.) from the University Budapest/Hungary, the Honorary Doctorate (Dr.-Ing. E.h.) from the University Duisburg/Germany and the IEEE Electromagnetics Award 2008. He is a Fellow of IEEE, an Honorary Life Member of IEEE GRSS, a Member of the IEEE Fellow Cmte, a Member of the Heidelberger Academy of Sciences and Humanities and a Member of the German Academy of Engineering and Technology (acatech).

Talk Abstract - Digital Beam-Forming in Remote Sensing

The invention of the Synthetic Aperture Radar (SAR) principle dates back to the early 1950s. The basic idea is to filter targets in a side looking radar according to their Doppler history in azimuth and by pulse or FM modulation compression in range. Since this time SAR systems have been, from a technical point of view, considerably refined to the state of the art where resolution and accuracy are close to the theoretical limits. The best innovations have been reached in polarimetry and interferometry. Nevertheless, the principles are still the same: The SAR is a side-looking radar where resolution is achieved in range by bandwidth and in azimuth by Doppler processing. The beam-forming concepts for coverage are still the same: dish antennas (scanned or fixed), antenna arrays (phased or fixed) or switchable antenna systems. All these have the drawback that the coverage defines the synthetic aperture length and by this the azimuth resolution or for scanned beams the loss of coverage has to be taken into account. These drawbacks can be overcome by Digital Beam-Forming. Significant advantages result by this. In its simplest form the transmit antenna illuminates a usually larger footprint, as do the multiple receive antennas. The beam-forming is accomplished in a digital process. Multiple receive beams may be processed simultaneously. The RF losses can significantly be reduced, allowing lower gain for the antennas, and thus larger footprints. In addition Digital beam-forming can handle coded signals, like OFDM, for range and azimuth compression. This talk will present the principles and applications and latest results of Digital Beam-Forming in Remote Sensing.



EDUCATION CORNER

THE HYPERSPECTRAL IMAGING NETWORK (HYPER-I-NET): A EUROPEAN PROJECT FOR EDUCATION IN GEOSCIENCE AND REMOTE SENSING

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1. Overview

This article describes the education-oriented activities carried out in the framework of the hyperspectral imaging network (Hyper-I-Net¹) Marie Curie Research Training Network (RTN). This project, with duration from 2007 to 2011, was designed to build an interdisciplinary European research community focusing on hyperspectral imaging, an emerging science and technology that has opened ground-breaking perspectives in many geoscience and remote sensing applications. The theme of Hyper-I-Net is at the confluence of heterogeneous disciplines, such as sensor design and calibration, aerospace engineering, remote sensing, geosciences, high-performance computing, signal processing and Earth observation related products. The consortium was formed by 15 highly experienced European partner organizations (see Fig. 1), with a total of 12 countries represented in the network including 9 Universities, 3 Research Institutions and 3 Industrial Companies (SMEs). Additional information about the project can be found at the official project website². Some of the initiatives carried out in the project have inspired other education-related activities now being carried out in the IEEE Geoscience and Remote Sensing Society (GRSS), such as the organization of a GRSS summer school³ starting this year in Munich, Germany. The relationship between Hyper-I-Net and current GRSS activities is highlighted in this article.

2. Main Scientific Areas of the Project

The Hyper-I-Net project comprises four main scientific areas related with remotely sensed hyperspectral imaging. These areas are summarized below [1]:

1) Hyperspectral sensor specification. The main goal of this activity was to investigate the sensor requirements for various applications and develop new sensor specifications. For this

purpose, the tasks carried out comprise the analysis of application needs in terms of derived parameters and variables in different application fields such as agriculture, forestry, geology, phenology/limnology or urban management, with the ultimate goal of compiling spectral databases to determine the spectral response related to the individual variables and parameters and to translate the observed needs into performance requirements of new hyperspectral sensors by developing a dedicated hyperspectral instrument model (optical layout and transfer, noise, etc.)

2) Processing chain definition and implementation. The main goal of this activity was to settle the basis for the generalization of a well-defined hyperspectral data collection and processing chain that might serve as a standardized procedure for processing this type of data in Europe. For this purpose, the tasks carried out comprise the definition of a processing chain able to address needs from scientific applications and constraints imposed by sensor design, and the preliminary implementation of the processing chain steps. The expected outcome of this activity was a series of standardized hardware/software processing techniques able to deal with the intrinsic complexity of the data, along with processing chain definition and implementation reports.

3) Calibration, validation and definition of standardization mechanisms. This activity was focused on the calibration/validation of hyperspectral sensors and the results from various processing steps of the processing chain described above. This is a crucial step to reduce the overall uncertainties introduced by hyperspectral imaging instruments. For this purpose, the tasks carried out comprised an inventory of existing calibration equipment and methodologies as well as an inventory of methods and processors for onboard, laboratory and vicarious calibration and assimilation, interaction with scientists and researchers.

4) Science applications. This activity was aimed at compiling relevant applications and methods applied using imaging spectrometer data, and creating a product catalogue of both. The main task carried out in this activity comprise the definition of an algorithm theoretical baseline document (ATBD) listing methods used for selected applications,

¹ Project reference MRTN-CT-2006-035927, funded by the European Commission under the Marie Curie Research Training Networks of the Sixth Framework Programme (FP6).

² <http://hyperinet.multimediacampus.it>

³ <http://www.igarss2012.tum.de/>



complemented partly by available models and source code.

It is important to emphasize that the results obtained from these activities (which have been approved for public distribution by the consortium) are available online from the Hyper-I-Net project website⁴, along with the publications⁵ obtained by Hyper-I-Net researchers and a monthly newsletter⁶. The fact that several of the deliverables resulting from the main scientific activities of the project are publicly available in the form of technical reports allows a rapid dissemination of such activities in the wide remote sensing community. The dissemination is supported by the network newsletter, which has provided a forum for presenting the main research and transfer of knowledge activities carried out by the different partners in the consortium. In this regard, an important goal of the network was to provide a timely and unique opportunity to bridge the gap between the operational procedures of hyperspectral imaging and the development of techniques for efficient data exploitation and management, overcoming the boundaries between traditionally disjoint disciplines such as sensor design, data processing and application insight [2,3].

3. Training and Transfer of Knowledge

Being an educational project, one of the main objectives of Hyper-I-Net has been to provide high-level training in hyperspectral imaging to young researchers, with the ultimate goal of introducing novel, standardized approaches and practices for this emerging research area in Europe. In this regard, the key elements of the proposed research methodology have been focused on the development of research and training activities on hyperspectral imaging, with the ultimate goal of training young researchers in this area and to allow such researchers to have significant competitive advantages and the potential to find better jobs in science and commercial environments. Among other training events, the network has organized a total of four summer schools.

- The first Hyper-I-Net summer school was organized by Prof. Antonio Plaza and held in Cáceres, Spain (from October 29 to October 31, 2007), with attendance of more than 100 international students [see Fig. 2(a)]. The school included in-depth tutorials and state-of-the-art presentations from leading experts in the field, covering a variety of topics including hyperspectral sensor design,

 		Main scientist in charge:
	University of Extremadura (UEx), SPAIN	Antonio J. Plaza
	German Remote Sensing Data Center (DLR), GERMANY	Andreas Mueller
	Norwegian Defence Research Establishment (FFI), NORWAY	Torbjorn Skauli
	Institute of Systems Biology and Ecology (ISBE), CZECH REPUBLIC	Jan Hanus
	Instituto Superior Técnico (IST), PORTUGAL	Jose M. Bioucas-Dias
	Kayser-Threde GmbH (KT), GERMANY	Stefan Hofer
	Technical Institute of Grenoble (INPG), FRANCE	Jocelyn Chanussot
	Laboratory of Planetology and Geodynamics (CNRS), FRANCE	Veronique Carrere
	Remote Sensing Laboratories, University of Zurich (UZH), SWITZERLAND	Michael Schaepman
	Spectral Imaging Oy, Ltd. (SPECIM), FINLAND	Timo Hyvarinen
	University of Pavia (UNIPV), ITALY	Paolo Gamba
	University of Iceland (UNIS), ICELAND	Jon Atli Benediktsson
	Norsk Elektro-Optics (NEO), NORWAY	Peter Kaspersen
	Wageningen University (WUR), THE NETHERLANDS	Jan Clevers
	Warsaw University (WURSEL), POLAND	Bogdan Zagajewski

Figure 1. The Hyper-I-Net consortium.

calibration/validation, data processing and scientific applications. The full programme and presentations of the school is available online⁷.

- The second Hyper-I-Net summer school was focused on Earth Science and Applications using Imaging Spectroscopy. It was organized by Prof. Michael Schaepman and held in Wageningen, The Netherlands (from September 15 to September 19, 2009), with attendance of more than 90 international researchers [see Fig. 2(b)]. The school included talks by experts from various fields, both in- and outside the remote sensing community, the PhD defense of the thesis of Dr. Raúl Zurita-Milla⁸, an excursion to Dutch national park De Hoge Veluwe, and several hands-on training experiments⁹.
- The third Hyper-I-Net summer school was organized by Prof. Paolo Gamba and held in Pavia, Italy (from September 8 to September 11, 2009), with attendance of more than 100 international researchers [see Fig. 3(b)]. The main aim of this school was to provide an environment able to give to the attendees, and especially to the students among them, a “flavour” of the data processing tools for hyperspectral data and related problems in real life. For this reason, together with lessons that described the data, the sensors behind them and the data processing chain in use by some of the most important actors in the field, the school was structured in order to have two afternoons dedicated to more interactive sessions in a laboratory¹⁰. A the student contest was organized focused on the classification map of a hyperspectral scene collected over a rural area in Hungary. The data sets were

⁴ <http://hyperinet.multimediacampus.it/publication4.htm>

⁵ <http://hyperinet.multimediacampus.it/publication.htm>

⁶ <http://hyperinet.multimediacampus.it/publication5.htm>

⁷ <http://hyperinet.multimediacampus.it/event1.htm>

⁸ <http://edepot.wur.nl/122029>

⁹ http://www.grs.wur.nl/UK/Workshops/HYPER_I_NET_Summer_School/

¹⁰ http://hyperinet.multimediacampus.it/images/Third_School.pdf



Figure 2. The Hyper-I-Net summer schools. (a) First school held in Cáceres, Spain. (b) Second school held in Wageningen, The Netherlands. (c) Third school held in Pavia, Italy. (d) Fourth school held in DLR Oberpfaffenhofen, Germany.

kindly provided by the Szent Istvan University and Birdlife Association, both based in Budapest, and the final result was that two teams were able to provide relevant classification results for the considered scene and were both entitled to receive a prize. The school attendees also had the chance to visit the famous churches and palaces of the medieval part of the town of Pavia. In so doing so they were able to spot some of the areas depicted in the hyperspectral data sets collected over Pavia city and used in so many papers.

- The fourth Hyper-I-Net summer school was organized by Dr. Andreas Mueller and held at the premises of the Deutschen Zentrums für Luft- und Raumfahrt (DLR) in Oberpfaffenhofen, Germany (from September 13 to September 15, 2010). Calibration and validation of hyperspectral sensors was the main topic of the summer school, which was attended by more than 50 international researchers. During two days, deep insights into laboratory and inflight calibration of airborne hyperspectral sensors were given by DLR experts. As part of the school programme, a round-robin calibration experiment for field spectrometers took place in DLR's calibration laboratory in close cooperation with experts from the

University of Zurich, such as the Hyper-I-Net experienced researcher Lola Suarez who organized the experiment with involvement of 7 different institutions with over 12 field spectrometers.

Finally, it is worth noting that a special session on Hyper-I-Net was organized in GRSS flagship conference, the IEEE International Geoscience and Remote Sensing Symposium (IGARSS) in Barcelona, Spain, in July 2007. The main goal of the session was to present the project to the GRSS community. Five presentations were focused on the main work packages of the project¹¹.

4. E-learning Platform

A distributed e-learning platform (see Fig. 3) offering a comprehensive learning environment to young researchers and external partners has been developed by Hyper-I-Net partners, in an effort coordinated by Prof. Paolo Gamba at the University of Pavia, supported by Opera Multimedia. This platform provides multimedia courses and resources on different topic areas related with the project. The platform is available from

¹¹ <http://hyperinet.multimediacampus.it/event2.htm>



the main project website and open to all prior request of a login/password. Most Hyper-I-Net partners have offered a multimedia course (audio and video) broken down into several units. Each unit is treated as a separate learning object which can be accessed independently so that users can decide which unit to access and in which order (flexible training path). Each course is accompanied by a pre-assessment and post-assessment in which the fellows can self-assess their progress. A total of 13 multimedia courses (summarized below) are currently available in the e-learning platform:

- **Urban Remote Sensing.** This course provides a first introduction of urban remote sensing and data fusion related to urban area analysis using remotely sensed data. A more specific analysis is then dedicated to hyperspectral data and their processing challenges.
- **Remote Sensing Measurements of Vegetation.** This course addresses the relevant topic of how to characterize vegetation parameters using remotely sensed hyperspectral image data.
- **Retrievals of the ecosystem variables from the remotely sensed (hyper) spectral data.** This e-learning course provides insight into the quantitative remote sensing of vegetation of terrestrial ecosystems.
- **Quantitative remote sensing.** This course introduces the use of (hyperspectral) remote sensing for deriving quantitative information on biophysical and biochemical properties of vegetation. The course highlights current developments and challenges in quantitative remote sensing of vegetation.
- **GIS Module.** This module provides the theoretical background that remote sensing specialists will require when working with geographic information systems.
- **Calibration and characterization of hyperspectral cameras.** This course provides an overview of methods for calibrating and characterizing hyperspectral cameras of the “pushbroom” type. It includes theory as well as practical examples.
- **High performance computing for hyperspectral imaging.** This course focuses on the development and efficient implementation of algorithms for hyperspectral imaging, with emphasis on endmember extraction and spectral unmixing.
- **Hyperspectral Imaging Techniques.** This course starts with a short hyperspectral history and then gives an introduction into the physical basics, necessary to understand hyperspectral sensor principles. It then provides insight into instrument development and design aspects. The course closes with an overview of existing and future sensors.

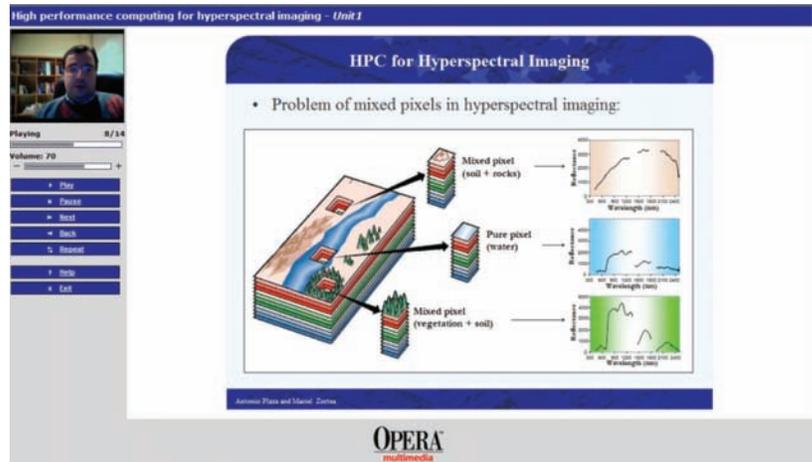


Figure 3. The Hyper-I-Net e-learning platform.

- **Campaign Planning and Operations.** In this course, the fundamental processes for the preparation and the realization of an airborne hyperspectral survey are presented. This includes planning of a whole airborne hyperspectral survey as well as single data acquisitions planning of a field campaign and introduction on field methods for remote sensing, general campaign management, calibration and operation of a sensor.
- **Hyperspectral Unmixing.** This course addresses the hyperspectral unmixing inverse problem, which, given a set of hyperspectral vectors, is the inference of the number of reference substances, also called endmembers, their spectral signatures, and their abundance fractions.
- **Hyperspectral camera technology.** This course gives a basic introduction to the technology of hyperspectral imagers. Emphasis is given to the topics of imaging optics and photodetectors. Examples are used to illustrate the effect of camera parameters on the outcome of hyperspectral image processing.
- **Applications of hyperspectral imaging to geologic and coastal environments.** This course presents some examples on how imaging spectrometer data can be used to map information relevant to geologic and coastal environments.
- **Source separation with Independent Component Analysis.** This course focuses on the adaptation of source separation techniques to the analysis of hyperspectral data, with particular emphasis on the characterization of mixed pixels and the estimation of fractional abundances.

5. Distinctions and Awards

Several awards have been already obtained by participants in the Hyper-I-Net project. For instance, Hyper-I-Net partners received one of the three best paper awards in the First IEEE/GRSS Workshop on Hyperspectral Image and Signal



Figure 4. (a) WHISPERS ceremony held during the third Hyper-I-Net summerschool organized in Pavia, Italy. (b) Distinction of Dr. Marian-Daniel Iordache, a former Hyper-I-Net early-stage researcher, as the best Romanian student of the year 2011 in Europe.

Processing: Evolution in Remote Sensing (WHISPERS¹²) organized in August 2009 in Grenoble, France. The paper, authored by J. Verrelst, M. E. Schaepman and J. Clevers from Wageningen University, the Netherlands, is entitled “Fusing Minnaert-k parameter with spectral unmixing for forest heterogeneity mapping using CHRIS-PROBA data.” [4]

In fact, WHISPERS and Hyper-I-Net have maintained a very close connection, since most of the partners involved in the organization of WHISPERS are also members of the Hyper-I-Net consortium. For instance, during the third Hyper-I-Net summer school held in Pavia, Italy, a small ceremony took place. A “W” symbol was provided by the organizing team of the WHISPERS 2009 conference, chaired by Prof. Jocelyn Chanussot, to Prof. Jon Atli Benediktsson, who served as the general chair of WHISPERS 2010 held in Reykjavik, Iceland [see Fig. 4(a)]. During the WHISPERS 2011 edition held in Lisbon, Portugal, Dr. Alberto Villa, a former Hyper-I-Net early-stage researcher, defended his PhD dissertation entitled “Advanced spectral unmixing and classification methods for hyperspectral remote sensing data,” supervised by Profs. Christian Jutten, Jocelyn Chanussot and Jon Atli Benediktsson.

A very important distinction received recently by Dr. Alberto Villa and his PhD advisors is the “IEEE Geoscience and Remote Sensing Society Transactions Prize Paper Award,” which recognizes the authors who have published in the very prestigious journal IEEE Transactions on Geoscience and Remote Sensing (TGARS) an exceptional paper in terms of content and impact on the society. The 2011 award went to a paper describing part of the PhD work carried out by Dr. Villa, who developed his PhD funded by Hyper-I-Net. The paper is entitled “Hyperspectral image classification with independent component discriminant analysis,” co-authored by Profs. Jon Atli Benediktsson, Jocelyn Chanussot and Christian Jutten (who served as supervisors of Dr. Villa’s thesis), and was pub-

lished in volume 49, number 12, pages 4865–4876 of TGARS. Dr. Alberto Villa carried out his PhD work in three different partners of Hyper-I-Net, starting at the Grenoble Institute of Technology, then continuing his training path at the University of Iceland and finalizing his training path at the Hyperspectral Computing Laboratory, University of Extremadura.

Another recent important recognition received by one of the Hyper-I-Net researchers who developed their PhD work in the framework of the project was the distinction of “Best Romanian student of the year 2011 in Europe” awarded to Dr. Marian-Daniel Iordache, as a result of his accomplishments in the framework of the Hyper-I-Net project. This recognition was awarded by the Romanian External Affairs Minister in a ceremony that took place in the Parliament Palace of Bucharest, Romania, in January 2011 [see Fig. 4(b)]. Dr. Iordache defended his PhD dissertation¹³ entitled “A sparse regression approach to hyperspectral unmixing,” supervised by Profs. Jose M. Bioucas-Dias and Antonio Plaza, in December 2011. More PhD dissertations and significant accomplishments by Hyper-I-Net early-stage and experienced researchers are expected in upcoming years.

6. Significant Outcomes

The main outcome of the Hyper-I-Net project has been, without a doubt, the training of a group of outstanding pre-doctoral students (early-stage researchers in the European Commission’s jargon) thanks to the involvement of several scientists at the participating institutions and a group of post-doctoral students (experienced researchers) appointed in the project. The Hyper-I-Net early-stage researchers have been: Karoly Bakos (Hungary), Katya Carmina (Israel), Petra D’Odorico (Italy), Jordi García Llongo (Spain), Lucie Homolova (Czech Republic), Julio Hernández (Mexico), Marian-Daniel Iordache (Romania),

¹² <http://www.ieee-whispers.com/>

¹³ http://www.lx.it.pt/~bioucas/files/PhD_Daniel_sparse_regression_2011.pdf



Figure 5. (a) PhD defense of Yuliya Tarabalka, a former Hyper-I-Net early-stage researcher. (b) The thesis defense took place in Iceland on June 14, 2010, during the WHISPERS 2010 conference.

Lukasz Paluchowski (Poland), Yuliya Tarabalka (Ukraine), Katja Urata (Brazil), Alberto Villa (Italy) and Lucía Yáñez Raussell (Spain). The Hyper-I-Net experienced researchers have been: Silvia Huber (Switzerland), Prashanth Marpu (India), Lola Suarez (Spain) and Maciel Zortea (Brazil). Many of the Hyper-I-Net early-stage researchers have already defended their PhD dissertations after enjoying 36-month research contracts within the network.

The first Hyper-I-Net early-stage researcher in doing so was Dr. Yuliya Tarabalka, who defended her thesis entitled “Classification of hyperspectral data using spectral-spatial approaches,” supervised by Profs. Jon Atli Benediktsson and Jocelyn Chanussot, in Reykjavik, Iceland, during the WHISPERS 2010 conference [see Fig. 5(a)]. The thesis defense took place on June 14, 2010, and the evaluation committee was integrated by a group of international experts in remotely sensed hyperspectral imaging, including Profs. Melba Crawford, Jean-Yves Tourneret, Xiuping Jia, Antonio Plaza, Paolo Gamba and Johannes Sveinsson [see Fig. 5(b)]. Yuliya gave a great talk, exhibiting clear pedagogical skills. She could also demonstrate her scientific maturity in answering the numerous questions that were asked after her presentation, both from the committee and from the large international audience attending the conference. The outcome of her thesis was a set of techniques for hyperspectral image classification that reached some of the best ever published results on several standard data sets [5,6], as indicated by the publications resulting from her work in prestigious journals such as the *IEEE Transactions on Geoscience and Remote Sensing* or the *IEEE Geoscience and Remote Sensing Letters*¹⁴. After the defence, she received her PhD diploma in presence of the French Ambassador in Iceland, Caroline Dumas, who was delighted to see the outcome of a fruitful collaboration between France and Iceland thanks to the support of the European Commis-

sion. After receiving various offers, Yuliya joined NASA Goddard Space Flight Center for a post-doc. She is now a researcher with the French Space Agency (CNES) and INRIA Sophia Antipolis.

Other significant outcomes resulting from the collaboration carried out in the Hyper-I-Net project are the introduction of a new standardized hyperspectral processing chain aimed at introducing a common data processing framework which was previously not available in the hyperspectral imaging community. The definition¹⁵, implementation¹⁶ and optimization¹⁷ of such chain are available through the project website. Another significant outcome of the project has been the development of a calibration and validation inventory reviewing current techniques and instruments to perform advanced calibration and validation of hyperspectral imaging instruments, an item that was previously not available in the scientific community devoted to this research topic. Other important deliverables of the project have been focused on the development of a survey of hyperspectral sensor requirements¹⁸, a sensor modeling programme¹⁹, a calibration training programme²⁰, and a Hyper-I-Net airborne data collection campaign²¹ carried out in July 2009.

7. Summary

In this article we have described some of the activities carried out in Hyper-I-Net, a recently finished Marie Curie Research Training Network which focused both on educational aspects

¹⁴ <https://notendur.hi.is/yut2/>

¹⁵ http://hyperinet.multimediacampus.it/images/HYPERINET_D4.1.pdf

¹⁶ http://hyperinet.multimediacampus.it/images/HYPERINET_D4.2.pdf

¹⁷ http://hyperinet.multimediacampus.it/images/HYPERINET_D4.3.pdf

¹⁸ http://hyperinet.multimediacampus.it/images/HYPERINET_D2.2.pdf

¹⁹ http://hyperinet.multimediacampus.it/images/HYPERINET_D32.pdf

²⁰ http://hyperinet.multimediacampus.it/images/HYPERINET_D5.2.pdf

²¹ http://hyperinet.multimediacampus.it/images/HYPERINET_D23.pdf



and on the scientific goals which are achieved through training in all the research areas that comprise the entire remotely sensed hyperspectral processing chain, from sensor design and flight operation to data collection, processing, management and interpretation. The focus of the article has been on providing an overview of the scientific aspects that have been covered by this project, as well as on describing the main training and transfer of knowledge events carried out during its implementation. In addition, we have described the project e-learning platform used to provide multimedia courses and resources on different topic areas related with the project. These activities, along with the research work carried out by the early-stage and experienced researchers appointed in the project, has introduced new methods for hyperspectral data collection, processing, validation and exploitation, thus creating an impact on the design of future and on-going remote sensing and exploration missions. Some of the activities carried out in Hyper-I-Net have influenced ongoing GRSS education activities [7].

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- [6] A. Plaza, J.A. Benediktsson, J. Boardman, J. Brazile, L. Bruzzone, G. Camps-Valls, J. Chanussot, M. Fauvel, P. Gamba, J.A. Gualtieri, J.C. Tilton and G. Trianni, "Advanced processing of hyperspectral images," in *Proceedings of the IEEE International Geoscience and Remote Sensing Symposium*, Denver, Colorado, vol. 1, pp. 1974–1978, 2006.
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RECENT PHD THESIS ON GEOSCIENCE AND REMOTE SENSING

Starting from this issue, the Newsletter will publish a section with information on the recently completed Ph.D. dissertations in the fields of activity of IEEE GRSS. We print the title of the dissertations, the student's and advisor's names and the date of the thesis defense. In addition, a link for downloading the electronic version of each thesis is given (when available). For publishing the PhD thesis information you can contact Dr. Antonio Plaza (aplaza@unex.es) or Dr. Lorenzo Bruzzone (bruzzone@ing.unitn.it).

Author: Mauro Dalla Mura	Supervisors: Lorenzo Bruzzone, Jon Atli Benediktsson
Title: Advanced techniques based on mathematical morphology for the analysis of remote sensing images	
Institution: University of Trento, Italy and University of Iceland, Iceland	
Date: April 2011	Link: http://eprints-phd.biblio.unitn.it/592/1/PhDThesis_Dalla_Mura.pdf
Author: Alberto Villa	Supervisors: Christian Jutten, Jocelyn Chanussot and Jon Atli Benediktsson
Title: Advanced spectral unmixing and classification methods for hyperspectral remote sensing data	
Institution: Grenoble Institute of Technology, France and University of Iceland, Iceland	
Date: May 2011	
Author: Jun Li	Supervisors: Jose M. Bioucas-Dias and A. Plaza
Title: Discriminative image segmentation: Applications to hyperspectral data	
Institution: Instituto Superior Técnico, Lisbon, Portugal	
Date: May 2011	Link: http://www.lx.it.pt/~bioucas/files/PhD_jun_li.pdf
Author: Anna Brook	Supervisor: Eyal Ben-Dor
Title: Reflectance spectroscopy as a tool to assess the quality of concrete in situ	
Institution: Tel-Aviv University, Israel	
Date: September 2011	
Author: Xavier Ceamanos	Supervisor: Sylvain Douté
Title: Evaluating the potential of statistical and physical methods to analyze multidimensional hyperspectral images of Mars	
Institution: Université de Grenoble, France	
Date: October 2011	



Author: Silvia Valero	Supervisors: Jocelyn Chanussot and Philippe Salembier
Title: Hyperspectral image representation and processing using binary partition trees	
Institution: Grenoble Institute of Technology, France and Technical University of Catalonia, Spain	
Date: November 2011	Link: http://cataleg.upc.edu/record=b1395428*cat
Author: Md. Al Mamun	Supervisors: Xiuping Jia and Michael John Ryan
Title: Sequential transmission of remotely sensed multi-temporal images	
Institution: University of New South Wales, Canberra, Australia	
Date: November 2011	
Author: Adamo Ferro	Supervisor: Lorenzo Bruzzone
Title: Advanced methods for the analysis of radar sounder and VHR SAR signals	
Institution: University of Trento, Trento, Italy	
Date: December 2011	Link: http://eprints-phd.biblio.unitn.it/659/1/Ferro_PhD_Thesis_2011.pdf
Author: Marian-Daniel Iordache	Supervisors: Jose M. Bioucas-Dias and Antonio Plaza
Title: A sparse regression approach to hyperspectral unmixing	
Institution: Instituto Superior Técnico, Lisbon, Portugal	
Date: December 2011	Link: http://www.lx.it.pt/~bioucas/files/PhD_Daniel_sparse_regression_2011.pdf
Author: Julia Amorós López	Supervisors: Luis Gómez-Chova and Javier Calpe-Maravilla
Title: Multi-resolution spatial unmixing for MERIS and Landsat image fusion	
Institution: University of Valencia, Spain	
Date: March 2012	



CALL FOR PAPERS IEEE Transactions on Geoscience and Remote Sensing

Special Issue on “Radio Frequency Interference: Identification, Mitigation, and Impact Assessment”

Due to sharing of allocated bands, limitations in hardware, and transmissions outside of allocations, remote sensing observations experience radio-frequency interference (RFI). Corrupted measurements may be difficult to identify, especially at low levels of interference. As the need for high-precision measurements expands — principally for ocean and terrestrial sensing, but also for radio astronomy — investigators have developed new methods for sharing spectrum and for identifying and mitigating RFI. For heritage hardware, post-processing software methods have proven invaluable for identifying radio-frequency interference, with some measured success in mitigation. For future sensors, digital receivers offer flexibility in handling RFI. Beyond the identification and mitigation of RFI, monitoring the radio-frequency environment informs scientific users of the spectrum of the expanding nature of RFI and shapes future policy. Understanding how contamination and mitigation affect measurements furthers data quality.

To catalog the important work being performed to identify, monitor, and mitigate RFI, and to assess the impact of interference, the Frequency Allocations in Remote Sensing technical committee is coordinating a special issue of TGRS covering this subject. Submissions will cover a combination of software and hardware solutions to the RFI problem. Moreover, the special issue will detail the challenges in monitoring radio-frequency interference, and attempt to quantify the impact that interference has on measurements. By collecting a range of papers concerning RFI, the issue will serve as a central resource to sensor designers, algorithm developers, and data users.

List of topics

Contributions for this special issue are welcome from the research community. This special journal issue will focus on the utilization of various methods to identify, mitigate, and monitor RFI. A secondary objective is to inform data users of the impact of RFI on observations to promote awareness and consideration of this important issue. The guest editors invite submissions that explore topics including, but not limited to, RFI detection and mitigation algorithms, comparisons of recent RFI detection methods, and RFI analyses and results from recent and forthcoming missions/instruments including SMAP, SMOS, Aquarius, AMSR-E, and WindSat.

Paper submission deadline: 30 August 2012

Submission guidelines

Normal page charges, peer-review, and editorial process will apply. Prospective authors should follow the regular guidelines of TGRS, and should submit their manuscripts electronically to <http://mc.manuscriptcentral.com/tgrs>. Please indicate during your submission that the paper is intended for this Special Issue. Inquiries with respect to the special issue should be directed to the Guest Editors.

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CALL FOR PAPERS IEEE Transactions on Geoscience and Remote Sensing

Special Issue on the 12th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment

Manuscript submissions are solicited for a Special Issue of the IEEE Transactions on Geoscience and Remote Sensing (TGRS) dedicated to expanded versions of the papers (both oral and posters) presented at the 12th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment (MicroRad 2012) held on March 5-9, 2012, at Villa Mondragone, Tor Vergata University of Rome. All colleagues participating in MicroRad 2012 are invited to submit papers on recent developments and advances in the field of microwave radiometry for Earth Remote Sensing. The proposed Special Issue will be a continuation of similar initiatives undertaken by previous MicroRad meetings. The most recent MicroRad, held in Washington, DC, in March 2010, published a TGRS Special Issue in September 2011 containing 19 papers. Contributions for the MicroRad 2012 Special Issue are welcome from the research community.

List of topics

- Spaceborne observations, ground-based and airborne campaigns, theoretical models, and retrieval algorithms for microwave radiometry of: soil and vegetation; snow and cryosphere; oceans; atmospheric temperature and water vapor; as well as clouds and precipitation.
- Synergy between passive and active microwave systems
- Cross calibration of spaceborne radiometers
- Advances in instruments and techniques
- Calibration theory and methodology
- Future missions
- RFI and spectrum management

Paper submission deadline: 1 July 2012

Submission guidelines

Prospective authors should follow the regular guidelines of TGRS, and should submit their manuscripts electronically to <http://mc.manuscriptcentral.com/tgrs>. Please indicate during your submission that the paper is intended for this Special Issue. Inquiries with respect to the special issue should be directed to the Guest Editors.

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This Special Issue is associated with the **9th European Conference on Synthetic Aperture Radar (EUSAR)**, which was in Nürnberg, Germany in April 2012 (<http://www.eusar.de>). **EUSAR** is the international conference worldwide entirely dedicated to the technology, techniques development, and applications of Synthetic Aperture Radar (SAR) for remote sensing. Over the past years **EUSAR** has provided an excellent forum for exchanging information and discussion on a wide variety of SAR topics, representing the latest SAR developments, and has established an international community of SAR engineers and scientists.

The objective of the Special Issue, open to all researchers, is to select outstanding contributions on recent advances in the field of SAR, bringing together participants from the research, industrial and academic communities who are engaged in projects on the technologies and techniques of SAR.

Contributions for this special issue are welcome on the following topics: SAR and ISAR systems and sensors, innovative SAR concepts and applications, advanced SAR modes (ScanSAR, Spotlight, Squint, Bistatic) and their signal processing, very low frequency SAR systems, bistatic and multistatic SAR systems, passive SAR systems, multimode and reconfigurable SAR systems, multi-satellite and small satellite SAR systems, sparse aperture SAR, ultra wide bandwidth and high resolution SAR, new SAR antenna concepts, SAR signal processing, motion compensation and geocoding, SAR data evaluation and handling, along and across-track interferometry, polarimetry and polarimetric interferometry, and moving target detection, STAP and change detection.

Paper submission deadline: 30 June 2012

Submission guidelines

Prospective authors should follow the regular guidelines of TGRS, and should submit their manuscripts electronically to <http://mc.manuscriptcentral.com/tgrs>. Please indicate during your submission that the paper is intended for this Special Issue. Inquiries with respect to the special issue should be directed to the Guest Editors (matthias.weiss@fhr.fraunhofer.de).

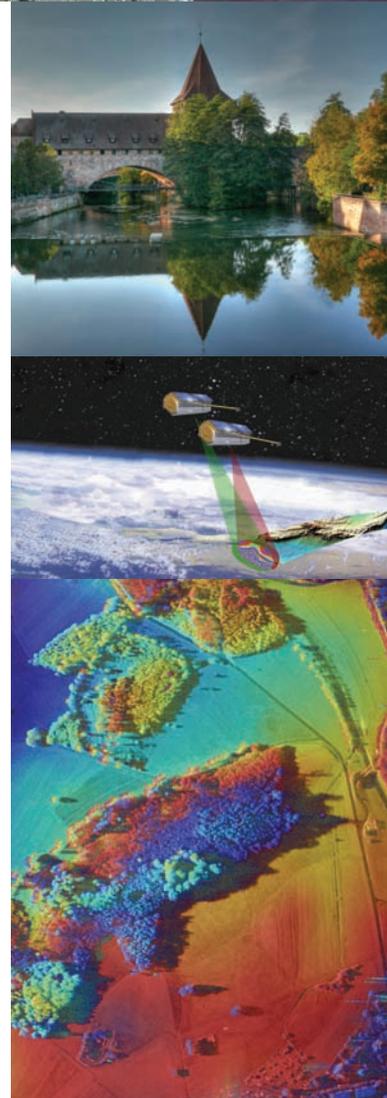
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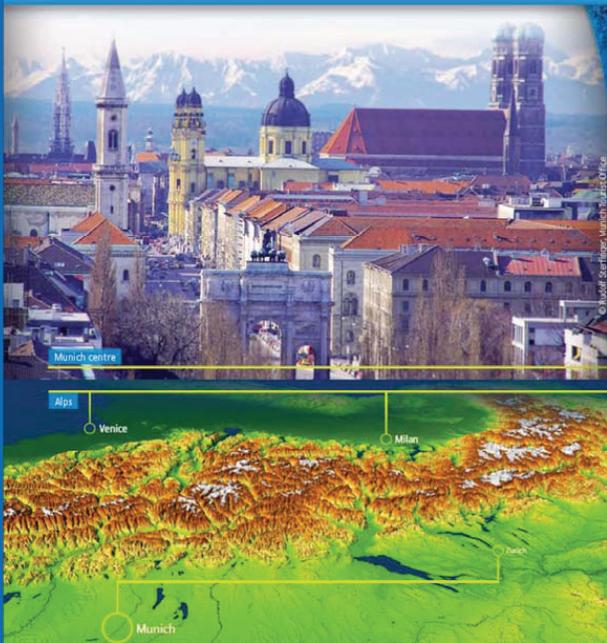


IGARSS 2012

IEEE International Geoscience and Remote Sensing Symposium
Remote Sensing for a Dynamic Earth



22-27 July 2012 | Munich
International Congress Centre



Important dates

7 October 2011	Invited Session Proposal Deadline
28 October 2011	Invited Session Notification
7 November 2011	Abstract Submission System Open
15 December 2011	Tutorial Proposal Deadline
12 January 2012	Abstract Submission Deadline
12 January 2012	Travel Support Application Deadline
12 January 2012	Student Competition Full Paper Application Deadline
23 March 2012	Abstract Acceptance Announcement & Registration Open
1 June 2012	Full Paper (4 pages) Submission
July 22-27 2012	IGARSS 2012

Contacts

info@igarss2012.org

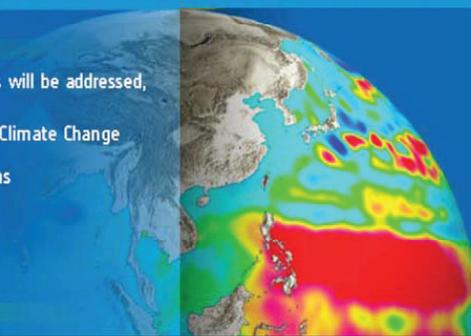
Themes

The technical programme will account for the following themes:

- Analysis Techniques
- Atmosphere
- Cryosphere
- Oceans
- Land
- Sensors and Platforms
- Data Management, Dissemination Education and Policy

In addition special scientific themes will be addressed, including:

- Dynamics of Earth Processes and Climate Change
- Data Assimilation
- Integrated Earth Observing Systems
- New Satellite Missions



www.igarss12.org





GIWRM2012:

International Symposium on Geomatics for Integrated Water Resources Management

October 19-21, 2012
Lanzhou, Gansu (China)
Lanzhou Jiaotong University



GIWRM2012 Chair:

Haowen Yan, Lanzhou Jiaotong University

Paper submission:

March 1, 2012~May 31, 2012

Email:

giwrm2012@gmail.com; giwrm2012vip@gmail.com

Registration:

US\$400/paper/author

Web Address:

<http://giwrm.org/>

Geoinformatics 2012: The 20th International Conference on Geoinformatics

June 15-17, 2012

Hong Kong SAR (China)

Organized by

The Institute of Space and Earth Information
Science at The Chinese University of
Hong Kong (CUHK) and
The International Association of
Chinese Professionals in
Geographic Information Sciences (CPGIS)
Sponsored by IEEE



Geoinformatics 2012 Co-Chairs: CUHK and CPGIS

Abstract submission: Before Dec. 1, 2011

Email: iseis@cuhk.edu.hk

Register: Before March 31, 2012

Registration fees:

Early bird on-line registration will open on Jan. 31, 2012. Fee varies based on membership status and registration date.

Web Address:

<http://www.iseis.cuhk.edu.hk/GeoInformatics2012>



12th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment

5-9 March 2012, Villa Mondragone,
Tor Vergata University of Rome, Italy

Visit <http://www.microrad2012.org>

The Meeting Program will include presentations on the following topics:

- Aquarius and SMOS Missions
- Microwave Radiometry of Ocean, Soil, Vegetation, Snow, Atmosphere, Clouds and Precipitation
- RFI, Calibration and Technological Issues

Early Registration Deadline: January 31st, 2012

Organizers: Paolo Ferrazzoli, Leila Guerriero,
Tor Vergata University of Rome
Tor Vergata



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34th Annual Chair:

Dr. Thomas Cooley, Electro Optical Space Sensing / AFRL Fellow

Abstract submission: Before April 2012

Email: gail.anderson@noaa.gov,

Copy: jeannette.vandenbosch.kirtland.af.mil

Pre-Register: Before May 2012

Registration: Members \$325., Non Members \$375., Students \$200.

Web Address: <http://www.2012transconf.org>



**EORSA 2012:
The Second International
Workshop on Earth Observation
and Remote Sensing Applications**

June 8-11, 2012
Shanghai, China



Technical Committee Chair:
Qihao Weng – Indiana State University, USA

Abstract submission:
Before March 15, 2012 through
<https://www.easychair.org/conferences/?conf=eorsa2012>
Inquiries send to
Email: eorsa2012@gmail.com

Early Registration:
Before April 15, 2012

Web Address:
<http://www.eorsa2012.org>

4th Workshop on
Hyperspectral Image and Signal Processing:
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w h i s p e r s

. 4 - 7, June 2012 .
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from Earth Observation to Homeland Security



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University of Napoli Parthenope, Italy
Full Paper Submission: May 14, 2012
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See also <http://www.techexpo.com/events> or <http://www.papersinvited.com>

Name: 12th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment (MICRORAD2012)

Dates: March 5–9, 2012

Location: Rome, Italy

Contact: Paolo Ferrazzoli

E-mail: info@microrad2012.org

URL: <http://www.microrad2012.org/index.html>

Name: 4th International Conference on Geographic Object Based Image Analysis (GEOBIA2012)

Dates: May 7–9, 2012

Location: Rio de Janeiro, Brazil

Contact: Raul Queiroz Feitosa

E-mail: geobia2012@dpi.inpe.br

URL: <http://www.inpe.br/geobia2012>

Name: 14th International Conference On Ground Penetrating Radar (GPR2012)

Dates: June 7–9, 2012

Location: Shanghai, China

Contact: Dr. Xiongyao Xie

E-mail: xiexiongyao@tongji.edu.cn

URL: www.gpr2012.org

Name: The Second International Workshop on Earth observation and Remote Sensing Applications (EORSA 2012)

Dates: June 8–11, 2012

Location: Shanghai, China

Contact: Qihao Weng

E-mail: eorsa2012@gmail.com

URL: <http://www.eorsa2012.org>

Name: 20th International Conference on Geoinformatics (Geoinformatics2012)

Dates: June 15–17, 2012

Location: Hong Kong, PRC

E-mail: iseis@cuhk.edu.hk

URL: <http://www.iseis.cuhk.edu.hk/GeoInformatics2012>

Name: 39th Scientific Assembly of the Committee on Space Research and Associated Events (COSPAR 2012)

Dates: July 14–22, 2012

Location: Mysore, India

E-mail: cospar@cosparhq.cnes.fr
URL: <http://www.cospar-assembly.org>

Name: 2012 IEEE Geoscience and Remote Sensing Symposium (IGARSS2012)

Dates: July 22–27, 2012

Location: Munich, Germany

E-mail: info@igarss2012.org

URL: <http://www.igarss2012.org/>

Name: Tyrrhenian Workshop 2012 on Advances in Radar and Remote Sensing

Dates: September 12–14, 2012

Location: Napoli, Italy

Contact: Fabio Baselice

E-mail: fabio.baselice@uniparthenope.it

URL: <http://www.tyrr2012.cnit.it>

Name: Workshop on Reflectometry using GNSS and Signals of Opportunity

Dates: October 10–11, 2012

Location: West Lafayette, IN, United States

Name: International Symposium on Geomatics for Integrated Water Resources Management (GIWRM2012)

Dates: October 19–21, 2012

Location: Lanzhou, Gansu Province, China

Contact: Dr. Tao Liu

E-mail: giwrm2012@gmail.com

URL: giwrm.org

Name: 7th IAPR Workshop on Pattern Recognition in Remote Sensing (PRRS2012)

Dates: November 11, 2012

Location: Tsukuba Science City, JAPAN

Contact: Jenny Q. Du

E-mail: du@ece.msstate.edu

URL: <http://www.iapr-tc7.org/prrs12>

Name: International Conference on Computer Vision in Remote Sensing (CVRS 2012)

Dates: December 6–8, 2012

Location: Xiamen, China

E-mail: CVRS2012@gmail.com

URL: <http://cvrs2012.xmu.edu.cn>