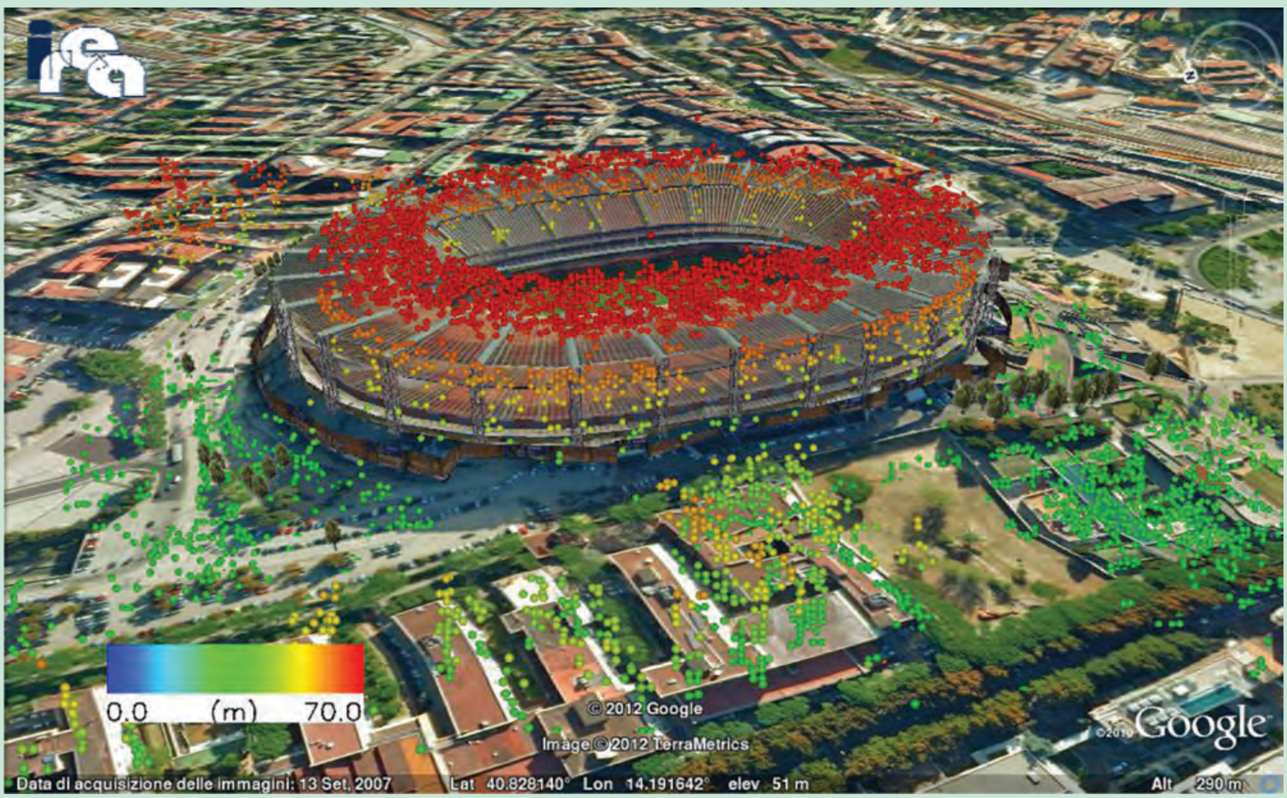
IEEE GEOSCIENCE and REMOTE SENSING Newsletter

http://www.grss-ieee.org/menu.taf?menu=Publications&detail=newsletter **Editor:** Lorenzo Bruzzone



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Newsletter Input and Deadlines

The following is the schedule for the GRSS Newsletter. If you would like to contribute an article, please submit your input according to this schedule. Input is preferred in Microsoft Word, WordPerfect or ASCII for IBM format (please send disk and hard copy) as IEEE now uses electronic publishing. Other word processing formats, including those for Macintosh, are also acceptable, however, please be sure to identify the format on the disk and include the hard copy.

GRSS Newsletter Schedule

Month	June	Sept	Dec	March
Input	April 15	July 15	Oct 15	Jan 15

IEEE GRSS AdCom, Officers and Committee Chairs – 2012 GRS-29 (Division IX)

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This is the last issue of the *IEEE Geoscience and Remote Sensing Newsletter* with the present organization of its contents. After many years of publication of the Newsletter in the current format, starting in 2013 it will become an e-Newsletter for the purpose of disseminating to Geoscience and Remote Sensing Society (GRSS) members important news and announcements related to our field of activity. The main reason for this change is that, as already announced in the previous issue, beginning in March 2013 GRSS will publish the new *Geoscience and Remote Sensing Magazine (M-GRS)*, which was approved by the *IEEE Technical Activities Board* in 2012. This is an important achievement for our society since we have never had a publication in the magazine format. The magazine will provide a new venue to publish high quality technical articles that by their very nature do not find a home in journals requiring scientific innovation. The idea is that the magazine will publish tutorial papers and technical papers on geoscience and remote sensing topics, as well as papers that describe relevant applications of and projects based on topics addressed by our society. All technical papers will undergo blind review by multiple reviewers. The review process will be managed on the *IEEE Manuscript Central* site as is already done for the three GRSS journals. The magazine will also publish regular columns on education in remote sensing, remote sensing systems, standard data sets, women in geoscience and remote sensing, space agency news, book reviews, etc. The new magazine will be published with an appealing layout, and its articles will be included in the *IEEE Xplore* online archive. I would like to take this opportunity to encourage all readers to prepare and submit articles and technical content for review to be published in the M-GRS. More details on the Magazine are reported in the call for papers published on page 49 of this issue.

The issue opens with an In Memoriam for James A. Weinman, who passed away on August 3, 2012, after a brave battle

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President's Message

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Another very successful year for the IEEE Geoscience and Remote Sensing Society (GRSS) is about to end. 2012 was a truly special year for the GRSS because the society celebrated its 50th anniversary at IGARSS 2012 in Munich. The location for the celebration was outstanding since IGARSS was previously held in Munich thirty years ago, and IGARSS 2012 was the largest IGARSS ever, with over 2700 delegates and more than 2500 papers presented. In 2013, the GRSS will reach another milestone when the *IEEE Transactions on Geoscience and Remote Sensing* (TGRS) celebrates its 50th anniversary. TGRS will enter its anniversary year under the leadership of new Editor-in-Chief (EIC), Antonio J. Plaza.

In early October a Memorandum of Agreement (MoA) was signed between the GRSS and the IEEE Committee on Earth Observations (ICEO) regarding the *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* (J-STARS). From the start of the publication of J-STARS, GRSS and ICEO had a joint Steering Committee that acted as the AdCom for the journal. GRSS and ICEO shared the financial responsibility, and the journal was jointly led by an Editor-in-Chief (EIC) and a Deputy EIC. With the new MoA, J-STARS has become a fully GRSS journal. That means the journal is now governed by the GRSS AdCom; GRSS takes 100% financial responsibility; and, similar to the other GRSS journals, J-STARS is led by a single EIC. I am delighted that

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Cover Information: SAR Tomography is a tool for full 3D reconstruction useful not only to image volumes, such as forest, at lower frequencies but also for the reconstruction and monitoring of vertical structures in complex scenarios, such as urban areas, with high and very high resolution data of high frequency sensors. The image shows an example of the application of such approach for the reconstruction of the San Paolo Stadium in Naples, Italy. The result has been obtained by processing 28 images acquired in stripmap mode (approximately 3 m resolution) by the X-Band COSMO/SKYMED sensors; colormap is set according to the estimated heights.

(Editor's Comments continued from page 3)

with cancer. As pointed out in the article, he was best known for his pioneering work in radiative transfer methods and their application to real-world problems related to both energy fluxes and remote sensing of atmospheric and hydrological parameters.

Also the second article in this issue is an obituary, for Richard K. Moore who passed away on November 13, 2012. As described in the article, he contributed to developing the University of Kansas' excellence in microwave remote sensing of the Earth and made outstanding and lasting contributions to the field.

The passing away of James A. Weinman and Richard K. Moore is a great loss for the IEEE GRSS.

This issue includes a principal tutorial article in the *Features* section. This is a paper on Synthetic Aperture Radar Tomography, which is a technique that permits resolving scatterer densities in the third native dimension radar co-ordinate, i.e. "elevation". Tomography extends the SAR principle, as used in the azimuth direction, to elevation by exploiting multiple passes of the radar at slightly different orbit positions to establish a virtual array of antennas that reduces the width of the elevation antenna beam. This enables the capability to generate high resolution 3D images. The article describes the main concepts of SAR tomography, illustrates the principal tomography approaches and reports interesting examples of application to imaging and to monitoring urban areas, including single buildings.

The *Book Review* column presents an overview of *Remote Sensing and Global Environment Change*, by Samuel Purkis and Victor Klemos and published by Wiley-Blackwell. The review of this book was written by Michael E. Schaepman of the Department of Geography, University of Zürich, Switzerland.

The *Reports* section contains two articles. The first is related to IGARSS 2012, held in Munich, Germany, on July 22–27, 2012. It focuses on the GRSS Publications Awards presented at IGARSS 2012 and provides information on all of these awards recipients. Congratulations to all of them! The second article is a report on the *Third International Polarimetric SAR Workshop* held in Niigata, Japan, August 23–26, 2012. This workshop is technically co-sponsored by the GRSS.

The *New Satellite Missions* column presents an article on the *Megha-Tropiques Mission,* which is a joint Indo-French (ISRO-CNES) collaboration to develop a satellite to study the tropical atmosphere for climate and atmospheric research as well as meteorological applications. This article describes the characteristics of this mission, its status and applications.

The *Technical Committee Corner* column describes the activities of the International Spaceborne Imaging Spectroscopy (ISIS) Technical Committee of the GRSS. The article presents the principal goals and activities of the committee,

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- Eligibility to hold executive IEEE volunteer positions.
- Can serve as Reference for Senior Member applicants.
- Invited to be on the panel to review Senior Member applications.
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Applications for senior membership can be obtained from IEEE website: https://www.ieee.org/membership_services/membership/senior/application/index.html

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

(President's Message continued from page 3)

this new MoA has been signed. I would like to thank Mike Lightner, Chair of ICEO, for his hard work in making the agreement possible. J-STARS is doing extremely well under the outstanding leadership of EIC Jocelyn Chanussot. The number of submissions to J-STARS, the rejection rate of the journal and the number of published papers have all increased significantly during the last two years. The plan is to move most special issues from TGRS to J-STARS during the next year. J-STARS will undoubtedly continue to grow and continue to establish itself as a leading journal in remote sensing.

As I mentioned in my last message, a GRSS Magazine will be published quarterly, starting in 2013. An electronic version of the Magazine will be included in the annual GRSS membership. The GRSS Magazine provides an additional venue to communicate topical ideas to a wide audience. The GRSS-M will publish reviewed technical papers that provide important information to the community but that are not appropriate for publication in our journals. The current Newsletter Editor, Lorenzo Bruzzone, will be the Editor-in-Chief of the GRSS Magazine. It will be exciting for us to see the first issue appear in the first quarter of 2013. Because of the new Magazine, the GRSS Newsletter will change in form and content in 2013. It will still be published electronically, but it will focus on announcements and information for GRSS members.

If you have not already joined the IEEE GRSS or renewed your membership for 2013, I strongly encourage you to do so as soon as possible so you can enjoy all the benefits the society offers, including electronic access to all of our journals (TGRS, GRSL, J-STARS) and the new GRS Magazine. You can access all information on our website ieee-grss.org, which has a wealth of information about the GRSS and how you can participate in the GRSS community. Social media is one way to participate in our activities. The GRSS is increasing its involvement in social media under the outstanding leadership of VP of Information Resources Steve Reising. The Society has a Facebook page and three LinkedIn groups on GRSS in general, Data Fusion Technical Committee and women in geoscience and remote sensing. The Facebook page and the LinkedIn groups can both be accessed through the GRSS website.

Regional activities continue to be a strong focus of the GRSS. The AdCom has focused on establishing active local GRSS Chapters all over the world to strengthen GRSS

(continued on page 42)

IN MEMORIAM

JAMES A. WEINMAN (1930–2012)

Gail Skofronick Jackson, NASA Goddard Space Flight Center and Christian Kummerow,
Department of Atmospheric Science, Colorado State University

James (Jim) A. Weinman, an internationally-known physicist in the area of atmospheric science and microwave remote sensing, passed away peacefully on Friday, August 3, 2012 at his home in Seattle, Washington, USA after a battle with cancer. Jim was best known for his pioneering work in radiative transfer methods and their application to real problems related to both energy fluxes and remote sensing of atmospheric and hydrologic parameters. Jim was born on March 10, 1930 in Chicago, the only child of Rose (née Eiseman) and Louis Weinman, both Jewish immigrants from Germany. With a thirst for learning, sharp scientific and mathematical mind, Jim started university when he was only 16. He earned a B.S. and M.S. from Illinois Tech and a PhD in Physics from University of Wisconsin-Madison (Advisor: Prof. Raymond G. Herb).

After working for the Carnegie Institution of Washington-Department of Terrestrial Magnetism and the Argonne National Laboratory, Jim joined the Meteorology Department at his alma mater in Madison where he was also a volunteer firefighter.

In 1989, Jim became a Senior Scientist at NASA's Goddard Space Flight Centre where he was heavily involved with the joint U.S.-Japan Tropical Rain Measuring Mission (TRMM). While at NASA, he continued to develop physically-based rain and falling snow retrieval algorithms to apply to space-borne passive microwave radiometers. In recent years, Jim served as a mentor to graduate students at the University of Washington Atmospheric Sciences Department. Dr. Weinman was awarded the American Institute of Aeronautics and Astronautics, Losey Atmospheric Science Award and he was a Fellow of the American Meteorological Society and a Senior Member of IEEE.

Across his long and distinguished career as a physicist, Jim worked at the Antarctic research station, in the Amazon rainforest, Indonesia, Japan, and Australia. Indeed, he managed to visit every continent where he collaborated with other scientists and made many lifelong friends. A dedicated teacher and professional mentor, Jim inspired and encouraged many students onto successful careers in the atmospheric sciences.

In October 2011, an Honorary Colloquium was held in Seattle, WA that bought together Jim's many colleagues to honor and celebrate Jim's long engineering and scientific career. The keynote speaker was Professor Roger Davies, University of Auckland, New Zealand. Additional short presentations followed from former students and colleagues in a timeline moving forward along Jim's long career in radiative transfer studies with Jim providing closing remarks.

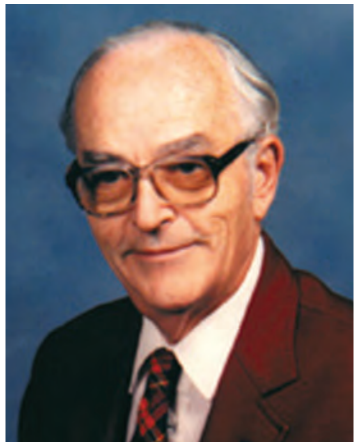
Jim is survived by his wife, Margaret King, and stepdaughters, Siobhan (Larry) and Claire (Adrian), as well as by his first wife, Antonia, and their children, Louise Simpson (Evan) and Roger Weinman. "Opa" Jim will be much missed by his three grandchildren, Theron, Lydia and Sasha, as well as by his friends, colleagues and graduate students worldwide.

RICHARD K. MOORE

Sivaprasad Gogineni, Information and Telecommunication Technology Center,
University of Kansas, Lawrence, Kansas, USA

Richard K. Moore, Professor Emeritus in the Electrical Engineering and Computer Science Department at the University of Kansas, died Nov. 13. He was 89. Moore began his career as a radar engineer and served as an electronics and radar officer in the Navy from 1944–1946. He then attended graduate school at Washington University in St. Louis, and in his master's thesis invented the VLF antenna for submarines. He completed his doctoral degree at Cornell University in 1951 and subsequently served as a lecturer at the University of New Mexico, where he became Chairman of the Electrical Engineering Department in 1955.

Moore joined the KU faculty in 1962 when he was offered the Black & Veatch Distinguished Professorship. While at KU, he started the interdisciplinary Remote Sensing Laboratory, where he worked until his retirement in 1994 doing seminal work in theoretical and experimental microwave remote



sensing of the earth. He continued to run sponsored projects until 2004 and participated in the Center for Remote Sensing of Ice Sheets research activities until his death. His research interests included microwave remote sensing of atmosphere, ocean, land, ice and planetary surfaces; radar systems; and radio wave propagation.

Moore was instrumental in developing KU's excellence in microwave remote sensing of the earth and made outstanding and lasting contributions to the field. Together with Bill Pierson, Moore developed the concept of wind-vector scatterometry; Moore also developed the concept of scanning Synthetic Aperture Radar (ScanSAR). Prof. Cal Swift in his preface to a special issue of IEEE Transactions of Antenna and Propagation in Radio Oceanography, published in January 1977, stated that the persistence of Moore and Pierson in advocating the wind vector scatterometry in spite of less than encouraging results from previous experiments has led to the development of more accurate aircraft and spacecraft instruments. These instruments were used to collect data under a variety of wind conditions and prove a concept that eventually resulted in satellite measurements of ocean winds. Now wind-vector data obtained from microwave scatterometers on satellites are being used in numerical weather forecasting. In addition, the ScanSAR concept was used in the Shuttle Imaging Radar mission for mapping the surface topography of the earth, and wide-swath imaging was used in both the RADARSAT and ENVISAT satellites. The ScanSAR concept will also be used in several forthcoming satellite radar missions.

In addition to his technical and scientific accomplishments, Moore served as a graduate advisor for more than 100 students during his tenure at the University of Kansas. He encouraged his students to explore and pursue new ideas. Moore also strongly advocated the use of ultra-wideband FM-CW radars for characterization of snow over sea ice and other applications. Today, ultra-wideband FM-CW radars developed at the University of Kansas are being used for airborne measurements of the thickness of snow on sea ice and mapping internal layers in polar firn from long range aircraft operated by NASA as a part of Operation IceBridge. Moore's dedication to the students of the University of Kansas garnered him the Louise E. Byrd Graduate Educator Award in 1984 and the Irving Youngberg Award in the Applied Sciences in 1989. Moore also established the Richard K. & Wilma S. Moore Thesis Award to honor the best graduate thesis and doctoral dissertation in the EECS department.

Moore was made a Life Fellow of IEEE in 1962 for contributions to electromagnetic propagation and engineering administration. He was awarded an Outstanding Technical Achievement Award by IEEE COE in 1978 and received a Distinguished Achievement Award by IEEE GRSS in 1982. He was awarded the IEEE Centennial Medal in 1984.

His additional professional accomplishments include the Australia Prize for Science and a Remote Sensing Award from Italian Center, both awarded in 1995. Moore authored or co-authored 10 books and over 300 journal articles and conference publications, and he and his brother were the only brothers ever in the National Academies.

(Editor's Comments continued from page 4)

including an interesting overview of the current and the planned spaceborne imaging spectroscopy missions.

The *Education Corner* column includes a list of recently completed Ph.D. dissertations in the remote sensing and geoscience fields. I encourage you to contact Antonio Plaza, Director of Education for IEEE GRSS, or me for information on submitting recently completed Ph.D. dissertations in the technical areas of GRSS. Starting with the next issue, information on these theses will be published in the new *IEEE Geoscience and Remote Sensing Magazine*.

The *University Profile* column describes activities in hyperspectral image processing at the LIESMARS remote sensing research group in China. The article introduces the group, lists its key members and describes the specific scientific activities under development.

The *Open Access Papers* column informs the reader of the open-access articles recently published in the three GRSS journals during the period September-December 2012. This includes the title, author, publication name, volume, issue and pages of each paper that can be can be downloaded from the IEEE Xplore online archives by anyone free of charge.

Finally, I would like to draw your attention to the various calls for nominations and calls for papers in this issue.

Season's Greetings!

Sincerely,

Lorenzo Bruzzone
Editor, IEEE GRSS Newsletter
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FEATURE

SAR TOMOGRAPHY: AN ADVANCED TOOL FOR 4D SPACEBORNE RADAR SCANNING WITH APPLICATION TO IMAGING AND MONITORING OF CITIES AND SINGLE BUILDINGS

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1. Introduction

Synthetic Aperture Radar (SAR) has become a routine geo-information source complementing optical imagery. The microwaves used by SAR can penetrate canopy, soil, snow and ice allowing for estimation of volumetric properties, e.g. biomass. SAR also can employ polarization for deriving structural parameters of objects [1] [2]. Another strong and unique selling point of SAR is that surface displacements and object deformations can be measured to mm-level accuracy by exploiting multitemporal acquisitions. In particular, the recent technological advancement in SAR systems has provided very high resolution (VHR) X-Band sensors, such as the TerraSAR-X/TanDEM-X mission and the Cosmo-Skymed constellation, characterized by spatial resolutions of the order of 1 meter. With respect to the former generation of medium resolution (a ten, or a few tens of meters) C-Band SAR systems, the increase of the resolution of such sensors allows much higher details of ground structures to be captured.

On the downside we have to cope with an imaging geometry that does not support an easy interpretation of SAR images, especially in complex scenarios. A single SAR image is the projection of the 3D scene into the azimuth (x) – range (r) coordinates. Whenever only surface scattering is present and the local slopes of the surfaces are smaller than the local incidence angle this mapping is injective: in this case the image can be easily converted to any other map projection. However, for volumetric scatterers (e.g. forests) and steep – or even vertical – surfaces, like in urban areas, SAR imaging becomes non-injective and real 3D imaging is required.

SAR Tomography (TomoSAR) is a technique that allows resolving scatterer densities in the *third* native radar co-ordinate "elevation (s)" (also referred to as slant–height, orthogonal to the azimuth-range plane). It extends the synthetic aperture principle – as used in the azimuth direction – also to the elevation direction by exploiting multiple passes of the radar at slightly different orbit positions to establish a virtual array of antennas, as depicted in Figure 1. The synthetic aperture in elevation allows reducing the width of the elevation antenna beam providing a fine beam "radar scanner" from the space able to generate high resolution 3D images, hence the additional name of 3D Imaging.

The inherent (Rayleigh) elevation resolution ρ_s of the tomographic arrangement is related to the spread Δb of this array [3]–[6]:

$$\rho_s = \frac{\lambda r}{2\Delta b} \quad (1)$$

where λ is the wavelength; it can reach values of the order of a few meters.

By stacking all the multiview coherent images and by performing the tomographic processing, s-profiles can be

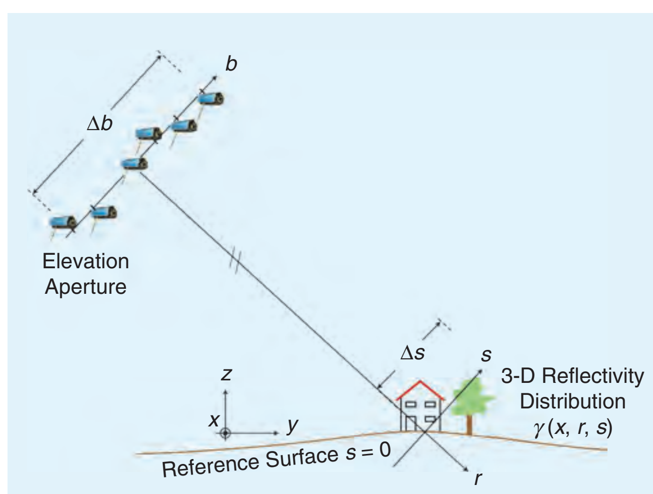

Figure 1. TomoSAR geometry

retrieved for every x–r pixel. These profiles can be continuous in the case of forest biomass imaging [3] or may consist only of a few discrete scatterers, typically corresponding to scatterers located on the ground, facade and roof, in the case of urban mapping. This article is devoted to the latter application.

Since the elevation antenna array is in the far-field of the imaged objects, the complex signal received at any of the radar positions b_n is a sample of the Fourier transform of the reflectivity profile in elevation $\gamma(s)$:

$$g_n = \int_{\Delta s} \gamma(s) \exp(-j2\pi\xi_n s) ds, \qquad n=1,\ldots,N \tag{2}$$

where $\xi_n = -2b_n/(\lambda r)$ is the spatial (elevation) frequency. Therefore, retrieval of the s-profile is framed as a spectral estimation problem and reliable scatterers showing a good degree of coherence can be identified by looking for the peaks in the focused reflectivity function.

Since the multipass dataset is acquired at different time instants, sometimes over a period of years, possible motion and deformation of objects must be additionally considered in the process of estimation of the s-profiles, either as useful information (subsidence, tectonics, landslides, etc.) or simply as nuisance parameters. Space/velocity (4D) imaging techniques, also known as Differential SAR Tomography (D-TomoSAR), extends the 3D imaging and can be applied to measure also the deformation parameters (velocity spectrum) of any temporal coherent scatterer in the focused 3D space [7][8][6]. If motion is considered, eq. (2) is in fact extended to a 2D or even higher dimensional Fourier transform, depending on how many motion modes are accounted for (e.g. linear, periodic, thermal, etc.) [7]–[10]. In this case the technique is referred to as Multi-Dimensional (MD) SAR imaging. Finally, the possibility of screening the reflectivity function in elevation allows discriminating the presence of multiple peaks, even exhibiting different velocities, and hence solve the interference and increase the density of monitored scatterers [8][11][6].

MD imaging (MDI) is in effect a technique that extends the Persistent Scatterer Interferometry (PSI) [12]–[15] approach. PSI assumes the presence of a dominant scattering mechanism in each pixel and therefore cannot resolve the layover problem. Moreover, theoretical and experimental results on both simulated and real data have shown [16] that the use of an imaging approach (i.e. SAR Tomography), which exploits the phase as well as the amplitude information, performs better even in the detection of dominant persistent scatterers and in the estimation of their localization and deformation parameters with respect to classical PSI which uses only the phase information.

2. Tomographic SAR Inversion Algorithms

In the following for sake of simplicity we refer to the 3D reconstruction case. Discretizing the elevation profile in eq. (2) leads to this standard linear system equation:

$$\mathbf{g} = \mathbf{R}\gamma + \boldsymbol{\varepsilon} \tag{3}$$

where $\mathbf{g}$ is the vector of measurements according to eq. (2), $\boldsymbol{\gamma}$ is the elevation profile, $\mathbf{R}$ is the irregular Fourier matrix composed of the so-called steering vectors and $\boldsymbol{\varepsilon}$ is noise.

The spectral estimation problem of s-profile reconstruction can be framed as the inversion of this linear system. The inversion must be carefully implemented because: (i) the Fourier samples are irregularly spaced at ξ_n, (ii) their number N may be small, (iii) the SNR may be low for the majority of the pixels, (iv) the data may contain non-Gaussian phase noise due to uncompensated atmospheric delay and unmodeled motion and (v) the orbit tube of modern SAR satellites is tight leading to a small Δb and, hence, to a low elevation resolution. Many different MDI algorithms have been proposed in the recent literature to cope with these problems.

The simplest algorithm is based on the Beam-Forming (BF) that is the matched filter, i.e., $\hat{\boldsymbol{\gamma}} = \mathbf{R}^H \mathbf{g}$. It computes the amount of backscattered energy at different elevations by digitally steering (through the column vectors of $\mathbf{R}$) the beam of the multibaseline array. Because of the irregular acquisition distribution BF reconstruction exhibits poor performances in terms of large sidelobes and also it does not allow exceeding the Rayleigh resolution of eq. (1) [5].

To overcome such limitations, advanced inversion approaches have been proposed in the literature. The need to achieve super-resolution involves a discretization that exceeds the Rayleigh limit thus making the problem in (3) underdetermined. A class of super-resolution TomoSAR algorithms is based on regularized inversion and tries to find the solution among the infinitely many solutions of the underdetermined system model by minimizing:

$$\hat{\boldsymbol{\gamma}} = \arg\min_{\gamma} \{ \|\mathbf{g} - \mathbf{R}\gamma\|_2^2 + \beta \|\boldsymbol{\Gamma}\boldsymbol{\gamma}\|_p^q \} \tag{4}$$

A rather simple and easily to be implemented solution is based on the use of the Singular Value Decomposition (SVD) *regularized* linear inversion [5][6]. In this case, Tikhonov (Wiener) filtering choices of the singular values allow achieving the solution to the problem in (4) with $\beta = \sqrt{SNR}$, $\boldsymbol{\Gamma} = \mathbf{I}$ and $p = 2$ and $q = 2$ [6]. Another solution strictly related to the above approach is based on Truncated SVD: in this case $\beta = 0$ and a hard limitation of the singular values is used [5] to control the ill-conditioning nature of the inversion. Super-resolution can be achieved by reducing the scene support with respect to the theoretical limit given by $\Delta s = \lambda r/(2\tilde{b})$, where $\tilde{b}$ is the average baseline separation, and controlling the inversion by choosing a suitable number of singular values during the inversion process, provided that the noise level is sufficiently low. SVD achieves typically also better sidelobe suppression than plain BF [5][6].

For many acquisition configurations SVD super-resolution is not sufficient. The orbits of TerraSAR-X, e.g., are controlled so accurately that Δb is typically in the order of 250–350 m leading to an elevation resolution of 30–50 m, which is unacceptably large compared to the range and azimuth resolutions of 1–3 m. The classical super-resolving spectral estimators that are used for TomoSAR are adaptive beam-forming (CAPON) [17] (non-linear, non-parametric) or MUSIC and ESPRIT (both non-linear, parametric) [18][19]. The latter parametric methods do not retrieve continuous *s*-profiles but rather estimate the positions of individual scatterers. They need the number of scatterers as prior information. These methods are computationally fast. However, they require the estimation of covariance matrices which is usually done by multilooking and reduces the azimuth and range resolution. In the case of two or more scatterers these estimators are not efficient, i.e. they do not reach the Cramér-Rao Lower Bound. They are also not energy conserving and the strength of the estimated spectral lines are not straightforwardly related to the reflectivity of the scatterer.

The optimum parametric method – under Gaussian noise assumption – is the non-linear least-squares estimator. However, it would require a combinatorial search of scatterer positions. Here the theory of Compressive Sensing (CS) comes into play.

CS is able to reconstruct sparse signals from their irregularly sampled Fourier transform in a quasi-parametric way. Indeed the elevation profiles of urban objects usually contain only a few scatterers, e.g. one at the ground and one on the façade. Since the elevation resolution ρ_s from eq. (1) is often much worse than the range resolution, the elevation extent of these scatterers is much smaller than ρ_s, rendering these scatterers *discrete*. These are the very prerequisites for using the theory of sparse signal reconstruction and CS. By referring to eq. (4), CS allows finding the solution by selecting $\beta = \beta_K$, $\mathbf{\Gamma} = \mathbf{I}$ and $p = q = 1$, where K is the number of sparse targets [20]. The first CS TomoSAR simulations were presented in [21] and the SR capability of CS for TomoSAR reconstruction and its robustness on elevation estimation against phase noise have been proven in [22]. To overcome the drawbacks of a simple CS estimator, the "Scale-down by L1 norm Minimization, Model selection, and Estimation Reconstruction" (SL1MMER) algorithm has been proposed in [23][24], a spectral estimation algorithm based on CS, with an additional model order selection and final maximum likelihood parameter estimation.

As a last remark it is important to point out that not only estimation of motion parameters (e.g., velocity, topography, etc.) associated with scatterers interfering in the same pixel can be achieved, but also separation of time series is possible by adoption of proper tomographic based filtering techniques. Results of experiments with real data have confirmed this peculiarity of MDI data processing [11].

3. Application Examples

The advanced processing via MDI of VHR X-Band data allows nowadays increasing the density of monitored scatterers dramatically compared to PSI. As a consequence, precise monitoring of even single buildings and in general of infrastructures as well as cultural heritage is possible. In the following, experiments on X-Band data acquired by both the TerraSAR-X and Cosmo-Skymed sensors are discussed. Processing is carried out with implementation of MDI at IREA-CNR and DLR-IMF.

3.1. MDI Systems of IREA-CNR and DLR-IMF

3.1.1. MDI system of IREA-CNR

The MDI approach developed in the last few years at IREA-CNR exploits a simple tomographic processing based on beam-forming to estimate the backscattering distribution in the elevation/velocity domain (4D MDI) and to identify scatterers (up to two), possibly interfering within the same image pixel [25]. The algorithm separates the problem in two steps: the first step is devoted to estimate the scatterers parameters, i.e. the position in space and deformation, whereas the second step concerns the selection of the number of scatterers in a detection framework, i.e., paying attention to achieve high detection performance for a given false alarm rate. Particularly, the selection stage exploits a detection scheme which is based on the sequential use of a detector based on the Generalized Likelihood Ratio Test for single scatterers in [16] .

The MDI technique developed in IREA has demonstrated, for the first time, the capability of this processing approach to resolve multiple scatterers interfering in the same pixel by using C-Band data in [26]: further significant results on C-Band data were reported in [8] and [11]. Nevertheless, the first demonstration of the capability of MDI to resolve distributed layover occurring over vertical structures as buildings have been shown in [32]: in this case the MDI beam-forming tomographic processing was applied to a dataset of TerraSAR-X data acquired over the area of Las Vegas. Particularly relevant were in this case the results achieved over the Mirage hotel which are not shown here for brevity.

In order to face the higher sensitivity of X-Band radiation to small changes of targets, such as those caused by thermal dilation, MDI processing has been extended to measure even this component in the 5D domain (space/velocity + thermal dilation). In fact, even if already observed in C-Band (ERS and Envisat) data [28][29], this effect is much more evident in X-Band data due to the increase of sensitivity associated with the shorter wavelength [30]–[32]. To account also for the thermal dilation component, the deformation model, typically made of the linear temporal term, is extended with a new one, measured in mm/K, which is linearly related to the temperature of the area at the acquisition instants [10].

3.1.2. MDI system of DLR-IMF: Tomo-GENESIS

The workhorse of interferometric processing at DLR is the GENESIS system [33]. It has been the basis for the developments of DLR's operational SRTM and TanDEM-X processors. An extended version of it (PSI-GENESIS) handles PSI processing of medium resolution data, wide-swath mosaics as well as very high resolution spotlight data. During the last years several new algorithms for TomoSAR processing have been developed at DLR extending the system to what we introduce as "Tomo-GENESIS" [34].

The layover phenomenon in a SAR image of an urban area is mainly caused by the following two scenarios: (i) buildings with different heights in layover with the ground or (ii) taller building in layover with the ground and the roof of a lower building. Both scenarios suggest that double scatterer pairs with smaller elevation distances will be more frequent than those with larger distances. Therefore, SR is crucial for VHR tomographic SAR reconstruction in urban environment. This makes super-resolving TomoSAR algorithms particularly important for urban mapping.

The SL1MMER algorithm is demonstrated to be an efficient estimator and achieves super-resolution factors of 1.5~25 at the interesting parameter range for TomoSAR (see Figure 2), i.e. N = 10~100 and SNR = 0~10 dB [22][23]. The results shown in Figure 2 are approximately applicable to nonlinear least-squares estimation as well, and hence, although it is derived experimentally, they can be considered as a fundamental bound for SR of spectral estimators. In [24] the super-resolution capability of the SL1MMER algorithm is demonstrated using TerraSAR-X data.

For an input data stack, the Tomo-GENESIS system retrieves the following information: number of scatterers inside a pixel, amplitude and phase, topography and motion parameters (e.g. linear deformation velocity and amplitude of thermal dilation induced seasonal motion) of each detected scatterer. Compared to other existing MDI processing systems, it has the following new features: the time warp method for multi-component nonlinear motion estimation [9]; the CS based SL1MMER algorithm and super-resolution capability [22]–[24]; fusion of PSI and TomoSAR processing for operational purpose [35]; RANSAC based point cloud fusion algorithm [36][35]. Currently, the system is extending for object reconstruction from the unstructured TomoSAR point clouds [37].

3.2. Application Examples

3.2.1. Space radar scanning with SAR tomography

To show the capabilities of MDI to achieve "synthetic" radar scanning for imaging ground structures we present the following results relevant to the San Paolo Stadium in the city of Naples, Italy. A dataset of 28 images acquired by the Cosmo-Skymed constellation on descending passes in the standard stripmap mode (~3 m spatial resolution) from February 2010 to February 2011 were processed with the 5D MDI algorithm. Figure 3 shows the three-dimensional reconstruction of the stadium visualized on a Google Earth map: the colors are set according to the estimated height. Note that even in this moderate resolution mode a large density of targets compared to PSI is achieved, especially on the roof [30]–[32].

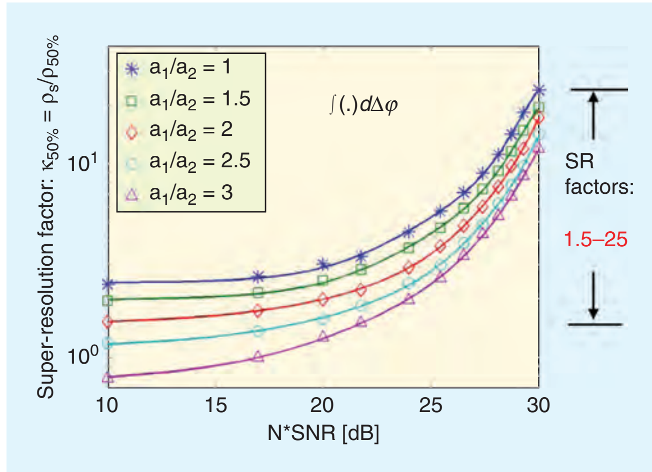

Figure 2. Fundamental bound of super-resolution (SR): SR factor of the SL1MMER algorithm as a function of N SNR under different amplitude ratios a_1/a_2 of two close scatterers [24].

3.2.2. Compressed Sensing SAR Tomography for super resolution spaceborne radar scanners

Figure 4 presents a 3D view of the single buildings visualized in GoogleEarth reconstructed by SL1MMER using a stack of 25 TerraSAR-X images [24]. The test building is the Bellagio hotel at downtown Las Vegas. Compared to PSI, TomoSAR offers in general a tremendous improvement in detailed reconstruction and monitoring of urban areas. Experiments using TerraSAR-X high resolution spotlight data stacks show the scatterer density to be in the order of 600,000~1,000,000/km^2 compared to a PS density in the

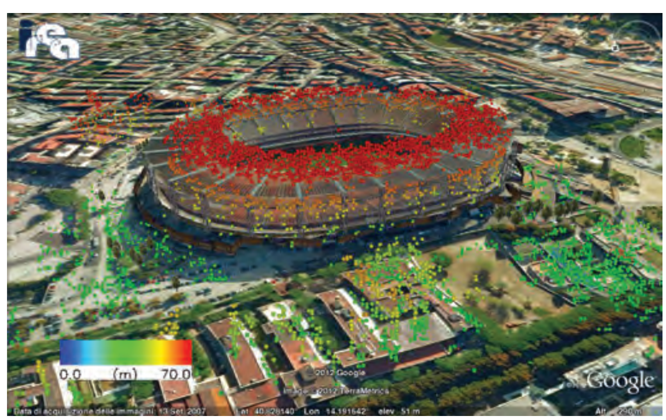

Figure 3. 3D view of the San Paolo Stadium, Naples, Italy, reconstructed by the 5D MDI with COSMO/SKYMED data provided by the Italian Space Agency. Colormap is set according to the estimated height [30]–[32].

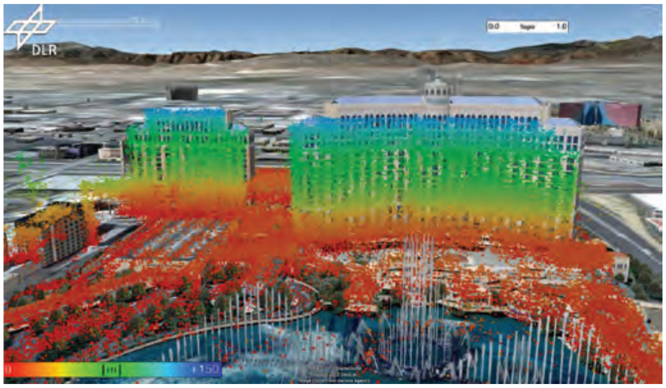

Figure 4. 3D view of the single building visualized in GoogleEarth reconstructed by SL1MMER using a stack of 25 TerraSAR-X images (the color represents height) [24].

order of 40,000~100,000 PS/km^2 [34][38]. In particular, together with its SR power, SL1MMER provides ultimate information one can retrieve from the data stack. Figure 5 presents the number of scatterers map obtained by SVD-Wiener inversion (left) and SL1MMER (right) over the test area where blue indicates zero scatterers inside the azimuth-range pixel, green stands for one and red for two. Non-parametric estimators can only detect two scatterers with an elevation distance larger than approximately the Rayleigh elevation resolution unit ρ_s. Therefore, it is not surprising that the double scatterers detected by the linear estimator are mainly located on the upper part of the building façade. The result of SL1MMER shows a much denser red color which indicates a larger amount of detected double scatterers. For an urban area like this typically about 30~40% of the scatterers detected by SL1MMER are double scatterers compared to less 10~20% detected by linear estimators.

3.2.3. TomoSAR point cloud fusion

Due to the side-looking geometry of SAR, a single stack of SAR images only provides information on one side of a building. To serve the function of urban structure monitoring, fusion of the TomoSAR results of multiple stacks from different view angles can provide us with a shadow-free point cloud with high degree of coverage over the entire urban area.

At the test site of Berlin, we have a luxury data archive with a large number of TerraSAR-X high resolution spotlight images including a stack of 94 SAR images from ascending orbit and another stack of 79 SAR images from descending orbit are processed. For both stacks, the acquisition time span is about four years. Figure 6 present the 3D positions of the fused point clouds small structures like the Victory Column, i.e. the statue at the center of the park can be easily identified. For this test-site, about 40 million scatterers are detected from the two data stacks.

3.2.4. Multicomponent motion estimation

D-TomoSAR was originally proposed in [7] for estimating linear motion of multiple scatterers inside a pixel. Motion,

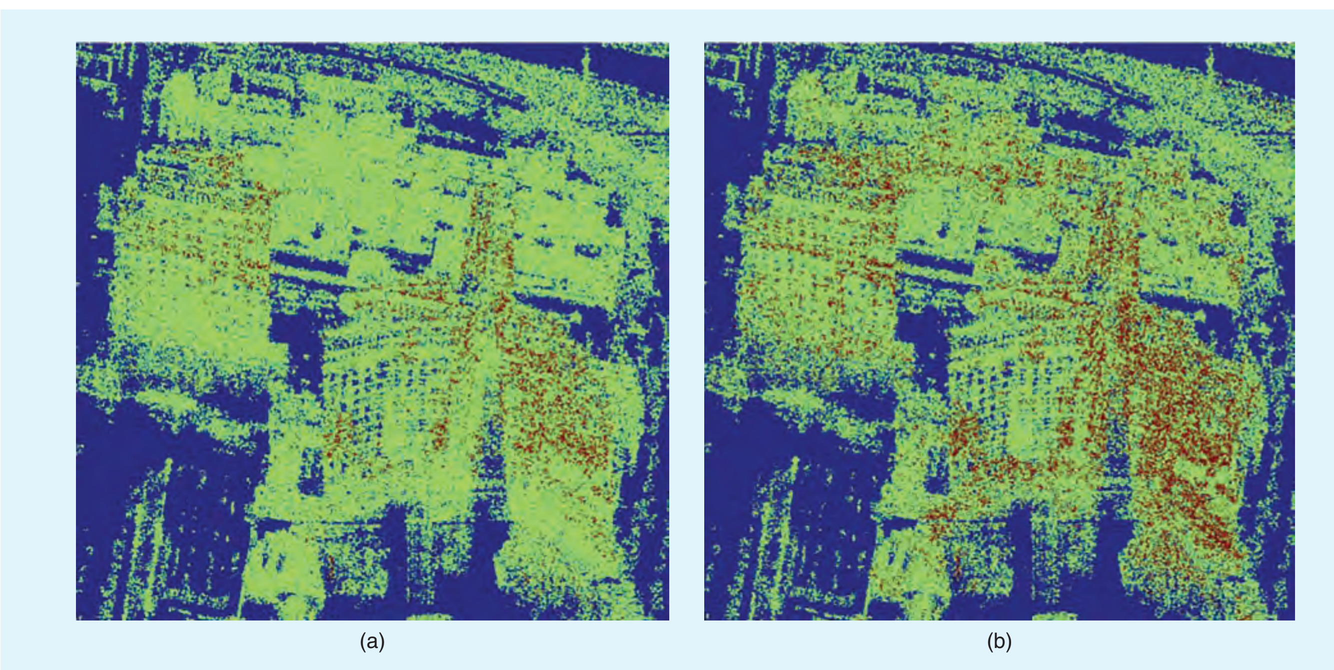

Figure 5. Double scatterer density for SVD-Wiener (a) and SL1MMER (b) reconstruction (Blue: Null scatterers per pixel; Green: Single; Red: Double) [24]. The superresolution capability of SL1MMER leads to more detected double scatterers, in particular at the lower parts of the facades.

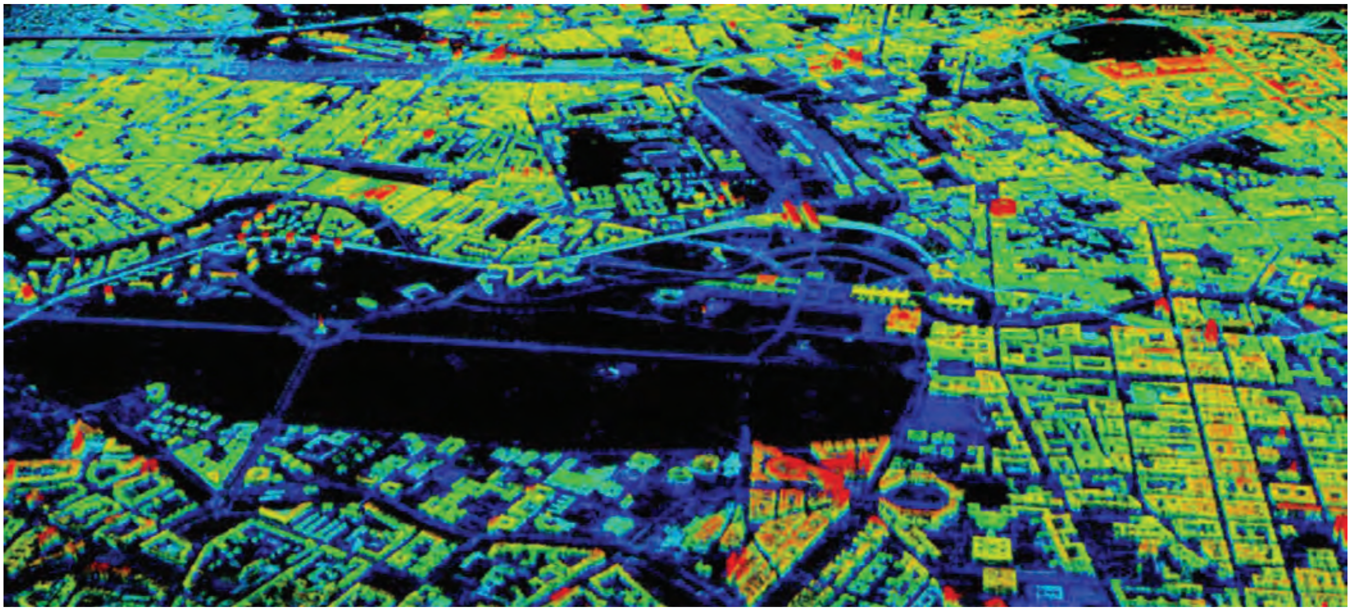

Figure 6. Fusion of two point clouds generated from TerraSAR-X data stacks of ascending and descending orbit. The color represents height [35].

however, is often nonlinear (periodic, accelerating, stepwise, etc.). Conventional D-TomoSAR has been extended to estimate multicomponent nonlinear motion in [9] by proposing the generalized ”time warp” method. It rewrites the D-TomoSAR system model to an M+1-dimensional standard spectral estimation problem, where M indicates the user defined motion model order and, hence, enables the motion estimation for all possible complex motion models.

Figure 7 shows an example of multicomponent motion estimation. Since July 2009, the selected area over Las Vegas (see Figure 7a) is undergoing a pronounced subsidence centered at the convention center. Together with the thermal dilation induced seasonal motion of the metallic building structure, the selected area is characterized by a two-component nonlinear motion. Here, we choose the motion basis function as a sine function with a period of one year for seasonal motion and linear function for linear subsidence. And hence the motion parameters to be estimated are amplitude of seasonal motion and linear deformation velocity. The final estimation results of the generalized time-warp method are presented in Figure 7 including elevation estimates in meter (b), amplitude of seasonal motion in millimeter (c) and the LOS linear deformation velocity in millimeter/year (d).

If we know the temperature at the time of data acquisitions, we can also accordingly choose the temperature as the basis function to model thermal dilation induced deformation [10][30][31]. In this case, the thermal coefficient is estimated that represents the strength of undergoing thermal dilation induced deformation. An example is presented in Figure 8. The site under investigation is relevant to the area of the Bellagio hotel and casino (see Figure 4). Figure 8(a) shows in the native radar geometry (range and azimuth are the horizontal and vertical directions, respectively), the topography retrieved by the MDI Beam-Forming imaging approach by using only single scatterers. Figure 8(b) and 8(c) show the estimated topography and thermal dilation with single and double scatterers by using the 5D Beam-Forming imaging: note that thermal dilation mostly affects the peripheral parts of building and exhibits different behavior on the same building according to the different projection of thermal dilation along the radar line-of-sight.

4. Conclusion and Further Developments

With reference to the current status of VHR tomographic SAR inversion presented in this article, the following conclusions can be drawn:

- VHR tomographic SAR inversion is able to reconstruct the shape and motion of individual buildings and entire city areas.
- Super-resolution is crucial and possible for VHR tomographic SAR inversion for urban infrastructure.
- TomoSAR reconstruction from *multiple* tracks enables us to reconstruct the complete structure of individual buildings and to generate 3D point clouds of the illuminated area with a point density comparable to LiDAR
- The motion or deformation of buildings is often nonlinear (periodic, accelerating, stepwise, etc.). This is particularly true with VHR SAR data. Multicomponent nonlinear motion of multiple scatterers can be separated and further estimated by tomographic reconstruction.

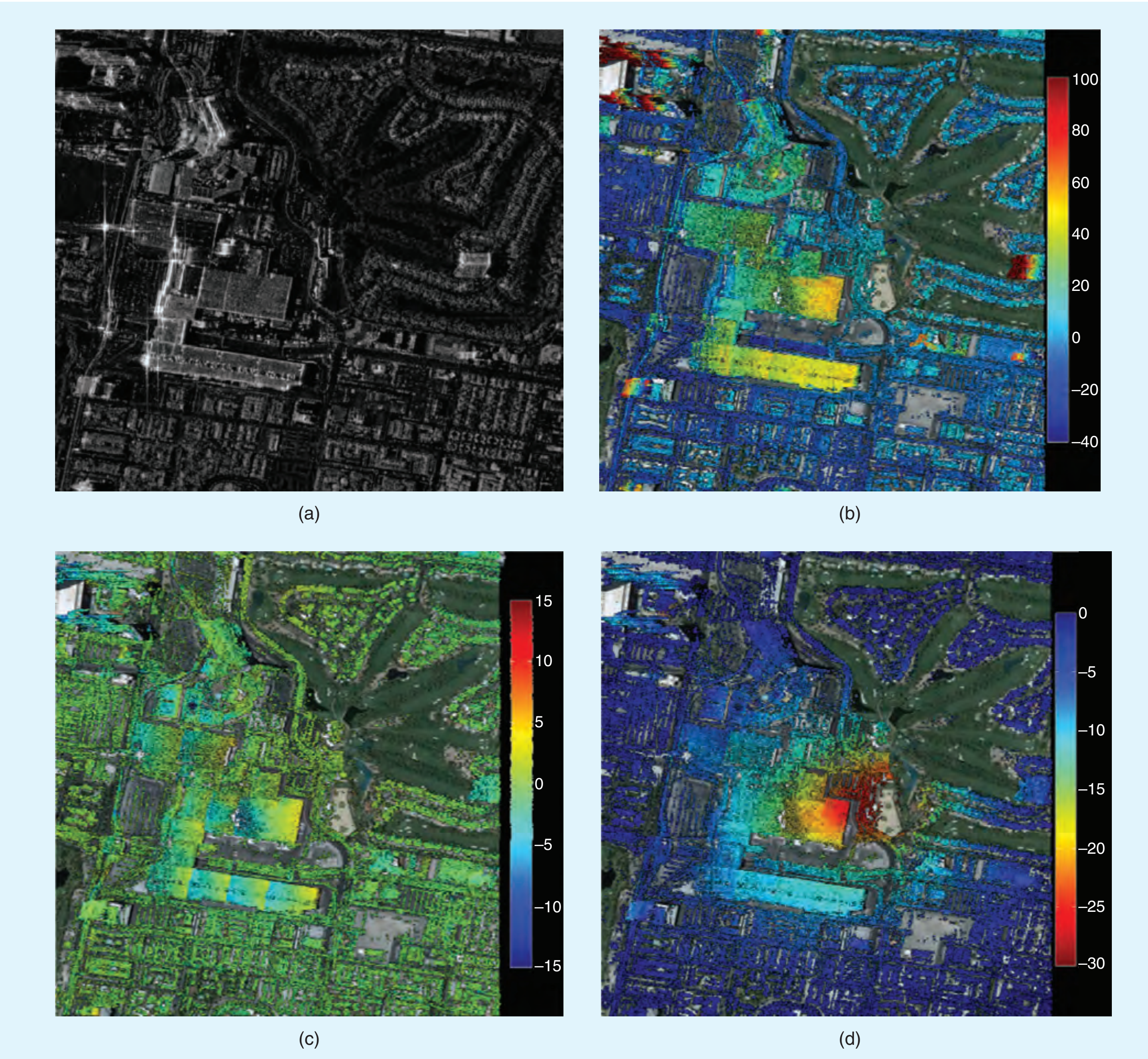

Figure 7. TomoSAR estimates of the selected area in Las Vegas: TerraSAR-X intensity map (a); Elevation estimates (b; unit: m) amplitude of seasonal motion (c; unit: mm) and linear deformation velocity (d; unit: mm/y) [9].

A few topics for further study are outlined which mainly concern 1) tomographic SAR reconstruction from mixed single-pass/multipass data stacks 2) object reconstruction from TomoSAR point clouds.

- Tomographic SAR reconstruction from mixed single-pass/repeat-pass data stacks:
  So far, the data used for spaceborne VHR tomographic SAR inversion are repeat-pass data stacks. With TanDEM-X, for the first time there is a real multi-antenna array system in space. It enables us to acquire data pairs simultaneously and repeatedly in time. The TanDEM-X data pairs are free of motion, atmosphere and temporal decorrelation and, hence, possess much higher data quality. The fusion of TerraSAR-X and TanDEM-X data, i.e. adding a couple of TanDEM-X acquisition pairs to the TerraSAR-X data stacks, can be used to improve the result of tomographic SAR inversion on the one hand, and to explore the limits of tomographic reconstruction on the other hand [39].

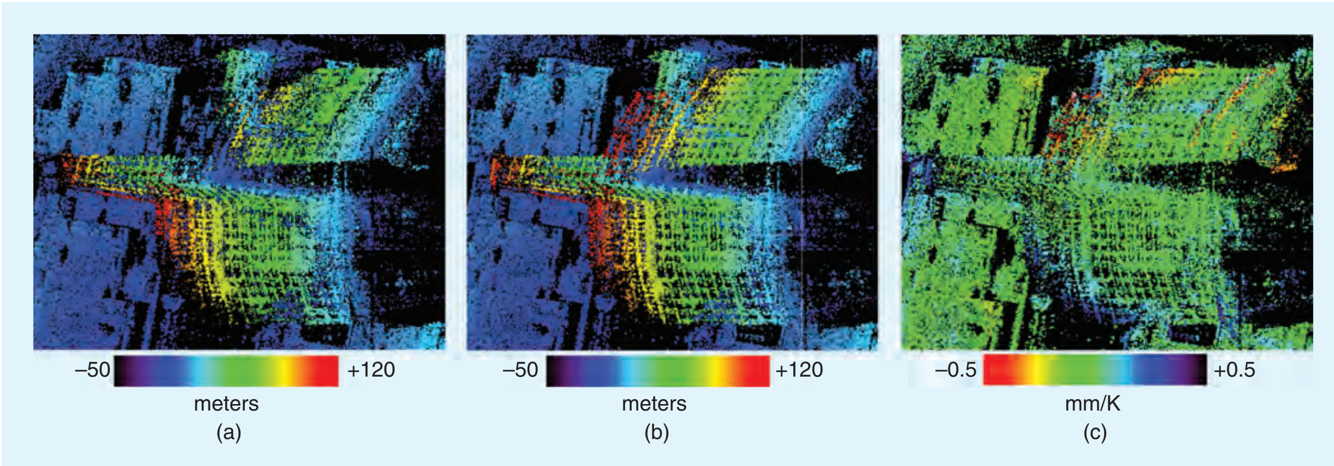

Figure 8. Thermal dilation analysis with TerraSAR-X data. (a) estimated topography with the 4D imaging (single scatterers); (b) estimated topography with the 5D imaging (single and double); (c) estimated thermal coefficients with the 5D imaging (single and double) [10][30][31].

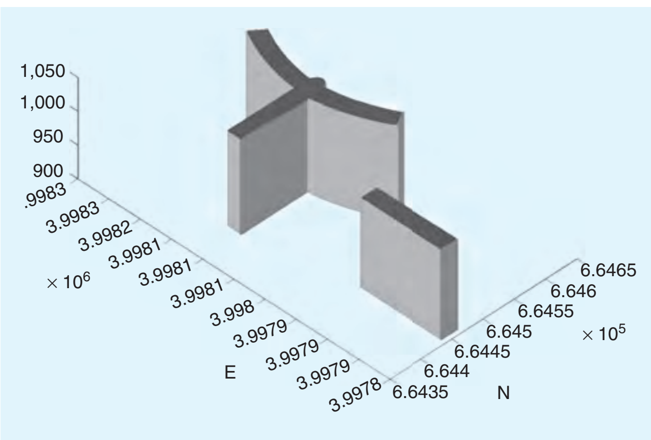

Figure 9. From TomoSAR point clouds to objects: reconstructed building façade of the test building Bellagio hotel in Las Vegas [37].

- Object reconstruction from TomoSAR point clouds:
  These tomographic point clouds can be potentially used for building façade reconstruction in urban environment from space with some special considerations such as side-looking geometry, anisotropic estimation accuracy and decorrelation. Yet in order to provide a high quality spatio-temporal 4D city model, object reconstruction from these TomoSAR point clouds is emergent. A 3D view of the reconstructed façades over a test building Bellagio hotel in Las Vegas (see Figure 4) using point clouds from multiple viewing angles, i.e. both ascending and descending orbits, is exemplified in Figure 9.

Acknowledgements

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BOOK REVIEW

REMOTE SENSING AND GLOBAL ENVIRONMENTAL CHANGE

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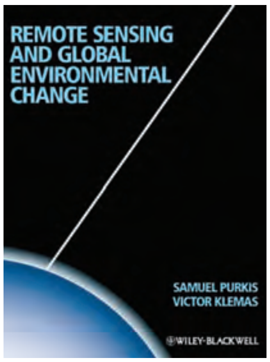
Dept. of Geography, University of Zurich, Switzerland



Authored by Samuel Purkis
and Victor Klemas
Wiley-Blackwell, 2011
ISBN: 978-1-4443-3935-2 (cloth),
-4051-8225-6 (pbk)

"Remote sensing is now a mature enough technology to answer some of the fundamental questions in global environmental change" state the authors in the introduction. Nothing more can be added to this statement and the authors take on the responsibility to prove it to be true on the following 367 pages of their book entitled 'Remote Sensing and Global Environmental Change'. While much of the global change discussion has been dominated using a climate forcing view in the past, Purkis and Klemas emphasize the importance of feedback mechanisms when putting forward their second grand challenge, namely 'How does the Earth system respond to natural and human-induced changes?'.

The book is a pleasure to read on all of its 367 pages and 14 chapters, of which 8 discuss an environmental issue of concern. The structure used is easily accessible and will support a broad audience finding a swift entry to the technology of remote sensing as well as getting a good understanding of the relevance and contribution of remote observations solving Earth science challenges. The introduction clearly states the books ambition and target audience, which – in this case – are not hard core remote sensing experts, rather than interested scientists and decision makers originating from a multitude of backgrounds generally interested in the topic of remote sensing and global environmental change.

An increasingly popular feature of books like this one is the availability of companion websites, allowing students and teachers to download book materials for own use or teaching purposes. In this case, the book's site is accessible through www.wiley.com/go/purkis/remote, where tables and figures can be easily downloaded for all chapters in pre-organized presentation files mostly with scalable graphics. Reuse is encouraged, with proper copyright information embedded, ready to be presented in classes or used in presentations aiming at any broader audience. Purkis and Klemas demonstrate with this approach consistency in their attitude on sharing data as promoted in Chapter 13. But more on this later.

Following an introduction chapter, Chapter 2 is introducing the reader to remote sensing basics. Concepts of electromagnetic waves, radiance and reflectance are discussed when further focus is moving on atmospheric effects, feature recognition and issues of scale. Like all other chapters of the book, Chapter 2 closes with a set of key concepts, allowing for fast and concise content summaries. These are either targeting at readers in a hurry or allow to refresh memories on the main content of a chapter.

In Chapter 3, key remote sensing sensors and systems are discussed. They range from multispectral systems to digital aerial cameras, and thermal infrared sensors, SAR systems to LIDAR. Several tables complement the technology introduction by listing particular uses and process length scales used for these technologies. The second part of Chapter 3 discusses remote sensing platforms and observing systems. Towards the end, even large programs such as GCOS and GEOSS amongst others are presented. The chapter concludes by discussing a choice of image archives, serving as entry points for particular data searches.

Chapter 4 dives into the process of discussing conversion of raw measurements to usable Earth observation products. Its content ranges from binary representation of image data to processing schemes and interpretation. Further in the chapter, concepts of uncertainty assessment and change detection approaches are discussed. Towards the end of the chapter, links to field sampling approaches are discussed as well as the integration of all these data sources into a GIS.

The following eight chapters (5–12) represent the backbone of the book. They discuss eight different approaches to monitoring specific parts of the Earth system. They include topics such as global vegetation cover, urban environments, surface and ground water, coral reefs, sea level rise, oceans, atmosphere, and cryosphere. Case studies for each of these topics are given and discussed in more detail in each chapter.

The global environmental change chapters focus on the biosphere (monitoring changes in global vegetation cover), anthroposphere (remote sensing of urban environments), hydrosphere (surface and ground water resources; coral reefs, carbon and climate; coastal impact of storm surges and sea level rise; and observing the oceans), atmosphere (monitoring the Earth's atmosphere), and cryosphere (observing the cryosphere).

All eight Earth spheres chapters are well structured and discuss the topics in a broad context, as well as listing the observational approaches and key concepts used. This substantially supports the understanding of the linkage between the challenges at hand and the contribution of remote observations to solving the issues. Access to the challenges is facilitated using conceptual graphs and images, allowing non-remote sensors to quickly familiarize themselves with the subject.

Chapter 13 is quite an unusual chapter content-wise in a remote sensing textbook, but of outmost importance. It discusses the necessity to communicate global change results and asks critically the responsibility question. It is a critical reflection on our responsibility to communicate adequately global change results. A second point in Chapter 13 is facilitation of communication through accessibility of data. Purkis and Kelmas state that 'the beauty of Earth observation data must not be confused with reliability and the public, as for scientists, must be helped to understand the message that the data are carrying'. The make the point that access to geospatial data should be further fostered and all geospatial data should be available. I argue that Chapter 13 should not be part of a textbook, because data sharing attitudes of geospatial data users and providers should be a commodity. The fact that it is not today likely prompted the authors to include it in the book. I therefore consider it inclusion as a wise decision and combine it with the hope that Chapter 13 will not be a necessity any longer in a textbook in 5–10 years from now.

In Chapter 14, the authors look ahead and discuss emerging technologies and discuss potential future trends and currently unsolved challenges posed on remote sensing. The book closes again with putting responsibility in our hands by stating that 'with the existence and of the technologies and services discussed in the book, we can no longer say that we were not warned.'

Finally, the book is complemented by a set of references (45 pages) and an index.

This book communicates remote sensing to its audience without the use of equations. It builds on clear illustrations and text written in a readable, understandable form and constant flow. Its narrative on the use of remote sensing for global environmental change allows readers to understand the subject without having to climb over barriers of fundamental physics, biology, or chemistry. The eight case studies cover a large range of environmental challenges, while four of them are related to the hydrosphere (surface and ground water resources, coral reefs, storm surges and sea level rise, as well as oceans) and these are treated with outmost competence and care. The book serves as an excellence reference for those who are interested in remote sensing, but did not find so far an entry to the subject as a whole.

Michael E. Schaepman (M'05–SM'07) received the M.Sc. degree and the Ph.D. degree in geography from the University of Zürich (UZH), Zürich, Switzerland, in 1993 and 1998, respectively. In 1999, he spent his postdoctoral time at the Optical Sciences Center, The University of Arizona, Tucson. In 2000, he was appointed Project Manager of the European Space Agency (ESA) Airborne Prism Experiment (APEX) spectrometer. In 2003, he accepted a position of Full Chair of geoinformation science and remote sensing at Wageningen University, Wageningen, The Netherlands. In 2009, he was appointed Full Chair of remote sensing at UZH, where he is currently heading the Remote Sensing Laboratories, Department of Geography. He also serves as director of the 'Global Change and Biodiversity' research priority programme at UZH and is responsible for the MSc and PhD curriculum in Earth System Science. His interests are in computational Earth sciences using remote sensing and physical models, with particular focus on the land–atmosphere interface using imaging spectroscopy. He is associate editor for IEEE J-STARS and editor-in-chief for Springer earth-perspectives.com. He is co-founder and board member of netcetera.com, a large independently owned software development company based in Switzerland.

REPORTS

GRSS PUBLICATIONS AWARDS PRESENTED AT IGARSS 2012 BANQUET

Martti Hallikainen and Werner Wiesbeck, IEEE GRSS Awards Committee Co-Chairs

The IEEE Geoscience and Remote Sensing Society's 2012 Publications Awards were presented at the IGARSS Awards Banquet on Thursday, July 26 at the imperial ballroom Kaisersaal (Emperor's Hall) of the Residenz Palace in Munich. The Residenz served as the seat of government and residence of the Bavarian dukes, electors and kings from 1508 to 1918. What began in 1385 as a castle at the north-eastern corner of the town (the Neuveste, or new citadel) was transformed over the centuries into a magnificent palace, its buildings and gardens extending further and further into the town. The architecture, interior decoration and works of art collected in the Residenz range in time from the Renaissance, via the early Baroque and Rococo periods to the neoclassical era.

When the Kaisersaal was built by Duke Maximilian I in the early seventeenth century it was the largest and most important room for festivities in the Residenz. The ceiling is decorated with an extensive cycle of paintings by Peter Candid and members of his workshop. The pictures aim to demonstrate that Reason and Virtue should form the twin foundations of princely rule. The theme is taken up by the tapestries, which are the work of the Dutch weaver Hans van der Biest. They depict exemplary heroes from classical antiquity and the Old Testament. The paintings at the top of the walls show episodes from ancient history and the Bible that in the seventeenth century were likewise viewed as models of virtuous behavior.

GRSS President Jon Benediktsson welcomed Banquet attendees. The following awards were presented by him (the first award by GRSS Past President Alberto Moreira) and GRSS Publications Awards Chair Martti Hallikainen during the dinner:

- Transactions Prize Paper Award
- Letters Prize Paper Award
- J-STARS Prize Paper Award
- Highest Impact Paper Award
- Symposium Prize Paper Award
- Symposium Interactive Prize Paper Award
- Three Student Prize Paper Awards
- GOLD Early Career Award

Additionally, two Certificates of Recognition were presented earlier at GRSS Administrative Committee's dinner.

1. IEEE GRSS Transactions Prize Paper Award

The GRSS established the **Transactions Prize Paper Award** to recognize authors who have published an exceptional paper in IEEE Transactions on Geoscience and Remote Sensing during the past calendar year. When selecting the paper, other factors considered are originality and clarity of the paper. Prize: Certificate and $3000, equally divided between the authors.

The 2012 Transactions Prize Paper Award was presented to **Alberto Villa, Jon Atli Benediktsson, Jocelyn Chanussot and Christian Jutten**, with the citation:

For a very significant contribution to the field of endeavor of the IEEE GRS Society in the paper authored by Alberto Villa, Jon Atli Benediktsson, Jocelyn Chanussot and Christian Jutten entitled ***"Hyperspectral Image Classification with***

The venue for the Awards Banquet was the Residenz Palace.

Kaisersaal of the Residenz Palace.

Independent Component Discriminant Analysis," published in IEEE Transactions on Geoscience and Remote Sensing, vol. 49, no. 12, pp. 4865–4876, December 2011.

Alberto Villa (S'09) received the B.S. and M.S. degrees in electronic engineering from the University of Pavia, Pavia, Italy, in 2005 and 2008, respectively. In 2011, he received the Ph.D. degree (a joint degree) from the Grenoble Institute of Technology (Grenoble INP), Grenoble, France, and the University of Iceland, Reykjavik, Iceland. He was a visiting researcher at the Hyperspectral Computing Laboratory (HyperComp), University of Extremadura, Spain, from September 2010 to February 2011. Since July 2011, he has been working as a research engineer for Aresys srl, a spin-off company of Politecnico di Milano in the areas of SAR antenna model, spectral unmixing, machine learning, hyperspectral imaging, signal and image processing. He is also an associate with Dipartimento Elettronica ed Informazione (DEI), Politecnico di Milano. He is involved in several projects with European Space Agency and Argentinean Space Agency (CONAE). Dr. Villa is a reviewer for the IEEE Transactions on Geoscience and Remote Sensing, IEEE Geoscience and Remote Sensing Letters, and IEEE Journal of Selected Topics in Signal Processing. He served as a reviewer for several conferences, such as IGARSS 2010–2011, WHISPERS 2009–2011.

Jón Atli Benediktsson received the Cand.Sci. degree in electrical engineering from the University of Iceland, Reykjavik, in 1984, and the M.S.E.E. and Ph.D. degrees from Purdue University, West Lafayette, IN, in 1987 and 1990, respectively. He is currently Pro Rector for Academic Affairs and Professor of Electrical and Computer Engineering at the University of Iceland. His research interests are in remote sensing, biomedical analysis of signals, pattern recognition, image processing, and signal processing, and he has published extensively in those fields. Prof. Benediktsson is the 2011–2012 President of the IEEE Geoscience and Remote Sensing Society (GRSS) and has been on the GRSS AdCom since 1999. He was Editor of the *IEEE Transactions on Geoscience and Remote Sensing* (TGRS) from 2003 to 2008. Prof. Benediktsson is a co-founder of the biomedical start up company Oxymap. He is a Fellow of the IEEE. He received the Stevan J. Kristof Award from Purdue University in 1991 as outstanding graduate student in remote sensing. In 1997, Dr. Benediktsson was the recipient of the Icelandic Research Council's Outstanding Young Researcher Award, in 2000, he was granted the IEEE Third Millennium Medal, in 2004, he was a co-recipient of the University of Iceland's Technology Innovation Award, in 2006 he received the yearly research award from the Engineering Research Institute of the University of Iceland, and in 2007, he received the Outstanding Service Award from the IEEE Geoscience and Remote Sensing Society. He is a member of Societas Scinetiarum Islandica and Tau Beta Pi.

Jocelyn Chanussot (M'04–SM'04-F'12) received the M.Sc. degree in electrical engineering from the Grenoble Institute of Technology (Grenoble INP), Grenoble, France, in 1995, and the Ph.D. degree from Savoie University, Annecy, France, in 1998. In 1999, he was with the Geography Imagery Perception Laboratory for the Delegation Generale de l'Armement (DGA – French National Defense Department). Since 1999, he has been with Grenoble INP, where he was an Assistant Professor from 1999 to 2005, an Associate Professor from 2005 to 2007, and is currently a Professor of signal and image processing. He is currently conducting his research at the Grenoble Images Speech Signals and Automatics Laboratory (GIPSA-Lab). His research interests include image analysis, multicomponent image processing, nonlinear filtering, and data fusion in remote sensing. Dr. Chanussot is the founding President of IEEE Geoscience and Remote Sensing French chapter (2007–2010) which received the 2010 IEEE GRSS Chapter Excellence Award "for excellence as a Geoscience and Remote Sensing Society chapter demonstrated by exemplary activities during 2009". He was the recipient of the NORSIG 2006 Best Student Paper Award, the IEEE GRSS 2011 Symposium Best Paper Award and of the IEEE GRSS 2012 Transactions Prize Paper Award. He was a member of the IEEE Geoscience and Remote Sensing Society AdCom (2009–2010), in charge of membership development. He was the General Chair of the first IEEE GRSS Workshop on Hyperspectral Image and Signal Processing, Evolution in Remote sensing (WHISPERS). He is the Chair (2009–2011) and was the Co-chair of the GRS Data Fusion Technical Committee

Past President Alberto Moreira (left) presented the Transactions Prize Paper Award to Alberto Villa, Jocelyn Chanussot, and Jón Atli Benediktsson; Publications Awards Chair Martti Hallikainen on the right.

(2005–2008). He was a member of the Machine Learning for Signal Processing Technical Committee of the IEEE Signal Processing Society (2006–2008) and the Program Chair of the IEEE International Workshop on Machine Learning for Signal Processing, (2009). He was an Associate Editor for the IEEE Geoscience and Remote Sensing Letters (2005–2007) and for Pattern Recognition (2006–2008). Since 2007, he is an Associate Editor for the IEEE Transactions on Geoscience and Remote Sensing. Since 2011, he is the Editor-in-Chief of the IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.

Christian Jutten received the PhD degree in 1981 and the Docteur ès Sciences degree in 1987 from the Institut National Polytechnique of Grenoble (France). He taught as associate professor in the Electrical Engineering Department from 1982 to 1989, before to become full professor in University Joseph Fourier of Grenoble, more precisely in the sciences and technologies department: Polytech'Grenoble. He was visiting professor in Swiss Federal Polytechnic Institute in Lausanne in 1989 and in Campinas University (Brazil) in 2010. He has been associate director of the Grenoble images, speech, signal and control laboratory (GIPSA, 300 people) and head of the Department Images-Signal (DIS) of this laboratory, from 2007 to 2010. For 30 years, his research interests are blind source separation, independent component analysis and learning in neural networks, including theoretical aspects (separability, source separation in nonlinear mixtures, sparsity) and applications in signal processing (biomedical, seismic, hyperspectral imaging, speech). He is author or co-author of more than 65 papers in international journals, 4 books, 19 invited papers and 150 communications in international conferences. He has been associate editor of IEEE Trans. on Circuits and Systems (1994–95), and co-organizer the 1st International Conference on Blind Signal Separation and Independent Component Analysis (Aussois, France, January 1999). He has been a scientific advisor for signal and images processing at the French Ministry of Research from 1996 to 1998 and for the French National Research Center (CNRS) from 2003 to 2006. He is a member of the technical committee "Blind signal Processing" of the IEEE CAS society and of the technical committee "Machine Learning for signal Processing" of the IEEE SP society. He is a reviewer of main international journals (IEEE Trans. on Signal Processing, IEEE Signal Processing Letters, IEEE Trans. on Neural Networks, Signal Processing, Neural Computation, Neurocomputing, etc.) and conferences in signal processing and neural networks (ICASSP, ISCASS, EUSIPCO, IJCNN, ICA, ESANN, IWANN, etc.). He received the EURASIP best paper award in 1992 and Medal Blondel in 1997 from SEE (French Electrical Engineering society) for his contributions in source separation and independent component analysis, and has been elevated as a Fellow IEEE and a senior Member of Institut Universitaire de France in 2008.

2. IEEE GRSS Letters Prize Paper Award

The GRSS established the **Letters Prize Paper Award** to recognize the author(s) who has published in the IEEE Geoscience and Remote Sensing Letters during the calendar year an exceptional paper in terms of content and impact on the GRS Society. If a suitable paper cannot be identified from among those published during the calendar year, papers published in prior years and subsequently recognized as being meritorious may be considered. When selecting the paper, originality, impact, scientific value and clarity are factors considered. Prize: Certificate and $1500, equally divided between the authors.

The 2012 Letters Prize Paper Award was presented to **Diego Reale, Gianfranco Fornaro, Antonio Pauciullo, Xiao Xiang Zhu and Richard Bamler** with the citation:

*For a very significant contribution to the field of endeavor of the IEEE GRS Society in the paper authored by Diego Reale, Gianfranco Fornaro, Antonio Pauciullo, Xiao Xiang Zhu and Richard Bamler entitled **"Tomographic Imaging and Monitoring of Buildings with Very High Resolution SAR Data,"** published in IEEE Geoscience and Remote Sensing Letters, Vol. 8, no. 4, pp. 661–665, July 2011.*

Diego Reale received the degree in telecommunication engineering from the University of Cassino, Italy, in 2007 and the Ph.D in information engineering from the University of Naples "Parthenope", Naples, in 2011. Since 2006, he is collaborating with the Institute for the Electromagnetic Sensing of the Environment (IREA) of the Italian National Research Council (CNR), where he is currently a Researcher. His main research interests are framed in the synthetic aperture radar (SAR) processing, particularly in multidimensional SAR tomography, SAR interferometry and Differential SAR Interferometry.

Gianfranco Fornaro (M'06) graduated summa cum laude in Electronic Engineering at the University of Napoli in 1992 and received the Ph.D. degree in 1997. Since 1993 he has been with the Istituto per il Rilevamento Elettromagnetico dell'Ambiente (IREA), formerly IRECE, of the Italian National Research Council (CNR) where he currently holds the position of Senior Researcher. He was also Adjunct Professor of Communication at the Universities of Cassino and Napoli "Federico II" and of Signal Theory at the University of Reggio Calabria. Dr. Fornaro was visiting scientist at the German Aerospace Establishment (DLR), also during the SIR-C/X-SAR mission in 1994, and at Politecnico of Milano and invited lecturer at the Istituto Tecnologico de Aeronautica (ITA) in Sao José dos Campos (Brazil) and RESTEC (Tokyo). He was responsible of the remote sensing unit of the Campania Regional Center of Competence "Analysis and Monitoring of the Environmental Risk". He has authored more than 100 papers in international peer-review journals and proceedings of international conferences in the SAR processing field. He served as an editor of the Advances in Interferometric SAR Processing special issue of the EURASIP Journal on Applied Signal Processing (JASP). His main research interests regards the signal processing field with applications to airborne and spaceborne Synthetic Aperture Radar (SAR) data processing, SAR Interferometry, differential SAR Interferometry and 3D and 4D SAR focusing.

Dr. Fornaro was awarded in 1997 of the Mountbatten Premium by the Institution of Electrical Engineers (IEE).

Antonio Pauciullo was born in Cercola, Italy, on October 10, 1969. He received the Dr. Eng. degree with honors in 1998 and the Ph.D. degree in information engineering in 2003, both from the University of Naples, Italy. Since 2001, he has been with the Institute for Electromagnetic Sensing of the Environment (IREA) of the Italian National Research Council (CNR), where he holds a position of Researcher, and since 2004, he has been an Adjunct Professor of digital signal processing at the University of Cassino (Italy). His current research interests regard the field of statistical signal processing with emphasis on synthetic aperture radar processing and CDMA systems.

Xiao Xiang Zhu (S'10-M'12) received the Bachelor degree in space engineering from the National University of Defense Technology (NUDT), Changsha, China, in 2006. She received the Master (M.Sc.) degree and her Doctor of Engineering (Dr.-Ing.) degree from Technische Universität München (TUM), München, Germany, in 2008 and 2011, respectively. Her Ph.D. dissertation "Very High Resolution Tomographic SAR Inversion for Urban Infrastructure Monitoring – A Sparse and Nonlinear Tour" won the Dimitri N. Chorofas Foundation Research Award in 2011 for its distinguished innovative and sustainability. In October/November 2009, she was a guest scientist at the Italian National Research Council (CNR) – Institute for Electromagnetic Sensing of the Environment (IREA), Naples, Italy. Since May 2011, she has been a full-time scientific collaborator with the Remote Sensing Technology Institute, German Aerospace Center (DLR) and with Remote Sensing Technology Department, TUM. Her main research interests are advanced InSAR techniques such as high dimensional SAR imaging and SqueeSAR, computer vision in remote sensing including object reconstruction and multidimensional data visualization, and modern signal processing, including innovative algorithms such as compressive sensing and sparse reconstruction, with applications in the field of remote sensing.

Richard Bamler (M'95–SM'00–F'05) received his Diploma degree in Electrical Engineering, his Doctorate in Engineering, and his "Habilitation" in the field of signal and systems theory in 1980, 1986, and 1988, respectively, from the Technische Universität München, Germany. He worked at the university from 1981 to 1989 on optical signal processing, holography, wave propagation, and tomography. He joined the German Aerospace Center (DLR), Oberpfaffenhofen, in 1989, where he is currently the Director of the Remote Sensing Technology Institute. In early 1994, Richard Bamler was a visiting scientist at Jet Propulsion Laboratory (JPL) in preparation of the SIC-C/X-SAR missions, and in 1996 he was guest professor at the University of Innsbruck. Since 2003 he has held a full professorship in remote sensing technology at the Technische Universität München as a double appointment with his DLR position. His teaching activities include university lectures and courses on signal processing, estimation theory, and SAR. Since 2010 he has been a member of the executive board of Munich Aerospace, a newly founded research and education project between Munich universities and extramural research institutions, incl. DLR. Since he joined DLR Richard Bamler, his team, and his institute have been working on SAR and optical remote sensing, image analysis and understanding, stereo reconstruction, computer vision, ocean color, passive and active atmospheric sounding, and laboratory spectrometry. They were and are responsible for the development of the operational processors for SIR-C/X-SAR, SRTM, TerraSAR-X, TanDEM-X, ERS-2/GOME, ENVISAT/SCIAMACHY, MetOp/GOME-2, and EnMAP. Richard Bamler's current research interests are in algorithms for optimum information extraction from remote sensing data with emphasis on SAR. This involves new estimation algorithms, like sparse reconstruction and compressive sensing. He has devised several high-precision algorithms for SAR processing, SAR calibration and product validation, GMTI for traffic

Recipients of the Letters Prize Paper Award Diego Reale (second from left), Xiao Xiang Zhu, Richard Bamler, and Gianfranco Fornaro with GRSS President Jon Benediktsson (left) and Publications Awards Chair Martti Hallikainen (right).

monitoring, SAR interferometry, phase unwrapping, persistent scatterer interferometry, and differential SAR tomography. Richard Bamler is the author of more than 200 scientific publications, among them 50 journal papers, a book on multidimensional linear systems theory, and holds eight patents and patent applications in remote sensing.

3. IEEE GRSS J-STARS Prize Paper Award

The GRSS established the **J-STARS Prize Paper Award** to recognize the author(s) who published in the IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing during the calendar year an exceptional paper in terms of content and impact on the GRSSociety. When selecting the paper, other factors considered are originality, clarity and timeliness of the paper. IEEE membership is preferable. The Award consists of a Certificate and an honorarium of $1,500. If the paper has more than one author, the honorarium shall be shared.

The 2012 J-STARS Prize Paper Award was presented to **Daniele Perissin and Teng Wang** with the citation:

For a very significant contribution to the field of endeavor of the IEEE GRS Society in the paper authored by Daniele Perissin and Teng Wang entitled ***"Time-Series InSAR Applications over Urban Areas in China,"*** *published in the IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 4, no. 1, pp. 92–100, March 2011.*

Daniele Perissin was born in Milan, Italy, in 1977. He received the M.S. degree in telecommunications engineering and the Ph.D. degree in information technology from Politecnico di Milano in 2002 and 2006, respectively. He joined the Signal Processing research group at Politecnico di Milano in 2002, and since then, he has been working on the Permanent Scatterers technique (PSInSAR) in the framework of radar remote sensing. Since October 2009 he holds a position as Research Assistant Professor in the Institute of Space and Earth Information Science (ISEIS) in the Chinese University of Hong Kong (CUHK). He is author of a patent on the use of urban dihedral reflectors for combining multisensor synthetic aperture radar data, and he is the developer of the software SARPROZ.

Teng Wang was born at Xinxiang, China, in 1980. He received the M.Eng. Degree in photogrammetry and remote sensing from Wuhan University, Wuhan, China, in 2006 and the Ph.D. Degree in information technology from the State Key Laboratory for Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan, China and Dipartimento di Elettronica e Informazione, Politecnico di Milano, Milan Italy in 2010. Since October 2010, he works as a post-doc researcher in the Earth and Environmental Sciences and Engineering Program, Division of Physical Sciences and Engineering at King Abdullah University of Science and Technology (KAUST), Saudi Arabia. His current research interests include time-series InSAR technique and its applications in geophysical fields.

4. IEEE GRSS Highest Impact Paper Award

The GRSS established last year the **GRSS Highest Impact Paper Award** to recognize the author(s) who have published during the past five years in an IEEE GRSS Journal the scientific paper that has received the highest number of citations and impact over the past five years as measured by the Thomson Reuters Web of Science citation index. A previously selected paper shall not be eligible for this award in the following years. The Award consists of a Certificate and an honorarium of $3,000. If the paper has more than one author, the honorarium shall be shared. The Highest Impact Paper Award was presented in 2012 for the first time.

J-STARS Prize Paper Award recipient Daniele Perissin with GRSS President Jon Benediktsson (left) and Publications Awards Chair Martti Hallikainen (right).

Antonio Plaza (middle) received the Highest Impact Paper Award on behalf of Lidan Miao and Hairong Qi from GRSS President Jon Benediktsson (left); Publications Awards Chair Martti Hallikainen on the right.

The 2012 Highest Paper Award was presented to **Lidan Miao and Hairong Qi** with the citation:

*For a very significant contribution to the field of endeavor of the IEEE GRS Society in the paper authored by Lidan Miao and Hairong Qi entitled **"Endmember Extraction from Highly Mixed Data Using Minimum Volume Constrained Nonnegative Matrix Factorization,"** published in IEEE Transactions on Geoscience and Remote Sensing, vol. 45, no. 3, pp. 765–777, March 2007.*

Lidan Miao received the B.S. and M.S. degrees in electrical engineering from Sichuan University, Chengdu, China, in 2000 and 2003, respectively, and the Ph.D. degree in computer engineering from University of Tennessee, Knoxville in 2007. She is currently a software engineer at Microsoft. Her research interests include signal and image processing, pattern recognition and remote sensing. Dr. Miao won the Best Paper Award at the 18th International Conference on Pattern Recognition and is the recipient of the Chancellor's Award for Extraordinary Professional Promise.

Hairong Qi (S'97-M'99-SM'05) received the B.S. and M.S. degrees in computer science from Northern JiaoTong University, Beijing, China in 1992 and 1995 respectively, and the Ph.D. degree in computer engineering from North Carolina State University, Raleigh, in 1999. She is currently a Professor with the Department of Electrical Engineering and Computer Science at the University of Tennessee, Knoxville. Her current research interests are in advanced imaging and collaborative processing in resource-constrained distributed environment, hyperspectral image analysis, and bioinformatics. She has published over 100 technical papers in archival journals and refereed conference proceedings, including a co-authored book in Machine Vision. She serves on the editorial board of *Journal of Mechanics in Medicine and Biology* and is the Associate Editor for *Computers in Biology and Medicine*. Dr. Qi is the recipient of the NSF CAREER Award and the Chancellor's Award for Professional Promise in Research and Creative Achievement. She also received the Best Paper Award at the 18th International Conference on Pattern Recognition and the 3rd ACM/IEEE International Conference on Distributed Smart Cameras.

5. IEEE GRSS Symposium Prize Paper Award

The GRSS established the **Symposium Prize Paper Award** to recognize the author(s) who presented at the IEEE International Geoscience and Remote Sensing Symposium (IGARSS) an exceptional paper in terms of content and impact on the GRSS. In selecting the paper, other factors considered are originality, clarity and timeliness of the paper. The published versions of the papers in the Digest shall also be evaluated. Prize: Certificate and $1250, equally divided between the authors.

The 2012 Symposium Prize Paper Award was presented to **Brian P. Salmon, Waldo Kleynhans, Frans van den Bergh, Jan C. Olivier, Willem J. Marais and Konrad J. Wessels** with the citation:

*For a very significant contribution to the field of endeavor of the IEEE GRS Society in the paper entitled **"Meta-Optimization of the Extended Kalman Filter's Parameters for Improved Feature Extraction on Hyper-Temporal Images,"** co-authored by Brian P. Salmon, Waldo Kleynhans, Frans van den Bergh, Jan C. Olivier, Willem J. Marais and Konrad J. Wessels, and presented at the 2011 International Geoscience and Remote Sensing Symposium, July 2011, in Vancouver, IGARSS´11 Proceedings.*

Brian P. Salmon received the B.Eng degree in computer engineering and the M.Eng degree in electronic engineering (signal processing) from the University of

Symposium Prize Paper Award recipients Brian Salmon (second from left), Waldo Kleynhans, Frans van der Bergh, and Jan Olivier with GRSS President Jon Benediktsson (left) and Publications Awards Chair Martti Hallikainen (right).

Pretoria, Pretoria, South Africa in 2004 and 2008, respectively. He is currently with the Remote Sensing Research Unit at the Council for Scientific and Industrial Research. He is working towards a Ph.D. in electronic engineering and his research interests are machine learning and graph theory.

Waldo Kleynhans received the B.Eng., M.Eng. and Ph.D. (Electronic Engineering) from the University of Pretoria, South Africa, in 2004, 2008 and 2011, respectively. He is currently a senior researcher with the Remote Sensing Research Unit at the Council for Scientific and Industrial Research in Pretoria, South Africa. His research interests include remote sensing, time-series analysis, wireless communications, statistical detection and estimation theory, and machine learning.

Frans van den Bergh received the M.Sc. degree in computer science (machine vision) and the Ph.D. degree in computer science (particle swarm optimization) from the University of Pretoria, Pretoria, South Africa, in 2000 and 2002, respectively. He is currently a principal researcher at the Council for Scientific and Industrial Research. His research interests include automated feature extraction from high-resolution satellite images, as well as automated change detection. He maintains an active interest in particle swarm optimization and machine learning.

Jan C. Olivier is a Professor of Engineering at the University of Tasmania in Australia. He was with Bell Northern Research in Ottawa Canada, Nokia Research Center in the United States, and the University of Pretoria in South Africa. He is an associate editor for the IEEE Transactions on Wireless Communication Letters and a past editor of the IEEE Trans. on Wireless Communications. His research interests are in the theory of estimation and detection applied to Remote Sensing and Communications theory.

Willem J. Marais received the B.Eng in computer engineering from the University of Pretoria, Pretoria, South Africa in 2005. He is currently doing the M.Sc. in electrical engineering at the University of Wisconsin, Madison. His research interests include signal processing in the domain of remote sensing.

Konrad J. Wessels received the M.Sc. in Landscape Ecology and Conservation Planning from the University of Pretoria (South Africa) in 1997 and a Ph.D. in Geography from University of Maryland (US) in 2005. He was a research associate at NASA Goddard Space Flight Center, Hydrospheric and Biospheric Laboratory (2005–2006). He is presently a principal researcher and leads the Remote Sensing Research Unit within the CSIR Meraka Institute in Pretoria, South Africa. His research interests include time-series analysis of satellite data for monitoring environmental change and the estimation ecosystem state variables and services with remote sensing.

6. IEEE GRSS Interactive Session Prize Paper Award

The GRSS established the **Interactive Session Prize Paper Award** to recognize the author(s) who posted at the GRSS Symposium (IGARSS) an exceptional paper in terms of content and impact on the GRSS. In selecting the paper, other factors considered are originality, clarity and timeliness of the paper. The published versions of the papers in the Digest shall also be evaluated. Prize: Certificate and $1250, equally divided between the authors.

The 2012 Interactive Session Prize Paper Award was presented to **Alain Bergeron, Linda Marchese, Bernd Harnisch, Martin Suess, Michel Doucet, Pascal Bourqui, Mathieu Legros, Nichola Desnoyers, Ludovic Guillot, Luc Mercier, Maxime Savard, Anne Martel, and François Châteauneuf** with the citation:

For an exceptional paper posted in the Interactive Session of the International Geoscience and Remote Sensing Symposium, IGARSS'11 entitled ***"Clustering of Detected Changes in Satellite Imagery Using Fuzzy C-Means Algorithm,"*** *co-authored by Alain Bergeron, Linda Marchese, Bernd Harnisch, Martin Suess, Michel Doucet, Pascal Bourqui, Mathieu Legros, Nichola Desnoyers, Ludovic Guillot, Luc Mercier, Maxime Savard, Anne Martel, and François Châteauneuf, and presented at the 2011 International Geoscience and Remote Sensing Symposium, July 2011 in Vancouver, IGARSS'11 Proceedings.*

Alain Bergeron has been involved in the development of optical systems for defense and civilian applications for the past 23 years. Among other works, he is involved in the development of optical correlators, infrared & terahertz systems, synthetic aperture radar processors and synthetic aperture lidar sensors. As a professional engineer, Dr. Bergeron also holds Ph.D. in Physics from Laval University. He is now Defense & Security Program Manager at INO in Québec City, Canada

Linda Marchese has been involved in the development of optical systems for defense and civilian applications for the past 14 years. She joined INO in 2006 and since then has participated in the development of synthetic aperture radar processing systems, terahertz imagers, and infrared cameras, including New Infrared Sensor Technology flying on SAC-D/Aquarius. Dr. Marchese holds a Ph.D. in Electrical Engineering from the University of Rochester.

Bernd Harnisch works as optical engineer in the optics section at the European Space Research and Technology Centre (ESTEC) of the European Space Agency (ESA) at Noordwijk in the Netherlands. He is working on new technology developments for optical payloads and is supporting space projects like the NIRSpec instrument payload development for the European contribution to the JWST telescope.

Martin Suess is currently the Head of the On-Board Payload Data Processing Section at the European Space Research and Technology Centre (ESTEC) of the European Space Agency (ESA) at Noordwijk in the Netherlands. He and his group are working on payload data processing systems and technologies for satellite missions in the field of Earth observation, planetary, and deep- space exploration. Some of his particular interests are SAR processing, new SAR system concepts and architectures and radar instrument technologies. He is member IEEE where he serves as co-chairman of the Technical Committee for Instrumentation and Future Technology in the Geoscience and Remote Sensing Society.

Michel Doucet has been actively involved in optical design and optics since 1991. He has participated in the design of many optical systems for Military, Security, Medical, Aerospace, Industrial, Telecommunication and Environmental Applications at INO. M. Doucet holds a Master degree in Optics from Laval University and a Bachelor degree in Physics from Université du Québec à Chicoutimi. He is currently a senior optical designer at INO.

Pascal Bourqui has been actively involved since 1997 in computer vision and system engineering. He has participated in the development of three generations of optical computing platforms and many R&D projects at INO. M. Bourqui holds a Master degree in Telecommunication from INRS-Telecommunication (Montreal, Canada) and a Bachelor degree in Electrical Engineering from Laval University (Quebec City, Canada). He is currently the leader of the Computer Vision Group at INO.

Mathieu Legros has been actively involved in optomechanical design since 2008. He has participated in the development of many optical systems for Military, Security, Aerospace, Industrial, Telecommunication and Environmental Applications at INO. M. Legros hold a Bachelor degree in Mechanical Engineering from Laval University. He is currently an optomechanical designer for the optomechanical department of INO, Québec City, Canada.

Nichola Desnoyers has been actively involved in optomechanical design since 1995. He has participated in the development of more than fifty optical systems for Military, Security, Medical, Aerospace, Industrial, Telecommunication and Environmental Applications at INO. M. Desnoyers holds a Master degree in Optomechanical Engineering and a Bachelor degree in Mechanical Engineering from Laval University. He is currently the leader of the Optomechanical Group at INO.

Ludovic Guillot has been involved in several project management roles both in R&D and manufacturing. He has been involved as a project manager in several Military, Security and Aerospace Applications at INO. Mr. Guillot holds a Bachelor degree in Mechanical Engineering from Laval University.

Luc Mercier has been actively involved in electronics design since 1999. He has participated in the development of more than twenty systems for Military, Security, Telecommunication and Industrial Applications at INO. Mr. Mercier holds a Bachelor degree in Electrical Engineering from Université de Sherbrooke. He is currently a researcher of the Optoelectronics Group at INO.

Maxime Savard has been actively involved in optomechanical design since 1997. He has participated in the development, assembly and alignment of hundreds of optical systems for Defense, Security, Aerospace, Industrial, Telecommunication, and Environmental Applications at INO. M. Savard holds a D.E.C in optics from Cegep De La Pocatiere. He is currently a senior technologist in the optical design group.

Anne Martel specializes in highly complex optical systems and has been involved in the development several optical systems for defense, civilian and space applications. She is currently with INO, Québec city, Canada, where she has been actively involved in optical design as a technologist since 2000.

François Châteauneuf has been involved in the development of optical payloads for space applications for the past 13 years. Among others, he was part of the development

Interactive Session Prize Paper Award recipients Alain Bergeron (second from left), Linda Marchese, and Martin Suess with GRSS President Jon Benediktsson (left) and Publications Awards Chair Martti Hallikainen (right).

team of the Cross-track Infrared Sounder flying on NPEOSS, the Atmospheric Chemistry Experiment Fourier Transform Spectrometer flying on SciSat-1 and the New Infrared Sensor Technology flying on SAC-D/Aquarius. Dr. Châteauneuf holds a Ph.D. in Chemistry from Laval University and a D.Sc. in Chemical Physics from Université Paris-Sud. He is now the Manager of the Environment program at INO.

7. Student Prize Paper Awards

A total of three prizes were presented including two **GRSS Student Prize Paper Awards** (third and second prize) and, for the fourth time, the **IEEE Mikio Takagi Student Prize** (first prize).

7.1. GRSS Student Prize Paper Awards

The GRSS **Student Prize Paper Award** was established to recognize the best student papers presented at the IEEE International Geoscience and Remote Sensing Symposium (IGARSS). It is believed that early recognition of an outstanding paper will encourage the student to strive for greater and continued contributions to the Geoscience and Remote Sensing profession. The award shall be considered annually.

Ten high-quality papers were preselected by the Student Prize Paper Awards Committee in cooperation with the Technical Program Committee. At IGARSS 2012 in Munich the students presented their papers in a special session and a jury, nominated by the GRSS Awards Co-Chair, evaluated and ranked them for the awards.

The Third Prize was presented to **Hongkun Li** with the citation:

*For the paper "**Sea Surface Infrared Emissivity with Surface Reflection.**"*

His advisor is Christophe Bourlier from the University of Nantes.

Hongkun Li was born in Guangdong, China, on July 21, 1984. He received the Master degree in Electronics from the University of Nantes in France in 2009, and is now a Ph.D student (third year) in the IETR (Institut d'Électronique et de Télécommunications de Rennes) Laboratory, University of Nantes, Nantes, France. He is now working on problems of emission and reflection from rough sea surfaces in the infrared band.

The *Second Student Prize Paper Award* was presented to **Emma Izquierdo-Verdiguier** with the citation:

*For the paper **"Semisupervised Nonlinear Feature Extraction for Image Classification."***

Her advisor is Gustavo Camps-Valls_from University of Valencia.

Emma Izquierdo-Verdiguier (S'12) received the B.Sc. degree in physics and the M.Sc. degree in remote sensing from the University of Valencia, Valencia, Spain, where she is currently working toward the Ph.D. degree with the Image Processing Laboratory. Her research interests are nonlinear feature extraction based on graphs and kernel methods. Previously she worked on automatic identification and classification of multispectral images.

7.2. 2012 IEEE Mikio Takagi Student Prize

The **IEEE Mikio Takagi Student Prize** was established in 2006. It is to recognize a student who has presented an exceptional paper at the IEEE Geoscience and Remote Sensing Symposium (IGARSS).

Student Prize Paper Award recipients Umamahesh Srinivas (second from left),Emma Izquierdo-Verdiguier, and Hongkun Li with GRSS President Jon Benediktsson (left) and Publications Awards Chair Martti Hallikainen (right).

The 2012 IEEE Mikio Takagi Student Prize was presented to ***Umamahesh Srinivas*** with the citation:

*For the paper **"Discriminative Graphical Models for Sparsity-Based Hyperspectral Target Detection."***

His advisor is Vishal Monga from Pennsylvania State University.

Umamahesh Srinivas (S'10) received the B.Tech degree in electronics and communication from National Institute of Technology Karnataka, Surathkal, India in 2007 and the M.S. degree in electrical engineering from The Pennsylvania

State University, University Park, PA in 2009. He is currently pursuing a Ph.D. in electrical engineering at Penn State. His research interests are broadly in statistical learning and computational color and imaging.

8. IEEE GRSS GOLD Award

The **GRSS GOLD Early Career Award** is to promote, recognize and support young scientists and engineers within the Geoscience and Remote Sensing Society that have demonstrated outstanding ability and promise for significant contributions in the future. Selection factors include quality, significance and impact of contributions, papers published in archival journals – papers presented at conferences and symposia, patents, demonstration of leadership, and advancement of profession. The candidate must be an IEEE GRSS Graduate of the Last Decade (GOLD) member (defined as any IEEE member within 10 years of their first professional degree) at the time of nomination and making contributions in a GRSS field of interest. Previous award winners are ineligible. The Award consists of a Certificate and an honorarium of US$ 1,500.

The 2012 GOLD Early Career Award was presented to ***Miguel O. Román*** with the citation:

In recognition of his outstanding ability and promise for significant contributions in the future.

Miguel O. Román received the B.S. degree in Electrical Engineering in 2004 from Universidad de Puerto Rico, Recinto Universitario de Mayagüez, Mayagüez, PR, the M.Eng. degree in Systems Engineering in 2005 from Cornell University, Ithaca, NY, and the Ph.D. degree in Geography in 2009 from Boston University, Boston MA. Miguel Román is a research physical scientist with the National Aeronautics and Space Administration (NASA). He is a member of NASA's Land Product Evaluation and Test Element (PEATE) team in charge of evaluating the operational Land algorithms that are being used for the Visible Infrared Imager Radiometer Suite (VIIRS) onboard the Suomi National Polar-Orbiting Partnership (NPP) satellite. Dr. Román has also taken the lead for the NASA Land Science community in developing plans and achieving consensus in the areas of global product validation and approaches for producing environmental data records to meet the needs of both the operational (NOAA) and science research (NASA) communities.

GOLD Early Career Award recipient Miguel O. Román (right) with GRSS President Jon Benediktsson.

Through his participation in several field campaign programs (FLUXNET, NACP, ARM-DoE, and BSRN) and intense observing periods (e.g., ChEAS'06, CLASIC'07, ARCTAS'08, ECO-3D'11), Román has used in-situ, airborne, and satellite data to understand the role of reflectance anisotropy (BRDF), scale, and spatial heterogeneity in the retrieval of terrestrial essential climate variables; especially under conditions of seasonal and rapid surface change.

His research and technical efforts as the Land scientist for NASA's Cloud Absorption Radiometer (CAR) and the BRDF, Albedo, Clouds and Aerosol Radiometer (BACAR) have led to new approaches for global intercomparison of moderate-resolution land science products and the development of new algorithms for the study of the land surface in the context of Climate and Global Change Research. He serves as a reviewer for IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Transactions on Geoscience and Remote Sensing, IEEE Transactions on Automation Science and Engineering, Remote Sensing of Environment, Journal of Applied Meteorology and Climatology, and Journal of Hydrometeorology. He is the recipient of several prestigious awards including the NASA Early Career Achievement Medal (2012).

9. Chapter Excellence Award

The GRSS established the **Chapter Excellence Award** to recognize excellence in a GRSS or Joint Local Chapter demonstrated by exemplary local GRSS activities during the previous year. The award shall be considered annually and presented only when a deserving Chapter is identified. The selection criteria are quantity, quality, breadth and significance of activities and technical meetings during the previous calendar year, active participation of members in IGARSS and other GRSS sponsored activities, and membership growth during the past 3 years. A Chapter that receives the GRSS Chapter Excellence Award is not eligible to receive it again within the next 3 years. The Award consists of a Certificate and an honorarium of $1,000 to be used only for Chapter activities.

The 2012 Chapter Excellence Award was presented to **the Western New York Chapter** with the citation:

Jan van Aardt (right) received the Chapter Excellence Award from GRSS President Jon Benediktsson.

For excellence as a GRSS Chapter demonstrated by exemplary activities during 2011.

The Chair of the Western New York Chapter is Jan van Aardt.

10. Certificates of Recognition

Certificates of Recognition are presented to persons, who have provided continuous contributions and leadership to the GRSS Administrative Committee and the GRS Society.

Two Certificates of Recognition were presented at GRSS Administrative Committee's Dinner on July 22.

A Certificate of Recognition was presented to **Karen St. Germain** with the citation:

For her service to the Geoscience and Remote Sensing Society as an elected Member of AdCom for the period 1997 to 2011.

Recipient of the Certificate of Recognition Karen St. Germain.

Recipient of the Certificate of Recognition Motoyuki Sato.

A Certificate of Recognition was presented to ***Motoyuki Sato*** with the citation:

For his service to the Geoscience and Remote Sensing Society as the General Chair of IGARSS 2011.

11. Congratulations to All 2012 Award Recipients

The GRSS Awards Committee would like to thank the evaluators of IGARSS'12 technical sessions and the Editorial Boards of IEEE Transactions on Geoscience and Remote Sensing, IEEE Geoscience and Remote Sensing Letters, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, and the GRSS Student Prize Paper Awards Committee for their valuable inputs to the awards process. We would also like to encourage all GRSS members to actively participate in nominating the GRSS Major Awards including the Distinguished Achievement Award, the Outstanding Service Award and the Education Award. GRSS members can nominate papers also for journal awards. Please see instructions on the GRSS Home Page.

12. Best Wishes for a Successful IGARSS 2013

The General Co-Chairs of IGARSS 2012 Alberto Moreira and Yves-Louis Desnos turned over the responsibility for the IEEE International Geoscience and Remote Sensing Symposium to IGARSS 2013 General Co-Chairs Peter Woodgate and Simon Jones, with their best wishes for a successful symposium in Melbourne, Australia, July 21–26, 2013.

We hope to see you in Melbourne at IGARSS 2013!

IGARSS'13 organizers Peter Woodgate (left), Simon Jones, and Mark Williams received the best wishes for a successful symposium from IGARSS'12 organizers Yves-Louis Desnos, Helmut Rott, Irena Hajnsek, and Alberto Moreira.

REPORT ON THE THIRD INTERNATIONAL POLARIMETRIC SAR WORKSHOP IN NIIGATA 2012 (AUG. 23–AUG. 26)

The third international polarimetric synthetic aperture radar workshop in Niigata 2012 was successfully held in Niigata University Satellite Office on August 23–25, and Scientific excursion to Sado Island on August 26, 2012. This workshop is organized by Yoshio Yamaguchi and Sang Eun Park of Niigata University under "Space Sensing Project" funded by the Ministry of Education, Japan, Niigata University, and IEEE GRSS Japan Chapter. The technical co-sponsorship were given by the Commission F of the International Union of Radio Science in Japan (URSI-F), as well as the technical group on Space, Aeronautical and Navigational Electronics of the Institute of Electronics Information, Communication Engineers (IEICE-SANE).

The aim of the workshop is to introduce the cutting-edge technologies and to exchange new ideas and methodologies for promoting researches on polarimetric radar remote sensing and their applications. It covers from the basic theory of polarimetry to its practical applications. In this respect, internationally celebrated scholars with long experiences in this field are invited as guest speakers. The workshop was carried out in a relaxed atmosphere, which brought very fruitful discussions among participants (more than 50). This workshop started in 2010 for the first time and continued to be held in 2011, and in 2012 under the "Space Sensing Project". The attendants in this third workshop 2012 are displayed in the photo.

Invited speakers:

- Prof. Wolfgang-Martin Boerner (University of Illinois at Chicago, USA, IEEE Life Fellow)
- Dr. Jong-Sen Lee (Naval Research Laboratory, USA, IEEE Life Fellow)
- Dr. Thomas Ainsworth (Naval Research Laboratory, USA)
- Dr. Shane Cloude (AEL Consultants, Scotland, UK, IEEE Fellow)
- Prof. Eric Pottier (University of Rennes 1, France, IEEE Fellow)
- Prof. Laurent Ferro-Famil (University of Rennes 1, France)
- Dr. Kostas Papathanassiou (German Aerospace Centre, Germany)
- Dr. Jakob J. Van Zyl (Jet Propulsion Laboratory, USA, IEEE Fellow)
- Dr. Yunjin Kim (Jet Propulsion Laboratory, USA)
- Dr. Scott Hensley (Jet Propulsion Laboratory, USA)
- Prof. Kun-Shan Chen (National Central University, Taiwan, IEEE Fellow)
- Dr. Bryan Chih-yuan Chu (National Central University, Taiwan)
- Prof. Wooil Moon (University of Manitoba, Canada, IEEE Life Fellow)
- Dr. Ridha Touzi (Canadian Center of Remote Sensing, Canada)
- Prof. Carlos López-Martínez (Universitat Politècnica de Catalunya, Spain)
- Prof. Bin Zou (Harbin Institute of Technology, China)
- Dr. Haipeng Wang (Fudan University, China)
- Dr. Shiv Mohan (Indian Space Research Organization, India)
- Prof. Dhamendra Singh (Indian Institute of Technology Roorkee, India)
- Prof. Y.S. Rao (Indian Institute of Technology Bombay, India)
- Dr. Masanobu Shimada (Japan Aerospace Exploration Agency, Japan, IEEE Fellow)
- Dr. Makoto Satake (NiCT, Japan)
- Prof. Motoyuki Sato (Tohoku University, Japan)
- Prof. Akira Hirose (The University of Tokyo, Japan)
- Dr. Motofumi Arii (Mitsubishi Space Software, Japan)
- Prof. Josaphat Tetuko Sri Sumantyo (Chiba University, Japan)
- Prof. Akira Kato (Chiba University, Japan)
- Dr. Ram (JAMSTEC, Japan)
- Prof. Ryoichi Sato (Niigata University, Japan)
- Dr. Gulab Singh (Niigata University, Japan)
- Dr. Yi Cui (Niigata University, Japan)
- Prof. Sang-Eun Park (Niigata University, Japan)

The number of attendants: 50+

MEGHA-TROPIQUES MISSION FOR CLIMATE AND ATMOSPHERIC APPLICATIONS

G. Raju, Project Director, Megha-Tropiques, ISRO Satellite Centre, Bangalore
S. K. Shivakumar, Director, ISRO Satellite Centre, Bangalore

Megha-Tropiques is a joint Indo-French (ISRO-CNES) collaboration of developing a satellite for the studies of the tropical atmosphere for climate and atmospheric research and meteorological applications. The Megha-Tropiques spacecraft was successfully launched on 12 October 2011 from ISRO's Satish Dhawan Space Centre (SDSC), Sriharikota. The data products are being made available to all the registered users including the Indian and French scientists and the International Announcement of Opportunity Principal Investigators (AO-PI's). Preliminary studies show that the science instruments have already demonstrated their remarkable capability in atmospheric studies.

1. Introduction

The tropical belt receives more energy from Sun than it radiates back into space. The excess energy is transported to temperate regions by the motion of atmosphere and oceans. Any variation in the energy budget of the tropics will therefore affect the whole planet. The energy exchanges are strongly linked to the water cycle and particularly to the tropical convective systems: huge amounts of latent heat are released in the tropical rains, while high humidity and thick clouds strongly affect the radiation budget.

Many interactions between radiation, water vapor, clouds, precipitation and atmospheric motion determine the life cycle of convective cloud systems, and the occurrence of extreme events such as tropical cyclones, monsoons, floods and droughts. Due to the dynamic nature of these parameters, the frequency of observations from low orbiting sun-synchronous orbits is inadequate. Only geo-stationary satellites allow continuous monitoring of the tropics, but their Vis-IR sensors give limited information on the cloud surface properties or horizontal distribution of water vapor. Low orbiting (<1000 km) satellites with low inclinations provide high repetitivity. An inclination at 20° provides 6 observations of each point on the Inter-Tropical Convergence Zone (ITCZ). The most energetic tropical systems, such as the cloud clusters of the ITCZ, the monsoon systems and the tropical cyclones, extend over hundreds of kilometers and hence a trade-off between large swaths and acceptable spatial resolutions is important.

Megha-Tropiques is a joint Indo-French (ISRO-CNES) mission for atmospheric applications and climate research. The major mission objectives are focused on global coverage of tropical regions with high spatial and temporal sampling. The mission goals address measurement of a large number of ocean and atmospheric parameters. Their realisation has demanded state-of-the-art technology in passive microwave and millimeterwave radiometry.

Megha in Sanskrit is 'cloud' and Tropiques in French is 'tropics'. The Megha-Tropiques Mission is intended for studying the water cycle and energy exchanges in the tropics using a satellite platform. The French Space Agency, CNES, has offered two entire payloads, viz., SAPHIR (Sounder for Atmospheric Profiling of Humidity in the Inter-tropical Regions), a millimeterwave humidity sounder, and SCARAB (Scanner for radiation budget) and also the RF front-end of another major payload, MADRAS (Microwave Analysis & Detection of Rain & Atmospheric Structures). Both ISRO and CNES have the joint responsibility of developing MADRAS. The fourth payload, ROSA (radio occultation sounder for atmosphere), which is a GPS occultation sensor for atmospheric studies, is procured by ISRO.

The satellite and payloads were integrated and tested at the ISRO Satellite Centre, Bangalore. It was successfully

Figure 1. Payload Instruments Module (PIM)

launched on 12 October 2011, from SDSC-SHAR, into an inclined orbit of 20 degrees to an altitude of 867 km to achieve a high repetitivity of up to 6 times a day, at certain latitudes. The spacecraft control and the science data reception are implemented from ISTRAC, Bangalore. In order to enhance the near-real-time (NRT) capability, the CNES ground stations at Kourou and HBK (South Africa) are also used to receive science data from orbits not visible from ISTRAC, Bangalore. The data is being shared between the two agencies.

At present, all the payloads are in the final stages of on-orbit characterisation and calibration/validation. Most of the science data products have been released operationally, in a progressive manner, to the Indian and French scientists and also to the registered national and international principal investigators. After complete validation, the data will also be available to the general science community.

A large number of national institutions, agencies and academic centers have shown interest and are now involved in the use of the science data for applications in weather forecasting as well as climate research. Global missions such as the US-Japanese global precipitation mission (GPM), the European EUMETSAT as well as many countries and agencies who have expressed interest in receiving the Megha-Tropiques data will be provided science data according to mutual agreements and ISRO-CNES data policy.

2. Science Objectives

The Megha-Tropiques mission focuses measurement and monitoring of the dynamic activities of the tropical atmosphere. The major parameters of interest are: cloud condensed water content, cloud ice content, convective-stratiform cloud discrimination, rain rate, latent heat release, integrated water vapor content, profile of water vapor content, radiation fluxes at the top of the atmosphere, sea surface wind, and profile of the atmospheric temperature. These are complemented and supplemented by data from other missions. Some of the parameters that will be synergistically used during the scientific studies using the Megha-Tropiques data are: cloud cover, cloud top height, cloud albedo, sea surface temperature, sea surface evaporation fluxes, temperature profile, 3-D wind field, and so on.

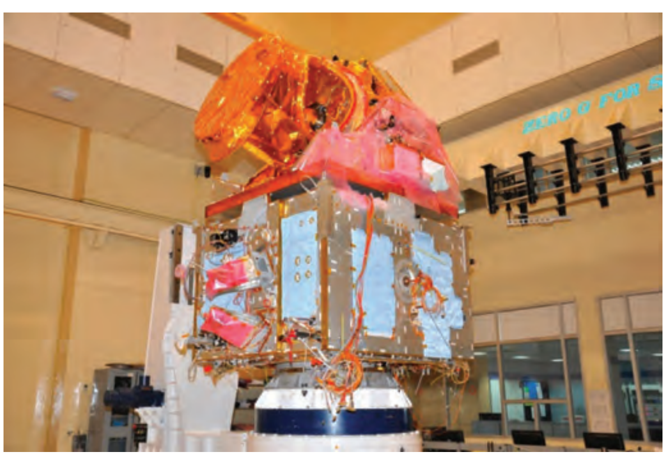


Figure 2. MEGHA-TROPIQUES in Clean Room

Scientific studies will be conducted both individually as well as jointly using the Megha-Tropiques data. The data will be shared between India and France and will also be available for other agencies based on a Data Policy agreed between ISRO and CNES.

One of the important operational features of the Megha-Tropiques satellite is that the payloads do not need sun illumination for their operation and are hence switched 'ON' throughout the orbit. Therefore the spacecraft and the payloads continuously require power configuration and management to support all the bus systems and the payloads throughout the orbit.

3. Spacecraft Configuration

The Megha-Tropiques spacecraft is configured using IRS platform and subsystems with proven heritage. The spacecraft structure has two separate modules viz. the main platform (MPL) and the payload instruments module (PIM).

The payloads are accommodated on a separate structure, the payload instruments module. Three of the payloads, viz., MADRAS, SAPHIR and SCARAB are accommodated entirely on PIM whereas the fourth payload, the ROSA instrument is accommodated on the platform itself.

The major technical features of the spacecraft are highlighted in Table.1. The platform consists of all the spacecraft subsystems such as: the power system, attitude and orbit control system, RF communication, including telecommand, telemetry systems and the satellite positioning system (SPS), the bus management unit (BMU), the data handling system (DHS), including the baseband and data handling (BDH) subsystem and the solid state recorder (SSR), three deployment mechanisms, the sensors, the reaction control system (RCS) and thermal control system. Most of the subsystems are of well-proven heritage derived from other ISRO missions. A few are new developments which are specifically developed and qualified for the Megha-Tropiques mission. Similar philosophy is generally followed for the CNES-delivered units as well as the ROSA payload that was procured commercially.

4. Payload Instruments Module (PIM)

The Payload Instruments Module is configured to accommodate the different payloads as well as the supporting electronics. It also meets the requirements and constraints of the IRS platform as well as the payloads. PIM structure is formed out of an assembly of composite sandwich flat panels connected by composite corner angles. The structure consists of: a horizontal deck, which incorporates the interface to the main bus; the back vertical deck that supports the MARFEQ (MADRAS RF Equipment) -A/MSM (MADRAS scan Mechanism)/ MARFEQ-B assembly during in-orbit condition; mechanism

Table 1. Main features of the Megha-Tropiques spacecraft	
Spacecraft Bus	I 1.5K-class
Spacecraft mass	1000 kg
Orbit	867 km
Control System	3-axis stabilized, with 4 reaction wheels, gyros and star sensors with hydrazine-based RCS (reaction control system)
Power	Two symmetrical solar array wings on both sides of the spacecraft High-efficiency multi-junction solar cells Two 24-AH Ni-Cd batteries 1325 Watts at end-of-life Bus voltage: 28–42 V
Thermal	Passive thermal control system
On-board data storage	16 GB capacity
TTC	S-Band
Pointing accuracy	+/– 0.05º (3-sigma)
Mission Life	Design life: 5 years
Inclination	20 degrees
Launcher	PSLV–C18
Date of launch	12 October 2011

deck, housing the hold-down & release mechanism, which helps in supporting the above assembly during launch.

5. Payloads

5.1. Madras

The MADRAS payload is a five-frequency, nine-channel, self-calibrating, imaging microwave radiometer system. The radiometer is designed to estimate atmospheric water parameters in the equatorial belt. The radiometers are of mechanically scanning type at a constant look angle of about 51 degrees (forward-looking). In each scan the radiometer is absolutely calibrated by observing into an accurate blackbody target maintained at the spacecraft ambient temperature and also towards the cold cosmic microwave background of 3 K. The choice of the channels has been driven by their potential contribution to the measurement of the parameters and also from the experience of processing and utilizing other radiometer data. Channels of MADRAS and their related mission objectives are summarised in Table. 2

5.2. Saphir

The main characteristics of the SAPHIR instrument are summarised in Table 3. The radiometer brightness temperature is 3 K to 320 K. The swath is about 1700 km. The Spatial resolution requirements of the SAPHIR have been defined as 10 km. The pixel size, defined through the scan mechanism and the beam characteristics, are consistent with this 10-km requirement. SAPHIR's 6 channels (at 183.31 GHz) are designated S1, S2, S3, S4, S5 and S6. The terms are defined in Table 3.

5.3. Scarab

The aim of this kind of instrument is to measure radiation fluxes, in the so-called shortwave (up to 4 μm) and longwave (above 4 μm) domains at the top of the atmosphere. The main characteristics of the ScaRaB channels are given in Table 4. The main

Table 2. Channels of MADRAS and their related mission objectives

Frequency	Channels	Polarisation	Pixel size	Parameter
18.7 GHz	M1-H, M1-V	H+V	≤40 km	Rain above oceans
23.8 GHz	M2-V	V	≤40 km	Integrated water vapor
36.5 GHz	M3-H, M3-V	H+V	≤40 km	Liquid water in clouds, rain above sea
89 GHz	M4-H, M4-V	H+V	≤10 km	Convective rain areas over land and sea
157 GHz	M5-H, M5-V	H+V	≤6 km	Ice at cloud tops

Table 3. Characteristics of the SAPHIR				
Channels	Central Nominal Frequencies (GHz)	Nominal Bandwidth (MHz)	ΔT (Sensitivity) Requirement	Polarisation
S1	183.31 ± 0.2	200	2 K	Linear
S2	183.31 ± 1.1	350	1.5 K	Linear
S3	183.31 ± 2.8	500	1.5 K	Linear
S4	183.31 ± 4.2	700	1.3 K	Linear
S5	183.31 ± 6.8	1200	1.3 K	Linear
S6	183.31 ± 11	2000	1.0 K	Linear

Table 4. Radiometric characteristics of the ScaRaB channels			
Channel	Wavelength	Signal dynamics	Noise (Crest)
Sc1 – Visible	0.5 to 0.7 μm	120 $W \cdot m^2 \cdot sr^{-1}$	<1 $W \cdot m^2 \cdot sr^{-1}$
Sc2 – Solar	0.2 to 4 μm	425 $W \cdot m^2 \cdot sr^{-1}$	<0.5 $W \cdot m^2 \cdot sr^{-1}$
Sc3 – Total	0.2 to 200 μm	500 $W \cdot m^2 \cdot sr^{-1}$	<0.5 $W \cdot m^2 \cdot sr^{-1}$
Sc4 – IR Window	10.5 to 12.5 μm	30 $W \cdot m^2 \cdot sr^{-1}$	<0.5 $W \cdot m^2 \cdot sr^{-1}$

channels are channels Sc2 and Sc3. The long-wave irradiance is deduced from the difference between Sc3 and Sc2 measurements. Channels Sc1 and Sc4 are used for scene identification (surface, clouds, partially covered) and for assuring compatibility and comparisons with the imagery of operational satellites.

5.4. GPS – ROSA (Radio Occultation Sounder for Atmosphere)

The Radio Occultation Sounder for Atmosphere (ROSA) is the fourth instrument to supplement/ complement data from other three instruments. Using its multireceiver configuration at L1 and L2 frequencies, it provides fine vertical resolution of about a km and coarser horizontal resolution of about 300 km. ROSA primarily measures vertical profiles of temperature and humidity. Ionosphere data can be derived as an additional science product. Using the existing GPS satellites and with both fore and aft antennas of the instrument, more than 350 occultations on an average per day have been recorded so far. The data would also complement SAPHIR humidity measurements.

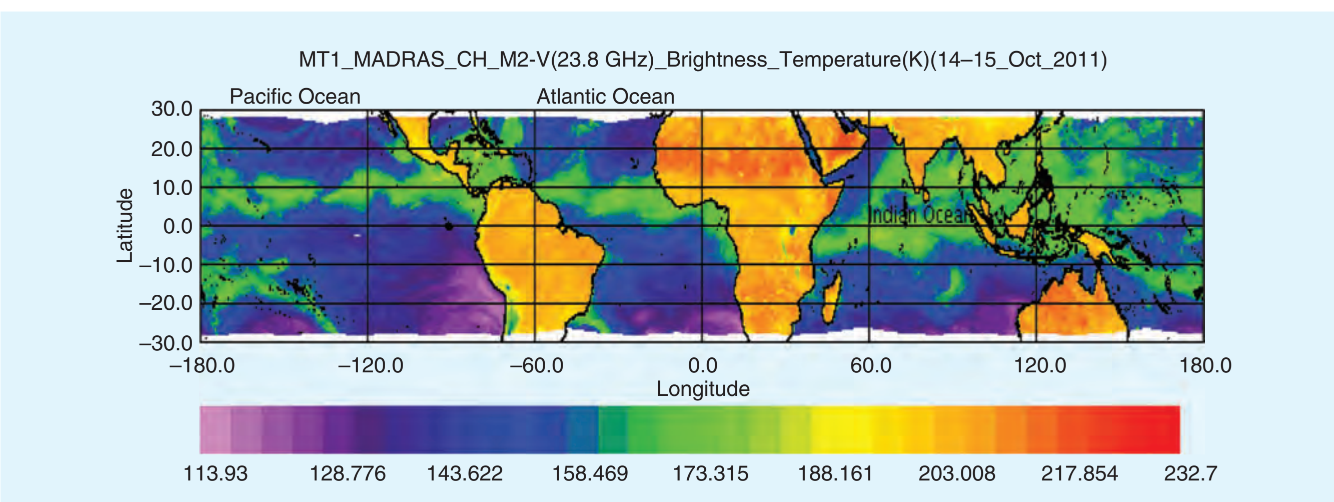


Figure 3. Representation of the 22 GHz channel data of MADRAS sensitive to atmospheric water vapor. The green coded band describes the concentration of water vapor in the inter-tropical convergence zone (ITCZ) (Product by DP Team, SAC)

5.5. Ground Station and Data Processing

The ground segment of Megha-Tropiques performs various functions, such as: telemetry, telecommand and communication, science data reception, and data processing. ISTRAC TTC network stations that are connected to the existing Spacecraft Control Centre (SCC) at Bangalore will provide the spacecraft control services in all the phases of the mission.

The global science data is downloaded by an S-Band carrier, at a data rate of 5.2 Mbps. This science data is being continuously collected over Bangalore ground station as well as the CNES ground stations at Kourou, South America and alternatively at HBK, South Africa.The science data thus received is subsequently sent to data processing center at the ISRO Satellite Science Data Centre (ISSDC) for further processing. ISSDC is the prime centre from where data will be sent to the French Data Centre, ICARE and ISRO's Meteorology and Oceanography Satellite Data Centre (MOSDAC) at Ahmedabad.

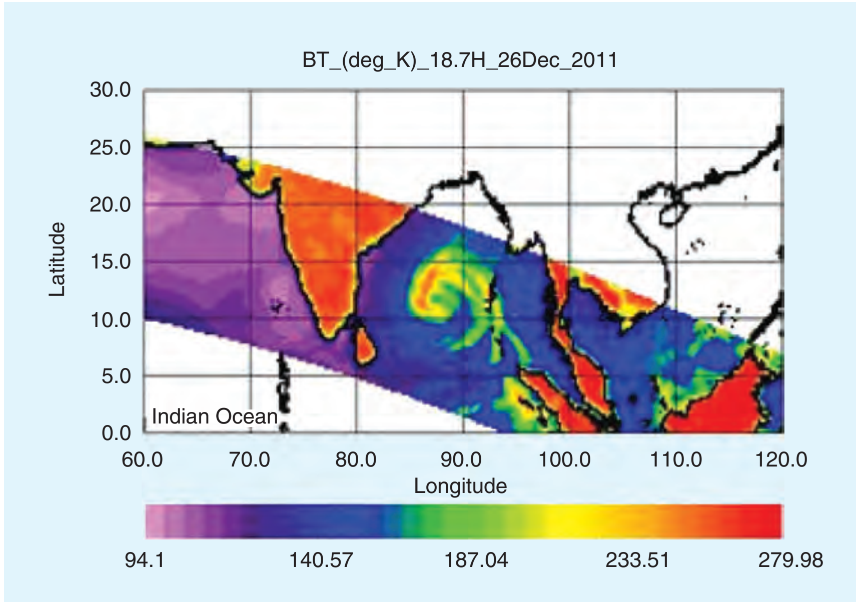


Figure 4. MADRAS 18.7 GHz Depiction of Thane cyclone in the Bay of Bengal (Generated by DP Team, SAC)

5.6. Data Products

As per the standard definition and scientific requirement, several levels of science data are generated. ***Level 0 products*** refer to the raw sensor and calibration data, the orbit/attitude data, the telemetry and housekeeping data which will be archived routinely for further analysis and evaluated for data quality etc. during the initial validation phase. ***Level 1 Products*** refer to the brightness temperature / radiance data sets which are available as routine products to users after the completion of the validation exercises lasting about several months after launch of satellite and will be validated for the performance of each of the payloads. ***Level 2 and above*** correspond to derived geo-physical parameters and any special products as may be required.

5.7. Preliminary Results

The science data is being received primarily at the ground station at ISTRAC, Bangalore, for all the orbits visible from the Bangalore Station. The data from the orbits that are not visible from Bangalore are received at the CNES ground stations at Kourou in French Guyana, and HBK in South Africa. Thus the scientific requirement of getting data in near-real-time (NRT) is met and the turn-around-time is less than 3.5 Hours.

The spacecraft has successfully completed more than one year of on-orbit operations. Based on the preliminary analysis of the data, several significant features observed during the early stages of the on-orbit performance, are shown in the form of image products.

Acknowledgments

The entire project team spread across all the ISRO Centres and the ISRO Centres themselves and the ISRO Head Quarters have contributed in the definition, realization, launch, on-orbit control and operation of the spacecraft, subsequent data reception and processing and product generation. The authors are thankful to all of them. The authors also wish to acknowledge the support from CNES, in this mission.

TECHNICAL COMMITTEES CORNER

INTERNATIONAL SPACEBORNE IMAGING SPECTROSCOPY (ISIS) TECHNICAL COMMITTEE

Karl Staenz (Co-Chair), Alberta Terrestrial Imaging Centre, University of Lethbridge
Andreas Mueller (Co-Chair), German Aerospace Centre (DLR)
Alex Held (former Co-Chair), Commonwealth Scientific and Industrial Organization (CSIRO)
Uta Heiden, German Aerospace Centre (DLR)

1. Introduction

The International Spaceborne Imaging Spectroscopy (ISIS) Working Group was formed on November 16/17, 2007 in Hilo, Hawaii based on an initiative from Alex Held, CSIRO, by individuals (Figure 1) interested in the development of space-based imaging spectroscopy (hyperspectral) missions and their data utilization. In 2010, the ISIS Working Group was established as a Technical Committee of IEEE GRSS. The purpose of ISIS is as follows:

> *The ISIS TC provides a forum for technical and programmatic discussion and consultation among national space agencies, research institutions and other spaceborne imaging spectrometer data providers.*

The main goals of ISIS are listed below:

- Coordination among key space agencies to share information and establish data acquisition strategies involving a "virtual satellite constellation";
- Promote the need for more efficient data delivery to processing facilities (at key global centres or to in-country institutions);
- Support the establishment of common data analysis protocols and a small set of 'core products';
- Promote production of a small number of core public-good hyperspectral satellite data sets;
- Support coordinated vicarious calibration and product validation activities with linkages to the airborne remote sensing community; and
- Promote the need for robust, underpinning R&D programs for continuous improvement.

The key issues are as follows:

- High-volume Data Downlink – upgrades to current satellite stations from basic X-band to Dual-pol X-band or Ka- band;
- Mass-data management, archiving and pre-processing;
- On-board and vicarious calibration standards and key sites;
- Data standards for delivery to users; and
- Data processing and key derived product definitions and algorithms for routine use.

The TC membership currently consists mostly of agencies involved in the development of spaceborne imaging spectroscopy missions or those interested in the data utilization.

Figure 1. Founding members of the Imaging Spaceborne Imaging Spectroscopy (ISIS) Working Group, Hilo, Hawaii.

However, the membership is generally open to individuals interested in imaging spectroscopy and its application to today's challenges for better understanding the Earth system.

2. Activities

ISIS conducts regular meetings once a year at IGARSS and organizes sessions on topics relevant to spaceborne imaging spectroscopy missions, such as mission updates, sensor calibration and data management, at these symposia. The following list gives a broad overview of the TC's activities to reach its goals of improved coordination:

- Keep a 'watching brief' and sharing information among space agencies and users on status of current and proposed imaging spectroscopy (hyperspectral) satellite missions;
- Provide an open forum for dialogue at least once a year, among key space agencies, to establish data acquisition strategies involving a "virtual satellite constellation" philosophy;
- Raise awareness among agencies on the need for more efficient data delivery to processing facilities;
- Encourage data providers to make a small number of core hyperspectral satellite data sets publicly available for the development of algorithm and information products;
- Convene meetings to discuss common data analysis protocols and a small set of 'core products'; and
- Organize sessions on calibration and product validation activities.

So far, the focus of the ISIS TC was mostly on the mission status and strategies and to a lesser degree on data management issues, such as data policies, data delivery, and public data sets. Accordingly, a brief overview of current and future terrestrial space-based civilian imaging spectroscopy missions is given in the next section based on the ISIS session on 'Spaceborne Imaging Spectroscopy Missions: Updates, and Global Datasets and Products' held at IGARSS'12 in Munich, Germany.

3. Overview of Spaceborne Imaging Spectroscopy Missions

With the development of the imaging spectroscopy concept in the early 1980s by American and Canadian researchers, many spaceborne missions have been under study, such as NASA's High Resolution Imaging Spectrometer (HIRIS) [1], the Australian Resource Information and Environment Satellite (ARIES) [2], ESA's Process Research by an Imaging Space Mission (PRISM) and Surface Process and Ecosystem Changes Through Response Analysis (SPECTRA) [3] and the Canadian Space Agency's Hyperspectral Environment and Resource Observer (HERO) [4], to list just a few initiatives. However, only a few made it into space within the last decade. NASA and ESA sucessfully launched Hyperion on EO-1 and CHRIS on PROBA, respectively in 2000 and 2001 [5,6]. These were followed by the Chinese HJ-1A [7] and the Indian HySI on IMS-1[8] in 2008, respectively. A year later, NASA's/Office of Naval Research's (ONR's) Hyperspectral Imager for the Coastal Ocean (HICO) started operating from the International Space Station [9]. With the exception of HJ-1A and HICO, these systems were launched to demonstrate the hyperspectral technology and, therefore, have limited data acquisition capabilities. On the other hand, HICO has its own unique orbit (space station), which restricts imaging areas up to mid-latitudes (e.g., up to 53° north). The spectral and spatial characteristics of these missions, currently operating in space, are listed in Table 1. It can be seen that all these sensors cover the visible near-infrared (VNIR) portion of the electromagnetic spectrum with the exception of Hyperion, which in addition acquires data in the shortwave infrared (SWIR). The ground sampling distance (GSD) varies from 17 m (CHRIS) to 500 m (HySI), which also results in a variation of the swath width from 7.65 km (Hyperion) to 129.5 km (HySI). The spectral resolution of these sensors is $\leq$ 10 nm with the exception of CHRIS whose bands vary from 5.6 nm to 32.9 nm. The latter is capable to acquire image data from the same area on the ground under five different viewing angles (–55°, –36°, 0°, 36°, 55°), a unique feature which no other spaceborne imaging spectrometer exhibits.

Future missions under construction as shown in Table 1 include the Indian Geostationary Hyperspectral Imager Satellite (GISAT) [10], the Italian Hyperspectral Precursor of the Application Mission (PRISMA) [11], the Japanese Hyperspectral Imager SUIte (HISUI) [12], and the German Environmental Mapping and Analysis Program (EnMAP) [13]. The latter three missions are very similar to Hyperion with respect to the spatial and spectral characteristics with a 30-m GSD, 15–30 km swath width, approximately 10-nm spectral resolution, and VNIR and SWIR wavelength coverage. As the next generation of sensors operating in space from 2014/16 and beyond, they have an increased data acquisition capacity and provide data with a superior data quality compared to the technology demonstrators Hyperion and CHRIS. HSUI on ALOS-3 has in addition to the hyperspectral sensor a four-band multispectral instrument on board, while the PRISMA payload includes a panchromatic instrument. An additional sensor, a three-band thermal infrared (TIR) imager, is also included in GISAT, which provides with a 500-km swath width (1500 km for the TIR sensor) a synoptic coverage compared to the other targeting sensors currently under construction.

Several new spaceborne imaging spectroscopy initiatives are currently on various levels of planning stages by agencies in different countries, and only a selection of missions, the HYperSPectral Infra-Red Imager (HyspIRI) [14], HYPXIM-P [15], FLuorescence EXplorer (FLEX)[16], and Spaceborne Hyperspectral Applicative Land and Ocean Mission (SHALOM) [17], are listed in Table 1. One of the features of the HyspIRI mission, which is listed in the NASA Tier-2

Table 1. Spectral and spatial characteristics of missions currently in operation, under construction, and in a planning stage (GSD = ground sampling distance, FWHM = full-width half-maximum, Res. = resolution, VNIR = visible and near infra-red; SWIR = short-wave infra-red, NA = not available, TBD = to be determined).

Sensor	Organization (Country)	GSD (m)	Swath at Nadir (km)	Wavelength Coverage	Number of Bands	Spectral Res. (nm @ FWHM)	Launch Date
Hyperion	NASA (USA)	30	7.65	357–2576	242	10	2000
CHRIS	ESA (UK)	17/34	13 (nominal)	400–1050	6/18/37	5.6–32.9	2001
HJ-1A	CAST (China)	100	≥50	450–950	110–128	5	2008
HySI	ISRO (India)	506	129.5	400–950	64	~10	2008
HICO	NASA/ONR (USA)	90	42	353–1081	128	5.7	2009
GISAT	ISRO (India)	500	NA	NA	210	NA	≥2013
PRISMA	ASI (Italy)	30	30	400–2500	237	~12	2014/15
HISUI	METI (Japan)	30	15	400–2500	185	10 (VNIR) 12.5 (SWIR)	≥ 2015
EnMAP	DLR/GFZ (Germany)	30	30	420–2450	218	5/10 (VNIR) 10 SWIR	2016
FLORIS/ FLEX	ESA	300	100–150	500–780	NA	0.3–3.0	~2018
HYPXIM- P	CNES (France)	8	16	400–2500	>200	≤10	~2019
HyspIRI	NASA (USA)	60	145	380–2500	>200	10	~2020
SHALOM	ISA/ASI (Israel/Italy)	10	10	400–2500	200	10	TBD

Missions currently in operation, Missions under construction, Missions in a planning stage

Decadal Survey, is to provide global coverage. It also includes a thermal imager with eight bands located between 4 to 12 μm and a 60-m GSD resulting in a swath width of 600 km. A thermal instrument (8–12 μm) is also planned for the French HYPXIM-P together with a panchromatic camera (2-m GSD) in addition to the hyperspectral instrument. The Italian/Israeli SHALOM mission includes also a panchromatic camera with a 2.5-m GSD. Both, HYPXIM's and SHALOM's VNIR/SWIR imaging spectrometers have a 8-m and 10-m GSD, respectively, which are the best GSDs of all the listed hyperspectral instruments in Table 1. Another hyperspectral sensor in planning stage is the FLuORescence Imaging Spectrometer (FLORIS) on board ESA's FLEX mission. With its narrow spectral resolution (0.3 to 3.0 nm) in the 500-nm to 780-nm wavelength range, its main goal is to provide global data of chlorophyll fluorescence of vegetation canopies. Other future missions considered are EnMAP-2 and KOMPSAT-6.

There are now five terrestrial imaging spectroscopy missions in space as shown in Figure 2. These missions will be replaced in the 2015/16 time frame by several missions, such as GISAT, PRISMA, HSUI and EnMAP. Accordingly, there could be a virtual constellation of about four satellites within a three- to four-year time span. The number of satellites could even increase, especially if China, which has an active hyperspectral program, will launch its second imaging spectroscopy mission towards 2015/16. With about a five-year lifetime of the missions currently under construction, it is important that the missions, such as HyspIRI,

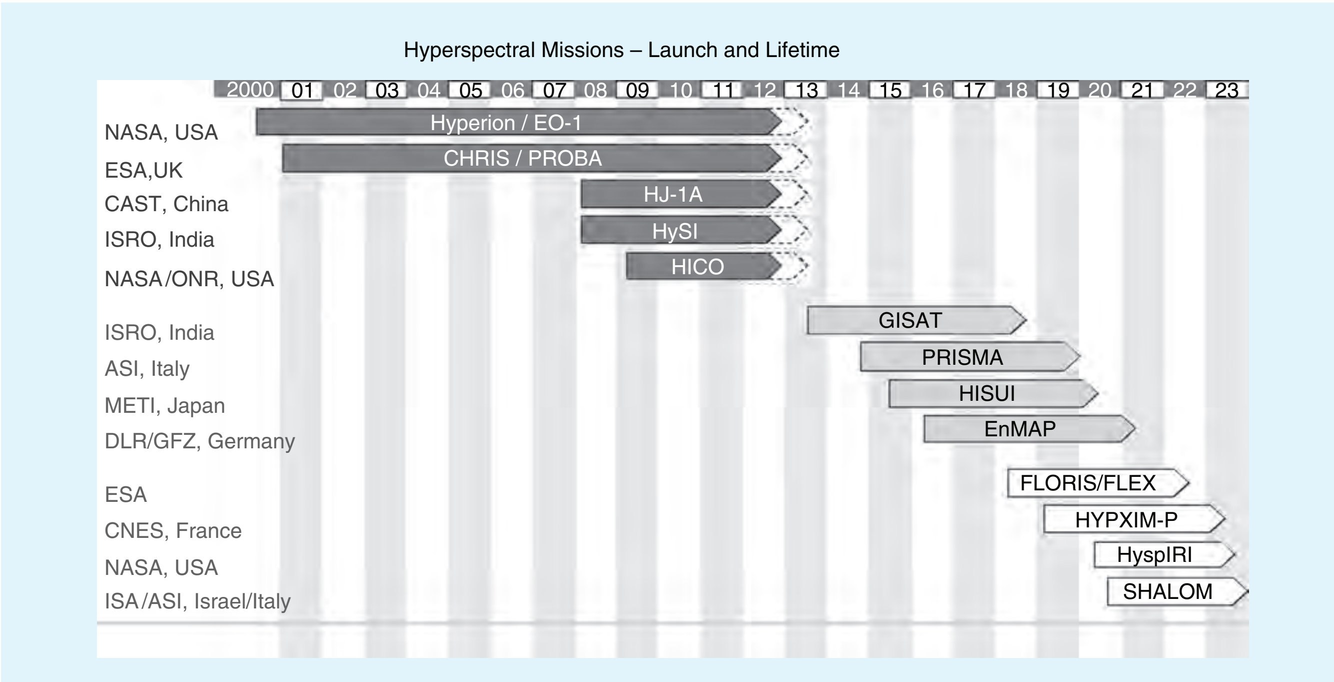


Figure 2. Spaceborne imaging spectroscopy mission launch dates and lifetimes (missions currently in operation, missions under construction, missions in a planning stage).

HYPXIM-P, SHALOM, FLEX, and EnMAP-2, currently in various levels of planning stages have to be realized in the future in order to guarantee hyperspectral data continuity in 2020 and beyond.

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(President's Message continued from page 7)

activities and promote a continued and sustained GRSS impact. Several new GRSS Chapters were formed in 2012, including chapters in Delhi, India; Guadalajara, Mexico; Kolkata, India; Malaysia; Benelux (joint chapter); and Central Illinois (joint chapter). Chapters are also currently being formed in Bengaluru, India; Singapore; and Indonesia. In addition, the society has worked on increasing activities in Africa, Asia and Latin America through its regional task forces. Several GRSS and AdCom members participated in the recent 9th African Association of Remote Sensing of the Environment (AARSE) conference in El Jadida, Moracco. GRSS Past President Tony Milne gave an invited plenary talk and spoke on the collaboration between AARSE and the GRSS, including our active partnership through an MOU. Tony encouraged increasing remote sensing work on the continent of Africa and invited conference guests to join the GRSS. Furthermore, former GRSS President Chuck Luther received an AARSE award for his remote sensing activities. I would like to take this opportunity to congratulate Chuck on this excellent award.

The new IEEE Fellows for 2013 have just been announced, and I am very happy to say that GRSS members did very well. The nominators and our GRSS Fellow Evaluation Committee, chaired by Leung Tsang, and GRSS Fellow Search Committee, chaired by Mahta Moghaddam, have done a wonderful job. I would like to congratulate the eleven new GRSS IEEE Fellows (Class of 2013): Maurice Borgeaud, Om-Prakash Calla, Mihai Datcu, Giles Foody, Paolo Gamba, Akira Hirose, Yann Kerr, Gerhard Krieger, Riccardo Lanari, Shunlin Liang, and Christian Pichot. Becoming IEEE Fellow is a most distinguished recognition.

This is my last message as GRSS President. It has been an honor to serve the society as President during the last two years. I have enjoyed greatly meeting and interacting with GRSS members during this time. I appreciate the continued support, dedication and hard work of the excellent GRSS AdCom. According to the GRSS tradition, the final AdCom meeting of my Presidency was held in my home town, Reykjavik, Iceland, in early November. I am sure AdCom members will remember this event because of the strong winds in the Reykjavik area on the dates of the meeting. As part of the meeting program, the AdCom and their guests had the pleasure of visiting the residency of President of Iceland, Dr. Olafur Ragnar Grimsson, who hosted a reception. President Grimsson has been active in promoting climate change awareness for more than a decade, and he gave a memorable 20-minute speech on the topic during the reception. After the speech President Grimsson enjoyed talking to his guests.

I am delighted to inform you that a new GRSS President, Melba Crawford, was elected at the Reykjavk AdCom. Melba will take over the presidency starting on Jan. 1, 2013, and I am sure she will do a terrific job. I wish her the best.

Best wishes for a happy holiday season and a wonderful 2013 to you and your families.

Jón Atli Benediktsson
2011–2012 President
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UNIVERSITY PROFILE

A DEEP LOOK INTO HYPERSPECTRAL IMAGES PROCESSING AT THE LIEMARS REMOTE SENSING RESEARCH GROUP IN CHINA

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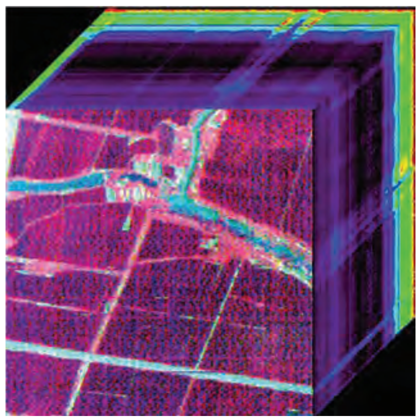
Liangpei Zhang LIEAMARS, Wuhan University, Wuhan, Hubei Province, China

1. Introduction

This paper introduces main work of LIESMARS (The state's key lab for information engineering on surveying, mapping, and remote sensing, China) remote sensing research group in hyperspectral image processing domain. Since the early years of spectral imaging in China, the group started its work on extracting information from hyperspectral remote sensing images. The major research field of the team is the detection of potential targets of interest and of anomaly targets from hyperspectral images. The group members have also dedicated their work to nearly every aspect in hyperspectral image processing: endmembers[1] extraction and spectral unmixing, classification, target/anomaly detection, and change detection.



Hyperspectral images by Chinese made push-broom sensor

2. Basic information about LIESMARS remote sensing research group

LIESMARS remote sensing research group is a large team led by Professor Liangpei Zhang. Prof. Zhang, guides his students into the fantastic hyperspectral world. Prof. Zhang was one of the earliest scientists on hyperspectral image processing in China. He started with hyperspectral remote sensing technique research around the year 1995, mainly on the information extraction in Poyanghu Lake, China. This lake is the largest freshwater lake in China, which is famous for its wetland and biological diversity. Long-term remote sensing observation on the area has been performed. However, the calibration of hyperspectral images is the foremost factor affecting the information extraction accuracy. Prof. Zhang did much work on hyperspectral calibration. He first proposed a nonlinear mixture model to solve the mixed pixel interpretation for the hyperspectral image processing in Poyang Lake. Prof. Zhang has extensively extended his work throughout the years to include image quality improvement, image super-resolution, hyperspectral image processing, and artificial intelligence in remote sensing images. Prof. Zhang has published over 260 academic papers, covering every aspect of extracting information from various remote sensing images.

Dr. Du is one of the leading researchers at both school of computer and LIESMARS, Wuhan University. He began his work in hyperspectral image processing around 2005, during his undergraduate years, when he recognized the existence of such fantastic images composed of so many spectral bands. For conventional images, such as JPEG, and TIFF, the foremost information is the spatial pattern where pixels from the same objects would comprise humongous areas. Pixels in each area present exactly the same grey value, so borders and edges are very important clues for obtaining distribution pattern. As spectral bands continue to increase, the additional spectral features can be used to separate sub-classes, such as water, soil and farmland. As the spectral resolution reaches a scale of only several nms, it becomes so fine that the corresponding spectrum will become virtually continuous. And it is indeed the first time that the spectrum provides an effective way to deepen into the internalphysically materially composition. What is amazing is that the different spectra are like the special representations for each sub-class object, even when the objects may be visually very alike. In the same way that molecular level study in chemistry reveals different molecular's structures, hyperspectral image provides typical and elaborate spectrum for each material so as to outperform traditional remote sensing images in depicting the ground objects.

During his Ph.D. years, Dr. Du focused his research on sub-pixel target detection and anomaly detection. He was influenced by the Ph.D. thesis titled "Detection and classification of subpixel spectral signatures in hyperspectral image

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[1]An **endmember** in mineralogy is a mineral that is at the extreme end of a mineral series in terms of purity.

sequences”[2]. He was encouraged to dig into the beam-forming filter theory as the proposed CEM is easy to understand and proves promising in detecting sub-pixel targets. For instance, in a scene covered with green fresh grass, it would be a very difficult task for visual-based detection methods to find tanks filled with green; however, by using a hyperspectral imaging sensor those tanks would be exposed to the observer given that a proper detection algorithm is used. Following the work published in IEEE T-PAMI, he did some work on combining the least squares based abundances estimation with the close-formed generalized likelihood ratio test based conventional detectors. He carried out some extension by further investigating the dynamic endmembers analysis in the background information of the images. This was the orientation of his first publication in IEEE TGRS[1]. After that, he looked into target detection without prior target spectrum, i.e. anomaly detection. Since the key of anomaly detection lies on the description and modeling of the background statistics, the background modeling manners were checked and combined with the global and local background statistics to obtain optimal background statistics for anomaly detector construction. This came out on his second publication in IEEE TGRS [2]. He was elected as the best reviewer of IEEE GRSS for his good work and service in the society.

Members of LIESMARS remote sensing group

3. Research fields in hyperspectral image processing

3.1. Target detection

Target detection refers to identification of the pixels containing probable objects of interest within an image. It is of great use in many applications, since only a few objects are usually of interest to be distinguished from the other backgrounds’ objects. For target detection from hyperspectral images, the focus is on determining the existence of the weak target signals in each pixel by use of the spectral information. It is also named sub-pixel target detection, due to the limited spatial resolution. Like most methods in hyperspectral image processing, linear mixture model (LMM) is the one most commonly used. Traditional ways exploit the LMM for sub-pixel analysis. One method employs the maximum likelihood ratio test to construct detectors. Both structured and unstructured background detectors are of this kind. Meanwhile, in LMM based spectral unmixing, least squares method is used to obtain the meaningful endmembers abundances. So combining these two types of methods can provide additional information taking advantage of both approaches. However, the group has done work beyond this. For each pixel under observation, their background information is different. In other words, different types of endmembers may be used in the formulation of detector in each pixel. By considering the different background endmembers, they proposed a hybrid detector based on selective endmembers. Extensive experiments have improved the improvement compared with traditional detection methods. The related work has been published in IEEE Transactions on Geoscience and Remote Sensing [1].

Another important issue in target detection for hyperspectral images is that LMM may not correspond to reality due to the multiple reflections in the objects’ surface. In this case, the data become nonlinear mixed. How to handle the

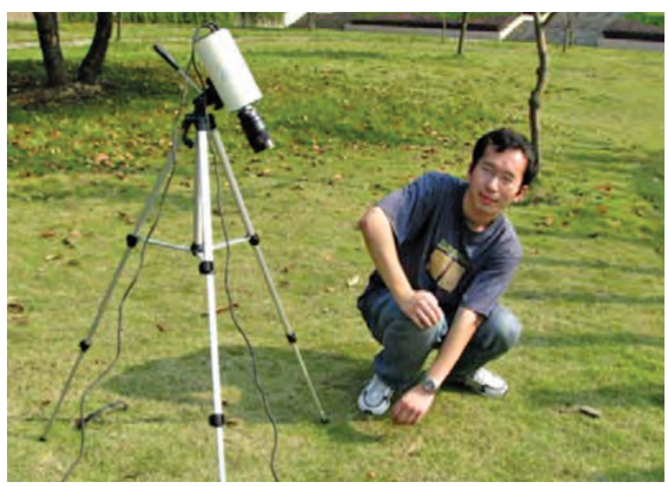

Figure 1. Obtaining near scene hyperspectral images by a CRI camera

[2]J.C. Harsanyi. Detection and classification of subpixel spectral signatures in hyperspectral image sequences. Ph.D. Dissertation, Department of Electrical Engineering, University of Maryland Baltimore County, Baltimore, MD, 1993.

Figure 2. Hyperspectral camera imaging system

detection problem from nonlinear mixed data is a challenge. Kernel learning has been introduced into target detection from hyperspectral images. However, one drawback is that current kernel target detection methods use no information to suppress the interference objects, which present the similar spectral signature with that of the target. So what they have done is to introduce a powerful beam-forming finite impulse response filter into kernel learning [3]. It is also actually a learning procedure by the non-linear dataset. They assume that in a proper projected feature space, the data fit LMM again, where both the target of interest and the interference signatures are both taken into consideration to construct the beam-forming filter. Then, by the kernel function the computation, it can be obtained in the original feature space. The corresponding paper has been submitted into the special issue of IEEE JSTARS [3].

3.2. Anomaly Detection

The major difference of anomaly detection with target detection is that anomaly detection needs no prior information about the targets. Its assumption is that those anomalies are those that deviate from the background statistics. So it is obvious that the key lies on the computation of background statistics. The benchmark RX algorithm used the background covariance to construct a Manhalanobis distance based anomaly measure. However, as no prior information about anomalies positions is known, the statistics of the whole data are used instead, resulting in a contaminated background statistics. Robust anomaly detection is thus proposed, aiming at getting most pure background statistics by iteration procedures, like blocked adaptive computationally efficientoutlier nominator (BACON), minimum volume ellipsoid (MVE), and so on. However, one drawback that cannot be avoided is that only global statistics are used, so that the anomalies in the localized areas may be missed. We have proposed a random sampling based robust anomaly detector. It selects several blocks of pixels from the image each time and obtains the corresponding detection. Then the selections and the following detections are done several times in order to consider the pixels from as more areas as possible. By the above procedure, both local and global statistics are taken into consideration. Finally, all the detection procedures' results are fused to enhance the final results. This interesting work has also published in IEEE Transactions on Geoscience and Remote Sensing[2].

3.3. Spectral unmixing

Spectral unmixing is a basic problem in hyperspectral image processing. The group members have done some work on this topic. Traditional approaches on spectral unmixing use some prior endmembers spectra. However, the prior information may be difficult to obtain. In this method, blind source separation (BSS) is introduced into spectral unmixing. The most famous one is Non-negative matrix factorization (NMF), which was introduced into the field of hyperspectral unmixing in the past decade. To overcome the non-convexity problem of NMF, some constraints are imposed to NMF, including spectra constraints and abundances constraints. We proposed a new constraint, termed *endmember dissimilarity constraint*. It aims at utilizing the spectral difference between different endmembers. Experimental performances of NMF with different types of constraints are compared and analyzed. The experimental results show that the proposed endmember dissimilarity constraint performs well even with high spectral variability and high noise level. The related paper has been reported in 2012 WHISPERS[4] and submitted to IEEE JSTARS. [5].

3.4. Classification

Hyperspectral classification is to label each pixel in the image to a particular land object kind by using spectral feature. Much research has been done on classification from hyperspectral images. How to use more powerful features for land objects classification is one research hot spot. Some people proposed novel methods combining spectral and spatial features, which have been proved very effective in classification. It is common that spectral and spatial features perform complementally in distinguishing different land objects. With recent progress in describing nonlinear data, manifold learning has been used in many fields. By considering the intrinsic structure in hyperspectral images, some research has revealed that the hyperspectral data is "locally linear and globally nonlinear", so that the manifold feature exists in hyperspectral images. Based on this point, we proposed a new semi-supervised dimension reduction (DR) algorithm based on a discriminative locally enhanced alignment technique. The proposed DR method has two goals: The distance between different classes is maximized according to the separability of pairwise samples; and, at the same time, the intrinsic geometric structure of the data is preserved by both labeled and unlabeled samples. Furthermore, two key problems determining the performance of semi-supervised methods are further discussed in this paper [6]. The first problem is the proper selection of the unlabeled sample set; the second is the accurate measurement of the similarity between the samples. In the proposed method, multi-level segmentation results are employed to solve the problems. Experiments with extensive hyperspectral image datasets show that the proposed algorithm is notably superior to other state-of-the-art dimensionality reduction methods for hyperspectral images classification. This work will be published in IEEE Transactions on Geoscience and Remote Sensing [6].

Besides, a new discriminative manifold learning based dimension reduction method for hyperspectral classification is also proposed. The purpose is to construct a more reasonable metric to enlarge the separability of different objects' pixels, learned from a wide scope of the image, not only from discriminative information but also the whole dataset's manifold. The corresponding work has been published in International Journal of Fuzzy System[7].

3.5. Change detection

Change detection is one of the earliest applications for remote sensing. With the development of hyperspectral technology, many researchers attempt to apply multi-temporal hyperspectral images for change detection. Recently, the method can be grouped into four classes: anomaly change detection, model-based change detection, image transformation and others. The group's contribution on change detection is a proposed subspace based change detection method. As the two correlated image datasets are mainly on the same scene, changes would be small. So the image in the early time would be employed to construct a background subspace while the image in the latter time would be used as the probable targets, and the detection measure by the targets deviated from the background subspace would be a direct clue to determine the probable changes. Besides, aiming at alleviating the errors caused by the geometry correlation, a spatial-based subspace change detection as well as an adaptive subspace-based change detection methods are proposed. Experiments proved their advantage of fully exploring the rich spectral information in hyperspectral images. The work would also be submitted to IEEE JSTARS. [8].

4. Conclusion

Remote sensing images have for a long time become a quick and large-scale observation approach. However, traditional remote sensing images just utilize limited spectra signal feature to depict the land surface objects. Hyperspectral images provide a new eye in observing the land surface changes. No other technique but HSI integrates the spectra and the spatial pattern so perfectly. What the group has done in hyperspectral image processing domain is not the whole story. In the future, the extending applications of hyperspectral images are their research interests, such as medical diagnosis and 3 D human face recognition. Besides, novel theories from machine learning, signal processing and computer vision will also be introduced in extracting information from hyperspectral images, for example, deep learning and active learning, and so on.

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By Shrestha, K. Y.; Carter, W. E.; Slatton, K. C.; Cossio, T. K.
Vol. 50, No. 11, Part 2, pp. 4771–4790
DOI: 10.1109/TGRS.2012.2192445
Link: http://dx.doi.org/10.1109/TGRS.2012.2192445

Detection of Radio-Frequency Interference Signal Over Land From FY-3B Microwave Radiation Imager (MWRI)
By Zou, X.; Zhao, J.; Weng, F.; Qin, Z.
Vol. 50, No. 12, pp. 4994–5003
DOI: 10.1109/TGRS.2012.2191792
Link: http://dx.doi.org/10.1109/TGRS.2012.2191792

IEEE Geoscience and Remote Sensing Letters

A Method to Rebuild Historical Satellite-Derived Soil Moisture Products Based on Retrievals from Current L-Band Satellite Missions
By Jinyang Du; Jiancheng Shi
Vol. 9, No. 5, pp. 910–914
DOI: 10.1109/LGRS.2012.2185922
Link: http://dx.doi.org/10.1109/LGRS.2012.2185922

PolSAR Mosaic Normalization for Improved Land-Cover Mapping
Antropov, O.; Rauste, Y.; Lonnqvist, A.; Hame, T.
Vol. 9, No. 6, pp. 1074–1078
DOI: 10.1109/LGRS.2012.2190263
Link: http://dx.doi.org/10.1109/LGRS.2012.2190263

CALL FOR PAPERS

IEEE Geoscience and Remote Sensing Magazine

Beginning in March 2013, GRSS will publish the new IEEE Geoscience and Remote Sensing Magazine, which was approved by the IEEE Technical Activities Board in 2012. This is an important achievement for GRSS since it has never had a publication in the magazine format. The magazine will provide a new venue to publish high quality technical articles that by their very nature do not find a home in journals requiring scientific innovation but that provide relevant information to scientists, engineers, end-users, and students who interact in different ways with the geoscience and remote sensing disciplines.

The magazine will publish tutorial papers and technical papers on geoscience and remote sensing topics, as well as papers that describe relevant applications of and projects based on topics addressed by our society.

The magazine will also publish columns on:

- New satellite missions
- Standard remote sensing data sets
- Education in remote sensing
- Women in geoscience and remote sensing
- Industrial profiles
- University profiles
- GRSS Technical Committee activities
- GRSS Chapter activities
- Conferences and workshops

The new magazine will be published in with an appealing layout, and its articles will be published in electronic format in the IEEE Xplore online archive. The Magazine content is freely available to GRSS members.

This call for papers is to encourage all readers to prepare and submit articles and technical content for review to be published in the IEEE Geoscience and Remote Sensing Magazine. Contributions to the above-mentioned columns of the magazine are also welcome.

All technical papers will undergo blind review by multiple reviewers. The submission and the review process will be managed on IEEE Manuscript Central, as is already done for the three GRSS journals. The review process will ensure high technical quality and/or high tutorial value of all articles.

The magazine will also publish special issues. Readers interested to propose a special issue can contact the Editor.

For any additional information and to submit papers, please contact the Editor:

Prof. Lorenzo Bruzzone
University of Trento,
Trento, Italy
E-Mail: lorenzo.bruzzone@ing.unitn.it
Phone: +39 0461 28 2056

IGARSS 2013

21-26 July 2013
MELBOURNE

INTERNATIONAL GEOSCIENCE AND REMOTE SENSING SYMPOSIUM

IEEE GRSS

Building a Sustainable Earth through Remote Sensing • 21-26 July 2013 • www.igarss2013.org

Welcome Message

On behalf of the IEEE Geoscience and Remote Sensing Society and the IGARSS 2013 Local Organising Committee, we are delighted to invite you to Melbourne, Australia for IGARSS 2013. We are looking forward to welcoming leading scientists, engineers and educators from the diverse disciplines that make up the Geoscience and Remote Sensing community. We also hope to attract new delegates from the Asia-Pacific and Oceania regions.

We will be offering a world class technical program encompassing traditional IGARSS topics and new topics reflecting the theme of the 2013 Conference, "Building a Sustainable Earth through Remote Sensing". This theme was selected to emphasize the issues that most affect the Earth's environment, and the human impact on the planet. We welcome both seasoned and new delegates to Melbourne in July 2013.

With best wishes

Peter Woodgate and Simon Jones, General Co-Chairs, IGARSS 2013

Themes

The Technical Program will include the following themes:

- Analysis Techniques and studies of Atmosphere, Cryosphere, Oceans and Land
- Sensors and Platforms
- Data Management, Dissemination Education and Policy
- Data Assimilation
- Emerging Space Programs
- Data Fusion and Integration
- In situ Observation and Data Scaling
- Advances in Analysis Techniques

In addition, the following special scientific themes will be addressed:

- Dynamics of Earth Processes and Climate Change
- Integrated Earth Observing Systems
- New Satellite Missions
- Remote Sensing in Carbon Accounting
- Disaster Management
- Calibration and Validation of Satellite Imagery

Key Dates	
Invited session proposal deadline	September 14 2012
Invited session notification	November 9 2012
Abstract submission system open	November 13 2012
Tutorial proposal deadline	November 30 2012
Abstract submission deadline	December 11 2012
Travel support application deadline	December 11 2012
Student competition full paper application deadline	December 11 2012
Abstract acceptance announcement & registration open	March 2013
Full papers (4 pages) submission deadline	June 25 2013
IGARSS 2013	Sunday 21 - Friday 26 July 2013

*refer to website for further information

Building a Sustainable Earth through Remote Sensing • 21-26 July 2013 • www.igarss2013.org

UPDATE FROM MELBOURNE

IEEE GRSS International Geoscience and Remote Sensing Symposium (IGARSS)

21–26 July 2013, Melbourne Australia

Peter Woodgate, Simon Jones and the Local Organising Committee wish to invite you to Melbourne Australia for IGARSS2013. It will be an action-packed six days consisting of engaging presentations, technical tours and plenty of networking opportunities through the Symposium social events in and around Melbourne. Melbourne, the most world's most livable city in the world (EIU's Global Liveability Report), offers fine wine, fabulous coffee, a myriad of culinary choices, sport and theatre entertainment and stunning architecture, much of which was constructed as a result of the Victorian gold rush.

IGARSS2013 includes many quality presenters at the forefront of international activities in the geosciences and remote sensing, including Mike Goodchild, Emeritus Professor of Geography at the University of California Santa Barbara who has been instrumental in promoting a connection to the user community and Peter Staecker, incoming 2013 President of IEEE, who brings a wealth of experience and knowledge to the IEEE community. In addition, we are thrilled that Guo Huadong, Director-General of the Center for Earth Observation and Digital Earth (CEODE), Chinese Academy of Sciences (CAS), will present a keynote and provide valuable insights into geoscience and remote sensing initiatives and activities within the China and Asia-Pacific region.

For the tech savvy, our dedicated social media sites for IGARSS2013 are up and running and increasing in activity. We encourage you to take the opportunity to become a part of IGARSS2013 through Twitter, LinkedIn, and Facebook. Connect with the Organising Committee, the presenters, exhibitors and sponsors before the Conference!

Key dates are on the conference website at: www.igarss2013.org. Currently, the abstract submission system is open and this will close on 10 January 2013. More information is available at: http://www.igarss2013.org/Papers.asp

Please visit our website and find out more about the Symposium at: www.igarss2013.org. We look forward to seeing you in Melbourne next July!

ICMARS-2012
8TH INTERNATIONAL CONFERENCE ON MICROWAVES, ANTENNA, PROPAGATION AND REMOTE SENSING

December 11th – 15th , 2012
Pre-Conference Workshop: 10th December, 2012
Jodhpur, India

ICMARS 2012 Chair
Prof. OPN Calla, Director, International Centre For Radio Science

Abstract submission:
Sep. 25, 2012 (likely to be extended up to October 25 2012)

Online Submission Link:
http://www.icmars2012.org/Abstract_Submission.php

Special Session on OCEANSAT-2, SMAP, SMOS, AQUARUIS, MEGHATROPIQUES, PLANETARY EXPLORATION, CRYOSPHERE, MOBILE COMM. SPECIAL ONE DAY SEMINAR ON RISAT

Register:
Before November 1, 2012

Web Address:
www.icmars2012.org

APSAR 2013:
The Asia-Pacific Conference on Synthetic Aperture Radar

Tsukuba International Congress Center
EPOCHAL TSUKUBA
September 23-27, 2013, Tsukuba, Japan

IEEE GRSS Japan Chapter& IEICE-ES

Technical Co-sponsors: IEEE GRSS, IEEE AESS Japan Chapter, IEEE APS Japan Chapter, IEICE EMT, IEICE SANE, URSI-F, RSSJ, JSPRS, Radar Society of KIEES

General Chair:
Akira Hirose Dept. EE & IS, Univ. Tokyo
Important dates:
Feb. 22, 2013: Abstract (2p) submission deadline
May 10, 2013: Acceptance notification
June 28, 2013: Final Paper (4p) submission deadline
June 28, 2013: Preregistration deadline
Web Address:
http://www.apsar2013.org/

Geoinformatics 2013:
The 21th International Conference on Geoinformatics

June 20-22, 2013
Kaifeng (China)

Organized by
The College of Environment and Planning at Henan University and The International Association of Chinese Professionals in Geographic Information Sciences (CPGIS)

Sponsored by IEEE

Geoinformatics 2013 Co-Chairs:
Henan University and CPGIS
Abstract submission:
Before Feb. 28, 2013
Email: Geoinformatics2013@gmail.com

Register:
Before June 10, 2013

Registration fees:
Early bird on-line registration opens on Dec. 10, 2012 and closes on May 10, 2013 at http://www.GeoInformatics2013.org
Registration fee varies based on membership status and registration date.

Web Address:
http://www.GeoInformatics2013.org

R·I·T Rochester Institute of Technology — Rochester, NY

Wiedman Professor Center for Imaging Science

Applicants are sought for the Frederick and Anna B. Wiedman endowed chair, a senior tenure-track/tenured endowed professorship in the Chester F. Carlson Center for Imaging Science (CIS) at RIT. We are seeking candidates that have a strong background and experience in Earth remote sensing. The successful candidate is expected to teach courses at the undergraduate and graduate levels in imaging science, to be a major contributor to research activities in the Digital Imaging and Remote Sensing Laboratory (DIRS) within CIS, and to have a track record in receiving externally funded research grants and contracts with a variety of sponsors such as private companies and state and federal government agencies.

Required Minimum Qualifications

- Doctoral degree (Ph.D. or international equivalent)
- A peer-reviewed publication record
- A history of successful research leadership in remote sensing of the Earth or related fields at the level of PI demonstrated through externally funded projects
- Experience in the development of theory, methods, or instrumentation for remote sensing

Anticipated Start Date 20-Aug-2013

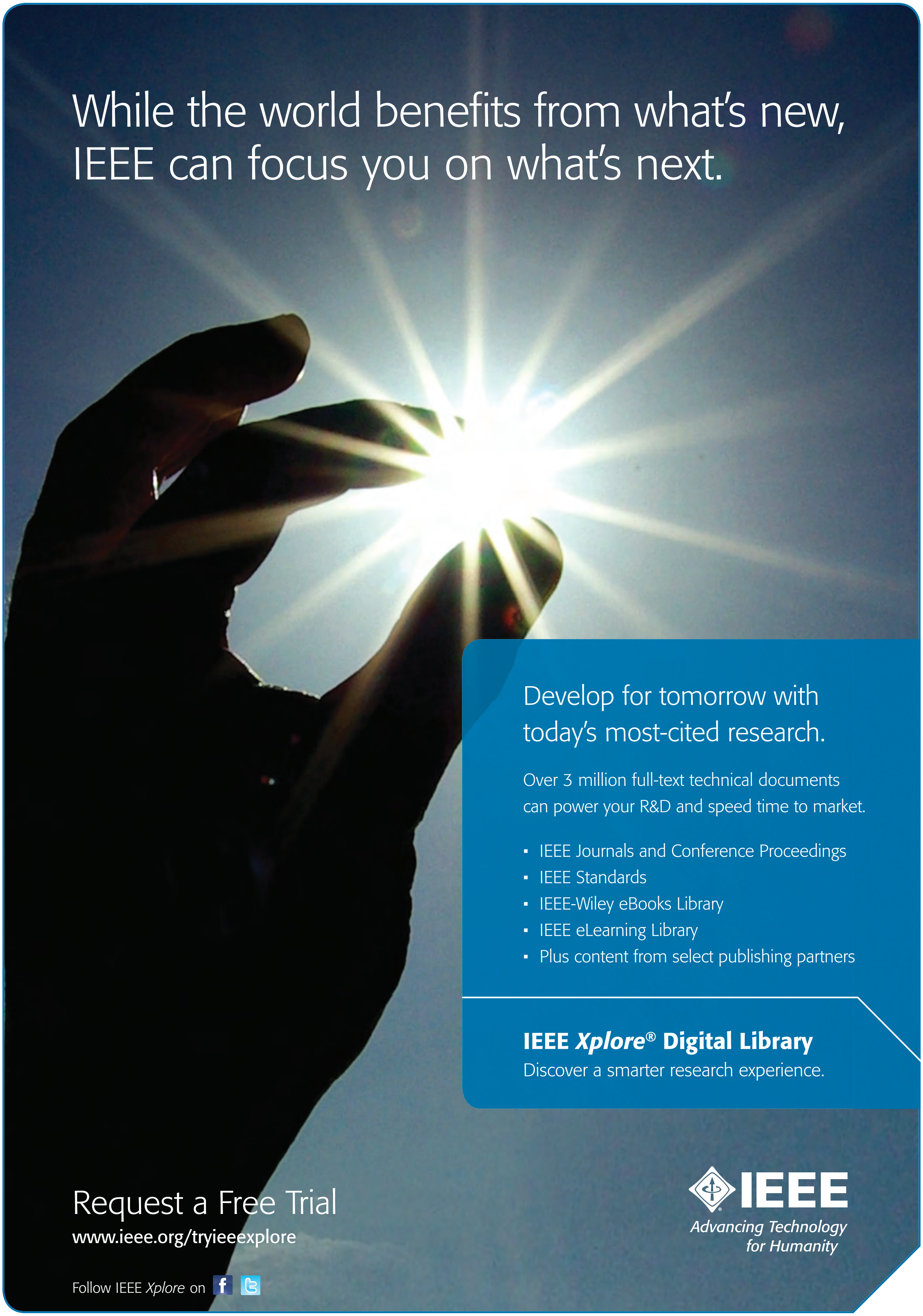
CIS is also seeking two outstanding candidates for junior tenure-track positions in the areas of vision and optics for imaging. Further details about all positions are posted online at http://www.cis.rit.edu/facultysearch. Questions about the junior positions can be sent to the search committee at facultysearch@cis.rit.edu.

Apply online at
http://apptrkr com/291409
Search: 186BR.

You can contact the search committee with questions on the position at: wiedmansearch@cis.rit.edu.

Applications will be reviewed immediately and continue until an acceptable candidate is found. Applicants are encouraged to apply by December 15, 2012.

The Rochester Institute of Technology is an equal opportunity/affirmative action employer.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UPCOMING CONFERENCES

See also http://www.ieee.org/conferences_events/index.html or http://www.techexpo.com/events

Name: 7th GRSS/ISPRS Joint Workshop on Remote Sensing and Data Fusion over Urban Areas 9thInternational Symposium on Remote Sensing of Urban Areas
Dates: April 19–21, 2013
Location: São Paulo, Brazil
E-mail: jurse2013@dpi.inpe.br
URL: http://www.inpe.br/jurse2013/

Name: 6th International Conference on Recent Advances in Space Technologies (RAST2013)
Dates: June 12–14, 2013
Location: Istanbul, Turkey
E-mail: rast2013@rast.org.tr
URL: http://www.rast.org.tr/

Name: 7th International Workshop on the Analysis of Multi-Temporal Remote Sensing images (MultiTemp 2013)
Dates: June 25–27, 2013
Location: Banff, Canada
URL: http://geog.ucalgary.ca/multitemp2013

Name: 5th Workshop on Hyperspectral Image and Signal Processing
Dates: June 25–27, 2013
Location: Florida
URL: http://www.ieee-whispers.com/

Name: IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2013)
Dates: July 21–26, 2013
Location: Melbourne, Australia
E-mail: info@igarss2013.org
URL: http://www.igarss2013.org/

Name: The Asia-Pacific Conference on Synthetic Aperture Radar
Dates: September 23–27, 2013
Location: Tsukuba, Japan
URL: http://www.apsar2013.org/

Name: The 21th International Conference on Geoinformatics (Geoinformatics 2013)
Dates: June 20–22, 2013
Location: Kaifeng, China
E-mail: Geoinformatics2013@gmail.com
URL: http://www.GeoInformatics2013.org