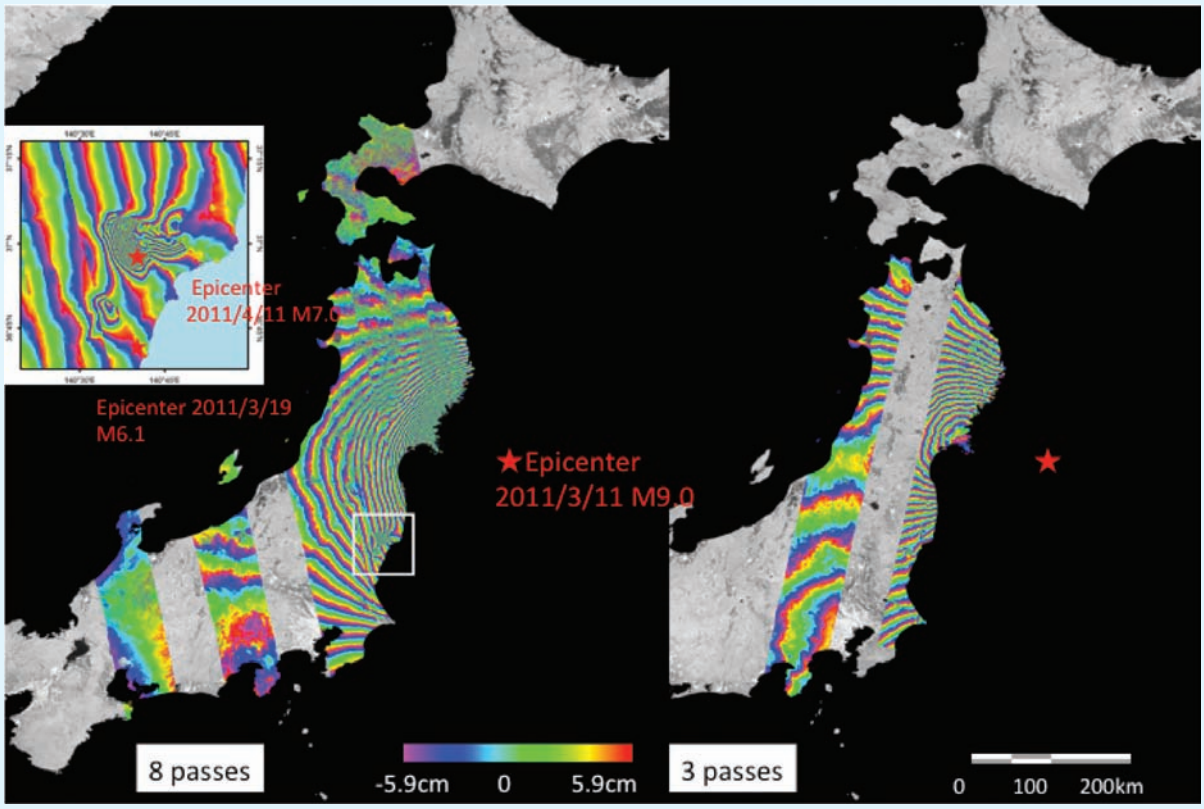
IEEE GEOSCIENCE and REMOTE SENSING Newsletter

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

PALSAR DinSAR for Tohoku-Oki Earthquake



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This is the last issue of the IEEE Geoscience and Remote Sensing Newsletter for 2011. This year has been very rich in interesting scientific, technical and social events in the remote sensing community. Unfortunately, it has also been the year of the terrible earthquake and tsunami in Japan, causing the death of many people and a lot of sorrow for our Japanese friends directly or indirectly affected by this tragedy. In this issue we devote attention to this event honoring the activity of the Japanese colleagues of Japan Aerospace Exploration Agency (JAXA) who used remote sensing to assess the damage and to mitigate the enormous effects of this natural disaster.

As you can observe, thanks to the contributions of many GRSS members, the content of the Newsletter is becoming richer with time. In this issue we have a very interesting mix of technical articles, reports on important topics in our field, and contributions on the social activities of our society. In addition, beginning with this issue we will have a new column on education activities (*Education Corner*) that is focused on education initiatives carried out in the context of GRSS. The Education Corner will be the responsibility of Dr. Antonio Plaza, whom we warmly welcome to the Newsletter editorial board.

The issue opens with a contribution in memoriam of David H. Staelin who died on November 10, 2011, at the age of 73, after a courageous battle with cancer. The passing of David Staelin is a great loss for the GRSS society. As pointed out in the article, he was a leader in many areas related to remote sensing and his work has had a strong and lasting impact on the remote sensing community. He is and will continue to be sorely missed.

The issue presents two main articles in the *Features* section. The first is a tutorial paper on quality assessment of pan-sharpening methods and products. Many very high geometrical resolution sensors acquire both a panchromatic image with very high geometrical resolution and a multispectral image with degraded resolution containing multiple spectral channels. The use of pan-sharpening techniques for merging these sources of information into a new multispectral image with enhanced spatial resolution is now quite common in many applications. However, pan-sharpening can introduce both spatial and spectral artifacts that can affect the results of data analysis. This tutorial paper provides an overview of pan-sharpening techniques and focuses on methods that can be used for assessing the quality of pan-sharpening products. As already mentioned, the second feature article addresses the

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President's Message

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The year 2011 has been very successful for the IEEE Geoscience and Remote Sensing Society (GRSS). The GRSS continues to do well on all fronts. The GRSS publication portfolio is excelling under the strong leadership of VP of Publications, Prof. Wooil Moon. Our three journal publications, TGRS, GRSL and J-STARS, continue to be very successful in terms of quality, timeliness and relevance for the remote sensing community. The submission rate has increased for all publications. Consequently, GRSL expanded to six issues this year. At the beginning of the year, Prof. Jocelyn Chanussot started his tenure as the new Editor of J-STARS. Under his leadership, J-STARS has done extremely well. The submission rate for J-STARS has tripled in 2011. Consequently, J-STARS will expand to 6 issues per year in 2012. The Editors of TGRS, Prof. Chris Ruf, and, GRSL, Prof. Paolo Gamba, have done an outstanding job during the last three years and were recently reappointed by the GRSS AdCom to serve as Editors for 2012–2013. The GRSS appreciates all the hard work of the journal Editors, the Associate Editors and reviewers. These volunteers ensure that the publications are of the highest quality. This year the IEEE TAB approved a new publication award, the IEEE GRSS Highest Impact Paper Award, which will be awarded in the future to papers that were published in the GRSS journals with the highest impact.

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Cover Information: DinSAR-based deformation pattern caused by the Earthquake of Magnitude 9.0 occurred March 11, 2011 at 2:46 p.m. in the Tohoku-oki area, Japan. (a) Images on the left are from the ascending passes; (b) images on the right are from the descending passes.

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use of remote sensing in the recent earthquake and tsunami that occurred in Japan. The article, prepared by colleagues of the Japan Aerospace Exploration Agency (JAXA), provides a brief overview of the terrible effects of this natural disaster and then focuses on the role that remote sensing has played in the post crisis phase, emphasizing the important contributions of the Advanced Land Observing Satellite (ALOS) in damage assessment.

The *New Remote Sensing Missions* column presents an article on the *Vegetation and Environment monitoring on a New Micro Satellite (Venμs)*, which is a demonstration satellite developed together by the French and Israeli Space Agencies (CNES and ISA, respectively). This article describes the characteristics of this mission, its development status and applications.

The *Reports* section contains six main contributions. Three articles are related to IGARSS 2011, which was held in Vancouver, Canada, July 24–29, 2011. The first report gives a general overview of the symposium, pointing out the major scientific, technical and social activities. The second article focuses on the GRSS Publications Awards presented at IGARSS 2011 and gives details on all the Awards recipients. Congratulations to all of them! The third article presents the results of the web-based survey among GRSS members and IGARSS'11 attendees. Another two reports address workshops technically co-sponsored by the GRSS: the 3*rd International Asia-Pacific Conference on Synthetic Aperture Radar (APSAR 2011)*, which was held in Seoul Education and Culture Center, Seoul, Korea, September 26–30, 2011; and the *3rd Workshop on Advanced RF Sensors and Remote Sensing Instruments (ARSI 2011)*, which was held at the European Space Agency's Research and Technology Centre (ESTEC), Noordwijk, The Netherlands, September 13–15, 2011. Finally, the section includes a report on the recent standards development activities that may be of interest to the GRSS membership.

The *Technical Committee Corner* column describes the output of the 2011 Data Fusion Contest and provides an overview of the 2012 upcoming contest. I encourage you to take part in this challenging contest.

The new *Education Corner* column describes some ongoing activities of GRSS in the area of education, including (present and planned) activities carried out as part of conferences and symposia, web-based tools, e-learning and social networks, etc.

The *Industrial Profile* column introduces the *U.S. National Institute of Standards and Technology (NIST)*. The article reports on the history, progress, and future directions of microwave remote sensing research and development at NIST.

As a final remark, I strongly encourage you to contribute to the success of the Newsletter by submitting technical, educational, and industrial profiles articles that are of interest of our community. Do not hesitate to contact me for any information on possible contributions you may need.

Season greeting!
Sincerely,
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GRSS MEMBER HIGHLIGHTS

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PRIZE TO PROFESSOR BULUSA LAKSHMANA DEEKSHATULU

Prof. Bulusu Lakshmana Deekshatulu—Fellow IEEE affiliated to Geoscience and Remote Sensing Society—has been recently conferred **CHEN Shupeng Award**, and he received this award during the opening ceremony of the 32nd ACRS (Asian Conference on Remote Sensing) on October 3 morning in Taipei, Taiwan. He is the only IEEE Fellow affiliated to GRSS from India. He is currently Chairman of Board of Governors, National Institute of Technology (NIT), Warangal, India, and Distinguished Fellow, Institute for Development and Research in Banking Technology (IDRBT) Hyderabad, an Institution under Reserve Bank of India (Govt. of India). He has distinguished himself through his research and technological contributions in the field of Control Systems, Remote Sensing and Digital Image Processing. He has over 150 research publications to his credit. His current research interests are Data Analysis, Digital Image Processing, Machine Learning and Neural Networks. Prof. Deekshatulu is considered to be the Father of Digital Image Processing and Remote Sensing in India.

He obtained B.Sc. (Engg. – Electrical) degree in 1958 from the Banaras Hindu University and M.E. and Ph.D. degrees from the Indian Institute of Science (I.I.Sc.), Bangalore. He was awarded Martin Foster Medal by I.I.Sc., for Best Ph.D. thesis. He joined IISc as Lecturer in 1964, became Professor in 1970, and continued in that position till 1976. Dr. Deekshatulu worked as Visiting Scientist at the IBM Watson Research Centre, York Town Heights, New York, and at the Environmental Research Institute of Michigan during 1971–72 on Digital Image Processing and Remote Sensing. Dr. Deekshatulu joined the National Remote Sensing Agency Hyderabad as Head, Technical Division in April 1976 and became Director in January 1982, and retired as "Distinguished Scientist (Secretary grade)

Prof. B. L. Deekshatulu recieving CHEN Shupeng Award on 3rd October 2011 at taipei, Taiwan.

& Director NRSA" in October 1996. He has been responsible for the upbringing of the National Remote Sensing Agency in all its facets, and for executing National and State level projects in many disciplines of Remote Sensing applications. He has received many national and international awards. He designed and fabricated for the first time in India, Grey scale and Color Drum Scanners for Computer Picture processing, which has subsequently won him, and his group a NRDC Award. He is a recipient of many awards such as the Bharat Ratna Sir M.VISVESWARAYA AWARD for "Outstanding Engineer" in 1984, NRDC Invention Awards in Jan. 1986 and in Aug. 1993, Dr. Biren Roy Space Science Award in 1988, "PADAMSRI" medal in Jan. 1991 by President of India, BRAHM PRAKASH MEDAL for significant contributions to Engineering Technology, OM PRAKASH BHASIN AWARD for Science and Technology for 1995. Received "Sivananda Eminent Citizen Award" from Vice President of India in Dec. 1998, Boon Indrambarya GOLD MEDAL by Thailand Remote Sensing and GIS Assoc. in Nov. 1999 in Hong Kong for contributions to Remote Sensing, 2002 Aryabhatta Award by Astronautical Society of India for life time contributions to Remote Sensing, Distinguished Alumni Award from IISc, Bangalore in 2006, "Life time Contribution Award" from ACRS, Beijing in Oct 2009, and 2011 National Award for Ocean Sci. & Techn from Ministry of Earth Sciences (MOES), Govt. of India. He is Fellow of 15 Scientific and Engineering Academies. He was Chairman, National Committee on International Geosphere, Biosphere Programme (IGBP) during 1994–97, Chairman of Remote Sensing Applications Missions India 1987–96. Dr. Deekshatulu was a UN / FAO Consultant in Beijing during November, 1981. He was the Government representative in the UN/ESCAP/RSSP Directors' meetings and Inter Governmental Consultative Committee meetings from 1985–95. He was a UN/ESCAP Senior Consultant during September – November, 1996. He was Director of Centre for Space Science and Technology Education in Asia and the Pacific (CSSTE-AP), Affiliated to the United Nations, IIRS Campus, Dehra Dun, India from November 1995 to April 2002. Dr. Deekshatulu was a Visiting Professor in the Dept. of Comp. & Infn. Sci, Univ. of Hyderabad, pursuing research and teaching in Image Processing, Machine Learning and Neural Networks. He is a great organization builder and a researcher.

(President's Message continued from page 3)

Over 1400 delegates attended the excellent IGARSS 2011 in Vancouver, Canada. The number of attendees was outstanding, especially considering that conference had to be moved only four months prior to its opening. In addition, this year, GRSS continued to sponsor or co-sponsor many specialty symposia all over the world in order to promote remote sensing and GRSS activities. Among these specialty symposia were JURSE 2011 held in Munich, Germany in April, the Atmospheric Transmission Models meeting held in Lexington, MA in June, WHISPERS 2011 held in Lisbon, Portugal in June and Multitemp 2011 held in Trento, Italy in July. All these meetings were of high quality and it was a personal pleasure for me to attend and address the audiences at JURSE 2011 and WHISPERS 2011 on behalf of the GRSS.

The GRSS AdCom continues to work hard to promote GRSS activities in Africa, Asia and Latin America under the umbrella of the GRSS Globalization Initiative led by GRSS Past President, Prof. Tony Milne. The task of the Globalization Initiative is to reach out to the international communities where GRSS has not been sufficiently visible. This year, the major focus has been on Asia. In September, the GRSS was involved in the 2011 Asian Conference on Remote Sensing in Taipei, Taiwan, where a GRSS workshop on Forest Monitoring, Carbon, and REDD+, beyond Reducing Emissions from Deforestation and Forest Degradation, was conducted. GRSS presenters included Prof. Tony Milne, Dr. David G. Goodenough and Dr. Anthea Mitchell. The workshop was attended by 55 delegates. Similar GRSS workshops will be held in other areas of the world in the future.

Under the leadership of Chapter Chair, Prof. Kun-Shan Chen, the GRSS AdCom is focused on establishing local GRSS Chapters in order to strengthen GRSS activities and promote a continued and sustained GRSS impact. Several new GRSS Chapters were formed in 2010, including chapters in Saudi Arabia, Croatia and Alaska. Additional GRSS Chapters are being established, for example in India.

Best wishes for a happy holiday season and a wonderful 2012 to you and your families.

Jon Atli Benediktsson, President
IEEE GRSS, benedikt@hi.is

IN MEMORIAM

IN MEMORY OF DAVID H. STAELIN

David H. Staelin (S'59–M'65–SM'75–F'79–LF'04), a professor in the MIT Department of Electrical Engineering and Computer Science and the Research Laboratory of Electronics, died Nov. 10 of cancer. He was 73. Staelin joined the MIT faculty in 1965, conducting research in radio astronomy. Among his first accomplishments, in 1968 he developed a computationally efficient algorithm that enabled him to co-discover the Crab Nebula Pulsar, helping confirm the existence of neutron stars predicted by theoretical physics. Over time, Staelin's interests expanded to include remote sensing for climate monitoring, a field to which he brought a strong command of electromagnetics, signal-processing methodology and computation trends. Among many examples of his leadership in this field, he was principal investigator in the development of the first two Earth-orbiting microwave imaging spectrometers launched in 1975 for mapping global temperature and humidity through clouds. He was also a co-investigator on the 1977 NASA Voyager 1 and 2 spacecraft missions, studying nonthermal radio emission from the outer planets. Staelin received the IEEE Geoscience and Remote Sensing Society (GRSS) Distinguished Achievement Award in 1996. Starting in 1998, he co-developed techniques using operational millimeter-wave sounding satellites for more frequent and complete mapping of global precipitation. In recent years, Staelin turned his attention to diverse emerging problems requiring sophisticated signal processing and estimation theory. These included the development of practical image- and video-compression technology, advanced methodologies for data-rich manufacturing problems, heterogeneous and wireless communication architectures, and, most recently, neuronal computation models. Highly entrepreneurial, Staelin helped start and direct several companies with colleagues and students. StaelinFest, an event held at MIT this past July to celebrate Staelin's career, was attended by faculty, colleagues and former students from around the country (see http://www.rle.mit.edu/staelinfest/ for highlights and guestbook). At the event, he also received the distinguished 2011 John Howard Dellinger Medal, awarded to him by the International Union of Radio Science for profound contributions to remote sensing over his career. Staelin was also a fellow of the IEEE and the American Association for the Advancement of Science and served as assistant director of MIT's Lincoln Laboratory from 1990 to 2001 and as a member of the U.S. President's Information Technology Advisory Committee from 2003 to 2005.

FEATURES

QUALITY ASSESSMENT OF PANSHARPENING METHODS AND PRODUCTS

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1. Overview

Pansharpening is a branch of data fusion that is receiving an ever increasing attention from the remote sensing community. New-generation spaceborne imaging sensors operating in a variety of ground scales and spectral bands provide huge volumes of data having complementary spatial and spectral resolutions. Constraints on the signal to noise ratio (SNR) impose that the spatial resolution must be lower, if the requested spectral resolution is higher. Conversely, the highest spatial resolution is obtained by a panchromatic (Pan) image, in which spectral diversity is missing. The tradeoff of spectral and spatial resolution makes it desirable to perform a spatial resolution enhancement of the lower resolution multispectral (MS) data or, equivalently, to increase the spectral resolution of the data set having a higher ground resolution, but a lower spectral resolution; as a limit case, constituted by a unique Pan image bearing no spectral information.

To pursue this goal, an extensive number of methods have been proposed in the literature over the last two decades. Most of them follow a general protocol, that can be summarized in the following two key points: 1) extract high-resolution geometrical information of the scene, not present in the MS image, from the Pan image; 2) incorporate such spatial details into the low-resolution MS bands, interpolated to the spatial scale of the Pan image, by properly modeling the relationships between the MS bands and the Pan image. Fig. 1 outlines the flow inside the fusion block and highlights possible connections with outer blocks.

Progresses in pansharpening methods have been substantially motivated by advances in spaceborne instruments. All instruments launched during the last decade exhibit a ratio of scales between Pan and MS equal to four, instead of two, like in earlier missions, together with the presence of a narrow band in the blue (B) wavelengths and a broadened bandwidth of Pan, enclosing also the near infrared (NIR) wavelengths. While the change in scale ratios has not substantially influenced the development of fusion methods, the presence of the B band, allowing natural or "true" color display, and of a Pan image that embraces NIR, but not B, to avoid atmospheric scattering, has created significant problems to earlier methods, thereby dramatically motivating the development both of quality assessment tools for pansharpened data, and of alternative fusion methods yielding better quality than earlier ones. In fact, such methods as intensity–hue–saturation (IHS) [1], Brovey transform (BT) [2], and principal component analysis (PCA) [3] provide superior visual high-resolution multispectral images but ignore the requirement of high-quality synthesis of spectral information [4]. While these methods are useful for visual interpretation, high-quality synthesis of spectral information is very important for most remote sensing applications based on spectral signatures, such as lithology and soil and vegetation analysis [5].

This article aims at providing an overview of materials and methods encountered for quality definition and assessment of pansharpened images. After a concise review and classification of pansharpening methods, the concept of spectral and spatial quality and the most widely used protocols and

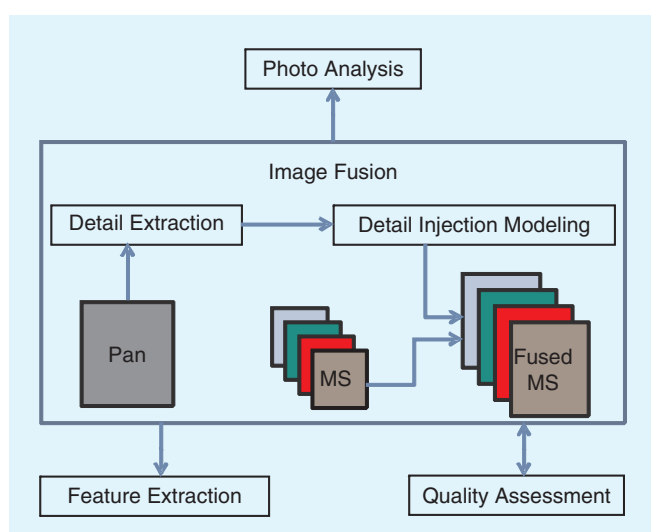

Figure 1. Pansharpening of multispectral imagery: a synopsis.

statistical indexes used for their measurements are presented and discussed. A brief experimental section presents selected examples of pansharpened IKONOS imagery and reports evaluations carried out according to two main protocols. Concluding remarks are drawn at the end.

2. A Critical Review of Fusion Methods

Over the last two decades, the existing image fusion methods have been classified into several groups. Schowengerdt [6] classified them into spectral domain techniques, spatial domain techniques, and scale space techniques. However, scale space techniques, e.g. wavelets, are generally implemented by means of digital filters that are spatial domain techniques. Therefore, methods like HPF [7] and AWL [8], which differ by the type of digital filter, actually belong to the same class.

Ranchin and Wald [9, 10] classified pansharpening methods into three groups: projection and substitution methods, relative spectral contribution methods, and those relevant to the ARSIS concept (Amélioration de la Résolution Spatiale par Injection de Structures), originally employing the decimated wavelet transform (DWT) [9]. It was found that many of the existing image fusion methods, such as HPF [7], GLP [11] and ATW [8], can be accommodated within the ARSIS concept. However, the first two classes, namely "projection and substitution", e.g. IHS, and "relative spectral contribution", e.g. BT, are equivalent. In fact, Tu *et al.* [12] performed a mathematical development and found that IHS, PCA, BT may not involve explicit calculation of the complete spectral transformation but only of the component that will be substituted, e.g. intensity for both IHS and BT. Therefore, IHS and BT differ only in the way spatial details are weighted before their injection and not in the way they are extracted from the Pan image. Both IHS and BT fusion can be generalized to an arbitrary number of spectral bands.

According to the most recent studies carried out by the authors [13], the majority of image fusion methods can be divided into two main classes. Such classes uniquely differ in the way the spatial details are extracted from the Pan image, as shown in Fig. 2(a,b).

- Techniques that employ linear space-invariant digital filtering of the Pan image to extract the spatial details that will be added to the MS bands [14]; all methods employing multiresolution analysis (MRA) belong to this class.
- Techniques that yield the spatial details as pixel difference between the Pan image and a nonzero-mean

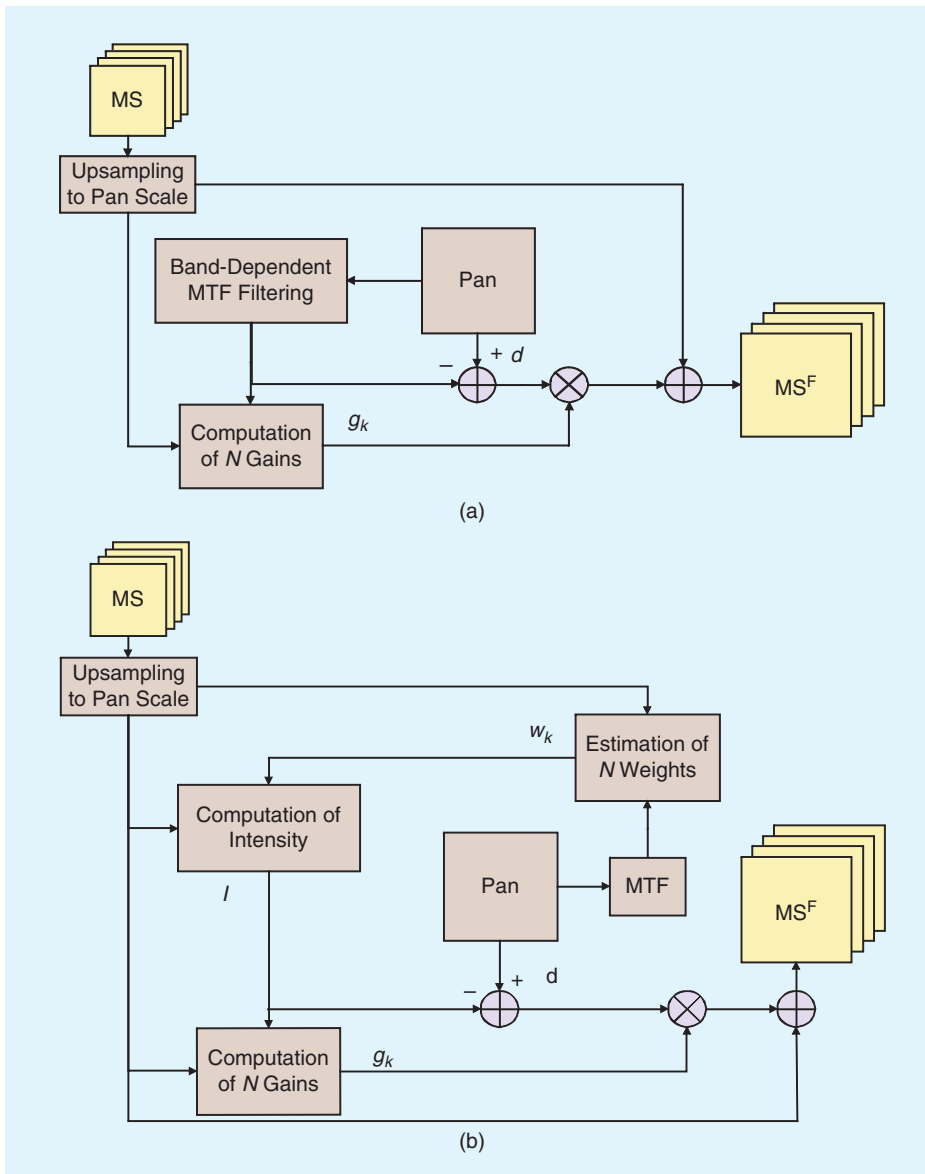

Figure 2. Flowchart of the two main pansharpening approaches: (a): based on filtering the Pan image, or more generally on multiresolution analysis; (b): based on a spectral combination of bands, without filtering the Pan image, or more generally on component/projection substitution.

component obtained from a spectral transformation of the MS bands, without any spatial filtering of the former. They are equivalent to substitution of such a component with the Pan image followed by reverse transformation to produce the sharpened MS bands [15].

Regardless of how spatial details have been obtained, their injection into the interpolated MS bands may be weighed by suitable gains,different for each band, possibly space-varying, i.e. a different gain at each pixel. Algorithms featuring context-adaptive, i.e. local, models generally perform better than schemes based on models fitting each band globally [16, 17]. A pixel-varying injection model $\{g_k\}$ is capable of defining fusion algorithms based on modulation [18], e.g. BT for the class of methods in Fig. 2(b) and SFIM [19] for the methods outlined in Fig. 2(a).

The two classes of methods described above exhibit complementary spectral-spatial quality tradeoff. Methods without spatial filtering, provide fused images with high geometrical quality of spatial details, but with possible spectral impairments. Methods employing spatial filtering are spectrally accurate in general, but may be unsatisfactory in terms of spatial enhancement. However, if the spectral combination of bands is optimized for spectral quality of pansharpened products [15] and spatial filtering is optimized for spatial quality (MTF filtering yields best results [20]), the two categories yield very similar results in terms of overall quality [17].

3. Quality Assessment of Fusion

Quality assessment of pan-sharpened MS images is a much debated topic [7, 4, 21, 22, 23, 24, 25, 26]. The most crucial problem is that if quality is evaluated at the highest resolution of the Pan image, the measured spectral and spatial qualities may follow opposite trends, with the paradox that the least spectrally distorted fused image is that obtained when no spatial enhancement is introduced. The so called spectral-spatial distortion tradeoff occurs because of incorrect definitions and measurements of either spectral or spatial distortion [10]. In absence of shortcomings, like performing fusion on spatially degraded MS and Pan data in order to evaluate the quality of fusion, the reference for spectral quality is the original MS data to be fused, while the reference of spatial quality is the Pan image. The majority of methods perform a direct comparison between data before and after fusion and this originates the tradeoff. To overcome this inconvenience, some authors have introduced new definitions of distortion measurements [25, 26], such that they do not depend on the unavailable true high-resolution MS data, but would measure zero distortions if such data were hypothetically available.

3.1. Quality Indexes

Quality indexes and/or distortion measurements have been defined in order to measure the similarity between images, either scalar or vector [27], as required by the various protocols. This review is limited to indexes that are established in the literature as providing results consistent with photoanalysis of pansharpened products. Under this perspective quality measures based on Shannon's entropy, or auto-information, though used sometimes, have never given evidence of being suitable for this task.

3.1.1. Indexes for Scalar Valued Images

- Mean bias ($\Delta\mu$): given two scalar images A and B with means $\mu(A)$ and $\mu(B)$, approximated by averages $\overline{A}$ and $\overline{B}$, the mean bias is defined as:

$$\Delta\mu \triangleq \mu(A) - \mu(B) \tag{1}$$

  $\Delta\mu$ is a distortion; hence its ideal value is zero.
- Root mean square error (RMSE): RMSE between A and B is defined as:

$$\text{RMSE} \triangleq \sqrt{E[(A-B)^2]} \tag{2}$$

  in which the expected value is approximated by a spatial average. RMSE is a distortion, whose ideal value is zero, if and only if $A = B$.
- Cross-correlation, or correlation, coefficient (CC): CC between A and B is defined as:

$$\text{CC} \triangleq \frac{\sigma_{A,B}}{\sigma_A \sigma_B} \tag{3}$$

  where $\sigma_{A,B}$ is the covariance between A and B, given by $E[(A-\mu(A))(B-\mu(B))]$, and σ_A is the standard deviation of A given by $\sqrt{E[(A-\mu(A))^2]}$. In the same way $\sqrt{E[(B-\mu(B))^2]}$ represents the standard deviation of B. CC takes values in the range $[-1, 1]$. CC $= 1$ means that A and B differ only by a global mean offset and gain factor. CC $= -1$ means that B is the negative of A (A and B still may differ by a gain and an offset). Being CC a similarity index, its ideal value is one.
- Universal image quality index (UIQI) [28] measures the similarity between two scalar images A and B and is defined as

$$Q = \frac{4\sigma_{A,B} \cdot \overline{A} \cdot \overline{B}}{(\sigma_A^2 + \sigma_B^2)[(\overline{A})^2 + (\overline{B})^2]} \tag{4}$$

  in which $\sigma_{A,B}$ denotes the covariance between A and B, $\overline{A}$ and $\overline{B}$ are the means, and σ_A^2 and σ_B^2 the variances of A and B, respectively. Eq. (4) may be equivalently rewritten as a product of three factors:

$$Q = \frac{\sigma_{A,B}}{\sigma_A \cdot \sigma_B} \cdot \frac{2\overline{A} \cdot \overline{B}}{[(\overline{A})^2 + (\overline{B})^2]} \cdot \frac{2\sigma_A \cdot \sigma_B}{(\sigma_A^2 + \sigma_B^2)}. \tag{5}$$

  The first one is the correlation coefficient (CC) between A and B. The second one is always ≤ 1, from

Cauchy-Schwartz inequality, and is sensitive to bias in the mean of B with respect to A. The third term is also ≤ 1 and accounts for changes in contrast between A and B. Apart from CC which ranges in $[-1, 1]$, being equal to 1 *iff* $A = B$, and equal to -1 *iff* $B = 2\bar{A} - A$, i.e., B is the negative of A, all the other terms range in $[0, 1]$, if $\bar{A}$ and $\bar{B}$ are nonnegative. Hence, the dynamic range of Q is $[-1, 1]$ as well, and the ideal value $Q = 1$ is achieved *iff* $A = B$ for all pixels. To increase the discrimination capability of the three factors in (5), all statistics are calculated on suitable $N \times N$ image blocks and the resulting values of Q averaged over the whole image to yield a unique global score.

3.1.2. Indexes for Vector Valued Images

- Spectral angle mapper (SAM). Given two spectral vectors, $\mathbf{v}$ and $\hat{\mathbf{v}}$, both having L components, in which $\mathbf{v} = \{v_1, v_2, \ldots, v_L\}$ is the original spectral pixel vector $v_l = A^{(l)}(m, n)$ while $\hat{\mathbf{v}} = \{\hat{v}_1, \hat{v}_2, \ldots, \hat{v}_L\}$ is the distorted vector obtained by applying fusion to the coarser resolution MS data, i.e. $\hat{v}_l = \hat{A}^{(l)}(m, n)$, the spectral angle mapper (SAM) denotes the absolute value of the spectral angle between the two vectors:

$$\mathrm{SAM}(\mathbf{v}, \hat{\mathbf{v}}) \triangleq \arccos\left(\frac{<\mathbf{v}, \hat{\mathbf{v}}>}{\|\mathbf{v}\|_2 \cdot \|\hat{\mathbf{v}}\|_2}\right). \tag{6}$$

  SAM(A, B) is defined according to (6) as $\mathrm{E}[\mathrm{SAM}(a, b)]$ where a and b denote the generic pixel vector element of MS images A and B, respectively. SAM is usually expressed in degrees and is equal to zero when images A and B are spectrally identical, i.e. all pixel vectors differ only by their moduli between A and B.
- *Relative dimensionless global error in synthesis* (ERGAS). ERGAS [14], an error index that offers a global indication of the quality of a fused product, is given by:

$$\mathrm{ERGAS} \triangleq 100\frac{d_h}{d_l}\sqrt{\frac{1}{L}\sum_{l=1}^{L}\left(\frac{\mathrm{RMSE}(l)}{\mu(l)}\right)^2} \tag{7}$$

  where d_h/d_l is the ratio between pixel sizes of Pan and MS, e.g. 1/4 for Ikonos and QuickBird data, $\mu(l)$ is the mean (average) of the lth band, and L is the number of bands. Low values of ERGAS indicates similarity between multispectral data.
- $Q4$ is a multispectral extension of UIQI suitable for images having four spectral bands, introduced by three of the authors for quality assessment of Pansharpened MS imagery [22]. For MS images with four spectral bands, let a, b, c, and d denote the radiance values of a given image pixel in the four bands, typically acquired in the B, G, R, and NIR wavelengths. $Q4$ is made up of different factors accounting for correlation, mean bias, and contrast variation of each spectral band, as well as of spectral angle. Since the modulus of the hypercomplex correlation coefficient (CC) measures the alignment of spectral vectors, its low value may detect when radiometric distortion is accompanied by spectral distortion. Thus, both radiometric and spectral distortions may be encapsulated in a unique parameter. Let

$$\begin{aligned} \mathbf{z}_A &= a_A + \mathbf{i}b_A + \mathbf{j}c_A + \mathbf{k}d_A \\ \mathbf{z}_B &= a_B + \mathbf{i}b_B + \mathbf{j}c_B + \mathbf{k}d_B \end{aligned} \tag{8}$$

  denote the 4-bands reference MS image and the fusion product, respectively, both expressed as quaternions or hypercomplex numbers. The Q4 index is defined as:

$$Q4 \triangleq \frac{4|\sigma_{z_A z_B}| \cdot |\bar{\mathbf{z}}_A| \cdot |\bar{\mathbf{z}}_B|}{(\sigma_{z_A}^2 + \sigma_{z_B}^2)(|\bar{\mathbf{z}}_A|^2 + |\bar{\mathbf{z}}_B|^2)}. \tag{9}$$

  Eq. (9) may be written as product of three terms:

$$Q4 = \frac{|\sigma_{z_A z_B}|}{\sigma_{z_A} \cdot \sigma_{z_B}} \cdot \frac{2\sigma_{z_A} \cdot \sigma_{z_B}}{\sigma_{z_A}^2 + \sigma_{z_B}^2} \cdot \frac{2|\bar{\mathbf{z}}_A| \cdot |\bar{\mathbf{z}}_B|}{|\bar{\mathbf{z}}_A|^2 + |\bar{\mathbf{z}}_B|^2} \tag{10}$$

  the first of which is the modulus of the hypercomplex CC between $\mathbf{z}_A$ and $\mathbf{z}_B$ and is sensitive both to loss of correlation and to spectral distortion between the two MS data sets. The second and third terms respectively measure contrast changes and mean bias on all bands simultaneously. Ensemble expectations are calculated as averages on $N \times N$ blocks. Hence, $Q4$ will depend on N as well. Eventually, $Q4$ is averaged over the whole image to yield the *global* score index. Alternatively, the minimum attained by $Q4$ over the whole image may represent a measure of *local* quality. $Q4$ takes values in [0, 1] and is equal to 1 only when $A = B$. $Q4$ has been recently extended to deal with images, whose number of bands is any power of two [29].

3.2. Wald's Protocol

A general protocol usually accepted in the research community for quality assessment of fused images was first proposed by [4] and re-discussed in [14]. Such a protocol relies on three properties the fused data have to satisfy.

The first property, known as *consistency*, requires that *any fused image* $\hat{A}$, *once degraded to its original resolution, should be as identical as possible to the original image* A. To achieve this, the fused image $\hat{A}$ is spatially degraded to the same scale of A, thus obtaining an image $\hat{A}^*$. $\hat{A}^*$ has to be very close to A. It is worthwhile that consistency measures spectral quality after spatial enhancement and is a condition necessary but not sufficient to state that a fused image possesses the necessary quality requirements, i.e. both spectral and spatial quality.

The second property, known as *synthesis* states that *any image* $\hat{A}$ *fused by means of a high resolution (HR) image should be as identical as possible to the ideal image* A_I *that the corresponding sensor, if existent, would observe at the resolution of the HR image*. Images are regarded here as scalar images, i.e.

one spectral band of an MS image. Similarity is measured by statistics of scalar pixels between fused image and ideal HR reference image. Besides scalar similarity indexes between individual bands of the MS image, the synthesis property is checked on the plurality of spectral bands constituting an MS image, in order to check the multispectral properties of the MS image, i.e. of the whole set of fused bands: *the multispectral vector of images $\vec{\hat{A}}$ fused by means of a high resolution (HR) image should be as identical as possible to the multispectral vector of ideal images $\vec{A}_I$ that the corresponding sensor, if existent, would observe at the spatial resolution of the HR image*. This second part of synthesis property is also known as third property. Both the synthesis properties may not generally be directly verified, since $\vec{A}_I$ is generally not available. Therefore, synthesis is usually checked at degraded spatial scales according to the scheme of Fig. 3. Spatial degradation is achieved by means of proper lowpass filtering followed by decimation by a factor equal to the scale ratio of Pan to MS data sets. The multispectral image $\vec{A}^*$ and the panchromatic image P^* are created from the original sets of images $\vec{A}$ and Pan. Pan is degraded to the resolution of the multispectral image and $\vec{A}$ to a lower resolution depending on the scale ratio for which fusion is assessed. The fusion method is applied to these two sets of images, resulting into a set of fused images at the resolution of the original MS image. The MS image serves now as reference and the second and third properties can be tested. It is noteworthy that fulfillment of synthesis properties is a condition both necessary and sufficient, provided that the similarity check performed at degraded spatial scale is consistent with the same check if it were hypothetically performed at the full scale; in other words, if the quality observed for the fused products is assumed to be close to the quality that would be observed for the fused products at the full scale. This point is crucial, especially for methods employing digital filters to analyze the Pan image. In fact, whenever simulations are carried out at degraded spatial scale, the lowpass filter of the fusion methods is cascaded with the lowpass filter used for decimation. Hence, fusion at full scale uses the former only; fusion at degraded scale uses the cascade of the former with the latter, that is, uses a different filter [20]. This explains why methods providing acceptable spatial enhancement at degraded scale yield poor enhancement when they are used at full scale [23].

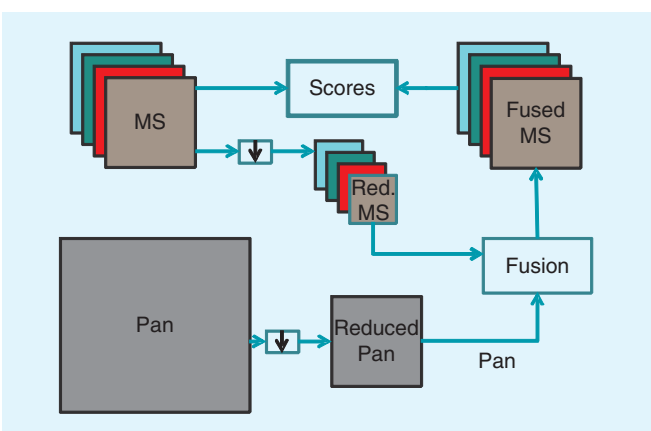

Figure 3. Procedure to assess Wald's synthesis property.

3.3. Zhou's Protocol

As an alternative to Wald's protocol, the problem of measuring the quality of fusion may be approached at the full spatial scale without any spatial degradation [21]. The spectral and spatial distortions are separately evaluated from the available data, i.e., from the original low-resolution MS bands and high resolution Pan image. The spectral distortion is calculated for each band as the average absolute difference between the fused band and the interpolated original bands, while the spatial quality is measured by the correlation coefficient (CC) between the spatial details of each of the fused MS bands and those of the Pan image; such details are extracted by means of a Laplacian filter and the outcome spatial CC (sCC) should in principle be as close to one as possible, though no evidence of that is given in the original paper [21] or in subsequent ones.

3.4. QNR Protocol

The Quality w/ No Reference (QNR) protocol [25] calculates the quality of the pansharpened images without requiring a high resolution reference MS image. QNR comprises two indexes, one pertaining to spectral and the other to spatial distortion. The two distortions may be combined together to yield a unique quality index. However, in many cases they are kept separate. Both spectral and spatial distortion are calculated through similarity measurements of couples of scalar images performed by means of UIQI.

The spectral distortion D_λ is calculated between the low resolution MS images and the fused MS images. Hence, for determining the spectral distortion two sets of inter-band UIQI values are calculated separately at low and high resolutions. The differences of corresponding UIQI values at the two scales yields the spectral distortion introduced by the pansharpening process. Thus, spectral distortion can be represented mathematically as:

$$D_\lambda = \sqrt[p]{\frac{1}{N(N-1)}\sum_{l=1}^{N}\sum_{r=1,\, r\neq l}^{N}\left|Q(\tilde{M}_l, \tilde{M}_r) - Q(\hat{M}_l, \hat{M}_r)\right|^p} \quad (11)$$

where, $\tilde{M}_l$ represents the low resolution lth MS band, $\hat{M}$ the pansharpened MS band, $Q(A, B)$ represents UIQI between A and B and N is equal to the number of MS bands. The exponent p is an integer possibly chosen to emphasize large difference values By default p is set equal to one.

The spatial distortion D_S is determined by calculating UIQI between each MS band and the Pan image degraded to the resolution of MS and again between fused MS and full resolution

Pan. The difference between the two values yields the spatial distortion:

$$D_s = \sqrt[q]{\frac{1}{N}\sum_{l=1}^{N}\left|Q(M_l, P_L) - Q(\hat{M}_l, P)\right|^q} \tag{12}$$

in which P_L denotes the Pan image degraded to the resolution of MS and P the high resolution Pan image. The exponent q is one by default.

The rationale of QNR protocol is the following:

1) The inter-relationships (measured by UIQI) between couples of the low resolution MS bands should not change with resolution, i.e. once the MS image has been pansharpened.
2) The relationships between each MS band and a low resolution version of the Pan image should be identical to those between each pansharpened MS band and the full resolution Pan image.
3) Differences in similarity values computed at low and high resolution measure the distortion, either spectral (MS-MS) or spatial (MS-Pan).

3.5. Khan's Protocol

Khan's protocol [26] borrows the consistency property from Wald's protocol, the matching of highpass spatial details from Zhou's protocol and the definition of spectral distortion from QNR protocol, in order to define separate spectral and spatial quality indexes at full scale. The unifying framework is that the pansharpened image can be regarded as the sum of a lowpass term, corresponding to the original interpolated low resolution MS image, and a highpass term, corresponding to spatial details extracted from Pan that have been injected. Such components are extracted by filtering the fused image with a bank of digital filters, the lowpass filter matching the shape of the MTF of the corresponding spectral channel, the highpass filter matching the one's complement of the MTF, that is, the highpass filter is an allpass filter minus the lowpass filter. Spectral quality is evaluated on such lowpass component, while spatial quality on the highpass one.

In a practical implementation, Gaussian models of the MTFs of instrument MS channels provide the lowpass components. Such components are decimated and the similarity with the original low resolution MS data is measured by means of Q4 [22], or any other similarity index for vector data if the number of bands is not four. The highpass components are simply given by the fused image minus the lowpass filtered image before decimation. Highpass details of Pan are extracted by means of the same highpass filter as MS. UIQI [28] is calculated between details of each fused MS band and details of Pan. The UIQIs of each band are averaged together to yield UIQI_H, which measures the similarity with Pan of spatial structures at high resolution. The procedure of highpass details extraction and matching is repeated for the original low resolution MS image and a spatially degraded version of Pan, achieved through a selective filter with 1:4 frequency cutoff. Thus, an index measuring the similarity with Pan of spatial structures at low resolution, UIQI_L, is obtained. Eventually, the (absolute) difference of UIQI_L and UIQI_H is taken as a measurement of spatial distortion.

4. Experimental Results

Quality assessments have been performed on very high-resolution image data acquired by the spaceborne IKONOS MS scanner, on the city of Toulouse, France. The four MS bands of IKONOS span the visible and NIR wavelengths and are non-overlapped, with the exception of B1 and B2. The bandwidth of Pan embraces the interval 450 ÷ 950 nm. The data set has been geo-coded to 4 m (MS) and 1 m (Pan) pixel size. The original Pan image is of size 2048 × 2048 and the original MS image of size 512 × 512. All statistics have been calculated on the whole fused image.

The following fusion methods have been utilized in the experiments. Generalized Intensity-Hue-Saturation (GIHS) [12]; Gram-Schmidt spectral sharpening [30], ENVI implementation (GS), with enhanced spectral transformation [15] (GS+) and context-adaptive detail injection model [17] (GSA+-CA); GLP-based method [11] with MTF adjustment [20] either without or with context-adaptive injection model [17] (GLP-CA). The "void" fusion method, corresponding to plain (bicubic) resampling of the MS dataset at the scale of Pan is included in the comparisons and referred to as EXP.

Firstly, the MS and Pan images were downsized by four to allow quantitative evaluations to be performed according to Wald's synthesis property. A Gaussian-like lowpass pre-filter with amplitude equal to 0.25 at Nyquist frequency has been used for all bands to avoid aliasing.

Fig. 4 shows the trends of average SAM (6), ERGAS (7) and Q4 (9). All indexes are substantially in accordance with one another and highlight advances in performances: GS is better than GIHS, as otherwise proven in [15]. However, when the spectral transformation of GS is optimized to yield GS+, performances become comparable with GLP, which is a method using MRA optimized to the instrument MTF. The introduction of a context-adaptive detail injection model (CA), same for both methods, allows further benefits to be achieved. In substance GS+-CA and GLP-CA, even though belonging to different classes of methods, perform identically.

The IKONOS data have been pansharpened at the full 1 m scale and QNR protocol has been applied. Table 1 reports values of the spectral distortion (11) and of the spatial distortion (12) that are separately calculated at full scale. Both distortions can be merged into a unique normalized quality index, referred to as QNR, for an easy comparison with indexes like UIQI and Q4. According to the QNR entry in Table 1, the ranking of fusion methods is substantially analogous to that in Fig. 4, e.g. Q4. A notable exception is the high QNR value

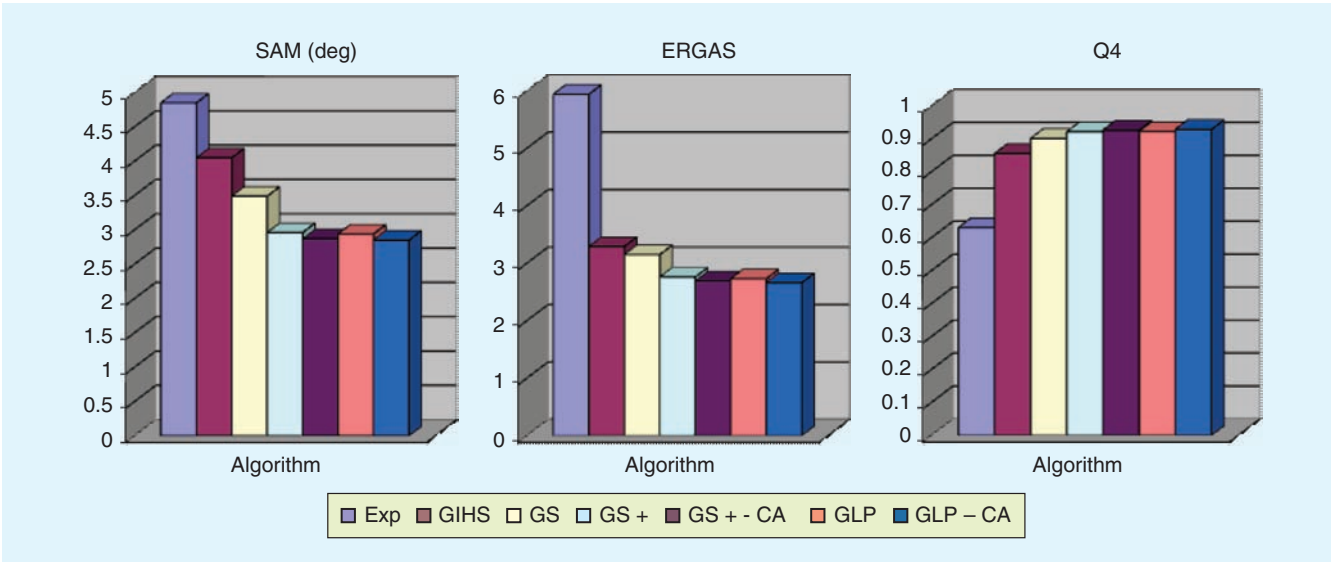

Figure 4. Distortion / Quality indexes calculated at degraded spatial scale according to the second of Wald's synthesis properties.

Table 1. Quality measures of pansharpened IKONOS data at full scale (1 m). QNR is defined as $(1 - D_\lambda)(1 - D_s)$ and is a global quality measurement in [0, 1], analogously to Q4.

	EXP	GIHS	GS	GS+	GS+-CA	GLP	GLP − CA
D_λ	0.002	0.125	0.055	0.056	0.034	0.075	0.066
D_s	0.168	0.139	0.096	0.087	0.073	0.099	0.082
QNR	0.830	0.753	0.854	0.862	0.895	0.834	0.857

of the resampled image (EXP), which is mostly due to the extremely low value of spectral distortion measured when no detail injection is performed. A proper nonlinear combination of D_λ and D_s, as that proposed in [25], might exactly match the trend of Q4 in Fig. 4, because the dependence of Q4 on spectral and spatial distortions is implicit and unknown.

Small fragments of original and pansharpened images are shown in Fig. 5 for all seven methods, including the *void* fusion EXP. By watching the EXP and GIHS icons one can realize why the QNR of EXP is higher than that of GIHS: because the former is under-enhanced ($D_s = 0.168$), but the latter is over-enhanced ($D_s = 0.139$) and also exhibits mediocre spectral quality ($D_\lambda = 0.125$) compared to the outstanding spectral quality of EXP ($D_\lambda = 0.002$).

5. Concluding Remarks

Whenever pansharpened data are used for automated tasks, like spatial/spectral feature extraction, and generally all applications based on analysis of spectral signatures and modeling of geophysical and biophysical processes, the quality of pansharpened products, trivially depending on the input data and type of fusion algorithm, becomes a crucial issue. While radiometric quality (SNR) of fusion products is generally lower than that of the original MS data, the spatial, or geometric, quality is greater than that of the original MS data and comparable to that of the Pan image. The main novelty of fusion methods developed over the last twelve years is that also spectral quality, or better spectral fidelity to the original low resolution MS data, may be thoroughly preserved. In other words, the information stemming from the spectral diversity of the original MS image is synthesized at the spatial scale of the fusion product, that is of the Pan image. Spectral quality, which can be associated to chromatic fidelity to originals in color compositions of three bands at a time, can be measured by means of statistical indexes and a suitable protocol, analogously to the spatial/geometric quality. The shortcoming of assessing quality at degraded spatial scale, that is the synthesis property check of Wald's protocol, does not allow spectral and spatial qualities to be separately measured.

Eventually, we wish to stress once more that the concept of *tradeoff* between the spectral and spatial qualities attainable by any fusion methods, introduced by several authors during the last few years, is definitely erroneous and occurs only if the two distortions are not correctly defined and/or measured. Therefore, whenever the design of a new fusion method is

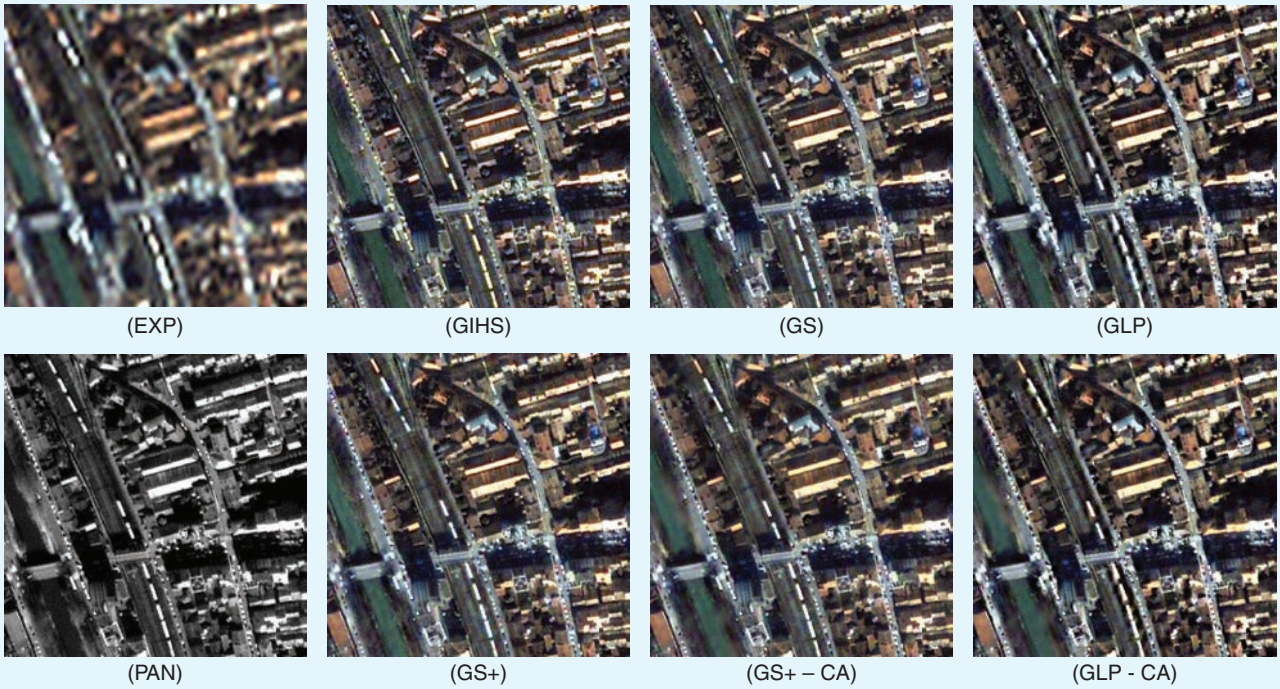

Figure 5. True color details at full scale (1 m): bicubically interpolated MS, Pan and six fusion products.

driven by some quality index, extreme care should be taken in the choice of the index, and related protocol, to avoid puzzling results.

Acknowledgments

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MONITORING THE GREAT EAST JAPAN EARTHQUAKE USING ALOS

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1. Introduction

Most of the Japanese people experienced an unforgettable nightmare on March 11, 2011. An earthquake of magnitude 9.0 (making it the world's fourth largest recorded earthquake) occurred at 2:46 p.m. Japan Standard Time at the plate border between the Pacific and North America, 150 km off the Ojika peninsula of Miyagi prefecture, Japan. Although the possible locations of earthquakes can be predicted, predicting the possible location of such an exceptionally large earthquake is difficult. The earthquake lasted about five minutes. The resulting tsunami, with a maximum height of 23 m as measured at Ofunato City, Iwate, struck the coastal Tohoku regions; the coastline length was greater than 500 km. The tsunami caused damage to property as well as human loss. The beautiful countryside of the Tohoku coastal areas was totally devastated. People hoped it could be a dream, but unfortunately, it was not. Before the earthquake, the Tohoku region was known for its agricultural production (i.e., rice and vegetables), the manufacture of electronic devices and cars, and electricity generation. The earthquake and tsunami dealt a devastating blow to these economic drivers, with losses estimated at approximately 200 billion USD.

2. ALOS Emergency Observations and Pi-SAR-L Flights

Immediately after the earthquake, the Japan Aerospace Exploration Agency (JAXA), which is a member of the International Disaster Charter, initiated the emergency observation of the disaster areas using the Advanced Land Observing Satellite (ALOS, Fig. 1(a)). Use of the L-band airborne SAR (Pi-SAR-L, Fig. 1(b)) began three weeks after the event. In this short article, we explain how these data sources proved useful.

ALOS, Japan's largest Earth observation satellite, was launched on Jan. 24, 2006. It carried three high-resolution sensors—the phase-array type L-band Synthetic Aperture Radar (PALSAR), and the advanced visible and near-infrared radiometer type-2 (AVNIR-2) and Panchromatic (PRISM). ALOS had four mission objectives: generation of a 1:25,000 map, disaster monitoring, regional observation (forest monitoring), and the location of resources. After a three-month mission check (from Jan. 24, 2006 to May 15, 2006) and five months for the initial calibration (from May 16, 2006 to Oct. 12, 2006), these sensors were put into standard operation. They collected eleven hours of data daily, supported by the Data Relay and Tracking Satellite (DRTS), for a total of one petabyte of data after five years of operation [1][2].

Table 1.ALOS images collected for the Tohoku-oki earthquake events.

Sensor	No. of orbits	No. of scenes
PALSAR	25 (4 ScanSAR + 21 Strip)	207
AVNIR-2	34	379
PRISM	3	57

When the ALOS mission was terminated on April 22, 2011, ALOS had operated for 62 orbits and collected 643 scenes of the Tohoku disaster. Table 1 displays the characteristics of the orbits and the scenes of these emergency events. PALSAR collected 207 scenes from 25 orbits, AVNIR-2 collected 379 scenes from 34 orbits, and PRISM collected 57 scenes from 3 orbits [3].

In addition, JAXA's airborne SAR, the Polarimetric Interferometric SAR in L-band (Pi-SAR-L), flew over the area for two days, on April 6 and 13, 2011. Pi-SAR-L provides a 3-m-resolution image with a 15 km swath in polarimetry mode.

As shown in Fig. 2, the Tohoku area can be covered by a ScanSAR strip of a descending orbit, and the east coastal area can be observed repeatedly by AVNIR-2 and PALSAR. Although the ascending pass is not as effective as the descending pass, many observational resources were focused on this area.

3. Change Detection

Using these data, we derived the following categories for the detection of changes: 1) Deformation using the Differential Interferometric SAR (DinSAR), 2) disaster area using the change-detection method, 3) estimation of the water-covered area and its temporal decrease, and 4) floating objects over the sea.

(a) (b)

Figure 1. (a) ALOS on left and (b) Pi-SAR-L on right.

3.1. Deformation Detection Using DinSAR

L-band SAR, PALSAR, has performed well in the area of interferometric change detection. Fig. 3(a) shows a mosaic of the surface deformation using eight PALSAR ascending strips, five of which cover most of the Tohoku area, and three of which cover the middle of Japan. This figure shows that the deformation caused by the M.9.0 earthquake had a large affect on much of Japan, not only the Tohoku region but also the middle part of the island. After March 11, 2011, there occurred several M7.0 or higher earthquakes, some of which were also detected (as shown in the square) in Ibaraki. Fig. 3(b) shows a mosaic of the surface deformation using the three PALSAR descending strips. These patterns show that the deformation occurred in concentric circles, with its epicenter 150 km off Ojika peninsula, Miyagi, Japan. Although these DinSAR data cannot explain the total amount of deformation due to the fact that there was too much deformation in Japan with no stable place found, the Geospatial Survey Institute determined that Japan shifted 5.2 m east and subsided 1.2 m at Ojika peninsula [4]. The background image is the PALSAR mosaic dataset generated in 2010 [5].

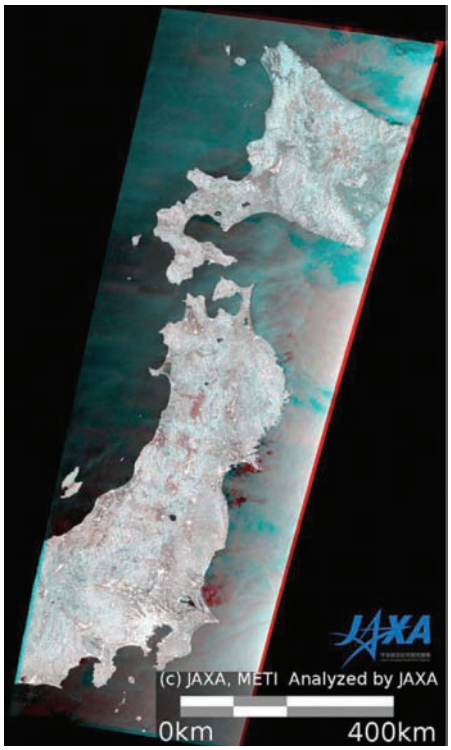

Figure 2. Overpass map for the Tohoku area, where the PALSAR ScanSAR data are shown. Two images are overlaid to illustrate the detection of changes, as described in the following section.

3.2. Change Detection

"Change detection" simply means ways to detect how and where the intensity or phase differs over two images. After the earthquake, PALSAR and AVNIR-2 were operated repeatedly for the Tohoku coastlines with different off-nadir angles. While AVNIR-2 provides radiance changes by comparing the two images manually, SAR cannot provide change information manually unless the change area is quite large. Since the SAR data were acquired in different off-nadir angles (because of the urgency of the observations for the limited area), an accurate co-registration of two images cannot be done unless ortho-rectification and slope correction are applied, the latter of which corrects the radiometric variation due to the terrain height variation. Fig. 4 shows the representative change detections obtained by AVNIR-2 and PALSAR for Souma-city and its surrounding area, Fukushima, Japan. Fig. 4(a) displays images acquired on March 14, and Fig. 4(b) presents images acquired on Feb. 27. The water-covered area can be confirmed

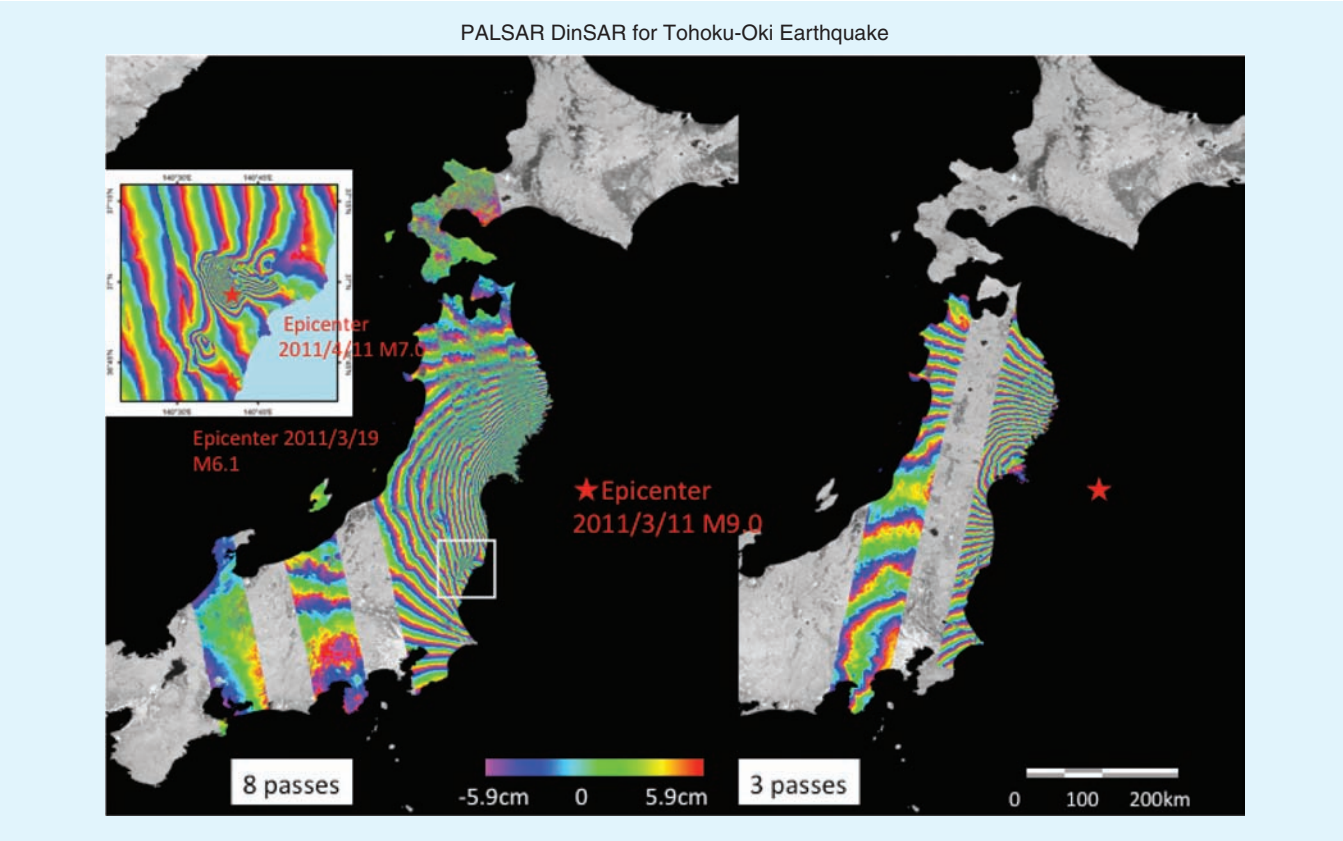

Figure 3. DinSAR-based deformation pattern caused by the 3.11 Mega Earthquake in the Tohoku-oki area, Japan. (a) Images on the left are from the ascending passes; (b) images on the right are from the descending passes.

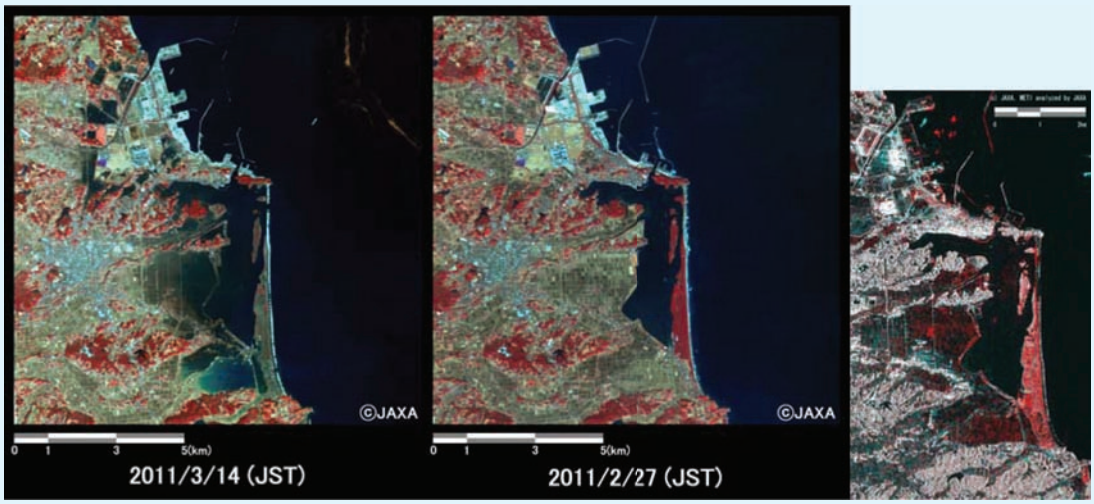

Figure 4. Three representative images obtained for the water-covered area in Souma-city, Fukushima, Japan. The two left images are from AVNIR-2, and the right one is the pseudo color showing the change detection with regard to the water coverage.

visually. Fig. 4(c) shows the PALSAR image overlay of before in red and after in green and blue, where the red region shows the non-water-covered area before and the water-covered area after the event. There is very clear evidence of the water coverage due to the tsunami. The distribution of floating objects on the ocean is also shown.

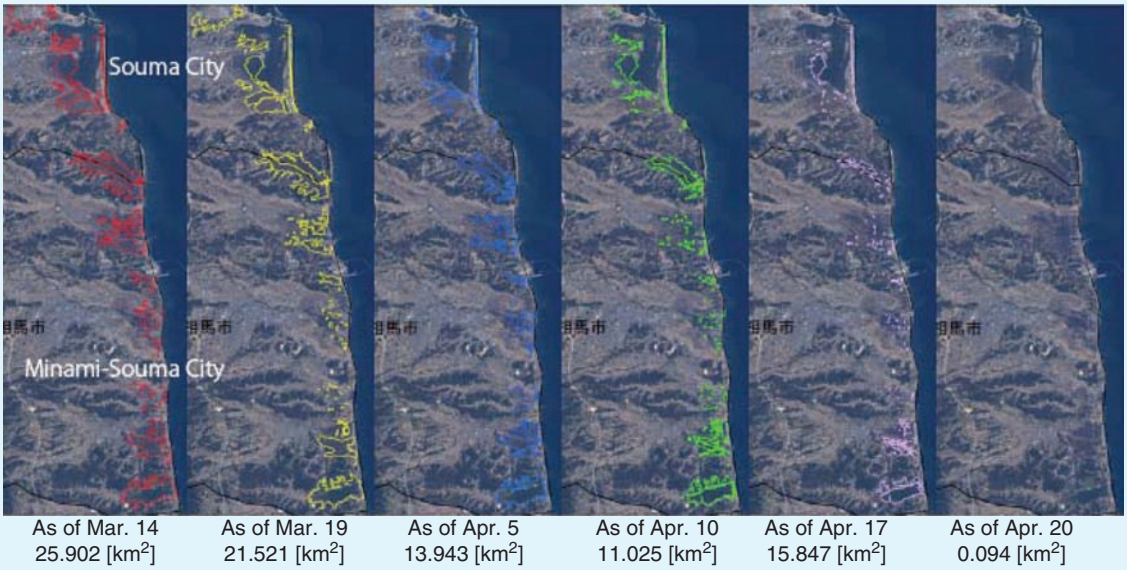

Figure 5. Estimated water-covered area using AVNIR-2 and its time-series change. The test area is Minami-Souma City.

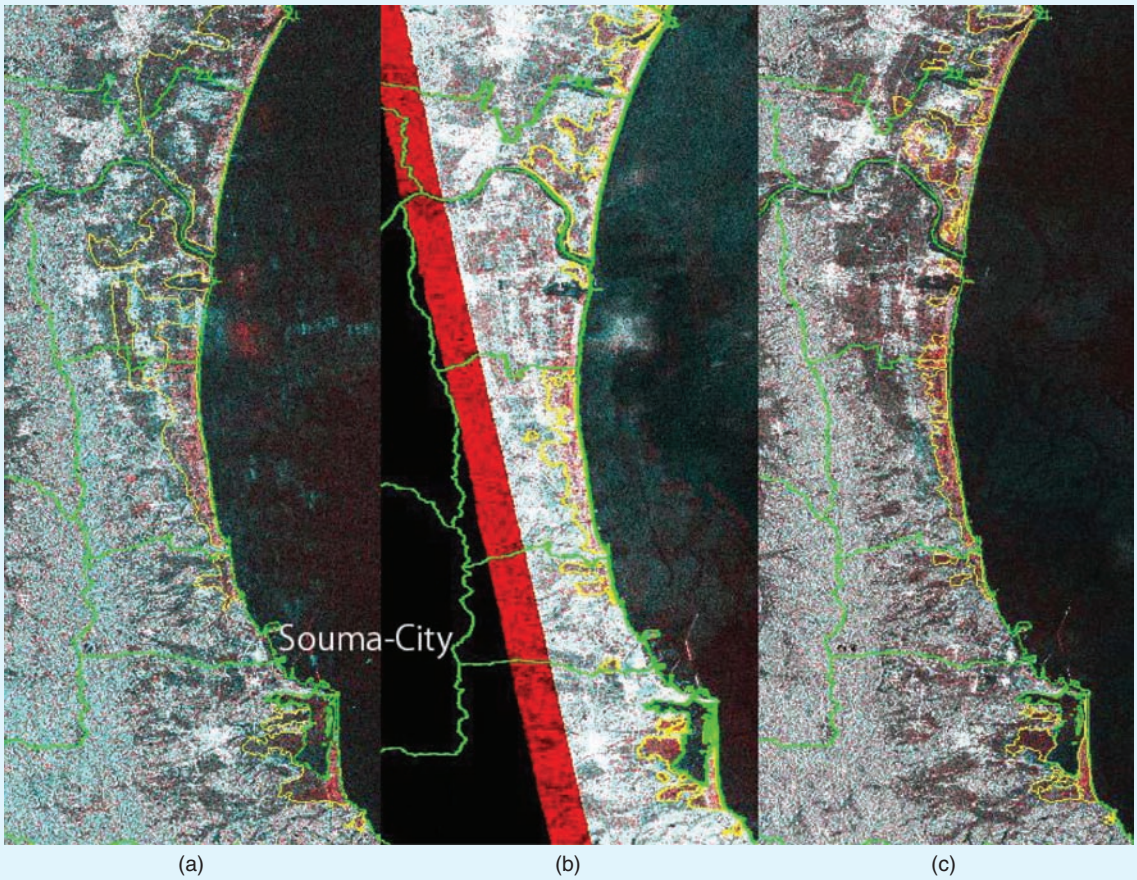

Figure 6. Estimated water-covered area (yellow line) using PALSAR and its time-series change, where the green line shows the governmental region. a) March 13, b) April 1, and c) April 7, 2011. The images cover Sendai, Miyagi to Minami-Souma City.

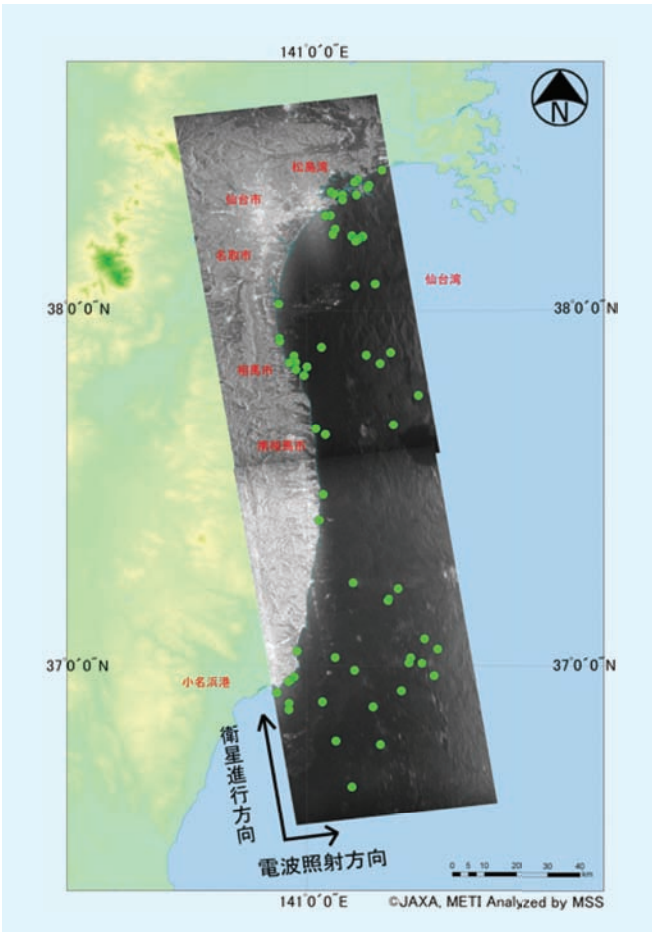

Figure 7. Floating objects on the sea. PALSAR with a 46.5° off-nadir angle was used. The image was acquired on March 13, 2011.

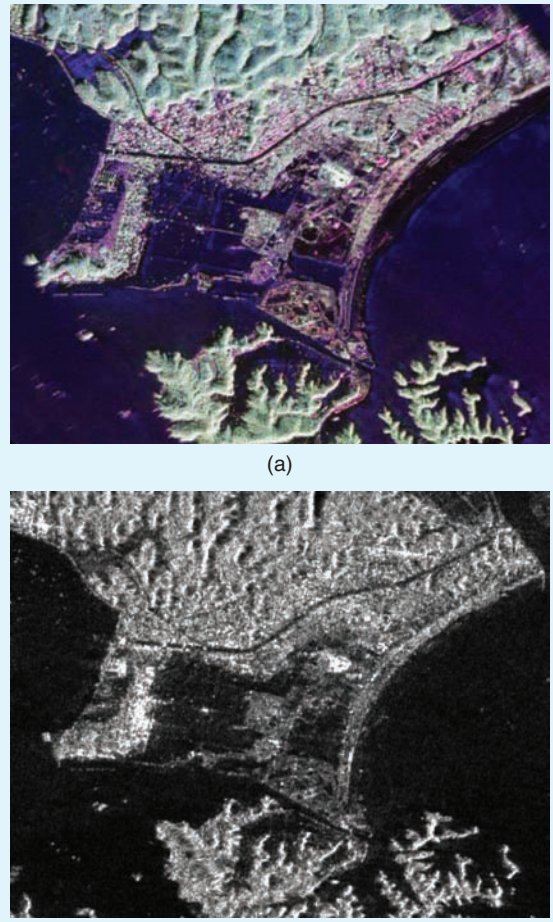

Figure 8. (a) Pi-SAR-L image at Wakabayashi Area, Sendai, on April 13, 2011, and (b) the corresponding PALSAR image.

3.3. Water-Covered Area and its Time Change

Due to the subsidence and the repeated tsunamis, most of the coastal and lowland areas were flooded by salt water. Soil contaminated with salt water cannot be adapted for rice production. Therefore, one of the main benchmarks for measuring the level of damage done to the agriculture was the estimation of the affected area and its temporal change. AVNIR-2 and PALSAR were individually used for this purpose. The target area was located almost parallel to the ALOS descending orbits (see Fig. 2), which were much more effective than the ascending passes. The AVNIR-2 provides four visible and infrared bands. Band 3, which ranges from 0.61 to 0.69 μm, has a lower reflectance from the water or water-covered areas. Using this principle with some appropriately selected threshold can provide the water-covered area. Manual interpretation of the area was combined with GIS software. While the PALSAR has the noise equivalent sigma-zero of –34 dB [2] and this value might be low enough to detect the target area, the coastal region is often contaminated with range ambiguities, which are caused by the brighter mountainous target nearby. Automatic detection of the water-covered area is very difficult. Thus, this is performed as a manual operation combined with GIS software as well as optical sensors. Fig. 5 shows a series of images of the water-covered area using AVNIR-2 for the Souma and South Souma City area, Fukushima. Fig. 6 presents the results for PALSAR in the Souma City area. From the AVNIR-2 images, we can estimate that the water-covered area decreased from 25.902 km^2 on March 14 2011 to 0.094 km^2 on April 20, 2011. The PALSAR results show that it decreased from 148.8 km^2 to 85.5 km^2, and then to 63.6 km^2.

3.4. Floating Objects on the Sea

Large amounts of debris due to the tsunami wound up floating on the sea. This debris was made up of various-sized objects, including ships, houses, buildings, cars, trees, etc. Since the scattered radar signal from this debris back to PALSAR was relatively brighter than the sea, it could be

detected easily. The signal-to-clutter ratio increases with the off-nadir angle; the larger off-nadir angle is appropriate to detect them [6]. Applying the simple threshold method, we can find several brighter targets in the ocean. Fig. 7 shows a sample image of the floating objects, for which 46.5° was used as the off-nadir angle [7].

3.5. Other Satellite Data

Since JAXA is a member agency of the International Charter, quite a large number of satellite data are provided, totaling more than 5800 (5700 for optical data and 100 for SAR data) [3]. They are Ikonos2, Geoeye-1, Quickbird-2, Worldview-1/2, SPOT-5, Kompsat-2, Rapideye, HJ, Landsat5-7, EO-1, Cartsat, Formasat-2, Theos, Dubaisat-2, Deimos-1, TerraSAR-X, RADARSAT12, ENVISAT, and COSMOSKYMED. The resolution ranges from 0.5 to 30 m of Landsat. The wavelength also has a wide variety of visible infrared to the microwave. JAXA would like express sincere thanks to all the members of the International Charter for this important information.

3.6. Airborne SAR Data Observations

Pi-SAR-L, JAXA's polarimetric, interferometric, and airborne SAR in L band, was also used to monitor the disaster area on April 7 and 13, 2011, almost one month after the disaster. The target areas were the coastal regions near Matsushima, Miyagi, which was one of the most heavily damaged areas. On these days, the surface was still covered by salty water and there remained a lot of garbage. Although Pi-SAR-L was not in full performance condition, the higher resolution and the polarimetric SAR data provided a better chance to examine the disaster area than the PALSAR image, as shown in Fig. 8.

4. Conclusions

Although seven months have passed since the earthquake (as of this writing), there is still a great deal of psychological suffering among the people of Japan. A poet who experienced the disaster first-hand and whose property was washed away by the tsunami right in front of her eyes, wrote, "It could be a dream but it was a reality." However, the best way to survive for the future is by preserving the energy and resources we have left today. Remote sensing is one of the most important methods for mitigating disasters. ALOS and the coordinated sensors provided a lot of information during this earthquake, and it was shown how they could be improved in the future. Based on these data, higher-performance satellites need to be built in the future to provide more effective information during times of disaster.

Acknowledgments

The authors would like to express their sincere thanks to all the researchers of JAXA and RESTEC, who collaborated to obtain the results presented in this letter.

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NEW SATELLITE MISSIONS

VENµS: TOWARDS HIGH QUALITY TIME SERIES OF OPTICAL IMAGES AT HIGH RESOLUTION

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1. Introduction

Time series of optical images acquired at high resolution are being used more and more frequently in various fields of research: change detection, land cover classification, biomass and yield estimates for agriculture, water demand monitoring, carbon and water budget, risk monitoring... However, obtaining high quality time series with a sufficient repetitivity of observations is not straightforward with the existing satellites: NASA/USGS LANDSAT satellites have been providing such data for a long time, but the 16 days cycle is often not sufficient on sites where cloud cover is frequent. CNES SPOT satellites can provide more frequent observations, but with changing observation angles and at a high cost. In the near future ESA's Sentinel-2 will provide such data with a much better repetitivity (5 days with 2 satellites), however it will not be sufficient to obtain a cloud free image per fortnight, on most sites.

In order to show all the potential of very frequent imagery at a high resolution, the French and Israeli Space agencies (CNES and ISA) are building a demonstration satellite named Vegetation and Environment monitoring on a New Micro Satellite (VENµS) [1]. This scientific mission aims at demonstrating the usefulness of repetitive acquisitions of high resolution images to monitor the dynamics of land surfaces, and especially vegetation. At least seventy sites around the world will be imaged by VENµS, every second day, during two years and a half. The Venµs products over these 70 sites will be provided to the scientific community at no charge. The resolution of VENµS products will be 10m, with a field of view of 27km. Thanks to the orbital repeat cycle of 2 days, a given site will be observed with a constant viewing angle. The instrument[2] will deliver images in 11 narrow spectral bands ranging from 415 nm to 910 nm. VENµS should be launched at the beginning of 2014.

All VENµS products will be ortho-rectified with a 0.3 pixel accuracy, the Level 1 will provide Top Of Atmosphere reflectance, the Level 2 will provide surface reflectances and a cloud/cloud shadows mask, and the Level 3 is a weekly composite of cloud free data.

VENµS sites will be chosen through a scientific call for proposal. A first call for proposal was issued in 2006, that yielded nearly 100 proposals and about 150 sites, but VENµS launch has been delayed since and a new call will be re-issued in 2012. Users who want to receive the new call may contact the authors.

2. VENµS Data Simulations and Applications

The development of VENµS products and its preparatory program benefited from the existence of the Taiwanese FORMOSAT-2 mission which has features very similar to Venµs' (See Table 1). Several time series of FORMOSAT-2 images were acquired over various sites: temperate agricultural sites in France (Muret, La Crau, Montelimar, Cestas), Spain (Barrax) or Canada (Ottawa), arid sites in Morocco (Tensift), Mexico (Yaqui) and Mali (Agoufou), mountain sites in Italy (Bardonecchia), Morocco (ATLAS) and Norway (Svalbard), desert sites (Libya and Mauritania), a tropical site at Reunion Island, a coastal and forest site in France (Arcachon) and an urban site in Canada (Montreal). Most of these data sets may be obtained for research purposes on demand to the authors.

These data sets were used to develop and test cloud detection and atmospheric correction methods ([3], [4]), and to produce level 2 products that were delivered to several test users. Figure 1 shows the smoothness of a time series for a wheat field pixel in Yaqui (Mexico). This excellent smoothness is mainly due to the absence of directional effects, since all acquisitions are made from the same viewing angle. Figure 2 shows the use of dense time series to determine the cutting date of irrigated meadows in South-East France [5]. Figure 3 compares the estimates with the water supplied to farmers by the local water authority. The gray dots in the plot correspond to fields where a part of the irrigation water comes from wells and is not accounted in the irrigation supplied [6]. In the fields where no well is available, the agreement is very good.

Table 1. Comparison of VENµS Formosat-2, Landsat and Sentinel-2 missions.						
Mission	**Repetitivity (days)**	**Resolution (m)**	**Field of view (km)**	**Acquisition capacity**	**Spectral bands**	**Launch date**
Venµs	2	10	28	100 sites	12 (VNIR)	2014
Formosat-2	1	8	24	A few sites	4	2004
Landsat	16	30	180	Global	7	1985
Sentinel-2	5 (2 satellites)	10–20	290	Global	13	2013

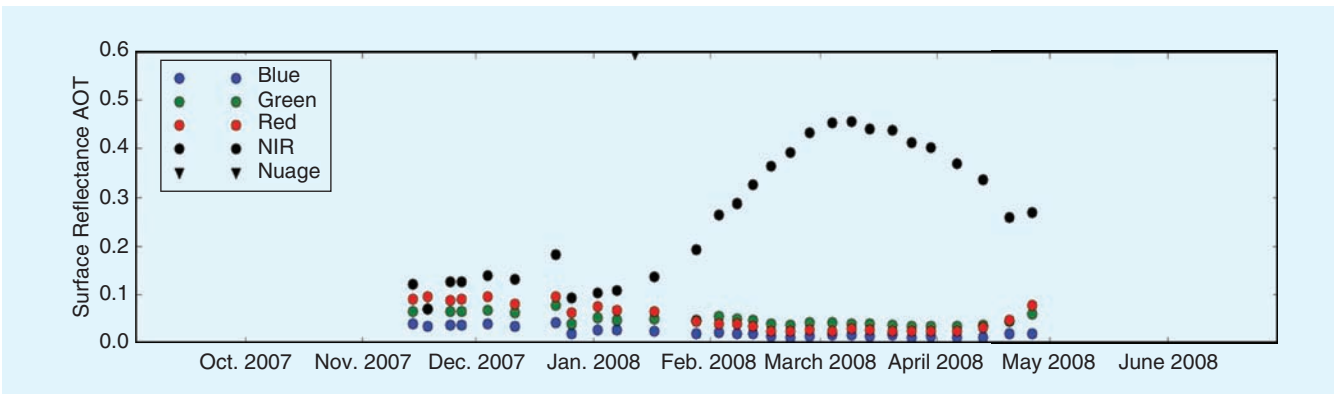

Figure 1. Surface reflectance of a wheat field near Yaqui (Mexico), as a function of time, for the 4 spectral bands of Formosat-2, processed to level 2. The crop was ploughed, sown and irrigated at the end of December 2007.

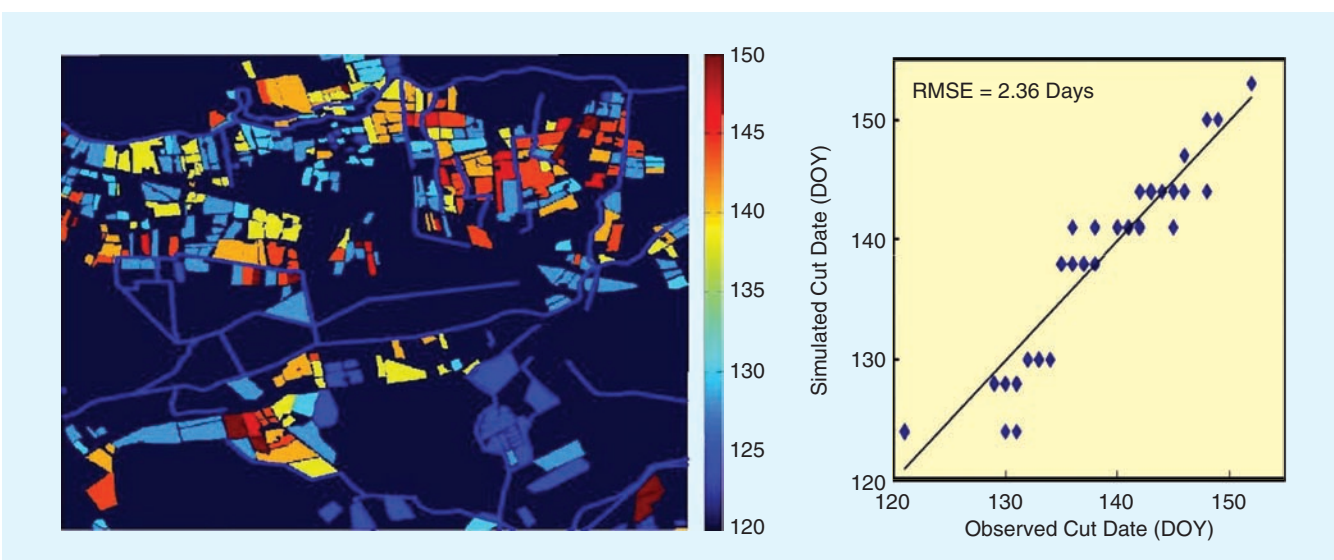

Figure 2. Estimate of cut dates of irrigated meadows from multi-temporal NDVI data obtained from Formosat-2 time series of images in La Crau (France). Cut dates are expressed as Day number Of the current Year (DOY).

Conclusion

As shown above, dense time series at a high resolution now allow a better monitoring of crop and water management thanks to the spatial and temporal scales very appropriate both to the field scale and time step of agricultural practice variability. Accurate parameters describing the surfaces can be obtained and used for various applications in Agronomy and hydrology. Formosat-2 data enabled to start to demonstrate some of the advantages of very dense image time series at high resolution over a limited number of sites. The coming launch of VENµS will soon enable to sharply increase the number sites continuously observed (with observations every second day, for

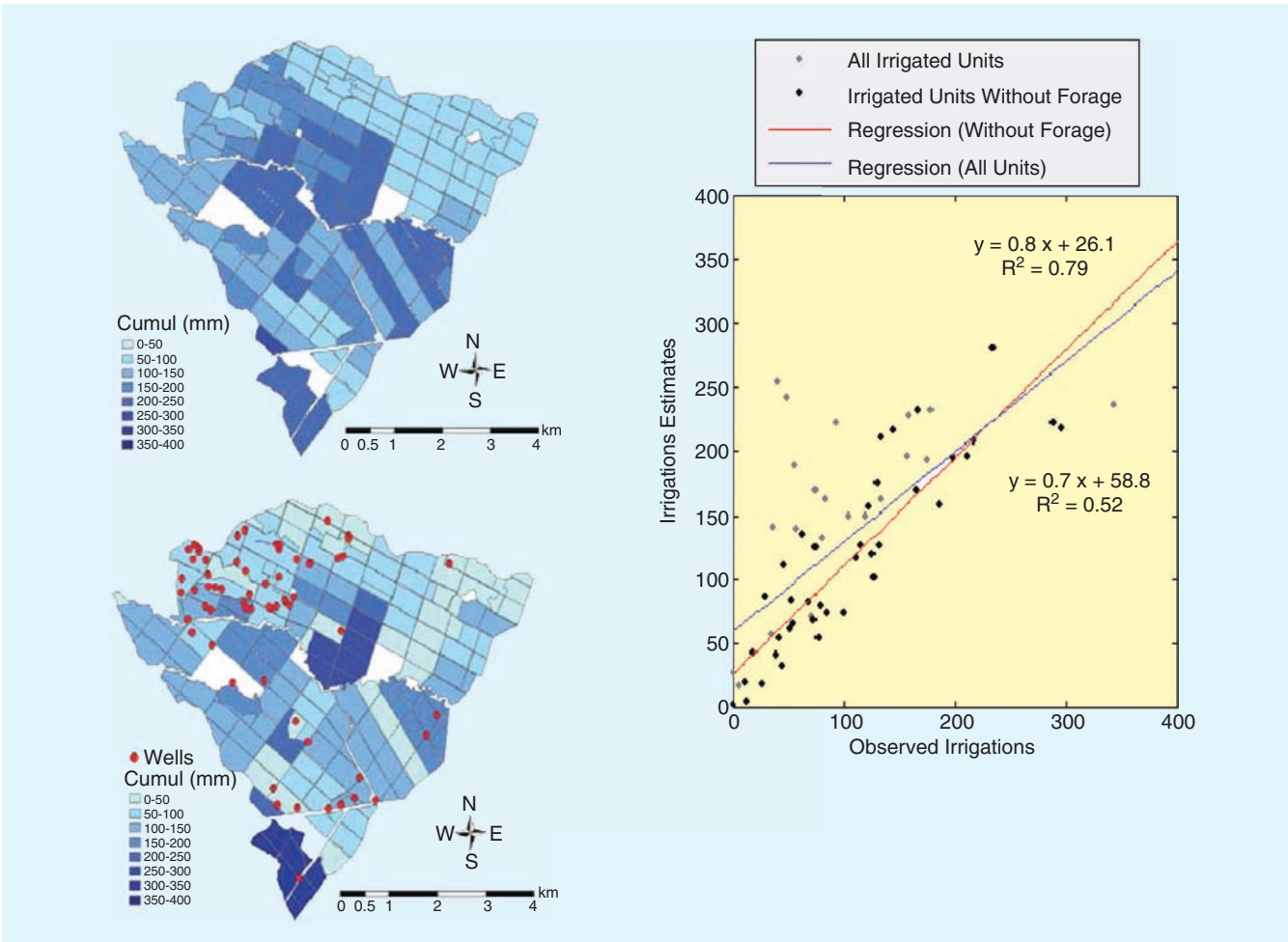

Figure 3. Comparison of estimates of needed irrigation volume (top left) with the measured irrigated dam water (bottom left). The scatter plot on the right shows that the agreement is excellent except in fields where wells are available (gray dots): the water pumped in the wells is not accounted for in the supplied irrigation volume.

at least two years, at 10 meters resolution). The scientific work that will be done with these data sets will help the remote sensing community to promote the launch of operational satellite constellations with a high multi-temporal repetitivity.

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REPORTS

IGRASS2011 SENDAI – VANCOUVER IEEE INTERNATIONAL GEOSCIENCE AND REMOTE SENSING SYMPOSIUM

Motoyuki Sato (Tohoku University, Japan), General Chair of IGARSS2011

1. Introduction

The IEEE GRSS Japan Chapter originally began preparations to host IGARSS (International Geoscience and Remote Sensing Symposium) in Japan in 2004. The first IGARSS in Japan was held in 1993 in Tokyo. After almost two decades, remote sensing technologies have seen tremendous development, and many countries (especially in Asia) have started very intensive research programs in these fields to help monitor and protect the environment. We can also find many good examples of international collaboration in earth environmental observation systems, and these were the motivations to invite the second IGARSS in Japan. In 2007, Sendai was selected as the city to host IGARSS2011.

We sent the call for papers to our colleagues after the IGARSS2010 meeting in Honolulu, and more than 2000 abstracts were submitted by January 2011. The technical committee meeting of IGARSS2011 was held in San Francisco on the 4th of March, and we selected the highest quality papers to be presented at the symposium.

Then the earthquake and the tsunami struck east Japan on the 11th of March 2011. The city of Sendai, one of the major cities in northeast Japan a population of 1 million, is located 150 km from the epicenter of this huge earthquake. More than 700 people were killed inside Sendai city alone, and almost 20,000 were killed all over Japan. Fortunately, Sendai has nearly recovered to its normal functioning. A few weeks after the earthquake, most of us had returned to our daily routine. However, at that moment the organizing committee still had many unknown factors that affected the planned symposium. In particular, some countries restricted trips to Japan.

We started a survey of alternative venues for IGARSS, and fortunately, we could find 10 session rooms and a technical exhibition area in the Vancouver convention center, one week before the originally scheduled start date of the IGARSS2011 in Sendai. Vancouver is located on the west coast of North America, and geographically not very far from Japan. Also, the city can easily be accessed from Europe, Asia, and other regions. We expected that the meeting venue could be moved with minimal inconvenience to the participants, and on the 25th of March, 2011, the President of IEEE GRSS Jón Atli Benediktsson, together with Motoyuki Sato, the General Chair of IGARSS 2011, officially announced the change of the venue.

At that point we had to prepare everything from the beginning. Although the original organization committee members continued their duties, we needed more help from the local community in Canada. Very fortunately, we were immediately offered warm and strong support from the Canadian Space Agency and the Canadian Remote Sensing Society. The local IEEE GRSS Chapter and universities and industries helped us with local organization. Our colleagues from the University of British Columbia were especially helpful in recruiting student volunteers, mostly from UBC but also from other local universities.

Figure 1. Vancouver Convention Centre.

Figure 2. Opening Session.

Figure 3. General Chair, Dr. Motoyuki Sato.

Figure 4. Dr. Masanobu Shimada.

For every IGARSS, IEEE GRSS provides travel grant to limited number of participants. Due to the change of venue, GRSS decided to provide additional Asian travel grant to 106 participants from Asian regions.

When the Symposium finally began, and we had 1475 registered participants from 56 countries, this year.

2. Organization Committee

The IGARSS is an annual symposium of IEEE-GRSS and a local organization committee steers the activities each year. The local committee of IGARSS2011 was composed mainly of Japanese members as listed below.

General Chair	Motoyuki Sato
Secretary	Yuya Yokota
Technical Co-Chairs	Yoshio Yamaguchi
	Ya-Qiu Jin
Finance Co-Chairs	Masanobu Shimada
	Takeo Tadono
	Osamu Isoguchi
Publicity Chair	Hiroshi Kimura
Sponsor/Exhibits Chair	Yoshihisa Hara
Sponsor/Exhibits	Makoto Satake
Industry Liaison	Koichi Kimura
	Koichi Kishi
Local Arrangements Co-Chairs	Hiroshi Kawamura
	David G. Michelson
Local Arrangement	Chinatsu Yonezawa
Student Activities Chair	Akira Hirose
Technical Tour Chair	Kazuo Oki
Tutorial Chair	Yoshikazu Iikura
Outreach Chair	Toru Sato
Conference Management	Billene Mercer, Conference Management Services, Inc.

3. Opening Session and Plenary

The opening session was introduced by the general chair of IGARSS2011, Dr. Motoyuki Sato. Then Dr. Jón Atli Benediktsson, President of IEEE GRSS, gave a welcoming speech to the symposium. His remarks were followed by speeches from Dr. Moshe Kam, President of IEEE, and Dr. Monique Bernier, representing Canada as the National Chair of the Canadian Remote Sensing Society.

The Major Awards and Recognitions event was chaired by GRSS Awards Co-Chair Dr. Martti Hallikainen.

After this ceremony, we had three talks in the plenary session. The first speaker, Dr. Masanobu Shimada (JAXA Principal Researcher, science program leader of the ALOS and ALOS-2 missions) gave a talk entitled "ALOS, Earth Monitoring, and 'Sayonara'". The Japanese earth observation satellite ALOS had been relaying data since 2006, but it stopped its operation in April 2011, shortly after the March 11 East Japan Earthquake. The ALOS satellite acquired valuable data for more than five years, and Dr. Shimada summarized its importance and introduced the continuing program of ALOS-2.

Then Dr. Shoichiro Fukao, Fukui (University of Technology/Research Institute for Sustainable Humanosphere, Kyoto University), gave a talk entitled "Advances in science and techniques for ground-based radar remote-sensing of the Earth's atmosphere". He has developed a middle- and upper atmospheric radar observation system "MU radar" in Japan, and he described the deployment of the system worldwide. Finally Mr.

Figure 5. Dr. Shoichiro Fukao.

Figure 6. Mr. Luc Brûlé.

Luc Brûlé (Director General, Space Utilization, CSA) gave a talk "The Evolution of Earth Observation in Canada – A perspective" and discussed the future of remote sensing in Canada.

Concluding the opening session, technical co-chairs Dr. Yoshio Yamaguchi and Dr. Ya-Qiu Jin introduced the remaining programs of the Symposium for attendees.

4. Tutorials

The tutorials offer very good opportunities for participants to see famous scientists attending the same meeting. Five full-day and six half-day tutorials were held on July 24th, one day prior to the opening of the IGARSS.

Full Day Tutorials:

FD-1: SAR Polarimetry: Basics, Processing Techniques, and Applications
Instructors: Eric Pottier, Jong-Sen Lee

FD-3: Recent Advances in Spectral Unmixing of Hyperspectral Data
Instructors: Qian Du, Antonio Plaza

FD-4: Advanced Classification Techniques for Remote Sensing
Instructors: Ranga Raju Vatsavai, Surya S. Durbha

FD-5: Image Information Mining – Methods and Applications Related to Earth Observation Data
Instructors: Mihai Datcu, Klaus Seidel

Half Day Tutorials:

HD-1: Data Models and Information Estimation in Multichannel Radar Remote Sensing
Instructor: Carlos Lopez-Martinez

HD-3: Complex-Valued Neural Networks in Remote Sensing and Imaging
Instructor: Akira Hirose

HD-4: InSar for Geoscientists
Instructor: Abuduwasiti Wulamu

HD-5: NPP Users Workshop
Instructor: John Furgerson

HD-6: SAR Tomography: from Basics to Applications
Instructor: Fabrizio Lombardini

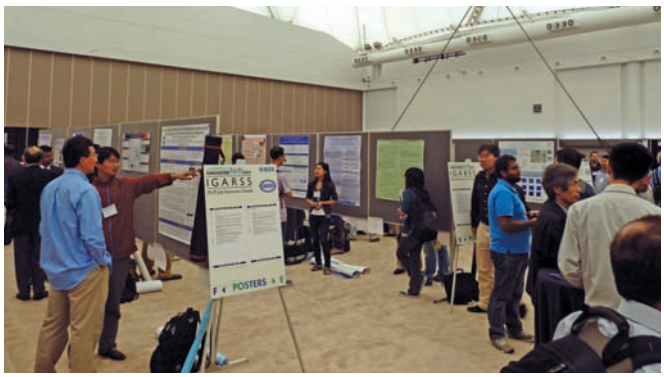


Figure 7. Poster session.

Figure 8. Hyperwall.

5. Technical Activities

The main theme of IGARSS 2011 was "Beyond the Frontiers: *Expand* our Knowledge of the World". In order to maintain a high-quality and attractive technical program of IGARSS, some technical themes were changed to accommodate participant interests and requests. International experts in each technical field served as TPC members to achieve this goal. They also introduced excellent new reviewers in their technical fields of expertise for reviewing papers.

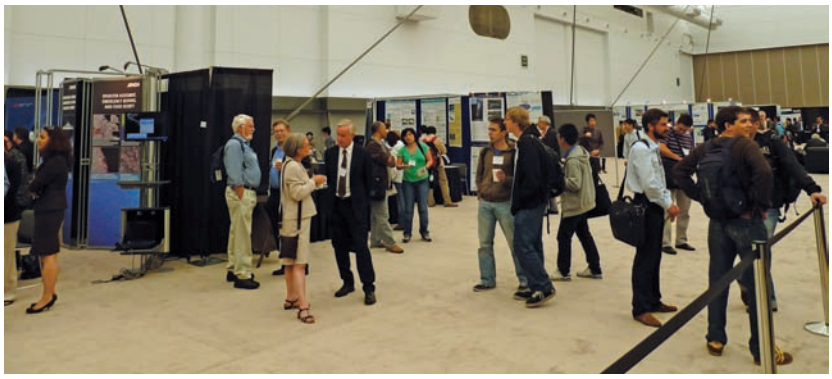


Figure 9. Technical exhibition

We would have had a total of 2216 abstracts submitted at the time of the original deadline (excluding 8 abstracts that were withdrawn due to submission errors, which had been critically reviewed by the experts. However, after the great March 11 earthquake struck the original Sendai venue, the location and dates of IGARSS 2011 were changed to keep the symposium safer and more effective. After this unexpected disaster, a number of papers were voluntarily withdrawn; the total number of papers withdrawn after acceptance reached as high as 351. We finally reorganized the program around 1497 accepted papers which were scheduled for presentation, including 288 for invited sessions and 1209 for contributed sessions; 661 papers were assigned to oral presentations and 836 for poster interactive sessions on Monday through Wednesday evening.

The presentations were organized into 173 half sessions of five oral papers each and 75 interactive poster sessions of up to 12 posters each. The technical program covered all remote sensing areas including advances in analysis techniques; applications to land, oceans, and atmosphere; environmental sensing; sensors and platforms; and data management/education and policy. In addition to these sessions, a "Special session on the great earthquake of East Japan on March 11, 2011" was presented showing very recent results obtained by remote sensing, and a poster session "Remote sensing in Canada" was organized by Canadian scientists. All these session organizations went very smoothly. The number of no-show poster presentations amounted to only 73 this year, which was the lowest number among all recent IGARSS events.

A total of 1134 papers and posters were published on the IGARSS 2011 DVD. We sincerely thank all TPC members for their efforts and hard work to bring about a very successful IGARSS2011.

Live webcast stated in IGARSS2010, and in this year, all the10 paralleled sessions were webcasted live. 75 students from UBC volunteered the operation.

6. Technical Exhibition

Nineteen companies attended the technical exhibition held from the afternoon of July 25 to July 28, including three platinum sponsors (JAXA, NASA, and NICT) and two silver sponsors (Mitsubishi Electric Corp. and NEC). Two companies canceled their attendance due to the change of the venue. The exhibition was held in the poster session area and attracted many participants. We would like to thank CMS, ICS convention design, and LEVY Show Service, Inc. for their hard work toward the success of the exhibition.

7. Social Activities

A welcoming reception was held on July 24th at the Vancouver Convention Centre. Participants met friends and colleagues gathered from more than 60 countries all over the world. This year's IGARSS awards evening took place at the Museum of Anthropology and the Nitobe Memorial Garden at the University of British Columbia. At the beginning of the event, participants enjoyed a walk through Nitobe Memorial Garden, one of the largest and most beautiful Japanese gardens in Canada, which honors the Japanese educator and statesman Inazo Nitobe who passed away in Victoria in 1933. He was appointed as the first assistant director general of the Leagues of Nations established in Geneva in 1920. This was a hard time for Japan, before the second World War. His words "becoming a bridge across the Pacific" are well known among Japanese; however, most Japanese recognize him by his portrait on the 5000 yen bank note. After the garden tour, the award ceremony started inside the Museum of Anthropology. Then, the handover of IGARSS2011 to IGARSS2012 team was held. A buffet reception party was held in a large tent outside the museum, and we enjoyed the pleasant breeze from the Pacific Ocean.

8. Outreach Activities

For the original Sendai meeting, we had planned to have public displays showing remote sensing technologies. Since remote sensing was very usefully employed for March 11 earth quake and tsunami, we decided to continue this idea in Vancouver.

Figure 10. Award ceremony.

JAXA and NASA jointly displayed remote sensing technology on the Hyperwall at the entrance to the Vancouver Convention Centre. The display was continuously shown and short oral presentations were also given. This area is a public space, so that not only the participants in IGARSS but also many visitors could observe the display and attend the presentations.

On July 28, we had two public activities. The first was the "Public Poster Display on March 11, 2011 East Japan Earthquake and Tsunami" prepared at the Exhibition Hall. More than 20 photographs were donated by the Japanese newspaper company, Kahoku Shimpo, located in Sendai. In addition, JAXA, NICT, RESTEC, and PASCO displayed remote sensing images and related information as posters in the same hall.

The second event was a public lecture by Dr. Shunichi Koshimura (Tohoku University, Sendai, Japan) entitled "The 2011 Tohoku Earthquake Tsunami Disaster: Its Impact and Lessons". Dr. Koshimkura is a tsunami scientist and reported the mechanism of the tsunami which occurred in Japan; he also discussed on the possibility of a tsunami in Vancouver. This lecture was open to the public, and local people also attended.

9. Young Professionals (YP)/GOLD luncheon

As a part of the Student Activities, IGARSS 2011 organized a "Young Professionals (YP) / GOLD" luncheon on July 26th. This is the fourth event of its kind at IGARSS, having received very strong reception in Boston, Cape Town and Honolulu. It was intended to provide a forum of discussion between current students and GOLD members (Graduates of the Last Decade) on career paths, skill sets beneficial to secure employment in the geosciences and remote sensing industries, as well as professional development opportunities. This year we received 50 YP/GOLD attendees. Seven invited and voluntary guests selected among the GRSS professionals with extensive careers in the field hosted YP/GOLD at respective tables with their attractive stories of career formation including missteps in their young days, excitement in the job, and friendship among colleagues.

10. Industry-University Liaison

This new event was organized by Dave Michelson, UBC and was hosted by the Vancouver Chapter of IEEE GRSS. Remote Sensing and GIS have widespread and important applications, including but not limited to mapping, imaging, tracking, and observing vegetation rates, erosion, pollution, forestry, weather, land use, and transportation. Applications of this technology can be used in a number of industries, including city planning, archaeological investigations, geomorphological surveying, and military observation. In order to strengthen the collaborations between industry and researchers, and to strengthen research and education in Remote Sensing and GIS, about 60 colleagues from the local GRSS chapter gathered in this meeting.

11. Conclusion

Although IGARSS2011 was shaken by the March 11 East Japan earthquake and tsunami, a very smooth transition was made from Sendai to Vancouver, and we were able to conclude the symposium successfully. We thank again our many colleagues who made it possible, and we feel very happy that we could host this important meeting without problems. Now more than half a year after the March 11 disaster, we cannot find any remnants of earthquake damages inside Sendai city. It is now our sincere hope to host IGARSS again in Japan, in order to demonstrate the quick recovery from the disaster in East Japan.

GRSS PUBLICATIONS AWARDS PRESENTED AT IGARSS 2011 BANQUET

Martti Hallikainen, IEEE GRSS Publications Awards Committee Chair

The IEEE Geoscience and Remote Sensing Society's 2011 Publications Awards were presented at the IGARSS Awards Banquet on Thursday, July 28 at the Museum of Anthropology of the University of British Columbia. Before the Banquet the attendees had an opportunity to visit the nearby Nitobe Memorial Garden, which is considered to be one of the best traditional Japanese gardens in North America and among the top five outside Japan. Nestled in two acres of native BC forest, this Shinto-style stroll garden includes a rare, authentic Zen garden and ceremonial Tea House. This tranquil oasis is a memorial garden created to enshrine the spirit of the Japanese scholar, educator and diplomat Dr. Inazo Nitobe (1862–1933). Set in BC and designed by Professor Mori from Chiba University, Japan, the garden realizes Dr. Nitobe's dream of "becoming a bridge across the Pacific" to foster inter-cultural understanding.

The Museum of Anthropology at the University of British Columbia is world-renowned for its collections, research, teaching, public programs, and community connections. It is also acclaimed for its spectacular architecture and unique setting on the cliffs of Point Grey. To extend its role as public and research institution, a major expansion and renewal project has been recently completed, creating new opportunities for research, teaching, and public enjoyment.

IGARSS 2011 General Chair Motoyuki Sato welcomed Banquet attendees and also provided information on the Nitobe Memorial Garden and Dr. Nitobe, who was honored in 1984 with his image on Japanese 5,000 yen note. The following awards were presented by GRSS President Jon Benediktsson and GRSS Publications Awards Chair Martti Hallikainen during the dinner:

- Transactions Prize Paper Award
- Letters Prize Paper Award
- J-STARS Prize Paper Award

Figure 1. Banquet attendees had an opportunity to visit the Nitobe Memorial Garden.

Figure 2. The venue for the Awards Banquet was the Museum of Anthropology.

Figure 3. Banquet attendees listening to the opening speech given by IGARSS 2011 General Chair Motoyuki Sato.

Figure 4. Chair of Publications Awards Committee Martti Hallikainen provided information on the Awards and announced the winners.

- Symposium Prize Paper Award
- Symposium Interactive Prize Paper Award
- Three Student Prize Paper Awards
- GOLD Award
- Three Certificates of Recognition.

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 2011 Transactions Prize Paper Award was presented to ***Andrea Abrardo, Mauro Barni, Enrico Magli, and Filippo Nencini***, with the citation:

For a very significant contribution to the field of endeavor of the IEEE GRS Society in the paper authored by Andrea Abrardo, Mauro Barni, Enrico Magli, and Filippo Nencini entitled ***"Error-Resilient and Low-Complexity Onboard Lossless Compression of Hyperspectral Images by Means of Distributed Source Coding,"*** *published in IEEE Transactions on Geoscience and Remote Sensing, Vol. 48, No. 4, pp. 1892–1904, April 2010.*

Andrea Abrardo graduated in Electronic Engineering at the University of Florence, Italy, in 1993. Since January 1994 to November 1994 he has worked in the Image Processing and Communications Laboratory of the Department of Electronic Engineering of the University of Florence collaborating with the Tuscany Region for the development of broad-band networks infrastructures. Since November 1994 to October 1997 he attended the Ph.D. at the same Department of Electronic Engineering. In June 1998 he got the Ph.D. degree discussing a Thesis on "Web based Teleradiology systems," In 1998 he joined the Department of Information Engineering of the University of Siena, Italy, as a Researcher. His current position at the Department of Information Engineering of the University of Siena is Associate Professor. His research interests are in the field of resource allocation strategies for wireless networks, with an emphasis on ad-hoc and sensor networks. He is currently teaching Digital Transmission and Mobile Communications at the University of Siena. As a result of his research activity he has published more than 90 works on international journals and conferences. During his research activity, he has been involved in several National and European Projects. In particular, he has been coordinator of the National project "Radio resource management and localization of users for multimedia vehicular applications," within the CNR-Agenzia2000 programme. Moreover, he has been local coordinator of the three years (2002–2005) National FIRB project "Reconfigurable Platforms for wide band radiomobile communications." The research activity in this context was in particular aimed at the definition and practical implementation of dynamic radio resource allocation strategies for OFDMA wireless systems. Eventually, he is WP leader in the ST@RT project following the activity: "Development of a wireless sensor network for the monitoring of historical and artistic edifices."

Mauro Barni graduated in electronic engineering at the University of Florence in 1991. He received the PhD in informatics and telecommunications in October 1995. He has carried out his research activity for almost 20 years first at the Department of Electronics and Telecommunication of the University of Florence, then at the Department of Information Engineering of the University of Siena where he works as associate Professor. During the last decade, his activity has focused on digital image processing and information security. Lately he has been working on the application of the Distributed Source Coding paradigm for lossless and lossy compression of remote sensing imagery. He is author/co-author of about 250 papers published in international journals and conference proceedings, and holds three patents in the field of digital watermarking. He is co-author of the book "Watermarking Systems Engineering: Enabling Digital Assets Security and other Applications", published by Dekker Inc. in February 2004. He is editor of the book "Document and

Image Compression" published by CRC-Press in 2006. He has been the chairman of the IEEE Multimedia Signal Processing Workshop held in Siena in 2004, and the chairman of the IV edition of the International Workshop on Digital Watermarking (IWDW 2005, Siena, September 15–17, 2005). In 2008, he was the recipient of the IEEE Signal Processing Magazine best column award. He was the founding editor in chief of the EURASIP Journal on Information Security. He serves as associate editor of the IEEE Trans. on Circuits and system for Video Technology and the IEEE Transactions on Information Forensics and Security. Prof. Barni is the chairman of the IEEE Information Forensic and Security Technical Committee (IFS-TC) of the IEEE Signal Processing Society. He has been a member of the IEEE Multimedia Signal Processing technical committee and of the conference board of the IEEE Signal Processing Society. Mauro Barni is a Senior Member of the IEEE and EURASIP.

Enrico Magli (M'01–SM'07) received the M.Sc. degree in electronics engineering and the Ph.D. degree in electrical engineering from Politecnico di Torino, Turin, Italy, in 1997 and 2001, respectively. He is now an Associate Professor at Politecnico di Torino. His research interests are in the field of distributed source coding, error-resilient image and video coding for wireless applications, compression of remote sensing images, and image security. He has coauthored more than 130 scientific papers in international journals and conferences and has organized several journal special issues and conference special sessions. He is an Associate Editor of the IEEE Transactions on Circuits and Systems for Video Technology, and of the EURASIP Journal on Information Security. Dr. Magli is currently a member of the Multimedia Signal Processing technical committee of the IEEE Signal Processing Society, the Multimedia Systems and Applications, and Visual Image Processing and Communications technical committees of the IEEE Circuits and Systems Society, and the Data Archiving and Distribution technical committee of the IEEE Geoscience and Remote Sensing Society. He has contributed to the ISO activities on JPEG 2000, and is co-editor of JPEG 2000 Part 11 (wireless applications). He is technical program co-chair of IEEE MMSP 2011 and IEEE ICME 2012, and has been a member of the technical program committee and session chair for several international conferences, including IEEE IGARSS, ICME, ICIP, ISCAS, ICASSP, MMSP, and ICC.

Filippo Nencini obtained the Laurea degree summa cum laude in telecommunication engineering from the University of Siena, Italy, in 2002, and the Ph.D. degree in information engineering in 2006 at the Department of Information Engineering of the University of Siena. From 2006 to 2008 he was a research associate at the same Department. He is currently employed as project manager by HespTechnology (San Giovanni Valdarno, Italy) working on image processing for cytogenetic, pathology and autoimmunity applications.

Figure 5. Andrea Abrardo (left) received the Transactions Prize Paper Award from GRSS President Jon Benediktsson.

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 2011 Letters Prize Paper Award was presented to ***Gustavo Camps-Valls, Joris Mooij and Bernhard Schölkopf*** with the citation:

*For a very significant contribution to the field of endeavor of the IEEE GRS Society in the paper authored by Gustavo Camps-Valls, Joris Mooij and Bernhard Schölkopf entitled "**Remote Sensing Feature Selection by Kernel Dependence Measures,**" published in IEEE Geoscience and Remote Sensing Letters, Vol. 7, No. 3, pp. 587–591, July 2010.*

Gustavo Camps-Valls (M'04, SM'07) was born in València, Spain in 1972, and received a B.Sc. degree in Physics (1996), a B.Sc. degree in Electronics Engineering (1998), and a Ph.D. degree in Physics (2002) from the Universitat de València. He is currently an Associate Professor in the Department of Electronics Engineering in the Universitat de València, where teaches electronics, advanced time series processing, and machine learning for remote sensing. He is also leading researcher at the Image Processing Laboratory (IPL), and has been visiting researcher at the Remote Sensing Laboratory (Univ. Trento, Italy) and at the Max Planck Institute for Biological Cybernetics (Tübingen, Germany). His research interests are tied to the development of machine learning

Figure 6. Francesca Bovolo (left) received the Letters Prize Paper Award on behalf of Gustavo Camps-Valls, Joris Mooij and Bernhard Schölkopf from GRSS President Jon Benediktsson.

algorithms for signal and image processing with special focus on remote sensing data analysis. He conducts and supervises research within the frameworks of several national and international projects, and he is Evaluator of project proposals and scientific organizations. He is the author (or co-author) of 70 international peer-reviewed journal papers, more than 100 international conference papers, 20 international book chapters, and editor of the books "Kernel methods in bioengineering, signal and image processing" (IGI, 2007), "Kernel methods for remote sensing data analysis" (Wiley & sons, 2009) and "Remote Sensing Image Processing" (Morgan & Claypool Publishers, 2011). He is a referee of many international journals and conferences, and currently serves on the Program Committees of International Society for Optical Engineers (SPIE) Europe, International Geoscience and Remote Sensing Symposium (IGARSS), International Workshop on Artificial Neural Networks (IWANN), Machine Learning for Signal Processing (MLSP), and International Conference on Image Processing (ICIP). Since 2007 he is member of the Data Fusion technical committee of the IEEE Geoscience and Remote Sensing Society, and since 2009 he is member of the Machine Learning for Signal Processing Technical Committee of the IEEE Signal Processing Society. He is involved in the MTG-IRS Science Team (MIST) of the European Organisation for the exploitation of Meteorological Satellites (EUMETSAT). He is Associate Editor of the ISRN Signal Processing Journal, IEEE Journal of Selected Topics in Signal Processing, and IEEE Geoscience and Remote Sensing Letters.

Joris M. Mooij was born in Nijmegen, the Netherlands, in 1980. He received the Master's degrees in physics and in mathematics in 2002 and 2003, respectively, both with honors, from the Radboud University Nijmegen, the Netherlands. In 2007 he received the Ph.D. degree in the natural sciences, mathematics and computer science, with honors, from the same university. From 2007 until 2010 he worked at the Max Planck Institute for Biological Cybernetics, Tübingen, Germany, as a research scientist. In 2011 he obtained a prestigious VENI grant from NWO, the Netherlands Organisation for Scientific Research, and started a post-doc at the Radboud University Nijmegen, the Netherlands. His main research interests are approximate inference in graphical models and causal discovery. He serves as (senior) program committee member on various conferences (NIPS, UAI, AISTATS, ICML). He is (co-)author of 19 international peer-reviewed journal and conference papers. One of these papers won the Best Student Paper Award at the 26th Conference on Uncertainty and Artificial Intelligence (UAI 2010). He also won in two categories of the 2010 UAI Approximate Inference Challenge.

Bernhard Schölkopf was born in Stuttgart on 20 February, 1968. He received an M.Sc. in mathematics and the Lionel Cooper Memorial Prize from the University of London in 1992, followed in 1994 by the Diploma in physics from the Eberhard-Karls-Universität, Tübingen. Three years later, he obtained a doctorate in computer science from the Technical University Berlin. His thesis on Support Vector Learning won the annual dissertation prize of the German Association for Computer Science (GI). In 1998, he won the prize for the best scientific project at the German National Research Center for Computer Science (GMD).

He has researched at AT&T Bell Labs, at GMD FIRST, Berlin, at the Australian National University, Canberra, and at Microsoft Research Cambridge (UK). He has taught at Humboldt University, Technical University Berlin, and Eberhard-Karls-University Tübingen. In July 2001, he was appointed scientific member of the Max Planck Society and director at the MPI for Biological Cybernetics; in October 2002, he was appointed Honorarprofessor for Machine Learning at the Technical University Berlin. In 2006, he received the J. K. Aggarwal Prize of the International Association for Pattern Recognition. The ISI lists him as a highly cited researcher. He serves on the editorial boards of JMLR, IEEE PAMI, and IJCV. He is on the boards of the NIPS Foundation and of the International Machine Learning Society.

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 GRS Society. 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 2011 J-STARS Prize Paper Award was presented *to* ***Michael Durand, Ernesto Rodríguez, Douglas E. Alsdorf, and Mark Trigg*** with the citation**:**

*For a very significant contribution to the field of endeavor of the IEEE GRS Society in the paper authored by Michael Durand, Ernesto Rodríguez, Douglas E. Alsdorf, and Mark Trigg entitled "**Estimating River Depth From Remote Sensing Swath Interferometry Measurements of River Height, Slope, and Width**," published in the IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, Vol. 3, No. 1, pp. 20–31, March 2010.*

Michael Durand received the B.S. degree in mechanical engineering and biological systems engineering from Virginia Polytechnic Institute, Blacksburg, in 2002, and the M.S. and Ph.D. degrees in civil engineering from the University of California, Los Angeles, in 2004 and 2007, respectively. He is currently an Assistant Professor with the School of Earth Sciences, The Ohio State University, Columbus.

Ernesto Rodríguez has worked at the Jet Propulsion Laboratory, California Institute of Technology on various aspects of remote sensing including altimetry, scatterometry, interferometry, scattering theory, and various geophysical applications of these data sets. He is currently the QuikSCAT Mission project scientist and the SWOT mission architect.

Doug Alsdorf and his research team study the Congo, Amazon, and other tropical, low relief wetlands. They are focused on understanding the enormous flux of water moving through these systems and the relationship of the water to flooding, ecology, and global change. Key methods involve spaceborne measurements of water surface elevations. Their research is a central part of a new satellite mission concept developed by an international team of scientists, engineers, and policy researchers. Doug Alsdorf is an alumnus of The Ohio State University (OSU), has a Ph.D. from Cornell University's Earth and Atmospheric Sciences Department, and is an Associate Professor in OSU's School of Earth Sciences. He serves as the Director of OSU's Climate, Water, and Carbon Program and is the U.S. hydrology lead for the SWOT satellite mission.

Mark Trigg received the B.Eng. degree in mechanical engineering from the University of Surrey, U.K., in 1991, and the M.Sc. degree in soil and water engineering in 1997 from Cranfield University, U.K. and the Ph.D. degree in geography from Bristol University, U.K., in 2010. He is currently a Postdoctoral Research Fellow studying surface water – groundwater interaction with the National Centre for Groundwater Research and Training, Flinders University, Australia.

4. 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 2011 Symposium Prize Paper Award was presented to ***Silvia Valero Valbuena, Philippe Salembier and Jocelyn Chanussot*** with the citation**:**

*For a very significant contribution to the field of endeavor of the IEEE GRS Society in the paper entitled "**New Hyperspectral Data Representation Using Binary Partition Tree**," co-authored by Silvia Valero Valbuena, Philippe Salembier and Jocelyn Chanussot, and presented at the 2010*

Figure 7. Michael Durand (right) received the J-STARS Prize Paper Award from GRSS President Jon Benediktsson.

Figure 8. Recipients of the Symposium Prize Paper Award Philippe Salembier (left), Silvia Valero Valbuena, and Jocelyn Chanussot with GRSS President Jon Benediktsson.

International Geoscience and Remote Sensing Symposium, July 2010, in Honolulu, Hawaii, IGARSS'10 Proceedings.

Silvia Valero Valbuena received the M.S. degree in electrical engineering from the Universitat Politècnica de Catalunya (UPC), Barcelona, Spain, in 2007, and the M.S. degree in computer science from the Grenoble Institute of Technology (Grenoble-INP), France, in 2008. Since 2008 she has been working toward the Ph.D. degree, a conjoint degree between the Grenoble-INP and the UPC. Her Ph.D. work is devoted to developing advanced image processing techniques for hyperspectral images. In particular, she is working on the construction and exploitation of hierarchical region-based representation for hyperspectral data. Her research interests are image processing, hyperspectral imaging, pattern recognition, information retrieval using spatial/spectral context and tree processing techniques.

Philippe Salembier received a degree from the Ecole Polytechnique, Paris, France, in 1983 and a degree from the Ecole Nationale Supérieure des Télécommunications, Paris, France, in 1985. He received the Ph.D. from the Swiss Federal Institute of Technology (EPFL) in 1991. He was a Postdoctoral Fellow at the Harvard Robotics Laboratory, Cambridge, MA, in 1991. Philippe Salembier is a Fellow of the IEEE. From 1985 to 1989, he worked at Laboratoires d'Electronique Philips, Limeil-Brevannes, France, in the fields of digital communications and signal processing for HDTV. In 1989, he joined the Signal Processing Laboratory of the Swiss Federal Institute of Technology in Lausanne, Switzerland, to work on image processing. At the end of 1991, after a stay at the Harvard Robotics Laboratory, he joined the Technical University of Catalonia, Barcelona, Spain, where he is currently professor lecturing on the area of digital signal and image processing.

His current research interests include image analysis, processing coding and indexing, segmentation, video sequence analysis, mathematical morphology, level sets and nonlinear filtering. In terms of standardization activities, he has been particularly involved in the definition of the MPEG-7 standard ("Multimedia Content Description Interface") as chair of the "Multimedia Description Scheme" group between 1999 and 2001. He served as an Area Editor of the Journal of Visual Communication and Image Representation (Academic Press) from 1995 until 1998 and as an AdCom officer of the European Association for Signal Processing (EURASIP) from 1994 until 1999. He has edited (as guest editor) special issues of Signal Processing on "Mathematical Morphology" (1994) and on "Video sequence analysis" (1998). He has also co-edited (with Prof. Fernando Pereira) a special issue of Signal processing: Image Communication on MPEG-7 Technology (2000). He was co-editor-in-chief of Signal Processing between 2001 and 2002. He was member of the Image and Multidimensional Signal Processing Technical Committee of the IEEE Signal Processing Society between 2000–2006 and was technical chair (with Prof. Ed. Delp) of the IEEE Int. Conf. on Image Processing, ICIP'2003 organized in Barcelona. He served as associate editor of the IEEE Transactions on Image Processing between 2002 and 2008 and of the IEEE Signal Processing Letters between 2005 and 2008. Finally, he is currently serving as associate editor of the Eurasip Journal on Image and Video Processing, Elsevier Signal Processing: Image Communication and the IEEE Transactions on Circuits and Systems for Video Technology.

Jocelyn Chanussot 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 a member of the IEEE Geoscience and Remote Sensing 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 Cochair of the GRS Data Fusion Technical Committee (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. He is a Senior Member of the IEEE (2004).

5. 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 2011 Interactive Session Prize Paper Award was presented to ***Ozy Sjahputera, Grant J. Scott, Matthew N. Klaric, Brian C. Claywell, Nicholas J. Hudson, James M. Keller, and Curt H. Davis*** with the citation:

For an exceptional paper posted in the Interactive Session of the International Geoscience and Remote Sensing Symposium, IGARSS'09 entitled ***"Clustering of Detected Changes in Satellite Imagery Using Fuzzy C-Means Algorithm,"*** *co-authored by Ozy Sjahputera, Grant J. Scott, Matthew N. Klaric, Brian C. Claywell, Nicholas J. Hudson, James M. Keller, and Curt H. Davis, and presented at the 2010 International Geoscience and Remote Sensing Symposium, July 2010 in Honolulu, Hawaii, IGARSS'10 Proceedings.*

Ozy Sjahputera (S'02 - M'06) received his BS degrees in Electrical Engineering and Computer Engineering in 1994 (summa cum laude and honors scholar), an MS degree in Electrical Engineering in 1996, and a Ph.D. in Computer Engineering & Science in 2004 from the University of Missouri-Columbia. Dr. Sjahputera recently joined DigitalGlobe Research and Development team as an R&D scientist specializing in computer vision. He previously served as a Research Assistant Professor in the Department of Electrical & Computer Engineering University of Missouri-Columbia. He is also a member of the Satellite and Remote Sensing Group at the Center for Geospatial Intelligence (CGI). He was a postdoctoral fellow with the Pathology and Anatomical Sciences Department, at the University of Missouri-Columbia Medical School where he performed multi-disciplinary bioinformatics research on cancer epigenetics. His research interest is on computational intelligence focusing on problems in pattern recognition, clustering, computer vision, fuzzy sets theory, fuzzy logic, and image processing with applications in scene analysis with spatial reasoning, linguistic description, bioinformatics, landmine detection, scene registration, change detection, and geospatial intelligence. His research results have been documented in 11 refereed journal publications and 16 symposia presentations and proceedings. Dr. Sjahputera has served as a referee for IEEE Transaction On Fuzzy Systems, Computational Biology and Bioinformatics, and Geoscience and Remote Sensing, and a number of conferences including IEEE International Geoscience and Remote Sensing Symposium and IEEE International Conference on Fuzzy Systems.

Grant J. Scott (S'02 - M'09) received the B.S. and M.S. degrees in computer science from the University of Missouri, Columbia, MO in 2001 and 2003, respectively. He received the Ph.D. degree in computer engineering computer science from the University of Missouri, Columbia, MO in 2008. He currently serves as an Assistant Research Professor in the Electrical and Computer Engineering Department at University of Missouri – Columbia. He preforms research as part of the Satellite and Remote Sensing Group at the Center for Geospatial Intelligence (CGI). During his Ph.D studies, he was a member of the Medical and Biological Digital Library Research Lab and the Center for Geospatial Intelligence at the University of Missouri, conducting research in the areas of high performance multimedia retrieval systems (databases), hybrid retrieval systems and protein structural retrieval/comparison engines, and high-resolution satellite image processing. During the course of his MS degree, he was a member of the Computational Intelligence Research Laboratory, with research emphasis in computational intelligence, pattern recognition, neural networks, fuzzy systems, image processing/machine vision, and bio-medical image databases. His current research is in the area of automated exploitation of high-resolution satellite imagery, including geospatial database development, imagery feature-extraction algorithm development, and distributed automatic imagery processing orchestration architectures. His research interests also include high-dimensional indexing and content-based retrieval in biomedical and geospatial databases. Other research interest includes computer vision, pattern recognition, computational intelligence, databases, parallel/distributed systems, and information theory in support of media databases systems.

Figure 9. John Kerekes (right) received the Interactive Session Prize Paper Award on behalf of Ozy Sjahputera, Grant J. Scott, Matthew N. Klaric, Brian C. Claywell, Nicholas J. Hudson, James M. Keller, and Curt H. Davis, from GRSS President Jon Benediktsson.

Matthew N. Klaric (S'06 – M'11) received the Ph.D. degree in computer engineering and computer science from the University of Missouri—Columbia in 2010. He graduated summa cum laude and received the Honors B.S. degree in computer science from Saint Louis University, St. Louis, MO, in 2003. He is currently an Assistant Research Professor at the Center for Geospatial Intelligence and the Department of

Electrical and Computer Engineering at the University of Missouri—Columbia. While pursuing his Ph.D. he worked at the University of Missouri as a Research Assistant in the Medical and Biological Digital Library Research Laboratory and at the Center for Geospatial Intelligence. Additionally, he served as an Instructor for several undergraduate computer science classes for the Department of Computer Science. Previously, he worked as a Teaching Assistant for introductory computer science courses at Saint Louis University. His current areas of research include geospatial content-based retrieval, image processing, pattern recognition, data mining and geospatial intelligence. Dr. Klaric is a member of the Institute of Electrical and Electronics Engineers (IEEE) and the IEEE Geoscience and Remote Sensing Society. He has served as a referee for the IEEE Transactions on Geoscience and Remote Sensing (TGRS) and multiple IEEE International Geoscience and Remote Sensing Symposium (IGARSS) conferences.

Brian C. Claywell (S '04) received the B.S. (summa cum laude and honors scholar) in electrical engineering in 2005 from the University of Missouri – Columbia. He is currently studying for the M.S. in electrical engineering and is a Graduate Research Assistant in the University of Missouri – Columbia Department of Electrical & Computer Engineering at the Center for Geospatial Intelligence. His research interests include computer vision, computational intelligence, and pattern recognition with applications to activity detection in both still images and video.

Nicholas J. Hudson was born in Naperville, Illinois, USA and received a B.S. in computer engineering from the University of Missouri-Columbia in 2005. He has worked as a research assistant in power quality analysis; satellite image change detection and feature extraction; and biological experiment control systems. He has served as a teaching assistant and instructor for microprocessor and embedded system courses in the Department of Electrical and Computer Engineering at the University of Missouri-Columbia. Currently he is occupied full-time with finishing his M.S. in electrical engineering at the University of Missouri-Columbia.

James M. Keller received the Ph.D. in Mathematics in 1978 from University of Missouri-Columbia. He holds the University of Missouri Curators' Professorship in the Electrical and Computer Engineering and Computer Science Departments on the Columbia campus. He is also the R. L. Tatum Professor in the College of Engineering. His research interests center on computational intelligence: fuzzy set theory and fuzzy logic, neural networks, and evolutionary computation with a focus on problems in computer vision, pattern recognition, and information fusion including bioinformatics, spatial reasoning in robotics, geospatial intelligence, sensor and information analysis in technology for eldercare, and landmine detection. His industrial and government funding sources include the Electronics and Space Corporation, Union Electric, Geo-Centers, National Science Foundation, the Administration on Aging, The National Institutes of Health, NASA/JSC, the Air Force Office of Scientific Research, the Army Research Office, the Office of Naval Research, the National Geospatial Intelligence Agency, the Leonard Wood Institute, and the Army Night Vision and Electronic Sensors Directorate. Professor Keller has coauthored over 350 technical publications.

Jim Keller is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) and the International Fuzzy Systems Association (IFSA), and a past President of the North American Fuzzy Information Processing Society (NAFIPS). He received the 2007 Fuzzy Systems Pioneer Award and the 2010 Meritorious Service Award from the IEEE Computational Intelligence Society. He finished a full six year term as Editor-in-Chief of the IEEE Transactions on Fuzzy Systems, is an Associate Editor of the International Journal of Approximate Reasoning, and is on the editorial board of Pattern Analysis and Applications, Fuzzy Sets and Systems, International Journal of Fuzzy Systems, and the Journal of Intelligent and Fuzzy Systems. Jim was the Vice President for Publications of the IEEE Computational Intelligence Society from 2005–2008, and is currently an elected AdCom member. He is the IEEE TAB Transactions Chair and a member of the IEEE Publication Review and Advisory Committee. He was the general chair of the 1991 NAFIPS Workshop and the 2003 IEEE International Conference on Fuzzy Systems.

Curt H. Davis (S '90 – M'92 – SM '98 – F'08) received the B.S. degree and Ph.D. degree in Electrical Engineering from the University of Kansas, Lawrence, KS in 1988 and 1992, respectively. He is presently the Naka Endowed Professor of Electrical & Computer Engineering at the University of Missouri – Columbia (MU) and Director of the Center for Geospatial Intelligence. His primary research involves the use of satellite microwave and optical remote sensing systems for applications in the areas of earth observation and science, ice sheet mapping and change detection, and urban area geospatial information processing. His ice sheet mapping and change detection research has been funded by NASA and NSF, and he is an internationally recognized expert in the measurement of polar ice sheet change using precision satellite altimeters, the influence of climate on these changes, and the impact of these changes on global sea levels. His urban area research focuses on the automated processing and development of high-resolution geospatial information products. Examples include high-resolution digital elevation models, urban land cover maps, automated feature extraction of anthropogenic features, and automated change detection. His research results have been documented more than 45 refereed journal publications and 70 symposia presentations and proceedings. His most significant scientific results have been published in top scientific journals like Science, Nature, and the Journal of Geophysical Research, while the majority of his technical contributions to the field of remote sensing have been published in the IEEE Transactions on Geoscience and Remote Sensing.

Dr. Davis was recently named an IEEE Fellow for his "contributions to satellite remote sensing". He has received numerous awards throughout his career. Examples include the NSF Antarctica Service Medal (1988, 1989), International Union of Radio Science (URSI) Young Scientist Award (1996), and the NASA New Investigator Program (1996–1999). Dr. Davis served as the Technical Program Co-Chairman of the 2004 IEEE Geoscience and Remote Sensing Symposium held in Anchorage, Alaska, and he presently serves as an Associate Editor for the IEEE Transactions on Geoscience and Remote Sensing.

Figure 10. Recipient of the Third Student Prize Paper Award Adel Elsherbini was not able to attend the Awards Banquet.

6. 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).

6.1. 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 2011 in Vancouver 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 Student Prize Paper Award was presented to ***Adel Elsherbini*** with the citation:

For the paper ***"Image Distortion Effects in Subsurface SAR Imaging of Deserts and Their Correction Technique."***

His advisor is Kamal Sarabandi from the University of Michigan.

Adel Elsherbini (S'04) received the B.S. and M.S. degrees in electrical engineering from Ain Shams University, Cairo, Egypt in 2004 and 2008, respectively and the Ph.D. degree in electrical engineering from the University of Michigan, Ann Arbor in 2011. He is now with Intel Corporation, Components Research, Chandler, AZ. His research interests include subsurface remote sensing and UWB antenna design. Mr. Elsherbini is a member of Phi Kappa Phi, Sigma Xi, Tau Beta Pi and Eta Kappa Nu. In 2008, he received the 2nd prize at the URSI General Assembly student paper competition for his paper on ultra-wideband antennas and the Rakham International Student Fellowship from the University of Michigan. In 2010, he received the 2nd prize in the 2010 USNC/URSI National Radio Science Meeting student paper contest and the 1st prize in the University of Michigan Graduate Symposium for his research on subsurface remote sensing.

The Second Student Prize Paper Award was presented to ***Mauro Dalla Mura*** with the citation:

For the paper ***"A General Approach to the Spatial Simplification of Remote Sensing Images Based on Morphological Connected Filters."***

His advisors are Lorenzo Bruzzone from University of Trento and prof. Jon Atli Benediktsson from University of Iceland.

Mauro Dalla Mura received the laurea (B.S.) and laurea specialistica (M.S.) degrees in Telecommunication Engineering from the University of Trento, Italy, in 2005 and 2007, respectively. He obtained in April 2011 the Ph.D. Degrees in Information and Communication Technology (Telecommunications Area) and in Electrical and Computer Engineering from the University of Trento and University of Iceland, respectively.

He is currently with the Remote Sensing Laboratory (RSLab) at the Department of Information Engineering and Computer Science, University of Trento. His main research activities are in the fields of remote sensing, image processing and pattern recognition. In particular, his interests include mathematical morphology, feature extraction techniques and classification. Dr. Dalla Mura is a Reviewer for the IEEE Transactions

Figure 11. Recipient of the Second Student Prize Paper Award Mauro Dalla Mura (right) with GRSS President Jon Benediktsson.

on Geoscience and Remote Sensing, the IEEE Geoscience and Remote Sensing Letters, the IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, the ISPRS Journal of Photogrammetry and Remote Sensing, the EURASIP Journal on Advances in Signal Processing, the Photogrammetric Engineering and Remote Sensing (PE&RS), the Journal of Selected Topics in Signal Processing, the IET Image Processing, and the Canadian Journal of Remote Sensing.

6.2. 2011 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).

The 2011 IEEE Mikio Takagi Student Prize was presentedto ***Xueyang Duan*** with the citation:

For the paper ***"Vector Electromagnetic Scattering from Layered Rough Surfaces with Buried Discrete Random Media for Subsurface and Root-Zone Soil Moisture Sensing."***

Her advisor is Mahta Moghaddam from the University of Michigan.

Xueyang Duan (S'07) received her B.Eng. degree in communication engineering from Shandong University, Jinan, China in 2004 and M.S. degree in microelectronics, communications technology from the University of Ulm, Ulm, Germany in 2006. From 2006 to 2007, she was with the Test and Measurement Division, Rohde & Schwarz, Munich, Germany, as a development engineer for vector network analyzer. She is currently working toward the Ph.D. degree in the Radiation Laboratory of the department of Electrical Engineering and Computer Science at the University of Michigan, Ann Arbor, USA, where she received her M.S. degree in applied mathematics in 2010. Her research interests include forward and inverse modeling of electromagnetic scattering from layered rough surfaces with or without buried objects, radar system design and radar measurements of vegetation and ground variables.

7. 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 2011 GOLD Early Career Award was presented to ***Franz Meyer*** with the citation

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

Franz Meyer (S'03-A'03-M'04) received the Diploma in geodetic engineering and the Doctor of Engineering degree from Technische Universität München, Munich, Germany, in 2000 and 2004, respectively. From August 2000 to September 2003 he was with the Chair for Photogrammetry and Remote Sensing of the Technische Universität München, where he mainly worked on SAR Interferometry and differential SAR Interferometry. From October 2003 to

Figure 12. The IEEE Mikio Takagi Student Prize recipient Xueyang Duan (right) with GRSS President Jon Benediktsson.

Figure 13. Franz Meyer (right) received the GOLD Early Career Award from GRSS President Jon Benediktsson.

February 2007 he was a scientific employee at the Remote Sensing Technology Institute, German Aerospace Center (DLR), Oberpfaffenhofen. There, his scientific work was focused on SAR Interferometry techniques for current and future SAR satellites (e.g. TerraSAR-X and -L), the conception of algorithms for traffic monitoring using SAR satellites (e.g. TerraSAR-X), the correction and modeling of atmospheric effects in INSAR data, and Persistent Scatterer Interferometry. From March 2007 until September 2008 he was with the Alaska Satellite Facility (ASF), University of Alaska Fairbanks, Fairbanks, Alaska, USA as a research scientist. Since October 2008 he is Research Assistant Professor Radar Remote Sensing at the Geophysical Institute, University of Alaska Fairbanks, where his current work includes studies of ionospheric and tropospheric effects on SAR and InSAR, new methods of SAR Interferometry processing, SAR Interferometry applications, SAR processing, and SAR data quality analysis. He is the author of more than 50 scientific publications, including three being acknowledged as "Best Papers."

8. Certificates of Recognition

In the past Certificates of Recognition have been in most cases presented to persons, who have provided continuous contributions and leadership to the GRSS Administrative Committee and the GRS Society. In 2011 three Certificates of Recognition were presented for scientific and technical merits.

A Certificate of Recognition was presented to ***Yann Kerr, Jordi Font and Manuel Martin-Neira*** with the citation**:**

Leadership in development of the first synthetic aperture microwave radiometer in space and success of the Soil Moisture and Ocean Salinity (SMOS) mission.

Yann H. Kerr (M '88, SM '01), received the engineering degree from Ecole Nationale Supérieure de l'Aéronautique et de l'Espace (ENSAE), the M.Sc. from Glasgow University in E&EE, and Ph.D from Université Paul Sabatier. From 1980 to 1985 he was employed by CNES. In 1985 he joined LERTS; for which he was director in 1993–1994. He spent 19 months at JPL, Pasadena in 1987–88. He has been working at CESBIO since 1995 (deputy director and director since 2007) His fields of interest are in the theory and techniques for microwave and thermal infra-red remote sensing of the Earth, with emphasis on hydrology, water resources management and vegetation monitoring.

He has been involved with many space missions. He was an EOS principal investigator (interdisciplinary investigations). and PI and precursor of the use of the SCAT over land. In 1989 he started to work on the interferometric concept applied to passive microwave earth observation and was subsequently the science lead on the MIRAS project for ESA with MMS and OMP. He was also a Co investigator on IRIS, OSIRIS and HYDROS for NASA. He was science advisor for MIMR and Co I on AMSR. He is a member of the SMAP science definition team.

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

Jordi Font obtained a B.Sc. (1973) and a Ph.D. (1986) in Physics in the University of Barcelona. He is Research Professor at the Physical Oceanography Department of the Institut de Ciències del Mar (Spanish Research Council, CSIC), Barcelona. Member of several international societies and committees. Participant in 42 oceanographic campaigns. Author or co-author of 300 communications to scientific symposia and 260 published papers (75 in SCI journals). Adviser of 9 PhD thesis. PI in several Spanish and European research contracts. Main research interests: Ocean remote sensing: determination of sea surface salinity by microwave radiometry. Physical oceanography of the Mediterranean Sea: water masses, circulation and climate change. Ocean circulation: operational measurements of ocean currents, technological improvements. Mesoscale dynamics: fronts, eddies, topographic interactions,

Figure 14. Recipients of the Certificate of Recognition, Manuel Martin-Neira (left), Jordi Font and Yann Kerr, with GRSS President Jon Benediktsson.

Figure 15. Marwan Younis (left), Yves-Louis Desnos, Jens Fischer, Irena Hajnsek, and Alberto Moreira received the best wishes for a successful IGARSS 2012 from the IGARSS'11 organizers Motoyuki Sato, Yoshio Yamaguchi, and Masanobu Shimada.

physical-biological processes coupling. At present he is Co-Lead Investigator for ocean salinity in the European Space Agency Soil Moisture and Ocean Salinity (SMOS) mission. Until May 2010 he was Chairman of the Ocean Physics and Climate Committee of the International Commission for the Scientific Exploration of the Mediterranean Sea CIESM. National Arts Award 2011 of the Catalan Government in the category of Thought and Scientific Culture.

Manuel Martín-Neira received the M.S. and Ph.D. degrees in telecommunication engineering in 1986 and 1996 respectively from the School of Telecommunication Engineering, Polytechnic University of Catalonia, Spain. In 1988, he was awarded a fellowship to work on microwave radiometry at ESA (European Space Agency), in The Netherlands. From 1989 to 1992 he joined GMV, a Spanish firm, as responsible for several projects on GPS spacecraft precise navigation and attitude determination. Since 1992, with ESA, in charge of the radiometer activities within the Payload, Equipment and Technology Section. He has developed new concepts for constellations of small satellites for Earth Observation. In particular he holds several patents related to aperture synthesis radiometry and on the use of GNSS signals reflected from the ocean (PARIS concept). He received the Confirmed Inventor Award from ESA in 2002, the Salva i Campillo Award and the Premio Jaime I in 2010 from Spain, and is member of the Academie des Technologies of France. Since 2001 he is the Instrument Principal Engineer of ESA's Soil Moisture and Ocean Salinity (SMOS) mission.

9. Congratulations to All 2011 Award Recipients

The GRSS Awards Committee would like to thank the evaluators of IGARSS'11 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.

10. Best Wishes for a Successful IGARSS 2012

The General Chair of IGARSS 2011 Motoyuki Sato turned over the responsibility for the IEEE International Geoscience and Remote Sensing Symposium to IGARSS 2012 General Co-Chairs Alberto Moreira and Yves-Louis Desnos, with their best wishes for a successful symposium in Munich, Germany, July 22–27, 2012.

We hope to see you in Munich at IGARSS 2012!

Martti Hallikainen

IGARSS 2011 SURVEY

John Kerekes and Michael Inggs,
Co-Chairs, IEEE GRSS Conference Advisory Committee

1. Introduction

The International Geoscience and Remote Sensing Symposium (IGARSS) is the premier conference organized by the Geoscience and Remote Sensing Society (GRSS). The annual gathering place for researchers and practitioners of remote sensing, IGARSS is held each year in different international locations. While IGARSS'11 was planned for Sendai, Japan, the tragic earthquake and subsequent tsunami necessitated a move. The event was held successfully in Vancouver, Canada the last week of July and attracted over 1400 participants.

Following up on the survey conducted after IGARSS'10, the Conference Advisory Committee of the GRSS Administrative Committee (AdCom) conducted a web-based survey among GRSS members and IGARSS'11 attendees. The survey was nearly identical to the one the previous year in order to assess trends. A total of 896 responses were received of which 171 provided open-ended text comments. We report here on the responses, with an emphasis on comparing the results to those from the previous year.

2. Respondent Demographics

Fifty-three percent responding to the survey were members of both IEEE and GRSS, with 19% members of IEEE only, 2% GRSS Affiliates and 25% that were not a member of either. Compared to the 2010 survey, the fraction of respondents who were IEEE GRSS members was a bit down (−8%) while that of IEEE only members went up (+6%). Most respondents were from the Asia/Pacific region (37%), followed by North America (31%), and Western Europe (26%). The remaining respondents were divided between Eastern Europe (3%), South America (2%), and Africa (1%). While other areas were about the same as in the 2010 survey, the fraction from Asia/Pacific (+13%) and North America (-12%) changed significantly. This was most likely due to the planned location of Sendai for this year's event and a higher participation in the conference from the Asia/Pacific region.

Most were working professionals (22% early, 36% mid, and 16% late career) while 23% were students and 3% were retired. Most were affiliated with an academic institution (66%), with the rest working for the government (19%), the private sector (8%), or a non-profit organization (5%). These were comparable to last year's distribution, with slight increases in the fraction of students and decreases in the private sector and government, which was consistent with the higher fraction of participants from academia.

3. Reasons for Attendance

In response to the question of "What is your primary reason for attending IGARSS?" 39% chose the "technical content of the sessions." 29% selected "to share work with others and obtain a publication" while 22% selected "networking". Two percent said they attend for the tutorials and workshops, while 7% said they do not generally attend. These results were nearly identical to last year.

4. Peer Review of Proceedings

Last year we sought opinions regarding a possible change from the IGARSS tradition of optional, non-peer reviewed proceedings papers to a full peer-review process for paper selection and program placement. Repeating the question this year, the results were nearly identical with 48% preferring to continue this tradition, 29% preferring a full review process, 13% preferring a mix and 10% with no opinion. This confirms participants are split, but with a slight preference for no change.

5. Balance of Invited and Contributed Sessions

In recent years IGARSS has had a significant fraction of the oral sessions formed by invitation of special session chairs selected through a proposal process. The response to a survey question on this topic this year was nearly identical to last year, with 85% of respondents selecting choices limiting the number of invited papers to 30% or less of the total number at the conference. This result confirms that of last year's survey, which was that participants prefer an open process with the best papers being selected for the conference, while still appreciating the value of special topic invited sessions.

6. Posters, Tours and Conference Venue

We repeated a set of questions addressing logistical aspects of IGARSS with results being nearly identical to last year, with one exception.

Similar to last year, a clear majority (68%) expressed a preference for dedicated poster sessions that do not overlap with oral sessions, with a modest fraction (17%) preferring the format used in IGARSS'10 (overlapping oral and poster sessions). Eight percent selected the option for day long sessions with no required time for authors to be present and 7% expressed no opinion.

Interest in local tours arranged through the conference was also unchanged with most (58%) expressing some level of

interest in participating, with 31% expressing no interest and 11% with no opinion.

Regarding the venue, there was a flip-flop compared to the 2010 survey in the relative preferences for a hotel versus a convention center. This year 39% preferred a convention center while 22% preferred a hotel. Last year the preferences were 25% convention center and 34% hotel. This may reflect a preference among respondents for whichever venue was most recent as this years event was in a convention center while IGARSS'10 was held at a hotel. Other options were nearly identical to last year's survey results with 29% preferring a university campus with lower cost and 10% expressing no opinion.

7. IGARSS'11 Experience

Several questions addressed specifics related to the most recent IGARSS, including one aimed at understanding the impact of the location/date change.

Approximately 70% of the respondents attended IGARSS'11, including 8% (71) who originally did not plan to attend. Thirty percent of the respondents did not attend including 8% (69) who had to cancel after the change. Among those who had to cancel, 37 reported it was due to the change in location, 22 due to the change in date, 10 due to visa issues and 20 who selected "other" as the reason.

Among those who did not attend IGARSS'11, the most cited reasons were too expensive (38%) and too far away (17%), with a large fraction (32%) selecting "other". The rest reported attendance as being not important for their career or they could not obtain visa. This distribution of reasons were similar to last year's survey, although the number reporting visa problems was less than one-third of those who reported a visa problem for IGARSS'10 in Hawaii.

With regard to specific questions about IGARSS'11, of those who attended 79% rated the technical program as excellent or good, with just 5% saying it needs improvement. Regarding the Plenary, over 75% of those saying they attended the conference reported attending the Plenary with the majority of this group (67%) saying "it served its purpose", 23% saying it was a "highlight of the conference", and just 10% responding they "did not find it useful". Of those attending the workshops and tutorials, over 94% rated them as excellent or good. These results were very similar to the results from IGARSS'10.

8. Attendance Plans for IGARSS'12

The final question addressed plans for attending IGARSS'12 in Munich, Germany. A majority of respondents (64%) indicated they do plan to attend. The most common reason (53%) for planning to not attend was "will not be able to secure travel funds." 26% cited "other reason" with only 13% selecting "too far away," while 8% of those respondents not planning to attend selected "not important for professional career." The fraction of respondents who indicated they plan to attend next year's IGARSS was 20% higher than last year, suggesting a popularity of European venues among survey respondents.

9. Open-ended Comments

The open-ended comments were reviewed and grouped into categories. Nearly one-half of the comments were very positive about IGARSS and its organization. Many found the conference very useful, with high technical quality and a good venue for keeping abreast of the state-of-the art. Respondents were also very complementary of the organizers in making the last-minute venue change. The rest of the comments were either critical in nature or offered suggestions for improvements. Many voiced concerns over the technical quality, review process and session organization. Others commented that IGARSS is too expensive, and expressed a desire for less exotic locations with lower cost venues and lodging. Not surprisingly, many comments were directly contrary such as those wishing the conference covered more topics while others saying the conference should be more focused.

We very much appreciate those who take the time to express their opinions. All survey results are being shared with the organizing committees of upcoming IGARSS to help ensure high quality events serving our community.

10. Summary

The results of the IGARSS 2011 survey confirm what was found last year: that IGARSS continues to serve well the diverse interests and preferences of GRSS members and conference attendees. There continues to be a variety of opinions on specific details, but we are confident that the basic format remains acceptable to the majority. Around these basics, we have variations, due to each conference being run by a Local Organizing Committee (LOC). Each LOC can take advantage of the creativity and capability of its volunteers and contribute unique improvements to the event, while maintaining traditional elements that are so important to many attendees. Thank you again to everyone who participated in the survey and for your thoughtful comments, and we shall continue with these annual surveys, with your help.

APSAR 2011

New Forum for Synthetic Aperture Radar in Asia
3rd International Asia-Pacific Conference on Synthetic Aperture Radar,
http://www.apsar2011.org

Young-Kil Kwag, Korea Aerospace University, and Yisok Oh,
Hongik University, Seoul, Korea

Today's high resolution, polarimetric and interferometric synthetic aperture radar (SAR) is the most powerful all weather sensor for monitoring the earth environment and disaster as well as security related military applications under the severe climate changing environments. The APSAR is the new forum established in 2006 for the Asia-Pacific community compared to the EUSAR community for the SAR and Radar engineers and scientists. The 3rd International Asia-Pacific Conference on Synthetic Aperture Radar (APSAR 2011) was held in Seoul during September 26–30, 2011 in the Seoul Education and Culture Center in Seoul, Korea (www.apsar2011.org). This APSAR 2011 was organized by the Radar Society of KIEES, and technically co-sponsored by the IEEE Aerospace and Electronics Systems Society (AESS) and IEEE Geoscience and Remote Sensing Society (GRSS). The APSAR conference is to be held biennially (every two odd year) in China, Korea, Japan, Australia, and Singapore in turn in the Asia-Pacific region. This 3rd APSAR 2011 is the first event in Seoul, Korea. Particularly, we have received strong supports from China and Japan, and even European SAR community to bridge the East APSAR to the West EUSAR (every two even year) community. In that sense, we believe that this conference will be a milestone for its first attempt to make APSAR a genuinely international event. As an evidence, the APSAR gathered around 350 attendees from 22 countries worldwide, as shown in Figure 1.

We have organized the conference to provide a full spectrum of the technical presentations, exhibitions, and tutorial and short courses. The key 5-topic areas were included: a) SAR Systems, b) SAR Technology, c) SAR Signal Processing, d) SAR Applications, and e) general RADAR technology. A total of 325 extended abstracts were submitted from 22 countries; China, Korea, Japan, India, Italy, Germany, United States, Taiwan, Poland, Ukraine, Russia, Australia, Netherlands, Sweden, United Kingdom, Canada, Iraq, Portugal, Saudi Arabia, Spain, Switzerland, and Yugoslavia in the order of the number of submitted papers. Each paper was reviewed by at least three reviewers and thus a total of 168 reviewers were invited from the international SAR/Radar expert. Finally 274 papers were selected and presented; 201 in oral sessions and 73 poster sessions. The formal presentations include 7 keynote speeches in the plenary session, 98 invited papers in the 20 sessions, 86 regular papers in the regular oral sessions, and 10 papers in the two Student Paper Contest sessions. All of these oral and poster papers were included in the USB memory sticks (4 GB) which were distributed to the participants. The proceedings will also be available soon at IEEE Xplore

Figure1. Participants in the Opening of the APSAR 2011.

(ISBN: 978-89-93246-17-9). The proceeding books were published and distributed only to the limited members of APSAR committee during the conference. The international program and organizing committee members are shown in Figure 2.

The Opening Session of the APSAR 2011 was dramatically started in the morning of the Sept. 27, 2011. The first welcoming message was delivered by the Prof Young K. Kwag (Korea Aerospace University), General Chair of APSAR 2011, and the followed honorary speakers were from Vice Minister of Education, Science and Technology of Korea, former Korea Aerospace Research Institute, President of Agency for Defense Development, Prof. Wooil Moon, Vice President (Publication) of IEEE GRSS, and President of KIEES, Korea. Finally, the TPC chair, Prof Yisok Oh, presented the overview of the technical program, the statistics of the paper submission, and final presentations. Followed by Opening Session, the plenary session was continued by the invited 7 keynote speakers. This plenary session were specially organized by inviting the representatives from 7 countries in order to emphasize on the state-of the art, progress over the past and future evolution of the SAR and Radar technologies in the Asia-Pacific region such as China, Japan, and Korea, followed by worldwide NASA/JPL, USA, UK, Germany, and European communities. The distinguished presentations were given as follows: "Synthetic Aperture Radar Systems and Applications in China" by Guifei Jing (Deputy Director of National Remote Sensing Center, China: Presented by Chao Wang), "SAR Technologies in JAXA" by Masanobu Shimada (ALOS Science Manager, JAXA, Japan), "SAR and Space Programs in Korea" by Sang Ryool Lee (Executive Director, Satellite R&D Head Office, KARI, Korea), "Developments in SAR: Looking Back and Looking Forward" by Hugh Griffiths (THALES/Royal Academy of Engineering Chair of RF Sensors, University College London, UK.; Vice-President of the IEEE AES Society), "Radar Technology Development at NASA/JPL" by Paul A. Rosen (Radar Science and Engineering Section Manager, Jet Propulsion Lab, NASA, USA), "Germany's Spaceborne Radar Program: TerraSAR-X, TanDEM-X and Beyond" by Alberto Moreira (Director, Microwaves and Radar Institute, DLR, Germany; Former President of the IEEE GRSS), and "Future Perspectives of Radar/SAR Polarimetry with Applications to Multi-parameter POLSAR Remote Sensing" by Wolfgang-Martin Boerner (IEEE GRSS Rep. on Asian/Pacific Affairs; Professor Emeritus, University of Illinois at Chicago, USA).

The Student Best Paper Awards were presented by the APSAR 2011 committee in order to recognize students who presented an excellent paper in the conference. In selecting the paper, main factors were originality, technical correctness, contribution to the field, and clarity of the paper and presentation. Ten high-quality papers were pre-selected by the Student Best Paper Award Committee. Ten students presented their papers in the special sessions and a jury evaluated and ranked them for the awards. The Student Best Paper Awards were presented to five students with the prize of Certificate Plaques and $1000 ($500 for the first place, $300 for the second place, and $200 for the third place). The Student Best Paper Award (First Place): Mr. Eun Sung Won (National Defense Academy, Japan) for the paper entitled "Comparison of Ship Detection Algorithms Using ALOS-PALSAR, Ground-Based Maritime Radar, and AIS" by Eun Sung Won and Kazuo Ouchi. The Student

Figure 2. APSAR 2011 Committee Members.

Best Paper Award (Second Place): Mr. Ki-Mook Kang (Seoul National University, Korea) for the paper entitled "Estimation of Ocean Surface Velocity in Tropical Cyclones Using Radarsat-1 ScanSAR Raw Data" by Ki-Mook Kang, Duk-jin Kim. The Student Best Paper Award (Third Place): Ryo Yamaguchi (University of Electro-Communications, Japan) for the paper entitled "Nonparametric UWB Radar Imaging Algorithm for Moving Target Using Multistatic RPM Approach" by Ryo Yamaguchi, Shouhei Kidera, Tetsuo Kirimoto.

The short course was specially prepared on Sept. 30, 2011 at the last day of the conference for the students and the engineers who want to learn the introduction of the SAR in a day. Dr. Scott Hensley (NASA/JPL, USA) was invited as special experts for this short course. He provided an excellent one-day short course to about 80 attendees. The title of the short course was "Introduction to SAR Technology: from Basic to Applications". In the morning class there were two main topics: "Overview of SAR remote sensing" and "Major factors affecting SAR performance". In the afternoon class there were also two main topics: "SAR applications" and "SAR polarimetry and interferometry".

As a social event during the conference, there two special programs were prepared: the APSAR committee meeting and Banquet. The APSAR committee meeting was held in the evening of Sept. 27, 2011. 14 members of the international program committee and 10 members of the local organizing committee were invited together at the beautiful Korean traditional restaurant outside the conference venue. The international committee members include: Prof Yingning Peng (China), Prof Chao Wang (China), Prof Yoshio Yamaguchi (Japan), Dr Masanobu Shimada (Japan), Dr Ender (Germany), Dr Alberto Moreira (Germany), Rudolf Zahn (Germany), Prof WM Borner (USA), Dr Paul Rosen (USA), Dr Scott Hensley (USA), Prof Hugh Griffiths (UK), Prof Chris Baker (UK), Prof Tony Milne (Australia), Prof Lukin (Ukraine). In this meeting, the future program of the APSAR conference was discussed and the next APSAR 2013 was decided to be held in Japan. Prof Yamaguchi and Dr Shimada accepted this decision as representatives of Japan, and will announce the venue and date of the APSAR 2013 later.

The conference banquet was held at the ball room of the conference venue in the evening of Sept. 28, 2011. About 270 participants were attended including the specially invited guests, and the mood was so excited by Korean musical performance during the banquet. In this event, 5 appreciation plaques were awarded to the special contributors for the APSAR development and financial sponsors. The awardees were Prof Shunjun Wu for his contribution to the APSAR 2009 in China and Prof Wooil Moon for his contribution to the APSAR 2011. For technical and financial contributions, former President of KARI, President of Samsung Tales, and President of LIG Nex1 were awarded. In the Student Best Paper Award, top-5 student's best papers were awarded with the certificate plaques and cash for each place. Figure 3 shows that Prof Griffiths delivered the congratulatory message of the president of IEEE AESS to Prof Kwag, General Chair, for the successful APSAR 2011 in the banquet, and Figure 4 shows the handover of the APSAR flag to Japan in 2013.

In summary, we achieved the monumental records through this APSAR 2011:

- 350 participants from 22 countries
- 325 abstracts submission
- 274 full paper presentation
- 7 keynote speakers in plenary session
- 6 tutorials and 1 short course
- 10 exhibitions
- 23 financial sponsors
- 12 technical sponsors
- 5 students paper awards
- 5 appreciation awards
- 1 technical tour to KARI

We would like to thank all the participants, international program local organizing committee members for their efforts and contributions. We hope to continue the next APSAR 2013 in Japan successfully.

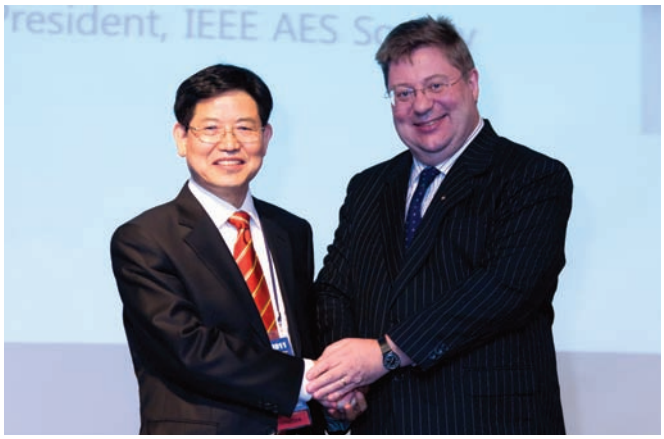


Figure 3. Congratulation of the successful APSAR 2011 from the Vice President of IEEE AESS.

Figure 4. Handover of the next APSAR 2013.

ARSI 2011

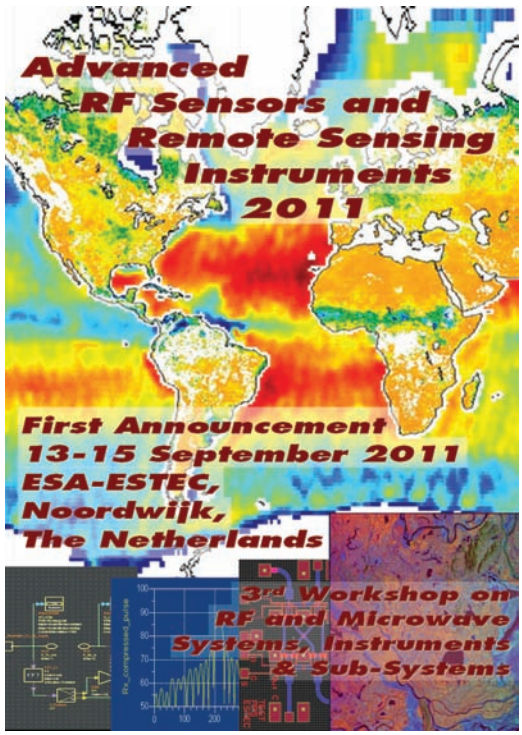
3rd Advanced RF Sensors and Remote Sensing Instruments Workshop, http://www.congrex.nl/11c11/

Christopher Buck, Martin Suess, Electrical Engineering Department, ESA/ESTEC, Noordwijk, The Netherlands, Eastwood Im, NASA/JPL, Pasadena, CA, USA

The 3rd Advanced RF Sensors and Instruments workshop was held at the European Space Agency's Research and Technology Centre (ESTEC) in Noordwijk, The Netherlands, on 13–15 September 2011.

The workshop attracted around 60 participants from industry and research institutions from across Europe, America, Canada and Japan. Many more ESA employees also attended some of the sessions. The more active participation from North America this time was due to the collaboration, for this third edition of the workshop, with the Instrumentation and Future Technologies Technical Committee (IFT-TC) of GRSS.

This added a new dimension in the workshop with interesting talks on NASA-funded programmes and developments. Some 50 papers were presented on topics ranging from



missions, through (novel) systems, data processing and hardware developments, covering SAR, altimetry, scatterometry, radiometry and GNSS reflectometry. Two keynote speeches were given by the IFT-TC senior advisors: the first by Mark Drinkwater, the head of ESA's Earth Science division, the other by George Komar the Director of the Earth Science Technology Office at NASA.

There was also a modest poster session and a selection of hardware on display including a radiator from the antenna array of Sentinel-1 (C-band SAR satellite being developed by ESA for the EU's GMES programme), an X-band digital beamforming demonstrator, a tile from an L-band concept SAR and one of the LICEF (lightweight cost-efficient) receivers from ESA's L-band radiometer mission: SMOS.

Figure 1. ESA's European Space Research and Technology Centre (ESTEC) in Noordwijk, the Netherlands.

Figure 2. George Komar, Director of the Earth Science Technology Office (ESTO) at NASA and IFT-TC senior advisor delivered his keynote speech.

Figure 3. Konigin Juliana on the countryside canals of Holland.

The full programme can be found on the website indicated in the title.

A social event was organized on the second evening involving dinner on board the cruise boat Konigin Juliana traveling through the countryside canals of Holland.

At the end of the workshop, many participants made highly complimentary remarks about the quality and the breath of the papers presented and the workshop as a whole was widely regarded as having been very successful.

Future technical events of similar nature with joint collaboration between ESA and GRSS

IFT-TC were firmly encouraged by all.

Our thanks go to the scientific committee for reviewing all the papers submitted, to ESTEC for hosting the event and for the valuable collaboration with IFT-TC.

STANDARDS FOR GEOSCIENCES AND REMOTE SENSING

Siri Jodha S. Khalsa, IEEE-GRSS Liaison to ISO/TC211,
Chair, SCC40, sirijodha.khalsa@ieee.org

The need to share data across disciplinary boundaries is becoming ever more important as science and technology are being called upon to help address pressing environmental concerns. Standards play an important role in increasing the interoperability and usability of data, and in improving the development, deployment and evaluation of sensor systems. This column will provide regular updates on recent standards development activities that may be of interest to the GRSS membership.

ISO/TC211 concluded their 33rd Plenary and committee meetings in Centurion, S. Africa on November 18, 2011. I will note here some relevant outcomes. First, a revision to the widely used metadata standard, ISO19115, has passed a milestone in being approved for the next stage of balloting. Metadata, i.e. information describing data, services and other resources, is vital for discovery, assessment and utilization of those resources. Secondly, a new project, ISO19159-1, *Calibration and Validation of Remote Sensing Imagery Sensors - Part 1 - Optical sensors*, has been approved and will be led by Wolfgang Kresse of Germany. Finally, China has agreed to lead a project on the harmonization of encodings for imagery and gridded data.

The IEEE Committee on Earth Observations (ICEO) leads the IEEE Standards Association's Standards Coordinating Committee on Earth Observations (SCC40), which is the sponsor of Project 2030.1, *Draft Guide for Electric-Sourced Transportation Infrastructure*. P2030.1 is part of the effort to improve the efficiency and sustainability of electrical power services, and will assist utilities, manufacturers, transportation providers, infrastructure developers and end users of electric-sourced vehicles plan for the future. Public and personal vehicles may become part of a global sensor network that will help monitor environmental conditions.

The Open Geospatial Consortium (OGC) develops standards and leads programs that intersect with the activities of many members of the GRSS. Some of the areas of focus for their next Web Services initiative, OWS-9, are: observation fusion, cross-community interoperability and sensor web enablement. NASA is proposing improvements to the Earth Observation profile of OGC's popular Web Coverage Service (WCS) to better support data products from NASA's Earth Observing System.

The evolution of standards and the progress of science and technology go hand in hand. The standards development process relies heavily on the expertise of the scientists and engineers who design instruments, processing systems and numerical models, and who acquire, validate, analyze, manage and interpret data. Any GRSS member who has ideas on how standardization might help in their work, or who is interested in the projects described above, please feel free to contact me.

REPORT ON THE 2011 AND THE UPCOMING DATA FUSION CONTEST

Fabio Pacifici, DigitalGlobe, U.S.A.
Qian Du, Mississippi State University, U.S.A.

1. Overview on the Previous Data Fusion Contests

The Data Fusion Contest is organized by the Data Fusion Technical Committee (DFTC) of the Geoscience and Remote Sensing Society (GRSS) of the International Institute of Electrical and Electronic Engineers (IEEE). The DFTC serves as a global, multi-disciplinary, network for geospatial data fusion, connecting people and resources. It aims at educating students and professionals, and at promoting best practices in data fusion applications.

The Contest is annually held since 2006. It is open not only to IEEE members, but to everyone, with the aim of evaluating existing methodologies at the research or operational level to solve remote sensing problems using data from different sensors.

The focus of the 2006 Contest was on the fusion of multispectral and panchromatic images [1]. Six Pleiades simulated images were provided by the French National Space Agency (CNES). Each data set included a very high spatial resolution panchromatic image (80 cm) and a corresponding multispectral image (3.2 m resolution). A multispectral airborne image with very high spatial resolution was available as ground reference and used by the organizing committee for result evaluation, which was not distributed to the participants.

In 2007, the Contest theme was urban mapping using radar and optical data [2]. A set of satellite radar and optical images (9 ERS amplitude data sets and 2 Landsat multispectral images) was available. The task was to obtain a classification map as accurate as possible with respect to the unknown (to the participants) ground reference, depicting land cover and land use patterns for the urban area under study.

The 2008 Contest was dedicated to the classification of very high spatial resolution (1.3 m) hyperspectral imagery [3]. The data set was distributed to every participant, and the task was to obtain a classification map as accurate as possible with respect to the unknown (to the participants) ground reference. The data set consisted of airborne data from the Reflective Optics System Imaging Spectrometer (ROSIS-03) optical sensor. The number of bands of ROSIS-03 was 115 with a spectral coverage ranging from 0.43 to 0.86 μm. Thirteen noisy bands were removed.

In 2009–2010, the aim of Contest was to perform change detection using multi-temporal and multi-modal data. Two pairs of data sets were available over Gloucester, UK, before and after a flood event. The data set contained SPOT and ERS images (before and after the disaster). The optical and radar images were provided by CNES. As in the previous editions of the Contest, the ground truth used to assess the results was not provided to the participants. Singular results were tested and ranked a first time using the κ coefficient. The best 5 results were used to perform information fusion with majority voting. Then, re-ranking was carried out after evaluating the improvement level to the fusion results.

2. 2011 Contest on Multi-Angular Very High Spatial Resolution OPTICAL Imagery

In the past few years, it has been shown how angular measurements can be exploited to provide not only improved accuracies relative to single-angle approaches, but also unique information about the surface considered. As a consequence, several satellite missions were designed to acquire optical imagery at different viewing angles, such as CHRIS/PROBA, MISR/TERRA, POLDER/ADEOS, and more recently, WorldView-2. The 2011 IEEE GRSS Data Fusion Contest was designed to investigate the unique benefits that very high spatial resolution multispectral imagery can bring to remote sensing scientists and the greater community.

A set of WorldView-2 (WV2) multi-sequence images was provided by DigitalGlobe. WV2, launched in late 2009, is the first commercial satellite to carry a very high spatial resolution sensor with one panchromatic and eight multispectral bands (C = Coastal, B = Blue, G = Green, Y = Yellow, R = Red, RE = Red Edge, N1 = Near-Infrared1, and N2 = Near-Infrared2, with center wavelengths at 425, 480, 545, 605, 660, 725, 835, and 950 nm, respectively). For comparison, QuickBird's (QB) four spectral bands (B, G, R, N1) centered at 485, 560, 660 and 830 nm, are illustrated in Fig. 1.

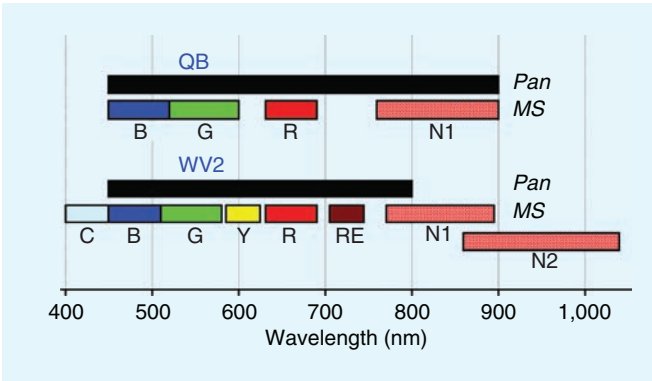


Figure 1. comparison of the WV2 and QB bands.

This unique set was composed of five Ortho Ready Standard multi-angular acquisitions, including both 16 bit panchromatic and multispectral 8-band images. The imagery was collected over Rio de Janeiro (Brazil) in January 2010 within a three minute time frame with satellite elevation angles of 44.7°, 56.0°, and 81.4° in the forward direction, and 59.8° and 44.6° in the backward direction, as shown in Fig. 2. The multi-angular sequence included the downtown area of the city, with a number of large buildings, commercial and industrial structures, the airport, and a mixture of community parks and private housing.

Since there were a large variety of possible applications, each participant was allowed to decide the research topic to work with. By May 31, 2011, each participant submitted a paper to be considered for the Contest. Successively, each submitted paper was automatically modified with author names and affiliations being hidden for fair review. Five independent judges reviewed the manuscripts.

By the end of May 2011, almost 800 researchers from 95 different countries subscribed the Contest and downloaded the dataset, with prevalence from USA, India, and Brazil. Fig. 3 shows the geographical distribution of the subscribers, where *other* indicates the countries with a total number of subscriptions less than 10. As illustrated in Fig. 4, more than 30% of the Participants were from Corporates or Government (and they actually submitted a manuscript to the Contest).

Several papers were submitted, showing numerous possibilities and variety of applications that optical multi-angular remote sensing can offer. The winners (*ex-aequo*) of the 2011 Data Fusion Contest are:

- **J. Syryczynski, G. Lemoine, C. Bielski, and D. Poli** [European Commission, Joint Research Centre], "BUILDING HEIGHT EXTRACTION FROM MULTI-ANGULAR WORLDVIEW-2 ORTHO READY IMAGES USING GPU-ACCELERATED TEMPLATE MATCHING"

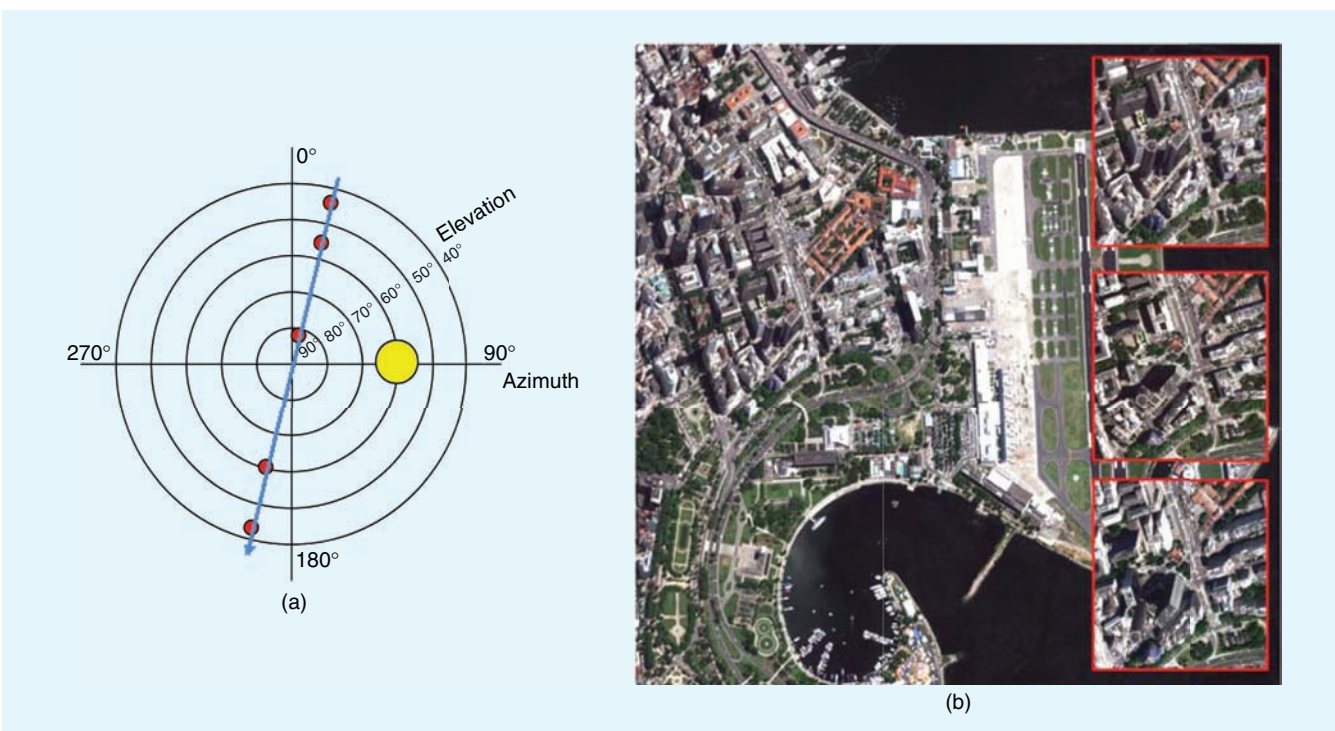


Figure 2. (a) azimuth and elevation of the multi-angle acquisition (red) and the sun (yellow); (b) the WorldView-2 scene with three details from the three most nadiral images.

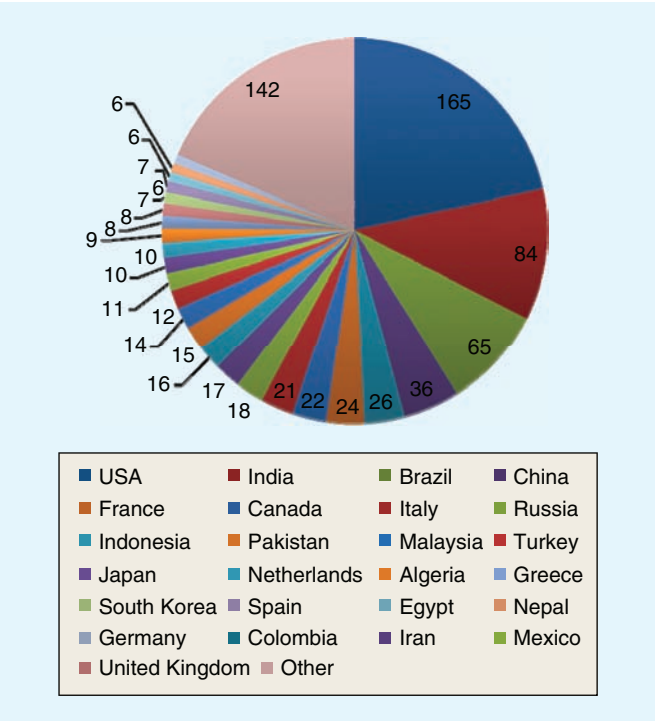


Figure 3. geographical distribution of the Contest subscribers.

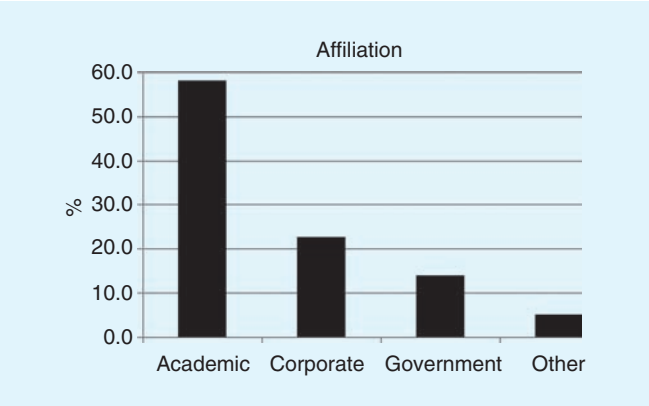


Figure 4. affilitations of the Contest subscribers.

Table I. Data sets to be used for 2012 Contest		
	First period	**Second period**
QuickBird/ WorldView-2	11 Nov 2007	9 Oct 2011
TerraSAR-X	5 Dec 2007 16 Dec 2007 27 Dec 2007	2 Oct 2011 13 Oct 2011 24 Oct 2011
LIDAR	June 2010	

- **L. Meng and J. P. Kerekes** [Rochester Institute of Technology], "OBJECT TRACKING USING HIGH RESOLUTION SATELLITE IMAGERY"
- **F. Cavayas** [University of Montreal], "RADIOMETRIC STANDARDISATION OF MULTI-ANGULAR HIGH RESOLUTION SATELLITE IMAGERY: PROBLEMS AND FEASIBILITY OF A GLOBAL SOLUTION"

Congratulations to the winners whose papers were judged to be superior in terms of sound scientific reasoning, problem definition, methodology, validation, and presentation. These teams have been awarded with an IEEE Certificate of Recognition during the Chapters and Technical Committees Luncheon at the IEEE International Geoscience and Remote sensing Symposium in Vancouver in July 2011.

3. UPcoming 2012 Data Fusion CONTEST: *Multi-Modal/Multi-Temporal Fusion*

This year the Data Fusion Contest aims at investigating the potential of multi-modal/multi-temporal fusion of very high spatial resolution imagery. More specifically, the participants will be able to download three different sets of images over the downtown of San Francisco, including very high spatial resolution QuickBird and WorldView-2, TerraSAR-X, and LIDAR data. Further, the optical and SAR data sets will be composed of a total of 8 images from two acquisition times in 2007 and 2011 as shown in Table I.

Since there are a large variety of possible applications, each participant can decide the research topic to work with. A paper must be submitted by May 1, 2012 to be considered for the Contest. The paper must be in English, and be no more than 4 pages including illustrations and references. The paper should describe in detail the addressed problem, method, result, etc.

All papers will undergo a reviewing process by the Data Fusion Award Committee:

1) Jocelyn Chanussot, Grenoble Institute of Technology, France
2) Curt Davis, University of Missouri, USA
3) Jenny Q. Du, Mississippi State University, USA
4) Paolo Gamba, University of Pavia, Italy
5) Karl Heidemann, USGS, USA
6) Oliver Lang, Astrium, Germany
7) Fabio Pacifici, DigitalGlobe, Inc., USA
8) Uwe Sörgel, Leibniz Universität Hannover, Germany

Each paper will be anonymously distributed to the Award Committee, i.e., the judges will not know the name and affiliation of the authors. This will favor the neutrality and impartiality of the review.

Final results will be announced at the 2012 IEEE International Geoscience and Remote Sensing Symposium to be held in Munich (Germany) in July 2012. The winning teams will be awarded with an IEEE Certificate of Recognition during the Chapters and Technical Committees Luncheon. Additionally, this year the Data Fusion Technical Committee is pleased to

Figure 5. The Data Fusion Technical Committee congratulates the winners of the 2011 Contest during the Chapters and Technical Committees Luncheon at IGARSS 2011. From left to right: Lionel Gueguen, Fabio Pacifici, Qian Du, Lingfei Meng, and John Kerekes.

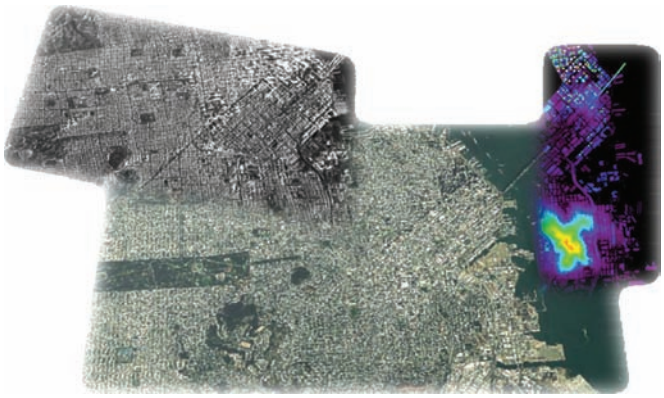


Figure 6. An example of the imagery provided by the 2012 Data Fusion Contest over the downtown of San Francisco.

announce that the winning teams will receive a monetary prize as follows:

- First Prize: $800
- Second Prize: $500
- Third Prize: $300

The Data Fusion Technical Committee will also cover the cost of the *Chapters and Technical Committees Luncheon* (where the award ceremony will be held) for the three winning teams. Finally, as tradition, a manuscript summarizing the contest outcomes will be submitted to a GRSS Journal. To further enhance its impact in the community, the Data Fusion Technical Committee will support its open-access publication cost.

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

For more information, please visit: this hyperlink is missing the /data-fusion/ part, so it is pointing just to the GRSS TC page, not to the specific DF TC one

References

[1] L. Alparone, L. Wald, J. Chanussot, C. Thomas, P. Gamba, and L. M. Bruce, "Comparison of pansharpening algorithms: Outcome of the 2006 GRS-S data fusion contest", *IEEE Transactions on Geoscience and Remote Sensing*, vol. 45, no. 10, pp. 3012–3021, Oct. 2007.

[2] F. Pacifici, F. Del Frate, W. J. Emery, P. Gamba, J. ChanuPcoarse SAR and optical data: outcome of the 2007 GRS-S data fusion contest", *IEEE Geoscience and Remote Sensing Letters*, vol. 5, no. 3, pp. 331–335, July 2008.

[3] G. Licciardi, F. Pacifici, D. Tuia, S. Prasad, T. West, F. Giacco, J. Inglada, E. Christophe, J. Chanussot, P. Gamba, "Decision fusion for the classification of hyperspectral data: outcome of the 2008 GRS-S data fusion contest", *IEEE Transactions on Geoscience and Remote Sensing*, vol. 47, no. 11, pp. 3857–3865, November 2009.

You can contact the Committee Chairs by email at: **dftc -at- ieee.org**

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

Your Name
Your Institution/Company
Country
Email

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

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

EDUCATION CORNER

AN OVERVIEW OF EDUCATION ACTIVITIES IN THE IEEE GEOSCIENCE AND REMOTE SENSING SOCIETY

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1. Overview

Education is very important for the IEEE Geoscience and Remote Sensing Society (GRSS). As the world's largest remote sensing science and engineering organization, GRSS has an important responsibility to educate the new generation of geoscience and remote sensing scientists. The outstanding work carried out by Granville Edward Paules, III, who served as Education Director of GRSS until January 2011, included many pioneering contributions, such as the setting-up of web broadcasts of plenary sessions of GRSS major international conferences, on-line tutorials developed with national and international academics, and a successful and equitable student travel program. Many of the education-related activities currently being pursued by GRSS are inspired by Gran Paules outstanding achievements as Education Director. In this contribution, we describe some ongoing activities of GRSS in the area of education, including (present and planned) activities carried in conferences and symposia, web-based tools, e-learning and social networks, the society's travel grant program, the student paper contest carried out in the society's GRSS flagship conference, the IEEE Geoscience and Remote Sensing Symposium (IGARSS), and other activities and future directions of GRSS in terms of education activities.

2. Education Activities in Conferences and Symposia

The GRSS tutorials are an important mechanism for dissemination of research topics of interest to both young and experienced geoscience and remote sensing scientists. They are held during IGARSS and other focused symposia. For instance, a total of nine tutorials were organized in conjunction with IGARSS 2011 in Vancouver, Canada, including four full-day tutorials on the topics of SAR polarimetry, spectral unmixing of hyperspectral data, advanced classification techniques, and image information mining. Also, five half-day tutorials were organized on the topics of data modeling and information estimation in multichannel radar remote sensing, complex-valued neural networks, InSar for geoscientists, SAR tomography and NASA's newest Earth-observing satellite, the Next Generation Joint Polar Satellite Mission Preparatory Project (NPP). These tutorials were taught by highly distinguished experts in their research fields. Their goal was to seek a consistent, high quality approach in the presentation of these specialized topics. The deadline for submitting tutorial proposals for IGARSS 2012 in Munich, Germany, is December 15th, 2011[1].

An ongoing effort in GRSS is the organization of a series of summer/winter schools, to be held in conjunction with IGARSS and/or other GRSS symposia. This effort follows successful cases in other IEEE societies, and the goal is to provide a general overview of selected topics in geoscience and remote sensing to graduate students, taking advantage of the expertise of worldwide experts attending the specialized symposium. Hence, the schools will be mainly directed to young scientists in the vicinity of the location where the GRSS symposium is being organized, but they will remain open to the wide scientific community and properly advertised through GRSS communication channels. The topics addressed in the schools will not overlap with those explored in the tutorials, with a clear target to transfer knowledge to new young scientists in the field (not necessarily attending IGARSS due to their young age or early-stage career). This initiative is currently under development at GRSS, with an active involvement of the Education Director taking advantage of other similar initiatives carried out in geoscience and remote sensing educational projects such as the Marie Curie Research Training Network "Hyperspectral Imaging Network" (Hyper-I-Net)[2] funded by the European Commission, which has made possible that part of the infrastructure to organize such schools is already in place.

3. Web-based Tools, E-learning and Social Networks

One of the main goals of GRSS is to establish the society website as the natural means of communication and technical information exchange between GRSS members and the global remote sensing community as a whole. For this purpose, the website has greatly expanded the capabilities for remote attendance at symposia and GRSS events. A good example is the live broadcast through the society's website of all oral technical sessions of IGARSS 2011 held in Vancouver,

[1] http://www.igarss12.org/TutorialProposals.asp

[2] http://www.hyperinet.eu

Canada. This effort, coordinated by Steven C. Reising (GRSS Vice-President of Information Resources), represents a major contribution that will increase the impact and outreach of our society's symposia even more. An ongoing activity in this area is the creation of interactive video education tools and their integration in the GRSS society website, which already comprises tutorials and documents including the interactive "Ask an Expert" feature[3], and a catalog of PhD Theses defended in recent years[4]. More advanced tools such as interactive online lectures, tutorial and courses, complemented by self-assessment tests, are currently under development to be integrated with GRSS website under the education section.

Another ongoing effort is the creation of a social network in GRSS, intended to communicate scientists working in different disciplines of geoscience and remote sensing. The main motivation is that social networks play an important role in our life and they can also help the GRSS community in automatically identify experts for education-related activities, paper reviewing, and other activities. In this regard, a very important development in recent years has been the extensive LinkedIn[5] community formed in the context of the GRSS Data Fusion Technical Committee chaired by Fabio Pacifici and Qian Du. The online group and discussion forum has boosted the number of participants in the last few months thanks to the outstanding effort by the chairs and could be used as a baseline for creating a GRSS social network.

4. Travel Grant Program

An important initiative within GRSS is the IGARSS travel merit scholarship selection process. This initiative allows many GRSS students and members to obtain funding support in order to travel to the GRSS flagship symposium. A total of 109 applications were received for the IGARSS 2011 in Vancouver, Canada. 22 applications were redirected to a separate fund to support requests coming from Asia. These applications were overseen by Motoyuki Sato, General Chair of IGARSS 2011, who did an outstanding effort to minimize the impact of the venue reallocation from Sendai, Japan, to Vancouver. The main innovation introduced in the travel grant program in 2011 is that, historically, travel grants were awarded only to researchers giving oral presentations at IGARSS. In 2011, however, the oral presentation rule was not observed as it was believed to downgrade poster presentations. After a careful selection process, in which lower priority was assigned to those applications in which other partial support (e.g. local funds) were available, a total of 59 applications were partially funded (this means around 70% of the eligible applications). Since the applicants estimated the travel costs assuming that Sendai would be the venue of IGARSS, the airfare costs were recalculated using Vancouver as the new destination. This involved a careful evaluation of the travel grants on a case-by-case basis. The whole procedure was overseen by Jon A. Benediktsson (GRSS President), Melba Crawford (Executive Vice-President), Adriano Camps (Vice-President of Meetins and Symposia), John Kerekes (Vice-President of Technical Activities), and Steven C. Reising (Vice-President of Information Resources). Their support and recommendation are gratefully acknowledged. The travel grant application form for IGARSS 2012 in Munich, Germany, is available at the IGARSS 2012 website[6].

5. Student Prize Paper Competition

The student prize paper competition, overseen by Martti T. Hallikainen (GRSS Publications Awards Committee Chair), is an important education-related activity in GRSS society. This year ten finalists were selected by a committee of experts to present their papers during a special session at IGARSS 2011 in Vancouver, Canada. The ten finalists gave rise to a high level and very tough competition. Prizes were announced at the IEEE GRSS awards banquet. The First Prize (Mikio Takagi Student Prize) was awarded to Xueyang Duan for the contribution "Vector electromagnetic scattering from layered rough surfaces with buried discrete random media for subsurface and root-zone soil moisture sensing," by Xueyang Duan and Mahta Moghaddam. The Second Prize was awarded to Mauro Dalla Mura for the contribution "A general approach to the spatial simplification of remote sensing images based on morphological connected filters," by Mauro Dalla Mura, Jon A. Benediktsson and Lorenzo Bruzzone. The Third Prize was awarded to Adel Elsherbini for the contribution "Image distortion effects in subsurface SAR imaging of deserts and their correction technique," by Adel Elsherbini and Kamal Sarabandi. All IEEE student members are invited and encouraged to enter the IGARSS 2012 student prize paper competition. Ten finalists will be selected and offered partial travel support funding. The guidelines to enter the student paper contest are available online[7].

6. Other Education-Related Activities

Although we have described some of the most relevant education-related activities currently being pursued by GRSS, other relevant activities have not been addressed in detail. For instance, the GRSS distinguished speakers program[8] chaired by David M. Le Vine (GRSS Distinguished Speakers

[3] http://www.grss-ieee.org/education/tutorials

[4] http://www.grss-ieee.org/education/phd-theses

[5] http://www.linkedin.com/groups/IEEE-GRSS-Data-Fusion-Discussion-3678437

[6] http:// www.igarss12.org/Grants/TravelAwardApplication.asp

[7] http:// www.igarss2012.org/StudentContest.asp

[8] http://www.grss-ieee.org/education/distinguished-lecturers

Committee Chair) provides GRSS members with an opportunity to interact with experts in areas of interest to the geoscience and remote sensing community. It is an opportunity to learn about some of the exciting work being done in our discipline and to meet some of the prominent members of our society. The society also promotes exhibits[9] and selected technical and general tutorials on various topics, all available through the society website (under education resources).

Another important work in progress is the GRSS Doctoral Fellowship Program, that will be coordinated with the GRSS Globalization Effort led by Anthony K. Milne (GRSS Past President). The overall strategy of this program, still under discussion in GRSS, is to support the PhD for outstanding students. Excellence of the PhD candidates should be a primary requirement, and the target will be on emerging countries. Travel support will be provided to recognized international mentors to work with these students. Among the potential benefits of such a program are the active collaboration of GRSS with the local institution through the involvement of an experienced mentor, the participation of the PhD student in major GRSS symposia such as IGARSS (through travel support awarded to the student), and the reinforcement and visibility of GRSS society in the country of origin of the PhD student, allowing for the establishment of solid links for collaboration in the future.

Last but not least, it is important to emphasize that the major education-related distinction in our society is the GRSS Education Award, which aims at rewarding significant educational contributions in the field of remote sensing. In selecting the individual, the factors considered are: significance of the educational contribution in terms of innovation, and the extent of its overall impact. The award is considered annually, but is only awarded when an outstanding recipient is identified. A description and nomination form is available online[10]. The 2011 Education Award was presented at IGARSS 2011 to Richard Bamler from the German Aerospace Center (DLR), Oberpfaffenhofen, Germany, with the citation: "In recognition of his significant educational contributions to Geoscience and Remote Sensing."

7. Summary and Future Directions

In this article, we have summarized some of the ongoing and planned education-related activities at GRSS. The society puts forth a lot of effort in remote sensing education initiatives, development and collection of educational resources, college/graduate education as well as continuing education for professionals. These initiatives are intended to provide GRSS members and all persons involved in GRSS' fields of interest with accessible and affordable high-quality education products. In the future this will not only be done using the mechanisms described here, but also through other IEEE channels such as our GOLD (Graduates of the Last Decade) program, the IEEE eLearning Library[11], the IEEE on-line education portal[12], the IEEE pre-University education portal[13], or the IEEE Women in Engineering (WIE)[14], the largest international professional organization dedicated to promoting women engineers and scientists. It is the goal of GRSS that the activities described here create an impact in the young scientists that will be leading the future expansion of geoscience and remote sensing. It is also the responsibility of GRSS to provide high-quality training (in both scientific aspects and complementary skills such as ethical issues, communication skills, enterprise and project management skills, etc.) to this new generation of researchers and scientists. To this end, the society will continue conducting dynamic programs that encourage interest in remote sensing and geoscience education and promote new approaches for remote sensing education and dissemination of knowledge.

[9] http://www.grss-ieee.org/education/exhibits

[10] http://www.grss-ieee.org/about/awards/grs-s-education-award

[11] http://ieee-elearning.org

[12] http://ieee-elearning.org/outreach

[13] http://www.tryengineering.org

[14] http://www.ieee.org/membership_services/membership/women/index.html

INDUSTRIAL PROFILE

MICROWAVE RADIOMETRIC STANDARDS DEVELOPMENT AT THE U.S. NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY[1]

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1. Introduction

NIST's stated mission is, "To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life." NIST offers an extensive range of resources of interest to the GRSS community, including measurement support and standards for optical radiometry and photometry, space weather, atmospheric spectroscopy, carbon mitigation, ozone photometry, atmospheric chemistry, and statistical data analysis.

Radiometric standards and metrology at NIST span the UV, visible, IR, millimeter and submillimeter wave bands, and recently expanded into the microwave frequency regime. The purpose of this article is to report on the history, progress, and future direction of microwave remote sensing research and development within NIST.

2. Motivation for Microwave Radiometric Standards

Many realizations of microwave brightness-temperature standards exist in the form of heated or cooled calibration targets, but none are currently maintained as a national standard by a National Measurement Institute (NMI). This is in contrast to the visible and infrared (IR) portions of the spectrum, in which radiance standards exist and have proven to be very useful [1]. A national microwave brightness-temperature (T_B) standard based on fundamental physical quantities as defined by the International System of Units (SI) would provide a constant reference for comparison of different instruments over periods of years or decades. Such a stable, accessible reference would benefit studies of long-term phenomena such as climate change, as well as potentially improving numerical weather prediction (NWP) forecasting.

An SI-based standard would also provide a means for resolving disagreements between different instruments or programs, including instruments based on entirely different measurement parameters, since those other measurements should also be traceable to fundamental physical quantities. In this way, the standard would support the goals of merging data from multiple measurement systems from different nations, as will be necessary, for example for the Global Earth Observation System of Systems (GEOSS). Furthermore, there is already an established international framework for harmonizing fundamental physical standards. The Meter Convention, through the International Committee for Weights and Measures (CIPM) and its consultative committees, and through the International Bureau of Weights and Measures (BIPM), defines the fundamental units and scales of the SI. The Consultative Committees (CCs) of the CIPM conduct international comparisons of national standards for the principal physical quantities. The results of these comparisons are compiled by the BIPM in a database that is publicly available [2]. Thus, not only is the set of fundamental units internally consistent, but the realizations of the standards at different NMIs are compared and kept consistent. The two relevant consultative committees for microwave radiometry would be the Consultative Committee on Electricity and Magnetism (CCEM) [3] and the Consultative Committee on Photometry and Radiometry [4]. Also, the World Meteorological Organization and BIPM recently held a joint workshop entitled "Measurement Challenges for Global Observation Systems for Climate Change Monitoring: Traceability, Stability and Uncertainty" that identifies some of the key measurement issues in climate science, NWP, and earth observation, where requirements for improved metrological underpinning exist [5].

3. NIST Microwave Remote Sensing Program Overview

The Electromagnetics Division within the Physical Measurements Laboratory at NIST in Boulder, Colorado, is the sole proprietor of the US primary standards for microwave noise and is a world leader in noise metrology, which forms the basis for SI traceability in microwave radiometry. NIST is actively developing metrology applicable to microwave remote-sensing radiometry, including T_B standards, reflectivity/emissivity measurement techniques, black-body target modeling and calibration, radiometer nonlinearity characterization, advanced radiometer calibration techniques, and antenna pattern measurements. While NIST has over 30 years' experience in microwave thermal noise and antenna metrology, the remote sensing (RS) effort is much more

recent. Begun in 2001, the Electromagnetics Division had a modest effort for several years that laid the conceptual foundation for a TB standard [6] and also investigated related phenomena like target reflectivity [7] and thermal imaging [8], electromagnetic (EM) characteristics of microwave absorbers [9], and detector diode nonlinearity [10]. A parallel effort resulted in the publication of a "dictionary" for microwave radiometry [11]. Funding ended in 2005, and for several years the RS effort lay dormant. Later, Congress provided initiative funding for "Greenhouse Gas and Climate Science," which resurrected the program in 2009. The following sections expand on the main areas of development we have been engaged in since funding renewed a little over two years ago.

4. T_B Standard

Over the years, the diagram in Figure 1 has been the point of much discussion as well as debate. In 2006, as described in [6], a T_B standard could consist of a well-understood black-body target, or alternatively, a standard radiometer-with-antenna, the difference being whether the T_B standard is emitting (radiance) or receiving (irradiance). We proposed that a "full" T_B standard could be composed of a combination of the two to reduce the overall uncertainty as well as for the potential utility of having both types available. Work has progressed on these two paths in parallel, as described below.

5. Radiometer Standards

NIST's extensive heritage working with radiometers, referenced to primary standards, has prompted us to spend much of our effort working on the radiometer T_B standard. The NIST suite of waveguide radiometers extends from 12.4 GHz up to 65 GHz, and has been fully characterized for SI-traceable noise temperature measurements made in rectangular waveguide or coaxial transmission line. Almost all of the RS development work has been in WR-62 (18 GHz to 26.5 GHz) waveguide, because well-characterized rectangular and conical horn antennas are readily available in that band, along with access to the NIST anechoic chamber for measurements. The anechoic chamber has been characterized up to 40 GHz.

Implementing the existing radiometers for free-space T_B measurements involves attaching a characterized antenna to the input port. "Characterized antenna" in this sense means that both the antenna efficiency (ohmic loss) and beam pattern (beam efficiency, or fraction of the received power from the target versus the background) at the frequency of interest are well defined. Antenna efficiency can be estimated from EM simulation and contributes little to the total uncertainty. However, the beam efficiency introduces a large uncertainty to the measurement unless the total (4π steradians) pattern is well known. In practice, this is fairly difficult to ascertain down to the few-tenths-of-a-percent level required for a target T_B measurement.

We've only recently overcome this impediment by developing and implementing a procedure that does not rely on *a priori* knowledge of the beam efficiency. Instead, by varying target temperatures and measurement distances from the antenna we can extract the beam efficiency as well as the target T_B. A full uncertainty analysis of the initial measurements in the 18 GHz to 26.5 GHz frequency range leads to a standard uncertainty of about 0.6 K for the target T_B [12]. Future work will be directed at identifying approaches aimed at reducing the uncertainty due to specific sources of error, as well as extending the measurements into other waveguide bands—a straightforward procedure now, since we require no antenna patterns.

6. Black-body Target Standards

While commercial black-body (BB) targets have reached a mature state and have been usefully employed for years, their design and construction is based more on heuristics than on a fundamental understanding of the components and architecture. For example, designing a BB target from first principles requires accurate knowledge of the frequency-dependent permittivity and permeability of the microwave absorbers employed, yet the manufacturer's data are usually limited; 18 GHz is a typical maximum frequency, even if some of the absorber compounds are useful above that frequency. Also, the complex combined thermal-EM modeling of typical target geometries is challenging both mathematically and computationally. NIST began investigating the EM properties of some candidate absorber materials in 2006 [9]. Since then, those measurements have been

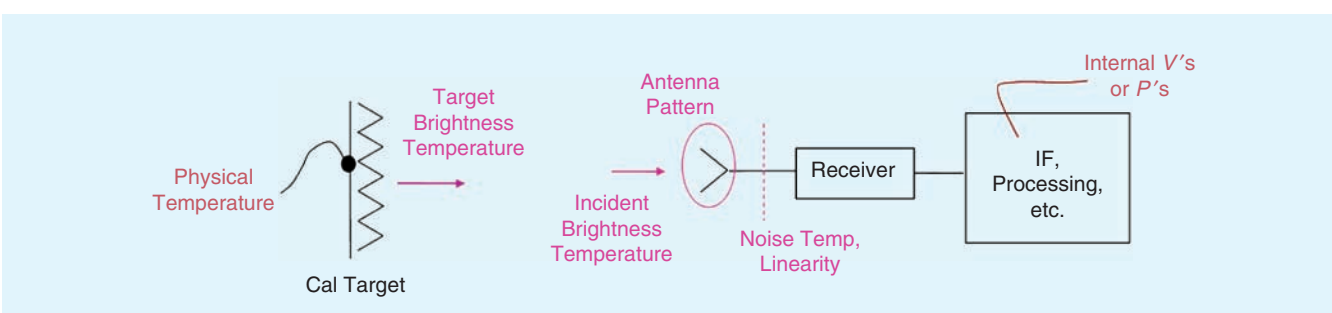

Figure 1. Microwave radiometry from a NIST perspective: What quantity is traceable?

extended to progressively higher frequencies, and we are now looking at more materials, with fabrication assistance from industry. The data are being used by collaborators at the University of Colorado's Center for Environmental Technology to develop useful modeling techniques for BB target performance [13]. Our primary goal is to first reconcile the modeled BB target performance with our radiometric measurements and then apply the model to aid in the design and fabrication of a standard BB target to complement the standard radiometers.

Figure 2. NIST waveguide radiometers. The crogenic primary standards are encased in the blue cylinders.

Closely related to target T_B is the issue of target emissivity. We've made substantial progress in measuring the target reflectivity by means of a vector network analyzer (VNA) with attached waveguide horn, as shown below. Accurate extraction of the reflectivity relies on a novel free-space VNA calibration method with a full uncertainty analysis [14]. A rigorous measurement of emissivity remains to be done; this involves extending the normal-incidence reflectivity measurements with bistatic measurements over the full half-hemisphere of the target face.

7. Advanced Radiometer Calibration Methods

NIST has a long-term MOU (Memorandum of Understanding) with NASA Goddard Space Flight Center for purposes of working together on various calibration issues in microwave radiometry. In addition to the helpful loan of several calibration targets used in many of our tests, we are also jointly (along with MIT-Lincoln Laboratory) pursuing advanced calibration schemes using Ensemble Detection and Analysis (EDA), which seeks to address some of the measurement challenges posed by naturally occurring random events. Ensemble Detection produces data that are admissible to statistical analysis and filtering algorithms that are otherwise not possible to implement. EDA is a form of Noise-Assisted Data Analysis (NADA) that has broad application to dynamic systems characterized by changing statistics. Our current efforts involve EDA technology for space applications, with focus on developing new specifications for receiver stability, advance calibration methodologies for traceability to International Standards (SI), and novel algorithms for detecting and filtering chaotic signals.

8. Antenna Patterns

Even if the target T_B can be measured without knowledge of the antenna pattern, in practice we still need to have an accurate knowledge of the antenna pattern in order to determine main-beam efficiency, sidelobe levels, possible interference with the spacecraft, etc. At the instrument level, the "antenna" is usually a system composed of feed horn(s), a main reflector, and sometimes a subreflector, so the patterns need to be taken with as much of the hardware in place as necessary to measure the pattern of the whole antenna subsystem. NIST's Radio Frequency Fields group, also part of the Electromagnetics Division, presently has an antenna range measurement capability up to 110 GHz. We are presently upgrading this capability to accommodate frequencies up to at least 220 GHz in the near term and 500+ GHz in the long term. All major mechanical parts for this new spherical range, including the robotic arm, large rotator, and six-axis positioner will be installed in early 2012. We are now anticipating that the millimeter-wave spherical range should be available for measurements at 118 GHz and 183 GHz (two of the main channels used in RS instrumentation) in March 2012. This range will be able to accommodate antennas up to 1 m^3 and 30 kg mass.

9. Other RS Related Research at NIST/Boulder

In other work at NIST, researchers in Boulder are exploring applying the technology of frequency combs to accurate remote sensing of greenhouse gases. Frequency combs are laser sources that emit light at many wavelengths across the spectrum, as compared to conventional laser sources that emit at a single wavelength. NIST is exploring applications of frequency combs in the near- and mid-infrared to precision spectroscopy of greenhouse gases, both to support existing remote sensing systems and for future point sensors. At millimeter and submillimeter wavelengths, NIST already has a thermal calibration source, called the "Aqueous Black-body Calibration" (or ABC) source [15], which is usable from

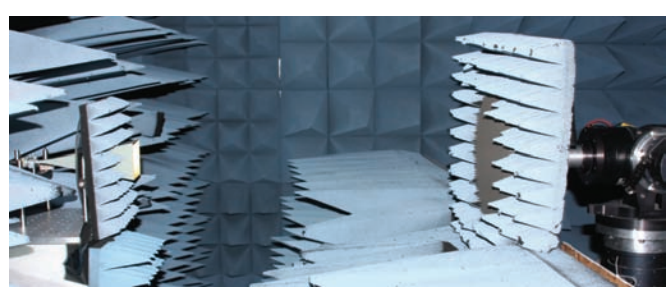

Figure 3. Target reflectivity measurement setup. The VNA is behind the antenna to the left, outside of the chamber.

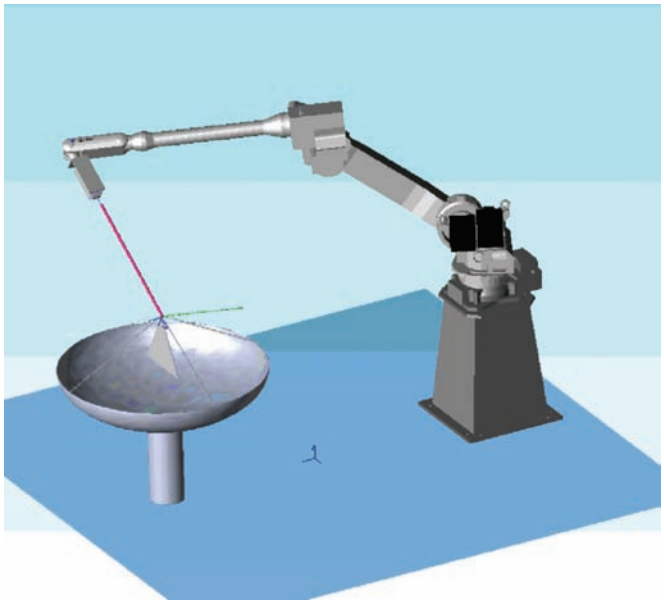

Figure 4. Robotic millimeter wave near-field spherical range conceptualization.

around 100 GHz up to 1 THz in frequency. We intend to bridge the gap between this and our microwave capabilities (presently up to 65 GHz) in the next few years. Within the Electromagnetics Division we are also developing SI-traceable measurements for low-emissivity reflective surfaces used in microwave RS instruments. This work is being done by the Electromagnetic Properties of Materials Project in Boulder.

10. Summary

The Microwave Remote Sensing project reflects NIST's core competencies, which are measurement science, rigorous traceability, and development and use of standards. The programs described above aim to fill those objectives and meet the needs of the international RS community. In the next few years, we anticipate being able to provide several key measurement services to our customers, including SI-traceable T_B calibrations for BB targets, transfer standards in the form of calibrated BB targets, pattern measurements for complex antenna systems, improved radiometer calibration methods, etc.

Acknowledgment

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CALL FOR PAPERS

IEEE Transactions on Geoscience and Remote Sensing

Special Issue on "Inter-Calibration of Satellite Instruments"

The ability to detect and quantify changes in the Earth's environment using remote sensing is dependent upon sensors providing accurate and consistent measurements over time. A critical step in providing these measurements is establishing confidence and consistency between data from different sensors and putting them onto a common radiometric scale. However, ensuring that this process can be relied upon long term and that there is physical meaning to the information requires traceability to internationally agreed, stable, reference standards ideally tied to the international system of units (SI). This requires robust on-going calibration, validation, stability monitoring, and quality assurance, all of which need to be underpinned and evidenced by comparisons involving a reference standard or sensor and a methodology with defined uncertainty (in an absolute or temporal sense). This process can be used to provide calibrations to other sensors (i.e. Inter-calibration).

Inter-calibration and comparisons between sensors have become a central pillar in calibration and validation strategies of national and international organizations. The Global Space-based Inter-Calibration System (GSICS) is an international collaborative effort initiated by World Meteorological Organization (WMO) and the Coordination Group for Meteorological Satellites (CGMS) to monitor and harmonize data quality from operational weather and environmental satellites. The Infrared Visible Optical Sensors (IVOS) sub-group of the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV) extends this vision to include all Earth observation sensors and satellite operating agencies. Inter-calibration techniques provide a practical means of correcting biases between sensors and bridging any potential data gaps between non-contiguous sensors in a critical time-series and the inter-calibration reference serves as a transfer standard. It is expected that promotion of the use of robust inter-calibration techniques will lead to improved consistency between satellite instruments, reduce overall costs, and facilitate accurate monitoring of planetary changes.

List of topics

Contributions for this special issue are welcome from the research community. This special journal issue will focus on how inter-calibration and comparison between sensors can provide an effective and convenient means of verifying post-launch sensor performance and correcting the differences. The guest editors invite submissions that explore topics including, but not limited to, pseudo-invariant calibration sites, instrumented sites, simultaneous nadir observations and other ray-matching comparisons, lunar and stellar observations, deep convective clouds, liquid water clouds, Rayleigh scattering and Sun glint. The inter-calibration results should focus on rigorous quantification of bias and associated sources of uncertainty from different sensors, crucial for long-term studies of the Earth. The goal of this special journal issue is to capture the state-of-the-art methodologies and results from inter-calibration of satellite instruments, including full end-to-end uncertainty analysis. Accordingly, it will become a reference anthology for the remote sensing community.

Paper submission deadline: 31 January 2012

Submission guidelines

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

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CALL FOR PAPERS

IEEE Transactions on Geoscience and Remote Sensing

Special Issue on "Analysis of Multitemporal Remote Sensing Data"

In the last decade a large number of new satellite remote sensing missions has been launched resulting in a dramatic improvement in the capabilities of acquiring images of the Earth surface. This involves an enhanced possibility to acquire multitemporal images of large areas of the Earth surface, with improved temporal and spatial resolution with respect to traditional satellite data. Such new scenario significantly increases the interest of the remote sensing community in the multitemporal domain, requiring the development of novel data processing techniques and making it possible to address new important and challenging applications. Nonetheless, the properties of the images acquired by the last generation sensors (e.g. very high geometrical resolution, large time series of images, etc.) pose new methodological problems that require the development of a new generation of methods for the analysis of multitemporal images and temporal series of data. This is common to both passive (multispectral, hyperspectral, etc.) and active (synthetic aperture radar, lidar, etc.) sensors. The potentials of the technological development are strengthen from the increased awareness of the importance of monitoring the Earth surface at local, regional and global scale. Assessing, monitoring and predicting the dynamics of land covers and of antrophic processes is at the basis of both the understanding of the problems related to climate changes and the definition of politics for a sustainable development. The enhanced capability to perform multitemporal analysis of local areas at a very detailed scale is put beside these global themes and represents another strategic area of application.

Contributions for this special issue are welcome from the research community developing new techniques for the analysis of multitemporal data, as well as from the application community using the results obtained from the automatic analysis on the following topics.

List of topics

- Multitemporal image calibration, correction and registration techniques;
- Multitemporal image analysis techniques;
- Classification of multitemporal data;
- Analysis of time series;
- Data mining in time series;
- Change detection methods;
- Change detection accuracy assessment;
- Multitemporal SAR and InSAR data analysis;
- Fusion of multitemporal data;
- Land-cover and land-use dynamics;
- Phenology monitoring;
- Applications of multitemporal data and time series;
- New satellite missions for acquiring time series.

Paper submission deadline: 29 February 2012

Submission guidelines

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IGARSS 2012

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Remote Sensing for a Dynamic Earth

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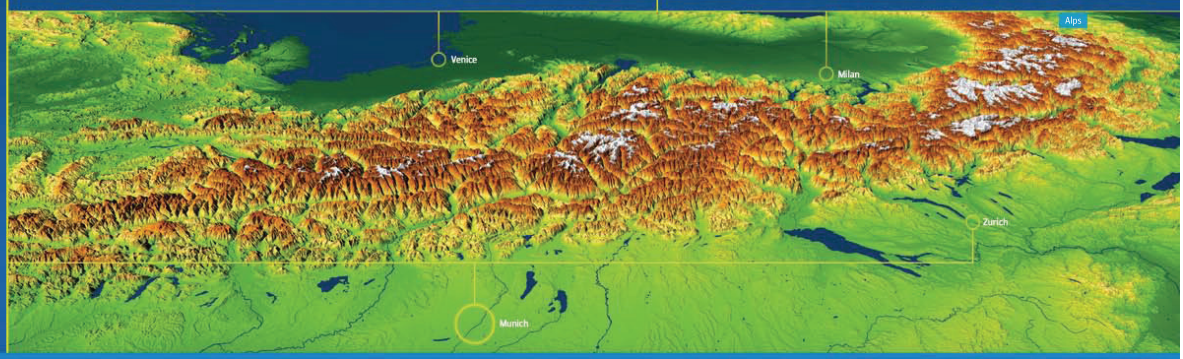
Themes

The technical programme will account for the following themes:

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

In addition special scientific themes will be addressed, including:

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



info@igarss12.org

www.igarss12.org

Student prize competition

All IEEE student members are invited to enter the IGARSS Student Prize Paper Competition. The selection will be done by a committee and the selected students will present their papers during a special session at the symposium. All finalists will be offered partial travel support funding.

2012 MUNICH IGARSS

22-27 July 2012 | Munich

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IEEE GRSS DLR esa

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UPCOMING CONFERENCES

See also http://www.techexpo.com/events or http://www.papersinvited.com

Name: 4th International Conference on GEographic Object Based Image Analysis (GEOBIA2012)
Dates: May 7–9 , 2012
Location: Rio de Janeiro, Brazil
Contact: Raul Queiroz Feitosa
E-mail: geobia2012@dpi.inpe.br
URL: http://www.inpe.br/geobia2012

Name: 14th International Conference On Ground Penetrating Radar (GPR2012)
Dates: June 7–9, 2012
Location: Shanghai, China
Contact: Dr. Xiongyao Xie
E-mail: xiexiongyao@tongji.edu.cn
URL: www.gpr2012.org

Name: 20th International Conference on Geoinformatics (Geoinformatics 2012)
Dates: June 15–17, 2012
Location: Hong Kong, PRC
E-mail: iseis@cuhk.edu.hk
URL: http://www.iseis.cuhk.edu.hk/GeoInformatics2012

Name: 39th Scientific Assembly of the Committee on Space Research and Associated Events (COSPAR 2012)
Dates: July 14–22, 2012
Location: Mysore, India
E-mail: cospar@cosparhq.cnes.fr
URL: http://www.cospar-assembly.org

Name: 2012 IEEE Geoscience and Remote Sensing Symposium (IGARSS2012)
Dates: July 22–27, 2012
Location: Munich, Germany
E-mail: info@igarss2012.org.
URL: http://www.igarss2012.org/

Name: Workshop on Reflectometry using GNSS and Signals of Opportunity
Dates: October 10–11, 2012
Location: West Lafayette, IN, United States

Name: International Symposium on Geomatics for Integrated Water Resources Management (GIWRM2012)
Dates: October 19–21, 2012
Location: Lanzhou, China

Name: International Conference on Computer Vision in Remote Sensing (CVRS 2012)
Dates: December 6–8, 2012
Location: Xiamen, China
E-mail: CVRS2012@gmail.com
URL: http://cvrs2012.xmu.edu.cn