IEEE GEOSCIENCE and REMOTE SENSING Newsletter

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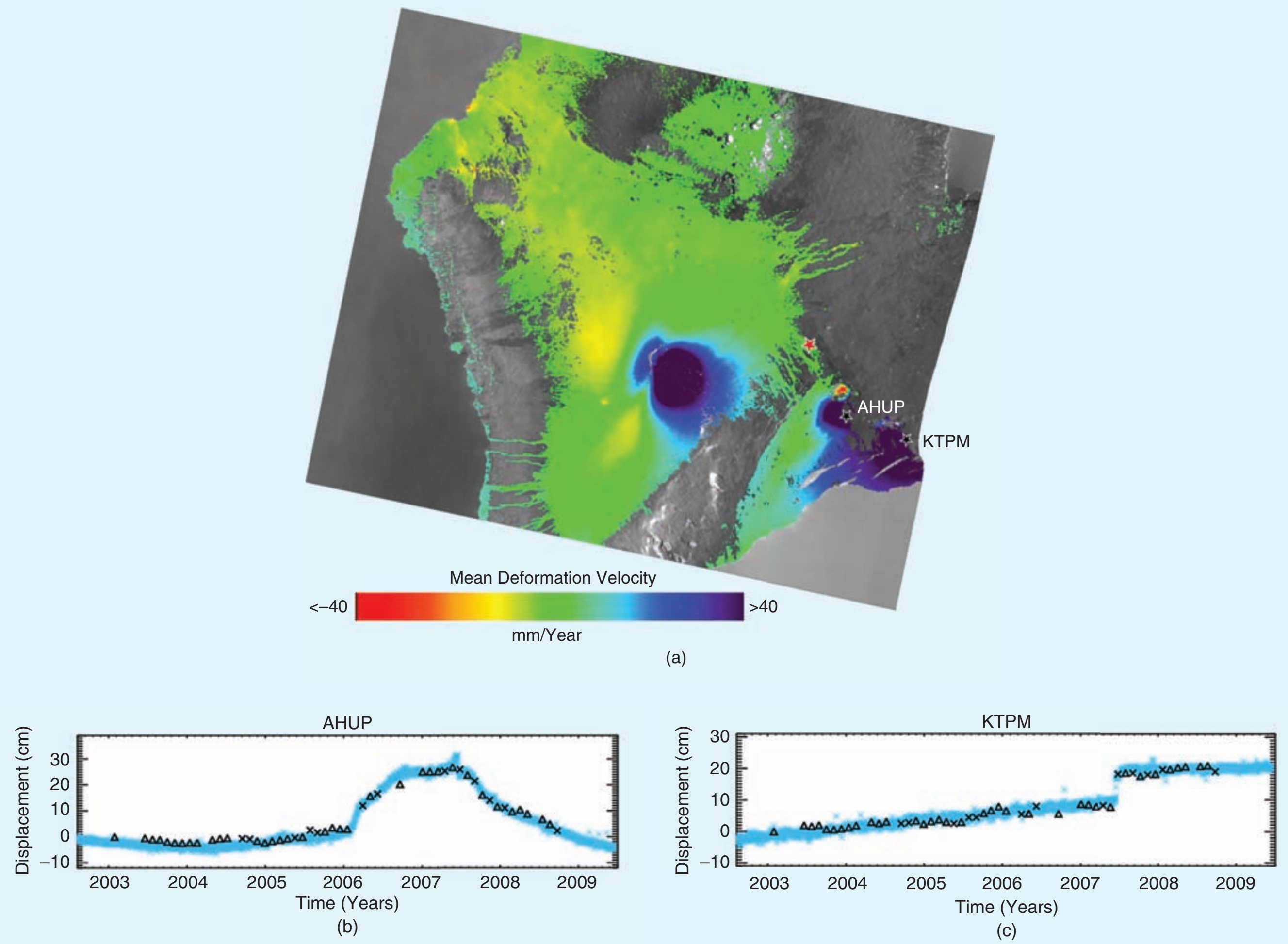

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The following is the schedule for the GRSS Newsletter. If you would like to contribute an article, please submit your input according to this schedule. Input is preferred in Microsoft Word, WordPerfect or ASCII for IBM format (please send disk and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

GRSS Newsletter Schedule

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

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This issue of the IEEE Geoscience and Remote Sensing Newsletter is published shortly before the IEEE IGARSS 2012 Symposium that will be held on July 22–27 in Munich, Germany.

I would like to draw your attention to the new policy instituted by the IEEE GRSS in 2012 in which each issue of its three peer-reviewed journals (i.e., *IEEE Transactions on Geoscience and Remote Sensing*, *IEEE Geoscience and Remote Sensing Letters*, and *IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing*) will contain one "Editor's Choice" open-access paper. That paper will be selected by the Editorial Board, and the associated paper charges will be covered by the GRSS. Papers will be selected based on their likelihood of impact and for the broadest possible interest to our community. These papers can be downloaded from the IEEE Xplore online archives by anyone free of charge. Beginning with this issue, the GRSS Newsletter will contain a new column entitled *Open Access Papers* to inform the reader of the recent open-access articles published in the three GRSS journals. We will publish the titles, authors, issue number and pages of the selected papers.

This issue includes interesting contributions on both scientific and technical topics of remote sensing, as well as the activities of the IEEE Geoscience and Remote Sensing Society (GRSS).

The *Features* section includes two main contributions. The first article is a tutorial paper on Synthetic Aperture Radar Interferometry (InSAR) and Differential InSAR (DInSAR). The article describes the main objectives of these techniques and some of the most relevant advances published in the recent literature. It also discusses the key role played by the Advanced Synthetic Aperture Radar (ASAR) on the ENVISAT

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President's Message

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On behalf of the IEEE Geoscience and Remote Sensing Society (GRSS), I invite you to participate in our annual International Geoscience and Remote Sensing Symposium (IGARSS). This year's IGARSS 2012 will be held at the International Congress Center in Munich, Germany from July 22–27 (please refer to www.igarss12.org for more information).

The organization of IGARSS starts approximately four years before the conference is held. The success of every IGARSS is due to the hard work of a large number of volunteers. IGARSS continues to grow, and this year more abstracts were received than ever before. As a result of a very careful review process, an outstanding technical program has been organized for IGARSS 2012. The conference will be larger than ever before in terms of the number of papers presented, with 16 parallel oral sessions and a number of poster sessions. The theme of the conference is "Remote Sensing for a Dynamic Earth." This year more than 50 scientists and engineers from around the world worked very hard to finalize the IGARSS technical program during our Technical Program Committee meeting held this March in Frascati, Italy. My congratulations and sincere thanks to all of the colleagues involved in the review process and session organization for their excellent work during the two-month review and abstract selection process. A special note of thanks goes to the excellent IGARSS 2012 team, led by General Co-Chairs Alberto Moreira and Yves-Louis Desnos, and Technical Program Committee Co-Chairs Irena Hajnsek and Helmut Rott. The IGARSS 2012 team has

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Cover Information: (a) Geocoded mean deformation velocity map relevant to the Big Island of Hawaii, computed in coherent pixels only (color scale) and superimposed to the SAR amplitude image (gray scale); the time interval extends between January 2003 and September 2008. The black stars mark the locations of the GPS stations, whose displacement time series are compared to the DInSAR ones in the following; the red star identifies the SAR reference pixel. (b–c) Comparison between the retrieved DInSAR measurements (ENVISAT Stripmap: black triangles; ENVISAT ScanSAR: black crosses) and the LOS-projected GPS time series (light blue stars) for the pixels labeled as AHUP and KTPM in (a).

(Editor's Comments continued from page 3)

satellite mission of the European Space Agency (ESA) for the development and application of InSAR and DInSAR during the past 10 years. The article also presents very interesting test cases with examples of the unique information that can be extracted by using DInSAR techniques. The second article is focused on the fundamental role that ENVISAT (the largest and most complex satellite ever built by ESA) played during the last 10 years. This is a very timely recognition of the many achievements resulting from ENVISAT, which ended its mission on April 8, 2012, when contact with the satellite was definitively lost. ENVISAT was a unique mission with a combination of ten instruments using very different techniques and benefitting numerous user communities ranging from many fields of Earth sciences including atmospheric science, cryospheric science, oceanography, land use and land movement to operational applications.

The *Book Review* column presents an overview of *Remote Sensing with Imaging Radar*, authored by John A. Richards. The review of this important book was written by Sebastiano Bruno Serpico, Professor in the Department of Telecommunications, Electronic, Electrical, and Naval Engineering at the University of Genoa, Italy.

The *Reports* section contains a contribution that recognizes the Best Reviewers for 2011 of the *IEEE Transactions on Geoscience and Remote Sensing*, *IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing*, and *IEEE Geoscience and Remote Sensing Letters*. We are all aware of the amount of effort required to complete high quality reviews; therefore, it is important to recognize those who have performed as outstanding reviewers. Congratulations to all the recipients!

The *Technical Committee Corner* column contains an article describing the activities of the Data Archiving and Distribution Technical Committee (DAD-TC), focusing on diverse aspects of managing remotely sensed data throughout their life cycle. The article presents the current status of the committee, its initiatives and accomplishments, and related research priorities.

The *Chapter Corner* column presents a short note that reminds the very important opportunity for GRSS Chapters to use the GRSS Distinguished Lecturer Program. This program provides GRSS Chapters with seminars by experts on topics of interest and importance to the geoscience and remote sensing community. The program is structured so that Chapters will incur little or no cost to use it. Therefore, I strongly encourage chapters to take advantage of this very important initiative.

The *Education Corner* column presents two contributions. The first is an article on the Remote Sensing Summer School 2012 (RSSS12), which will be held on July 19–20, 2012, shortly before IGARSS 2012, in Munich, Germany. The RSSS12 is intended for Master's and Ph.D. students

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(President's Message continued from page 3)

truly done an outstanding job. The IGARSS 2012 technical program is available online at http://www.igarss2012.org/RegularProgram.asp.

A new initiative for the GRSS this year is the 2012 Remote Sensing Summer School (RSSS12) held in conjunction with IGARSS 2012 (see http://www.igarss2012.tum.de/). The RSSS12 is intended for Master's and Ph.D. students focusing on geoscience and remote sensing topics. At the school, participants are offered the opportunity to meet internationally renowned specialists and experts in the field of remote sensing and to gain an in-depth education in state-of-the-art knowledge on selected topics of remote sensing. The program of RSSS12 covers a wide range of topics, from radar fundamentals to hyperspectral data processing. I would like to acknowledge all the volunteers who are working on making the RSSS12 a fantastic new initiative. In particular, I would like to thank GRSS Education Director Antonio Plaza and Uwe Stilla of the Technical University of Munich for their outstanding job.

This year is a very special year for the GRSS as we celebrate our 50th anniversary. A commemorative book celebrating the history of the society will be given to all participants at IGARSS 2012 in Munich. The roots of the society can be traced back to February 1962 in Dallas, Texas, when a small group of mostly Texas-based engineers and scientists met for the first time as the Institute of Radio Engineers (IRE) Professional Technical Group on Geoscience Electronics (G-GE). The name changed to the IEEE Geoscience and Remote Sensing Society (GRSS) in 1981, and the focus became satellite and airborne remote sensing. The current GRSS is very different from the G-GE of 1962. It is now a very successful international society with 3400 members, and the membership continues to grow worldwide every year.

Both the IGARSS 2012 team and the GRSS AdCom look forward to seeing you in Munich in July!

Jón Atli Benediktsson
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FEATURE

TEN YEARS OF ENVISAT ACQUISITIONS: A MILESTONE FOR THE DEVELOPMENT OF ADVANCED DInSAR TECHNIQUES

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1. Introduction

Launched in March 2002, the ENVISAT satellite operated for more than 10 years until April 8, 2012, when contacts with the satellite were unexpectedly interrupted. After attempting to re-establish normal operations for one month, eventually the European Space Agency (ESA) declared the end of the mission.

Ten different instruments were mounted onboard the satellite and, over the mission lifetime, they collected an enormous amount of data that contributed to the formation of one of the largest archives for Earth Observations.

Among these instruments, the Advanced Synthetic Aperture Radar (ASAR) played a fundamental role because of its continuous imaging capability (all weather, night and day) based on a C-band (5.6 cm wavelength) radar system acquiring data through multiple operation modes (Stripmap and ScanSAR) with variable look-angles and multiple polarizations [1] [2]. Moreover, and most importantly, ENVISAT was crucial for the continuation of the European Remote Sensing satellite (ERS-1 and ERS-2) missions, particularly for what concerns the SAR Interferometry (InSAR) techniques [3] [4] [5].

Differential Synthetic Aperture Radar Interferometry (DInSAR) is an InSAR technique that allows generating spatially dense deformation maps of large areas on Earth, with centimeter to millimeter accuracy [6] [7]. In particular, the DInSAR approach exploits the phase difference (interferogram) between SAR image pairs relevant to acquisitions gathered at different times, but with the same illumination geometry and from sufficiently close flight tracks (ideally the same), thus allowing the extraction of information on the displacements occurred between the two "observations", projected on the radar line of sight (LOS) [4] [5] [8] [9] [10] [11] [12].

Although the deformation measurement capabilities of DInSAR had been demonstrated earlier [6] [7], it was the successful measurement of the displacements associated with the 1992 Landers earthquake, achieved by using interferograms computed from the ERS-1 SAR images, that made clear the revolutionary nature of such a technique. As a matter of fact, scientists were able to image the deformation surrounding the earthquake rupture with astonishing details [13] [14]. Since then, DInSAR techniques have been used to investigate a large number of phenomena, mostly based on single deformation episodes [7] [8] [13] [15].

The continuously growing set of interferometric data produced first by the ERS sensors and then by the ENVISAT system boosted the development of innovative DInSAR techniques. In particular, at the beginning of the 2000's the DInSAR technology was characterized by a major step forward. Indeed, the "advanced" DInSAR techniques were introduced for the analysis of the temporal evolution of the surface displacements detected through the generation of deformation time series.

These new DInSAR approaches are based on the inversion of properly generated sequences of DInSAR interferograms. These techniques require tens of images (typically at least 20–30) to be reliably used and they can be roughly grouped in two main categories: techniques that work on localized targets, referred to as Persistent Scatterers (PS) methods [16] [17] [18] [19] and those that also utilize extended targets, referred to as Small Baselines (SB) methods [20] [21] [22] [23], although a solution that incorporates both the PS and SB approaches has been also recently proposed [24].

In particular, the PS techniques, pioneered by the Permanent Scatterers approach [16], operate on the pixels of the full resolution SAR images that include a dominant scatterer with stable electromagnetic characteristics over time; such pixels are, therefore, affected by neither temporal nor spatial decorrelation effects. Conversely, SB methods allow also the exploitation of extended targets, which are usually associated with spatial and temporal decorrelation phenomena. In this case, it is carried out a proper selection of sequences of SAR data pairs with a limited spatial and temporal separation between the acquisition orbits, which is usually referred to as baseline (hence, the original name Small Baseline). As a consequence, in PS approaches the interferometric pairs can be chosen without any constraint on their baselines, the simplest and most effective way being the selection of one single master image in common to the whole dataset. Conversely, SB approaches require the use of multiple master interferograms, because of the baseline constraints, which may cause the data to be arranged in few small baseline subsets separated by large baselines. These subsets result to be independent of each other, thus leading to an underdetermined problem; this issue can be addressed via a minimum norm Least Squares solution, e.g., via the application of the Singular Value Decomposition (SVD) method, as originally proposed within the Small BAseline Subset (SBAS) approach [20]. One relevant feature of the SB methods is their capability to work also at reduced spatial resolution, through a complex averaging (multilook) operation on the interferograms, which is particularly relevant for geophysical application when large areas have to be investigated. In this context, it has also been proposed the SqueeSAR method [25], which allows the analysis of distributed targets, by operating on multitemporal interferograms computed at the same spacing of the full resolution ones, but following a pixel-selective low-pass filtering step.

Regardless of the selected approach or its particular implementation, the advanced algorithms offer many advantages with respect to classical DInSAR. First of all, atmospheric phase artifacts affecting single interferograms can be detected and filtered out because of their different space-time behavior with respect to the deformation signal [16] [20]. Second, topography artifacts and phase unwrapping errors can be mitigated by using the space-time data redundancy [26] [27]. Finally, possible orbital phase errors can be effectively compensated for [28]. All these characteristics contribute to improve the measurement final precision up to about 1-2 mm/year and 5-10 mm for deformation velocity maps and time series displacements, respectively [29] [30].

In spite of the mentioned improvements brought by the advanced DInSAR approaches, it is also evident their need to have available large and regularly updated archives of SAR data, all acquired with the same geometric and electromagnetic configuration (data stacks).

In this context, the availability of the ASAR sensor onboard the ENVISAT satellite was particularly timely. Indeed, in the post-2000 scenario, when the ERS-1 system was no more available and the interferometric capability of the ERS-2 system was impaired because of a gyroscope failure occurred on January 2001 [31], the use of this sensor has permitted to guarantee the continuity of the ERS time series, leading to extend them for nearly twenty years. Moreover, the multimode capability of the ASAR sensor, potentially representing a drawback for advanced DInSAR applications because preventing the system from acquiring with a fixed configuration, has turned out to be an opportunity for new developments of the DInSAR technology.

In the following we discuss the important contribution given to the development of the advanced DInSAR techniques by the ten years of operation of the ENVISAT system. This is done by considering a number of selected case studies, which are mostly based on the exploitation of the SBAS technique. The final section is devoted to some conclusive remarks and to present some future developments, which are envisaged by the forthcoming Sentinel sensors.

2. Integration of ERS and ENVISAT SAR Acquisitions for Long Term Surface Deformation Time Series Analysis: the Istanbul city (Turkey) Case Study

The Stripmap mode of the ASAR sensor on board ENVISAT could acquire with a looking angle of about 23 deg (swath IS2). This option is geometrically compatible with the ERS-1/2 sensors and, therefore, it can be effectively exploited within a multi-sensor ERS/ENVISAT advanced DInSAR processing. However, the integration of these data is not trivial because the two radar sensors, although operating both at C-band, use slightly different carrier frequencies: 5.331 GHz for the ENVISAT-ASAR sensor and 5.3 GHz for the ERS ones. This 31 MHz frequency difference leads to a large range spectral shift effect [32] that strongly reduces the superimposition of the relative range frequency bands, thus inducing relevant decorrelation effects in the ERS/ENVISAT cross-interferograms [33]. Although this can be compensated by selecting cross-interferograms with an appropriate (very large) perpendicular baseline [34], this characteristic represents a drawback for DInSAR applications since it strongly limits the use of cross-interferograms.

An effective way to overcome this limitation is the combination of ERS and ENVISAT data based on the dedicated implementation of the SBAS approach originally proposed in [33]. The key idea of this solution is to consider the images acquired by the ERS and ENVISAT radar systems as belonging to independent subsets: accordingly, no ERS/ENVISAT cross-interferograms are produced and the combination of the conventional ERS-ERS and ENVISAT-ENVISAT (IS2 swath) interferograms is easily carried out by applying the SBAS strategy without major changes. Of course, enough temporal overlap between the time series of the acquisitions of the two sensors is needed.

When applied to ERS and ENVISAT data, this approach allows obtaining 18 years of deformation time series from 1992, when ERS-1 entered into operation, to 2010, when ENVISAT was moved to a lower orbit, thus interrupting the long time series of interferometric acquisitions.

To illustrate the potentiality of this application, we present in the following an experiment that investigates the surface deformation in the greater city area of Istanbul (Turkey), including the co-seismic displacement caused by the Izmit earthquake occurred on August 17, 1999 [35] [36], and several subsiding areas within the city limits. In particular, we used 67 ERS-1/2 and 22 ENVISAT SAR data acquired on descending

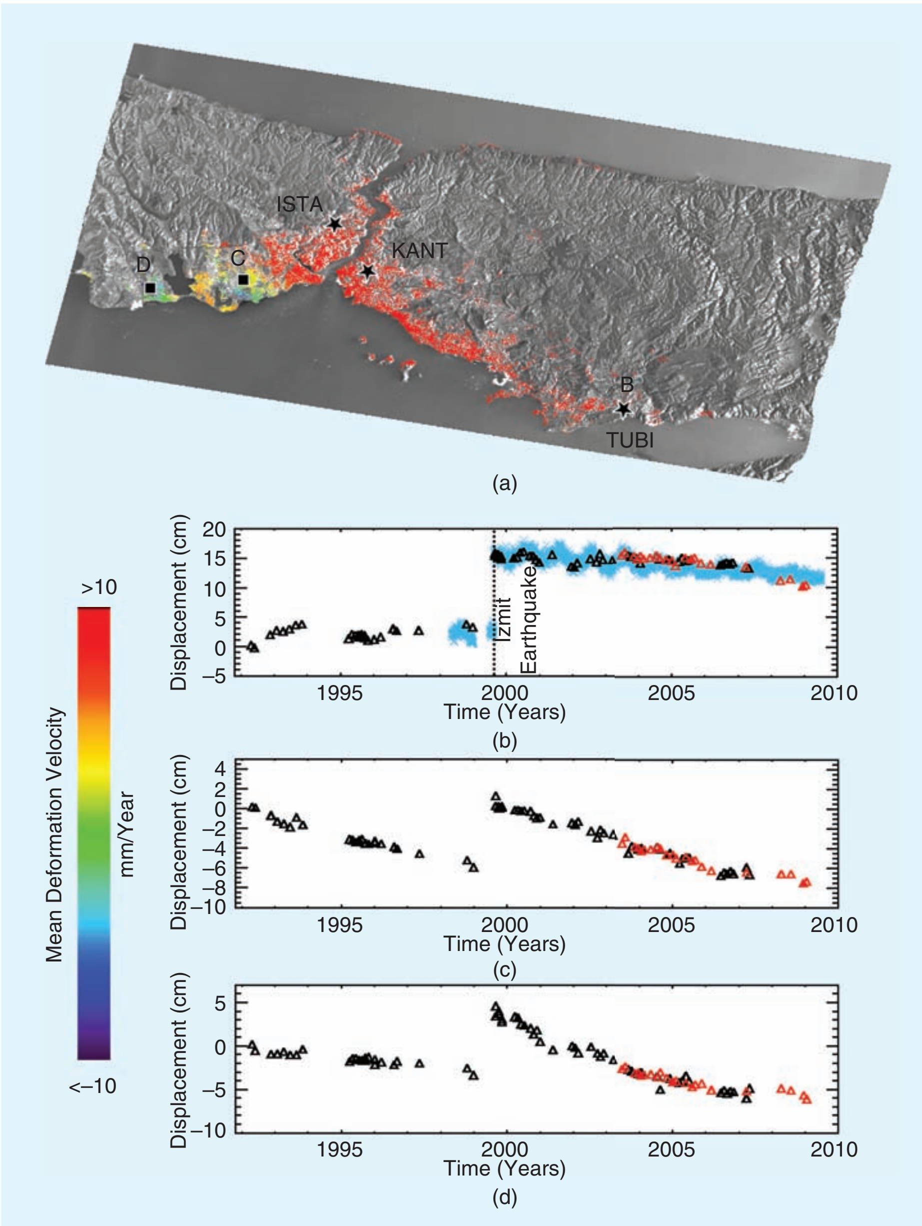

Figure 1. (a) Geocoded absolute mean deformation velocity map relevant to the Istanbul city area and surroundings, computed in coherent pixels only (color scale) and superimposed to the SAR amplitude image (gray scale); the time interval extends between April 1992 and January 2009. The black stars and squares mark the locations of the GPS stations used to compute the absolute velocity map and of the pixels whose displacement time series are reported in the following. (b) Comparison between the retrieved DInSAR measurements (ERS: black triangles; ENVISAT: red triangles) and the LOS-projected GPS time series (light blue stars) for the pixel labeled as B in Fig. 1a and located in correspondence to TUBI GPS station. The vertical dashed line indicates the date of the Izmit earthquake (c-d). Deformation time series (ERS: black triangles; ENVISAT: red triangles) for the pixels marked as C and D in Fig. 1a.

orbits (Track 336, Frame 2781) from April 1992 to January 2009 [37]. From these acquisitions, 175 ERS-ERS and 54 ENVISAT-ENVISAT differential interferograms (with spatial and temporal baseline values smaller than 400m and 4 years, respectively) were computed. A complex multilook operation with four looks in the range direction and twenty looks in the azimuth one was also applied, resulting in a pixel dimension of about 100 m × 100 m.

Fig 1a shows the mean deformation velocity map (in colors) of the area, geocoded and superimposed on a multilook amplitude image (grey scale), wherein low coherence zones are masked out [37]. This kind of representation is particularly effective because it provides direct information on the estimated mean deformation rate. Note that we show the absolute deformation field, despite what DInSAR usually provides, i.e., measurements relative to a reference point. This result was possible because we could use the measurements of the GPS stations [38] [39], whose positions are indicated by black stars in Fig. 1a.

The time series corresponding to points labeled as B, C and D in Fig 1a are depicted in Fig. 1b, Fig. 1c and Fig. 1d, respectively. It is evident a large discontinuity in the time series in correspondence to the date when the Izmit earthquake took place, thus making evident the ability of the technique to measure the far field deformation related to this event. In particular, Fig. 1b shows the comparison between the retrieved SBAS-DInSAR time series (black and red triangles for the ERS and ENVISAT acquisitions, respectively) and the LOS-projected GPS one (light blue stars) for the pixel labeled as B and located in correspondence to the TUBI GPS station; the good agreement between the two measurements is evident. Finally, Fig. 1c and 1d report the deformation time series for two pixels located in the Western sector of the grater city area of Istanbul and reveal both the effect of the Izmit earthquake and surface subsidence.

It is evident from the plots shown in Fig. 1 the possibility to significantly extend in time the deformation time series computed from the ERS data by exploiting the geometrically compatible ENVISAT SAR images. Note that the displacement time series are estimated without using any model for the temporal evolution of the deformation, thus allowing the analysis of dynamic deformation phenomena characterized by non-linear regimes, as for the case of the investigated test site.

3. Deformation Time Series Generation From Multi-Mode ENVISAT SAR Acquisitions: The Big Island of Hawaii (U.S.A.) Case Study

The capability of acquiring data in the ScanSAR mode [40] [41], in addition to the conventional Stripmap one, was a significant feature of the ASAR sensor onboard the ENVISAT satellite. In this acquisition mode, the system is able to image, within a single orbit cycle, wide areas on the ground, by periodically steering the antenna beam in the range direction to neighboring swaths, referred to as subswaths, which are subsequently combined at the signal processing stage. As a consequence of this beam steering, the whole range swath dimension is significantly increased up to 400 km at the expenses of a degraded azimuth resolution since, for each target, only some portions (bursts) of the full synthetic antenna aperture length are available; in addition, the subsequent data focusing step becomes more complex. Fig. 2 sketches the ScanSAR acquisition configuration. It is clear that while acquiring in this mode, no Stripmap acquisitions are possible. Accordingly, if only Stripmap SAR image sequences are considered, it often occurs that temporal gaps exist because of the ScanSAR operation.

However, in the presence of a stack of data composed by mixed ScanSAR and Stripmap acquisitions, there are several DInSAR processing strategies that can be implemented for the generation of ground deformation time series with no gaps caused by the multi-mode operation. One possibility is to compute Stripmap-Stripmap and ScanSAR-ScanSAR interferograms and then merge them by using, for example, the SBAS approach. This is similar to what is done for the merging of data acquired by different sensors with similar characteristics, such as the ERS and ENVISAT case presented in the previous section. However, ScanSAR-ScanSAR interferograms are potentially affected by a limited burst overlap in the along track direction, which can be responsible for a significant coherence degradation [42] [43].

Another approach is to exploit cross-mode ScanSAR-Stripmap pairs in addition to the usual Stripmap-Stripmap ones. It is clear that, since Stripmap acquisitions have a continuous and complete azimuth coverage, it is always possible to extract, from the Stripmap acquisitions, a portion of the azimuth data which perfectly overlaps with the

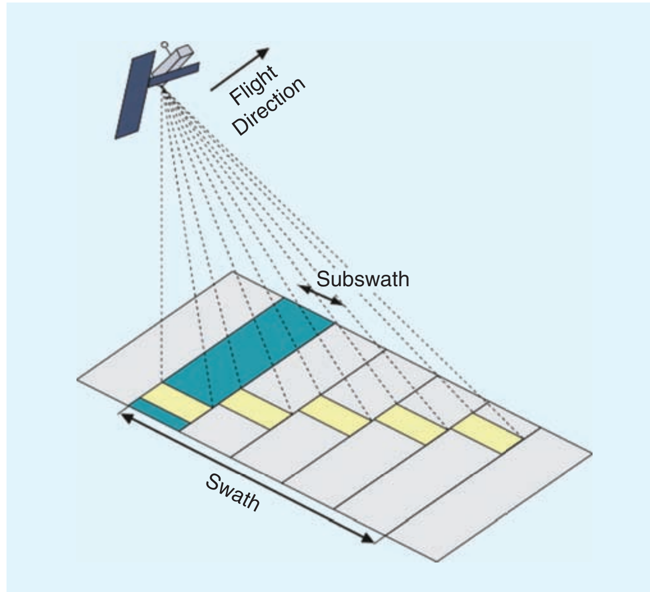

Figure 2. ScanSAR acquisition geometry.

ScanSAR burst, thus overcoming the problem of burst synchronization and making it possible to generate cross-mode interferograms.

One way to generate these interferograms is to appropriately "burst" the Stripmap raw data leading to images that are compatible, at the pixel dimension scale, with the ScanSAR ones [44]. This Stripmap bursting operation must be carried out carefully to maintain the azimuth spectral overlap between the two SAR images, in order to preserve the coherence of the interferograms generated from the burst image pairs. Therefore, this approach requires an ad-hoc processing step, in order to perform the appropriate bursting and focusing of the Stripmap raw data, as well as to carry out the necessary co-registration step [44] [45]. On the other hand, it is possible to choose an alternative processing strategy [46] that allows for a straightforward implementation of both the image co-registration and interferogram generation steps. This approach is somehow similar to what originally proposed in [47] but, instead of processing the overall burst sequence padded with zeros within the intraburst period, the ScanSAR raw data are properly focused on a burst-by-burst basis [48] by using one of the available phase-preserving Stripmap focusing algorithms [5]. Accordingly, the focused burst data have an output geometry and an azimuth spacing consistent with that of the Stripmap image, thus making easier the subsequent registration, interferogram generation and phase unwrapping steps [46].

Once all the interferograms are unwrapped, they can be used to compute the overall deformation time series and velocity maps through advanced DInSAR algorithms.

To illustrate an application of this technique, based on the use of the SBAS approach, we consider an archive of 36 Stripmap and 13 ScanSAR images acquired on descending orbits

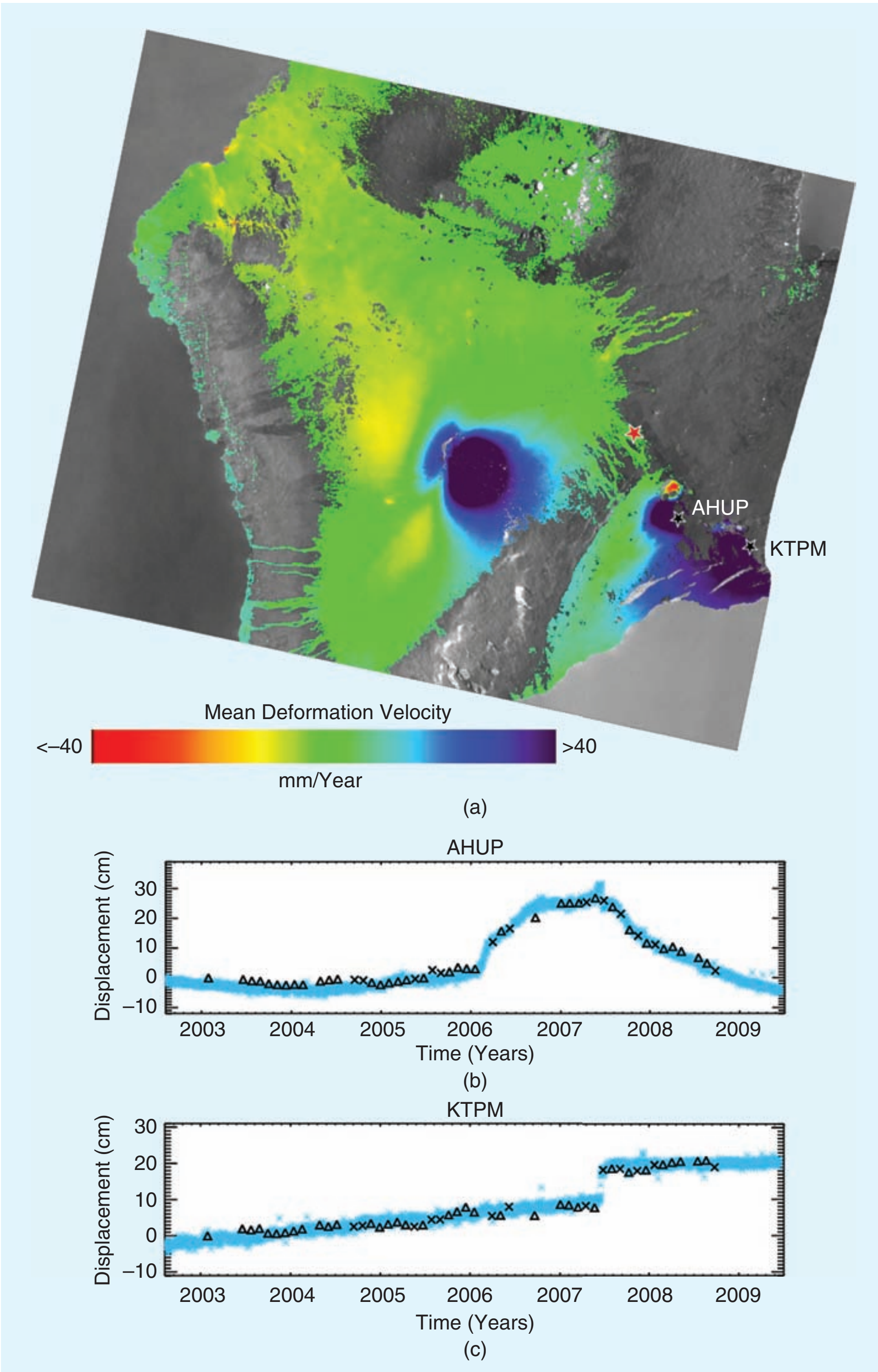

Figure 3. (a) Geocoded mean deformation velocity map relevant to the Big Island of Hawaii, computed in coherent pixels only (color scale) and superimposed to the SAR amplitude image (gray scale); the time interval extends between January 2003 and September 2008. The black stars mark the locations of the GPS stations, whose displacement time series are compared to the DInSAR ones in the following; the red star identifies the SAR reference pixel. (b–c) Comparison between the retrieved DInSAR measurements (ENVISAT Stripmap: black triangles; ENVISAT ScanSAR: black crosses) and the LOS-projected GPS time series (light blue stars) for the pixels labeled as AHUP and KTPM in Fig. 3a.

(Track 200, Frame 3231) by the ASAR instrument onboard the ENVISAT satellite, from January 2003 to September 2008, over the Big Island of Hawaii (U.S.A.). From these acquisitions, 100 Stripmap-Stripmap and 62 Stripmap-ScanSAR differential interferograms were computed, provided that upper limits of 400m and 4 years were set up for the spatial and temporal baselines, respectively. A complex multilook operation with four looks in the range direction and twenty looks in the azimuth one was also applied, resulting in a pixel dimension of about 100 m $\times$ 100 m.

Fig. 3a shows the geocoded mean deformation velocity map (in colors) of the investigated area for the overall 2003–2008 time interval, superimposed to an amplitude multilook image (gray scale) of the study area. Note that all measurements are evaluated with respect to a reference point (red star) assumed to be stable. It is evident the complexity and extension of the detected deformation pattern.

Fig. 3b and Fig. 3c report the deformation time series of two pixels labeled as AHUP and KTPM in Figure 3a, respectively. The capability of the retrieved time series to follow non-linear and also discontinuous signals is clear. Moreover, the successful integration between the ScanSAR (crosses) and Stripmap (triangles) data is evident, allowing to significantly improve the temporal sampling of the retrieved time series.

Finally, a comparison between the computed time series and continuous GPS measurements (light blue stars), properly projected along the radar line of sight, is also given. The plots make it evident the agreement between the two techniques, while the standard deviation of their difference, which is of about 1 cm in both cases, gives a figure of the accuracy of the method that is in accordance with that expected for the Stripmap only SBAS results [29].

4. Conclusion and Future Developments

The availability of the ASAR sensor operating from the ENVISAT satellite has been particularly timely and effective for the development and the sustainability of advanced DInSAR techniques for surface displacement deformation analysis. In particular, it guaranteed the continuity of the ERS time series, thus permitting almost 20 years of observations. These archives represent a vast source of information, which is of great importance for the comprehension of several deformation phenomena affecting many areas of the world.

Moreover, the multi-mode capability of the ASAR sensor, potentially representing a drawback for advanced DInSAR applications, has been in many cases an opportunity for new developments of the DInSAR technology.

However, in the context of deformation time series analysis, there are also limitations that ENVISAT could not contribute to reduce. This is particularly the case of the revisit time of the satellite. Indeed, ENVISAT did not bring any significant improvement with respect to the 35 days repeat time already characterizing the ERS systems. This monthly interval represents a major limitation for the exploitation of SAR systems, particularly in scenarios related to the investigation of phenomena characterized by rather fast dynamics.

This issue has become rather more evident with the growing availability of the SAR data collected in X-band (3.1 cm wavelength) through second generation radar systems onboard the COSMO-SkyMed [49] and TerraSAR-X [50] sensor constellations, which combine improved ground resolutions (1-3 m) and much shorter revisit times (8 days for COSMO-SkyMed and 11 days for TerraSAR-X) with respect to first generation C-band sensors.

The improvement of the spatial resolution is particularly relevant when dealing with localized phenomena or effects related to buildings and man-made structures; however, the drawback is a decrease of spatial coverage, which typically reduces from hundred to few tens of kilometers.

However, the great improvement of such X-band sensors is their capability of investigating deformation phenomena with rapid dynamics, which has a major impact in geophysics. A key example has been shown following the L'Aquila (Italy) earthquake occurred on April 6, 2009. In this case, thanks to the 8 days revisit time of the COSMO-SkyMed constellation, it has been possible to investigate the temporal evolution of the post-seismic displacements caused by the earthquake with an unprecedented level of detail [51].

Another relevant example is shown in Fig. 4, where we present data of the Campi Flegrei volcanic area, located in the Napoli Bay (Italy) and characterized by alternated subsidence and uplift phases [52]. Fig. 4a shows the mean deformation velocity map computed from ENVISAT data acquired between 2002 and 2010, while in Fig. 4b a comparison of the time series computed, through the SBAS technique, from ENVISAT (red triangles) and COSMO-SkyMed (black triangles) data is presented. Since COSMO-SkyMed data are available starting from July 2009, we report in Fig. 4c a zoom of the

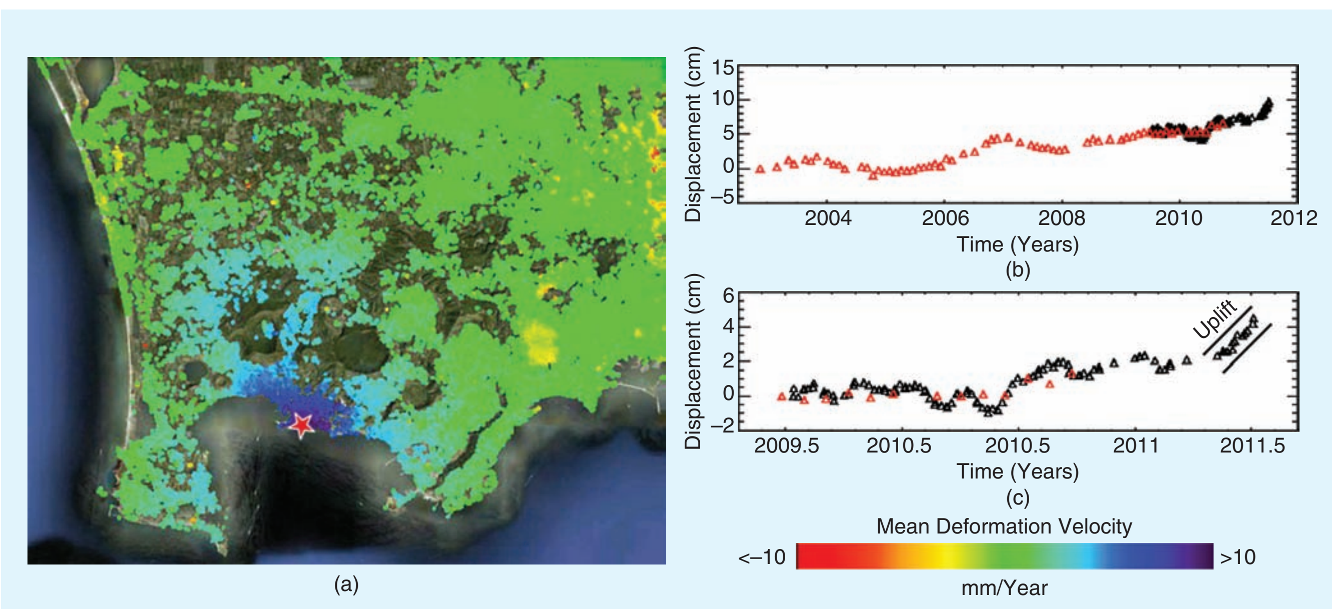

Figure 4. (a) Geocoded mean deformation velocity map of the Campi Flegrei area (Italy) computed by using ENVISAT data acquired between 2002 and 2010, superimposed on an optical image. (b) Deformation time series of the point indicated by a red star in (a); red triangles are ENVISAT data, black triangles COSMO-SkyMed data. (c) Zoom of the plot in (b) for the period July 2009-July 2011; the clear new uplift phase started in the area is clearly detected by COSMO-SkyMed data.

time series, for the period July 2009–July 2011. The relevance of the much shorter revisit time is evident, particularly in the early detection of the renewed fast uplift phase started in May 2011. Once again, the importance of short revisit time is essential to investigate rapid deformation phenomena.

In this context, the forthcoming Sentinel-1 system represents a major step forward for the advanced DInSAR techniques. The Sentinel program is focused on the development of a constellation of operational satellites developed by ESA [53] and the first mission will be Sentinel-1, with a satellite (Sentinel-1A) to be launched on 2013, followed by a second one (Sentinel-1B) planned after two years. The Sentinel-1 mission will ensure the continuity of SAR C-band systems onboard the Canadian Radarsat-1 and -2 systems and, above all, of the ERS-1, ERS-2 and ENVISAT sensors of ESA. This will be a part of the European contribution to the Global Earth Observation System of Systems (GEOSS) and of the Global Monitoring for Environment and Security Programme (GMES) space segment.

For what concerns the DInSAR applications, Sentinel-1A will have a 12-day revisit time, which will be reduced to a 6 day effective repeat cycle after the launch of the Sentinel-1B twin satellite, potentially allowing a weekly monitoring of deformation effects, with a strong mitigation of the temporal decorrelation phenomena. Moreover, the Sentinel-1 systems will operate on land areas with the Interferometric Wide Swath Mode with 250 km swath and 5 m $\times$ 20 m spatial resolution (range and azimuth, respectively). This rather large swath will allow to integrate the DInSAR results with Continuous GPS measurements of ground deformation, thus permitting to isolate different signals such as displacement effects, orbital phase patterns and atmospheric artifacts. In addition, the maximum expected perpendicular baseline will be shorter than 100 m, thus reducing dramatically the effects of the spatial decorrelation and opening amazing scenarios for the SB advanced DInSAR techniques.

These characteristics of Sentinel-1 acquisitions will give the possibility, through advanced DInSAR analyses, to detect and measure displacements with an accuracy, which is expected to be even better than 1 mm/year [54], with a major impact on the comprehension of several phenomena related, for instance, to seismic and volcanic areas.

Ten years of ENVISAT acquisitions have represented a significant step in the development of the advanced DInSAR techniques. In spite of the abrupt end of ASAR sensor operations, the future is extremely promising because of the forthcoming Sentinel-1 systems. In this case, in addition to the DInSAR oriented characteristics of the SAR sensors, the continuity and certainty of data acquisition, together with the rapid and (hopefully) open distribution data policy will contribute to the advancement of the knowledge in the Earth Observation field. These are the features that the scientific community is waiting for to give an ultimate contribution to the development of advanced DInSAR technologies for analyzing the surface deformation phenomena characterizing our planet.

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ENVISAT [2002–2012]

Henri Laur, Directorate of Earth Observation Programmes,
European Space Agency

1. Introduction

Envisat, the largest and most complex satellite ever built in Europe, has been monitoring Earth for a decade. Launched in 2002, it has operated for 10 years, i.e. twice its planned lifetime, until a major anomaly stopped the satellite operations on 8 April 2012.

Envisat was a unique mission, with its combination of 10 instruments using very different techniques and with its numerous user communities ranging from many fields of Earth sciences (atmosphere, cryosphere, oceanography, land use and land movements) to operational applications. As a package, Envisat's capabilities exceeded those of any previous or planned Earth observation satellite. The payload included three atmospheric sounding instruments designed primarily for atmospheric chemistry, including measurements of ozone in the stratosphere (GOMOS, MIPAS, SCIAMACHY). The Advanced Synthetic Aperture Radar (ASAR) collected high-resolution images with a variable viewing geometry, with new wide-swath and selectable dual polarization capabilities. Envisat also carried an imaging spectrometer for ocean color and vegetation monitoring (MERIS), as well as improved versions of the ERS radar altimeter, a microwave radiometer and visible/near-IR radiometers (AATSR), together with a very precise orbit measurement system.

Over the last decade numerous research findings have demonstrated the value of the Envisat mission to the Earth science community. Each Envisat symposium, held every three years, brings together more than 1000 participants, who have often announced major results, such as:

- Salzburg 2004: evidence of global sea-level rise of ~3 mm yr^{-1} and sea surface temperature increase of ~0.1°C since 1992 (Envisat and ERS missions); evidence of growing air pollution in China since 1995 (Envisat and ERS missions); and the identification of the blind tectonic fault at the epicentre of the Bam earthquake (Iran) in December 2003.
- Montreux 2007: the first global measurements of greenhouse gases by Envisat's SCIAMACHY demonstrating the increasing concentration of CO_2 and seasonal variations in methane concentrations in the atmosphere. Other results include measurements of the increased velocity of large glaciers in Greenland and Antarctica by ERS and Envisat SAR instruments, and the first description of a very large magma intrusion event between two tectonic plates in Ethiopia.
- Bergen 2010: evidence of the rapid reduction in the extent of Arctic sea ice in the last five years, monitoring data showing the break-up of several ice shelves (e.g. Larsen and Wilkins) in Antarctica since 2002, and observations of the Eyjafjallajökull eruption in Iceland in April 2010.

Over the years, the demand for Envisat data for scientific and operational uses has grown steadily, requiring continuous adaptations of the ground segment facilities to improve the quality and delivery of data.

An orbit change of the Envisat satellite was performed in October 2010. This major change, after eight years of

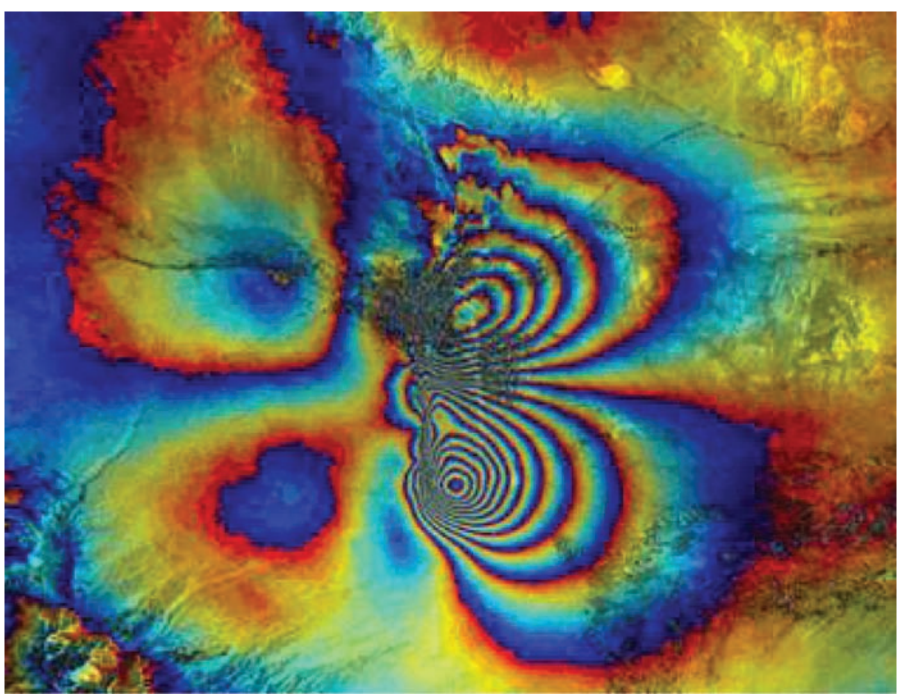

Figure 1. Interferogram showing ground displacements in the area around Bam, Turkey, following the earthquake in December 2003. (PoliMi/PoliBa)

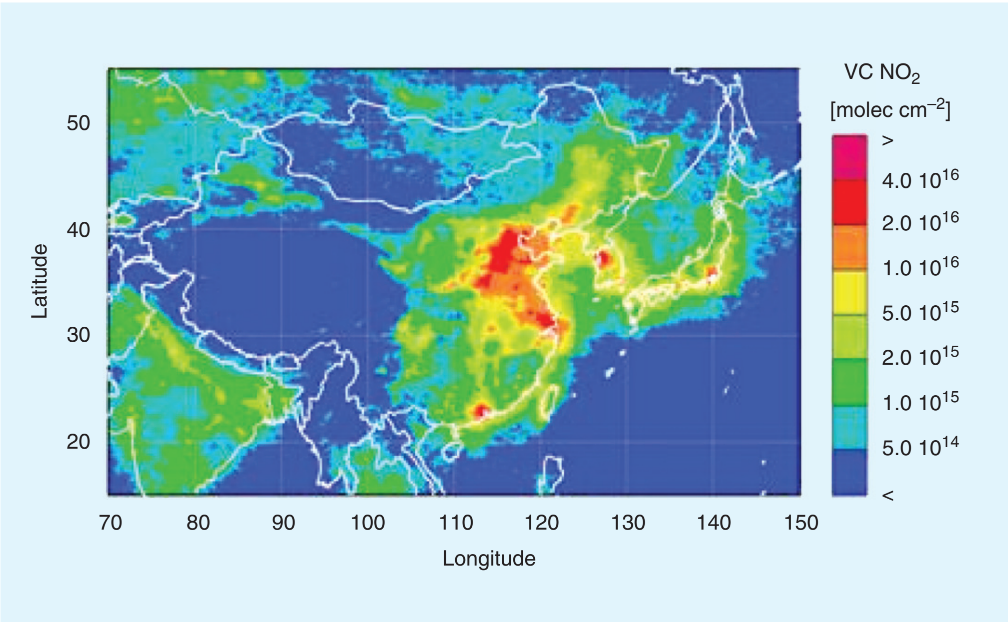

Figure 2. Map of tropospheric NO_2 vertical column density over northeast China, between December 2003 and November 2004. (Institute of Environmental Physics, University of Bremen, Germany)

operation, was needed to allow the satellite to operate for more years, well beyond its originally planned five-year lifetime. Unfortunately a major anomaly suddenly interrupted the Envisat data acquisition few weeks after celebrating its 10th year birthday in space.

Envisat has performed with high performances until its sudden termination. For example, following the disastrous earthquake in Japan in March 2011, Envisat provided a detailed map of ground displacements along an area extending for 800 km using the SAR Interferometry technique. A scientific publication

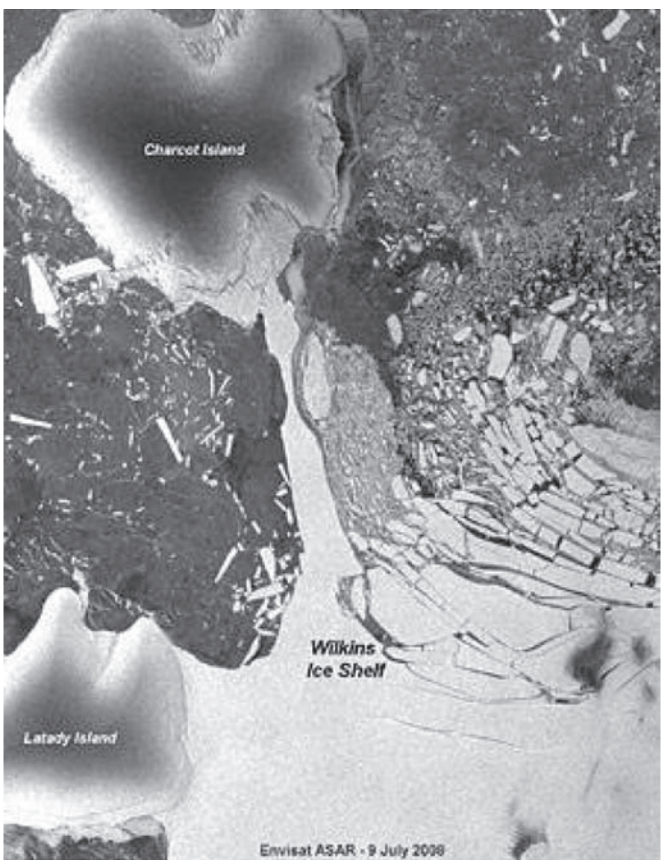

Figure 3. ASAR image of the Wilkins ice shelf in Antarctica, 9 July 2008. (ESA)

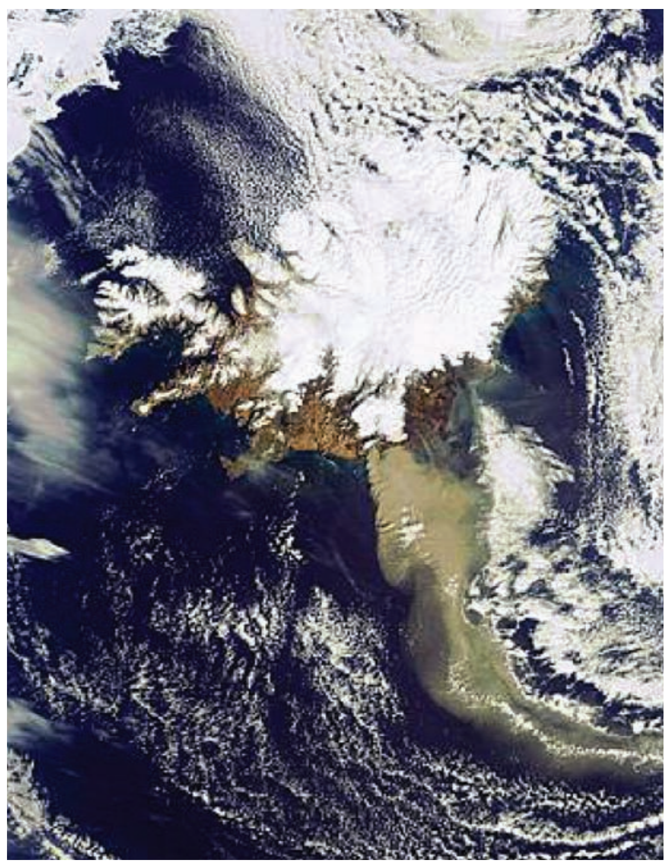

Figure 4. MERIS image of the Eyjafjallajökull volcano in Iceland, acquired on 19 April 2010. (ESA)

based on Envisat SAR data, reported the first observational evidence that a tsunami in the northern hemisphere (such as the one generated by the earthquake in Japan) can trigger ice-shelf calving in Antarctica, more than 13 000 km away.

Using the Sciamachy and MERIS instruments, the Envisat mission provided remarkable observations of the Grimsvötn volcano eruption in Iceland in May 2011.

In September 2011, Envisat observed the extent of Arctic sea ice at its minimum, very close to the previous minimum record of September 2007.

Many remarkable results based on Envisat and ERS SAR interferometry were presented at ESA's 8th Fringe workshop, 'Advances in the Science and Applications of SAR Interferometry', in September 2011. Among these were the first Antarctica ice velocity map, based on SAR data acquired during the International Polar Year, produced in coordination between ESA (Envisat), the Canadian Space Agency (Radarsat) and JAXA (Advanced Land Observing Satellite, ALOS).

2. Selected Envisat Results

2.1. Bam Earthquake, Turkey, 2003

The interferogram in Fig. 1 shows the contours of ground displacements towards and away from the Envisat satellite following the earthquake in Bam, Turkey, in December 2003. The four-quadrant pattern is consistent with a near-vertical strike–slip fault oriented north–south. The ground moved approximately 30 cm towards the satellite in the southeast quadrant, and approximately 15 cm away from it in the northeast quadrant.

The black areas in the image indicate locations where the ground surface had moved, preventing the measurement of displacements. Those around the city of Bam (image center) and neighboring towns were caused by damage to buildings and by vegetation. The narrow linear black band extending south of the centre of Bam is the surface expression of the fault, previously hidden, on which the earthquake occurred.

2.2. NO_2 Measurements over China, 2003–2004

Figure 2 shows the tropospheric nitrogen dioxide vertical column density over northeast China as measured by Envisat's Sciamachy instrument, averaged between December 2003 and November 2004.

2.3. Wilkins Ice Shelf Break-up, 2008

Figure 3 shows an image of the Wilkins ice shelf in Antarctica, acquired on 9 July 2008 by Envisat's ASAR instrument, showing the ice bridge connecting Charcot Island and Latady Island (bottom left) before its final break up in April 2009.

2.4. Eyjafjallajökull Volcano Eruption, Iceland, 2010

Figure 4 shows an image of the Eyjafjallajökull volcano in Iceland, acquired by Envisat's MERIS sensor on 19 April 2010. A heavy plume of ash from the volcano in Iceland can be seen moving in a roughly southeasterly direction. The plume, visible in brownish-grey, is approximately 400 km long.

2.5. Ice Velocity over Antarctica and Ground Displacements in Northern Japan, 2011

The two most important Envisat science results in 2011 are presented in Figs 5 and 6. Figure 5 shows the first map of ice

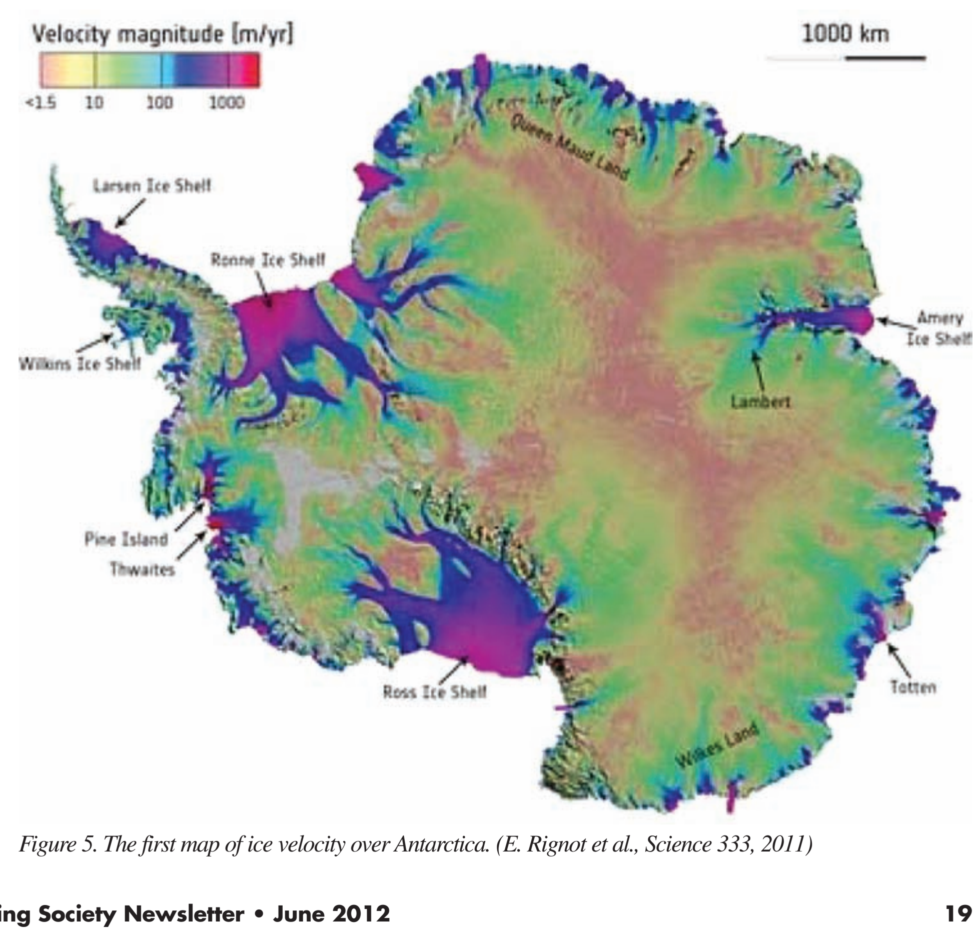

Figure 5. The first map of ice velocity over Antarctica. (E. Rignot et al., Science 333, 2011)

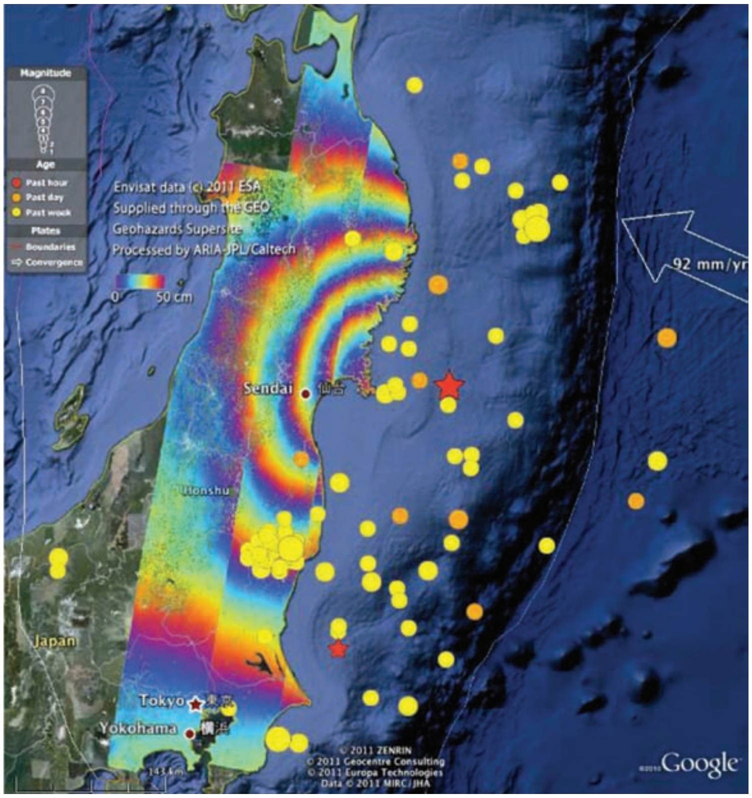

Figure 6. Ground displacements in northern Japan following the earthquake of March 2011. (Envisat data, ESA, supplied through the GEO Geohazards Supersite, processed by ARIA-JPL/Caltech; ZENRIN; Geocentre Consulting; Europa Technologies; Data MIRC/JHA; Google)

velocity over the entire continent of Antarctica, mainly derived from Envisat, Radarsat-2 and ALOS SAR data, with contributions from ERS-1/ERS-2 and Radarsat-1 data. These findings are critical for studies of the global impact of sea-level rise resulting from the more rapid flow of ice into the ocean. Figure 6 shows ground displacements in northern Japan following the earthquake of March 2011.

2.6. Envisat Sea Level Trends (Envisat altimetry)

Fig. 7 shows the map of regional patterns of Envisat observed sea level (in mm/year) between December 2003 and December 2011. Although the global trend indicates a rise in the mean level of the oceans of about 3 mm per year, there are marked regional differences that vary between –20 and 20 mm/year. These spatial patterns are not stationary. As a result, sea level trends patterns observed by *satellite altimetry* are transient features (Credits CNES/ESA/CLS).

2.7. Methane (Envisat SCIAMACHY Instrument)

Carbon dioxide (CO_2) and methane (CH_4) are the two most important anthropogenic (man-made) greenhouse gases and contribute to global warming. The reliable prediction of future atmospheric greenhouse gas concentrations and associated climate change requires an adequate understanding of their (natural

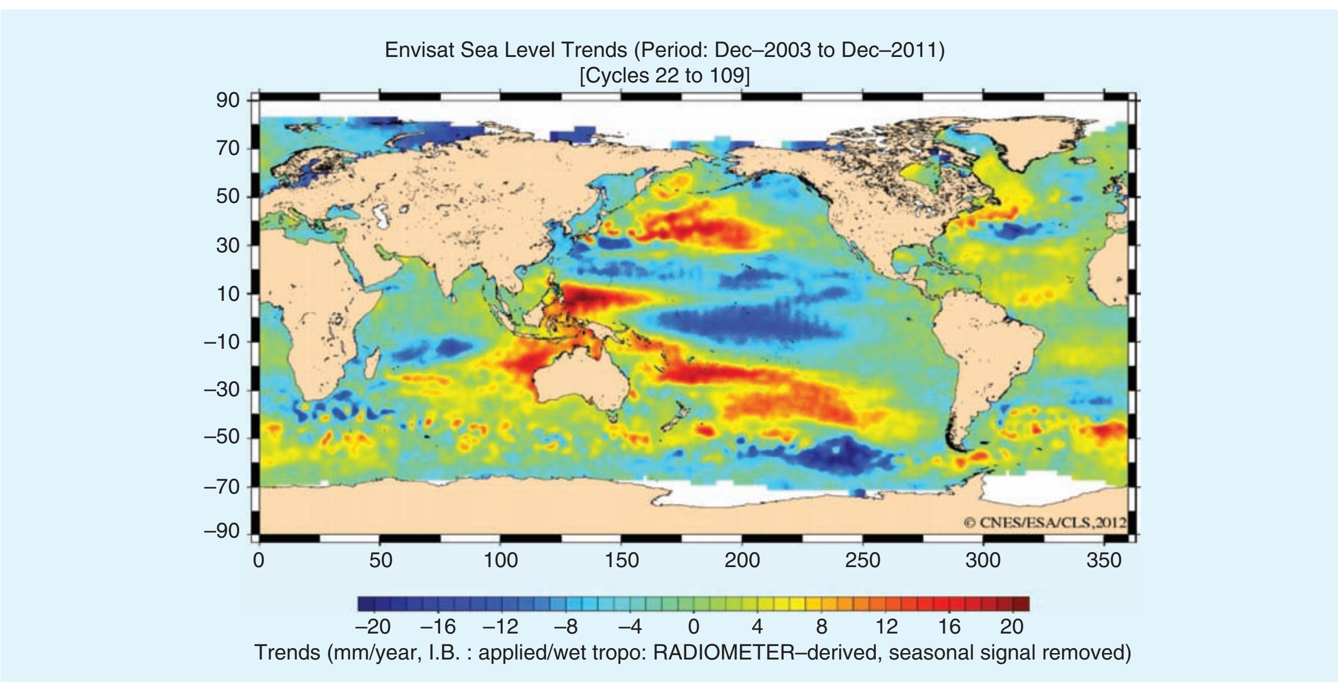

Figure 7. Map of regional patterns of Envisat observed sea level (in mm/year) between December 2003 and December 2011 (Credits CNES/ESA/CLS).

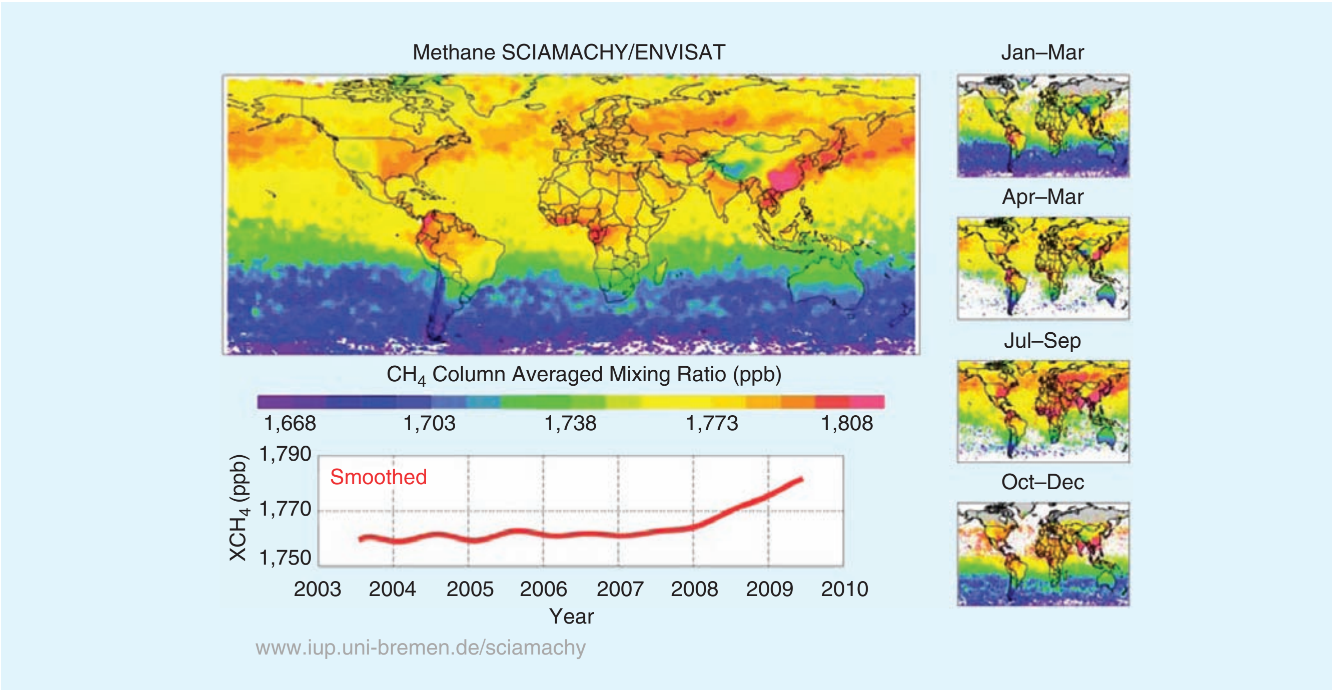

Figure 8. Global and seasonal maps of atmospheric methane retrieved from Envisat SCIAMACHY data measurements. (Credits: University of Bremen, IUP/IFE).

and anthropogenic) sources and sinks. SCIAMACHY on Envisat is the first satellite instrument whose measurements contain information on the vertical columns of both gases due to high measurement sensitivity down to the Earth surface where the major sources and sinks of these greenhouse gases are located. The vertical column of a gas is the number of molecules of this gas located in an air column which extends from the Earth's surface to the top of the atmosphere per surface area (unit: molecules/cm^2). For the greenhouse gases (CH_4 and CO_2) the columns is normalized with the corresponding (measured) number of air molecules (obtained, e.g., using oxygen (O_2) measurements) to get dry air column-averaged mixing ratios or mole fractions of the greenhouse gases (unit: ppb for CH_4).

The red curve shown in Fig. 8 is a smoothed time series. As can be seen methane was rather stable until about 2007 but started to increase in recent years. The reason for this is not yet fully understood.

High values typically indicate a major methane source region. Methane sources are wetlands, rice, ruminants, waste handling, coal mining, and many others. As methane is long-lived atmospheric transport is very important. Therefore, high values may also appear far from source regions, especially when the region is poorly sampled for example due to persistent cloud cover. Interpretation of the maps is therefore not straight forward and is typically done using complex models.

BOOK REVIEW

REMOTE SENSING WITH IMAGING RADAR

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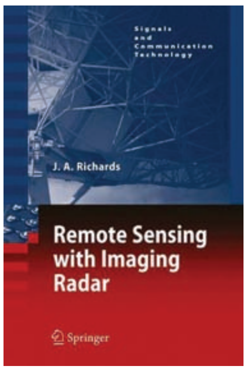

Authored by John A. Richards
Springer, 2009,
ISBN: 978-3-642-02019-3
(hardcover), -26113-8 (softcover),
-02020-9 (ebook)

The book *Remote Sensing with Imaging Radar* focuses on the characteristics and potential of radar technologies in remote sensing and the interpretation of the resulting images. These topics are of great importance in contemporary remote sensing because radar represents a major imaging technology in this field, allowing all-weather and day-and-night acquisition for a number of civil and military applications, and because of the current availability of spaceborne radar missions with very high spatial resolution, short revisit time and polarimetric and interferometric capabilities. This book, organized into nine chapters and five appendices, is written by an outstanding scientist and leading figure in the GRS field who has also authored other renowned textbooks on remote sensing image analysis and radio waves. As explicitly mentioned in the preface, this treatise is mostly targeted at Earth scientists, remote-sensing practitioners, and senior undergraduate or graduate students. Accordingly, the explanation style, especially in terms of mathematical formalization, is always carefully tuned with respect to the typical background of this target reader. The result is remarkable because, although radar image acquisition and interpretation generally involve analytically sophisticated concepts in computational electromagnetics, signal processing, pattern recognition, etc., the book successfully provides clear insights into all key concepts without resorting to complex mathematical tools.

Chapter 1 provides a general overview of the addressed topics, clearly introducing the motivations for the use of microwaves in remote sensing, the main components of radar imaging systems, and the structure of book. Prerequisites are also stated, a useful feature with respect to the aforementioned target readership, and several previous books on related topics are critically recalled.

Chapters 2 and 3 collectively address the physical and technological aspects behind radar imaging. Chapter 2 introduces the underlying physics. First, the radiation laws are illustrated and the primary role of active systems in microwave remote sensing is explained. Next, the basics of sinusoidal electromagnetic fields and their polarization, including characterization by the Jones vector and Stokes parameters, are thoroughly discussed. The Doppler effect, which plays an important role in synthetic aperture radar (SAR), is also explained. Chapter 3 presents the key technological concepts and is organized into two parts: one devoted to the radar system and another devoted to the scattering properties of the target. The treatment is very clear and, remarkably, ranges from classical notions of SAR, range and azimuth resolutions, radar cross section (RCS), scattering and covariance matrices, and so forth to more sophisticated topics, such as those associated with ScanSAR, spotlight acquisition, and compact polarimetry.

Chapter 4 offers an interesting overview of correction and calibration issues, including classical layover, foreshortening, and shadowing defects; radar calibrators; and geometric and radiometric correction. An introductory treatment of speckle statistics, focused on some of the most popular models (exponential, Rayleigh, and Gamma), and speckle reduction through multilooking or simple filters is also provided. Having studied the basic concepts presented here, those readers who are interested in developing a more in-depth knowledge may easily learn about other widely used statistical models for SAR signal distribution and more sophisticated speckle filtering from the ample literature on these topics.

Chapter 5 is focused on the scattering properties of the imaged scene and encompasses surface scattering models (e.g., Lambertian surfaces, the Bragg model), subsurface signal penetration and its impact on recorded imagery, volume scattering and extinction, strong targets and models for their RCS, Bragg scattering from periodic structures, and scattering from sea water or ice. The chapter is particularly successful in offering a thorough treatment, also emphasizing the roles of polarization, incidence angle, and wavelength, without involving the advanced mathematical tools generally used in electromagnetic scattering studies.

Chapters 6 and 7 focus on the topical subjects of interferometric, tomographic, and bistatic SAR. Interferometry and tomography are addressed in Chapter 6. The estimation of height and slow-movements from interferometric phase;

the related processing tasks (e.g., phase unwrapping); the properties of InSAR, differential InSAR (D-InSAR) and PolInSAR systems; and the concepts of complex coherence and orthogonal baseline are discussed. Next, the problem of reconstructing the vertical structure within a pixel is addressed by explaining the approaches of both multi-baseline SAR tomography and model-based single-baseline polarization coherence tomography. Bistatic SAR is introduced in Chapter 7 within the general framework of multiple-input multiple-output (MIMO) radar networks. The related properties in terms of RCS and spatial resolution are nicely illustrated and compared to the monostatic case presented in earlier chapters. A number of configurations, including tandem systems and the use of microsatellites or GNSS constellations, are discussed. An especially interesting feature of the book is that a basic understanding of both consolidated radar material and advanced current developments, such as tomographic or bistatic SAR, is offered to the user.

With Chapter 8, the focus shifts from the properties of the acquisition system and the imaged surface to data interpretation. This topic is vast, but the chapter succeeds in highlighting the main concepts underpinned by qualitative interpretation and quantitative analysis (the latter mostly through image classification), also mentioning the capability to investigate the landscape vertical structure within a resolution cell. The impacts of incidence angle, wavelength, and polarization on the visual behavior of SAR imagery are discussed, and several cases of practical interest (e.g., forest canopy or seawater) are also provided. Concerning quantitative analysis, approaches based on both statistical pattern recognition and electromagnetic modeling are taken into account. A strong focus is placed on statistical models typical of radar data (e.g., complex Gaussian or Wishart distributions) and PolSAR structural models (e.g., Freeman-Durden or Cloude-Pottier decompositions). A well-reasoned and insightful analysis of the ground property information (mostly associated with geometrical structure and moisture) that can generally be extracted through the quantitative analysis of radar data, including a comparison with optical multispectral imagery, is presented. General-purpose classifiers (e.g., support vector machines) that have been applied to radar images are cited and referenced but not detailed, a reasonable choice for a radar-specific textbook. Nonetheless, a critical overview of a number of classical and recent papers on radar image classification is reported, giving the reader an up-to-date picture of the state-of-the-art techniques in this area.

Chapter 9 nicely complements the previous chapters on active microwave systems by providing an introduction to passive microwave remote sensing. The key concept of brightness temperature and its relationship to the properties of the imaged surface (e.g., roughness, absorptivity) and the imaging system (e.g., observed polarization) are clearly outlined. The interesting cases of the microwave brightness temperatures of seawater and of vegetation over soil are also illustrated.

The appendices recall a few basic mathematical tools (complex and matrix algebra) and symbols from the International System of Units and provide additional details on SAR image formation and multilooking.

This book addresses with outstanding clarity all of the main issues associated with the physics, technology, and use of radar as an imaging tool for remote sensing. The treatment is convincing, well written, and always accessible to a wide readership. The subject coverage is remarkable and ranges from the basics of the underlying electromagnetic principles to the classical radar and SAR systems to current advanced applications and technologies. Such a broad and accurate picture of contemporary radar remote sensing makes this book an excellent reference and a rich source of information for remote-sensing scientists, users, and students.

Sebastiano B. Serpico

Sebastiano received the Laurea degree in electronic engineering and the doctorate in electrical communications from the University of Genoa, Italy. A full professor of telecommunications at the Faculty of Engineering of the University of Genoa, he is the Head of the Signal Processing and Telecommunications laboratory of the Department of Telecommunications, Electronic, Electrical, and Naval Engineering (formerly the Department of Biophysical and Electronic Engineering) of the University of Genoa. His current research interests include pattern recognition for remote sensing images and biomedical images. He is the chairman of the Institute of Advanced Studies in Information and Communication Technologies (ISICT). He has been the project manager of numerous research contracts and an evaluator of project proposals for various programmes of the European Union. He is the author (or coauthor) of over 200 scientific articles published in journals and conference proceedings. He is an associate editor of the international journal *IEEE Transactions on Geoscience and Remote Sensing* (TGRS). He was a guest editor of two Special Issues of TGRS on the subject of the analysis of hyperspectral image data (July 2001 issue) and the subject "Advances in techniques for the analysis of remote sensing data" (March 2005 issue). From 1998 to 2002, he was the chairman of a SPIE/EUROPTO series of conferences on Signal and Image Processing for Remote Sensing. He is a Fellow of the IEEE Society.

REPORT

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(Editor's Comments continued from page 4)

dealing with geoscience and remote sensing topics. The second contribution follows the initiative established in the March 2012 issue of the Newsletter of presenting a list of the recently completed Ph.D. dissertations in the remote sensing and geoscience fields. This is an important opportunity for early-career researchers to increase the visibility and impact of their work. I encourage you to contact Antonio Plaza, Director of Education for IEEE GRSS, or me for information on submitting recently completed Ph.D. in the technical areas of GRSS.

As a final remark, as usual I encourage you to contribute to the success of the Newsletter by submitting technical, educational, and industrial profiles articles that are of interest to our community.

I wish you a relaxing and productive summer, and I am looking forward to meeting most of you at IGARSS 2012 in Munich.

Lorenzo Bruzzone
Editor, IEEE GRSS Newsletter

DATA ARCHIVING AND DISTRIBUTION (DAD) TECHNICAL COMMITTEE (TC)

H. K. "Rama" Ramapriyan (Chair), NASA Goddard Space Flight Center,
Liping Di, George Mason University
Gilbert Rochon (Co-Chair), Tuskegee University

1. Introduction

The Data Archiving and Distribution Technical Committee (DAD TC) is a group of individuals from many countries and organizations with common interests in diverse aspects of managing remotely sensed data throughout their life cycle. It has been in existence since 1994 (originally called the Data Standardization and Distribution Technical Committee) and known by its present name since 2001. Its mission is:

> *"To provide recommendations and responses to issues related to the archival and distribution of remotely sensed geospatial and geotemporal data, and on how new media, transmission means, and networks will impact the archival, distribution, and format of remotely sensed data. Also, to study the impact of media, channel, and network scaling on the archival and distribution of data."*

Currently, the DAD TC has 72 members and collaborators from 10 different countries: Brazil, Canada, China, Germany, Italy, Japan, South Africa, Switzerland, United Kingdom and the United States of America. The main activities of the DAD TC are:

- Organizing and conducting special sessions at the annual IGARSS meetings
- Publishing special issues of TGARS and JSTARS
- Developing and maintaining GEOSS Component and Service Registry
- Maintaining a set of research priorities in technologies for data archiving and distribution
- Participating and /or leading standards efforts

Each of these activities was described briefly in the previous report in the GRSS Newsletter (June 2011 issue). In this issue we will focus on two topics: 1. Provenance and Preservation and 2. GEOSS support.

2. Provenance and Preservation

At IGARSS 2011, the DAD TC held a special session titled "Provenance in Geoscience Data". The DAD TC has also proposed and recently received AdCom approval for a "Special Issue on Data Provenance" of the Transactions on Geoscience and Remote Sensing (TGARS). This reflects the increased interest in recent years in establishing and documenting provenance in data and derived products to ensure that it is possible to understand and convey the pedigree of archived scientific products for use in research. Of course, it is important to capture provenance through the entire data life cycle, including acquisition, processing, archiving, distribution and permanent preservation. Complete and accurate provenance brings transparency to data sharing, ensures appropriate credits are given to data producers and algorithm developers, enables reproducibility of scientific results and increases confidence in the overall scientific enterprise. The importance and the challenges associated with capturing provenance increase in the highly distributed environment that prevails today in data and information management. In this environment, a large community of scientific investigators interact with a large number of data centers to generate, transform, publish, store and disseminate data and derived products. Whether data products are at large institutional facilities or at smaller Principal Investigator-managed facilities, it is essential that users have access to provenance information. The proposed special issue calls for papers on the latest developments of provenance awareness in all aspects of remote sensing data archiving, information management, search and access, and specialized services for data users, such as on-demand processing and visualization. Enabling technologies such as data management, Cyberinfrastructure, workflow, high performance computing, error propagation, Semantic Web, evolving standards, security, and Web services will be involved. The emphasis will be on approaches using those technologies to address such issues as provenance capture, representation, storage, query, and usage for understanding, management, traceability, and quality analysis of the diverse Earth remote sensing data and processing flow.

There are three other aspects of provenance and preservation that are of interest to the DAD TC, namely, Data Sharing, Data Citations, and Provenance and Context Content Standard (PCCS). All these are covered with the active involvement of some of the DAD TC members in the Data Stewardship Committee (formerly known as the Data Stewardship and

Preservation Cluster) of the U.S. Federation of Earth Science Information System Partners (ESIP).

2.1. Data Sharing

In the January 2012 meeting of the ESIP Federation, the General Assembly approved "Interagency Data Stewardship Guidelines". These guidelines articulate principles that promote free and open sharing of data to the maximum extent possible. These principles are based on existing data sharing principles and data and information policies of various U.S. and international organizations. The principles and practices recommended therein apply to data creators, data intermediaries and data users, and are discussed separately.

Examples of principles that apply to data creators are: having data management plans; identifying long-term archival organizations where their data worthy of preservation will be placed; providing easily accessible information about the data and related mission parameters, including user guides, quality assessments, and other supporting information; and providing sufficient metadata (defined as all the information necessary for data to be independently understood by users and to ensure proper stewardship of the data) to the data repositories responsible for long-term archival.

Examples of principles that apply to data intermediaries are: full and open exchange of data, metadata, and products while complying with relevant international instruments, national agency policies and legislation, and commercial/proprietary interests; making available to users explanation of any necessary restrictions to full and open exchange of data; making data, metadata and products available to all users with minimum time delay and on a non-discriminatory basis; making data, metadata and products from government and publicly funded non-government intermediaries available free of charge or at no more than cost of reproduction; using community-accepted standard formats for data and metadata, and supporting format transformations as required by the designated communities; holding restrictions on redistribution to a minimum consistent with ensuring appropriate credits and citations, and ensuring provision of appropriate metadata and documentation along with the data to prevent misunderstanding, misrepresentation, or misuse.

Examples of principles that apply to data users are: crediting and citing all significant data sources and authors, including creators and repositories of the data and products used in their work, offering co-authorship as appropriate; following any restrictions on redistribution of data that were indicated by the data intermediaries; using the data in a manner compatible with the documentation and quality caveats available from the data intermediaries; supplying impact metrics to data intermediaries indicating the utility of data, metadata and products they received; and participating in community groups to promote data and metadata standards and their evolution over time.

For a full text of the Interagency Data Stewardship Guidelines, the reader is referred to [1].

2.2. Data Citations

Also in the January 2012 meeting of the ESIP Federation, the General Assembly approved "Data Citation Guidelines for Data Providers and Archives". These guidelines are intended to improve the ability to formally cite data sets. There are several purposes to be served by data citations: aid scientific reproducibility through direct, unambiguous reference to the precise data used; provide fair credit for data creators or authors, data stewards, and other critical people involved in data production and curation; ensure scientific transparency and reasonable accountability; and aid in tracking the impact of a given data set and the associated data center through reference in scientific literature. While it is currently impossible to satisfy fully the requirement for reproducibility, a rigorous approach to data citations, version tracking, comprehensive documentation and due diligence by authors and data stewards will go a long way to meet this need. The suggested approach to citing data sets is similar to that used for books, with the important exception that the datasets can be dynamic and hence it is also important to indicate when a dataset was accessed. Thus, the required elements in a citation are: Author(s), Release Date, Title, Version, Archive (and/or distributor), Locator/Identifier (e.g., URL or Digital Object Identifier – DOI), Access Data and Time. A detailed discussion of data citations with several examples can be found in [2]. Several organizations are currently working on making datasets precisely citable by associating DOIs with their holdings. For example, the Distributed Active Archive Center (DAAC) at the Oak Ridge National Laboratory, which is one of 12 DAACs that are part of NASA's Earth Observing System Data and Information system (EOSDIS), has been using DOIs to help users cite its datasets for a few years. The EOSDIS Project has recently undertaken the task of broadening the use of DOIs to most of the datasets held at the DAACs. The U.S. National Science Foundation's Directorate for Geosciences recently published a "Dear Colleague" letter encouraging the scientific community to meet the challenges of data citation [3]. This letter states: "This may involve working with: (1) collaborators to decide which data sets are appropriate for citation; (2) data centers, libraries, repositories, and publishers to develop appropriate data citation methods and concomitant DOIs; and 3) research institutions to make data citation a common practice and a metric of value in institutional culture and practice."

2.3. Working towards a Provenance and Context Content Standard

The data and derived products useful in long-term studies (such as climate change) come from many different sources. These include spaceborne instruments, airborne instruments and in situ measurements and models that utilize data from some of these sources. In order to ensure proper utilization of these data it is important to understand their pedigree, quality and other relevant information. These items are covered by the terms provenance and context. The Reference Model for an Open Archival Information System (OAIS) [4], developed by the Consultative Committee for Space Data Systems (CCSDS) defines the terms provenance and context as follows:

- Provenance - The information that documents the history of the Content Information. This information tells the origin or source of the Content Information, any changes that may have taken place since it was originated, and who has had custody of it since it was originated. Examples of Provenance Information are the principal investigator who recorded the data, and the information concerning its storage, handling, and migration.
- Context - The information that documents the relationships of the Content Information to its environment. This includes why the Content Information was created and how it relates to other Content Information objects.

When data and information are to be preserved for use long after their acquisition and/or creation, it is essential to preserve the provenance and context. Generally, the content items that need to be preserved are held during a mission by multiple organizations, and as missions come to an end they have to be gathered and conveyed to a long-term preservation organization. To ensure that all items needed are indeed accounted for, it is essential to have a standard that identifies all content items that need to be preserved. Such a standard will help minimize inconsistencies among organizations, and will assist missions in planning ahead for preservation of required content. The standard will also help users assess completeness of content for use by future scientists.

At this time, there are several standards relating to preservation. However, there is not a single standard that addresses the entire suite of information that must be preserved in order to ensure the long-term usability of Earth science data. The Reference Model for OAIS [4] defines the types of information needed for a full understanding of digital data objects in general terms. Metadata standards [5, 6] and the OpenGIS Sensor Model Language (SensorML) Encoding Standard [7] provide a useful framework for recording the information to be preserved, but do not define the specific types of information that should be preserved along with Earth science observational data.

Some of the members of DAD TC who are active on the U.S. ESIP Federation's Data Stewardship Committee proposed in January 2011 that the committee work towards developing a "Provenance and Context Content Standard (PCCS)" that enumerates all of the items needed to capture completely the provenance and context of the data important to climate change studies including products resulting from Earth science missions. Starting with a report from the 1998 workshop held by the U.S. Global Change Research Program (USGCRP) [8], NASA's experience with some of its remote sensing instrument science teams, and NOAA's Satellite Products and Services Review Board (SPSRB) Documentation Guidelines, a list of items that should be preserved has been developed. These items are grouped into eight categories: Preflight/Pre-Operations Calibration, Science Data Products, Science Data Product Documentation, Mission Data Calibration, Science Data Product Software, Science Data Product Algorithm Input, Science Data Product Validation and Science Data Software Tools. The detailed list of items and their attributes can be found at http://wiki.esipfed.org/index.php/Provenance_and_Context_Content_Standard. In addition, NASA has adopted the content list developed above and has developed a specification based upon it for use by its missions [9]. The rigor with which this specification should be applied to a given project depends on the current stage in the life cycle of the project. Projects that are currently being planned will be in the best position to meet the specifications.

The progress made in the ESIP Federation and NASA environments provides a good starting point for developing a more broadly accepted community standard, which in turn will ensure consistency among organizations collecting, generating and archiving data and derived products for use in long-term analyses.

3. GEOSS Component and Service Registry (CSR)

Several Petabytes of Earth science data have been accumulated through space- and air-borne Earth observation programs during the last several decades by a number of organizations around the world. These data are valuable both scientifically and socioeconomically. The value of these data could be further increased significantly if they can be more easily discovered, accessed, integrated, and analyzed. The Global Earth Observation System of Systems (GEOSS) is designed to address this need. Coordinated by the Group on Earth Observations (GEO), a voluntary partnership of 86 governments, the European Commission, and 61 intergovernmental, international, and regional organizations the implementation of GEOSS has been in progress since 2005.

The GEOSS, by its architecture, is a distributed, service oriented system with its components and services contributed by GEO member countries and participating organizations. In order for those contributed components and services to work together as an integrated system, they have to comply with GEOSS recommended standards and specifications. Also, a common infrastructure is needed to facilitate the discovery, access, and integration of those contributed resources for supporting the applications and decision making in GEOSS Societal Benefit Areas (SBA). For this purpose, GEOSS Architecture and Data Committee has recommended a set of standards and specifications for implementing GEOSS components and services. The GEOSS Common Infrastructure (GCI) has been established after four years of international collaboration. GCI consists of the Standards and Interoperability Registry (SIR), the Component and Service Registry (CSR), the GEO Clearinghouse, and the GEO Portal. The SIR maintains the list of the public standards recognized by the GEO. CSR provides a centralized registry for available Earth Observation resources. The GEO Clearinghouse works as a single search facility for GEOSS-wide resources and the GEO Portal provides an integrated Web-based interface for users.

The DAD TC has been supporting the Global Earth Observation System of Systems (GEOSS) effort in collaboration with other GEOSS participating organizations. The DAD TC has been involved, through its members, in providing data and services to a number of GEOSS Architecture demonstrations organized by the IEEE and the Open Geospatial Consortium (OGC), including at IGARSS 2005 in Seoul, FIEOS 2006 in Beijing, IGARSS 2006 in Denver, and GSDI 2006 in Chile. Since January 2007, DAD TC members at the Center for Spatial Information Science and Systems (CSISS), George Mason University (GMU), have collaborated with researchers from the Federal Geographic Data Committee (FGDC) and the GEOSS Architecture Task AR-07-01 team on designing, implementing, maintaining, upgrading, and operating the CSR. The registry manages the registration and discovery of GEOSS-wide resources.

Currently, the CSR provides the following capabilities to data providers: user registration, resource registration, and service interface registration. The CSR clients can discover the resources registered in CSR through the OGC Catalog for Web (CSW), UUDI, and other standard interfaces. During the resource registration process, providers may provide detailed descriptive information for their resources, in particular, the targeted societal benefit area and sub-areas of focus, and the targeted critical Earth Observations. The service interfaces to these resources can also be registered with CSR, where standards references information may be supplied. Providers may also self-nominate their resources to be part of the GEOSS-DataCORE. The GEOSS-DataCORE was initialized in early 2011 for establishing a distributed pool of documented, well-calibrated, and persistently available key Earth observation datasets, contributed by the GEO community on the basis of full and open exchange (at no more than the cost of reproduction and distribution) and unrestricted access. The registered resources have to be approved by CSR operators and/or the GEO Secretariat before they are searchable and discoverable by the GEOSS users.

In May 2009, a process for approval of CSR registered entries was established. Each entry is manually approved to ensure that it meets certain quality criteria. Only the approved records are listed on the holding page, are searchable through the public non-secure search interface, and are viewable through the API interface. As of this writing, 410 components and 252 services have been registered (see http://geossregistries.info).

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[2] Winter Meeting 2012, ESIP iCommons, March 2012, “Data Citation Guidelines for Data Providers and Archives”, http://myitsc.org/icommons2/node/308. (Content licensed under a Creative Commons Attribution 3.0 License.)

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CHAPTERS CORNER

THE GRSS DISTINGUISHED LECTURER PROGRAM

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

The GRSS Distinguished Lecturer Program provides GRSS Chapters with talks by experts on topics of interest and importance to the Geoscience and Remote Sensing community. The program is structured so that Chapters will incur little or no cost in making use of this program. A list of lecturers, details on how to use the program and an application form can be found at the GRSS website: http://www.grss-ieee.org/education/distinguished-lecturers. Normal procedure is for the chapter to contact a speaker of their choice, draft a rough budget (the lecturer's responsibility) and submit an application via the website. For questions or help with the process contact the program chair at d.levine@IEEE.org. The purpose of this program is to serve the membership and suggestions, especially for topics and/or potential speakers, are welcome.

Lecturers for 2012:

Lorenzo Bruzzone: Current Scenario and Challenges in the Analysis of Multitemporal Remote Sensing Images

Melba Crawford: Advanced Methods for Classification of Hypersectral Data

David Goodenough: Methods and Systems for Applications

Ya-Qiu Jin: Research on the Modeling and Simulation of Polarimetric Scattering and Information Retrieval for Microwave Remote Sensing

Yann Kerr: SMOS First Successes and Related Issues: The First Global Soil Moisture and Sea Salinity Maps are Coming.

Ricardo Lanari: Differential SAR Inteferometry: Basic Principles, Key Applications and New Advances

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

Werner Weisbeck: Digital Beam-Forming in Remote Sensing

EDUCATION CORNER

OVERVIEW OF THE FIRST IEEE GRSS REMOTE SENSING SUMMER SCHOOL

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1. Overview

This article provides an overview of the first IEEE Geoscience and Remote Sensing Society (GRSS) Remote Sensing Summer School, to be organized in Munich, Germany, on July 19–20, 2012. The school (called RSSS12) is intended for BS, MS and PhD students dealing with geoscience and remote sensing topics. The school will offer these students the opportunity to meet international renowned specialists and experts in the field of remote sensing and to gain an in-depth-education with the state-of-art knowledge on selected topics of remote sensing. The programme of the school will cover a wide range of topics. In this article we describe the rationale for establishing a series of yearly summer schools within GRSS, and also provide an overview of the main activities that will be held in RSSS12. The school will be organized by Technische Universitaet Muenchen (TUM), one of the leading Universities in Germany.

2. Rationale and Motivation

Following the impulse and strong support and motivation coming from Prof. Jon Atli Benediktsson, GRSS President, the administrative committee (AdCom) of GRSS has witnessed that the society can greatly benefit from the organization of summer schools [1], mainly intended for BS, MS and PhD students, in conjunction with the society's flagship event, the IEEE International Geoscience and Remote Sensing Symposium (IGARSS). There have been similar successful examples in other IEEE societies, including the Information Theory Workshop which has attracted 40, 100

Figure 1. RSSS12: The First IEEE GRSS Remote Sensing Summer School to be Held in Conjunction with IGARSS 2012 in Munich, Germany, organized by Technische Universitaet Muenchen (TUM).

Figure 2. Analysis of Multitemporal Remote Sensing Images, as Described in a Lecture of the Summer School to be Given by Prof. Lorenzo Bruzzone.

and 200 attendees from 2009–2011. Part of the organizational infrastructure is already in place, based on previous experience in organizing summer schools in education-oriented projects such in the Hyperspectral Imaging Network (Hyper-I-Net) [2]. Some of the students attending the Hyper-I-Net summer schools are now experienced scientists in GRSS fields, and these activities have the potential to provide high-quality training to a new generation of scientists in geoscience and remote sensing.

With the aforementioned rationale in mind, GRSS AdCom has recently approved the initiative of organizing a summer school in conjunction with the upcoming editions of IGARSS. The first IEEE GRSS summer school (RSSS12)[1] will be organized by Prof. Uwe Stilla and his team at Technische Universitaet Muenchen (TUM), an academic center of excellence with over 140 years of experience[2]. TUM is conveniently located on the main campus in the Munich museum district near the city center, within walking distance of many hotels. The TUM main campus area can be easily reached from any location in Munich, a fascinating city with historical buildings from every period and architectural style. The organization, for the first time, of a summer school in conjunction with IGARSS represents a significant advance and step forward towards fostering education-oriented activities in our society. In the remainder of this article we describe the activities planned for the first IEEE GRSS summer school in the beautiful city of Munich, along with the topics covered, the speakers that will be providing tutorials in RSSS12, and the anticipated impact of this series of summer schools in the new generation of geoscience and remote sensing scientists.

[1] http://www.igarss2012.tum.de/

[2] http://www.igarss2012.tum.de/rsss12_ven.html

3. School Programme and Lecturers

The presentations at RSSS12 will be given by a combination of IEEE GRSS distinguished speakers [3] and other lecturers[3]. The school will comprise two days: Thursday, July 19 (full day + icebreaker) and Friday, July 20 (full day + social event). The presentations will be of 90 minutes each and will cover- a wide variety of topics in geoscience and remote sensing. The speakers of the summer school will be:

- Prof. Richard Bamler (DLR & Technische Universität München, Germany)
- Prof. Lorenzo Bruzzone (University of Trento, Italy)
- Prof. Jocelyn Chanussot (Grenoble Institute of Technology, France)
- Prof. Melba Crawford (Purdue University, USA)
- Dr. Mauro Dalla Mura (Fondazione Bruno Kessler, Italy)
- Prof. Paolo Gamba (University of Pavia, Italy)
- Prof. David Goodenough (University of Victoria, Canada)
- Dr. Prashanth Marpu (Masdar Institute of Science and Technology, UAE)
- Prof. Antonio Plaza (University of Extremadura, Spain)
- Prof. Uwe Stilla (Technische Universität München, Germany)

The detailed program of the summer school is available online[4]. In the following we provide a summary of the different technical lectures that will be given at the school:

1) The lecture entitled "**Methods and Systems for Forest Applications**" will be given by Prof. David Goodenough on Thursday, July 19, at 9:30. In order to monitor the resources and environment of the planet, it is necessary to use remote sensing from multiple sensors and integrate these data with historical information contained within

[3] http://www.igarss2012.tum.de/rsss12_lec.html

[4] http://www.igarss2012.tum.de/rsss12_prg.html

geographical information systems (GIS). Multiple sensors are required to identify attributes of interest. In forestry, resource managers want to know the amount of the resource by species, area, timber volume, etc., the spatial distribution, the health (chemistry) of the forests, and the temporal changes of the resource, both past and predicted for the future. The technologies of GRSS are used to create information systems to support resource and environmental management. In this presentation we describe hyperspectral and radar methods and systems to obtain valuable forest information, such as chemistry, above-ground carbon, species, and biomass. Polarimetric satellite radars can be used to detect and map current and historical fire scars. Radars provide all-weather monitoring capability and estimates of biomass. National and global monitoring requires systems for distributed data management. A system has been created[5] using GRID architecture, optical light paths, and petabyte data stores at the University of Victoria. SAFORAH serves out to the public and research community remotely sensed data of Canada and forest information products for land cover, biomass, and change. Hyperspectral sensing is used to obtain species distribution and forest chemistry. Examples of this work for forest applications and the generation of above-ground products are presented in this lecture, which will also discuss operational issues in monitoring forests.

2) The lecture entitled "**Challenges in the Analysis of Multitemporal Remote Sensing Images**" will be given by Prof. Lorenzo Bruzzone on Thursday, July 19, at 11:00. In the last decade a large number of new satellite remote sensing missions have been launched resulting in a dramatic improvement in the capabilities of acquiring images of the Earth surface. This involves an enhanced possibility to acquire multitemporal images of large areas of the Earth surface, with improved temporal and spatial resolution with respect to traditional satellite data (see Fig. 2). 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. After a general overview of the problems related to the analysis of multitemporal images, this lecture focus on the crucial problem of automatic change detection between multitemporal images. The development and the use of effective automatic techniques for change detection are of major importance in many application scenarios. The increased geometrical resolution of multispectral and synthetic aperture radar (SAR) sensors, the increased revisit time of high resolution systems, and the expected availability of time series of hyperspectral images in the near future result in many different methodological problems as well as in very important new possible applications. The lecture will address these problems by pointing out the state of the art and the most promising research directions for change detection on images acquired by the last generation of satellite sensors. Examples of the use of change-detection approaches in real scenarios will be provided.

3) The lecture entitled "**Advanced Methods for Classification of Hyperspectral Data**" will be given by Prof. Melba Crawford on Thursday, July 19, at 13:30. Increased availability of hyperspectral imagery and greater access to advanced computing provide opportunities and challenges for development and application of advanced classification methods that more fully exploit the unique characteristics of these data. While the hundreds of narrow spectral bands allow detailed characterization of spectral responses and provide greatly improved capability for atmospheric correction, band redundancy is problematic. Additionally, supervised classification methods require ground reference information, which is difficult and expensive to acquire, particularly for inaccessible areas, and spectral signatures of the same class often vary with location and/or time. These problems are further exacerbated by the high dimensionality of hyperspectral data, which necessitates collection of a large number of training samples to properly represent class distributions, and by the sensitivity of narrow bands to spectral "drift" across space and time. This lecture will focus on strategies for dealing with these issues. Linear and nonlinear feature extraction methods will be presented as means of dimensionality reduction. Semi-supervised learning will be explored for exploiting unlabeled data when labeled data are scarce. Active learning heuristics will be introduced as strategies for better utilizing existing labeled data and providing guidance for efficient acquisition of additional labeled information for the classification problem. Examples will be provided from airborne and space-based Hyperion hyperspectral data.

4) The lecture entitled "**Hyperspectral Image and Signal Processing**" will be given by Profs. Jocelyn Chanussot and Antonio Plaza on Thursday, July 19, at 15:30. Acquiring the same scene using hundreds of narrow and contiguous spectral bands, hyperspectral images offer an invaluable diversity of information, enabling the accurate physical description and discrimination of the sensed materials. Over the past decade, hyperspectral remote sensing became more and more popular, with a blooming number of available sensors, for airborne or satellite platforms. More and more applications are addressed using such data, from precision agriculture, to the monitoring

[5] http://www.saforah.org

of the environment and natural hazards, mining industry, forestry or defense related issues. However, exploiting these very high dimensional data where each pixel is represented as a vector with several hundred of components is very challenging and specific image and signal processing methods must be developed. The goal of this lecture is to introduce some of the most classical issues and standard approaches. This includes classification (supervised or unsupervised), segmentation and hierarchical representations, spectral unmixing with geometric or statistical methods, and high performance computing using parallel systems.

5) The lecture entitled "**SAR Urban Remote Sensing**" will be given by Prof. Uwe Stilla on Friday, July 20, at 9:00. New SAR sensors on satellites like TerraSAR-X allow flexible mapping with a large coverage or a high resolution of about one meter. Leading-edge airborne SAR sensors provide spatial resolutions on the order of a decimetre. In such data, many features of urban objects can be identified, which were beyond the scope of radar remote sensing before. But SAR images are often really difficult to be interpreted: the presence of speckle as well as of some distortion effects, like shadowing and layover, makes the analysis of this kind of image complex. The impact of high resolution SAR data on the analysis of urban scenes and typical SAR effects are discussed. Examples for the appearance of buildings and other man-made objects are given in this lecture. The benefit of SAR-simulation is addressed and examples are shown. Finally, typical problems in SAR simulation are discussed.
6) The lecture entitled "**Multispectral Urban Remote Sensing and Data Fusion**" will be given by Prof. Paolo Gamba on Friday, July 20, at 11:00. This lecture will describe the aim and main methodologies involved in the use of Earth Observation (EO) data to monitor, characterize and analyze human settlements (see Fig. 3). Human settlements are very complex environments, and can be described at multiple geographical scales. Examples of different applications, including settlement monitoring, road network extraction and building characterization will be provided, as well as a general framework to extract and fuse multiscale features from multisource data for urban remote sensing. Focus will be mostly on very high resolution (VHR) data, but coarse resolution data will be also considered for applications at the regional/global level. At the end of this tutorial the students will be able to select the most suited data set for a specific urban remote sensing application, and design a system to solve a task addressing an urban problem by means of EO and other ancillary data.
7) The lecture entitled "**SAR Interferometry and Tomography**" will be given by Prof. Richard Bamler on Friday, July 20, at 13:30. SAR interferometry (InSAR) has become a universal tool for many Earth observation applications like digital elevation model (DEM) generation, deformation and subsidence measurements, and assessment of volcanic and tectonic activities. This lecture gives an introduction to the classical InSAR technique for DEM generation as well as to more advanced new developments, like PSI and SAR tomography. These new methods enable exciting measurements of building shapes and their deformation or subsidence with accuracies down to 1 mm/year. The following topics will be specifically discussed: imaging geometries of the different InSAR configurations; the concept of coherence and phase noise; baseline decorrelation and critical baseline; differential InSAR and PSI; correlation techniques; introduction to multibaseline InSAR and tomography. All the concepts will be illustrated by examples from ERS, ENVISAT, SRTM, TerraSAR-X and TanDEM-X data.
8) The lecture entitled "**Morphological Profiles and Attribute Profiles**" will be given by Drs. Prashanth

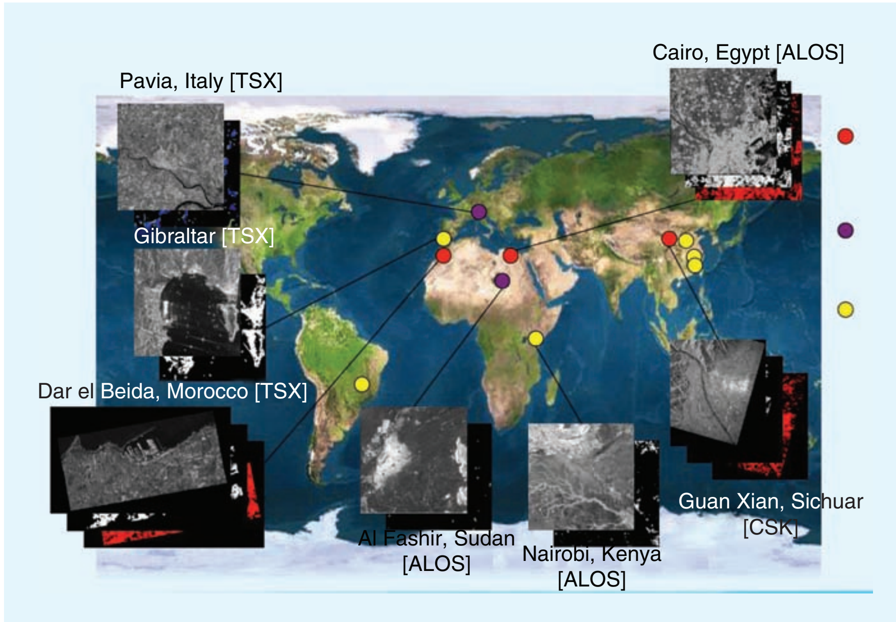

Figure 3. Use of Earth Observation Data to Monitor, Characterize and Analyze Different Human Settlements, as Described in a Lecture of the Summer School to be Given by Prof. Paolo Gamba.

Marpu and Mauro Dalla Mura on Friday, July 20, at 15:30. VHR images are one of the most striking results of the latest technological advances in remote sensing. When dealing with images of meter or sub-meter geometrical resolution, the spatial information is of fundamental importance. In fact, owing to this improved spatial resolution, the geometrical features of the structures in a scene become valuable information for characterizing objects in the scene (e.g., for object extraction) or increasing the capability of discrimination between different land-cover classes (e.g., in a classification task). This lecture is devoted to present one of the most successful strategies for extracting spatial features in remote sensing images, the morphological profiles (MPs). MPs have been proved to be powerful tools to model the spatial information (e.g., contextual relations) of the image through the extraction of structural features (e.g., size, geometry, etc.) from the objects present in the scene. This lecture will also address attribute profiles (APs), a recent extension of the MP concept, which permit to model and extract spatial information with a greater flexibility compared to MPs, further increasing their potential in modeling spatial features. The use of MPs and APs in practical remote sensing applications (e.g., classification, object detection, segmentation, change detection, etc.) is demonstrated considering different types of remote sensing images.

4. Organizing Team

The RSSS12 summer school will be organized and directed by Prof. Uwe Stilla and his team. They possess wide experience in organization of many international events such as the highly successful, GRSS-sponsored Joint Urban Remote Sensing Event (JURSE 2011)[6] in Munich. Prof. Stilla is Head of the Department of Photogrammetry and Remote Sensing and director of the Institute of Photogrammetry and Cartography (alternating with Prof. Meng) of TUM. He is vice dean of the Faculty of Civil Engineering and Surveying and dean of Student Affairs of the Bachelors and Master Program Geodesy and Geoinformation and the Master Programme Earth Oriented Space Science and Technology (ESPACE). He has the chair of the ISPRS working group Image Sequence Analysis, is principal investigator of the International Graduate School of Science and Engineering (IGSSE), member of the Scientific Board of German Commission of Geodesy (DGK), and member of Commission for Geodesy and Glaciology of the Bavarian Academy of Science and Humanities. His research focuses on image analysis in the field of photogrammetry and remote sensing. He published more than 250 scientific contributions. Other members of the organizing team are Ludwig Hoegner (local organizing committee chair, in charge of web pages and schedule), Michael Schmitt (in charge of lecture notes), Dorota Iwaszczuk (in charge of the social events), Oliver Maksymiuk (in charge of technical assistance), and Tessio Novack (in charge of coffee breaks). Additional contact information for the local organizing committee members is available online[7].

5. Summary

In this article we have provided an overview of the first IEEE Geoscience and Remote Sensing Society (GRSS) Remote Sensing Summer School that will be organized in Munich, Germany, on July 19–20, 2012. GRSS has witnessed that the society can greatly benefit from the organization of summer

[6] http://www.jurse2011.tum.de/

[7] http://www.igarss2012.tum.de/rsss12_con.html

schools intended for young students in the area, and such initiative of organizing summer schools in conjunction with the upcoming editions of the IEEE Geoscience and Remote Sensing Symposium (IGARSS) has the potential to provide high-quality training to a new generation of scientists in geoscience and remote sensing. It is the goal of the society to maintain the outstanding quality and international recognition of the lecturers that will participate in the education-oriented activities organized for this year's edition of the summer school. The society looks forward to a continued success of this initiative through the active participation of international students, as it has been the case this year with a total of 110 applications received and 70 accepted students. We take this opportunity to gratefully thank the local organizers, the lecturers and all the students interested in participating in the summer school. Last but not least, we gratefully thank the President of GRSS for inspiring and encouraging this important education-oriented initiative in our society.

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For publishing the PhD thesis information you can contact Dr. Antonio Plaza (aplaza@unex.es) or Dr. Lorenzo Bruzzone (bruzzone@ing.unitn.it). Ph.D. dissertations should be in the fields of activity of IEEE GRSS and should be recently completed. Please provide us with the following: title of the dissertation, the student's and advisor's names, the date of the thesis defense and a link for downloading the electronic version of the thesis.

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Title: Three-Dimensional Electromagnetic Scattering from Layered Media with Rough Interfaces for Subsurface Radar Remote Sensing	
Institution: University of Michigan	
Date: December 2011	**Link:** http://deepblue.lib.umich.edu/handle/2027.42/91459
Author: Yuriy Goykhman	**Supervisors:** Mahta Moghaddam
Title: Retrieval of Parameters for Layered non-Smooth Interface Media: Theory and Experiment	
Institution: University of Michigan	
Date: August 2011	**Link:** http://deepblue.lib.umich.edu/handle/2027.42/89647
Author: Luca Pasolli	**Supervisors:** Lorenzo Bruzzone, Claudia Notarnicola
Title: Advanced Methods for the Retrieval of Geo-/Bio-Physical Variables from Remote Sensing Imagery	
Institution: University of Trento, Department of Information Engineering and Computer Science and Eurac Research, Institute for Applied Remote Sensing	
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OPEN ACCESS ARTICLES IN TGRS, GRSL AND JSTARS

IEEE refereed publications now support Open Access (OA) distribution, which allows papers to be downloaded from the online IEEE archives by anyone free of charge, rather than the normal situation in which there are charges or subscription fees associated with downloads of published papers. The income needed to support publication and distribution expenses associated with running a journal is front loaded in the OA model, with mandatory fees charged to the authors but no fees imposed on the readers. This differs from the more traditional model, in which page charges are often optional for authors but subscription fees are mandatory for readers. Some non-IEEE journals now require all papers to be OA and some do not support it at all. IEEE uses a hybrid model in which authors are offered a choice between traditional and OA publication.

Since the distribution of OA papers is free and unrestricted, it is expected that over time they will have a wider circulation. To this end, the Geoscience and Remote Sensing Society has instituted a new policy in 2012 with its three refereed journals (TGRS, GRSL and JSTARS) in which each issue will contain one "Editor's Choice" OA paper that is selected by their Editorial Board and for which the associated charges will be covered by the society. We select papers based on their likelihood of impact and on the broadest possible interest to our community.

Sincerely,
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Paolo Gamba, Editor-in-Chief, IEEE Geoscience and Remote Sensing Letters
Jocelyn Chanussot, Editor-in-Chief, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing

Open Access Articles Published in the Period January–June 2012

IEEE Transactions on Geoscience and Remote Sensing

Merging and Analysis of Elevation Time Series Over Greenland Ice Sheet From Satellite Radar Altimetry
by Khvorostovsky, K.S.
Vol. 50, No. 1, January 2012, pp. 23–36
DOI: 10.1109/TGRS.2011.2160071
Link: http://dx.doi.org/10.1109/TGRS.2011.2160071

Near-Space Vehicle-Borne SAR With Reflector Antenna for High-Resolution and Wide-Swath Remote Sensing
by Wen-Qin Wang
Vol. 50, No. 2, February 2012, pp. 338–348
DOI: 10.1109/TGRS.2011.2158224
Link: http://dx.doi.org/10.1109/TGRS.2011.2158224

Simulation of L-Band Bistatic Returns From the Ocean Surface: A Facet Approach With Application to Ocean GNSS Reflectometry
by Clarizia, M. P., Gommenginger, C., Di Bisceglie, M., Galdi, C., Srokosz, M. A.
Vol. 50, No. 3, March 2012, pp. 960–971
DOI: 10.1109/TGRS.2011.2162245
Link: http://dx.doi.org/10.1109/TGRS.2011.2162245

Combination of AVNIR-2, PALSAR, and Polarimetric Parameters for Land Cover Classification
by Bagan, H.; Kinoshita, T.; Yamagata, Y.
Vol. 50, No. 4,April 2012, pp. 1318–1328
DOI: 10.1109/TGRS.2011.2164806
Link: http://dx.doi.org/10.1109/TGRS.2011.2164806

The SMOS Soil Moisture Retrieval Algorithm
By Kerr, Y. H.; Waldteufel, P.; Richaume, P.; Wigneron, J. P.; Ferrazzoli, P.; Mahmoodi, A.; Al Bitar, A.; Cabot, F.; Gruhier, C.; Juglea, S. E.; Leroux, D.; Mialon, A.; Delwart, S.
Vol. 50, No. 5, Part 1, May 2012, pp. 1384–1403

DOI: 10.1109/TGRS.2012.2184548
Link: http://dx.doi.org/10.1109/TGRS.2012.2184548

Overview of the First SMOS Sea Surface Salinity Products. Part I: Quality Assessment for the Second Half of 2010
by Reul, N.; Tenerelli, J.; Boutin, J.; Chapron, B.; Paul, F.; Brion, E.; Gaillard, F.; Archer, O.
Vol. 50, No. 5, Part 1, May 2012, pp. 1636–1647
DOI: 10.1109/TGRS.2012.2188408
Link: http://dx.doi.org/10.1109/TGRS.2012.2188408

Seismic Monitoring of the North Korea Nuclear Test Site Using a Multichannel Correlation Detector
by Gibbons, S. J.; Ringdal, F.
Vol. 50, No. 5, Part 2, May 2012, pp. 1897–1909
DOI: 10.1109/TGRS.2011.2170429
Link: http://dx.doi.org/10.1109/TGRS.2011.2167978

A First Assessment of IceBridge Snow and Ice Thickness Data Over Arctic Sea Ice
by Farrell, S. L.; Kurtz, N.; Connor, L. N.; Elder, B. C.; Leuschen, C.; Markus, T.; McAdoo, D. C.; Panzer, B.; Richter-Menge, J.; Sonntag, J. G.
Vol. 50, No. 6, June 2012, pp. 2098–2111
DOI: 10.1109/TGRS.2011.2170843
Link: http://dx.doi.org/10.1109/TGRS.2011.2170843

IEEE Geoscience and Remote Sensing Letters

First Bistatic Spaceborne SAR Experiments With TanDEM-X
by Rodriguez-Cassola, M.; Prats, P.; Schulze, D.; Tous-Ramon, N.; Steinbrecher, U.; Marotti, L.; Nannini, M.; Younis, M.; Lopez-Dekker, P.; Zink, M.; Reigber, A.; Krieger, G.; Moreira, A.
Vol. 9, No. 1, January 2012, pp. 33–37
DOI: 10.1109/LGRS.2011.2158984
Link: http://dx.doi.org/10.1109/LGRS.2011.2158984

Four-Component Scattering Power Decomposition with Extended Volume Scattering Model
by Sato, A.; Yamaguchi, Y.; Singh, G.; Sang-Eun Park
Vol. 9, No. 2, pp. 166–170
DOI: 10.1109/LGRS.2011.2162935
Link: http://dx.doi.org/10.1109/LGRS.2011.2162935

Kernel Entropy Component Analysis for Remote Sensing Image Clustering
by Gómez-Chova, L.; Jenssen, R.; Camps-Valls, G.
Vol. 9, No. 2, March 2012, pp. 312–316
DOI: 10.1109/LGRS.2011.2167212
Link: http://dx.doi.org/10.1109/LGRS.2011.2167212

CryoSat SAR-Mode Looks Revisited
by Raney, R.K.
Vol. 9, No. 3, May 2012, pp. 393–397
DOI: 10.1109/LGRS.2011.2170052
Link: http://dx.doi.org/10.1109/LGRS.2011.2170052

IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing

Classification in High-Dimensional Feature Spaces—Assessment Using SVM, IVM and RVM With Focus on Simulated EnMAP Data
by Braun, A. C.; Weidner, U.; Hinz, S.
Vol. 5, No.2, April 2012, pp. 436–443
DOI: 10.1109/JSTARS.2012.2190266
Link: http://dx.doi.org/10.1109/JSTARS.2012.2190266

CALL FOR PAPERS
IEEE Transactions on Geoscience and Remote Sensing

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

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

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

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

Paper submission deadline: 30 August 2012

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

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CALL FOR PAPERS
IEEE Transactions on Geoscience and Remote Sensing

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

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

List of topics

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

Paper submission deadline: 1 July 2012

Submission guidelines

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IEEE Transactions on Geoscience and Remote Sensing
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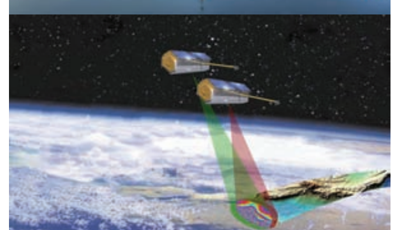
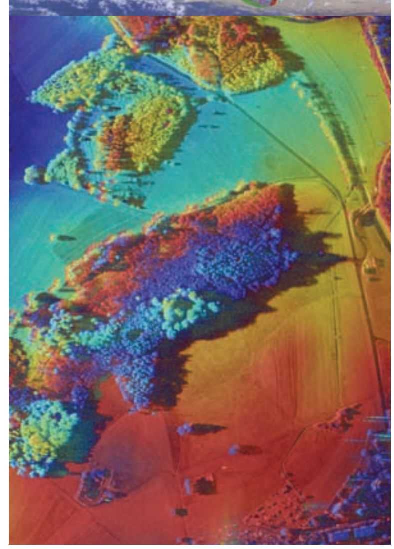
Special Issue on "Scientific and Technological Progress of Synthetic Aperture Radar (SAR)"





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

The objective of the Special Issue, open to all researchers, is to select outstanding contributions on recent advances in the field of SAR, bringing together participants from the research, industrial and academic communities who are engaged in projects on the technologies and techniques of SAR.
Contributions for this special issue are welcome on the following topics: SAR and ISAR systems and sensors, innovative SAR concepts and applications, advanced SAR modes (ScanSAR, Spotlight, Squint, Bistatic) and their signal processing, very low frequency SAR systems, bistatic and multistatic SAR systems, passive SAR systems, multimode and reconfigurable SAR systems, multi-satellite and small satellite SAR systems, sparse aperture SAR, ultra wide bandwidth and high resolution SAR, new SAR antenna concepts, SAR signal processing, motion compensation and geocoding, SAR data evaluation and handling, along and across-track interferometry, polarimetry and polarimetric interferometry, and moving target detection, STAP and change detection.

Paper submission deadline: **30 June 2012**

Submission guidelines
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CALL FOR PAPERS

IEEE Transactions on Geoscience and Remote Sensing

Special Issue on "Geoscience Data Provenance"

Today, there is an increasing demand to capture provenance in the whole life cycle of remotely sensed geoscience data from acquisition, archival, processing, distribution, to applications and make the provenance information available to user community. The complete and accurate provenance information can bring transparency to data sharing and geoscientific processing, give credit to data and algorithm contributors, make scientific results reproducible and trustworthy, and support advanced data quality analysis. Motivation for capturing and sharing provenance also comes from the distributed data and information infrastructure that has been benefitting the Earth science community in the last decade, such as Spatial Data and Information Infrastructure, e-Science, and Cyberinfrastructure. Traditionally, Earth science data products are produced in the scientific data centers with preestablished processing steps or workflows. In the distributed information infrastructure, data and high-level information products are generated, transformed, published, and disseminated frequently by a broad community of scientific users. In such a data-rich production environment, provenance information is even more important, since scientists rely on the provenance to understand and determine the reliability and usability of a scientific product generated from distributed services and inputs provided by various providers.

Contributions for this special issue are welcome from the research community. The technology covered by this special issue will include latest developments of provenance awareness in all aspects of remote sensing data archiving, information management, search and access, and specialized services for data users, such as on-demand processing and visualization. Enabling technologies such as data management, Cyberinfrastructure, workflow, high performance computing, error propagation, Semantic Web, evolving standards, security, and Web services will be involved. The emphasis will be on the approaches using those technologies to address such issues as provenance capture, representation, storage, query, and usage for understanding, management, traceability, and quality analysis of the diverse Earth remote sensing data and processing flow. The special issue will include, but not be limited to, the following set of topics:

List of topics

- Provenance-aware geoscientific data system architecture;
- Geospatial provenance models for heterogeneous geoscientific data;
- Provenance and geospatial metadata;
- Provenance and geoscientific workflow;
- Provenance and Geo-Cyberinfrastructure;
- Provenance capturing in Earth science data and sensor systems;
- Geoscience data provenance management including storage, query, and dissemination of the provenance;
- Interoperability approaches for sharing geoscience data provenance;
- Geoscience data provenance visualization and navigation;
- Provenance applications in geoscience such as geoscientific data quality evaluation and trust analysis;

Paper submission deadline: 30 September 2012

Submission guidelines

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The Second International Workshop on Earth Observation and Remote Sensing Applications

June 8-11, 2012
Shanghai, China

Technical Committee Chair:
Qihao Weng – Indiana State University, USA
Abstract submission:
Before March 15, 2012 through
https://www.easychair.org/conferences/?conf=eorsa2012
Inquiries send to
Email: eorsa2012@gmail.com
Early Registration:
Before April 15, 2012
Web Address:
http://www.eorsa2012.org

2012 International Conference on Indoor Positioning and Indoor Navigation (IPIN)

13-15th November, 2012, Sydney, Australia
University of New South Wales

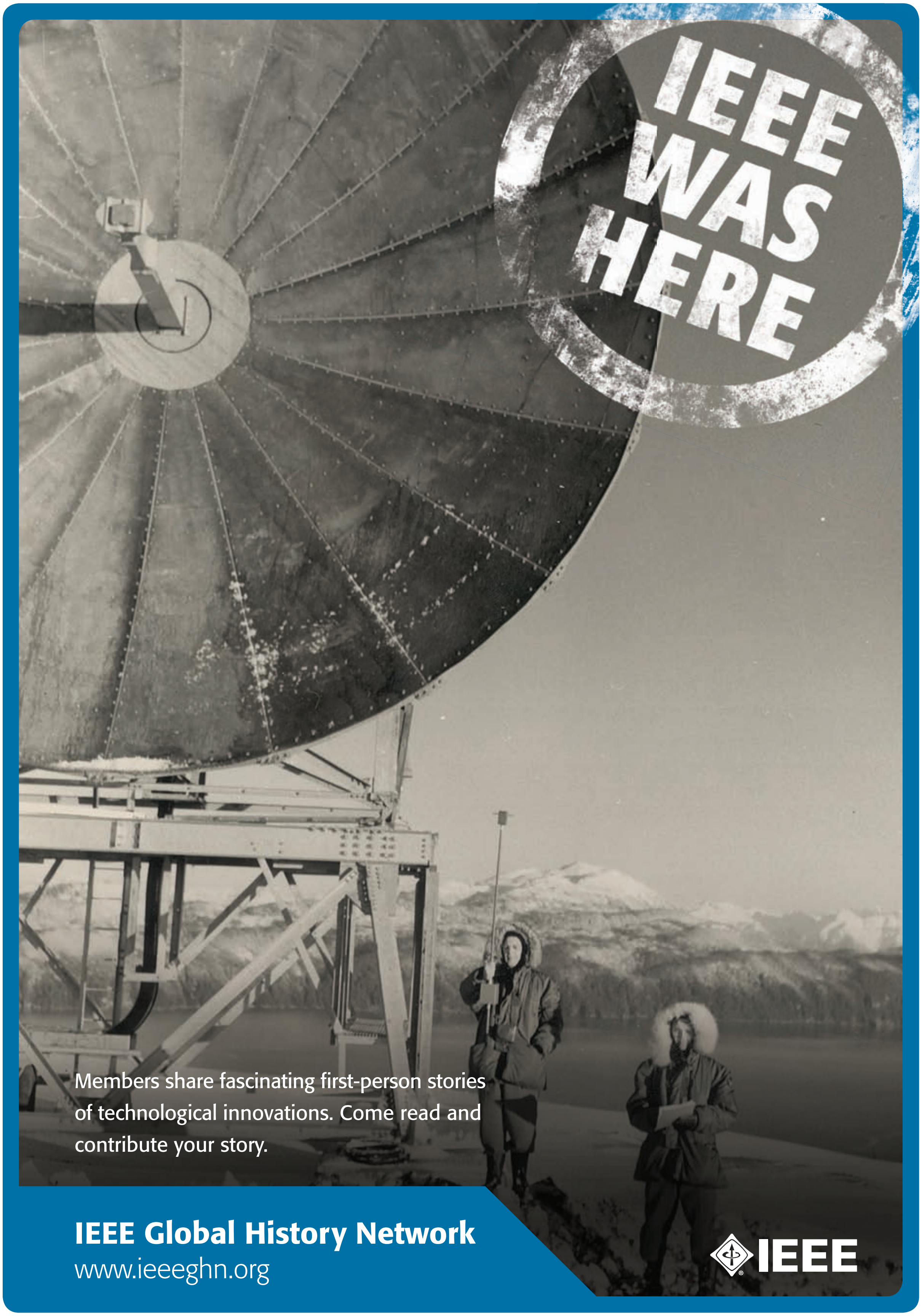
Chair:
Prof. Chris Rizos (UNSW); Dr. Rainer Mautz (ETH)
Abstract submission:
Before 15 of May 2012
Register:
Open on 1 May
Registration fees (early bird before 10 September 2012)**:**
Students *330 AUD*
IEEE, FIG, IAG, SSSI NSW members *495 AUD*
Other delegates *660 AUD*
Web Address:
http://www.surveying.unsw.edu.au/ipin2012/

PRRS 2012

7th IAPR Workshop on Pattern Recognition in Remote Sensing

(In conjunction with ICPR 2012)
November 11, 2012
Tsukuba Science City, Japan

PRRS 2012 Chairs:
Jenny Q. Du, Mississippi State University, USA
Eckart Michaelsen, Fraunhofer IOSB, Germany
Peijun Du, Nanjing University, China
paper submission:
Before April 30, 2012
4-page full paper
Email: du@ece.msstate.edu
Register:
Before July 15, 2012
Registration fees:
IAPR/IEEE Member: 10,000 JPY
Non-member: 12,000 JPY
Student: 7,000 JPY
Web Address:
http://www.iapr-tc7.org/prrs12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UPCOMING CONFERENCES

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

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, Gansu Province, China
Contact: Dr. Tao Liu
E-mail: giwrm2012@gmail.com
URL: giwrm.org

Name: 21st IAPR International Conference on Pattern Recognition (ICPR 2012)
Dates: November 11–15, 2012
Location: Tsukuba Science City, Japan
E-mail: secretary@icpr2012.org
URL: http://www.icpr2012.org

Name: 7th IAPR Workshop on Pattern Recognition in Remote Sensing (PRRS 2012)
Dates: November 11, 2012
Location: Tsukuba Science City, Japan
Contact: Jenny Q. Du, Eckart Michaelsen
E-mail: du@ece.msstate.edu, Eckart.Michaelsen@iosb.fraunhofer.de
URL: http://www.iapr-tc7.org/prrs12

Name: 2012 International Conference on Indoor Positioning and Indoor Navigation (IPIN2012)
Dates: November 13–15, 2012
Location: Sydney, Australia
E-mail: ipin2012@unsw.edu.au
URL: http://www.surveying.unsw.edu.au/ipin2012/

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