On orbit measurement of response vs. scan angle for the infrared bands on TRMM/VIRS

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ABSTRACT

The Visible and Infrared Scanner on the Tropical Rainfall Measuring Mission (TRMM/VIRS) is a whiskbroom imaging radiometer with two reflected solar bands and three emissive infrared bands. All five detectors are on a single cooled focal plane. This configuration necessitated the use of a paddlewheel scan mirror to avoid the effects of focal plane rotation that arise when using a scan mirror that is inclined to its axis of rotation. System radiometric requirements led to the need for protected silver as the mirror surface. Unfortunately, the SiOx coatings currently used to protect silver from oxidation introduce a change in reflectance with angle of incidence (AOI). This AOI dependence results in a modulation of system level response with scan angle. Measurement of system response vs. scan angle (RVS) was not difficult for the VIRS reflected solar bands, but attaining the required accuracy for the IR bands in the laboratory was not possible without a large vacuum chamber and a considerable amount of custom designed testing apparatus. Therefore, the decision was made to conduct the measurement on-orbit.

On three separate occasions, the TRMM spacecraft was rotated about its pitch axis and, after the nadir view passed over the Earth's limb, the VIRS performed several thousand scans while viewing deep space. The resulting data has been analyzed and the RVS curves generated for the three IR bands are being used in the VIRS radiometric calibration algorithm. This, to our knowledge, the first time this measurement has been made on-orbit. Similar measurements are planned for the EOS-AM and EOS-PM MODIS sensors and are being considered for several systems under development.

The VIRS on-orbit results will be compared to VIRS and MODIS system level laboratory measurements, MODIS scan mirror witness sample measurements and modeled data.

Keywords: VIRS, on-orbit calibration, spacecraft maneuvers, reflectance, infrared, imaging radiometry
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1/8/1999
Remote Sensing

20-24 September 1999
University of Florence, Italy

Symposium Chairs:
Hatem Nasr, Baker Hughes, Houston, Texas USA
Luca Pantani, CNR-IROE, Florence, Italy

Symposium Co-Chair:
Enzo Pranzini, University of Florence, Italy

Invitation to Attend

A few decades ago aerial photography, photogrammetry, and radio ionospheric studies gave birth to the field of remote sensing, with some of the most dramatic developments occurring during World War II. Various national space programs helped evolve the technology into what it is today and made it a viable tool for environmental monitoring and other very practical applications. Today, remote sensing is one of the fastest growing technologies around. It is a multibillion dollar industry and remote thematic images are routinely used in an increasing number of fields. Remote sensing data has even become part of our daily lives. Weather satellites are the primary source for weather forecasting. Satellite data is being used today for crop forecasting, mining and exploration, archeological discoveries, and even real estate development, to name few. This was almost unimaginable a couple of decades ago. In the next millennium, as the technology continues to evolve, we will witness an even faster growth of remote sensing applications and commerce.

Today, there are very few yearly conferences on Remote Sensing that offer a comprehensive coverage of scientific topics, applications, sensors, systems and satellite platforms. The EUROPTO® Symposium is one such conference. The EUROPTO® Symposium also brings a unique blend of international participants, where over 20 countries have been represented every year. The remote sensing community has four main participants:

- Scientists, who research new sensors, data processing techniques, phenomenology, and applications;
- Industry, which develops new platforms and sensors and engages in the commerce of remote sensing technology;
- Users, who employ remote sensing products for their daily needs;
- Governments, which want to develop the technology to improve and protect their societies and promote commerce.

We invite participants from all these communities to participate in our next EUROPTO® Symposium on Remote Sensing in Florence, Italy, 20-24 September 1999. This Symposium is the sixth in this series. We continue to improve on this meeting. Last year's very successful Symposium in Barcelona attracted about 400 participants. This will be a unique forum to get informed and debate the state of the art of the technology: sensors, platforms, and applications.

Eleven conferences will be held in the framework of the Symposium. Each conference will include oral presentations and posters. We warmly invite you to participate in the EUROPTO® Symposium on Remote Sensing. We are working hard to make it a symposium of the highest quality.

Hatem Nasr
Baker Hughes, Houston, Texas

Luca Pantani
CNR-IROE "Nello Carrara", Florence, Italy
Conference Chairs: U. Schreiber, TU Munich, Koetzing, Germany, Ch. Werner, DLR, Oberpfaffenhofen, Germany

Conference Co-Chairs: K. Asai, Tohoku Institute of Technology, Sendai, Japan; P. Ingman, ESA-ESTEC, Noordwijk, The Netherlands; P. Flamant, CNRS, Palaiseau, France; M. Huffacker, CTI, Lafayette, CO USA; M. Kavaya, NASA, Huntsville, AL USA; G. Matviienko, IAO, Tomsk, Russia; N. Sugimoto, NIES, Ibaraki, Japan; I. Prochazka, TU Prag, Tchech Republic; John Degnan, NASA, Greenbelt, MD USA; G. Bianco, ASI, Matera, Italy; D. Winker, NASA, Langley, MD USA

The major interest of this conference is focused on Satellite / Lunar Laser Ranging (S/LLR) and Atmospheric Lidar.SLR contributed a lot to the earth sciences over the last two decades, enhancing the resolution of the measured ranges continuously. Nowadays the domain below one centimetre has been reached. Therefore, the structure of the targets and the rapidly changing propagation properties of the atmosphere and a high level of system stability have become relevant. Multiple sensor models, near real-time data consistency checks in clustered stations and in situ measurements of atmospheric parameters via remote sensing techniques are becoming keywords of a mm-level SLR community.

There are a lot of similarities between SLR and lidar, beginning from the laser radar technique and ending in the application for atmospheric monitoring or correction. Tomography is a new technique that can be applied from ground stations using retro-refectors in space or from space using hard targets on the ground. There are lidars or laser radars in orbit. Results of these sensors and discussions of planned missions are the goal of the second part of the conference.

The conference will be the continuation of the Europto® London conference in 1997 and is aimed to be a market for ideas. The session chairs are advised to stimulate the discussion. Therefore the number of accepted papers is limited to relevant new material and one or two invited papers. It is planned to provide time for extended discussions (accompanied with wine and cheese) to trade ideas or to present problems for discussions.

For the atmospheric propagation conference again a joint session is scheduled on the multiple scattering aspect.

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Conference Chairs: Anton Kohlme, FGAN - Forschungsinstitut für Optik, Tübingen, FR Germany; John D. Gonglewski, Philips Laboratory, Kirkland AFB, New Mexico, USA

Conference Co-Chairs: Luc R. Bissonnette, Defence Research Establishment, Valcartier, Canada; Piero Bruscagli, University of Florence, Florence, Italy; J. Christopher Dainty, Imperial College of Science, London, United Kingdom; Adam D. Devir, EORD, Technion, Haifa, Israel; Marc Séchaud, ONERA, Paris, France; Mikhail A. Vorontsov, U.S. Army Research Labs., Adelphi, MD USA

The use of satellites and high elevated platforms for active and passive remote sensing of earth and its atmosphere, as well as for high resolution imaging of ground-based and airborne objects, is a field of growing interest from civilian and military perspectives. Different sophisticated systems are currently used or scheduled for deployment for the purpose of covering the spectral regions from UV to CM waves. The measurement analysis depends crucially on the thorough understanding of all optical effects that limit the sensor performance through an atmosphere that acts as an absorbing, scattering, and radiating random medium.

High resolution space to ground (or ground to space) imaging is very much dependent on the long path geometries involved, especially due to altitude-dependent atmospheric propagation parameters and different radiating backgrounds.

Papers are solicited on the following and related topics:
• Imaging (band, spectral and hyperspectral) of ground-based and airborne objects from space and vice versa;
• Techniques for mitigation of atmospheric effects on imaging: adaptive optics, deconvolution, sensor fusion, post processing etc;
• Propagation and imaging through inhomogeneous dense media; multiple scattering effects on LIDAR and imager performance;
• Propagation and imaging through optical turbulence, including strong turbulence regimes;
• Propagation models and correction methods for atmospheric effects in remote sensing;
• Statistics of propagation parameters, statistics of cloud free line of sights, etc. Effects of depolarisation, pulse stretching, loss of coherence for active (laser) systems;
• Characterisation of the propagation environment: profiles of temperature, humidity, extinction, refractivity, radiance (also non-LTE), optical turbulence; updates of transmission and radiance codes.

A special session is planned to combine this conference with the conference on Laser Radar Techniques. The session will be dedicated to multiple scattering effects with respect to laser propagation and backscattering.

Conference Chair: Jacqui Russel, Imperial College, London, United Kingdom

All aspects of the remote sensing of clouds and the atmosphere is the focus of this conference but special emphasis will be placed on:
• High spectral resolution observations
• Polarised measurements and their interpretation
• Radar and passive microwave measurements
• Lidar measurements

Topics will include:
• Cloud detection and characterization
• Cirrus
• Scattering and absorption by nonspherical particles
• Temperature and humidity profiling
• Lidar, microwave and radar measurements
• Inversion problems and techniques
• Remote sensing of ozone, aerosols, and trace gases
• Earth radiation budget
• Sensor systems and requirements for future satellites
Papers are solicited on the following and related example topics:

- planned and proposed photonics and fiber optics nuclear reactor and space experiments.
- Quantification and qualification of photonic systems, materials and component responses in radiation environments.
- MEMS-MOEMS system and component radiation effects studies.
- Optical interconnects and optical bus architectures for space systems.
- Advances in photonic materials suitable for radiation applications.
- Research emphasizing FO components and systems.

The object of this conference is to address the field of commercial remote sensing and help clarify market issues, commercial viability of remotely sensed data and data products, and associated legal issues. There will be sessions on space systems, on ground station technology to facilitate commercial use of data, and on applications. Abstracts may address a wide range of subjects but should focus on the commercial aspects. Suggested topics include:

- Satellite systems for commercial remote sensing.
- Tools which facilitate product generation for the commercial marketplace.
- Data fusion tools.
- Archiving and distribution tools.
- “Exploitation” tools to extract information from imagery.
- Ground stations – how to adapt to commercial customer requirements.
- New stations.
- Upgrades to existing stations.
- Legal issues, licenses, liability.
- Commercial Applications – what is the market and what are the products?
- Agriculture.
- Communications.
- Real Estate.
- Insurance.
- Forestry.

The potential utility of the data for solving a wide variety of problems is unquestioned but, in many cases, the commercial viability is unproven. This data is only useful (and the systems producing it commercially viable) if products derived from it can be shown to be readily understandable by the user and lead to enhanced profitability. Tools to convert imagery to information will play a crucial role in the commercial marketplace. Equally important will be the ability to store and distribute the data in a timely manner. Another issue is the potential use of multiple data types (e.g., high resolution panchromatic and multispectral) to solve problems.

Over the next several years new satellite imaging systems, many launched by commercial companies, will collect remotely sensed data of differing resolutions in a variety of spectral bands. An unprecedented quantity and quality of data will be commercially available in a very short time after acquisition. The putative utility of the data for solving a wide variety of problems is unquestioned but, in many cases, the commercial viability is unproven. This data is only useful (and the systems producing it commercially viable) if products derived from it can be shown to be readily understandable by the user and lead to enhanced profitability. Tools to convert imagery to information will play a crucial role in the commercial marketplace. Equally important will be the ability to store and distribute the data in a timely manner. Another issue is the potential use of multiple data types (e.g., high resolution panchromatic and multispectral) to solve problems.

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Satellite remote sensing has become a common tool of the investigation in the different fields of Earth science. The progress of the performance capabilities of the optoelectronic devices mounted on-board space platforms have further improved the capability of instruments to explore inside the structure of the lithosphere and related resources, and to achieve the necessary information for a land-use global assessment, allowing us to make expanded and more detailed use of the electromagnetic spectrum. Satellite imagery is also an important complementary support in the description of spatial distribution of urban areas and archaeological sites, being largely dependent on environmental characteristics such as landform, soil fertility, rock type, water proximity, climatic conditions.

The present conference will be an occasion to outline how scientists involved in the Earth studies can take advantage of new remote sensing techniques, what their needs are, and what perspectives are just around the corner for tomorrow.

Particular subjects are:

- Imaging spectrometry and its hyperspectral dimension
- Image texture and spatial analysis and the 3-D computer vision
- Radar interferometric techniques to detect small displacements in relation to geodynamic events
- GIS for retrieval of land resource information
- Integration between remote sensing and geophysical prospecting

This announcement is an invitation to present new research results in these fields of satellite remote sensing applications in the following and related topics:

- Structural geology and tectonics
- Mineral and petroleum exploration
- Hydrogeology in arid and semi-arid zones
- Landform analysis and Quaternary geology
- Lithological classification and mapping
- Geological hazard and land degradation
- Soil properties and land-use classification
- Archaeological site identification
- Paleo-environmental reconstruction
- Infrastructures and urban areas
- Ocean currents and fronts
- Detection of deep water formation
- Water-quality monitoring
- Sea ice classification and sea ice dynamics
- Studies and modelling of microwaves and optical signatures of sea and ice
- Studies of shore-fast ice with interferometry
- Multi-satellite, sensor integration, and sensor studies
- Data fusion
- Regional and global sea ice monitoring in climate change research
- Operational monitoring systems and their requirements
Many new remote sensing programs are under way throughout the world, specifically by U.S., European countries and Japan. NASA’s office of Earth Science Enterprise (ESE) is developing plans for a series of programs including EOS, Landsat, Earth System Science Pathfinder (ESSP), and the New Millennium Earth Orbiting Flight. Japanese NASDA has a series of ADEOS and ALOS programs. ESA has ENVISAT and METOP programs. Each of these programs is developing a set of remote sensing systems to address their science objectives.

Papers are solicited on the following and related topics:

- Sensors being developed.
- Satellites being developed.
- Technologies required to enable these sensors and satellites.
- New design concepts of sensors, systems and satellites.
- Hyper spectral sensors in space.
- Sensor calibration techniques.
- Modeling and simulation techniques for sensor concept development.
- Focal plane assemblies including detectors and spectral filters.
- Space cryogenics
- System precursors including test beds and airborne simulators.
- Data system being developed.
- New data processing techniques.

Sessions on the following topics are being planned:

- ADEOS/ALOS mission and technologies.
- ENVISAT/METOP mission and technologies.
- ESE mission and technology.
- New satellite technologies (navigation, on-board data processing, cooling system, etc.).
- Calibration.
- Hyper spectral sensors (mission analysis, design, performance, technologies, airborne sensors, etc.).

Remote sensing has been responsible for major advances in our understanding and ability to manage agriculture, forestry and water resources. In spite of this progress there are still many areas where the potential of remote sensing has not been fully realized and these are areas of active research. Much of the new research is directly related to the development of new sensors and an improved understanding of what the sensors are actually measuring as well as new and improved analysis techniques.

This session seeks papers on new applications of remote sensing and recent research results in agriculture, forestry, and hydrology. Contributions using visible, near and far infrared, thermal infrared and microwave measurements are requested, but special consideration will be given to papers addressing use of satellite data or proposing synergism of different sensors.

Papers are requested that address the following and related topics:

- Agriculture, including crop yield modeling, early warning, disease and insect damage, drought effects, crop monitoring at regional and global scales, radiative transfer modeling of vegetation canopies, and related topics;
- Ecosystems, including forest management, biomass estimates, LAI/FPAR products, vegetation indices, land cover products, fires, deforestation, urban ecosystems, radiative transfer modeling of ecosystem properties, and related topics;
- Hydrology including parameterization of regional and macro hydrological models, water resource monitoring, estimates of latent and sensible heat, snow, soil moisture, urban hydrology, water quality, sedimentation, and erosion, and related topics;

The main goal of this conference is to examine all aspects of image and signal processing for remote image analysis and understanding. Papers describing recent and original work in the following and related research topics are welcome:

- Signal and image enhancement and restoration
- Registration techniques
- Stereoscopic images analysis
- Shape and texture analysis
- Image segmentation and object recognition
- Multisensor and multisource techniques
- Data fusion
- Statistical, structural and hybrid pattern recognition techniques
- Integration of remotely sensed data and geodata
- Neural techniques
- Scene analysis and image understanding
- Knowledge-based image understanding
- Expert systems, fuzzy logic, and AI technologies

Note: Those wishing to participate in this conference should prepare extended 500 word abstracts on two A4 pages. All other abstract submission instructions should be followed.
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Authors and co-authors are expected to pay a reduced registration fee. Included with the fee payment is a copy of the Proceedings volume in which the participant’s role or paper appears.

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