Tuesday, September 13, 2022 | 10:00 a.m.

Radiometric Calibration Equipment, Capabilities, and Facilities

Hardware and resources to support National and international requirements for radiometric calibration of remote sensing instruments, including long-term trending and performance enhancements of existing facilities

A Novel Vacuum FIR Calibration System in Support of ESA's 9th Earth Explorer Mission at PTB

Julian Gieseler, Max Reiniger, Dirk Fehse, Robert Häfner, Jamy Schumacher, Albert Adibekyan, Christian Monte – Physikalisch-Technische Bundesanstalt

ABSTRACT: ESA's 9th earth explorer mission Far-Infrared-Outgoing-Radiation Understanding and Monitoring (FORUM) aims for the first time to perform spectrally resolved, traceable measurements over extended time periods of earth's outgoing FIR radiation in the wavelength range from 3.62 µm to 100 µm, providing valuable data for climate research, modeling and prediction. So far, only spectral measurements up to 17 µm have been realized. However, about half of earth's outgoing total energy is found at wavelengths beyond 15 µm, making the FIR region crucial for earth's energy budget and hence climate development. FORUM aims to close the data gap with an aspired absolute uncertainty of 30 mK in spectral radiation temperature equivalent.

PTB will support FORUM by traceable calibration of its on-board reference source under vacuum via its Reduced Background Calibration Facility 2 (RBCF2). An absolute radiometric uncertainty of 30 mK in radiation temperature demands an FIR laboratory reference source with an absolute uncertainty of 10 mK or less, which lies beyond currently available radiometric reference sources, not just for the FIR, but for the MIR and NIR as well. Additionally, to reach the challenging radiometric target uncertainty, background radiation must be considered and actively controlled. This necessitates the development of a new reference blackbody for FIR calibration under vacuum in combination with a precisely temperature controlled and uniform scenery.

In this talk we will present the development of a novel radiometric FIR calibration system consisting of a Variable temperature Reference Blackbody (VRBB) and a thermal shroud called Coldscreen (CS) which combined will reach radiometric uncertainties in-lab below 10 mK in the FIR region. The design principles guiding development and manufacturing will be presented and first hardware prototypes for the CS are discussed. The blackbody is designed to be coated with carbon nanotubes, because these show the highest emissvity in the FIR region, which poses unique challenges for manufacturing. The CS will realize different background radiation environments and thus help correct background signals, which can be applied beyond the needs of FORUM to help calibrate reference sources from NIR to FIR with unprecedented uncertainty.

Developing the IEEE P4001 Standard for Characterisation and Calibration of Hyperspectral Imaging Devices

Christopher Durell – Labsphere Inc.; John Gilchrist – Clyde HyperSpectral Imaging; Torbjorn Skauli – University of Oslo

ABSTRACT: Hyperspectral imaging has over the last thirty years developed into a power analytical tool for the determination of chemical and other properties. As a result, there has been strong development in both the design of spectral cameras and in the applications for which they are used. This has led to a diversity in the way fundamental instrument performances are characterized, reported, and understood. As a result, this makes it difficult to compare instruments for application-specific needs, or for commercial market needs.

In 2018, the IEEE P4001 group was formed to facilitate the development of a standard to unify the use of terminology, spectral camera characterization methods, and the meta-data structures that are needed to represent spectral camera performance. This talk provides an update on the work to date, and the significant progress made towards the first draft of the standard.

Radiometric Uncertainty Analysis of the GLAMR Calibration Facility

Brendan McAndrew, Joel McCorkel – NASA Goddard Space Flight Center; Julia Barsi – Science Systems and Applications, Inc.; Andrei Sushkov – Genesis Engineering, Inc.

ABSTRACT: The Goddard Laser for Absolute Measurement of Radiance (GLAMR) is a spectral and radiometric calibration facility developed for hyperspectral earth science instruments. A detailed study of the radiometric uncertainty has been conducted as part of our preparation for the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission Ocean Color Instrument testing. This instrument has particularly stringent calibration requirements, necessitating a comprehensive set of measurements to characterize sources of radiometric uncertainty. Included in these measurements are the spectrally dependent linearity, repeatability, uniformity, measurement noise, and fluorescence. Uncertainty of the absolute calibration provided by the National Institute of Standards and Technology is also included to establish an overall uncertainty of the radiance.

Improvements and additions to the hardware that have been implemented as part of this study are described, and corrections for linearity and fluorescence are presented. Total radiometric uncertainty at k=1 in the visible and near infrared is 0.2%, in the ultraviolet 0.3%, and in the short-wave infrared 0.4% outside of atmospheric absorption features. Primary contributors to uncertainty are the absolute calibration of the transfer radiometers and the uniformity of the integrating sphere.

BRDF Measurements using a Large-area Uniform Illumination Scatterometer (LUIS) in Support of NASA Remote Sensing Programs

Jinan Zeng – Fibertek, Inc.; James Butler, Xiaoxiong Xiong – NASA Goddard Space Flight Center

ABSTRACT: There are two newly developed scatterometers at the Diffuser Calibration Lab (DCL) NASA GSFC. One of them is a laser/lamp-based table-top scatterometer (TTS) covering the spectral range from 300 nm to 2300 nm with a relative small beam size of 5 to 10 mm in diameter. The spatial non-uniformity of BRDF is requested when a large diffuse sample is measured on TTS. In order to test the BRDF along with spatial non-uniformity, a Large-area Uniform Illumination Scatterometer (LUIS) was built to meet the requirements for different large samples, especially volume diffuse samples. The LUIS system at NASA GSFC is capable of generating a 6” dia. uniform collimated beam using a 16” dia. 2.5 m long telescope, high power LEDs from 340 nm to 1650 nm, and different field-of-view detectors, and applies the same measurement equation as that used in flight. BRDF results of selected white and black diffuse samples measured using LUIS are presented, including surface diffusers and volume diffusers, and compared with those from TTS. Several new capabilities of BRDF measurements of LUIS are also demonstrated. In addition, another approach of BRDF tests for a large-area sample was attempted to simulate a large-area uniform illumination by rastering a 532 nm pencil laser across it. These BRDF results are compared with that from LUIS, showing a good agreement. To extend the spectral coverage of LUIS beyond 2000 nm, a high power SWIR tunable laser is used to generate the large-area uniform collimated light. Some related results will be reported. Also discussed in this presentation are the BRDF validation and uncertainty budget.

Radiometric Calibration of the SkyRange High-fidelity Automated Airborne Reconfigurable Tracking System (HAARTS)

David Goorskey – Perikin; Gordon Scriven – Torch Technologies

ABSTRACT: The Department of Defense (DoD) Test Resource Management Center (TRMC) established a fleet of Unmanned Aircraft Systems (UAS) called SkyRange. SkyRange is currently comprised of RQ-4 Global Hawk and MQ-9 Reaper UAS. The aircraft are outfitted with optimal sensor payloads to meet specific hypersonic test objectives. One such sensor payload is the High-fidelity Automated Airborne Reconfigurable Tracking System (HAARTS) designed to characterize the performance of flight test vehicles during boost and reentry. HAARTS is a multi/hyperspectral imaging system designed to produce spatially resolved temperature images. To meet temperature retrieval uncertainty requirements, a multi-level radiometric calibration process was developed. The calibration process involves: 1) a multi-source lab Calibration Cart, 2) in-flight calibration and 3) automated calibration data collection and processing.

An overview of the HAARTS design and envisioned CONOPS will be presented along with updates from the recent Global Hawk integration, ground testing, and early flight testing. The presentation will provide an overview of the Calibration Cart design, automation, and operation. Finally, HAARTS performance characterization and radiometric calibration results will be presented.