Tuesday, September 13, 2022 | 2:05 p.m.

Sensor Calibration and Testing for Hosted Small Satellite Payloads

Examining small satellite payload calibration testing processes and methods, including accuracy and precision, to discover ways to reduce cost and schedule while still meeting mission requirements

VENµS Mission Evolutions and Radiometric Performances During VM5 in-orbit test phase

Arthur Dick, Gérard Dedieu, Olivier Hagolle, Jean-Louis Raynaud, Sophie Pelou – Centre National D'Etudes Spatiales (CNES); Morgan Farges – Magellium; Cécile Peschoud – CS Group

ABSTRACT: VENµS (Vegetation and Environment New micro (µ) Satellite) is a micro satellite launched in 2017 by the Israeli Space Agency (ISA) and the French Centre National d'Etudes Spatiales (CNES). VENµS is a research satellite that embarks two very different devices, an electric Hall Effect thruster, and a multispectral optical camera. This article focuses on the multispectral camera.

Since March 2022, VENµS has begun the final phase of its mission called VM5. At the beginning of this project, it had been planned to divide the mission in 3 phases specially to use the small thrusters, which are dedicated to a technological mission. Regarding to the highly satisfactory results of the first scientific phase VM1, it has been decided to create two new phases to finally reach an orbit at 560 km. This new orbit allows attaining increased characteristics such as a 1-day revisit cycle, a ground resolution of about 4m and a swath of around 20 km.

This article presents the different phases of the mission, its main characteristics and available products. A special focus is made on the radiometric calibration during VM5 in-orbit test phase. These activities include equalization (dark and non-uniformity coefficients), absolute calibration using desert and Moon images and performance assessment such as SNR or FPN. The results of each part are detailed.

VENµS data of the VM1 phase are freely available to everybody for peaceful and non-commercial uses on the French Theia land data center: http://www.theia-land.fr.

Results of the Radiometric Calibration Update for the SkySat Fleet using Near-Simultaneous Crossovers with Sentinel-2

Hannah Bourne, Alan Collison, Arin Jumpasut – Planet Labs

ABSTRACT: SkySats are Planet's fleet of 21 high resolution Earth observation satellites. They have sub-meter resolution, are capable of imaging at a range of viewing angles, have high intra-day revisit rate capabilities and can image regions in areas typically difficult to observe. In early 2022, SkySats were updated to use Sentinel 2 as their radiometric reference. This change increased consistency across Planet's fleet of over 200 satellites as the medium resolution fleet, Planetscope Superdoves, are also calibrated using Sentinel 2 as the radiometric reference.

In order to achieve optimal radiometric calibration, SkySats were tasked to image calibration sites daily to generate numerous near-simultaneous crossovers of these sites with Sentinel-2. Unlike Planet SuperDoves, simultaneous crossovers with Sentinel 2 are limited to well characterized calibration sites as their Relative Spectral Responses are quite different from those of Sentinel 2. SkySats are also tasked to image the Radiometric Calibration Network (RadCalNet) daily to collect radiometric validation data. The new coefficients are now active in production. Since their release, the radiometric accuracy of SkySats relative to Sentinel 2 over calibration sites as well as RadCalNet sites has improved.

Adaptive Calibration of CubeSat Radiometer Constellations

John Bradburn, Mustafa Aksoy – University of Albany, SUNY

ABSTRACT: “Adaptive Calibration of CubeSat Radiometer Constellations" (ACCURACy) is a novel, constellation-level calibration framework developed to address the challenges in calibrating constellations of CubeSat radiometers. CubeSats are smaller than conventional monolithic systems, and so while cheaper and easier to develop and deploy, a lack of sufficient radiation shielding and thermal mass results in gain fluctuations due to the increased sensitivity to ambient conditions. Weight, cost, and power requirements also mean that CubeSats need to rely on vicarious calibration measurements, rather than external blackbody references, which cannot be collected frequently.

ACCURACy is a multi-module framework which uses onboard telemetry data to cluster radiometers in similar states, creating cluster-level calibration data pools to share calibration data between radiometers in the same cluster. This is in contrast to existing constellation-level inter-calibration methods, in which a) one target sensor is selected within the constellation as an absolute calibration reference calibrated using blackbodies or RTMs, and then b) calibration measurements are collected from co-located constellation members in orbit when available and are used to eliminate biases between them in post-processing. This method is not suitable for constellations of identical CubeSat radiometers to obtain frequent-revisit, real-time, consistent observations with broad coverage.

ACCURACy has been developed and tested using a radiometer simulator, which was created in MATLAB to produce synthetic radiometer data for simulated constellations of CubeSats across a broad range of conditions. It has also been tested using various clustering algorithms and many different clustering parameters in order study the propagation of error in the system, and to reduce and quantify errors and uncertainties in calibrated products. This analysis establishes a relationship between uncertainties in calibration measurements and telemetry data in input data, cluster size and variance, and RMSE and uncertainty in calibrated products. ACCURACy is also evaluated against existing constellation-level inter-calibration methods using constellation simulations, comparing the RMSE and uncertainty in the calibrated antenna measurements for all radiometers in a constellation.

Calibration and Validation Plans for the Carbon Mapper Mission

Brandon Rasmussen, Keely Roth, Justin Haag, Paul Giuliano – Planet Labs

ABSTRACT: Planet is a key implementing partner in the Carbon Mapper Consortium (CMC), a public-private partnership with a primary goal of measuring and monitoring Earth’s high-emitting methane point sources via satellite. Effectively mapping, quantifying, and attributing methane sources from orbit drives the performance requirements for the first two demonstration satellites equipped with VIS-SWIR Dyson imaging spectrometers and planned for launch in 2023. These high radiometric, spatial, spectral and uniformity performance needs will be met by relying upon decades of imaging spectroscopy experience from another key CMC partner - NASA’s Jet Propulsion Laboratory. JPL is developing the first payload and is working closely with Planet on technology transfer. This partnership will enable Planet to manufacture, operate, and scale the constellation to meet market demand.

This work will present a broad overview of our current plans for the full suite of calibration and validation activities through the satellite commissioning process and production of calibrated radiance on orbit. This will include an overview of in-lab calibration experiments, synthetic and surrogate imagery experiments, calibrated radiance processing, and initial on-orbit calibration/validation activities. We will also present initial synthetic and surrogate data analyses being used to guide mission planning.

EarthDaily Mission and Cal/Val Concepts

Keith Beckett, Paul Cottle, Chris Rampersad, Rob Irwin – EarthDaily Analytics

ABSTRACT: The EarthDaily Analytics team is actively building a constellation of highly innovative satellites, capable of covering the earth's landmass every day with a novel set of spectral channels selected to serve a wide range of applications. This new data will flow through our EarthPipeline, a completely automated Ground Segment-as-a-Service offering, capable of processing, calibrating and validating not only the data from EarthDaily Analytics' constellation but data from multiple partners's constellations as well.

We know that nearly every application targeted by EarthDaily Analytics, agriculture, forestry, water and many more, will all benefit greatly from the science-grade imagery and analytics that the EarthPipeline will deliver. With novel spectral channels, ranging from visible through to thermal, combined with the objective to deliver high-value imagery and analytics, comes several calibration and validation challenges.

We will discuss the EarthDaily constellation and the EarthPipeline, and will delve into how our post-launch cal/val solutions will address these various challenges in order to achieve the radiometric, geometric and retrieval accuracy requirements.

Characterizing Superdove Calibration Over Different Geographies and Seasons

Arin Jumpasut, Alan Collison – Planet Labs

ABSTRACT: Planet currently operates a constellation of over a hundred satellites that collect a current image of the Earth each day. The latest of these are the Superdove satellites of which over a hundred are in orbit and actively delivering data to customers. This presentation will describe an on-orbit study that uses simultaneous crossovers with Sentinel-2 as a reference to characterize the Superdove radiometry. Due to the similarity of the Superdove bands to Sentinel-2, any crossover can be used instead of crossovers limited to well-characterized calibration sites. The pipeline that produces the calibration dataset is highly automated and looks for crossovers over the entire globe. Using this data set, this presentation will investigate if there are any differences in radiometric calibration with different geographies and throughout the year.