Technical Session

Calibration Challenges in Remote Sensing for Environmental Studies

Understanding radiometric calibration and characterization of remote sensing instruments for environmental studies

- Implications of remote sensing strategy (wide-area coverage, indirect sampling, time trending) for radiometric calibration
- Relating accuracy and precision of remote sensing radiometry to calibration and characterization of remote sensing instruments
- Comparison of radiometrically-calibrated measurements to direct sampling and in situ measurements
- Validation and maintenance of calibration accuracy across measurement data gaps
- Assimilation of radiometric calibration knowledge, information, and data products into environmental (e.g., weather) models

3:50

Impact from Radiometric Calibration Error on MicroCarb Sensors on CO2 Concentration Retrieval

Charlotte Revel, Denis Jouglet, Pierre Lafrique – Centre National d’Études Spatiales (CNES)

ABSTRACT: The goal of the MicroCarb project is to design, build, launch and operate a satellite in low earth orbit that measures atmospheric CO2 volume mixing ratios in the atmosphere. The target accuracy on the atmospheric integrated column (random error) is 1ppm and the maximum bias is 0.2ppm. These concentration measurements shall then be used to assess CO2 surface exchanges and then to localize and characterize the CO2 sinks and sources on the earth’s surface.

The MicroCarb instrument acquires the solar light reflected by the Earth at a high spectral resolution for each Field of View of 4.5km across-track (ACT) by 9km along-track (ALT). These spectra are located in 4 spectral windows. Two windows (1.6μm and 2.0μm) are rich in CO2 absorption lines and two other windows (0.76μm and 1.27μm) are rich in O2 lines. The CO2 and other atmospheric or surface parameters like the surface pressure, the surface albedo, the H2O profile and others are retrieved using the inversion code 4ARTIC, which is based on optimal estimation.

The CO2 information for the sounding mission can be extracted, at first order, from the relative depth of the absorption lines, that is why the radiometric absolute calibration is not considered as part of the major sources of issue. Indeed, in a first approximation, the radiometric error can be associated with an error on the albedo which is retrieved by 4ARTIC and therefore does not impact the CO2 concentration estimation. However, scattering is known to influence the apparent albedo as well as the optical path, causing troubles in the CO2 retrieval accuracy.

We got interested in the impact of such radiometric error in the CO2 estimation, considering various atmospheric conditions: with and without Rayleigh scattering, with and without aerosol scattering. Our study shows that, for MicroCarb, the absolute radiometric error cannot be neglected because of scattering.

Several vicarious calibration methods will be applied on MicroCarb during the commissioning phase. Considering the current accuracy of these methods on each spectral band, the impacts of the residual radiometric error on the CO2 concentration retrieval were computed. The MicroCarb mission and the inversion method will be briefly described to a better understanding of the impact of the radiometric error. Afterwards we will focus on the accuracy of the vicarious calibration methods planned for MicroCarb.
4:15

**Characterization and Calibration of Hyperspectral Imager for Low, Medium and High-Altitude Earth Observation Payload**
Mathieu Maisonneuve, Genevieve Gariepy, Huge Bourque, Jacques Giroux – ABB

**ABSTRACT:** In the context of using data fusion from different kind of platforms to gather quality data for a wide range of hyperspectral applications, it is essential to focus on the calibration and traceability of the data acquired from each platform. This traceability allows to form a reliable data set useful to the end user, especially for Earth observation applications.

In this talk, ABB will present a compact hyperspectral imager payload and the various characterization and calibration activities we performed to address the issue of calibration and traceability. In particular, we will detail the on-ground characterization methodology developed at ABB, specific to the technology used for this imager, as well as calibration techniques used during UAV and airborne campaigns, with their pros and cons. Finally, this talk will cover calibration methodology that could be used for stratospheric bus in a long endurance flight.

4:40

**Experiences Learned in the Acquisition, Processing, and Assessment of In-situ Point Spectroscopy Measurements Supporting Airborne Hyperspectral Cal/Val Activities**
Raymond Soffer, Gabriela Ifimov – Flight Research Laboratory, National Research Council Canada

**ABSTRACT:** The process of acquiring and processing in-situ point spectroscopy measurements as ‘ground-truth’ reflectance is often viewed as straightforward and uncomplicated. In reality, the process requires significant attention to detail. This is particularly true as it applies to its use in activities related to the calibration and validation of airborne and/or satellite hyper/multi-spectral imagery where unbiased traceable results are crucial.

In this presentation, I review methodologies employed by the airborne hyperspectral remote sensing group at the National Research Council Canada to optimize the acquisition of in-situ point spectroscopy measurements and the processing of target reflectance spectra as performed in support of a bottom-up (lab → field → airborne → satellite (Sentinel-2)) data end-product validation project. In addition, methodologies to assess the quality of the resulting reflectance spectra are discussed.

The laboratory portion of the approach was designed to provide an initial reference panel reflectance characterization in terms of the biconical reflectance factor (BCRF) followed by regular monitoring of panel degradation. Making use of a laboratory implementation of a SVC 1024i field spectrometer, the BCRF of field reflectance reference panels were cross-calibrated at a 0°:45° view/illumination geometry against our primary lab reference panel. This lab panel had, in turn, been calibrated by the Remote Sensing Group at the University of Arizona tying our results to the NIST reflectance standard. Assessment of these data sets, acquired under controlled laboratory conditions, identified potential artifacts related to the detector temperature and integration times in the SVC 1024i field spectrometer. We see many examples where these effects have gone unnoticed within datasets acquired in less aware field deployments.

Experiences related to the acquisition of robust field spectrometry measurements are then reviewed along with methods we apply to evaluate the quality and suitability of the resultant datasets given the less than ideal atmospheric conditions commonly encountered. Biases due to inconsistent location of in-scattering objects, reference panel leveling, solar angle procession, and variances in downwelling illumination conditions are also considered.

5:05

**Earth Observation Platform, Rise of Low, Medium and High-Altitude Platforms**
Mathieu Maisonneuve, Genevieve Gariepy, Jacques Giroux – ABB
ABSTRACT: Satellite data and products currently drives several remote sensing applications, such as weather monitoring and Earth observation for both land and sea monitoring. However, in certain applications, there is still a need for better resolved, more acute data with an increased revisit time. While planned satellite constellations aim to address the issue of revisit time, and larger, more costly satellites could allow to improve the imaging performances of their payload, other solutions are sought after to address the demanding requirements of many applications. One of the proposed solution is to perform data fusion from multi-level platforms. In this scenario, the use of lower altitude platforms could be combined with space-based platforms to provide better resolved and more acute data.

In this presentation, we will explore this solution from different perspectives. First, we will review the available platforms, which we will split into three categories: low altitude UAV, mid-altitude UAV and high altitude long endurance platforms, the latter divided into two categories: heavier or lighter than air. The constraints on the optical payload for each category will be discussed. Second, we will focus on the potential uses of lower altitude platforms for both European and North American context, with the pros and cons of using such platforms. Finally, we will discuss the different applications that could benefit from this solution and the different possible optical payload to be used.

5:30

Total Propagated Uncertainty of the Surface Reflectance of the Satellite Imagery
Minsu Kim – KBRwyle

ABSTRACT: The radiometric conversion of the raw satellite sensor data is performed to calculate the top-of-the-atmosphere radiance and its associated uncertainty is estimated at first step. The next step of the satellite data processing is the atmospheric correction. This study focuses on the TPU created during the atmospheric correction procedure. The atmospheric correction consists of the angular geometry of the sun-sensor orientation and the atmospheric properties. The optically dominant atmospheric components are aerosol, ozone, water vapor. The atmospheric correction introduces additional uncertainties propagated through the atmospheric correction equation.

In this study we propose the methodology to estimate the statistical TPU created by the atmospheric correction. The uncertainty of each atmospheric component is estimated first as a standard deviation. Next, the Jacobian matrix as a partial derivative of all surface reflectance bands with respect to several atmospheric parameters is formed and the TPU matrix is calculated using Jacobian matrix and the uncertainty covariance matrix. The TPU matrix represents the uncertainty of the surface reflectance for each band of each pixel. Any downstream application product will be able to assess its uncertainty based on the associated TPU of the surface reflectance. For example, if a user computes NDVI, the associated uncertainty of the NDVI can be calculated based on the TPU of the surface reflectance. Having the NDVI uncertainty image will allow a user to see the area with larger or smaller NDVI uncertainty and help a decision making in an educated use of the NDVI product.