Scientific report **SAC/EPSA/CVD/CAL-VAL/03/18**

Phase-2 Calibration field campaign for AVIRIS-NG sensor over Desert sites

By
K. N. Babu, R. P. Prajapati, and A. K. Mathur

Calibration-Validation Division (CVD)
Earth, Ocean, Atmosphere, Planetary Sciences & Applications Area (EPSA)
Space Applications Centre (ISRO)
Ahmedabad – 380 015

July, 2018

Document control sheet

1. Report No.	SAC/EPSA/CVD/CAL-VAL/03/18
2. Publication date	July, 2018
3. Title and subtitle	Phase-2 Calibration field campaign for AVIRIS-NG sensor over Desert sites
4. Type of report	Scientific
5. Number of pages	12
6. Number of references	4
7. Authors	K. N. Babu, R. P. Prajapati, and A. K. Mathur
8. Originating unit	CVD-EPSA
9. Abstract	This technical report brings out the proposed calibration site details for the second phase AVIRIS-NG aerial mission of ISRO-JPL project and the field measurement details during the actual flight campaign on 25th March 2018 over Desalpar and 27th March 2018 over the new proposed sites. These sites are completely undisturbed natural, desert sites in Rann of Kuchchh, Desalpar and Amarapur respectively. Surface reflectance measurements were carried out using ASD spectrometer and MicroTOPS-II sun-photometer and Ozonometer for the aerosol, water vapor and total ozone content. These essential minimum observations are required for the simulation of top-of-the-atmosphere radiance using atmospheric radiative transfer model for the given Sun-Earth-Sensor geometric configuration.
10. Key words	Desalpar, Amarapur, Desert, CAL-VAL site, reflectance
11. Security classification	Unrestricted
12. Distribution statement	General

Contents

Abstract

This technical report brings out the proposed calibration site details for the second phase AVIRIS-NG aerial mission of ISRO-JPL project and the field measurement details during the actual flight campaign on 25th March 2018 over Desalpar and 27th March 2018 over new proposed sites which are completely undisturbed natural, desert sites in Rann of Kuchchh, Desalpar and Amarapur respectively. Surface reflectance measurements were carried out using ASD spectrometer and MicroTOPS-II sun-photometer and Ozonometer for the aerosol, water vapor and total ozone content. These essential minimum observations are required for the simulation of top-of-the-atmosphere radiance using atmospheric radiative transfer model for the given Sun-Earth-Sensor geometric configuration.

Introduction

Remote sensing and calibration-validation are critical aspects of Earth observation measurements and the associated methods used to retrieve terrestrial parameters that are not compromised by sensor and data processing effects. The challenge is to ensure that the measurements and methods yield self-consistent and accurate geophysical products. Sensor radiometric calibration, the most fundamental part of the calibration–validation process, is a broad and complex field that imposes the greatest limitations on quantitative applications of remote sensing (Teillet, 1997; Teillet, Horler, & O'Neill 1997). The methods and instrumentation involved can be grouped into three domains (Dinguirard & Slater, 1999): on the ground prior to launch, onboard the spacecraft post launch, and vicarious or indirect approaches using Earth scenes imaged in-flight. Whereas preflight methods encompass a vast array of painstaking sensor characterizations in the laboratory (e.g., Guenther et al., 1996) and occasionally outdoors (Biggar, Slater, Thome, Holmes, & Barnes, 1993), onboard and vicarious calibrations are devoted primarily to the monitoring of the radiometric responsivities or gain coefficients of sensor spectral bands over time. In all cases, the objective is traceability of data calibration accuracies to the International System of Units (SI) for science users and data products with consistent quality for the broader user community.

This report brings out the experimental work carriedout during the AVIRIS-NG sencond phase for the purpose of feasibility of using reference data to carryout vicarious calibration. The vicarious calibration approach predict the radiances at the top of the atmosphere over a selected ground test site/s with the help of atmospheric radiative transfer code calculations and synchronous measurements of atmosphere; surface characteristics which are pertaining to the particular sensor.

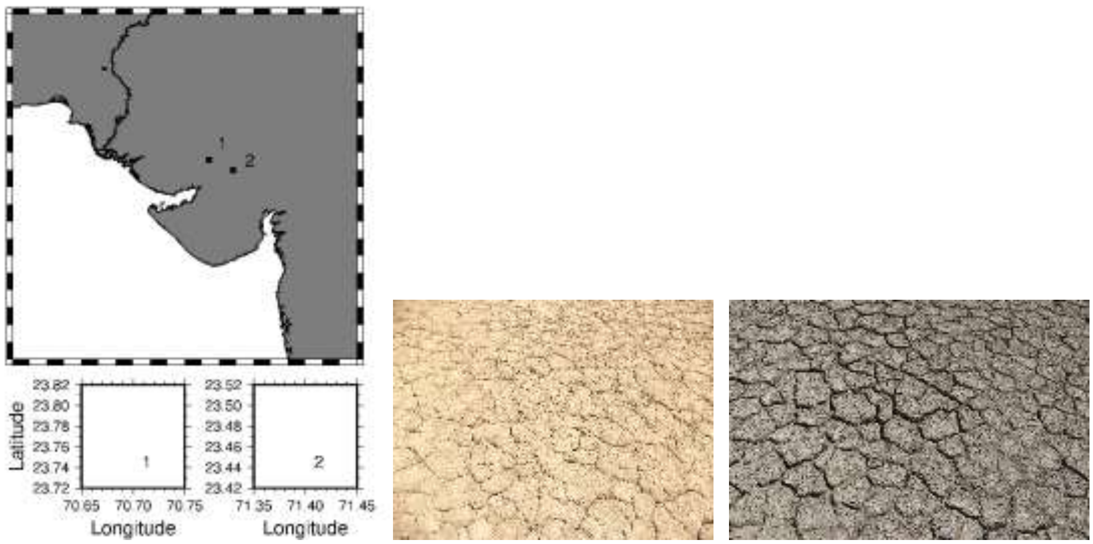


Figure 1: The proposed sites to carryout the calibration campaign for the AVIRIS-NG mission.

Figure 2: The photographic view of the calibration sites: Desalpar/Amarapur (left/right).

Calibration sites

Vicarious calibration test sites are usually flat, homogeneous areas generally located in desert regions. Desert regions have bright surfaces, a low probability of interference from clouds, and generally low aerosol loading. All these factors decreases the calibraion uncertainties due to the atmospheric characterization involved in the method. The phase-2 mission of AVIRIS-NG make use of the Desalpar site ID 72 (as mentioned 1 in Figure 1) and Amarapur site ID 205 (as mentioned

2 in Figure 1) which are qualifying as natural terresterial calibration sites of ISRO's Earth observation satellites. The Desapar site is smaller and more suitable to the calibration of high-resolution sensors such as ResourceSat, CartoSat, OceanSat series of satellites. The Amarapur playa extends over a very large area and lends itself better for calirbating high spatial resolution sensors such as INSAT-3D, -3DR which have 1km pixel resolution. The details of sites and date of ground measurements is mentioned in Table 1.

Table 1a: Calibration and validation test sites for AVIRIS-NG sensor

Sr. No.	Site name/site ID	Latitude (^{o}N)	Longitude (^{o}E)	Altitude (m)
1	Desalpar / 72	23.77	70.72	11
2	Amarapur / 205	23.48	71.39	9

Table 1b: The field campaign site, ground sampling interval, and total no. of spectrum collected

Sr. No.	Site name/site ID	Date	Ground sampling interval	No. of spectrum collected
1	Desalpar / 72	25 March 2018	6m x 6m	270
2	Amarapur / 205	27 March 2018	6m x 6m	260

Table 2: Field campaign dates and the instruments used for data collection

Sr. No.	**Site name/ site ID**	**Campaign dates for cal-val exercise of AVIRIS-NG**	**Instruments operated**
1	Desalpar	25 March 2018	ASD, spectro radiometer, MicroTOPSII (sunphotometer, Ozonometer), CIMEL sunphotometer, Labsphere Spectrolon reflectance panel
2	Amarapur	27 March 2018	ASD, spectro radiometer, MicroTOPSII (sunphotometer, Ozonometer), Labsphere Spectrolon reflectance panel

The list of instruments used during the cal-val campaign of AVIRIS-NG mission and the sites is mentioned in **Table 2**. The geo-location of radiometric data acquired are shown in figure 3. The spectrolon plate was deployed sequentially in the center of the main quadrants and used in conjunction with the spectrometer measurements for the adjacent cells. The spectrometer measurements were made using nadir-viewing geometry condition.

AVIRIS-NG sensor

AVIRIS is an acronym for the Airborne Visible InfraRed Imaging Spectrometer. AVIRIS is a premier instrument in the realm of Earth Remote Sensing. It is a unique optical sensor that delivers calibrated images of the upwelling spectral radiance in 224 contiguous spectral channels (also called bands) with wavelengths from 400 to 2500 nanometers (nm). The new generation AVIRIS (AVIRIS-NG) has been developed by NASA-JPL and has been used for various airborne missions. The technical details are given in Table 3.

Table 3: Technical specifications of AVIRIS-NG system

Sr. No.	Parameter	Specifications
1	Spectral range	380 – 2510nm
2	Position	5nm
3	Response	1 to 1.5 times sampling
4	Calibration	±0.1nm
5	Range	0 to specified saturation radiance
6	SNR	>2000@600nm >1000@2200nm
7	Accuracy	95% (<5% uncertainty)
8	Linearity	≥99% characterization
9	IFOV	1mrad
10	Geometric model	Full 3 axes cosines

Ground-based spectrometer measurements

Variable spatial sampling method is adopted for the collection of target reflectance using analytical spectral device (ASD) spectrometer. The FieldSpec spectro-radiometer is specifically

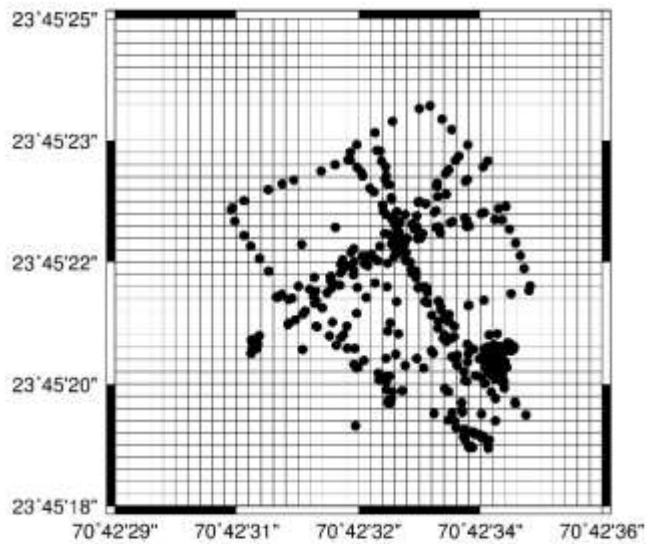


Figure 3: Sampling strategy for surface hyper-spectral measurements at Desalpar. The solid dots represent the locations of measurement and the spectrolon panel is kept at the center.

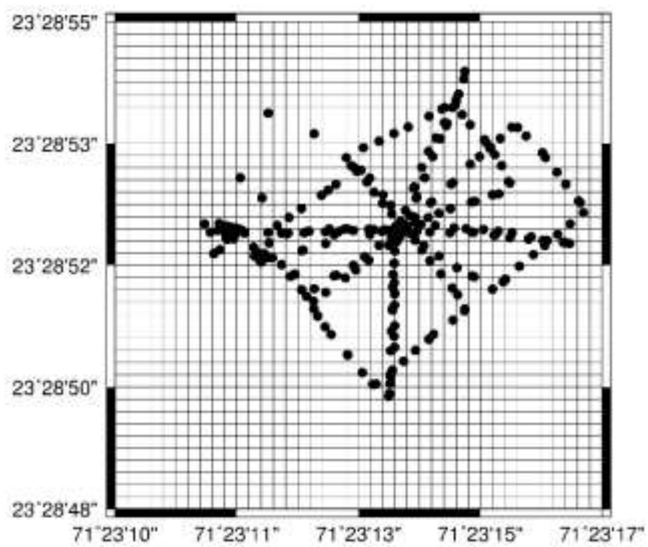


Figure 4: Sampling strategy for surface hyper-spectral measurements at Amarapur. The solid dots represent the locations of measurement and the spectrolon panel is kept at the center.

designed for field environment remote sensing to acquire visible-infrared (VNIR) and short-wave infrared (SWIR) spectra. This instrument is a compact, field portable, and precision instrument with a spectral range of 350-2500nm and a rapid data collection time of 0.1 second per spectra. It operates with a fiber cable, 3m in length, with a 25^o field-of-view. Three spectrometers are used to cover the full spectral-range. The first spectrometer uses a 512-element photo-diode array and a holographic reflective grating to cover the wavelength range from350 to 1000nm. This spectrometer has a sampling interval of 1.4nm and the spectral resolution is 3nm at 700nm.

Prior to the actual measurements, the spectrolon panel is placed at middle point of the measurement grid. The spectrolon panel azimuthal leveling is confirmed using bubbler sprit level. The spectral measurements are optimized with respect to spectrolon and quick (in less than 5 minutes) surface spectral measurements were carried out for a particular quadrant. Measurements over each quadrant are always initiated with spectrometer optimization and white reference measurements. In this report four quadrants measurement at a given time is ensured and treated as complete.

Statistically very large numbers of spectrum are collected for the calibration purpose. These reflectance spectrums are processed to 1nm interval using “viewspec pro” software, as provided by the equipment manufacturing company. Further these spectrum is subjected for the spectral uniformity and non-uniform spectrum are rejected in calculating the average spectrum (The rejected spectrum may not be a mean/true representative of the calibration target and also this non-uniform spectrum may lead to an uncertainty in the final calculation). The non-uniform spectra are removed from the calculation using one standard deviation criterion. The spectral surface reflectance measurements from Desalpar and Amarapur is given in Figure 5.

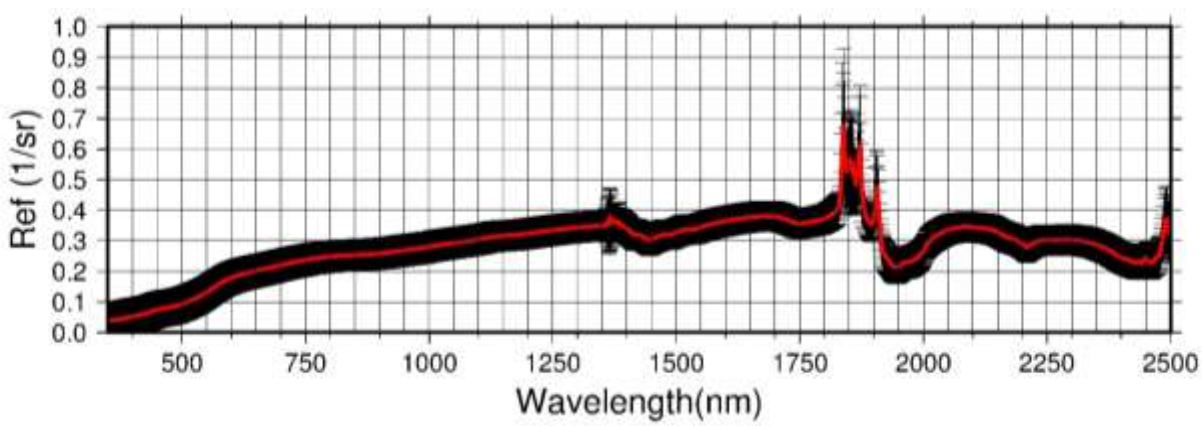


Figure 5a: The surface reflectance measured using ASD FieldSpec4 spectrometer at Desalpar on 25th March 2018.

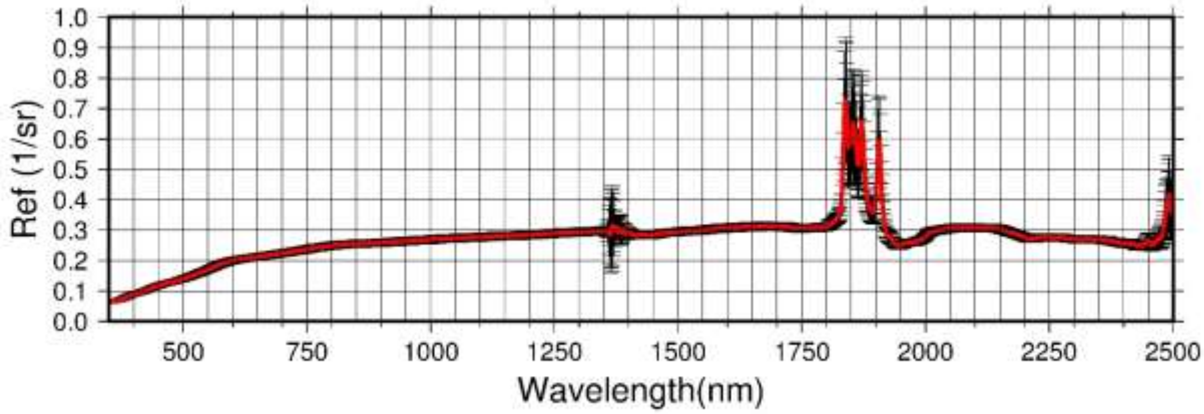
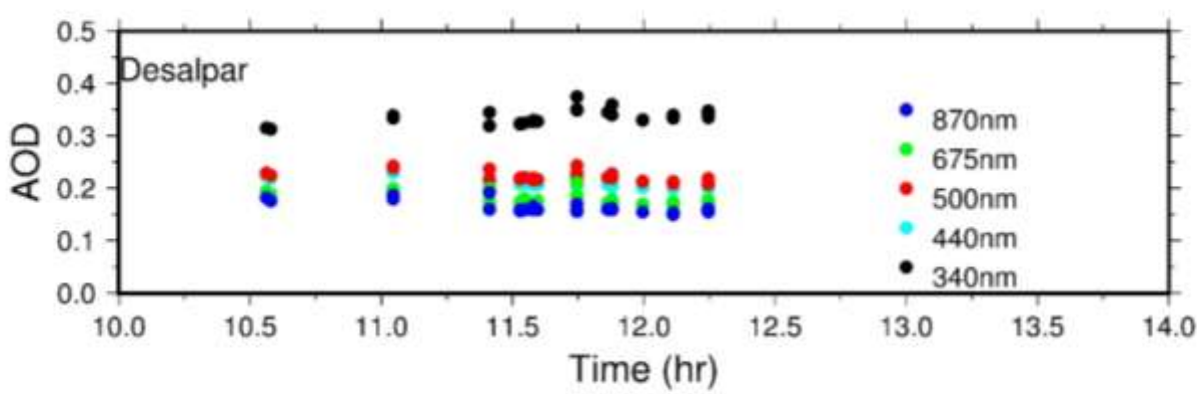


Figure 5b: The surface reflectance measured using ASD FieldSpec4 spectrometer at Amarapur on 27th March 2018.

Sunphotometer/Ozonometer measurements

Sunphotometer and Ozonometer measurements were made from the centre of the site grid using a handheld, calibrated MicroTOPS-II sunphotometer and Ozonometer unit. The sunphotometer/Ozonometer has built-in processing capability to compute a variety of atmospheric parameters at several wavelengths from instantaneous solar disk readings. The derived aerosol optical depth, ozone, water vapor from handheld sunphotometer and ozonometer is shown in **Figure 6**.

The instrument pointing accuracy is very important in measuring these parameter using MicroTOPS-II unit as these equipment uses narrow field of view to point the Sun. The error due to miss-pointing is avoided through the concept of triplet measurement (the lowest value from triplet AOD has the maximum pointing accuracy), the lowest AOD value from a given triplet measurement is taken as valid while the Ozone and columnar water vapor are averaged.



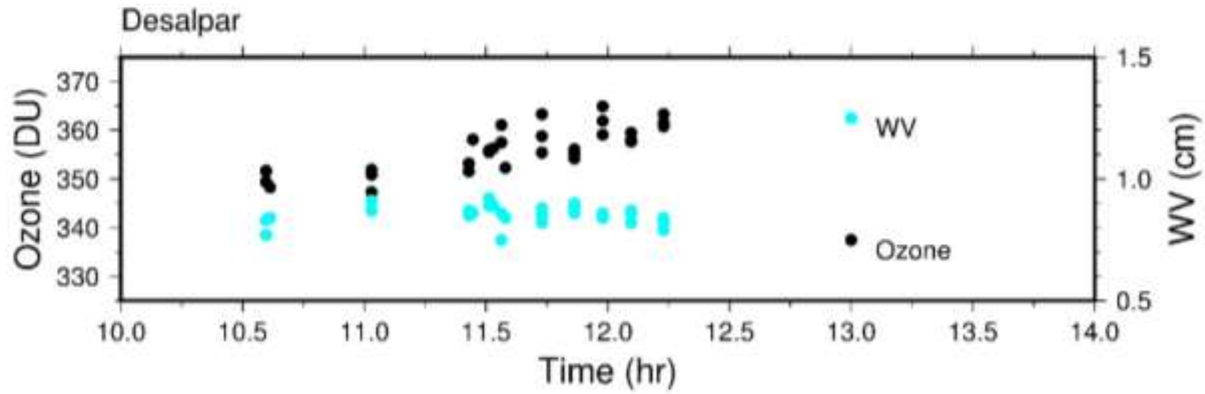


Figure 6a: Aerosol, Ozone, and integrated water vapor during Hyderabad calibration campaign.

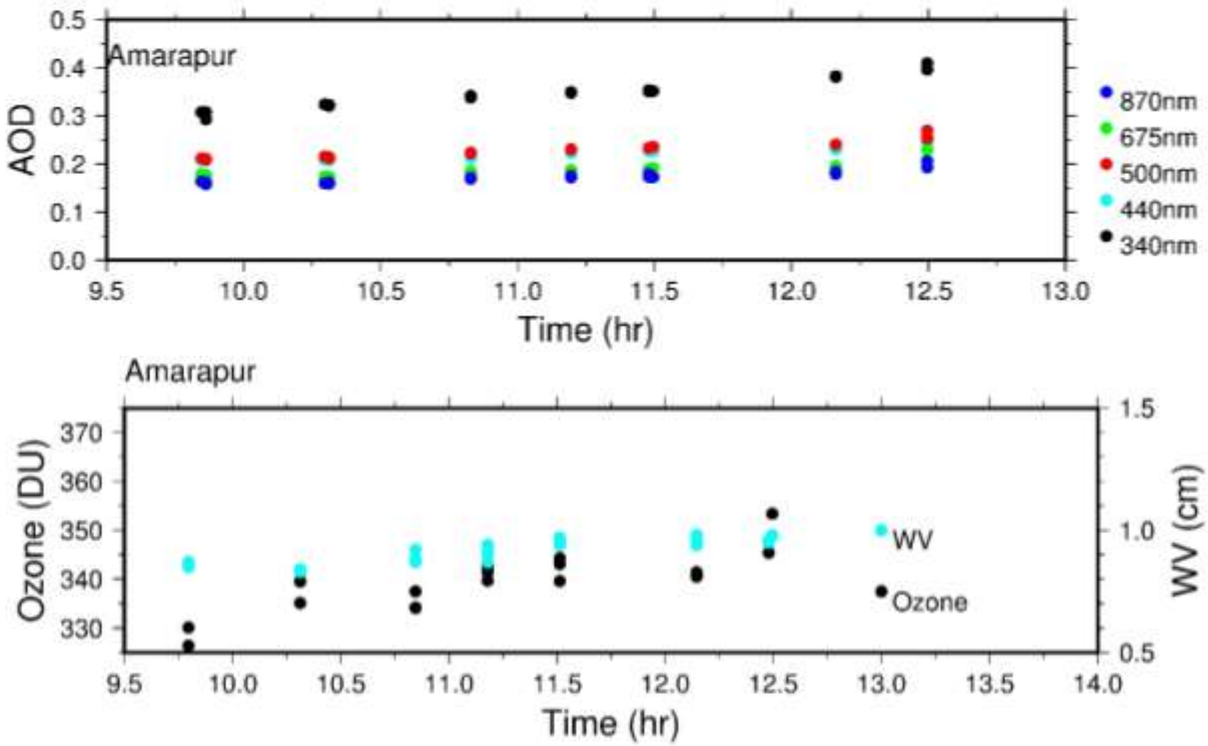


Figure 6b: Continuation …

Conclusion

Systematic field measurements were carried out during the AVIRIS-NG calibration campaign over the proposed two sites. Desalpar and Amarapur desert sites are chosen as the calibration sites in this campaign mission of hyper-spectral aerial measurement by AVIRIS next generation sensor. In this report we are reporting the measurement details, procedure, and the parameters measured using ASD spectroradiometer and MicroTOPS-II units (for the measurements of aerosol optical depth, water vapor and Ozone concentration).

Acknowledgments

The authors gratefully express their sincere gratitude to Shri Tapan Misra, Director, Space Applications Centre (SAC) for encouragement to carry out this study. The valuable suggestions and guidance received from Dr. Raj Kumar, Deputy Director, EPSA are gratefully acknowledged.

References

Biggar, S. F., Slater, P. N., Thome, K. J., Holmes, A. W., and Barners, R. A. (1993). Preflight solar-based calibration of SeaWiFS. In: Proceedings of SPIE Conference. 1939. (pp. 233-242).

Guenther, B., Barnes, W., Knight, E., Barker, J., Harnder, J., Weber, R., Roberto, M., Godden, G., Montgomery, H., and Abel, P. (1996). MODIS calibration: a brief review of the strategy for the at-launch calibration approach. Journal of Atmosphere and Oceanographic Technology, 13 (2), 274-285.

Teillet, P. A. (1997). A status overview of Earth observation calibration/validation for terrestrial applications. Canadian Journal of Remote Sensing, 23 (4), 291-298.

Teillet, P. M., Horler, D. N. H., and O'Neil, N. T. (1997). Calibration, validation, and quality assurance in remote sensing: a new paradigm. Canadian Journal of Remote Sensing, 23(4), 401-414.