Vicarious Calibration of LISS 3/ResourceSat 2A over desert, vegetation and water body

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Abstract

Post launch absolute calibration of space borne sensors is essential to frequently monitor and characterize sensor performance. This becomes an important requirement to provide quality data. This document describes a procedure adopted for the post-launch calibration of Resourcesat 2A LISS 3 bands over arid/crop/water terrains. The natural sites are chosen carefully with uniform radiometric variability suitable for performing vicarious radiometric calibration. The results based on the study show that band 2 & 3 show under-estimation of 2 to 12 percentage w.r.to all terrains of in-situ measurements. Band 4 shows under-estimation of 10 to 14 percentage for soil and crop sites whereas it shows close to 35 percentage over estimation for water site. Band 5 shows wider variations in estimation across different terrains. It shows about 27 and 66 percentage over-estimation for soil and water respectively, whereas about 35 percentage under-estimate for crops.

Introduction

Resourcesat 2A (RS2A) was launched in December 2016. It carries four sensors on-board namely, LISS 3, LISS 4 and AWiFS. LISS 3 has four spectral bands – 1) band 2: 520 to 590 nm, 2) band 3: 620 to 680 nm, 3) band 4: 770 to 860 nm and 4) band 5: 1550 to 1700 nm.

This document describes vicarious calibration of LISS 3 sensor carried out during two recent field campaigns. Field Campaign 1 was at desert soil site in Amarapur, Gujarat and Field Campaign 2 was at lake (Bada Talaav) and crop sites in Bhopal.

Field Campaign 1 was carried out by Cal-VAL Team of EPSA, SAC during RS2A pass over a wide barren soil near Amarapur, Gujarat on 6th Feb 2017. To cover wider dynamic range of the sensors, field measurement at water and crop site was planned. For this, we had to wait until next year January for favorable weather condition and proper growth of crops. Field Campaign

2 was undertaken by CAL-VAL Team in collaboration with Remote Sensing Applications Center, M P Council of Science & Technology, Bhopal (MP) headed by Dr G D Bairagi in Bhopal on 9th January, 2018. (Plan was to calibrate all three cameras of RS 2A. But, only LISS 3 was calibrated since, other two cameras did not cover the sites on that day of overhead pass.)

Methodology

The calibration method is based on measuring the surface reflectance (in suitable spectral ranges), aerosol optical thickness (AOT), columnar water vapor to include the water vapor absorption effect and ozone content over a calibration site at the time of satellite overhead pass. These measurements are used as an input for 6S RT code to simulate an absolute radiance at the sensor level. AOT becomes an important measurement as it is used to describe the aerosol and molecular scattering effect in the atmosphere.

Field Campaign 1

Fig. 1 Soil site at Amarapur, Gujarat

Soil site is shown in Fig. 1. Geo-Tiff (geo-corrected) satellite image of Amarapur site is shown in Fig. 2 shows.

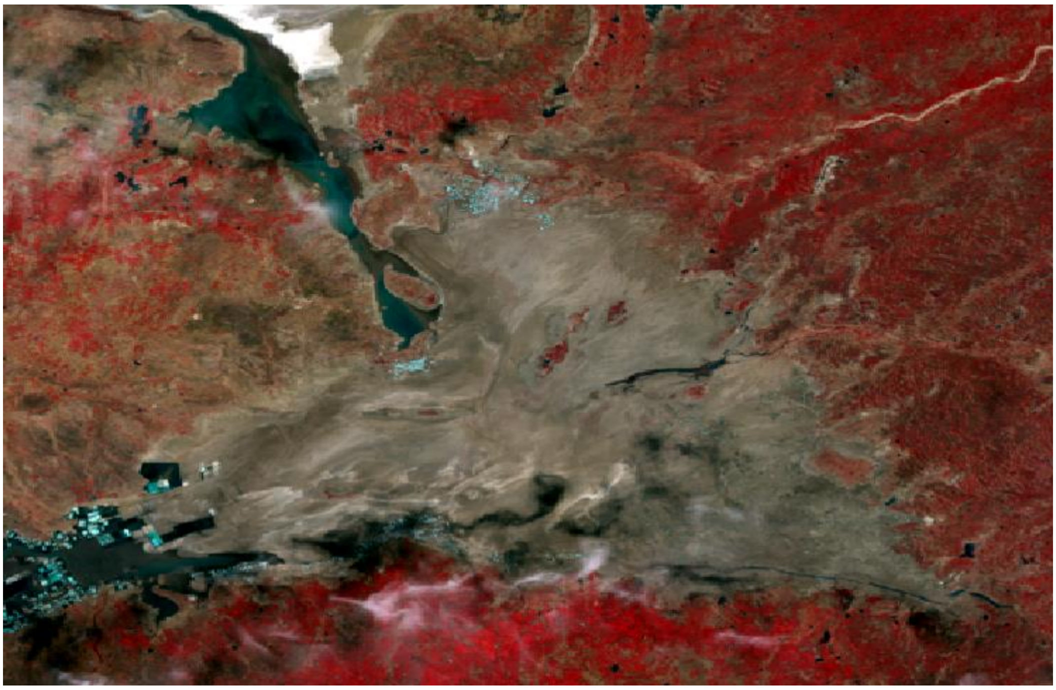


Fig. 2 Geo-tiff image of Soil site at Amarapur, Gujarat

Field Campaign 2

Fig 3a & 3b show water and crop sites respectively in Bhopal.

Fig. 3a. Water site (Lake) in Bhopal

Fig. 3b. Crop site in Bhopal

Geo-tiff and Rad-Cal satellite images of in and around the sites are shown in Fig. 4 & Fig. 5.

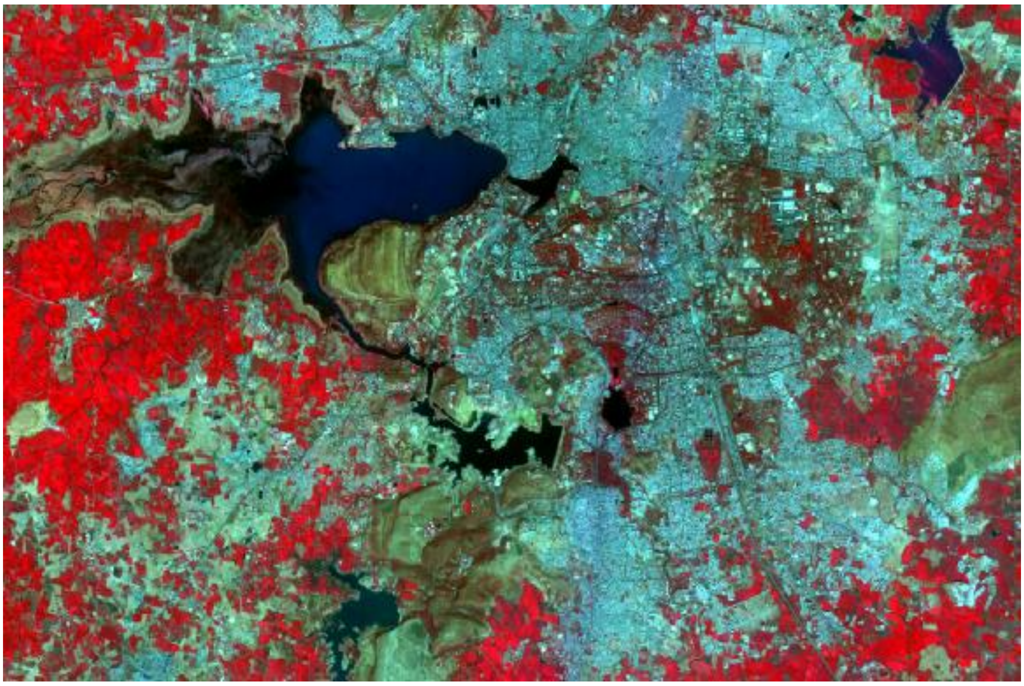


Fig. 4. Geo-tiff satellite image

Rad-Cal satellite is shifted by about 36 pixels of LISS 3 as compared to Geo-Tiff. Rad-Cal image was then spatially corrected by using feature matching technique. Fig. 6 is the final Rad-Cal image.

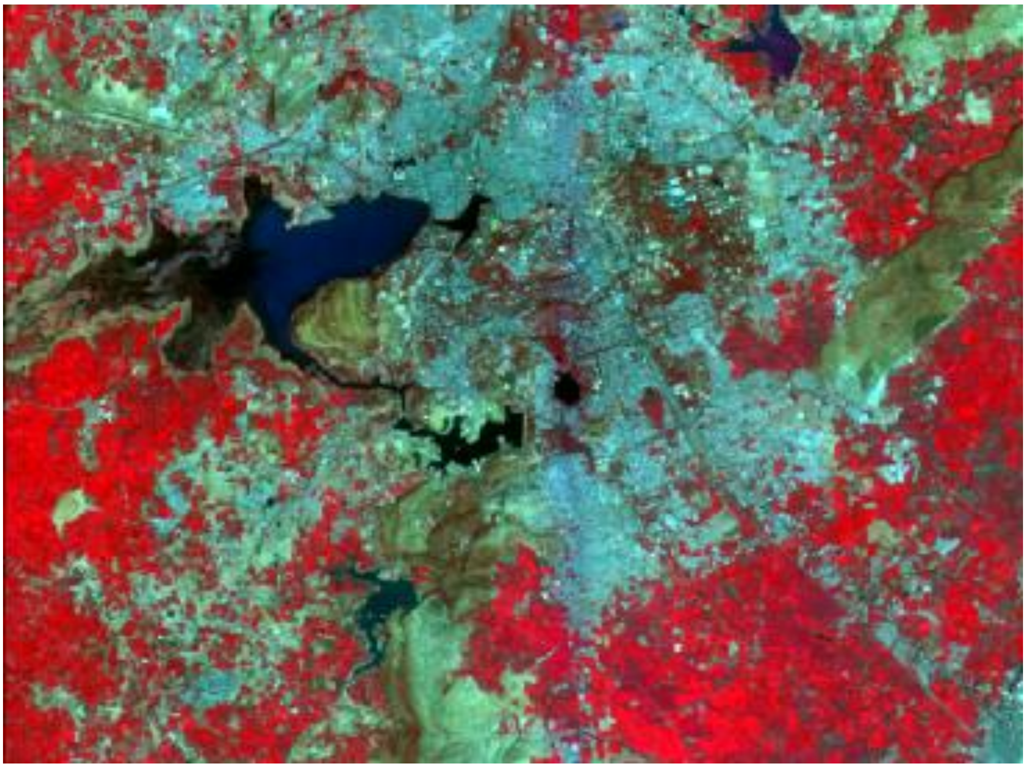


Fig. 5. Rad-Cal satellite image

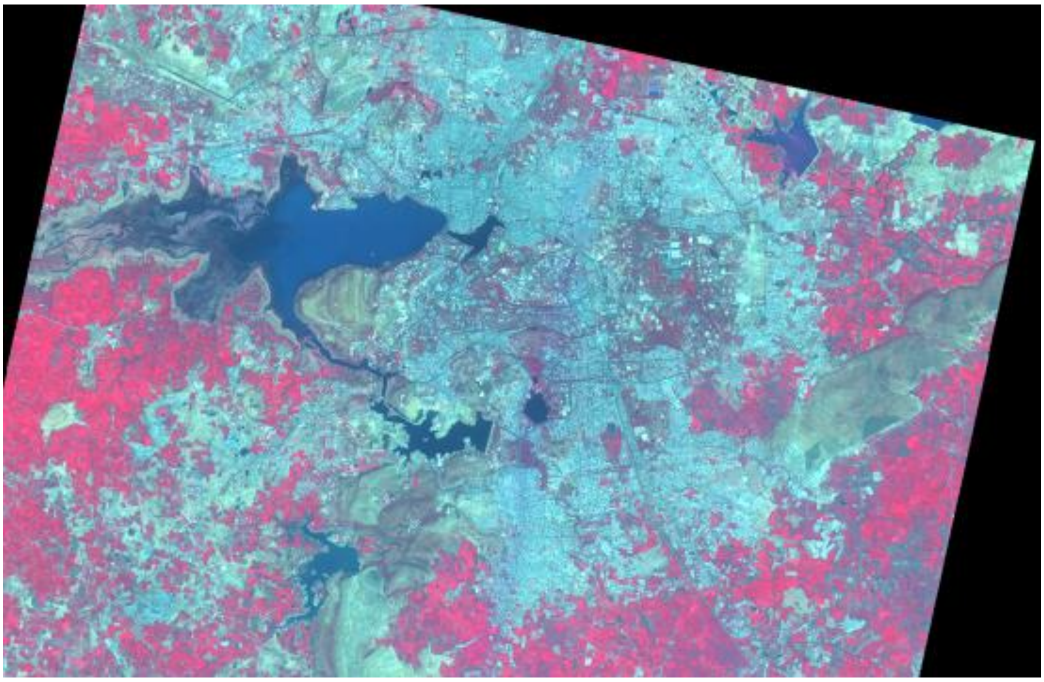
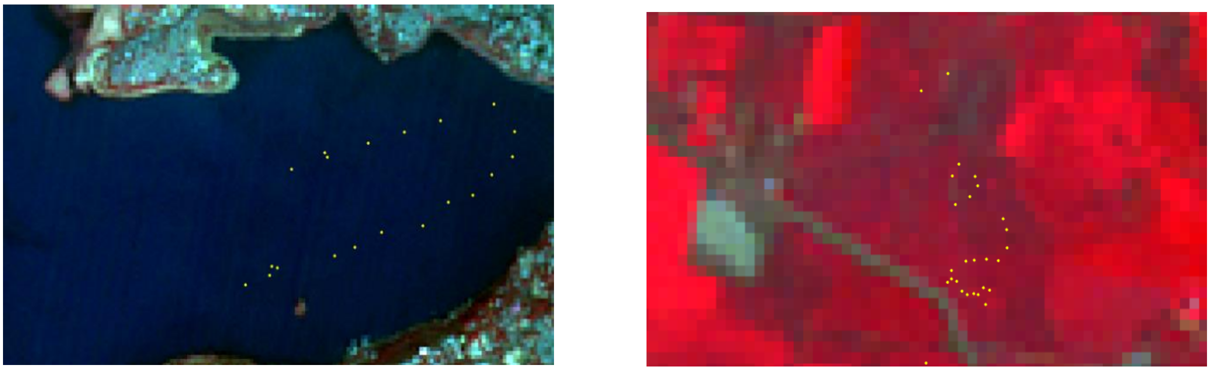


Fig. 6. Corrected Rad-Cal satellite image



(a) **(b)**

Fig. 7. In-situ measurement locations of (a) water site and (b) crop site

Results and Discussions

Mean and +/- 1σ values of radiances of in-situ and satellite data are compared in the following tables for water and crop sites:

Table 1a & 1b: Soil data of RS 2A LISS 3 Calibration

Lattitude	deg	23.506
Longitude	deg	71.433
Solar Zenith angle	deg	44.623
Solar Azimuth angle	deg	148.954
WV	gm/cm^2	0.314
O_3	cm-atm	0.2614
AOD		0.1707

Bands	Wavelength Range (nm)		Radiance (Top of Atmosphere) (mW/cm2/sr/µm)		Estimation Error (%)
			In-situ	Sat (Geo)	
Band 2	520 – 590	Mean + σ	9.540	8.272	
		Mean	9.168	8.156	-11.04
		Mean - σ	8.797	8.039	
Band 3	620 – 680	Mean + σ	9.287	8.887	
		Mean	8.911	8.769	-1.59
		Mean - σ	8.536	8.651	
Band 4	770 - 860	Mean + σ	7.634	6.646	
		Mean	7.300	6.567	-10.04
		Mean - σ	6.967	6.489	
Band 5	1550 - 1700	Mean + σ	1.998	2.429	
		Mean	1.905	2.416	26.82
		Mean - σ	1.812	2.404	

Table 2a & 2b: Water data of RS 2A LISS 3 Calibration

Lattitude	deg	23.243
Longitude	deg	77.381
Solar Zenith angle	deg	49.205
Solar Azimuth angle	deg	155.742
WV	gm/cm^2	0.645
O_3	cm-atm	0.279
AOD		0.4275

Bands	Wavelength Range (nm)		Radiance (Top of Atmosphere) (mW/cm2/sr/µm)			Estimation Error (%)	
			In-situ	Sat (Geo)	Sat (Rad)	Sat (Geo)	Sat (Rad)
Band 2	520 – 590	Mean + σ	4.248	3.819	3.840		
		Mean	4.217	3.724	3.748	-11.69	-11.12
		Mean - σ	4.187	3.629	3.655		
Band 3	620 – 680	Mean + σ	2.397	2.114	2.141		
		Mean	2.375	2.064	2.090	-13.09	-12.00
		Mean - σ	2.352	2.013	2.038		
Band 4	770 - 860	Mean + σ	0.840	1.157	1.179		
		Mean	0.832	1.121	1.140	34.74	37.02
		Mean - σ	0.823	1.085	1.101		
Band 5	1550 - 1700	Mean + σ	0.037	0.062	0.062		
		Mean	0.035	0.058	0.059	65.71	68.57
		Mean - σ	0.033	0.053	0.056		

Table 3a & 3b: Crop data of RS 2A LISS 3 Calibration

Lattitude	deg	23.132
Longitude	deg	77.424
Solar Zenith angle	deg	49.088
Solar Azimuth angle	deg	155.750
WV	gm/cm^2	0.741
O_3	cm-atm	0.340
AOD		0.4596

Bands	Wavelength Range(nm)		Radiance (Top of Atmosphere) (mW/cm2/sr/µm)			Estimation Error (%)	
			In-situ	Sat (Geo)	Sat (Rad)	Sat (Geo)	Sat (Rad)
Band 2	520 – 590	Mean + σ	4.070	3.741	3.775		
		Mean	3.904	3.689	3.711	-5.51	-4.94
		Mean - σ	3.739	3.637	3.647		
Band 3	620 – 680	Mean + σ	2.452	2.227	2.273		
		Mean	2.270	2.134	2.162	-5.99	-4.76
		Mean - σ	2.088	2.041	2.050		
Band 4	770 - 860	Mean + σ	7.440	5.456	5.548		
		Mean	6.009	5.141	5.163	-14.44	-14.08
		Mean - σ	4.598	4.826	4.777		
Band 5	1550 - 1700	Mean + σ	0.684	0.400	0.409		
		Mean	0.605	0.389	0.393	-35.7	-35.04
		Mean - σ	0.527	0.378	0.378		

Since, Rad-Cal satellite image of Bhopal is shifted by about 36 pixels before spatial correction, we are sceptical about the validity of the Rad-Cal satellite data. However, for the sake of completion, both geo-tiff as well as Rad-Cal data are used for calibration purpose.In general, it is observed that low reflectance bands show larger variations between in-situ measurements and satellite data and periodic vicarious calibration is required to monitor the sensor performance.

Conclusions

Post-launch calibration of RS2A LISS 3 bands over arid/crop/water terrains is carried out and the satellite derived radiances are compared with TOA (Top of the atmosphere) radiances derived using field measurements and RT simulations using 6S code.

The results based on the study show that band 2 & 3 show under-estimation of 2 to 12 percentage w.r.to all terrains of in-situ measurements. Band 4 shows under-estimation of 10 to

14 percentage for soil and crop sites whereas it shows close to 35 percentage over estimation for water site. Band 5 shows wider variations in estimation across different terrains. It shows about 27 and 66 percentage over-estimation for soil and water respectively, whereas about 35 percentage under-estimate for crops.

References

System Level Relative Spectral Response Measurements of LISS-III Payload of Resourcesat-2A: SAC/EOSG/SSD/17/06/2016/16*