MODIS on-orbit spatial characterization results using ground measurements

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Introduction

MODIS has thirty-six bands that are located in four Focal Plane Assembles (FPAs): Visible (bands 3-4, 8-12), Near Infrared (bands 1-2, 13-19), Short-and Middle-Wavelength Infrared (bands 5-7, 20-26), and Long-Wavelength Infrared (bands 27-36), shown in figure 1. Band to band Registration (BBR) is an important parameter for sensor spatial characterization. In this study, a ground scene with unique features has been selected as our study area to calculate the spatial registration in both along-scan and along-track for bands 1 - 7. The results from the earth scene targets have been compared with that from on-board calibrator, the Spectro-Radiometric Calibration Assembly (SRCA), with good agreement. For Aqua MODIS instrument, the spatial deviation is very small between the bands located on the warm FPA (VIS and NIR) or cold FPA (SMIR and LWIR) but is relatively large between the bands located on the warm and cold FPAs. The spatial deviation for MODIS/Terra is very small and can be ignored. The results from this study show that the spatial deviation of Aqua MODIS may impact the science data sets when multi-band data from both warm and cold FPAs are combined.

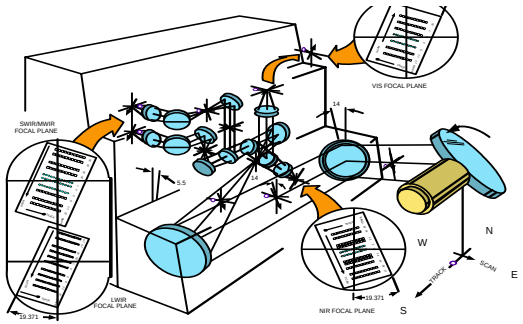

Figure 1. MODIS optical system

Spatial characterization using ground measurements

1. Examples of spatial deviation

Figure 2 is an example showing that the spatial deviation exists between different FPAs in both along-track and along-scan direction on 11:50am. Date: Jan 4th 2003. In figure 2(a), band 1 and 4 scan the dark target at pixel number 11 in along-track direction but band 5 and 7 observe the same target about one pixel earlier. Similarly, in figure 2(b), band 1 and 4 scan the dark pixel at pixel number 10 but band 5 and 7 observe the dark target about one pixel later in along-scan direction.

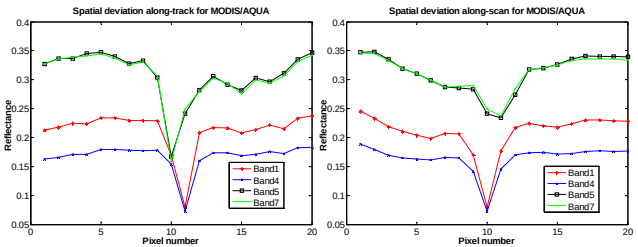

Figure 2 Spatial deviation between VIS and SMIR FPAs for Aqua MODIS
(a) left image: along-track (b) right image: along-scan

2. The site used for spatial characterization

Following a series of searching and analyzing, an area located at the Sahara desert in Libya, Africa is selected for spatial characterization, in which more than one hundred dark targets are arranged regularly.

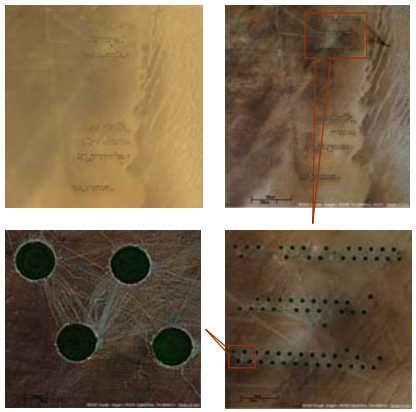

Figure 3. The image in the top left is MODIS RGB image for the select area (Latitude: 26.5N-28.0N, Longitude: 21.5E-22.5E) generated by the software ENVI in 500 meter spatial resolution. Others are Google's images with difference enlargements for the same site (Courtesy of Google).

3. Algortihm for spatial characterization

When sensor scans the surface in along-track or along-scan direction, several signal valleys were observed, shown in fiugre 4.

1. The valleys with high signal contrast are selected to calculate the centroid location of this valleys.
2. The centroid location of a certain band is the average of all the centroid location values qualifed in sixteen days.

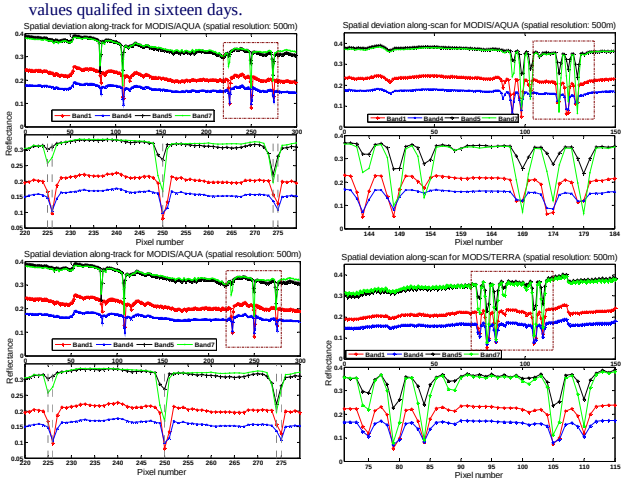

Figure 4. MODIS/Aqua. Bottom: MODIS/Aqua
Left: along-track. Right: along-scan

4. Results

The 16-day (Jan 1st-16th 2003) averaged spatial deviation for both MODIS/Terra (table 1) and MODIS/Aqua (table 2) is calculated with qualified L1B measurements. In these two tables, the results shown in black color are for along-track direction and those in blue color are for along-scan direction.

Band	1	2	3	4	5	6	7
1		0	1	-13	-261	-217	-219
2	-2		1	-13	-261	-217	-219
3	-46	-44		-14	-262	-218	-220
4	-55	-53	-9		-248	-204	-206
5	244	246	290	299		44	42
6	167	169	213	222	-77		-2
7	219	221	265	274	-25	52	

Table 1. The spatial deviation for band 1-7 of MODIS/Aqua

Band	1	2	3	4	5	6	7
1		0	-27	-15	2	14	13
2	-6		-27	-15	2	14	13
3	-11	-5		12	29	41	40
4	-6	-0	5		17	29	28
5	-45	-39	-34	-39		12	11
6	-41	-35	-30	-35	4		-1
7	-44	-38	-33	-38	1	-3	

Table 2. The spatial deviation for band 1-7 of MODIS/Terra

Table 3 is the comparison between the spatial deviation from the ground measurements (GM) and that from the SRCA for MODIS Terra and Aqua in along-track and along-scan directions. For Aqua MODIS, the average differences between the SRCA and GM are: 2m (scan) and 19m (track) for VIS/NIR FPAs; 19m (scan) and 176 m (track) for SWIR FPA. For Terra MODIS, the average differences between the SRCA and GM are: 2m (scan) and 14m (track) for VIS/NIR FPAs; 30m (scan) and 95m (track) for SWIR FPA.

MODIS	Direction/Measurement	Band2	Band3	Band4	Band 5	Band 6	Band 7
Aqua	Along-track/GM[1]	-2	-46	-55	244	167	219
	Along-track/SRCA	0	-9	-38	366	382	409
	Along-scan/GM	0	1	-13	-261	-217	-219
	Along-scan/SRCA	-40	30	4	-246	-285	-223
Terra	Along-track/GM	-6	-11	-6	-45	-41	-44
	Along-track/SRCA	0	4	16	52	18	86
	Along-scan/GM	0	-27	-15	2	14	13
	Along-scan/SRCA	20	-28	-40	40	46	33

Table 3. The comparison of the spatial deviation between GM and the SRCA

Potential application

Spatial deviation between warm FPA and cold FPA for Aqua MODIS will impact on the science data when multi-band measurements from these FPAs are combined. For example, (Normal Difference Snow Index) NDSI is defined as the normalized ratio of band 4 to band 7.

NDSI=(Band 4-Bang7)/(Band 4+Band7).

About one pixel mis-registration between these two bands will bring the uncertainty to the final snow index especially for the boundary area.

Summary

1. Using GM is one of effective approaches for validating the results of the SRCA.
2. The 16 days average spatial deviation for MODIS bands 1-7 are calculated. The results are compared with that measured by the SRCA with good agreement
3. The spatial deviation of MODIS/Terra is small with negligible impact on the science data. For Aqua MODIS, the spatial deviation between warm FPA (VIS and NIR) and cold FPA (SWIR) is relative large, which should be considered when multi-band data sets are combined.
4. The proposed approach provides an effective way to study spatial characterization for the remote-sensed satellite imagers without on-orbit calibrators.

Acknowledgement

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