Characterization of the Uyuni desert for validation of GOES-16 ABI

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INTRODUCTION

The primary goal of this study is to validate a suitability of Uyuni desert for vicarious calibration target and evaluation of GOES-16 Advanced Baseline Imager (ABI) solar reflective radiance using desert reflectance. Uyuni desert covered by a few meters of salt can be a good target for Earth observation satellite with its flatness, brightness, and high altitude. We selected two candidate targets over the Uyuni desert and conducted monitoring of the reflectance trending for the two targets from both the G16 ABI and NPP-VIIRS data. The results confirm that the Uyuni desert has a good characteristics as suitable for a vicarious calibration site, especially during June to September and the Target 2 is more stable and uniform than the Target 1 in terms of temporally and spatially. The reflectance of GOES-16 ABI Bands 1-2 shows 3 – 6 % brighter than the VIIRS data, especially Band 2 with 6 % reflectance bias due to uncertainty in the detector and solar diffuser. For the other bands, variations and magnitudes of the reflectance from both the ABI and the VIIRS are in a good agreement.

Data

G16-ABI: Compared for both the test position (89.5 °W) for year of 2017 and operational position (75.2 °W) for year of 2018 and 2019.
NPP-VIIRS: VIIRS SDR data for M3, I1, M7, M10, and M11 Bands between 16–18 UTC is used to identify radiometric and temporal stable areas with cloud-free images.

Table 1. A brief information about GOES-16 ABI sensor and NPP-VIIRS sensor regarding bands and central wavelength.

ABI L1b data		VIIRS SDS data	
Onboard geostationary satellite		Onboard polar orbit satellite	
Launched on Nov. 29, 2016		Launched on Oct. 28, 2011	
Band/Wavelength	Resolution	Band/Wavelength	Resolution
B1 (0.47 μm)	1 km	M3 (0.488 μm)	750 m
B2 (0.64 μm)	0.5 km	I1 (0.64 μm)	375 m
B3 (0.865 μm)	1 km	M7 (0.865 μm)	750 m
B5 (1.6 μm)	1 km	M10 (1.61 μm)	750 m
B6 (2.2 μm)	2 km	M11 (2.25 μm)	750 m

METHODS

- **To remove the contaminated pixels from the targets, we used normalized difference vegetation index (NDVI) values and a specific threshold of covariance (Yu and Wu, 2010).**
- **The calculated daily mean reflectance is only considered when the criterion is met for the NDVI less than 0.05 and covariance less than 7%.**
- **The NDVI is defined as the ratio of the difference between reflection of electromagnetic energy in the visible (0.4–0.8μm) and near IR (0.75–1.4μm).**

The NDVI value and covariance value are expressed as follows:

$$\text{NDVI} = \frac{NIR\ (at\ 0.86\ \mu m) - RED\ (at\ 0.64\ \mu m)}{NIR\ (at\ 0.86\ \mu m) + RED\ (at\ 0.64\ \mu m)}$$

$$\text{covariance} = \frac{standard\ deviation\ of\ reflectance\ at\ 0.64\ \mu m}{averaged\ reflectance\ at\ 0.64\ \mu m}$$

METHODS

Site selection from GOES-13 satellite;
1. Target area: 20.8ºS – 19.6ºS and 68.2ºW – 66.8ºW
2. Collect data between 17:00-18:59 UTC time
3. Apply the post-launch calibration for each image using calibration coefficients generated by Yu et al. (2014)
4. Calculate the standard deviation (STD) of reflectance for each desert pixel
5. Identify the areas with low contiguous STD of reflectance for pixels and NDVI less than 0.05

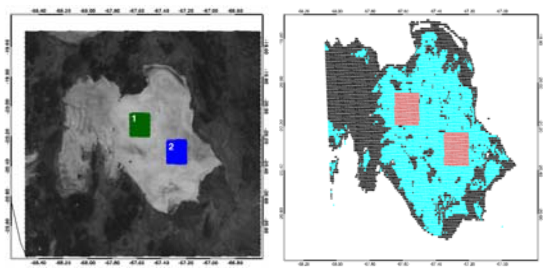

Fig. 1 Reflectance from GOES-13 (left) and red box with NDVI < 0.05 & COV < 0.07 (right). Target 1 (20.20º - 20.05º S, 67.65º- 67.50º W) and Target 2 (20.38º- 20.23º S, 67.35º- 67.20º W).

The selected targets are nearly 15 x 15 km in size and 225 pixels are collected in each target. The light grey color shows the Uyuni desert shape from the GOES-13 Imager visible data. The Uyuni desert observed by the satellite sensor is clearly distinct from the environment due to its brightness. The identified two targets are used as uniform areas to monitor desert reflectance for the G16 ABI VNIR channels in this study.

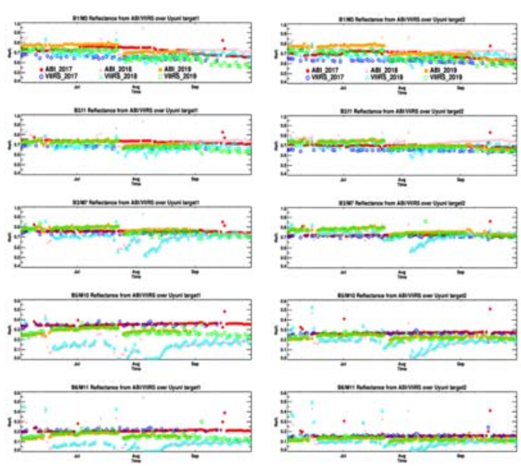

Fig. 2 Time series of daily mean reflectance variations from the G16 ABI and SNPP VIIRS five VNIR channels during only Jun. 1 – Sep. 30, 2017 - 2019 (left panel for the Target 1 and right panel for the Target 2).

Figure 2 displays daily mean reflectance from the two sensors during June – September 2017-2019. In general, the two datasets are comparable and show a good agreement in variations and magnitudes of reflectance. Note that there is a sudden change in reflectance values in early of August in 2018 from the both sensors and this is mainly from surface condition changes of the Targets not due to the instrument performance. The Target 2 has a better temporal uniformity than the Target 1 from Figure 2. Also, we can learn that the Targets have less uncertainty in the bidirectional reflectance distribution function and this may come from their flatness and high altitude.

RESULTS

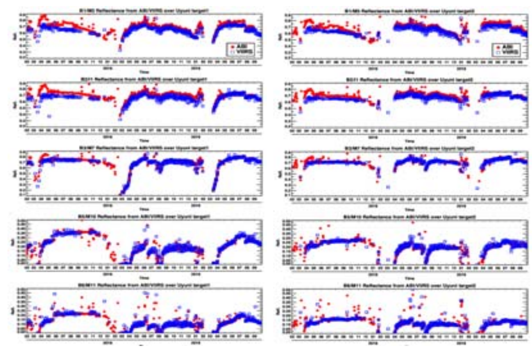

Fig. 3 Time series of reflectance variations over the Target 1 (left) and the Target 2 (right) from the ABI and VIIRS five VNIR bands during Feb. 1, 2017 – Sep. 30, 2019.

Table 2. Mean reflectance values (standard deviation values in parenthesis) obtained from the two sensors over the two targets during June – September, 2017 – 2019.

Band	ABI		VIIRS	
	Target 1	Target 2	Target 1	Target 2
B1/M3	0.7032 (0.07465)	0.6943 (0.08004)	0.6553 (0.05827)	0.6577 (0.05746)
B2/I1	0.7132 (0.05903)	0.7118 (0.04937)	0.6494 (0.1043)	0.6697 (0.07974)
B3/M7	0.6956 (0.12881)	0.7184 (0.05793)	0.6801 (0.1319)	0.7162 (0.05559)
B4/M10	0.2129 (0.11071)	0.2107 (0.06036)	0.2005 (0.1011)	0.2107 (0.05560)
B5/M11	0.1250 (0.07336)	0.1225 (0.05121)	0.1189 (0.07157)	0.1227 (0.04935)

The reflectance of G16 ABI Bands 1-3 shows 3–7 % brighter than the VIIRS data, for the other bands, both the ABI and the VIIRS are in a good agreement. The reflectance values decrease drastically in the winter time from December to March due to existences of clouds and precipitation events.

CONCLUSIONS

1. The selected two candidate targets with cloud-free scenes are nearly homogeneous in space and relatively invariant in time during the dry season. In summary, the Target 2 is more stable than the Target 1 in terms of spatial uniformity and temporal variability from both ABI and VIIRS.

2. The GOES-16 ABI results produce somewhat brighter reflectance at Bands 1-2 than the VIIRS bands, especially the ABI Band 2 is brighter than VIIRS I1 band about 7 %. On April 23, 2019, this issue has resolved by implementing the new K values look up table and now the ABI Band 2 radiance is reduced by about 6.2 %. For the other bands, variations and magnitudes of the reflectance from both the ABI and the VIIRS are in a good agreement and this demonstrates that the Uyuni desert is an idealized site for long-term desert monitoring and cross-calibration of satellite sensors.

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