The Absolute Radiometric Calibration of Earth-Observing Sensors Using Ground-Based Techniques

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Introduction

Ground-based vicarious techniques have been instrumental in ensuring that the data retrieved from airborne and spaceborne platforms are of the highest quality. The 40-year Landsat program is one example of a long-term data set that has benefited from vicarious calibration, and as more and more sensors are used to create Earth science data records, it becomes increasingly important to ensure that their radiometric calibration remains on the same SI-traceable scale.

The Remote Sensing Group of the College of Optical Sciences at the University of Arizona routinely collects vicarious calibration data at various test sites for the purpose of calibrating airborne and spaceborne sensors. The two main methods currently in use are the traditional reflectance-based approach, which uses ground personnel at a suitable test site, and more recently the Radiometric Calibration Test Site (RadCaTS), which is an automated facility at Railroad Valley, Nevada.

This work presents examples of the current radiometric calibration results obtained using the reflectance-based approach and RadCaTS for a variety of sensors including Landsat 8 OLI, Landsat 7 ETM+, Terra and Aqua MODIS, MISR, and the RapidEye constellation of satellites. The results are also used to analyze the uncertainty and scaling effects of RadCaTS when using sensors with spatial resolutions ranging from 5 m to 1 km.

Acknowledgements

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We would also like to thank:
- Bureau of Land Management (BLM), Tonopah, Nevada, Office, for their assistance in gaining access to Railroad Valley.
- BLM, Needles, California, office for their assistance and permission in using Ivanpah Playa.

Ground-Based Vicarious Radiometric Calibration

The Remote Sensing Group at the University of Arizona uses the reflectance-based approach, where measurements of the atmospheric and topographic properties are made during a sensor overpass. The input is used in the radiative transfer code MODTRAN to determine the top-of-atmosphere spectral radiance. The results are then compared to the sensor under test.

To validate the model against in situ data at RadCaTS, we used sensors ranging from 5 m to 1 km spatial resolution. Not all data were collected at the same time and some locations were dry lakes (playas) in arid regions. The image below left shows the WRS-2 path for each of the sites, which are on the same approximate scale in the image below right.

Test Sites

Test sites are typically dry lakes (playas) in arid regions. The Remote Sensing Group currently uses four main test sites in Arizona, Nevada, and California. The image below left shows the WRS-2 path for each of the sites.

Data

The data used in this work consists of imagery from Landsat 7 ETM+, Landsat 8 OLI, Terra and Aqua MODIS, MISR, and RapidEye. Typically, Level 1 data that have been radiometrically calibrated and geolocated are used. The period of study for the RadCaTS work is from 2012–2013, while the in situ data with on-site personnel spans a larger period.

Radiometric Calibration Test Site (RadCaTS)

RadCaTS was developed to supplement the in situ data that are collected by on-site personnel. The system resides at Railroad Valley, Nevada, and consists of three eight-channel, temperature-stabilized ground-viewing radiometers (GVRs), a Cimel sun photometer, and a meteorological station. It is based on the reflectance-based approach, and has been used to determine the radiometric calibration of sensors such as Landsat 7 ETM+, Landsat 8 OLI, Terra and Aqua MODIS, MISR, Hyperion, and RapidEye.

Conclusions and Future Work

- RadCaTS provides results similar to those obtained using on-site personnel.
- Salt on site will generally create a bias in the results because of decreased spatial uniformity.
- Ground site personnel results may vary.
- Continued comparison with Landsat 8 and on-site personnel results are required.
- Work in progress to define uncertainty of RadCaTS product.
- Work in progress to automate the quality control of RadCaTS.

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