# Automated Ground-Based Vicarious Calibration of MODIS

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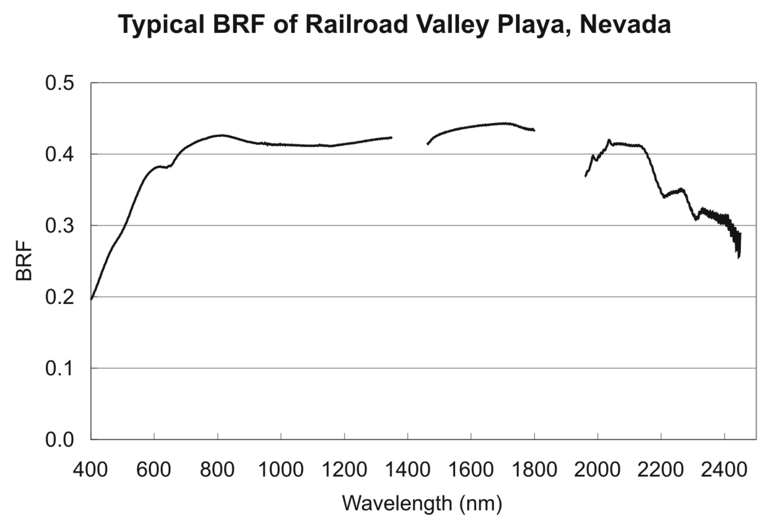
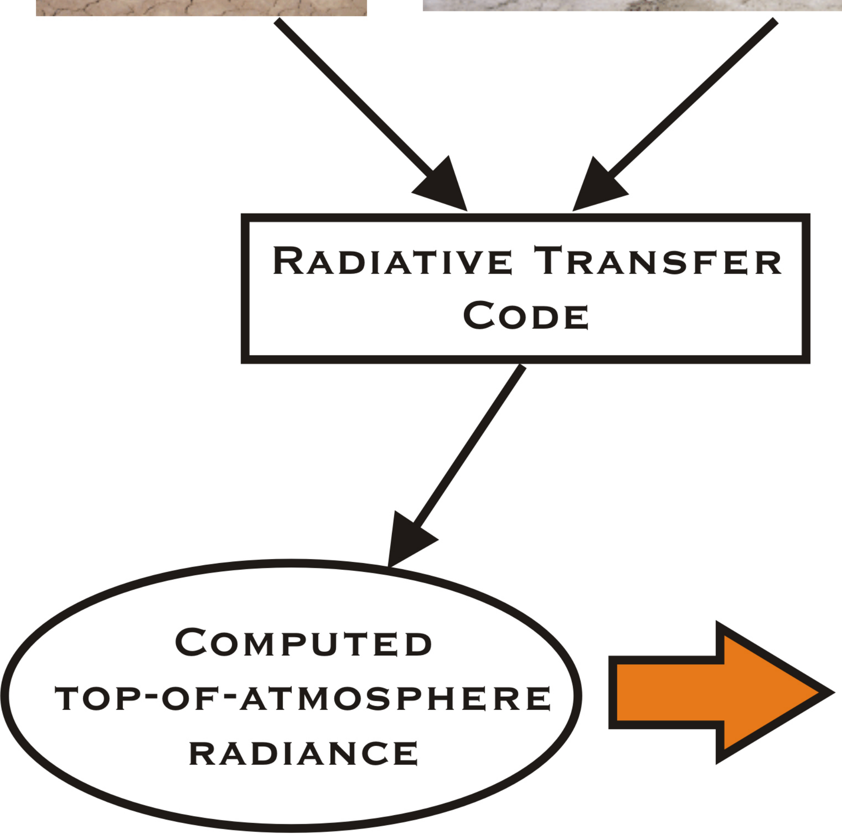
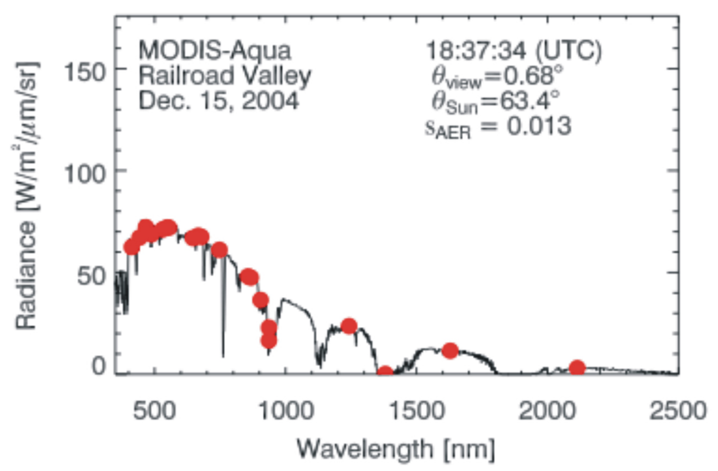
## Vicarious Calibration Using the Reflectance-Based Method

Atmospheric and surface reflectance measurements are obtained during satellite overpass, and are used in a radiative transfer code to calculate top-of-atmosphere radiance. These radiance values are compared directly to those reported by the satellite sensor.

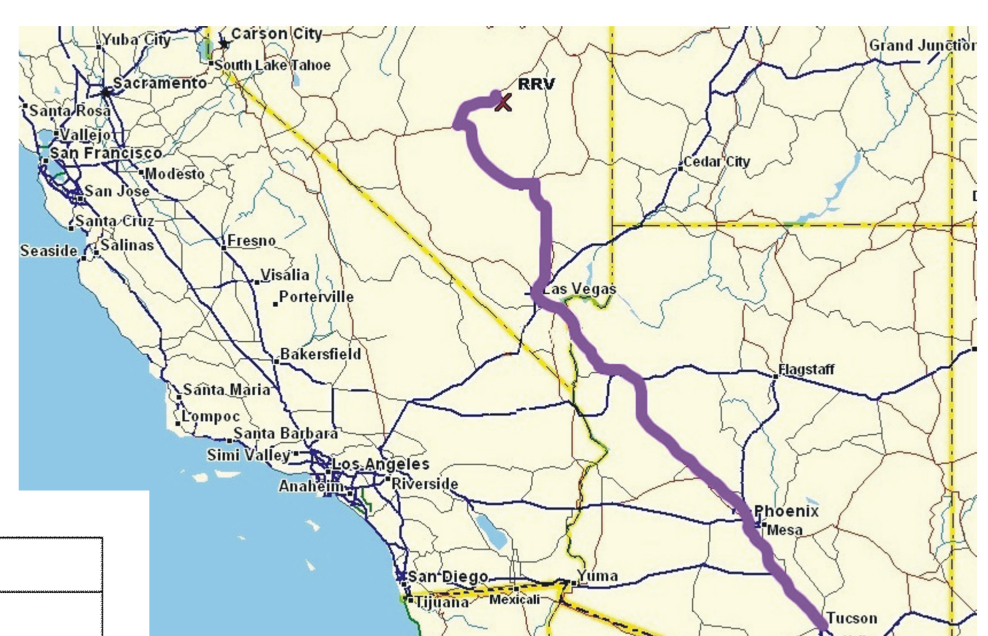


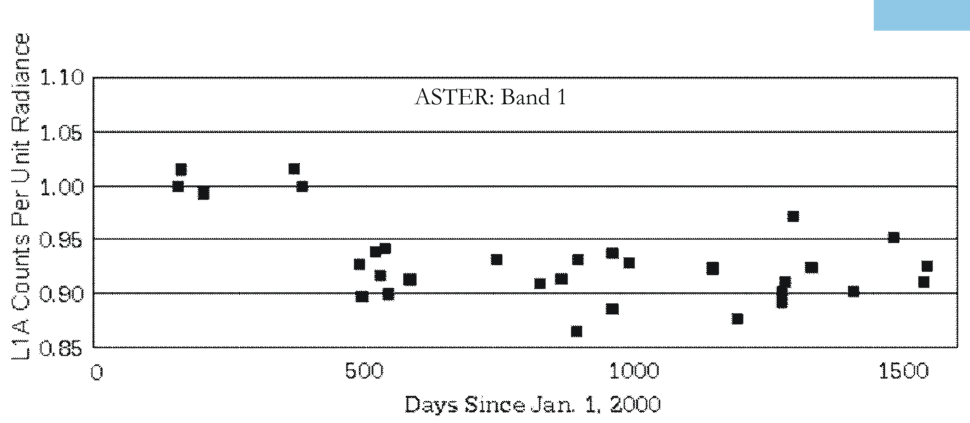




## Goal: An Automated Approach to Vicarious Calibration:

The Remote Sensing Group is working on a methodology that allows the ground-based vicarious calibration of airborne and satellite sensors to be conducted in the absence of on-site personnel. Presently, field campaigns occur approximately once per month, and poor weather conditions or equipment malfunction can impede data collection. In addition, sensors like MODIS and Landsat 7 ETM+ are always on, so it would be advantageous to collect data during every overpass. An increased amount of temporal data also aids in determining any trends occurring in sensor degradation.



Above: The 13-hour drive from RSG's laboratory to Railroad Valley Playa, Nevada



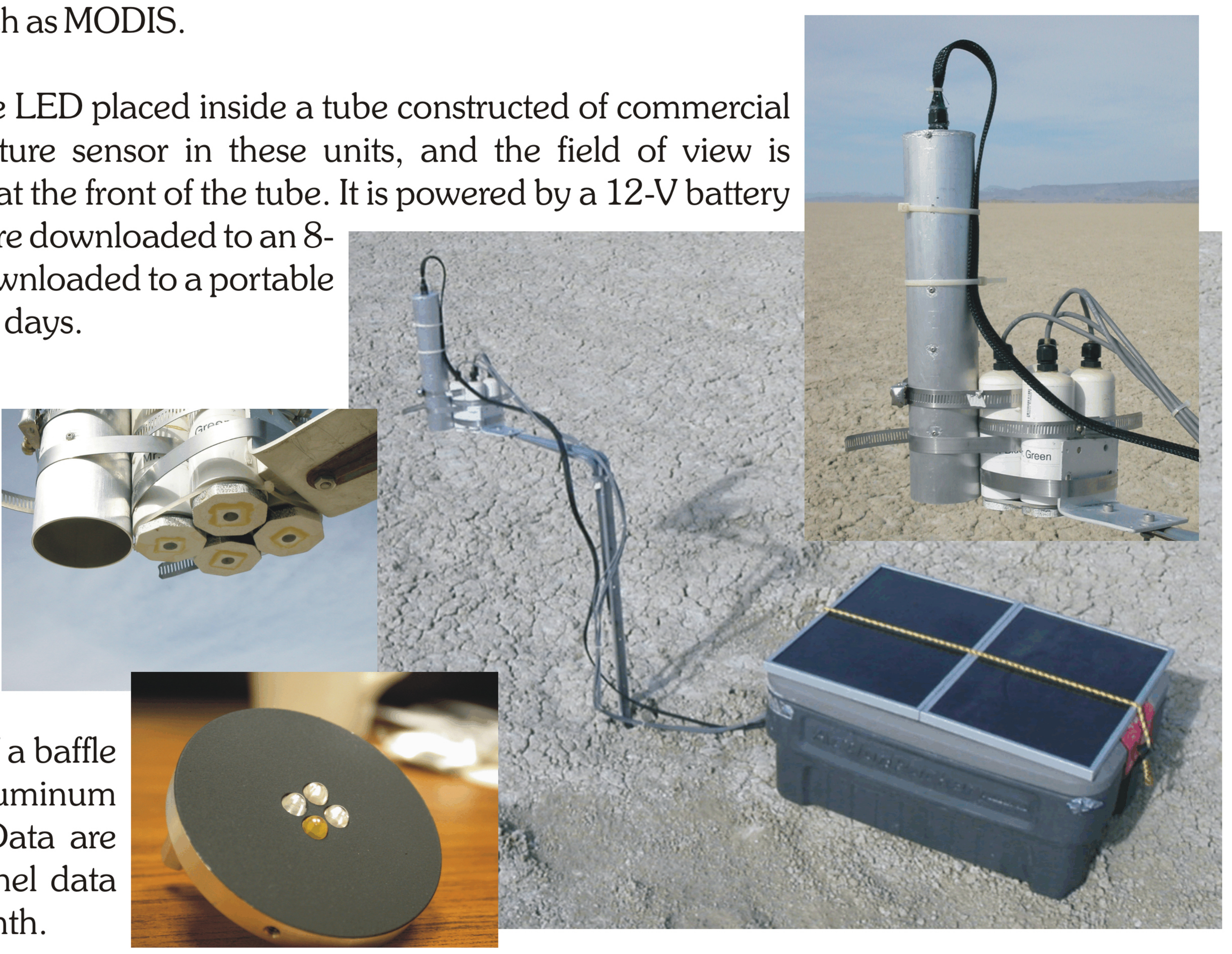

Left: Ambiguous change in calibration coefficient of ASTER. More temporal data would help improve the accuracy of trend analysis.

## LED-Based Radiometers

Radiometers using light emitting diodes as detectors are being used to measure surface reflectance of RSG's test site at Railroad Valley Playa, Nevada. LED-based radiometers are chosen over a typical silicon detector and interference filter combination because they are inexpensive, robust, and stable over time. Their low-cost means that RSG can develop and deploy more units in the field, which aids in the spatial sampling of sites for large-footprint sensors such as MODIS.

The first design consists of a single LED placed inside a tube constructed of commercial PVC pipe. There is no temperature sensor in these units, and the field of view is controlled simply by the aperture at the front of the tube. It is powered by a 12-V battery connected to a solar panel. Data are downloaded to an 8-bit, 4-channel data logger, and downloaded to a portable computer approximately every 30 days.

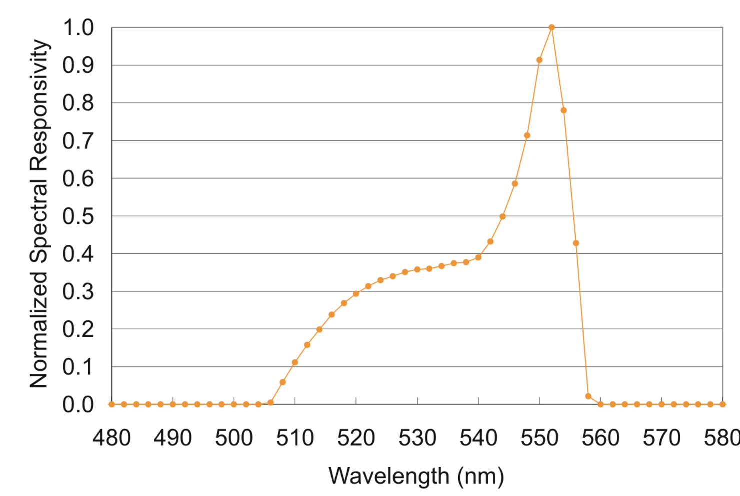
The most recent design is a three-channel unit that contains a temperature sensor mounted on the focal plane. The use of an objective lens and field lens creates a more uniform illumination on the focal plane. Additional improvements over the PVC design include the use of a baffle to control stray light, and an aluminum tube that serves as a housing. Data are downloaded to an 8-bit, 4-channel data logger, and retrieved once per month.



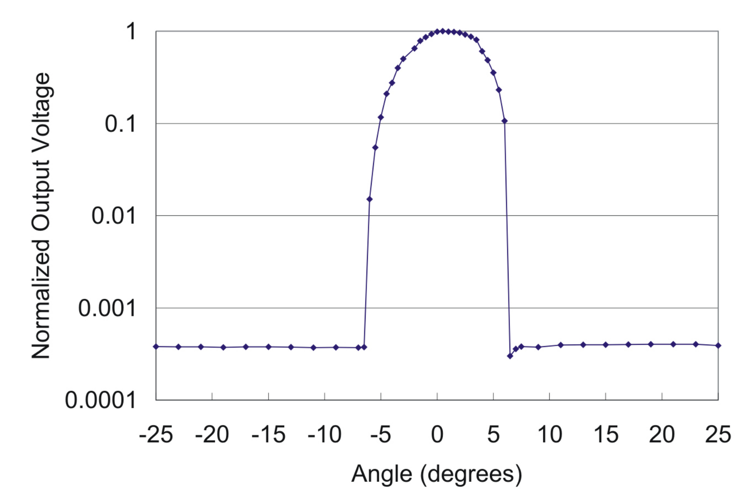
LED focal plane.

## Laboratory Characterization

Once the radiometers are assembled at RSG, they undergo various calibration and characterization tests that measure spectral responsivity, temperature stability, and field of view.



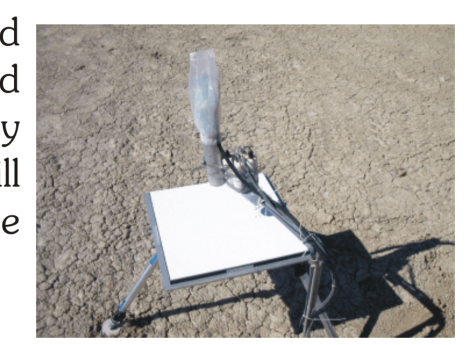

Spectral responsivity measurement for a green LED. The bands are generally larger than those on earth-observing sensors.




Field of view measurement for a near infrared LED. Similar measurements are taken with the green and red LEDs.

## Surface Reflectance Measurements in the Field

Presently, surface reflectance is measured using a simple ratio of the ground measurement to that of a well-calibrated Spectralon panel (right). The ground and reference measurements are taken as close as possible to sensor overpass to reduce any effects due to a non-Lambertian ground surface. Note that this measurement still requires personnel to be present, but is being used to test the field performance of the LED radiometers.

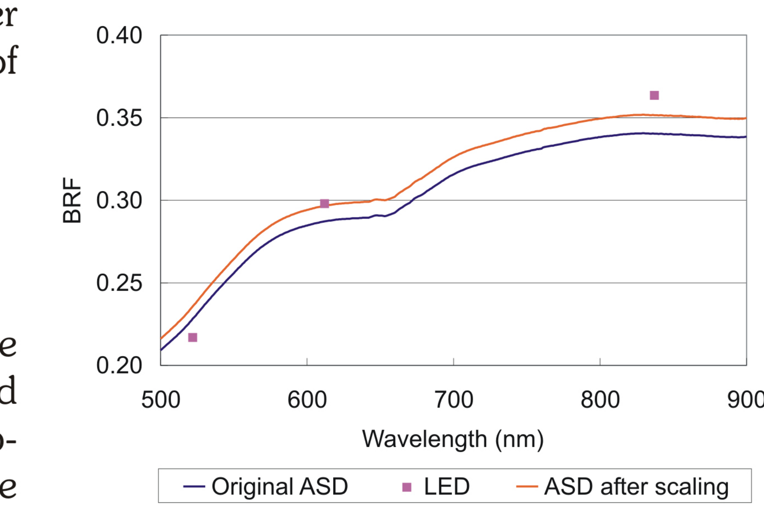


The next phase will eliminate the requirement for on-site personnel. The surface reflectance will be measured by LED radiometers, and atmospheric conditions will be measured by the AERONET Cimel radiometer present at Railroad Valley. These instruments will provide input for the radiative transfer code that will produce top-of-atmosphere radiance.

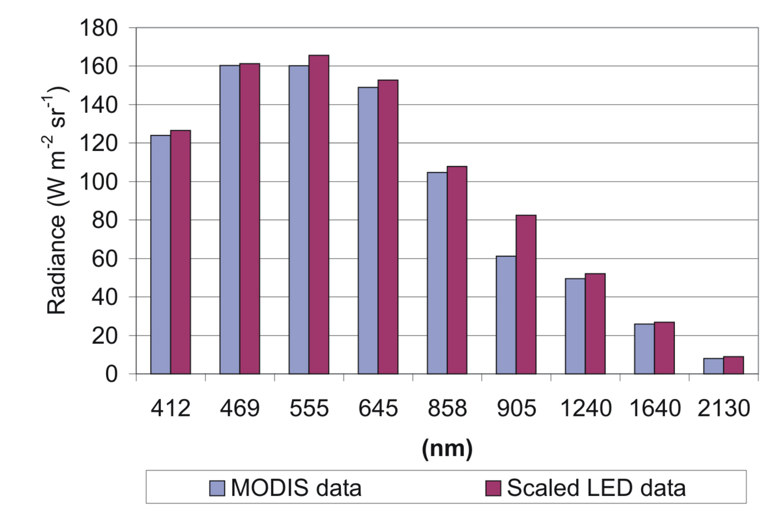
## Results with MODIS

The two test cases presented here are for Terra MODIS overpasses at Railroad Valley Playa, Nevada on 18 March 2004 and 13 December 2004. In each case, an aluminum three-channel LED radiometer is present on the MODIS test site during overpass. A reference Spectralon panel is placed under the radiometer close to the overpass time, and the BRF of the ground is calculated using a simple ratio of output voltages when viewing the panel and the ground.

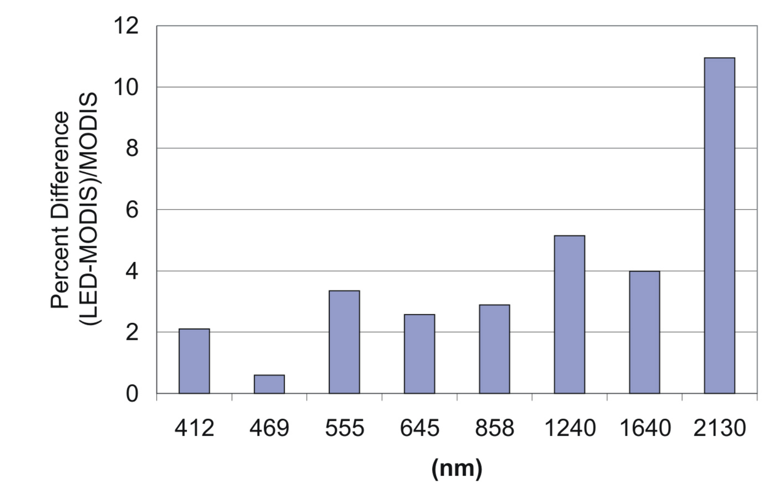
This three-wavelength calculated BRF is then converted to a hyperspectral BRF by scaling data collected by an ASD portable spectrometer (right). These hyperspectral data, ranging from 350-2500 nm, are used as input into a radiative transfer code to calculate a top-of-atmosphere radiance that is compared to those reported by MODIS.




18 March 2004

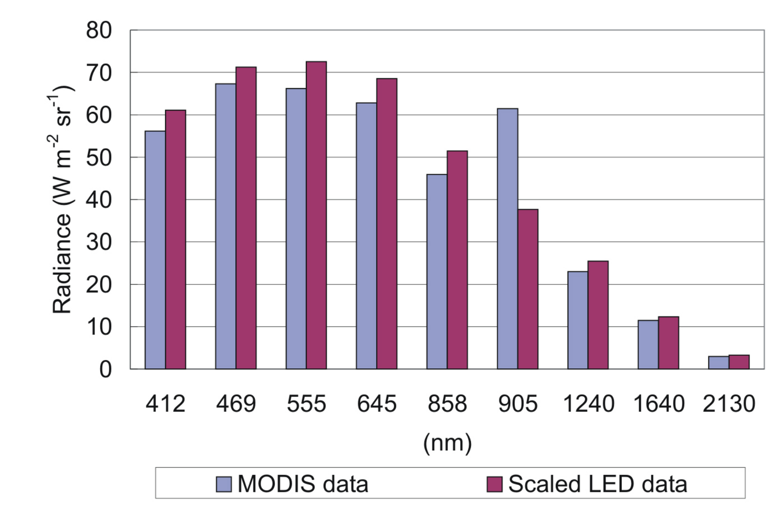



Top-of-atmosphere radiance reported by MODIS compared to that calculated using LED radiometer data.

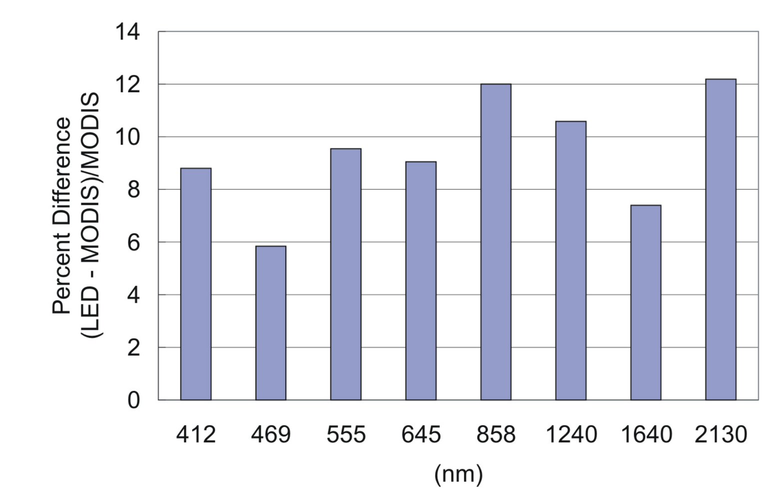



Percent difference in reported MODIS top-of-atmosphere radiance, and radiance calculated using LED radiometer data.

13 December 2004




Top-of-atmosphere radiance reported by MODIS compared to that calculated using LED radiometer data.




Percent difference in reported MODIS top-of-atmosphere radiance, and radiance calculated using LED radiometer data.

## Conclusions

~ The accuracy in calculated top-of-atmosphere radiance should increase after spatial sampling is extended with the deployment of more LED radiometers. Spatial uniformity can be an issue after weather events with the 1x1-km MODIS site at Railroad Valley.

~ LED radiometers are not meant to replace manned vicarious calibration field campaigns, rather, they provide more temporal data, which will increase trend analysis accuracy.

## Future Work

~ Additional LED radiometers are being built for deployment at Railroad Valley.

~ AERONET data will be integrated into methodology for unmanned vicarious calibration.