SAFARI 2000 Surface Spectral Reflectance at Sua Pan, Botswana, Dry Season 2000

Abstract

The Multi-angle Imaging SpectroRadiometer (MISR) Validation team was deployed to Sua Pan, a salt playa in the desert in the Magkadigkadi region of Botswana, from August 18 to September 4, 2000, during the SAFARI 2000 Dry Season Aircraft Campaign. The experiment was designed to collect the suite of data necessary for multi-angle top-of-atmosphere radiance predictions in order to provide a vicarious calibration of the MISR instrument aboard the Terra satellite. In addition, aircraft overflights collected in-situ aerosol and BRDF data on the 27th of August and on the 3rd of September. Reported here are the ground-based reflectance measurements collected using an Analytical Spectral Devices (ASD) spectroradiometer at Sua Pan and adjacent grassland targets. Additional ground measurements were collected to enable radiometric characterization of atmospheric aerosols.

Background Information

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Project: SAFARI 2000

Data Set Title: SAFARI 2000 Surface Spectral Reflectance at Sua Pan, Botswana, Dry Season 2000

Site: Sua Pan, Botswana
Westernmost Longitude: 26.04889° E
Easternmost Longitude: 26.08033° E
Northernmost Latitude: -20.523° S
Southernmost Latitude: -20.57717° S

Site: Sua Pan Grassland, Botswana
Westernmost Longitude: 26.0298° E
Easternmost Longitude: 26.0394° E
Northernmost Latitude: -20.5168° S
Southernmost Latitude: -20.5259° S

Data Set Citation:

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Web Site: http://www-misr.jpl.nasa.gov/mission/valwork/val_reports/000813_safari/safari.html

Data File Information

The data files contain numeric values that represent mean reflectance over space (grassland) or wavelength range (pan) . The data files are stored as ASCII table files, one file per site, in comma-separated-value (.csv) format, with column headers. The Sua Pan data, collected over a 1 km x 2 km area, are presented as rows of mean reflectance (every 10 nm) for 20 points, where the mean represents the average local reflectance spectra collected within 150 m of the given latitude and longitude. The Sua Pan grassland data, on the other hand, cover a 1 km^2 area and are provided every nm from 1 to 2500. Each row of data contains a mean and standard deviation at a given wavelength, where the mean represents the average of 570 measurements taken over the 1 km^2 area. The files are:

Sua_Pan_ASD_spectra.csv
Sua_Grass_ASD_refl.csv

Sua Pan Data file description

Column Name	Definition	Units
Latitude	Latitude of sample location	decimal degrees
Longitude	Longitude of sample location	decimal degrees
Number of Spectra	Number of Spectra	numeric
Mean Standard Deviation	Average (over wavelength range) standard deviation of each spectrum	fraction
350 nm	Percent reflectance, Mean of N spectra at 350 nm	percent
360 nm	Percent reflectance, Mean of N spectra at 360 nm	percent
....	and so on, every 10 nm...	....

2490 nm	Percent reflectance, Mean of N spectra at 2490 nm	percent
2500 nm	Percent reflectance, Mean of N spectra at 2500 nm	percent

Sua Pan Grassland Data file description

Column Name	Definition	Units
Wavelength	Wavelength of measurement (every nm from 1 to 2500)	nm
Reflectance	Mean reflectance at given wavelength	dimensionless
Standrard Deviation	Standard deviation of reflectance at given wavelength (n=570)	dimensionless

Site Description

Sua Pan was chosen as an in-region vicarious calibration target because of the appearance of large areas of uniform bright reflectance from space. Also, its proximity to areas of interest for atmospheric transport meant that radiometric measurements made could be used to estimate atmospheric aerosols and thus help to validate circulation models. With additional data from overflights of sampling aircraft, optical techniques for measuring atmospheric aerosols could be compared to the results obtained via in-situ collection methods.

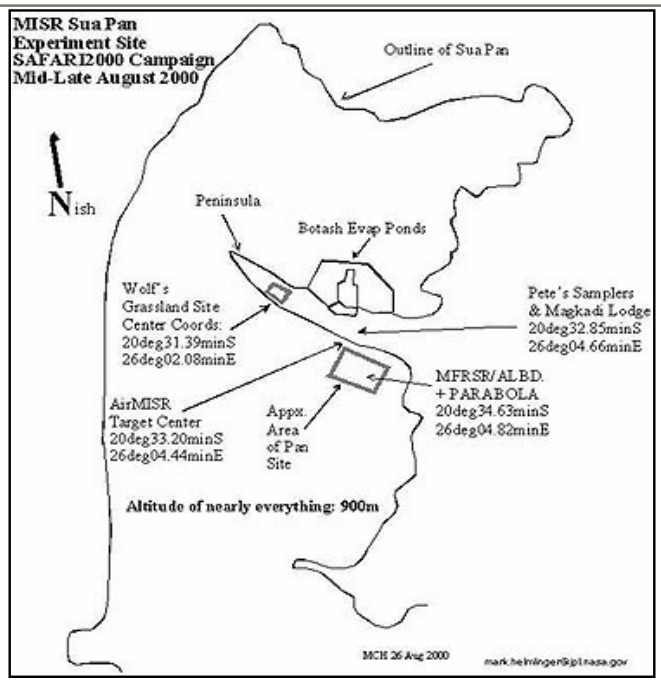
The pan surface itself, while homogenous at the 100 m scale, is somewhat heterogeneous at the 1 m scale. It is essentially a semi-hard clay mud with varying degrees of water saturation in its upper layers and a thin salt crust (mostly halides) on top. The entire pan surface floods seasonally. A multi-angle surface bi-directional reflectance function (BRF) analysis of MISR satellite data was performed to determine where the driest zones on the pan might be to set up the experiment. Fortunately, a large relatively dry area was found near the researchers' encampment on the peninsula.

Sua Pan is nearly bisected by a long peninsula (see imagery below under Site Overview), some 2-3 meters above the pan surface, which supports vegetation. The peninsula is actually an ancient riverbed, and its sediments have enough permeability to resist saltation and allow plant growth. The dominant vegetation here are grasses, mainly *Odyssea paucinervis* and *Sporobolus spicatus.* The grasslands provided large homogeneous areas for comparison of scale between ground measurements and remote sensing results.

Sua Pan Site Overview

This image of Sua Pan was taken by the MISR sensor aboard Terra satellite on the 18th of August, 2000.

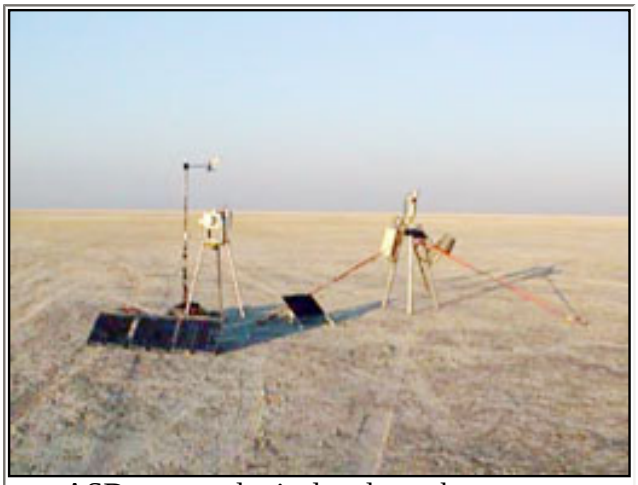
Sua Pan Site Map



Overview of the Sua Pan and Grassland experiment site.

Sua Grassland.


Sua Grassland closeup.


ASD meteorological and sunphotometer instrumentation at the Sua Pan.


Cleaning the ASD calibration standard at the Sua Pan.

Data Collection

Sampling

The conditions at the time of measurement were dry, as it was the end of the dry season, and the grasses at the grassland site were completely senescent. Data were collected on the Sua Pan on August 24, 25, and 27, 2000 and also on September 3, 2000. At the Sua Pan grassland site, data were collected on August 30, 2000. Reflectance measurements were made on cloud-free days of Terra satellite overpasses. The data were taken near the overpass times, thus solar geometry existed for each set of measurements. It was assumed that the reflectance of the pan surface and senescent grasses would be invariant over the few weeks of the experiment.

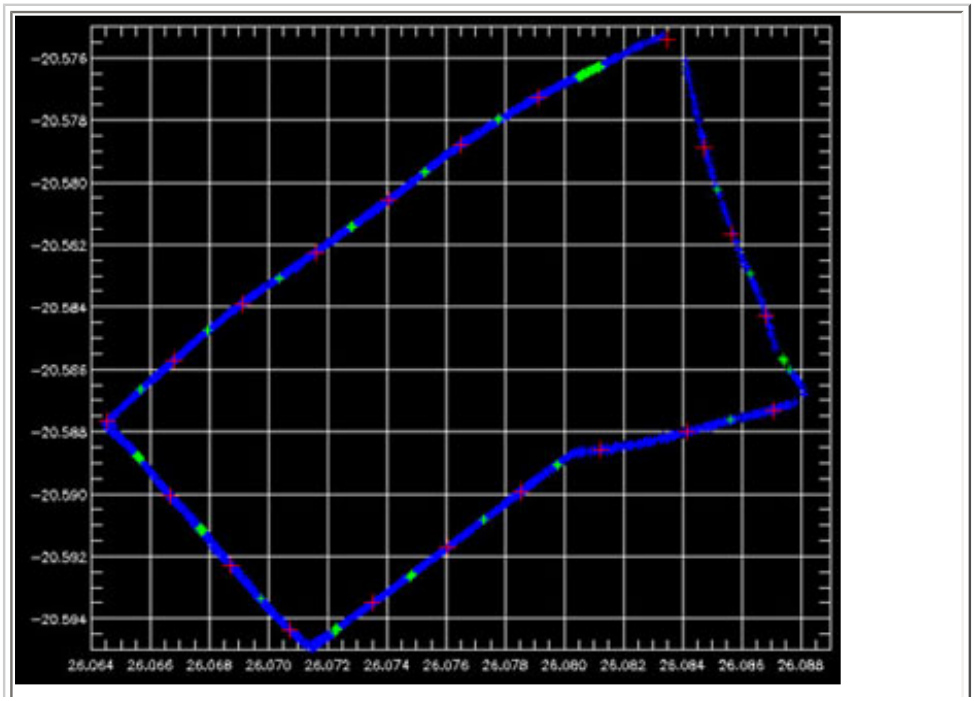
Measurements were made with an Analytical Spectral Devices, Inc. (ASD) FieldSpec Pro FR spectroradiometer. This spectroradiometer has a relatively small field of view. For all

measurements, the 8° field-of-view fore-optic was used, as it allows a larger instantaneous field-of-view for each raw spectrum while excluding light from angles too far off nadir.

The sampling technique used was to take readings of the target at various locations along a representative transect interspersed with readings of a known reflectance standard. Clear days with consistent illumination conditions were chosen and target/standard measurements were made close together in time to ensure as near identical as possible light levels on the target and reflectance standard.

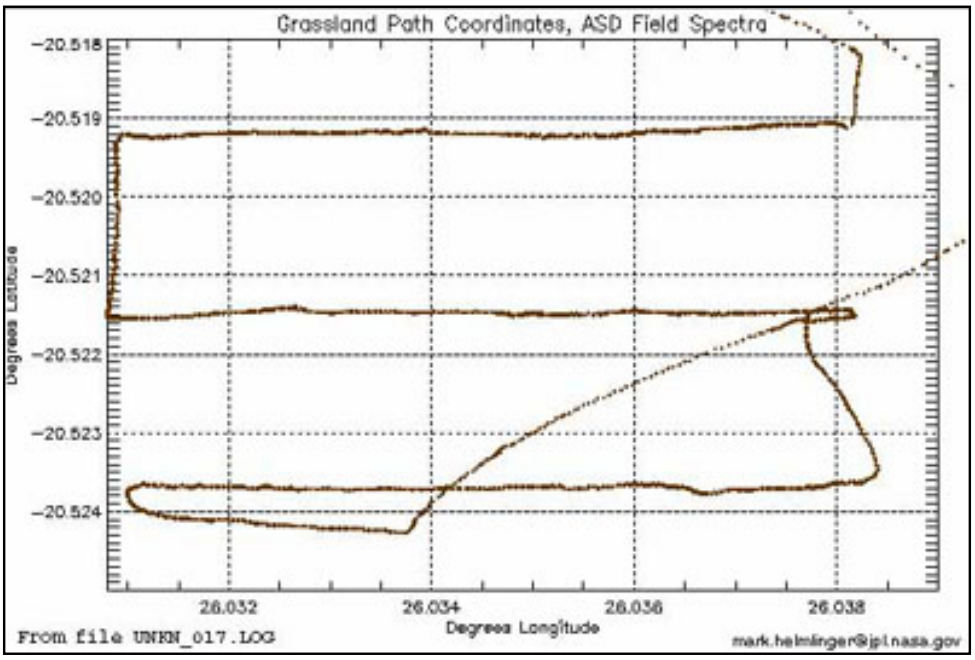
The perennial problem with using field measurements to calibrate space-borne instruments is one of scale. With large satellite pixels (in the case of MISR, some 250 meters), this problem is exacerbated. Large homogeneous targets are selected, but often times this homogeneity is not nearly as apparent to the ground truth equipment. In practice, the sample size and coverage of the field measurements is increased and data are averaged in order to approach the integration that occurs over a satellite pixel.

In the case of Sua Pan, a series of adjacent transects that covered an area of about a two square km were laid out in order to cover several MISR pixels. The instrumentation was mounted in the rear of a small truck, which traversed these transects over the course of the experiment (see picture under Site Description). Hundreds of spectra were collected over several days -- always at and around the time of Terra overpass. Those spectra were then averaged and processed as reported here, with the assumption that the reflectance of the pan surface would not change significantly from day-to-day. The data have been compressed by reporting a single spectrum at 10 nm intervals for 20 locations along those transects. Each reported spectrum is an average of all spectra taken within 150 m of the given Lat/Lon.



Plot of the actual sampling path followed at the Sua Pan site. The axes are in degrees latitude and longitude. The red +'s are the reported coordinates of each of the local averages, the blue +'s are the spectra included in each local average, and the green +'s were not included and separate the local averages. Thus, the red + is center of the average of all reflectances collected at the blue + symbols.

The transect paths chosen for the grassland target roughly follow the paths established for LAI/FPAR sampling (Buermann and Helmlinger, 2004). The Buermann transects were a set of 3, each 750 m long, spaced 250 m apart. Since the grassland target was relatively homogeneous within the square kilometer sampling area, all grassland spectra were averaged. Because all of these data were averaged, they are reported here at 1 nm intervals. The sampling path used at the grassland site is pictured below:



Spectral Resolution

The FieldSpec Pro FR spectroradiometer reports data at 1 nm intervals, which is the spectral sampling interval; however, like all spectroradiometers, each sampling step has a larger bandwidth, increasing from about 1.5 nm at 350 nm to about 15 nm at 2500 nm. Thus, resampling at 10 nm intervals is an efficient compression of the data without a real loss of spectral resolution. More details about this characteristic of field spectroscopy can be found in the published literature and in the manuals that accompany each instrument.

Data Processing

In analysis, raw data outliers were thrown out by manual examination. Each raw calibration standard reading is fit to a second-order polynomial function by time over the beginning and end of each transect. An interpolated standard spectrum is then generated for the exact time of the target raw spectrum and the standard values are divided by the target values for each wavelength. This cancels out all values that each raw spectrum share and produces the dimensionless quantity of reflectance. This is then corrected for the standard true reflectance by multiplying by about a 2% factor that is wavelength dependent, provided by the manufacturer of the calibration standard material. The Sua Pan numbers are reported in units of percent, which is reflectance divided by 100.

Standard Deviation by wavelength is related to the target heterogeneity at the sampling scale (~1 m). The reported Standard Deviation for Sua Pan grassland data is a true standard deviation (SD) of 570 samples taken within the 1 km x 1 km target area, and can be used computationally. The reported Mean Standard Deviation for Sua Pan data is an average of 20 SD determinations and should not be interpreted in a strictly quantitative sense. When the SD for each local average is plotted on top of the others, it is clear that the average of all 20 is a good description of the typical SD for each of the 20 local averages. For the sake of data compression, only the typical case is reported. Those desiring a more rigorous treatment can contact the author.

Calibration

The FieldSpec Pro FR is sent annually to the manufacturer in Boulder, CO for calibration. The field method used here has been found to be insensitive to most calibration drifts.

Quality Assessment

Data quality is assessed by examining the standard deviation (provided) of all spectra included in the average.

Field Instrument

The Analytical Spectral Devices, Inc. (ASD, Boulder, CO) FieldSpec Pro FR spectroradiometer.

Web site: http://www.asdi.com/index.cfm

ASD Specifications

Spectral Range	350-1050 nm
Spectral Resolution	3 nm @ 700 nm, 10 nm @ 1400 & 2100 nm
Sampling Interval	1.4 nm @ 350-1050 nm, 2 nm @ 1000-2500 nm
Scanning Time	100 milliseconds
Detectors	One 512 element Si photodiode array 350-1000 nm. Two separate, TE cooled, graded index InGaAs photodiodes 1000-2500 nm.
Noise Equivalent Radiance (NeDL)	UV/VNIR 1.4 x 10^{-9} W/cm^2/nm/sr @ 700 nm
	NIR 2.4 x 10^{-9} W/cm^2/nm/sr @ 1400 nm
	NIR 8.8 x 10^{-9} W/cm^2/nm/sr @ 2100 nm

Acknowledgments

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Additional Sources of Information

More information can be found at: http://www-misr.jpl.nasa.gov/mission/vinstrum.html

Detailed photographs that complement the experimental descriptions for this data set are available on the S2K Photo Gallery pages.

Related Data Sets

Buermann, W. and M. Helmlinger. 2004. SAFARI 2000 LAI and FPAR Measurements at Sua Pan, Botswana, Dry Season 2000. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Helmlinger, M., W. Buermann, and F. Eckardt. 2004. SAFARI 2000 BRDF Measurements at Sua Pan and Skukuza, Dry Season 2000. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Extensive digital photographs and digital video documentation exist for both sites and MISR Ground Truth activities. A one-hour video documentary of SAFARI 2000 has been produced for public outreach. DVD and tape formats are available upon request. Inquiries should be directed to: mark.helmlinger@jpl.nasa.gov.

References

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Bruegge, C. J., M. C. Helmlinger, J. E. Conel, B. J. Gaitley, and W. A. Abdou. 2000. PARABOLA III: a sphere-scanning radiometer for field determination of surface anisotropic reflectance functions. Remote Sensing Reviews, Vol 19: 75-94.

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