Documentation of Kalahari Transect Measurements
In Botswana, March 2000

Summary

The Boston University team collected several data sets to validate the MODIS LAI/FPAR algorithm. Ground measurements of LAI, FPAR, leaf hemispherical reflectance, leaf hemispherical transmittance and canopy transmittance were made using the LAI-2000 plant canopy analyzer, AccuPAR ceptometer, LI-1800 portable spectroradiometer and ASD handheld spectroradiometer during period from Mar. 3 to Mar. 18, 2000, in Botswana. LAI/FPAR were intensively measured at 4 different sites, Pandamatenga, Maun, Okwa and Tshane (from north to south in Botswana), where vegetation type ranges from moist closed woodland to arid sparsely-shrub covered grassland. The final processed LAI/FPAR is contained in ASCII files.

Objective

1. Obtain LAI/FPAR in the Kalahari transect and validate the MODIS LAI/FPAR algorithm.
2. Describe the spatial variability of LAI/FPAR for the four sites.
3. Investigate the scale effect on LAI/FPAR measurement and retrieval.

Investigators

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Title of Investigation

Collection of LAI and FPAR Data Over the TERRA Core Sites
Documentation of LAI Measurements

Parameter Definition

Leaf Area Index (LAI) is defined as one-side green leaf area per unit ground area.

Instrument Description

The LAI-2000 plant canopy analyzer is composed of a LAI-2070 control unit and a LAI-2050 sensor head. The control unit has connectors for two sensor heads, two connectors for other LI-COR sensors, and a connector for RS-232 communication. The sensor head projects the image of its nearly hemispheric view onto five detectors arranged in concentric rings (approximately 0-13, 16-28, 32-43, 47-58, 61-74 degrees). Radiation above 490 nm is rejected.

Sample Methods

At each of the four sites, LAI was measured at a 1km*1km transect scale and a 250m*300m pixel scale (Fig. 1). At the site of the transect scale, we have three straight transect lines parallel to one another from south to north. The first line is “B line”. The second line is “A line”, which is 250 m north of B line. The last line is “N line”, which is 250 m north of A line. The length of each line is 750 m. We took LAI measurements in 25 m intervals from west to east, giving us 31 sample points on each 750 m line. We number each sample point as A375W, A350W, A00, A350E, A375E … and so on. “A” represents A line. “A00” represents the middle sample point on A line. “A375W” represents the sample point that is 375 m west of A00. “A375E” is the sample point that is 375 m east of A00. Thus, there are a total of 93 sample points on the 1km*1km transect site. Almost all the measurements were taken from sample point of west “375” to east “375” along each of these three lines.

The pixel scale measurements were taken at the 50 m * 50 m resolution in a 250m*300m rectangular area which is located in the southwest corner of the 1km*1km site. There are 6 east-west orientated lines (300m in length) and 7 south-north orientated columns (250m in length). In total, we have 6*7=42 sample points in this area. Each line is named A, B, C, D, E and F from south to north. Line F is coincident with (or part of) line B of the transect scale site. Line A here is part of line A of the transect scale site. There are 7 sample points, numbered 1 to 7 from west to east, on each line (A, B, C, D, E or F). Therefore, we named the sample points in this rectangular area as F1, F2, F7 … and so on. The measurements were taken as the follows: from F1 to F7, E7 to E2, D2 to D7, C7 to C2, B2 to B7, A7 to A1, and then to E1.

Calibration

Three LAI-2000 units were used, two on the sample stands, the other on the ground in an open space used as a reference for the above-the-canopy radiation. The two sample units
were calibrated against the reference unit under overcast condition or shortly before sunset, prior to each of these four sites’ field measurement. The calibration procedures are given in the LAI-2000 Plant Canopy Analyzer Instruction Manual, Chapter 4-1 (LI-COR, 1991). The reference unit was set in remote logging mode at a sampling frequency of one sample per 60 seconds.

Data Acquisition Methods

The LAI-2000 measures the attenuation of diffuse sky radiation at five zenith angles simultaneously. LAI measurements were mostly made during dusk, shortly before and after sunset. Some measurements in Pandamatenga and Maun were taken during dawn. In Tshane, one set of measurements was taken in the afternoon under overcast condition.

All the measurements were taken by putting the sensors (three) facing opposite to the sunlight direction, in a horizontal position. A 90-degree mask was used in Pandamatenga and Maun to prevent interference caused by operator’s presence. A 270-degree mask was used in Okwa and Tshane because of the heterogeneous distribution of shrubs and trees on the grassland. The same mask was used for the reference sensor to reduce the influence of the sun.

The LAI-2000 was hand held in a horizontal position at the ground in Maun, Okwa and Tshane. In Pandamatenga, two horizontal levels were used. One was placed 2.0 m above the ground to get the LAI of trees and the other was at ground level for total LAI.

Data Set Introduction

We organized the LAI measurement data by sites (Pandamatenga, Maun, Okwa and Tshane). For each site, there are two sub-directories. One for the transect scale, and the other for 250m*300m rectangular area. There is a “readme” file in each sub-directory describing details about the measurement information such as time, sky condition, degree of mask and so on.
Documentation of FPAR Measurements

Sample methods

The same as LAI measurements.

Calibration

a) In Pandamatenga and Maun:
   Two AccuPAR units were used, one in the sample stands, the other on the ground in an open space used as a reference for the above-the-canopy radiation. These two units were calibrated against the other.

b) In Okwa and Tshane
   Just one AccuPAR was used.

Data Acquisition

Because the canopies were too high in Pandamatenga and Maun, we could not measure canopy reflectances on the ground. The AccuPAR measurements were mostly for canopy transmittances of 400-700 nm. In Maun, we measured canopy reflectance on the 40 m tower using AccuPAR. The averaged reflectance value can be used as an estimation of canopy reflectance.

Both canopy reflectances and transmittances were collected in Okwa and Tshane if the canopy at the sample point was not higher than 2.0 m.

AccuPAR measurements were mainly taken on the transect scale.

Documentation of Leaf hemispherical reflectance and transmittance (400nm – 1100nm, at 1nm resolution)

Leaf spectral hemispherical reflectance and transmittance were measured on site with LI-1800 (1800-12S External Integrating Sphere) right after the leaves were cut from trees or shrubs. The spectral range was from 400 nm to 1100 nm, at 1nm resolution. Leaves from 4-5 dominant vegetation types were measured. Because of the limited time, three or four sample leaves of each type were measured. When individual leaves were too small, we measured several leaves on one leaf stalk. Leaf spectral data from Mongu were measured one day after these leaves were collected (they were kept fresh in plastic bags).
Documentation of ASD Measurements of hemispherical Canopy Transmittances (400nm – 1100nm, at 1 nm resolution)

Sample methods

The same as LAI measurements.

Calibration

a) In Pandamatenga and Maun
   LI-1800-11 Remote Cosine Receptor was used as a reference for the above-the-canopy radiation. ASD Cosine Receptor was used in the sample stands. They were calibrated against each other.

b) In Okwa and Tshane
   Canopy was not so dense, we could find open space on site. We used ASD measuring both incident radiation and transmitted radiation by canopy.

Data Acquisition Methods

Hemispherical canopy spectral transmittances in the range from 400nm to 1100nm at 1nm resolution were measured during daytime, mostly under clear sky condition. If there were clouds around the sun, we had to wait until the clouds passed. All the measurements were taken by putting the sensor face up in a horizontal position. The above-the-canopy radiation was measured about 2.0 m above the ground using ASD at open space or LI-1800-11, which was put on the top of a van. Transmitted radiation was measured by putting ASD on the ground.

Canopy transmittances were taken mainly on the transect scale. When we had time, we made intensive measurement in a 50m*50m area, at 10m*10m resolution. We also made notes about the sample character (grass or shrub or open space).

Other Data Measured by ASD

Reflectance of background, canopy and individual plants at some sites was measured using ASD with 20-degree field-of-view (FOV) foreoptics by putting the sensor face down. A white reference panel was used to get incident radiation before or after reflectance was measured. The spectral range was from 400nm to 1100nm, at 1nm resolution.

a) In each of the four sites, under nadir reflectance of background (soil or soil plus grasses) was measured.

b) In Maun, canopy reflectance was measured at 30, 45, 60 degree zenith angle and under nadir, from a tower of 40 m height.

c) In Okwa, under nadir reflectances of 4-5 species of individual shrubs were measured. ASD sensor was about 0.5 m above the shrub.
Fig. 1 Sample Diagram
<table>
<thead>
<tr>
<th>Site</th>
<th>Pandamatenga</th>
<th>Maun</th>
<th>Okwa</th>
<th>Tshane</th>
</tr>
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<tbody>
<tr>
<td><strong>Measurement</strong></td>
<td>Transect scale</td>
<td>Pixel scale</td>
<td>Transect scale</td>
<td>Pixel scale</td>
</tr>
<tr>
<td>LAI-2000</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td><strong>AccuPAR</strong></td>
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<td></td>
</tr>
<tr>
<td>Incident flux</td>
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<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Transmitted flux</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Reflected flux</td>
<td>-</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Reflected flux from 40 m tower</td>
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<td>-</td>
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<tr>
<td><strong>LI-1800</strong></td>
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<td></td>
</tr>
<tr>
<td>Leaf reflectance, transmittance</td>
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<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Incident flux</td>
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<td>+</td>
<td>-</td>
</tr>
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<td><strong>ASD</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Canopy transmittance</td>
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<td>+</td>
<td>-</td>
</tr>
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<td>Under nadir background reflectance</td>
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<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Canopy reflectance at 30, 45, 60 degree zenith angle</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Under nadir reflectance of individual plant</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

+: There are measurements on the site.
-: No measurements on the site.