SAFARI 2000 FPAR TRAC Data for Mongu, Zambia, 1999-2002

Abstract

Data from the Tracing Radiation and Architecture of Canopies (TRAC) instrument were processed to determine the fraction of intercepted photosynthetically active radiation (FPAR) at the EOS Validation Core Site in Kataba Local Forest, approximately 20 km south of Mongu, Zambia. Measurements began in 1999 and continued into 2002 with measurements collected about every month. The TRAC instrument was carried along three parallel transects, each 750 m long and spaced 250 m apart. Each transect was divided into 25 m segments, and Fpar values are reported for each segment. TRAC measurements were collected on clear days near midday.

Background Information

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Project: SAFARI 2000
Southern Africa Validation of EOS (SAVE)

Data Set Title: SAFARI 2000 FPAR TRAC Data for Mongu, Zambia, 1999-2002

Site: Mongu, Zambia
Westernmost Longitude: 22.027572
Easternmost Longitude: 24.277347
Northernmost Latitude: -14.934194
Southernmost Latitude: -16.866708

Data Set Citation:

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Data File Information

The data are stored in an ASCII text file, in comma-separated-value (csv) format, with column headers.

Column Name	Definition	Units/Format
Transect	The Transect ID name: A, B, or C	ASCII
Segment number	Within the transect, the 25 m long subdivision ID. Starting from the eastern transect end increasing as one goes west. If segment number is AVG values are summaries for the entire transect.	numeric
Date	The date of data collection	MM/DD/YY
START TIME	The starting time of data collection	HH:MM GMT
END TIME	The ending time of data collection	HH:MM GMT
NUM PTS	The number of data values collected	numeric
MIN VAL Trans PAR	The minimum value of PAR transmitted through the canopy	µmol m^{-2} s^{-1}

MAX VAL Trans PAR	The maximum value of PAR transmitted through the canopy	µmol m^{-2} s^{-1}
AVG Reflected PAR from Soil	The average value of PAR reflected from the background	µmol m^{-2} s^{-1}
Avg FPAR	The average Fpar	unitless
Data file	Original file name for raw TRAC data	ASCII
Notes	Further information about the data. If the direction of data collection is not given in this column, segment numbers were determined by comparing data with other transects.	ASCII

Sample Records

```
Transect,segment number,Date,START TIME,END TIME,NUM PTS,MIN VAL Trans PAR,MAX VAL
Trans PAR,
AVG Reflected PAR from Soil,Avg FPAR,Data file,Notes
A,30,3/29/01,10:15,10:16,1107,25,1737,51,0.6575,MT29031A.TRC,West to East
A,29,3/29/01,10:17,10:17,1470,44,1720,43,0.6204,MT29031A.TRC,West to East
A,28,3/29/01,10:17,10:18,629,187,1882,170,0.1009,MT29031A.TRC,West to East
```

TRAC data were collected on the following dates:

10-Aug-99	3-Feb-01
29-Feb-00	20-Mar-01
19-Apr-00	29-Mar-01
20-Apr-00	16-Apr-01
17-May-00	25-May-01
14-Jun-00	23-Jun-01
29-Jun-00	17-Jul-01
7-Jul-00	25-Jul-01
17-Jul-00	4-Aug-01
5-Aug-00	12-Sep-01
7-Aug-00	29-Sep-01
16-Aug-00	10-Nov-01
2-Sep-00	22-Dec-01
27-Sep-00	24-Dec-01
17-Oct-00	16-Jan-02
18-Oct-00	23-Feb-02
6-Nov-00	
21-Nov-00	
19-Dec-00	

Site Description

Surface observations were collected from the area surrounding the flux tower at the Kataba Local Forest, approximately 20 km south of Mongu in western Zambia. The tower was located at -15° 26.3' S., 23° 15.2' E, on a flat area adjacent to the Zambezi River flood plain. The land cover was miombo woodlands on Kalahari Sand (Privette et al., 2002) or Kalahari woodlands. Around the tower the woodland tree and shrub basal area measured at breast height averaged 8.19 m^2/ha with a standard deviation of 2.75 m^2/ha, for 42 samples, with canopy cover averaging 49.3% with a standard deviation of 10.6% (Scholes et al., 2002). There were five dominant species in the forest canopy: *Brachystegia spiciformis*, *Burkea africana*, *Guibourtia coleosperma*, *Brachystegia bakerana*, and *Ochna pulchra.* Average canopy height was about 12 m. Beneath the canopy there was a sparse understory of the grass *Pogonarthria squarrosa*, various shrubs and geoxylic suffrutices (*Copaifera baumiana*, *Paropsia brazzeana*, *Baphia massaiensis*, *Bauhinia petersiana*, and *Lannea gossweileri*, among others), moss, and leaf litter. The soil was a pale gray, deep, excessively well drained, fine sandy regosol of largely aeolian

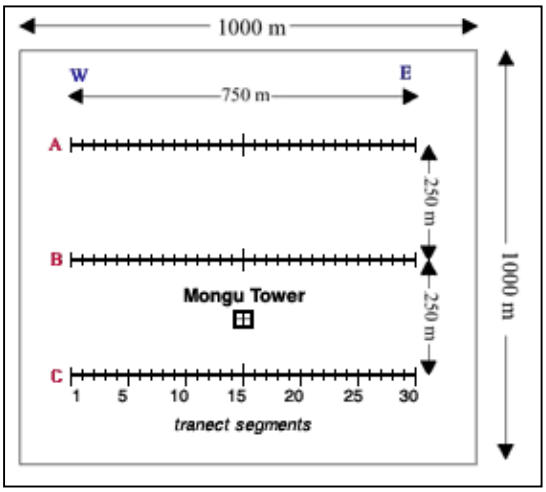
origin ('Kalahari sand') that showed almost no profile development with depth (Otter et al., 2002; Swap et al., 2002).

The site experiences a hot continental climate with pronounced wet and dry seasons. Nearly all of the rain occurs from November to April, while typically no rainfall occurs from June to September. The vegetation is deciduous, responding to the seasonal variation in rainfall.

Data Collection

Measurements of FPAR were made along three parallel east-west running transects, each 750-m long. The northern-most transect was labeled A, the middle transect B, and the southern-most transect was named C. The flux tower was located half way between the centers of the B and C transects. The transects were separated by 250 m. Each transect was divided up into 25-m long segments, numbered 1 to 30. The length and spacing of the transects were chosen to sample an area large enough to be representative of a 1 km MODIS pixel.

The Tracing Architecture and Radiation of Canopies (TRAC) instrument was used to measure FPAR. TRAC contains three pyranometers sensitive to PAR wavelengths, with two sensors upward looking and one downward looking. TRAC was carried through the forest along a transect at a steady pace while the sensors measured PAR at 32 Hz, resulting in a horizontal sampling interval of about 1.7 cm (Privette et al., 2002). The sensors were held about 0.7 m off the ground. After each 25 m segment along the transect, the operator entered a date/time stamp into the data by pressing a button. TRAC measurements were collected on clear days near midday. If a cloud obscured the sun, data collection was paused until the cloud passed.



Data Processing

The raw TRAC data were processed to calculate FPAR directly as described in Equation 3. PAR transmittance values were determined from the upward viewing pyranometers on the TRAC instrument. Due to the large gaps in the canopy, incident PAR was estimated from the TRAC data as 95% of the maximum PAR transmittance value for each transect. The 95% factor was used to adjust for the TRAC not being completely level in each measurement. As TRAC data were collected over a relatively short period of time, with each transect measurement set generally taking less than a half hour to collect, the incident PAR was considered constant over the period of time covered to measure each transect. With a value for incident PAR determined for a transect measurement set, each upward-viewing pyranometer measurement was used as a value of PAR transmittance. FPAR values greater than one were set to one. The FPAR values of all the observations were averaged to give segment-average FPAR values. The segment average FPAR values were averaged together go give a transect-average FPAR.

Theory

This study examined Fpar through the seasons. The total absorbed photosynthetically active radiation (PAR) by a canopy (APAR) is the balance of the fluxes into and out of the canopy, usually expressed as:

$$APAR = Q_{in} + Q_b - Q_t - Q_r \qquad (1)$$

where Q_{in} is the incident PAR flux
Q_b is the PAR reflected into the canopy from the soil background
Q_t is the PAR transmitted through the canopy
Q_r is the above-canopy reflected PAR

To determine FAPAR, we normalize APAR by the incident PAR:

$$FAPAR = APAR/Q_{in} = (Q_{in} + Q_b - Q_t - Q_r)/Q_{in} \qquad (2)$$

Frequently, Q_b is small and is set to zero in the calculation of FAPAR. In the tall vegetation at Mongu, it was difficult to measure above-canopy reflected PAR (Q_r). In that case, we report fraction of intercepted PAR (FPAR) as:

$$FPAR = (Q_{in} - Q_t)/Q_{in} \qquad (3)$$

Because PAR reflectance from vegetation (energy loss from the system) is usually small and somewhat canceled out by the background reflectance (Q_b, energy gained by the system), FPAR is generally about 10% lower than FAPAR.

Instrumentation

The TRAC contains three pyranometers sensitive to PAR wavelengths, with two sensors upward looking and one downward looking (Chen and Cihlar, 1995; Chen, 1996; Chen et al., 2000).

Sensor or Instrument Measurement Geometry:

In operation, the TRAC is held level as it is carried through the forest along a transect at a steady pace while the sensors measured PAR (Chen and Cihlar, 1995; Chen, 1996; Chen et al., 2000). The sensors are held about 0.7 m off the ground. After each 25 m segment along the transect, the operator entered a date/time stamp into the data by pressing a button. TRAC measurements were collected on clear days near midday. If a cloud obscured the sun, data collection was paused until the cloud passed.

Manufacturer of Sensor or Instrument:

3rd Wave Engineering
14 Aleutian Road
Nepean, Ontario
Canada K2H7C8
Tel. 813-828-2195

Errors and Limitations:

For records that do not have notes stating the direction data were collected, e.g. "East to West", the segment numbering order had to be guessed at based on comparisons with data collected on other days.

Known Problems with the Data:

Data collected for transect A on 29-Feb-00 and 19-Dec-00 had only 28 segments recorded, thus the segment numbers may be wrong and there is a bias in the transect average. Data collected for transect B on 4-Aug-01 had a time-stamp error in the middle of the data collection. The start and end times for several of the segments were not recorded.

Quality Assessment Activities:

FPAR values were compared with MODIS FPAR products. There was a significant offset between the satellite and ground-measured FPARs.

Additional Sources of Information

TRAC data were also collected at Skukuza, South Africa, but have not been processed completely to date. Please contact the investigators for information on this data set.

Global Positioning System (GPS) coordinates for the grid transect endpoints were collected at the Kalahari Transect sites and can be found in the file GPS_Coords_transect_endpts.txt

Related Data Sets:

Privette, J. L. and M. Mukelabai. 2004. SAFARI 2000 Leaf Area Index and Canopy Structure, Kalahari Transect, 1999-2000. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Privette, J. L., M. M. Mukelabai, and K. F. Huemmrich. 2005. SAFARI 2000 Leaf Area Measurements at the Mongu Tower Site, Zambia, 2000-2002. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Additional related data sets collected at the Mongu site during SAFARI 2000 are archived by ORNL DAAC. A list of these data sets is available at: http://www.daac.ornl.gov/S2K/safari.html.

References:

Chen, J. M. and J. Cihlar. 1995. Plant canopy gap size analysis theory for improving optical measurements of leaf area index. Applied Optics, 34: 6211-6222.

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