MODIS SEMI-ANNUAL REPORT: JAN/01/00 - JUN/30/00

Radiative Transfer Based Synergistic MODIS/MISR Algorithm for the Estimation of Global LAI & FPAR

(Contract: NAS5-96061)

Y. Tian, Y. Zhang, S. Hoffman, Y. Wang, Y. Knyazikhin, R. B. Myneni
Geography Department, Boston University, 675 Commonwealth Avenue, Boston, MA 02215

Summary of the algorithm. The objective of the contract is to develop a radiative transfer based synergistic algorithm for estimation of global leaf area index (LAI) and fraction of photosynthetically active radiation absorbed by vegetation (FPAR). The algorithm consists of a main procedure that exploits the spectral information content of MODIS measurements and the angular information content of MISR measurements to derive accurate estimation of LAI and FPAR. Should this main algorithm fail, a backup algorithm is triggered to estimate LAI and FPAR using vegetation indices. Both algorithms are capable of executing in MODIS-only or MISR-only mode, should cloud contamination, data frequency and spatial or temporal resolution requirements hinder a joint MODIS/MISR mode of operation. The MODIS-only mode of the algorithm requires a land cover classification that is compatible with the radiative transfer model used in the derivation. Such a classification based on vegetation structure was proposed and it is expected to be derived from the MODIS Land Cover Product. Therefore, our algorithm has interfaces with the MODIS/MISR surface reflectance product and the MODIS Land Cover Product. Validation of the LAI/FPAR product is an important part of algorithm development. Multiple validation techniques will be used to develop uncertainty information on Terra LAI/FPAR products. Successful validation will be accomplished if timely and accurate product uncertainty information becomes routinely available to the product users within two years after Terra's launch.

Summary of work performed during the first half of 2000 (January through June)

- Participation in the SAFARI 2000 wet season field campaign. Data needed for validation of the LAI/FPAR product were collected, archived and analyzed.
- Participation in the Ruokolahti field campaign, Finland, June 10-24, 2000. Data needed for validation of the LAI/FPAR product were collected, archived and analyzed.
- Data collected during SAFARI 2000 campaign are available at the BU anonymous ftp directory.
- A detailed report on SAFARI 2000 field campaign is available at http://cybele/modismisr/atbds/atbds.html.
- Preparation has been made for Harvard Forest and Canada field campaigns.
- Estimation of the quality of MODIS LAI and FPAR over Africa has been performed.
- Comparison of MODIS LAI with SAFARI 2000 field measurements has been carried out.
- At launch MODIS LAI&FPAR results were presented at the MODIS Science Team Meeting.
- After launch product QA work has been conducted on schedule. QA definition and process modifications have been proposed aiming at public release of the product.
- Invited to talk on CEOS meetings on validation of vegetation products from coarse resolution sensors, Ispra, Italy, May 23-26, 2000.
- Talk at the MISR Science Team Meetings, JPL, Pasadena, June 12-14, 2000 was given.
- Paper describing a method to improve quality of the MODIS LAI/FPAR product has been submitted for publication in Remote Sensing of Environment

SAFARI 2000 Wet Season Field Campaign

The Boston University team (Yuhong Tian, Yujie Wang, Yu Zhang and Karyn Tabor) participated in the SAFARI 2000 wet season field campaign from Mar. 3 – Mar. 18, 2000, in collaboration with Dr. Jeff Privette. Our objectives were to obtain LAI/FPAR in the Kalahari transect; validate the MODIS LAI/FPAR algorithm; to describe the spatial variability of LAI/FPAR for the four sites and to investigate the scale effect on LAI/FPAR measurement and retrieval. Ground measurements of LAI, FPAR, leaf/ canopy hemispherical reflectance and transmittance were made using the LAI-2000 plant canopy analyzer, AccuPAR ceptometer, LI-1800 portable spectroradiometer and ASD handheld spectroradiometer. 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. Table 1 lists all the measurements taken during the SAFARI 2000 wet season field campaign. A detailed report on this campaign is available at http://cybele/modismisr/atbds/atbds.html. Data are available at our anonymous ftp directory (ftp: /pub/cliveg/ytian/Botswana/lai-measurement/).

Sampling strategy (Fig. 1). At each of the four sites, LAI/FPAR 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. All the measurements were taken between the sample points of west “375” and east “375” along each of these three lines.

The pixel scale measurements were taken at the 50m×50m 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 rows (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 row is named A, B, C, D, E and F from north to south. 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 row (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.

The collected data are currently under analysis. The preliminary results are reported below. Table 2 shows mean LAIs and standard deviations at transect and pixel scales for four sites. The vegetation type of Pandamatenga and Maun is classified as savannas. The Okwa and Tshane sites represent grasses. The standard deviations are quite high. This means these vegetation canopies are heterogeneous even at 1km×1km and 300m×250m resolutions. We can see this situation more clearly in the histogram of LAI values (Fig. 2).

Table 1. Measurements taken during the SAFARI 2000 campaign

Site / Instruments	Pandamatenga		Maun		Okwa		Tshane	
	Transect Scale	Pixel scale	Transect Scale	Pixel scale	Transect scale	Pixel scale	Transect scale	Pixel scale
LAI-2000	+	+	+	+	+	+	+	+
AccuPAR								
Incident flux	+	+	+	+	+	-	+	-
Transmitted flux	+	+	+	+	+	-	+	-
Reflected flux	-	-	-	-	-	-	-	-
Reflected flux from 40 m tower	-	-	+	+	-	-	-	-
LI-1800								
Leaf reflectance, transmittance	+	+	+	+	+	+	+	+
Incident flux	+	-	+	-	+	-	+	-
ASD								
Canopy transmittance	+	-	+	-	+	-	+	-
Under nadir background reflectance	+	+	+	+	+	+	+	+
Canopy reflectance at 30, 45, 60 degree zenith angle	-	-	+	+	-	-	-	-
Under nadir reflectance of individual plant	-	-	-	-	+	+	-	-

+: Measurement was taken; -: No measurements on the site.

Table 2. Mean LAI and standard deviation in Pandamatenga, Maun, Okwa, and Tshane

Site Name	Mean		Standard deviation	
	Transect scale	Pixel scale	Transect scale	Pixel scale
Pandamatenga	1.25956	-	0.783491	-
Maun	1.503913	1.207143	0.774568	0.680704
Okwa	1.276129	1.752195	0.802867	0.894132
Tshane	0.776667	0.777619	0.858399	0.900463

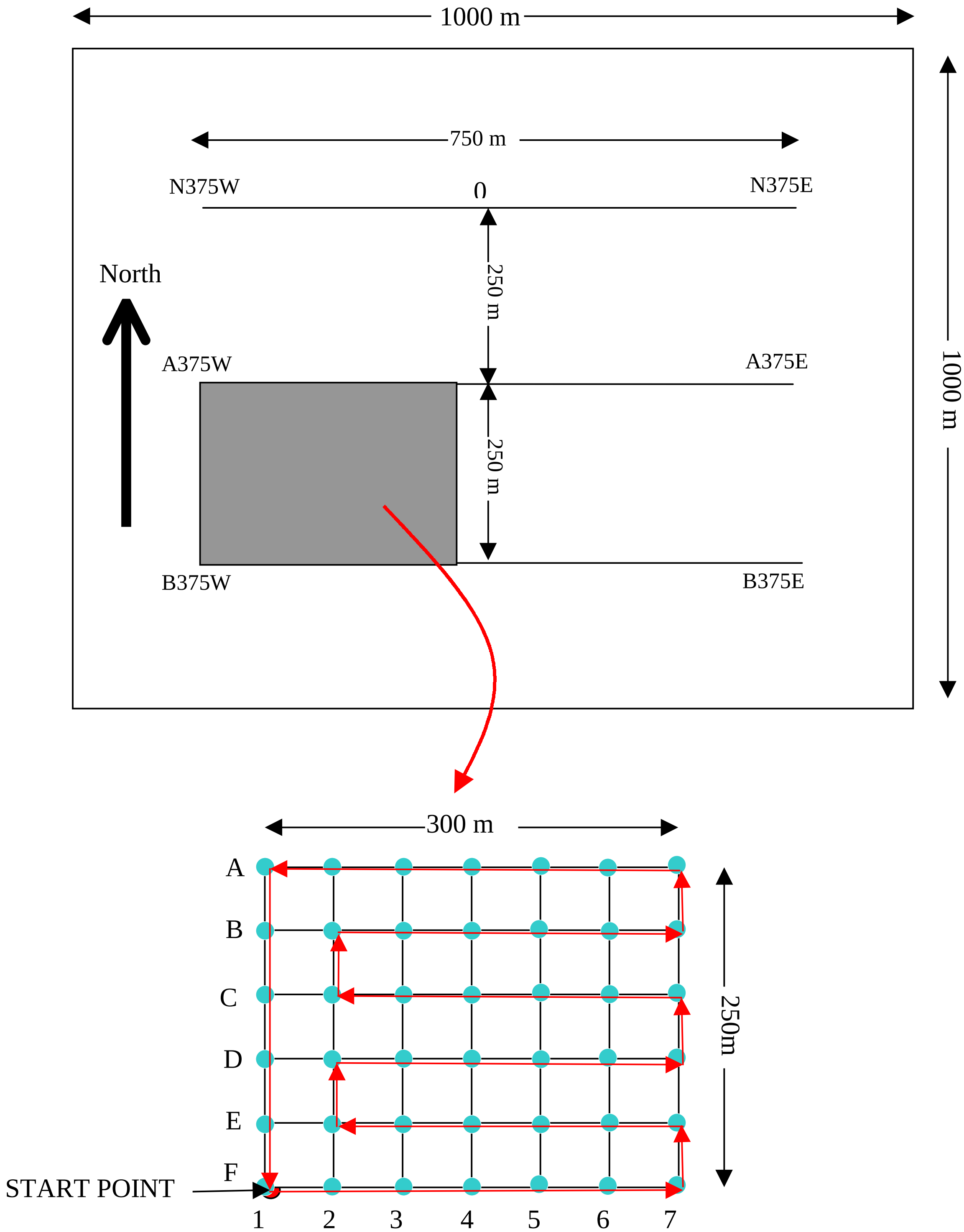
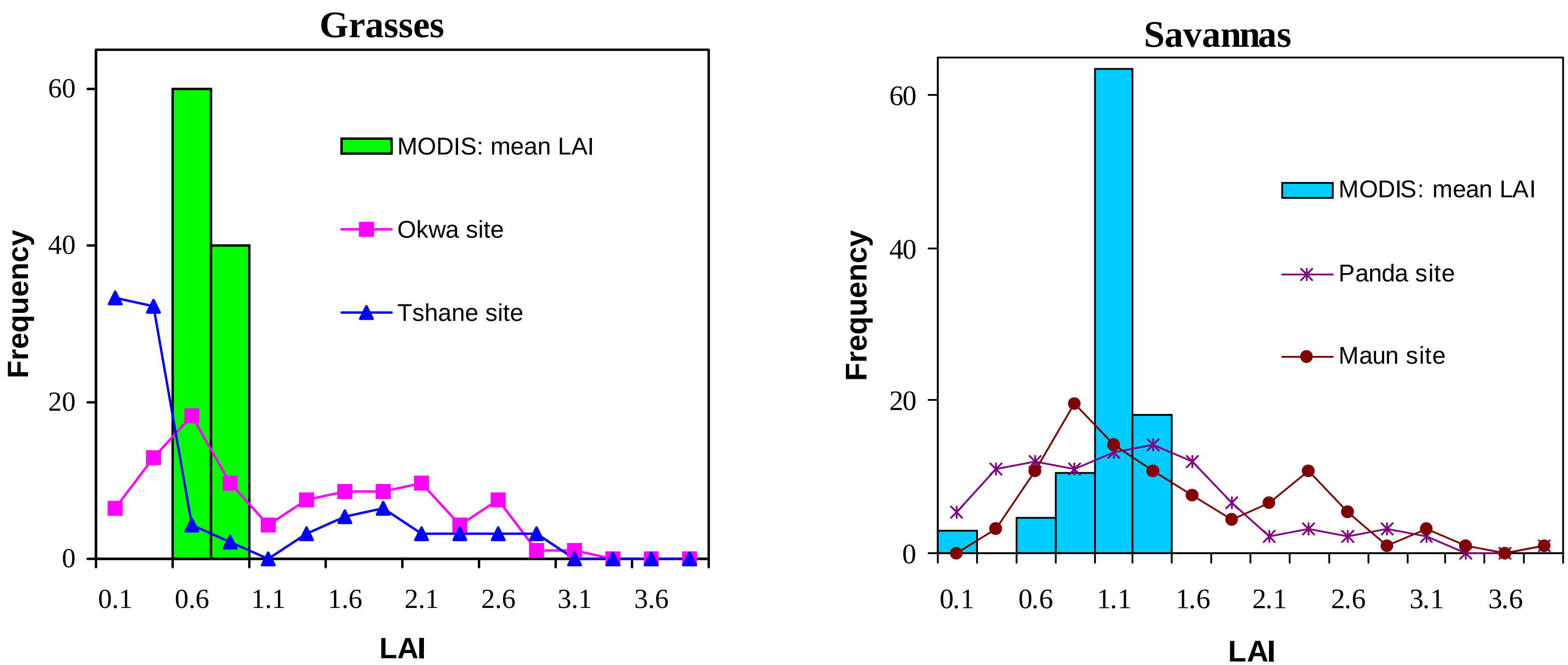


Figure 1. Sample strategy.



	Mean LAI	Dispersion
MODIS	0.70	0.22
Okwa site	1.27	0.80
Tshane site	0.78	0.85

	Mean LAI	Dispersion
MODIS	1.07	0.20
Panda site	1.26	0.78
Maun site	1.50	0.78

Figure 2. Comparison of MODIS LAI with SAFARI 2000 field measurements. Figures show the distribution of LAI values derived from field measurements and evaluated with the MODIS LAI/FPAR algorithm. Dispersions derived from field measurements are higher than those derived from MODIS retrievals because the MODIS LAI/FPAR algorithm only accounts for the most probable situations encountered in reality. Mean MODIS LAIs agree with mean LAI values derived from field measurements.

MODIS At Launch LAI/FPRA Algorithm Performance

Three variables are used to describe the quality of LAI/FPAR retrievals. They are the retrieval index, dispersion and the saturation rate. A good result should have high retrieval index, low dispersion and low saturation rate. Two spectral bands, RED and NIR, are currently used in the MODIS at launch algorithm to produce the global LAI and FPAR field. Table 3 shows the quality of the MODIS LAI/FAPR product over Africa. The retrieval index is high and the saturation index is low for the first four biomes. Fig. 3a demonstrates the LAI distribution over Africa and the uncertainty (dispersion) in LAI/FPAR retrievals. The LAI distribution is reasonable. The NDVI-LAI and NDVI-FPAR relation derived from MODIS data over Africa (Fig. 3(b)) shows that the LAI/FPAR product follows regularities expected from physics.

Table 3. Algorithm performance (main algorithm)

Biome Type	*Retrieval Index, %*	*Saturation Index, %*	*Mean LAI*
Grasses and Cereal Crops	91.3	0.0	0.74
Shrubs	80.9	0.0	0.48
Broadleaf Crops	69.0	1.8	1.65
Savanna	80.7	2.2	1.44
Broadleaf Forests	21.6	16.7	3.91

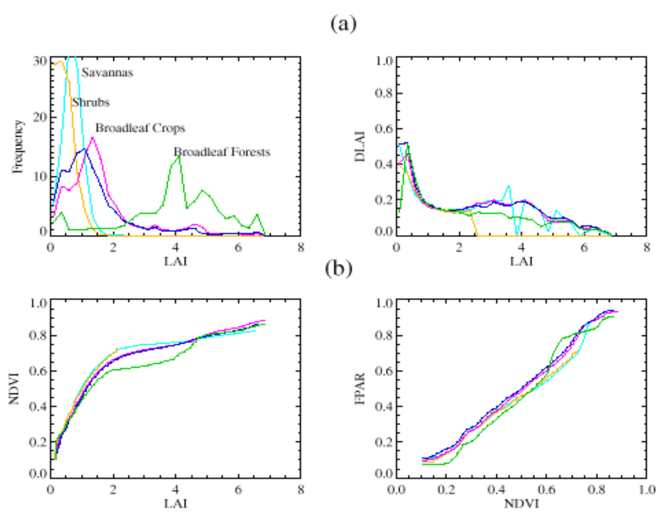


Figure 3. (a) Histograms of LAI values, their dispersions, (b) NDVI-LAI and NDVI-FPAR relationships derived from MODIS data over Africa.

March-25-2000

(a) MOD15A1: QA map without cloud mask

(b) MOD15A1: QA map with cloud mask

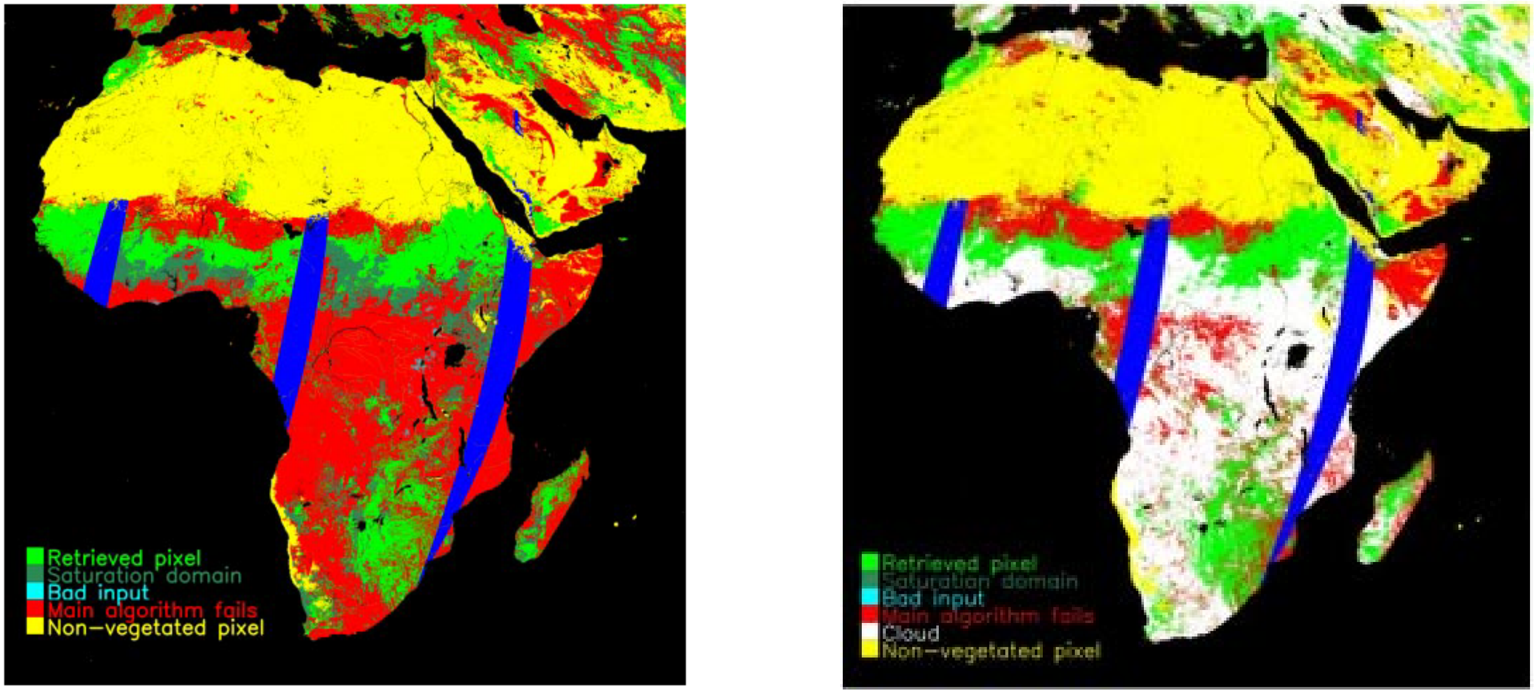


Figure 4. Performance of the main algorithm. LAI&FPAR daily QA maps (a) without and (b) with a cloud mask show that the main algorithm mainly fails when the pixels are corrupted due to clouds; that is, the algorithm can discriminate between cloud and vegetation reflectances.

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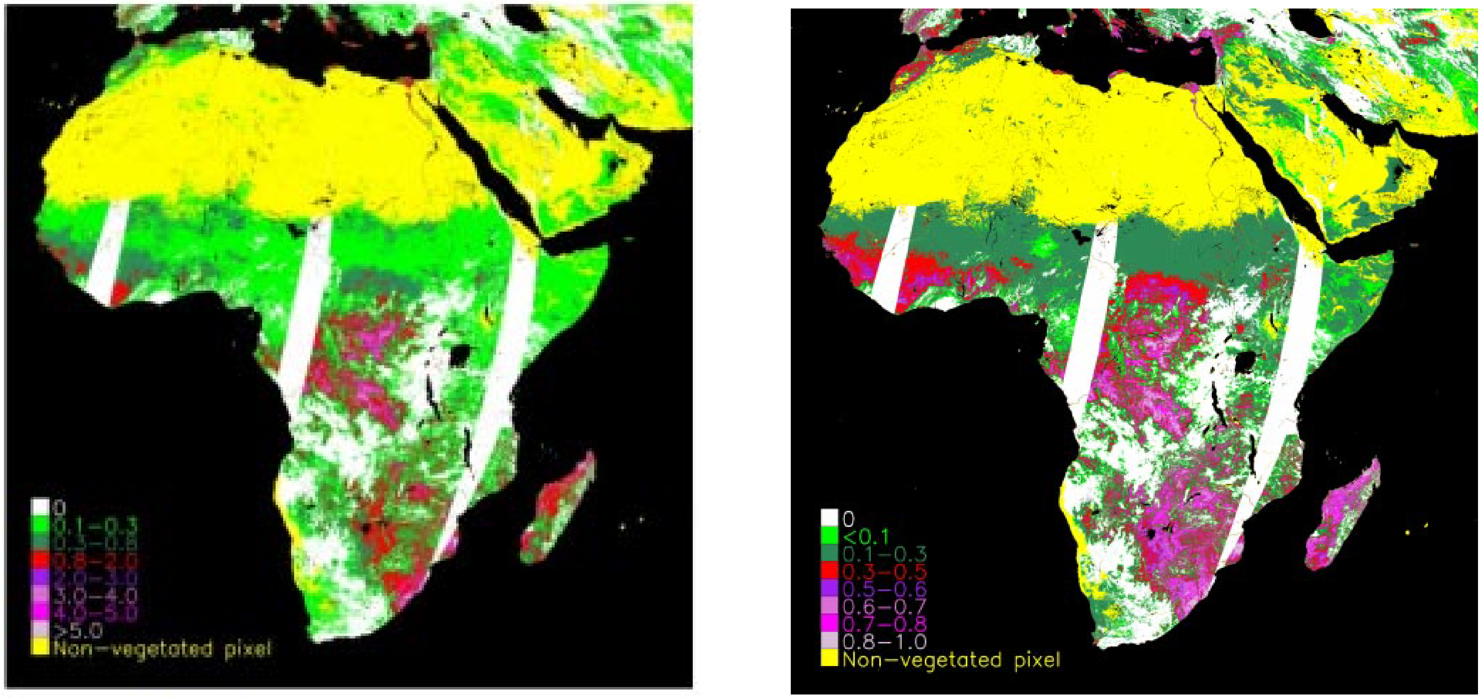

Figure 5. MOD15A1 LAI (left panel) and FPAR (right panel) maps. Daily LAI and FPAR maps show that large LAI/FPAR values are around Broadleaf forests, which is reasonable. This demonstrates that the LAI/FPAR algorithm behaves as expected and LAI/FPAR product can be released at the same time as the surface reflectance product.

MOD15 product QA work summary

The activities that have been conducted on the product QA work during this period are:

After participating in pre-launch processing tests and end-to-end test, we gathered operational information, reported the problems and suggested MOD15 QA definitions and operational system.

Conducted routine QA activities for MOD15 product, identified and reported problems encountered and exchanged ideas with MTU on QA definition and setting methodology. Participated in MODLAND telecom to be informed about recent product issue and report QA results.

Visited GSC (by Yu Zhang in late June) to communicate and cooperate with MODAPS on the issues of SCF QA task and action items, to become familiar with existing QA tools and online production reports and to exchange ideas about QA setting and preparation for public release.

Proposed and followed the new modification to the QA definition and applied it to product QA processes. Used and developed QA related tools to expand the ability for effective product checking and QA management.

Conclusions

- THE AT LAUNCH LAI/FPAR ALGORITHM BEHAVES AS EXPECTED
- THE LAI/FPAR PRODUCT FOLLOWS REGULARITIES EXPECTED FROM PHYSICS
- LAI/FPAR PRODUCT CAN BE RELEASED AT THE SAME TIME AS THE SURFACE REFLECTANCE PRODUCT

Publications

Wang, Y., Tian, Y., Zhang, Y., El-Saleous, N., Knyazikhin, Y., Vermote, E., and Myneni, R. B., Investigation of Product Accuracy as a Function of Input and Model Uncertainties: Case Study with SeaWiFS and MODIS LAI/FPAR Algorithm, *Remote Sens. Environ*, submitted for publication.