MODIS SEMI-ANNUAL REPORT: JUL/01/00 - DEC/31/00

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

(Contract: NAS5-96061)

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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 second half of 2000 (July through December)

- Participation in the Nova Scotia field campaign, Canada, August 10-24, 2000. Data needed for validation of the LAI/FPAR product were collected, archived and analyzed.
- Participation in the Harvard Forest field campaign, Massachusetts, July 21-25, 2000. Data needed for validation of the LAI/FPAR product were collected, archived and analyzed.
- Participation in the SAFARI 2000 dry season field campaign, Botswana, August 20-29, 2000. Data needed for validation of the LAI/FPAR product were collected, archived and analyzed.
- Data collected during field campaigns are available at the BU anonymous ftp directory. All data were registered with the Mercury system.
- Detailed reports on field campaigns are available at http://cybele/modismisr/atbds/atbds.html.
- Comparison of MODIS LAI and FPAR with field measurements has been carried out.
- Estimation of the quality of global MODIS LAI and FPAR products has been performed.
- Talk at the MISR Science Team Meetings, JPL, Pasadena, December 11-13, 2000 was given.
- Paper describing a method to improve quality of the MODIS LAI/FPAR product has been accepted for publication in Remote Sensing of Environment.
- Two papers describing our MODIS scientific activities have been submitted for publication in Remote Sensing of Environment.

Field Campaigns

The Boston University team participated in the following field campaigns: SAFARI 2000 dry season field campaign (Botswana, August 20-29, 2000); Nova Scotia field campaign (Canada, August 10-24, 2000) and the Harvard Forest field campaign (Massachusetts, July 21-25, 2000). Our objectives were to collect data needed for validation of the LAI/FPAR product; validate the MODIS LAI/FPAR algorithm; to describe the spatial variability of LAI/FPAR for all sites and to investigate the scale effect on LAI/FPAR measurements and retrievals. Ground measurements of LAI, FPAR, canopy hemispherical reflectance and transmittance were made using the LAI-2000 plant canopy analyzer, AccuPAR ceptometer, LI-1800 portable spectroradiometer and ASD handheld spectroradiometer. Optical property measurements of leaves from the dominant overstory species were made, at the Harvard Forest LTER site, on September 6th with the LI-1800 portable spectroradiometer. Detailed reports on these campaigns are available at http://cybele/modismisr/atbds/atbds.html. Data are available at our anonymous ftp directory (ftp: /pub/cliveg/ytian/Botswana/lai-measurement/). Some results are reported below.

SAFARI 2000 wet season field campaign

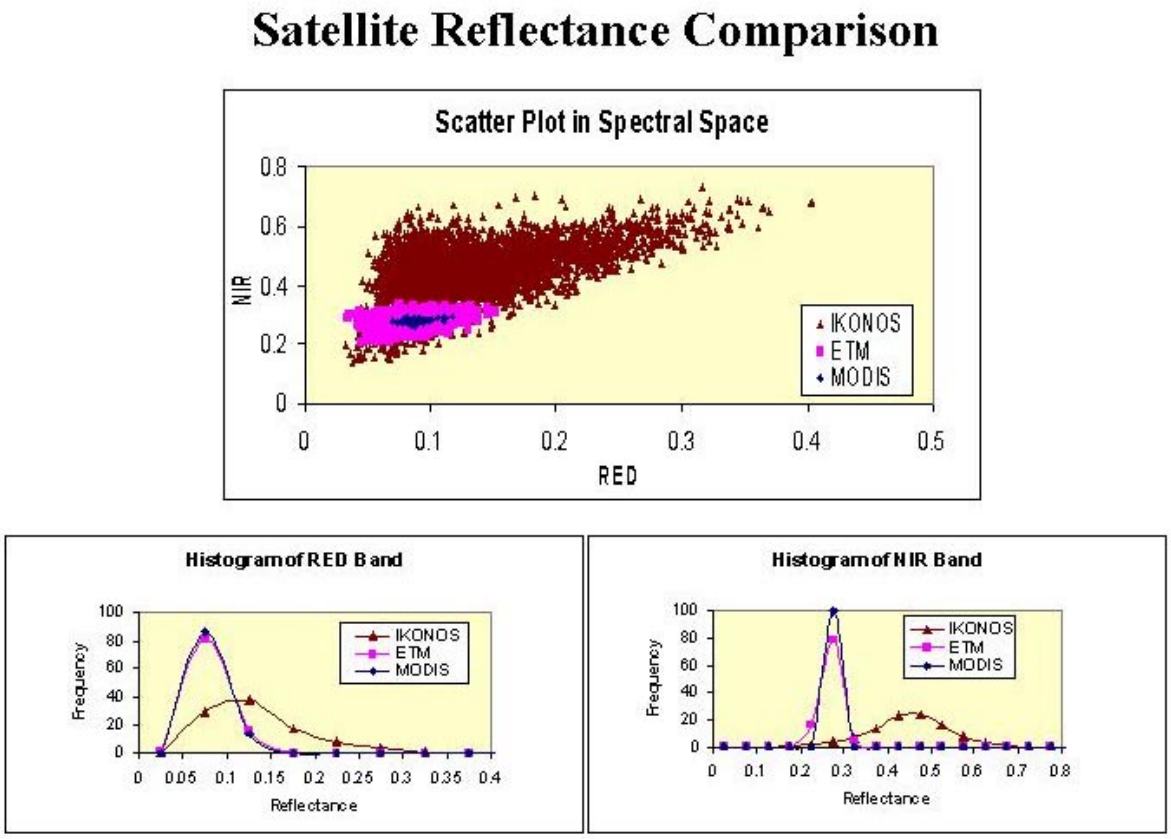

Figure 1. Distribution of pixels with respect to their reflectances at near-infrared and red wavelengths derived from the MODIS, ETM LANDSAT and IKONOS surface reflectances (top) and their statistical properties (bottom). These data were shown to be consistent. The MODIS LAI/FPAR algorithm was applied to these data to produce LAI maps of different resolutions.

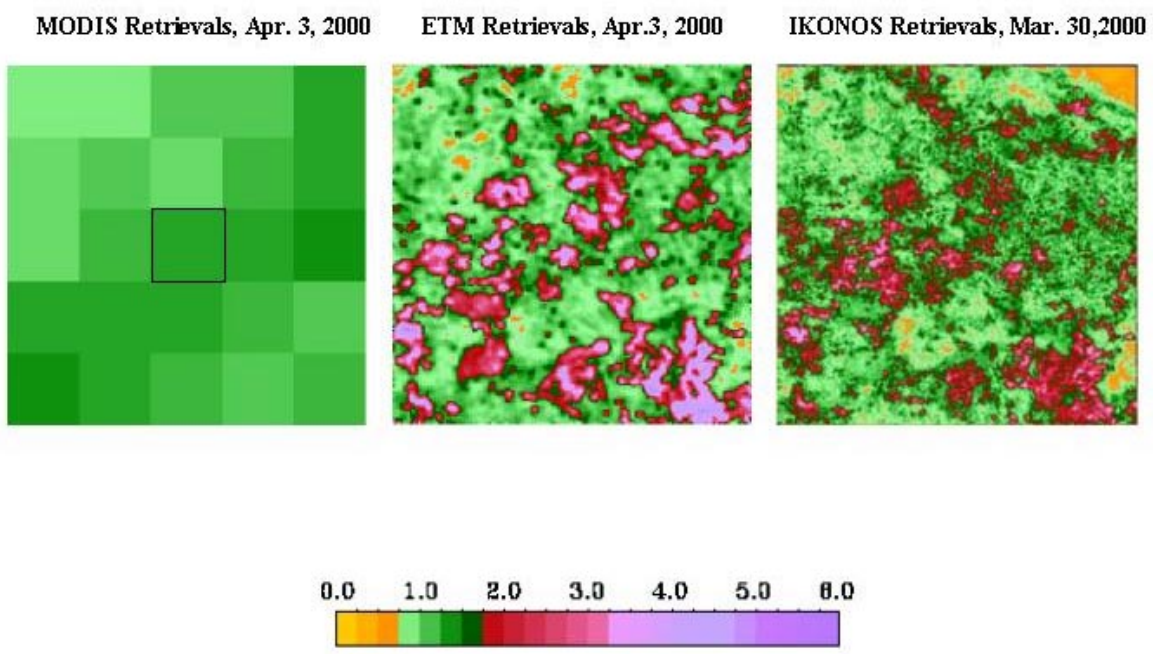

Figure 2. MODIS LAI map of a 5 by 5 km area (left). The black square in the center is the Maun validation site. LAI maps of the Maun site at 30m (center) and 4m (right) resolutions derived from ETM LANDSAT and IKONOS data using MODIS LAI/FPAR algorithm.

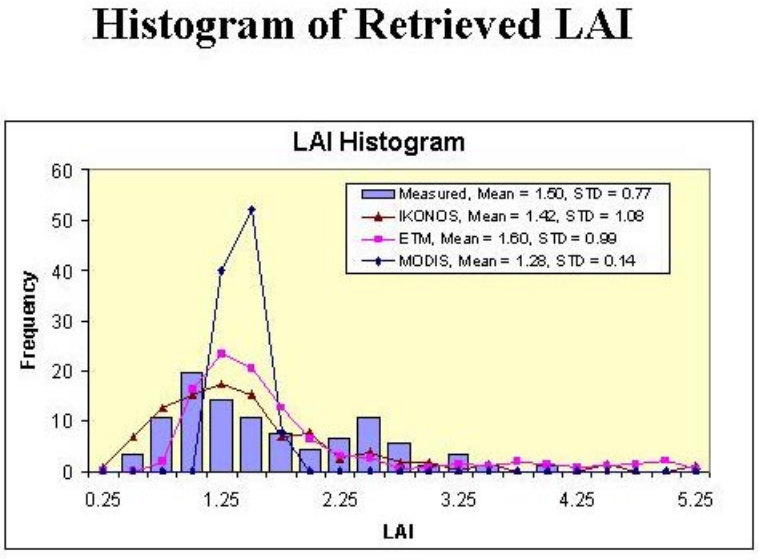

Figure 3. Comparison of MODIS LAI with SAFARI 2000 (wet season) field measurements and LAI values derived from the ETM LANDSAT and IKONOS surface reflectances. Figure shows distributions of LAI values provided by the MODIS LAI Product and derived from field measurements and ETM LANDSAT and IKONOS surface reflectances. Mean MODIS LAI agrees well with mean LAI values derived from measurements and ETM LANDSAT and IKONOS surface reflectances.

Harvard Forest LTER site, Massachusetts, July 21-25, 2000

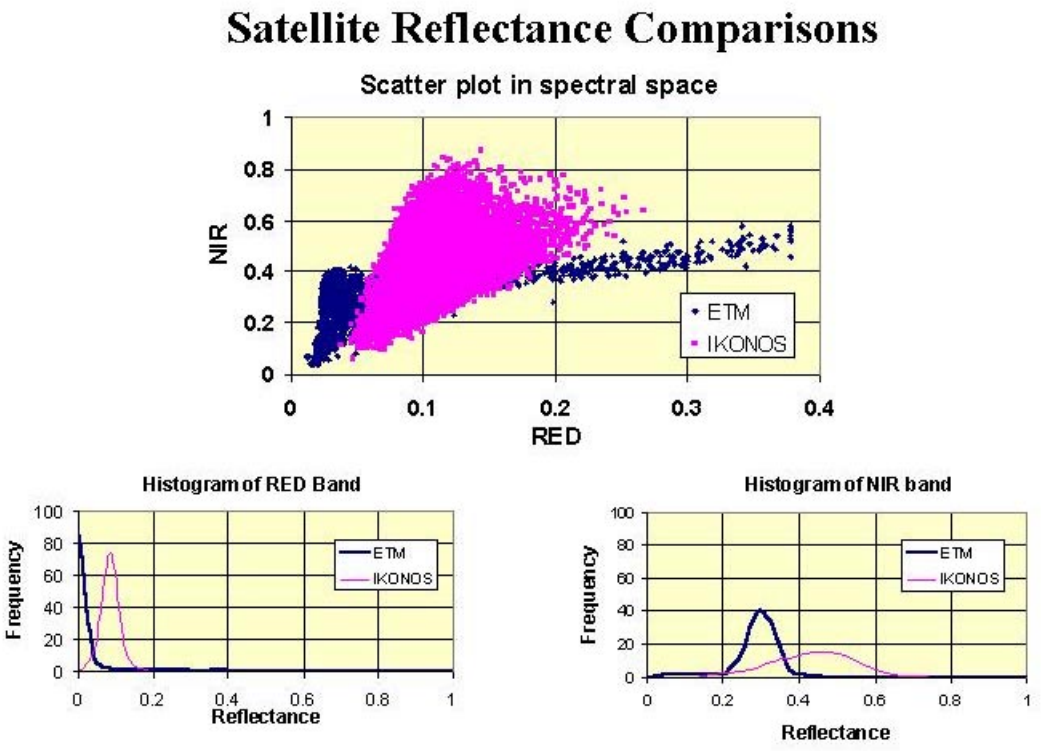

Figure 4. Distribution of pixels with respect to their reflectances at near-infrared and red wavelengths derived from the MODIS, ETM LANDSAT and IKONOS surface reflectances (top) and their statistical properties (bottom). The MODIS LAI/FPAR algorithm was applied to these data to produce LAI maps of different resolutions.

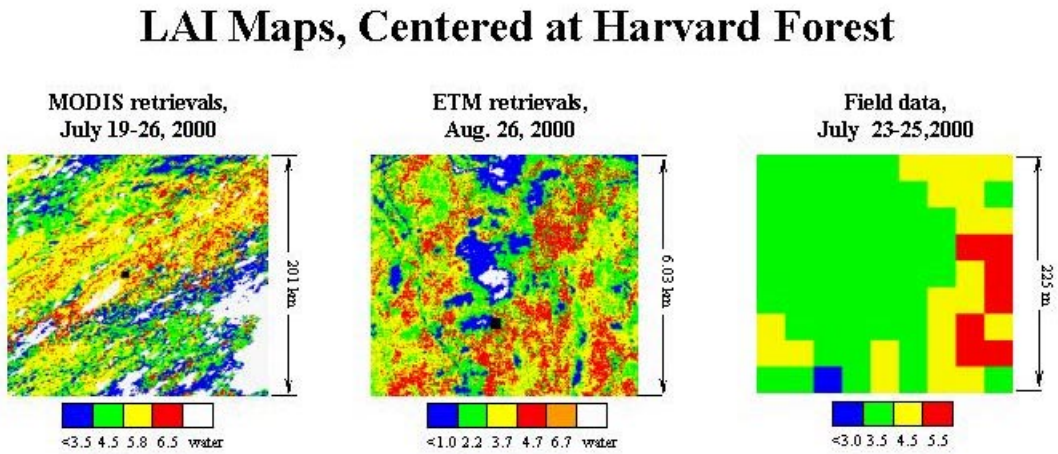

Figure 5. MODIS LAI map for July 21-25, 2000 at 1 km resolution (left). The black square in the center depicts an area of 6 by 6km where the field campaign was carried out. LAI map of August 26 at 30 m resolution derived with the MODIS LAI/FPAR algorithm using ETM LANDSAT data (center). This 6 by 6 km area is the Harvard Forest LTER site. The location of field measurements is shown as a black square. The right panel shows LAI map at 25 m resolution derived from field measurements (July 21025, 2000).

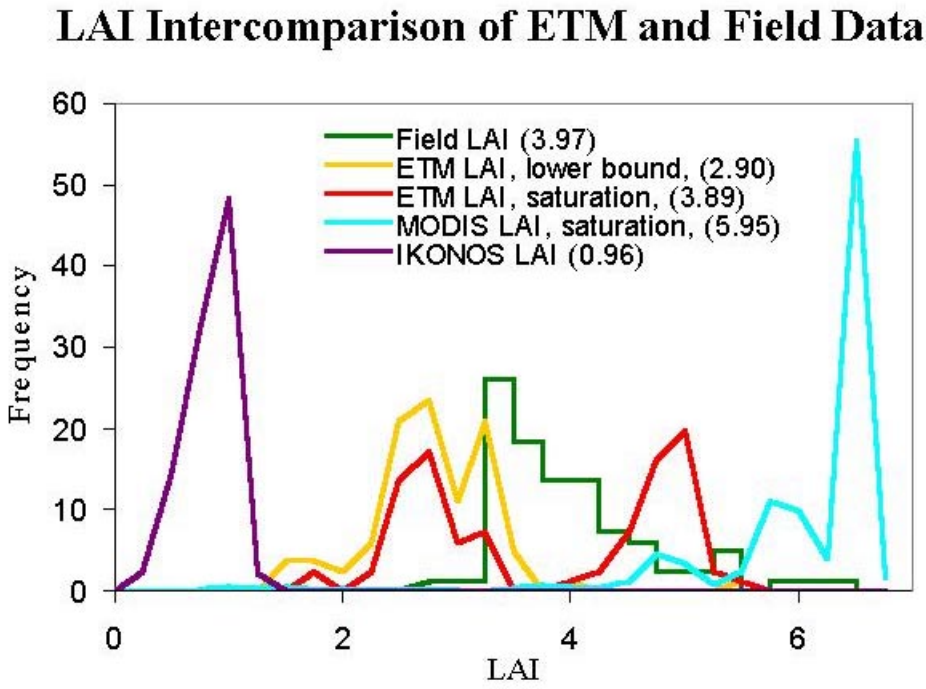

Figure 6. Distribution of MODIS LAI and LAI values derived from field measurements and evaluated with the MODIS LAI/FPAR algorithm using ETM LANDSAT data. The MODIS and ETM LANDSAT LAI values were derived under a condition of saturation. The histograms show the upper and lower limits of retrieved LAI values. The mean LANDSAT LAI (3.89) agrees with measured mean LAI value (4.1). The MODIS algorithm overestimates LAI values in the case of a dense canopy.

MODIS At Launch LAI/FPAR 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. Figure 7 (upper row) demonstrates the same tile H11V09 (Amazonian forest) for two days in July. This example shows that there can be considerable day-to-day variations in LAI values, some of which may not be biophysically driven. Figure 7 (lower row) shows LAI/FPAR QA map of this tile for the same days. For July 3-10, 2000, the retrieval index (fraction of green points on the QA map) is low. One can see that the main algorithm fails when the pixels are corrupted due to clouds; that is, the main algorithm can discriminate between vegetation and non-vegetation reflectances. The cloud mask is currently suppressed (i.e., the LAI/FPAR algorithm is executed independently of the cloud mask). This explains a low value of the retrieval index. However, the backup algorithm always provides a value of LAI using the NDVI-LAI and NDVI-FPAR regression curves. Because NDVI of cloud is very low, the backup algorithm applied to a pixel obscured by clouds produces a low LAI value. This example demonstrates that the use of the retrieval and saturation indices provided by the Fparlai_QC and FPARExtra_QC data sets are critical to interpret the MODIS LAI/FPAR product.

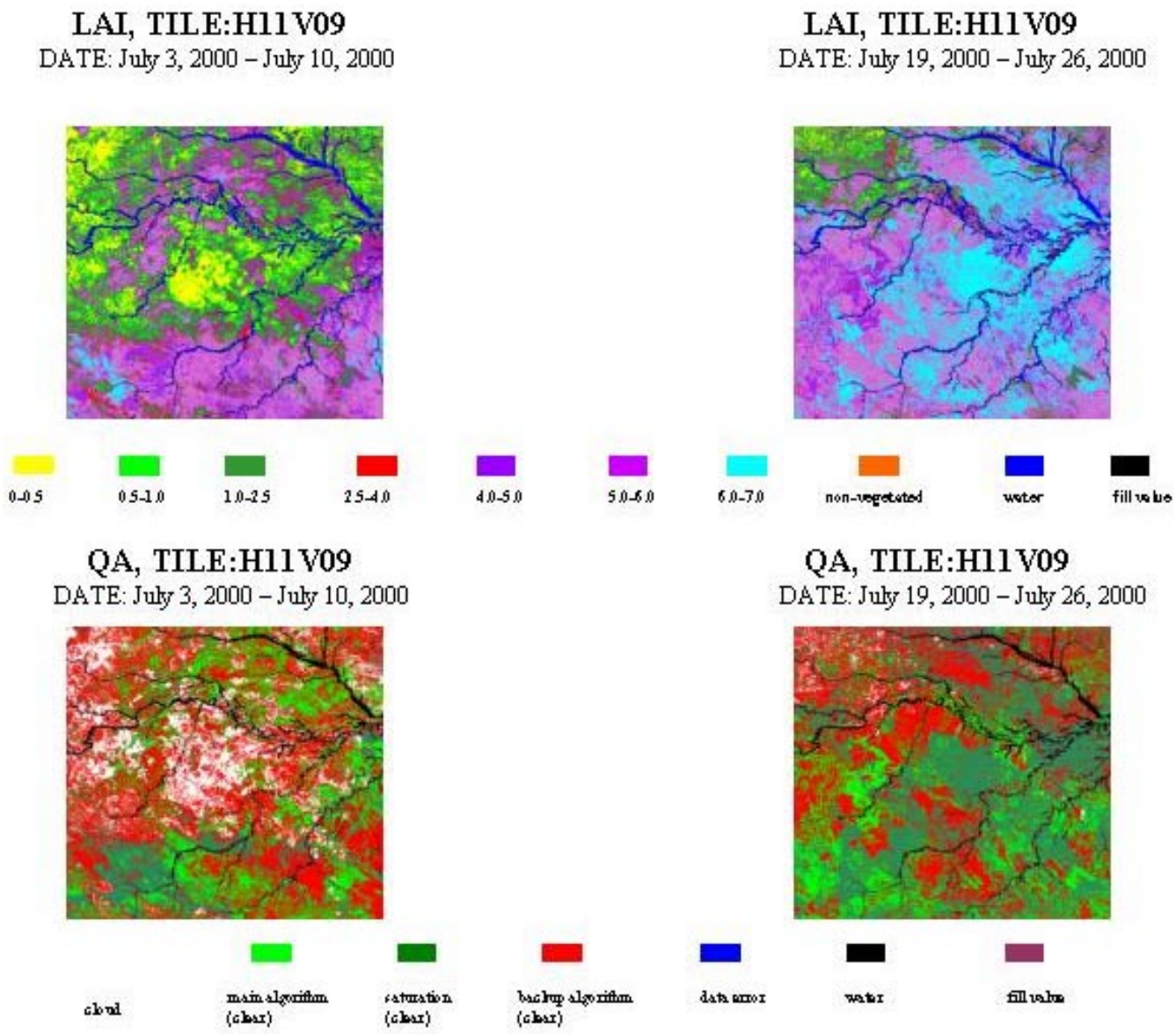

Figure 7. MOD15A2.A2000185.h11v09 and MOD15A2.A2000201.h11v09.

Conclusions

- THE AT LAUNCH LAI/FPAR ALGORITHM BEHAVES AS EXPECTED
- THE LAI/FPAR PRODUCT FOLLOWS REGULARITIES EXPECTED FROM PHYSICS
- COMPARISON OF MODIS LAI WITH FIELD MEASUREMENTS HAS BEEN CARRIED OUT

Publications

Y. Zhang, Y. Tian, R.B. Myneni, Y. Knyazikhin, and C. Woodcock, Required Consistency Between Biome Definitions and Signatures with the Physics of Remote Sensing. Part 1: Empirical Arguments, *Remote Sens. Environ*, submitted for publication (Dec, 2000).

Y. Zhang, N. Shabanov, Y. Knyazikhin, and R.B. Myneni, Required Consistency Between Definitions and Signatures with the Physics of Remote Sensing. Part 2: Theoretical Arguments, *Remote Sens. Environ*, submitted for publication (Dec, 2000).