LAI/FPAR Research at the Boston University Science Computing Facility: Collection 5 MODIS LAI/FPAR Products and Long-term LAI/FPAR from AVHRR NDVI
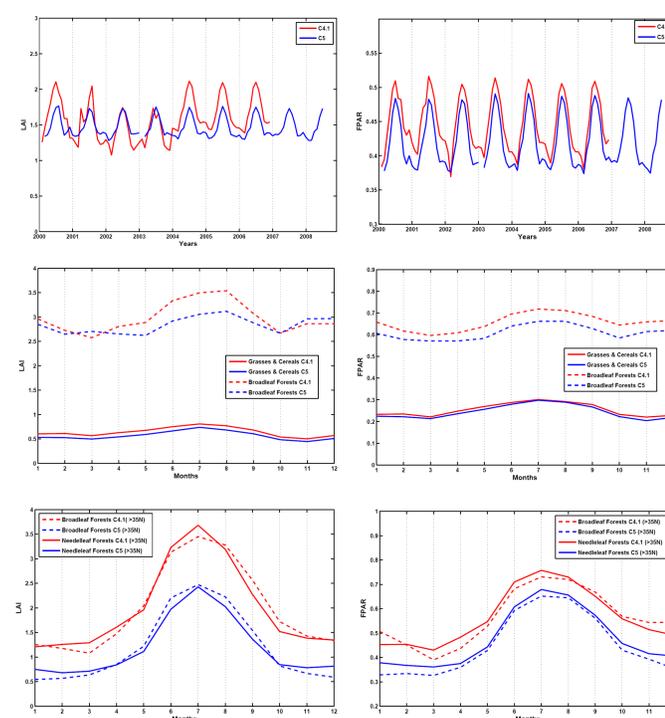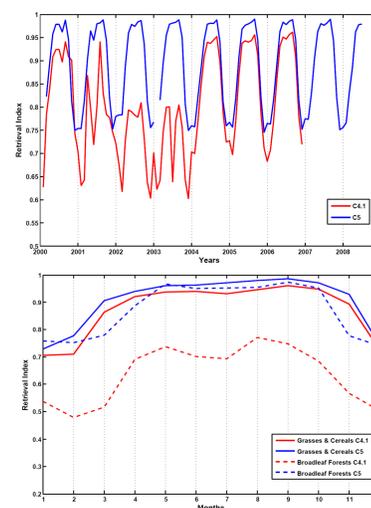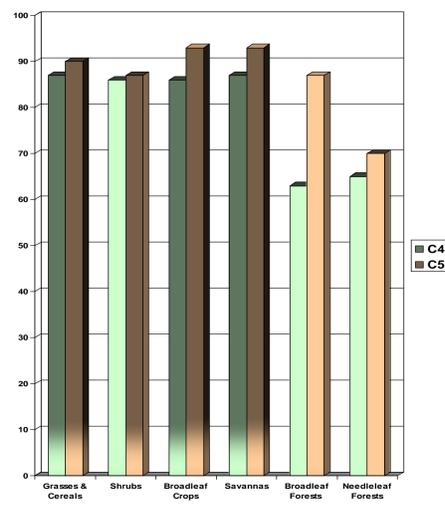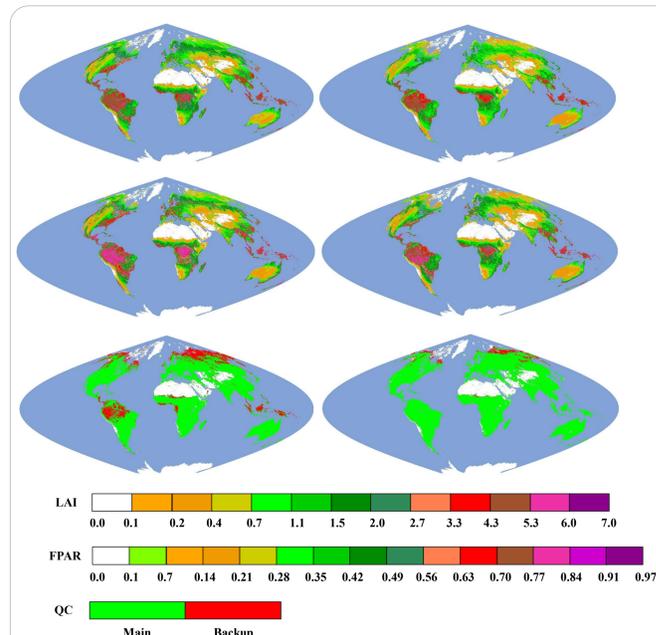
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Abstract. MODIS LAI algorithm was substantially refined for the Collection 5 (C5) reprocessing to optimally use suite of MODIS observations from Terra and Aqua sensors. Refinements are based on advancements in RT theory, and the C5 suite of LAI/FPAR products possesses higher quality retrievals than previous versions. The following 1-km products are operationally generated at NASA Science Computing Facilities (SCF): 8-day Terra and Aqua products, 8-days Combined Terra and Aqua product, and 4-day Combined Terra and Aqua product. In addition, monthly Collection 5 Terra products are processed and archived at the Boston University (BU) SCF. We analyzed Collection 5 LAI/FPAR products and compared them with Collection 4 LAI/FPAR products over a range of spatial and temporal scales: Global annual mean, Global monthly time-series, biome-based Global and Northern Hemisphere (>35N) analysis. For analysis we used Collection 4 (C4.1) and Collection 5 (C5) BU monthly Terra products. The BU SCF has also been involved in the generation and evaluation of a new global monthly leaf area index (LAI) data set for the period July 1981 to December 2006 derived from AVHRR Normalized Difference Vegetation Index (NDVI) data. This is based on the radiative transfer theory of canopy spectral invariants. This LAI data set was evaluated both by direct comparisons to ground data and indirectly through inter-comparisons with similar data sets. The indirect validation showed satisfactory agreement with existing LAI products – MODIS C5 LAI, at a range of spatial scales. The data set reproduced well-documented spatio-temporal trends and inter-annual variations in vegetation activity in the northern latitudes and semi-arid tropics. Overall, the inter-comparison with short-term LAI data sets, evaluation of long term trends with known variations in climate variables, and validation with field measurements together build confidence in the utility of this new 26 year LAI record for long-term vegetation monitoring and modeling studies.

Collection 5 MODIS LAI/FPAR

Global maps of Leaf Area Index (LAI, top), Fraction of Photosynthetically Active Radiation (FPAR, middle) and Quality Control (QC, bottom) produced for Collection 4 (C4.1, left) and Collection 5 (C5, right) covering the period February, 2000 – December, 2006.

Temporally and spatially averaged RI (%) of six biomes for Collection 4 (C4.1) and Collection 5 (C5).

Retrieval Index (RI) – fraction of main algorithm retrievals for Collection 4 (C4.1) and Collection 5 (C5). Top: Time series of RI for all vegetated pixels. Bottom: Time series of RI for two biomes – Grasses & Cereals, and, Broadleaf Forests.

Time series of LAI (left) and FPAR (right) for Collection 4 (C4.1) and Collection 5 (C5). Top: Global - all vegetated pixels. Middle: Two biomes – Grasses & Cereals, and, Broadleaf Forests. Bottom: Two biomes in the Northern Hemisphere (>35N) – Broadleaf Forests and Needleleaf Forests.

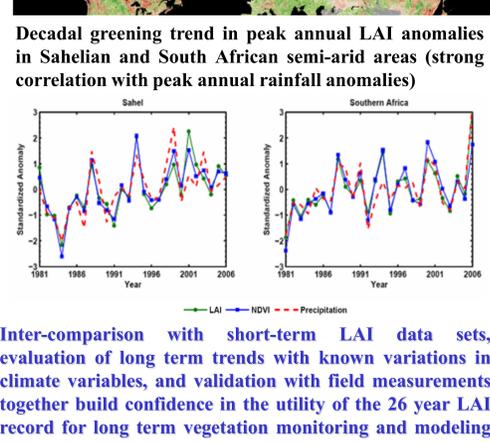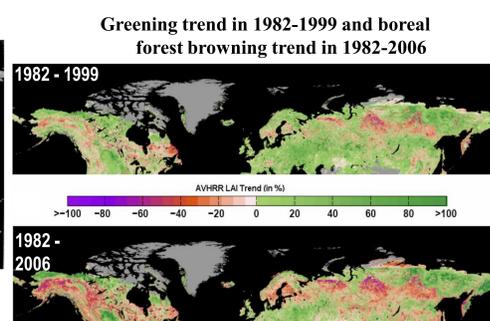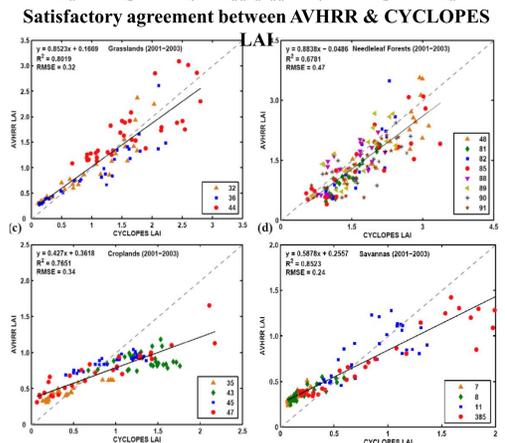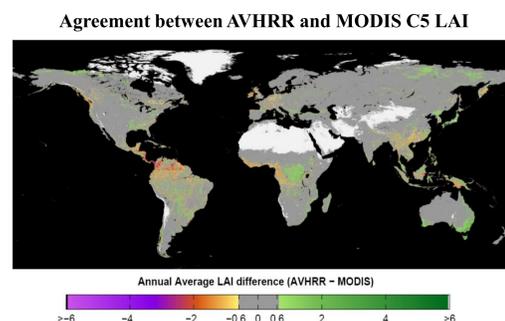## JOINING LAI FROM AVHRR NDVI AND MODIS SURFACE REFLECTANCE
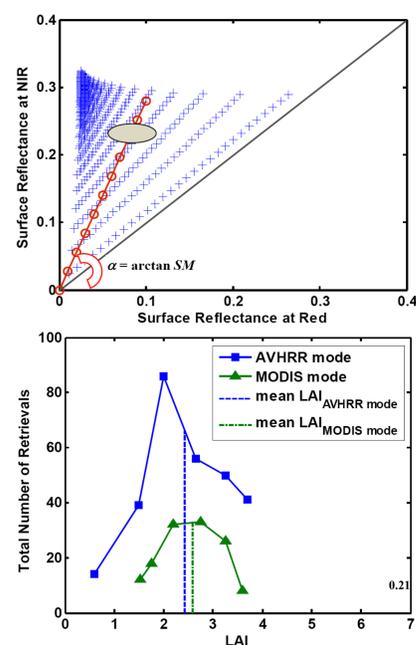
Consistency conditions for multi-sensor algorithms

➢ the algorithm should generate a set of acceptable solutions given AVHRR NDVI

➢ this set should include all acceptable solutions generated by the MODIS algorithm when given the corresponding AVHRR spectral reflectances;

➢ the algorithm should also be capable of admitting AVHRR spectral reflectances, in addition to NDVI, and generate the same set of acceptable solutions as the MODIS algorithm
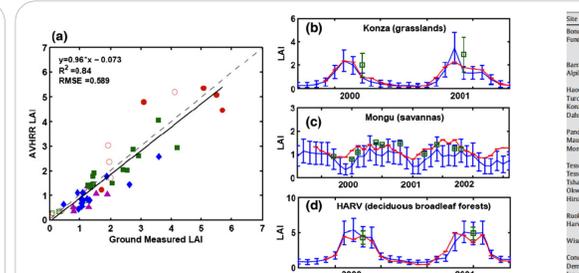
Achieving the consistency in NDVI and MODIS LAI is reduced to finding values of sensor-specific measurement uncertainty and single scattering albedo for which

✓ the consistency conditions are met
✓ the retrieval index (RI) is maximized
✓ the difference (RMSE) between AVHRR and MODIS LAI is minimized

The upper panel shows reflectance in the red-NIR plane for a range of LAI and background brightness. Pixels having the same value of Simple Ratio (SM) lie on a line. The ellipse represents measurement uncertainty. The lower panel shows distribution of LAIs corresponding to surface reflectances located (a) in the ellipse (blue points) and (b) lying on the SM line (green points).

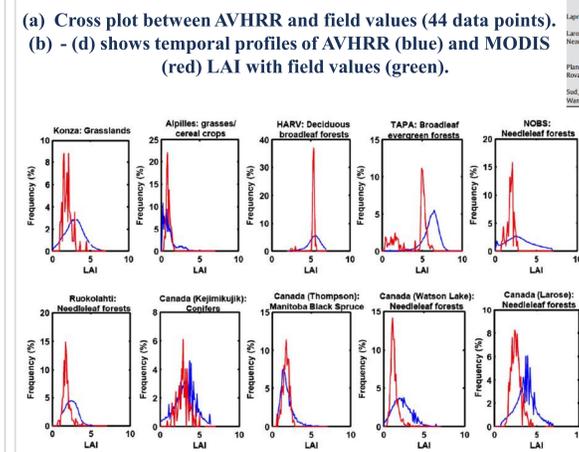## 26 YEAR RECORD OF GLOBAL LAI (JULY 1981 TO DECEMBER 2006)

Agreement between AVHRR and MODIS C5 LAI

Annual Average LAI difference (AVHRR – MODIS)

Satisfactory agreement between AVHRR & CYCLOPES LAI

Greening trend in 1982-1999 and boreal forest browning trend in 1982-2006

1982 - 1999

1982 - 2006

AVHRR LAI Trend (in %)

Decadal greening trend in peak annual LAI anomalies in Sahelian and South African semi-arid areas (strong correlation with peak annual rainfall anomalies)

Sahel

Southern Africa

Inter-comparison with short-term LAI data sets, evaluation of long term trends with known variations in climate variables, and validation with field measurements together build confidence in the utility of the 26 year LAI record for long term vegetation monitoring and modeling studies

VALIDATION WITH FIELD DATA

(a) Cross plot between AVHRR and field values (44 data points). (b) - (d) shows temporal profiles of AVHRR (blue) and MODIS (red) LAI with field values (green).

Table showing the sites used for validating the AVHRR LAI product.

Histograms from fine resolution LAI maps (blue color) and AVHRR LAI (red color) over different sites.

References:
1) Ganguly, S., Samanta, A., Schull, M. A., Shabanov, N. V., Milesi, C., Nemani, R. R., Knyazikhin, Y., and Myneni, R. B., Generating vegetation leaf area index Earth system data record from multiple sensors. Part 2: Implementation, analysis and validation, Remote Sensing of Environment, 2008, 112, 4318–4332, doi:10.1016/j.rse.2008.07.013.
2) Ganguly, S., Schull, M. A., Samanta, A., Shabanov, N. V., Milesi, C., Nemani, R. R., Knyazikhin, Y., and Myneni, R. B., Generating vegetation leaf area index Earth system data record from multiple sensors. Part 1: Theory, Remote Sensing of Environment, 2008, 112, 4333–4343, doi:10.1016/j.rse.2008.07.014.