MODIS
Global Burned Area Product: Status and validation

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http://modis-fire.umd.edu/MCD45A1.asp
Global C5 MODIS Burned Area Product

- Funded as part of NASA MODIS Fire Science Team (Justice et al.) to complement the well established (Collection 1,3,5) MODIS 1km active fire product

- Global applications
  - Green house gas & aerosol emissions estimation
  - Applied users (e.g., natural resource management)
  - LCLUC research (e.g., Fire – Climate – People)

- Product prototyping by regional algorithm development during the MODIS Collection 4 era

- Collection 5 processing now almost completed for MODIS data sensed 2000+ (reprocessing) and Feb. 2007+
Algorithm

- **Rolling BRDF based expectation change detection**

- Semi-Physically based; less dependent upon imprecise but noise tolerant classification techniques; very few thresholds

- Automated, without training data or human intervention

- Applied independently per pixel to daily gridded MODIS 500m land surface reflectance time series

  => globally map 500m location and approximate day of burning
Conceptual Scheme

Algorithm

Background

\[ \hat{\rho}_{(t|t-1)} > \text{predicted} \]

BRDF Inversion window
Conceptual Scheme

Algorithm

Background
Conceptual Scheme

Algorithm

Background
• Burned Area algorithm run **globally** for first time in MODIS C5 - purposefully running to map burned areas conservatively

• **Product QA and Testing underway** to incrementally improve product and reduce the impact of known issues throughout C5 …
MODIS Burned Area

C5 Global Evaluation

Inter-Comparison with MODIS 1km Active Fire Detections
Scatter plot of proportion of active fire against proportion burned area detected in 40km x 40km cells. Robust (Theil Sen) regression line is plotted in red; the white blue logarithmic color scale represents the point density distribution of the scatter plot.

- **0% <= Tree Cover <= 10%**
  - 61,523 cells
  - mean tree cover = 3.84%
  - Slope = 0.173
  - Intercept = 0.002
  - \( r = 0.71 \)

*Global Evaluation*

*2001-2002*
10% < Tree Cover <= 30%

Proportion Active Fire vs. Proportion Burned Area

417 cells

mean tree cover = 22.5 %

Slope = 0.359
Intercept = 0.006
r = 0.87

Global Evaluation

Global
2001-2002
30% < Tree Cover <= 60%

Proportion Active Fire

Proportion Burned Area

2,197 cells
mean tree cover = 43.2%
Slope = 0.562
Intercept = 0.006
r = 0.65
Global
2001-2002

Global Evaluation
60% < Tree Cover <= 100%

1,403 cells
mean tree cover = 76.2 %

Slope = 2.276
Intercept = 0.002
r = 0.67

Global
2001-2002
Proportion Active Fire vs Proportion Burned Area

- **Range:** $0 < \text{LAI} \leq 1$

**Statistics:**
- **Cells:** 49,798
- **Mean LAI:** 0.498
- **Slope:** 0.225
- **Intercept:** 0.003
- **Correlation:** $r = 0.67$

**Global Evaluation 2001-2002**
$1 < \text{LAI} \leq 2.5$

- 15,762 cells
- Mean LAI = 1.67
- Slope = 0.351
- Intercept = 0.006
- $r = 0.80$

Proportion Active Fire vs. Proportion Burned Area

Global Evaluation

2001-2002
2.5 < LAI <= 5

1,224 cells
mean LAI = 3.35
Slope = 0.371
Intercept = 0.005
r = 0.79

Global
2001-2002
Proportion Active Fire

Proportion Burned Area

LAI > 5

2,855 cells
mean LAI = 6.22
Slope = 1.260
Intercept = 0.003
r = 0.38

Global Evaluation

Global
2001-2002
Pattern Clearly Apparent …

Australia
500m burned areas
1 month 2002

Global Evaluation
Pattern Clearly Apparent ...

Australia
1km active fires
1 month 2002
Brazil,
Southern Para,
500m burned areas
1 month 2002
Brazil, Southern Para, 1km active fires 1 month 2002
And this pattern confirmed for Global Land Cover Analysis

<table>
<thead>
<tr>
<th>Vegetation Class</th>
<th>Burned Area (MCD45) [km²]</th>
<th>Active fires (MOD14) [km²]</th>
<th>Area [km²]</th>
<th>Avg. Unmapped Area MCD45 [%]</th>
<th>Avg. Unmapped Area MOD14 [%]</th>
<th>MCD45 in the class [%]</th>
<th>MOD14 in the class [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evergreen needleleaf forest</td>
<td>1.18E+04</td>
<td>2.54E+04</td>
<td>5.67E+06</td>
<td>73.81%</td>
<td>65.72%</td>
<td>0.32%</td>
<td>0.91%</td>
</tr>
<tr>
<td>Evergreen broadleaf forest</td>
<td>4.84E+04</td>
<td>1.61E+05</td>
<td>1.46E+07</td>
<td>70.00%</td>
<td>46.04%</td>
<td>1.32%</td>
<td>5.80%</td>
</tr>
<tr>
<td>Deciduous needleleaf forest</td>
<td>2.50E+03</td>
<td>8.82E+03</td>
<td>9.59E+05</td>
<td>76.79%</td>
<td>30.22%</td>
<td>0.07%</td>
<td>0.32%</td>
</tr>
<tr>
<td>Deciduous broadleaf forest</td>
<td>8.87E+04</td>
<td>7.86E+04</td>
<td>2.33E+06</td>
<td>34.41%</td>
<td>57.68%</td>
<td>2.42%</td>
<td>2.83%</td>
</tr>
<tr>
<td>Mixed forests</td>
<td>4.87E+04</td>
<td>4.87E+04</td>
<td>6.82E+06</td>
<td>63.13%</td>
<td>24.26%</td>
<td>1.33%</td>
<td>1.75%</td>
</tr>
<tr>
<td>Closed shrublands</td>
<td>3.67E+04</td>
<td>2.14E+04</td>
<td>8.00E+05</td>
<td>26.43%</td>
<td>38.46%</td>
<td>1.00%</td>
<td>0.87%</td>
</tr>
<tr>
<td>Open shrublands</td>
<td>4.19E+05</td>
<td>3.27E+05</td>
<td>2.66E+07</td>
<td>39.97%</td>
<td>17.31%</td>
<td>11.43%</td>
<td>11.78%</td>
</tr>
<tr>
<td>Woody savannas</td>
<td>9.76E+05</td>
<td>7.07E+05</td>
<td>1.10E+07</td>
<td>46.49%</td>
<td>35.30%</td>
<td>26.65%</td>
<td>25.45%</td>
</tr>
<tr>
<td>Savannas</td>
<td>1.37E+06</td>
<td>8.10E+05</td>
<td>1.02E+07</td>
<td>32.30%</td>
<td>30.24%</td>
<td>37.40%</td>
<td>29.15%</td>
</tr>
<tr>
<td>Grasslands</td>
<td>3.46E+05</td>
<td>2.03E+05</td>
<td>1.35E+07</td>
<td>45.41%</td>
<td>20.10%</td>
<td>9.46%</td>
<td>7.30%</td>
</tr>
<tr>
<td>Croplands</td>
<td>2.76E+05</td>
<td>3.43E+05</td>
<td>1.61E+07</td>
<td>44.20%</td>
<td>26.02%</td>
<td>7.53%</td>
<td>12.35%</td>
</tr>
<tr>
<td>Barren or sparsely vegetated</td>
<td>3.71E+04</td>
<td>2.58E+04</td>
<td>2.21E+07</td>
<td>15.51%</td>
<td>23.86%</td>
<td>1.01%</td>
<td>0.93%</td>
</tr>
<tr>
<td>Other</td>
<td>7.60E+03</td>
<td>2.68E+04</td>
<td>3.63E+06</td>
<td>67.46%</td>
<td>56.81%</td>
<td>0.23%</td>
<td>0.97%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3.66E+06</strong></td>
<td><strong>2.78E+06</strong></td>
<td><strong>1.31E+08</strong></td>
<td><strong>42.96%</strong></td>
<td><strong>29.82%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
C5 Burned Area Product Validation
Burned Area Product Validation Protocol

- Compare MODIS burned area product with independent spatially explicit burned area data derived from multitemporal Landsat ETM+ data

- SAFNet field trip held to develop the mapping protocol and to discuss southern African fire information needs, Zimbabwe-Zambia, July 2000

- SAFNet members map the areas burned between 2+ Landsat acquisitions, augmented by limited fieldwork

- Consensus mapping protocol to ensure regionally consistent independent validation data

- Protocol followed 2000-2002 at ~11 ETM+ scenes/year

Landsat ETM+ validation scenes distributed from dry savanna to wet miombo woodland to quantify product accuracy over range of representative biomass burning conditions.

**MODIS 1km land cover product:** 
of the 17 MODIS land cover classes, predominant classes illustrated include: evergreen broadleaf forest (dark green), barren or sparsely vegetated (gray), woody savannas (light green), open shrublands (cream), grasslands (light brown), savannas (orange), croplands (yellow), cropland/natural vegetation mosaic (olive brown), urban (red).
All MODIS C5 Data (294148 km^2)
R^2 = 0.746  n = 11719  y = -0.005 + 0.75 x^1

Africa
2001
5km x 5km
grid cells

Validation
C5 Burned Area Product Inter-Comparsion

L3JRC – SPOT VEGETATION 1km
GLOBCARBON -
GlobCarbon - A/S/O 2001

Inter-comparison
All L3JRC Data (294851 km$^2$)
R$^2 = 0.128$  n = 11747  $y = 0.001 + 0.136 x^1$

Africa
2001

5km x 5km
grid cells

Inter-comparison
All GlobCarbon Data (294851 km\(^2\))
\[ R^2 = 0.509 \quad n = 11747 \quad y = 0.013 + 0.595 x^{1} \]

Africa
2001

5km x 5km grid cells
All MODIS C5 Data (294148 km^2) 
R^2 = 0.746  n = 11719  y = -0.005 + 0.75 x^1

Africa 2001
5km x 5km grid cells
Product Validation Plan

• To Validation Stage 2
  – emphasis on sampling a range of continentally representative conditions
  – including where the burned area product has apparent limitations, i.e., in regions with high forest cover, high LAI, and in croplands.

• Europe – partnership with JRC-EC

• Australia – in progress (GOFC)

• Southern Africa – Done - SAFNET

• Boreal – in progress

• South America – INPE & Imazon collaboration

• China – planning

• India – planning
Collection 6 planned improvements
C5 monthly burned area (MCD45) product

Greece
August 2007
Example refinement
C5 monthly burned area (MCD45) product

Greece August 2007
1. What changes (if any) do you feel are important to make to your algorithm?
   i. Fix a bug handling Aqua data in concert with Terra in the intermediate product (MCD45A2).
   ii. Potential improvement to MOD/MYDHDFSR handling of MOD09 cloud and aerosol bits & masking. (Note we are responsible for MOD/MYDHDFSR). Benefit from new Land Water mask
   iii. Introduce Active Fire (MOD14A1) data to refine the output of the intermediate product (MCD45A2) to give a more robust final product (MCD45A1) – collaboration with L. Giglio.

2. What upstream algorithm changes would your algorithm benefit from?
   i. Any upstream changes to the content of MOD09 L2G (full) including reflectance, aerosols, and clouds will necessitate a reprocessing for the burned area algorithm.
   ii. Any changes to MOD09 L2G (full) structure, this is used to generate MOD/MYDHDFSR, will certainly need through testing.
   iii. Potential improvement to MOD/MYDHDFSR handling of MOD09 cloud and aerosol bits & masking.

3. Based on 1 and 2, what are the significant scientific benefits from a C6 reprocessing for your algorithm?
   An improved product; C5 is the first time we have run the burned area algorithm globally, preliminary testing shows that the accuracy of the results can be significantly improved.

4. Are there any other changes, such as product format changes, that are also needed? Why?
   For Collection 6 we plan to introduce an annual 500m summary product.
Thanks