Where are the Missing Burned Areas?
Global Hotspots of Burned Area - A Multiresolution Analysis

David Roy a, b, Haiyan Huang a, Luigi Boschetti c, Hugo De Lemos a, Louis Giglio d

a Center for Global Change and Earth Observations (CGCEO), Michigan State University
b Department of Geography, Environment, and Spatial Sciences, Michigan State University
c College of Natural Resources, University of Idaho
d Department of Geographical Sciences, University of Maryland, College Park

NASA LCLUC Science Team Meeting, May 8-12th, College Park, MD, USA
The definitive global burned area record:

NASA MODIS 500m burned area product

Giglio, Boschetti, Roy, Humber, Justice, 2018, RSE
Mean Burned Area mapped by NASA MODIS 500m product for 2002-2021

on average 2.7% of the land surface reported as burned each year

Paper in Preparation
Mean Burned Area mapped by NASA MODIS 500m product for 2002-2021

on average 2.7% of the land surface reported as burned each year

Well established that MODIS under-reports small burns …

But where and when? Are there hot-spots?
Under-reporting example

August 24th 2001

Road North to the Chimaliro forest reserve, Malawi

miombo woodland reserve - the hilly area on the horizon
September 26th 2001, Chimaliro forest reserve

MODIS 500 m pixels (1.65μm, 1.24μm, 0.86μm)

31km x 23km
September 26th 2001, Chimaliro forest reserve

Landsat 30 m pixels (1.65 μm, 0.82 μm, 0.66 μm)

31km x 23km
Quantifying small burns is rather important for applications and science!

Global burned area and biomass burning emissions from small fires

J. T. Randerson, Y. Chen, G. R. van der Werf, B. M. Rogers, D. C. Morton

First published: 11 December 2012

“Accounting for small fires increased total global burned area by ~35%, but a formal quantification of uncertainties was not possible … “
Under our previous NASA LCLUC funding:

**Africa 30 m**

**NASA Harmonized Landsat Sentinel-2 (HLS)**

**Burned Area Product Generation**

Landsat 8 and Sentinel S2
same day
• 30 m gridded
• atmospherically corrected
• near-global coverage
• global median revisit 3 days

New opportunity for monitoring land surface change at scales where human activity is discernable
Sentinel-2 & Landsat-8 30 m Burned Area

Jan 2019

2861
109 x 109 km HLS tiles
Sentinel-2 & Landsat-8 30 m Burned Area

June 2019

2861 109 x 109 km HLS tiles
Sentinel-2 & Landsat-8 30 m Burned Area

Aug 2019

2861 109 x 109 km HLS tiles
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**Task #1** Identify global hot-spots of burned areas, specifically where the burns are missing at MODIS 500 m resolution.

**Task #2** Map the burned area in the identified hot-spots at 30 m resolution.

**Task #3** Validate the 30 m burned area hot-spot mapping results using contemporaneous 3m PlanetScope data.

**Task #4** Provide the hot-spot 30 m burned area maps and 3 m PlanetScope validation data to the public.

**Task #5** Quantify the global MODIS 500 m burned area product underestimation due to its omission of small burns.
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Well established that thermal λ active fire detection algorithms can detect small fires not apparent in reflective λ data.
Hot-spot selection approach

- Spatial stratification
  - HLS 109 x 109 km tile grid
  - 7 biome global map

- Temporal stratification
  - calendar months

- Rank the HLS tiles in each month by the proportion of VIIRS 375 m active fire detections occurring outside 500 m MODIS burned areas
All 12 months of 2019

Top 1000 hot-spots with greatest incidence of VIIRS 375 m active fire detections outside of MODIS 500 m burned areas (different number selected per biome using a biome area proportional allocation)
January 2019

Of the 1000 the **top 110 hot-spots** with greatest incidence of VIIRS 375 m active fire detections outside of MODIS 500 m burned areas
January 2019

Top 110 hot-spots with greatest incidence of VIIRS 375 m active fire detections outside of MODIS 500 m burned areas

August 2019

Of the 1000 the top 136 hot-spots with greatest incidence of VIIRS 375 m active fire detections outside of MODIS 500 m burned areas
• We have generated monthly ranked hot-spot lists with 1000s of entries per month (as there are >18,000 HLS land tiles)

• Final ones used (for Tasks #2-5) depend on HLS and PlanetScope availability
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HLS 30 m burned area

Jan 2019

109 x 109 km HLS tiles
center at 6.70°N, 18.77°E

Example selected hot-spot tile
MODIS 500 m
burned area

Jan 2019

109 x 109 km HLS tiles
center at 6.70°N, 18.77°E

Example selected hot-spot tile
HLS 30 m burned area

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PlanetScope constellation average revisit interval analysis
Roy, Huang, Houborg, Martins, RSE, 2021

Global median PlanetScope revisit 30.3 hours!

- ~200 sensors
- ~3m
- blue / green / red / NIR \( \lambda \)
Isalo National Park
Madagascar

630 nm
820 nm
545 nm

surface reflectance

15.4 × 10.7 km
5134× 3568 3 m pixels

July 16th 2019
Used Landsat-8 two date image pairs interpreted into burned, unburned, and unmapped classes

(Landsat-8 interpreted data used previously to validate the MODIS burned area product)

for transfer learning to PlanetScope
PlanetScope 2019 July 5th

25 km × 11.5 km, 3m pixels
PlanetScope 2019 July 6th

25 km × 11.5 km, 3m pixels
Deep learning burned area classification

25 km × 11.5 km, 3m pixels
Detailed HLS burned area validation example

6.9 x 5.3 km
Mexico province, Angola
Detailed HLS burned area validation example

6.9 x 5.3 km Moxico province, Angola
This year we updated the Deep Learning Model with active learning derived training data

Use active learning / deep learning to efficiently derive large training data sets from PlanetScope time series
Singida, Tanzania (6°52'10.98" S, 34°51'37.76" E)
17 km × 10 km, 3m pixels
Singida, Tanzania (6°52'10.98" S, 34°51'37.76" E)
17 km × 10 km, 3m pixels
Published deep learning model results

Singida, Tanzania (6°52'10.98" S, 34°51'37.76" E)
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Updated deep learning model results

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• We have generated monthly ranked HLS tile hot-spot lists

• Currently searching through the entries considering the highest ranked (i.e. greatest incidence of VIIRS 375 m active fire detections outside of MODIS 500 m burned areas) to find locations where both HLS and PlanetScope imagery are available
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• **Task #5**  Quantify the global MODIS 500 m burned area product underestimation due to its omission of small burns.  Exciting pay-off
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THANKS