Africa Burned Area Product Generation with Landsat-8 and Sentinel-2 and testing the use of high resolution Planetscope imagery

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University of Idaho

2020 NASA LCLUC Annual Science Team Meeting
October 19th 2020

Department of Geography, Environment, and Spatial Sciences
MICHIGAN STATE UNIVERSITY

NASA

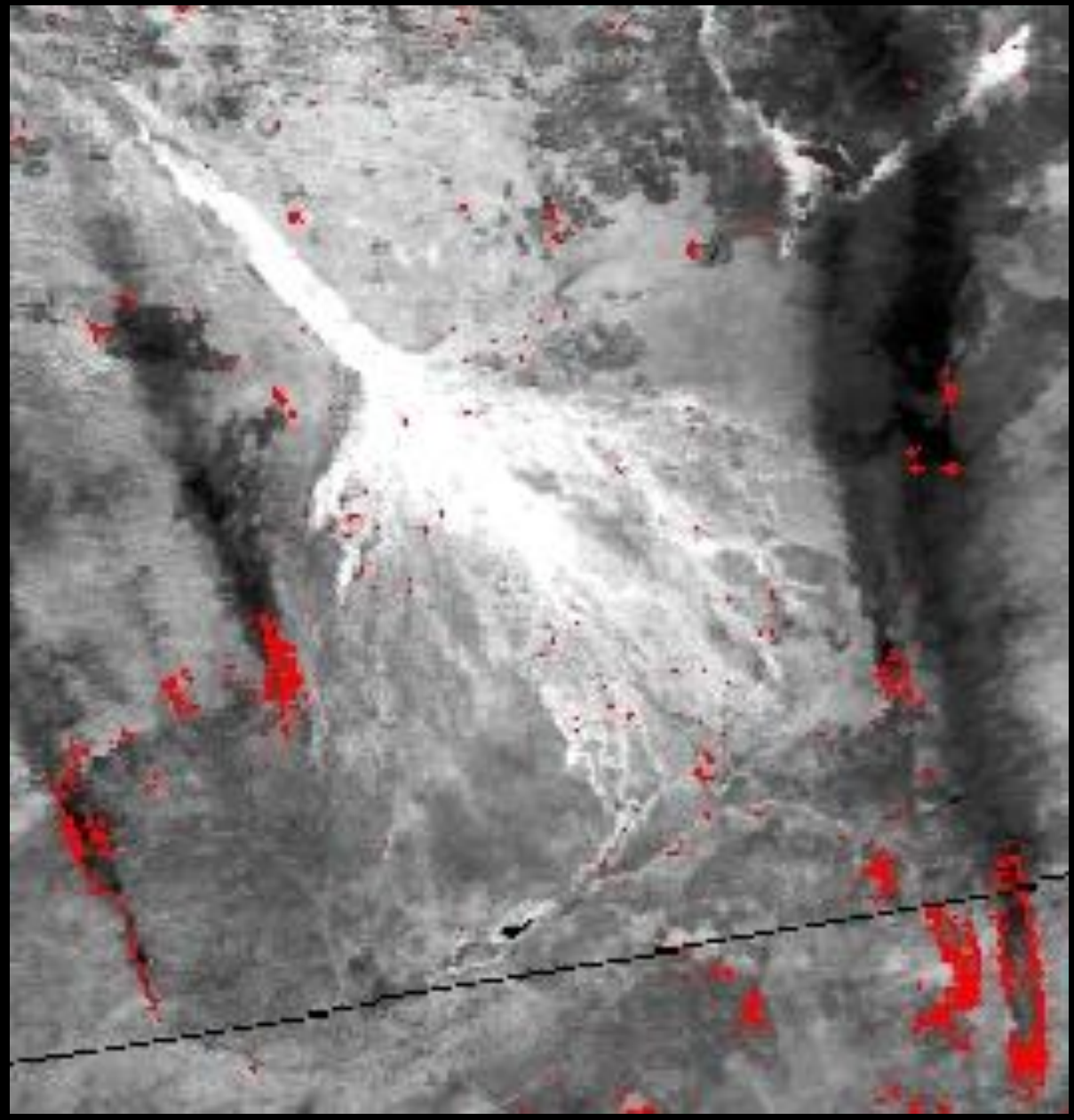
AVHRR

1km NDVI

active fire detections

Red dots don’t provide reliable burned area

Okavango Delta, Botswana, Sept 6th 1989



Roy, Giglio, Kendal, Justice, 1999, *IJRS*

AVHRR

Science of Remote Sensing 2 (2020) 100007

Contents lists available at ScienceDirect

Science of Remote Sensing

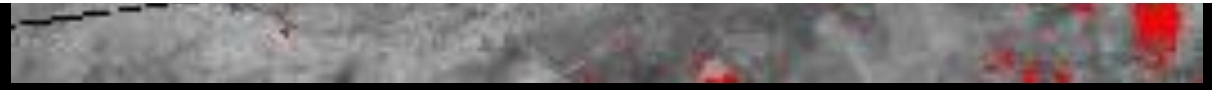
journal homepage: www.journals.elsevier.com/science-of-remote-sensing

Full Length Article

On the outstanding need for a long-term, multi-decadal, validated and quality assessed record of global burned area: Caution in the use of Advanced Very High Resolution Radiometer data

L. Giglio [a,*], D.P. Roy [b]

[a] Department of Geographical Sciences, University of Maryland, College Park, MD, 20742, USA
[b] Center for Global Change and Earth Observations, and Department of Geography, Environment, & Spatial Sciences, Michigan State University, East Lansing, MI, 48824, USA



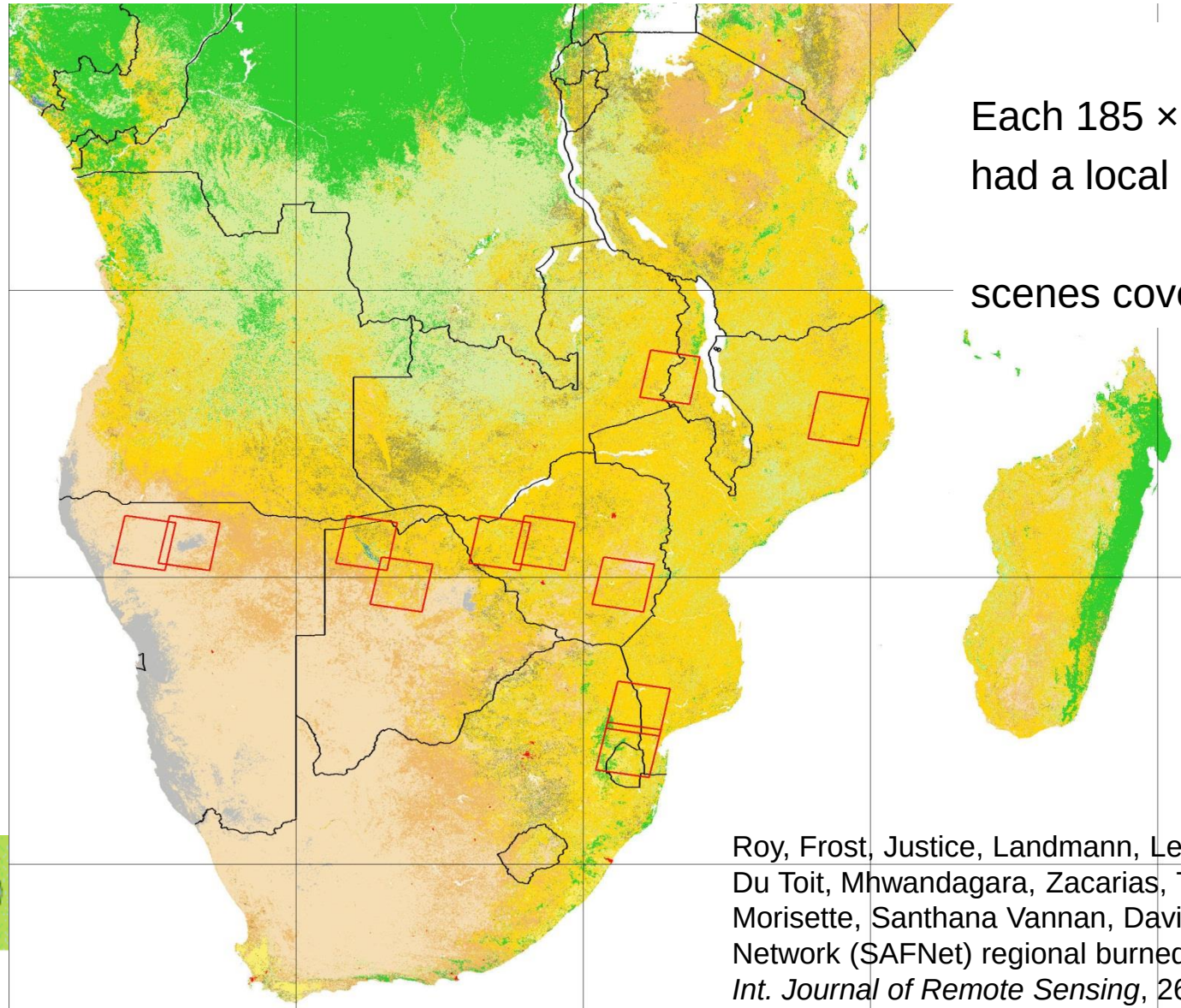
Roy, Giglio, Kendal, Justice, 1999, *IJRS*

Movie:

5 Months of 500m MODIS mapped burning, Okavango Delta, Botswana

Roy, Lewis, Justice, *RSE,* 2002

MODIS Burned Area Product Validation undertaken at 12 Landsat ETM+ scenes distributed from dry savanna to wet miombo woodland to quantify product accuracy over range of representative burning conditions -> became the CEOS protocol for burned area product



Each 185 × 185 km ETM+ scene had a local SAFNet collaborator

scenes cover 3% of southern Africa

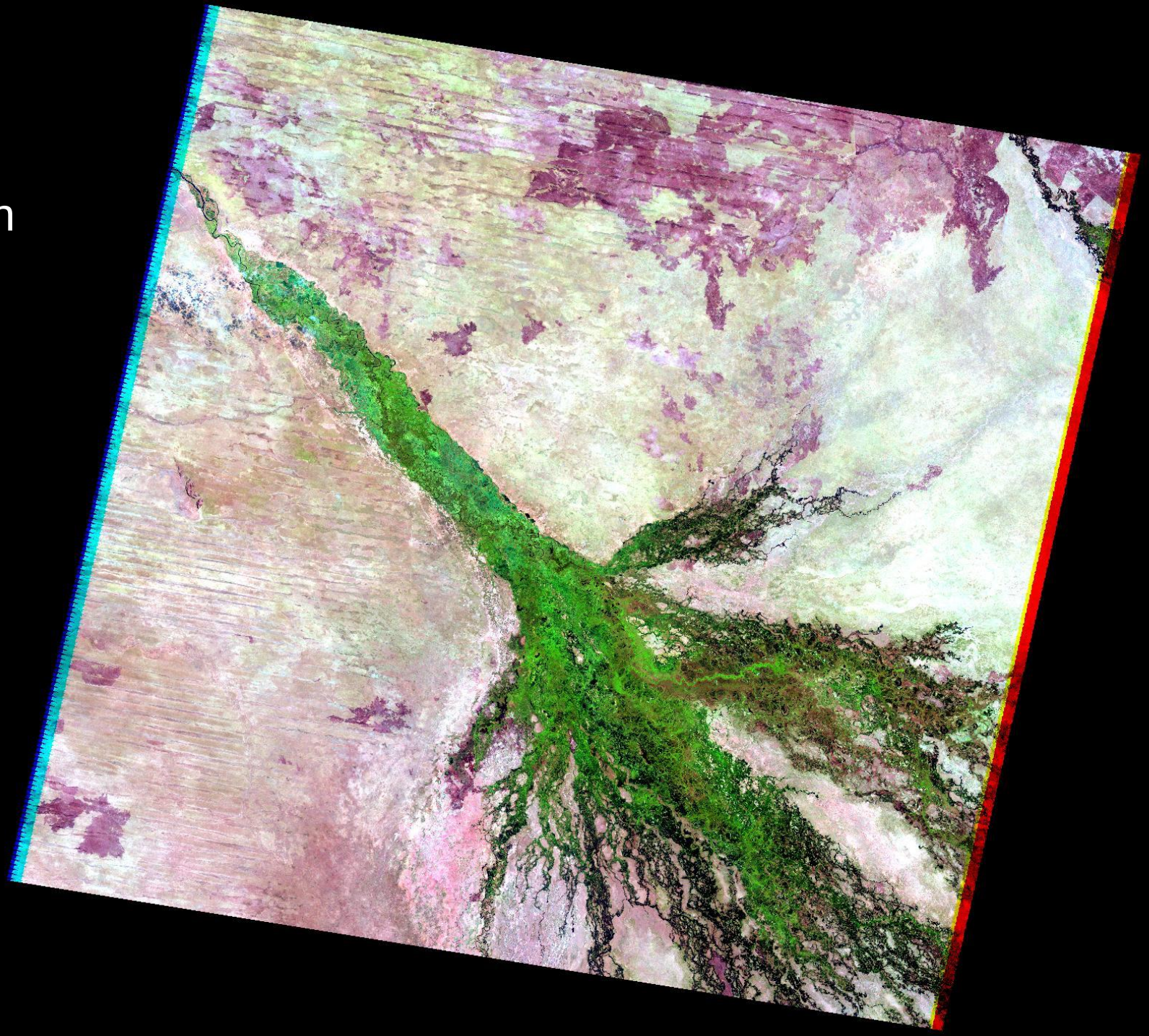
S A F Net

GOFC-GOLD

Roy, Frost, Justice, Landmann, Le Roux, Gumbo, Makungwa, Dunham, Du Toit, Mhwandagara, Zacarias, Tacheba, Dube, Pereira, Mushove, Morisette, Santhana Vannan, Davies, 2005, The Southern Africa Fire Network (SAFNet) regional burned area product validation protocol, *Int. Journal of Remote Sensing*, 26, 4265-4292.

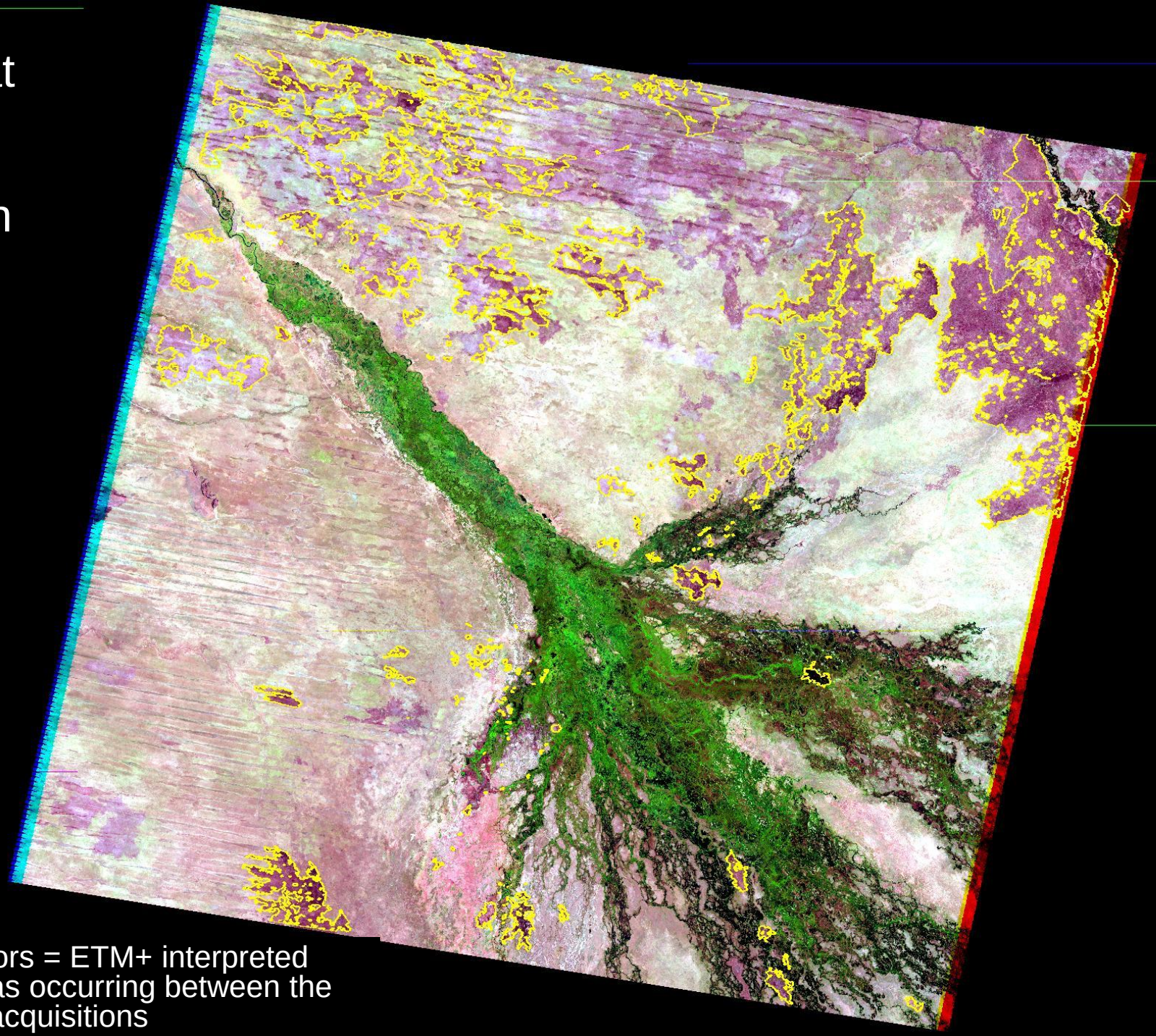
Landsat
ETM+

Sept. 4th



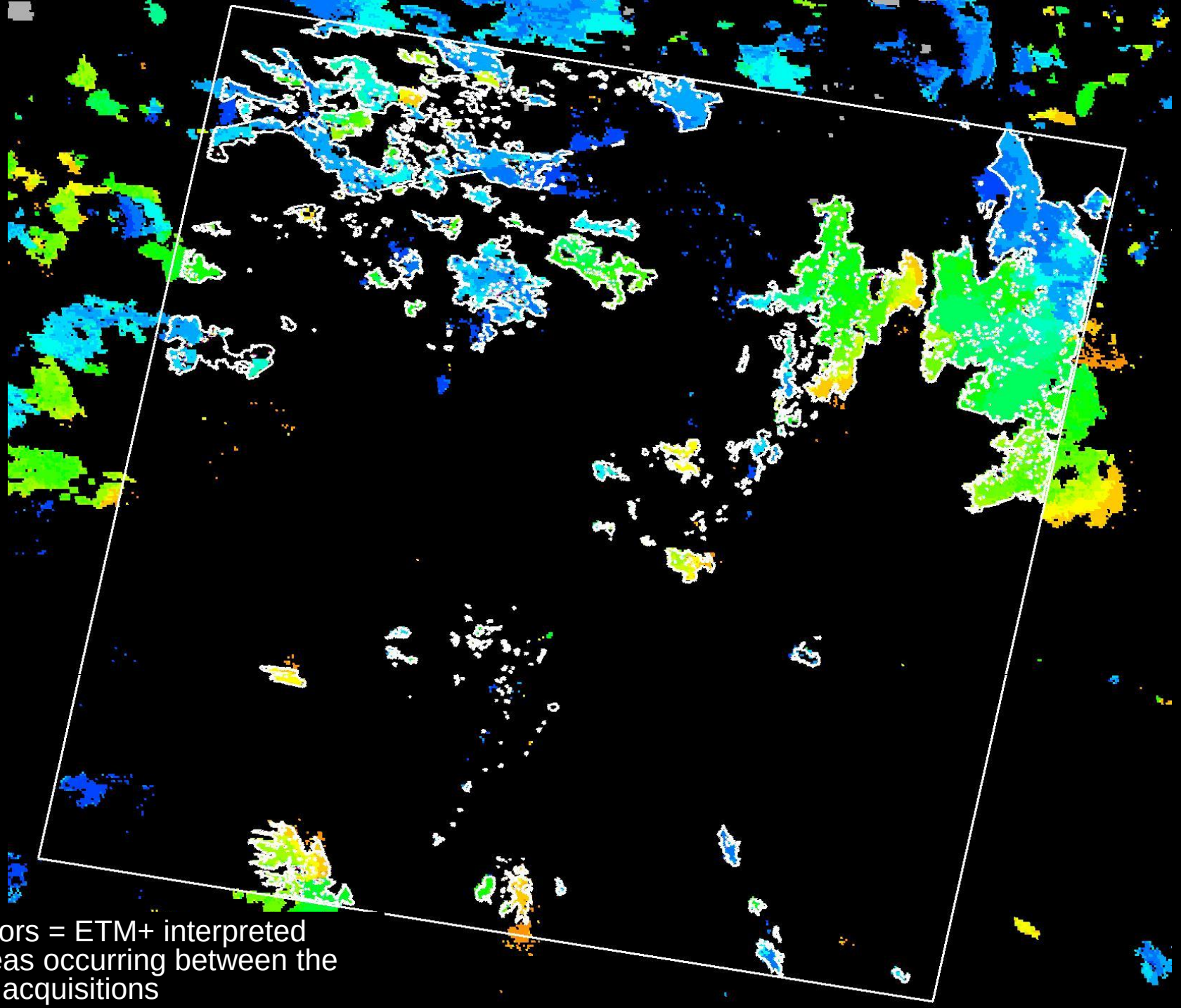
Landsat
ETM+

Oct. 6th



Yellow vectors = ETM+ interpreted burned areas occurring between the two ETM+ acquisitions

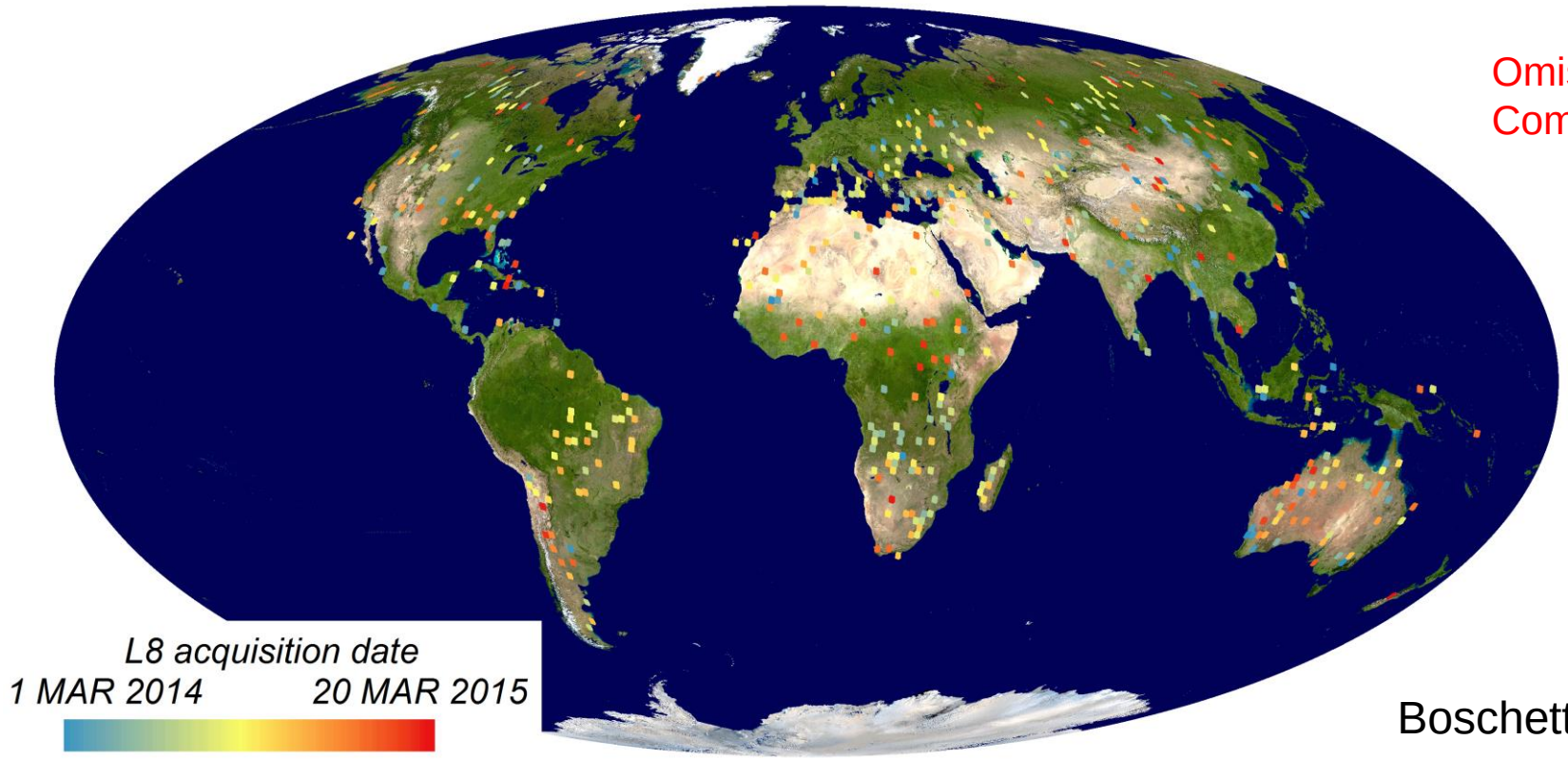
Colors show approximate day of burning mapped at 500 m by MODIS between the two Landsat ETM+ acquisition dates



White vectors = ETM+ interpreted burned areas occurring between the two ETM+ acquisitions

NASA MODIS Collection 6 500 m Burned Area Product Global Validation

following CEOS protocol: comparison with burned area maps interpreted from 558 Landsat-8 two date image pairs



Omission Error (0-1) = 0.73
Commission Error (0-1) = 0.40

Boschetti, Roy, Giglio, et al. *RSE*, 2019

Giglio, Boschetti, Roy, et al. *RSE*, 2018

JOURNAL OF GEOPHYSICAL RESEARCH
Biogeosciences
AN AGU JOURNAL

JGR

Explore this journal >

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

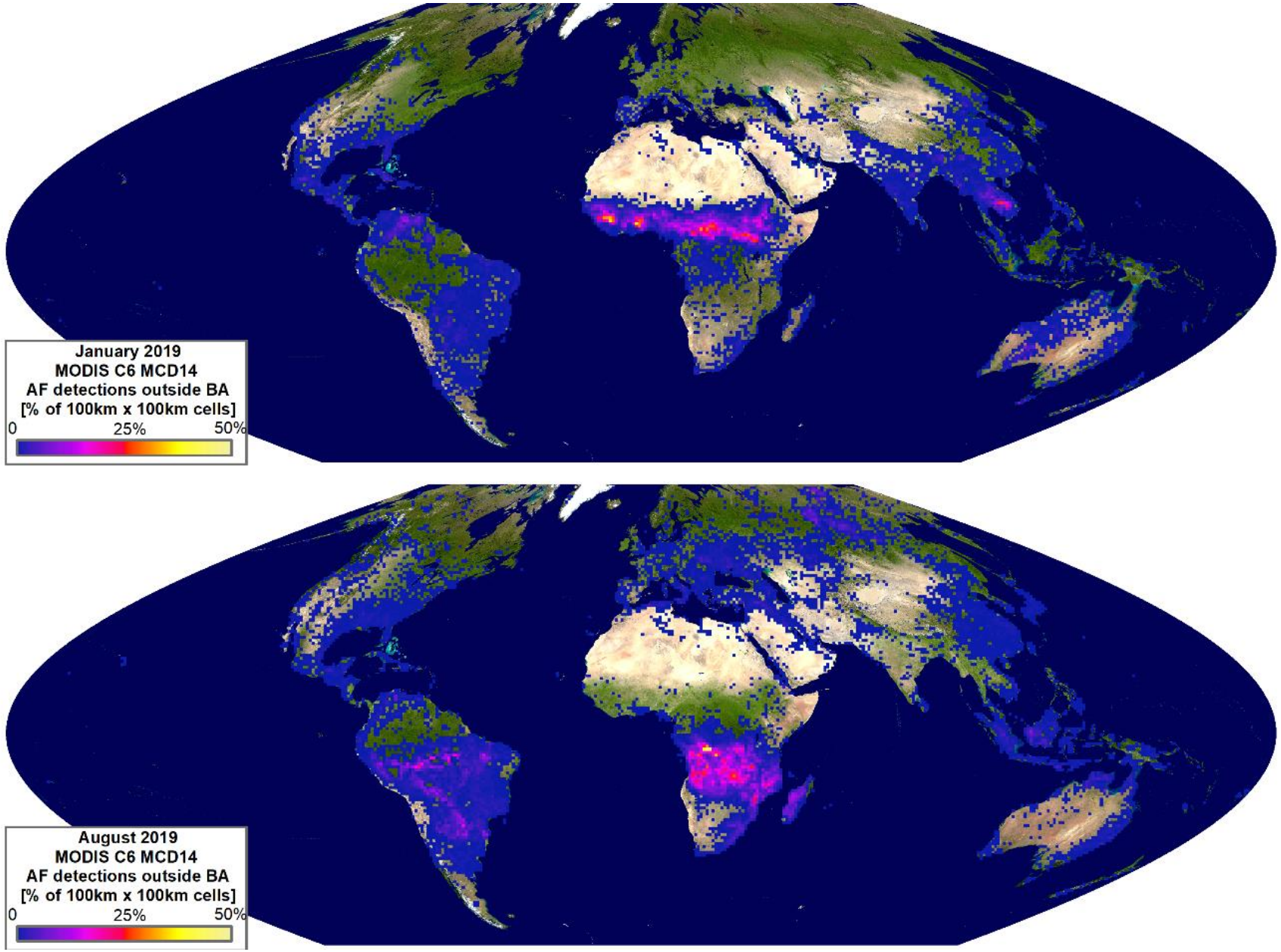
First published: 11 December 2012 Full publication history

DOI: 10.1029/2012JG002128 View/save citation

Accounting for small fires increased total global burned area by ~35%, from 345 Mha/yr to 464 Mha/yr

“A formal quantification of uncertainties was not possible …”

Where & When are the missing small fires occurring ?

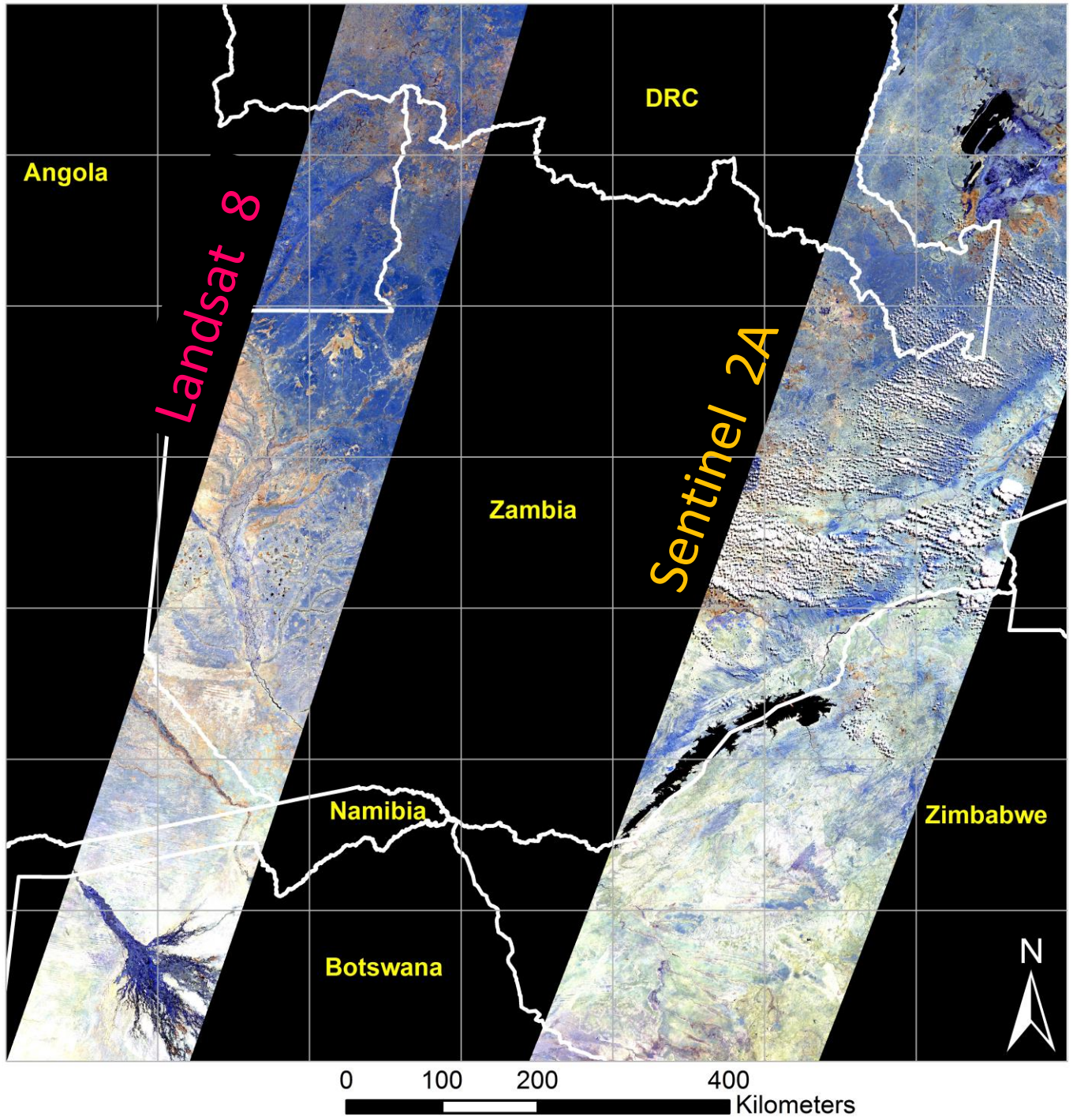


Harmonized Landsat Sentinel-2

Home | Algorithms | Products Description | Test Sites | Data | QA | Documents | News

Landsat 8

MODIS tile h20v10



Number of cloud-free observations July 2016

Landsat 8

Sentinel-2A

1

2

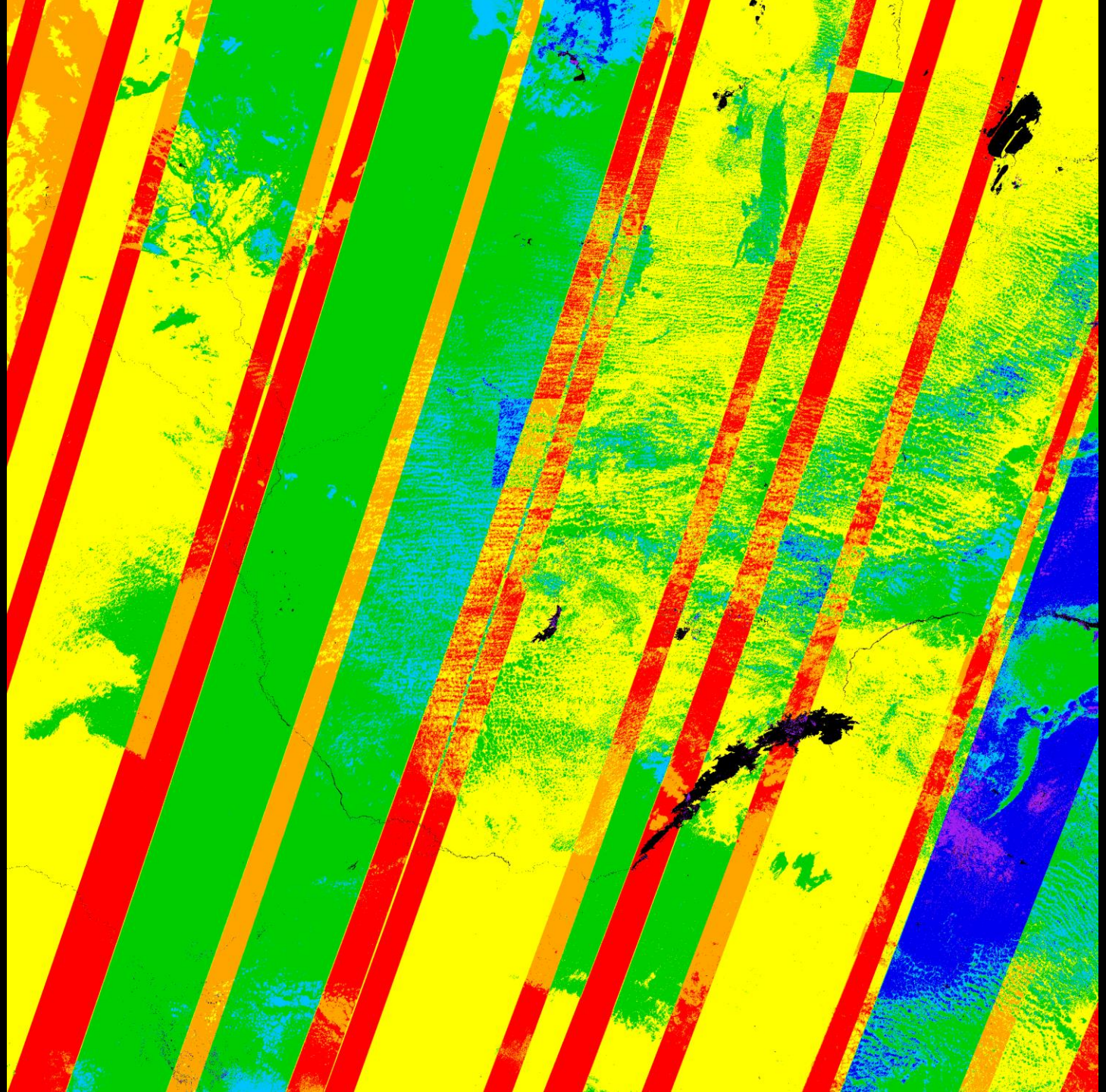
3

4

median 5

6

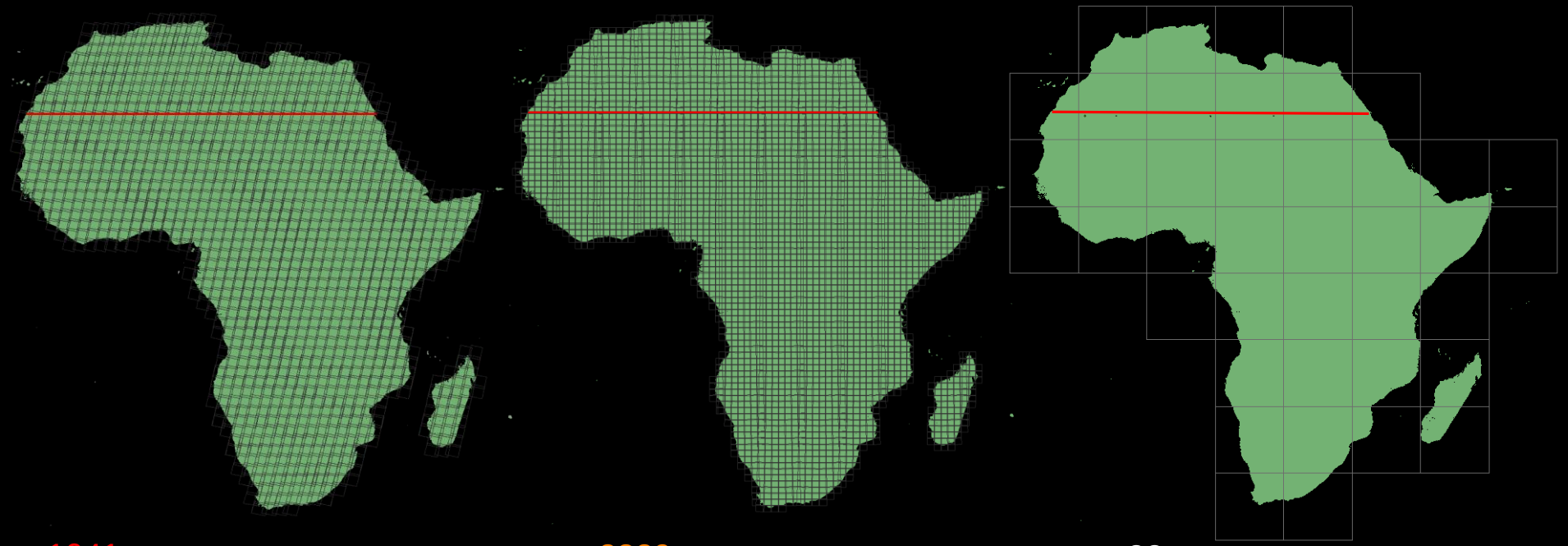
≥7



MODIS tile h20v10

NASA LCLUC Multi-Source Land Imaging (MuSLI)

30 m Burned Area Production: all of Africa, including Madagascar, south of the Tropic of Cancer (23.44° N)



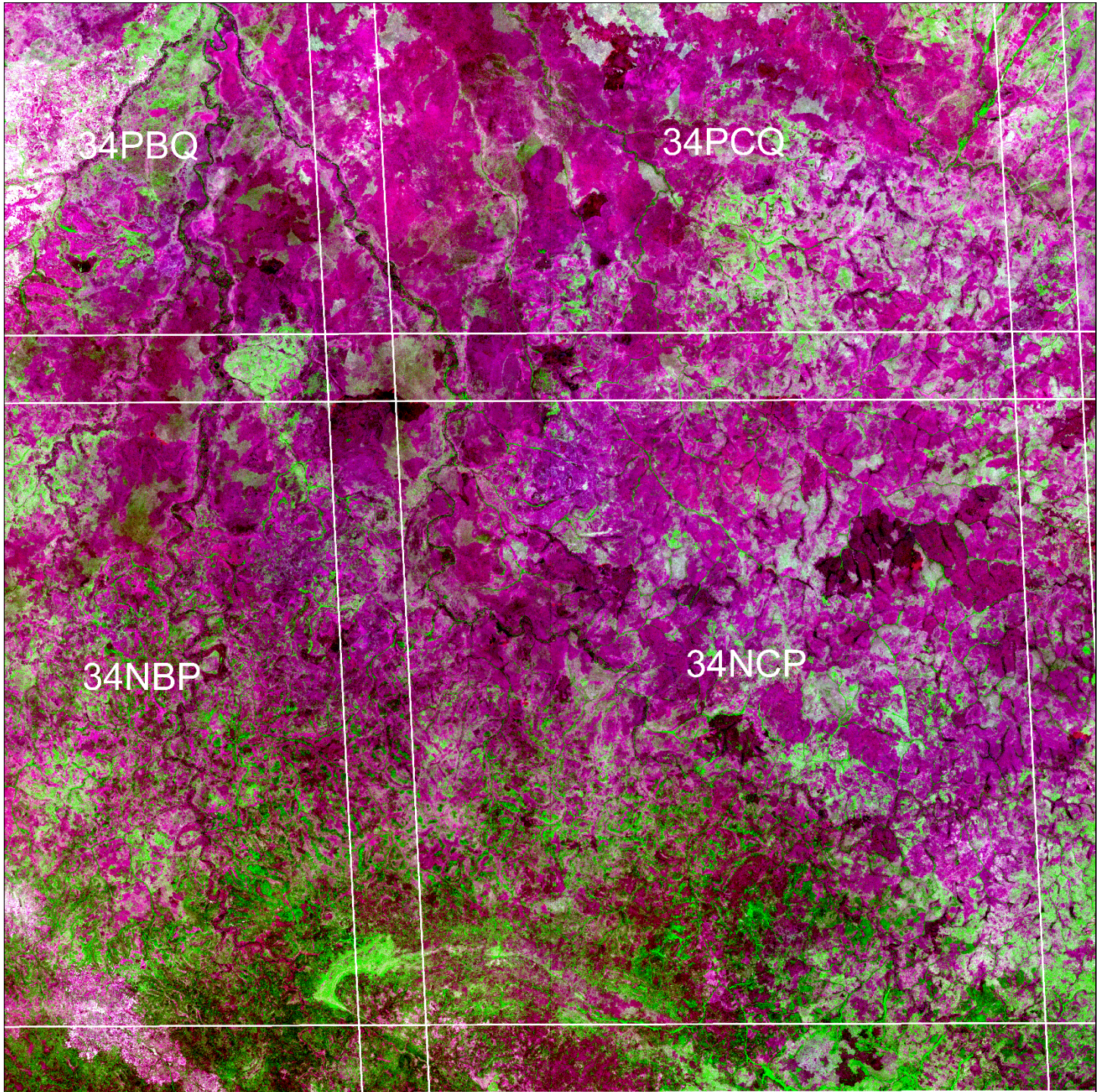
1041
Landsat-8 Collection 1
WRS-2 path/rows (UTM)

2829
Sentinel-2
L1C tiles (UTM)

33
MODIS
Tiles (sinusoidal)

NASA
HLS 30 m surface NBAR
(2.2, 0.86, 0.66 μm)

burned areas apparent in magenta

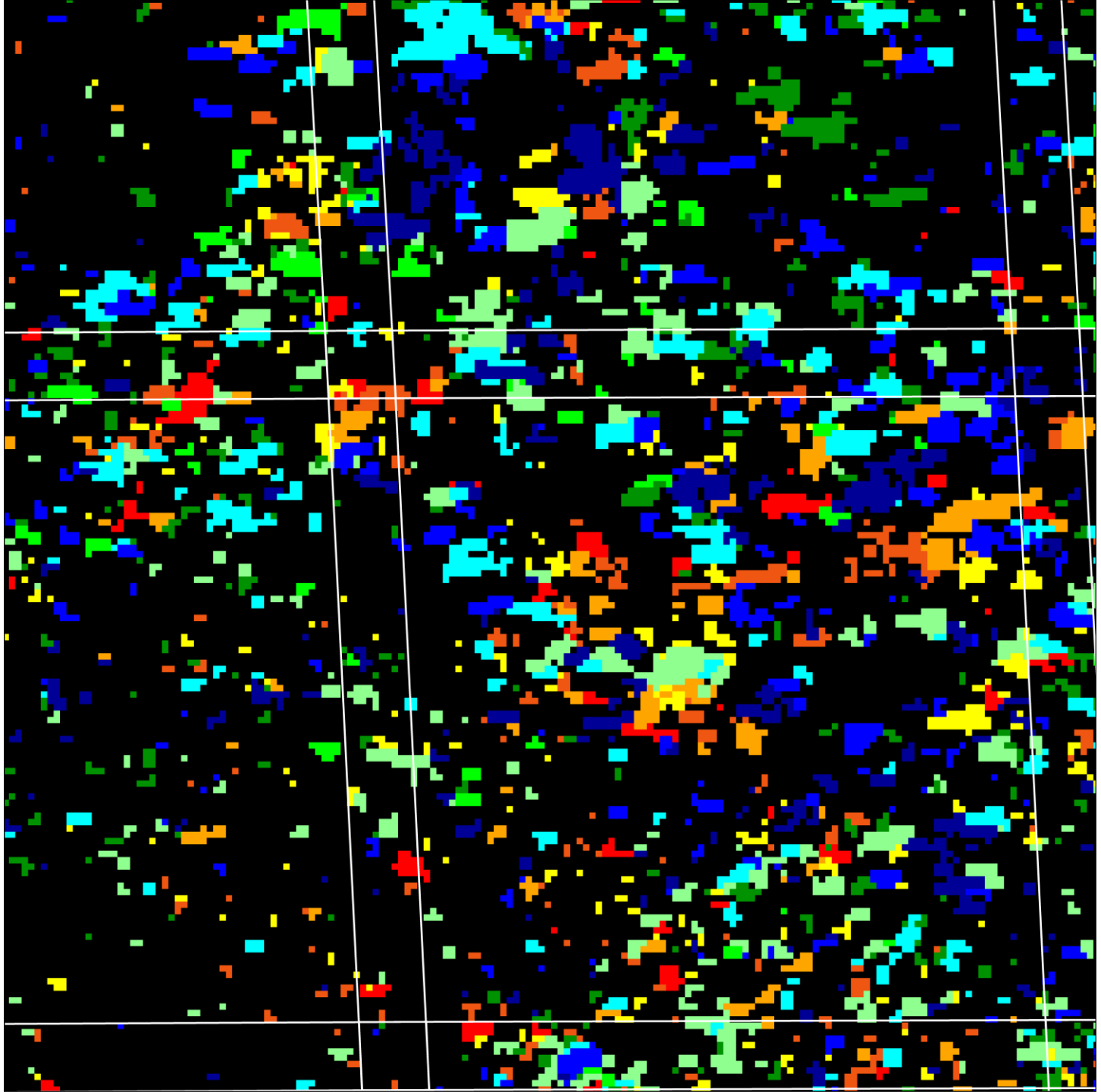


109 x 109 km
HLS tiles

January 28th 2019

Central African Republic

MODIS 1 km active fire detections
(Terra & Aqua, Day & Night)

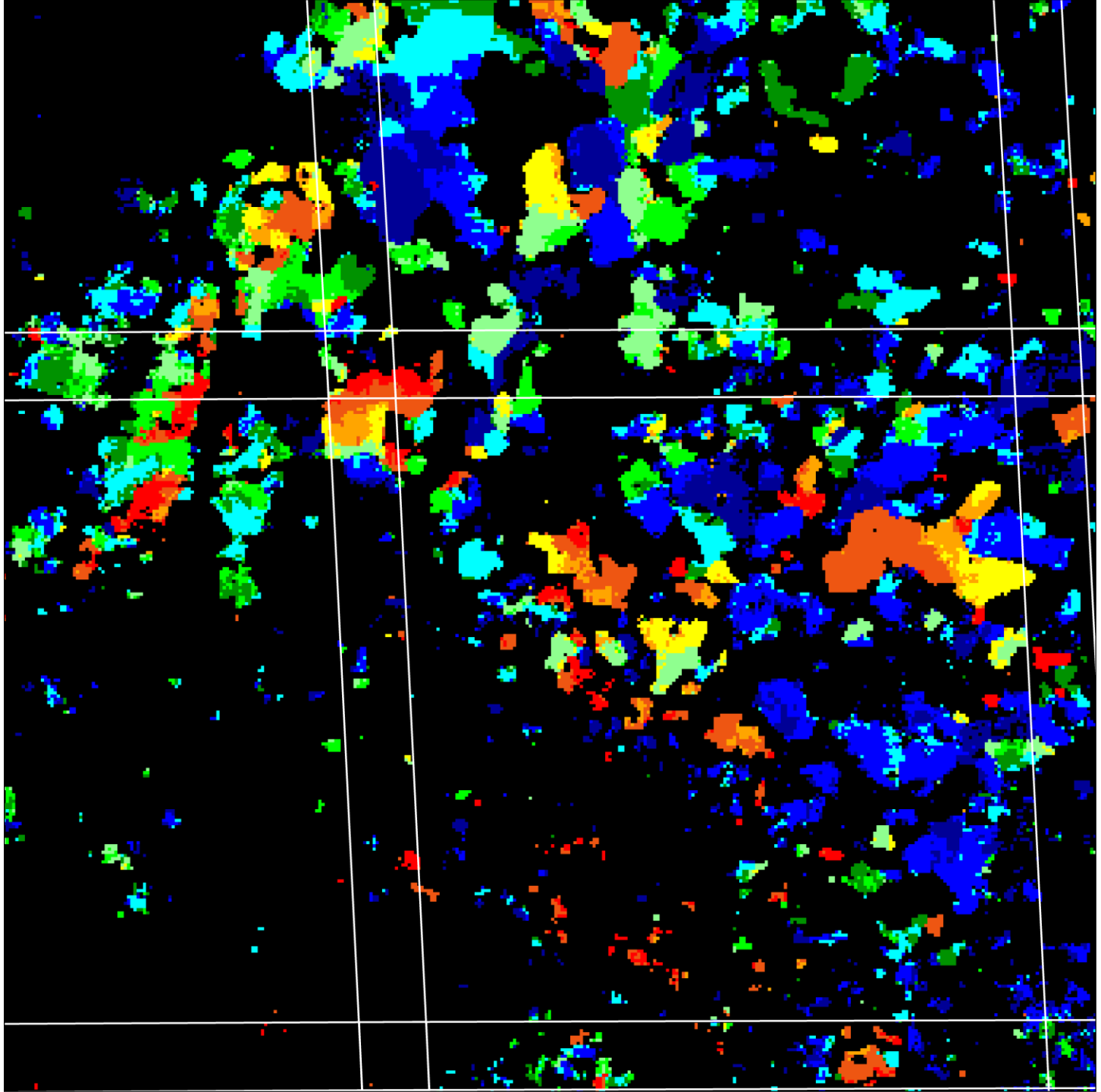


109 x 109 km
HLS tiles

January 2019

Central African Republic

MODIS 500 m
Burned area product

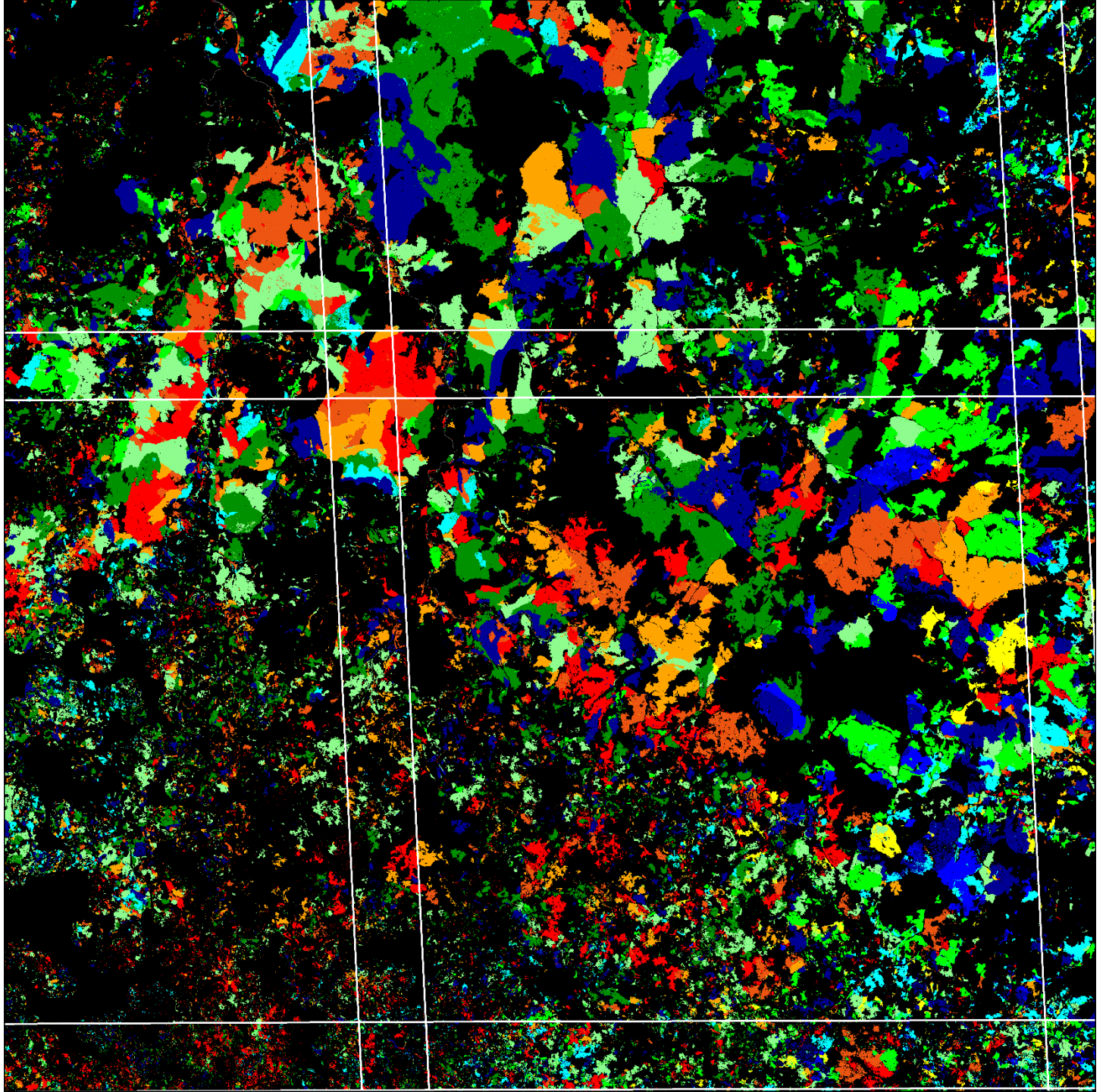


109 x 109 km
HLS tiles

January 2019

Central African Republic

30 m Burned area product derived from HLS

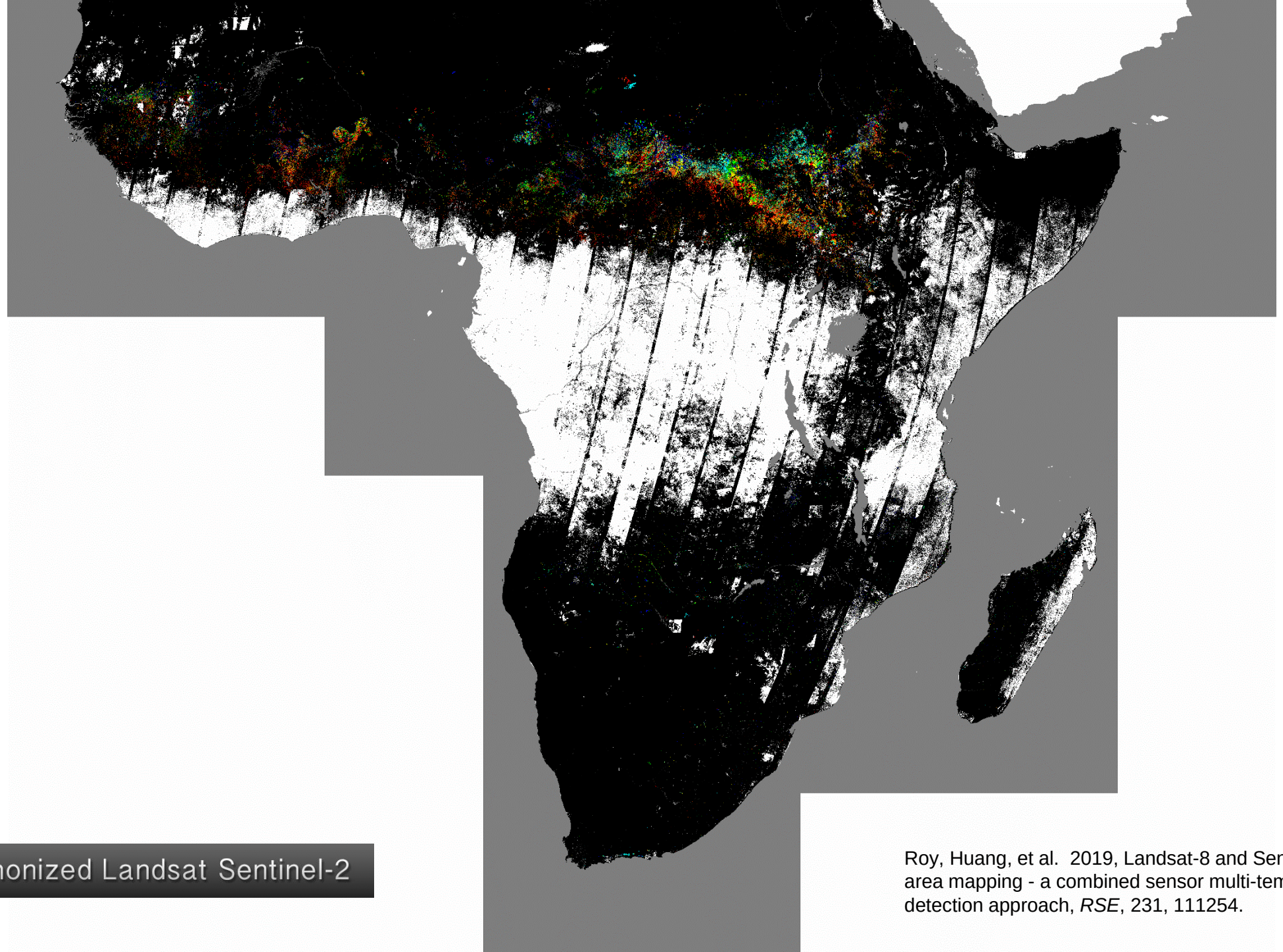


109 x 109 km
HLS tiles

January 2019

Central African Republic

Nov 2018

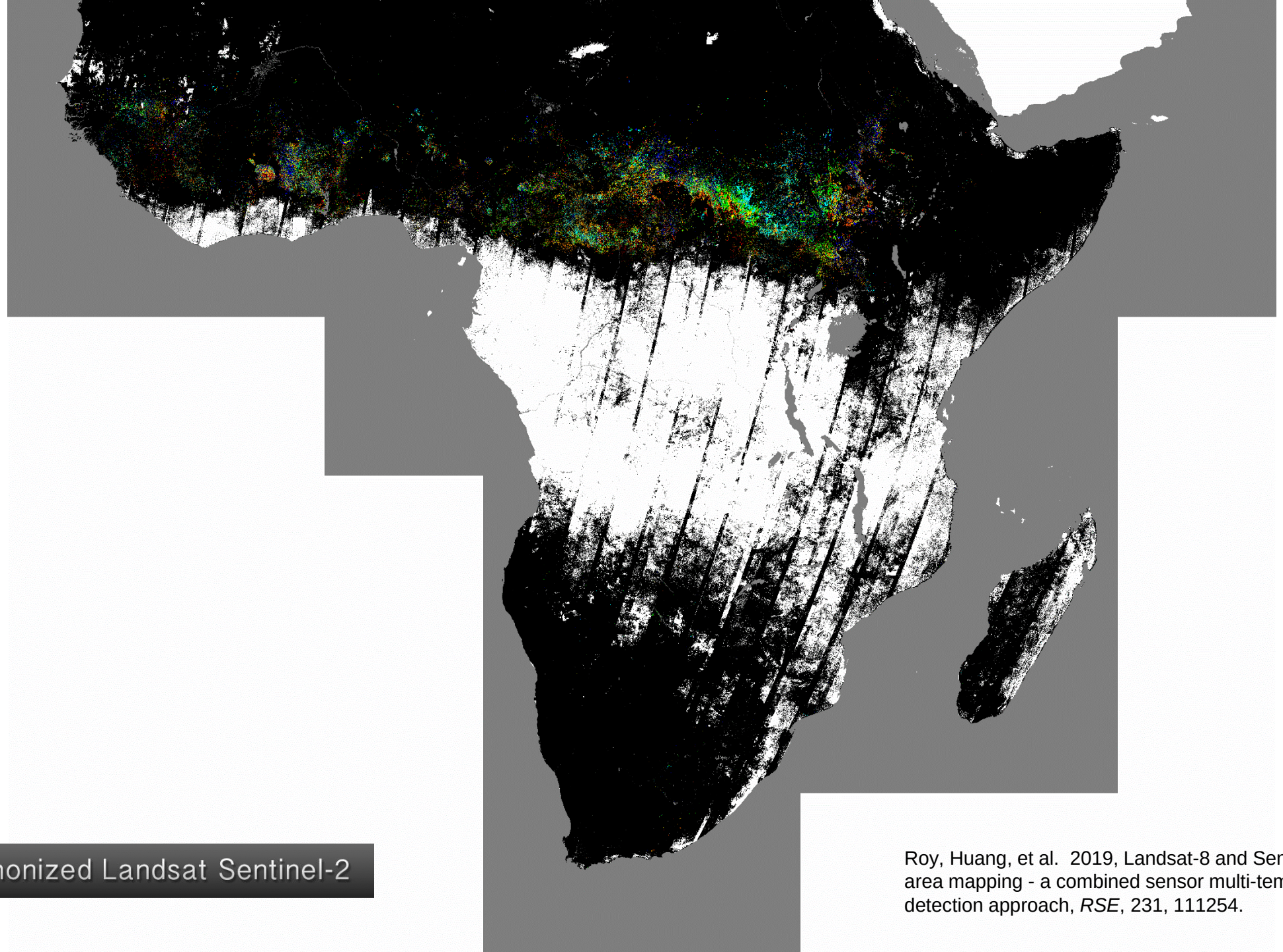


1-2
3-5
6-8
9-11
12-14
15-17
18-20
21-23
24-27
28-31
water

Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Dec 2018



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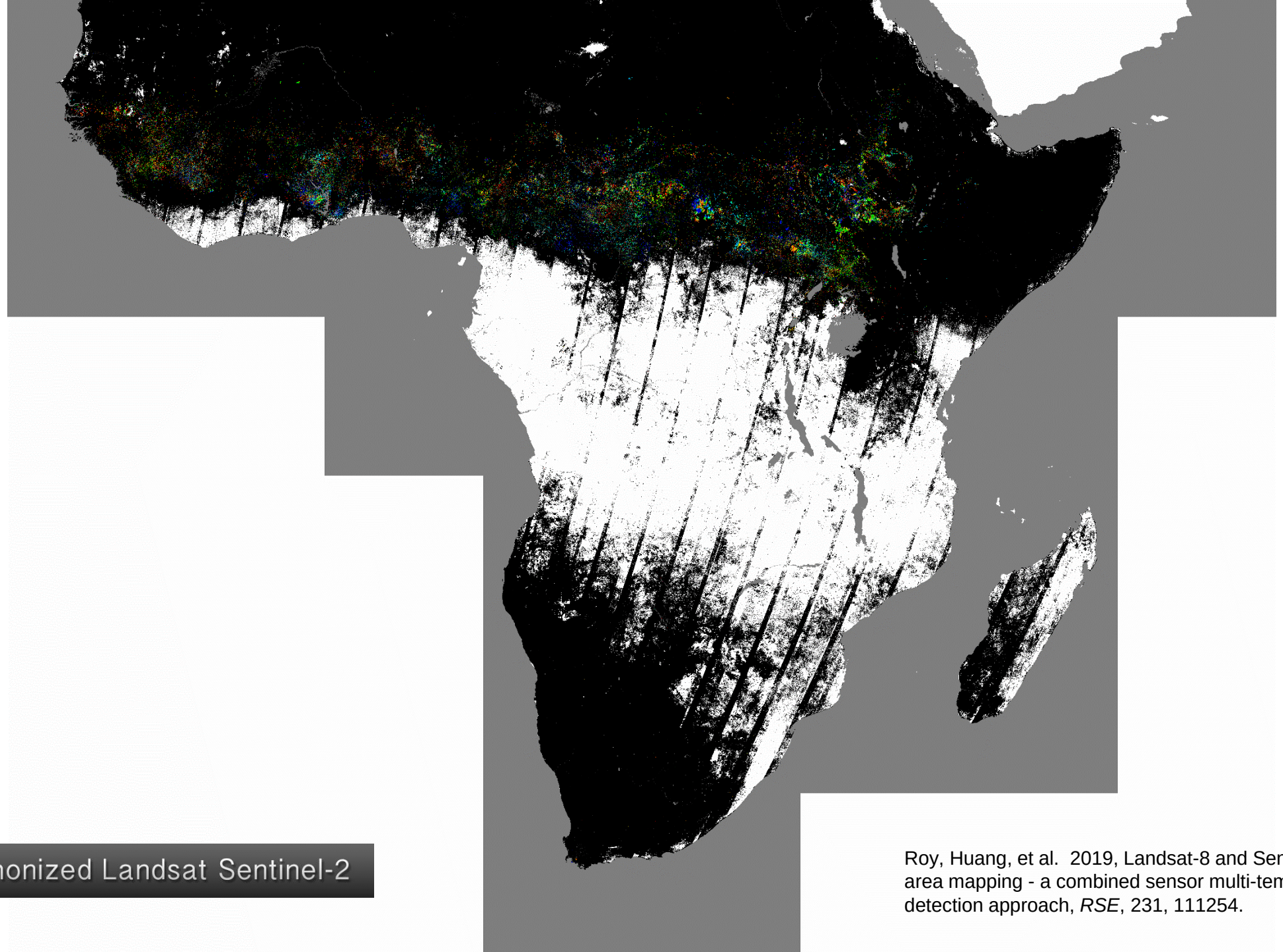
water

Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Jan 2019



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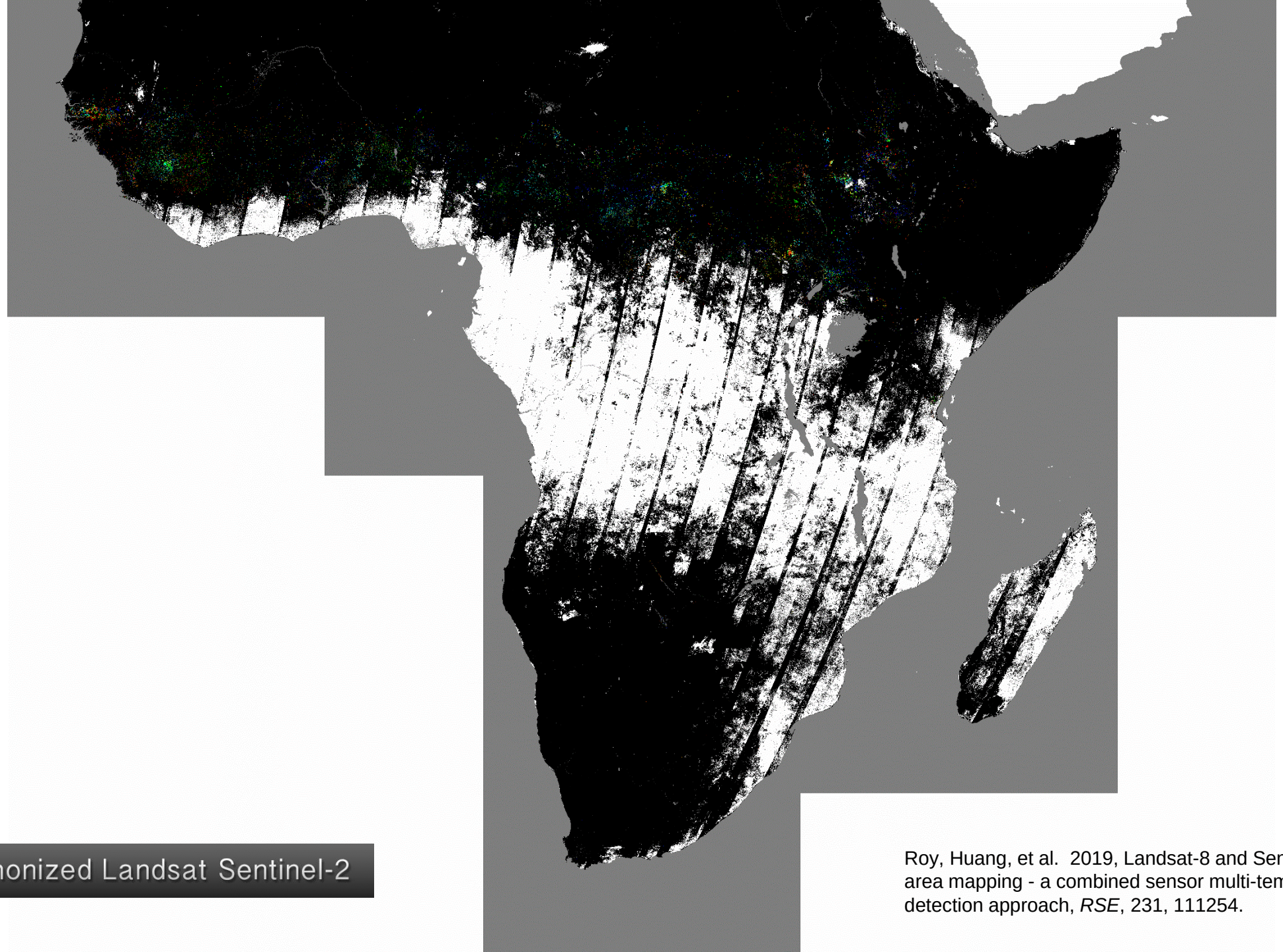
water

Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Feb 2019



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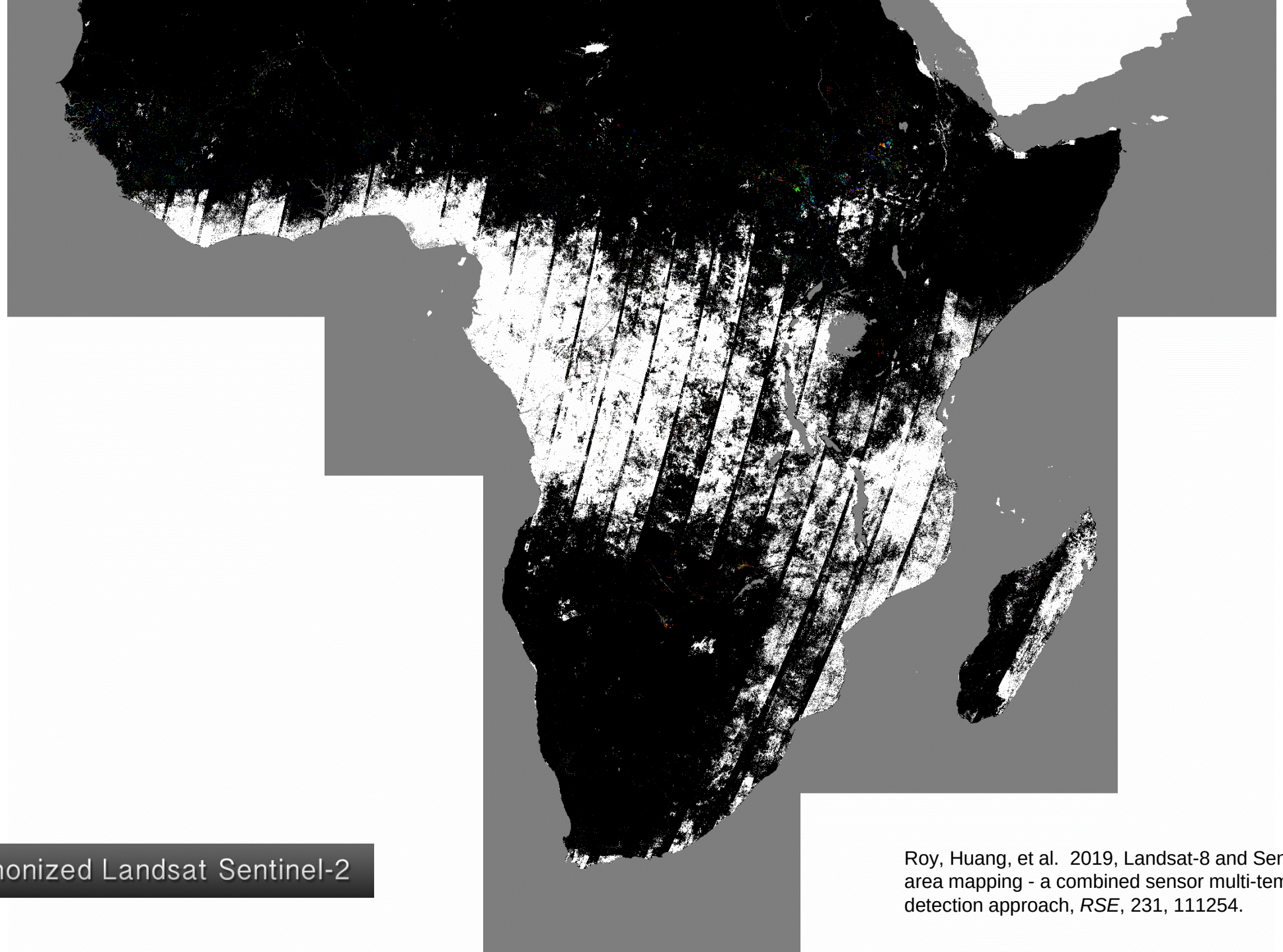
water

Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Mar 2019



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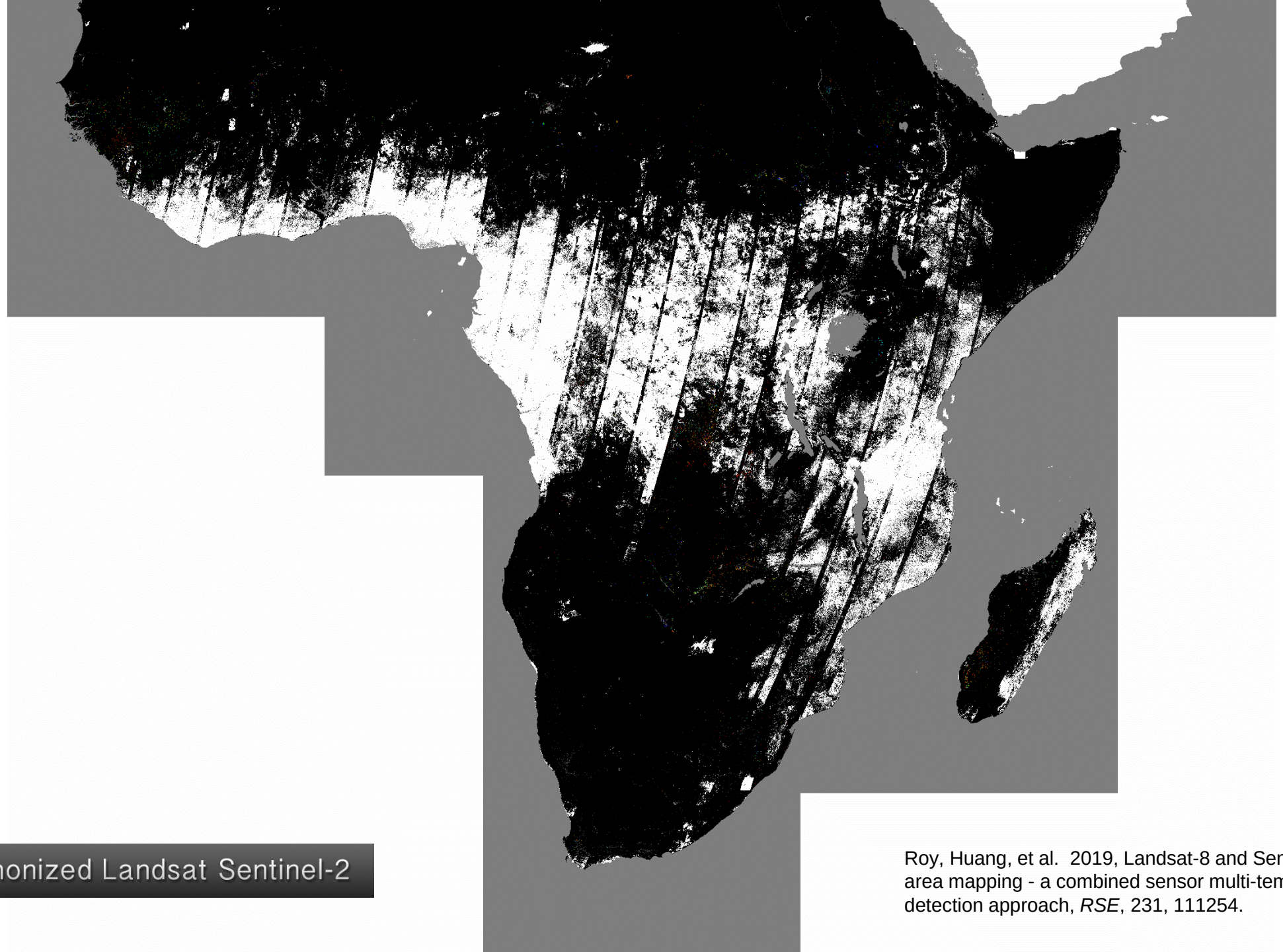
water

Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Apr 2019



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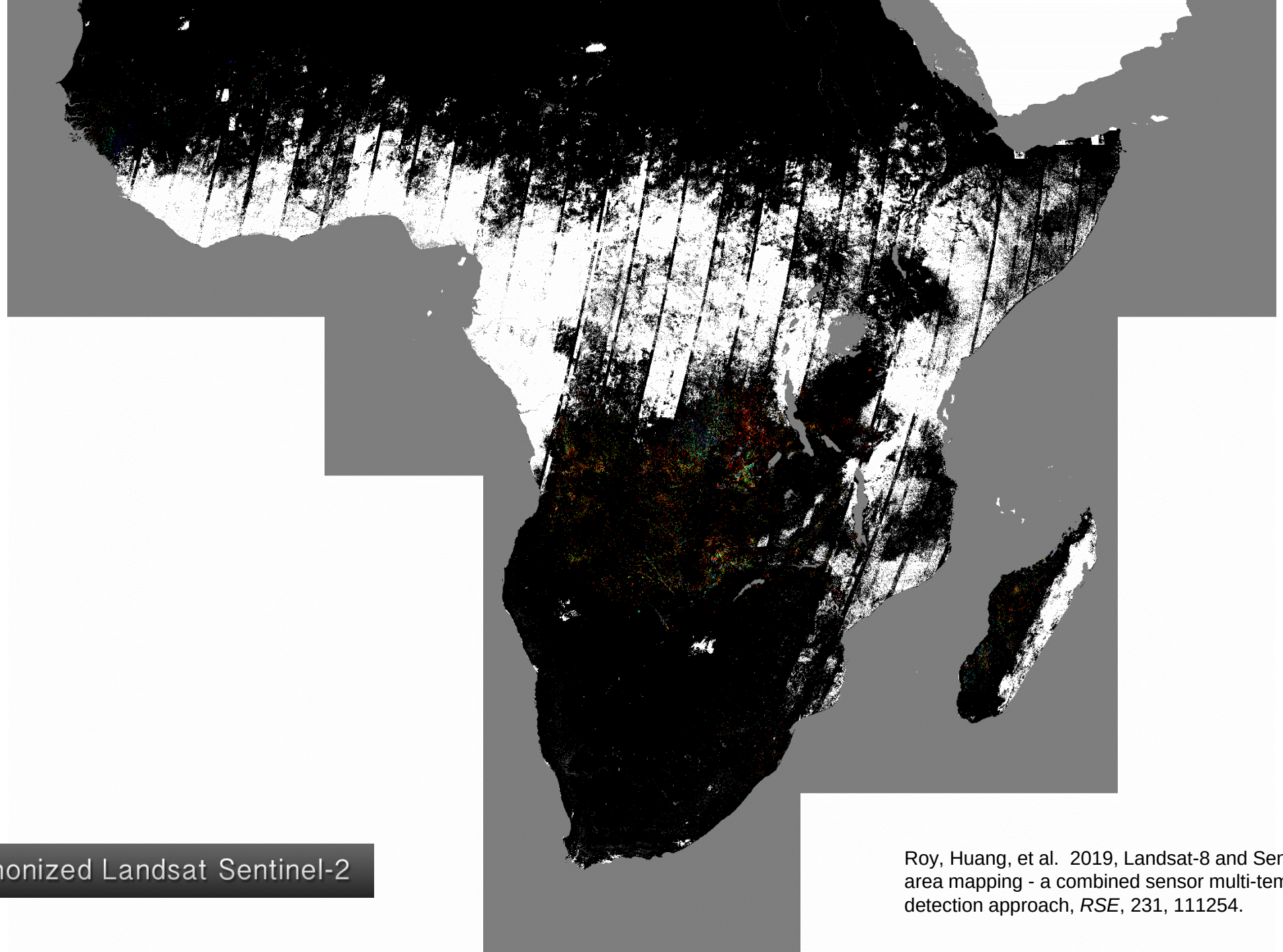
Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

May 2019



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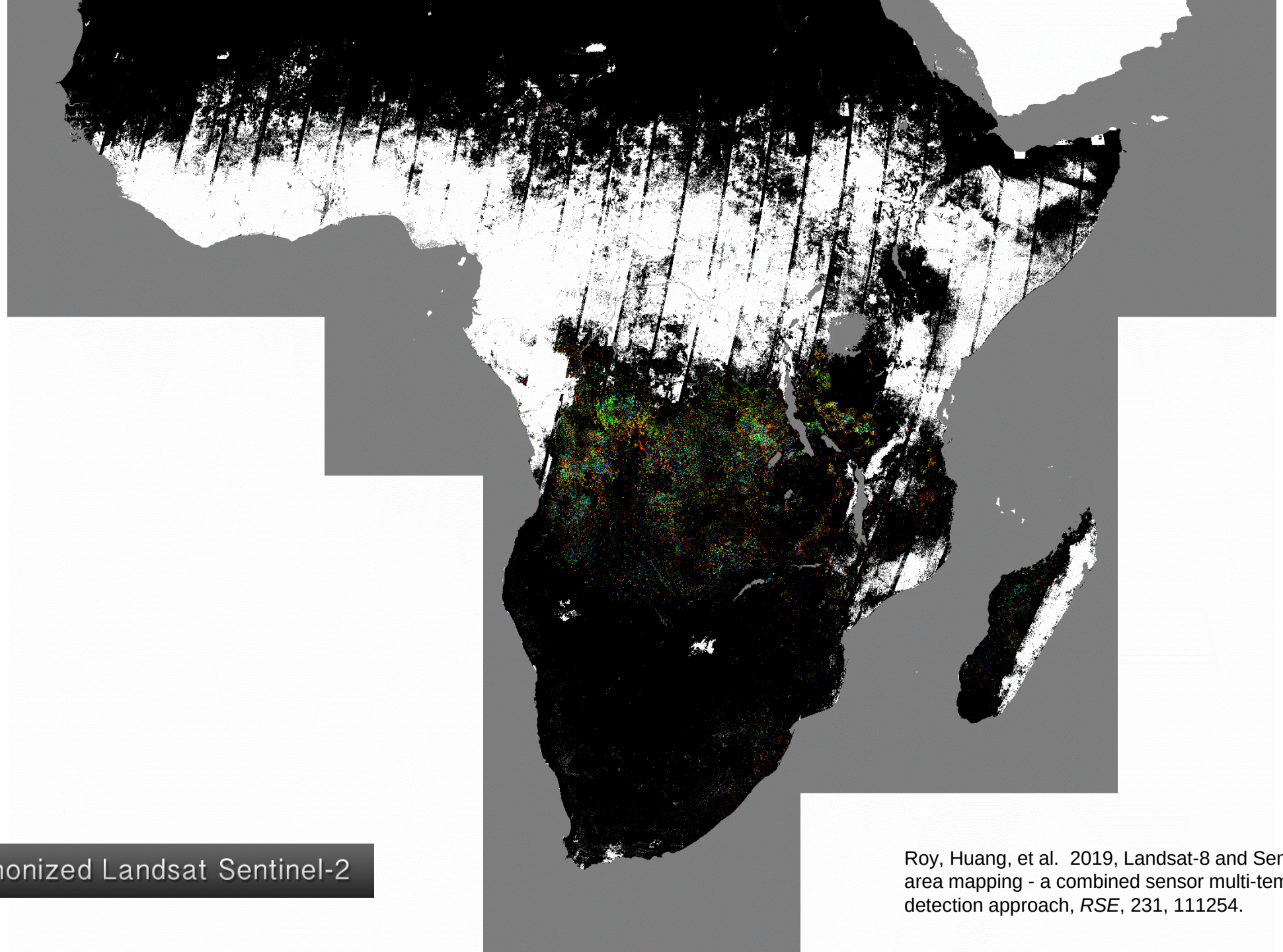
water

Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Jun 2019



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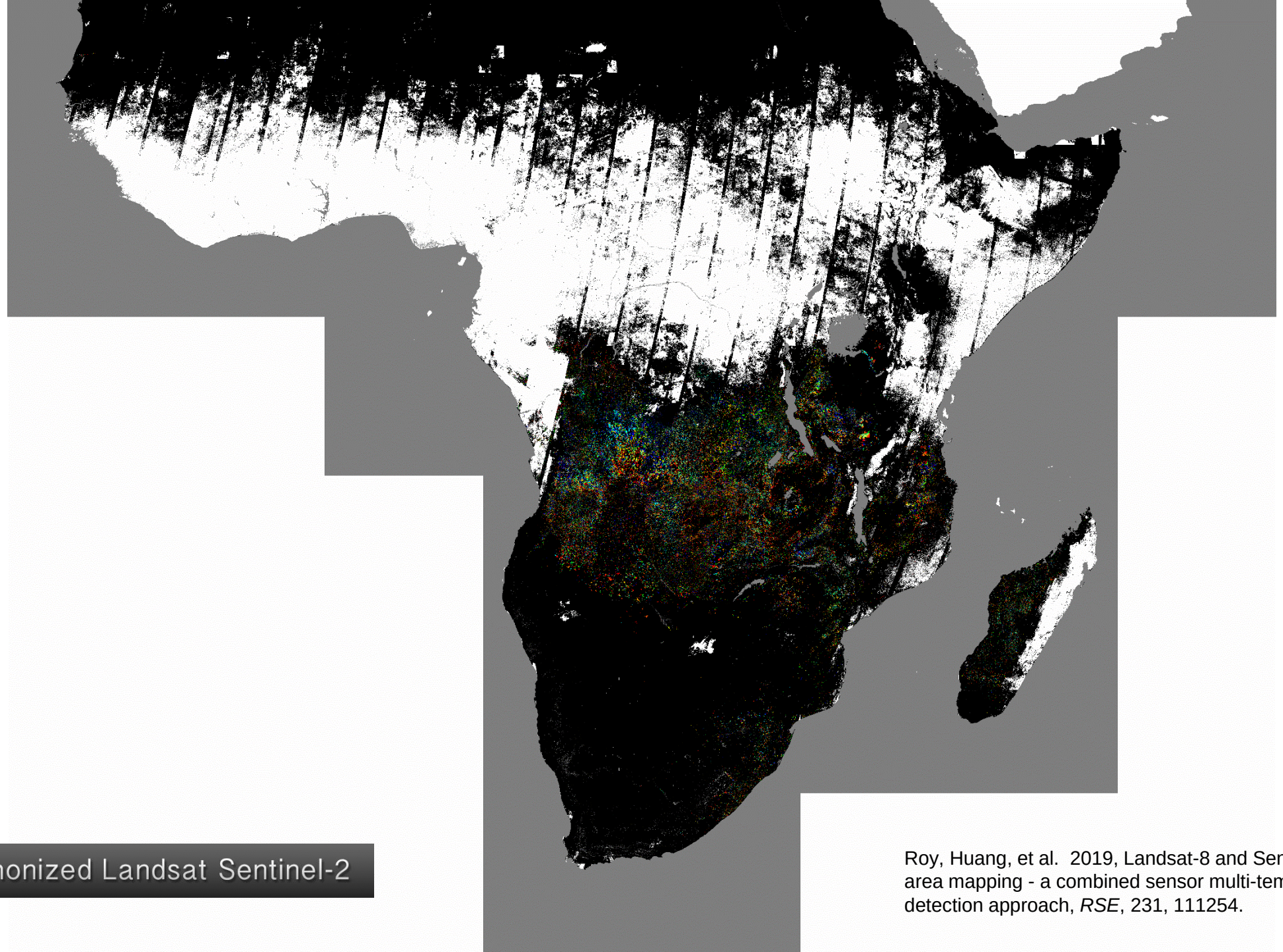
water

Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Jul 2019



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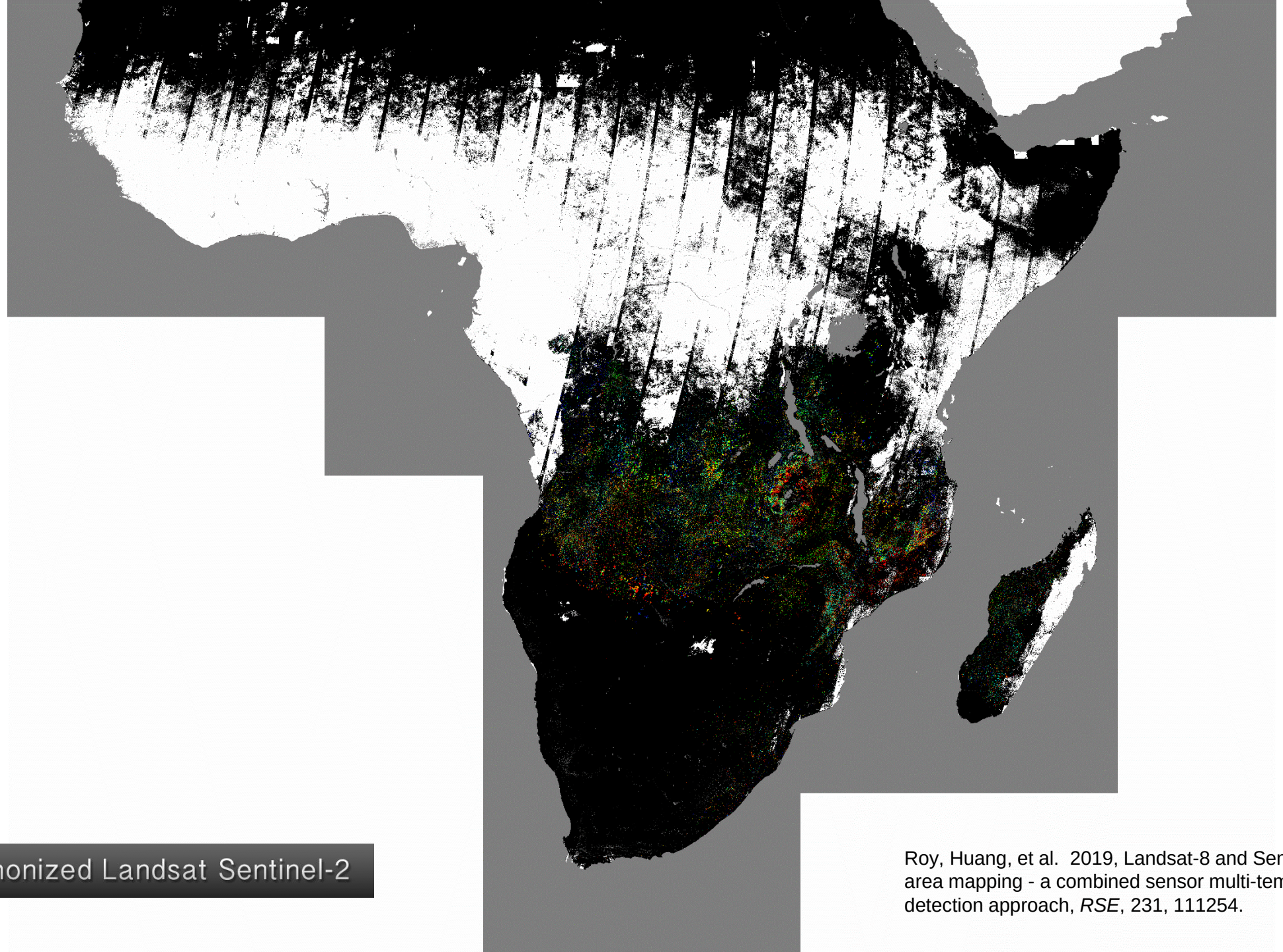
Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Aug 2019



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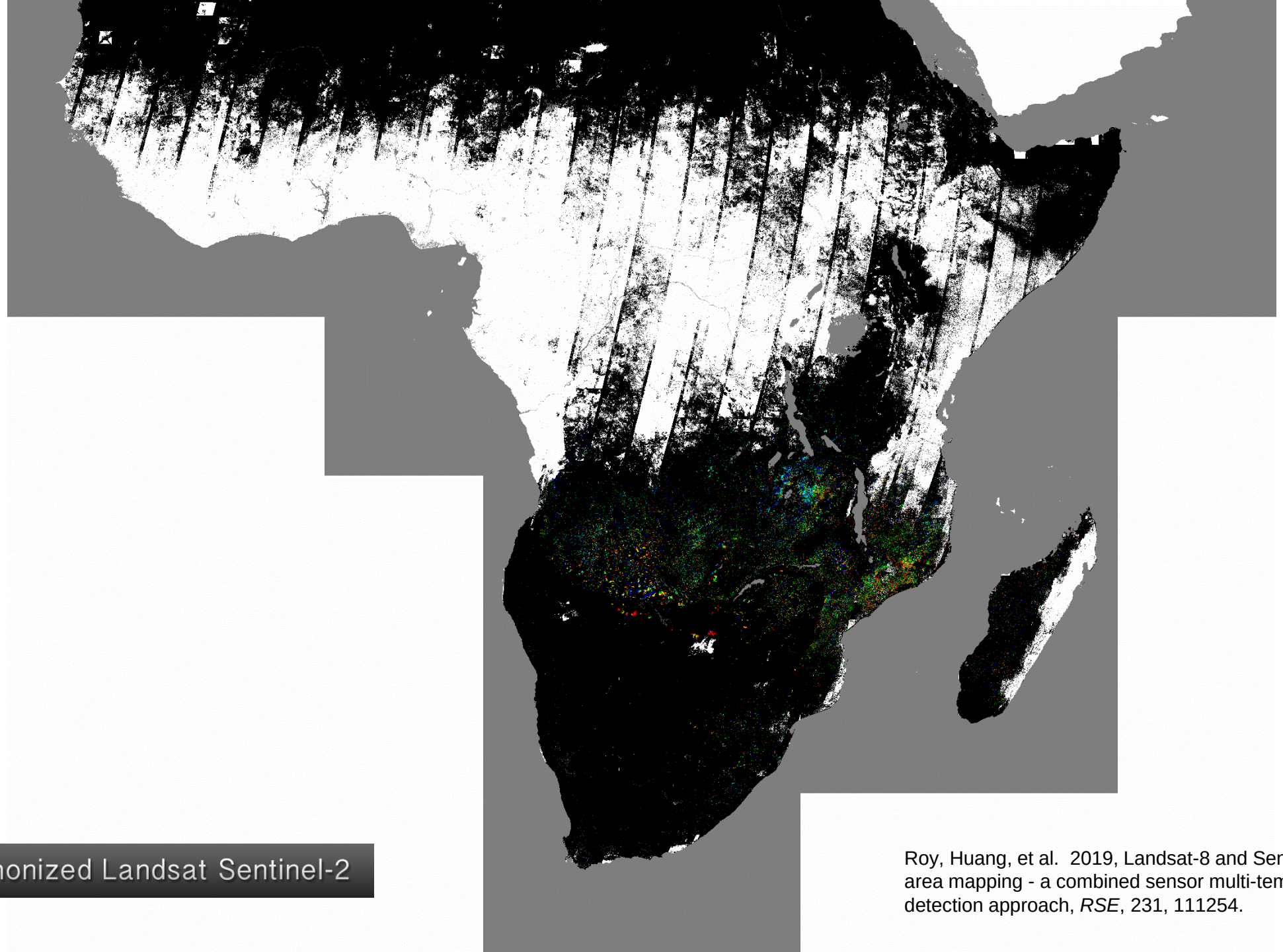
Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Sep 2019



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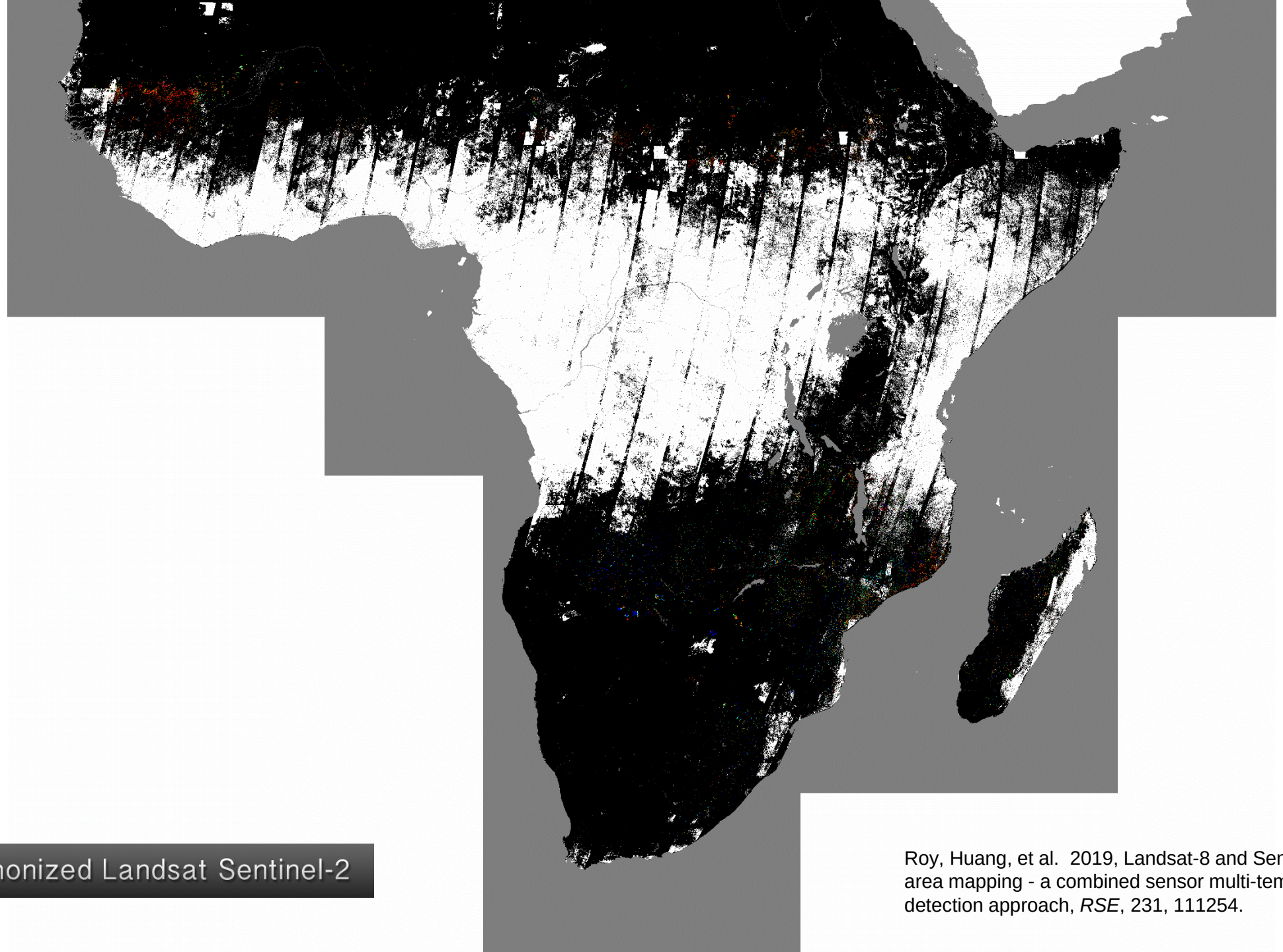
Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Oct 2019



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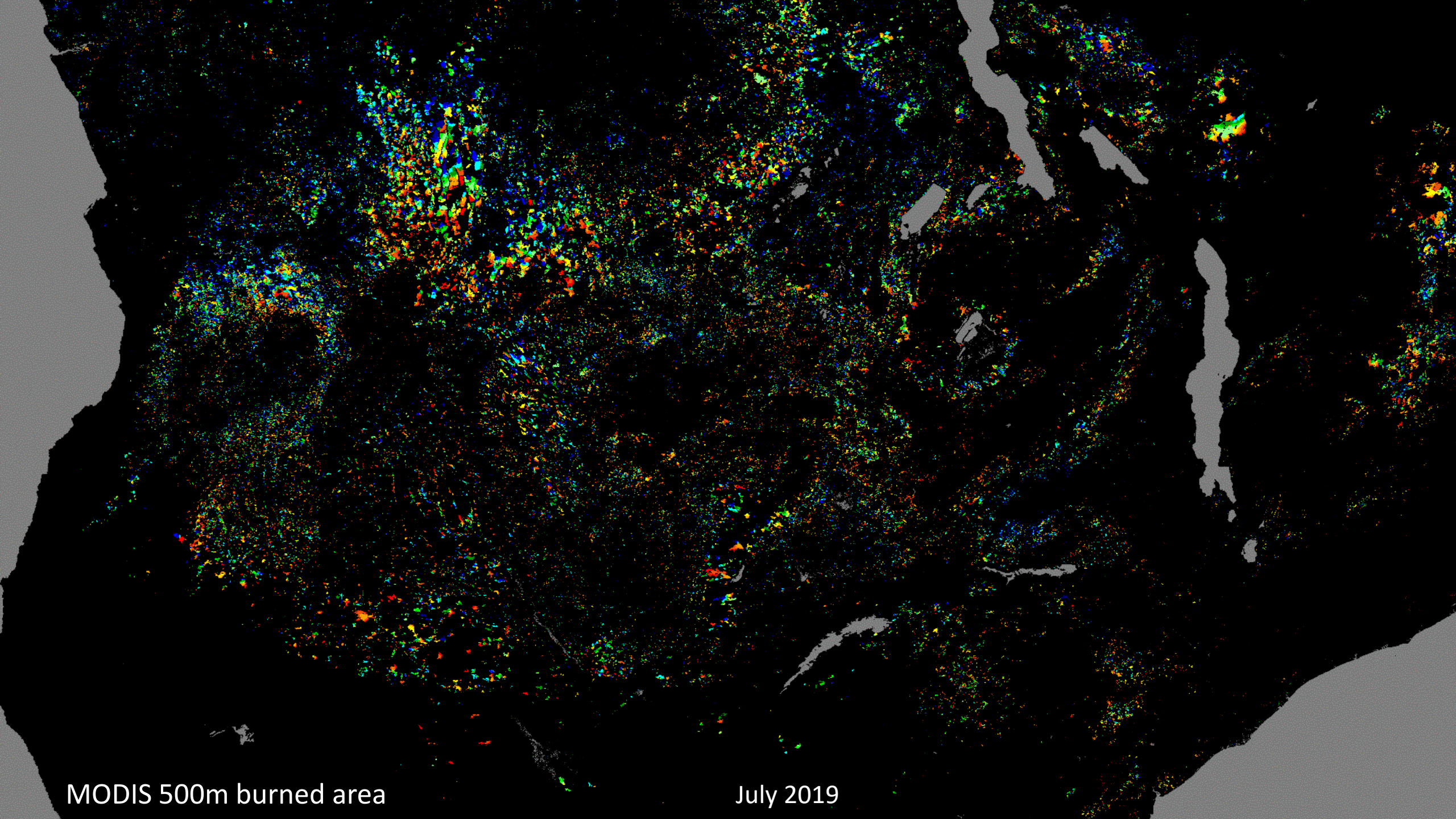
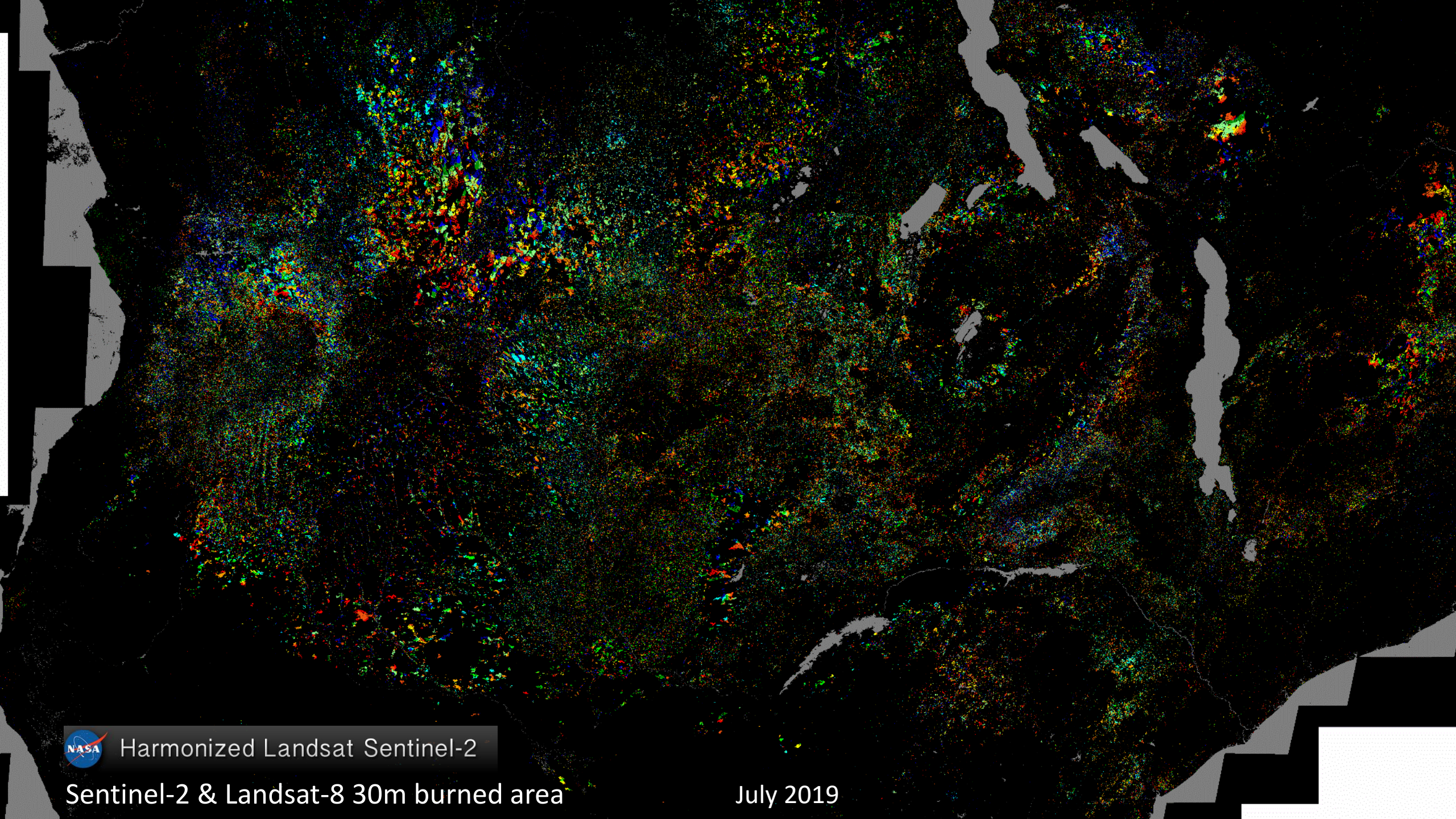
water

Harmonized Landsat Sentinel-2

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.


MODIS 500m burned area
July 2019


Harmonized Landsat Sentinel-2
Sentinel-2 & Landsat-8 30m burned area
July 2019

Ground assessment

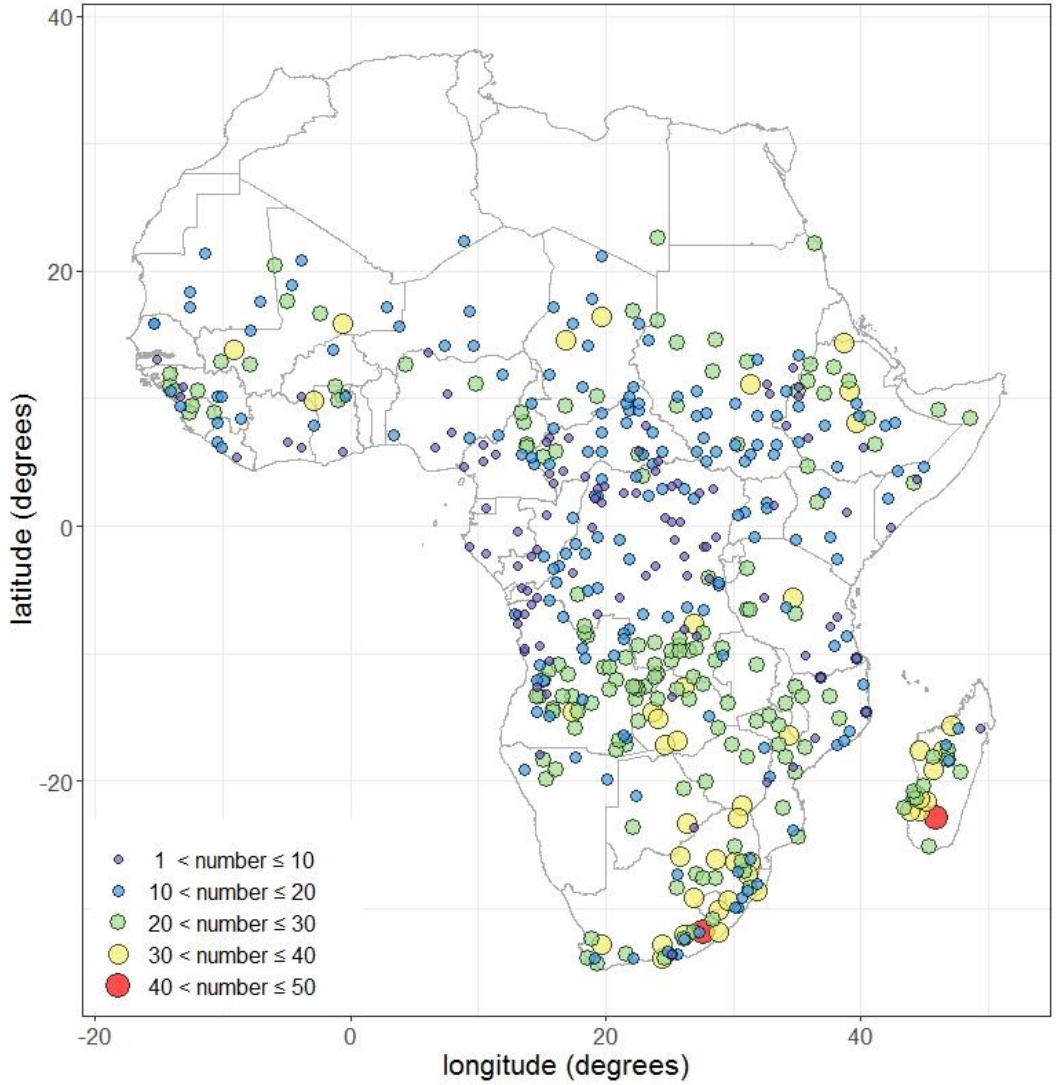
Kruger National Park, South Africa, October 2018

Validation: Acquired >9100 Planetscope images under the NASA Commercial Smallsat Data Acquisition (CSDA) program

Numbers show the number of ordered images with cloud cover <= 30%

Images sampled in space and time based on MODIS active fire detections, stratified by biome (colors)

Images sample Africa Fire Year 2019 (Nov. 2018 – Oct. 2019)



Total number of Planet images ordered = 9109

Planetscope

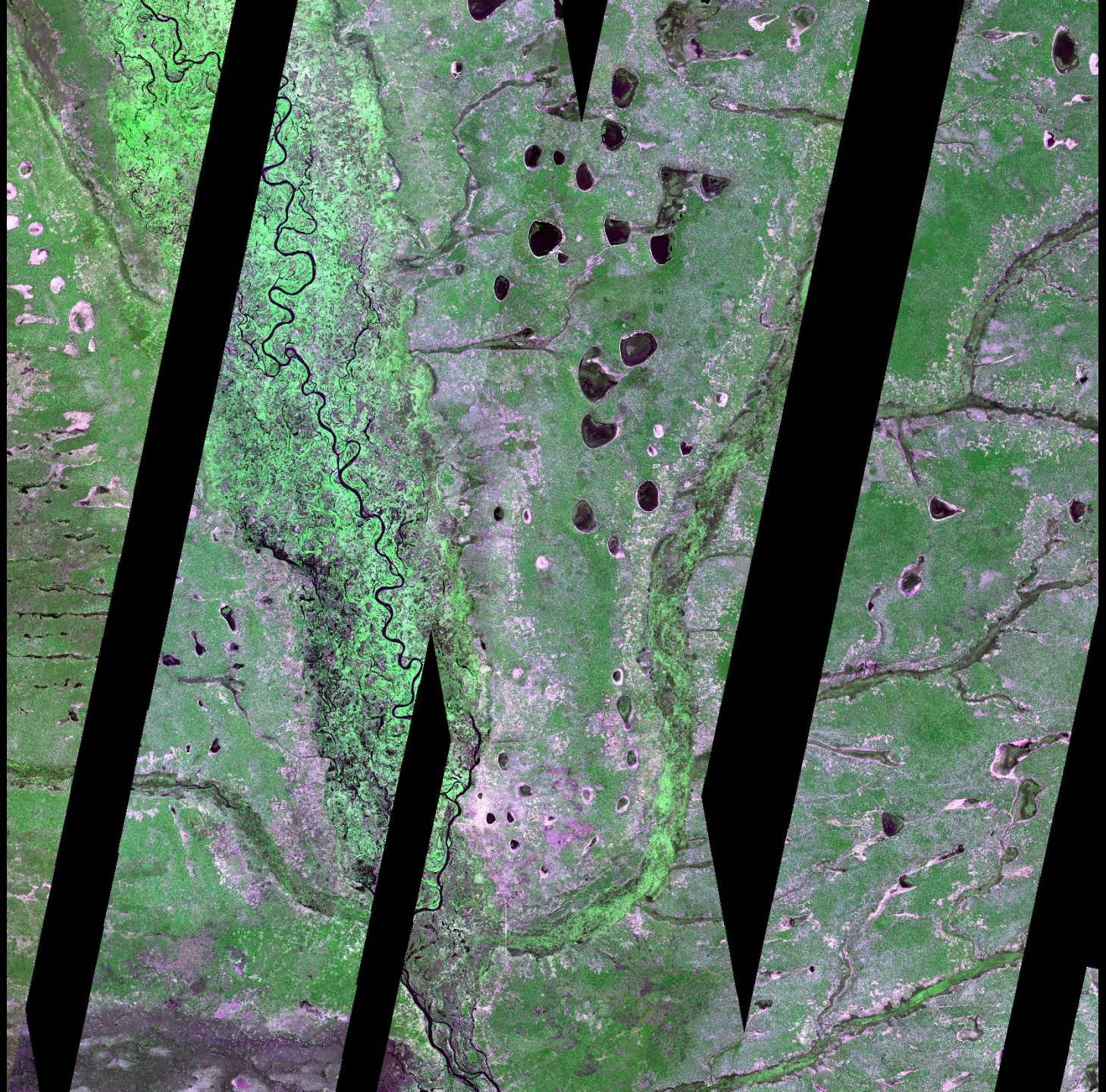
July 3 rd

630nm
820 nm
545 nm

Preliminary
Example
validation

Zambia
Western Province

110 x 110 km
36600 x 36600 3m pixels

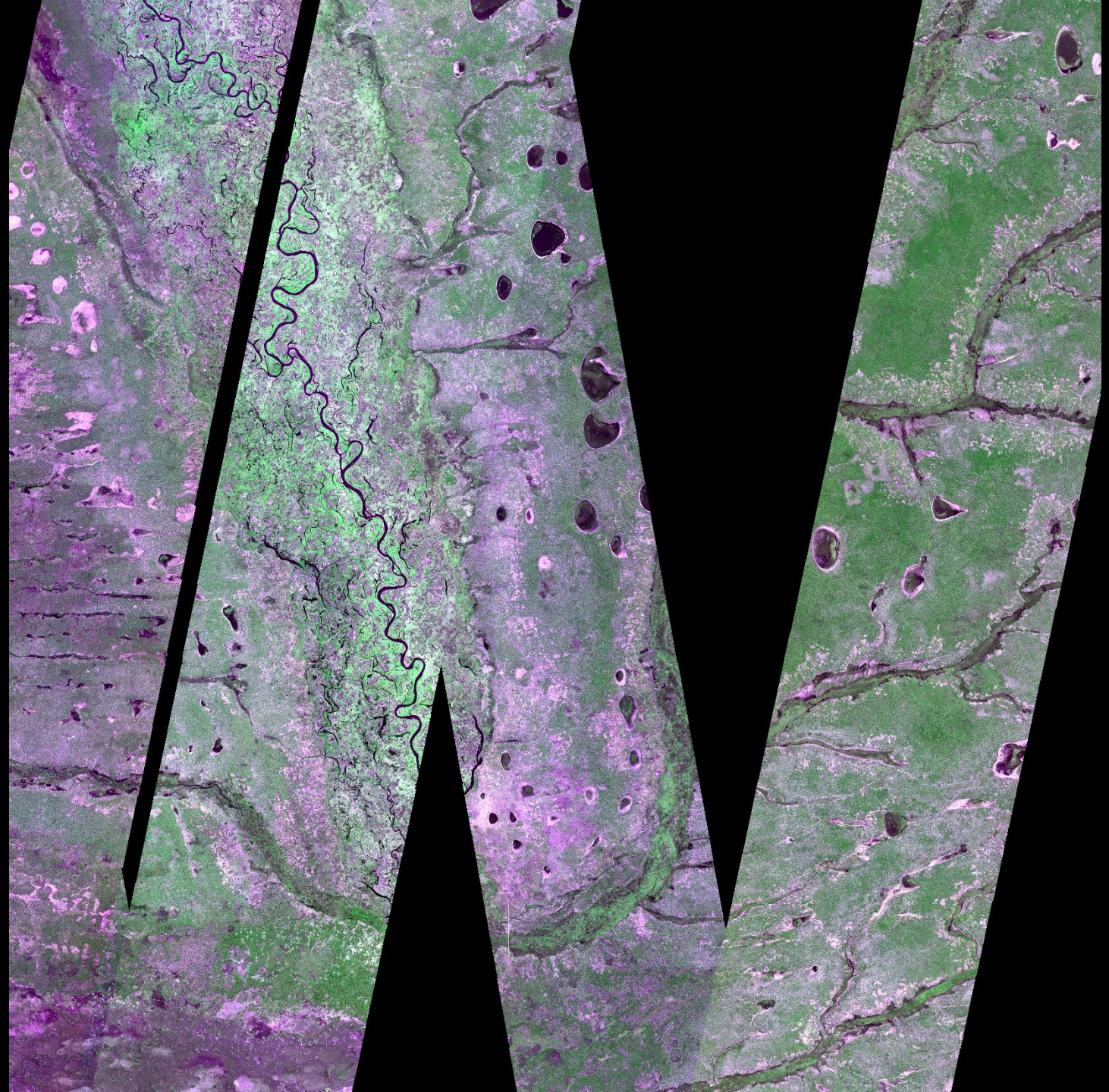


Planetscope

July 31st

630nm
820 nm
545 nm

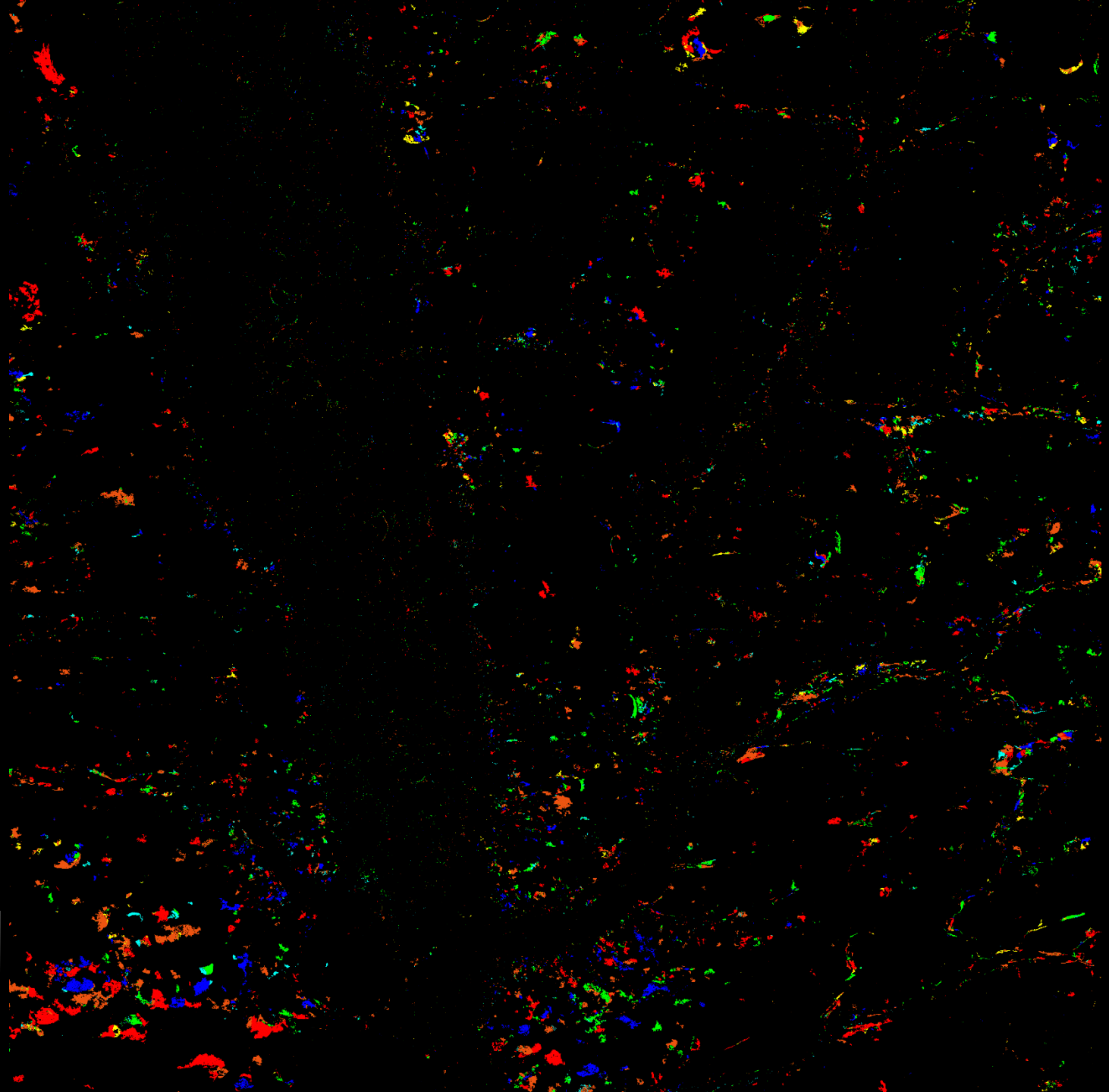
Preliminary
Example
validation



Zambia
Western Province

110 x 110 km
36600 x 36600 3m pixels

planet.


Day of burning
July
Sentinel-2A/2B
Landsat-8
0-2
3-5
6-8
9-11
12-14
15-17
18-20
21-23
24-27
28-31
Preliminary
Example
validation
Harmonized Landsat Sentinel-2
110 x 110 km
3660 x 3660 30m pixels

Comparison of July burned proportions mapped by 3 m PLANET reference and 30 m Landsat-8 & Sentinel-2

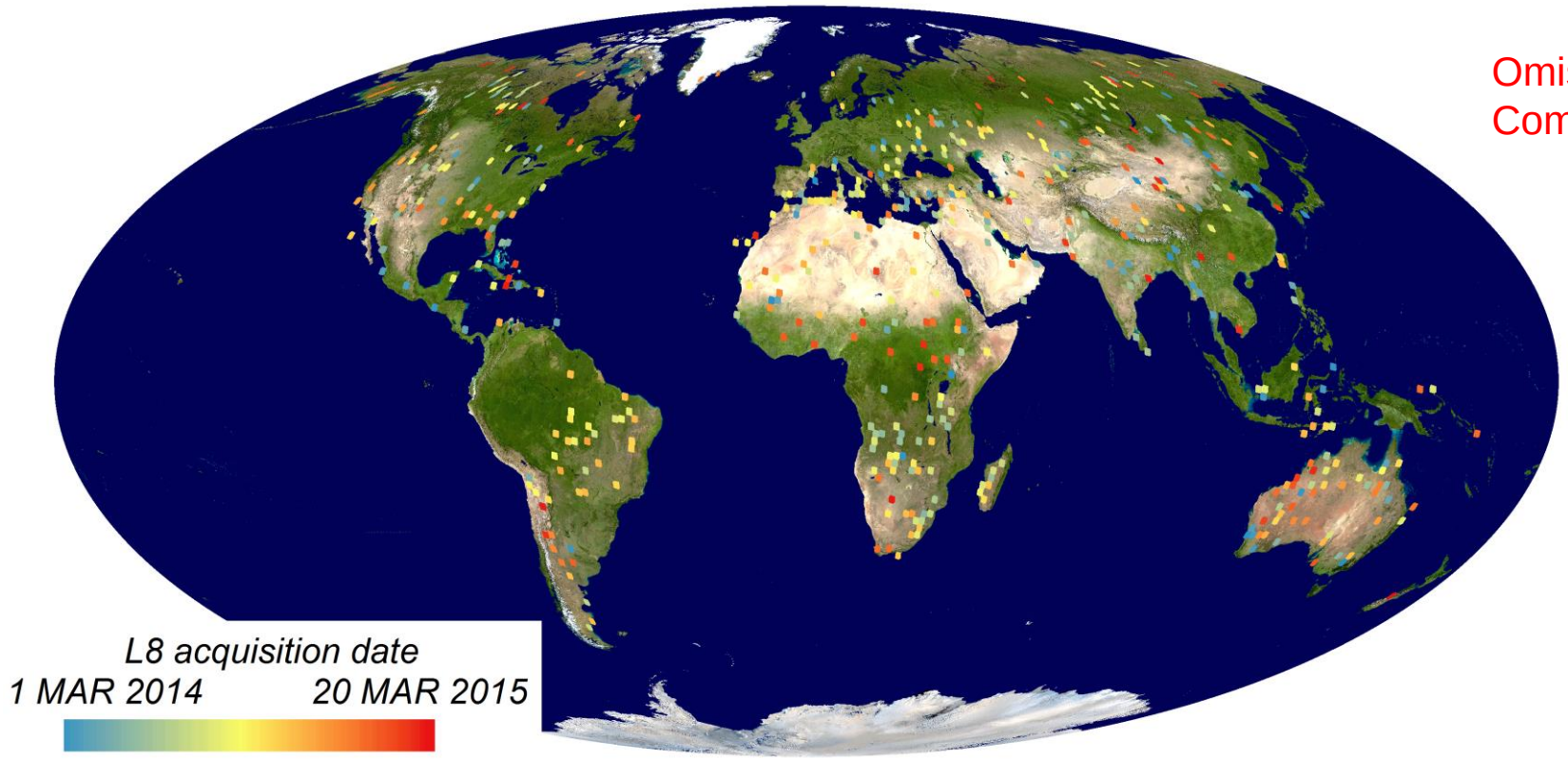
Preliminary example validation results

8093.4 km² compared		PLANET reference (assumed to be truth)		
		Burned [km²]	**Unburned** [km²]	Row total [km²]
Landsat-8 & Sentinel-2	**Burned** [km²]	83.7	56.4	140.7
	Unburned [km²]	173.6	7780.3	7953.7
	Column total [km²]	257.0	7836.7	8093.4

Overall accuracy = 97% Omission error [0-1] = 0.40 Commission error [0-1] = 0.67

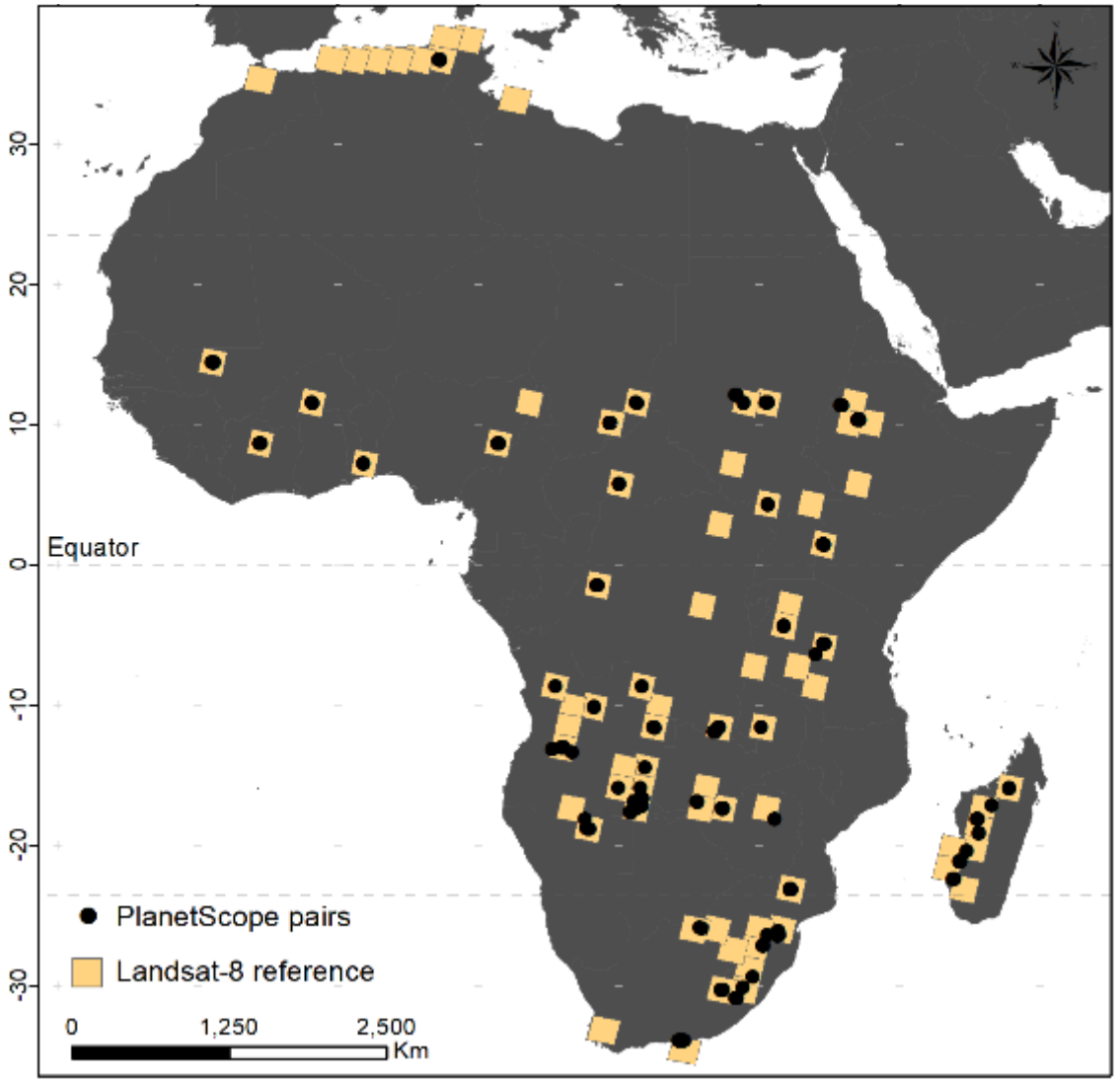
NASA MODIS Collection 6 500 m Burned Area Product Global Validation

following CEOS protocol: comparison with burned area maps interpreted from 558 Landsat-8 two date image pairs

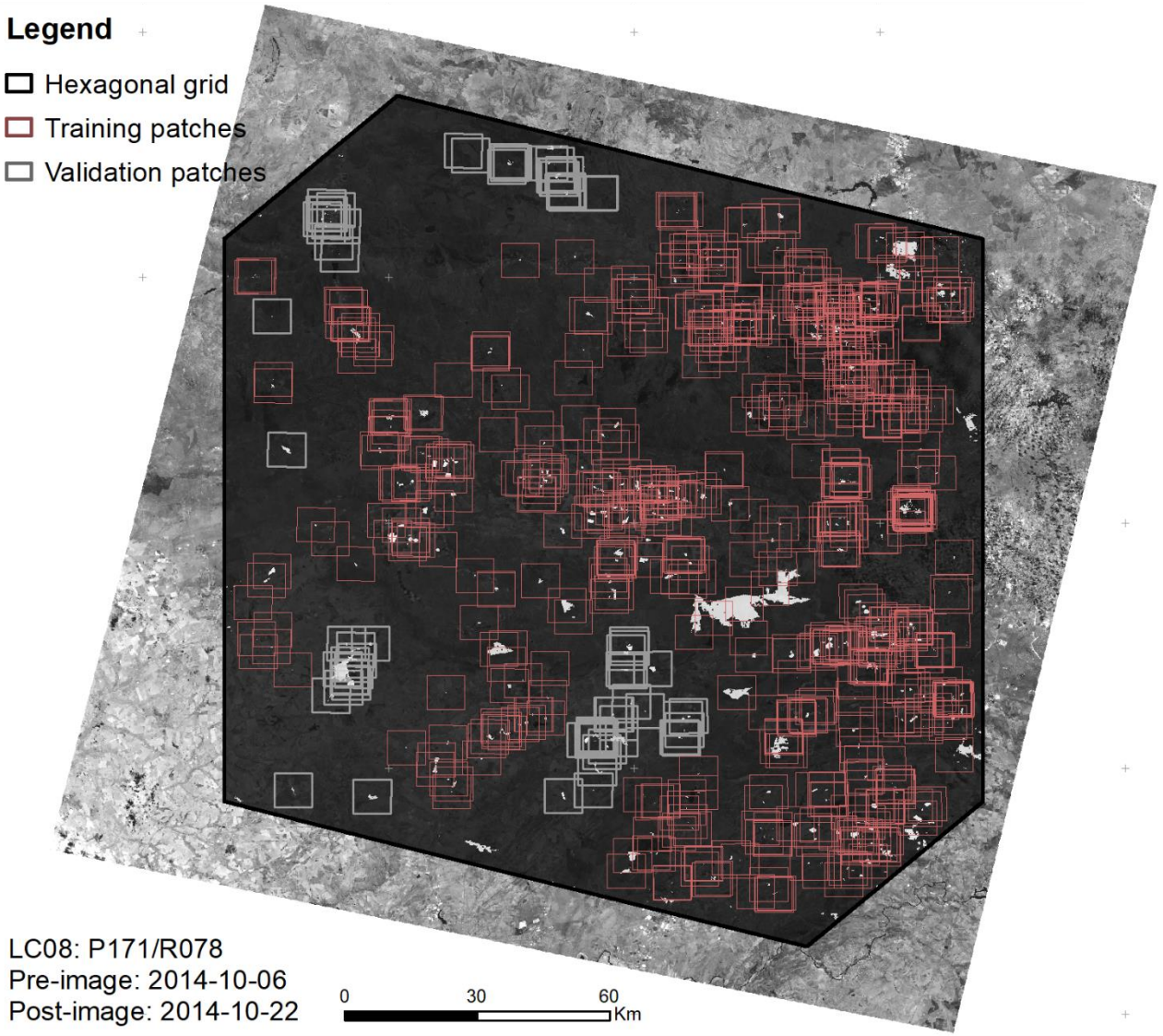


Omission Error (0-1) = 0.73
Commission Error (0-1) = 0.40

Transfer learning: use the Landsat-8 burned area validation data as a training source to classify 2019 PlanetScope 3 m data

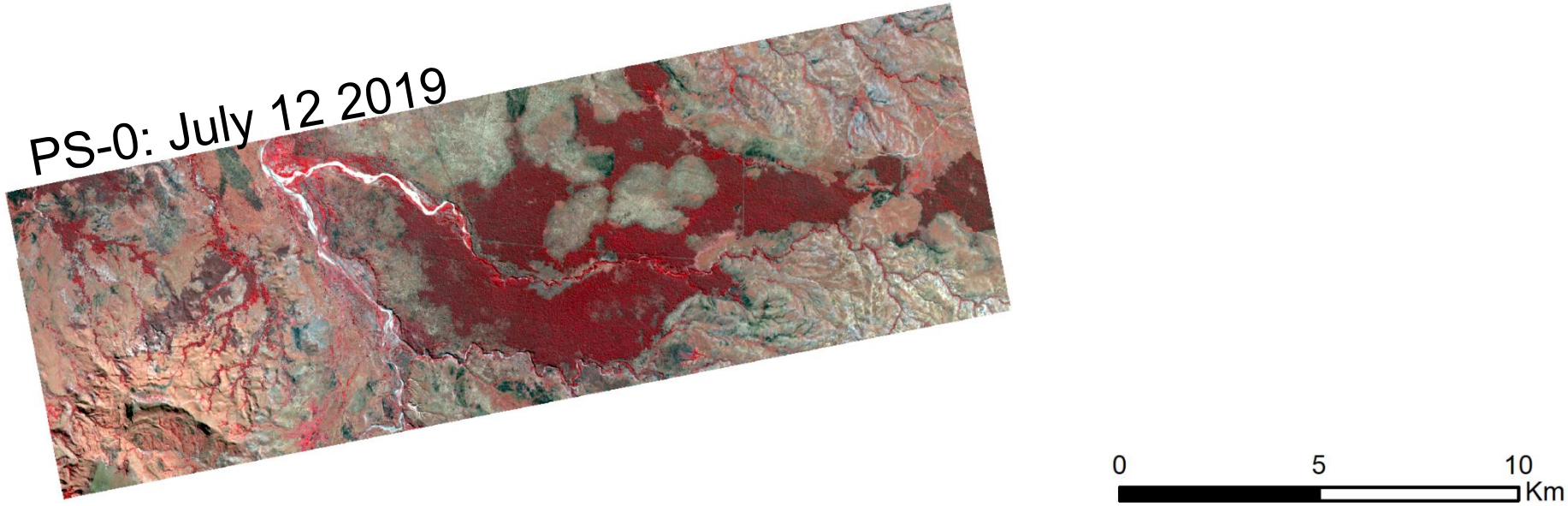


Deep Learning: Training and Validation 256 x 256 Landsat 30 m pixel patches



Madagascar

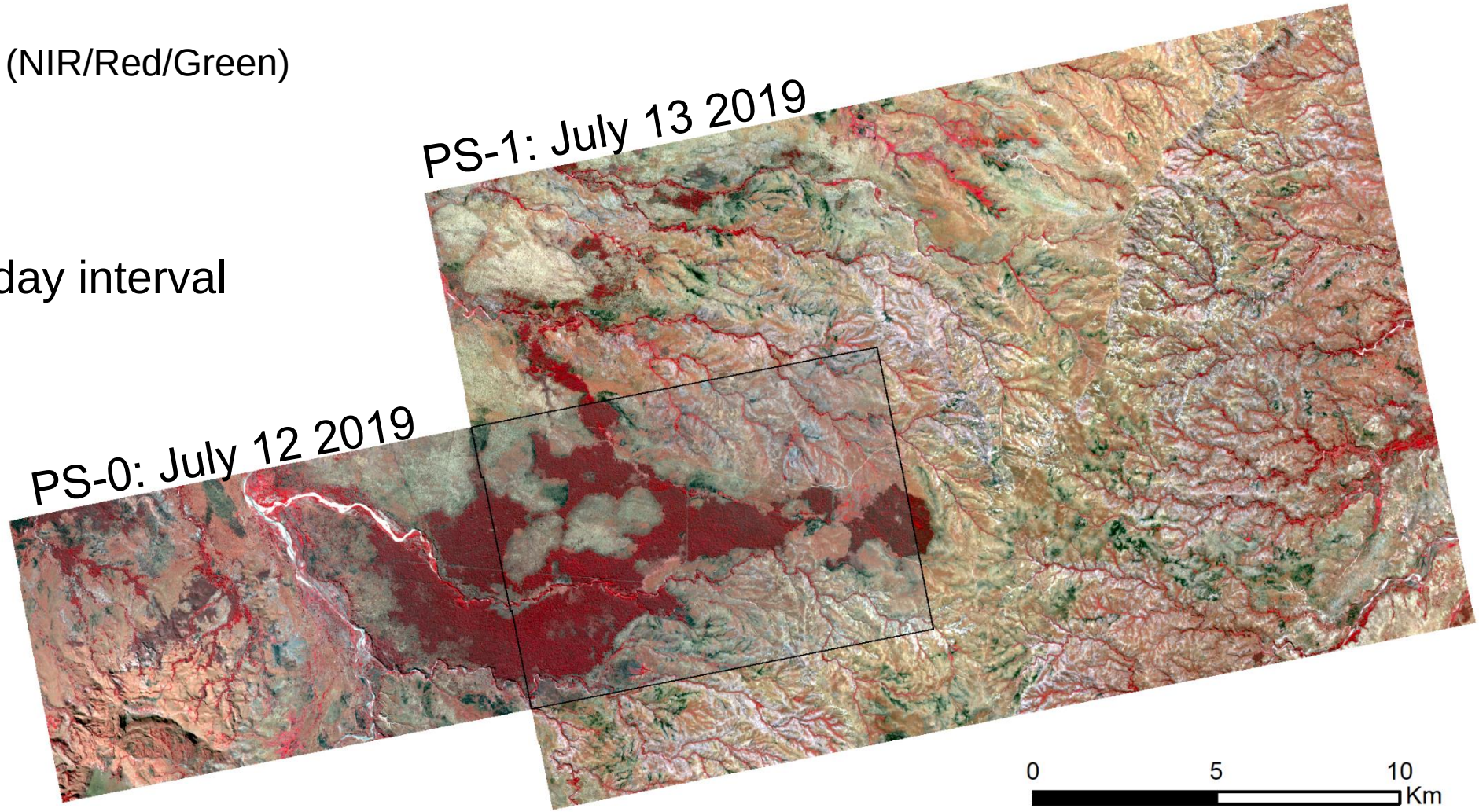
False-color (NIR/Red/Green)



Madagascar

False-color (NIR/Red/Green)

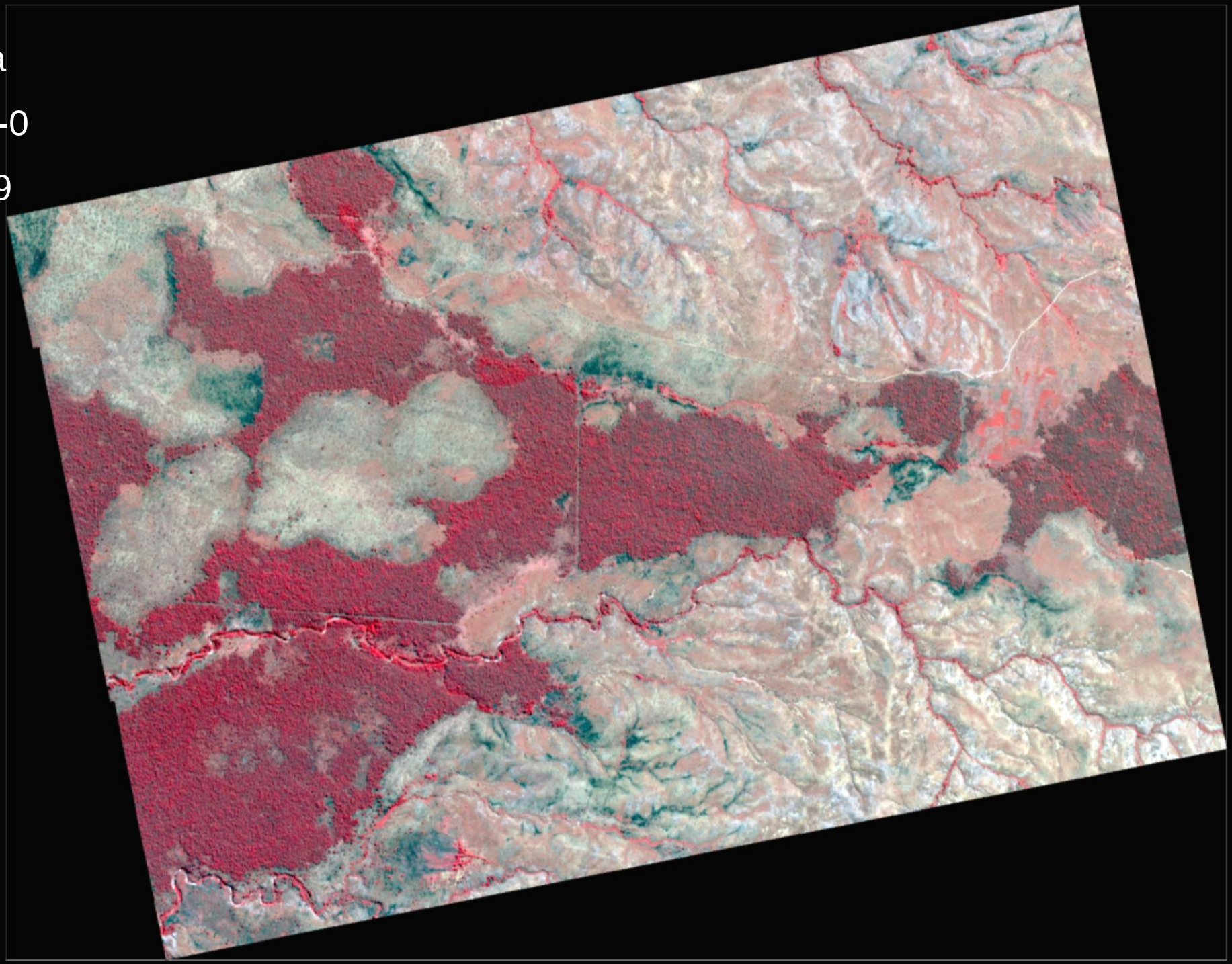
1-day interval



Overlap area

Planetscope-0

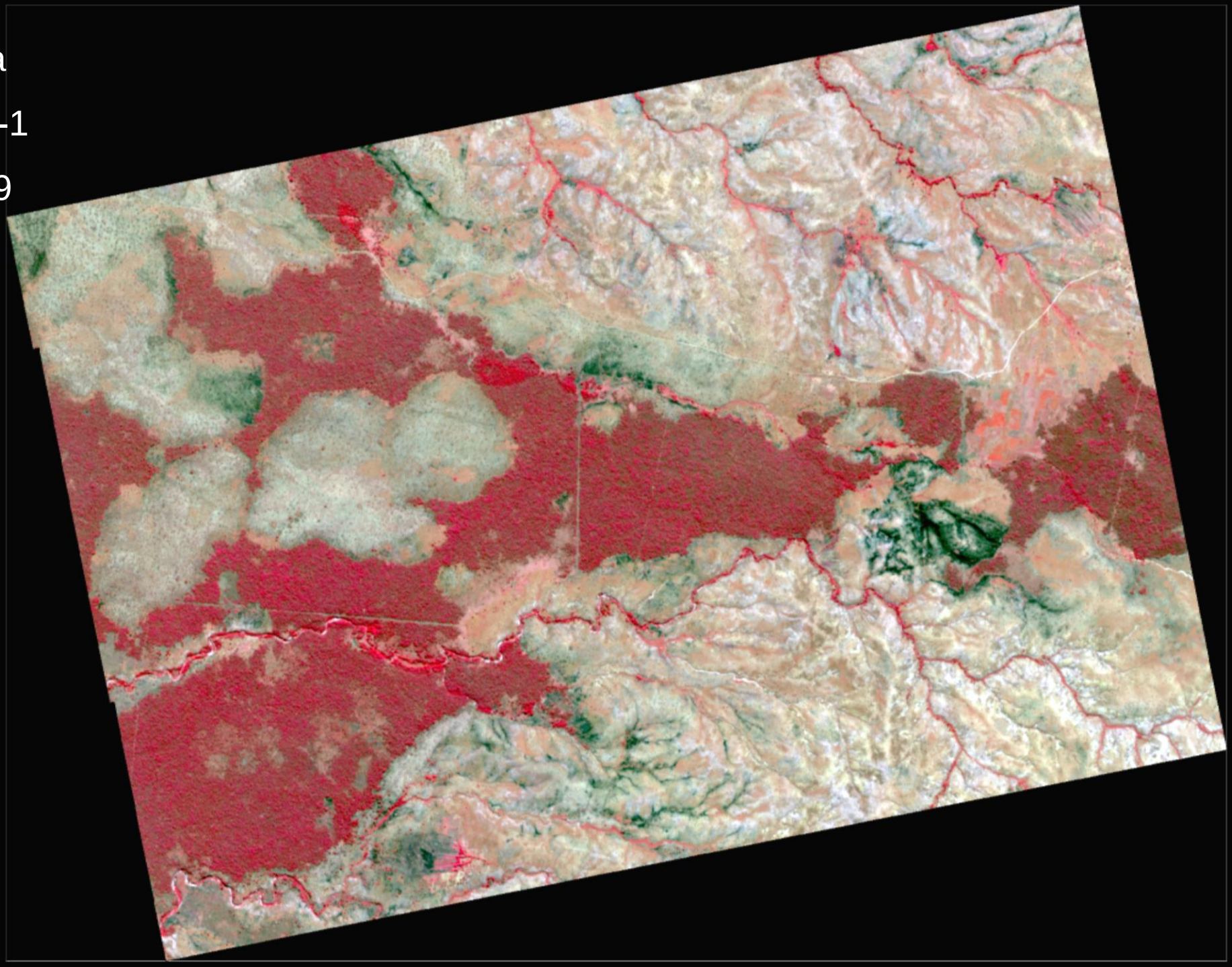
July 12 2019



Overlap area

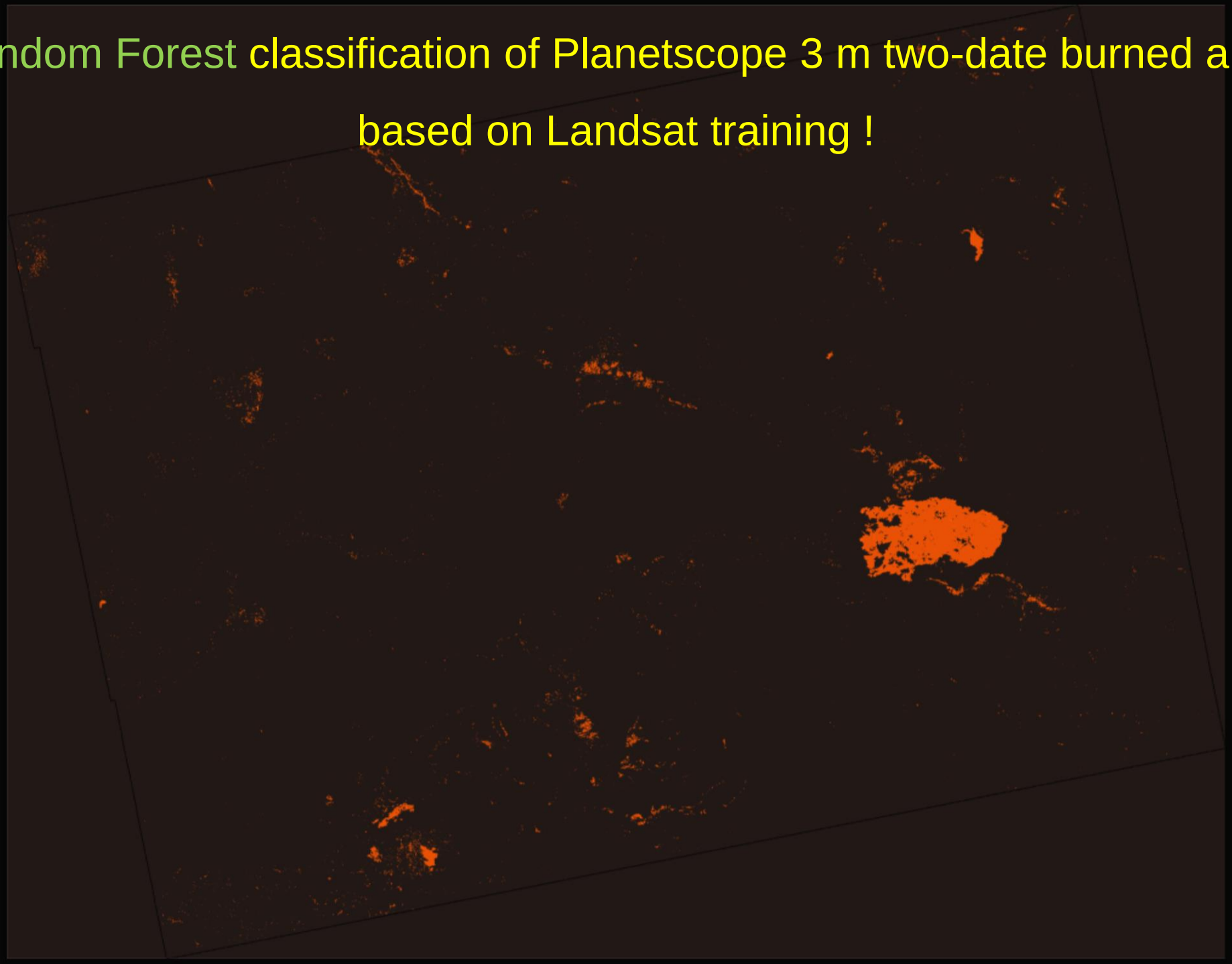
Planetscope-1

July 13 2019

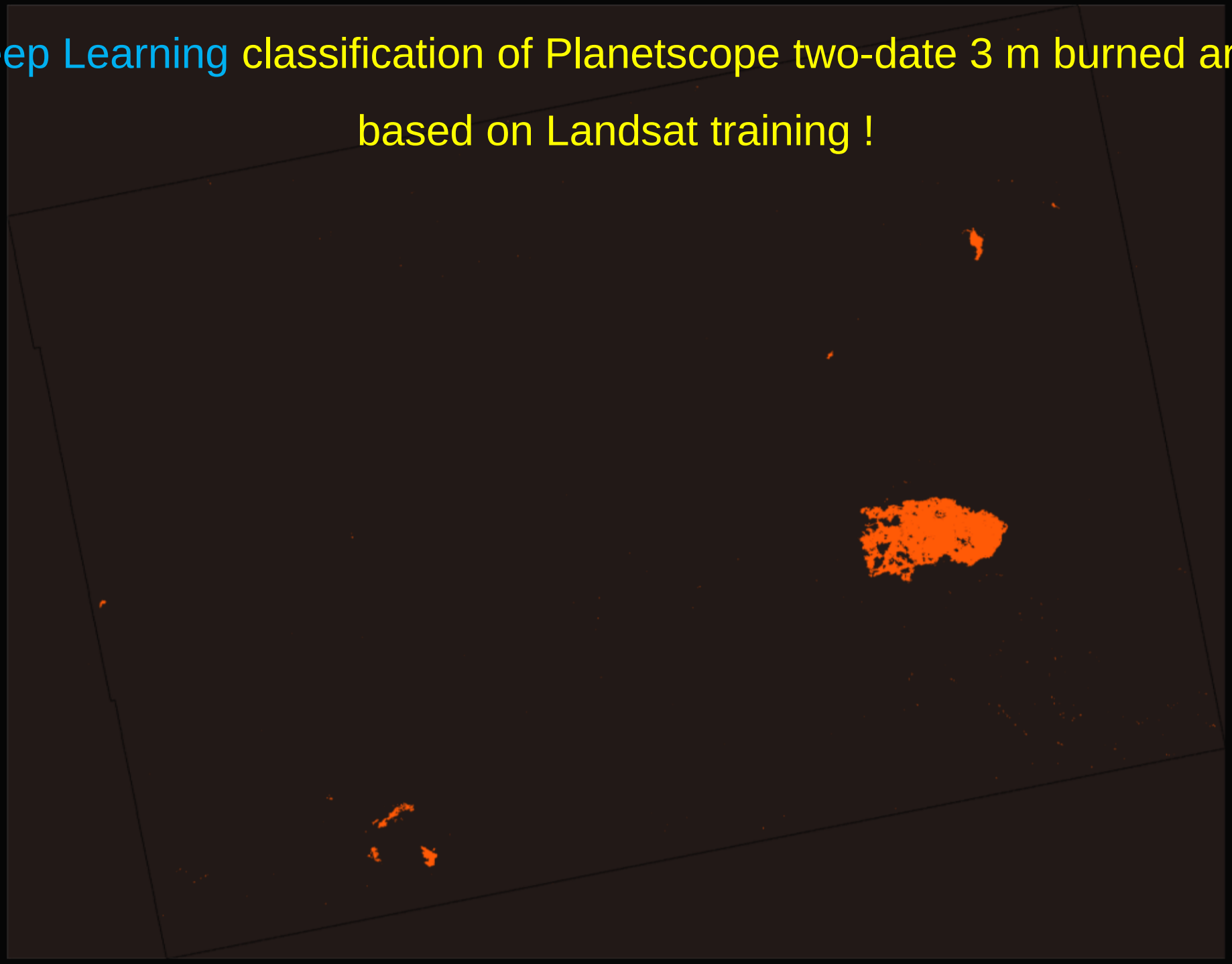


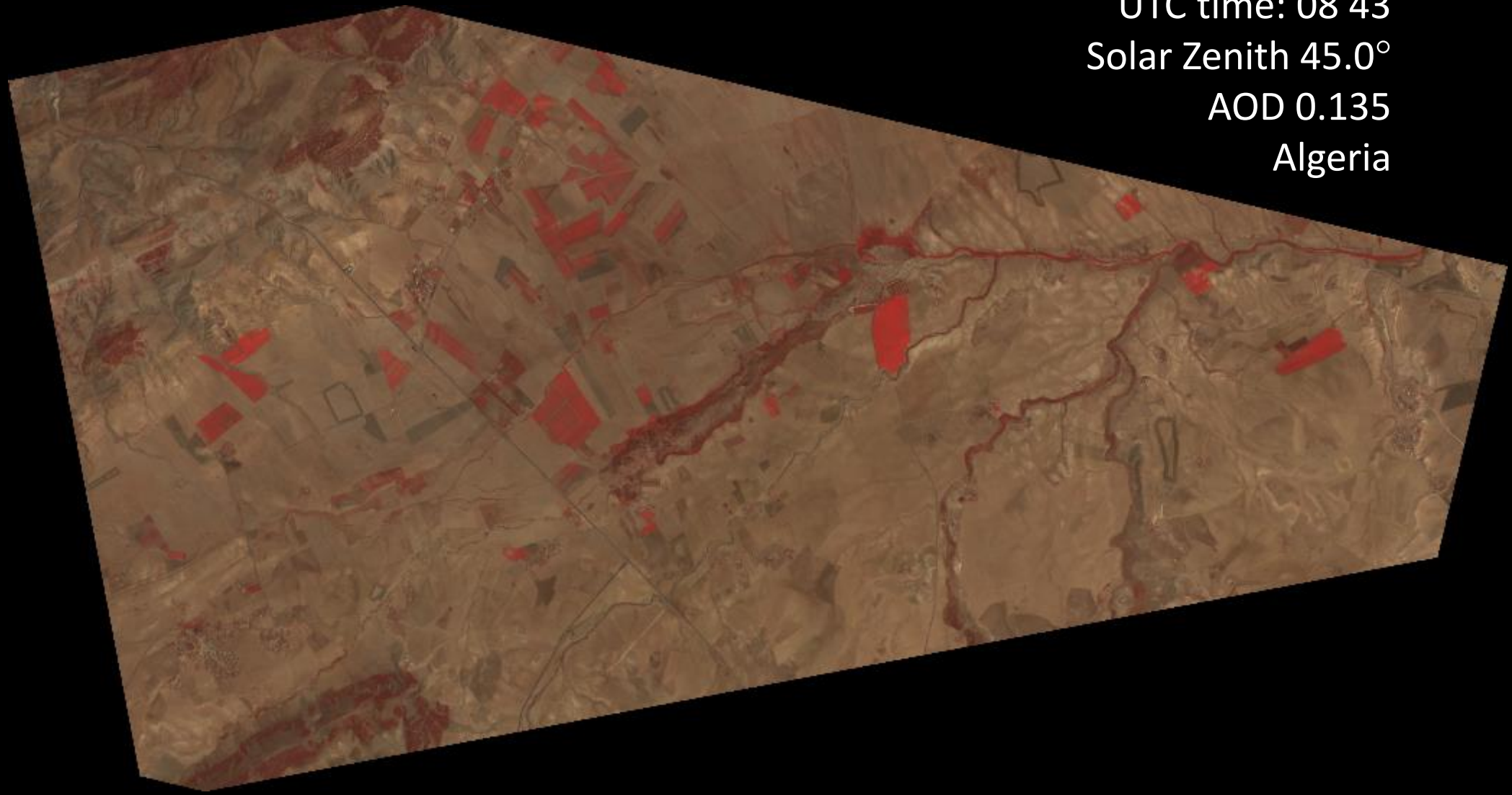
Random Forest classification of Planetscope 3 m two-date burned area

based on Landsat training !

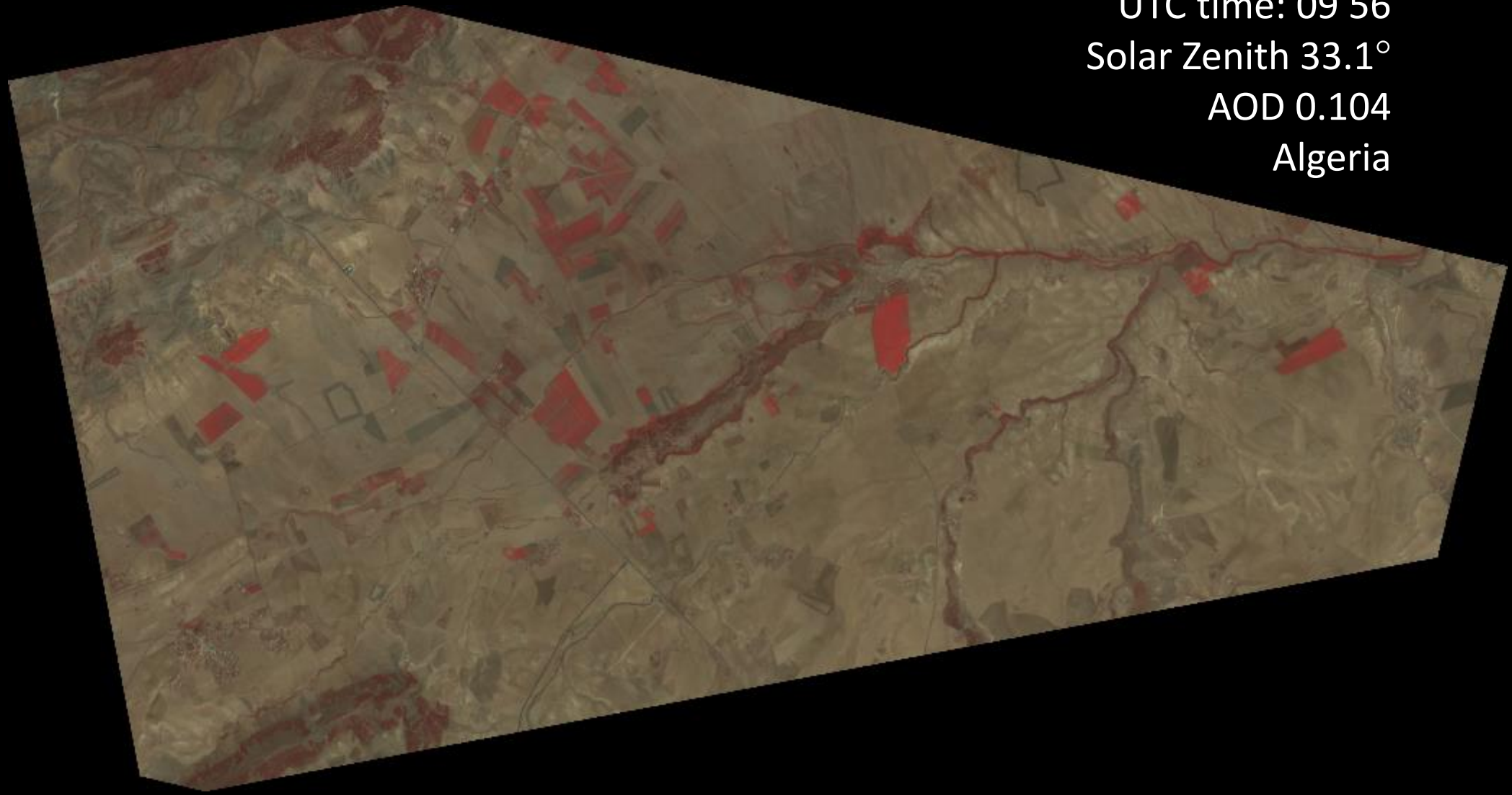


Deep Learning classification of Planetscope two-date 3 m burned area based on Landsat training !



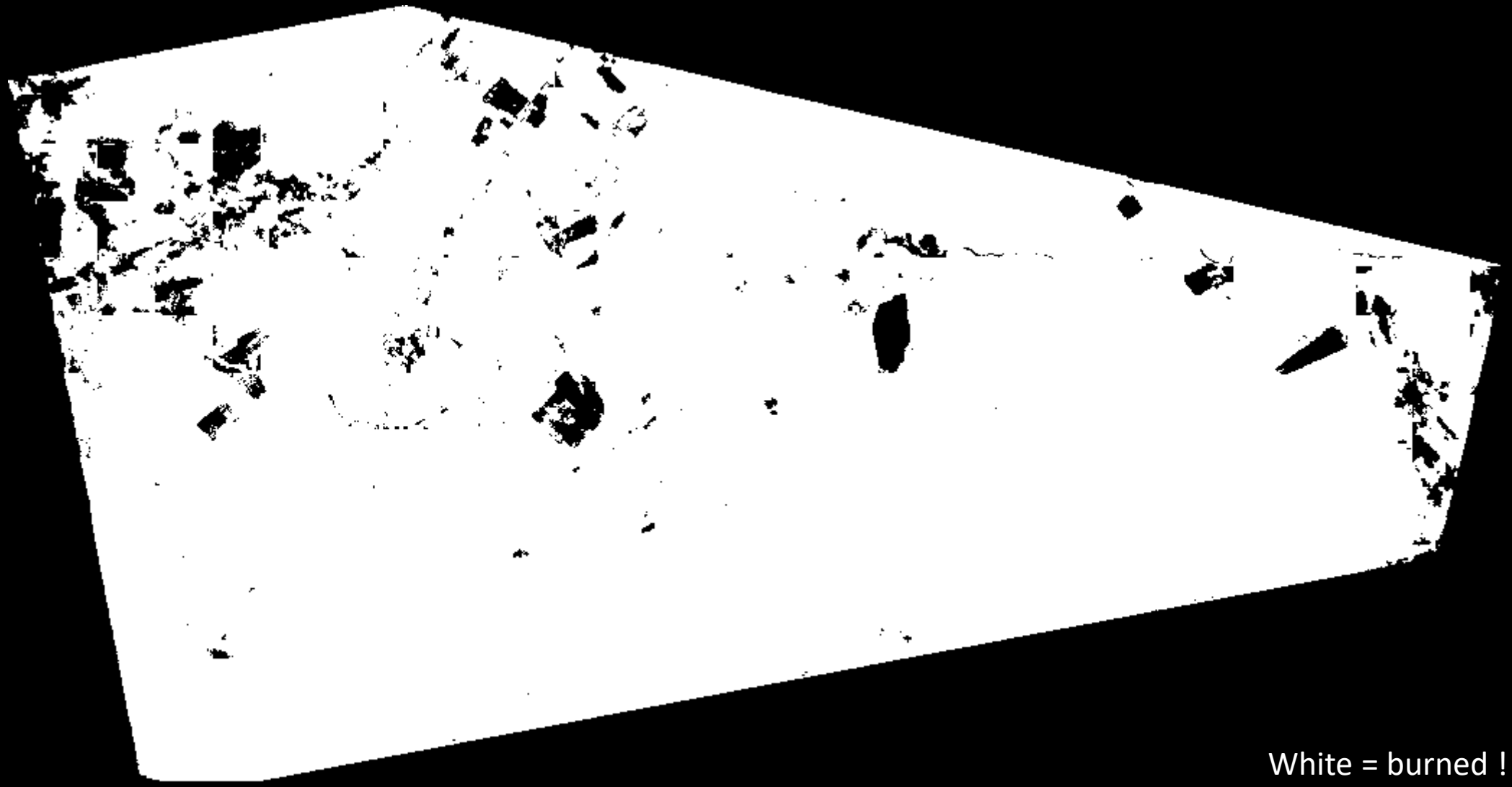


August 21 2019
Planetscope-0
UTC time: 08 43
Solar Zenith 45.0°
AOD 0.135
Algeria



August 22 2019
Planetscope-0
UTC time: 09 56
Solar Zenith 33.1°
AOD 0.104
Algeria

Deep Learning classification of Planetscope two-date 3 m burned area based on Landsat training

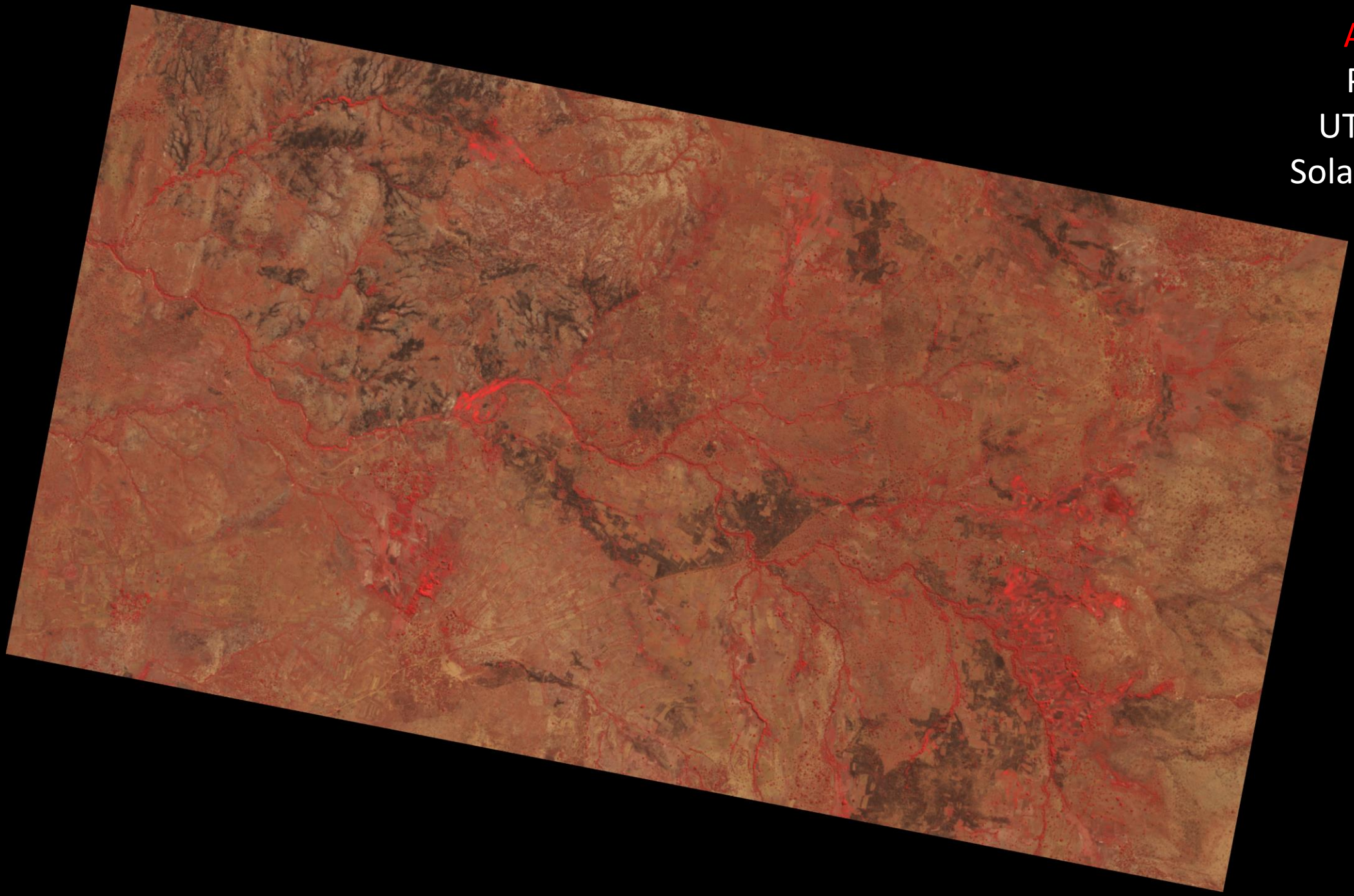


White = burned !

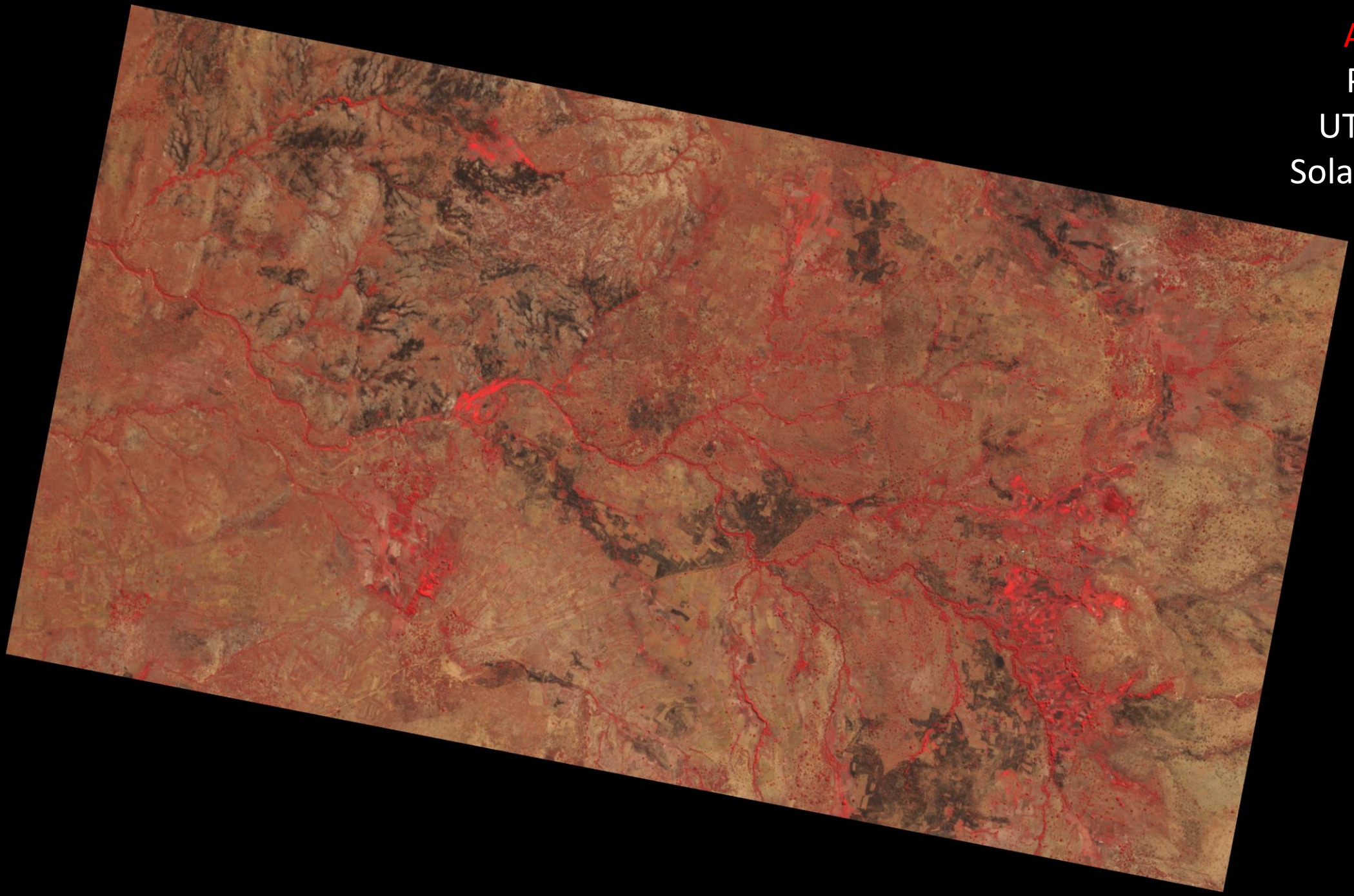
Deep Learning classification of Planetscope two-date 3 m burned area based on Landsat training

After relative normalization of Planetscope data

White = burned

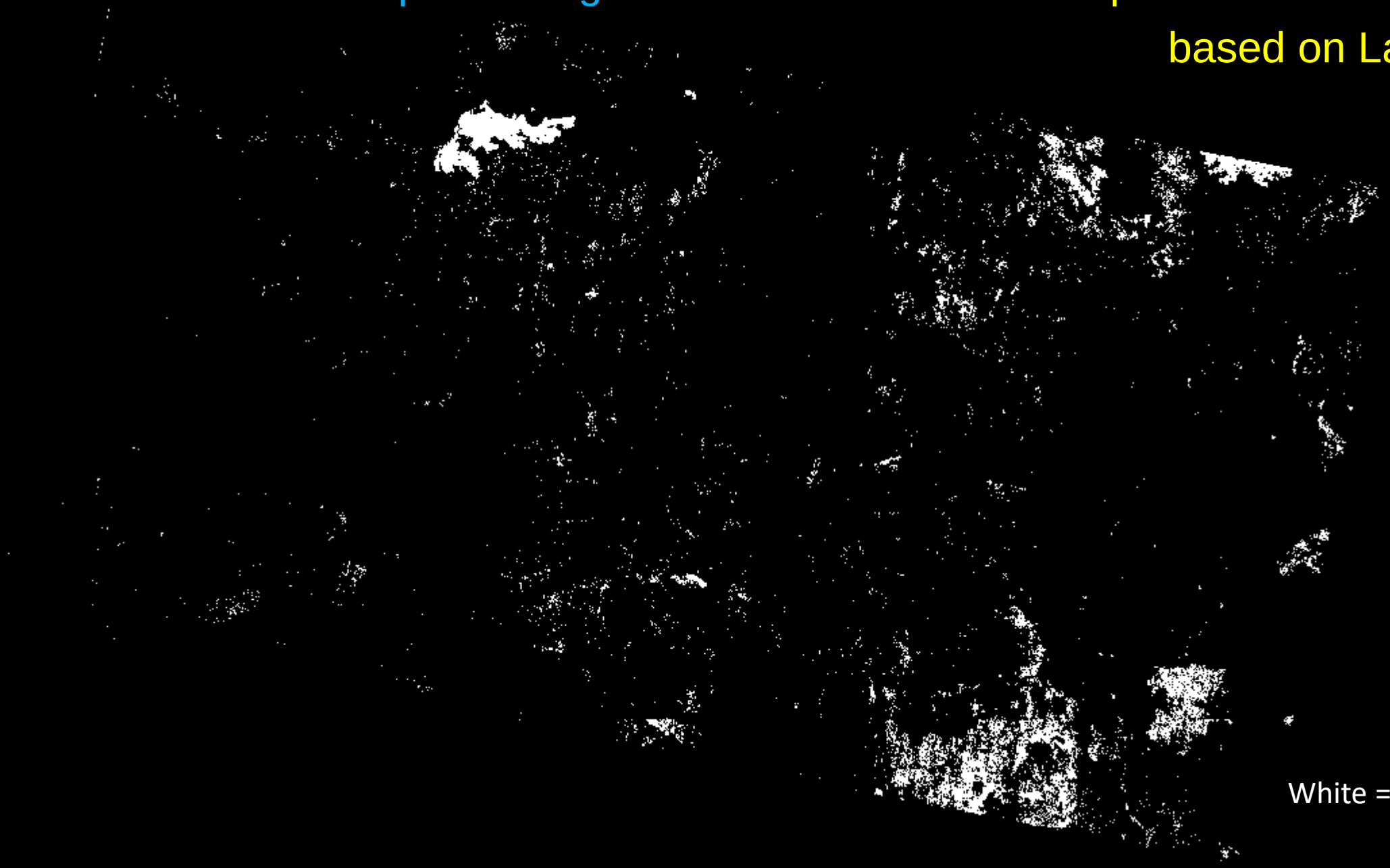


August 5 2019
Planetscope-0
UTC time: 06 53
Solar Zenith 50.7°
AOD 0.080
Madagascar



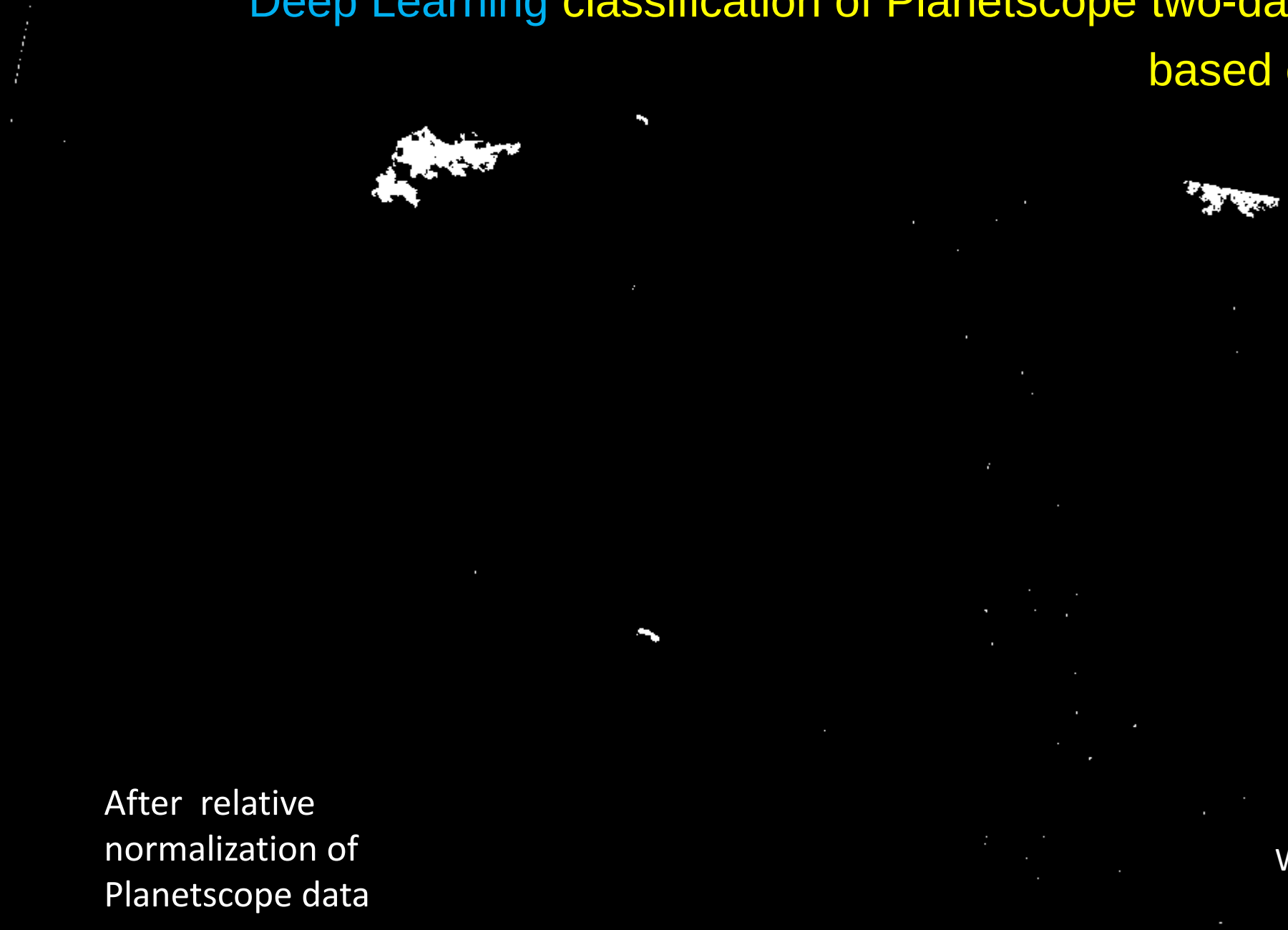
August 6 2019
Planetscope-0
UTC time: 06 52
Solar Zenith 50.7°
AOD 0.104
Madagascar

Deep Learning classification of Planetscope two-date 3 m burned area based on Landsat training



White = burned !

Deep Learning classification of Planetscope two-date 3 m burned area based on Landsat training



After relative normalization of Planetscope data

White = burned

Summary

Good news

- New medium resolution burned area product for Africa developed to take advantage of freely available Sentinel-2 and Landsat-8 NASA HLS, to provide improved mapping of
  - small and spatially fragmented burns
  - low combustion completeness burns
  - ephemeral burns

- HLS V1.5 now a mature multi-sensor ARD

Ongoing research

- PLANET multi-date images can be used to validate 30m Sentinel-2 Landsat-8 burned area product
- Develop a semi-automated deep learning PLANET time series burned area mapping algorithm (under new NASA ACCESS program funding)
- Use results to validate the Sentinel-2 Landsat-8 30m burned area product for all of Africa

- Go Global – primarily a compute and resource issue – where are the missing small burns ? (under new NASA LCLUC program funding)