Evaluation of High Resolution Data for LCLUC Science

2019 NASA LCLUC Spring Science Team Meeting, Rockville MD, April 9-11 2019

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Affiliation: South Dakota State University

Project Title: Commercial satellite data evaluation for burned area mapping & validation of Landsat-8 Sentinel-2 African burned area product

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

Center for GLOBAL CHANGE & Earth Observations
Michigan State University

NASA

planet.

DigitalGlobe

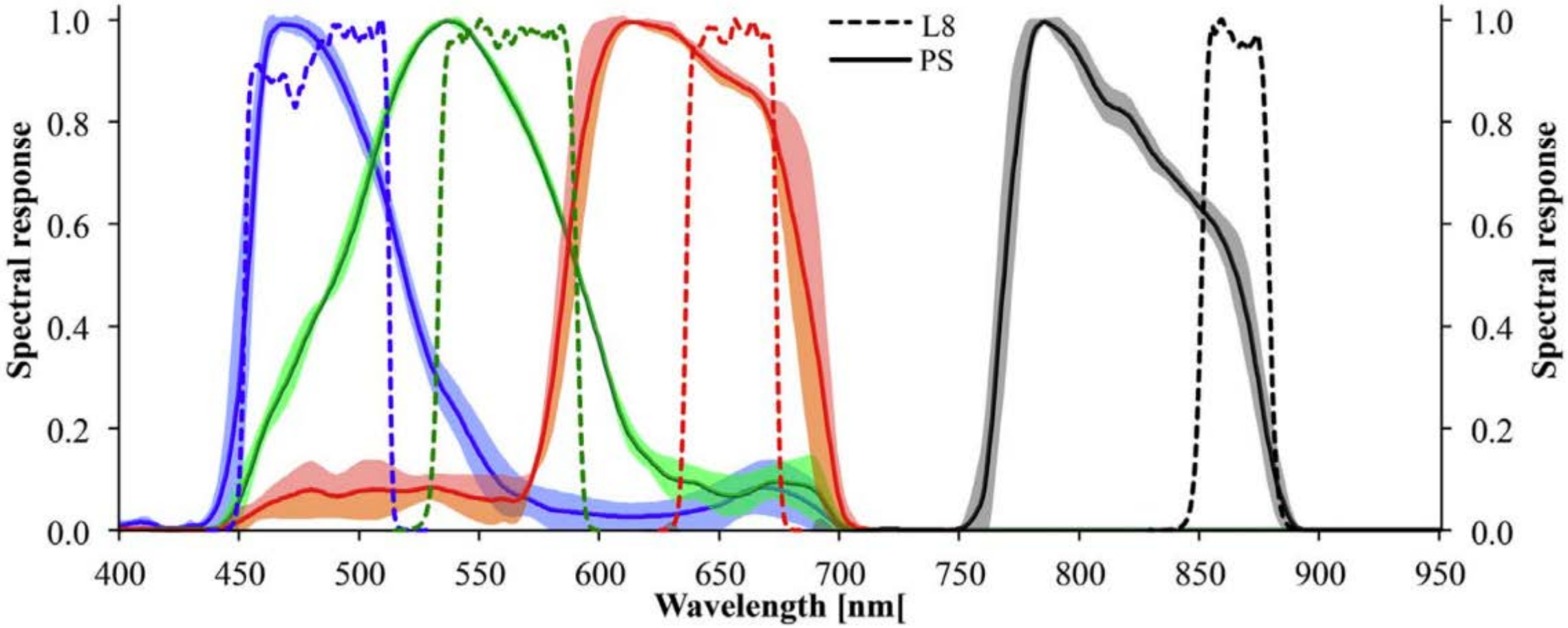
Study Regions

Russia	68.2 × 68.2 km
Zambia	53.3 × 42.2 km
CA	45.0 × 28.5 km

Data download status

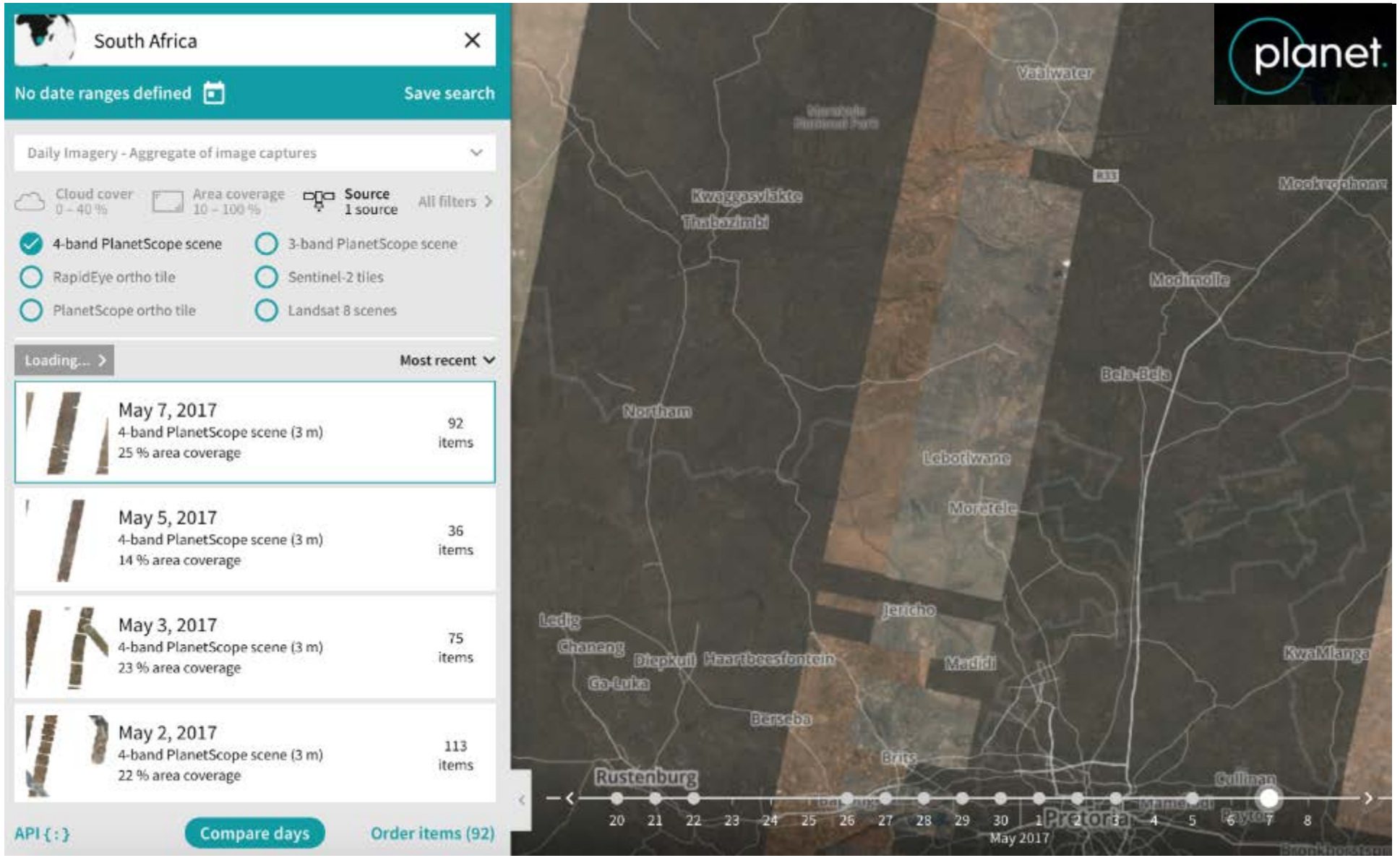
Russia	- Planet 4-band surface reflectance (4.8 GB)
Zambia	- Planet 4-band surface reflectance (4.2 GB)
CA	- Planet 4-band surface reflectance (2.7 GB) - Worldview 3 (8.2 GB)

PLANET 3 m B / G / R / NIR (high temporal coverage)



Houborg and McCabe 2018

Planet Explorer GUI: easy and intuitive

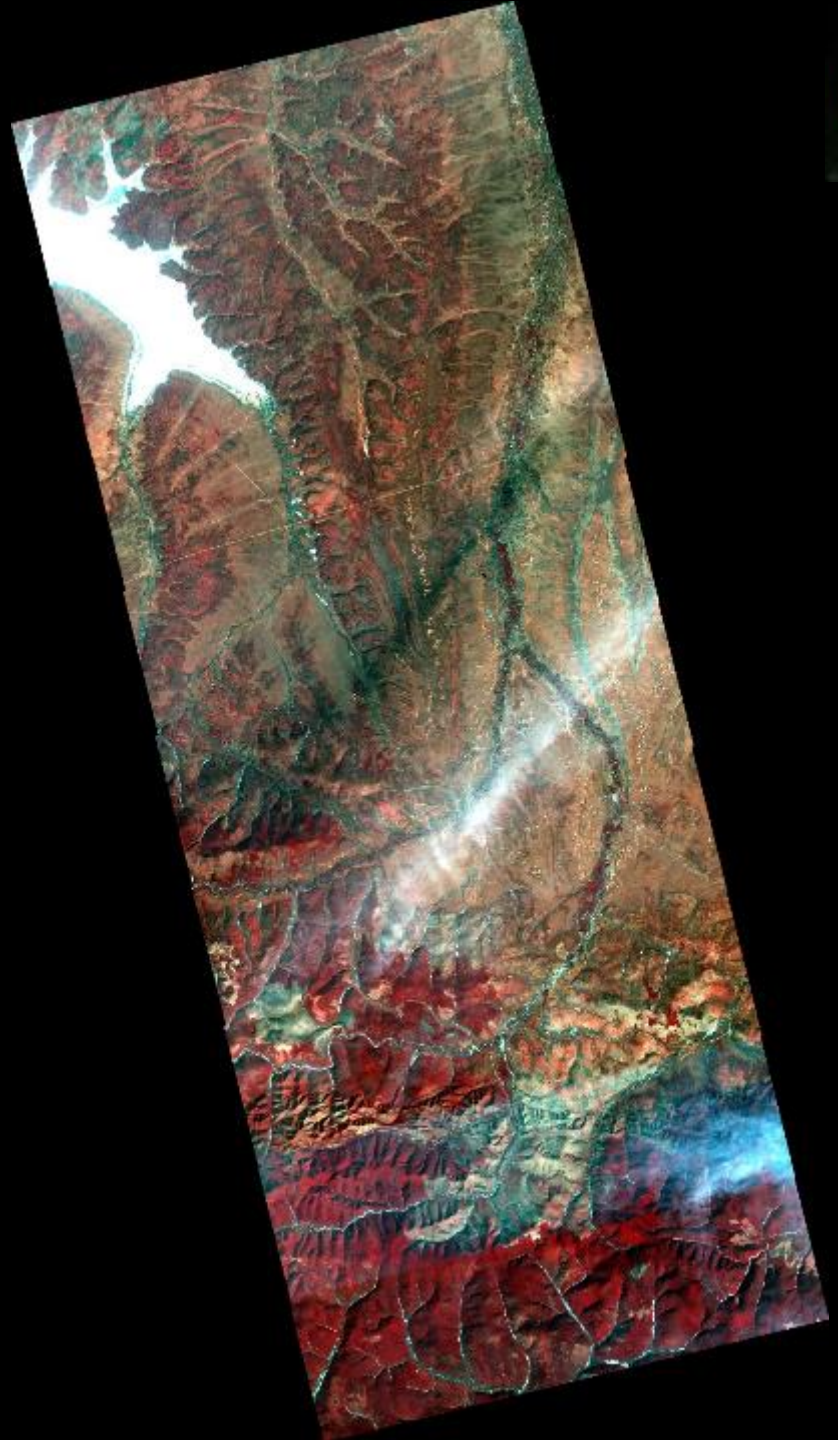


9 PLANET images in the same orbit

each 8500 × 4500 3m pixels
(25.5 × 13.5 km)

False color surface reflectance
(820 nm, 630 nm, 545 nm)

Russia
54.31°N, 127.78 °E
May 4 2018



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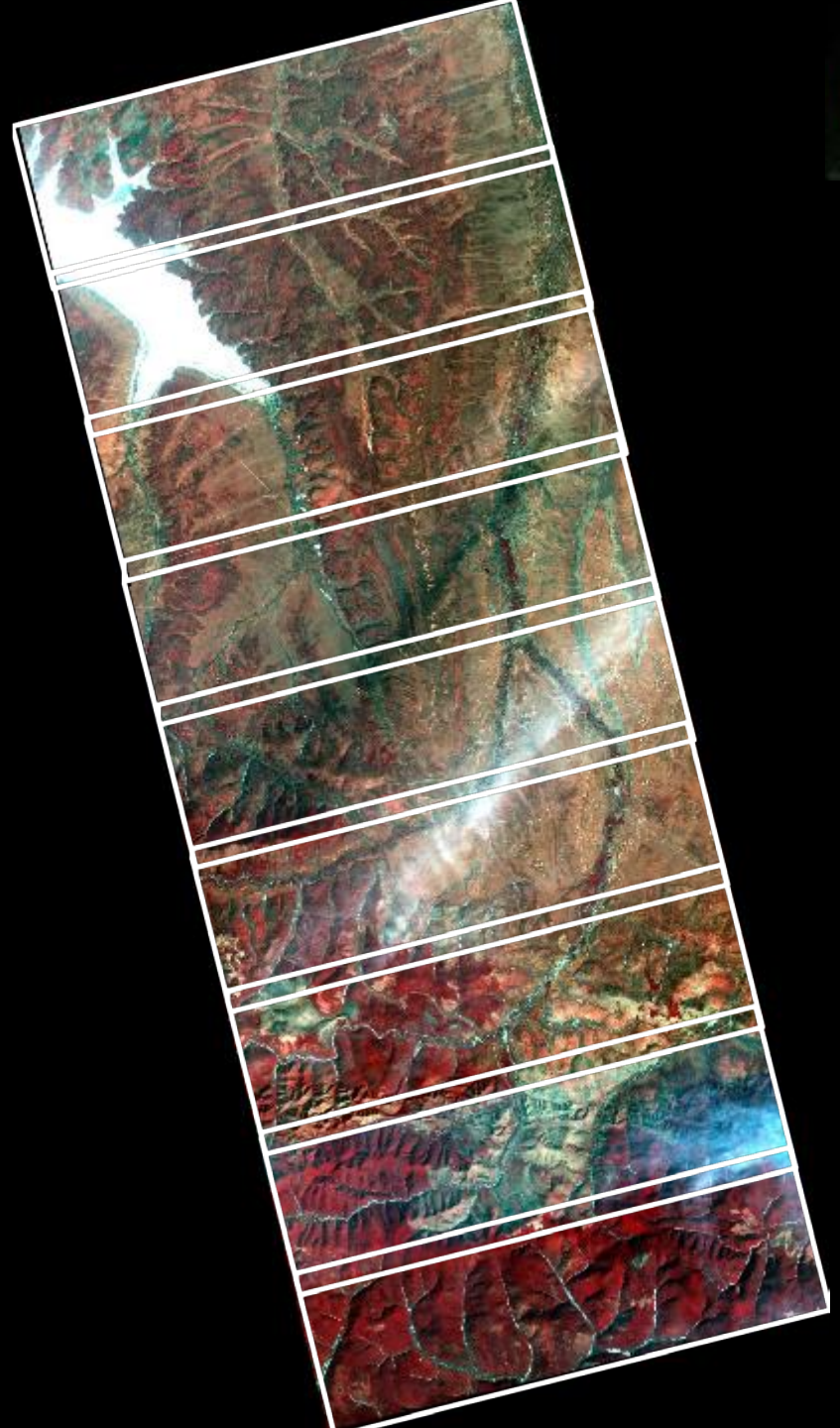

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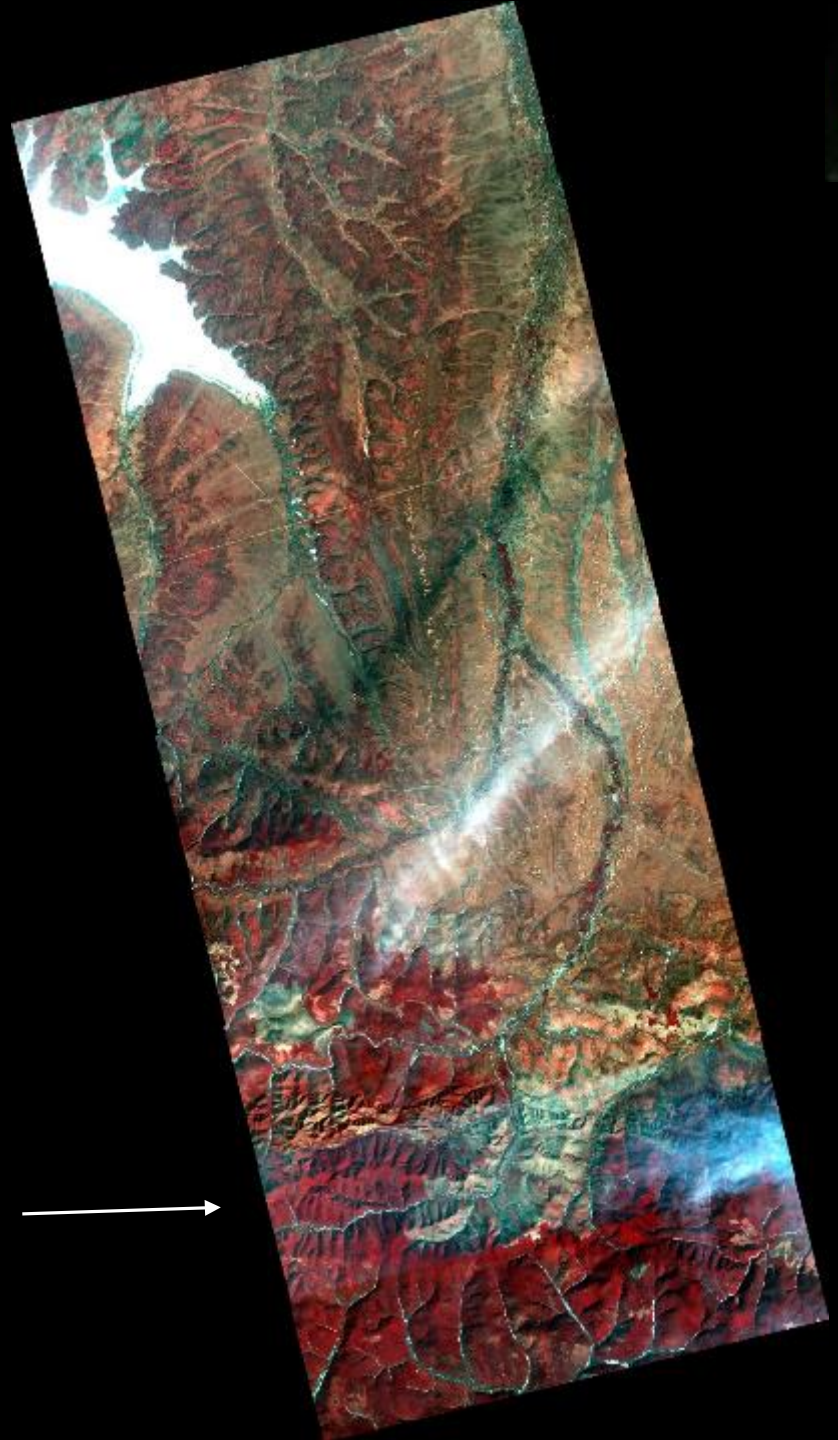
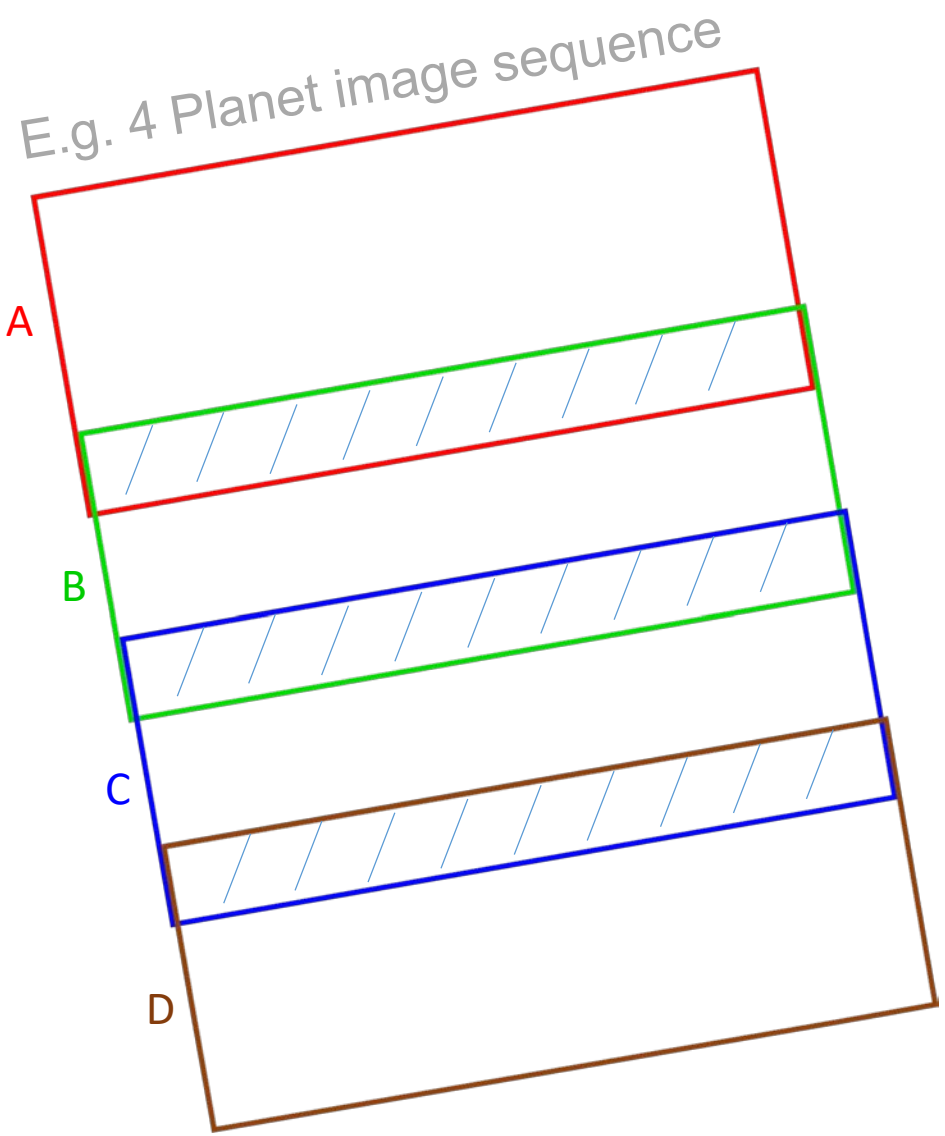
May 4 2018

ISSUE: between image atmospheric correction discontinuities (particularly problematic over high AOD e.g., smoke from fires)



Developed a reflectance normalization least-squares-adjustment (LSA) approach



- Loop **control image** over sequence {A, B, C, D}

  Solve (*gain*, *bias*) for each image

  minimize, by LSA, residuals Δ of all $i = 1 \ldots n$ overlapping pixels among all the image pairs :

  $$\Delta_i = (\rho_i^{\,j} \cdot \text{gain}^{\,j} + \text{bias}^{\,j}) - (\rho_i^{\,k} \cdot \text{gain}^{\,k} + \text{bias}^{\,k})$$

  image j = { A, B, C, D }
  image k= ! j and = { A, B, C, D }
  $\text{gain}^{\text{control image}} = 1$
  $\text{bias}^{\text{control image}} = 0$

  $$D^{\text{control}} = \sum_{m=\{A,B,C,D\}} \left((\rho_i^{\,m} \cdot \text{gain}^{\,m} + \text{bias}^{\,m}) - \rho_i^{\,m} \right) / n$$

- Select the **control image** that provides the smallest D^{control} then apply corresponding image (*gain*, *bias*) values to the images

2 PLANET images in the same orbit

each 8500 × 4500 3m pixels
(25.5 × 13.5 km)

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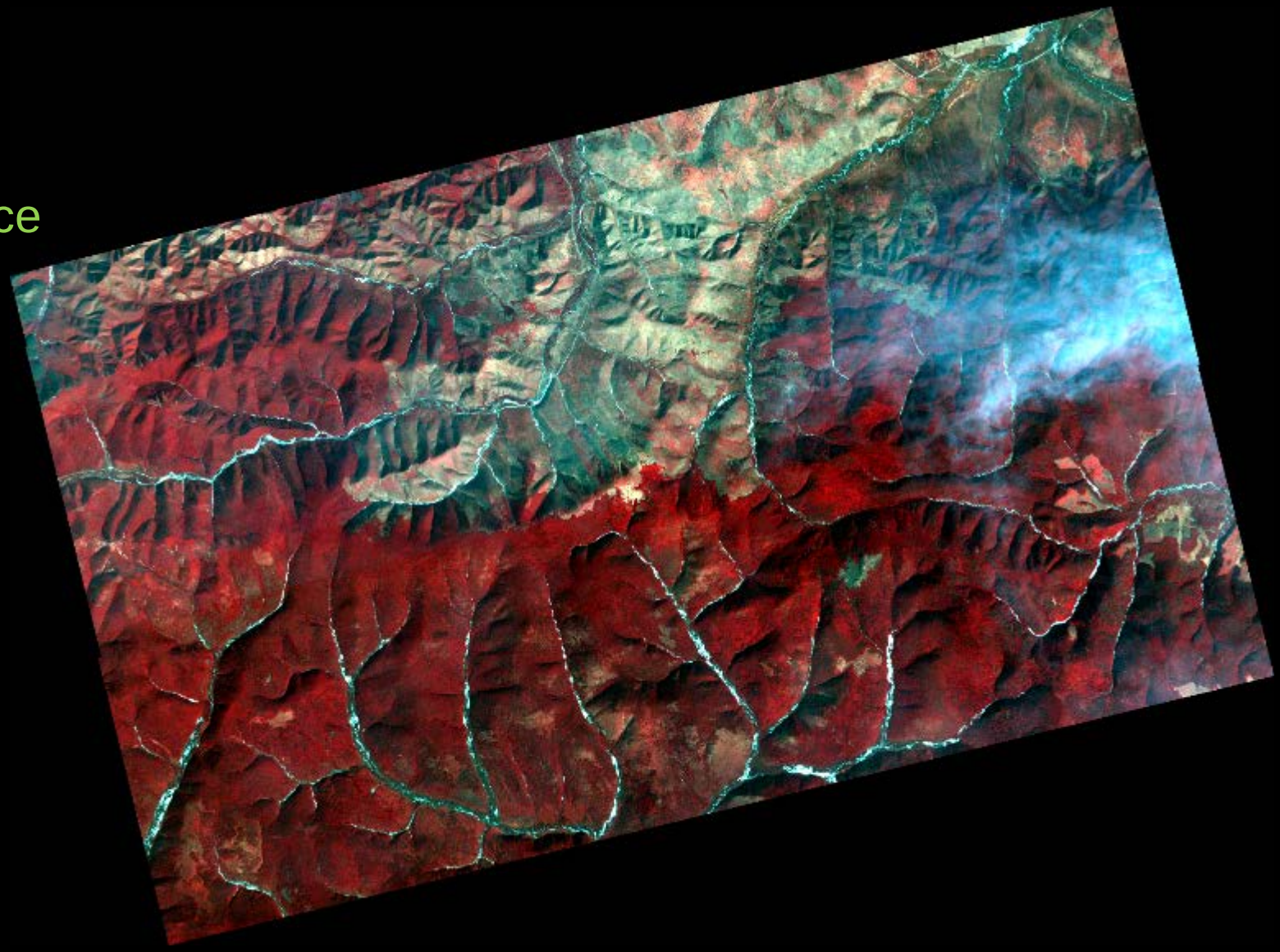
(820 nm, 630 nm, 545 nm)

Russia
54.31°N, 127.78 °E
May 4 2018



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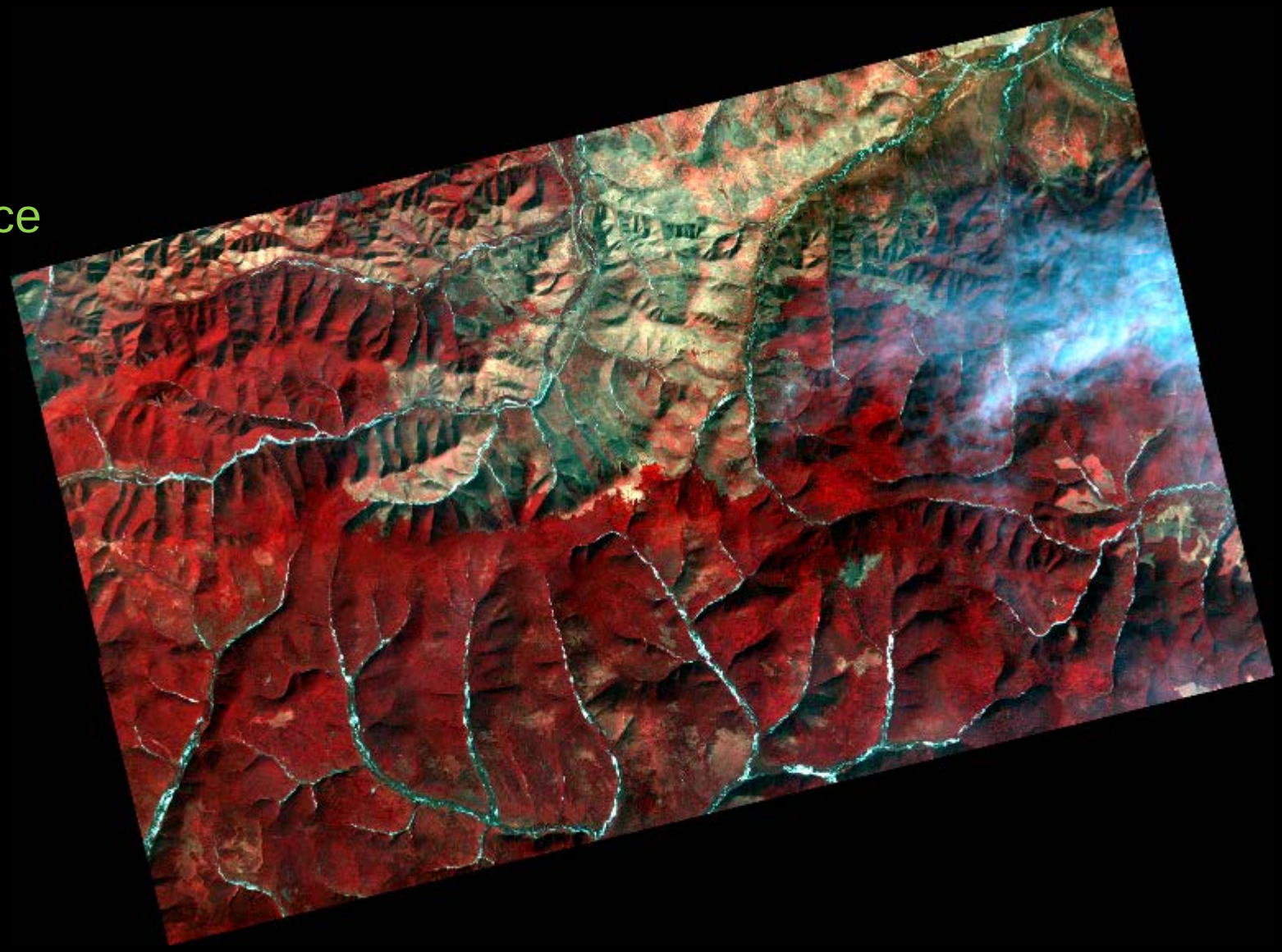
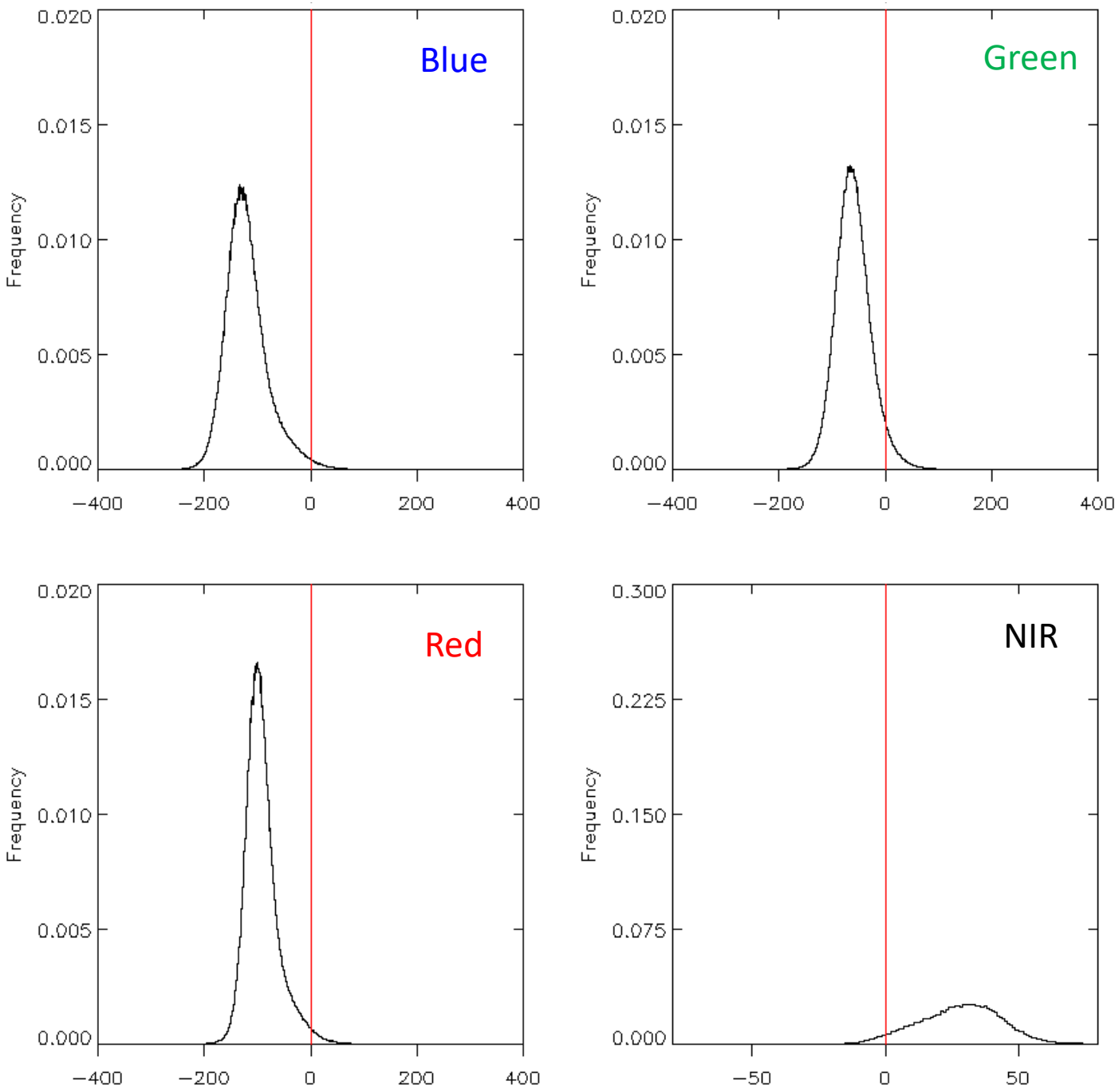


After Normalization

Histograms of surface reflectance differences in the PLANET Image overlap regions

(× 10,000)



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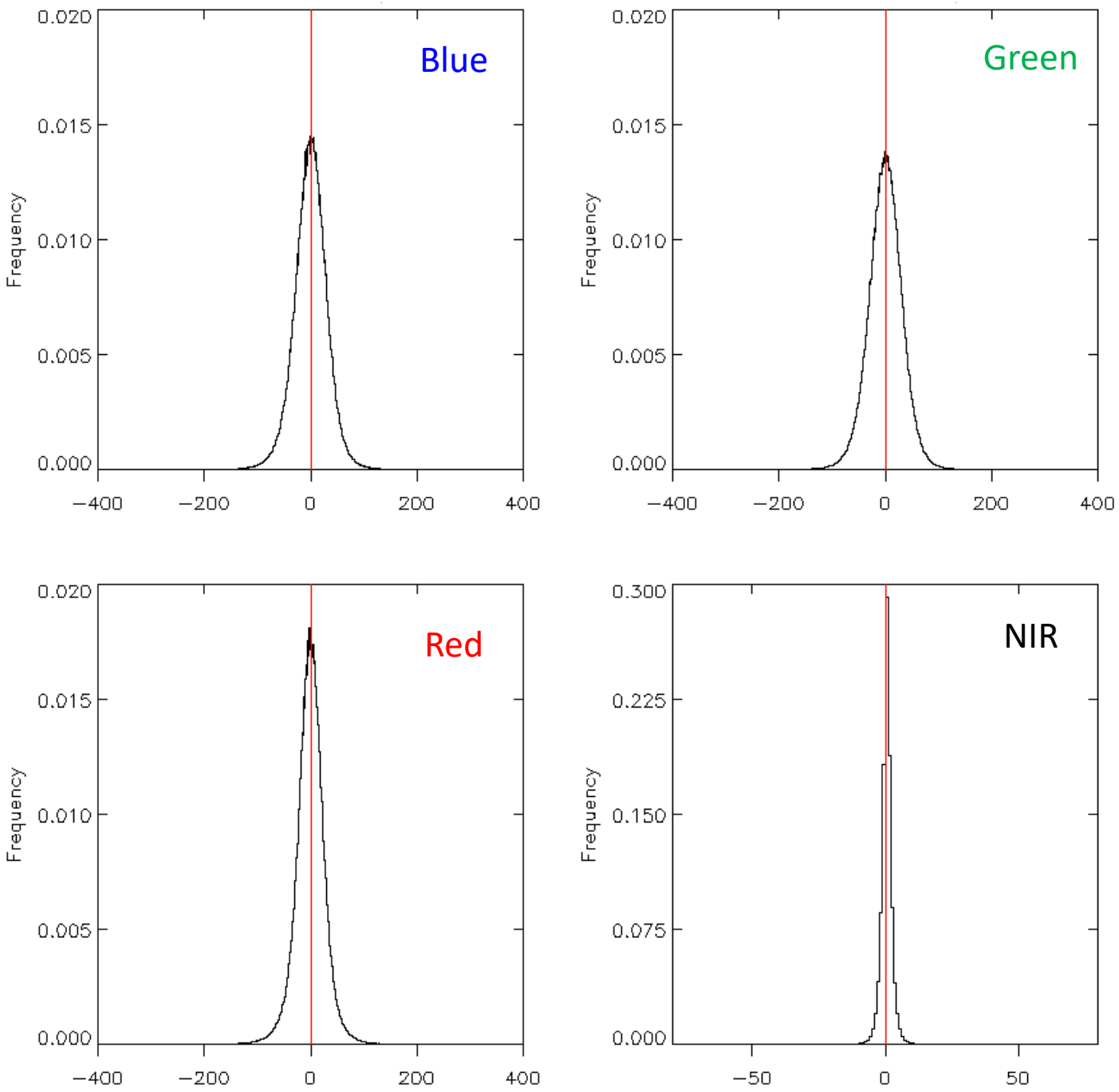

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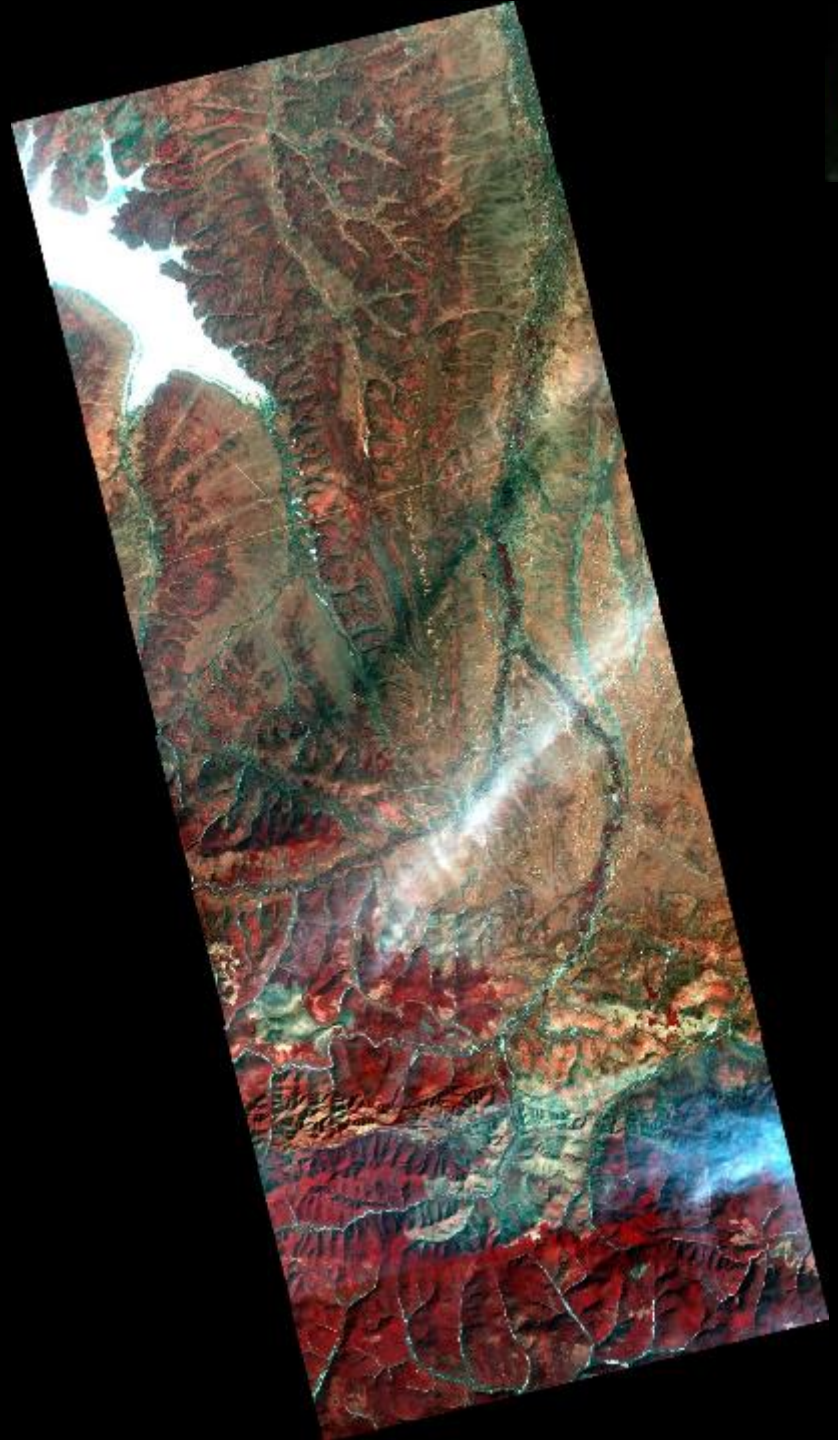

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(820 nm, 630 nm, 545 nm)

Russia
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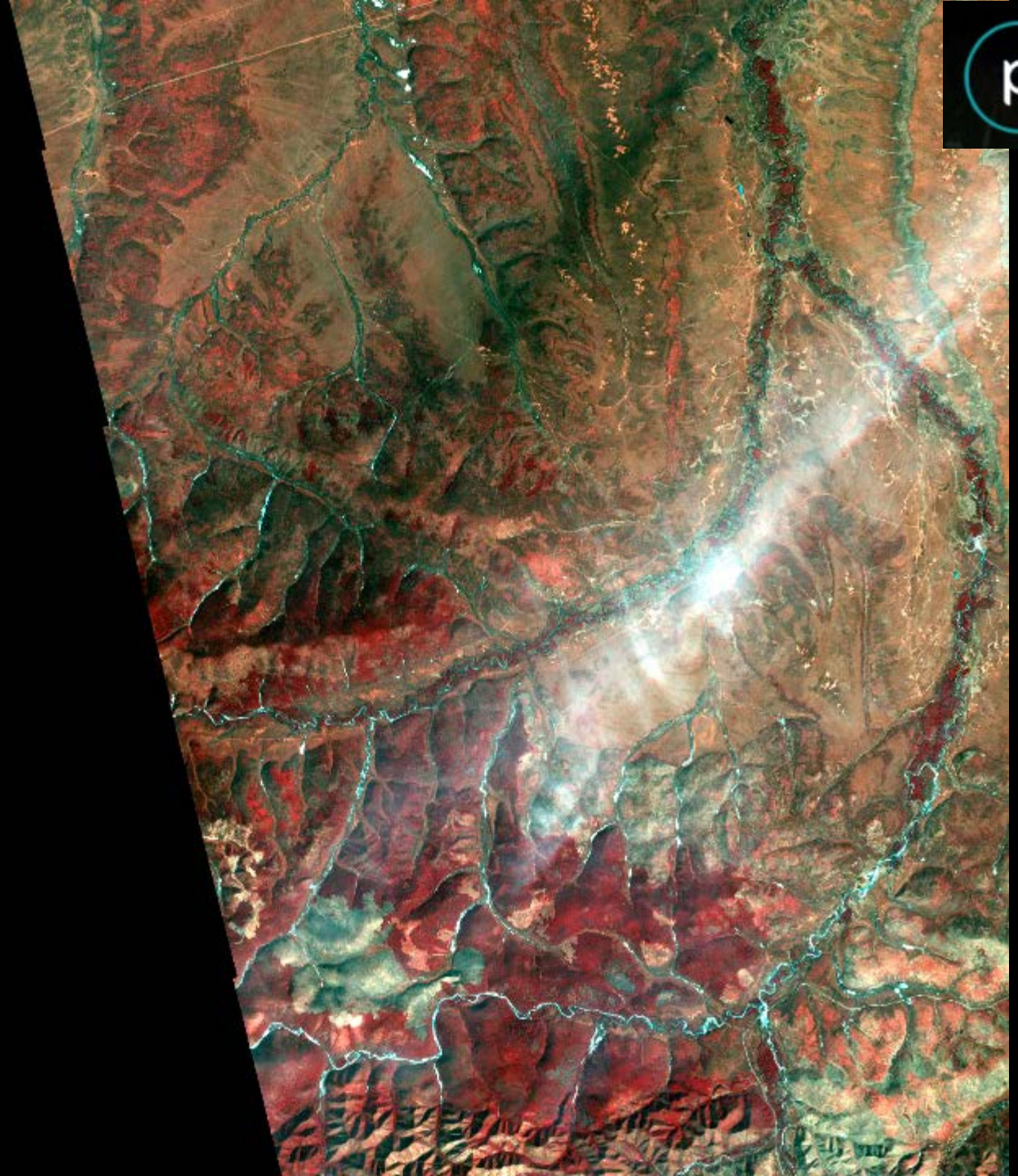
May 4 2018

After Normalization

4 PLANET images

May 4 2018
Russia

False color surface reflectance
(820 nm, 630 nm, 545 nm)



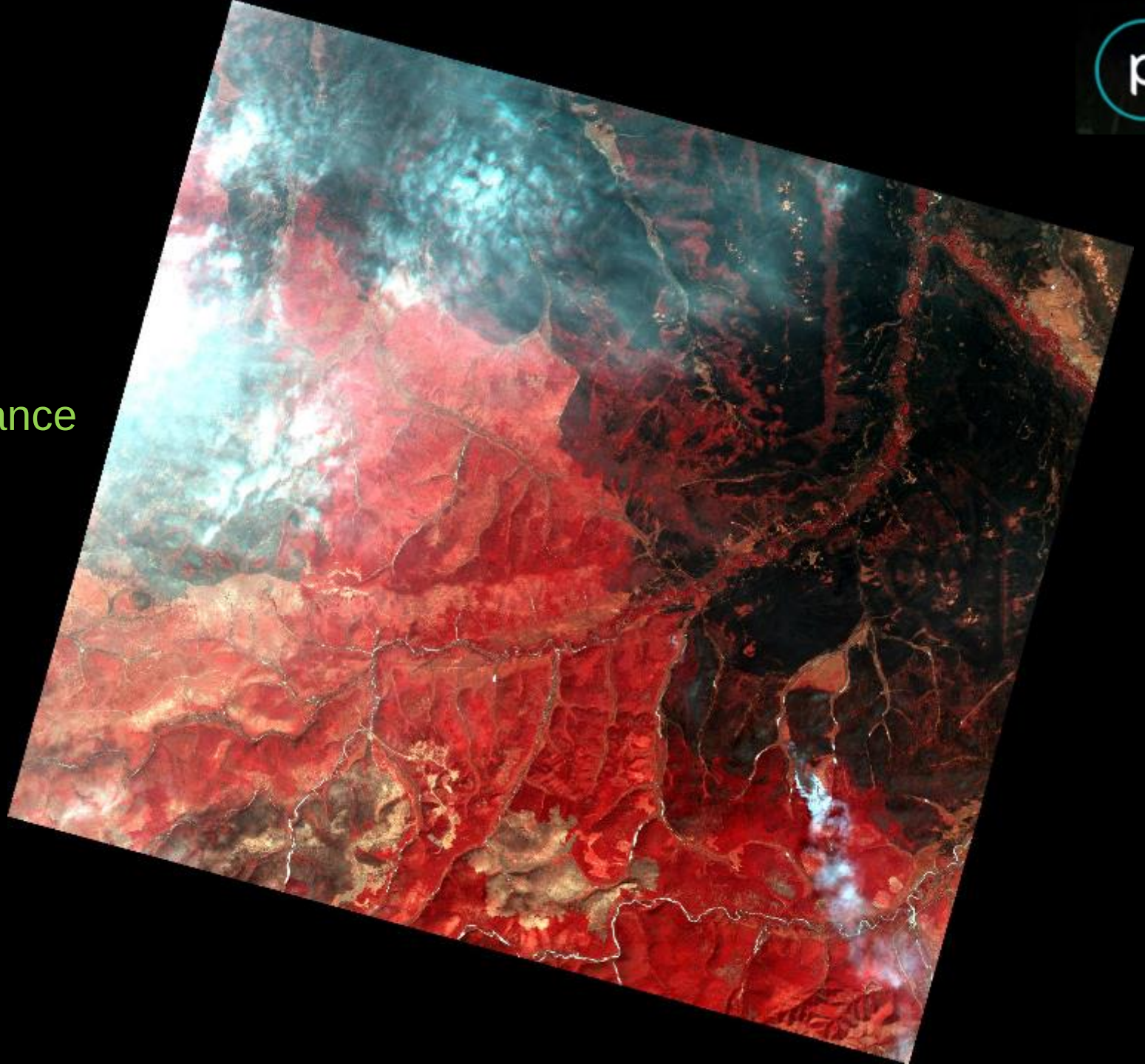
Burned training

Unburned training

3 PLANET images

May 16 2018
Russia

False color surface reflectance
(820 nm, 630 nm, 545 nm)



Burned training

Unburned training

3 PLANET images

May 16 2018
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False color surface reflectance
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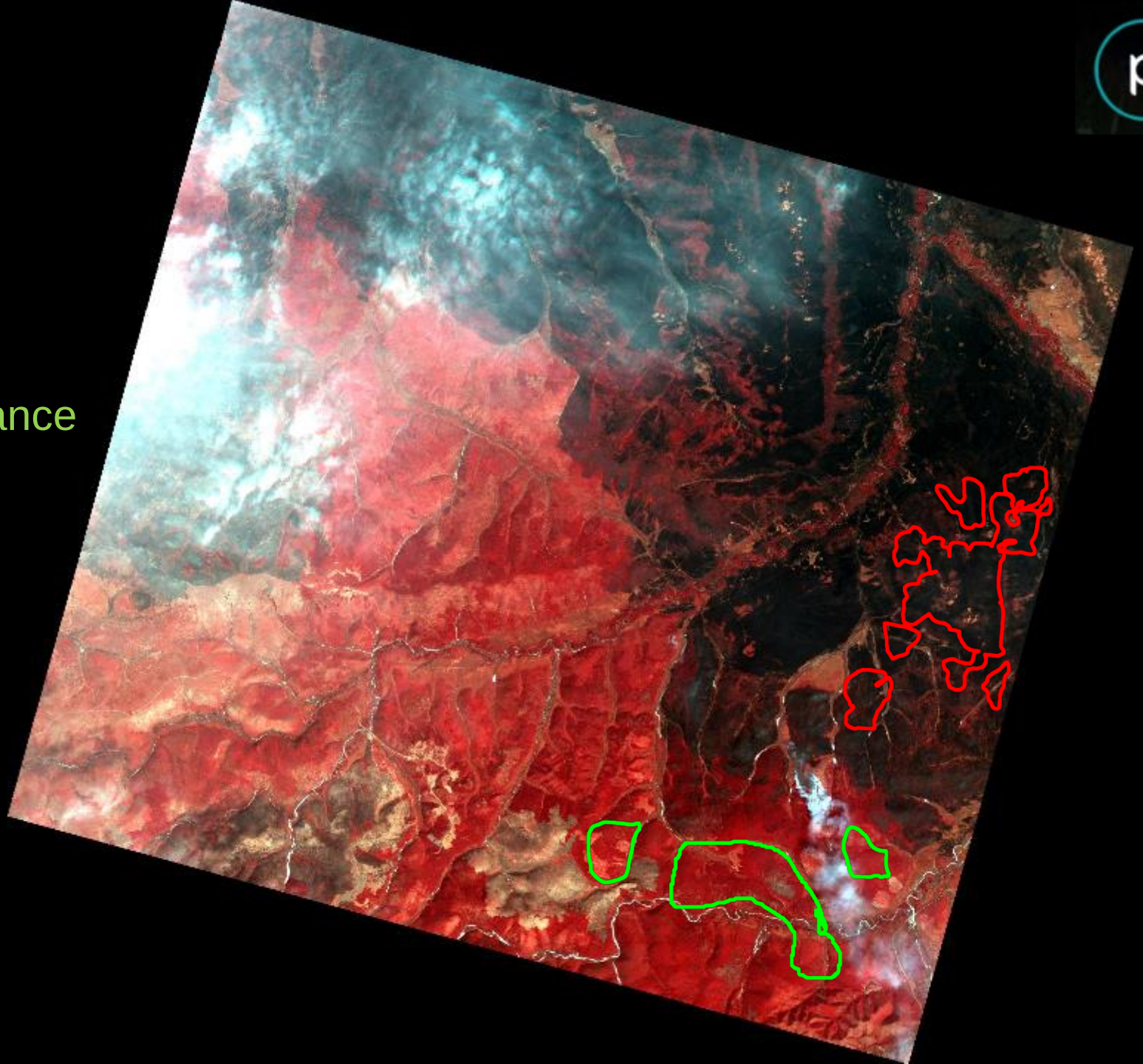
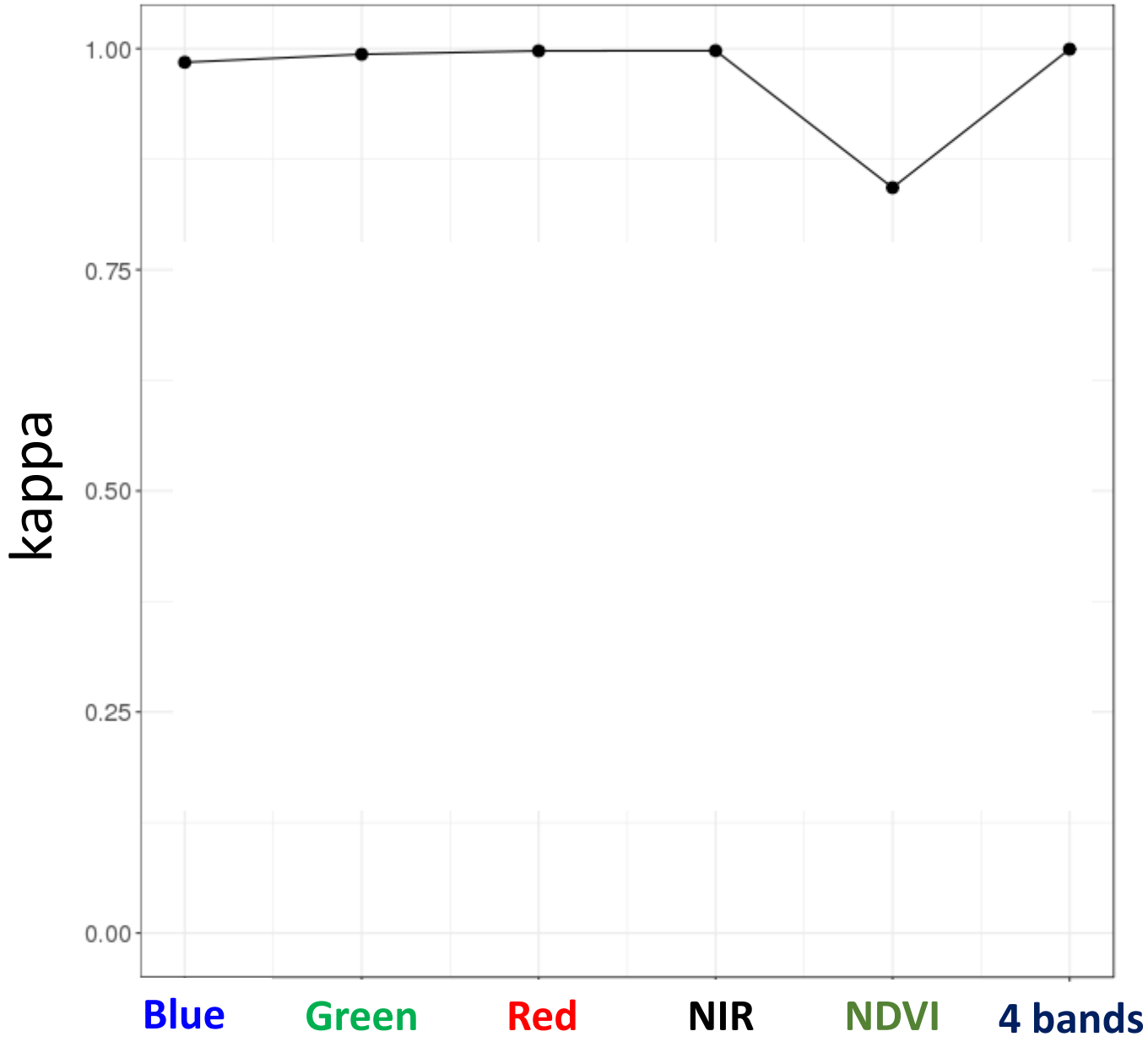


Burned training

Unburned training

PLANET band non-parametric separability analysis

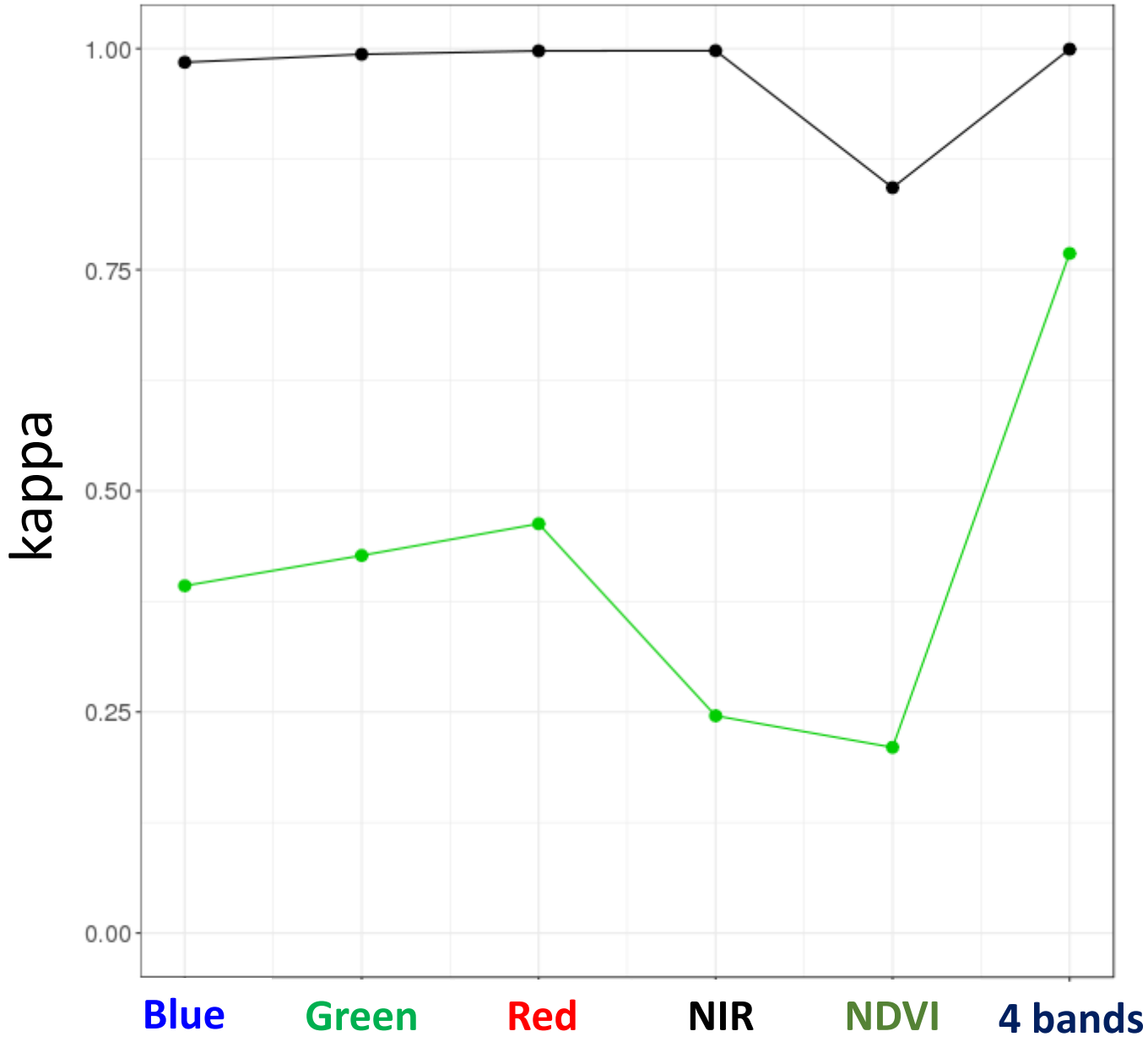


May 4th unburned -> May 16th 2018 burned

Huang et al. 2016

- 200 decision trees grown
- each time using 20% of the training samples selected randomly with replacement
- remaining “out-of-bag” 80% classified

PLANET band non-parametric separability analysis



May 4th unburned -> May 16th 2018 burned

May 4th unburned -> May 16th 2018 unburned

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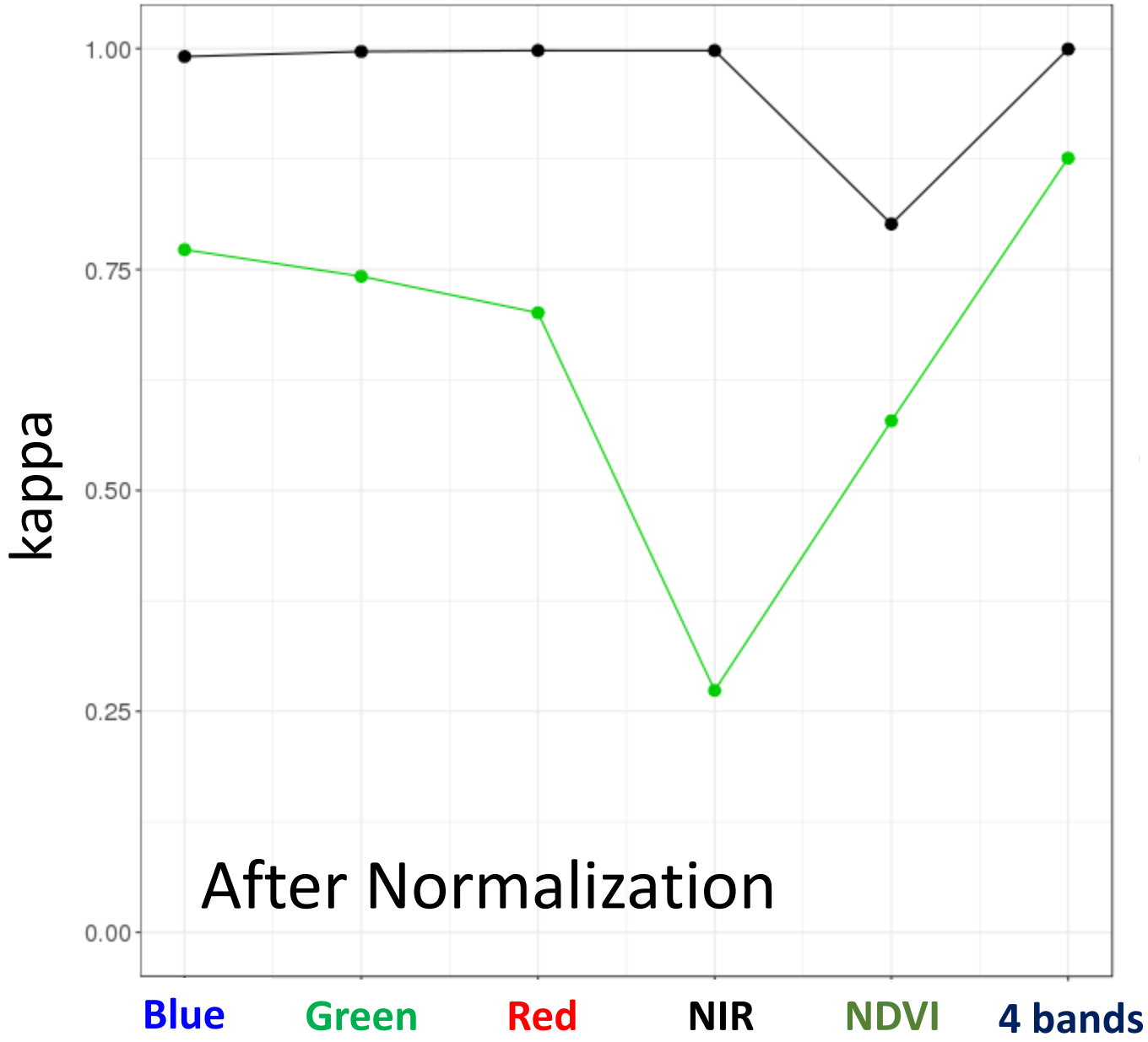

May 4th unburned -> May 16th 2018 burned

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Huang et al. 2016

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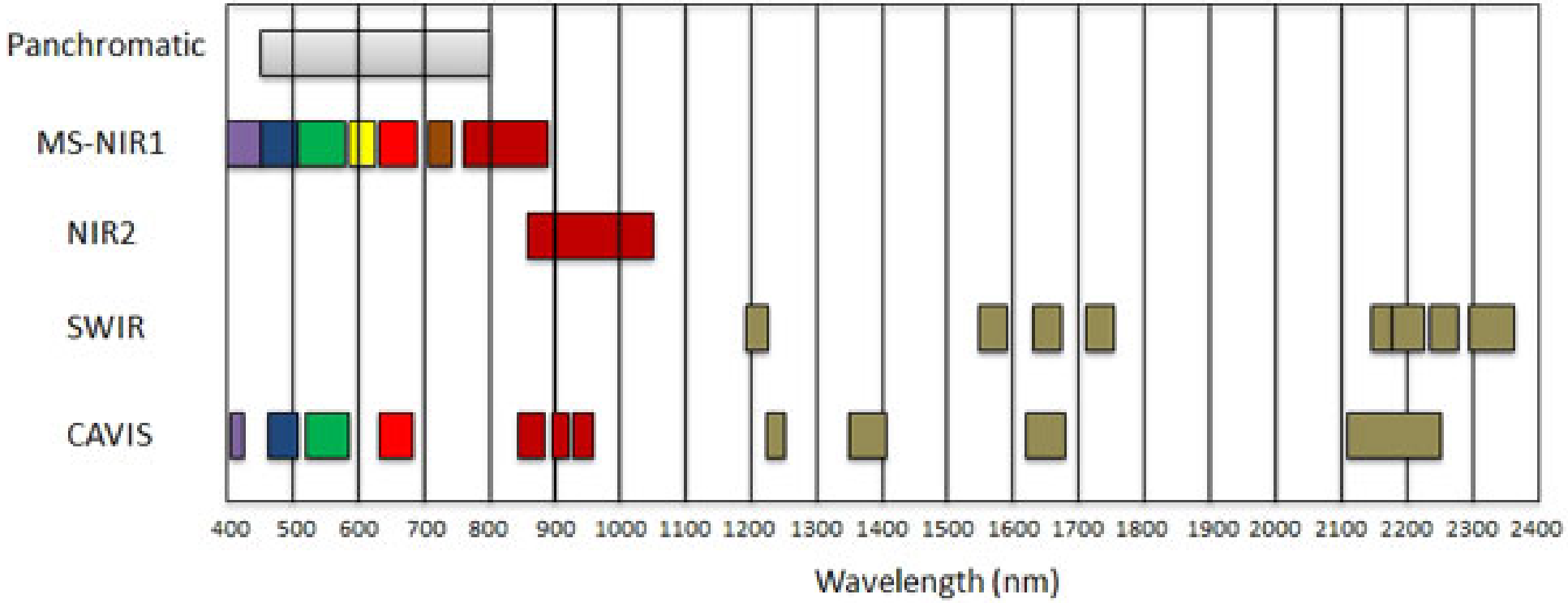
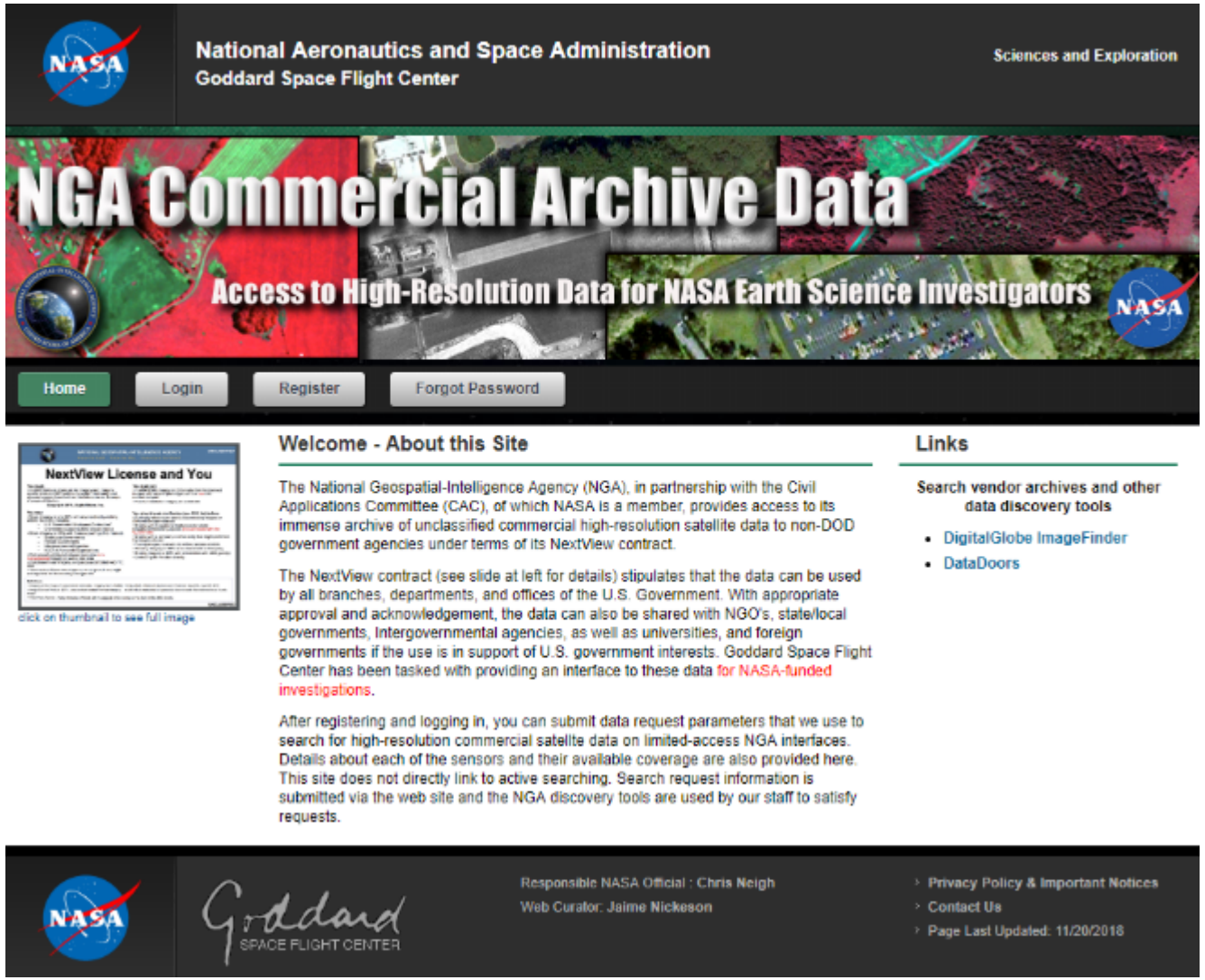
World View 3

VIS 1.24 m
NIR 1.24 m
SWIR 3.7 m (not orthorectified) 7.5 m (orthorectified) <- useful for burned area mapping with NIR



World View 3

NASA CAD access: ! easy && ! intuitive



Jamie and the NASA CAD team are *great* but

– not able to interactively browse archive contents (“human in the loop” email process)

- slow to find WV3 data where we have contemporaneous PLANET data
- some WV3 spectral bands not in the NASA CAD archive

World View 3

1.24 m NIR (948 nm)

ISSUE: many WV3 images over burned locations are not orthorectified

Los Padres National Forest
California
December 7 2017

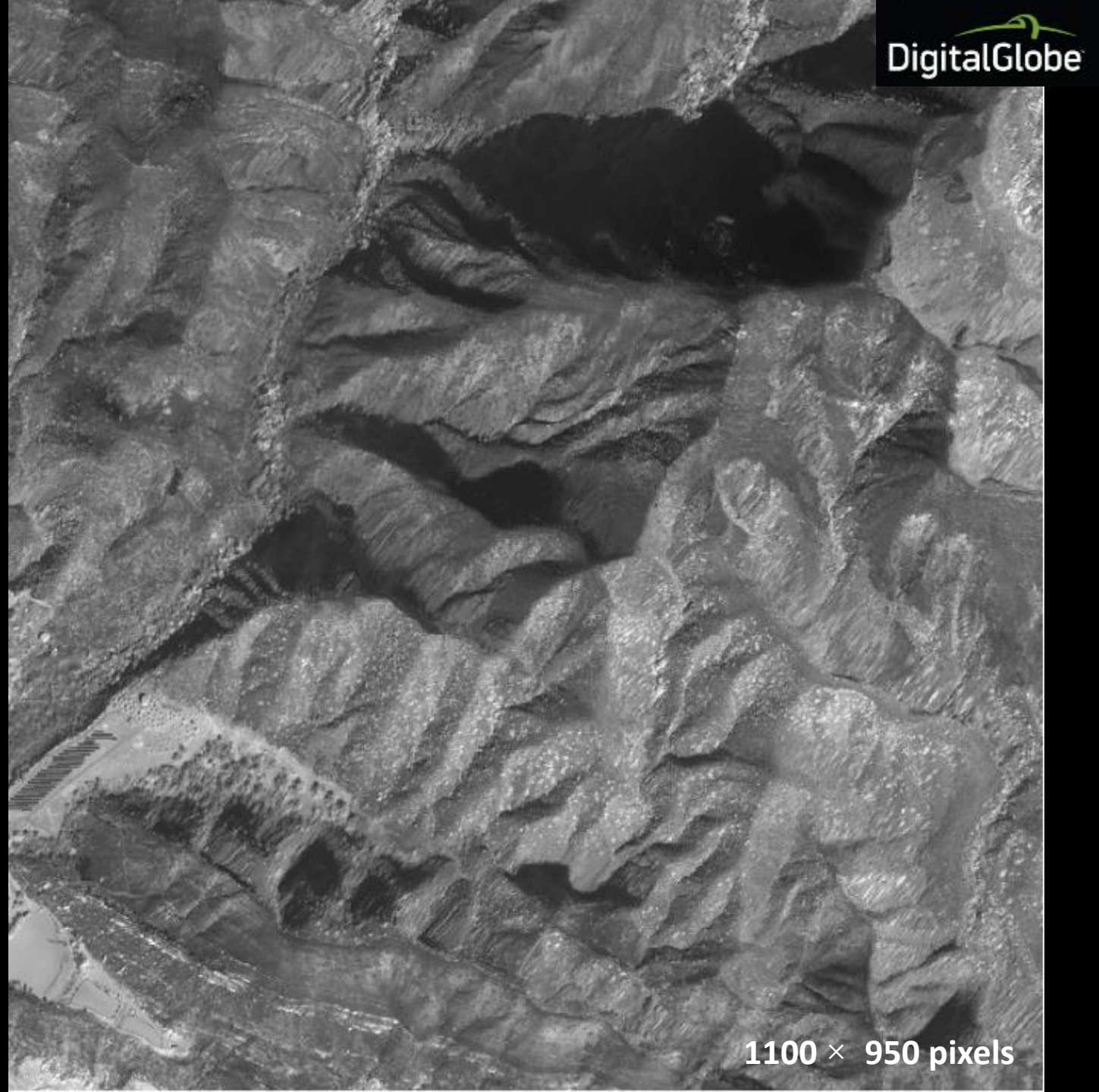
World View 3

1.24 m NIR (948 nm)

Orthorectified using 1/3 arc-sec (~10 m) USGS 3D Elevation Program (3DEP) DEM

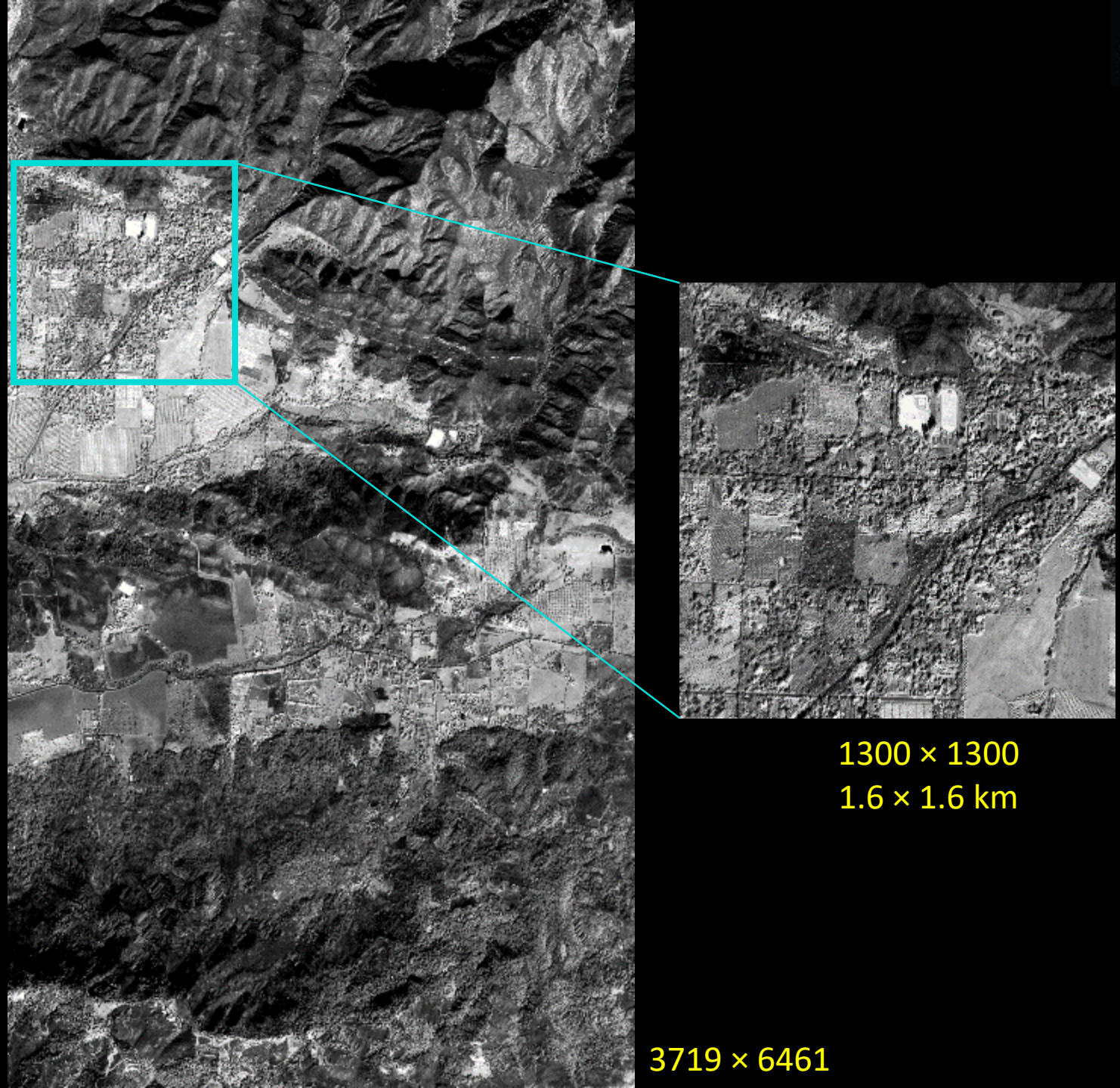
ISSUE: high res. DEM unavailable outside US

Los Padres National Forest
California
December 7 2017



World View 3

1.24 m NIR (948 nm)



1300 × 1300
1.6 × 1.6 km

3719 × 6461

Los Padres National Forest
California
December 7 2017

World View 3

1.24 m NIR (948 nm)

1300 × 1300

1.6 × 1.6 km

Los Padres National Forest
California
December 7 2017

World View 3

3.7 m SWIR
(1210, 1570, 1660 nm)
Resampled to
1.24 m

ISSUE: SWIR bands lower spatial resolution & not well aligned with other bands

1300 × 1300

1.6 × 1.6 km

Los Padres National Forest
California
December 7 2017

World View 3

3.7 m SWIR
(1210, 1570, 1660 nm)
Pansharpened and coregistered to
1.24 m

1300 × 1300

1.6 × 1.6 km

Los Padres National Forest
California
December 7 2017

World View 3

1.24 m NIR (948 nm)

1300 × 1300

1.6 × 1.6 km

Los Padres National Forest
California
December 7 2017

Planet

3 m NIR (948 nm)

December 4 2017

537 × 537

Los Padres National Forest
California

1.6 × 1.6 km

World View 3

1.24 m NIR (948 nm)

December 7 2017

Los Padres National Forest
California

1300 × 1300

1.6 × 1.6 km

DigitalGlobe

Planet

3 m NIR (948 nm)

December 18 2017

537 × 537

1.6 × 1.6 km

Los Padres National Forest
California

Summary: Commercial satellite data evaluation for burned area mapping & validation of Landsat-8 Sentinel-2 African burned area product

Plan to use

- PLANET 3m VIS and NIR (near daily)
- World View 3 1.24 m NIR (less frequent)
  1.24 m pansharpened SWIR (less frequent)

Issues

- PLANET among image atmospheric correction discontinuities (developed a normalization solution)
- World View 3
  - ordering vis NASA CAD cumbersome
  - orthorectification unlikely to be reliable where no high res. DEM
  - SWIR band coregistration and panshapening needed (developed a solution)

See our MuSLI Talk Thursday 10.50-11.10 am for PLANET validation examples