The potential of Landsat-like Sentinel-2 multi-spectral instrument (MSI) data for burned area discrimination

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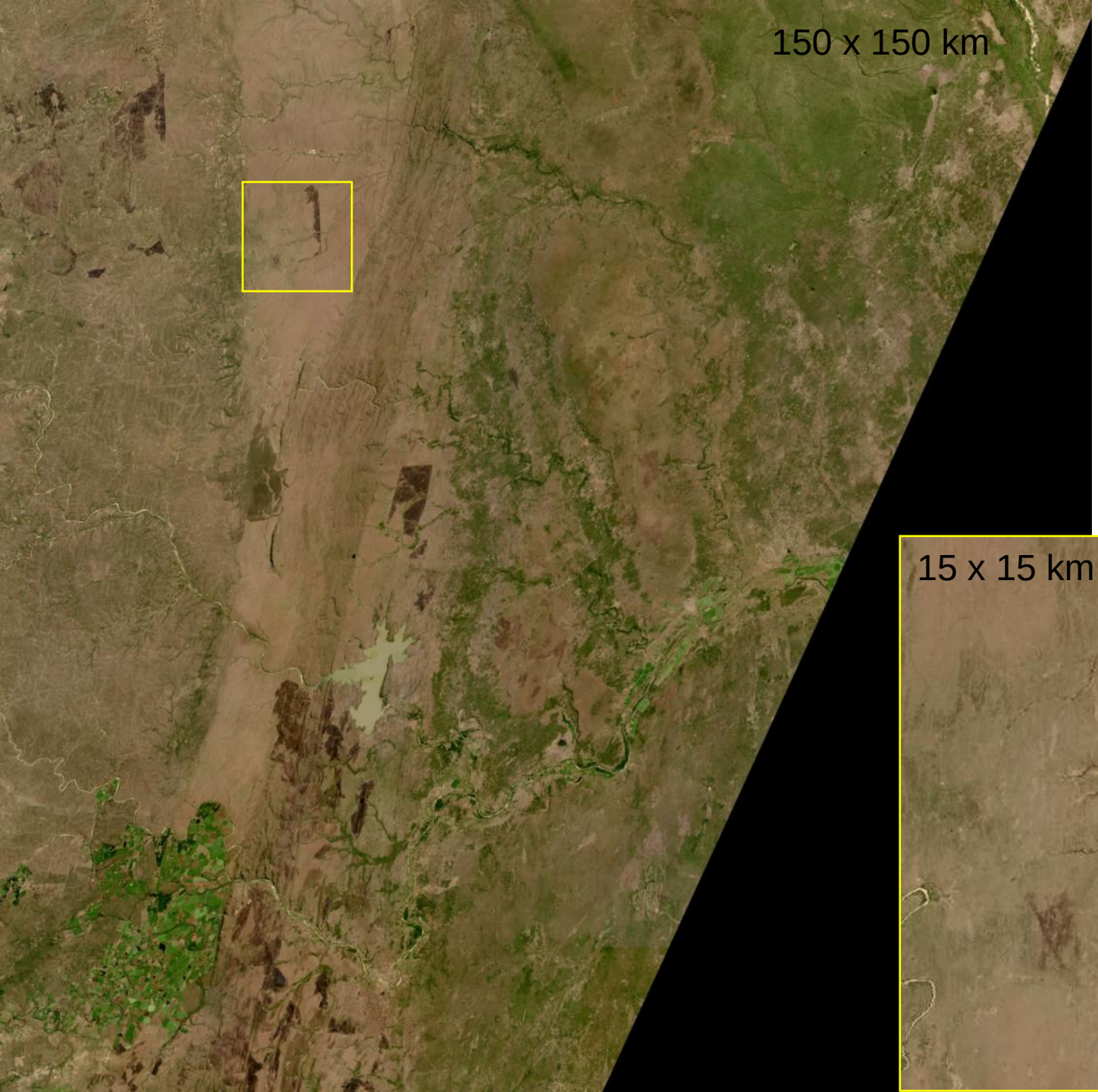
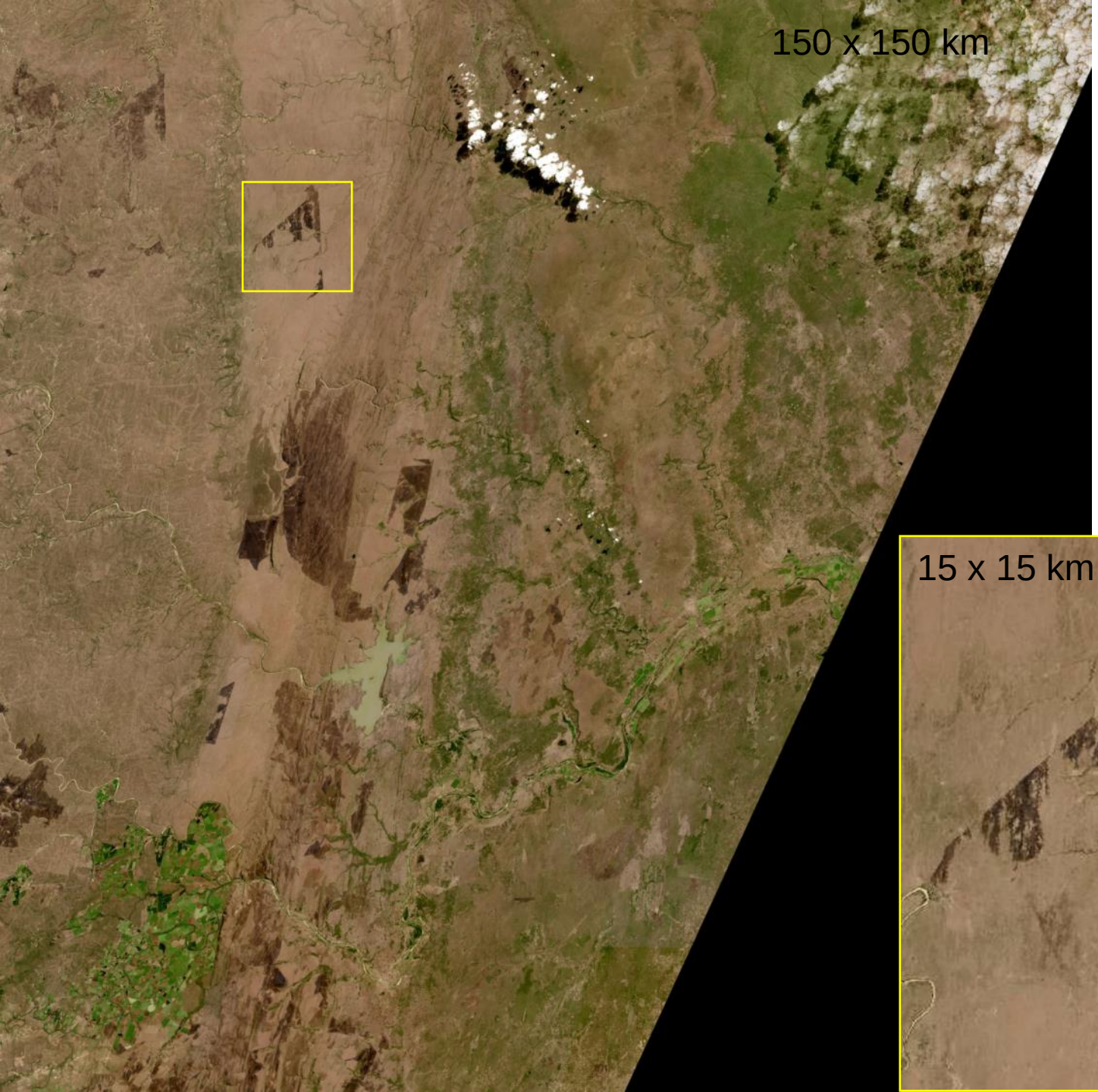
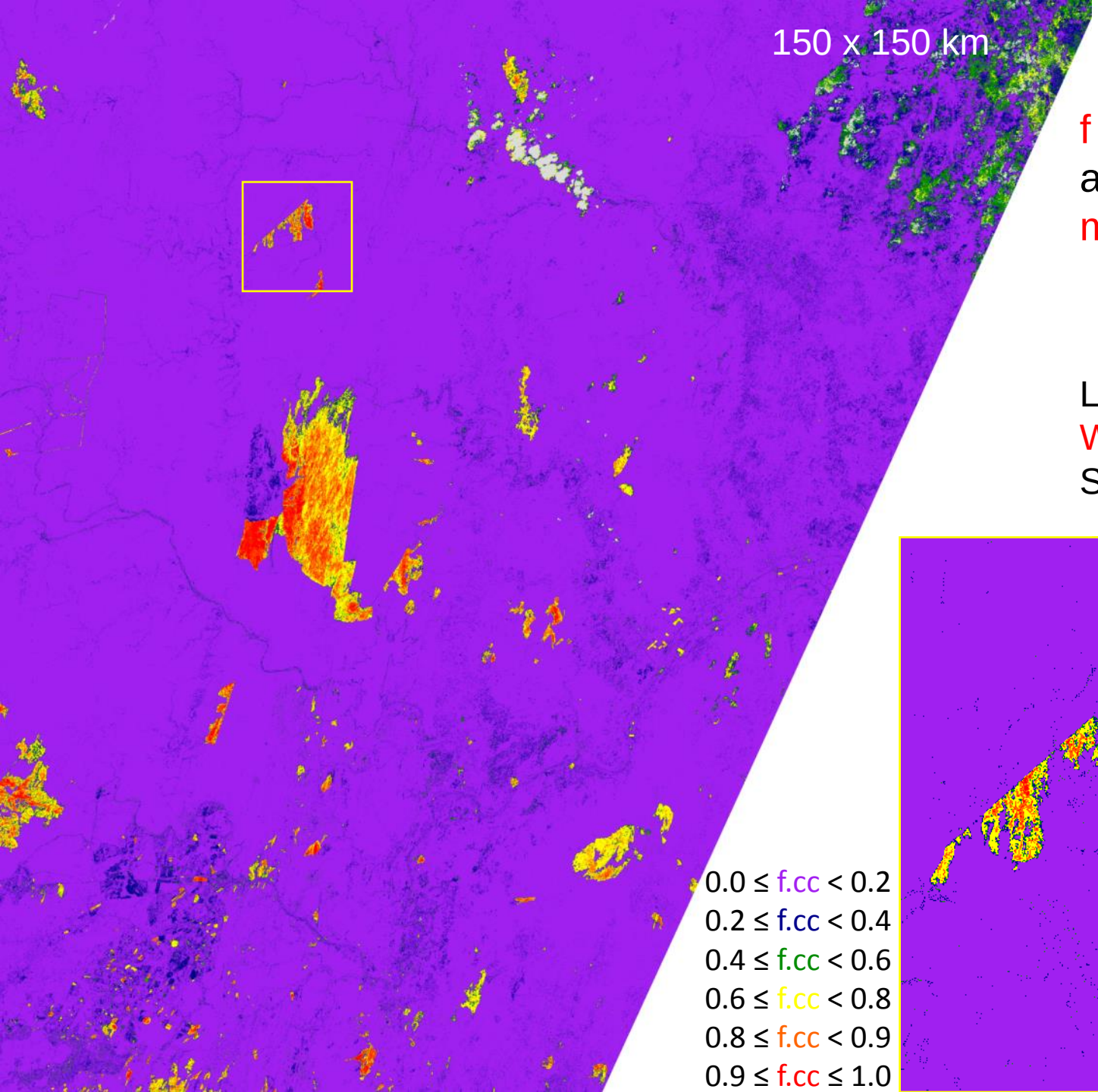
Haiyan Huang, David P. Roy, Luigi Boschetti, Hankui K. Zhang, Lin Yan, Sanath Sathyachandran Kumar, Jose Gomez-Dans, Jian Li, Separability analysis of Sentinel-2A multi-spectral instrument (MSI) data for burned area discrimination, submitted to Remote Sensing, 2016.



WELD Landsat 8,
30m true color,
Week 23 2014
South Africa/Moz.

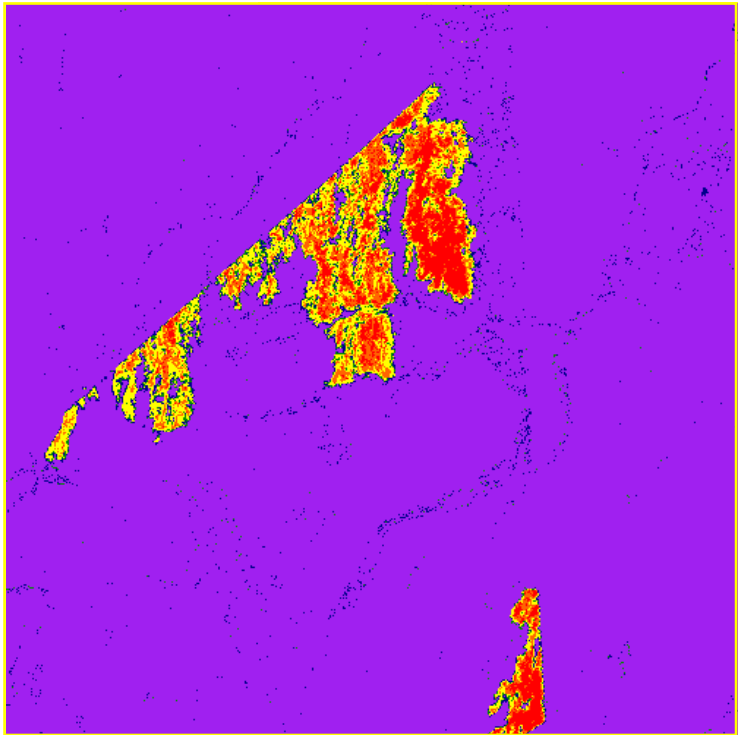


WELD Landsat 8,
30m true color,
Week 25 2014
South Africa/Moz.



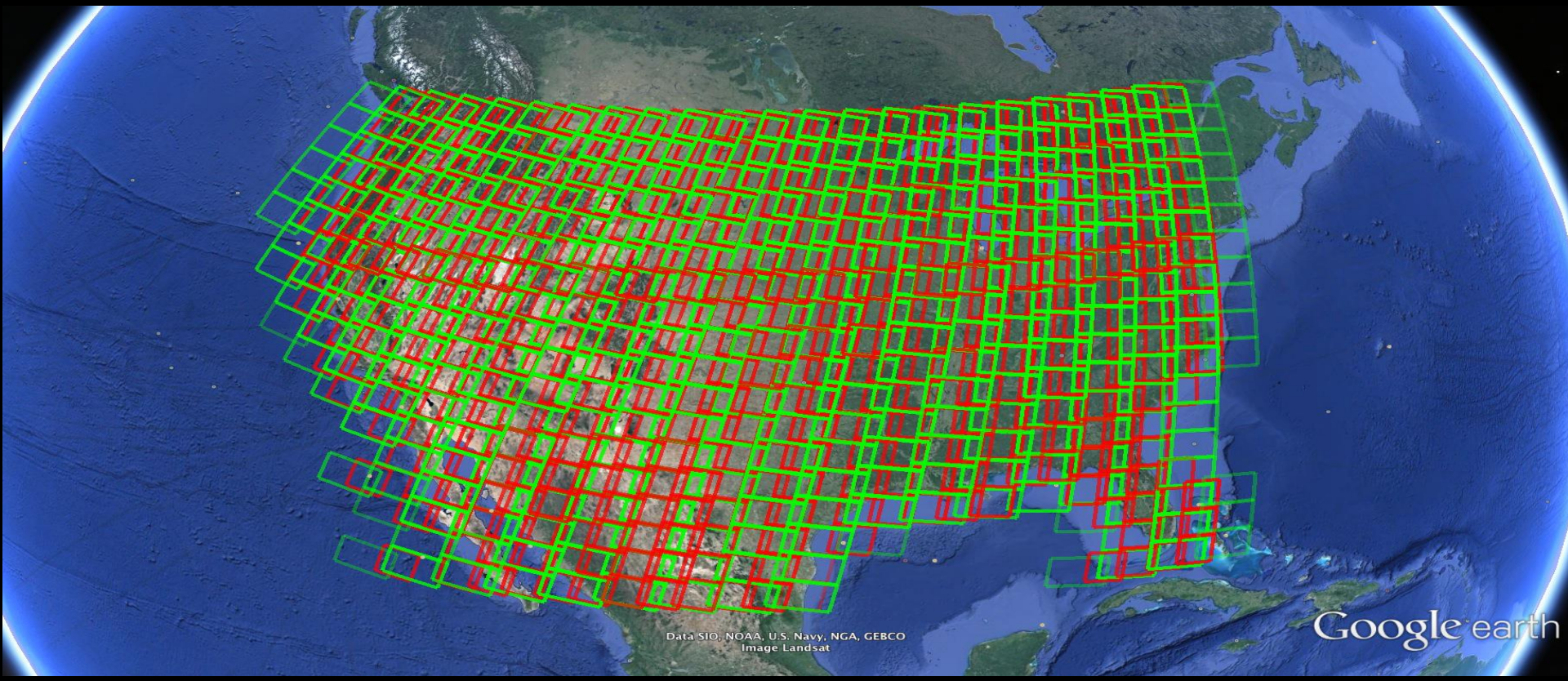
f . cc retrieval,
and burned area
mapping

Landsat 8,
Week 23 to 25 2014
South Africa/Moz.



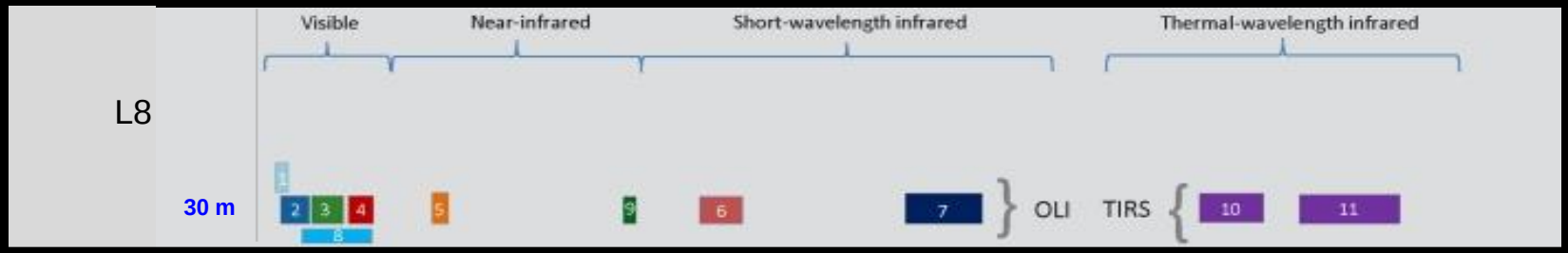
0.0 ≤ f.cc < 0.2
0.2 ≤ f.cc < 0.4
0.4 ≤ f.cc < 0.6
0.6 ≤ f.cc < 0.8
0.8 ≤ f.cc < 0.9
0.9 ≤ f.cc ≤ 1.0

Conterminous U.S. Landsat 8 (16 day repeat) Sentinel-2A (10-day repeat) paths

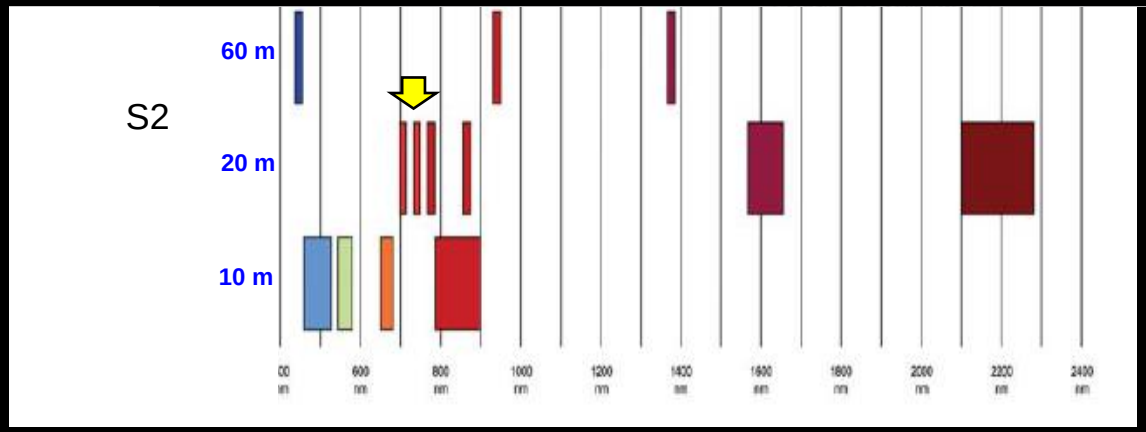


Landsat 8 & S2A & S2B combined global ~3 day repeat coverage

Landsat 8 OLI and Sentinel 2 MSI have different spatial and spectral resolutions



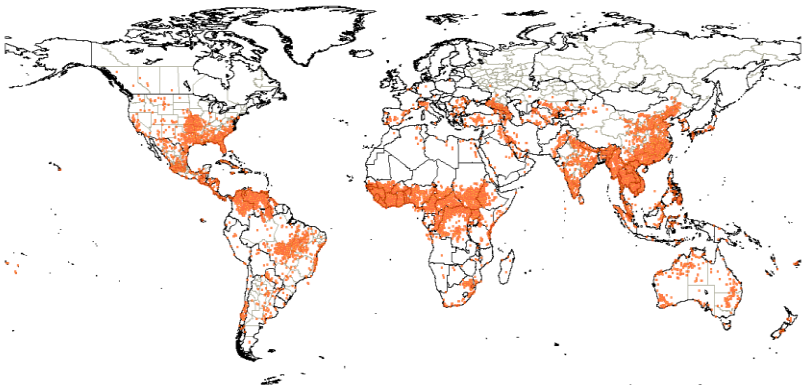
Question:



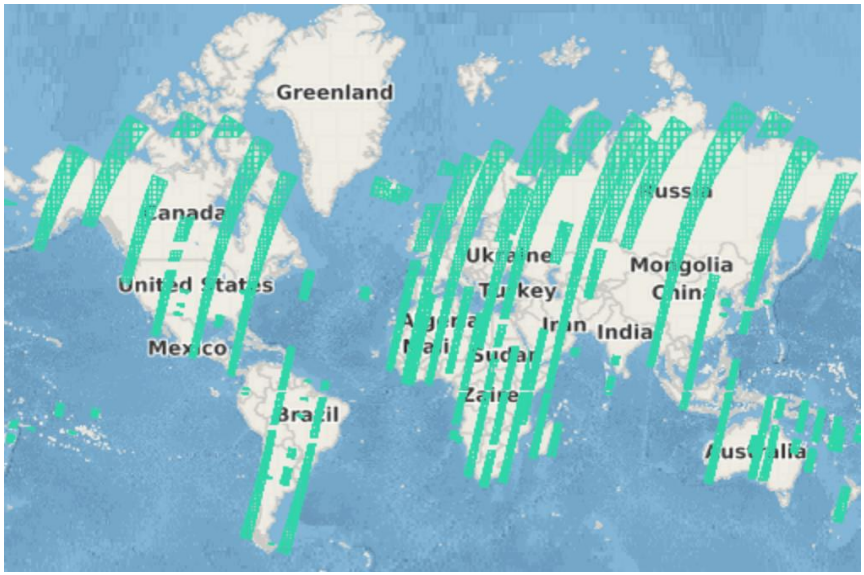
What Sentinel 2 bands provide reliable burned - unburned discrimination ?

Select global distribution of Sentinel-2 pre-fire and post-fire images sensed 10 or 20 days apart

- Examine Sentinel-2 archive (Amazon S3)
- Examine MODIS active fire detections for same period (FIRMS web site)



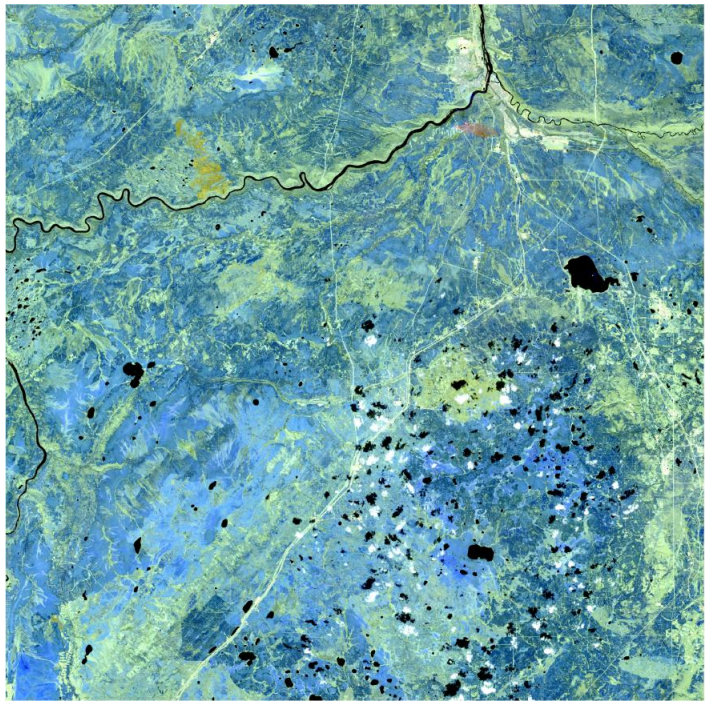
MODIS active fire detections
March 01 –March 05, 2016



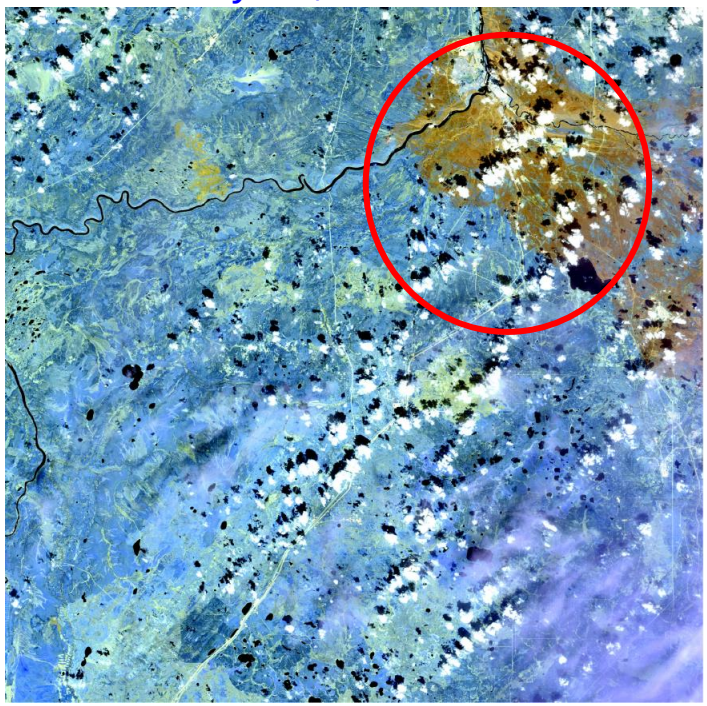
Sentinel-2 coverage: March 01 – March 05, 2016

Check Sentinel-2 image pairs contain new burned areas

May 02, 2016

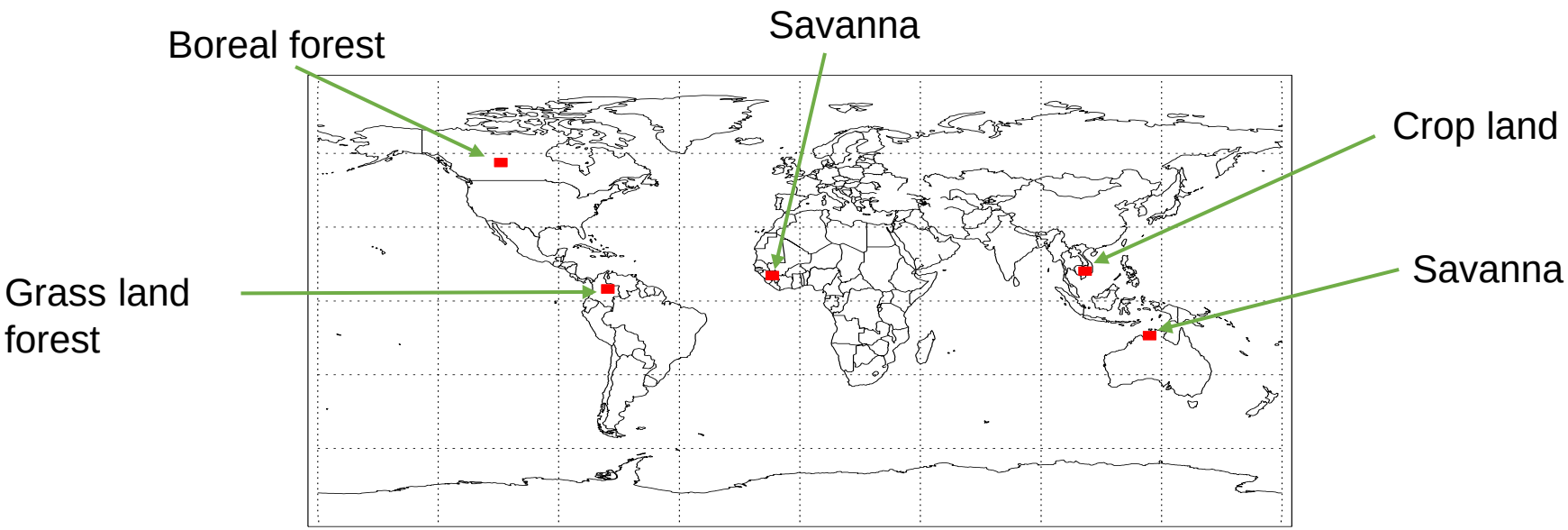


May 12, 2016



TOA False color: 2190, 1610, 865 nm, 5490 × 5490 pixels 20 m
Canada, Fort McMurray

Selected Images (5 two-date pairs)



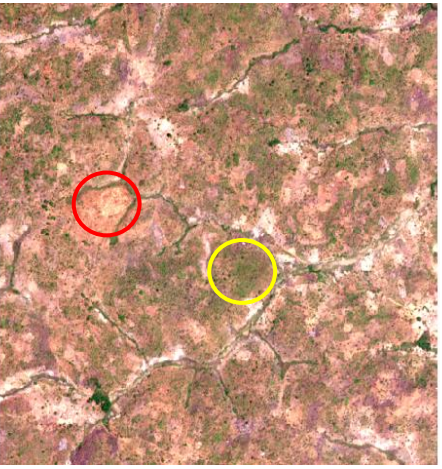
Site location	**Acquisition date 1**	**Acquisition date 2**
Australia, Northern Territory, near Fish River Block Gorge National Park	Apr 10, 2016	Apr 30, 2016
Cambodia, Kratié region, near Snoul	Jan 07, 2016	Jan 17, 2016
Canada, Alberta, Fort McMurray	May 02, 2016	May 12, 2016
Guinea, Faranah Prefecture, Parc National du Hour Niger	Mar 15, 2016	Mar 25, 2016
Colombia, Casanare Department, northern side of the Rio Cravo Sur river	Jan 17, 2016	Feb 06, 2016

Interactive training data collection

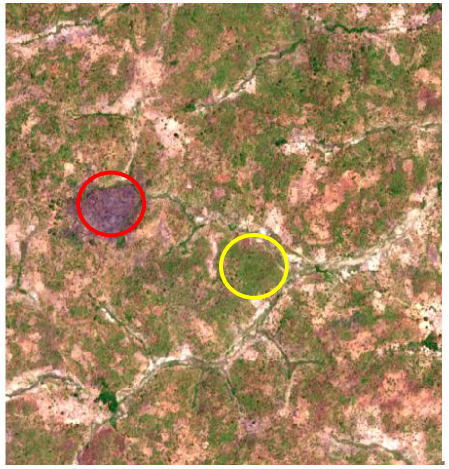
(> 8000 10m pixels pairs, > 2000 20 m pixel pairs per site)

- unburned -> burned
- unburned -> unburned (use as control)

Date 1: March 15, 2016

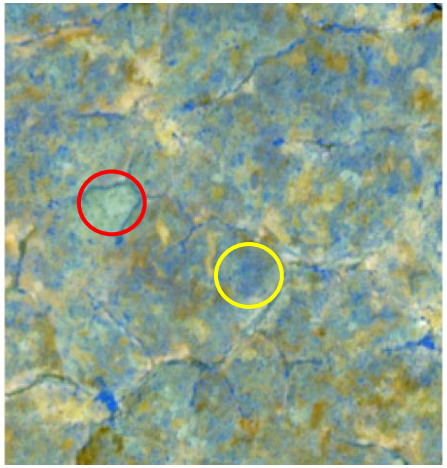


Date 2: March 25, 2016

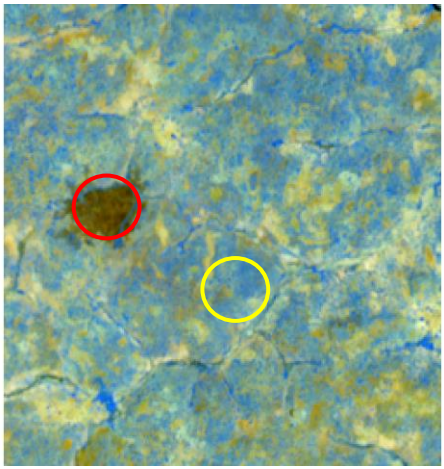


True color TOA ρ (b04, b03, b02),
500 x 500 10 m pixels
Guinea

Date 1: March 15, 2016



Date 2: March 25, 2016

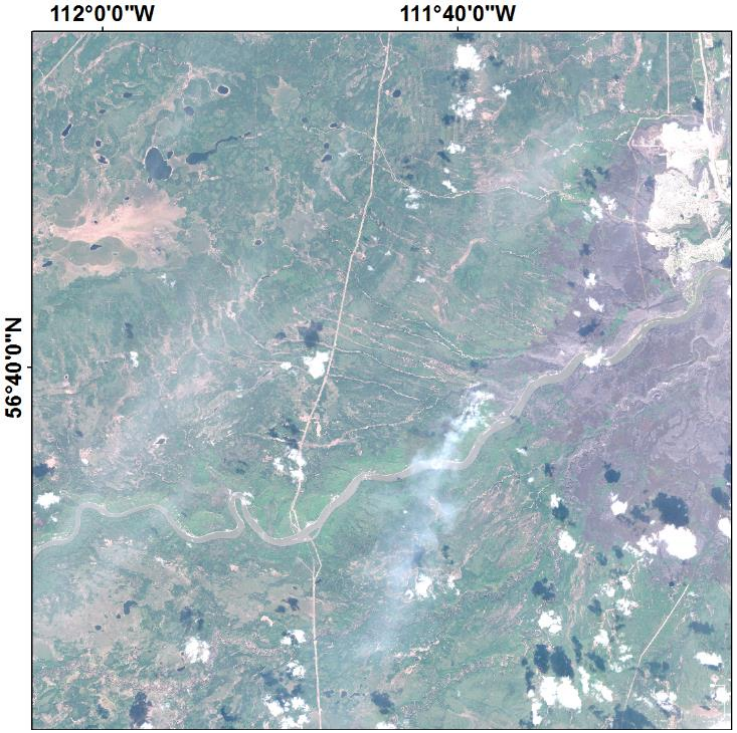


False color TOA ρ (b12, b11, b8a),
250 x 250 20 m pixels
Guinea

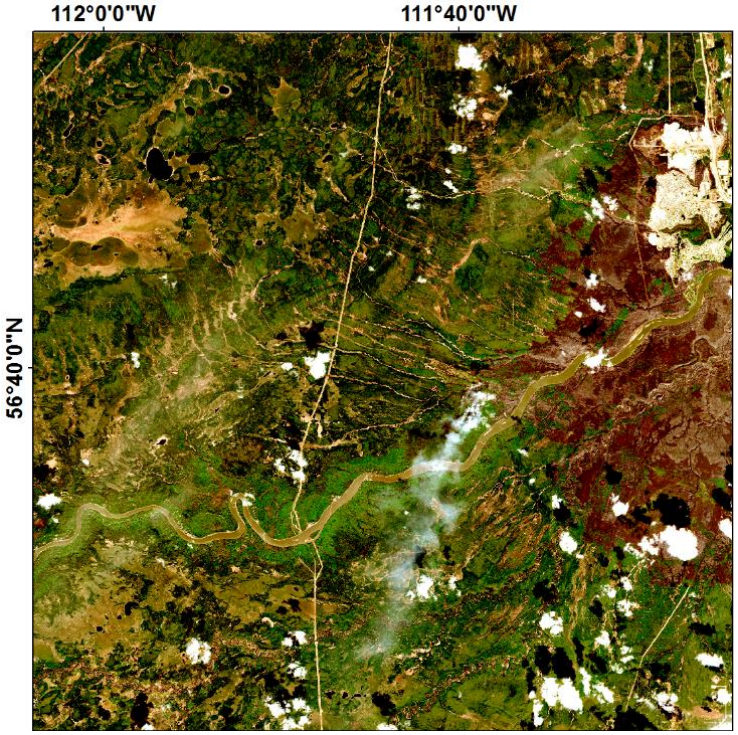
Data pre-processing

- Didn't correct the misregistration of the two images at each site (occasionally ~one pixel)
- SEN2COR atmospheric correction

10 m TOA reflectance



10 m surface reflectance

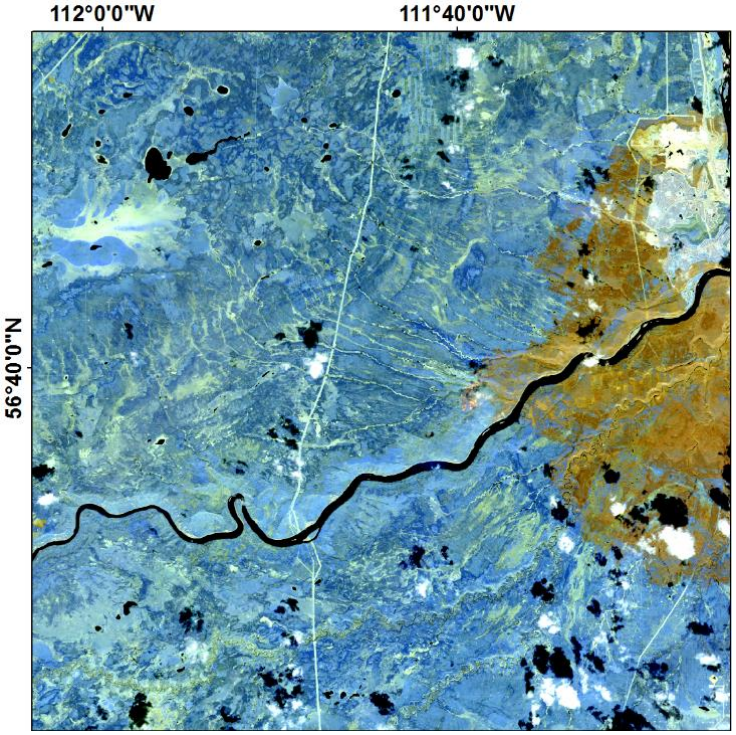


True color (665, 560, 490 nm), 4000 x 4000 pixels, Canada, Fort McMurray

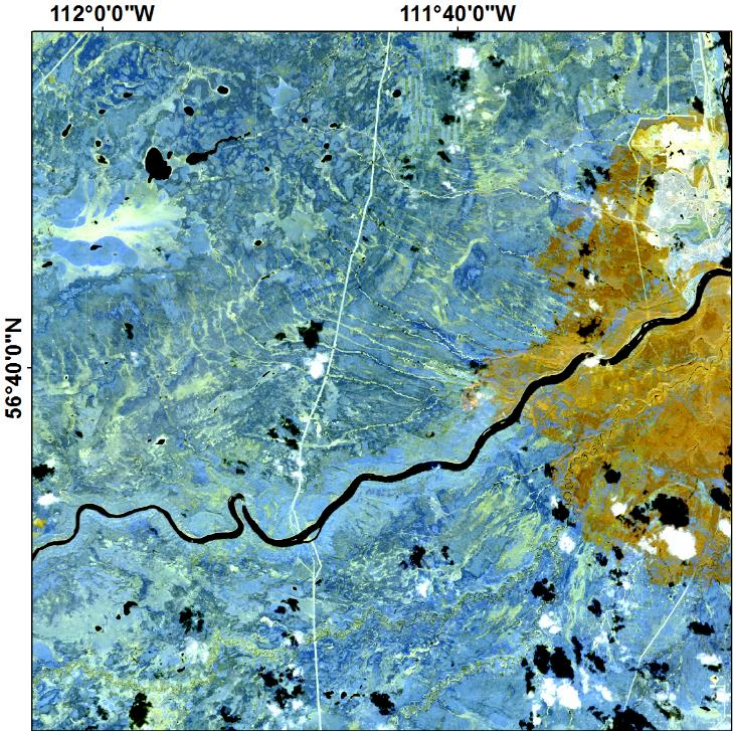
Data pre-processing

- Didnt correct misregistration of the two images at each site (occasionally ~one pixel)
- SEN2COR atmospheric correction applied

20 m TOA reflectance



20 m surface reflectance



False color (2190, 1610, 865 nm), 2000 x 2000 pixels, Canada, Fort McMurray

Separability analysis

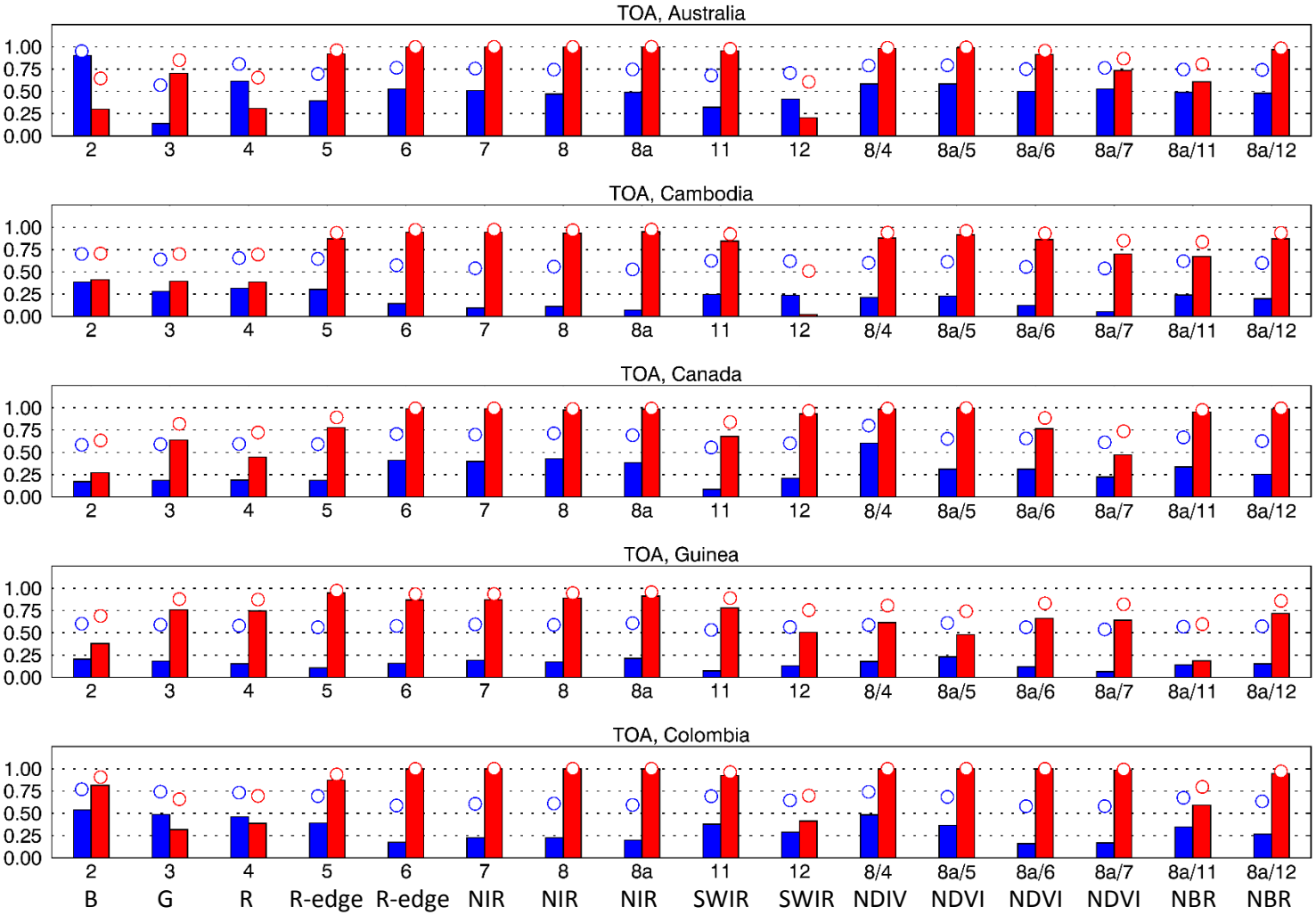
- Standard non-parametric classification
- Bagged decision tree (200 runs, 20% sample with replacement)
- Confusion matrix
  - Overall accuracy
  - Kappa coefficient

Sentinel-2 bands and indices considered

Band	Spatial resolution (m)	Central wavelength (nm)
Band 2 Blue	10	490
Band 3 Green	10	560
Band 4 Red	10	665
Band 5 Vegetation Red Edge	20	705
Band 6 Vegetation Red Edge	20	740
Band 7 NIR	20	783
Band 8 NIR	10	842
Band 8A NIR	20	865
Band 11 SWIR	20	1610
Band 12 SWIR	20	2190

Spectral Index	Spatial resolution (m)	Formulation
Normalized Difference Vegetation Index	10	(b08-b04)/(b08+b04)
Normalized Difference Vegetation Index red-edge	20	(b8a-b05)/(b8a+b05)
Normalized Difference Vegetation Index red-edge	20	(b8a-b06)/(b8a+b06)
Normalized Difference Vegetation Index	20	(b8a-b07)/(b8a+b07)
Normalized Burn Ratio	20	(b8a-b11)/(b8a+b11)
Normalized Burn Ratio	20	(b8a-b12)/(b8a+b12)

Results: TOA reflectance and indices



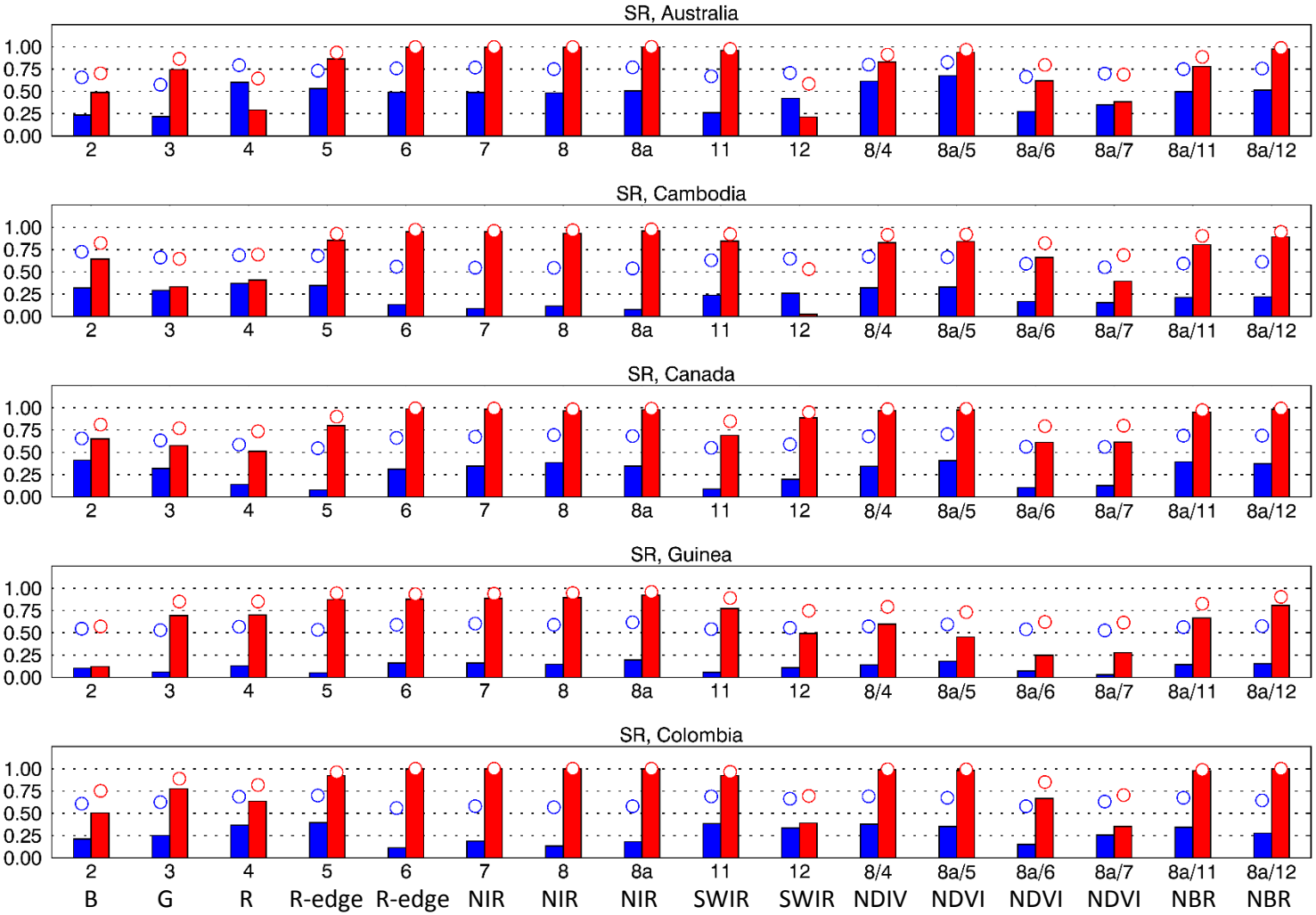
Unburned to unburned separability (control)

Unburned to burned separability

Overall accuracy

Kappa

Results: surface reflectance and indices



Unburned to unburned separability (control)

Unburned to burned separability

○ Overall accuracy

▮ Kappa

Summary

- The NIR and the 1610 nm SWIR spectral regions provide high burned-unburned discrimination
- The MSI red-edge bands also demonstrate good discrimination and this has also been observed using coarser resolution MERIS data
- The NDVI and NBR derived from the 10 m or the 20 m provided variable among site discriminative ability
- These findings are similar to other studies undertaken using different sensors and data (including Landsat)
- Atmospheric correction was less important than we expected
- To date, burned area mapping has been undertaken over large areas using >20 m resolution data
- The findings reported in this study suggest the potential for systematic Sentinel-2 MSI 20 m burned area mapping capability
- But how to integrate Sentinel 2 with Landsat 8 …. that's another story ☺

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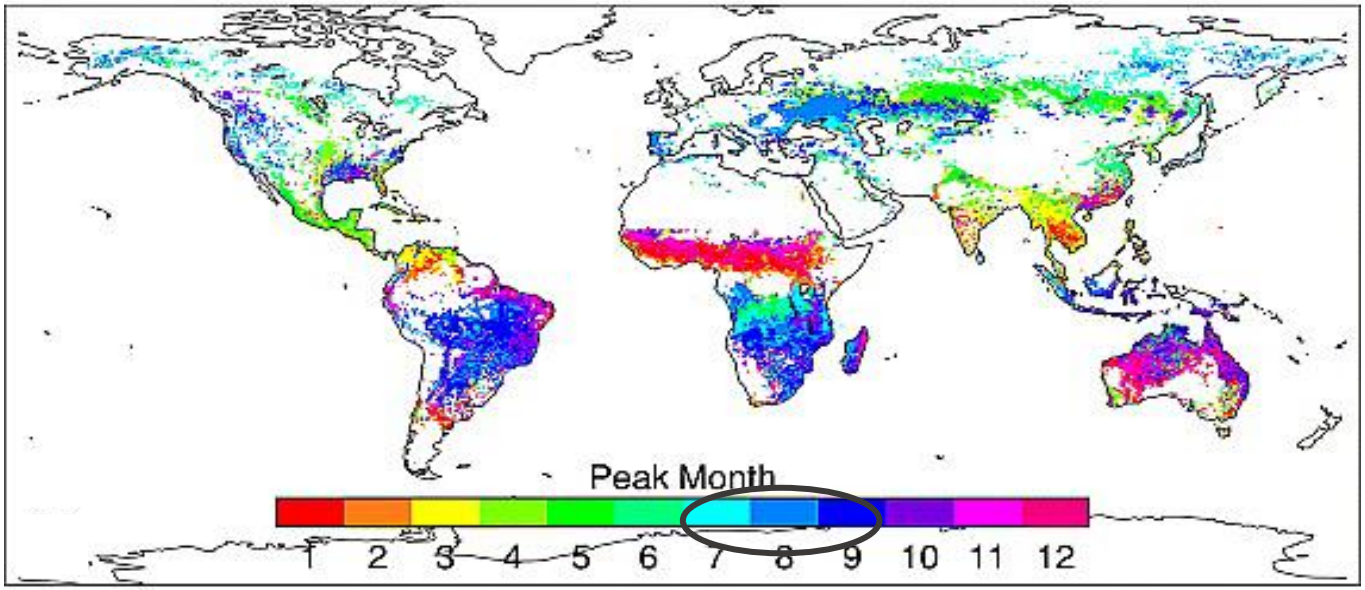
Backup



Global MODIS fire seasonality, Giglio et al. 2006