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

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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.

- $0.0 \leq f\text{.}cc < 0.2$
- $0.2 \leq f\text{.}cc < 0.4$
- $0.4 \leq f\text{.}cc < 0.6$
- $0.6 \leq f\text{.}cc < 0.8$
- $0.8 \leq f\text{.}cc < 0.9$
- $0.9 \leq f\text{.}cc \leq 1.0$
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)
Check Sentinel-2 image pairs contain new burned areas

TOA False color: 2190, 1610, 865 nm, 5490 × 5490 pixels 20 m
Canada, Fort McMurray
Selected Images (5 two-date pairs)

<table>
<thead>
<tr>
<th>Site location</th>
<th>Acquisition date 1</th>
<th>Acquisition date 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Australia</strong>, Northern Territory, near Fish River Block Gorge National Park</td>
<td>Apr 10, 2016</td>
<td>Apr 30, 2016</td>
</tr>
<tr>
<td><strong>Cambodia</strong>, Kratié region, near Snoul</td>
<td>Jan 07, 2016</td>
<td>Jan 17, 2016</td>
</tr>
<tr>
<td><strong>Canada</strong>, Alberta, Fort McMurray</td>
<td>May 02, 2016</td>
<td>May 12, 2016</td>
</tr>
<tr>
<td><strong>Colombia</strong>, Casanare Department, northern side of the Rio Cravo Sur river</td>
<td>Jan 17, 2016</td>
<td>Feb 06, 2016</td>
</tr>
</tbody>
</table>
Interactive training data collection
(> 8000 10m pixels pairs,  > 2000 20 m pixel pairs per site)

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

True color TOA $\rho$ (b04, b03, b02),
500 x 500 10 m pixels
Guinea

False color TOA $\rho$ (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

- Did not 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

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

<table>
<thead>
<tr>
<th>Spectral Index</th>
<th>Spatial resolution (m)</th>
<th>Formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normalized Difference Vegetation Index</td>
<td>10</td>
<td>(b08-b04)/(b08+b04)</td>
</tr>
<tr>
<td>Normalized Difference Vegetation Index red-edge</td>
<td>20</td>
<td>(b8a-b05)/(b8a+b05)</td>
</tr>
<tr>
<td>Normalized Difference Vegetation Index red-edge</td>
<td>20</td>
<td>(b8a-b06)/(b8a+b06)</td>
</tr>
<tr>
<td>Normalized Difference Vegetation Index red-edge</td>
<td>20</td>
<td>(b8a-b07)/(b8a+b07)</td>
</tr>
<tr>
<td>Normalized Burn Ratio</td>
<td>20</td>
<td>(b8a-b11)/(b8a+b11)</td>
</tr>
<tr>
<td>Normalized Burn Ratio</td>
<td>20</td>
<td>(b8a-b12)/(b8a+b12)</td>
</tr>
</tbody>
</table>
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 😊
Global MODIS fire seasonality, Giglio et al. 2006