Fire severity and impact on carbon emission estimates from wildfires

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Carbon emissions from wildfires account for 20-40% of the total global carbon emissions (van der Werf et al. 2010)

Uncertainties in wildfire emission estimates are large.
Research aims

Demonstrate:

1) Synergy of VSWIR (0.4-2.5 μm) and TIR (3.5-12.5 μm) data for assessing fire severity (HyspIRI)

2) the impact of including a remotely sensed fire severity product on carbon emission estimates
**VSWIR (0.4-2.5 μm) and TIR (3.5-12.5 μm) synergy: data and methods**

**Data**
- Post-fire airborne MASTER imagery (*HyspIRI surrogate*)
- Spectra library of char, green vegetation (GV), non-photosynthetic vegetation (NPV) and substrate
- Geo Composite Burn Index (GeoCBI) plots

**Methods**
Spectral Mixture Analysis (SMA) applied on:
- simulated data
- airborne MASTER data (*HyspIRI surrogate*)

3 different scenarios were run:
1) VSWIR data only
2) TIR data only
3) VSWIR and TIR synergy (*HyspIRI*)
VSWIR and TIR synergy: results

- VSWIR outperforms TIR for all ground cover types
- VSWIR-TIR synergy outperforms VSWIR for all ground cover types (HyspIRI)

<table>
<thead>
<tr>
<th>Spectral region</th>
<th>Char</th>
<th>GV</th>
<th>NPV</th>
<th>Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>a</td>
<td>b</td>
<td>R²</td>
</tr>
<tr>
<td>VSWIR</td>
<td>0.88</td>
<td>0.00</td>
<td>0.98</td>
<td>0.91</td>
</tr>
<tr>
<td>TIR</td>
<td>0.31</td>
<td>0.03</td>
<td>0.86</td>
<td>0.22</td>
</tr>
<tr>
<td>VSWIR-TIR</td>
<td>0.93</td>
<td>0.00</td>
<td>1.01</td>
<td>0.92</td>
</tr>
</tbody>
</table>

A. 118°25’00.00”W 118°20’00.00”W
Char fraction

B. 118°25’00.00”W 118°20’00.00”W
R: NPV + Substrate
G: GV
B: Char

C. Char fraction estimated by SMA on VSWIR data
D. Char fraction estimated by SMA on MTIR data
E. Char fraction estimated by SMA on VSWIR-MTIR data

y = 0.81 + 2.37x  \[ R^2 = 0.79 \]
y = 1.30 + 2.55x  \[ R^2 = 0.43 \]
y = 0.64 + 2.41x  \[ R^2 = 0.82 \]

F. Char fraction estimated by SMA on VSWIR-MTIR data
y = 0.02 + 0.99x  \[ R^2 = 0.64 \]

y = 0.09 + 1.32x  \[ R^2 = 0.53 \]

y = -0.08 + x  \[ R^2 = 0.66 \]
Fire severity and impact on carbon emission estimates

Retrieval of char, GV, NPV and substrate fractions

\[
\text{Burned fraction} = \frac{\text{Combusted material}}{\text{Combustible material}}
\]
\[
\text{Burned fraction} = \frac{\text{char}}{\text{char + vegetation}}
\]

\[\text{Emission} = \text{Area} \times \text{Mass} \times \text{Combustion factor} \times \text{Emission factor}\]

Combustion factor depends on:
- Fuel type
- Fuel moisture
- Fire severity

Modeling → Remote sensing
Fire severity and impact on carbon emission estimates

C emission from modeling only

C emission from modeling and remote sensing

<table>
<thead>
<tr>
<th>Fire</th>
<th>Burned area (ha)</th>
<th>CC estimation methodology</th>
<th>Total C emission (Tg)</th>
<th>Area normalized C emission (kg/m²)</th>
<th>% carbon emitted relative to ‘modeling-only’ approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wallow</td>
<td>218 000</td>
<td>Modeling</td>
<td>3.44</td>
<td>1.57</td>
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</tr>
<tr>
<td>Wallow</td>
<td>218 000</td>
<td>Modeling and remote sensing</td>
<td>1.52</td>
<td>0.70</td>
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<td>Canyon</td>
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<td>Modeling</td>
<td>0.12</td>
<td>2.02</td>
<td>1</td>
</tr>
<tr>
<td>Canyon</td>
<td>5900</td>
<td>Modeling and remote sensing</td>
<td>0.09</td>
<td>1.47</td>
<td>0.73</td>
</tr>
</tbody>
</table>
Conclusions

1) A synergy of VSWIR and TIR data improves fire severity assessments (HyspIRI)

2) Fire severity data have big potential to refine combustion completeness and carbon emissions estimates