National Aeronautics and Space Administration

Remote sensing of post-fire effects

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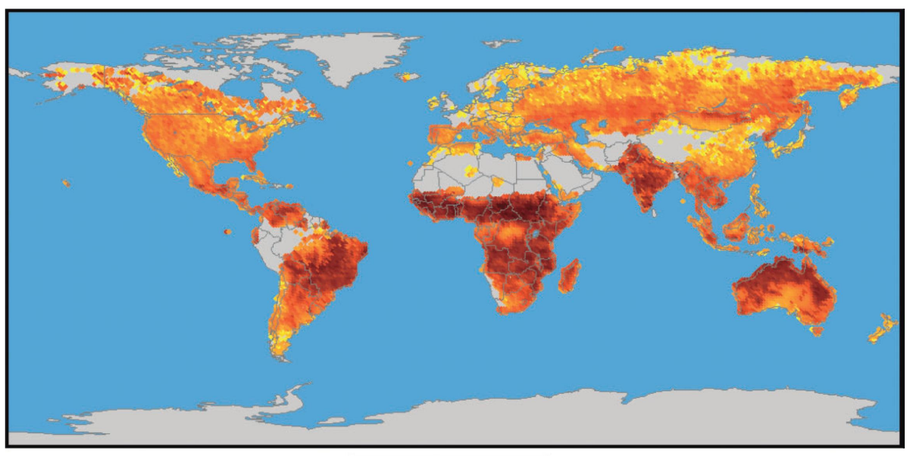
Introduction

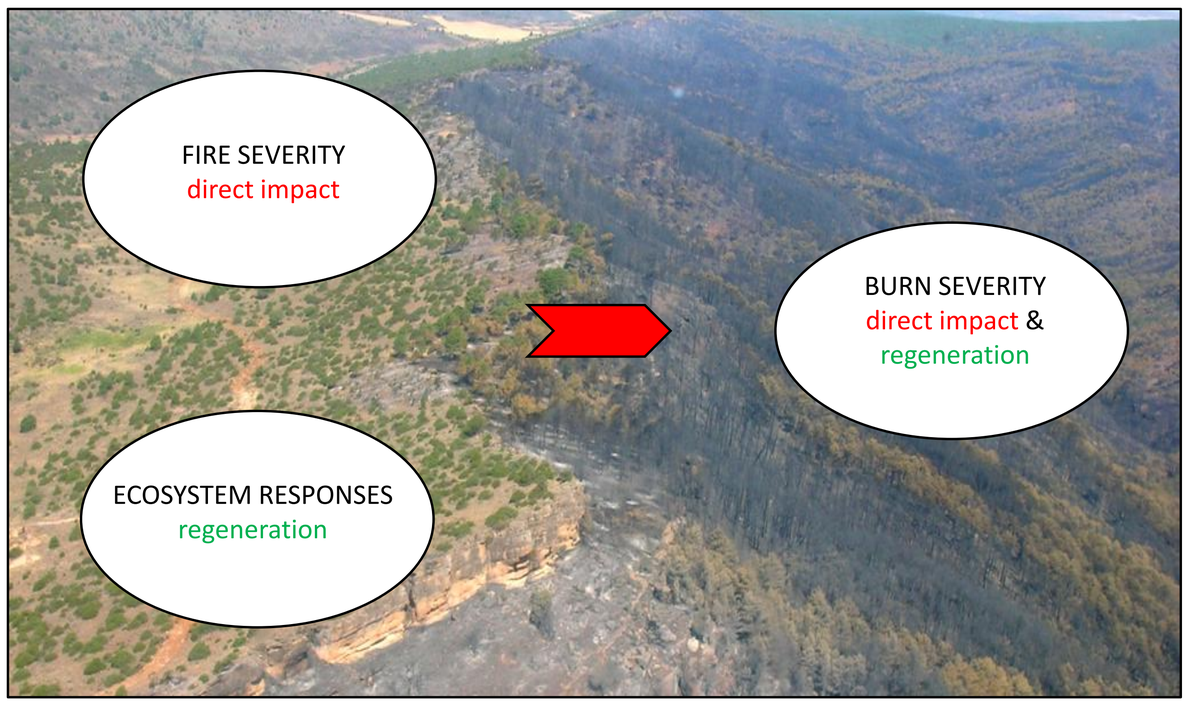
- Biomass burning is a major disturbance in almost all terrestrial ecosystems
- Wildfires significantly contribute to the emission of trace gasses in the atmosphere
- Fires partially or completely remove the vegetation layer and affect post-fire vegetation composition
- Burned surfaces are sensitive to nutirent leaching and soil erosion

➡ Remote sensing can offer regional to global fire regime assessments



Global average annual burned area (after Mouillot and Field 2005)

Some terminology



Post-fire effects terminology (Veraverbeke et al. 2010)

Case 1: burned area mapping in SoCal *(Veraverbeke et al. 2011a)*

Table 3
Spectral indices tested in this study (B: Blue, R: Red, NIR: Near Infrared, SSWIR: shorter short wave infrared, LSWIR: longer short wave infrared, MIR: mid infrared, TIR: thermal infrared, E: emissivity and T_s: surface temperature, see Section 2.3 for specifications on wavelength intervals).

Index	Abbreviation	Formula	Reference
Normalized Difference Vegetation Index	NDVI	$NDVI = \frac{NIR-R}{NIR+R}$	Tucker, 1979
Global Environment Monitoring Index	GEMI	$GEMI = \gamma(1-0.25\gamma) - \frac{R-0.125}{1-R}$ with $\gamma = \frac{2(NIR^2-R^2)+1.5NIR+0.5R}{NIR+R+0.5}$	Pinty and Verstraete, 1992
Enhanced Vegetation Index	EVI	$EVI = 2.5\frac{NIR-R}{NIR-6R-7.5B+1}$	Huete et al., 2002
Vegetation Index 3	VI3	$VI3 = \frac{NIR-MIR}{NIR+MIR}$	Kaufman and Remer, 1994
Soil Adjusted Vegetation Index	SAVI	$SAVI = (1+L)\frac{NIR-R}{NIR+R+L}$ with L=0.5	Huete, 1988
Modified Soil Adjusted Vegetation Index	MSAVI	$MSAVI = \frac{2NIR+1-\sqrt{(2NIR+1)^2-8(NIR-R)}}{2}$	Qi et al., 1994
Burned Area Index	BAI	$BAI = \frac{1}{(0.1+R)^2+(0.06+NIR)^2}$	Chuvieco et al., 2002
Global Environment Monitoring Index 3	GEMI3	$GEMI3 = \gamma(1-0.25\gamma) - \frac{MIR-0.125}{1-MIR}$ with $\gamma = \frac{2(NIR^2-MIR^2)+1.5NIR+0.5MIR}{NIR+MIR+0.5}$	Barbosa et al. 1999b
Normalized Burn Ratio	NBR	$NBR = \frac{NIR-LSWIR}{NIR+LSWIR}$	Key and Benson, 2005
Char Soil Index	CSI	$CSI = \frac{NIR}{SWIR}$	Smith et al., 2007
Mid Infrared Burn Index	MIRBI	$MIRBI = 10.LSWIR - 9.8SSWIR + 2$	Trigg and Flasse, 2001
Normalized Difference Vegetation Index Thermal	NDVIT	$NDVIT = \frac{NIR-R\times TIR}{NIR+R\times TIR}$	Smith et al., 2007
Soil Adjusted Vegetation Index Thermal	SAVIT	$SAVIT = (1+L)\frac{NIR-R\times TIR}{NIR+R\times TIR+L}$ with L=0.5	Smith et al., 2007
Normalized Burn Ratio Thermal	NBRT	$NBRT = \frac{NIR-LSWIR\times TIR}{NIR+LSWIR\times TIR}$	Holden et al., 2005
Char Soil Index Thermal	CSIT	$CSIT = \frac{NIR}{SWIR\times TIR}$	Smith et al., 2007
Vegetation Index 6 Thermal	VI6T	$VI6T = \frac{NIR-TIR}{NIR+TIR}$	Holden et al., 2005
NIR-SWIR-Emissivity Version 1	NSEv1	$NSEv1 = \frac{NIR-LSWIR}{NIR+LSWIR}\times E$	This study
NIR-SWIR-Emissivity Version 2	NSEv2	$NSEv2 = \frac{NIR-(LSWIR+E)}{NIR+LSWIR+E}$	This study
NIR-SWIR-Temperature Version 1	NSTv1	$NSTv1 = \frac{NIR-LSWIR}{NIR+LSWIR}\times T_S$	This study
NIR-SWIR-Temperature Version 2	NSTv2	$NSTv2 = \frac{NIR-(LSWIR+T_S)}{NIR+LSWIR+T_S}$	This study

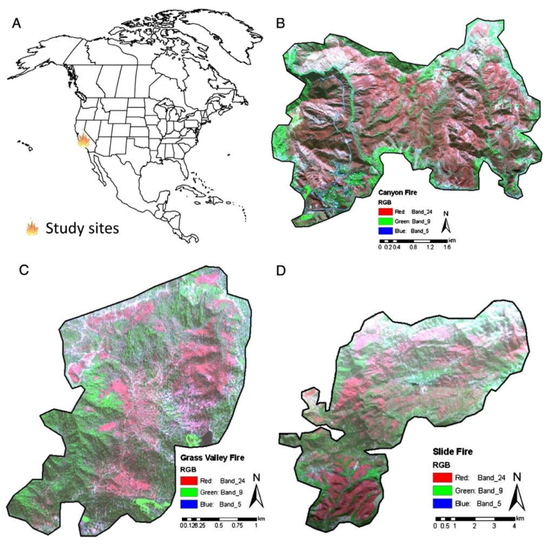


Table 4
MODIS/ASTER (MASTER) airborne simulator bands revealing the best spectral separability M for each spectral region. These bands were used to generate the indices listed in Table 3 (B: Blue, R: Red, NIR: Near Infrared, SSWIR: shorter short wave infrared, LSWIR: longer short wave infrared, MIR: mid infrared, TIR: thermal infrared, E: emissivity and T_s: surface temperature, see Section 2.3 for specifications on wavelength intervals).

Spectral region	MASTER band (μm)	M statistic (average over three fires)
B	0.45 to 0.48	0.15
R	0.65 to 0.68	0.13
NIR	0.86 to 0.88	0.64
SSWIR	1.59 to 1.62	0.09
LSWIR	2.31 to 2.36	0.58
MIR	3.54 to 3.64	0.71
TIR	8.51 to 8.76	0.58

Table 5
M values of the spectral indices over the Canyon, Grass Valley and Slide fires. Values higher than one are given in bold. For explanation on the indices, reference is made to Table 3 and Section 2.3.

Spectral indices	Canyon fire	Grass Valley fire	Slide fire	Average over three fires
NDVI	**1.22**	0.42	0.78	0.80
GEMI	0.07	0.04	0.06	0.06
EVI	0.28	0.10	0.04	0.14
VI3	**1.30**	**1.29**	0.83	**1.14**
SAVI	**1.42**	0.55	0.83	0.94
MSAVI	0.23	0.25	0.13	0.21
BAI	0.34	0.47	0.07	0.29
GEMI3	0.04	0.03	0.01	0.03
NBR	**1.46**	**1.00**	0.94	**1.13**
CSI	0.04	0.00	0.00	0.01
MIRBI	0.67	0.76	0.55	0.66
NDVIT	0.92	0.22	0.42	0.52
SAVIT	0.88	0.21	0.41	0.50
NBRT	0.08	0.03	0.16	0.09
CSIT	0.04	0.00	0.00	0.01
VI6T	0.66	0.92	0.36	0.65
NSEv1	**1.47**	0.88	**1.06**	**1.13**
NSEv2	**1.57**	**1.02**	**1.07**	**1.22**
NSTv1	**1.47**	0.88	**1.06**	**1.14**
NSTv2	0.71	0.96	0.41	0.69

- Spectral separability (burned-unburned) measured by:

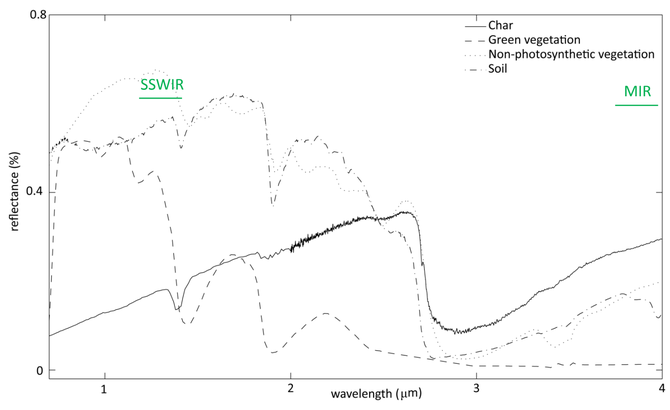
$$M = \frac{\mu_b - \mu_u}{\sigma_b - \sigma_u}$$

-Results show strong potential in combining MTIR data with the traditional NIR-SWIR region

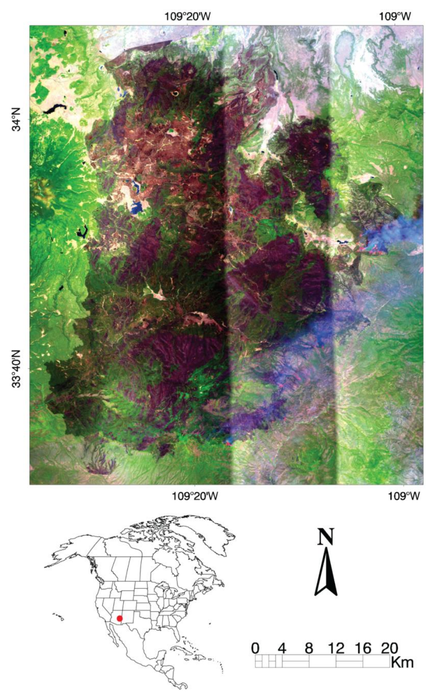
Case 2: Fire severity mapping in AZ *(Veraverbeke et al. 2011b)*

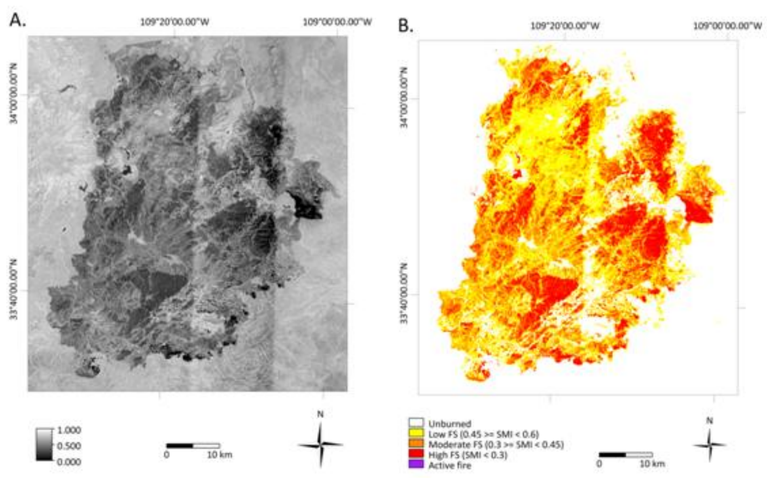
- A novel SWIR-MIR index to discriminate fire severity:

$$SMI = \frac{SSWIR - MIR}{SSWIR + MIR}$$



Spectral signatures of char, green vegetation, non-photosynthetic vegetation and soil in the 0.7 to 4.0 μm region.



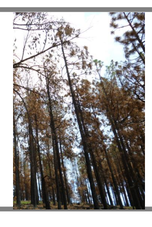


SMI map of the area (A) and corresponding fire severity classification (B)

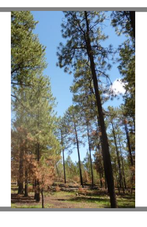
Further outlook

- Assessing the potential of spectral indices, spectral mixture analysis and radiative transfer models
- Validation with field data

High severity



Moderate severity



Low severity

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References

Mouillot, F. & Field, C. (2005). *Fire history and the global carbon budget: a 1° by 1° fire history reconstruction for the 20h century.* Global Change, 11, 398–420

Veraverbeke, S., Lhermitte, S., Verstraeten, W.W., & Goossens, R., (2010). *The temporal dimension of differenced Normalized Burn Ratio (dNBR) fire/burn severity studies: the case of the large 2007 Peloponnese wildfires in Greece*. Remote Sensing of Environment 114, 2548-2563

Veraverbeke, S., Harris, S. & Hook, S. (2011a). *Evaluating spectral indices for burned area discrimination using MODIS/ASTER (MASTER) airborne simulator data*. Remote Sensing of Environment, 115, 2702-2709

Veraverbeke, S., Hulley, G. & Hook, S. (2011). *A novel SWIR-MIR index for rapid wildfire damage assessments*. Remote Sensing of Environment, in review

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