The GOES-R ABI Wild Fire Automated Biomass Burning Algorithm

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Jay P. Hoffman*, Christopher C. Schmidt, Elaine M. Prins, Jason C. Brunner
Cooperative Institute for Meteorological Satellite Studies (CIMSS)/ Space Science Engineering Center (SSEC)/ University of Wisconsin-Madison (UW)
*jay.hoffman@ssec.wisc.edu http://wfabba.ssec.wisc.edu

Introduction

Real-time satellite fire detection and characterization is possible primarily due to the behavior described by the Planck Function. At typical fire temperatures, the 4µm band emission increases faster with increasing temperature than the 11µm band emission. The WildFire Automated Biomass Burning Algorithm (WF_ABBA), developed at CIMSS, is a complex contextual algorithm that identifies hotspots by locating pixels with significant differences in the 4µm and 11µm brightness temperature and applying a series of contextual tests.

Advanced Baseline Imager (ABI) Summary

Band Number	Bandwidth (µm)	Range Limit	Spatial Resolution	in Fire Code
2	0.59 – 0.69	515 $W/m^2/sr/µm$	0.5 km	optional
7	3.8 – 4.0	400 K	2 km	✓
14	10.8 – 11.6	330 K	2 km	✓
15	11.8 – 12.8	330 K	2 km	optional

- 5 min CONUS / 15 FD coverage

GOES-R ABI Algorithm Development

Development of the WF_ABBA for GOES-R ABI is multifaceted:

- Adapt the legacy algorithm to the new satellite system
- Take advantage of the improved spatial, spectral, and temporal resolution
- Address user needs
- Research focused on: surface emissivity, diffraction, atmospheric attenuation, and solar contamination

User Communities

Emissions:
The biomass burning team at CIMSS works along with global, regional, and local models including those by the US Navy, NASA, and NOAA.

Land use/Land change:
WF_ABBA products have been used to track land use changes in peer-reviewed literature.

Hazards:
WF_ABBA products are part of NOAA's HMS fire maps.

The Global WF_ABBA

CIMSS is working with the international community to create a global geostationary fire monitoring system. Coverage will continue to expand as new satellites come on-line.

Current coverage:

- GOES-E/-W/-SA (-13/-15*/-12) Imager (75°W / 135°W/ 60°W)

*at the time of printing, GOES-15 scheduled to replace GOES-11 on 6 Dec 2011

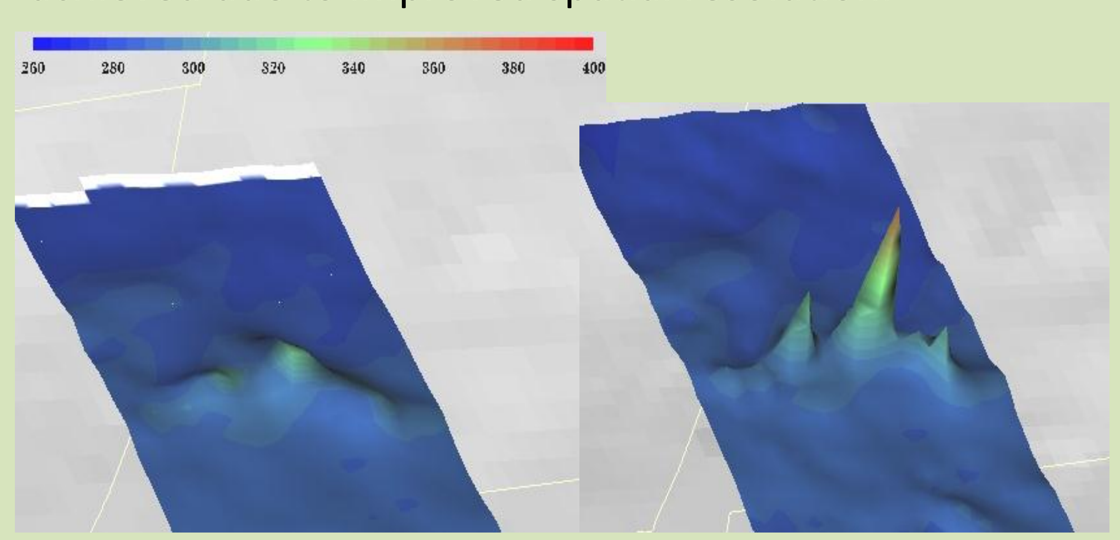
- Met -8/-9 SEVIRI (9.5°E / 0°)
- MTSAT -1R (JAMI) / MTSAT-2 (HRIT) (140°E / 145°E)

Future coverage

- GOES-14 Imager (on-orbit standby)
- GOES-R ABI (launch est. FY 2015)
- FY-2C/2D SVISSR (105°E / 86.5°E)
- GOMS Elektro-L N1 /-N2 (76°E / 14.5°E)
- COMS (128°E)

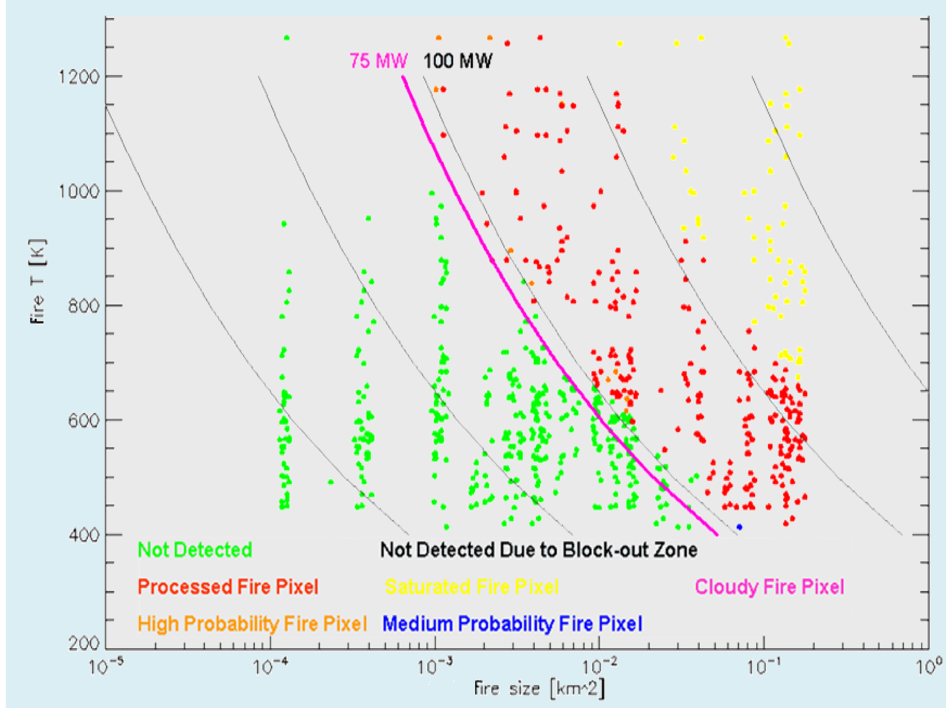
Improved ABI Resolution

Fire detection and characterization will benefit from the improved spatial, spectral, and temporal resolution provided by GOES-R ABI. Spatial resolution of the 3.9 micron brightness temperature is illustrated below. On the left, 4km GOES-12 data from Oct 27, 2003 is shown, and, on the right, the corresponding 2km simulated ABI 3.9 micron brightness temperature data. Greater contrast between fire and background is achieved due to improved spatial resolution.



ABI Fire Algorithm Performance

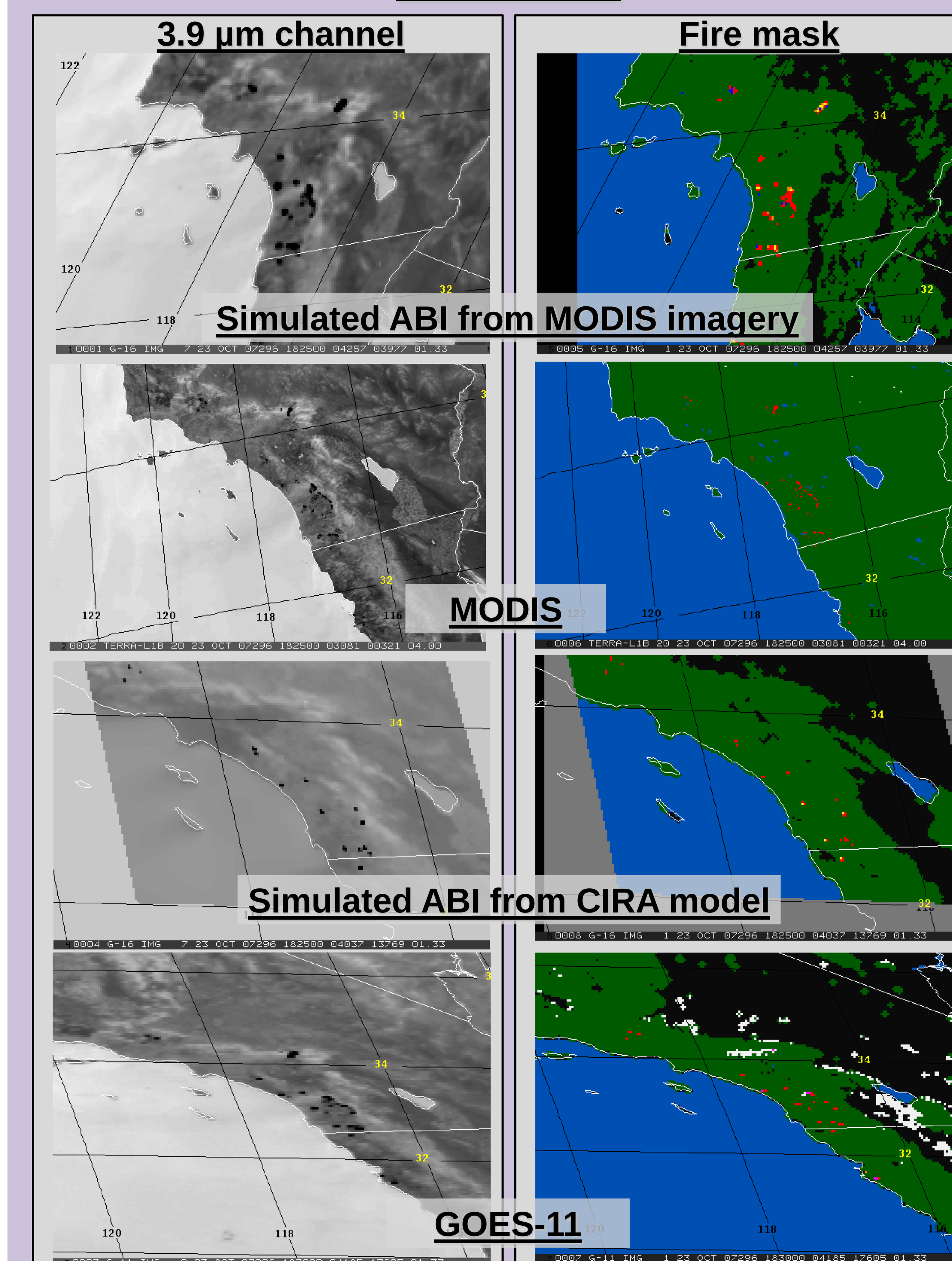
	Simulated Conditions				WF_ABBA Performance			
	Fire clusters	Fire pixels	Fire area (km^2) non-saturated	Total FRP (MW) non-saturated	% of fire clusters detected	% of fire pixels detected	% of fire area detected	% of FRP detected
May 8, 2003 Kansas constant fires without clouds	9600	$3.7x10^4$	$4.2x10^3$	$2.0x10^7$	95%	82%	98%	90%
May 8, 2003 Kansas variable fires without clouds	5700	$1.9x10^4$	$3.9x10^3$	$1.6x10^7$	98%	73%	76%	65%
May 8, 2003 Kansas constant fires with clouds	8400	$2.1x10^4$	$3.1x10^3$	$1.7x10^7$	84%	74%	81%	79%
Apr 23, 2004 Cent. Amer. variable fires with clouds	830	$1.5x10^3$	110	$6.5x10^5$	89%	78%	56%	59%
Oct 23, 2007 California variable fires with clouds	860	$1.7x10^3$	120	$8.9x10^5$	95%	77%	109%	73%
Oct 26, 2007 California variable fires with clouds	120	240	15	$8.1x10^4$	92%	72%	47%	71%
Nov 5, 2008 Arkansas variable fires with clouds	280	510	37	$1.1x10^5$	93%	76%	64%	76%
Aug 14, 2010 British Columbia variable fires with clouds	450	640	$7.9x10^4$	$3.2x10^5$	59%	58%	60%	52%



The above chart illustrates WF_ABBA fire detection and classification as a function of the CIRA model simulated ABI fire size and fire temperature. This example is from the Oct 23, 2007 California case. Notice that WF_ABBA is quite successful detecting fires with fire radiative power (FRP) > 75 MW.

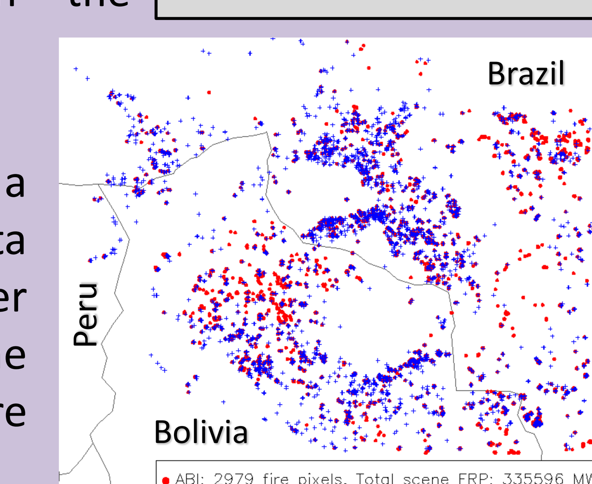
The above table depicts the WF_ABBA detection statistics for multiple case studies of simulated ABI data (developed at CIRA). The algorithm is able to detect nearly 100% of the detection of fire clusters – groups of individual fire pixels. The performance is not quite as good for the detection of individual fire pixels or fire characteristics in large part due to subpixel fire detection and characterization issues described under the "Subpixel Fire Detection and Characterization" section.

Proxy Data

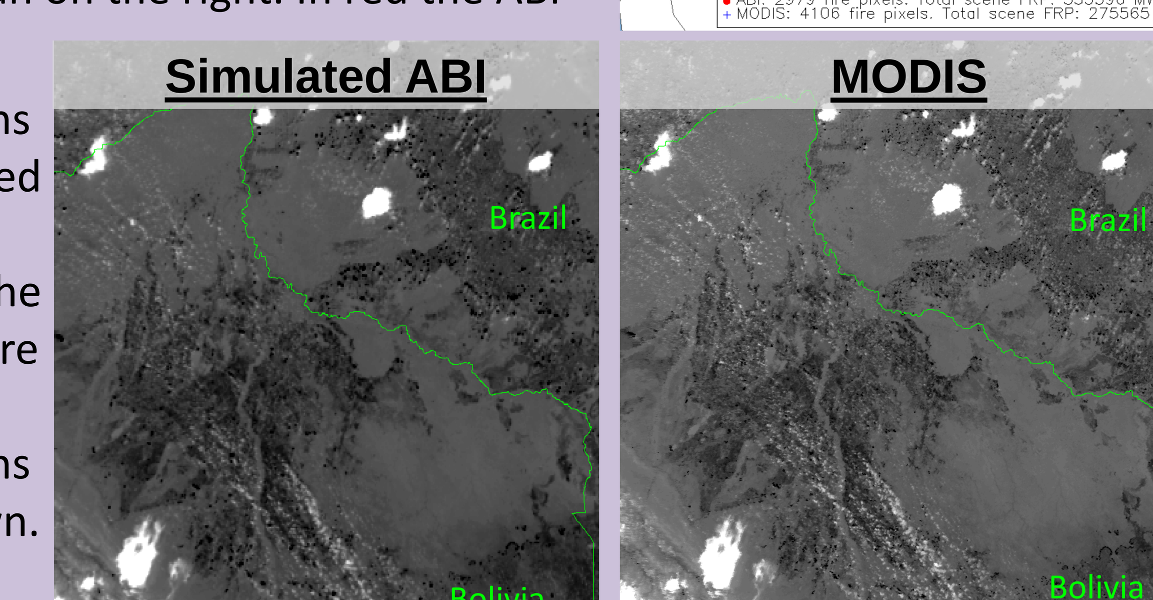


Mask Legend
- Processed Fire
- Saturated Fire
- Cloudy Fire
- High Possibility Fire
- Medium Possibility Fire
- Biome Block-out Zone
- Processed Region

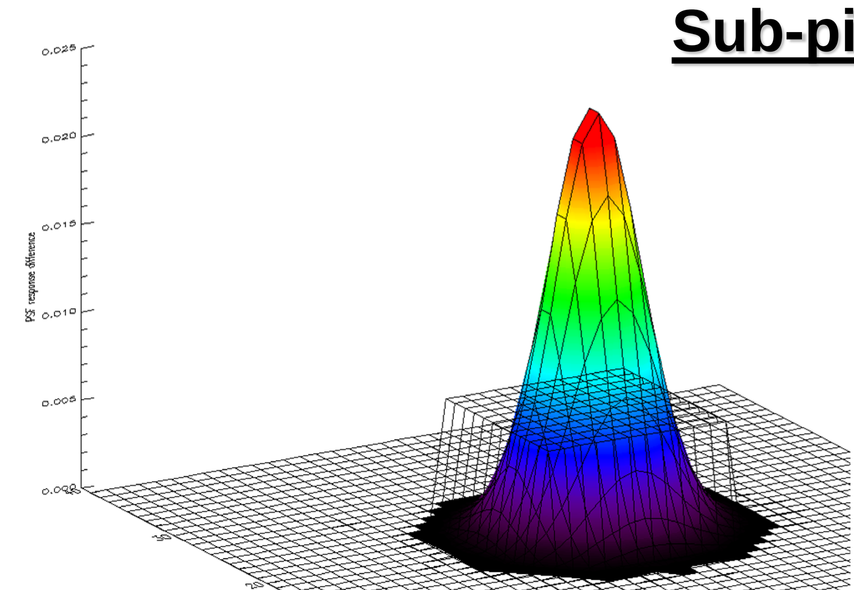
The examples to the above show the 2007 Oct. Southern California fire outbreak. Simulated ABI and MODIS source data are presented in the top two image sets. A numerically based simulated ABI model data from CIRA is also shown with the corresponding GOES-11 data in the bottom two image sets.



The images below and right show a case study from Sep 7, 2004. ABI data (left) is simulated from MODIS (lower right). WF_ABBA is run using the simulated ABI data and the results are shown run on the right. In red the ABI fire detections are plotted while in blue the MODIS fire product detections are shown.



Sub-pixel Fire Detection and Characterization



Satellite observation of fire is sensitive to the characteristics of the sensor. One way to measure the Pointspread function(PSF) is by the "ensquared energy". The figure to the above compares a Gaussian PSF (color filled) with a step function PSF (transparent), both having the same ensquared energy.

Fire Size and Temperature

To solve fire size and temperature, a system of two equations (4 and 11 micron radiance) with two unknowns (fire temperature and fire size) can be solved numerically.

FRP

Fire radiative power (FRP) is a parameter widely used in emissions modeling as studies have shown a linear relationship between fire emissions and FRP.

The image to the below shows GOES-R ABI nominal pixels (grid) overlaid on coincident 30m resolution ASTER image (RGB 8-3-1) acquired on 19 Oct 2002 14:21:59UTC. WF-ABBA fire pixels are marked in red (credit: Wilfrid Schroeder).

Subpixel hotspot features can appear in multiple full-resolution pixels as an artifact of the shape of the imager response function and relative position of the subpixel feature.