GOES-R AWG Product Validation Tool Development

Fire Detection and Characterization Application Team

Christopher Schmidt (CIMSS)
Ivan Csiszar (STAR)
Wilfrid Schroeder (CICS/UMD)

OUTLINE

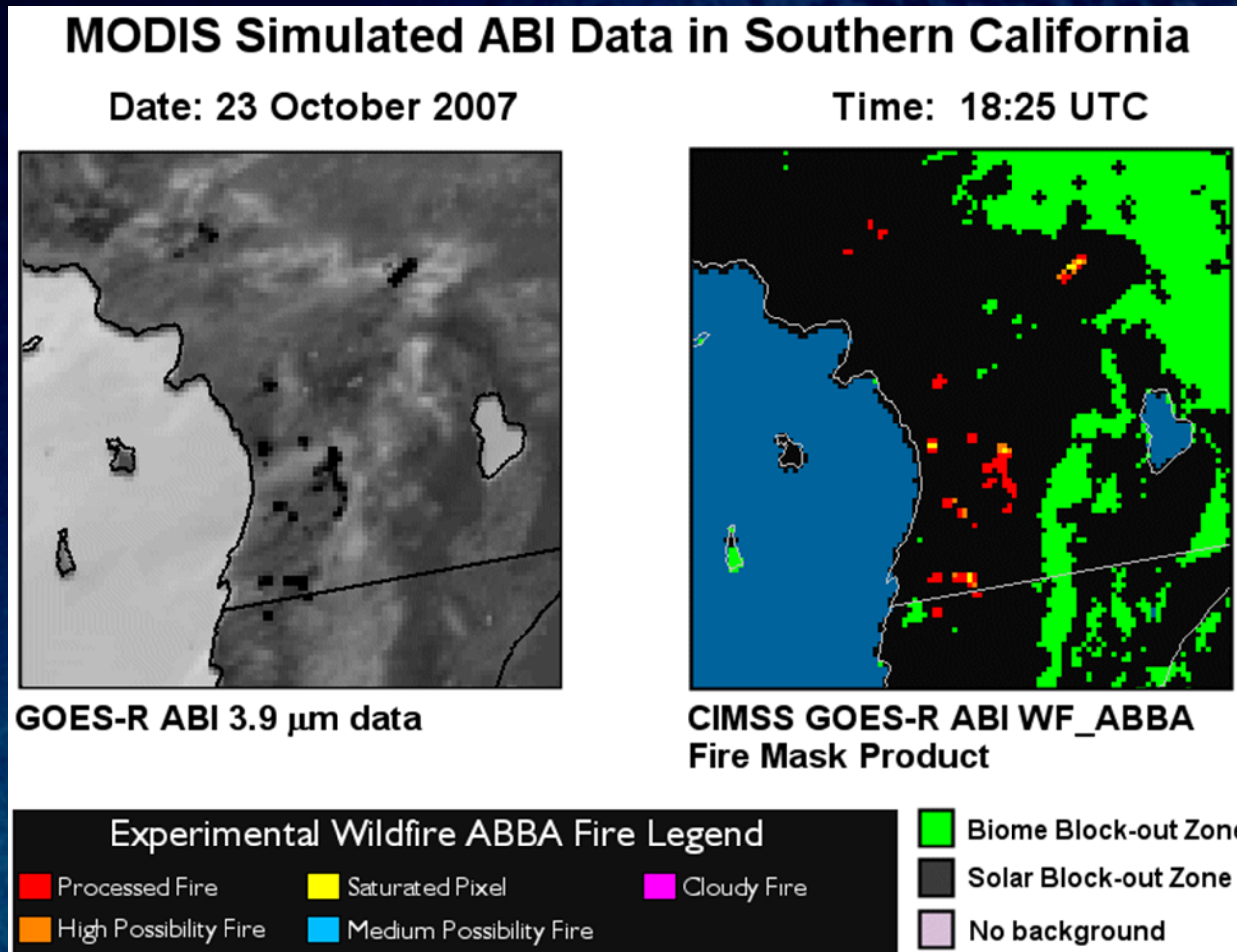
- Products
- Validation Strategies
- Routine Validation Tools
- “Deep-Dive” Validation Tools
- Ideas for the Further Enhancement and Utility of Validation Tools
- Summary

Products

Fire detection and characterization algorithm properties:

- Refresh rate: 5 minute CONUS, 15 minute full disk
- Resolution: 2 km
- Coverage: CONUS, full disk
- ABI version of the current GOES Wildfire Automated Biomass Burning Algorithm (WF_ABBA)
- Product outputs:
  - Fire location
  - Fire instantaneous size, temperature, and radiative power
  - Metadata mask including information about opaque clouds, solar reflection block-out zones, unusable ecosystem types.

Products


MODIS Simulated ABI Data in Southern California
Date: 23 October 2007
Time: 18:25 UTC
GOES-R ABI 3.9 μm data
CIMSS GOES-R ABI WF_ABBA Fire Mask Product
Experimental Wildfire ABBA Fire Legend
Processed Fire
Saturated Pixel
Cloudy Fire
High Possibility Fire
Medium Possibility Fire
Biome Block-out Zone
Solar Block-out Zone
No background

Validation Strategies

FDCA Routine Validation

Current practice for GOES WF_ABBA:

No automated realtime method is available. Ground-based fire reports are incomplete and typically not available in realtime. At the Hazard Mapping System Human operators look at fire detections from various satellites and at satellite imagery to remove potential false alarms. This method is labor intensive and actual fire pixels are often removed.

FDCA Routine Validation

ABI near realtime validation:

- **Co-locate ABI fire pixels with other satellite data**
  - **Ground-based datasets tend to be incomplete and not available in realtime**
  - **Fire detections from other satellites (polar orbiting) can be used in near realtime**
  - **Perfect agreement is not expected. Due to resolution, viewing angle, and sensor property differences a substantial number of valid fires will be seen by only one platform**
- **Other fire properties (instantaneous fire size, temperature, and radiative power) have no available near realtime validation source (see Deep-Dive tools)**
- **Important note: the product requirement does not align with user expectations. The requirement states:**

  "2.0 K brightness temperature within dynamic range (275 K to 400 K)"

  This applies to a pixel brightness temperature, and the algorithm achieves it for 100% of the fires where fire characteristics are calculated. When used to recalculate the input brightness temperature the fire characteristics match the input data to better than 0.0001 K.

FDCA Validation Tools

Routine validation tools:

- **Perform co-locations for individual fires and for clusters of fires**
- **Provide statistics on matches**
- **Table on following slide shows example of routine statistics from model-generated proxy data cases. 75 MW of fire radiative power is the estimated threshold for fire detectability.**

Deep-Dive validation tools:

- **Allow for validation of fire location *and* properties**
- **Utilize high-resolution data from satellite or aircraft to provide fire locations and enable estimates of fire size, temperature, and radiative power**
- **Can be partially automated, availability of high resolution data is limiting factor**

Validation Strategies

CIRA Model Simulated Case Studies^								
	CIRA Truth			ABI WF_ABBA				
	Total # of fire clusters*	Total # of ABI fire pixels*	Total # of ABI fire pixels > FRP of 75 MW*	Total # of detected clusters	% Fire clusters detected*	Total # of fire pixels detected > FRP of 75 MW*	% Fire pixels detected > FRP of 75 MW*	% False postives (compared to model truth, will not be available for routine validation)
Kansas CFNOCLD	9720	63288	52234	9648	99.3%	47482	90.9%	<1%
Kansas VFNOCLD	5723	36919	26600	5695	99.5%	551	80.6%	<1%
Kansas CFCLD	9140	56553	46446	8768	95.9%	39380	84.8%	<1%
Cent. Amer. VFCLD	849	2859	1669	808	95.2%	1424	85.3%	<1%
Oct 23, 2007 California VFCLD	990	4710	2388	989	99.9%	2090	87.5%	<1%
Oct, 26 2007 California VFCLD	120	522	252	120	100%	211	83.7%	<1%

CFNOCLD	Constant Fire No Cloud	^ Limit to ~ 400K minimum fire temperature
VFNOCLD	Variable Fire No Cloud	
CFCLD	Constant Fire with Cloud	* In clear sky regions, eliminating block-out zones
VFCLD	Variable Fire with Cloud	

”Deep-Dive” Validation Tools

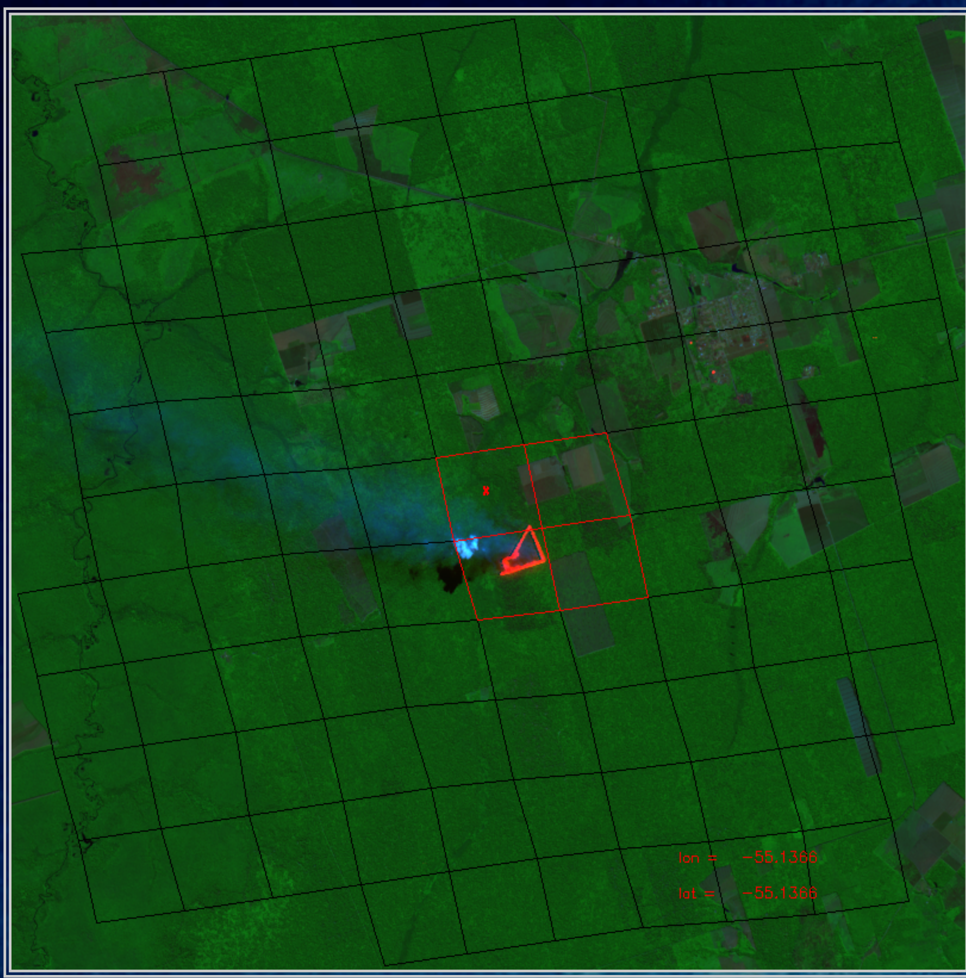
- Deep-dive fire detection and characterization validation tool builds on methods originally developed for MODIS and GOES Imager
  - Use of near-coincident (<15min) Landsat-class and airborne data to generate sub-pixel summary statistics of fire activity
    - Landsat-class data are used to assess fire detection performance
      - History of successful applications using ASTER, Landsat TM and ETM+ to estimate MODIS and GOES fire detection probabilities and commission error rates (false alarms). Methods published in seven peer reviewed journal articles
      - Limited fire characterization assessment (approximate fire size only). Frequent pixel saturation and lack of middle infrared band prevent assessment of ABI’s fire characterization parameters
    - Airborne sensors are used to assess fire characterization accuracy
      - High quality middle-infrared bands provide fine resolution data (<10m) with minimum saturation allowing full assessment of ABI’s fire characterization parameters (size, temperature, Fire Radiative Power)
      - Sampling is limited compared to Landsat-class data
        - » Regional × hemispheric/global coverage
        - » Targeting case-study analyses
- Validation routines developed in IDL
  - Perform reference data co-location
  - Run pixel-based validation (relate ABI pixels with presence (amount) or absence of fire activity as indicated by near-coincident reference data)
  - Create outputs (graphic and tabular)
- Proxy data generator developed in IDL and McIDAS
  - Using input MODIS 1km L1B radiance data
  - Testing alternative method using input 30m ASTER data: goal is to improve sub-pixel representation of fires not resolved by 1km MODIS L1B data

"Deep-Dive" Validation Tools

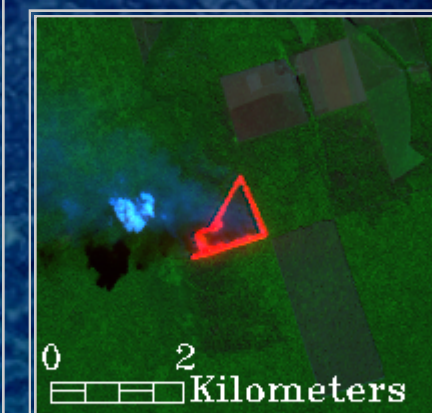
- Several national and international assets will be used to support ABI fire validation
  - USGS Landsat Data Continuity Mission (2013)
  - ESA Sentinel-2 (2013)
  - DLR BIROS (2013)
  - NASA HysPIRI (TBD ~2020)
  - Airborne platforms (NASA/Ames Autonomous Modular Sensor-Wildfire; USFS FireMapper)
- Will perform continuous assimilation, processing and archival of reference fire data sets
  - Daily alerts targeting false alarms, omission of large fires
    - Main output: Quick looks (PNG) for visual inspection of problem areas showing ABI pixels overlaid on high resolution reference imagery
  - Probability of detection curves and commission error rates derived from several weeks/months of accumulated validation data
    - Main output: Tabular (ASCII) data containing pixel-based validation summary (graphic output optional)

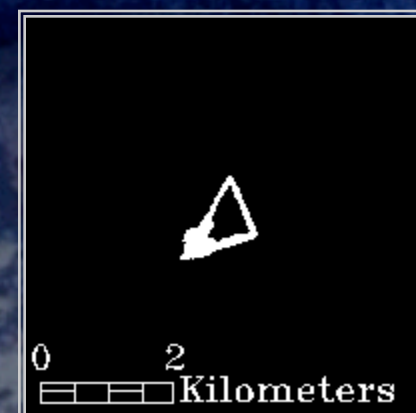
"Deep-Dive" Validation Tools

Using Landsat-class imagery to validate ABI fire detection data



Sample visual output of simulated ABI fire product (grid → 2km ABI pixel footprints) overlaid on ASTER 30m resolution RGB (bands 8-3-1). Red grid cells indicate ABI fire detection pixels; green on background image corresponds to vegetation; bright red is indicative of surface fire



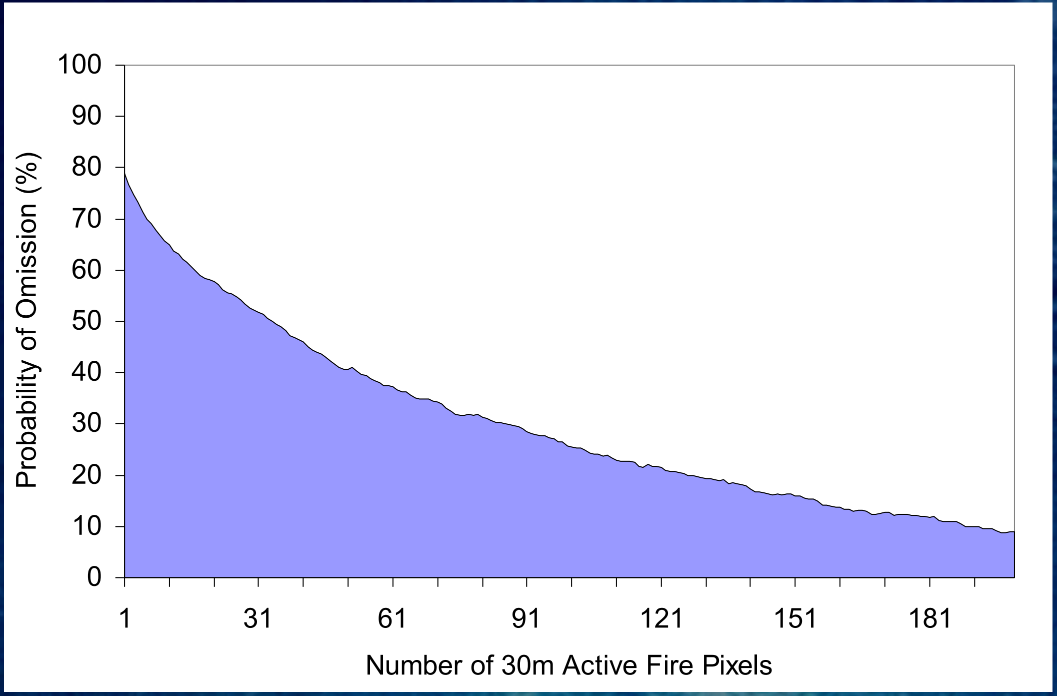


ASTER binary (fire – no fire) active fire mask indicating 494 (30m resolution) active fire pixels coincident with GOES-R ABI simulated fire product

"Deep-Dive" Validation Tools

ABI Lon,	ABI Lat,	30m Fires,	30m Clusters,	WF_ABBA,	Sfc_01,	Sfc_02,	Adj_Fires,	Ajd_Cluster,	Distance,	Azimuth
-54.9388123,	-12.3929567,	11,	2,	100,	0.0000000,	0.0000000,	0,	0,	0.0000000,	0.0000000
-54.9003563,	-12.3929567,	3,	2,	100,	0.0000000,	0.0000000,	0,	0,	0.0000000,	0.0000000
-54.9992371,	-12.4121828,	15,	1,	10,	0.0000000,	0.0000000,	0,	0,	0.0000000,	0.0000000
-54.9992371,	-12.4314098,	479,	1,	10,	0.0000000,	0.0000000,	0,	0,	0.0000000,	0.0000000
-55.1969986,	-12.4451427,	19,	1,	100,	0.0000000,	0.0000000,	0,	0,	0.0000000,	0.0000000
-55.1805153,	-12.4478893,	10,	2,	100,	0.0000000,	0.0000000,	0,	0,	0.0000000,	0.0000000

Sample tabular (subset) output depicting ABI pixel-level fire activity derived from one 30m ASTER reference scene



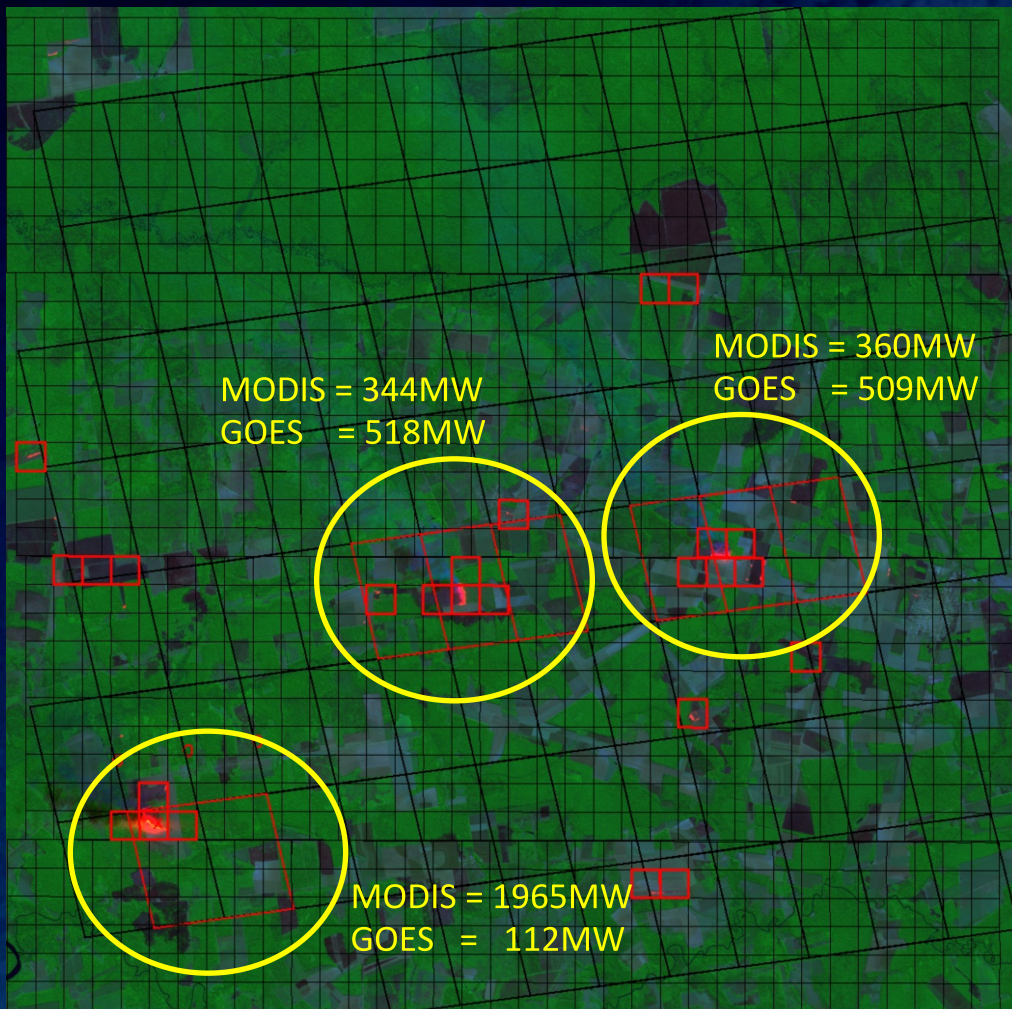
Probability of fire omission calculated for ABI using 161 ASTER scenes acquired over South America

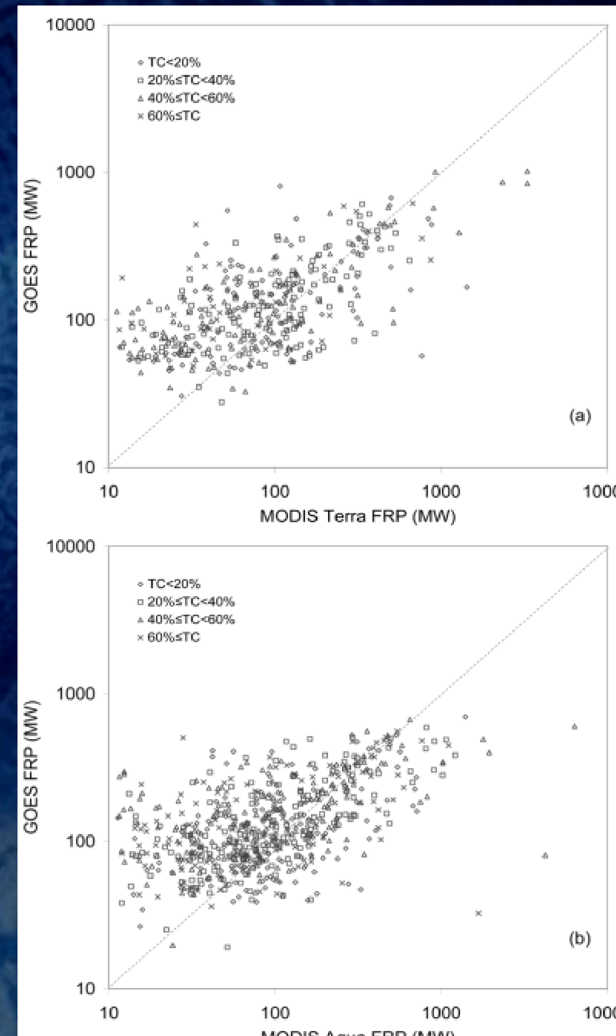
"Deep-Dive" Validation Tools

- Landsat-class data are **NOT** suited for the validation of ABI fire characterization parameters (Fire Radiative Power (FRP), size and temperature)
  - Frequent fire pixel saturation
  - Lack of middle-infrared band
- **Cross-validation** of pixel-level fire characterization data using other similar satellite products proven **impractical** [Schroeder *et al*., 2010]
  - No single product has been sufficiently validated to date therefore cross-validation analyses provide little useful information
  - Differences in resolution and observation geometry are problematic

"Deep-Dive" Validation Tools

MODIS×GOES Imager FRP data intercomparison





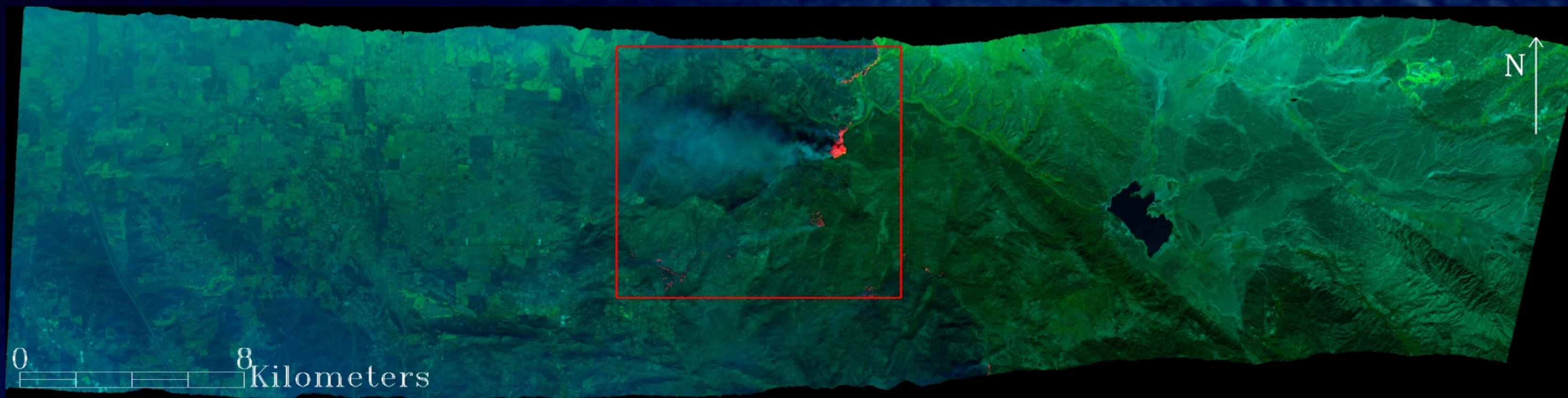
Credit: Schroeder et al, 2010

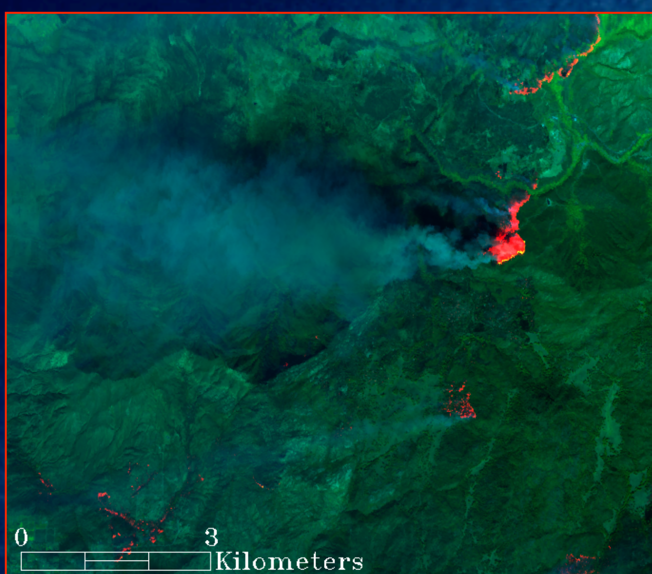
”Deep-Dive” Validation Tools

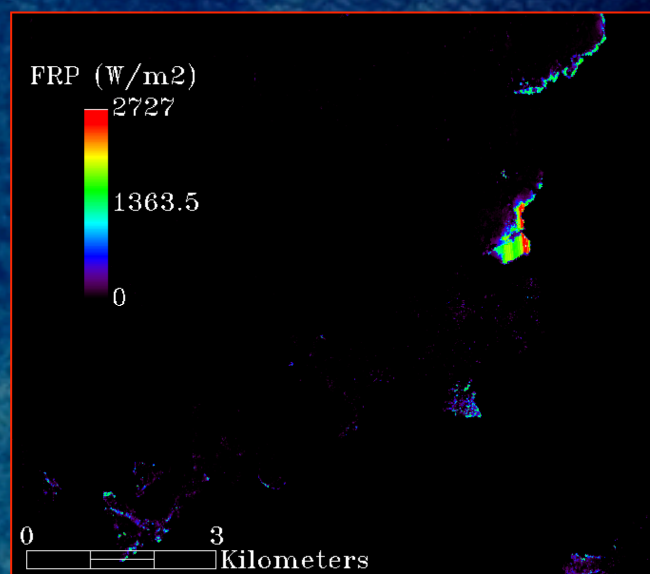
- Data simulation is prone to misrepresent sub-pixel features in fire-affected pixels
  - Lack of quality reference data lead to overly simplistic (**unrealistic**) fire pixel representation
- Airborne sensors provide fine resolution quality fire reference data
  - **Support** detailed analyses of **fire characterization retrievals** (test-case)
  - Airborne data can **help** us better **constrain data simulation**

"Deep-Dive" Validation Tools

Airborne fire reference data acquisition plan will <u>benefit/leverage</u> MODIS and JPSS/VIIRS fire algorithm development/funding







Airborne (AMS) data collected over Southern CA fire in 2007. Fire radiative power (FRP), fire size and temperature are derived for use in the validation of GOES-R ABI fire characterization parameters.

Ideas for the Further Enhancement and Utility of Validation Tools

- Off-line (IDL) interface would greatly improve management of reference data sets for use in the fire product validation
  - Data sources are dynamic: new data sets may be added, others may be modified, reference sensors can fail partially or completely (e.g., ASTER, ETM+) requiring quick adaptation
  - Data formats can vary significantly depending on the provider
  - Off-line processor could add flexibility and agility to system
    - Built-in IDL functions could minimize implementation costs of new or modified modules using specific data formats
    - Would create standard reference data files for use as input by the core deep-dive fire validation tool
      - Eliminate need to modify on-line code
      - Operational risks are reduced
      - Reprocessing of revised input reference data could be more easily implemented
- Must secure ways to maintain off-line system running and to perform updates
- Techniques are applicable to reprocessed ABI data
- Deep-dive tools could be automated presuming regularly available high resolution data sources are secured
- New development could include a web tool that allows interactive comparison of fire datasets from different satellites, including fire properties and metadata
- Further extension of that tool would allow comparisons with high resolution data used in the deep-dive tools, showing ABI pixels and fires overlaid on the high resolution data (similar to graphic on earlier slide)

Summary

- Fire detection and characterization is a baseline product derived from a current Operational fire algorithm, the WF_ABBA
- Routine validation consists of co-locating ABI detected fires with those from polar orbiting platforms (JPSS, for example). Current tools developed in IDL.
- Deep-dive tools utilize high resolution data from satellite instruments similar to ASTER and could conceivably be automated if a reliable source of high resolution data is secured