Global Geostationary Network and Fire Products

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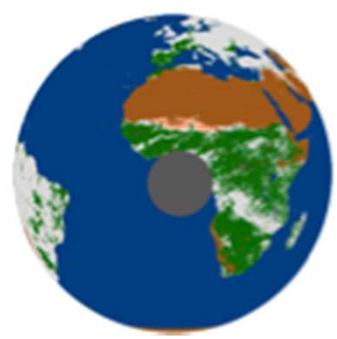
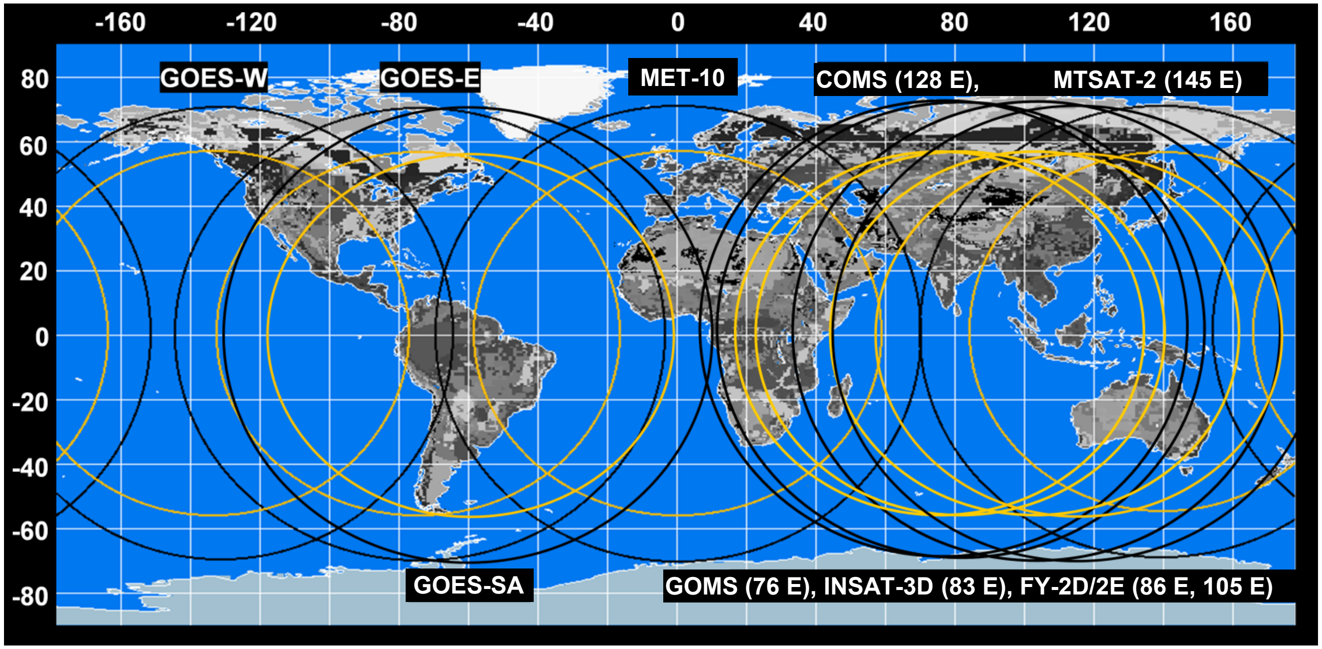
GOFC-GOLD Fire-IT Meeting
15-18 April 2013





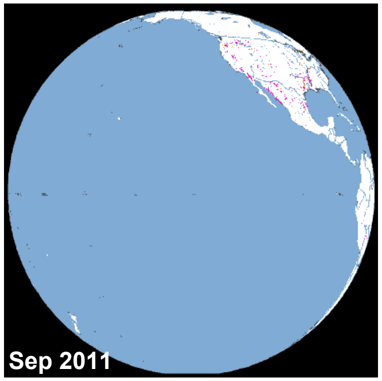
Current Operational Global Geostationary Satellites

Active Fire Monitoring Capabilities

Satellite	Active Fire Spectral Bands	Resolution IGFOV (km)	SSR (km)	Full Disk Coverage	3.9 µm Saturation Temperature (K)
GOES-E/-W Imager (75ºW / 135ºW)	1 visible 3.9 and 10.7 µm	1.0 4.0	0.57 2.3	3 hours (30 min NHE and SHE)	~337-340 K (G-15) ~337-340 K (G-13)
GOES-12 Imager (South America) (60ºW)	1 visible 3.9 and 10.7 µm	1.0 4.0	0.57 2.3	3 hours (Full Disk) 15 min (SA)	>337 K (G-12)
Met-10 SEVIRI (0º)	1 HRV 2 visible 1.6, 3.9 and 10.8 µm	1.6 4.8 4.8	1.0 3.0 3.0	15 minutes	~335 K
FY-2D/2E SVISSR (86ºE / 105ºE)	1 visible, 3.75 and 10.8 µm	1.25 5.0		30 minutes	~330 K
MTSAT-2 Imager (HRIT) (145ºE) Operational (2010)	1 visible 3.7 and 10.8 µm	1.0 4.0		1 hour	~320 K
GOMS Elektro-L N1 MSU-GS (76ºE) (2011) GOMS Elektro-L N2 MSU-GS (76ºE) (12/2013)	3 visible 3.75 and 10.7 µm	1.0 km 4.0 km		30 minutes	TBD
COMS MI (128ºE)	1 visible 3.9 and 10.7 µm	1.0 km 4.0 km		3 hours	~350 K

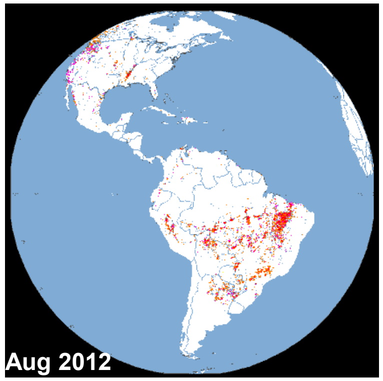
WFABBA Fire Monitoring Around the Globe

GOES-11 (West)



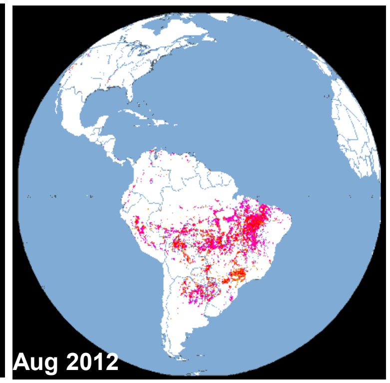
- Schedule:
  Full disk (NHE+SH) - 30 minute
  CONUS - 15 minute
- Western U.S., Alaska, Canada, South America on limb
- Biome block-out limits fire monitoring in arid west
- Saturation minimal

GOES-13 (East)



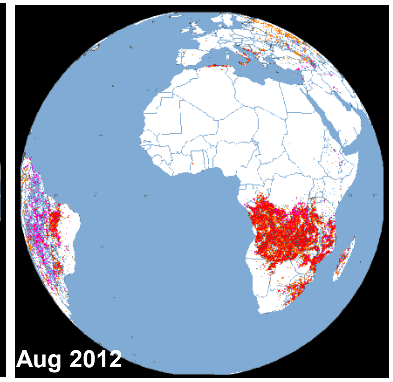
- Schedule:
  Full disk (NHE+SH) - 30 minute
  CONUS - 15 minute
- Good coverage of South America which dominates fire signal
- Although number of detected fires is smaller than GOES-12, year to year variability is similar
- Saturation minimal

GOES-12 (South America)



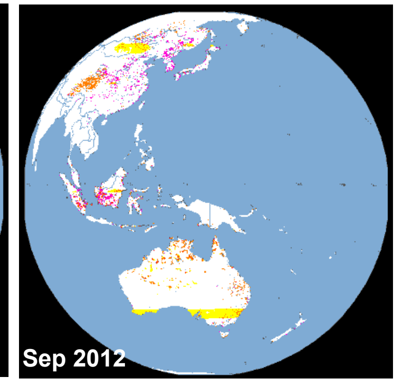
- Schedule:
  Full disk - 3 hour
  South America -15 minute
- Excellent spatial and temporal coverage of South America allows for nearly twice as many fire detects compared with GOES-E
- Higher # of cloud contaminated and low possibility fires
- Saturation minimal

Meteosat-9



- Schedule:
  Full disk- 15 minute
- Excellent spatial and temporal coverage of Africa
- Biome block-out limits fire monitoring in Africa and Middle East
- The number of low possibility fires is high especially over South America
- Saturation slightly higher than GOES series

MTSAT-2



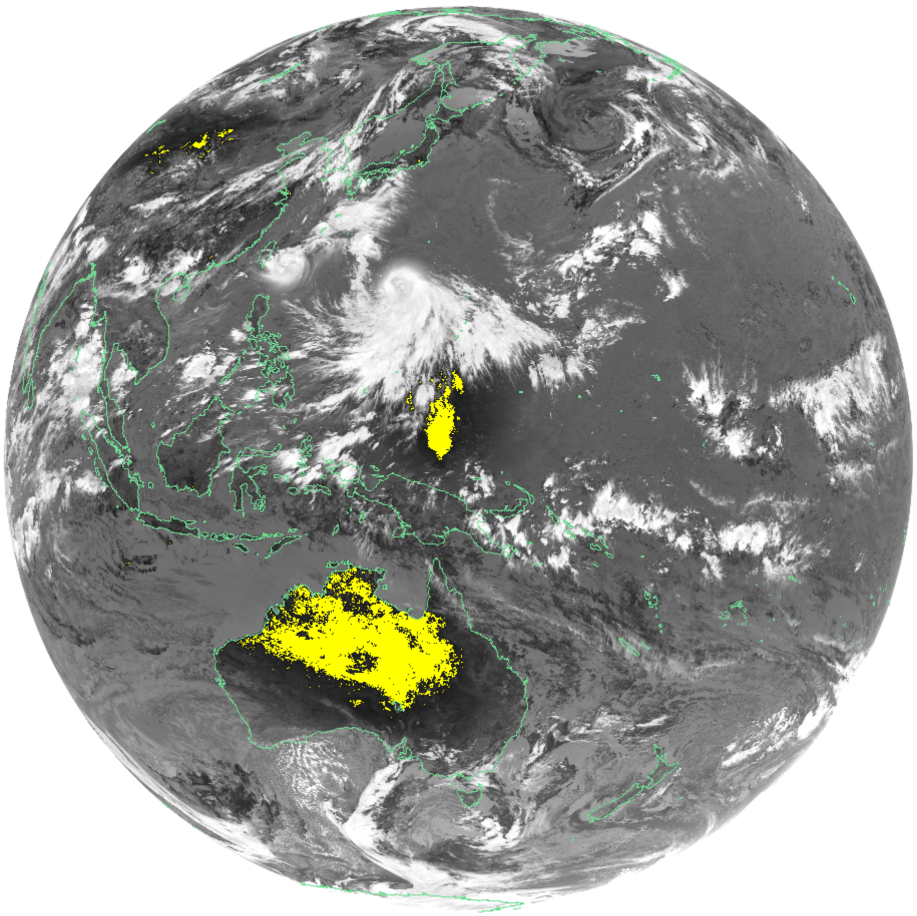
- Schedule:
  Full disk- 1 hour
- Excellent spatial coverage of Indonesia
- Fire monitoring limited by low saturation in the 3.9 μm band
- Low possibility fires dominate the fire signature
- Many saturated fire pixels

The global WFABBA is operational at NOAA/NESDIS with fire product text file download available in near-real time. Fire mask imagery is available online at http://wfabba.ssec.wisc.edu.

Example of Improved Geostationary Fire Monitoring in SE Asia With the Korean COMS

Saturation in the short-wave IR window

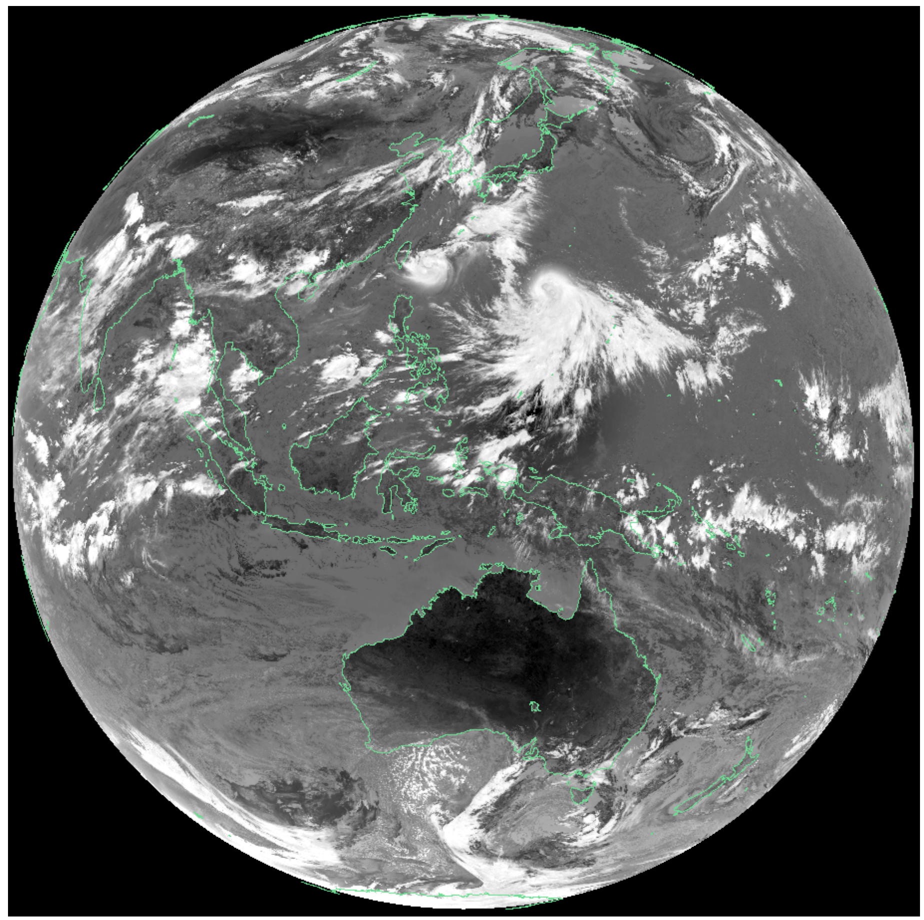
MTSAT-2



4 micron data
Date: 22 August 2012
Saturation: ~320K
Time: 02:32 UTC

Saturated Values

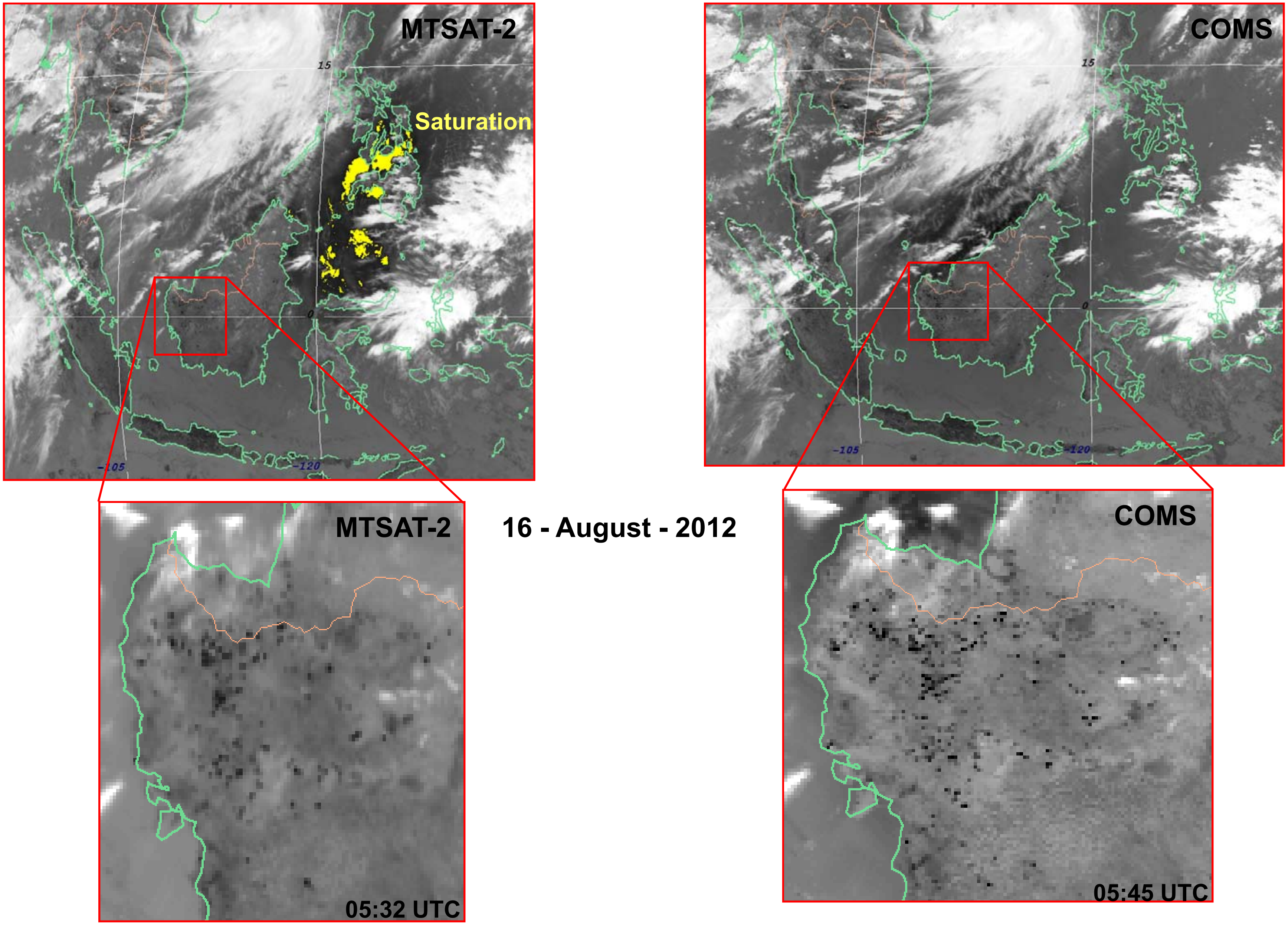
COMS



4 micron data
Date: 22 August 2012
Saturation: >350K
Time: 02:15 UTC

Adaptation of WF_ABBA for COMS nearly complete

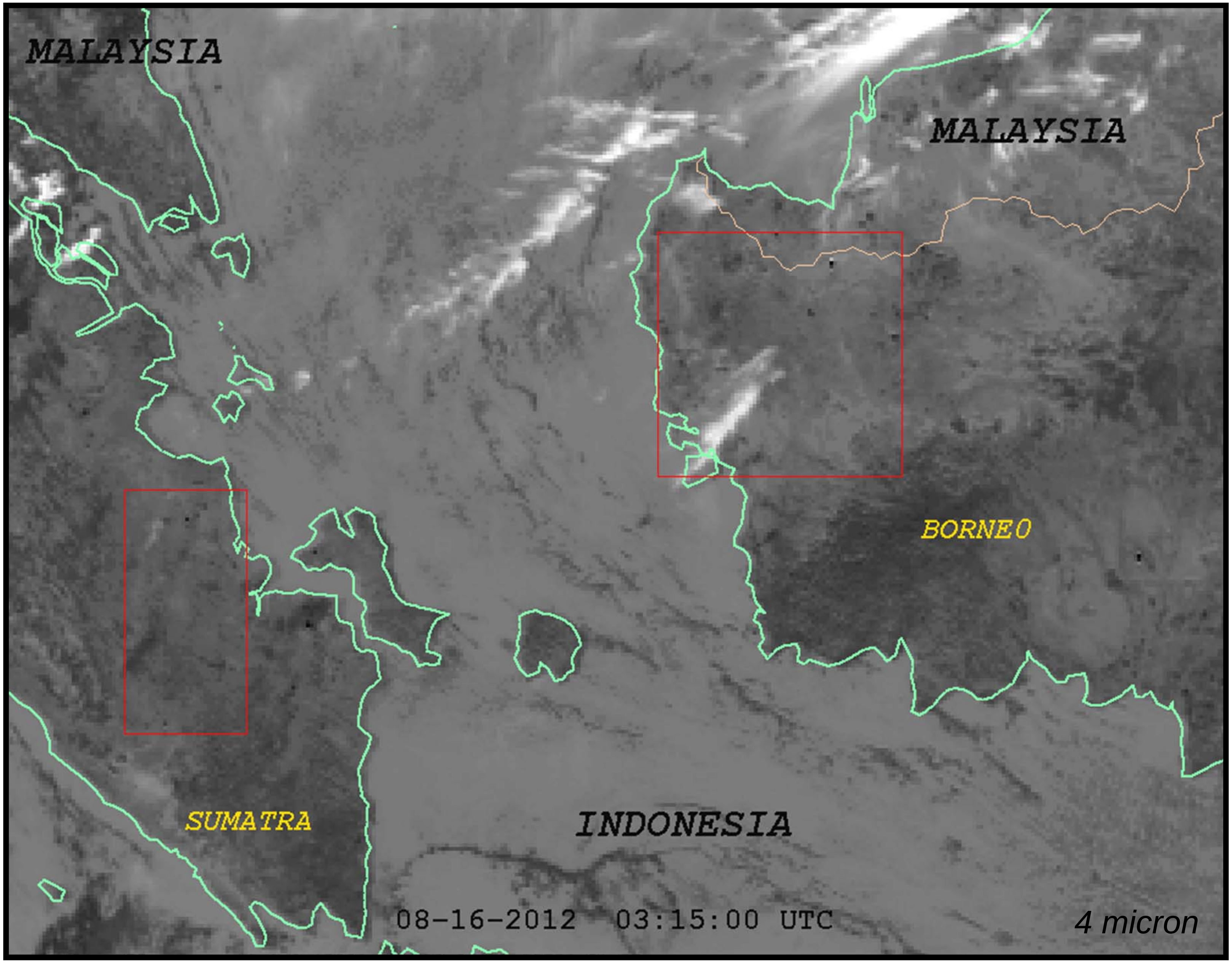
Observations of Fires in Borneo Using MTSAT-2 and COMS



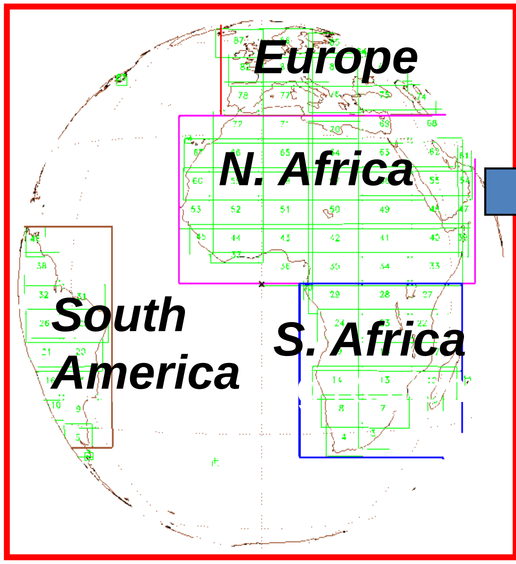
Dark hot spots indicate active fires in COMS and MTSAT-2 4-micron imagery. Fire signatures in the COMS data are more readily distinguished from the background conditions allowing for enhanced detection/characterization.

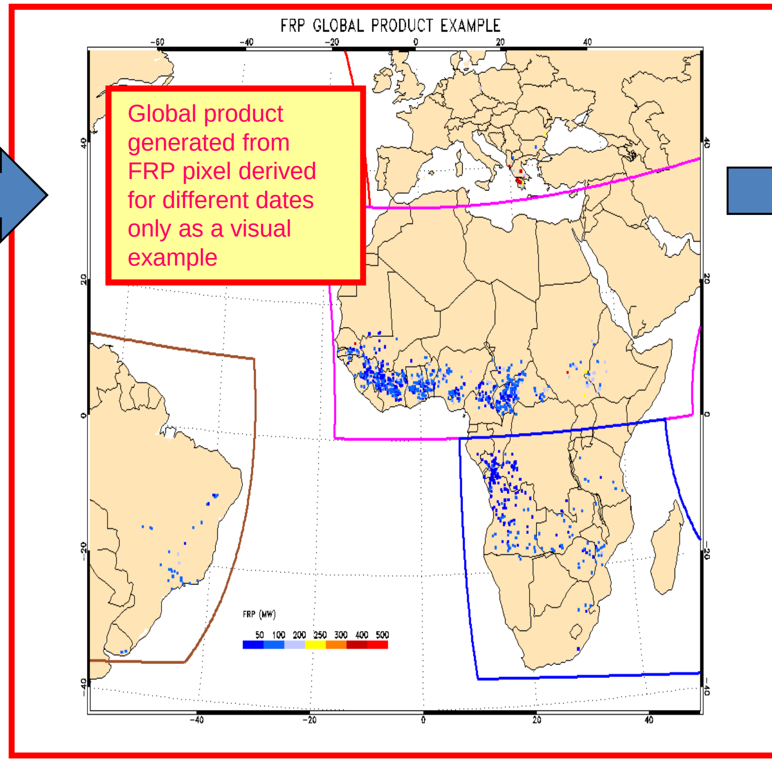
COMS Captures Diurnal Variability in Fire Activity in Borneo and Sumatra

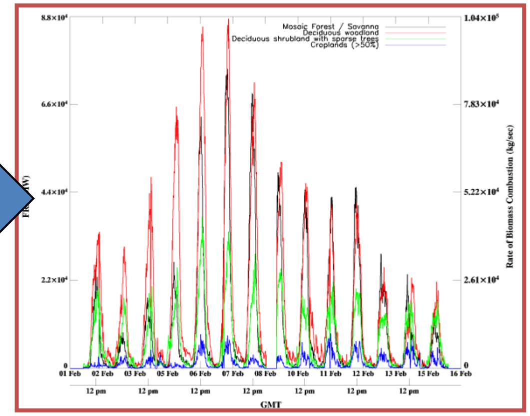
August 16, 2012 03:15 – 07:15 UTC



Operational SEVIRI FRP Product







- Active Fire Detection
- FRP Assessment
- Uncertainty Estimates

- Available from EUMETSAT Land Surface Analysis Satellite Application Facility (LSA SAF) using KCL algs.

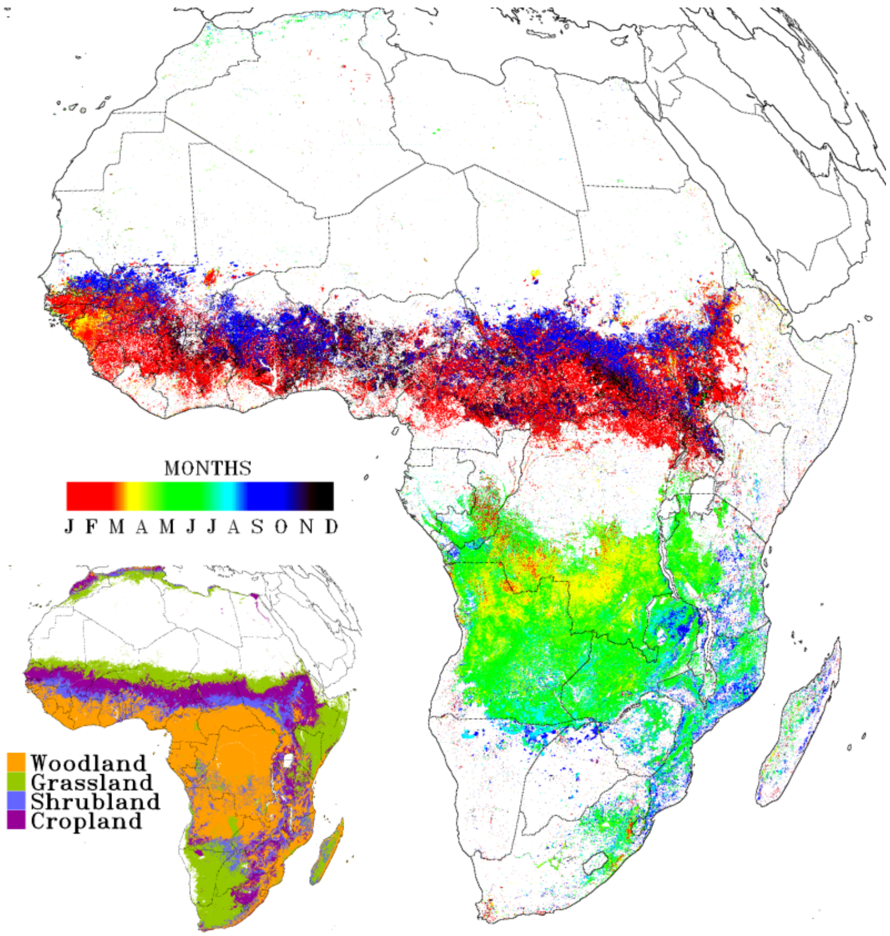
Available free via FTP or EUMETCast for last few years:

http://landsaf.meteo.pt/

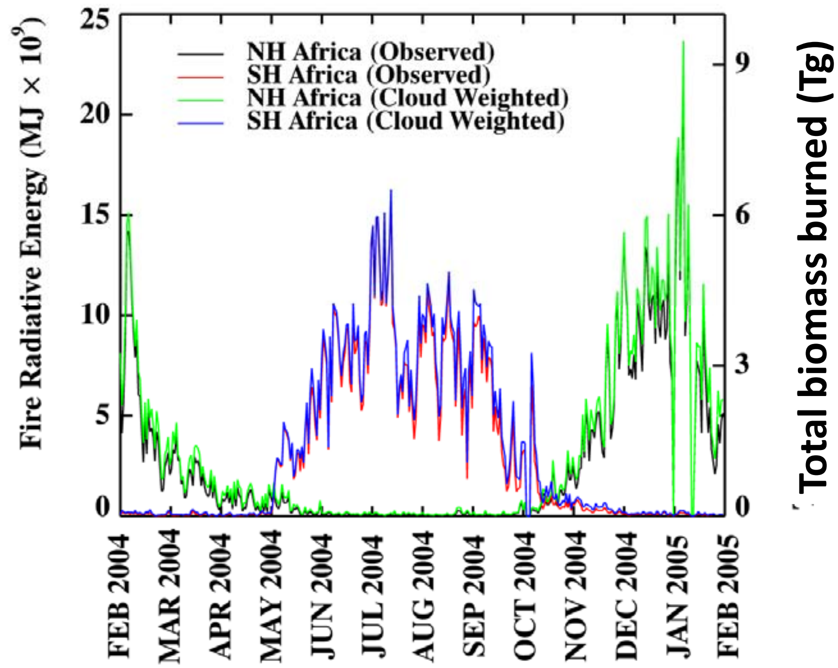
- **FRP Pixel Product** (native spatial/temporal resolution) – available within 30 mins
- **FRP Gridded product** - inc. adjustments for "small fires" and "clouds" also available.

Example LSA SAF FRP Data

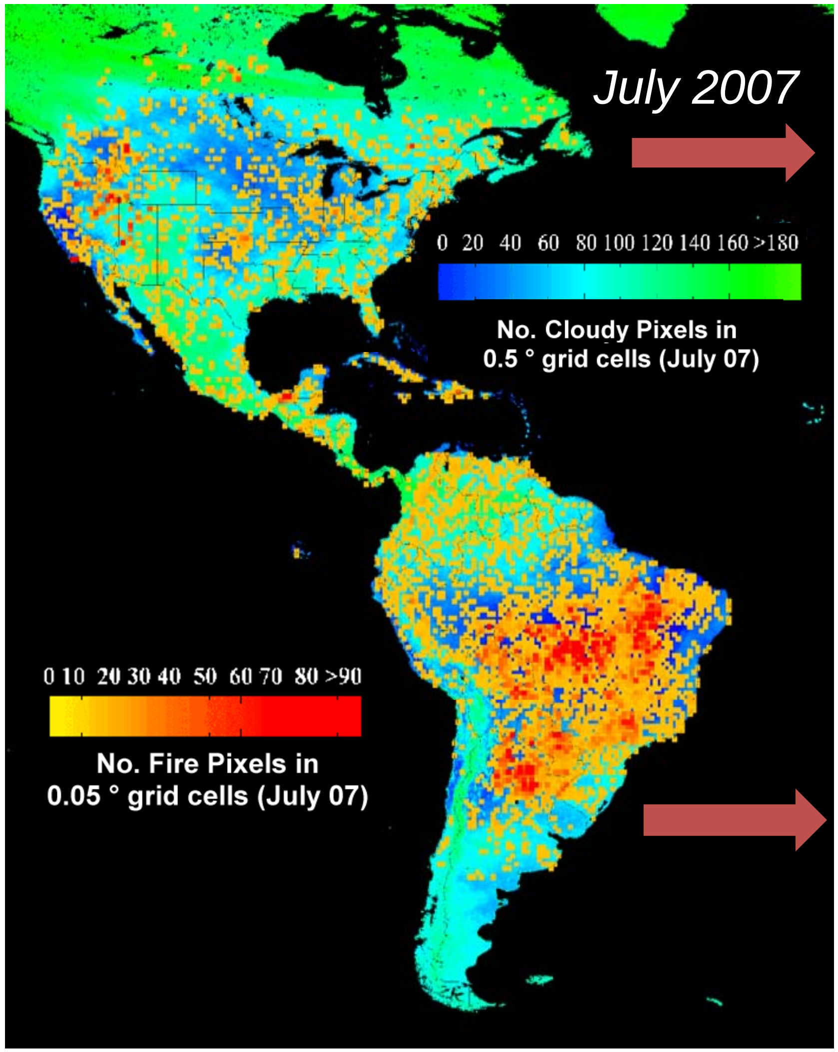
SEVIRI Fire Pixel detections (2004)

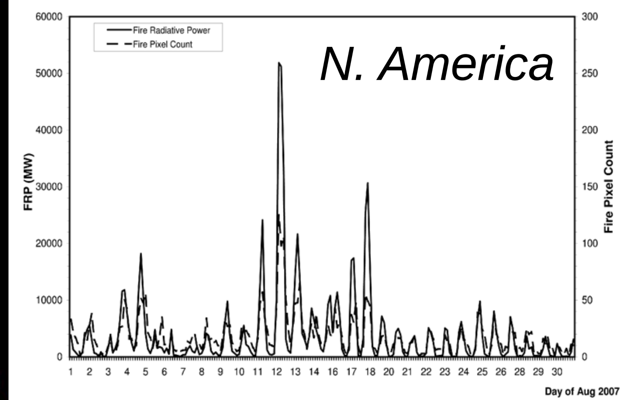


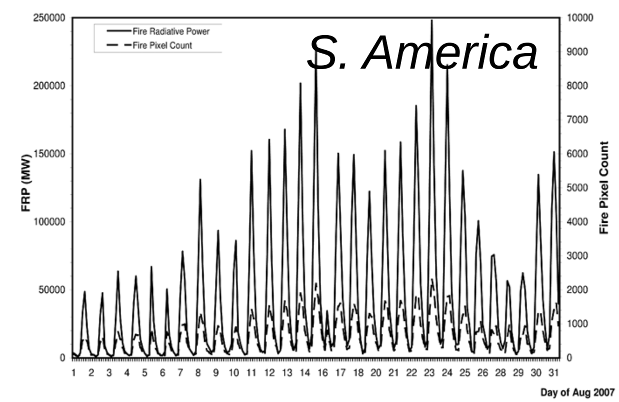
SEVIRI FRP Time-series (2004)



GOES FRP Product (forthcoming from the LSA SAF)







- *Being Migrated to the LSA SAF Processing chain this year (2013)*
- *Currently available on request in NRT from King's College London*

Near Term and Next Generation
Global Geostationary Active Fire Monitoring Capabilities

Satellite	Launch	Active Fire Spectral Bands	Resolution IGFOV (km)	Full Disk Coverage	3.9 μm Saturation Temperature (K)
India INSAT-3D (82ºE, Prime: 74ºE)	2013/2014	1 vis, 1.6 μm 3.9 and 10.8 μm	1.0 4.0	30 minutes	TBD
JMA Himawari-8 AHI (140ºE)	2014	1 visible 5 visible/NIR 3.9,10.4,11.2 μm	0.5 1.0 - 2.0 2.0	10 minutes	~400 K (?)
USA GOES-R ABI (75ºW / 137ºW)	2015	1 visible 5 visible/NIR 3.9,10.4,11.2 μm	0.5 1.0 – 2.0 2.0	15 minutes	~400 K
CMA FY-4A AGRI (86.5ºE)	2015	1 visible 5 visible/NIR 3.9,10.4,11.2 μm	0.5 – 1.0 1.0 – 2.0, 4.0 2.0 & 4.0	15 minutes	?
European MTG-I1 FCI (9.5 ºE, 0º)	>2018	2 visible (RSS*) 8 visible/NIR 3.8 and 10.5 μm	0.5 1.0 **1.0 (RSS-3.8μm)** 2.0 for both	10 minutes	~450 K (?)
KMA GEO-KOMPSAT-2A AMI (128.2 or 116.2 ºE)	>2017	1 visible 5 visible/NIR 3.9,10.4,11.2 μm	0.5 1.0 – 2.0 2.0	10 minutes	~400 K (?)
Russia Elektro-M MSU-GSM (76ºE) (considered)	2017	~20 channels from 0.38-14.25 μm (?)	0.5-1.0 km (VNIR/SWIR) 1.0-2.0 km (IR)	10 minutes	TBD

***MTG-I1 RSS- Regional Rapid Scan (2.5 minutes over Europe, .25 full disk)**

GOES-R Advanced Baseline Imager Bands and how they are used for Fire Detection and Characterization Algorithm (FDCA)

Future GOES Imager (ABI) Band	Nominal Wavelength Range (µm)	Nominal Central Wavelength (µm)	Nominal Central Wavenumber (cm-1)	Nominal sub-satellite IGFOV (km)	Required/optional
1	0.45-0.49	0.47	21277	1	
2	0.59-0.69	0.64	15625	0.5	Optional, spec can be met without
3	0.846-0.885	0.865	11561	1	
4	1.371-1.386	1.378	7257	2	
5	1.58-1.64	1.61	6211	1	
6	2.225 - 2.275	2.25	4444	2	Future research
7	3.80-4.00	3.90	2564	2	Required
8	5.77-6.6	6.19	1616	2	
9	6.75-7.15	6.95	1439	2	
10	7.24-7.44	7.34	1362	2	
11	8.3-8.7	8.5	1176	2	
12	9.42-9.8	9.61	1041	2	
13	10.1-10.6	10.35	966	2	Optional
14	10.8-11.6	11.2	893	2	Required
15	11.8-12.8	12.3	813	2	Required
16	13.0-13.6	13.3	752	2	

Current Input

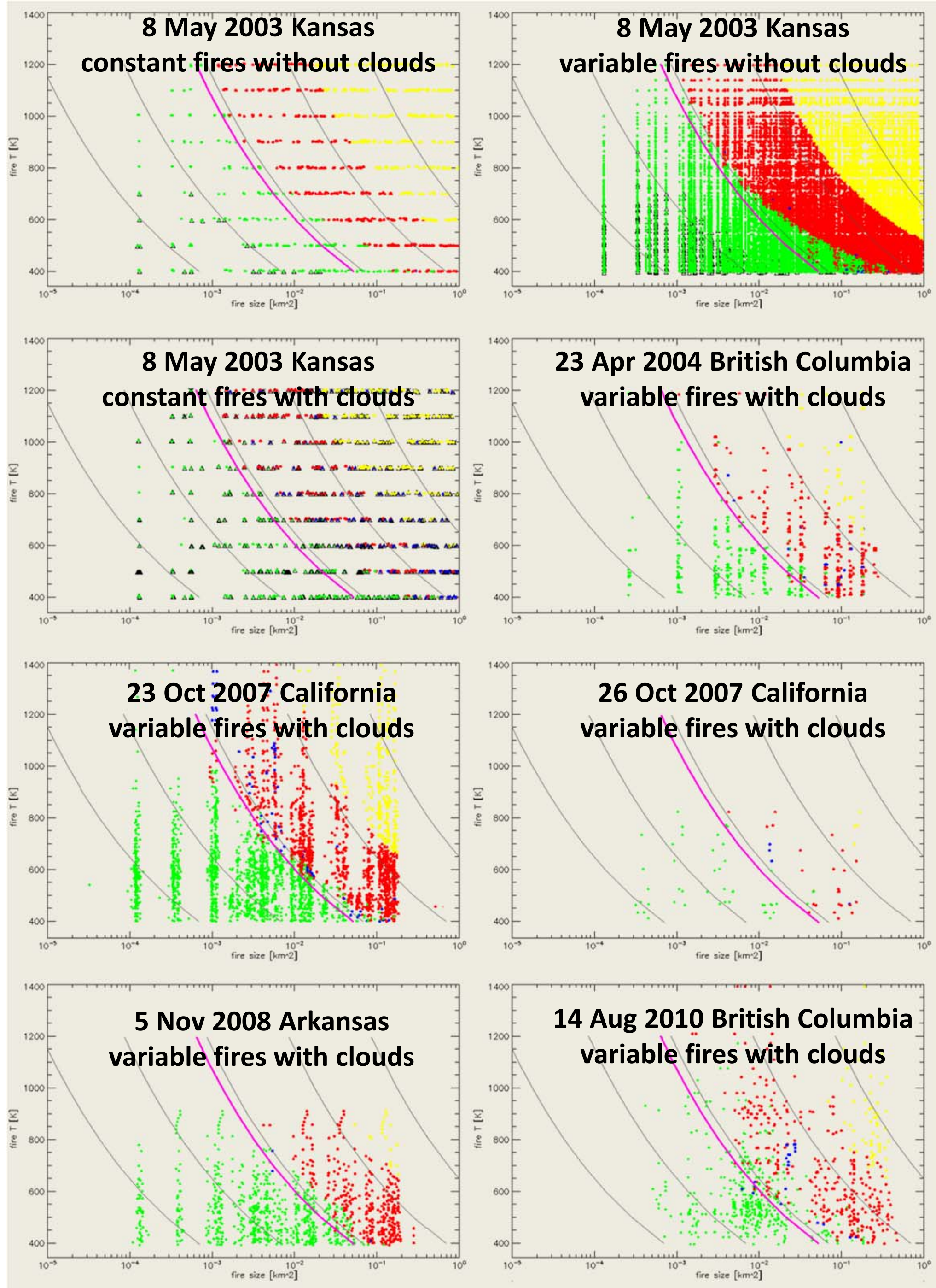
Expected Added Input

Possible Added Input

11

The detection threshold in ABI simulated data

The charts depict the GOES-R Fire Detection Algorithm fire detection and classification as a function of the model simulated ABI fire size and fire temperature. Fire detection case studies of simulated ABI data (developed at CIRA). The WFABBA is quite successful detecting fires with FRP > 75 MW (purple curved line, gray curved lines are on a log scale of MW).

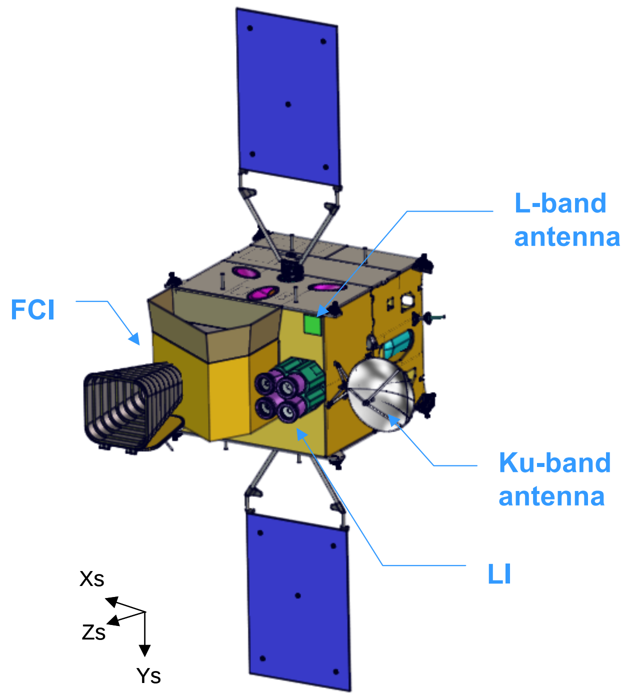


Not Detected
Processed Fire Pixel
Cloudy Fire Pixel
Medium Probability Fire Pixel
Not Detected, Block-out zone
Saturated Fire Pixel
High Probability Fire Pixel

FUTURE EUROPEAN GEOSTATIONARY MISSION

MTG in Orbit Configuration

KING'S College LONDON
University of London



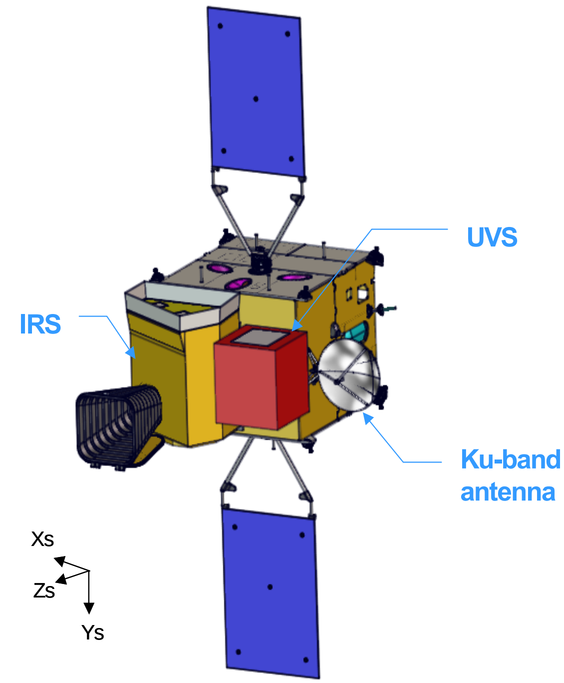
MTG-I Imaging Satellite

The payload complement of the MTG-I satellite consists of:

- the Flexible Combined Imager (FCI)
- the Lightning Imager (LI)
- the Data Collection System (DCS) and Search and Rescue (GEOSAR)

The payload complement of the MTG-S satellite consists of:

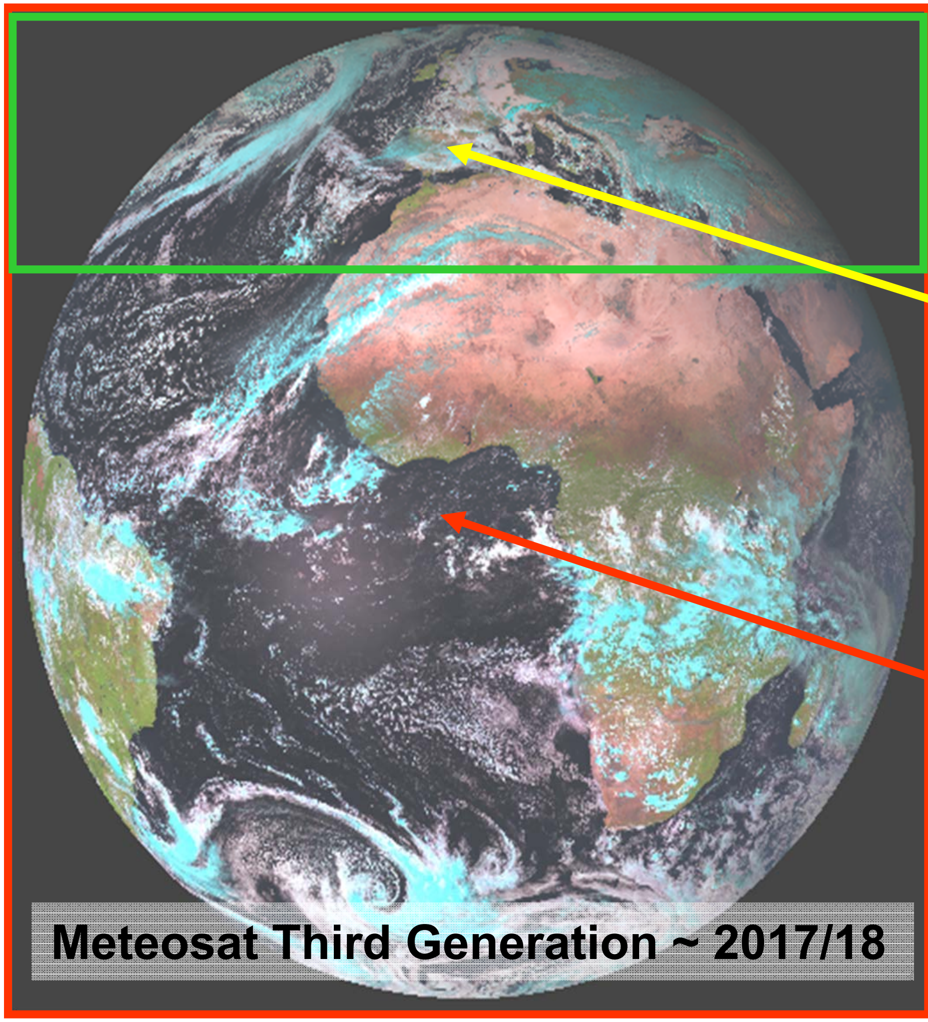
- the Infrared Sounder (IRS)
- the Ultra-violet, Visible and Near Infrared Sounder (UVN). UVN is provided as GMES Sentinel 4 Instruments



MTG-S Sounding Satellite

Meteosat Third Generation ~ 2017/18

MTG - Flexible Combined (FC) Imager



- The Flexible Combined Imager supports the FDHSI and HRFI missions.
- Basic repeat cycle of 10 min Full Disk coverage
- The Local Area Coverage zone can be positioned anywhere over the Full Disk Coverage. Possible repeat cycle of 10/2, 10/3 or 10/4 minutes, with the coverage reduced proportionally.

- Challenges compared to MSG:
- improved Spatial Resolution (0.5 - 2 km)
- faster basic repeat cycle (brc = 10 min)
- better spectral coverage (more channels and with low gain "fire" channel)
- improved spectral accuracy
- improved radiometric accuracy

Should allow improved "geostationary fire product" – KCL & EUMETSAT LSA SAF to work on these In the coming few years.

General Overview of Next Generation Global Geostationary Fire Monitoring

- Many of the new geostationary instruments include mandates for fire detection.

- Although these instruments are similar in many ways, pre-processing and saturation limits may not be the same. One of the biggest issues is the lack of information regarding sub-pixel detector saturation.

- Rapidly growing geo sensor & fire product network demands increased coordination between operational data producers, fire product development and implementation teams, and the user community.

- Existing cal/val plans included in many of the upcoming platforms need systematic validation efforts to understand cross platform differences and coordinated validation activities with CEOS LPV.

- Success requires support by operational agencies to sustain the global geostationary fire monitoring network and produce standardized long-term data records and fire inventories of known accuracy.

Geostationary Fire Product Validation

- Few detailed validation studies using GOES Imager (WF_ABBA) data
  - Landsat-class reference data freely available for fire detection validation ✔
  - Some airborne reference data available for fire retrieval validation ✔
  - GOES Imager navigation errors make data co-location difficult ✗

- Few satellite fire product inter-comparison studies
  - Ex.: FRP/FRE GOES × MODIS & SEVIRI × MODIS ✔
  - Limited information on fire retrieval accuracy ✗

- Few intensive fire sampling studies
  - Limited information on biome-specific as well as inter-satellite fire product performance ✗

Future Geo Validation Options

- Expand on the use of freely-available 30 m Landsat-class sensor reference data to establish common data base for in-depth assessment of sensor-specific detection performance and to support product inter-comparison
  - *Landsat-8 (✔), Sentinel-2a (~2014), 2b (2015?)*

- Other potential candidates providing moderate resolution reference fire data:
  - *DLR TET-1 (✔) and BIROS (2014?) ➔ 370 m fire detection and retrieval, non-public/on-demand only*
  - *SNPP/VIIRS I-band ➔ 375 m fire detection only (✔)*

- Field campaigns using manned/unmanned (UAV) airborne active fire imaging and ground sampling
  - *Community coordination required to leverage off funding and reduce costs*
  - *Few airborne sensors providing quality reference data (✔)*

Conclusions

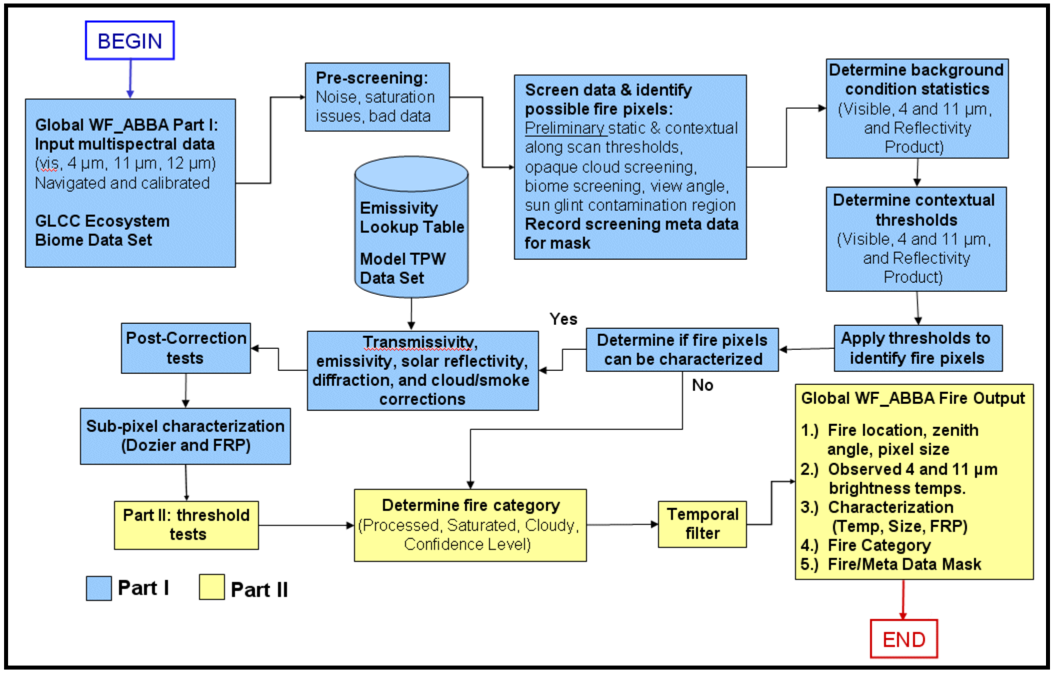
- Global network of geostationary fire observing systems now a reality
  - Will continue to expand & improve over the next few years
    - Better sensors plus enhanced coverage

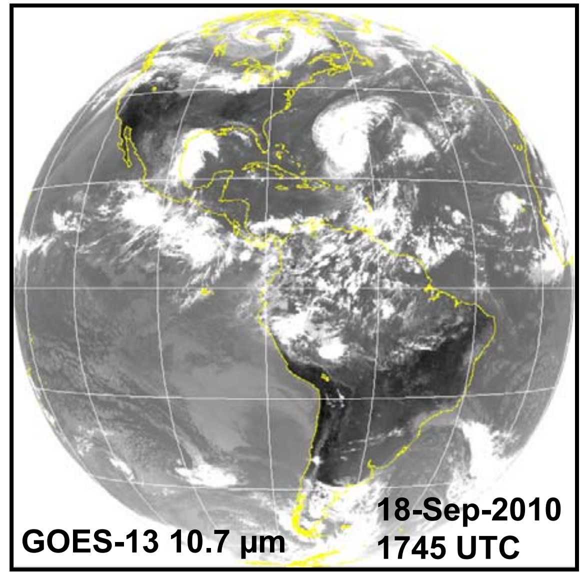
- Community coordination is a top priority
  - Geo-focused workshop is overdue
  - New products must be properly validated/assessed and inter-compared
    - Product data and documentation must be readily accessible
    - Must take advantage of array of reference data sets
    - Improve communication/coordination among groups interested/involved in field campaigns
    - Must engage user community and facilitate feedback

- Integration with existing and new polar orbiter products (MODIS, VIIRS, Sentinel-3) must be expanded and improved
  - Improve characterization of sensor view angle, and biome-related geostationary fire product dependencies

Backup Slides

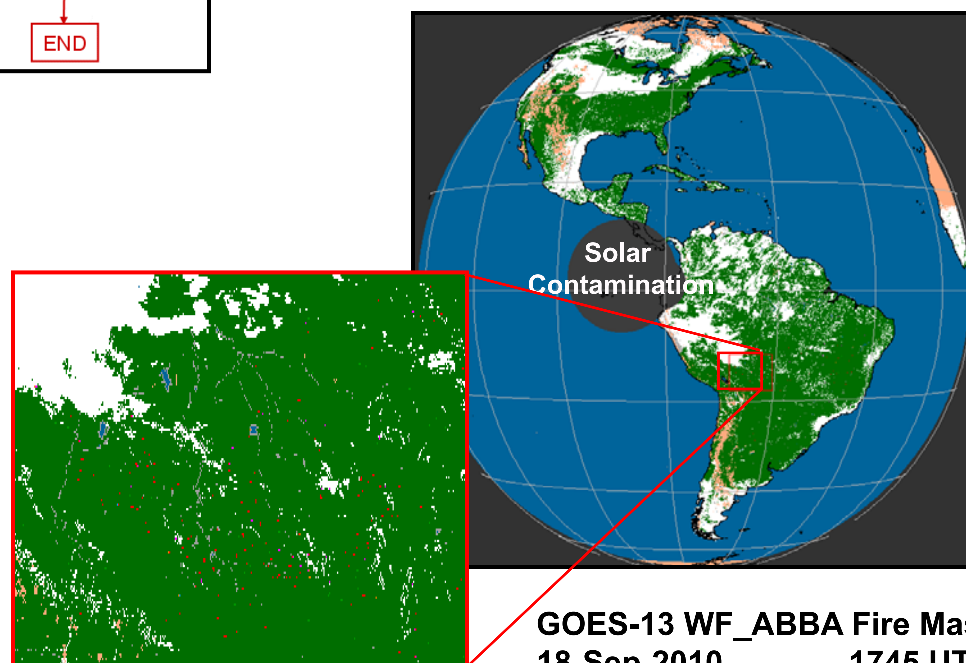
The Global WF_ABBA (Version 6.5.007)





GOES WF_ABBA Version 6.5.007

- Opaque cloud product indicating where fire detection is not possible.
- Fire Radiative Power and Dozier instantaneous estimates of fire size and temperature.
- Meta data on processing regions; opaque cloud coverage; block-out zones due to solar reflectance, clouds, extreme view angles, biome type, etc.
- Fire/meta data mask: view real-time imagery online at **http://wfabba.ssec.wisc.edu**



GOES-13 WF_ABBA Fire Mask
18-Sep-2010 1745 UTC

WFABBA and GOES-R

- GOES-R is the next generation GOES
- The Advanced Baseline Imager (ABI) provides 2 km resolution and a full disk image every 15 minutes, CONUS every 5
- The instrument’s specifications were designed with fires in mind, specifically for the “fire bands”; saturation for 4 µm band is 400 K
- Fire detection and characterization will be a “day 1” product
- Development has been underway since ~2004
- Development of proxy data has been a challenge
- ABI data will be remapped to a fixed grid
- Known as the “Fire Detection and Characterization Algorithm” (FDCA) in the GOES-R development world

Fire detection and characterization algorithm properties

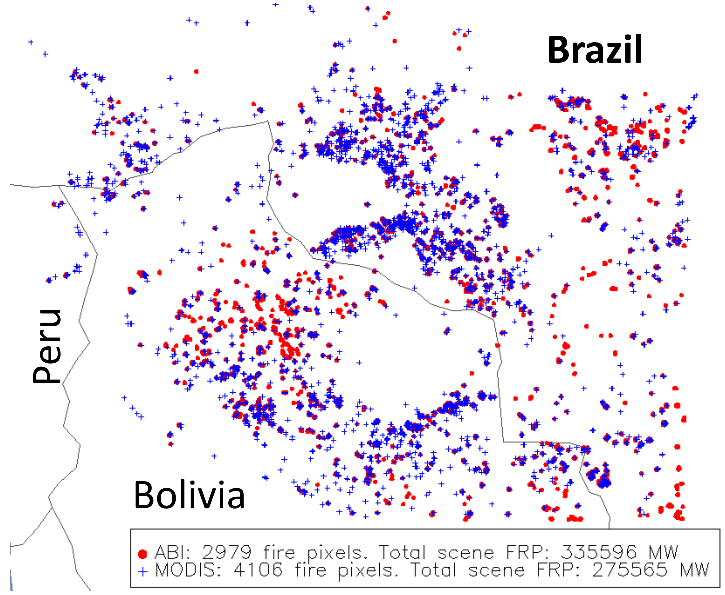
- Required refresh rate: 5 minute CONUS, 15 minute full disk
- Resolution: 2 km
- Coverage: CONUS, full disk (“mesoscale”, aka 1 minute/30 second frequency coverage *not* required)
- Product outputs (same as WFABBA):
  - Fire location
  - Fire instantaneous size, temperature, and radiative power
  - Metadata mask including information about opaque clouds, solar reflection block-out zones, unusable ecosystem types.

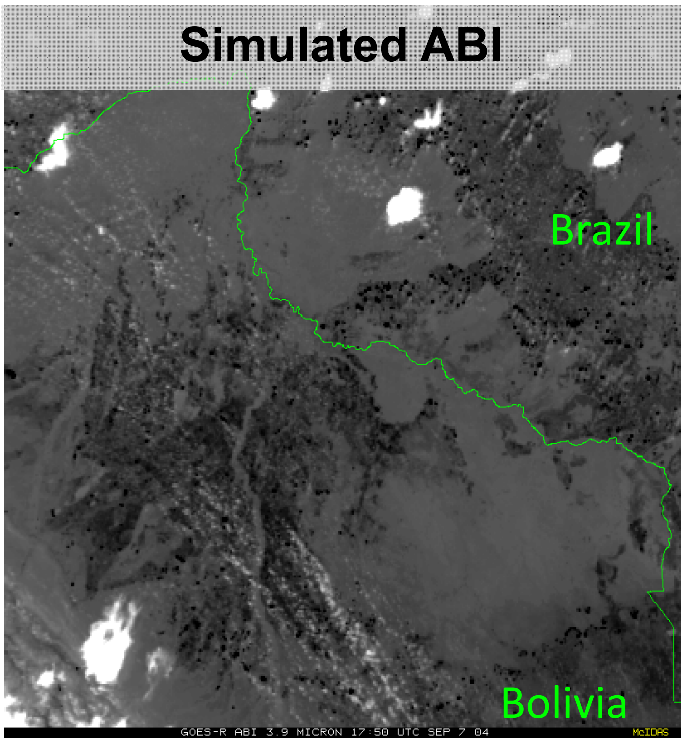
Proxy data

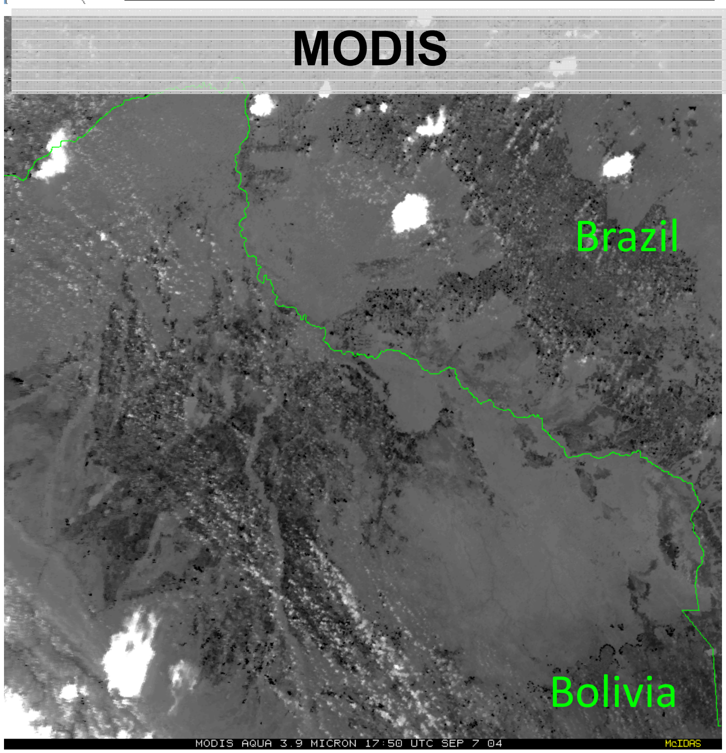
- Developing proxy data has been difficult
- Two approaches:
  - Remap higher resolution data (such as from MODIS) to ABI projection using estimated point spread functions
  - Create data in models (provided by proxy data team from CIRA)

Proxy Data

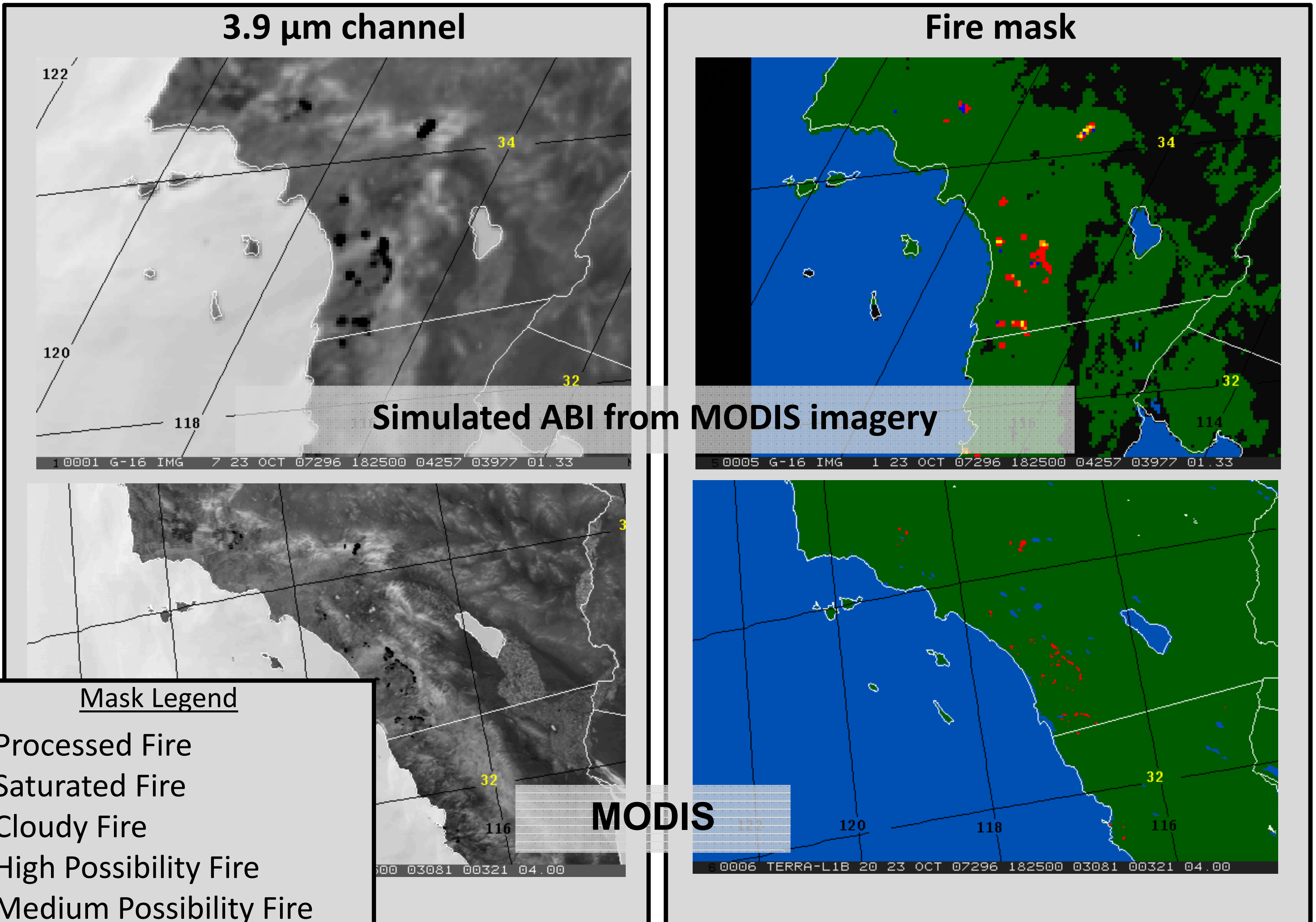
The ABI from MODIS simulated data for 7 September 2004 involved a remapping using a simulated point spread function. To the right, MODIS fires are blue and ABI simulated fires are red. The differences are in part attributable to that remapping, but also to differences in how the algorithms determine fires.







Proxy Data from MODIS



Mask Legend

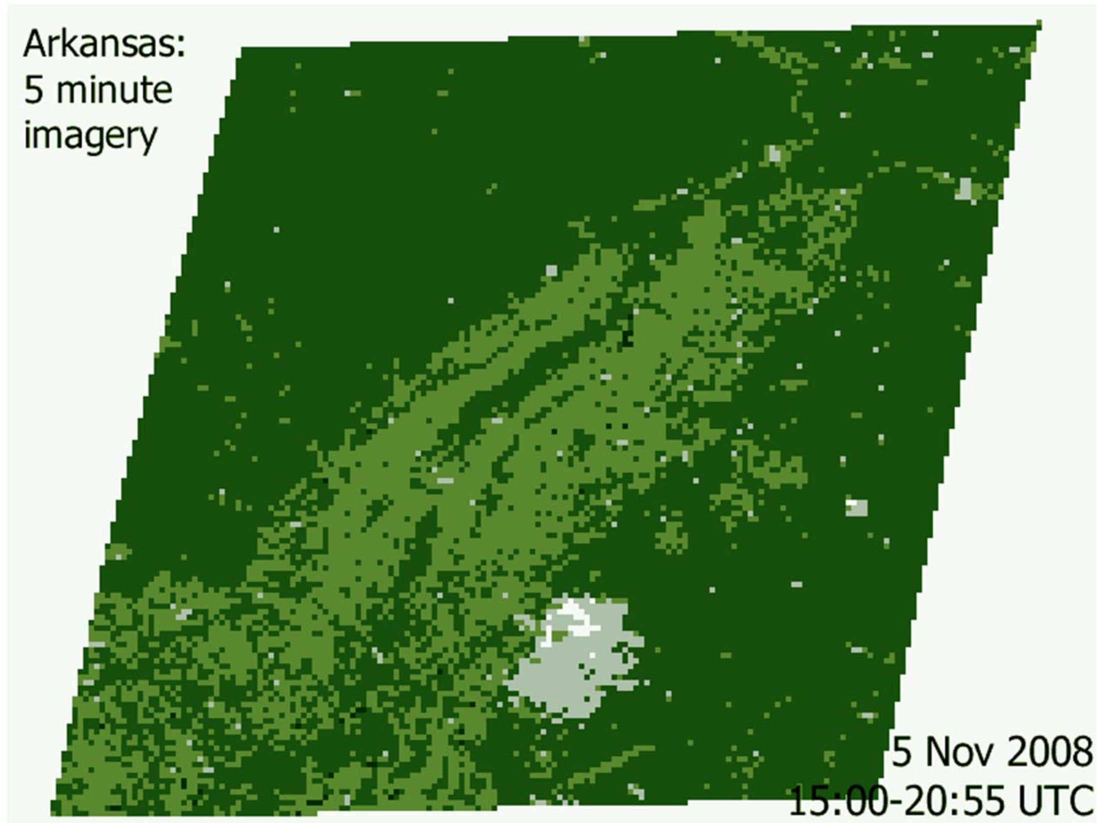
- Processed Fire
- Saturated Fire
- Cloudy Fire
- High Possibility Fire
- Medium Possibility Fire
- Biome Block-out Zone
- Processed Region

2007 Oct. Southern California fire outbreak simulation

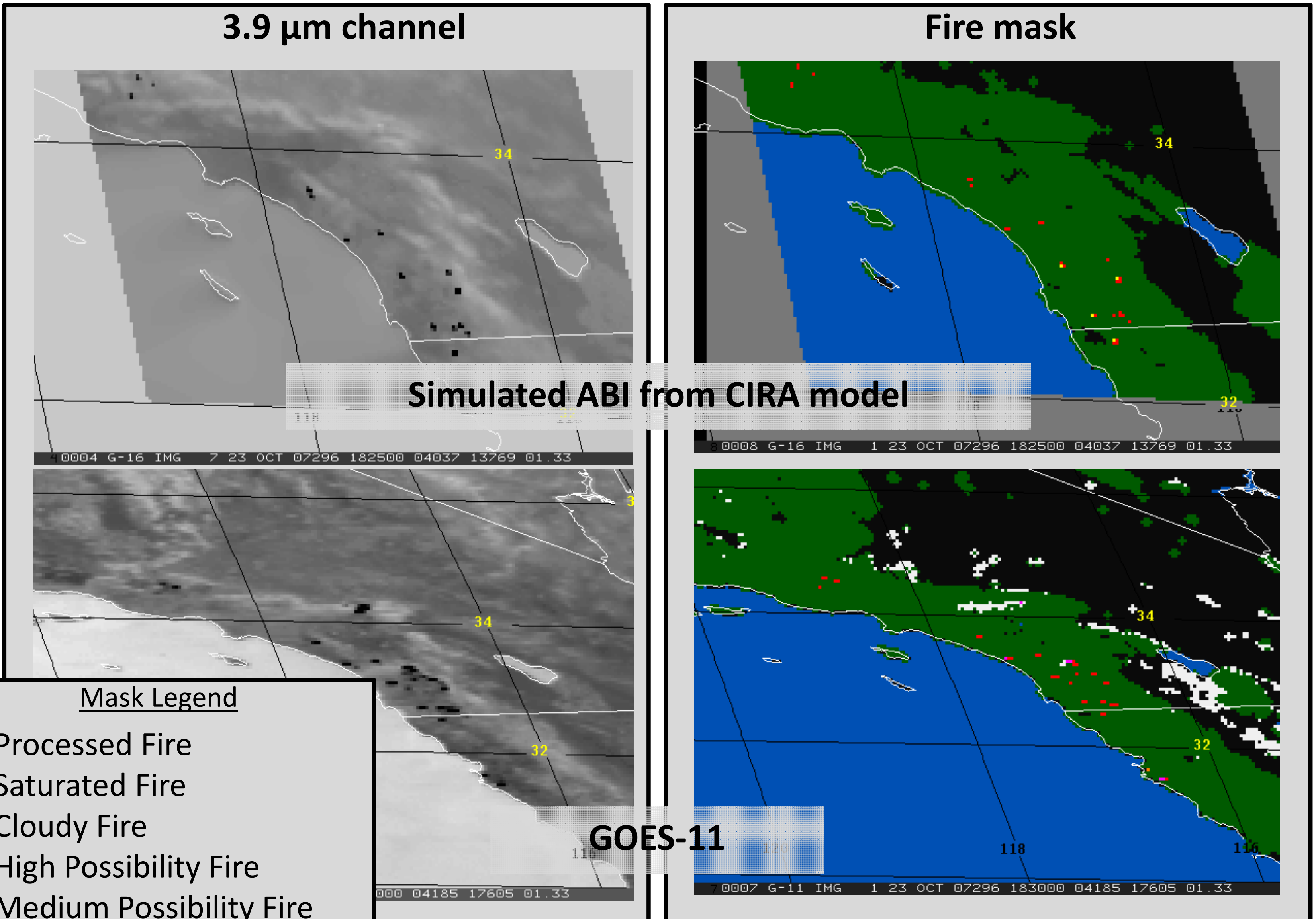
ABI proxy examples from models

Example case:

- Model-derived courtesy CIRA
- 5 minute, 2 km imagery
- Fires initialized from GOES-12 WFABBA fire product
- “Alphablended” imagery – ecosystem map used to represent surface, clouds appear in shades of white, fires are predominantly red (processed) in this case



Proxy Data from a model



Mask Legend

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

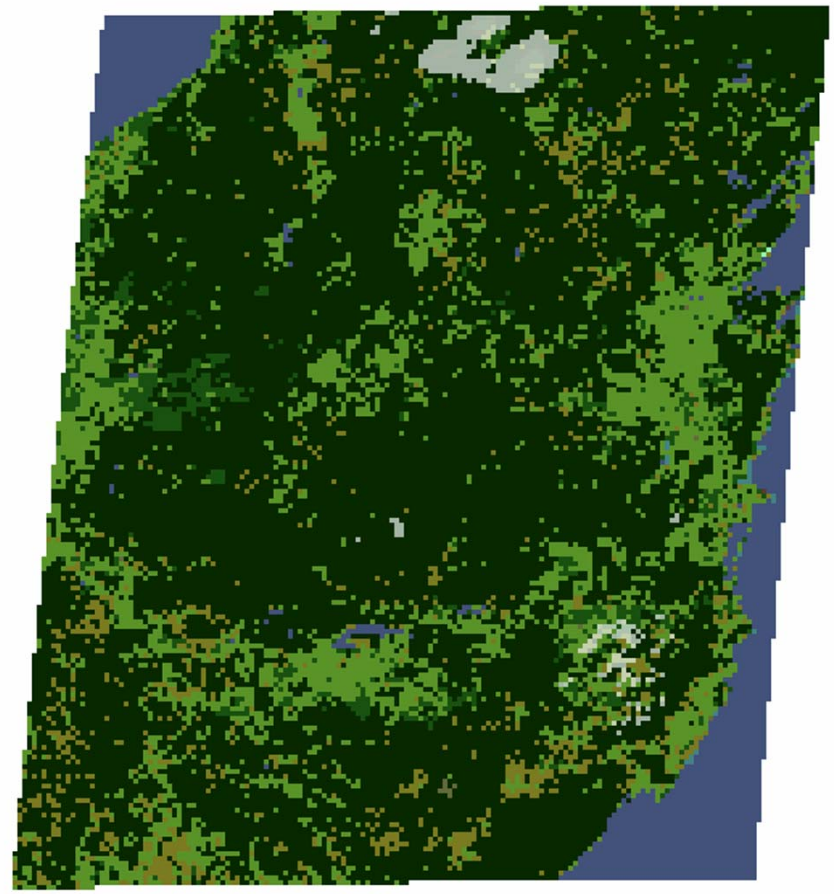
2007 Oct. Southern California fire outbreak simulation

ABI proxy examples from models

Example case:

- Model-derived courtesy CIRA
- 5 minute, 2 km imagery
- Fires initialized from GOES-12 WFABBA fire product
- Fires are red (processed) and yellow (saturated)
- Gray region is the solar blockout zone, consisting of two regions of high solar reflection

Central America: 5 minute imagery



24 Apr 2004, 15:00-20:55 UTC

Model data validation

CIRA Model Simulated Case Studies^									
	CIRA Truth			ABI WFABBA					
	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%

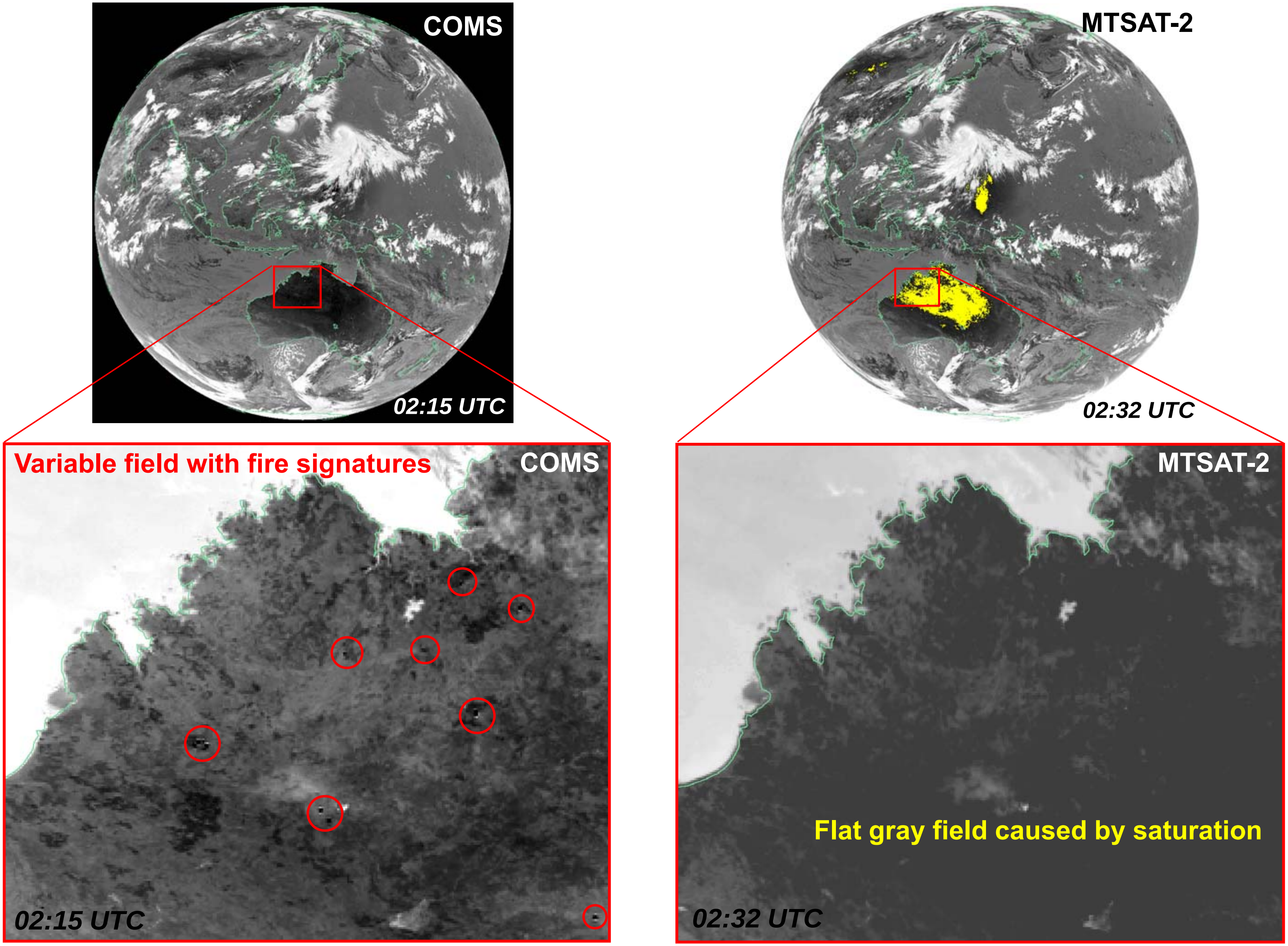
CFNOCLD	Constant Fire No Cloud	^ Limit to ~ 400K minimum fire temperature
VFNOCLD	Variable Fire No Cloud	
CFCLD	Constant Fire with Cloud	* In clear sky regions, eliminating block-out zones
VFCLD	Variable Fire with Cloud	

Example of Improved Geostationary Fire Monitoring in SE Asia With the Korean COMS

- COMS centrally located to observe fires in Australia, Eastern Asia and the Maritime Continent (SE Asia)
- High saturation temperature (>350K) in the short-wave IR window allows for unique and improved diurnal fire monitoring with COMS
- Initial observations indicate that pre-processing of COMS data results in less smearing of the fire signal along the scan line which may allow for improved geostationary fire detection and characterization in SE Asia and Australia.
- COMS high temporal monitoring over Indonesia (15 minutes) allows for monitoring short-lived agricultural fires.
- Initial adaptation of the WF_ABBA for COMS is nearly complete.

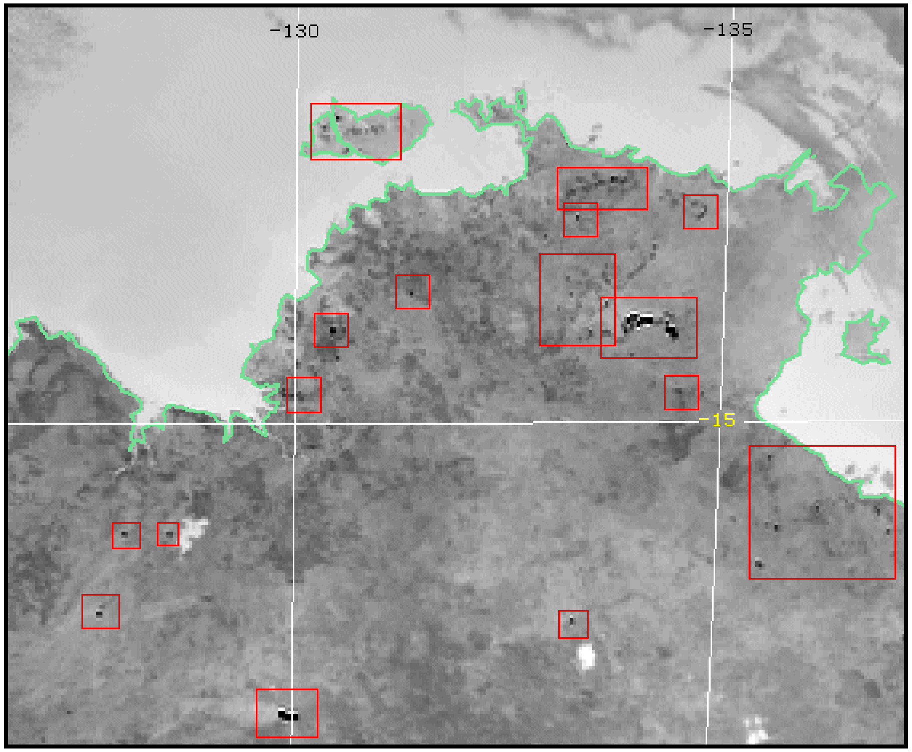
COMS and MTSAT-2: Example of short-wave IR band over Northern Australia

Date: 22 August 2012

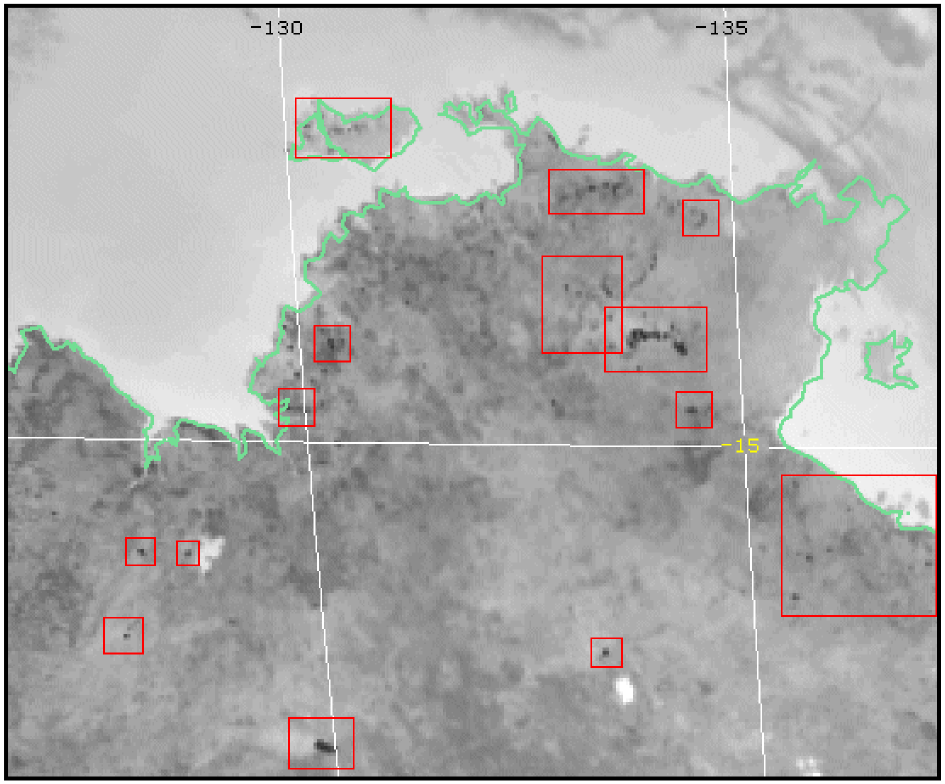


Observations of Fires in Northern Australia Using COMS and MTSAT-2

COMS: 4 micron: **Sub-satellite point: 0º, 128º E**
Date: 25-Jun-2012 **Time: 05:15 UTC**



MTSAT-2: 4 micron **Sub-satellite point: 0º, 145º E**
Date: 25-Jun-2012 **Time: 05:32 UTC**



The view angle for COMS and MTSAT-2 is similar for this region (slightly larger for MTSAT-2) in Northern Australia. Pre-processing of COMS data results in reduced smearing of the fire signal along the scan line allowing for improved fire detection and characterization.