Global Geostationary Network

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Some major US activities

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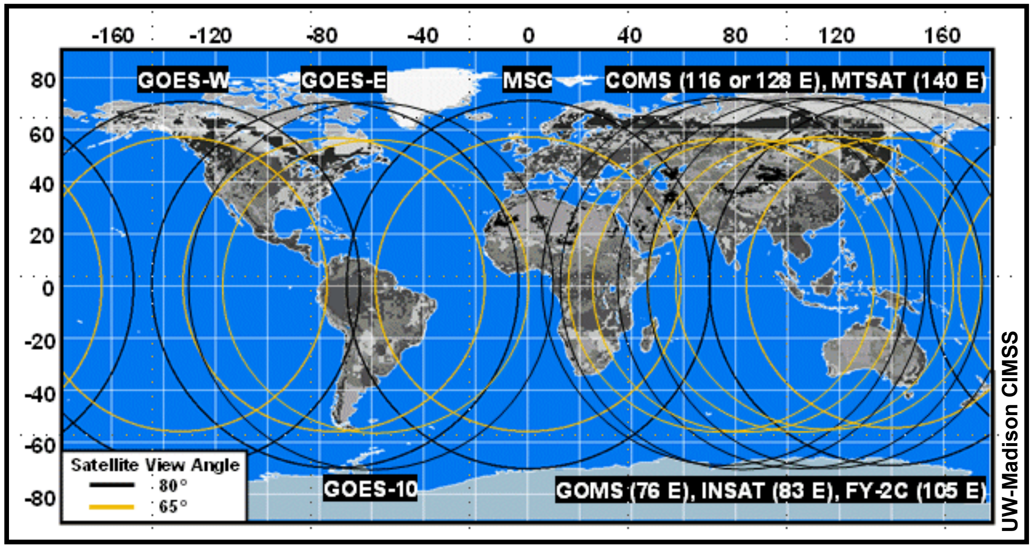
GOES: Wildfire Automated Biomass Burning Algorithm (WF_ABBA)

- Since GOES-8 became operational in 1995
- 4km resolution Imager on the GOES series
- Run operationally by NOAA/NESDIS since 2002
  - real-time applications, utilizing high temporal frequency
- >15 years of time series – beginning of a geostationary-based long-term data record
  - consistent with community consensus guidelines

New WF_ABBA product and GOES Reprocessing

- Version 6.5 of the GOES WF_ABBA code provides additional parameters and metadata:
  - opaque cloud product
  - FRP in addition to Dozier output of instantaneous estimates of fire size and temperature
  - block-out zones due to solar reflectance, clouds, extreme view angles, biome type, etc.
  - fire/meta data mask
  - revised ASCII fire product output: latitude, longitude, satellite view angle, pixel size, 4 and 11 micron brightness temperatures, fire size and temperature, FRP, biome type, fire confidence flag

- The entire archive of 30min GOES-East database for 1995 – 2010 has been retrieved from archive tape and reprocessed
  - 1995 and 1996 data are noisy



Global Geostationary Active Fire Monitoring Capabilities

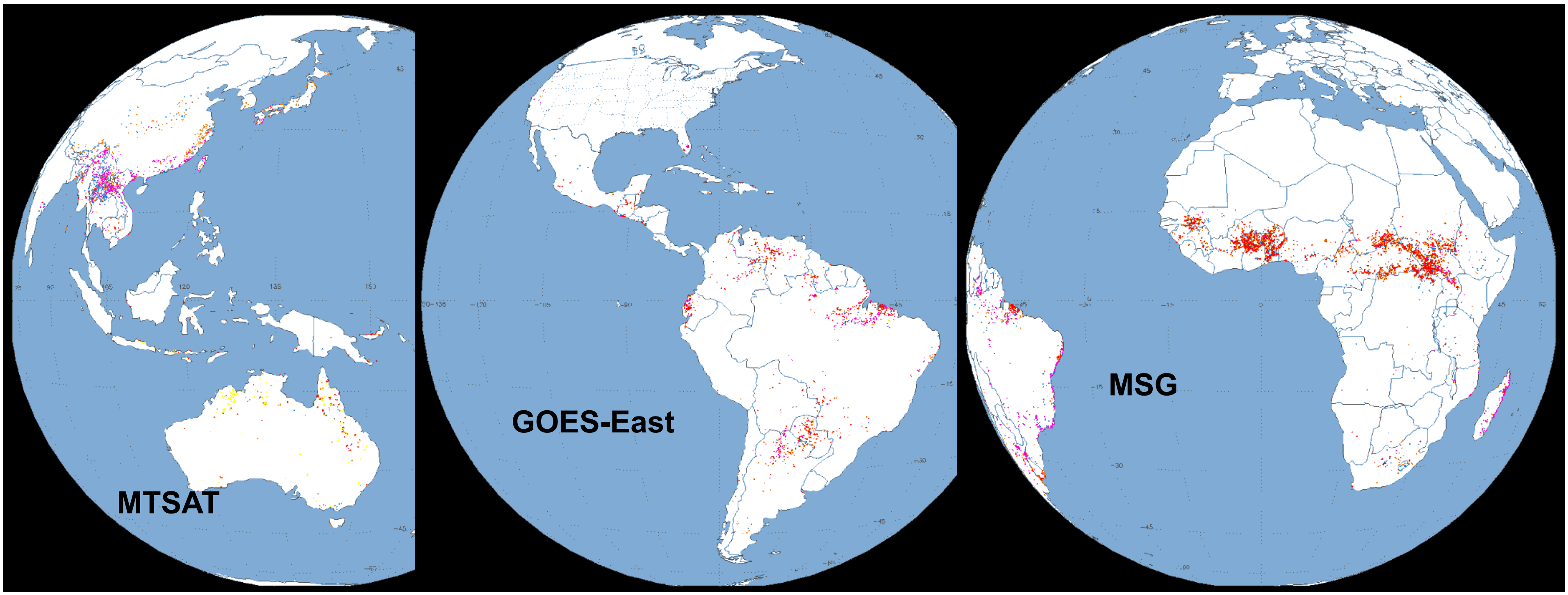
Satellite View Angle

- 80° (black line)
- 65° (yellow line)

Satellite	Active Fire Spectral Bands	Resolution IGFOV (km)	SSR (km)	Full Disk Coverage	3.9 µm Saturation Temperature (K)	Minimum Fire Size at Equator (at 750 K) (hectares)
GOES-E/-W Imager (75°W / 135°W)	1 visible 3.9 and 10.7 µm	1.0 4.0	0.57 2.3	3 hours (30 min NHE and SHE)	>335 K (G-11) >335 K (G-12)	0.15
GOES-10 Imager (60°W) (Ceased operation December 2009, replaced with GOES-12 in May 2010)	1 visible 3.9 and 10.7 µm	1.0 4.0	0.57 2.3	3 hours (Full Disk) 15 min (SA)	~322 K (G-10) >335 K (G-12)	0.15
Met-8/-9 SEVIRI (9.5 °E, 0°)	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	0.22
FY-2C/2D SVISSR (105 °E / 86.5°E)	1 visible, 3.75 and 10.8 µm	1.25 5.0		30 minutes	~330 K	
MTSAT-1R JAMI (140°E) MTSAT-2 (HRIT) (145°E)	1 visible 3.7 and 10.8 µm	1.0 4.0		1 hour	~320 K (MTSAT-1R) 330 K (MTSAT-2)	0.15
INSAT-3D (83 °E ?, TBD)	1 vis, 1.6 µm 3.9 and 10.7 µm	1.0 4.0	0.57 2.3	30 minutes	?	
GOMS Elektro-L N1 (76 °E) GOMS Elektro-L N2 (14.5 °E)	3 visible 1.6, 3.75 and 10.7 µm	1.0 km 4.0 km		30 minutes	?	
COMS (128 °E)	1 visible 3.9 and 10.7 µm	1.0 km 4.0 km		30 minutes	~350 K	

NOAA/NESDIS Operational Product

WF_ABBA v65 Fires: 2009336



Red represents characterized fires and blue is low possibility fires.

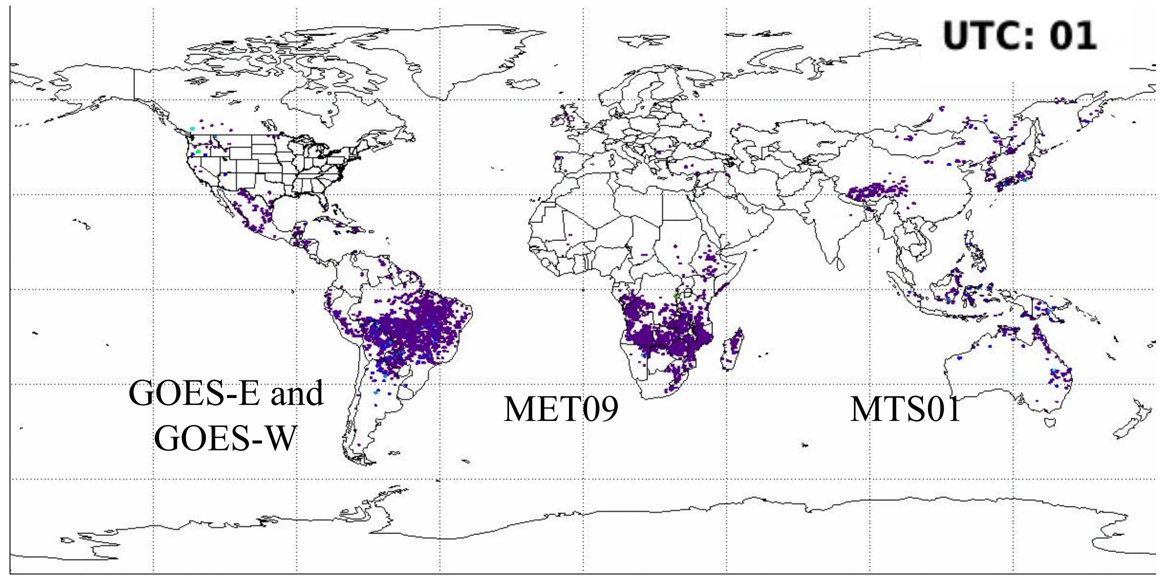
Schmidt et al.

NOAA/NESDIS operational Product

- ABBA version 6.5 – full fire mask, reprocessing done for GOES-East
- Real-time fire detections (7-day rotating archive) available in text file format at
  - ftp://140.90.213.161/FIRE/ABBA/
    - GOES 11 and 13
  - ftp://140.90.213.161/FIRE/forPo/
    - METEOSAT-9 and MTSAT-1 or MTSAT-2
- Archived data are available at
  - ftp://ftp.orbit.nesdis.noaa.gov/pub/smcd/xzhang/BIOMASS/Burn_mass/2010_gl
  - MTSAT – August 2009
  - MSG – September 2009
  - Please e-mail to Shobha.Kondragunta@noaa.gov for information
- Satellites to be considered to included in the future
  - INSAT-3D: funding secured once data are available after launch in 2012
  - NESDIS is working on bilateral / umbrella agreements for data access
    - COMS
    - ELECTRA
    - FY2D
- NOAA user request is needed - NCEP

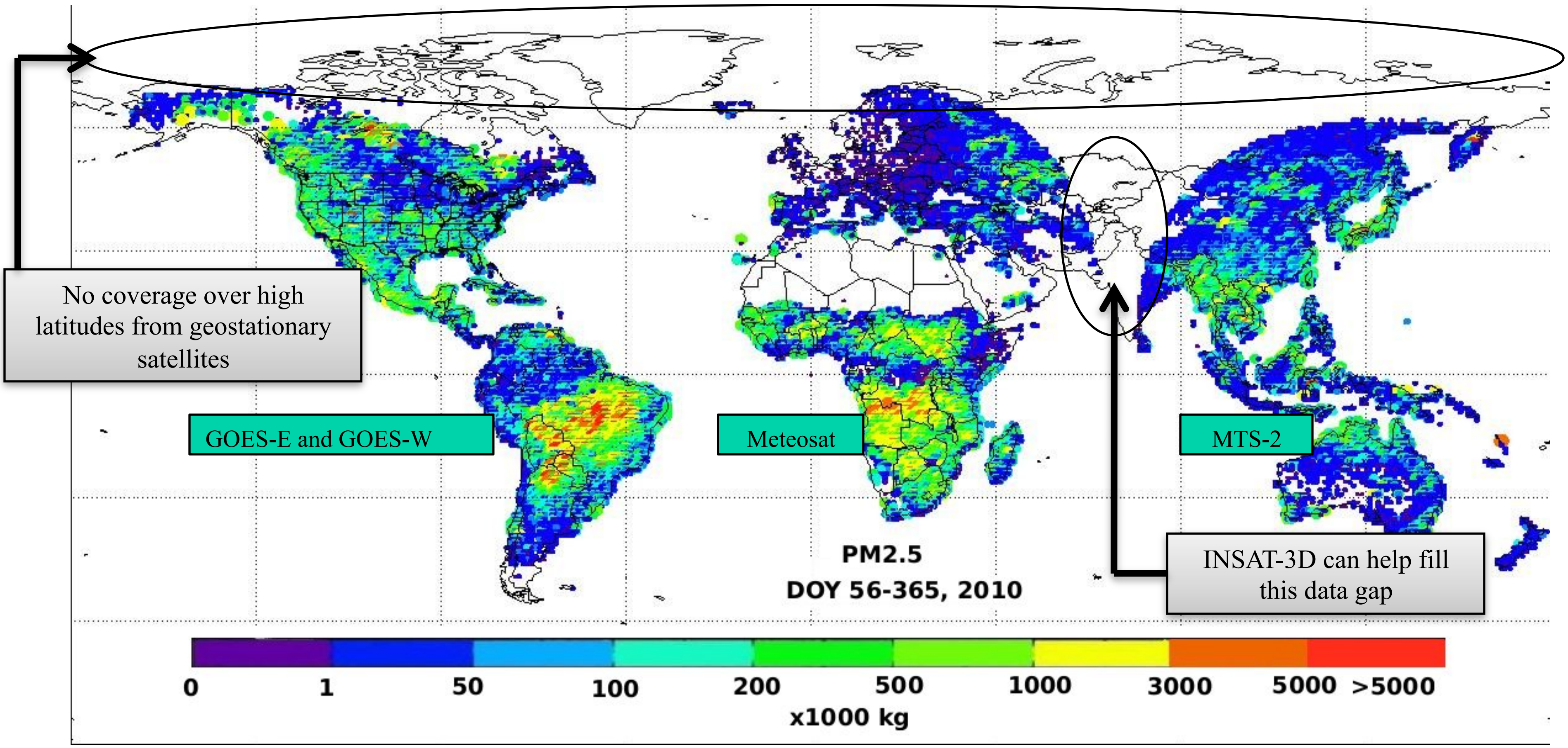
Global Biomass Burning Emissions Product from a Network of Geostationary Satellites (GBBEP-Geo)

- Derive aerosol and trace gas emissions from fires at high temporal (**hourly**) and spatial resolution for air quality monitoring and modeling applications:
  - Geostationary satellites for temporal coverage
  - Polar orbiting satellites for high latitude coverage



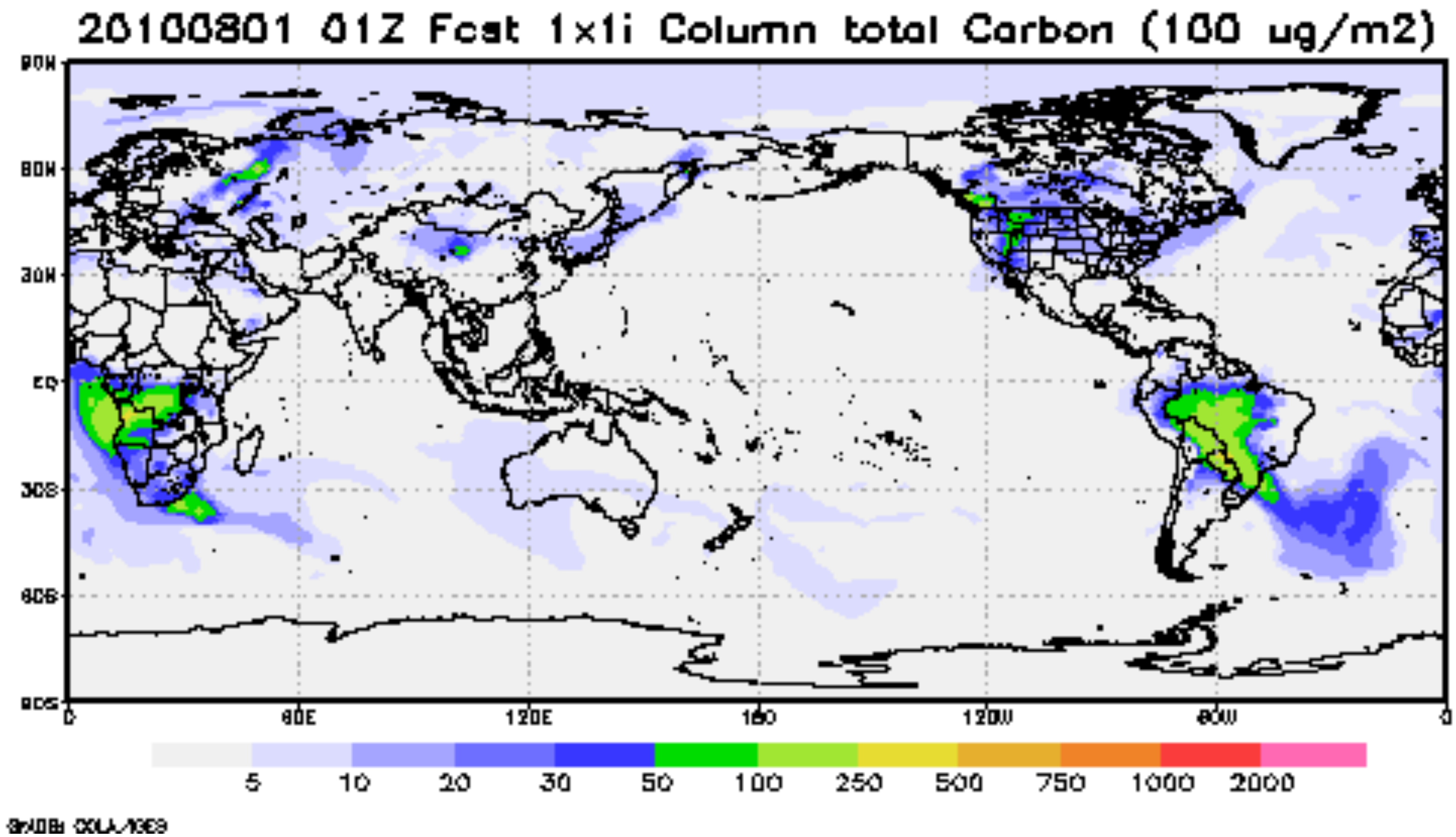
Satellite	Spatial Coverage	Spatial Resolution	Temporal Resolution
GOES-11 & GOES-13	North and South America	4 km	30 min
Meteosat-9	Africa and Europe	3 km	15 min
MTSAT-1	Asia and Australia	4 km	30 min
INSAT-3D*	Asia	4 km	30 min

Annual Global Biomass Burning Aerosol Emissions from Satellite-derived Fire Radiative Power (FRP)



Key:
PM2.5: Aerosol particulate matter for particles smaller than 2.5 um in size
DOY: Day of the Year
Kg: Kilograms

NCEP GFS-GOCART Model Simulation of Aerosols using GBBEP-Geo



GCOS 2010 Implementation Plan

- *"Some geostationary satellites allow active fire and FRP data generation at coarser spatial resolutions as rapidly as every 15 minutes to provide the best sampling of the fire diurnal cycle that may be required for certain applications (e.g. temporal integration of FRP data to estimate total carbon emissions; linking to atmospheric chemistry models/observations). Geostationary products also offer a near-real time capability. A global suite of fire products from the operational geostationary satellites needs to be developed."*
- Action T39: *Develop set of active fire and FRP products from the global suite of operational geostationary satellites*

GCOS 2010 IP Satellite Supplement

- *"Some geostationary satellites are capable of active fire and FRP observation at coarser spatial resolutions (≥3km) at temporal frequencies of between 15 and 30 minutes. Geostationary satellites provide the best sampling of the diurnal fire cycle required for certain applications (e.g., for temporal integration of FRP data to estimate total carbon emissions."*

Variable/ Parameter	Horizontal Resolution	Vertical Resolution	Temporal Resolution	Accuracy	Stability
Active Fire Maps	1 km	N/A	6h (all latitudes)	5% error of commission 30% error of omission compared to 30 m spatial resolution detections (based on per-fire comparisons)	N/A

Variable/ Parameter	Horizontal Resolution	Vertical Resolution	Temporal Resolution	Accuracy	Stability
FRP (polar orbiting platform)	1km	N/A	Sub-daily (e.g., 6h at all latitudes)	25% down to FRP of 10 MW	10%
FRP (Geostationary platform)	1 km	N/A	1 hour	25% down to FRP of 50 MW	10%

CEOS Response to GCOS IP

- Reinforces the needs called out by the GCOS Satellite Supplement
  - Provides more detail on the deliverables, coordination, activities and who will lead the effort.
  - Calls out agency activities
  - Calls out international coordination
- Can include additional activities not called out by GCOS but may be considered important by CEOS.
- Provides to CEOS, what can be achieved with current funding and additional funding

Approach for CEOS Response (1/2)

- 47 Actions to respond to.
- Identified domain leads (atmosphere, ocean, terrestrial)
  - Goldberg – Atmosphere
  - Dowell – Ocean
  - Dwyer – Terrestrial
- Coordinate with CEOS working groups, CEOS virtual constellations, and Climate related external groups (e.g. SCOPE-CM, GSICS, WCRP, CGMS), and experts to develop plans responding to the GCOS IP10 actions via templates
- We expect that the new CEOS response will help agencies to plan their Climate Data programs and vice versa

Approach for CEOS Response (2/2)

- Identify Subject Matter Experts(~3) for each GCOS-IP action to develop response via common template
- Identify existing coordination groups (eg. GOFC-GOLD for fire) for vetting the response
- Use input from the GCOS satellite supplement
- WGC to review and provide input to templates
  - Key activities should intersect agency climate programs
- Use templates to develop the report
- Report will be reviewed by Working Group on Climate
- Finalize report by September 2012

Template: The CEOS Response to the GCOS Implementation Plan & Satellite Supplement (Describing 2011-2015 CEOS Activities)

Throughout the completion of this template, please bear in mind the GCOS IP/SS content associated with this action in its entirety. These templates will compile to form a comprehensive, coordinated CEOS response to addressing the satellite Earth observation needs discussed thoroughly in the GCOS Implementation Plan and Satellite Supplement (IP/SS).

GCOS Action T39 [IP-04 NONE]

Action: Develop set of active fire and FRP products from the global suite of operational geostationary satellites.
Who: Through operators of geostationary systems, via CGMS, GSICS, and GOFC-GOLD
Time-Frame: Continuous
Performance Indicator: Availability of products
Annual Cost Implications: 1-10M US$ (Mainly by Annex-I Parties)

CEOS Agencies:

- Leads: NOAA
- Contributors: EUMETSAT

Team:

- Leads: Ivan Csiszar (NOAA NESDIS), Hans-Joachim Lutz (EUMETSAT), Prins (UW-Madison CIMSS – consultant)
- Members: Christopher Schmidt (UW-Madison, CIMSS), Martin Wooster (Kings College, London), Wilfrid Schroeder (UMd/ESSIC)

International Coordination Bodies:

- GOFC-GOLD Fire Implementation Team
- Coordination Group for Meteorological Satellites (CGMS)
- Global Space-based Inter-Satellite Calibration System (GSICS)
- CEOS WGCV LPV

Relevant existing CEOS actions:

- No currently active relevant CEOS actions

CEOS Deliverable(s) as related to this GCOS Action –

Please list all current and planned CEOS activities, outcomes, and deliverables that address the needs identified in the GCOS IP/SS for this action. Describe each one, including a brief recap of the significance of the deliverables' role in climate observations (it is not necessary to restate the content of the GCOS IP/SS). Elaborate or add any relevant content as necessary. Please also discuss the needs that CEOS is not currently planning to address, but that CEOS agrees are important. Include satellites/instruments, products/programs, coordination, etc., making sure to fully address the content of GCOS IP/SS sections such as "Requirements for satellite instruments and satellite datasets" and "Immediate action, partnerships, and international coordination", etc.

- Specific Deliverable #1:

The deliverable is standardized long-term active fire and Fire Radiative Power (FRP, Watts or J/s) products from the global suite of operational geostationary satellites.

The active fire product provides information on the location of pixels containing fire activity and associated metadata. Detailed metadata is crucial for the proper interpretation of active fire products especially given the significant differences in the fire monitoring capabilities of the global geostationary satellite systems. Metadata should include specifics such as: an indication of the fire pixel confidence level; satellite and processing coverage regions; algorithm block-out zones associated with viewing geometry, solar reflection contamination, and specific biomes; data and algorithm anomalies and limitations; instrument saturation; an opaque cloud mask; atmospheric attenuation information; and geo-location characterization uncertainties.

Fire Radiative Power (Watts or J/s) is the time derivative of the fire radiative energy, which is proportional to the biomass consumed by the fire. Multiple FRP observations can in principle provide estimates of total fire emissions (CO_2, PM 2.5, etc.) through estimating time-integrated Fire Radiated Energy (FRE).

Fire is a global phenomenon with large variability in both time and space. It is an important ecosystem disturbance factor and contributes to atmospheric emissions on multiple time scales. Active fires have a strong diurnal component and geostationary monitoring is essential for providing a more complete view of regional, diurnal, seasonal, and interannual variability in fire activity. Detection of active fires is also required by some burned area product algorithms. Active fire information can serve as part of the validation process for burned area products and diurnal information on emissions is vital for modeling applications. In recent years modelers have shown interest in utilizing fire radiative energy/power to characterize emissions. One may assert that the total FRE of a fire is directly related to mass consumed by the heat of combustion, which can then be related to PM 2.5, CO_2 and other emissions.

Due to the disparity and inadequacy in regional and national fire reporting protocols, satellite remote sensing represents the most suitable and cost effective method for consistent, long-term regional and global scale monitoring. Over the past 10 years the use of geostationary satellites for both diurnal fire detection and characterization has grown appreciably with applications in hazards monitoring, fire weather forecasting, climate change research, emissions monitoring, aerosol and trace gas transport modeling, air quality, and land-use and land-cover change detection. Current (GOES-E/-W/-South America, Met-8/-9, MTSAT-1R/-2, FY-2C/2D) and future (Indian INSAT-3D, Russian GOMS Elektro L MSU-GS, Korean COMS) operational geostationary platforms will enable nearly global geostationary fire monitoring with significant improvements in capabilities over the next 5-7 years (e.g. GOES-R, MTG).

The development of the Global Geostationary Fire Monitoring Network is coordinated through the Global Observation of Forest and Landcover Dynamics (GOFC-GOLD) Fire Mapping and Monitoring Implementation Team (IT). The GOFC-GOLD Fire IT is organizing a meeting on October 18-19 in Stresa, Italy, where the status of the network will be discussed. A separate workshop hosted by NOAA/NESDIS is planned for Spring 2012.

- Specific Deliverable #2
- Specific Deliverable #3

Accuracy –

Discuss how they differ from that requested in the GCOS IP/SS, why, how to get closer, and any planned/potential CEOS activities addressing the discrepancies.

- For deliverable 1

The accuracy of current and future global geostationary active fire and FRP products is dependent on a variety of factors including spatial resolution, viewing conditions (e.g. viewing angle, cloud coverage, solar contamination, etc.), calibration, noise levels and saturation levels in the 3.9 and 11 μm bands at higher temperatures, and multi-spectral data pre-processing chains.

Although active fire products and FRP from the current global geostationary sensors are limited by the relatively coarse resolution (4-5 km at sub-satellites point) in the 3.9 and 11 μm bands, this will improve over the next five years. The requirements for next generation geostationary sensors, such as the GOES-R Advanced Baseline Imager (2 km resolution) include a detection rate of 50% for fires emitting more than 75 MW within a fire temperature range of 500 to 1200 K and a mapping accuracy of 1 km (at sub-satellite point). Estimates of sub-pixel fire radiative power are required to be within 50% of truth.

Further detailed analysis is needed to determine omission and commission errors and the accuracy of the FRP retrievals against the requirements listed in the Satellite Supplement. This work needs to be done in coordination with CEOS WGCV LPV and GOFC-GOLD Fire. The 5% error of commission is potentially achievable on a global basis after algorithm improvements to eliminate false alarms over previously burned areas whose size is comparable to the satellite pixel. The 30% error of omission (on a per fire basis, compared to 30m spatial resolution detections) is unlikely to be achieved to the pixel size and the large number of small fires below the corresponding detection limit.

- For deliverable 2
- For deliverable 3

Stability –

List the current, planned, and future stability capabilities, if applicable, specific to each of the deliverables mentioned above. Discuss how they differ from that requested in the GCOS IP/SS, why, how to get closer, and any planned/potential CEOS activities addressing the discrepancies.

- For deliverable 1

Sensors used for fire detection and characterization need to be consistently and systematically calibrated at the high end of the dynamic range. Sensor saturation levels need to be well known and stable over time and sensor behavior at and beyond saturation needs to be properly characterized; sensor artifacts need to be minimized or eliminated. The monitoring of sensor behavior needs to be coordinated by GSICS.

- For deliverable 2
- For deliverable 3

Horizontal resolution –

above. Discuss how they differ from that requested in the GCOS IP/SS, why, how to get closer, any planned/potential CEOS activities addressing the discrepancies.

- For deliverable 1

Horizontal resolutions of next generation global geostationary fire products and FRP are on the order of 2 km (at sub-satellite point). Therefore neither the active fire detection nor the FRP product meets or is expected to meet the 1km horizontal resolution requirement listed in the GCOS Satellite Supplement.

- For deliverable 2
- For deliverable 3

Vertical resolution –

List vertical resolution capabilities (current, planned, future), if applicable, specific to each of the deliverables mentioned above. Discuss how they differ from that requested in the GCOS IP/SS, why, how to get closer, any planned/potential CEOS activities addressing the discrepancies.

- For deliverable 1

This is not applicable, since global geostationary active fire and FRP are land surface products.

- For deliverable 2
- For deliverable 3

Temporal resolution –

List temporal resolution capabilities (current, planned, future), if applicable, specific to each of the deliverables mentioned above. Discuss how they differ from that requested in the GCOS IP/SS, why, how to get closer, any planned/potential CEOS activities addressing the discrepancies.

- For deliverable 1

For temporal resolution, the requirement is 6 hrs for active fire detection, which will be exceeded by the 15-30min frequency of observations. For FRP, a separate 1-hr requirement is listed, which is likely to be met even if ~50% of the observations are obscured by cloud cover.

Data & Science Requirements –

Discuss and respond to the data/science requirements mentioned in the GCOS IP/SS as related to this GCOS action and the relevant CEOS deliverables. What does CEOS need in terms of data and science help, in order to accomplish these deliverables? Why are they needed and who can help?

- For deliverable 1

A global geostationary fire monitoring network is technically feasible but must be supported by operational agencies to sustain the activity and produce standardized long-term data records and derived active fire products and FRP of known accuracy. This requires commitment from operational agencies for ongoing support of global geostationary fire monitoring through appropriate sensor design and application and subsequent ongoing characterization and consistent validation programs. A major constraint with some of the current operational geostationary sensors is low saturation in the 3.9 μm fire channel which severely hinders the ability to detect and characterize fires during peak solar heating when many anthropogenic fires occur.

The development community, implementation teams, and operational fire product producers require the following information/data:

- near real-time access (< 5 minutes) to well calibrated and navigated full spatial resolution

- detailed information on data pre-processing chains
- indication of saturation of pre-aggregated detector samples in both the 3.9 and 11 µm bands
- calibration of the 3.9 and 11 µm bands at higher temperatures
- noise characterization at higher temperatures
- band-to-band co-registration information
- information regarding point spread functions.

Specifically, there is a need for minimum and ideally no smoothing or filtering of information within the 3.9 µm band, and for detailed characterization of its behavior beyond 300K and up to the saturation point. It is imperative that agencies provide detailed information on how observations in this channel are pre-processed and converted to level 1 radiance imagery from which fire products will be derived.

- New datasets potentially improving product over next 5 years

The recent launch of the Korean COMS and Russian GOMS Electro-L MSU-GS platforms and the expected launch of INSAT-3D in 2011 will enable nearly global fire monitoring with unprecedented coverage of fire in Eastern Europe and Asia. These systems are somewhat similar to the current GOES and Meteosat series in terms of fire monitoring capabilities and limitations. We expect to see significant improvements with the next generation GOES-R Advanced Baseline Imager (ABI, launch in 2015) and Meteosat Third Generation (MTG, launch in 2017). Both of these missions have a fire monitoring requirement and will include improved spatial resolution (2 km) and 400-450K saturation in the 3.9 µm band with enhanced diurnal temporal monitoring.

In order to ensure that future geostationary sensors provide continuity from current products and are capable of enhanced active fire detection and characterization, the fire monitoring community should be involved in evaluating specifications for next generation operational geostationary satellites and provide feedback to operational agencies on issues relating to data access and pre-processing chains, saturation in the middle and long-wave IR window bands, characterization of sensor behavior at high temperatures, navigation, band-to-band co-registration, PSF implications, and cal/val.

- Key datasets for validation

The international fire community has been working with the CEOS WGCV LPV in an effort to standardize the validation of satellite fire products, specifically identifying the three-stage CEOS Hierarchy of Validation as a good approach. Although various fire databases exist on the regional and national level, they must be used cautiously due to inconsistencies in reporting protocols and other discrepancies. The CEOS/WGCV/LPV subgroup is working to establish a network of sites for long term validation of fire products. These sites must meet specific selection criteria to ensure consistency, completeness, and accuracy in reporting.

To date geostationary active fire and FRP product validation studies have been limited in scope due to the lack of adequate ground truth and limited funding and resources for aircraft validation studies in various biomes and under different viewing conditions. Routine operational cal/val 30 m Landsat7 ETM+, Terra ASTER, Landsat Data Continuity Mission OLI) and should be automated (to the extent possible). Ideally, high spatial resolution instruments capable of detecting the radiative power of a fire without the influence of sensor saturation should be employed. This could involve over-flights of fires by airborne systems, for example, NASA Ames (UAV), data from USFS over-flights, and dedicated over-flights by fire-dedicated airborne systems (e.g. AMS, FIREMAPPER). This effort should be done in cooperation with the CEOS WGCV LPV.

- **Science Requirements**
  - Calibration/Intercalibration

For sub-pixel fire characterization fire algorithms require well-calibrated data from the cold (for background and weak fire pixel signal assessment) to very hot brightness temperatures (for strong fire pixel signal assessment). If calibration and noise (NEdT) on the hot end for the 3.9 and 11 µm bands are not well characterized, FRP will be suspect on the hot end. Current and planned missions typically offer adequate calibration and noise information at lower temperatures (<330K) but do not adequately address calibration and NEdT on the hot end (>375K). The fidelity of global geostationary fire products can only be maintained with ongoing calibration of the 3.9 and 11 µm bands at higher temperatures and characterization of noise levels at higher temperatures.

Characterization of sensor behavior beyond saturation is also needed. Experience with current and previous satellite sensors has demonstrated spurious sensor output when the incoming radiance exceeds the sensors' saturation level. The spurious behavior is a consequence of the folding of the output count value, resulting in either a physically interpretable (but incorrect) value below the saturation value, or in a near-zero value. In some cases saturated pixels can result in a "stuck bit" effect that results in a false elongation of a fire signature along a scan line. This was observed on the GOES-8 instrument and has also been documented in Met-8/-9 SEVIRI imagery in Europe and South America.

- Intercomparisons

The global suite of operational geostationary sensors are similar yet present diverse and unique fire monitoring capabilities and limitations. In order to develop consistent merged or fused global geostationary active fire and FRP products, it is necessary to characterize and understand the differences between the sensors and their respective products. This will require intercomparison studies with each other, higher resolution instruments (MODIS, ASTER, Landsat, airborne systems), and ground truth.

- Additional Sensor and Data Issues

Additional work must be done to address the impact of pre-processing protocols on fire detection and characterization. This includes smoothing that occurs as a result of georectification procedures and the methodology used to aggregate and flag saturated sub-pixel detectors. Other issues that must be investigated include sensor specific band-to-band co-registration and PSF implications for active fire detection and characterization of FRP.

- For deliverable 2
- For deliverable 3

Planned activities/time frames to meet deliverables (2011 – 2015) –

Include resources/websites where a reader might find more information on these activities, if possible.

- For deliverable 1
- NOAA NESDIS operations currently provides Wildfire Automated Biomass Burning Algorithm (WF_ABBA) active fire locations and FRP in various formats for GOES-E/-W, Meteosat-9, and MTSAT-1. WF_ABBA fire masks and metadata have not yet been released as part of the NESDIS operational fire product, although they are available from UW-Madison CIMSS. The time frame for operational release is currently unknown.
- EUMETSAT is implementing a global geostationary fire product.
- Provided the data are accessible in near real-time and well-calibrated/navigated, the WF_ABBA will be adapted to COMS, GOMS Elektro L MSU-GS over the next 2 years. Funding is being sought for the operational implementation of the extended product by NOAA/NESDIS.
- UW-Madison CIMSS has delivered the initial GOES-R ABI fire algorithm and will continue to evaluate and update the algorithm
- GOFC-GOLD Fire is planning a thematic workshop in Spring 2012, hosted by NOAA/NESDIS.

- For deliverable 2
- For deliverable 3

Are the above activities sufficient to accomplish the GCOS action? If not, what is missing? What additional activities in support of this GCOS action can be accomplished with additional funding? Discuss.

- For deliverable 1
- Additional funding is needed to complete the adaptation of the WF_ABBA to Korean COMS and INSAT-3D and to adapt to GOMS Elektro L MSU-GS. Funding is also needed to transfer to NESDIS operations.
- Funding is needed to develop and implement routine cal/val activities. This will require timely access to ground truth data and higher resolution satellite data (Landsat, ASTER, etc.).
- In order to create consistent fused global geostationary active fire and FRP products, funding is needed to perform intercomparison studies. Funding is needed to develop and implement consistent fused global geostationary fire products.
- For deliverable 2
- For deliverable 3

Supporting Material from GCOS-IP: ECV – Fire Disturbance

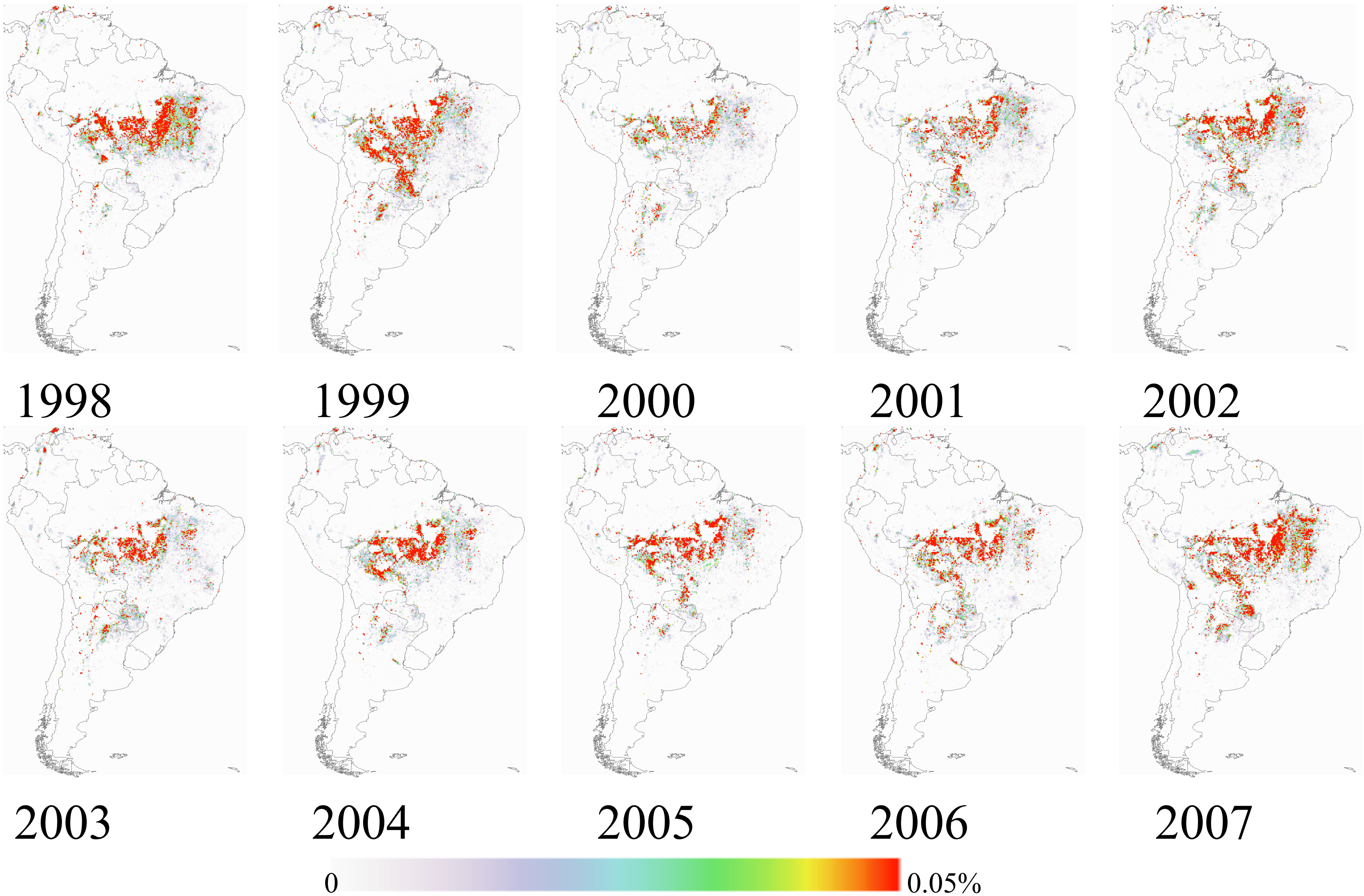
Fire disturbance on Earth is characterised by large spatial and temporal variations on multiple time scales (diurnally, seasonally and inter-annually). By consuming vegetation and emitting aerosols and trace gases, fires have a large influence on the storage and flux of carbon in the biosphere and atmosphere, can cause long-term changes in land cover, and affect land-atmosphere fluxes of energy and water.

In general, fires are expected to become more severe under a warmer climate, depending on changes in precipitation. At the same time, some ecosystems, particularly in the Tropics and boreal zones, are becoming subject to increasing fire due to growing population, economic, and land-use pressures. The amount of burned biomass in ecosystems can vary by an order of magnitude, especially between wet and dry years, and these strong year-to-year variations may influence the interannual change seen in the global atmospheric CO2 growth rate. Informed policy- and decision-making clearly requires timely and accurate quantification of fire activity and its impacts nationally, regionally, and globally. Burned area, active fire detection, and Fire Radiative Power datasets together form the Fire Disturbance ECV, and the separate products can be combined to generate improved information, e.g., mapping of fire affected areas to the fullest extent, including the timing of burning of each affected grid-cell. Estimates of total dry matter fuel consumption (and thus carbon emission) can be calculated from these products. By applying species-specific emissions factors, emission totals for the various trace gases and aerosols can then be calculated.

Fires are typically patchy and heterogeneous. Measurements of global burnt area are therefore required at a spatial resolution of 250 m (minimum resolution of 500 m) from optical remote sensing, ideally on a weekly basis, and, if possible with day of burn information. Detection of actively burning fires and measurement of Fire Radiative Power (FRP) is often adequately done at lower spatial resolutions (1 km), but the sensor must have mid- and thermal-infrared spectral channels with a wide dynamic range to avoid sensor saturation. Active fires should be detected from Low Earth Orbit satellites multiple times per day, with one of the measurements being located near the peak of the daily fire cycle, and their FRP should be calculated. Some geostationary satellites allow active fire and FRP data generation at coarser spatial resolutions as rapidly as every 15 minutes to provide the best sampling of the fire diurnal cycle that may be required for certain applications (e.g., for temporal integration of FRP data to estimate total carbon emissions; and to link to atmospheric chemistry models/observations).

The various space-based products require validation and inter-comparison. Validation of medium- and coarse-resolution fire products involves field observations and the use of high-resolution imagery, in collaboration with local fire management organizations and the research community. The CEOS WGCV, working with the GOFC-GOLD, is establishing internationally-agreed validation protocols that should be applied to all datasets before their release. A fully stratified sampling scheme (designated CEOS level 3) that adequately represents the nature of fire activity over the globe is needed. The validation protocol for burned area products, based on multi-temporal higher resolution reference imagery, is mature and has been documented. The active fire validation protocol requires simultaneous high resolution airborne or satellite imagery, which is not readily available except for the single platform Terra MODIS/ASTER configuration. Therefore, an effective active fire and FRP validation protocol is still under development.

Geo-based fire data record: GOES-EAST Fraction of GOES clear-sky observations with fire detections (JAS)



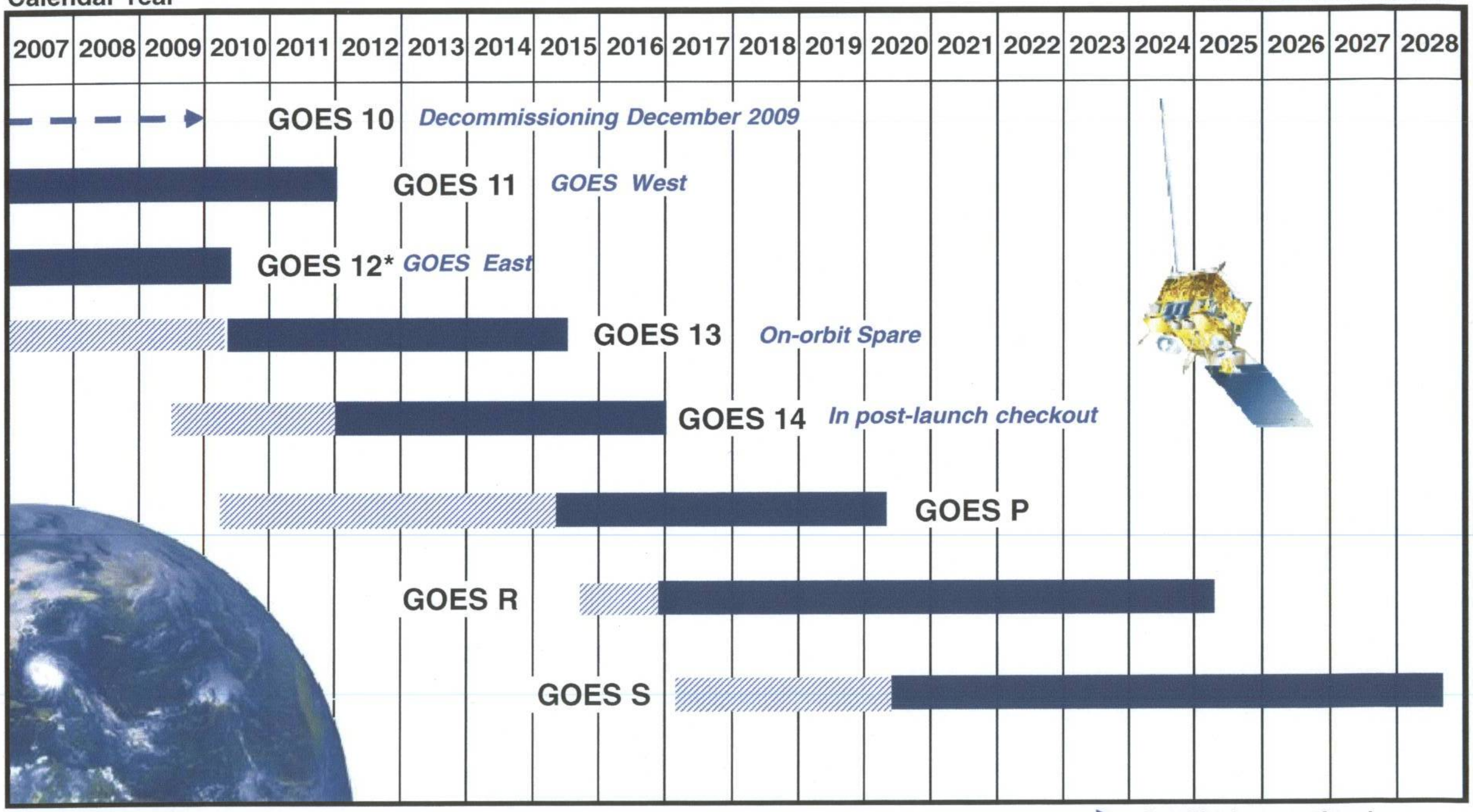
Additional fire actions

- T35: Reanalyse the historical fire disturbance satellite data (1982 to present)
- T36: Continue generation of consistent burnt area, active fire, and FRP products from low orbit satellites, including version intercomparisons to allow un-biased, long-term record development.
- T37: Develop and apply validation protocol to fire disturbance data.

Continuity of GOES Operational Satellite Program

Calendar Year

As of December 1, 2009



Approved: [signature]
Deputy Assistant Administrator
for Systems

* Backup and South American Coverage beginning June 2010

Satellite is operational beyond design life

On-orbit GOES storage

Operational

The Advanced Baseline Imager

	ABI	Current
Spectral Coverage		
	16 bands	5 bands
Spatial resolution		
0.64 μm Visible	0.5 km	Approx. 1 km
Other Visible/near-IR	1.0 km	n/a
Bands (>2 μm)	2 km	Approx. 4 km
Spatial coverage		
Full disk	4 per hour	Scheduled (3 hrly)
CONUS	12 per hour	~4 per hour
Mesoscale	Every 30 sec	n/a
Visible (reflective bands)		
On-orbit calibration	Yes	No

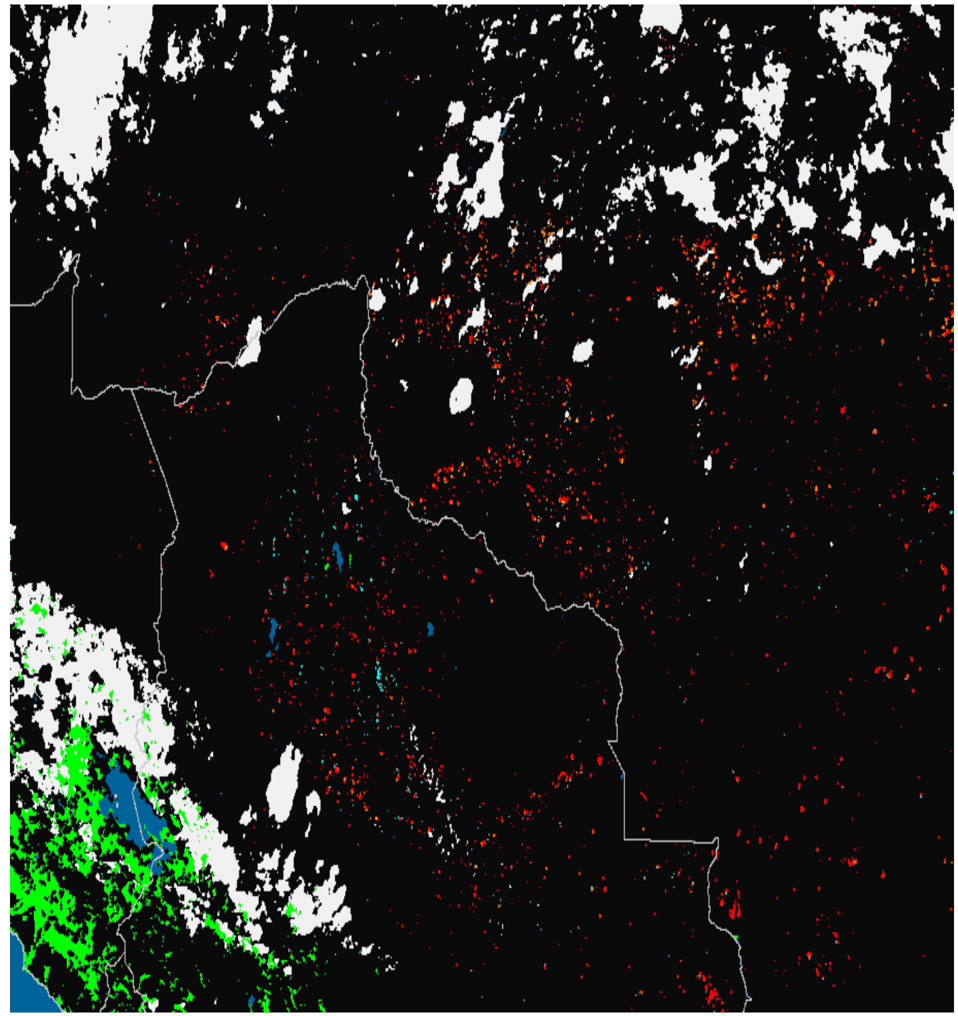
courtesy T. Schmit, UW-Madison/CIMSS

ABI Sensor: Channels

ABI Band	Wavelength Range (μm)	Central Wavelength (μm)	Central Wavenumber (cm-1)	sub-satellite IGFOV (km)	Land Product Use
1	0.45 – 0.49	0.47	21277	1	Albedo
2	0.59 – 0.69	0.64	15625	0.5	**Fire, albedo, NDVI/GVF Flood**
3	0.846 – 0.885	0.865	11561	1	**Albedo, NDVI/GVF, Flood**
4	1.371 - 1.386	1.378	7257	2	**Albedo**
5	1.58 - 1.64	1.61	6211	1	**Albedo**
6	2.225 - 2.275	2.25	4444	2	**Fire, Albedo**
7	3.80 - 4.00	3.90	2564	2	**Fire**
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	**Fire**
14	10.8 - 11.6	11.2	893	2	**LST, Fire, Flood**
15	11.8 - 12.8	12.3	813	2	**LST Fire, Flood**
16	*13.0 - 13.6*	*13.3*	*752*	*2*	

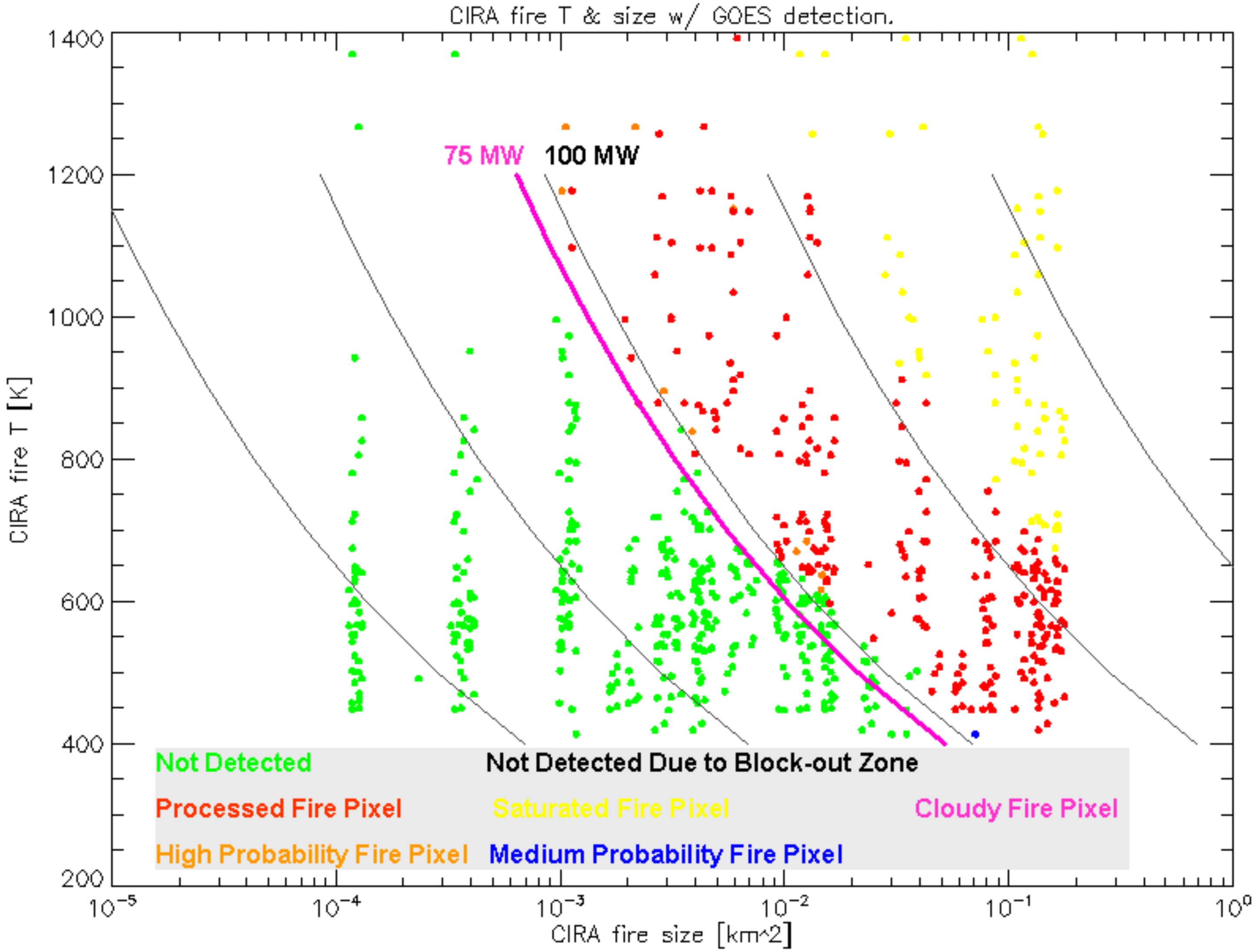
ABI fire product development status

- Adapted WA_ABBA
- Examined using a comprehensive simulation dataset from proxy satellite data via a point spread function (PSF)
- Tested using MODIS and SEVIRI data
- Critical design review, test readiness review have been done
- 100% readiness ATBD and software have been delivered
- Current focus is on collection ground Fire and satellite data for comprehensive *in situ* and multi-satellite validation and development for validation system/tools



GOES-R WF_ABBA Fire Mask tested using MODIS data on Sept. 7, 2004, at 17:50 UTC.

Expected detection capabilities



Since last IT meeting: stoplight chart

- Progress has been steady, but moderate
- Comprehensive validation of all products
  - Landsat-class imagery
- Research quality products
  - fire masks etc.
- Improved data distribution system
- Identify fire POCs for all satellites/agencies
- Continued advocacy for future sensors
  - GOES-R, MTG, etc.
- Better intergrate geostationary data into fire ECV
- Third workshop needed

Backup slides

Recommendations from 2nd workshop

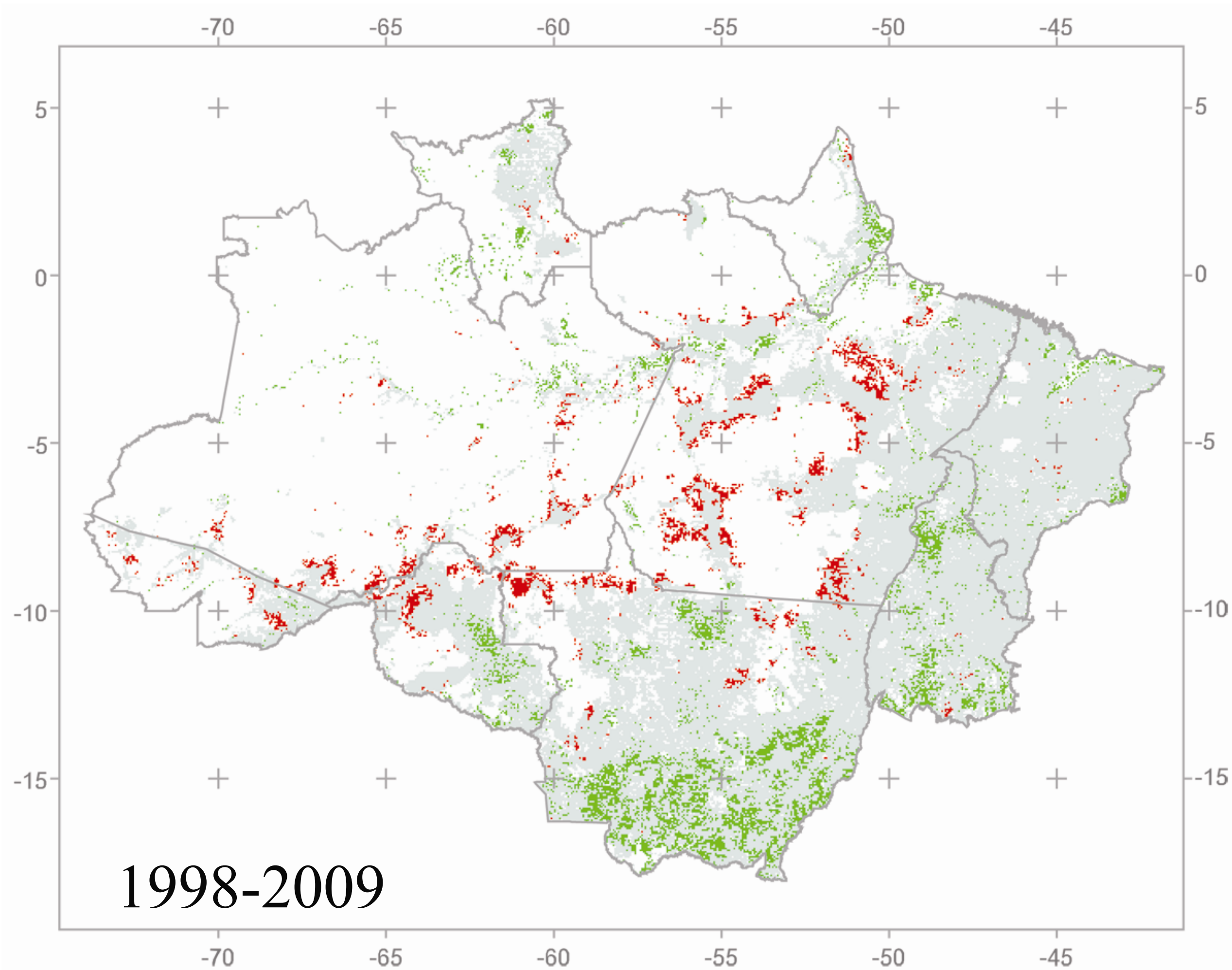
- *Research and Product Development*
  - Continue data fusion efforts and characterization
  - Encourage products based on a multi-sensor approach
  - Evaluate the Dozier technique and comparison of FRP and Dozier products
- *Data Sharing*
  - Develop a coordinated depository to share data sets with each other and the general user community
  - Provide ancillary data sets for algorithm development (e.g. improved land/water data sets, known locations of false alarms, emissivity, etc.).
- *Validation and Calibration Activities*
  - Encourage joint validation efforts regarding global fire detection and characterization products within the geostationary network (GOES, Met-8/-9, MTSAT, FY-2C/2D, etc.)
  - Provide access to ground truth including location, size and temperature, and higher resolution imagery (Landsat, ASTER). Regional validation should also be encouraged
  - Utilize aircraft validation campaigns/experiments (e.g. NASA-Ames)
  - Encourage investigators working with similar instruments to intercompare products
  - Improve characterization of the 3.9 micron band on existing geostationary sensors

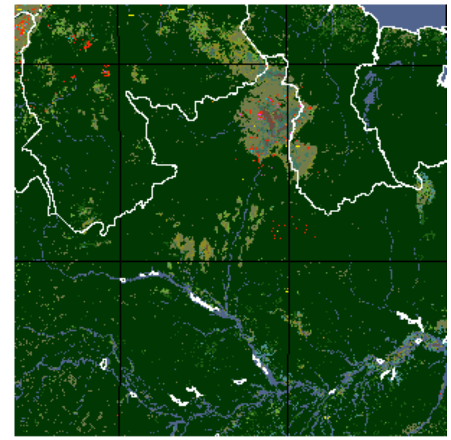
Recommendations from 2nd workshop

- *Future Sensors*
  - Encourage active involvement of the fire monitoring community in evaluating specifications for next generation operational geostationary satellites and provide feedback to operational agencies (e.g. calibration on hot end, pre-processing, flagging of saturated raw data, etc.).

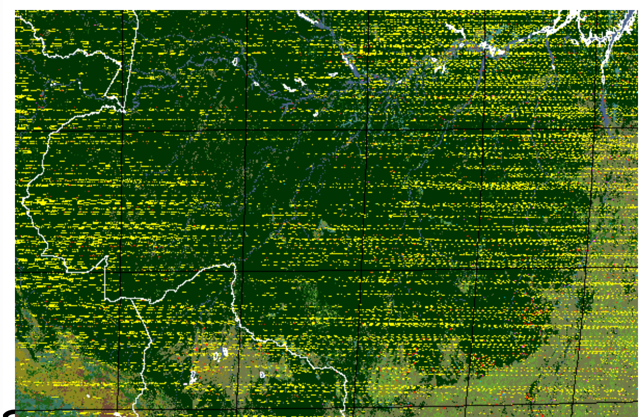
- *International Coordination*
  - Increase involvement of climate community and gain a better understanding of their needs
  - Encourage greater involvement from agencies with new sensor capabilities in Asia. (Korea, Japan, India, Russia). Collaborate with surrounding countries and dialogue on user needs/requirements.
  - Continue active participation in GEOSS/GEO tasks and planning
  - Establish link with CGMS and operational agencies
  - Adapt elements of the CEOS constellation process and maintain a strong relationship with the CEOS WGCV LPV to ensure ongoing cal/val activities in the community
  - Convene follow-on meeting to address progress on global geostationary products, applications, and validation

Fire trends from GOES data





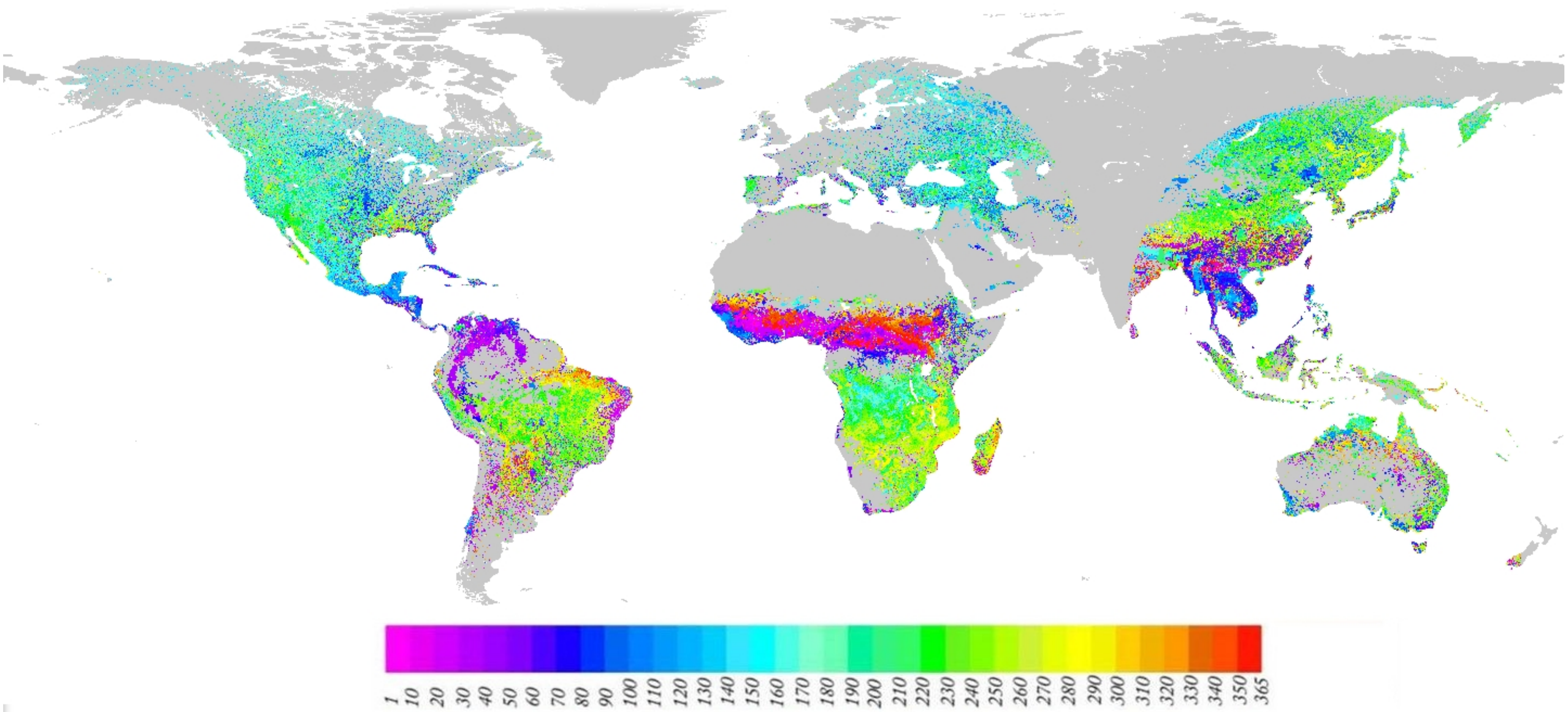
1997 Jan



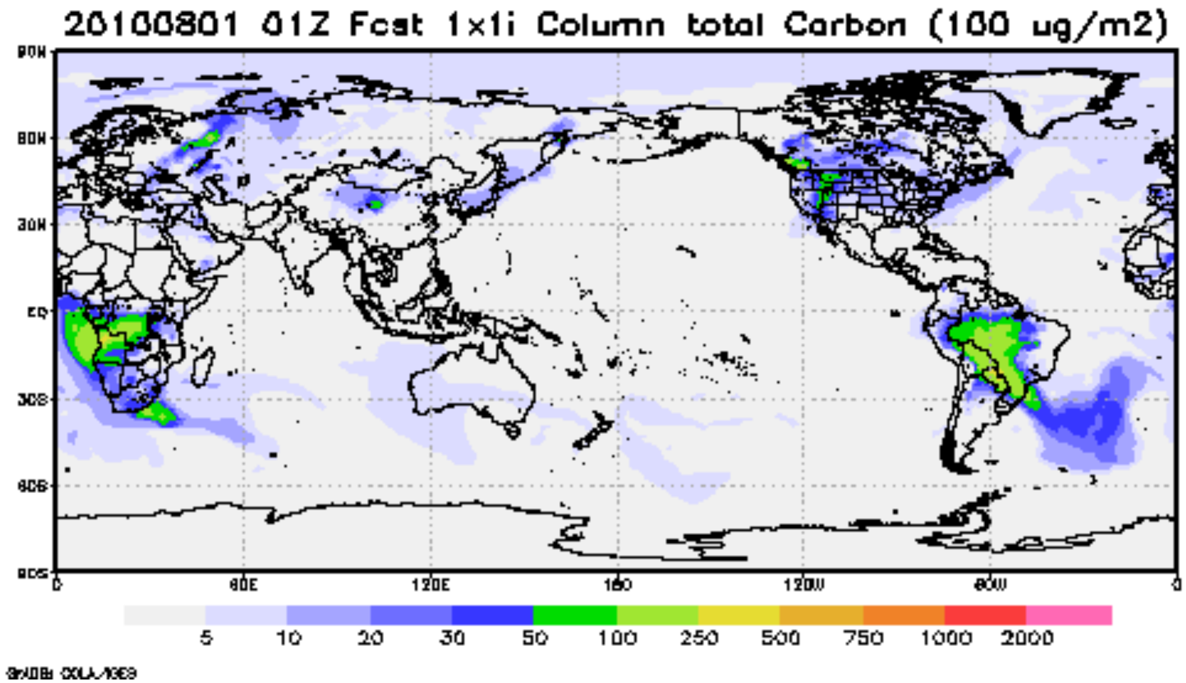
1995 Jan

white - no fire

Peak Time (Day of the Year) in Biomass Burning

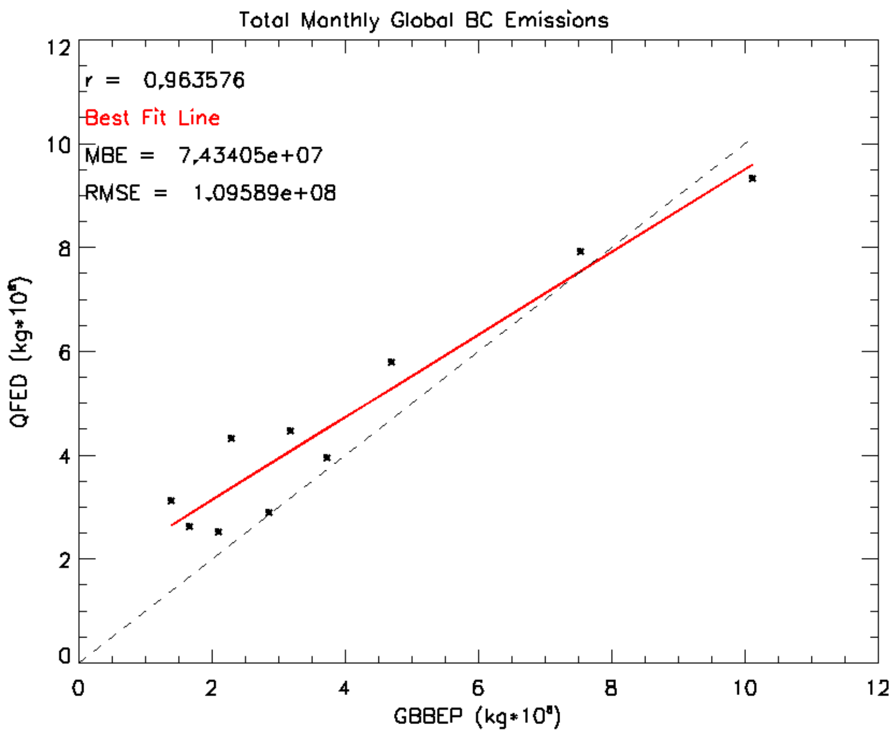


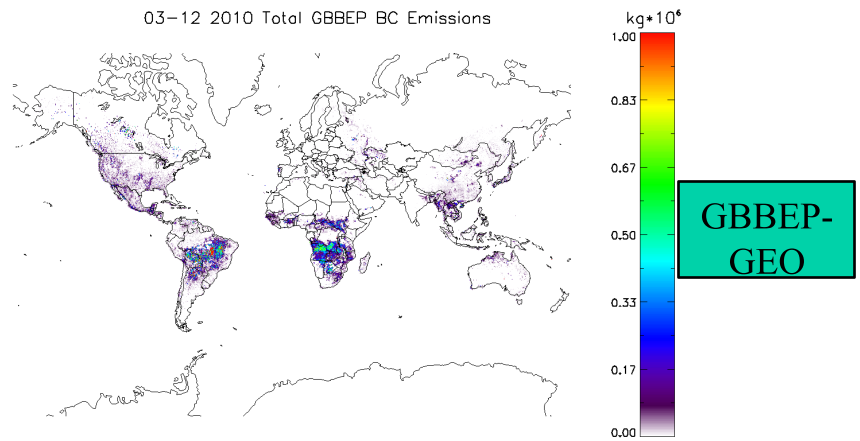
NCEP GFS-GOCART Model Simulation of Aerosols using GBBEP-Geo

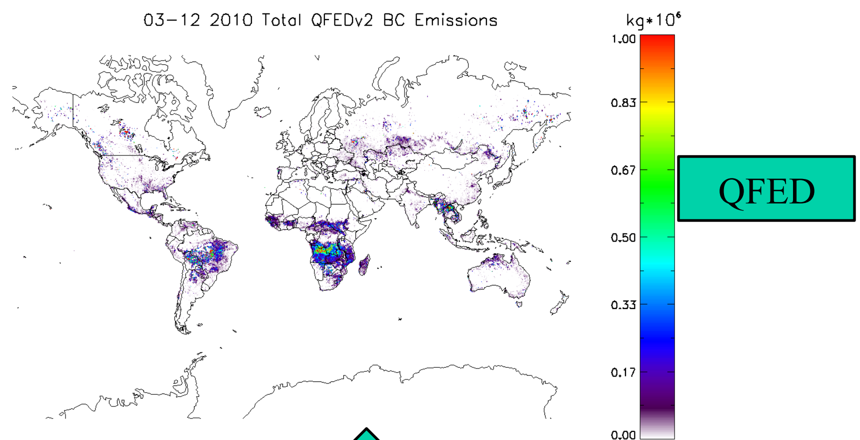


- Model simulations show that using satellite derived fire emissions improve aerosol forecasts (spatial and temporal features) .
- Predicted AOD was found to be much lower than observed AOD. This is due to ingestion of finer spatial scale fire emissions into a 1 X 1 degree global model grid. Similar findings were reported by Reid et al ., JSTARS, 2010 and Yang et al., JGR, 2009.
- NASA’s MODIS-based Quick Fire Dataset (QFED, V2) is currently being scaled to account for this discrepancy and when GBBEP-Geo are scaled by a factor of three, the two datasets agree well.

Comparison of Black Carbon Emissions from GBBEP -Geo and QFED







QFED data courtesy of Da Silva, NASA/GSFC

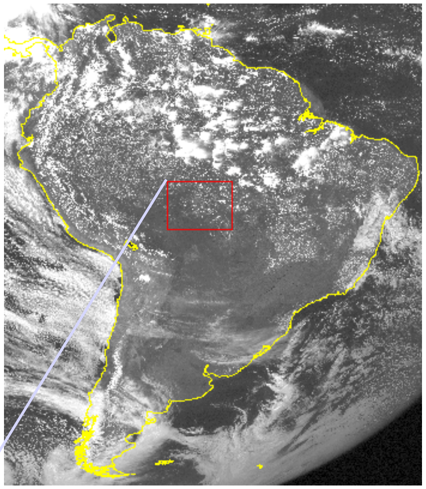
GCOS satellite supplement provides

- Products, Target Requirements, Benefits
- Rationale
- Currently Achievable Performance
- Requirements for satellite instruments and data
- Calibration, Validation and Archiving Needs
- Adequacy and Inadequacy of Current Holdings
- Immediate Actions, Partnerships and International Coordination.

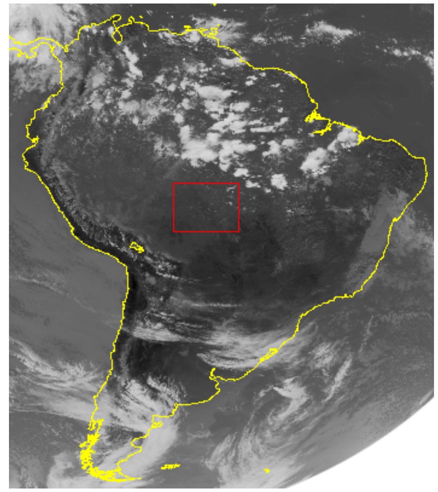
Climate SBA Coordinator’s assessment

- “My initial survey, was that a few were very good, and a few was an echo of the GCOS supplement.
- Enlisted the System Engineering expertise of the SEO to review all the completed templates and to recommend a modified template so there would be no confusion.
- <u>We found T39 to be the best, and T39 was converted to the new template and now we are ready to complete the other actions.</u>

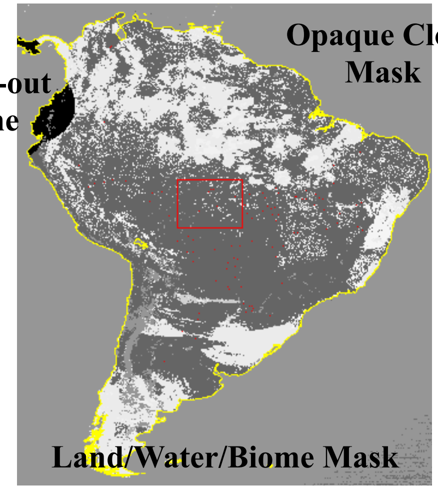
GOES WF_ABBA (version 6.5)



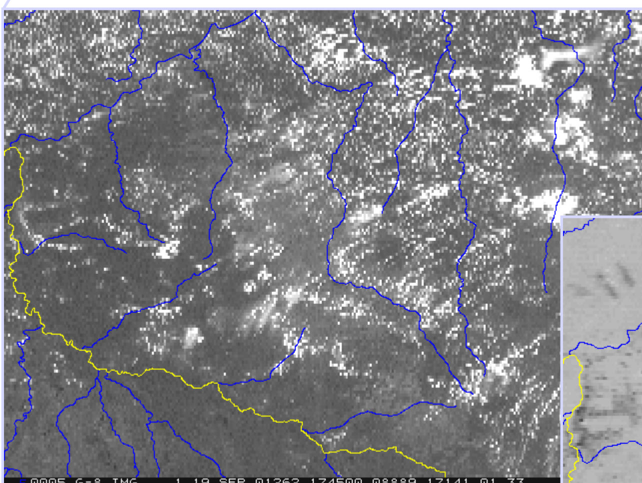
GOES visible image



GOES 11 micron image



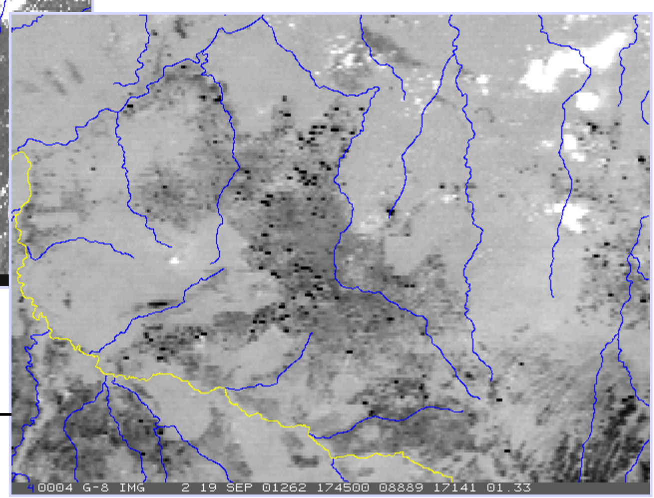
Fire Mask

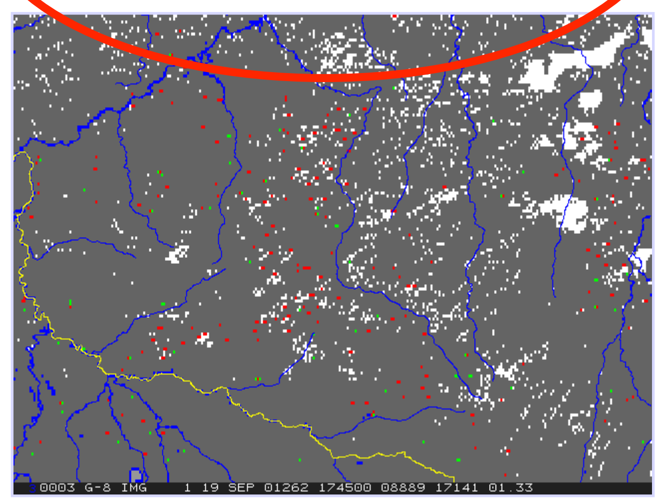


GOES visible image

Fire Mask
(fire location/confidence, opaque clouds, land/water mask, other biome masks, block-out zones, bad data indicator, processing region, etc.)

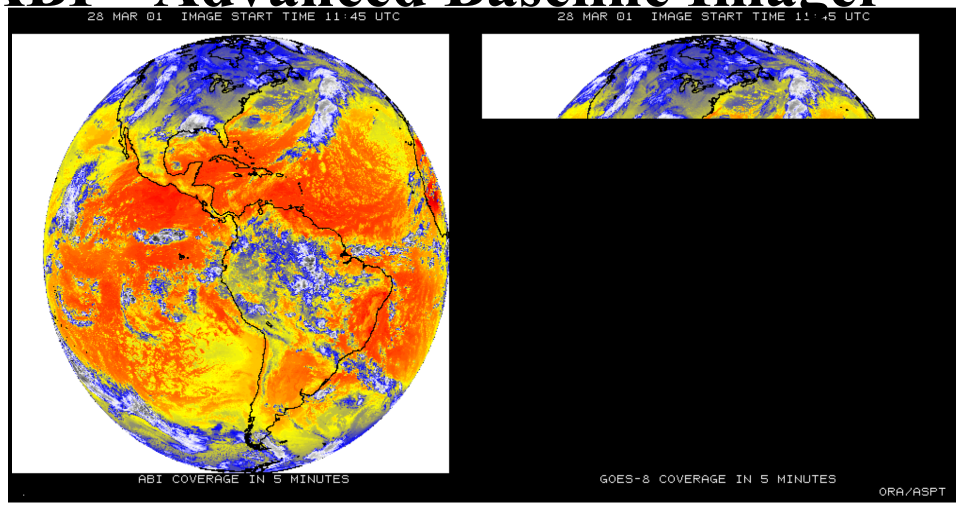
GOES 3.9 micron image



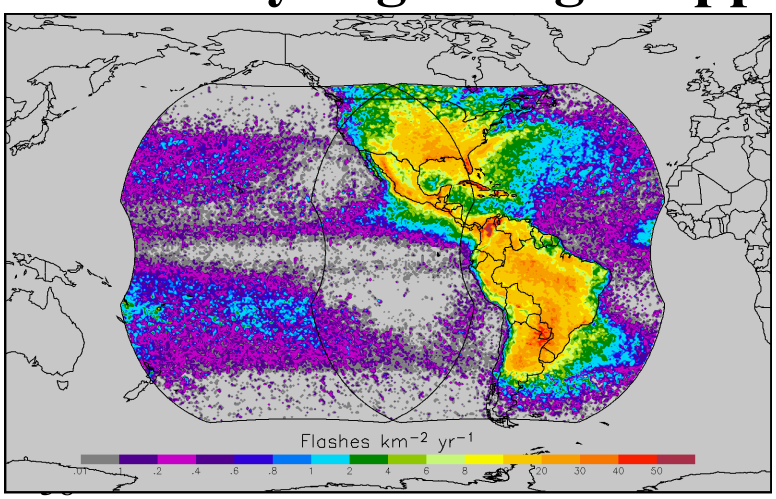


GOES-R main instruments

ABI – Advanced Baseline Imager

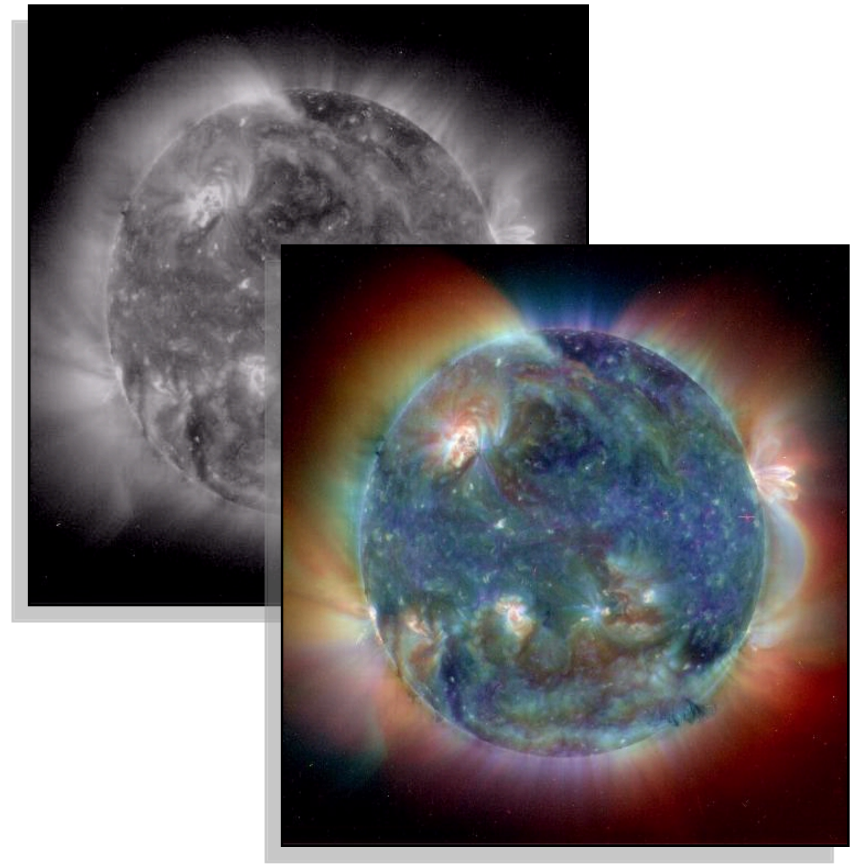


Geostationary Lightning Mapper



courtesy T. Schmit, UW-Madison/CIMSS

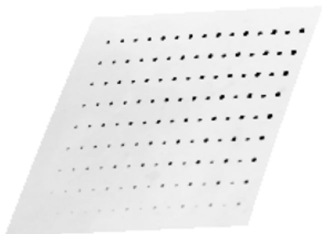
Space Weather/Solar



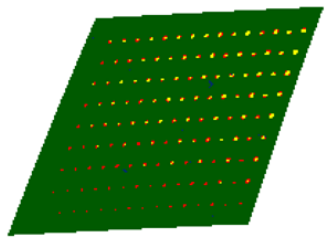
Images courtesy of SOHO EIT, a joint NASA/ESA program

GOES-R fire algorithm evaluation

Application of Prototype ABI WF_ABBA Fire Algorithm
to Model Simulated Data in Kansas
Date: 8 May 2003 Time: 1915 UTC
Variable Fire - No Clouds (VFNOCLD)



CIRA Model Simulated ABI
3.9 µm band



CIMSS ABI WF_ABBA
Fire Mask Product

Experimental WF_ABBA Fire Legend
Processed Fire **Saturated Fire** **Cloudy Fire**
High Possibility Fire **Medium Possibility Fire** **Low Possibility Fire**
Processed – non-fire region

Application of Prototype ABI WF_ABBA Fire Algorithm
to Model Simulated Data in California
Date: 23 October 2007 Time: 1500 UTC
Variable Fire with Clouds (VFCLD)

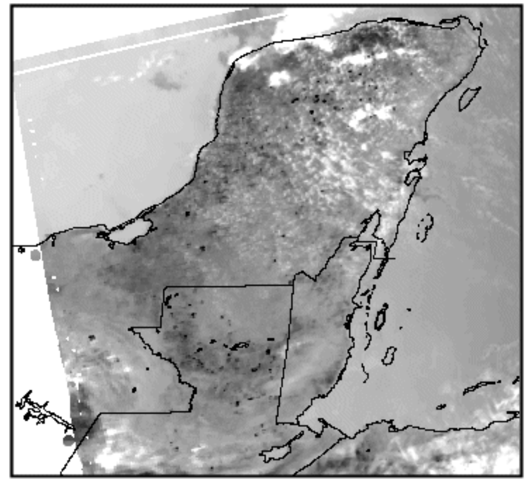
CIRA Model Simulated ABI
3.9 µm band

CIMSS ABI WF_ABBA
Fire Mask Product

Experimental WF_ABBA Fire Legend
Processed Fire **Saturated Fire** **Cloudy Fire**
High Possibility Fire **Medium Possibility Fire** **Low Possibility Fire**
Processed – non-fire region

MODIS Simulated
ABI Data
in Central America

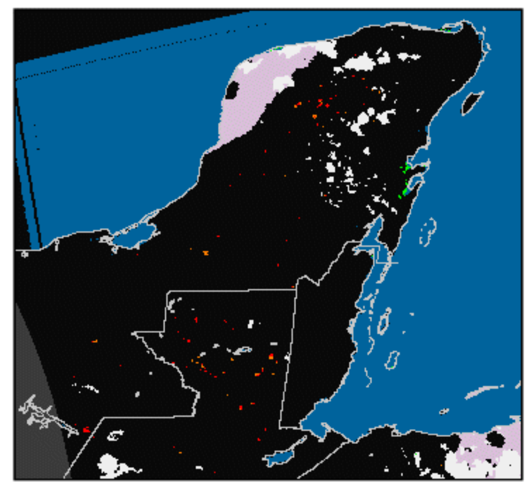
Date: 24 April 2004
Time: 18:45 UTC



GOES-R ABI 3.9 µm data

Experimental WF_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



CIMSS GOES-R ABI WF_ABBA
Fire Mask Product