Tracking Fires from 22,000 Miles Above the Earth

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Anniversary of the Great Fires of October 1871

October 8, 1871

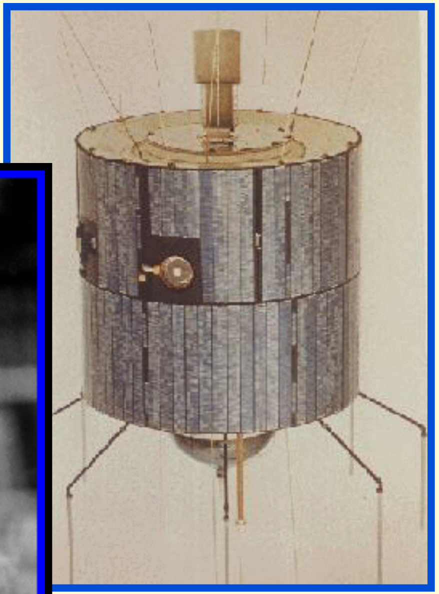
"But for sheer destructiveness and loss of life, the great fires raging on the weekend of October 8-9, 1871 will go down in U.S. history as its greatest fire disaster. On October 8, major fires broke out… in Michigan, Wisconsin, and Illinois. When the fires were finally extinguished, over 1700 people had died and millions of acres of forest land reduced to charcoal."

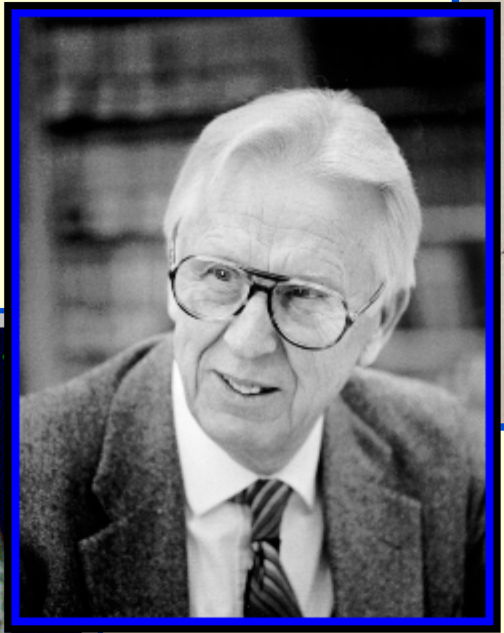
Weather Almanac for October 2000, THE GREAT FIRES OF OCTOBER 1871, Keith C. Heidorn, PhD, ACM

Weather Almanac for October 2000
THE GREAT FIRES OF OCTOBER 1871
Keith C. Heidorn, PhD, ACM

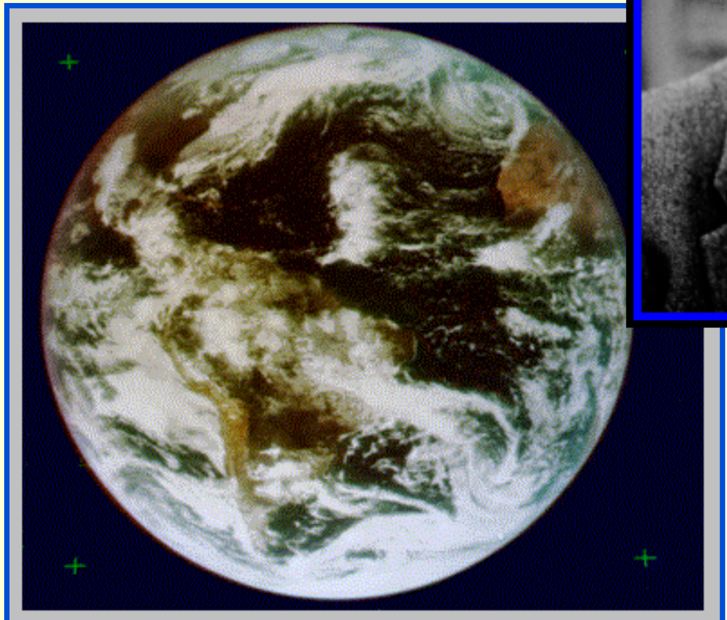
Julia Lemos's "Memories of the Chicago Fire," 1912
http://www.chicagohistory.org/fire/witnesses/

The Birth of Satellite Meteorology



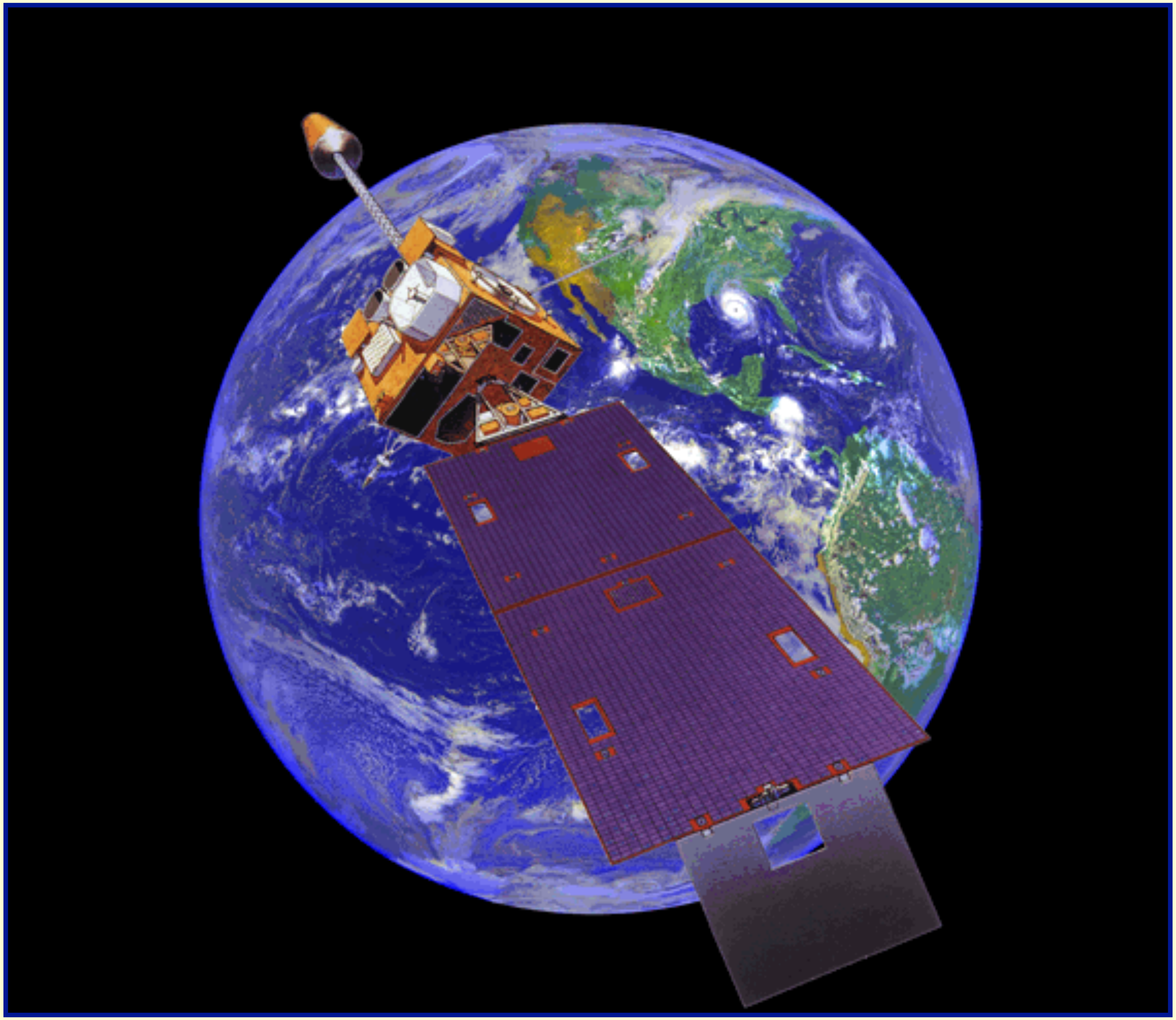


Verner E. Suomi

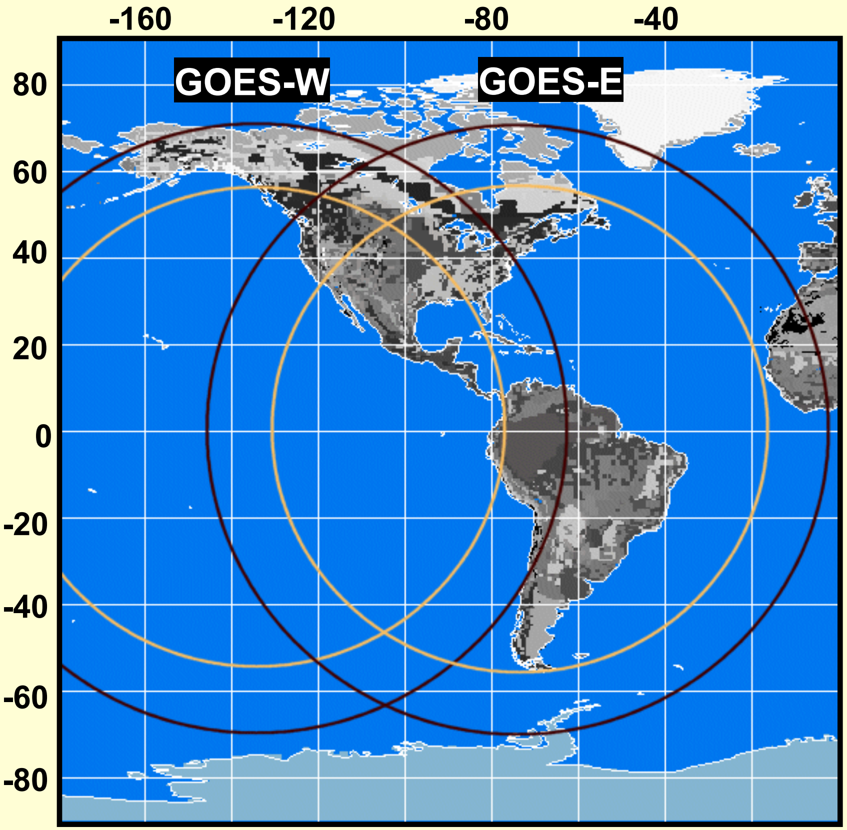


8 November 1967

The Current Geostationary Operational Environmental Satellite (GOES)



Current U.S. Geostationary Coverage and Fire Monitoring Characteristics



GOES Imager Characteristics

Band	Wavelength (microns)	IGFOV (km)	Sampled Subpoint Resolution (km)	NEDT
1	0.52-.72	1.0x1.0	0.57x1.0	10-bit data
2	3.78-4.03	4.0x4.0	2.3x4.0	.23 K @ 300 K
3	6.47-7.02	8.0x8.0	2.3x8.0	.30 K @ 230 K
4	10.2-11.2	4.0x4.0	2.3x4.0	.14 K @ 300 K
5	11.5-12.5	4.0x4.0	2.3x4.0	.26 K @ 300 K

Satellite View Angle
- 80° (black line)
- 65° (yellow line)

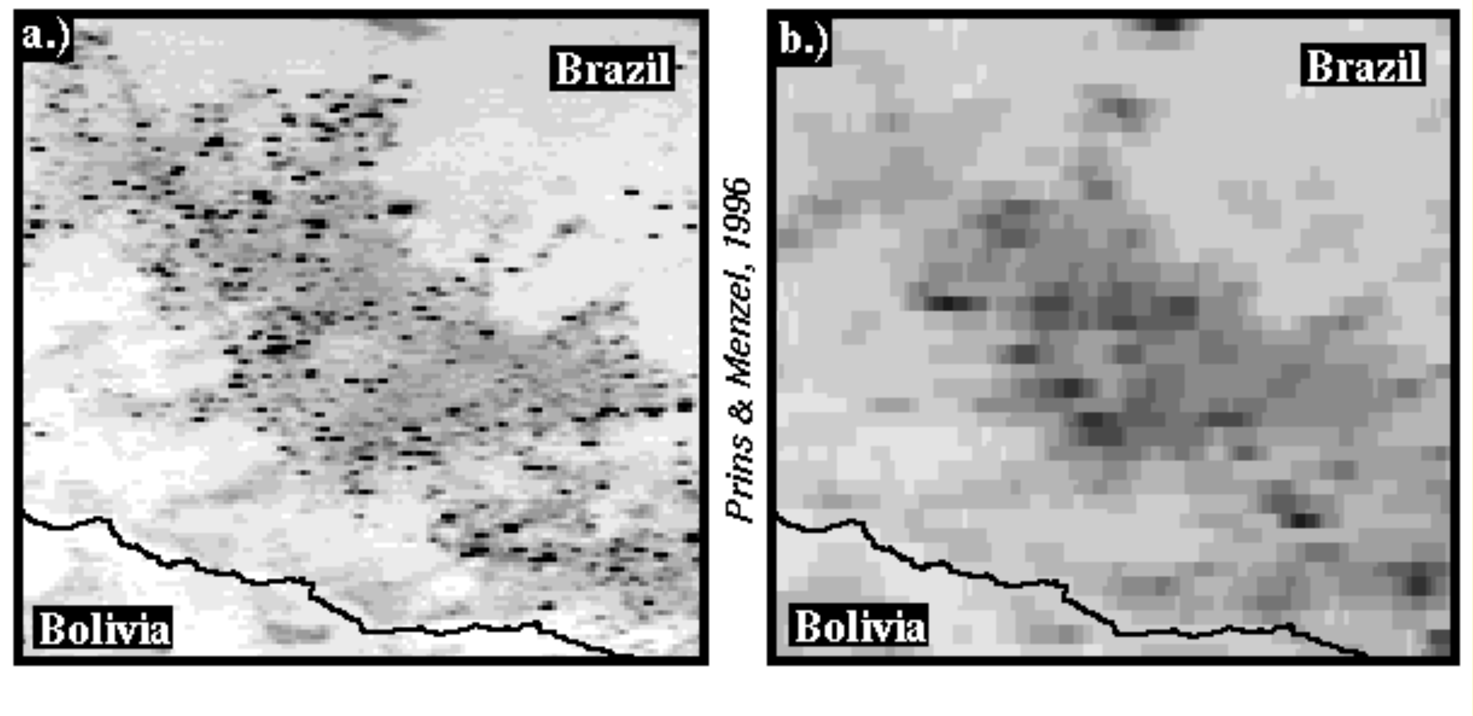
Fire Monitoring Characteristics

- ✴ Oversampling in the East/West direction with a sub-sampled res of 2.3x4.0 km
- ✴ High temporal resolution: every 15 minutes over portions of North America, half-hourly elsewhere, capability for 1-minute imaging in Super Rapid Scan Operational mode.
- ✴ GOES-8 band 2 has an elevated saturation temperature of 338 K.
  Elevated GOES-8 band 2 saturation temperature gives improved fire characterization.
- ✴ Fire size detectability limits with a fire temperature of 750K:
  Equator: .15 ha 50°N: .32 ha

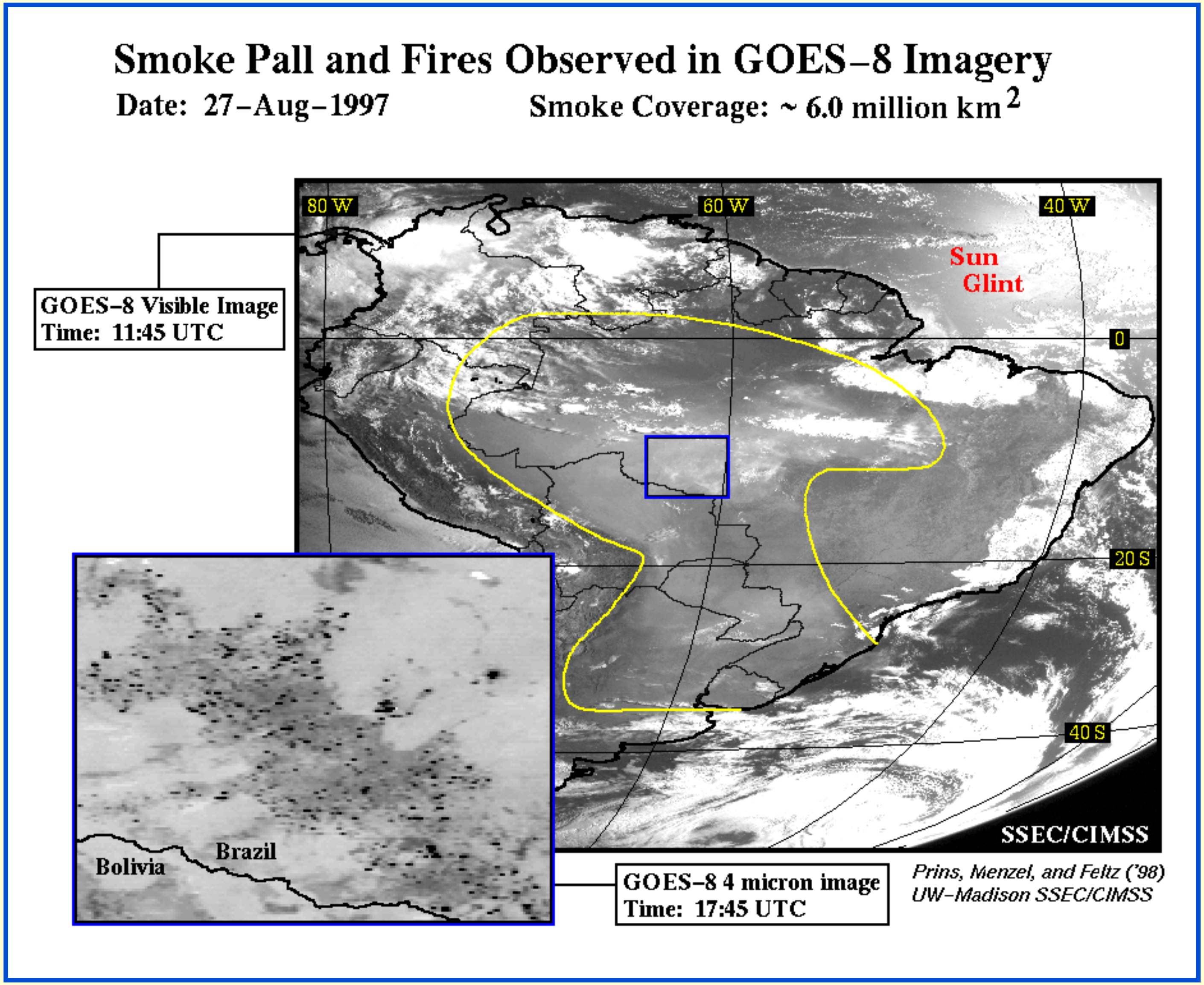
Before and After

GOES-8
August 1995

GOES-7
August 1988



What Do Fires and Smoke Look Like From Space?



Applications of Operational Geostationary Satellite Fire Products

>>> *Routine diurnal fire products and stable long-term records of fire activity* <<<

❖ Hazards Detection and Monitoring

Each year millions of acres of forest and grassland are consumed by wildfire resulting in loss of life and property with significant economic costs and environmental implications.

- Although the capabilities of current operational geostationary satellites are limited, they can provide valuable regional and global fire products in near real-time, and are critical for fire detection and monitoring in remote locations and developing countries.

❖ Global Change Monitoring

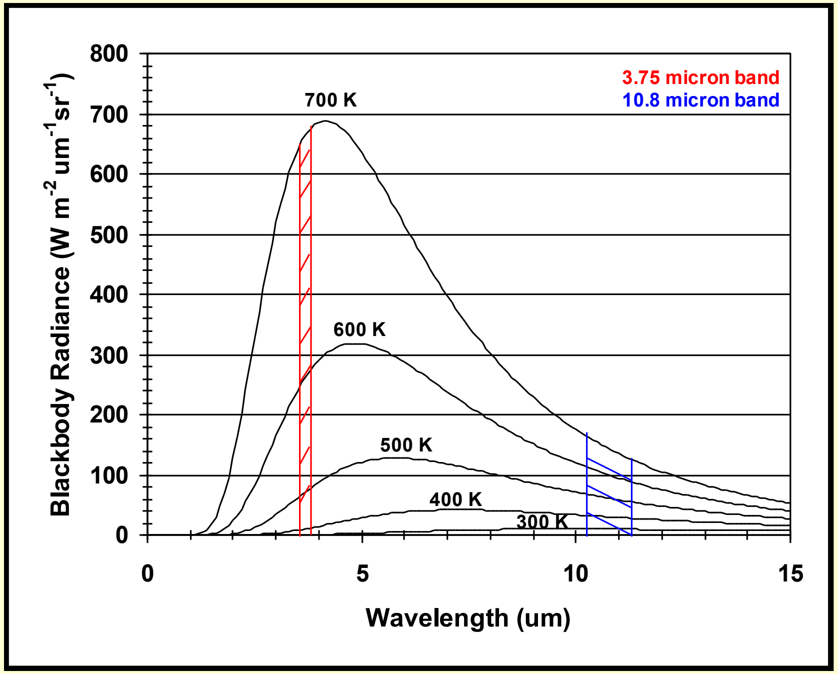
Biomass burning is a distinct biogeochemical process that plays an important role in terrestrial ecosystem processes and global climate change

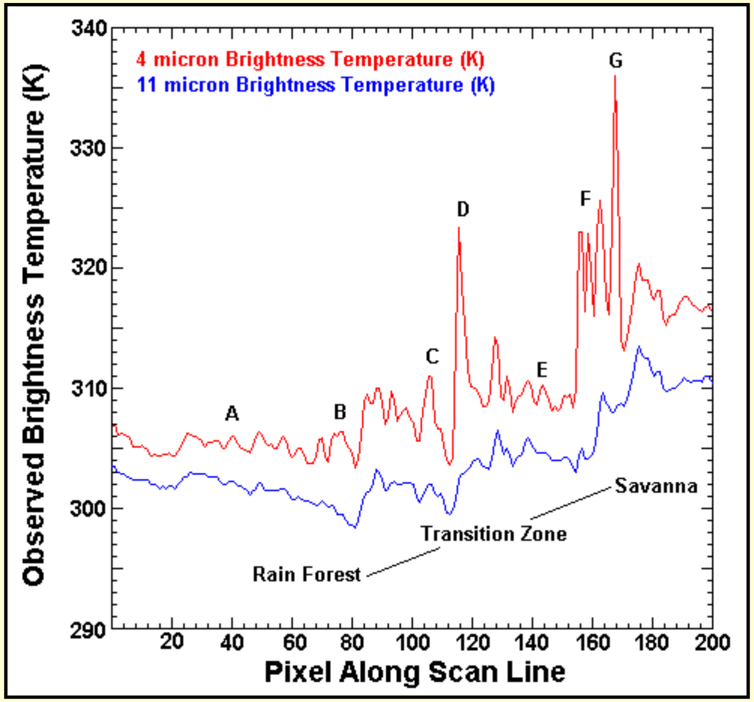
- Land use and land cover change monitoring:
  Fire is used in the process of deforestation and agricultural management. Approximately 85% of all fires occur in the equatorial and subtropical regions and are not adequately documented.

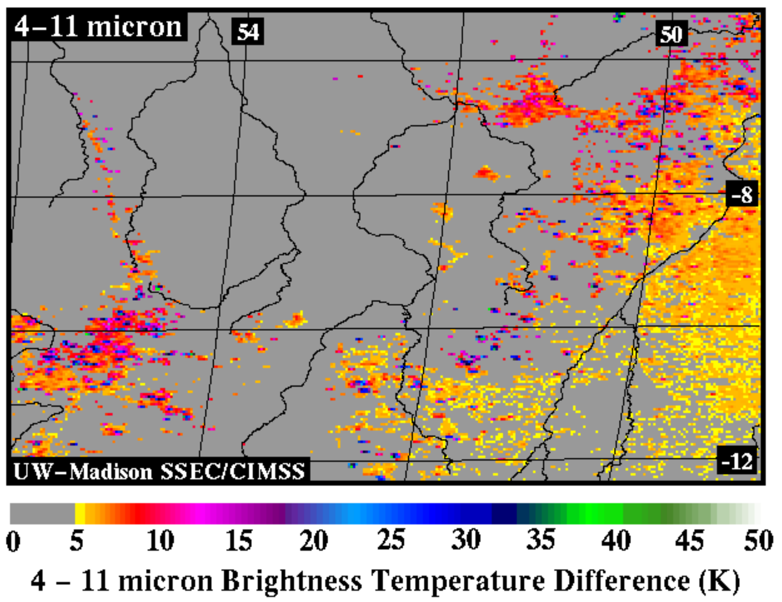
- Estimates of atmospheric emissions:
  Biomass burning is a major source of trace gases and an abundant source of aerosols
  NO, CO_2 (40%), CO (32%), O_3(38%), NO_X, N_2O, NH_3, SO_X, CH_4(10%), NMHC (>20%) , POC (39%)

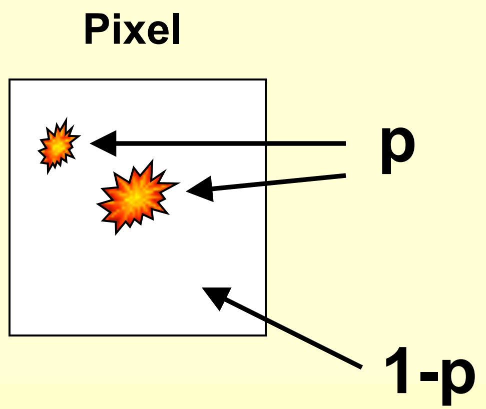
- Within the Framework Convention on Climate Change (FCCC) countries will need to report on greenhouse gas emissions including those from biomass burning.

How are Meteorological Satellites Used to Monitor Fires?





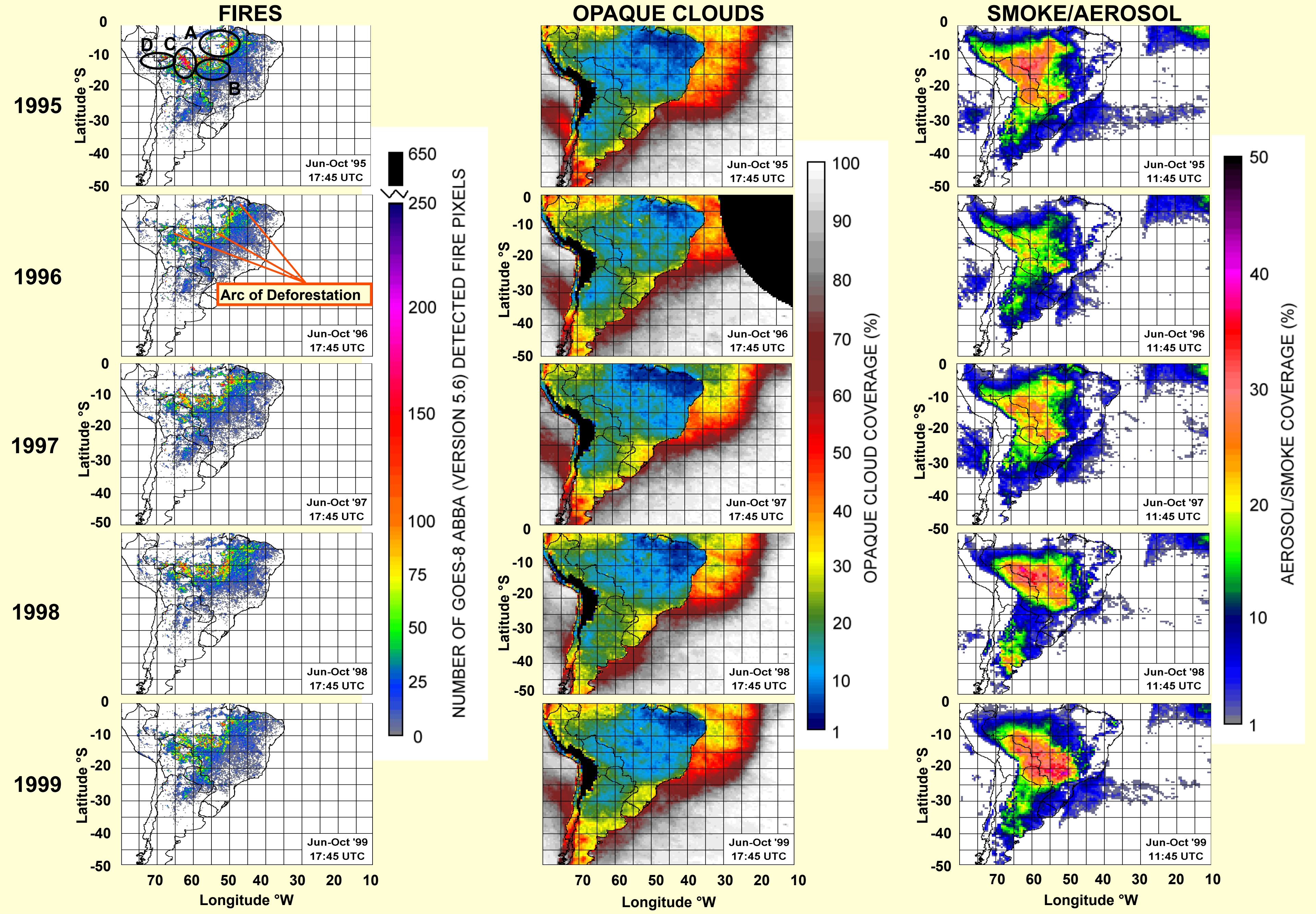




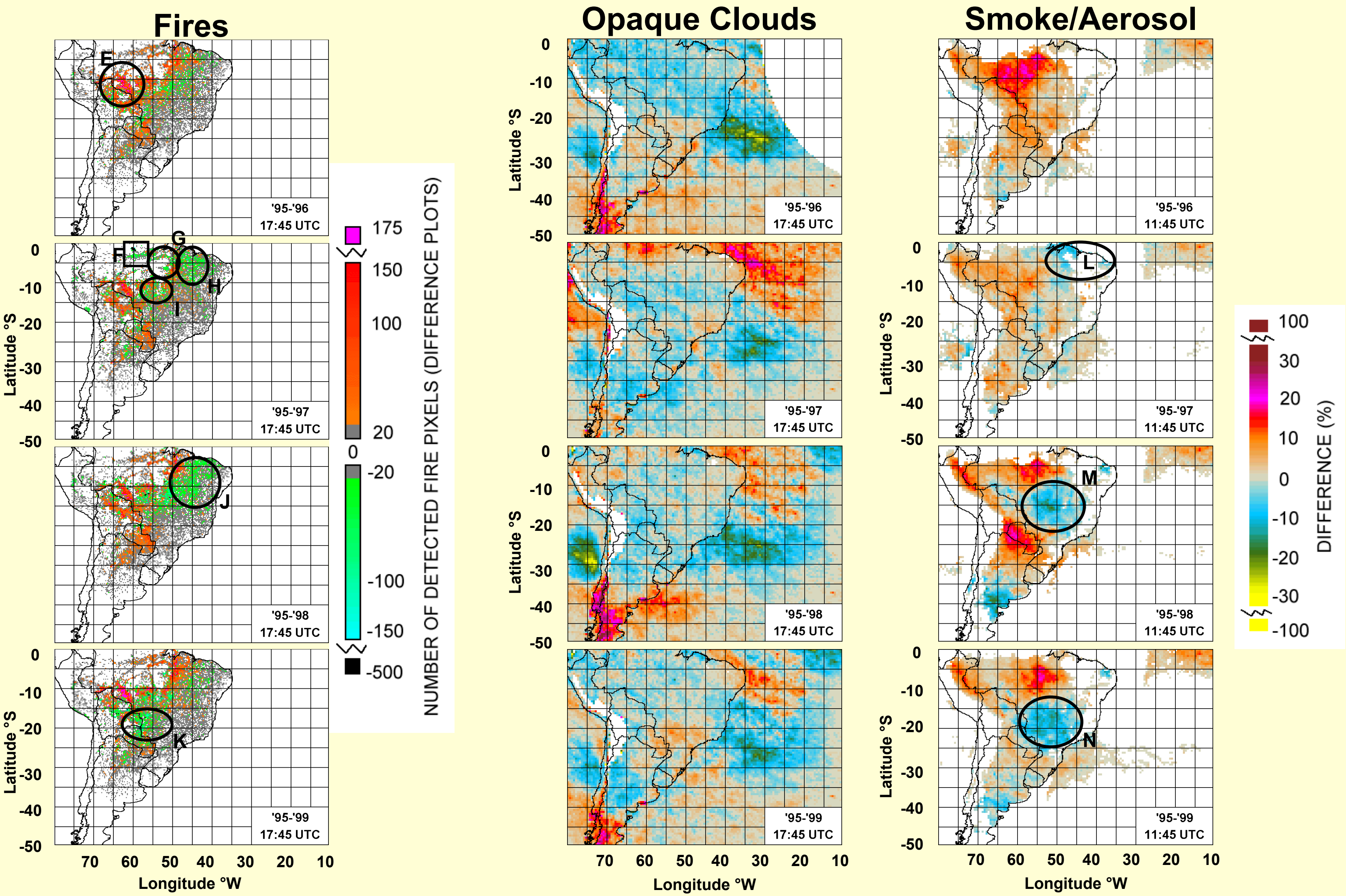
$$L_4(T_4) = p\,L_4(T_f) + (1-p)\,L_4(T_b) + (1-\varepsilon_4)\,\tau_{4s}\,L_{4\ solar}$$

$$L_{11}(T_{11}) = p\,L_{11}(T_f) + (1-p)\,L_{11}(T_b)$$

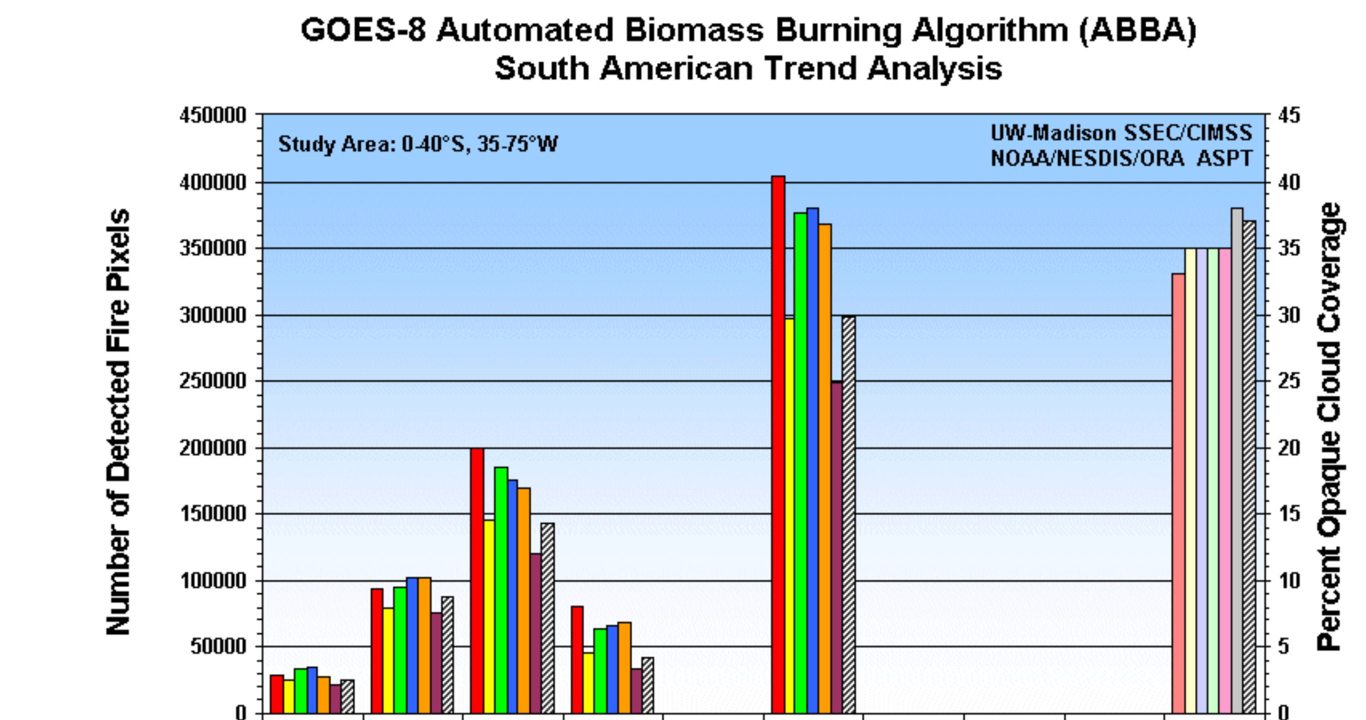
Overview of Fires, Opaque Clouds, and Smoke/Aerosol Coverage in South America Derived from the GOES-8 ABBA and MACADA: 1995 - 1999



Interannual Differences in Fires, Opaque Clouds, and Smoke/Aerosol: Each Fire Season (June - October) is Compared to the 1995 Benchmark Season



GOES-8 ABBA/MACADA South American Trend Analysis

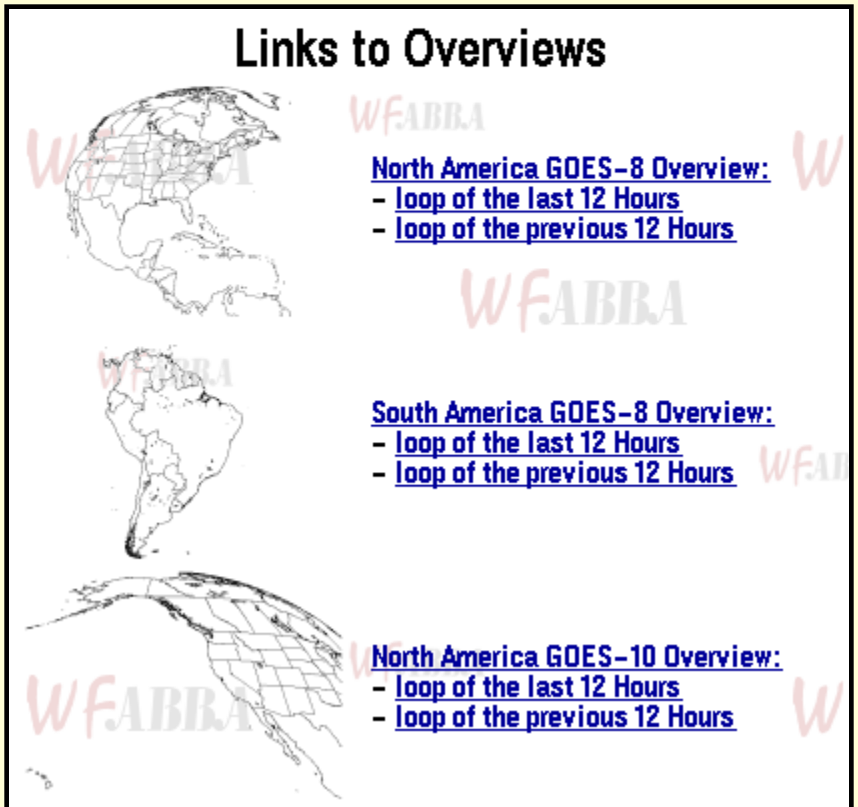


	12 UTC	15 UTC	18 UTC	21 UTC		Total (all times)		Compared to 1995 (%)		Opaque Clouds (%)
1995: # of Fire Pixels	29460	93681	199696	81558		404394				
1996	25865	78854	145674	46291		296684		-27		
1997	33509	95247	184081	62940		375777		-7		
1998	35597	102060	175435	66364		379455		-6		
1999	28781	101658	169160	68401		368000		-9		
2000	21198	74723	119504	33638		249063		-38		
2001	25337	88235	143043	42199		298814		-26		
1995: Opaque clouds (%)										33
1996										35
1997										35
1998										35
1999										35
2000										38
2001										37

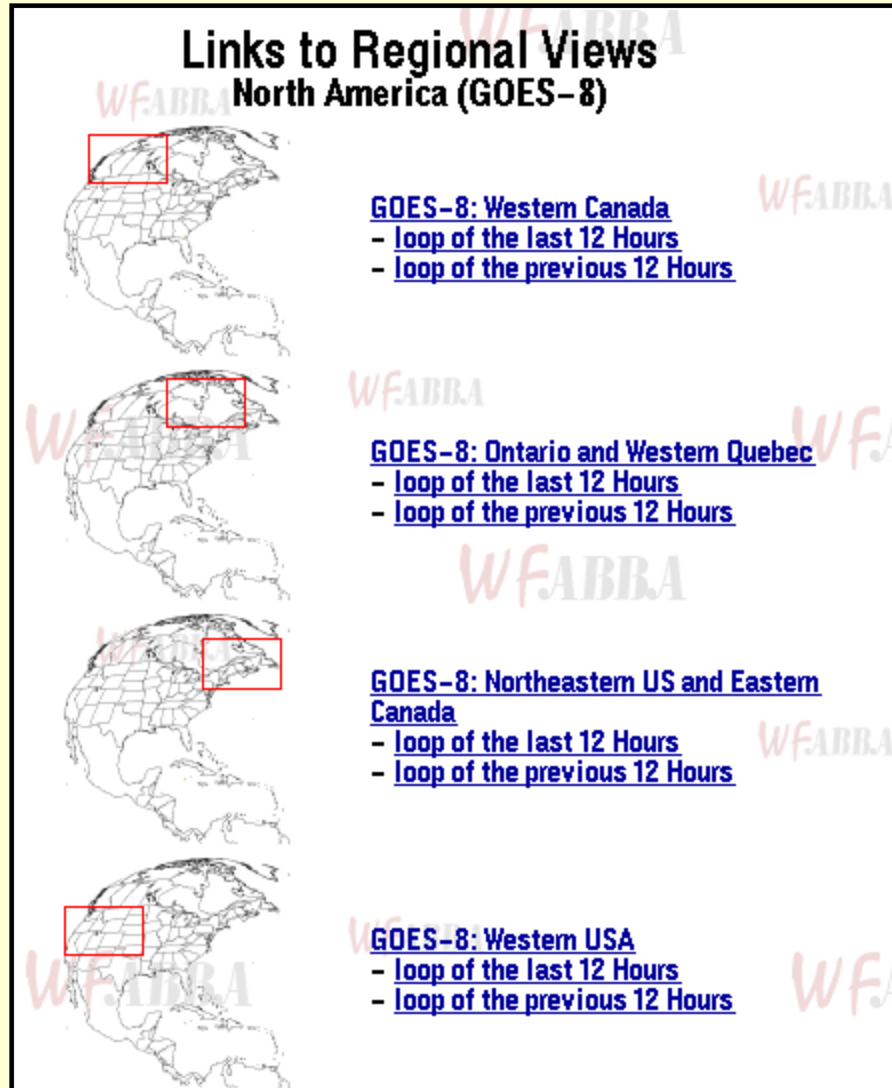
GOES-8/-10 Half-hourly
Wildfire Automated Biomass Burning Algorithm (WF_ABBA)
Web Distribution Online Since September 2000

Animations of Wildfire ABBA composite image products are being provided via anonymous ftp and the web every half-hour at: http://cimss.ssec.wisc.edu/goes/burn/wfabba.html

Displays include three overviews and 35 regional views providing coverage of the entire Western Hemisphere.

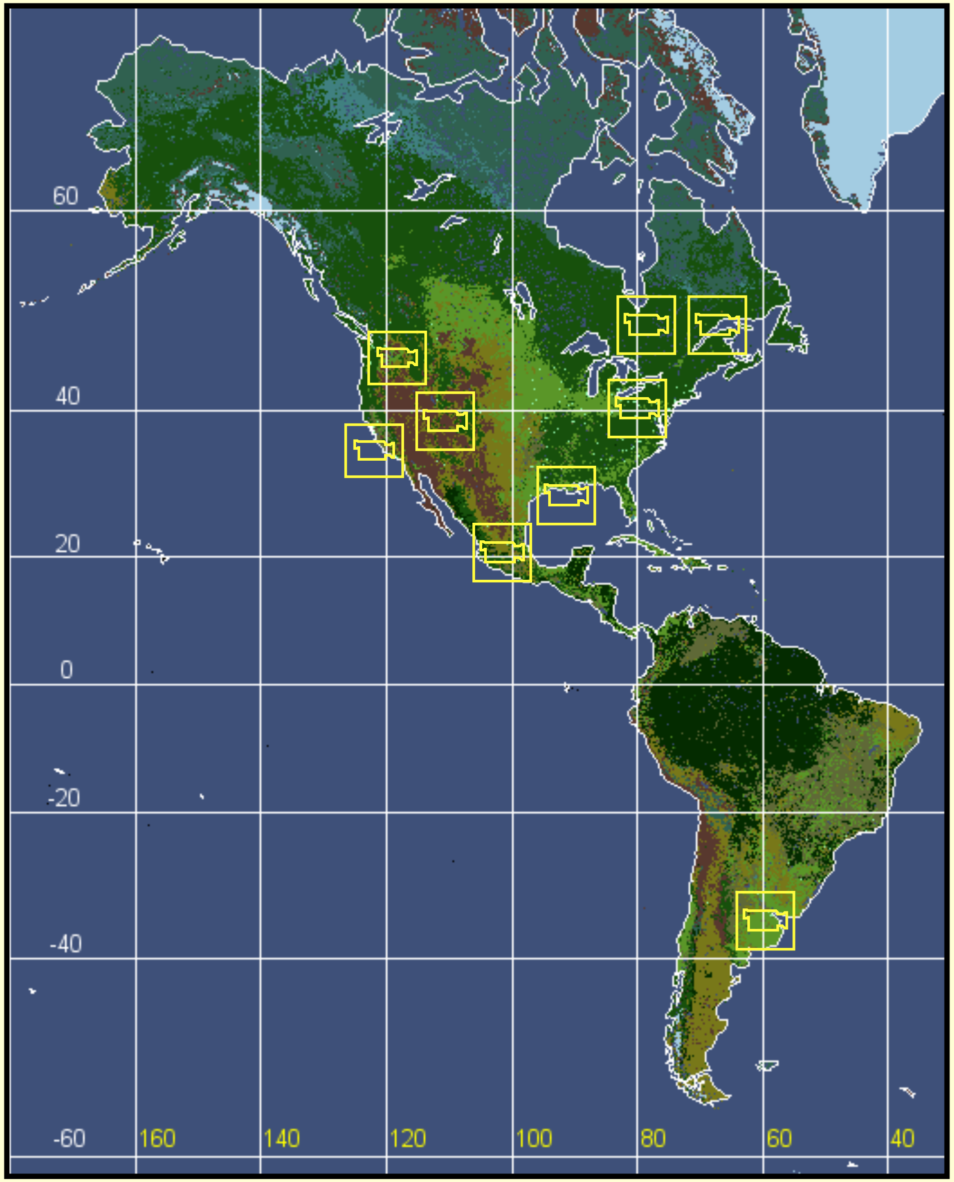


Examples of Regional View Sectors



Examples of the GOES Wildfire ABBA Monitoring System in the Western Hemisphere

http://cimss.ssec.wisc.edu/goes/burn/wfabba.html



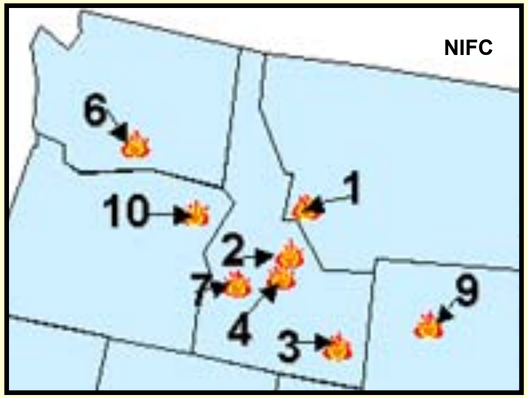
Experimental Wildfire ABBA Fire Legend

- Processed Fire
- High Possibility Fire
- Saturated Pixel
- Medium Possibility Fire
- Cloudy Fire
- Low Possibility Fire

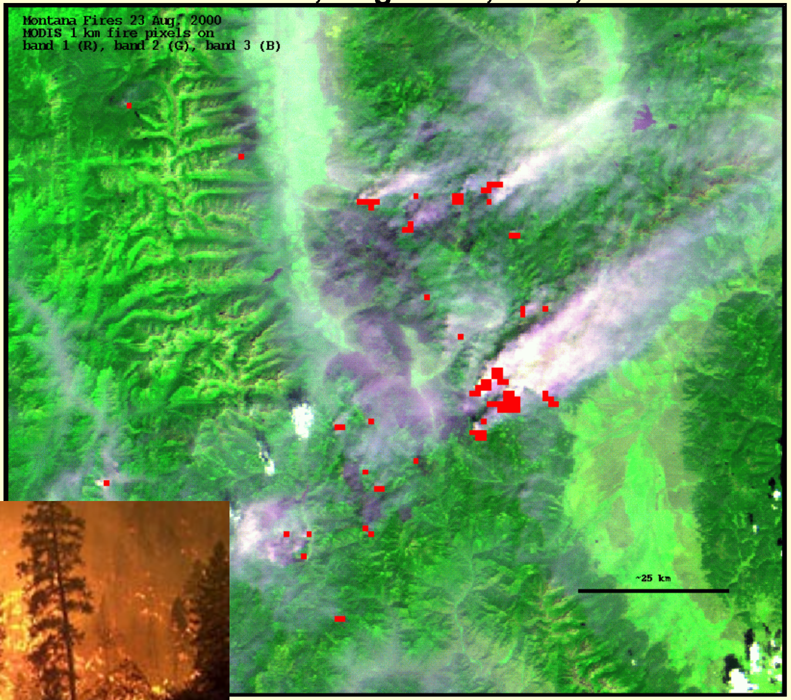
AVHRR-Derived Landcover Legend

- Tropical Forest
- Forest
- Savanna
- Cropland
- Grassland
- Swamp/Marsh
- Coast
- Water
- Tundra
- Bare Rock
- Desert
- Urban Area
- Ice

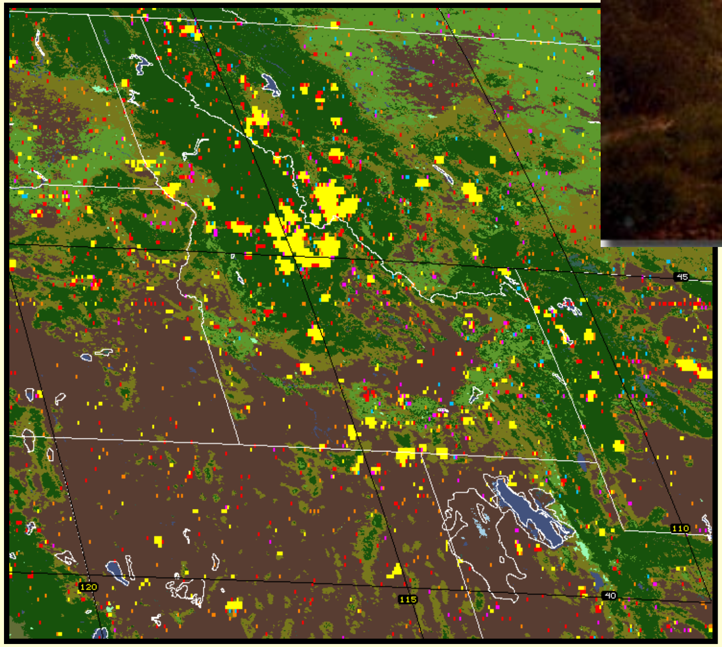
Valley Complex, Bitteroot National Forest, MT
July 31 – October 3, 2000 292,070 acres
National Interagency Fire Center, Boise, Idaho



MODIS, August 23, 2000, NASA GSFC



Sula Complex, Sula, Montana
August 6, 2000
John McColgan, BLM
Alaska Fire Service



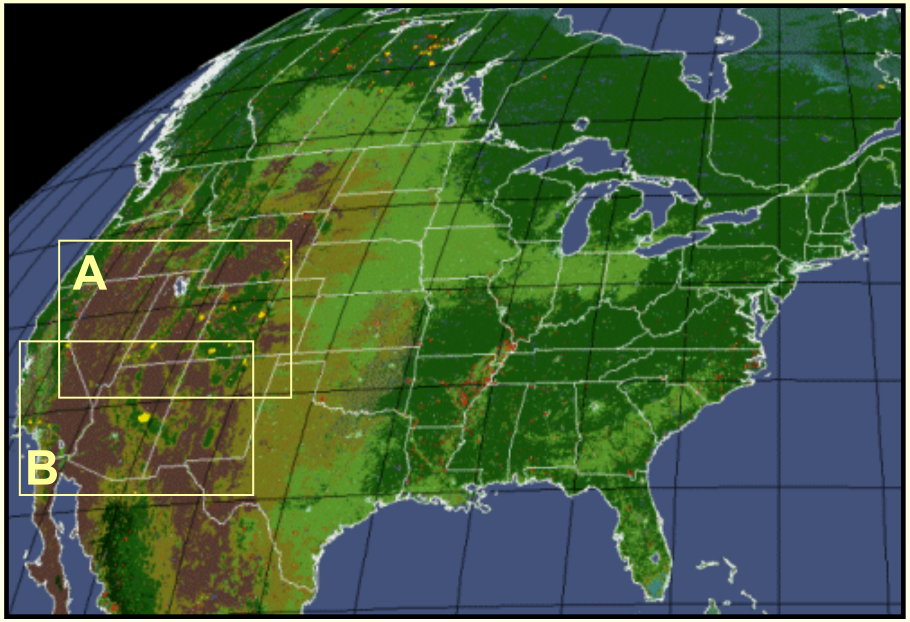
GOES Composite for August 2000, UW-Madison/CIMSS

2000 Fire Season in the U.S. (NIFC)

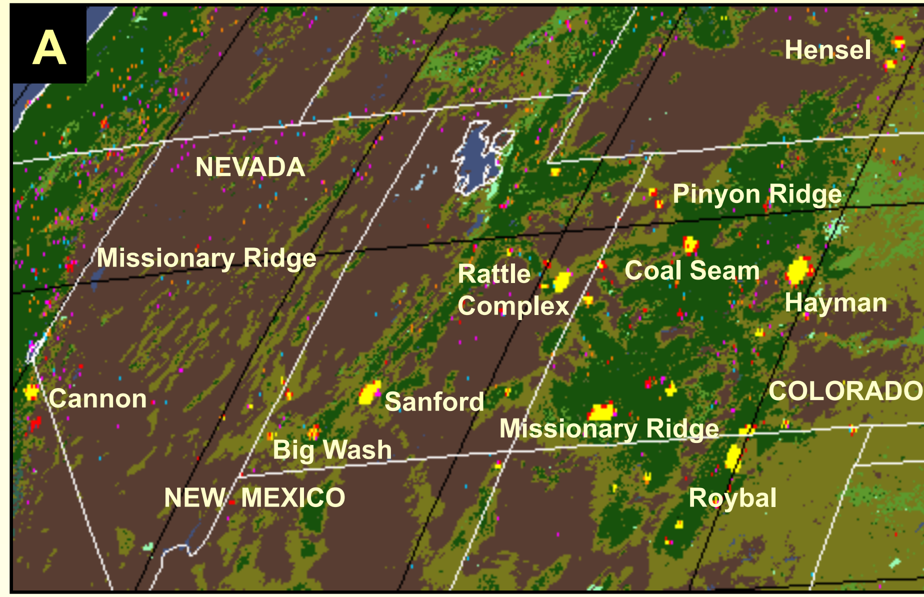
# of fires: 122,827 **10-year average: 106,343**

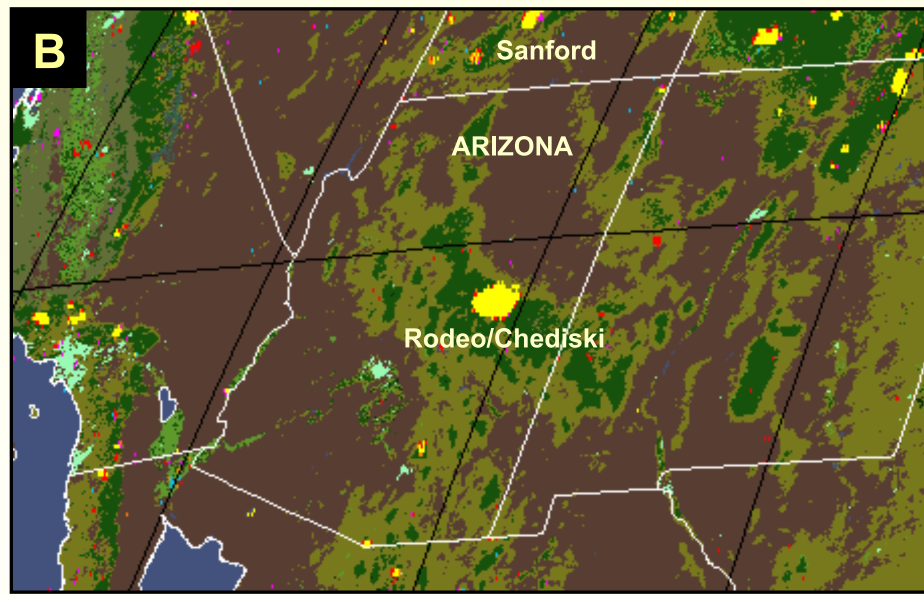
Acres burned: 8,422,237 **10-year average: 3,786,411**

Estimated Cost of Fire Suppression: $1.3 billion



WF_ABBA Fire Product: June 2002



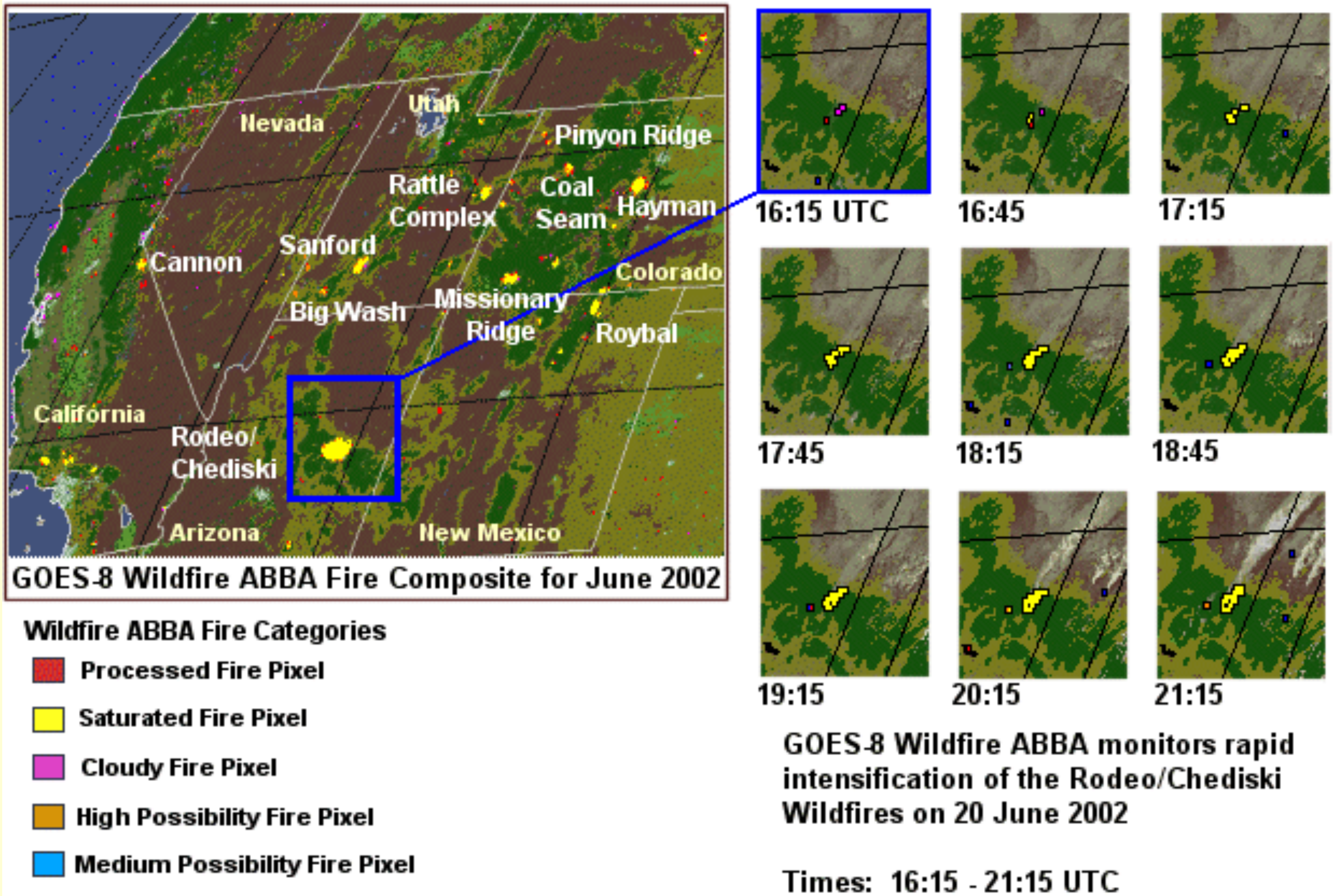


By June 2002 acreage consumed by wildfires in the Western United States was twice the 10-year average for this time of year. The GOES WF_ABBA monitored many of the conflagrations that occurred during the month of June as depicted in these composites of half-hourly fire products for the month of June.

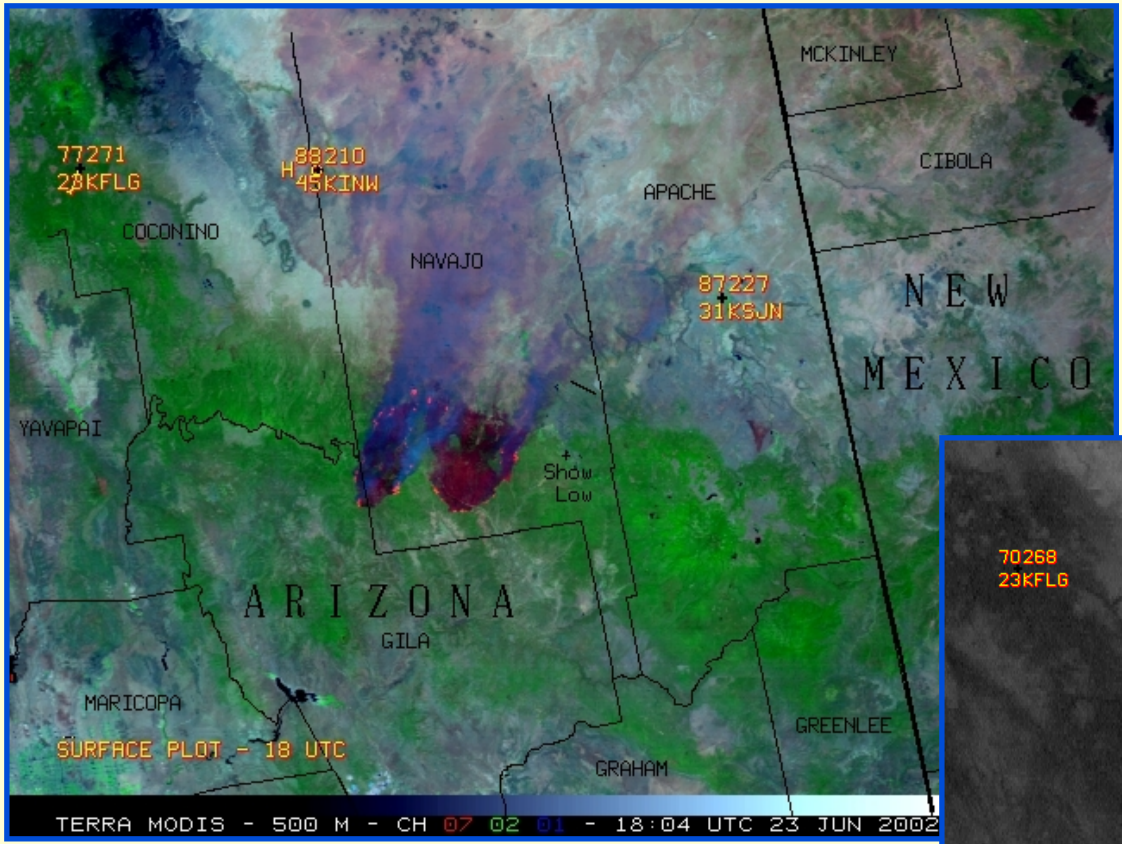
Wildfire ABBA Fire Legend

- Processed
- High Possibility
- Saturated
- Medium Possibility
- Cloudy

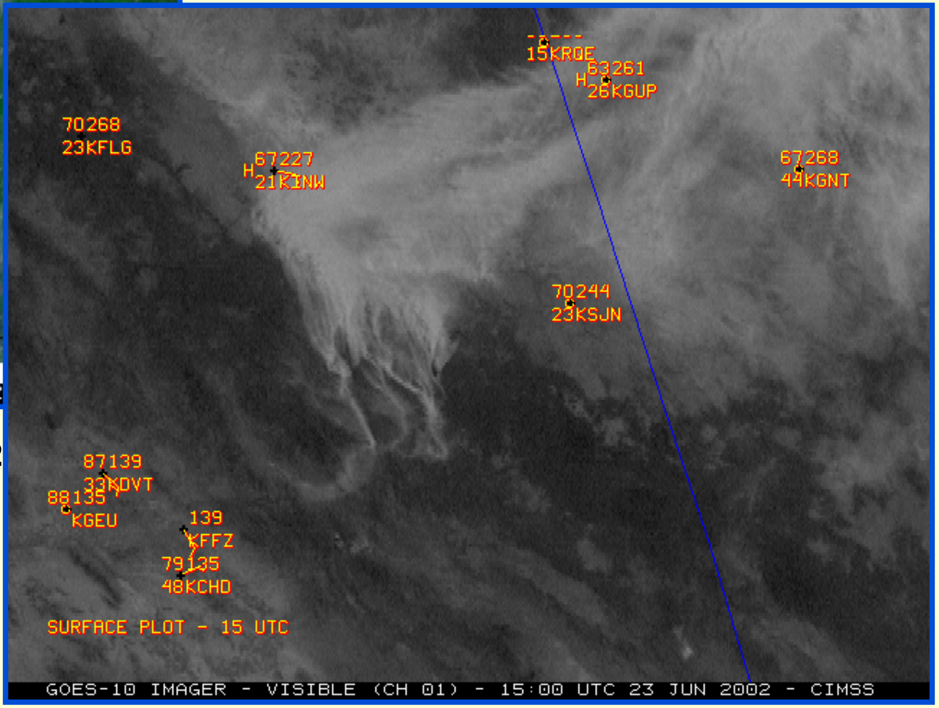
GOES WFABBA Monitors Rapid Intensification of Wildfires



Observations of the Rodeo/Chediski Fire in Arizona



TERRA MODIS Composite Image at 18:04 UTC, 23 June 2002
Courtesy of the CIMSS GOES Gallery

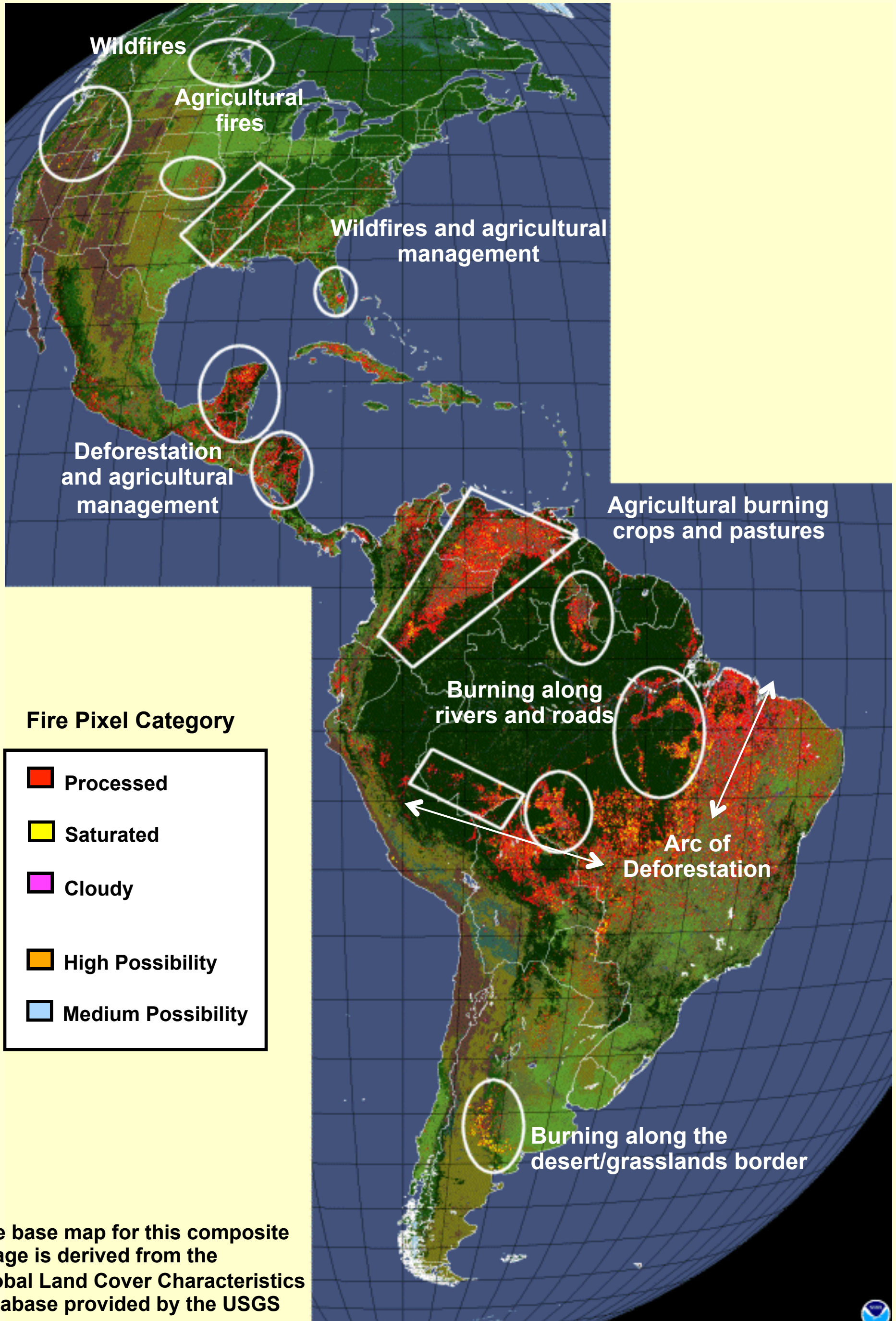


GOES-10 Visible Image at 15:00 UTC, 23 June 2002
Courtesy of the CIMSS GOES Gallery

GOES-8 Wildfire ABBA Summary Composite of Filtered Half-Hourly Fire Observations for the Western Hemisphere

Time Period:

September 1, 2000 to August 31, 2001

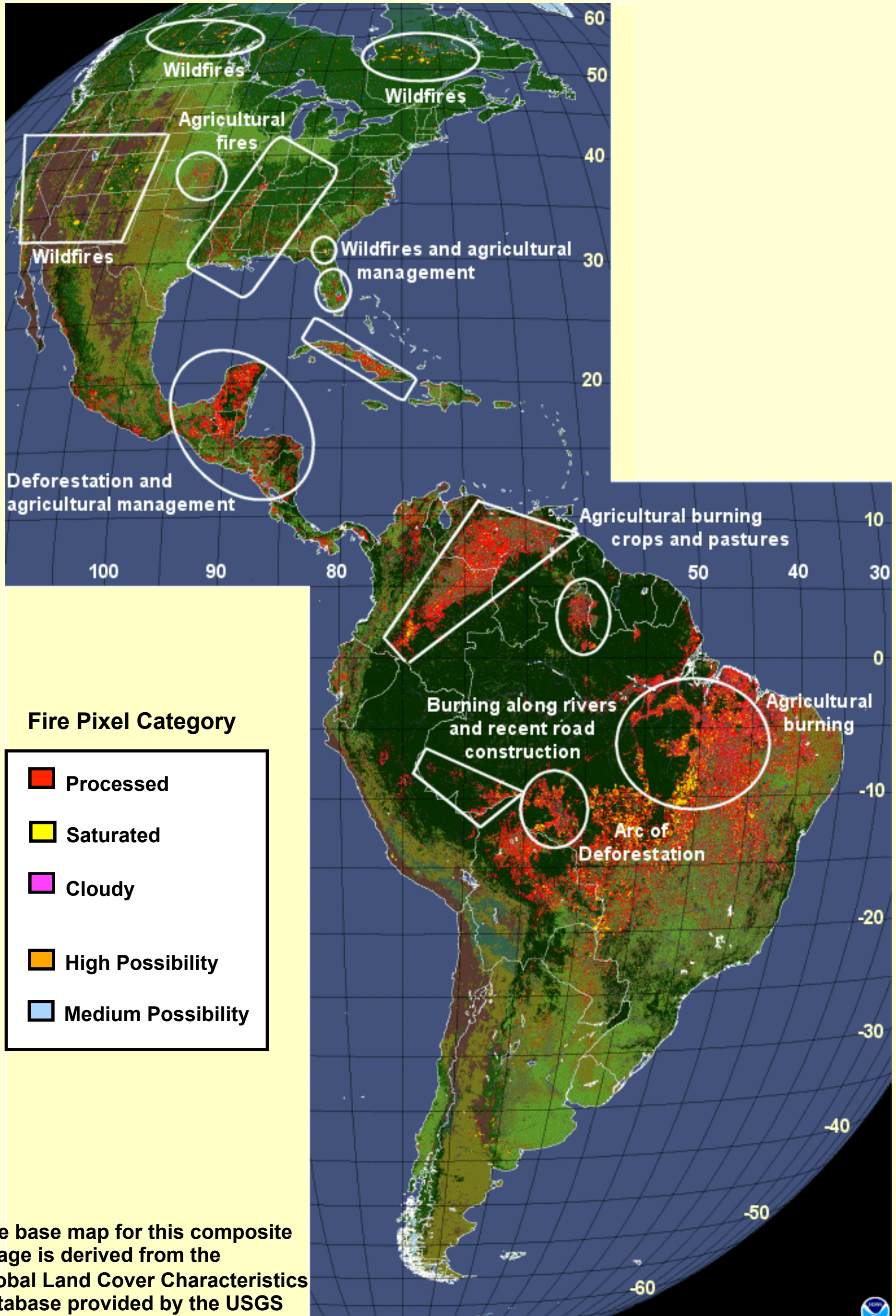


The base map for this composite image is derived from the Global Land Cover Characteristics database provided by the USGS

The composite shows the much higher incidence of burning in Central and South America, primarily associated with deforestation and agricultural management.

Fire Pixel Distribution

North America (30-70°N): 11%
Central America (10-30°N): 11%
South America (70°S-10°N): 78%



The base map for this composite image is derived from the Global Land Cover Characteristics database provided by the USGS

GOES-8 Wildfire ABBA Summary Composite of Filtered Half-Hourly Fire Observations for the Western Hemisphere

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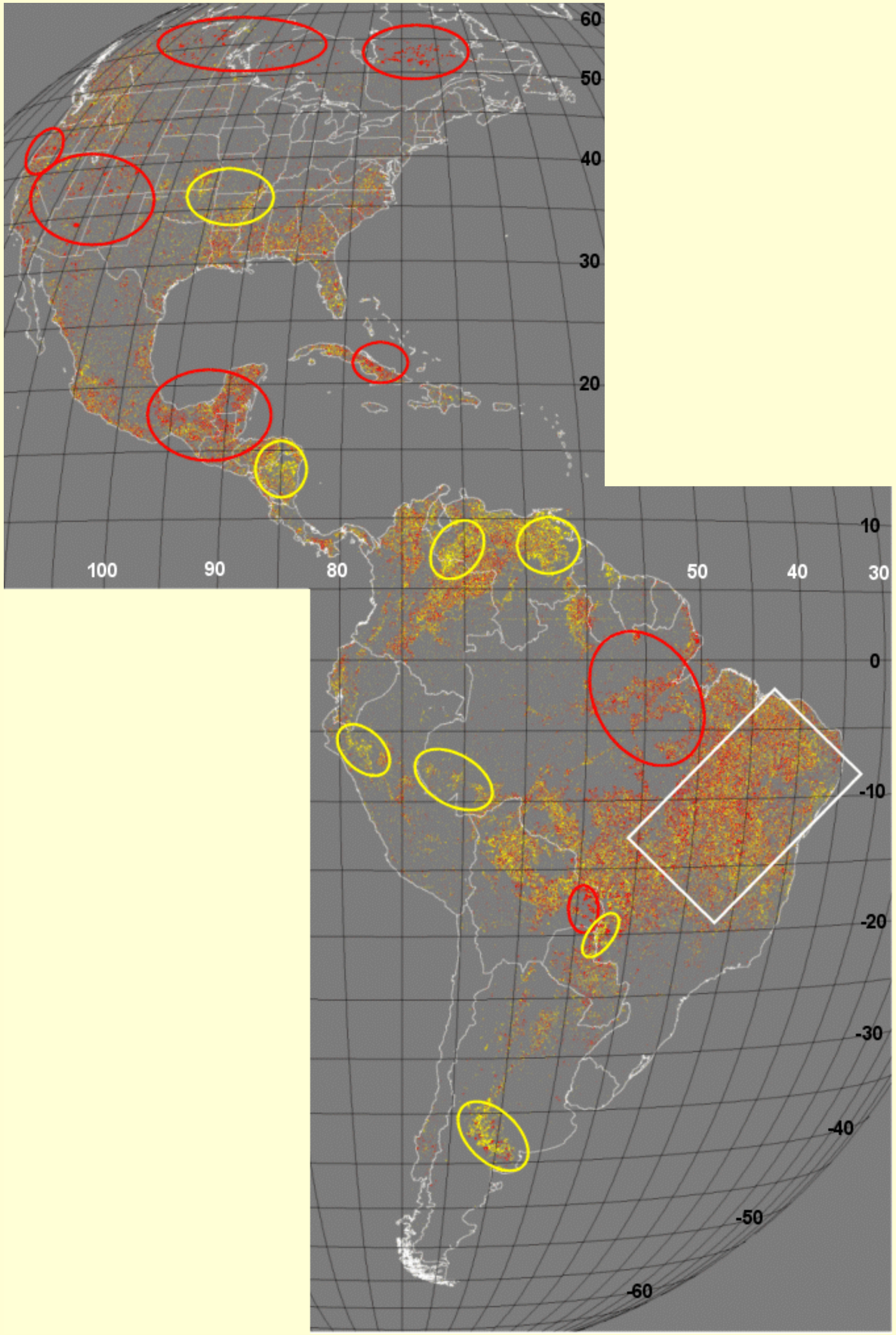
September 1, 2001 to August 31, 2002

The composite shows the much higher incidence of burning in Central and South America, primarily associated with deforestation and agricultural management.

Fire Pixel Distribution

North America (30-70°N): 12%
Central America (10-30°N): 11%
South America (70°S-10°N): 77%

GOES-8 Wildfire ABBA Filtered Fire Pixel Difference Composite For the Western Hemisphere

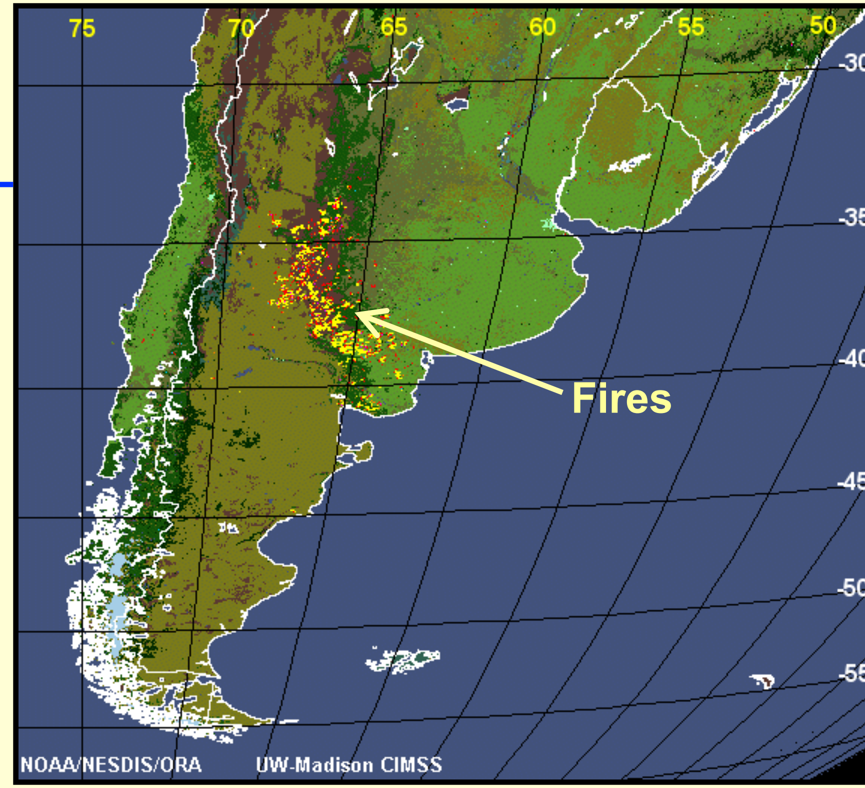


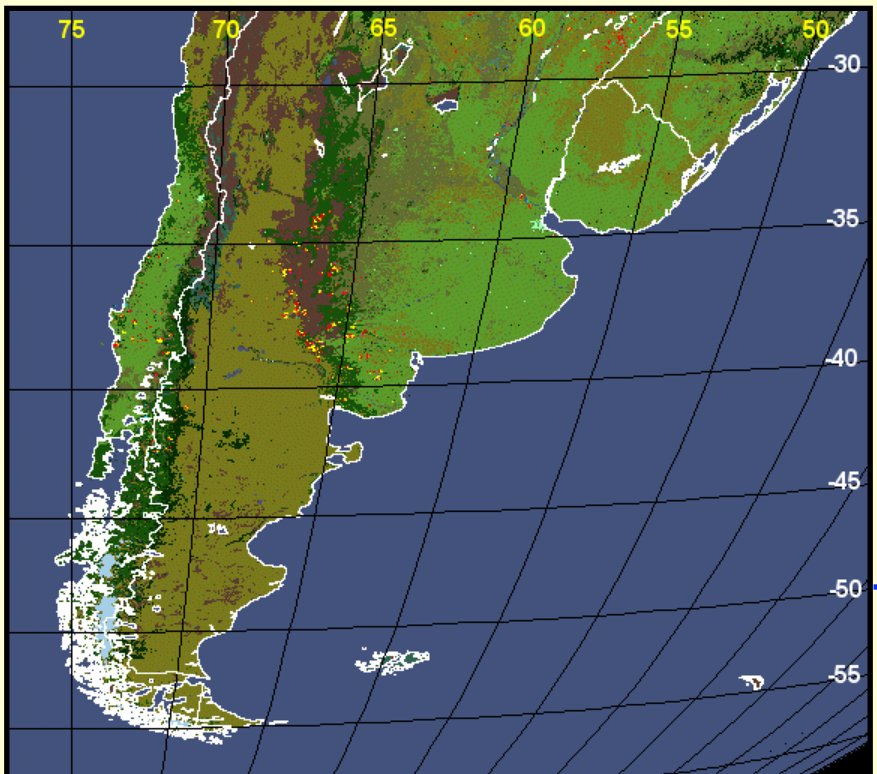
Yellow indicates fire pixels only detected in the first year: September 2000 – August 2001

Red indicates fire pixels only detected in the second year: September 2001 – August 2002

Comparisons of Agricultural Burning and Wildfires in Argentina in Austral Summer 2001 and 2002

1 December 2000 through 31 January 2001

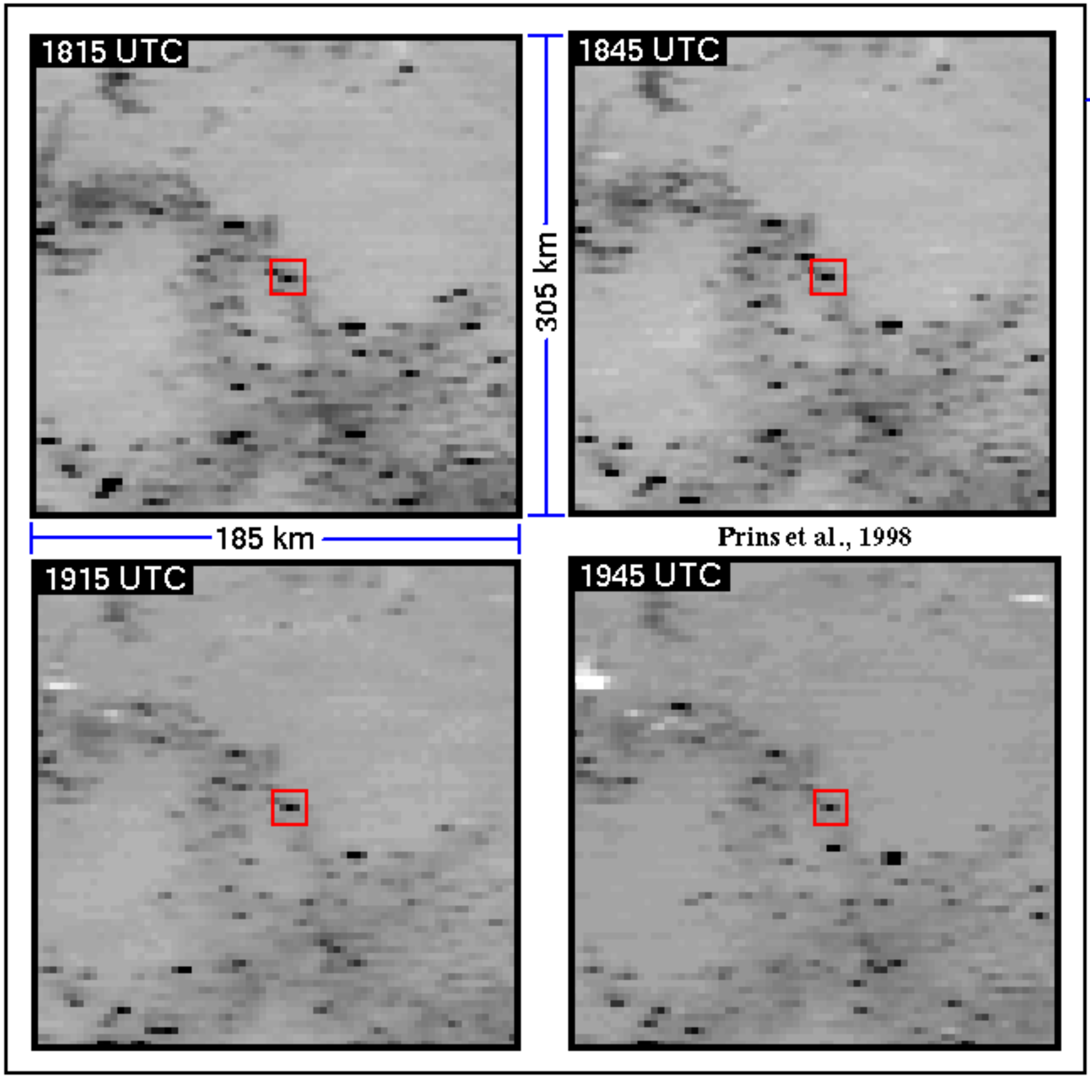




1 December 2001 through 31 January 2002

GOES-8 Observations of SCAR-B Prescribed Burn

UW-Madison SSEC/CIMSS   NOAA/NESDIS/ORA/ASPT



Prins et al., 1998

Time series of GOES-8 4 micron observations of the prescribed burn on 4 September 1995. The prescribed burn is outlined in red.

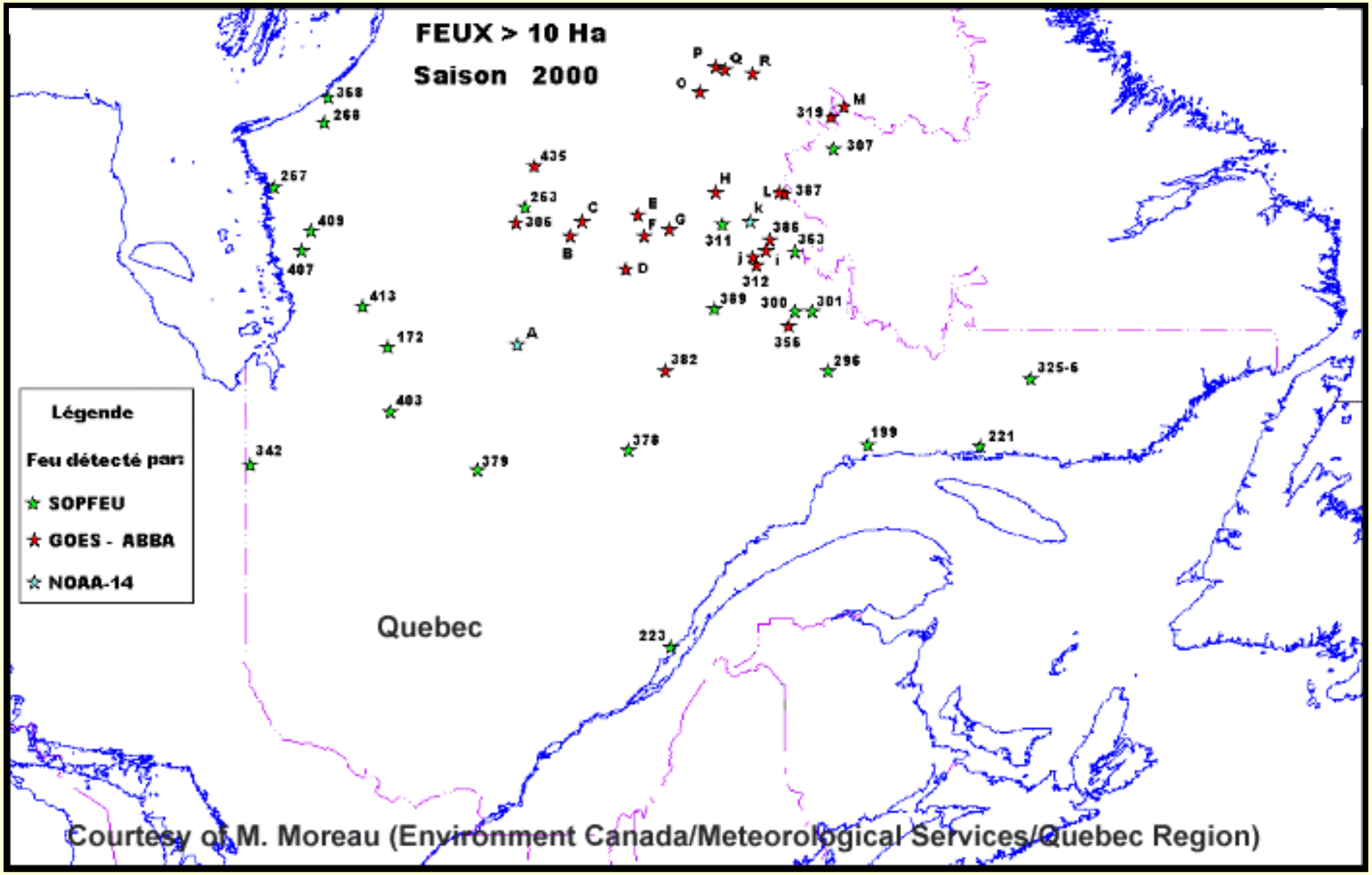
GOES-8 ABBA (Version 5.5) observations of the SCAR-B prescribed burn on 4 September 1995.

Location: 9.2 S, 63.2 W Rondonia, Brazil

Time (UTC)	GOES-8 Obs. SIRW T(K)	GOES-8 Obs. LIRW T(K)	GOES-8 Obs. Albedo	GOES-8 ABBA Fire Estimates Area (Acres)	GOES-8 ABBA Fire Estimates T(K)
1745	320.6	302.1	.16	8.9	594
1815	326.4	301.8	.15	2.2	838
1845	326.4	297.8	.18	INP	INP
1915	328.9	299.4	.18	INP	INP
1945	320.0	299.1	.20	4.2	686
2015	314.2	298.9	.19	2.8	678

NA indicates not available
INP indicates the fire was identified, not processed
Prins et al., 1998

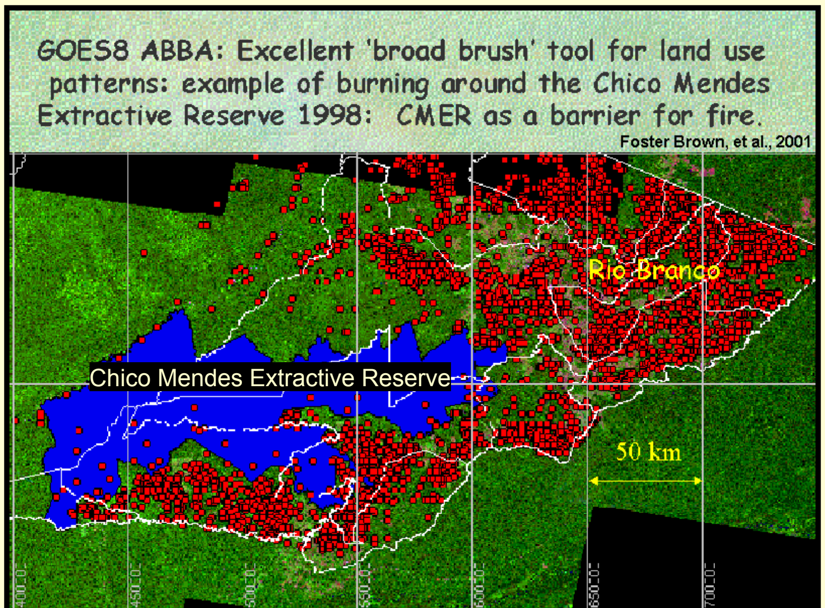
Remote Sensing Wildfire Detection Validation Study for the 2000 Fire Season in Quebec



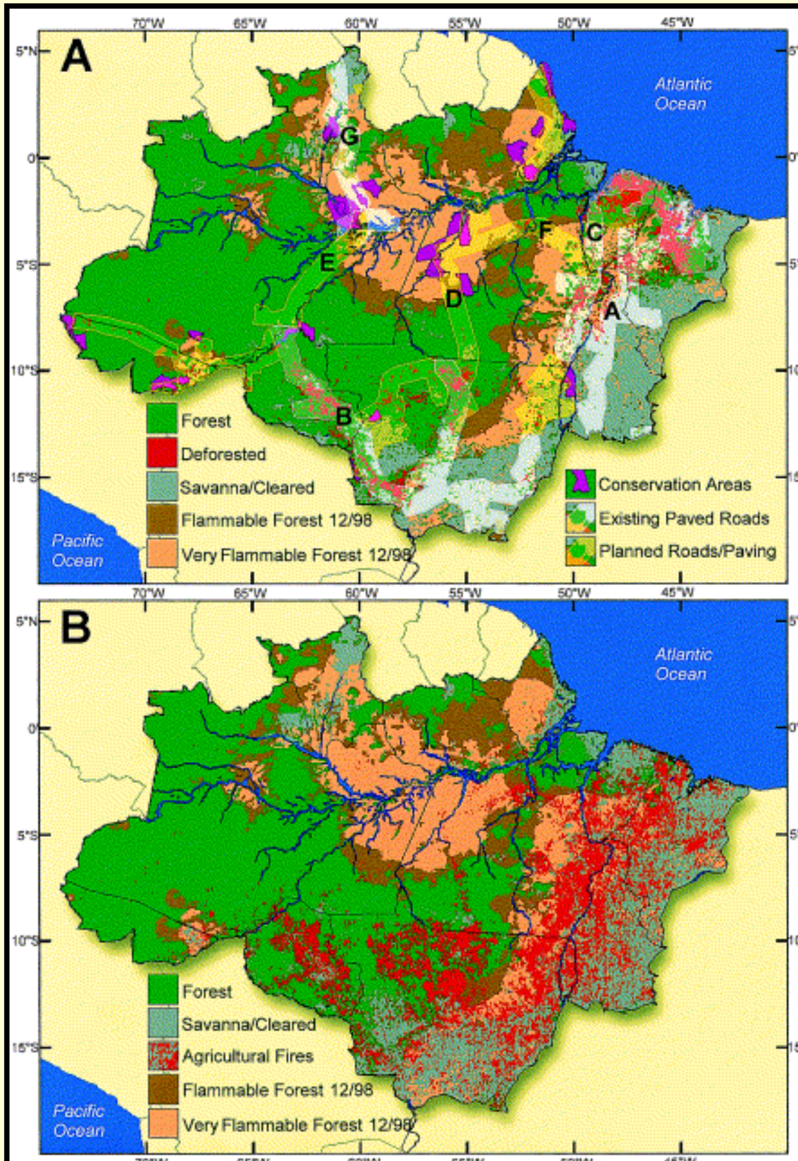
When considering fires that burned more than 10 ha, the GOES and AVHRR were the first to detect many of the fires in the restricted protection zone of Quebec. Approximately 16 of the fires detected by the GOES were in remote locations and were not detected by the SOPFEU, Quebec's forest fire detection and prevention agency.

GOES South American ABBA Fire Products Used in Land Use/Land Cover Change and Fire Dynamics Research

Universities, research institutes, and government planning agencies are using the GOES ABBA fire product as an indicator of land-use and land-cover change and carbon dynamics. GOES fire products also are being used to study the impact of road paving in South America on fire regime feedbacks and the future of the Amazon forests.

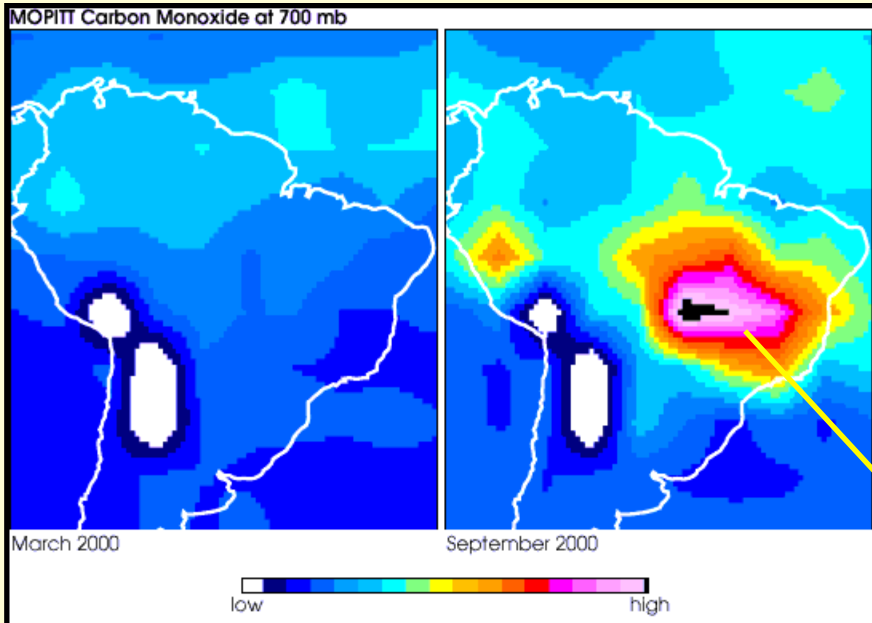


Foster Brown, et al., 2001



Nepstad, et al., 2001: Road paving, fire regime feedbacks, and the future of Amazon forests, Forest Ecology and Management, 154, 395-407.

Comparison of GOES ABBA Fire Observations and the EOS MOPITT CO Product



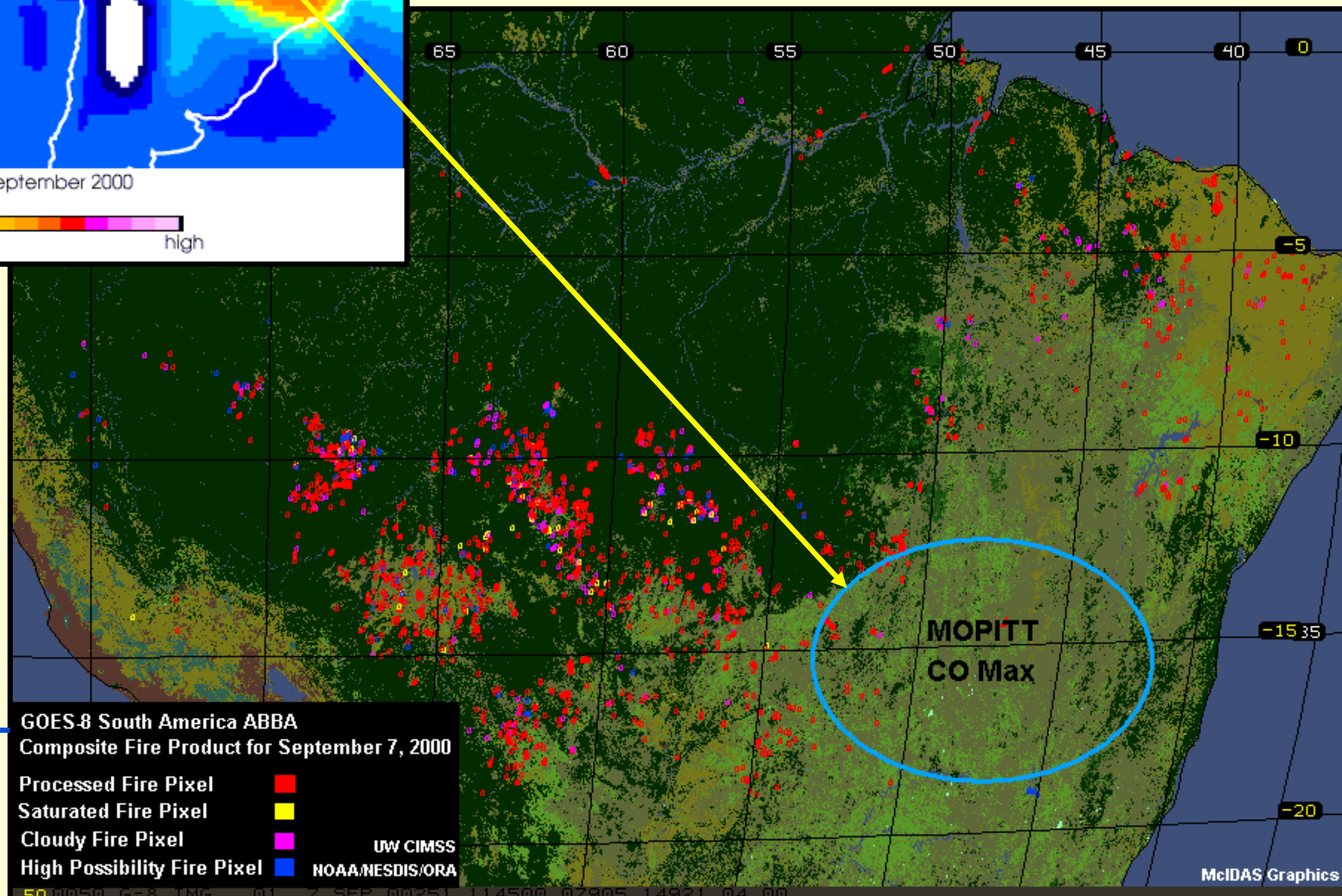
EOS MOPITT identifies elevated carbon monoxide associated with biomass burning detected with the GOES ABBA

MOPITT CO composite is courtesy of the MOPITT team:

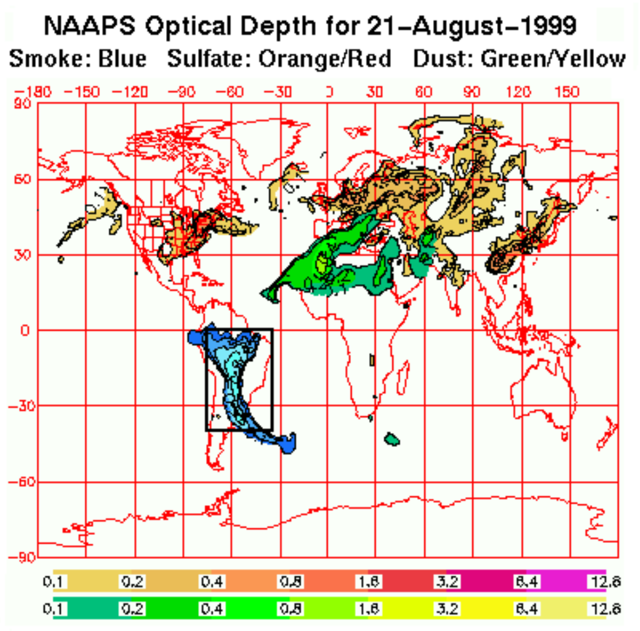
John Gille (NCAR),
James Drummond (University of Toronto),
David Edwards (NCAR)

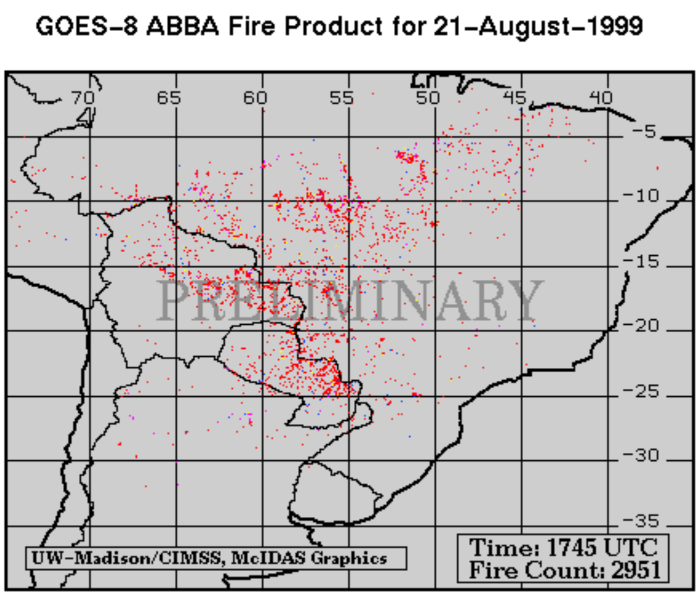
GOES-8 South American ABBA Composite Fire Product

September 7, 2000



Model Data Assimilation Activities

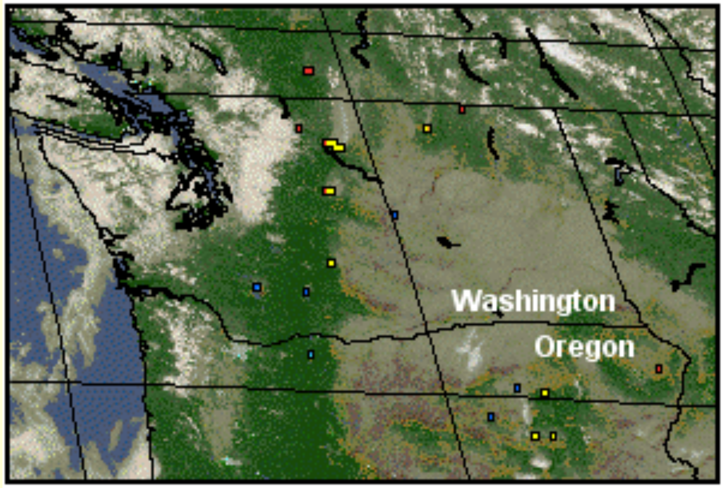




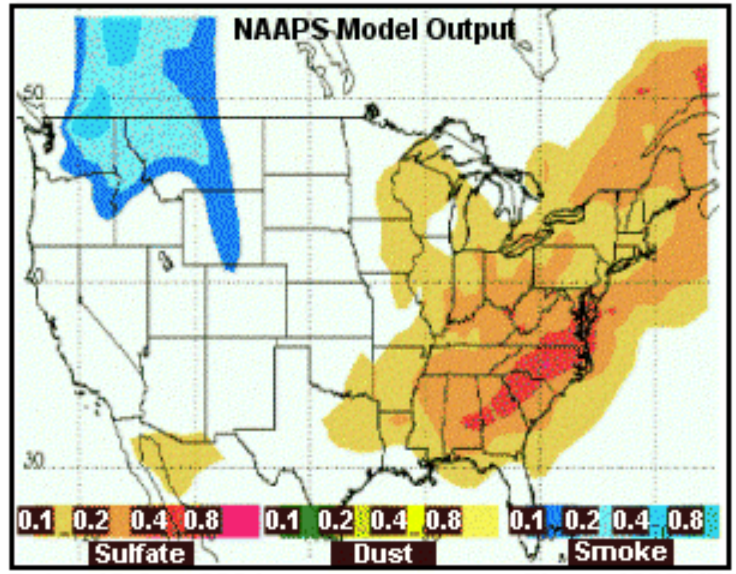
- At the Naval Research Laboratory (NRL-Monterey) GOES ABBA fire product information is being assimilated into the Navy Aerosol Analysis and Prediction System (NAAPS) to analyze and predict aerosol loading and transport as part of the NASA-ESE Fire Locating And Mapping of Burning Emissions (FLAMBE) project.

NAAPS animation: 1 - 15 September, 1999 (D. Westphal)

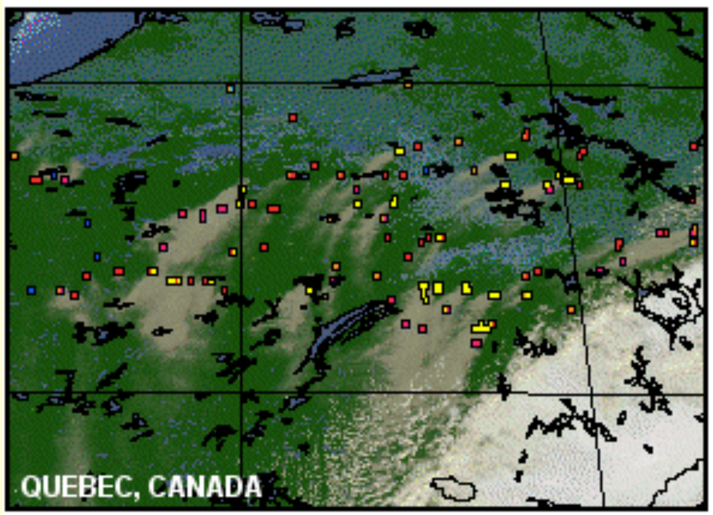
- Model output is being compared to GOES satellite derived aerosol products and TOMS products. Initial studies show the model output and aerosol products are in close agreement.



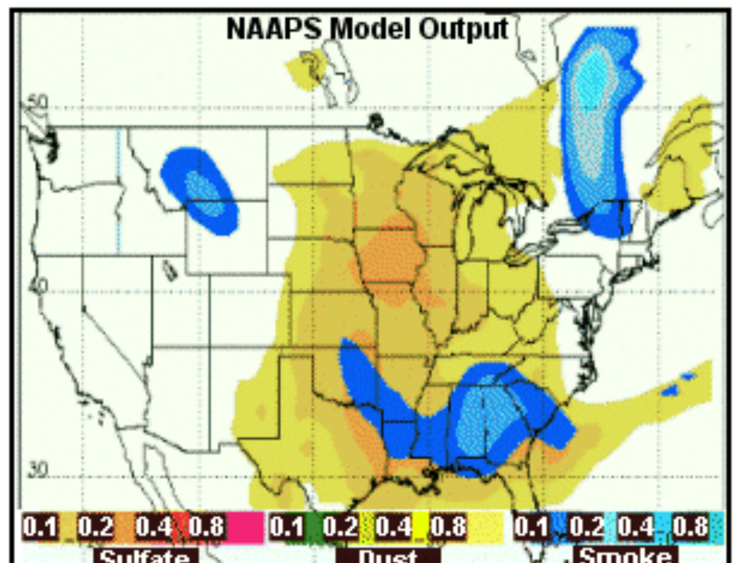
Wildfire ABBA Fire Product
Date: 17-Aug-2001
Time: 2200 UTC



Date: 18-Aug-2001 Time: 1200 UTC



Wildfire ABBA Fire Product
Date: 6-Jul-2002
Time: 17:45 UTC



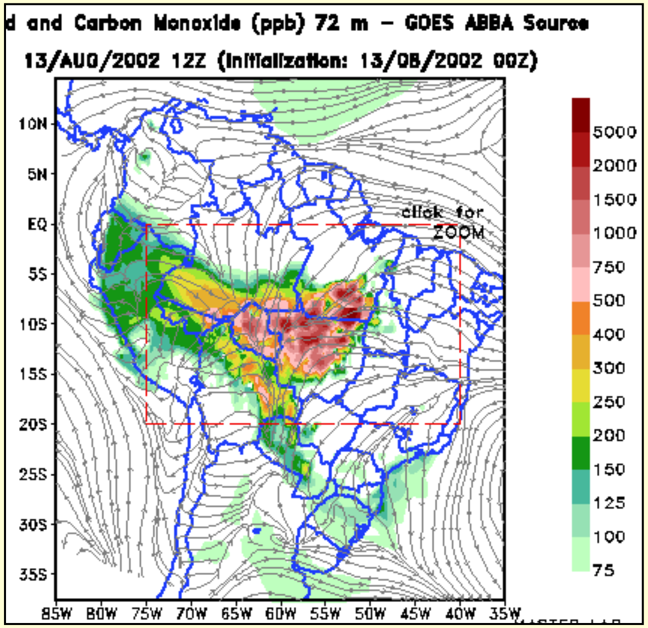
Date: 7-Jul-2002 Time: 1200 UTC

NOAA/NESDIS/ORA ASPT UW-Madison CIMSS

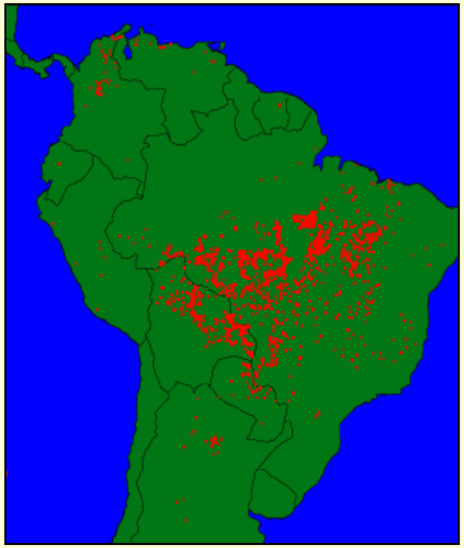
Navy Aerosol Analysis and Prediction System (NAAPS)
Courtesy of Doug Westphal, NRL, Monterey, CA

Real-Time Model Assimilation of the GOES-8 Wildfire ABBA (WF_ABBA) Fire Product at the University of Sao Paulo, Brazil

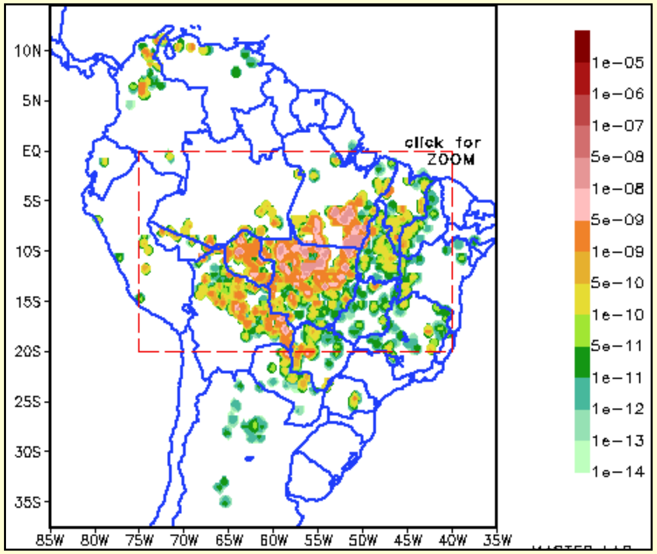
In South America, GOES-8 WF_ABBA fire products are assimilated into the Regional Atmospheric Modeling System (RAMS, CSU-USA) in real-time to diagnose the transport of biomass burning emissions of carbon monoxide and PM2.5. (Freitas and Longo, University of Sao Paulo)



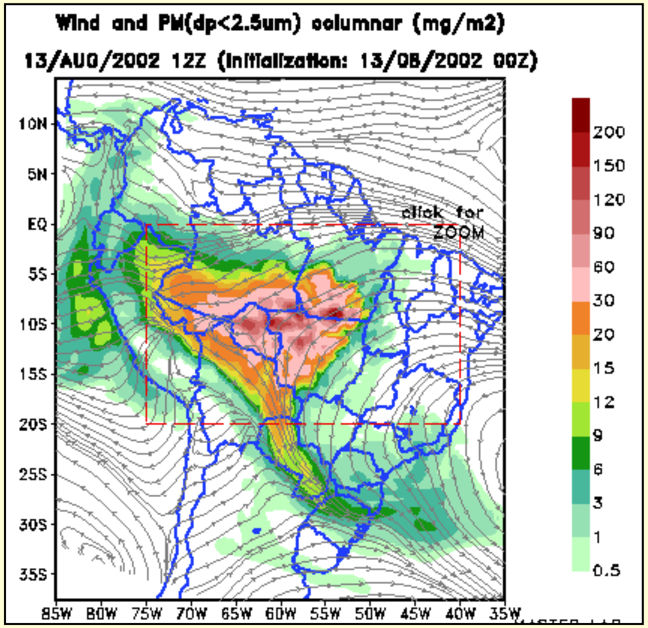
Modeled CO at surface for 13 August 2002 at 12 UTC



GOES WF_ABBA Fire Product Point Sources for 13 August 2002



Emissions based on WF_ABBA (kg [CO]/m2 sec)



Modeled PM2.5 (int. column) for 13 August 2002 at 12 UTC

Imagery courtesy of S. Freitas and K. Longo, USP

Future Environmental Satellite Fire Monitoring Capabilities

❖ Global Geostationary Fire Monitoring System

- **GOES-E/W** Imager
- METEOSAT Second Generation (**MSG**) (2002)
  Spinning Enhanced Visible and InfraRed Imager (SEVIRI)
- Multi-functional Transport Satellite (**MTSAT-1R**) (2003)
  Japanese Advanced Meteorological Imager (JAMI)

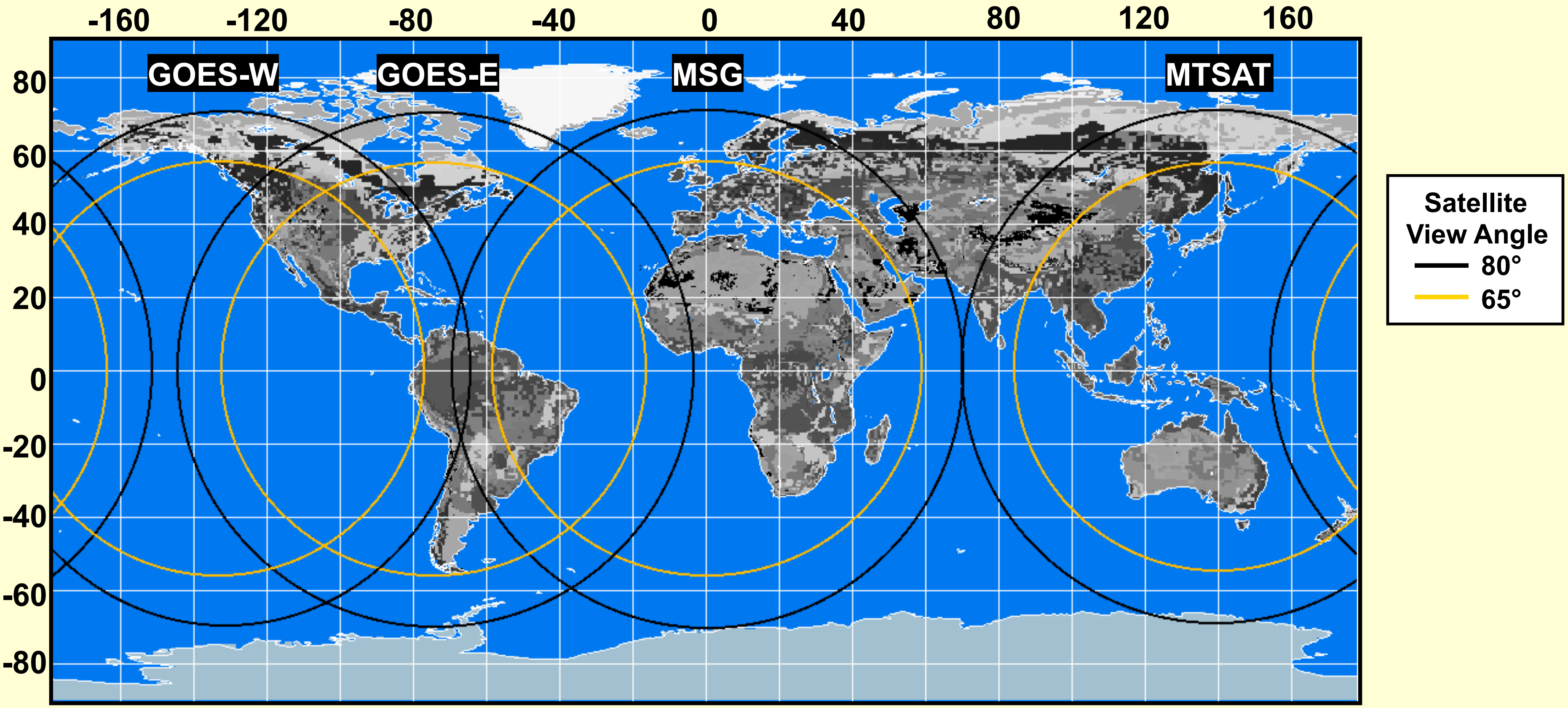
❖ NOAA Operational Systems

- NPOESS Preparatory Project Visible/Infrared Imager Radiometer Suite (**VIIRS**) (2005)
- Advanced Baseline Imager (**ABI**) (2010)

❖ International Platforms Designed for Fire Detection

- German Aerospace Center (DLR) Bi-spectral Infrared Detection (**BIRD**) (2001)
- German Aerospace Center (DLR) Intelligent Infrared Sensor System (**FOCUS**) (ISS) (2004-2006)
- Consortium of DLR and European space industries are designing the Forest Fire Earth Watch (**FFEW-FUEGO**) satellite mission (2005)

International Global Geostationary Active Fire Monitoring: Geographical Coverage

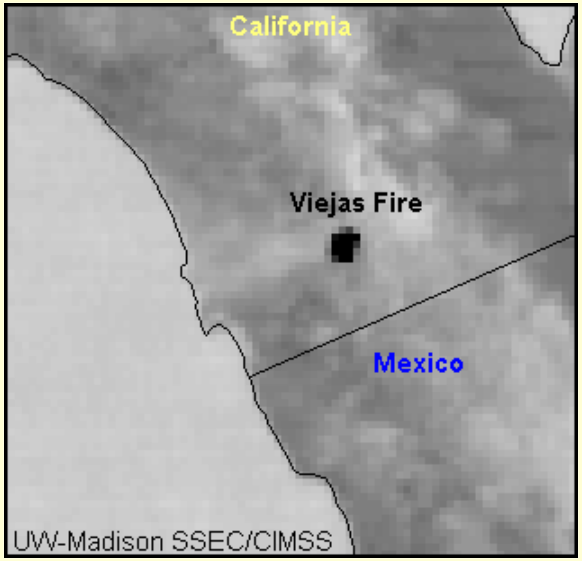


Satellite	Spectral Bands	Resolution IGFOV (km)	SSR (km)	Full Disk Coverage	4 µm Saturation Temperature (K)	Minimum Fire Size at Equator (at 750 K)
GOES-E	1 visible 4 IR	1.0 4.0 (8)	0.57 2.3	3 hours	335 K	0.15
GOES-W	1 visible 4 IR	1.0 4.0 (8)	0.57 2.3	3 hours	322	0.15
MSG **SEVIRI** (2002)	3 visible 1 near-IR 8 IR	1.6 (4.8) 4.8 4.8	1.0 (3.0) 3.0 3.0	15 minutes	> 335	0.22
MTSAT-1R JAMI (2003)	1 visible 4 IR	0.5 2.0		18 minutes	~320	0.03

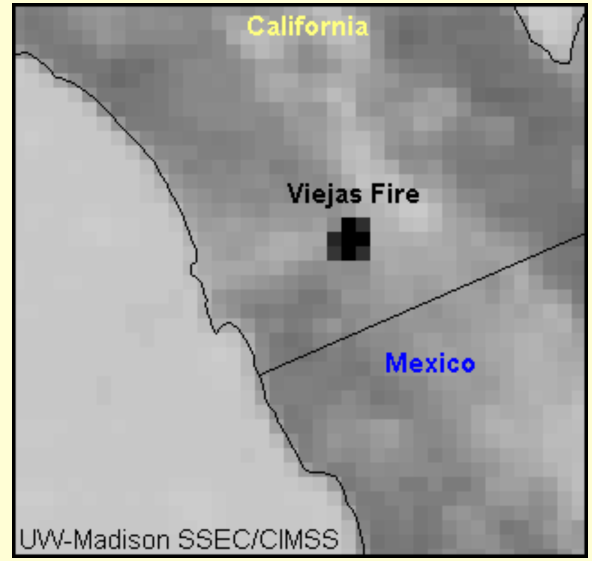
What Will NOAA's Geostationary Satellites Offer Ten Years From Now?

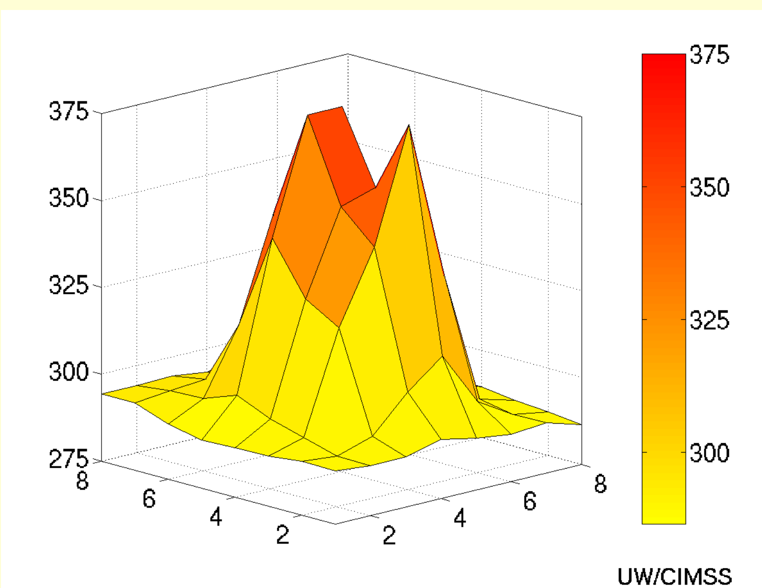
GOES-R and GOES-I/M Simulations of Viejas Fire
Using MODIS Data: January 3, 2001 at 1900 UTC

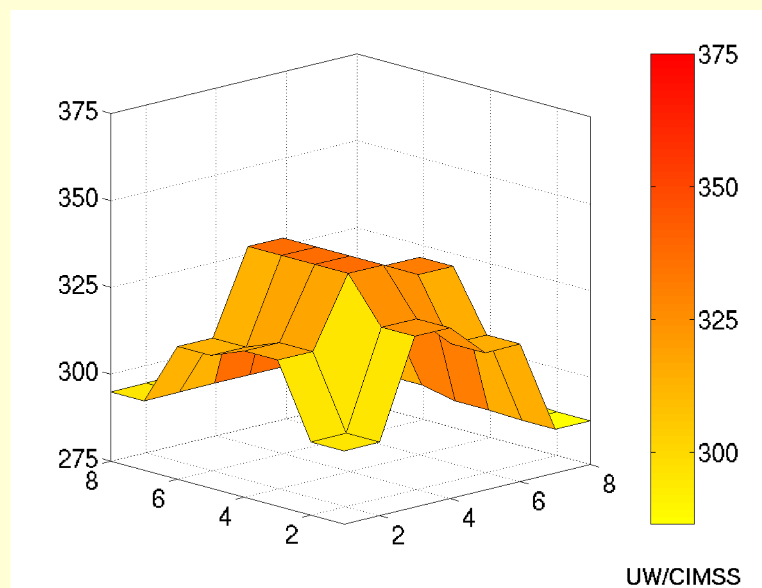
Simulated GOES-R: 3.9 micron



Simulated GOES-I/M: 3.9 micron







For more information on
The GOES Biomass Burning
Program visit our web site at:

http://cimss.ssec.wisc.edu/
goes/burn/abba.html