Production of Synthetic GOES-R ABI Fire Hotspot Proxy Datasets

RAMMB GOES-R AWG Proxy Data Group

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Production of GOES-R ABI Synthetic Fire Hotspot Imagery

- Use the CSU RAMS forecast model (nested grids) to simulate observed mesoscale weather with horizontal grid spacing as small as 400 m.
- Add fires to simulated mesoscale events:
  - For simulated fires: Add equally-distributed artificial fire hotspots.
  - For real fires: use CIMSS ABBA-retrieved datasets (based on GOES-11 and 12) for location and fire temperature information.
- The RAMS output is used as input to an observational operator. In conjunction with OPTRAN code and radiative transfer models, synthetic radiances (and brightness temperatures) are produced for the 3 GOES-R ABI wavelengths (3.9 μm, 10.35 μm, 11.2 μm) that are expected to be used for fire detection.
- GOES-R ABI synthetic imagery is produced at the appropriate locations by using an approximation of the point spread function (PSF) and the latitude and longitude of the pixels.
- McIDAS and GIF imagery is created for all proxy datasets, in addition to ASCII files, for AWG testing.

GOES-R ABI Bands and Bandwidths

ABI Band	Central Wavelength (μm)	Wavelength Range (μm)	Band Explanation	Spatial Resolution (km) @ nadir
1 (blue)	0.47	0.45 - 0.49	Visible/reflective	1
2 (red)	0.64	0.59 - 0.69	Visible/reflective	0.5
3	0.865	0.846 - 0.885	Reflective	1
4	1.378	1.371 - 1.386	Cirrus	2
5	1.61	1.58 - 1.64	Snow/ice	1
6	2.25	2.225 - 2.275	Particle size	
7	3.90	3.80 - 4.00	Shortwave IR window	2
8	6.19	5.77 - 6.6	Water vapor	
9	6.95	6.75 - 7.15	Water vapor	
10	7.34	7.24 - 7.44	Water vapor	
11	8.5	8.3 - 8.7	Water vapor, SO2	
12	9.61	9.42 - 9.8	Ozone	
13	10.35	10.1 - 10.6	Longwave IR window	
14	11.2	10.8 - 11.6	Longwave IR window	
15	12.3	11.8 - 12.8	Longwave IR	
16	13.3	13.0 - 13.6	Longwave IR	

GOES-R ABI Dynamic Range

ABI Band	Central Wavelength (μm)	Wavelength Range (μm)	Scene Temperature (min – max)	Max Radiance (mW/(m^2•sr•cm^{-1}))
1 (blue)	0.47	0.45 - 0.49		14.4
2 (red)	0.64	0.59 - 0.69		21.1 day (1.05 night)
3	0.865	0.846 - 0.885		22.8
4	1.378	1.371 - 1.386		21.7
5	1.61	1.58 - 1.64		20.0
6	2.25	2.225 - 2.275		12.1
7	3.90	3.80 - 4.00	4 – 400 K	
8	6.19	5.77 - 6.6	4 – 300 K	
9	6.95	6.75 - 7.15	4 – 300 K	
10	7.34	7.24 - 7.44	4 – 320 K	
11	8.5	8.3 - 8.7	4 – 330 K	
12	9.61	9.42 - 9.8	4 – 300 K	
13	10.35	10.1 - 10.6	4 – 330 K	
14	11.2	10.8 - 11.6	4 – 330 K	
15	12.3	11.8 - 12.8	4 – 330 K	
16	13.3	13.0 - 13.6	4 – 305 K	

Synthetic Fire Hotspot Datasets created by the RAMM Team

- **Case 1:**

  Artificial fire hot spots embedded in severe weather event Kansas - 8 May 2003

- **Case 2:**

  Agricultural fires in Central America - 24 April 2004

- **Case 3:**

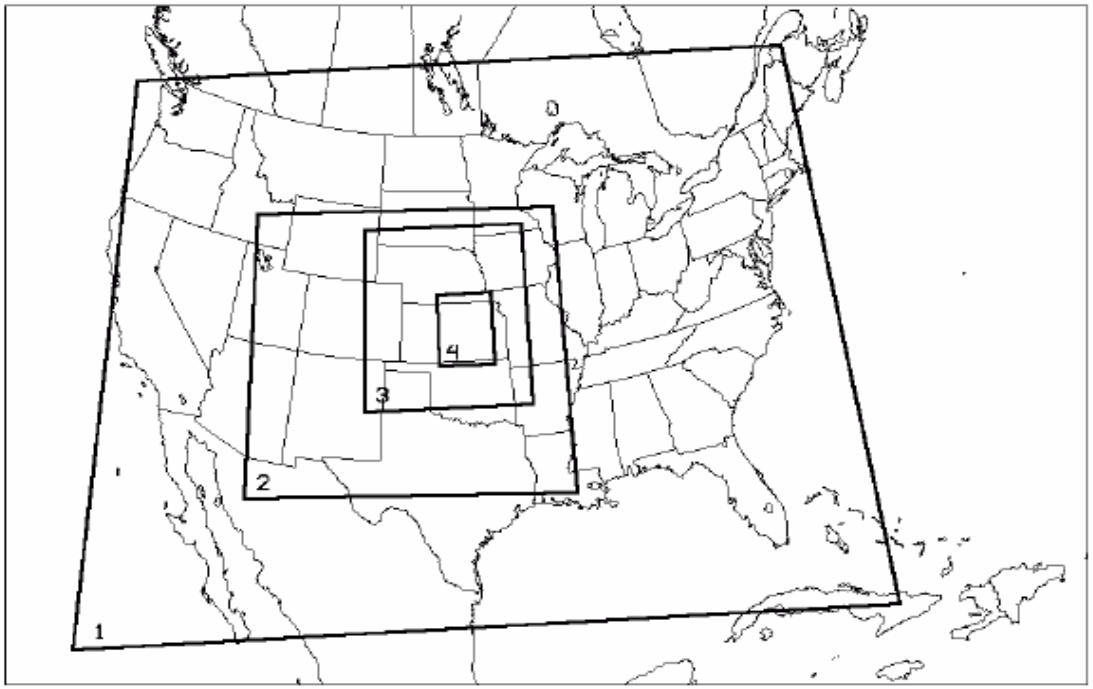
  Lightning-induced fires in Southern California - 23 and 26 October 2007

- **Additional Case Study:**

  Rich Wildland Lightning Fire California - 31 July 2008

Case Study 1:
Kansas Fire Hotspots - 8 May 2003

Map of the United States along with boundaries of grids 1 through 4 that were used for the 8 May 2003 severe weather simulation.



RAMS Forecast Model: Nested Grids

Grid 1: 90 x 66 points
50 km spacing

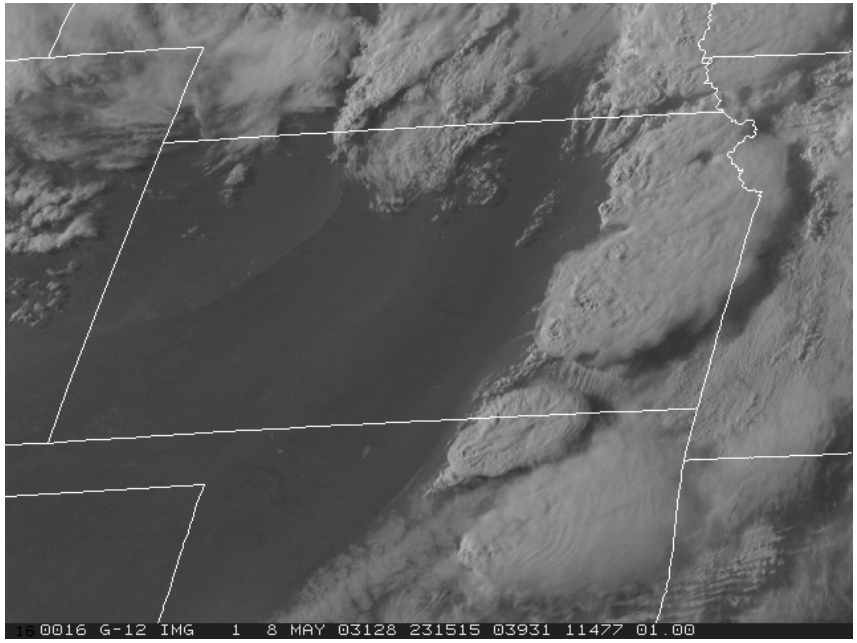
Grid 2: 192 x 162 points
10 km spacing

Grid 3: 502 x 522 points
2 km spacing

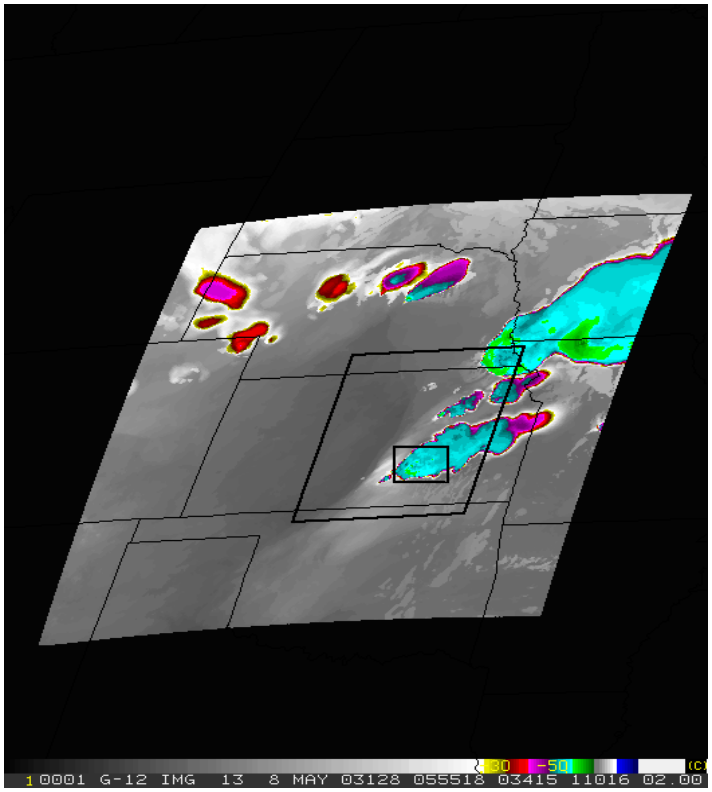
Grid 4: 852 x 1027 points
400 m spacing

Example of Synthetic Satellite Imagery

Severe Weather Event - 8 May 2003



1 km GOES-12 visible image at 2315 UTC



Synthetic data: 2 km GOES-ABI at 10.35 μm at 2000 UTC

The larger black box shows the size of grid 4

Fire Hot Spot Simulation

CIMSS Guidelines October 2006

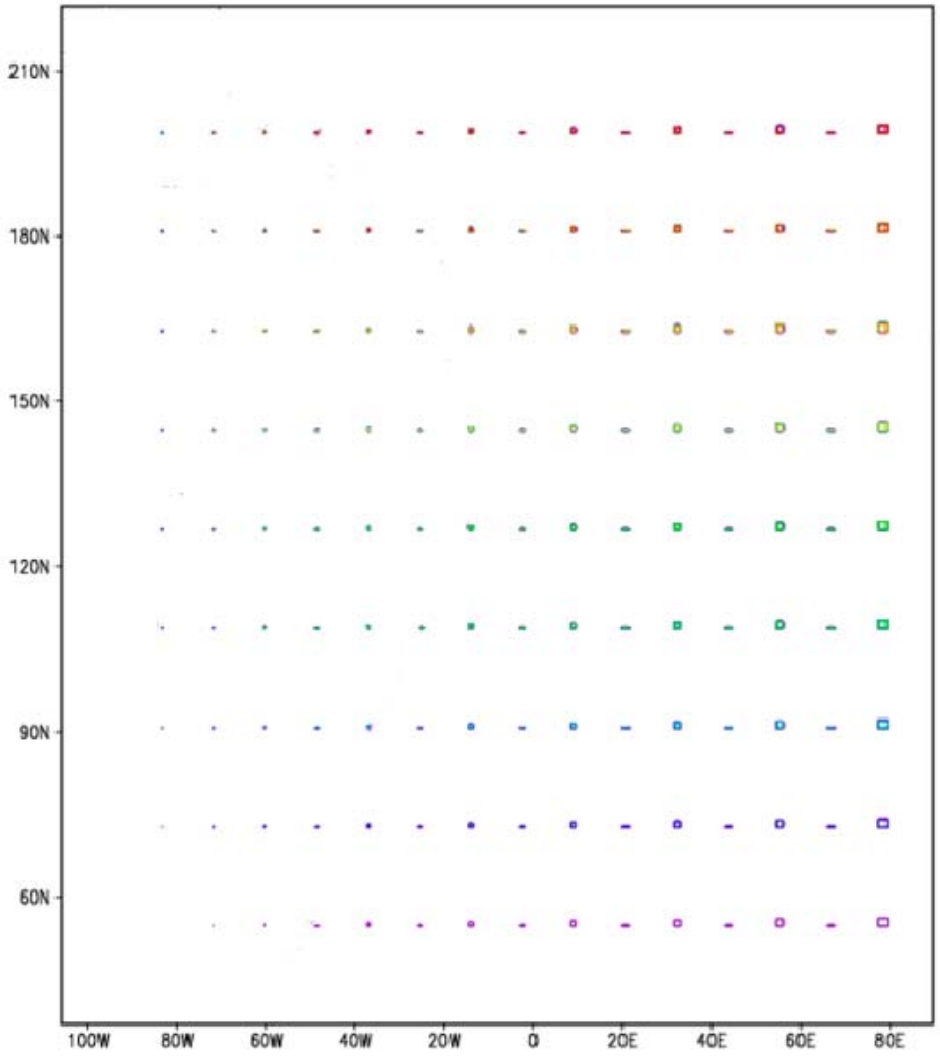
- **GOES ABI Fires**
  - Spatial resolution is 2.0 km, IGFOV is ~1.78 km
  - Saturation in the 3.9 μm (shortwave IR) band is 400 K
  - Saturation in the 10.3 μm and 11.2 μm bands is 330 K

- **Suggested/Estimated Measurement Ranges:**
  - Temperature 400 K – 1200 K

Area (at sub-satellite point with no atmospheric attenuation):

Average Subpixel Fire Temperature (K)	Min Area for Detection (m^2)	Max Area at Saturation (m^2)
400	~ 35,000 m^2	4,000,000 m^2 (4 km^2)
750	~ 500 m^2	~ 52,000 m^2
1200	~ 75 m^2	~ 7,900 m^2

Fire Hot Spot Matrix



Grid 4:

400 m pixel resolution

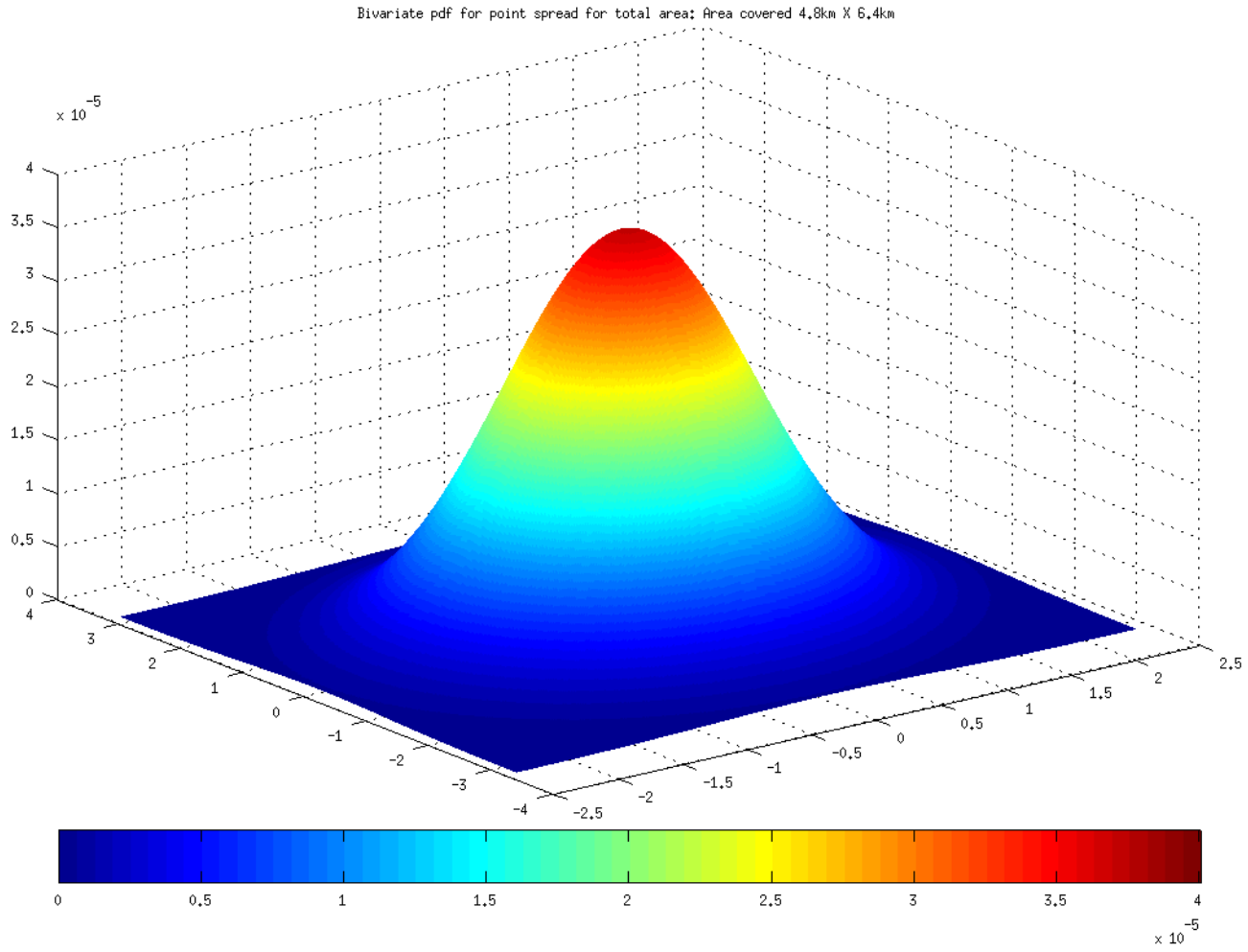
Fire Matrix:

9 x 15 fire hot spots

↑ 9 rows of increasing fire temperature from 400 K (bottom, purple) to 1200 K (top, red) in 100 K intervals

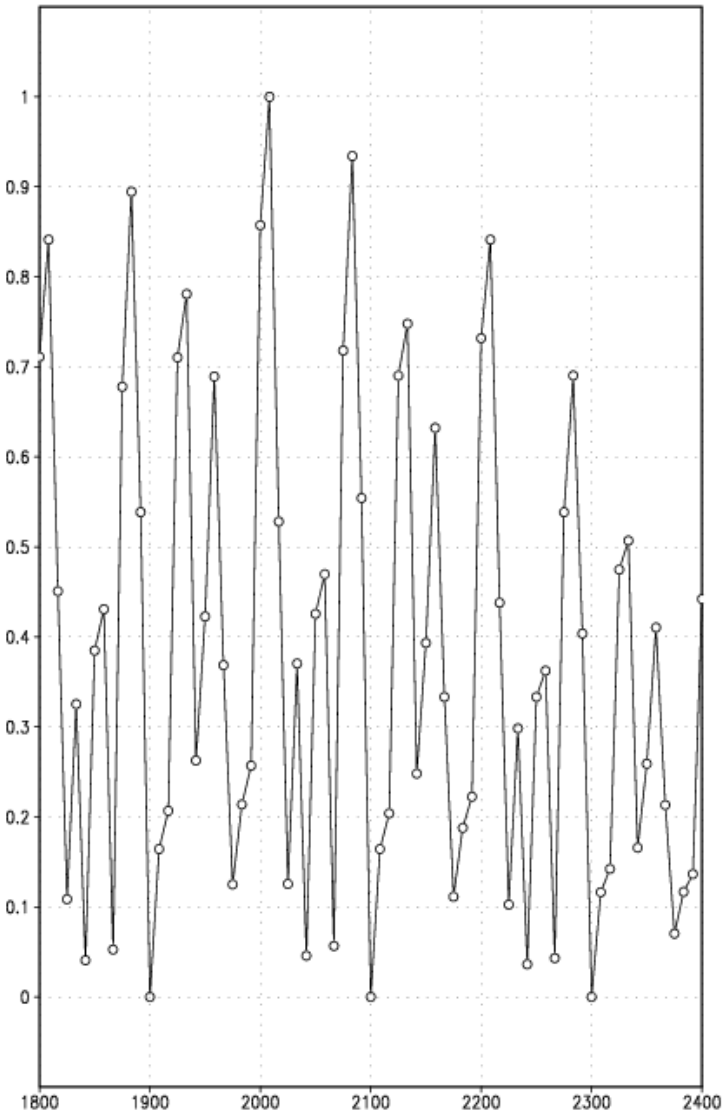
→ 15 columns of increasing fire size (and dot size) from 1x1 pixels, 2x1, 2x2, …… 15x1, 15x15 pixels

Three dimensional view of the point spread function used to build GOES-R ABI footprints from RAMS model produced synthetic 400 m data.



High-frequency flickering fire hot spots

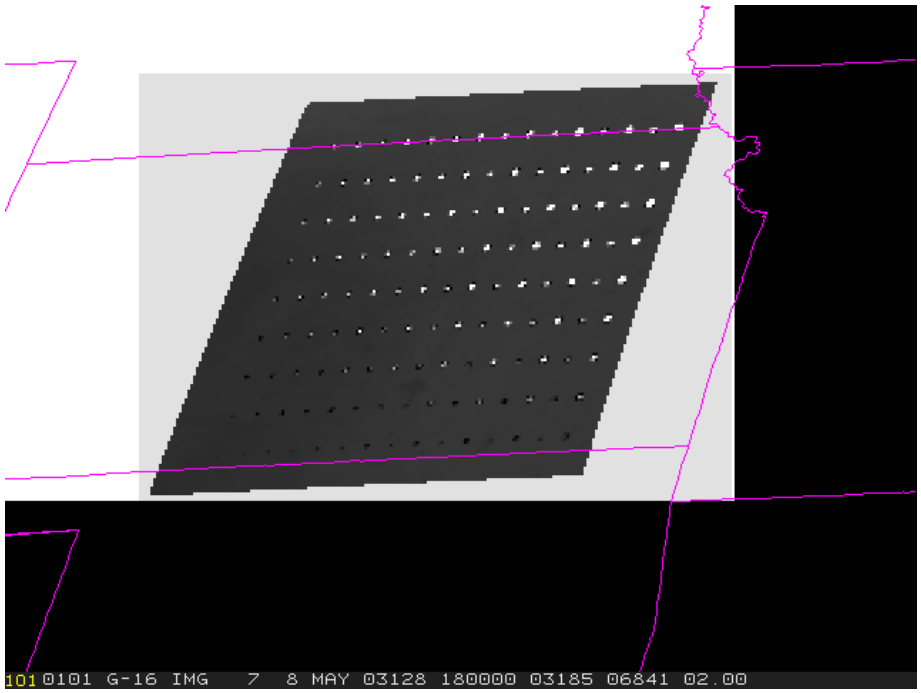
- 6-hour Kansas fire forecast period:
  8 May 2003 - 1800 to 2400Z
- Fire temperature Production:
  5-min interval
- Variable surface emissivity
  (Ben Ruston, NRL)
- Consultation with Doug Fox (NPS):
  - Flickering fire frequency: 10-15 min
  - Diurnal damping of fire temperature amplitude



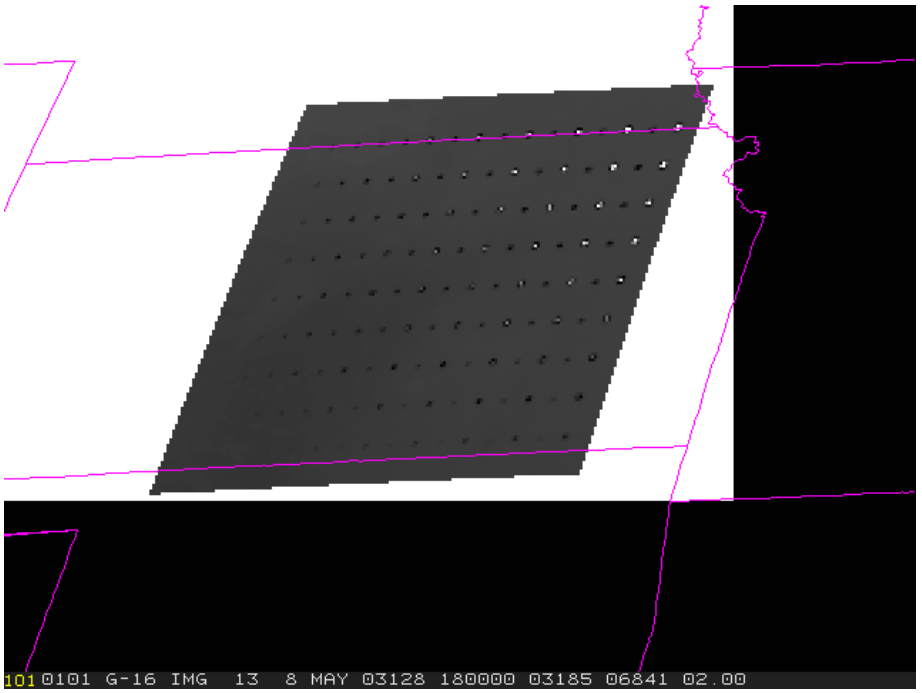
Brightness Temperature

9 x 15 fire hot spots / flickering fires - no clouds

3.9 µm



10.35 µm



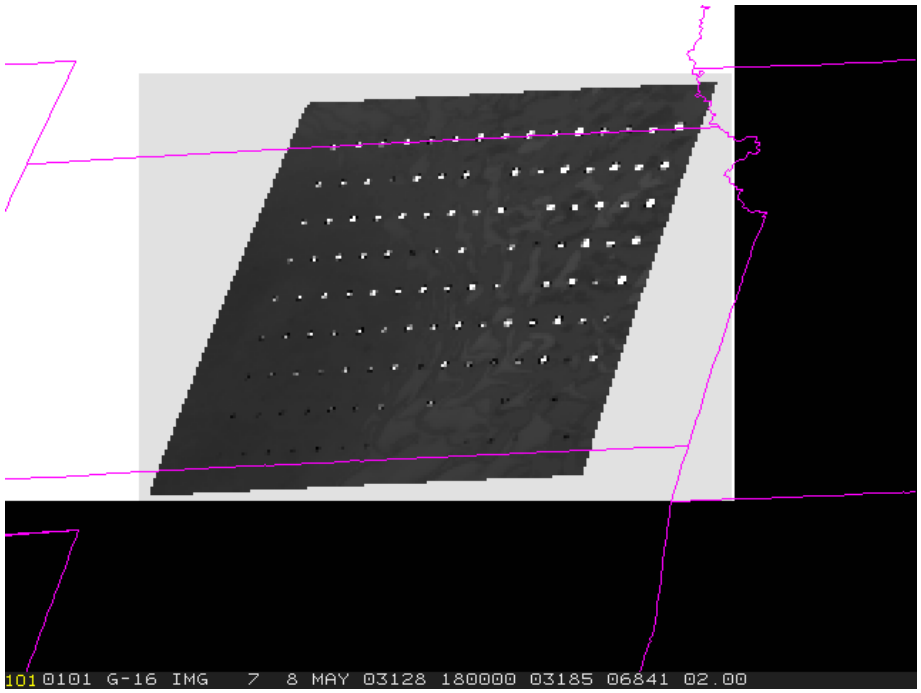
Black and white pixels are fires.

Black pixels are **not** saturated; **white** pixels are **saturated**.

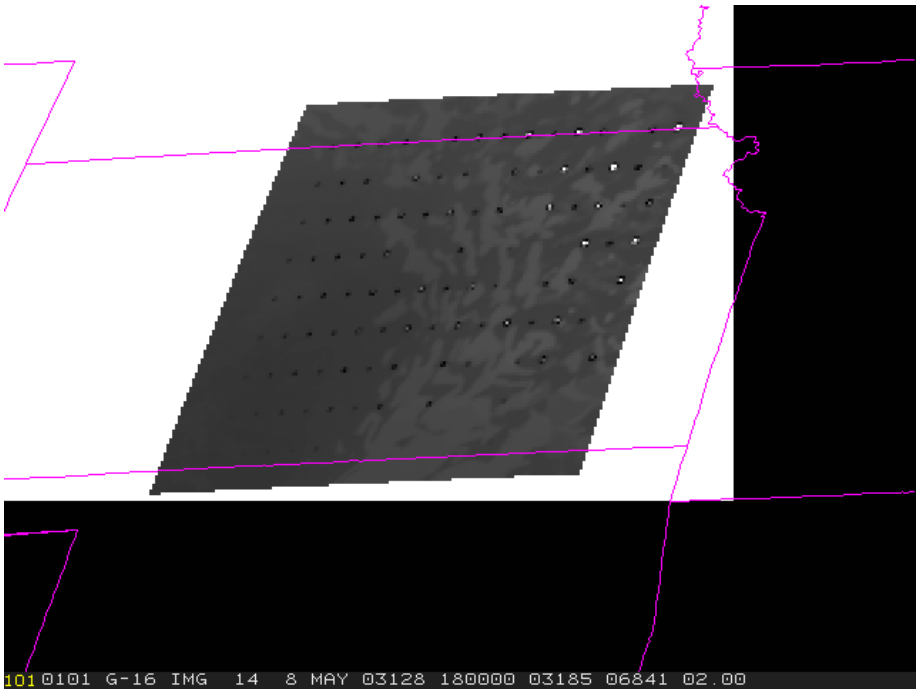
Brightness Temperature

9 x 15 fire hot spots / constant fires - with clouds

3.9 µm



11.2 µm

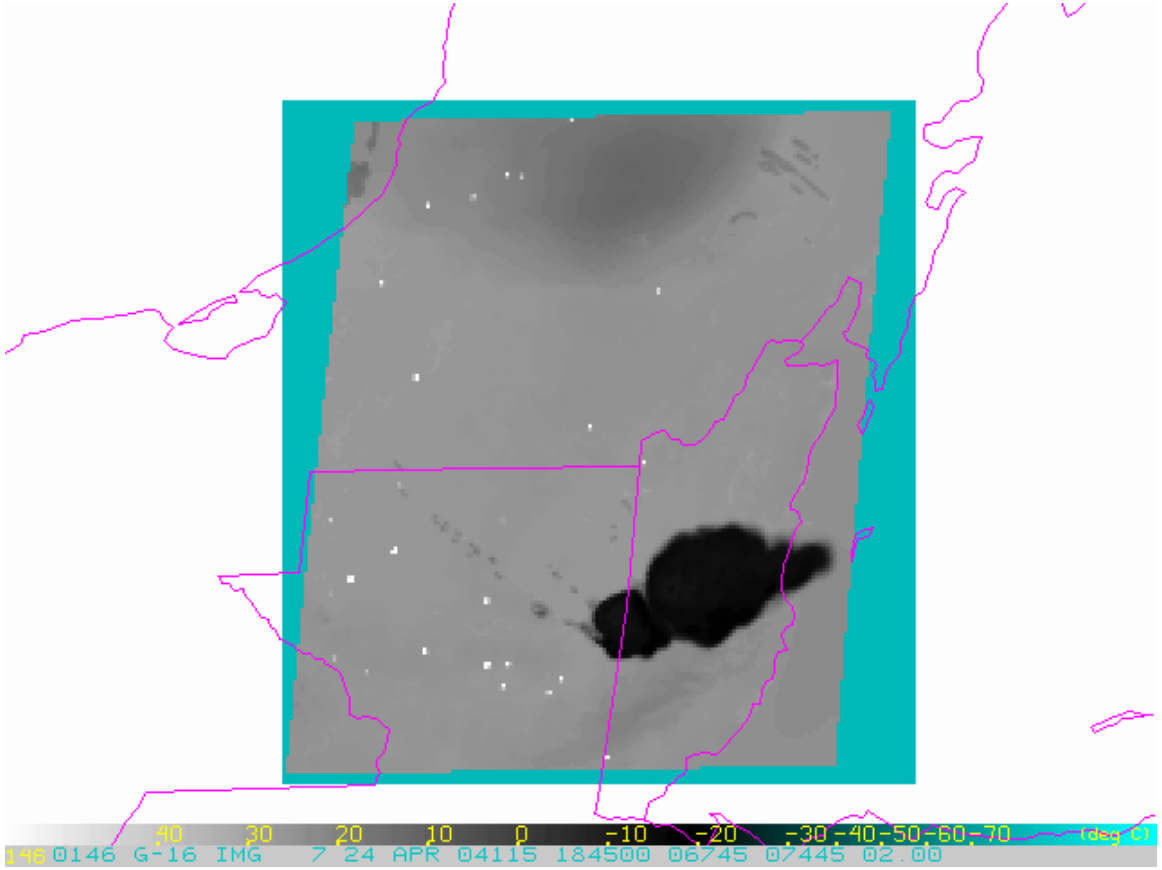


Black and white pixels are fires.

Black pixels are **not** saturated; **white** pixels are **saturated**.

Case 2: Central America – 24 April 2004

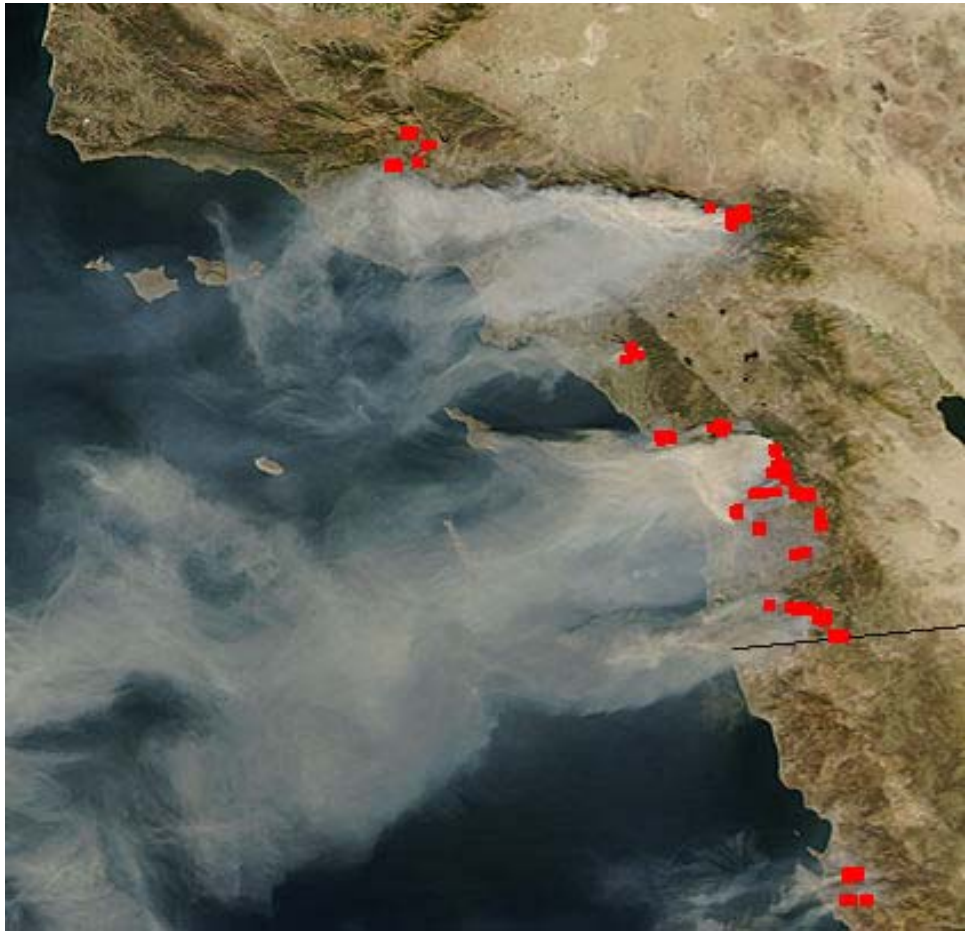
Agricultural Fires in Mexico, Guatemala, and Belize

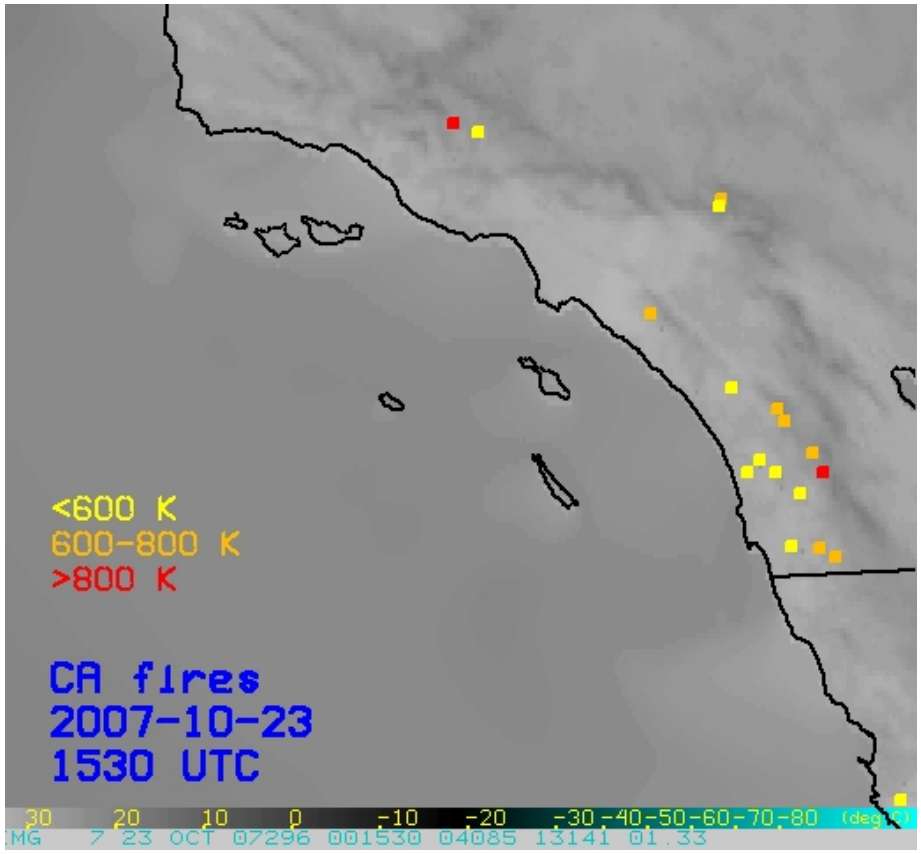


Synthetic GOES-R ABI 3.9 µm
24 April 2004 - 1840 to 2100 UTC (5 min interval)

Click here to view GOES-12 observations of the same fire event

Case 3: California Fires - 23 October 2007

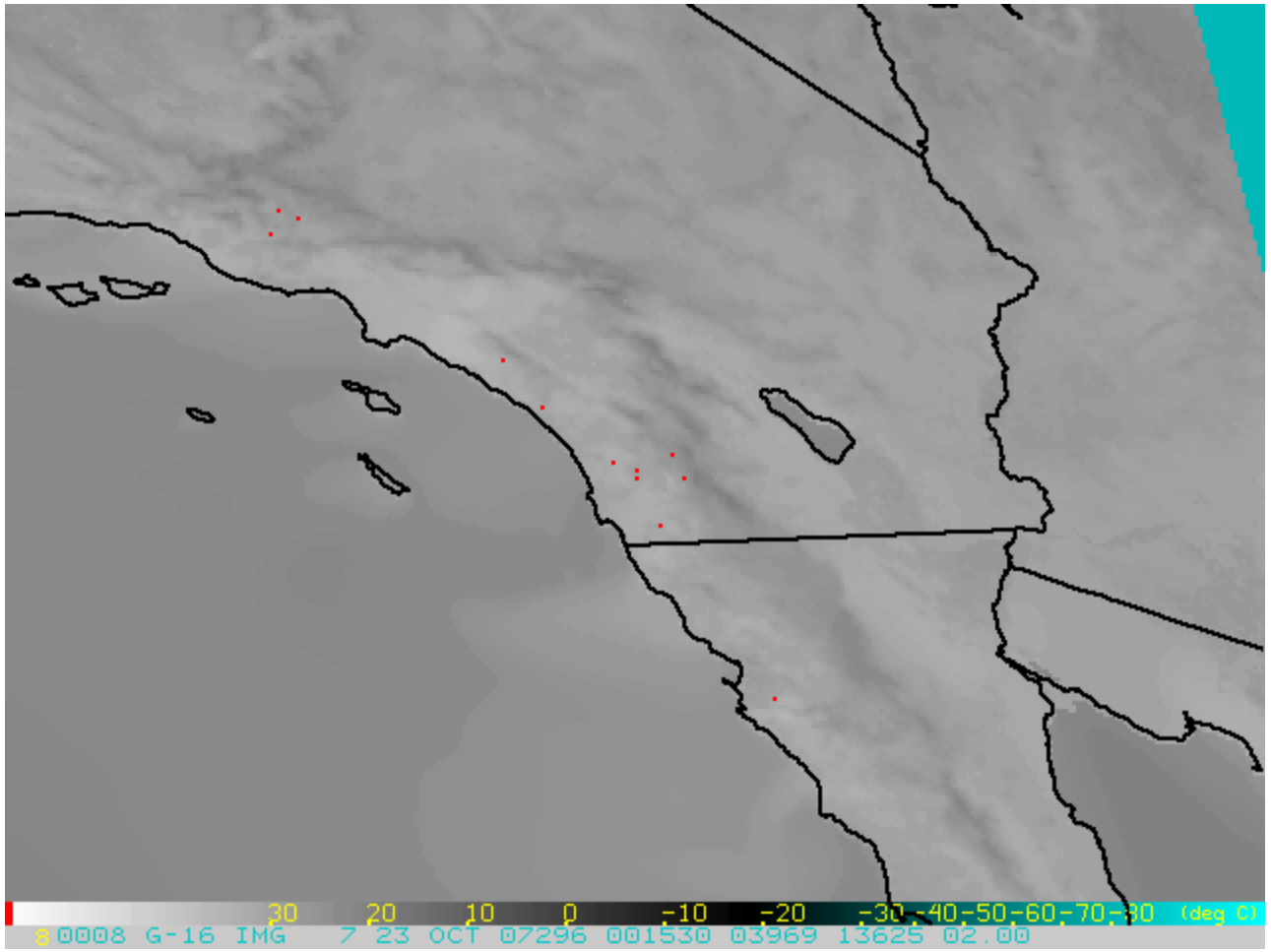




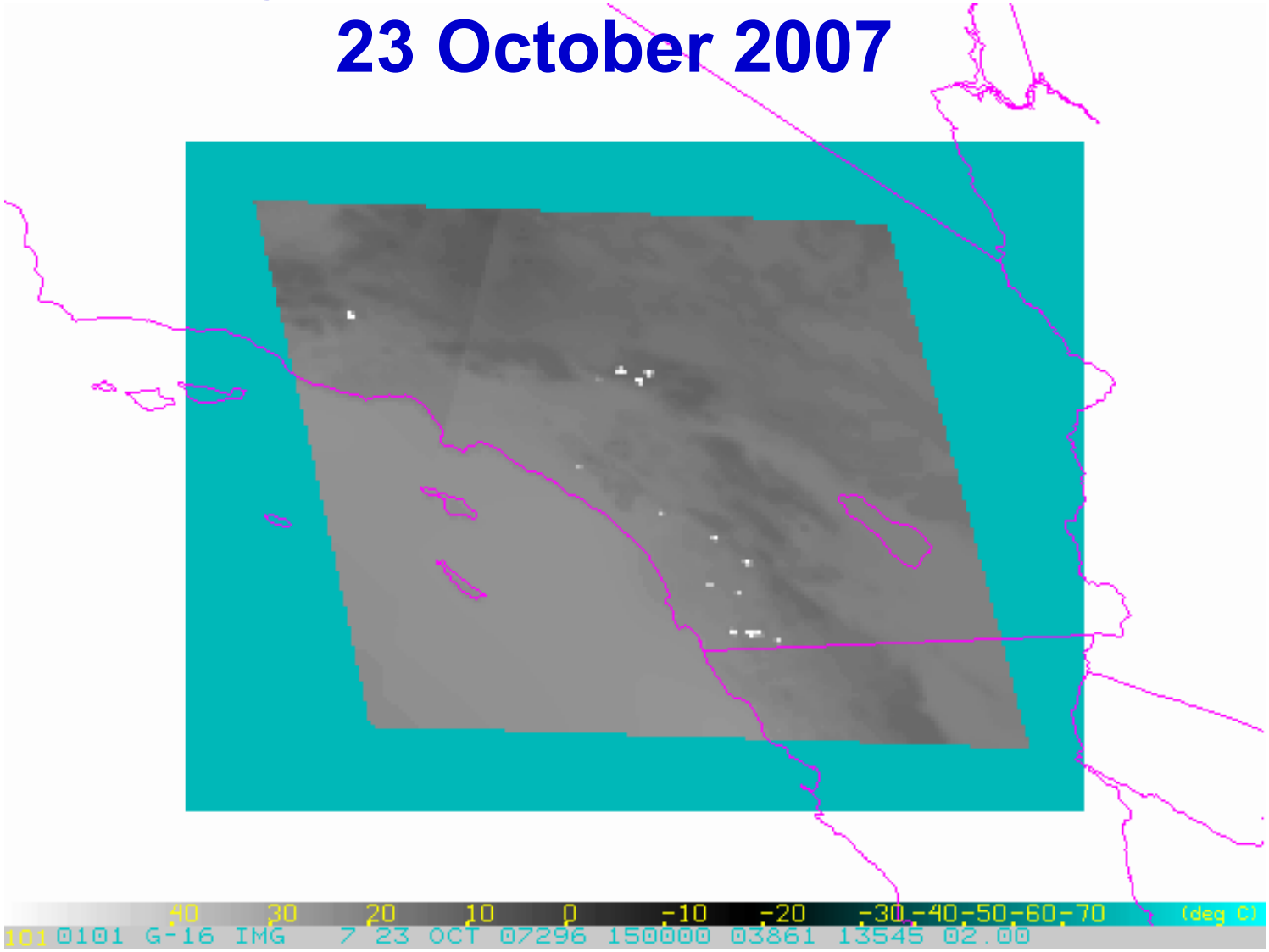
MODIS Satellite Image
True color - Satellite: Aqua - Pixel size: 1 km
Date: 2007-10-23 (created by NASA)

Synthetic ABI 3.9 µm Image
produced by CIRA's RAMM Branch.
Date/time: 2007-10-23 15:30 UTC

Synthetic Fire Hotspots
23 October 2007



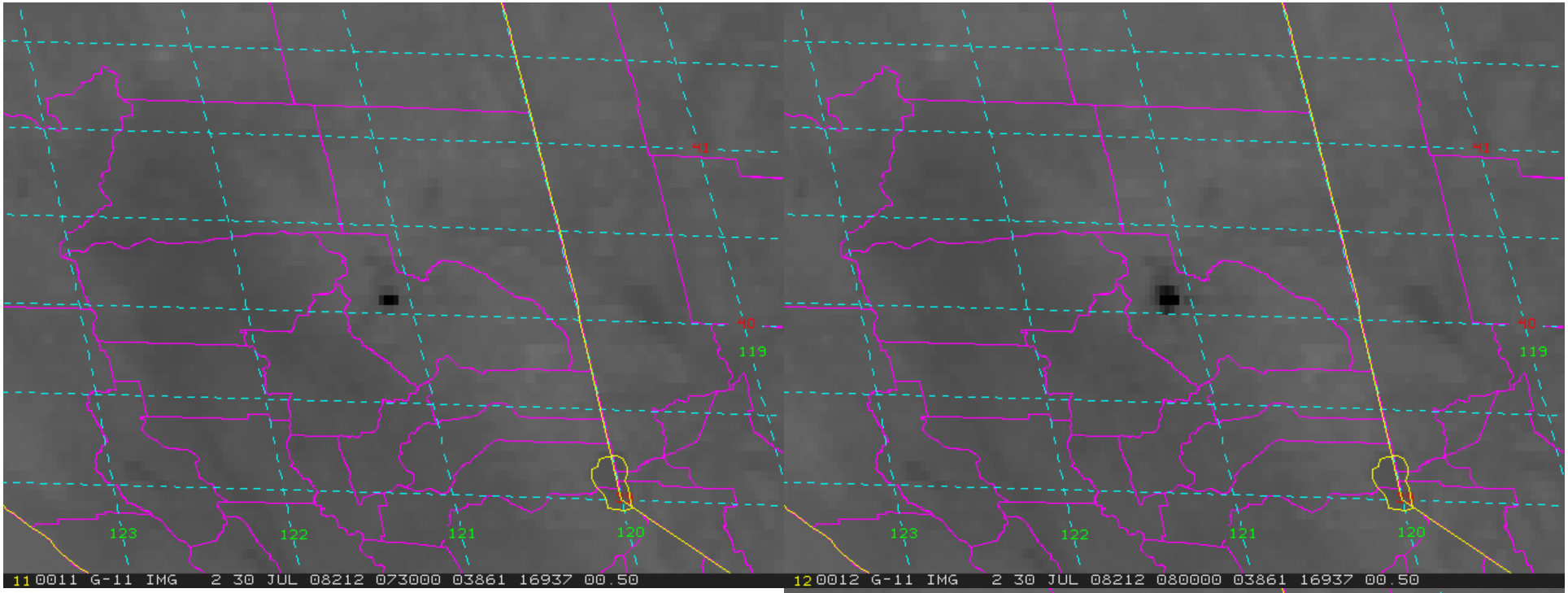
Synthetic Fire Hotspots
23 October 2007



Case 4:
N. California Rich Wildland Fire
30 July 2008

- A rapid (nighttime) blowup of the fire was noted between 0730 and 0800 UTC, and then a similar rapid decrease from 0800 to 0830 UTC.
- Images from a half-hour before and half-hour after are compared to the 0800 UTC blowup image. (Later 15 min imagery was used as well.)
- The fire is most obvious in the band-2 (3.9 μm) images and in the Shortwave Albedo images.
- The fire is either hot enough or large enough (mostly or completely filling pixels) that some of the band-4 (10.7 μm) pixels appear hot.

Rich Wildland Fire – map from www.inciweb.org



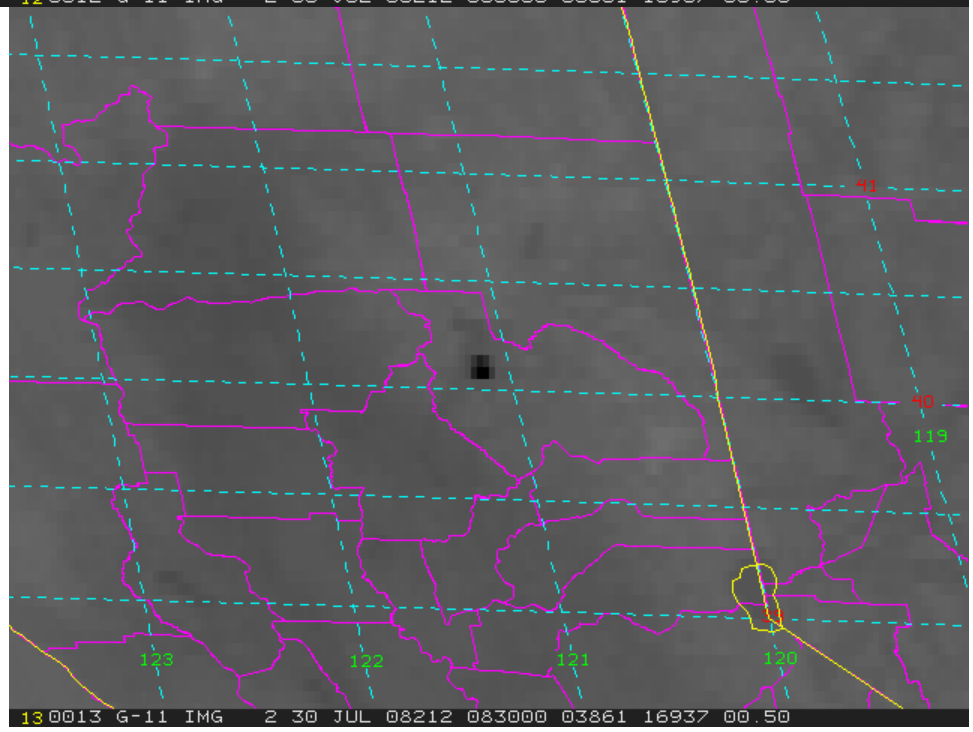
0730 UTC

Rich Wildland Fire flare-up

2008-07-30

Latitudes-longitudes and county outlines

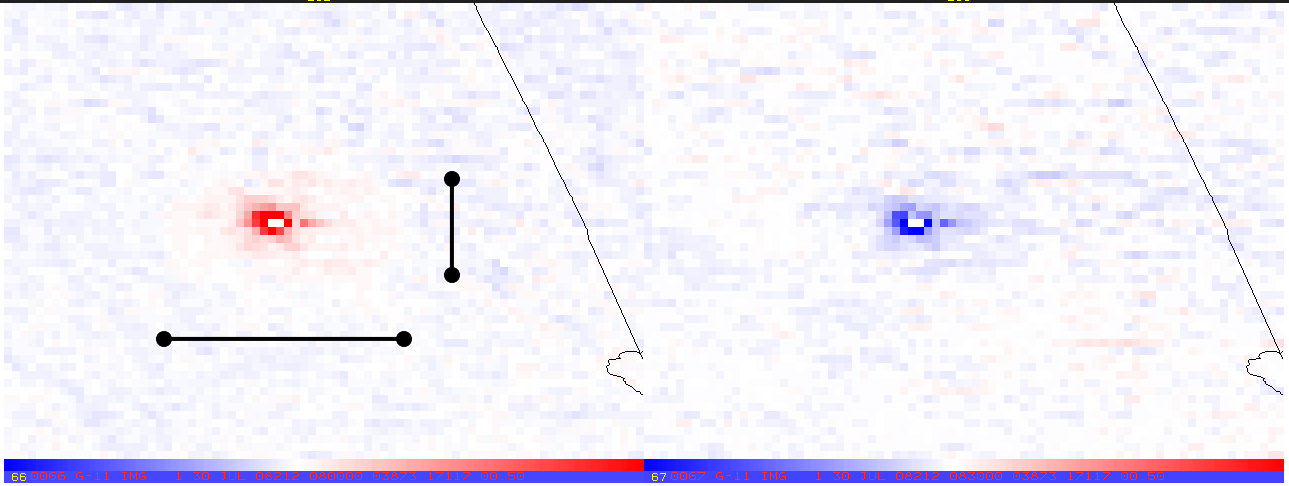
0800 UTC



0830 UTC

0730 UTC 0800 UTC 0830 UTC

See the SW-albedo images (ahead two frames) for an explanation of the lines.



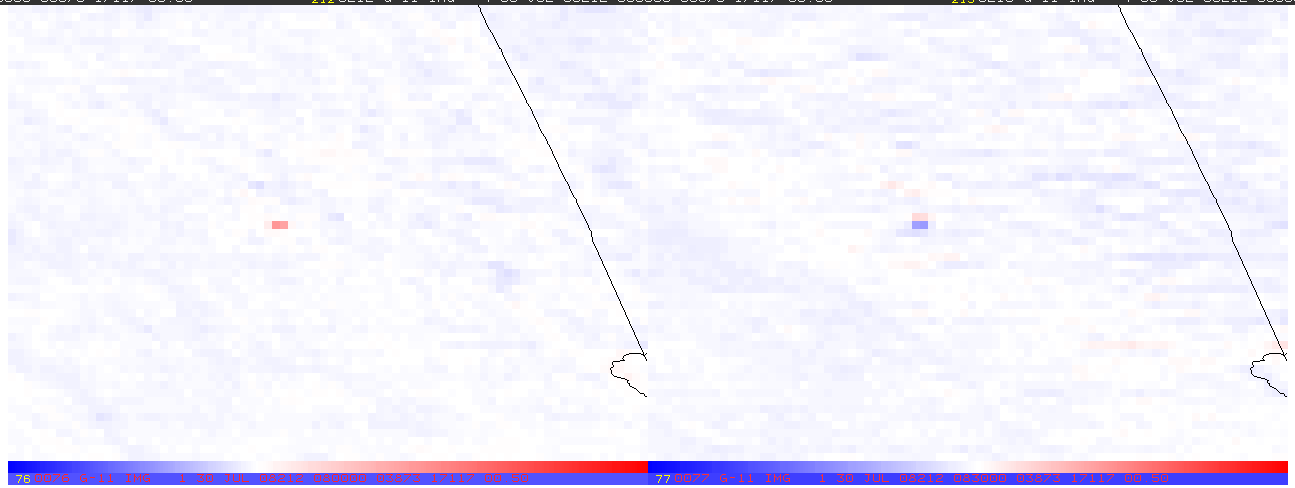
0730 to 0800 change
(red is most positive ~3 K)

0800 to 0830 change
(blue is most negative ~ -4 K)

Northern California - Rich Wildland Fire – 2008-07-30
GOES Band-2 (3.9 μm) – 4 km blowup to 0.5 km

0730 UTC 0800 UTC 0830 UTC

The fire is hot enough or large enough that some of the band-4 (10.7 μm) pixels are hot.

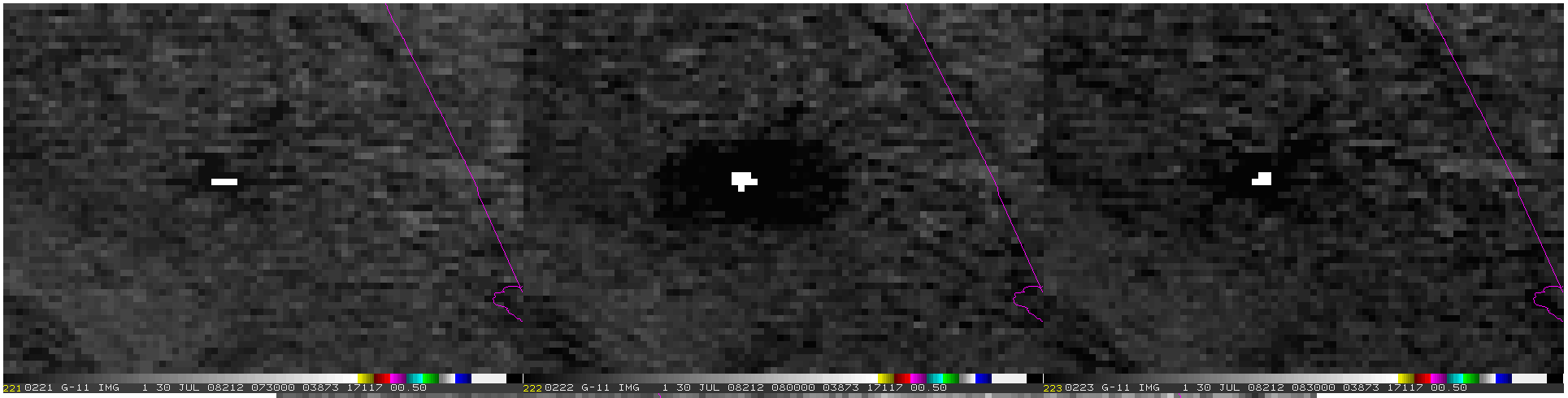


0730 to 0800 change
(red is most positive ~3 K)

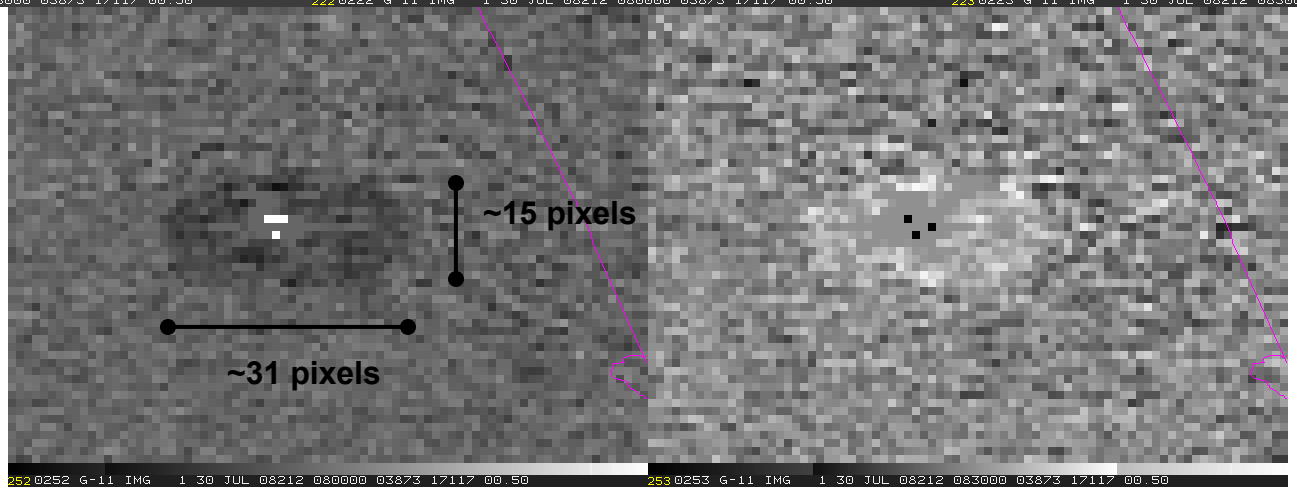
0800 to 0830 change
(blue is most negative ~ -2 K)

Northern California - Rich Wildland Fire – 2008-07-30
GOES Band-4 (10.7 μm) – 4 km blowup to 0.5 km

0730 UTC 0800 UTC 0830 UTC

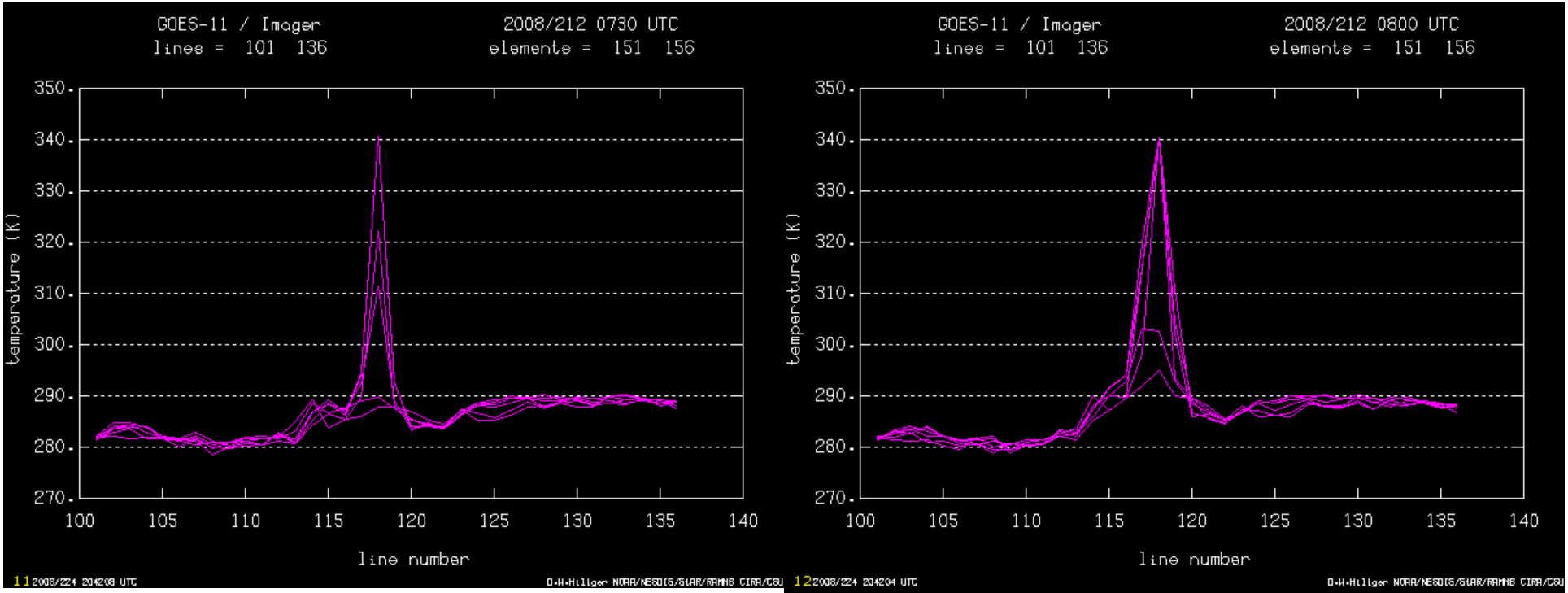


Note the wide area affected by the fire, ~15 x ~31 pixels, which can also be seen in the band-2 images alone (back two frames).



0730 to 0800 change 0800 to 0830 change

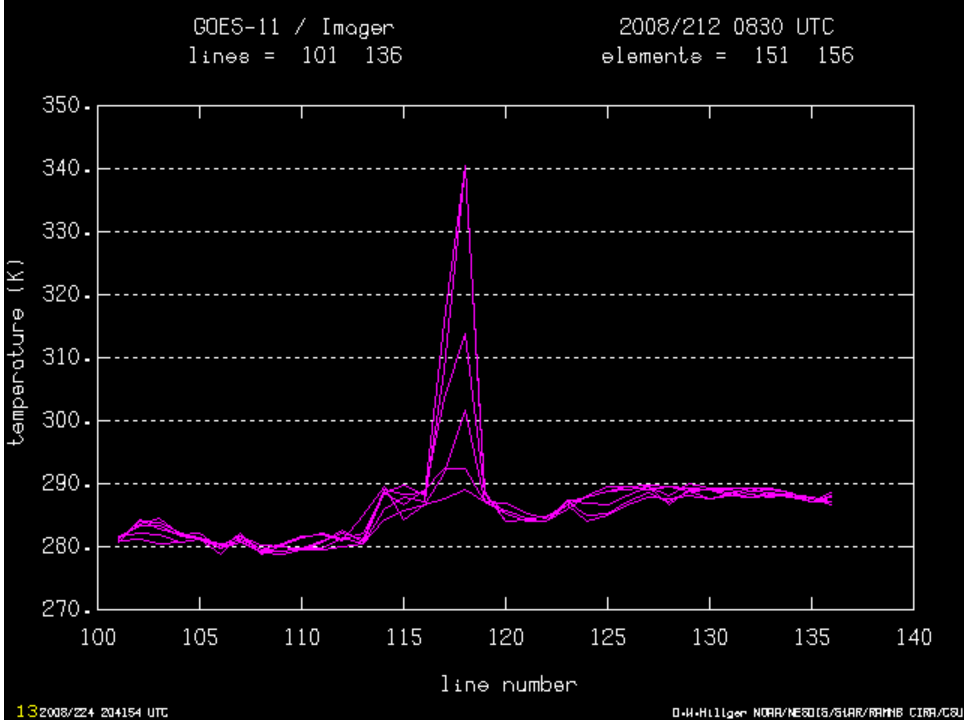
Northern California - Rich Wildland Fire – 2008-07-30
GOES SW-albedo – 4 km blowup to 0.5 km



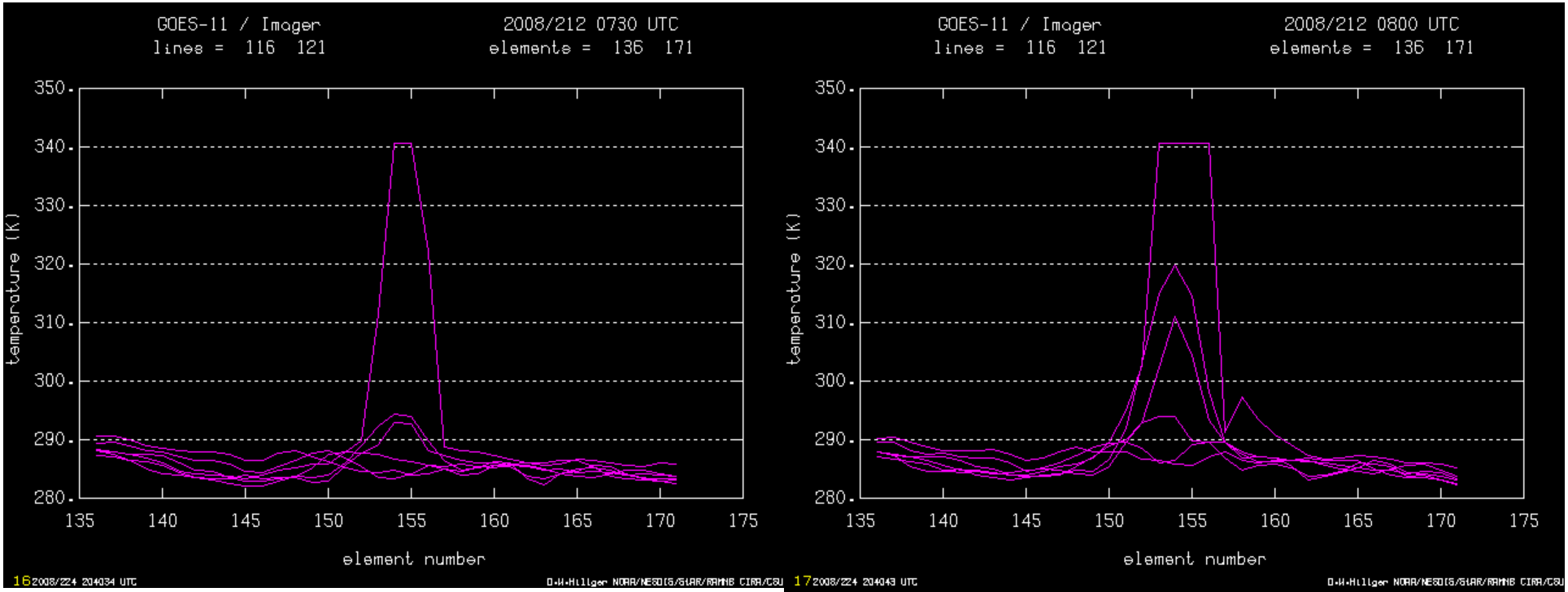
0730 UTC

0800 UTC

Rich Wildland Fire flare-up 2008-07-30 Along-element (North-South) plots across the fire



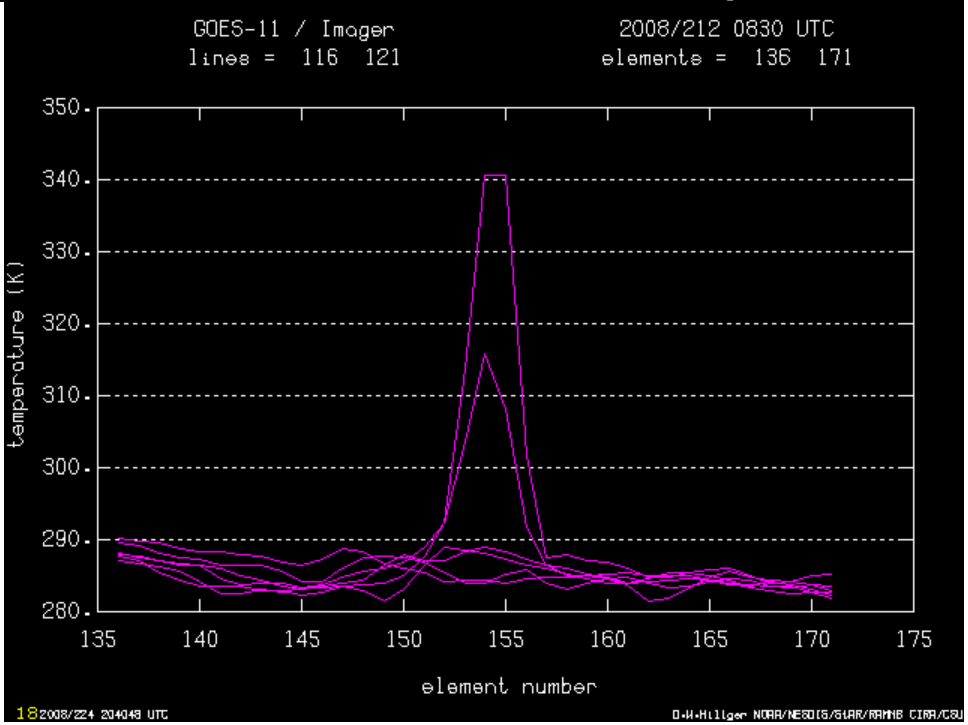
0830 UTC



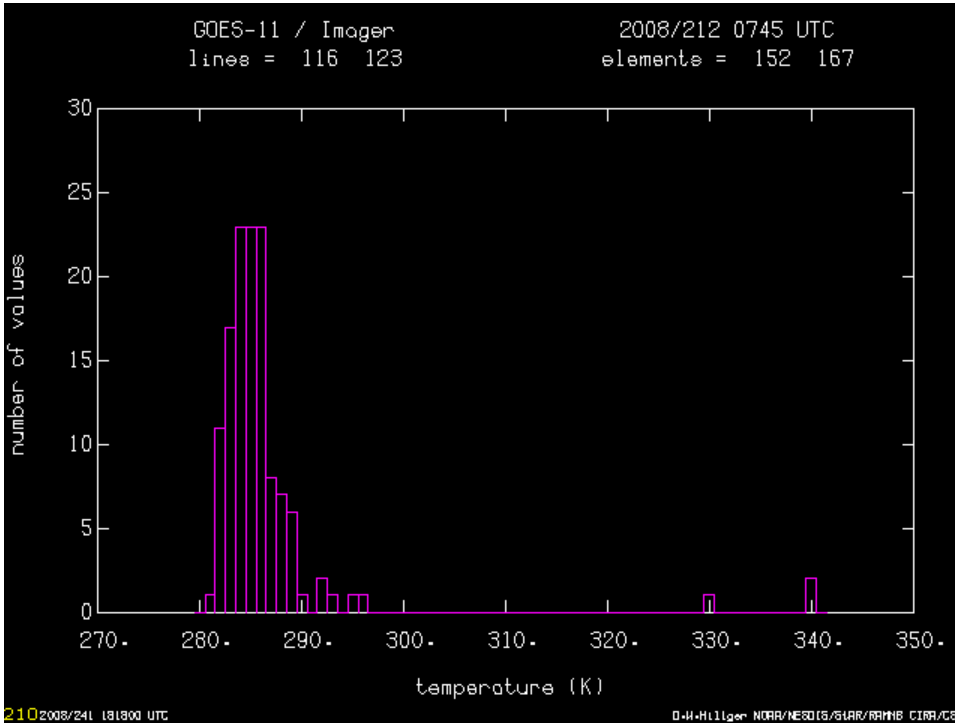
0730 UTC

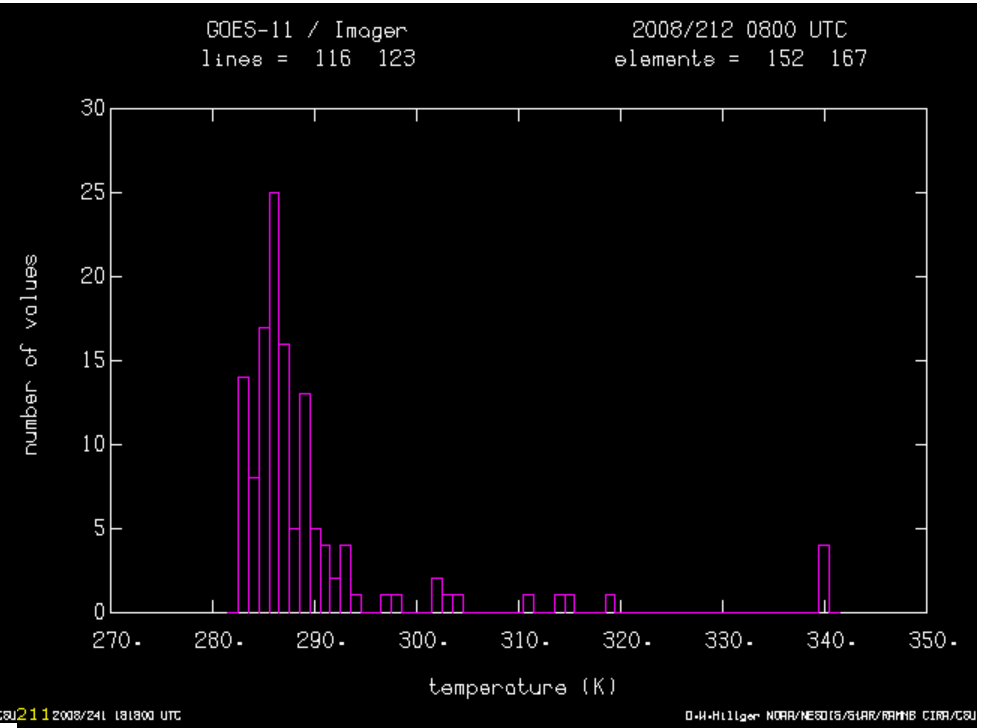
0800 UTC

Rich Wildland Fire flare-up 2008-07-30 Along-line (East-West) plots across the fire



0830 UTC



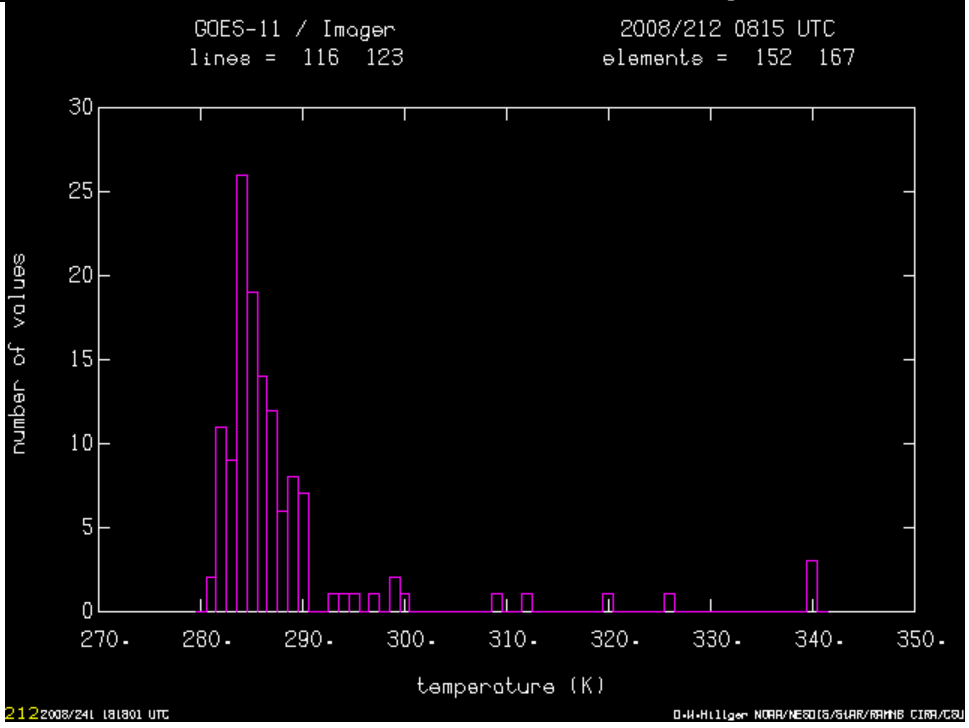


0745 UTC

0800 UTC

Rich Wildland Fire flare-up 2008-07-30 Histogram of fire pixels

0815 UTC



Rich Wildland Fire
view from Meadow Valley
photo from www.inciweb.org

N. California Rich Wildland Fire
30 July 2008

- Note the large area (number of pixels) affected by the blowup, ~15 pixels North-South by ~31 pixels East-West, or ~465 pixels, or ~400 pixels considering the rounded corners of the affected area.

- The larger East-West than North-South distance is expected because of East-West pixel oversampling (by a factor of almost 2 compared to the pixel size) and an inherent lag in sensor response as it scans across the fires.

- At the time of the images the fire was estimated to be 59,440 acres (93 mi^2 or 240 km^2). Since the GOES Imager pixels in the image are 6.2 x 2.5 km at this latitude/longitude, or 15.5 km^2 , the fire should encompass only 240/15.5 = ~15 pixels, compared to the ~400 pixels that appear to be affected in the images.

- Much of the obviously-affected area may be due to hot gasses or cloud in the area. But not knowing for sure, the question is whether some of the more distant effect of the fires might be due to the wide point spread function of the GOES Imager! A wide point spread function would cause especially hot fires to affect pixels at a large distance from the fires.

Band-2 (3.9 μm) statistics for the 15 x 31 affected area:

	0730 UTC	0800 UTC	0830 UTC
Number of saturated pixels (340 K)	2	4 (+2 change)	2 (-2 change)
Number of pixels with Temp>290 K	10	28 (+18 change)	13 (-15 change)
Average temperature for all (465) pixels	285.0 K	286.1 K (+1.1 K change)	284.8 K (-1.3 K change)
Background/minimum temperature	280.4 K	280.4 K (+0 K change)	279.5 K (-0.9 K change)

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- Use the CSU RAMS forecast model to simulate observed mesoscale weather.
- Add fires to simulated mesoscale events:
  - For simulated fires: Add equally-distributed artificial fire hotspots.
  - For real fires: use CIMSS ABBA-retrieved datasets (based on GOES-11 and 12) for location and fire temperature information.
- The RAMS in conjunction with OPTRAN code and radiative transfer models, to produce synthetic radiances for the 3 GOES-R ABI wavelengths (3.9 μm, 10.35 μm, 11.2 μm) that are expected to be used for fire detection.
- GOES-R ABI synthetic imagery is produced at the appropriate locations by using an approximation of the point spread function (PSF).
- McIDAS and GIF imagery is created for all proxy datasets, for AWG testing.