# GOES-R ABI Fire Detection and Characterization Product

NOAA Satellite Science Week 2014

Chris Schmidt
Jay Hoffman
Wilfrid Schroeder
Yunyue Yu

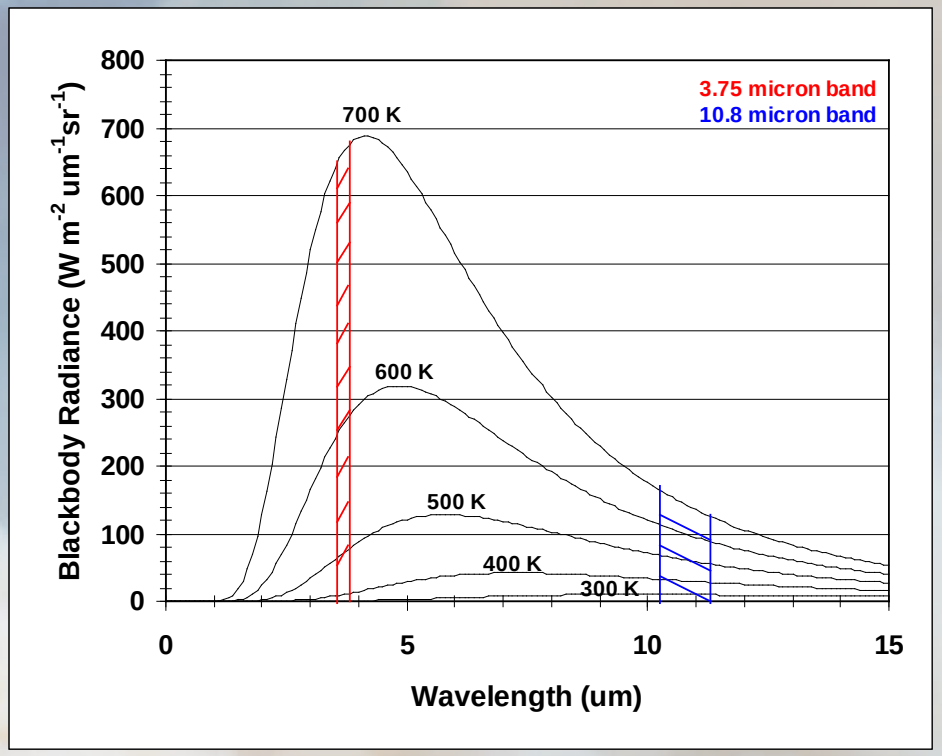
# FDCA Overview

- Contextual Fire Detection and Characterization Algorithm, a baseline product
- FDCA is the ABI implementation of the Wildfire Automated Biomass Burning Algorithm (WFABBA)
- WFABBA is been operational at NESDIS since 2002
- WFABBA has been implemented on a global geostationary constellation consisting of GOES, MSG, MTSAT, and COMS

# Fire Detection and Characterization

- Works best with at least 2 IR bands: ~4 µm and ~11 µm
- Requires some ancillary data (total precipitable water, surface emissivity, surface type)
- Algorithm is contextual to best handle estimating background surface radiance
- Current hardware can process a current GOES full disk image in 5-10 minutes. Best hardware <5 minutes
- Location given is the center of the pixel and subject to navigation error of satellite

# How short and long-wave IR bands are used to detect & characterize fires



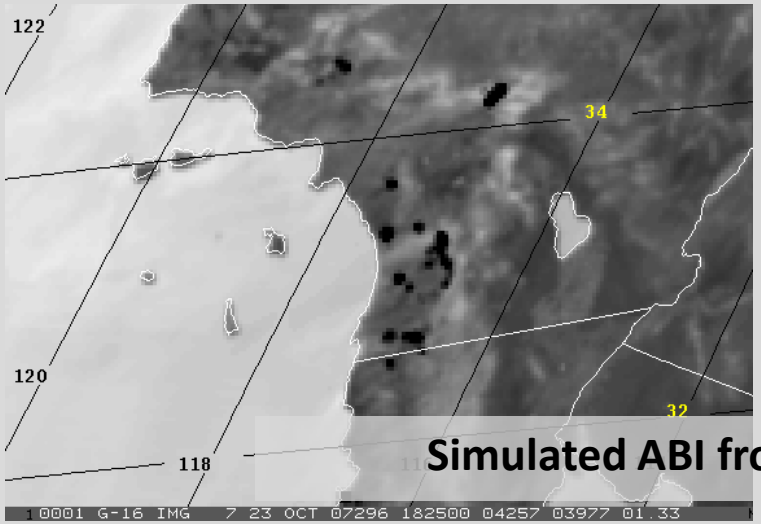

As the surface temperature increases, the peak of the Planck function shifts toward shorter wavelengths, so the radiance increases more rapidly at ~4 µm than ~11 µm. The different brightness temperature responses in these two infrared windows and background conditions can be used to detect fires and estimate sub-pixel fire size, temperature and fire radiative power (FRP).

# Product Generation and Assessment Using Available Proxy Data

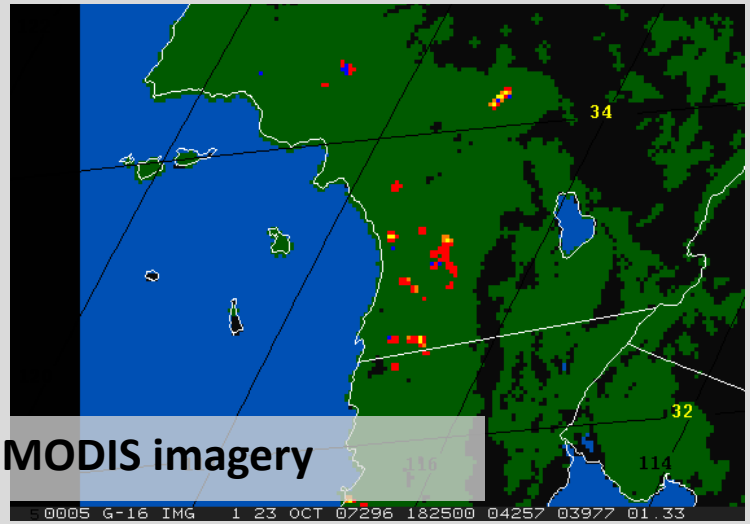
- There is no ABI proxy data containing fires that is produced on a regular basis; there have been discussions about creating some.
- Routine validation is expected to consist of comparison with other sources of satellite fire detections.
- The ABI algorithm has been retrofitted to run on MSG SEVIRI data.
- Differences between operational SEVIRI algorithm and this version are being investigated.

# Proxy Data from MODIS

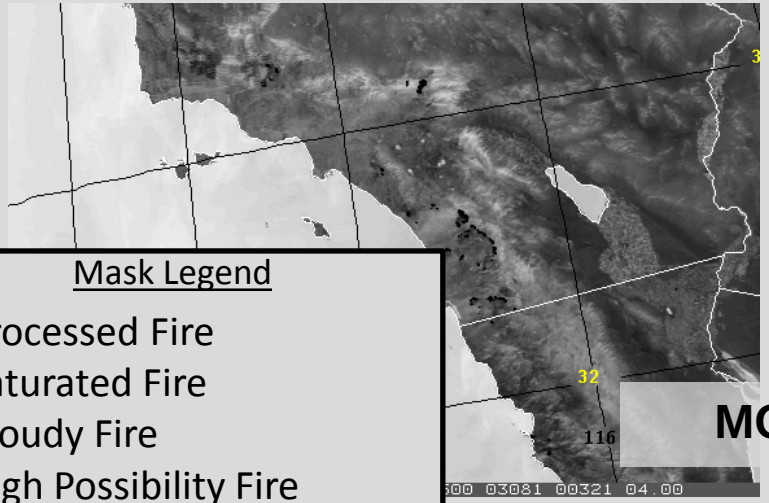
## 3.9 µm channel

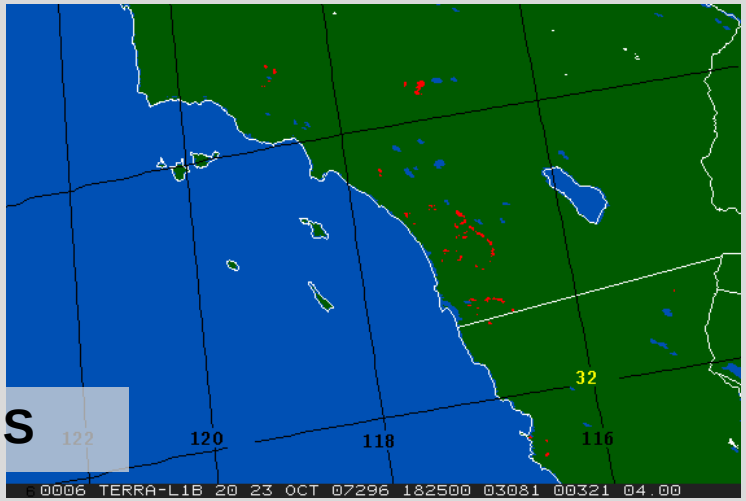



## Fire mask




**Simulated ABI from MODIS imagery**




**MODIS**

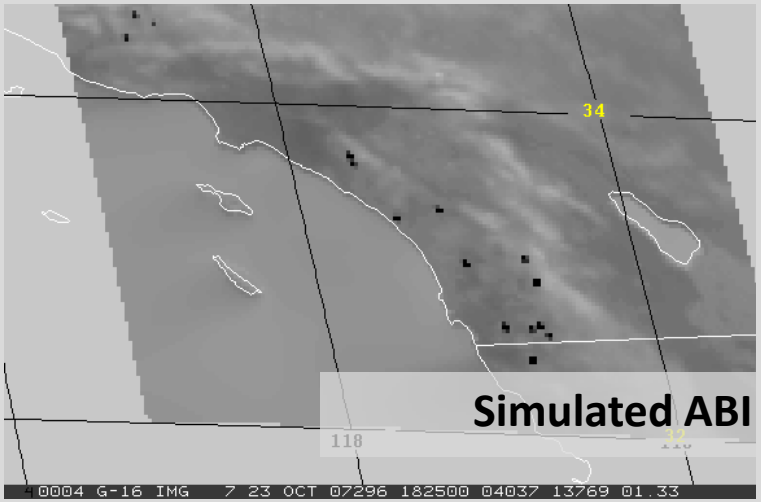
Mask Legend

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

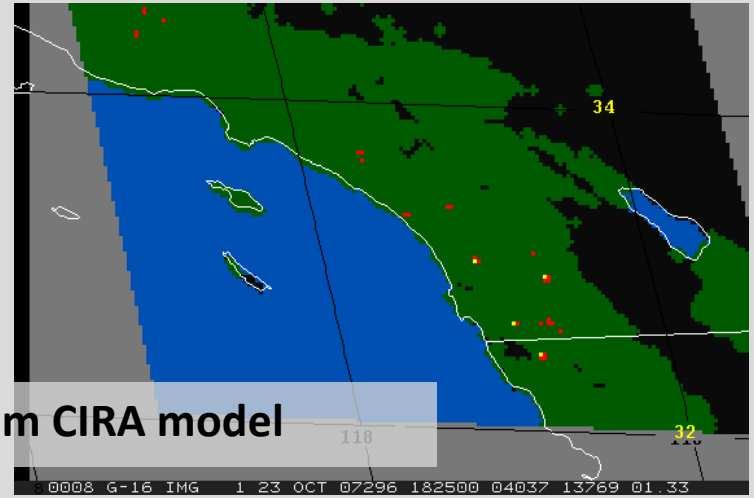
2007 Oct. Southern California fire outbreak simulation

# Proxy Data from a model

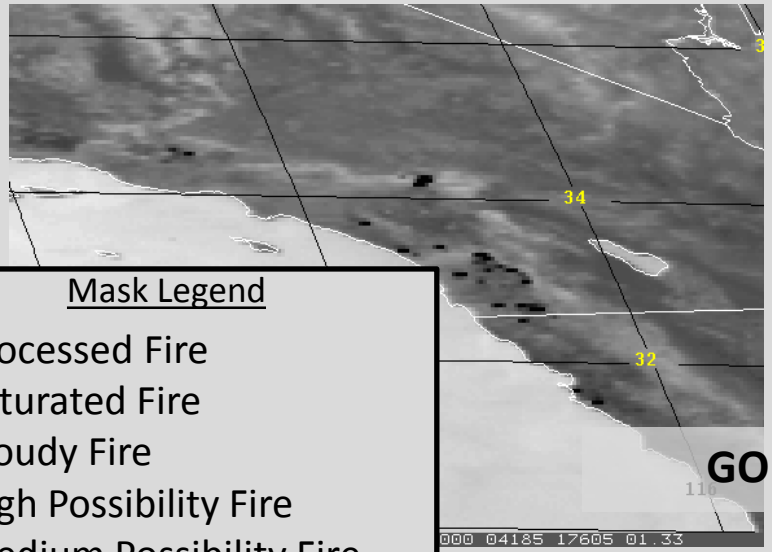
## 3.9 µm channel

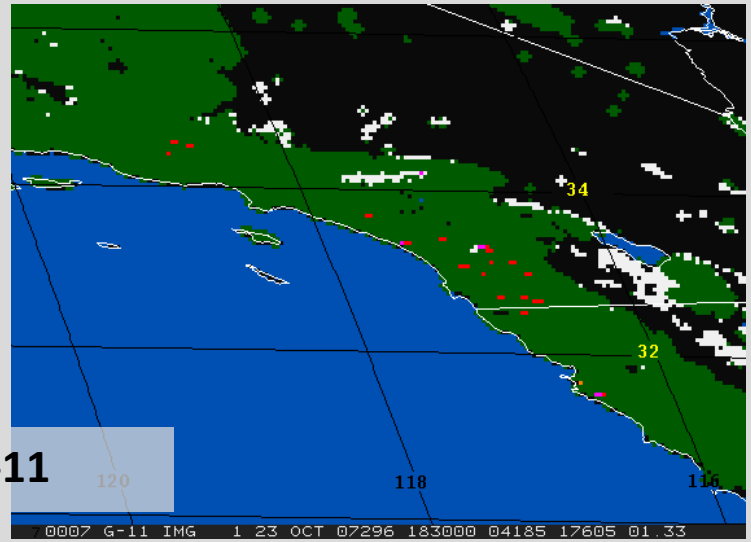



## Fire mask




**Simulated ABI from CIRA model**




**GOES-11**

Mask Legend

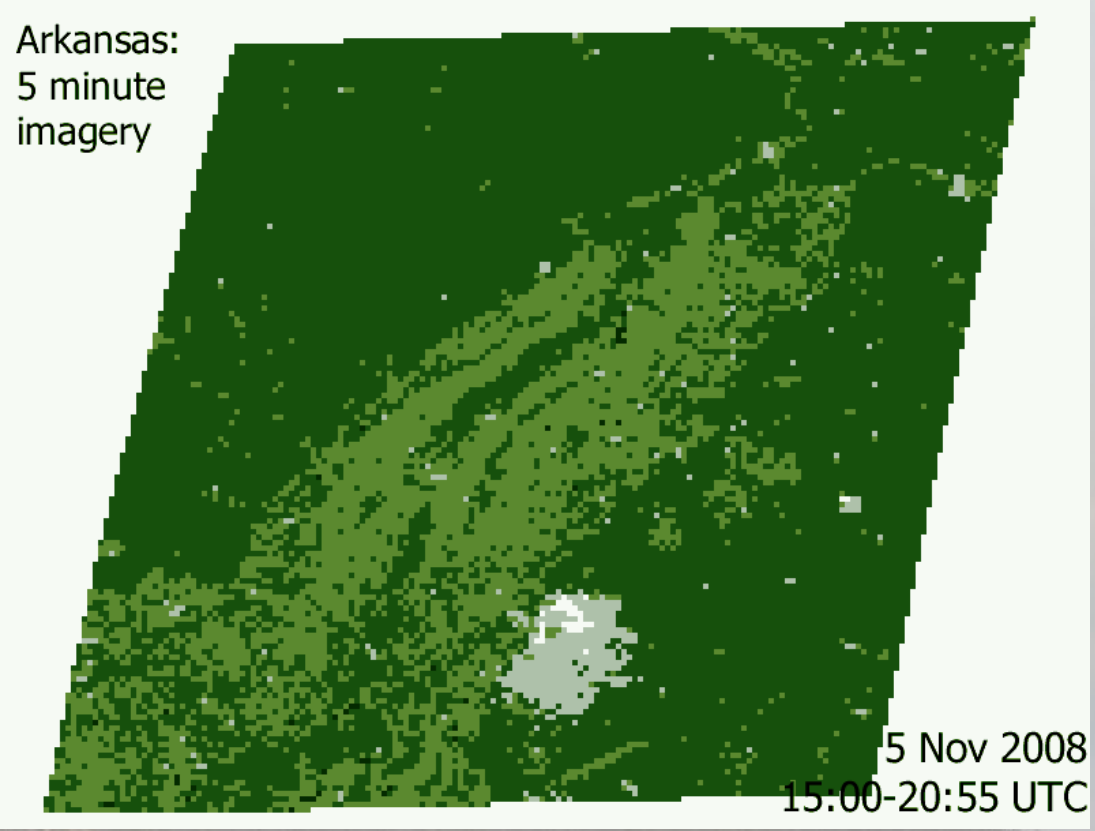
- Processed Fire
- Saturated Fire
- Cloudy Fire
- High Possibility Fire
- Medium Possibility Fire
- Biome Block-out Zone
- Processed Region

2007 Oct. Southern California fire outbreak simulation

# ABI Proxy Examples

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



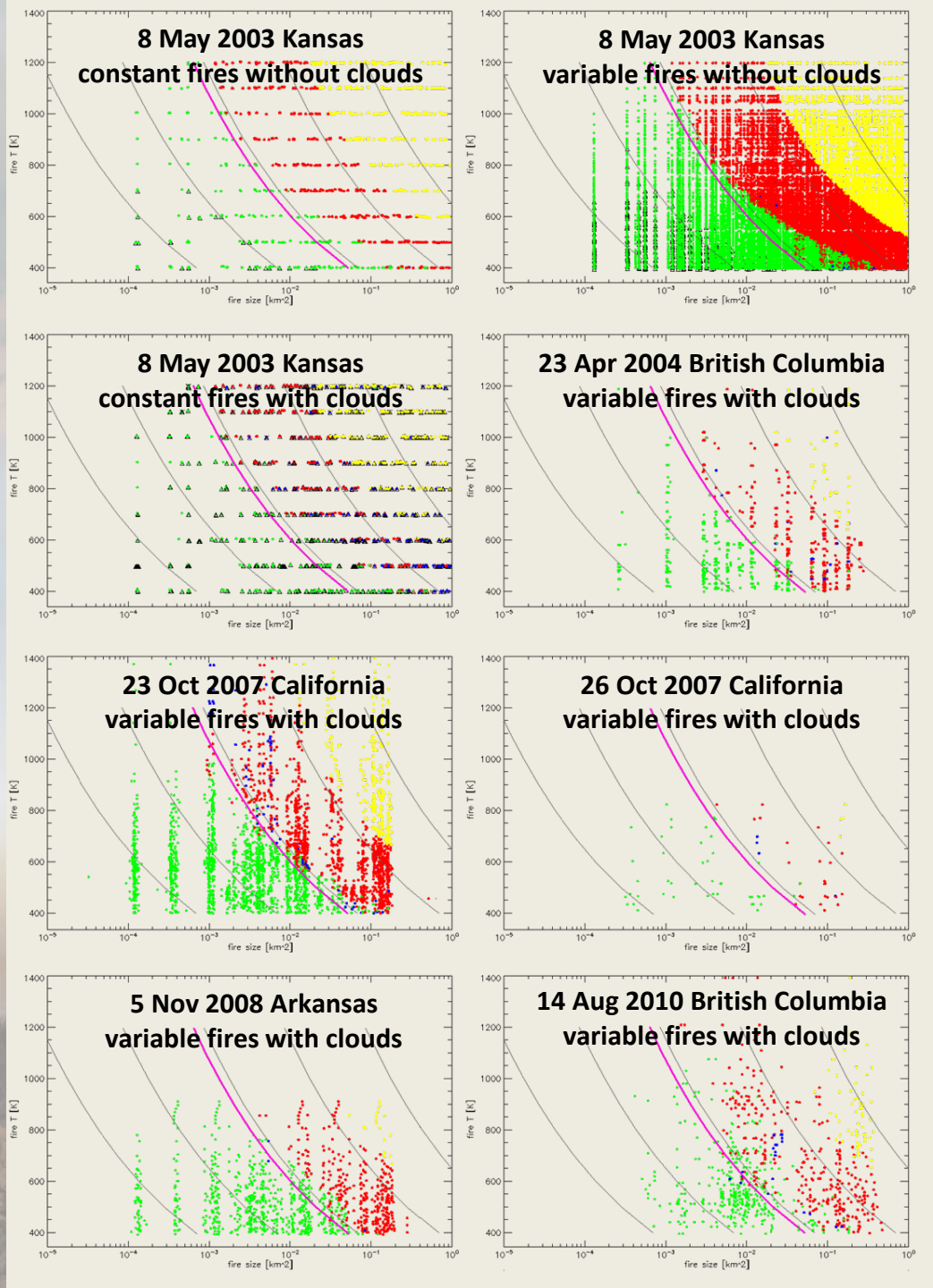
# Model data validation

| 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 | |

# 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).



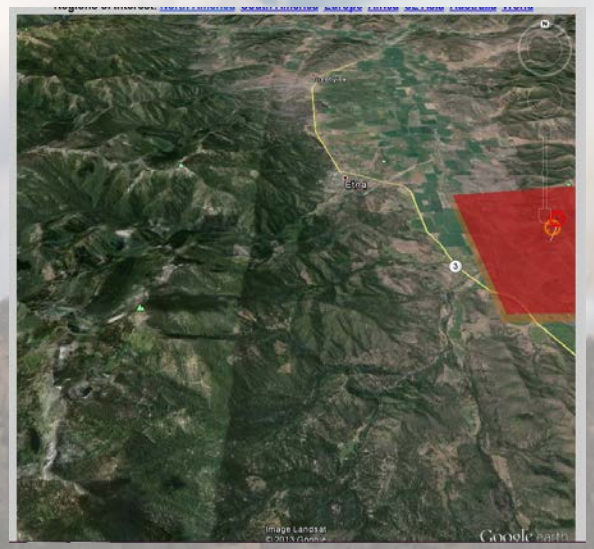

Not Detected
Processed Fire Pixel
Cloudy Fire Pixel
Medium Probability Fire Pixel
Not Detected, Block-out zone
Saturated Fire Pixel
High Probability Fire Pixel

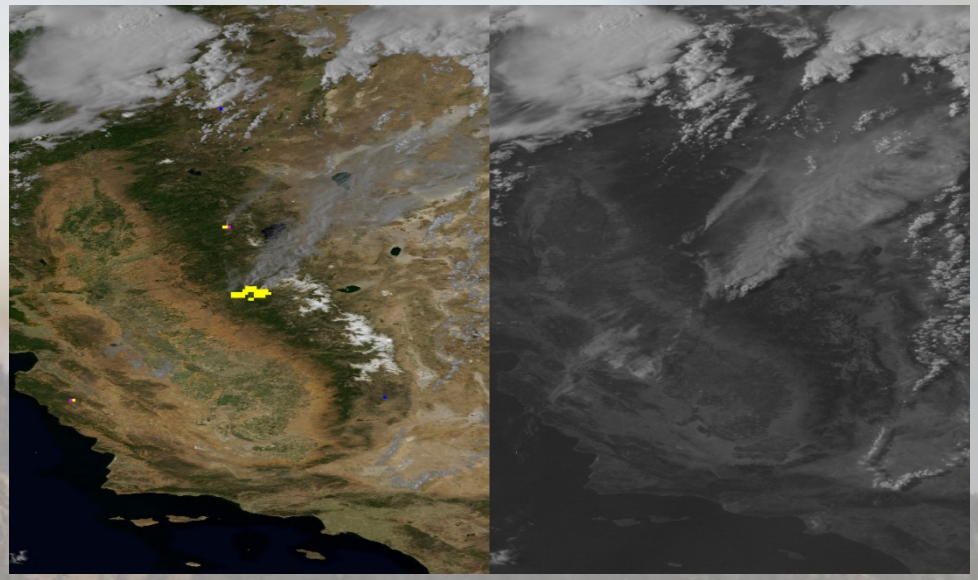
# FDCA Users

- Widespread interest in fire data from GOES-R given its higher temporal and spatial frequency.
- There have been discussions with NWS Incident Meteorologists (IMETs) from the NWS offices in Boulder and Monterey regarding how the algorithm output can best be tailored to fit their needs. IMETs provide weather monitoring and forecast support during major wildfires.
- Other users include emergency managers, smoke and aerosol modelers, pilots, and the US Navy.
- Users such as IMETs need the fire data quickly and in easy to understand formats.

# FDCA Users

Left: An example of the resolution an IMET would find useful for FDCA and WFABBA visualizations. The fire pixel is red.
Right: WFABBA fire data (yellow) merged with Blue Marble Second Generation and concurrent visible imagery.  “Pretty pictures” such as this (and animations of them) are useful to a wide variety of users and are popular with the general public.



# Identifying and Planning for Algorithm Enhancements Beyond Baseline

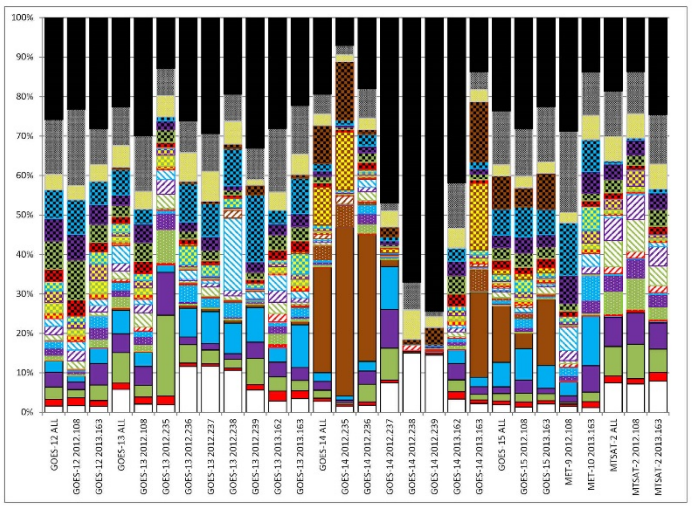
- Development of WFABBA enhancements through GIMPAP are expected to be transitioned to the GOES-R as funding allows.
- Primary focus of GIMPAP work has been to improve temporal filtering. Old method was developed based on 30 minute imagery, today imagery can be much more frequent, and even moreso for GOES-R ABI.
- Enhanced temporal filtering considers more than just whether a fire was detected in the previous 12 hours, it considers the time since that detection and the presence of clouds during that time.
- Enhanced temporal filtering is still under development.
- Additional enhancements that would leverage the advantages of ABI data may be in development by the time launch occurs due to the availability of MTSAT-3 AHI data

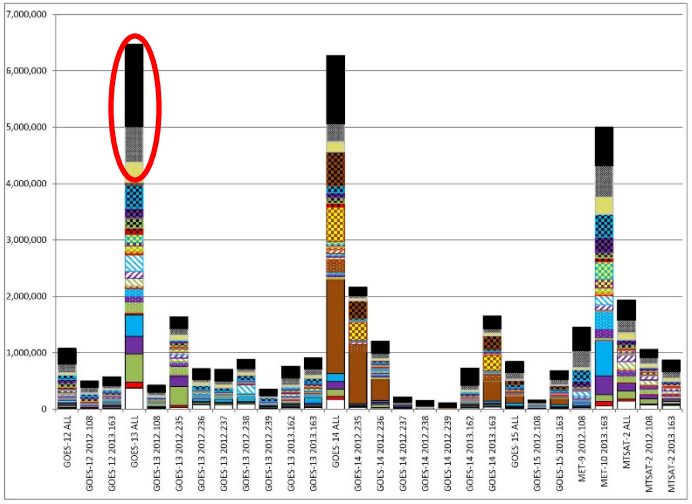
# Identifying and Planning for Algorithm Enhancements Beyond Baseline

The two plots at right (relative frequency on top, absolute counts below) are the 29 categories analyzed during development of the advanced temporal filtering. The red oval below highlights an example of the three categories (black, gray, light yellow) that were excluded by the original WFABBA and FDCA temporal filter.

The dates chosen cover some “normal” dates while others cover RSO and SRSO operations for GOES satellites. Data from GOES-12/-13/-14/-15, Met-9, and MTSAT-2 were examined.

The next slide describes the categories in the plot.



# Identifying and Planning for Algorithm Enhancements Beyond Baseline

**Detected fires that will not pass any temporal filtering:**

- Black: Single detection fires. Most false alarms fall into this category.
- Gray: Fires detected just once that will eventually be seen for more than 3 hours. Similar to the black fires but much less likely to be false alarms.
- Light yellow: First detection of a series lasting less than 3 hours. Similar to the gray category.

**Fires that can pass temporal filtering:**

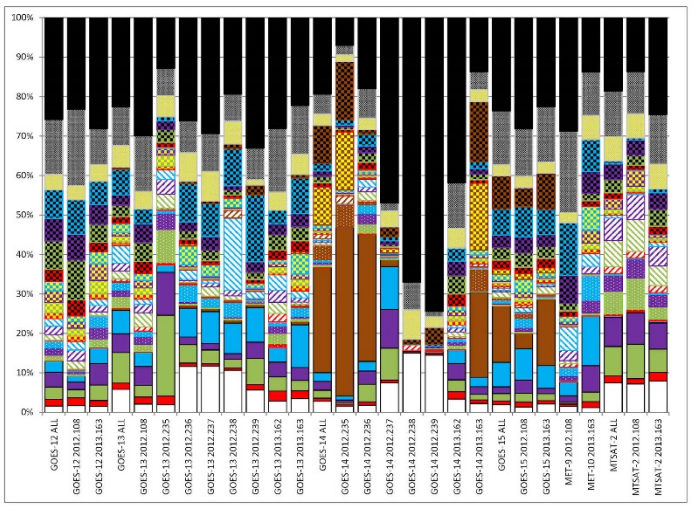
White: Fires with a match 3-12 hours in the past.

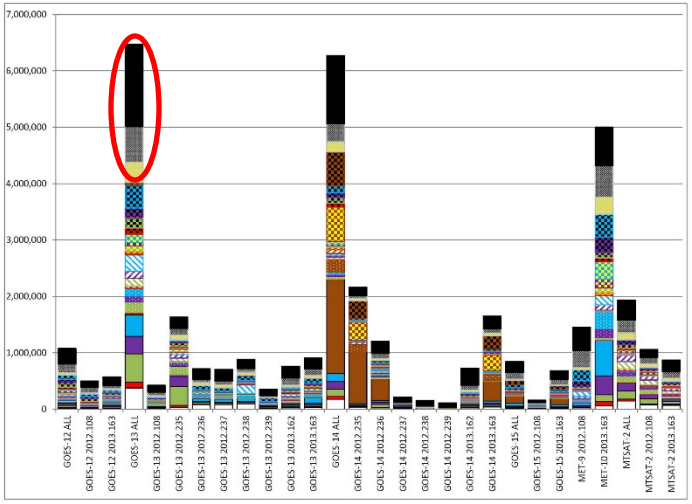
**Other colors indicate fires lasting at least three hours:**

- Brown: Closest match within 5 minutes
- Cyan: Closest match within 5-15 minutes
- Purple: Closest match within 15-30 minutes
- Green: Closest match within 30-60 minutes
- Red: Closest match within 60-180 minutes

**The same colors with:**

- White dots: The fire has not yet existed for more than 3 hours (but it will in the future) and at least half of the satellite scans met the "clear" criteria. To qualify as "clear" a scan had to have at least one pixel that could have been or was a detected fire in the 7x7 box centered on the pixel being examined.
- Yellow alternating squares: Similar to white dots but less than 50% of the satellite scans met the "clear" criteria.
- White diagonal bars: The fire has not nor will in the future span at least 3 hours and more than 50% of the boxes were clear.
- Black alternating squares: Similar to the white diagonals, except that less than 50% of the boxes met the "clear" criteria.

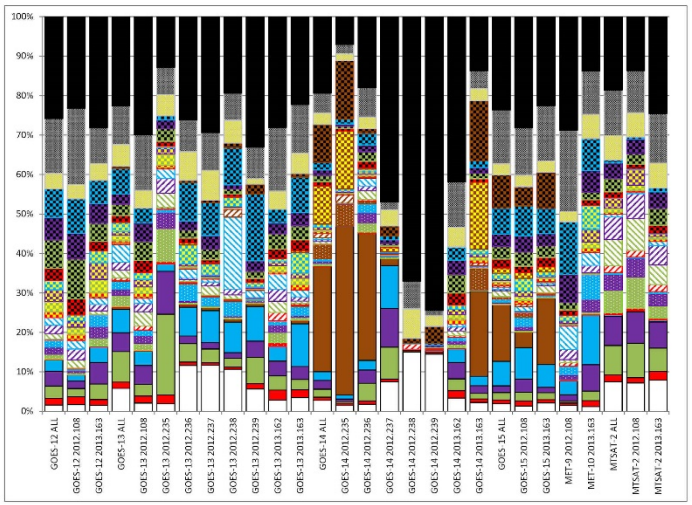


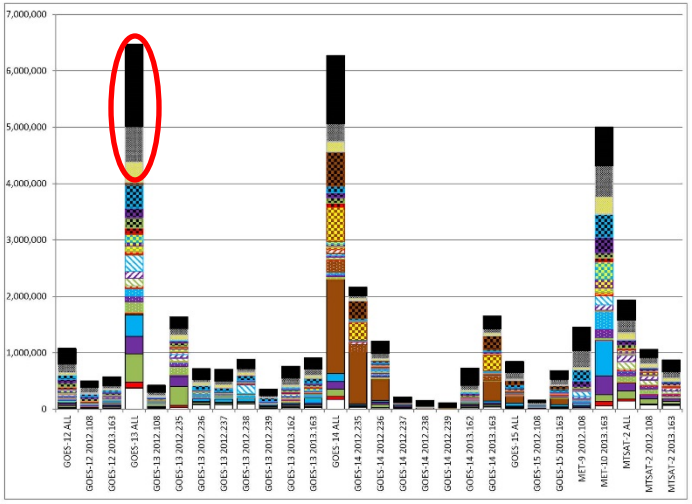



# Identifying and Planning for Algorithm Enhancements Beyond Baseline

**The take-away:**

The temporal filtering does need to be more robust for GOES-R (and current satellites as well). Short term false alarms are common for high temporal resolution data as most are caused by solar contamination, heating of the ground, and/or cloud edges, effects that can persist for 15 or so and thus appear to be persistent fires. Fires that have only been detected for a short time need to be flagged with lower confidence than fires that have been active longer to help the user distinguish between the two categories.



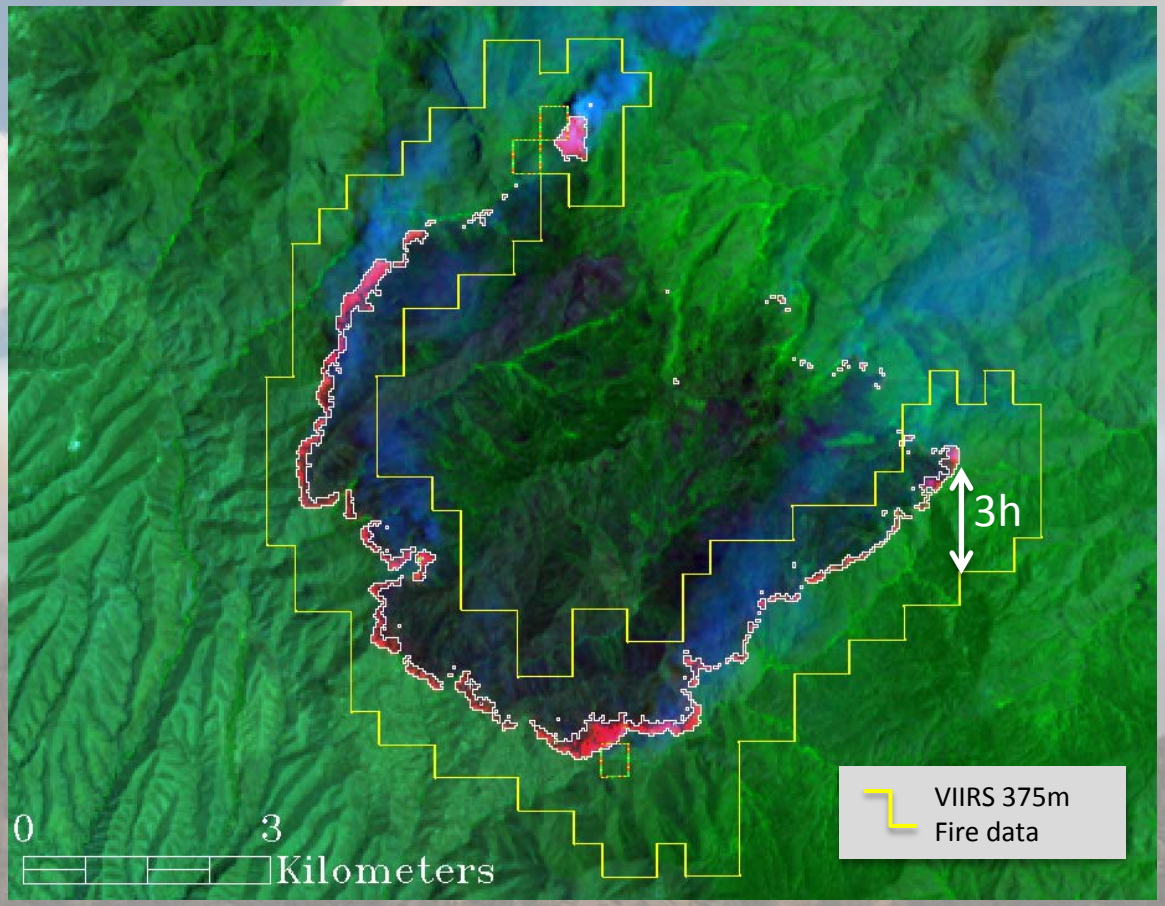
# Road to GOES-R Post-Launch Test (PLT) and Post-Launch Product Validation

Post-launch validation would ideally be approached in three ways

- Comparison with other satellite fire products
  - Semi-qualitative comparisons with products from VIIRS and other satellites. Perfect matches aren't expected.
- Manual examination of cases to assess whether algorithm is performing as expected
  - Similar to what is done by the Hazard Mapping System at NESDIS today, involves looking at ABI and other satellite data to verify detected fires and identify those that were missed.
- Utilize very high resolution data (30 m scale) to validate fire location and size
  - The deep-dive tool developed by Dr Wilfrid Schroeder took this approach
  - This is the only approach that will enable quantitative analysis of fire detection and characterization performance
  - Development of the tool needs to be completed
  - The same technique can be applied to any moderate resolution sensor (VIIRS, MODIS, ABI, current GOES Imager, etc)
  - The next three slides illustrate this technique with Landsat-8 data compared to VIIRS

# New Landsat-8 30 m Active Fire Data

Built on proven ASTER/Landsat (5&7) fire algorithms [Giglio *et al.*, 2008; Schroeder *et al.*, 2008]
Day & nighttime detections 16/8-day revisit (day/&night)
Spatial resolution providing detailed fire perimeter information (plus area estimate)

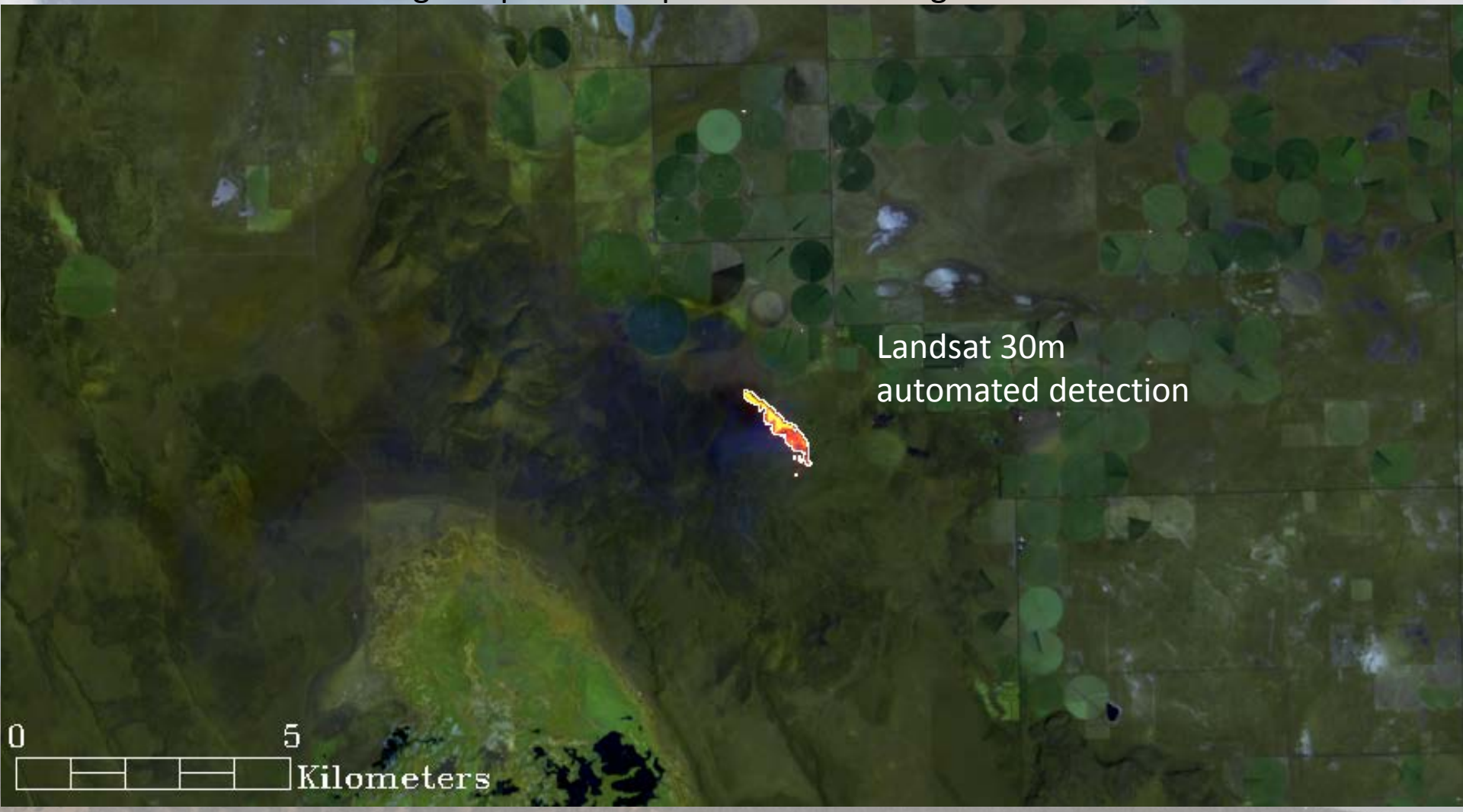





Slide courtesy of Dr Wilfrid Schroeder

# New Landsat-8 Active Fire Data

Image acquired 23 April 2013 over Oregon state




16 day revisit on one sensor (daytime only)

Potential for significantly improved revisit time by incorporating other Landsat-class sensors

Slide courtesy of Dr Wilfrid Schroeder

# New Landsat-8 Active Fire Data

Image acquired 23 April 2013 over Oregon state

16 day revisit on one sensor (daytime only)

Potential for significantly improved revisit time by incorporating other Landsat-class sensors

Slide courtesy of Dr Wilfrid Schroeder

End