GOES-Early Fire Detection (EFD) Project Overview

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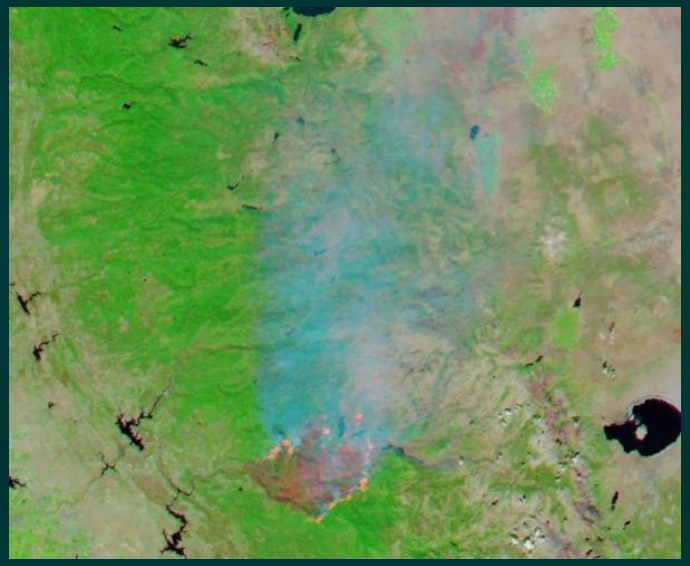
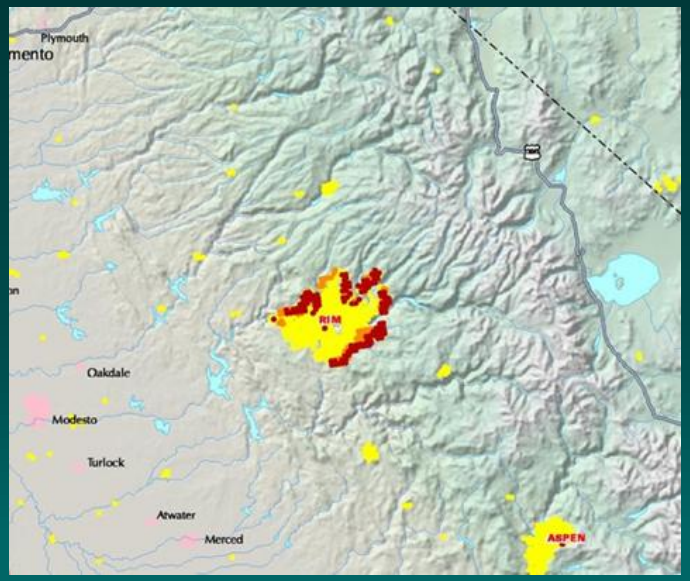
Active Fire Mapping (AFM) Program

(http://activefiremaps.fs.fed.us)

- Developed and implemented at RSAC in 2001
  - Coordination w/NASA, NOAA & space agency science teams
- Operational near real-time (NRT) satellite data/mapping/visualization products for wildfire management
  - "Value-added" data/products
  - All lands and ownerships in U.S. and Canada
- Facilitates wildfire decision support
  - Prioritize allocation of fire suppression assets
  - Focus tactical airborne reconnaissance assets
  - Key data input to several fire-related operational applications





GOES-Early Fire Detection (EFD) Project

What is it?

- An effort to develop a low-cost and reliable capacity for systematic rapid detection and initial confirmation of new ignitions at a regional level.

Project Goals

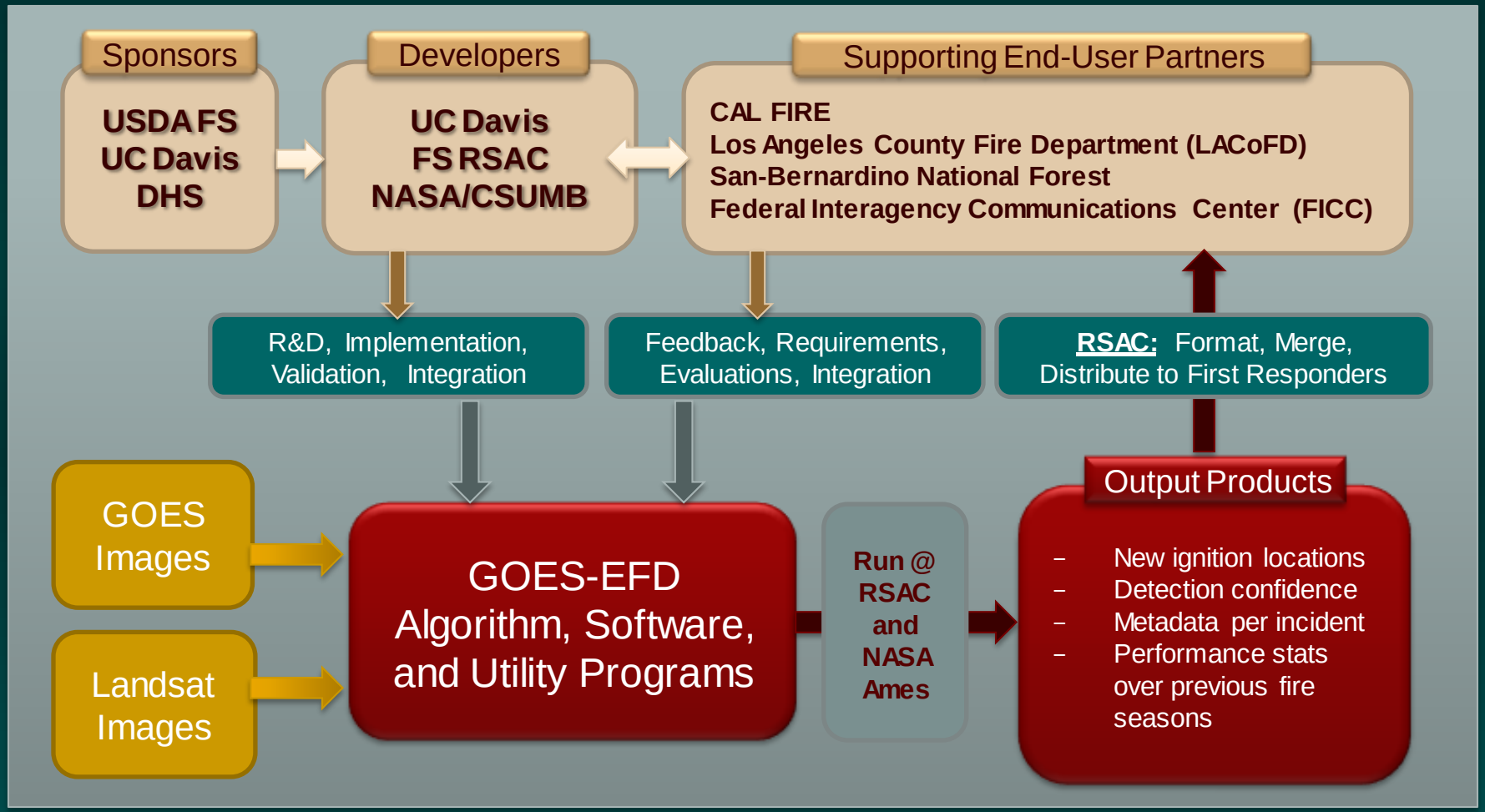
- 24/7 real-time surveillance for new fire ignition activity
  - Detect new incidents consistently within first 1-2 hours
  - Initially at a regional scale (Western U.S.)
- Low latency information for new ignition events to first responders
- Corroborating data/information for reports by conventional sources

GOES-EFD & Active Fire Mapping Program

Objective is to integrate GOES-EFD into AFM to:

- Complement existing related fire detection/monitoring products (MODIS, VIIRS, GOES, AVHRR)
- Provide standardized operational geospatial EFD products and web services to interagency fire community
- Facilitate integration EFD products/services into existing decision-making environment at dispatch centers and GACCs
- Support improvement of situational awareness and response planning/prioritization

GOES-EFD Effort: Structure and Participants



- Funding Sources:
  - Forest Service/UC Davis Interagency Cost Share Agreement (I0-CS-11130400-009)
  - DHS Science and Technology (S&T) Directorate's Long-Range Broad Agency Announcement (BAA): BAA 11-03-IDD.08-0011-I

Where are we today?

- *Alpha*-version (GOES-EFD v0.3) recently completed
  - Simulated real-time mode
  - Mainly Matlab implementation
- Case studies in California indicate:
  - Consistently and significantly more successful at early detection than the operational satellite algorithm
  - Commits 35% fewer false alarms than GOES-EFD v0.2
  - Potential to provide earliest alarm
- Algorithm optimizations and tests are continuing (as resources permit)

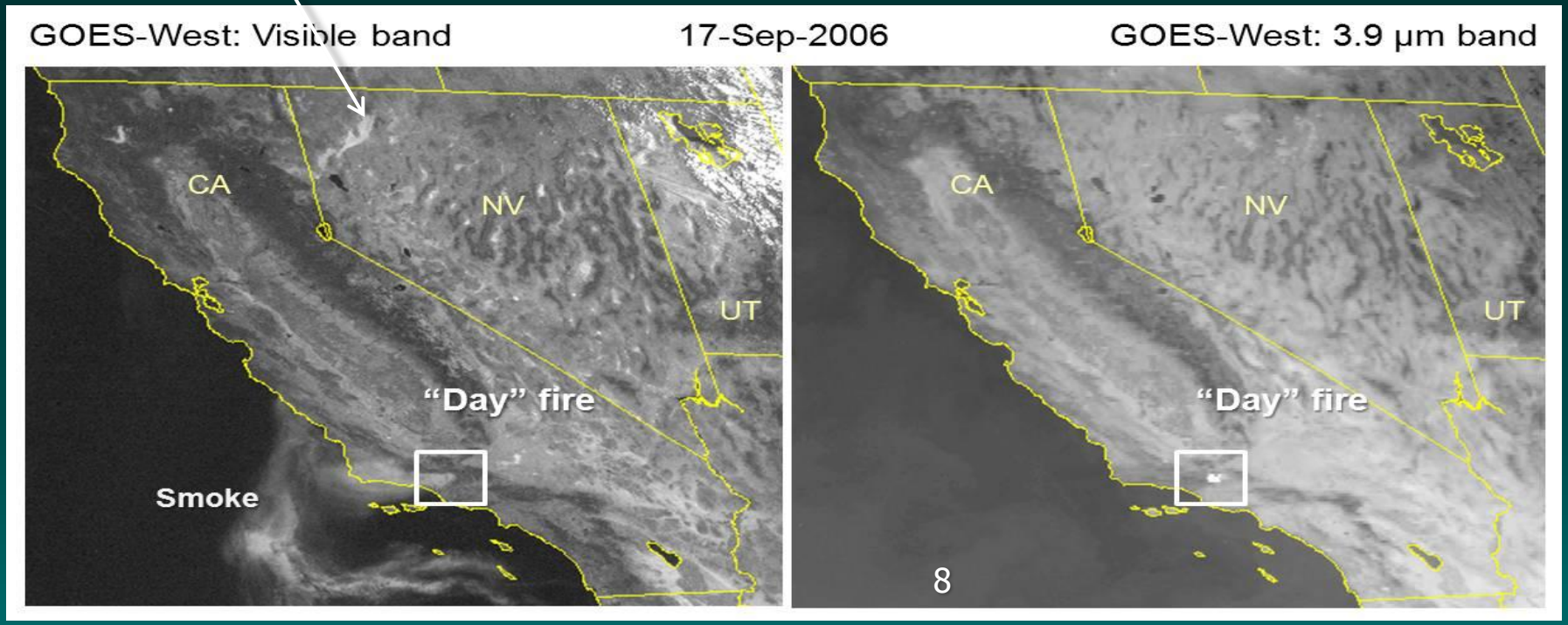
GOES-EFD: Intended Schedule

- 2013-15: Major development-test iterations, implementation, and integration: complete the GOES-EFD β-version
- 2015: Deployment of GOES-EFD-β at USFS RSAC as a component of the FS Active Fire Mapping Program
- 2015-2016: Near-real-time delivery to participating users;
  - Initial training and evaluation by participating users
  - User feedback and performance documentation
  - Follow-up optimizations
- 2017: Post-Deployment system maintenance and enhancement
- 2016-2017: Adaptation to GOES-R Advanced Baseline Imager

Geostationary Satellites (GOES East/West): Frequent, Low-Cost Imaging of Vast Territories

GOES Imager (NOAA):

- Viewing geometry – fixed
- Visible + Thermal Infrared (TIR) images
- @ ~15-30 min step (5-min during Rapid Scan)
- Effective TIR pixel size ~ **6** x **4 km** over CA



Active Fire Monitoring *vs.* Early Fire Detection

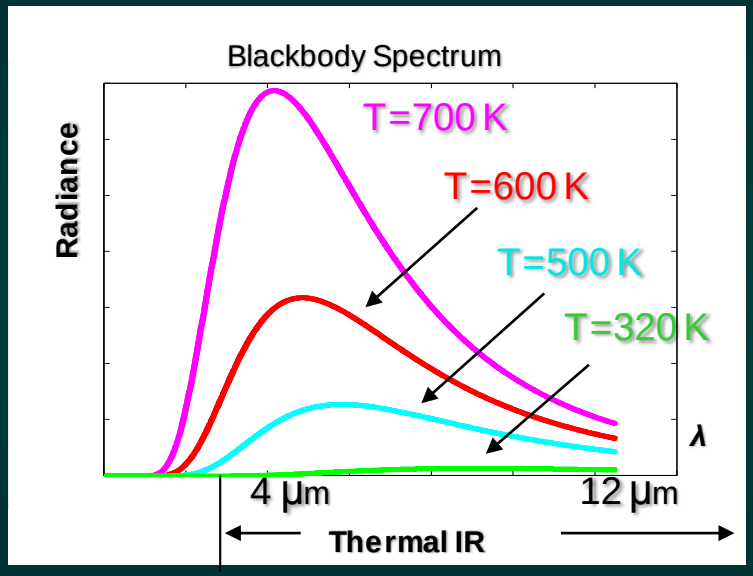
Primary Objectives are Related but Rather Different:

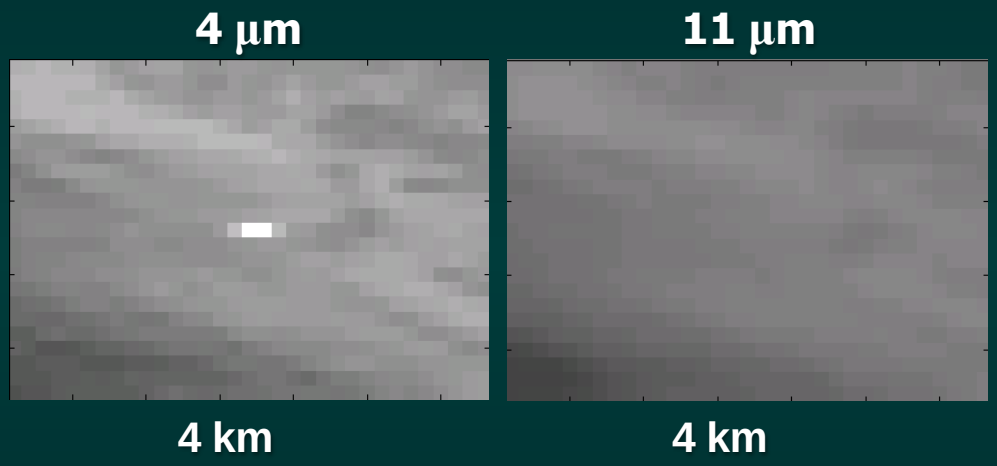
Active Fire Monitoring	Early Fire Detection
Maximize % of detected burning **pixels**	Maximize % of detected **new** fire ***incidents (ignitions)***
Minimize % of false fire **pixels**	Minimize the number of false **new incidents** (alarms)
Estimate **flaming area, temperature,** etc.	Minimize **time to initial detection** of an incident
Perform **consistently all year-round globally** (e.g. for comparative studies)	Optimize for **fire season** and a chosen surveyed **scene**

… and So Are the Optimal Algorithms

GOES-EFD is a tool specifically optimized for the objectives of early detection…

Physical Basis for Infrared Fire Detection





Planck's Law: **Radiance (λ) = *B* (λ, T)**

wavelength temperature

fire $R_{4\mu m} >> R_{11\mu m}$

soil $R_{4\mu m} \sim R_{11\mu m}$

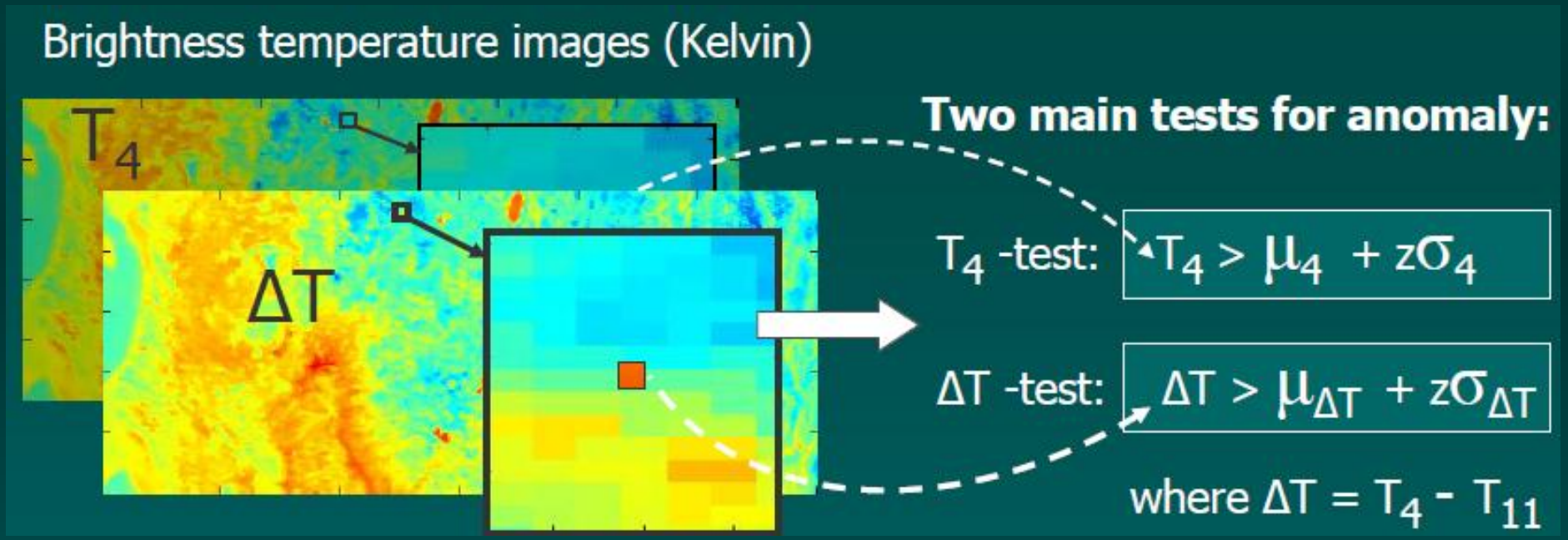
Primary regions used for detection:

Mid-wave TIR (3 - 5 μm)

Long-wave TIR(10 - 12 μm)

Heritage Fire Detection Algorithms

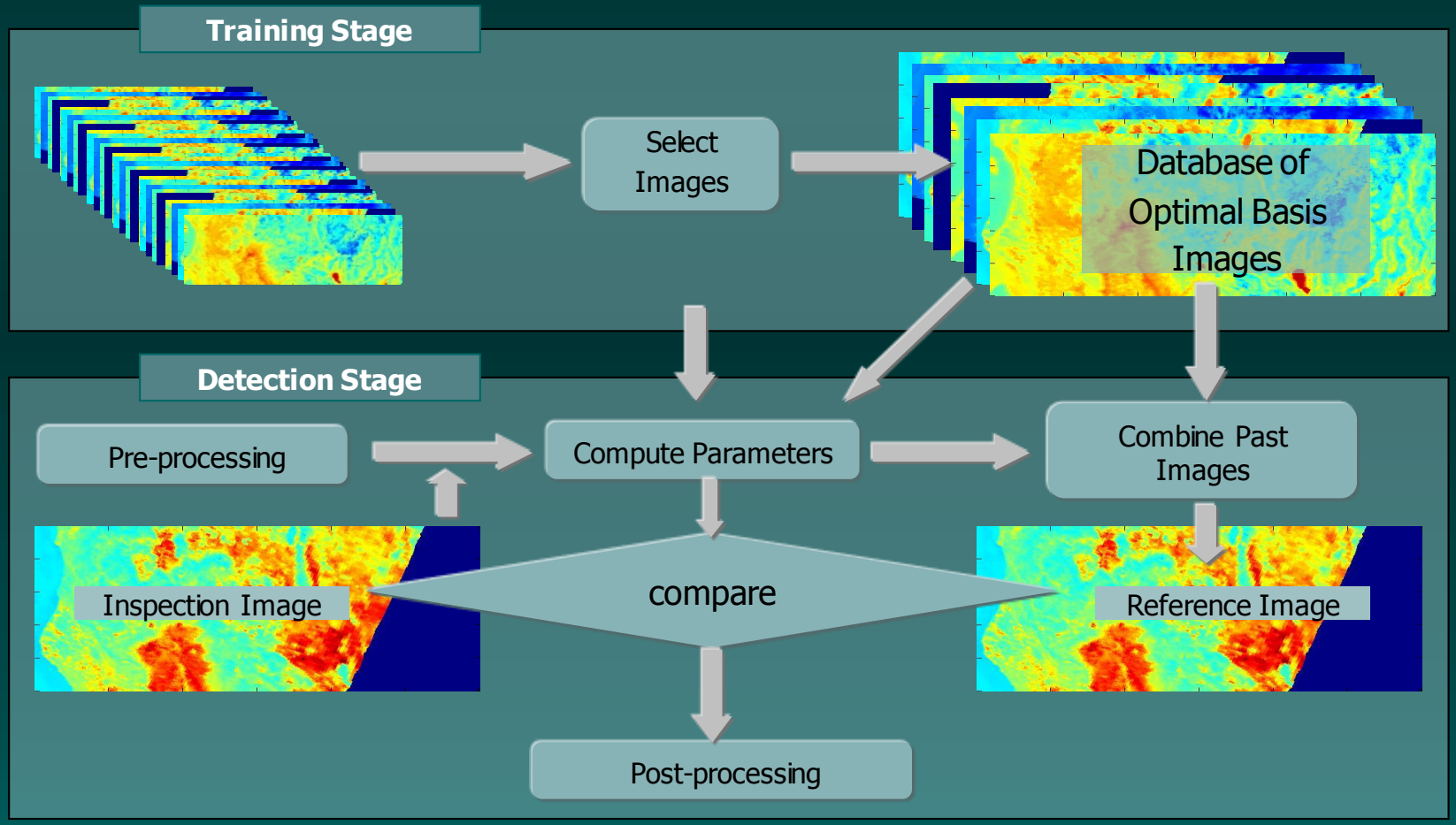
Based on contextual detection… find pixels that are much hotter than neighbors



- Good for detecting large/hot fires relative to sensor spatial resolution
- Performs well in thermally homogenous areas

GOES-EFD Algorithmic Principle: Merge Temporal + Contextual Information

Multitemporal background prediction by Dynamic Detection Model:



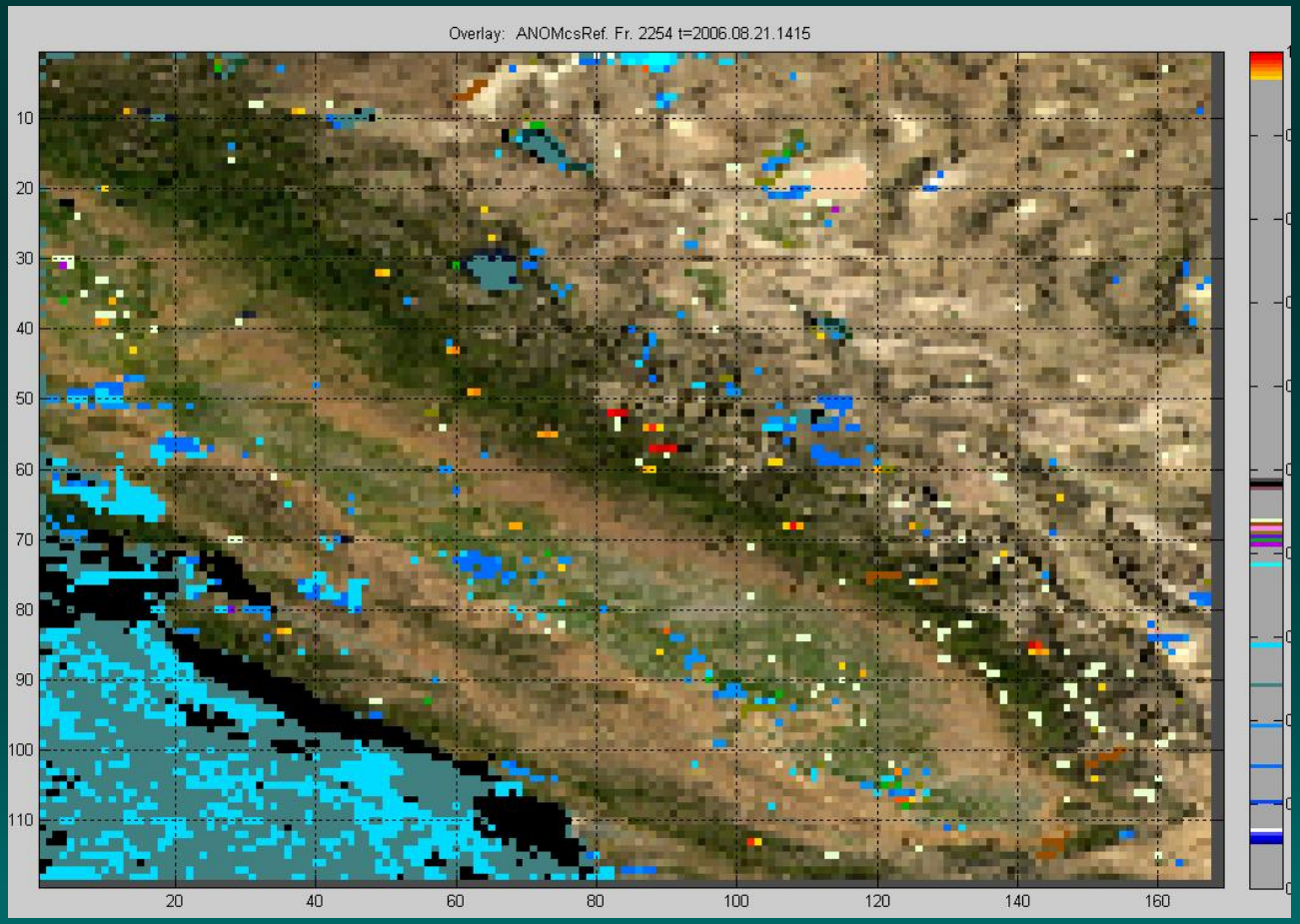
Koltunov & Ustin S.L. (2007) *Rem Sens Environ*

Koltunov, Ben-Dor, & Ustin (2009) *Int J of Rem Sens*

Pixel-wise "Unfiltered" Fire Mask

GOES-EFD analyzes basis images and inspection image in the detection stage

Anomaly Classifier: Excludes pixels affected by cloud, glint, etc. and classifies remaining pixels into one of 12 anomaly classes (7 for fire confidence classes)



Fire Pixels

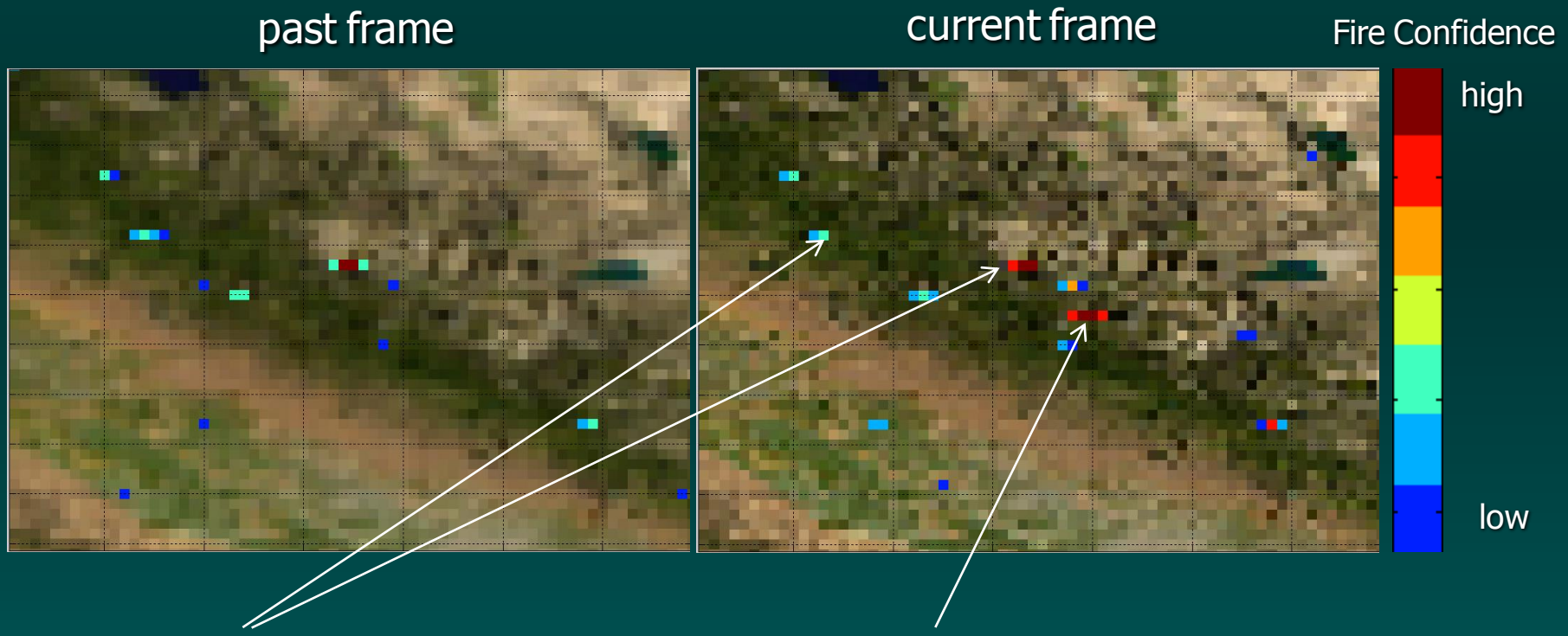
Rejected Thermal Anomalies

Cloud Snow

From Pixels to Events (potential incidents)

GOES-EFD target objects are New Incidents (multi-pixel, multi-frame objects)

Event Tracker: Analyze the temporal evolution of spatially connected groups of fire pixels



Retrospective Assessment of Incident Detection Timeliness and Accuracy

- Very different from validating an Active Fire Product
  - Not a trivial problem:
    - Official wildfire records -> Frequently are incomplete
    - High resolution imagery -> Infrequent acquisition schedule
- Truth Data Sources:
  - Official wildfire incident records
  - Landsat-based burn detection
- While any kind of error in the database is possible, not all kinds of errors are equally probable
- Challenge is to derive useful and reliable performance measures despite uncertainties and biases in truth data

Koltunov A., Ustin, S. L., Prins, E (2012) "On timeliness and accuracy of wildfire detection by the GOES WF-ABBA algorithm over California during the 2006 fire season", *Remote Sensing of Environment*, v.127: 194-209

GOES-EFD Experiment With 2006 Fire Season

Detection Period:	**40** days; **2852** images: **Aug 3 – Oct 1** at ~**20**-min time step on average. -- Substantial Cloud Cover
Wildfire Incidents Used:	Large (>2 ha final size) wildfires; Central California only

Sample #1: **13** fires with known initial report HOUR

Sample #2: **25** fires with known initial report DATE

Used wildfire incident databases from:

- California Department of Forestry and Fire Protection (CALFIRE)
- Geospatial Multi--Agency Coordination (GeoMAC) group

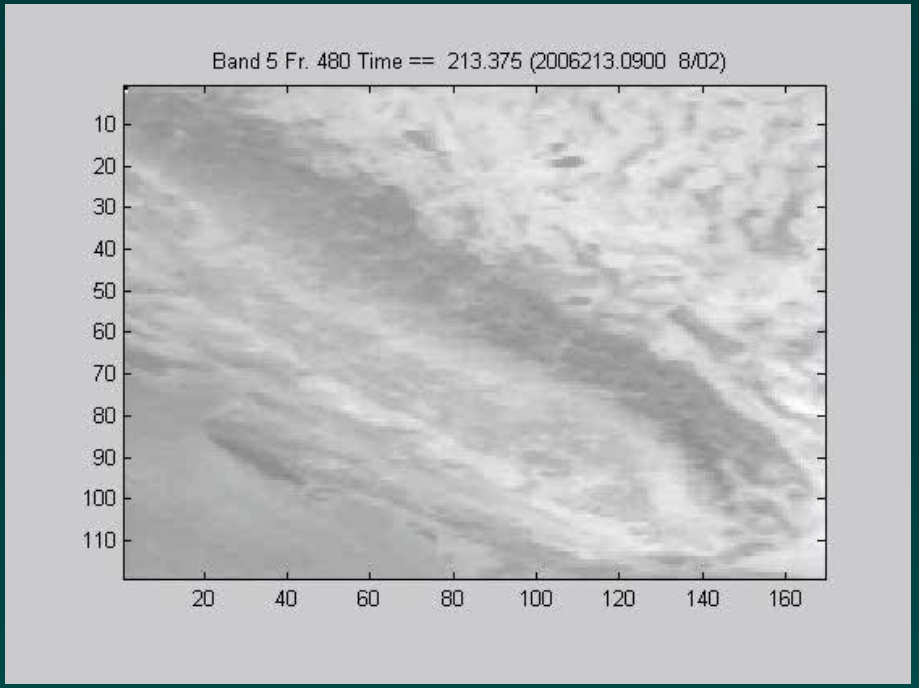
Performance Statistics: GOES-EFD v03

Detected incidents	GOES-EFD regular	WF--ABBA @30min
for 13 test fires with recorded report hour:		
Detected in < 1 hour	**10/13**	**7/13**
Detected before reported	**4/13**	**2/13**
Total latency reduction	**142 min**	**45 min**
for 25 test fires with recorded report date:		
Detected in < 12 hours	**15/25**	**11/25**
False (non-wildfire) or unconfirmed incidents	**51**	**55**

- GOES-EFD tends to detect fires earlier than WF-ABBA
- Reduction of ~35% of false new incidents vs. v0.2
- GOES-EFD can provide the earliest detection alarm

GOES-R Advanced Baseline Imager (2016)

- Full disk coverage: every 15 minutes
- Continental US coverage: every 5 minutes.
- Spatial resolution : 2 km in TIR
- A new channel at: 10.3 μm.
- Fewer saturated pixels



When GOES-R is available:

- Mature, well tested GOES-EFD system
- EFD-prepared, EFD-friendly user community
- Acceptance by scientific community

Ongoing GOES EFD Activities

- Advance to a beta version level through continued algorithm/system optimization via test/development iterations
  - GOES image registration
  - Anomaly detection/classification
  - Improved filters for false alarms
  - Improved temporal filtering
  - Event tracking
  - Etc., etc.
- Retrospective validation
  - Preparing a large-area test for year 2012
- Increase involvement with end users to ensure sustained and informed use of data/products
  - Determine their decision-making bottlenecks
  - How to best use fire-candidates from GOES-EFD?
  - How to best combine GOES-EFD product with conventional wildfire identification means?

Ongoing GOES EFD Activities

- Continue to increase project visibility/acceptance
  - Scientific publications/presentations
  - Workshops
  - Project website
- Exploring mechanisms to implement a complete baseline system for deployment
  - NRT GOES imagery collection and ingest
  - IT infrastructure for data processing and repository/archiving
  - GOES EFD software
  - Output data products
  - Forest Service interface with GOES EFD

Conclusions/Potential Benefits

- GOES EFD shows significant promise while still in the alpha development phase
  - System enhancements are continuing based on resource availability
- GOES EFD is more successful than at early fire detection than GOES WF-ABBA algorithm
- GOES EFD offers substantially more accurate geolocation of detected fire candidates
- Anticipated results:
  - 20%-50% of wildfires detected before the documented report; 50%-80% within the first hour
- Significant technical advancements of GOES R will improve timeliness and reliability of GOES EFD