GOES Early Fire Detection System Development

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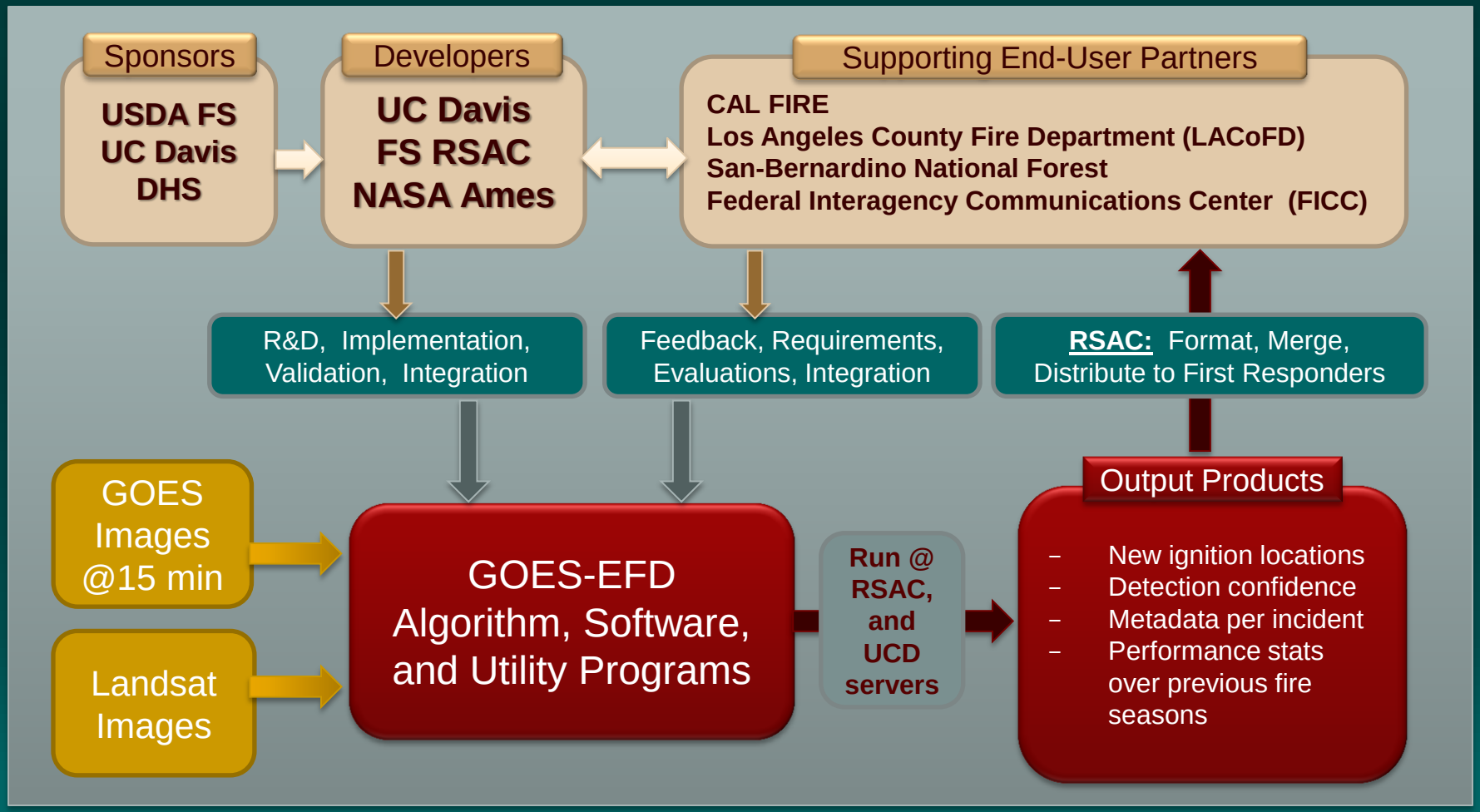
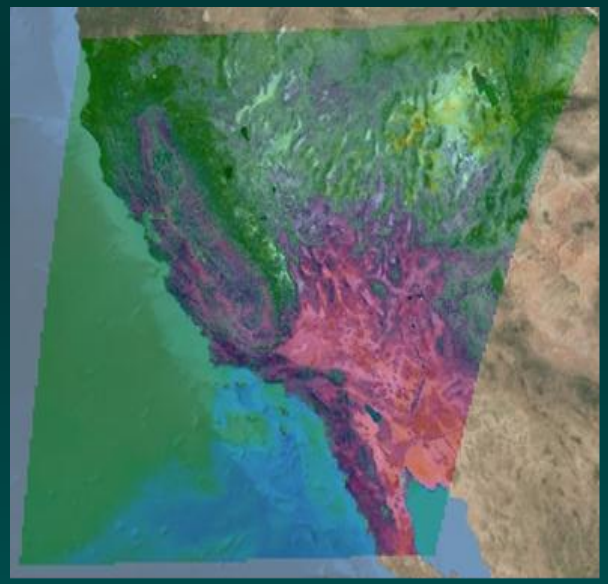
GOES-EFD effort: Data/Work Flow and Participants

Co-Investigators: Susan Ustin (UC Davis),
Brad Quayle, (USFS RSAC)
Brian Schwind (USFS RSAC),
Vince Ambrosia (NASA Ames)



GOES Early Fire Detection (GOES-EFD) System

Objective: A low-cost and reliable capacity for systematic *rapid* detection and initial confirmation of new ignitions at regional level (TBD)



Detect new wildfire incidents consistently

within first 1-2 hours after start,

preferably before they are reported

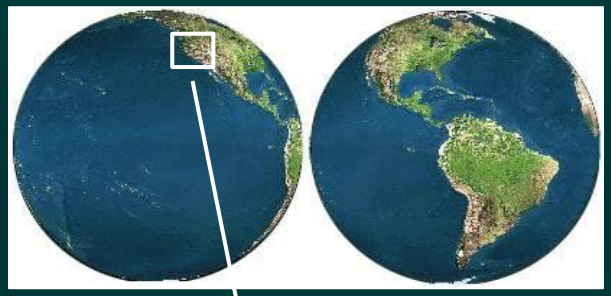
by conventional sources

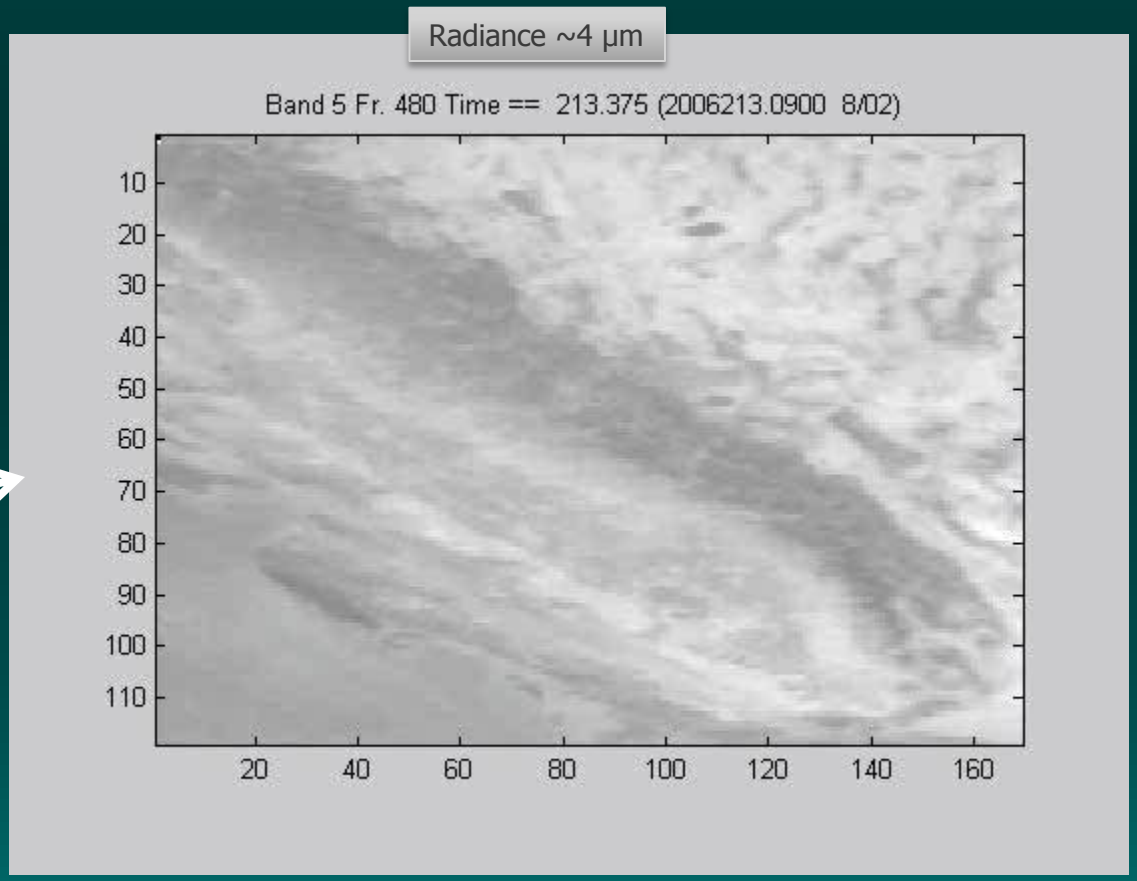
Geostationary Satellites: GOES

GOES Imager :

- Viewing geometry – fixed
- VIS and TIR images every 15-30 min
- TIR pixel size ~ **6** x **4 km** over CA

GOES-West GOES-East





WF-ABBA* operational algorithm for active fire monitoring

Designed for applications interested in, for example:

- **% eventually detected fires**
- **burned area accuracy**
- **number of false positive pixels**

Optimized well for global scale performance

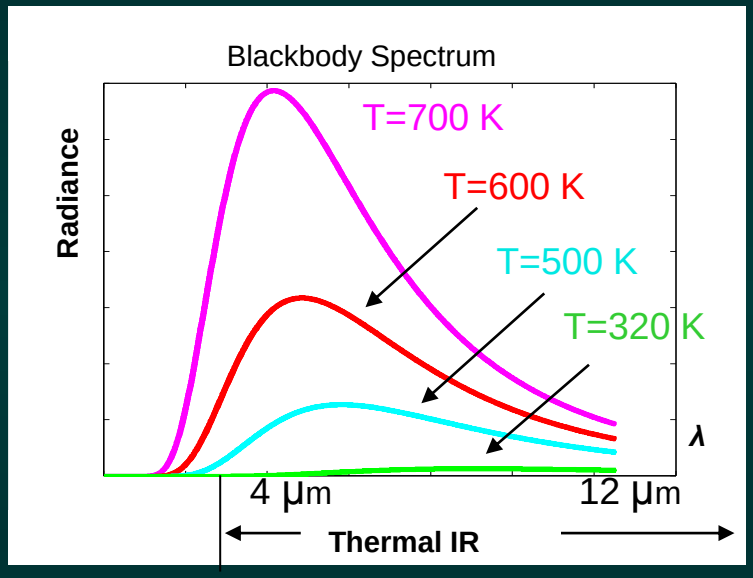
***Wildfire Automated Biomass Burning Algorithm** (Prins & Menzel, 1994)

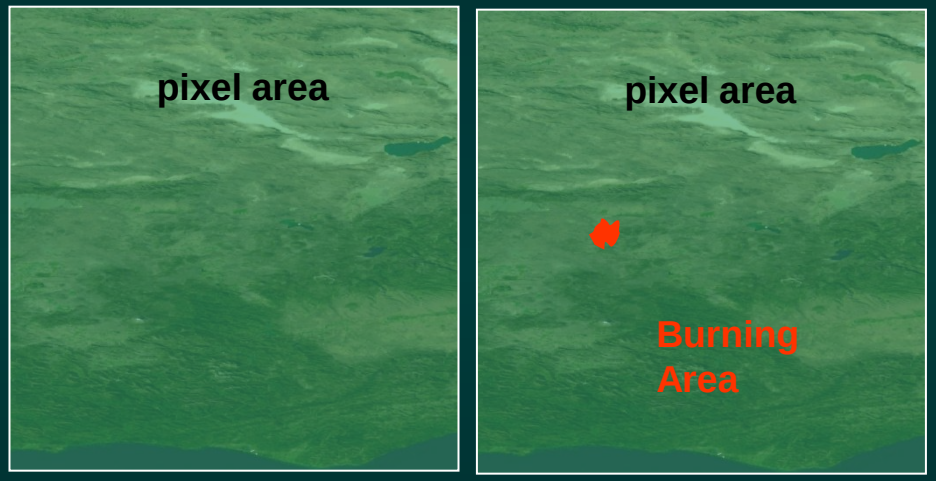
In contrast,

Early Detection has different priorities:

- Minimize the time to initial detection of an incident
- Minimize the number of false incidents (alarms)

Physical Basis for Infrared Fire Detection





6 km 6 km

Planck's Law: Radiance (λ) = B (λ, T)

wavelength temperature

fire $T_{4\mu m} >> T_{12\mu m}$

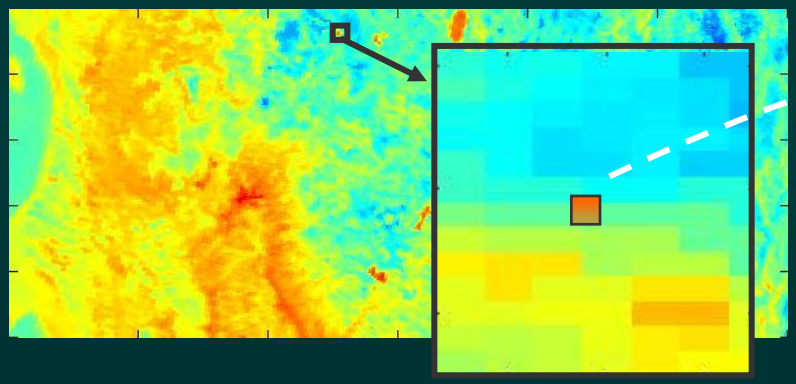
soil $T_{4\mu m} \sim T_{12\mu m}$

Primary regions used for detection:

Short-wave TIR (3 - 5 μm)

Long-wave TIR(10 - 12 μm)

WF-ABBA Principle: Contextual Detection
(find pixels that are much hotter than neighbors)



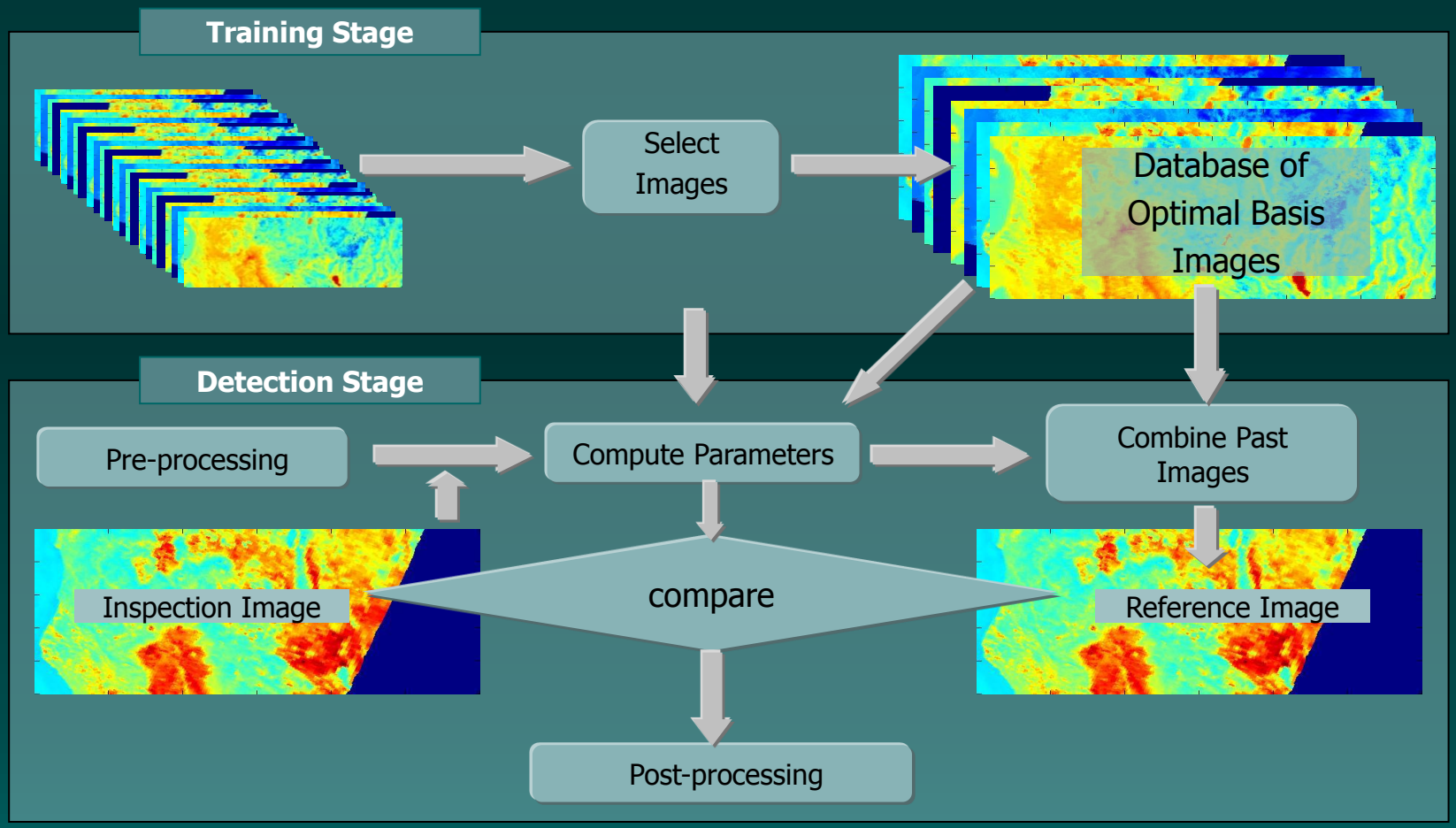
Fire Candidate

$$T_{3.9\,\mu m} > \mu + 3\sigma$$

- Good for detecting large/hot fires (sooner or later)
- OK for thermally homogeneous areas (**σ is small**)
- Less effective on ecosystem boundaries

GOES-EFD principle: Temporal + Contextual
(detect anomalous changes in surface properties)

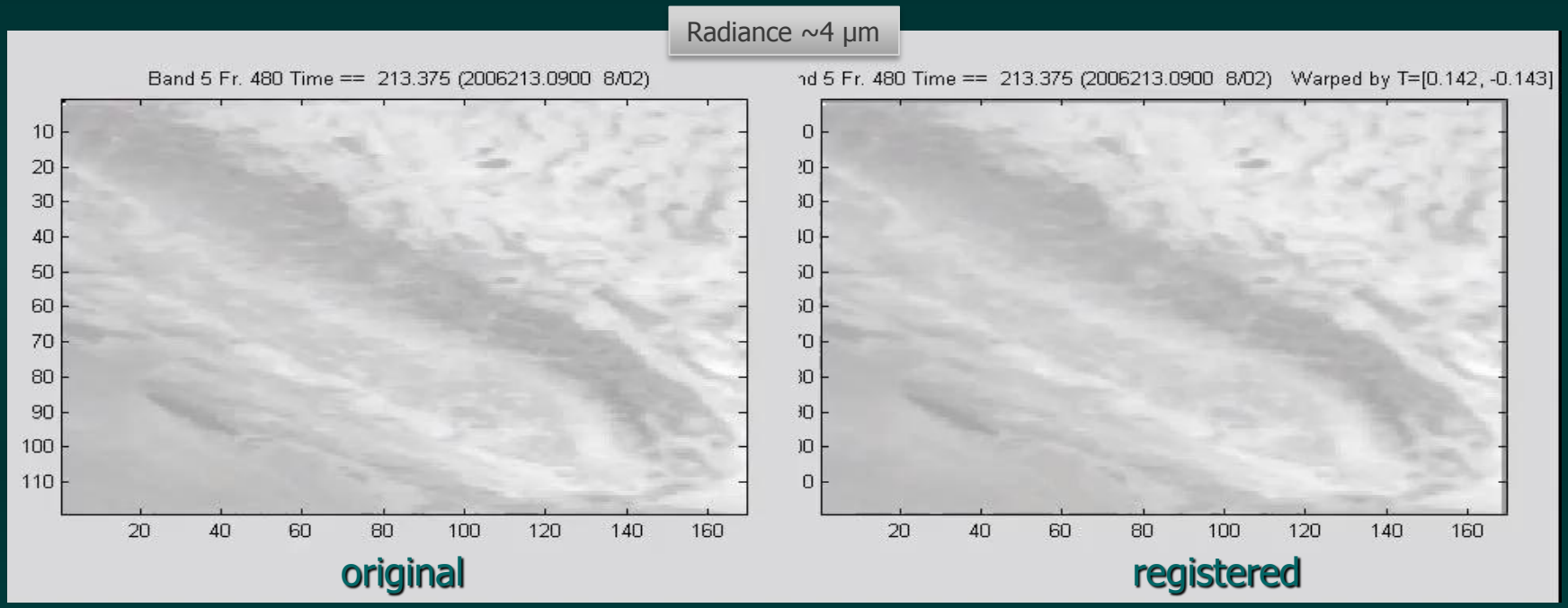
Multitemporal background prediction by Dynamic Detection Model:

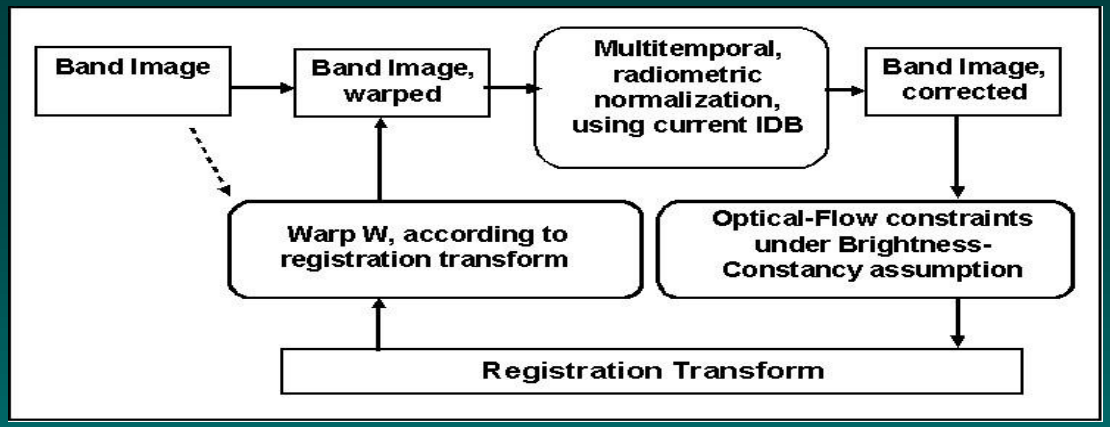


Koltunov & Ustin S.L. (2007) *Rem Sens Environ*

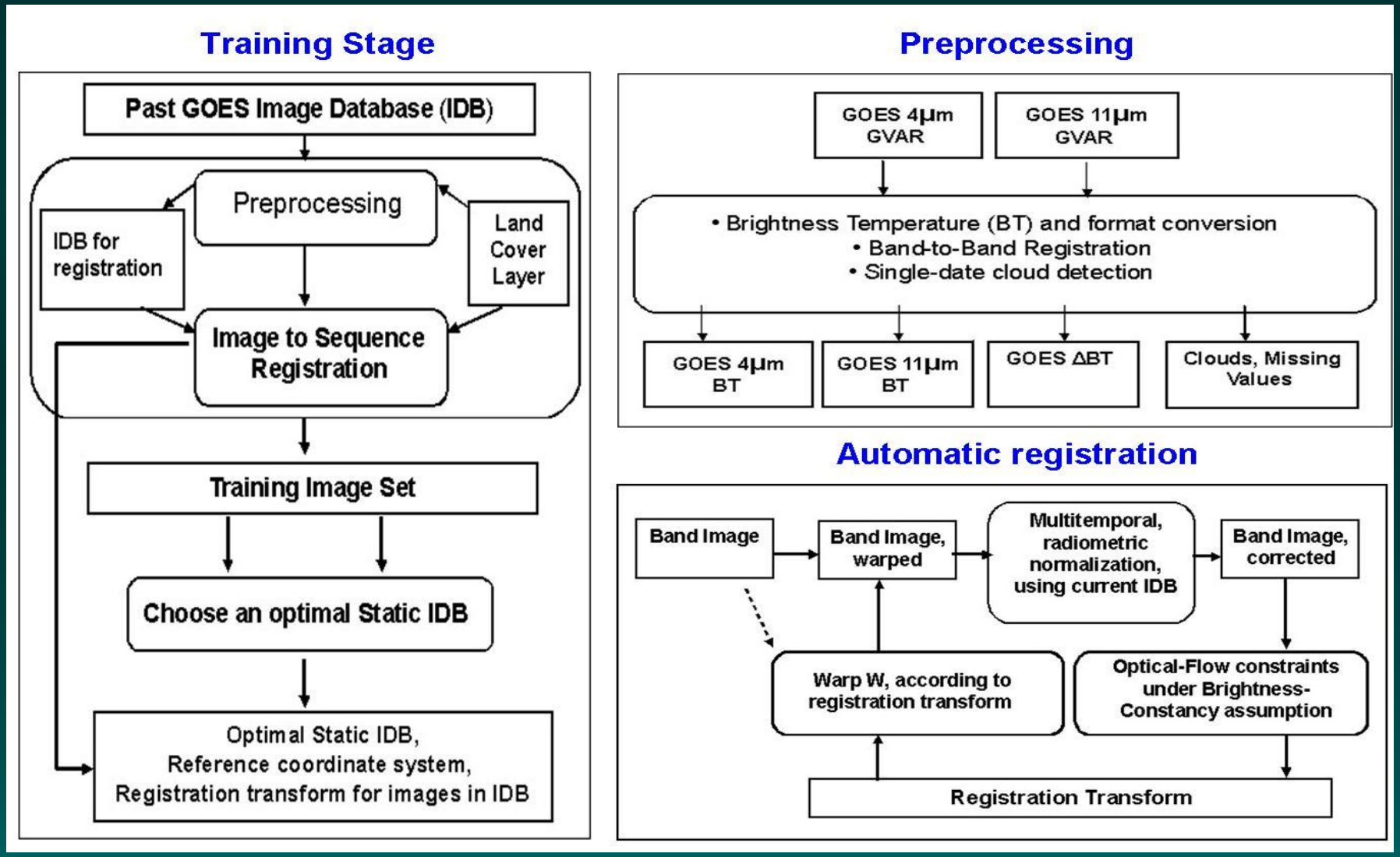
Koltunov, Ben-Dor, & Ustin (2009) *Int J of Rem Sens*

Automatic Thermal Image Registration

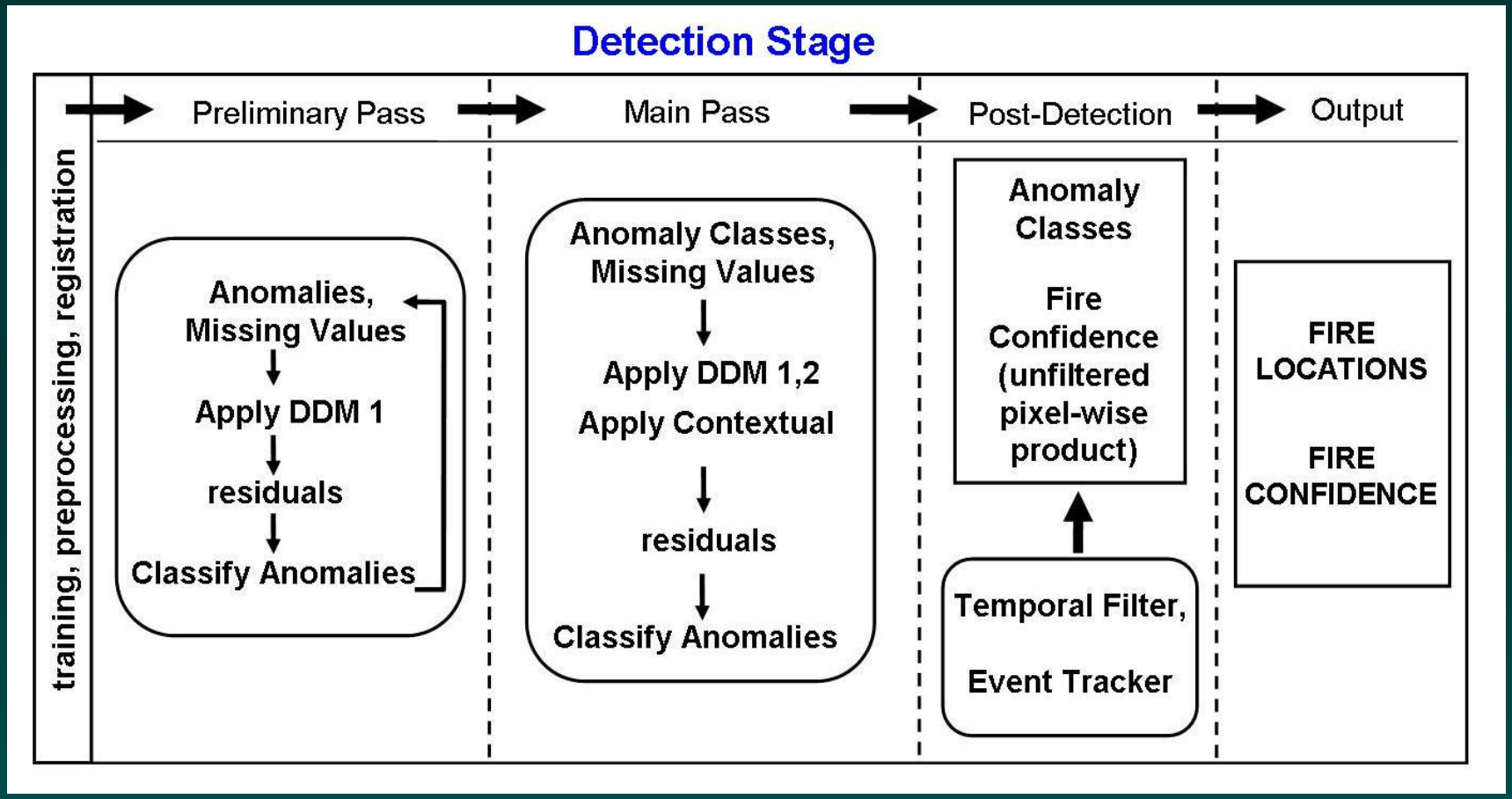




GOES-EFD ver. 0.2: Training and Preprocessing



GOES-EFD ver. 0.2: Detection Stage



Event Tracking: from pixels to events

1) Do pixels flagged "fire" in this frame form the same fire incident/complex?

2) A new incident?

Event == group of fire pixels to be considered a single wildfire incident

- An "existing" event: No action is necessary
  - a re-detected wildfire
  - a re-detected false
- A "new" event: An action may be required
  - a true new ignition, or
  - a false positive

Initial Experiment with fire season 2006 Central California

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;

CA 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 (CAL FIRE)
- Geospatial Multi-Agency Coordination (GeoMAC) group

Include wildfire incident reports from: USFS, BLM, NPS, CAL FIRE, et al.

Validation methodology: use official incident reports and Landsat imagery

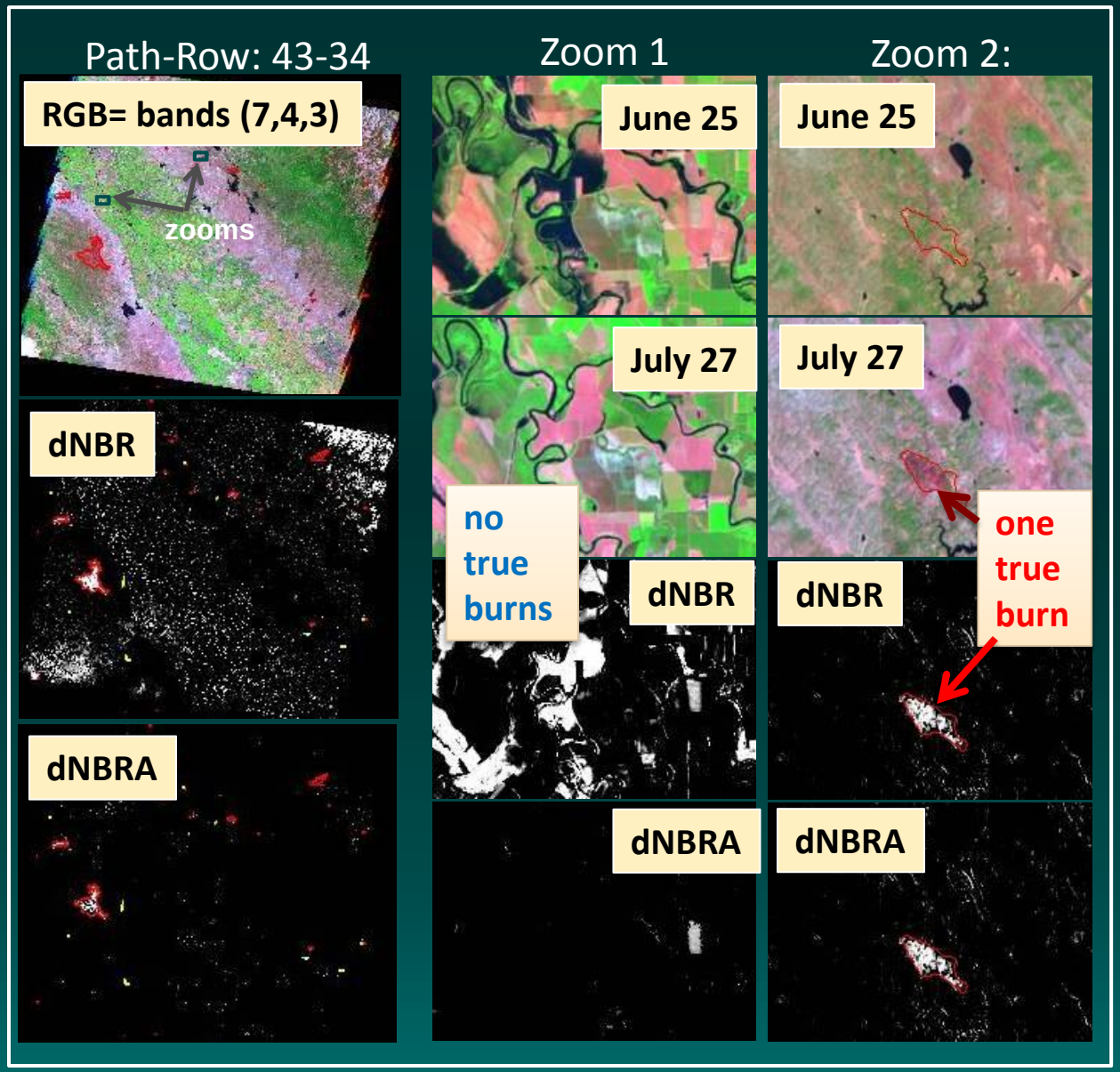
Koltunov, Ustin, & Prins (2012)

1. Match events in space and time to official wildfire incident records (including fire initial report/start time and estimated end time)
2. Matched incidents == true positives
3. Unmatched incidents == a false positive OR unreported actual fire

Check unmatched events against new burns in Landsat imagery

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*, in review

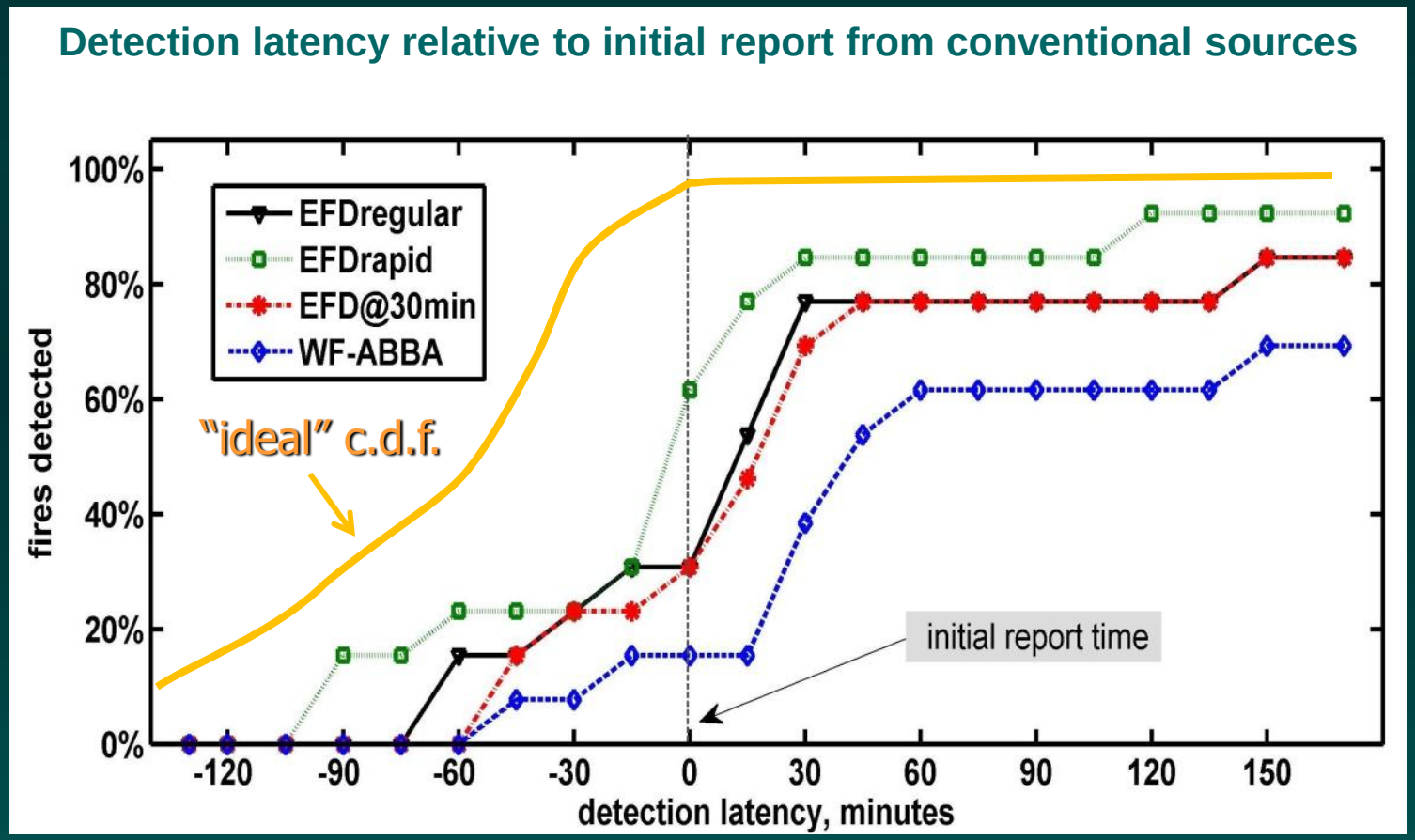
New burn detection in Landsat pairs



What if, there is a new burn near suspected false positive?

What if, no new burns found near suspected false positive?

Detection timeliness: cumulative distribution function (c.d.f.)



Performance statistics

Detected incidents	GOES-EFD rapid	GOES-EFD regular	GOES-EFD @30min	WFABBA @30min
for 13 fires with recorded report hour				
Detected in < 1 hour	11/13	10/13	10/13	7/13
Detected before reported	4/13	4/13	3/13	2/13
Total latency reduction	216 Min	142 min	105 min	45 min
for 25 fires with recorded report date				
Detected in < 12 hours	16/25	15/25	15/25	11/25
False / non-wildfire incidents	up to 784	up to 79	38 to 53	39 to 55

GOES-EFD detects fires earlier than WF-ABBA

Summary

- Initial, proof-of-concept version ready (optimizations under way)
- GOES-EFD will complement WF-ABBA global monitoring capabilities at regional level:

GOES Early Fire Detection algorithm	WF-ABBA algorithm
Optimized for Regional Scale Surveillance	Optimized for Global Scale Surveillance
Best for Detecting New Ignitions ASAP	Best for Consistently Monitoring Active Fires

Next steps:

- Development-test iterations
- Work with end-users partners to ensure sustained and informed use
- Validate extensively
- Deploy

We gratefully acknowledge

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- **University of California, Davis**
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CIMIS (California Irrigation Management Information System) program

http://wwwcimis.water.ca.gov/cimis

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