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THE DEVELOPMENT OF

GOES Early Fire Detection System to Reduce Disaster Vulnerability

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Rim wildfire in the Sierra Nevada Mountains is first reported on August 17, 2013 at 14:29 PM PST.

At the fire's peak, approximately 5,000 personnel and more than 400 engines and 40 helicopters supported Rim fire suppression efforts.

Extreme fire behavior resulted in 40% of the 400 square mile extent of the Rim fire burning at high severity.

Wildfire First Response: Every Minute Counts

Though not the system's primary objective, GOES data are leveraged by NOAA to monitor fire activity. The GOES Wildfire Automated Biomass Burning Algorithm (WF-ABBA) monitors and characterizes active fires, but is designed and optimized for applications where timeliness of the initial detection is a lower priority. For many users, however, the speed and timeliness of the detection is at a premium.

The GOES Early Fire Detection (EFD) algorithm has been developed to meet this need. Using enhanced data processing techniques designed to utilize multitemporal characteristics of the GOES data stream, GOES-EFD is able to more rapidly detect and confirm wildfire ignitions.

The primary benefit of timely wildfire ignition detection is increased situational awareness and improved strategic and tactical planning/response by emergency management and first responders. Once operational, the GOES-EFD system will provide first responders more time to respond to incidents and reduce of the risk of potentially disastrous wildfires.

DIFFERENT OBJECTIVES – DIFFERENT ALGORITHMS

Active Fire Monitoring (WF-ABBA)	Early Fire Detection (GOES-EFD)
Maximize detected fire **pixels**	Maximize detected fire **ignitions**
Minimize false detection fire **pixels**	Minimize false **alarms**
Estimate fire characteristics	Minimize time to initial detection
Globally, not regionally calibrated	Regionally and seasonally calibrated

GOES-EFD Goal: Rapid, Reliable Ignition Detection

- Provide synoptic, persistent regional surveillance
- Alert first responders to new fire ignitions
- Improve situational awareness for response planning
- Minimize uncertainties in resource deployment

GOES-EFD Algorithm Combines Temporal & Contextual Information

A GOES-EFD system instance is installed for a user-defined scene and operates in two stages: Training (Initial Calibration) and Detection. Training is performed once a year, before the surveillance season. The Detection Stage is a regular mode of operation, in which the incoming GOES multispectral images are automatically inspected to detect fires.

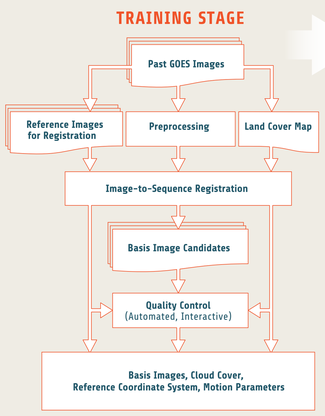
A system's core module is the Dynamic Detection Model (DDM)†,†† which estimates background signal and detects anomalies in the image sequence across two GOES bands: 3.9μm and 10.7μm.

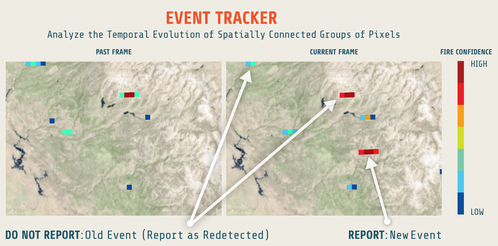
GOES-EFD TRAINING STAGE

- Automatic analysis and selection of optimal "basis images" from a pool of past GOES images
- Interactive review and refinement of basis image-candidates

GOES-EFD DETECTION STAGE

- Input images are calibrated, screened for clouds, and co-registered
- Anomaly detection, including multiple temporal DDM-based tests and a contextual test
- Pixels are classified to 12 fire/non-fire classes, using standardized residuals from anomaly tests and auxiliary masks
- Pixels assigned to fire classes are further processed by Temporal Filter and fed to Event Tracker
- Event Tracker decides if a fire pixel represents a new event or an ongoing and previously detected event

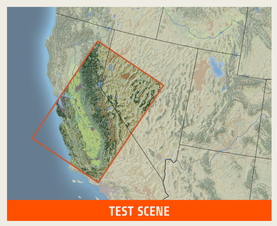




▲ IDENTIFYING PREVIOUSLY UNDETECTED IGNITIONS. The GOES-EFD Event Tracker morphologically analyzes recent detection history to decide whether a fire pixel is a new or existing event. New events extracted by the Event Tracker are the primary output of GOES-EFD.

◀ SCHEMA-OVERVIEW OF GOES-EFD SYSTEM. Training Stage prepares several static datasets and parameters to be used during the Detection Stage. Detection Stage routinely processes real-time imagery to identify fire ignitions. In both stages, GOES images are automatically aligned across bands and across frames using an intensity-based image alignment technique (Koltunov et al., in prep). Temporal Filter reduces false positives by requiring two subsequent detections.

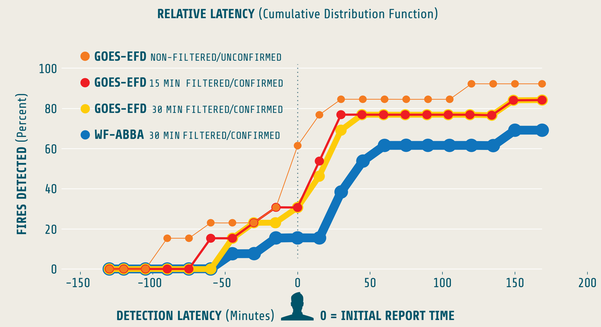
Case Studies: 2013 Rim Fire and 2006 California Fires



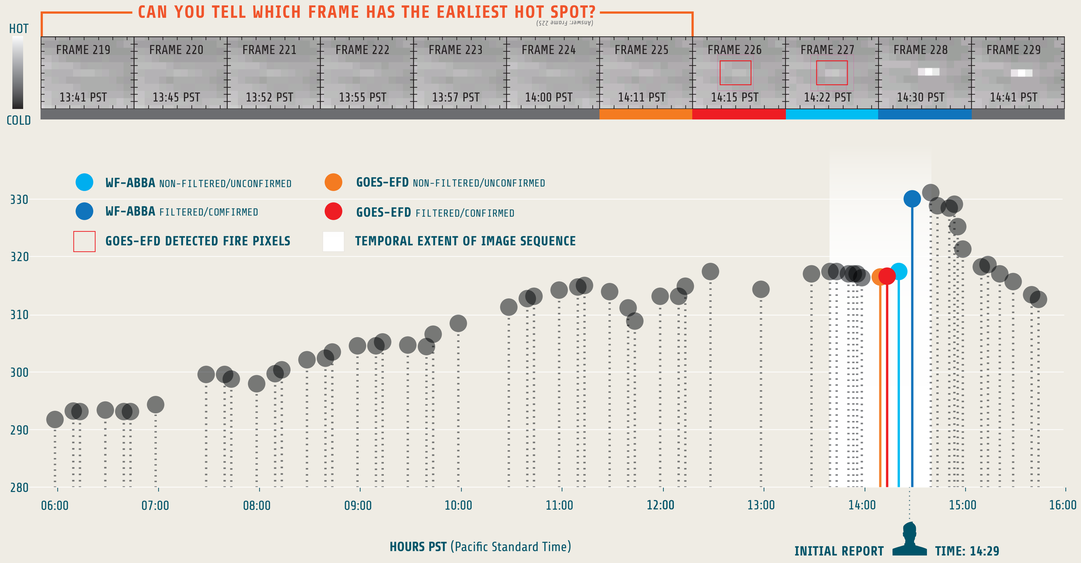
A retrospective analysis of the 2013 Rim Fire demonstrated the ability of GOES-EFD to reduce detection latency compared to WF-ABBA. Both, GOES-EFD and WF-ABBA, were applied to GOES-15 Rapid Scan imagery and detected the Rim Fire soon after start. GOES-EFD, however, detected the fire 15 minutes before WF-ABBA and also about 15 minutes before it was first reported by traditional means.

Retrospective analyses were also conducted for 25 fires during the 2006 fire season in central and southern California. GOES-EFD consistently detected ignitions faster than WF-ABBA with similar false positive rates, and for 25-30% of the fires GOES-EFD detected the fire before reports by the public.

▶ RELATIVE ALGORITHM DETECTION LATENCY FOR 2006 CALIFORNIA WILDFIRES. Cumulative distribution function (CDF) of detection timeliness relative to documented times of initial reports from conventional sources for 25 California wildfires occurring in 2006. The CDF curves represent results of three variants of the GOES-EFD v.0.2 algorithm and temporally filtered WF-ABBA v.6.1 for an approximately 40 day period. Incident report times compiled from interagency wildfire data provided by California Department of Forestry and Fire Protection (CAL FIRE) and US Geological Survey (USGS) GeoMac.



▼ GOES-15 THERMAL RESPONSE SEQUENCE AT THE RIM FIRE IGNITION PIXEL, AUGUST 17, 2013. A typical diurnal temperature cycle trajectory for the Rim Fire start pixel is followed by an abrupt increase at 14:30, also showing as a 3-pixel bright spot in the corresponding zoom image. That is when the fire was first reported to the dispatch. Prior to 14:22 when an unconfirmed ("non-filtered") fire pixel was detected by WF-ABBA, neither temporal history nor spatial context provides visual clues about ignition. Nevertheless, GOES-EFD detects a unique subtle anomaly over 10 minutes earlier, leading to a confirmed ("filtered") detection 15 minutes before the initial report and WF-ABBA.



Early Fire Detection Status and Schedule

EFD 2015 STATUS

- Ready to run in simulated real-time mode
- Algorithm optimization, component level tests, and system integration
- Expanding collaborations with scientific and user communities

EFD 2016-2017 PROJECTION

- Beta version deployed for user evaluation
- Leverage GOES-R Advanced Baseline Imager observations to detect fires 3x faster
- Broader operational support from additional agency sponsors and partners, such as NOAA GOES-R Program and NESDIS

GOES-EFD OFFERS AN OPPORTUNITY FOR NOAA TO MAXIMIZE THE GOES PROGRAM CONTRIBUTION TO WILDFIRE DISASTER REDUCTION

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