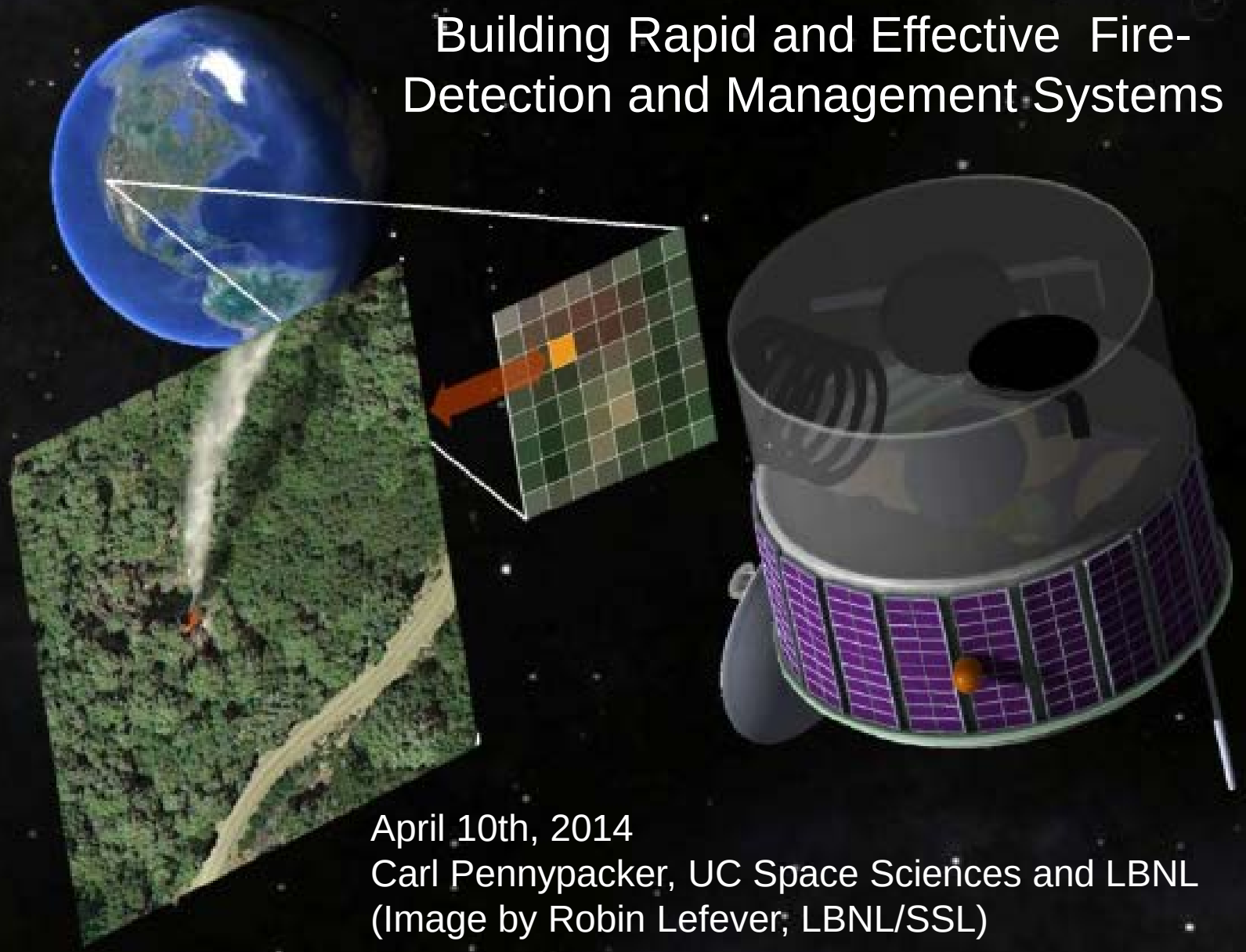
Building Rapid and Effective Fire-Detection and Management Systems



April 10th, 2014

Carl Pennypacker, UC Space Sciences and LBNL
(Image by Robin Lefever, LBNL/SSL)

What is *FUEGO?*

Fire Urgency Estimator from Geosynchronous Orbit

(and Associated Data Systems and hoped-for UAV steps in between…)

Supported by the Vice Chancellor for Research, UC Berkeley

- Early detection and *on-going management* of wildland fires
  - natural; accidental; terrorist
  - The Fire Data Cube
- Potentially valuable for the United States
- Geosynchronous orbit for 24/7 coverage
- Supplement ground & air observations
- Provide real time input for models for prediction and resource allocation
- Supplement other space-borne geo observatories
- Requires real-time assessment of **urgency.**
  - Urgency is the key ingredient! *Must* be made quantitative!
  - Requires tight integration with **Geographic Information Systems**

Our Berkeley Paper:

- We are not the first to employ (a bit) or suggest such a system.
- Assembled a bigger and better growing collaboration and many new ideas (ref. on handout)

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Article

FUEGO—Fire Urgency Estimator in Geosynchronous Orbit—A Proposed Early-Warning Fire Detection System

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- Gen. Larry Grundhauser (Ret.), Boeing Aerospace
- Carl Pennypacker, UC Berkeley Space Sciences Lab/LBNL
- Chris Schmidt, U. Wisc, GOES Satellite Fire Team
- Donn Walklet, Terra-vista, Inc.
- Alex Held, CSIRO, Australia

What Have We Accomplished?

- Web site: fuego.ssl.berkeley.edu
- Mailing list: fuego@lists.berkeley.edu (thanks to Alex Duda for website and mailing list)
- Discovered a possible way we can help early detection and management of wildfires
- Beginning to develop business plans, potential funders, etc.
- Assembled a great International team! Much support from UC Berkeley VC's offices!
- Tested and developed algorithms on real data from GOES and other Satellites
- Filed a US Provisional patent
- Conceptual design and calculations for satellite
- Interfaced effectively with Aerial Tanker Community, US Forest Service, Boeing, CalFire – political process may be emerging..
- Developed initial plans for CHIRP data collaboration
- Planning near term and longer term steps, including much less expensive UAV 's over LA !

What we hope *FUEGO (in satellite or UAV) can Provide to this Community:*

- Digital alert to Aerial Tankers within a minute or two of a fire growing beyond 10 sq. meters in size
- Tracking of the fire size continuously, with resolutions approaching 10's of meters
- Temperatures, amount of fire, spread rate,
- Supplement ground & air observations
- Provide real time input for models for prediction and resource allocation – direct feed of FUEGO and other local data into models and advice for fire-fighters
- Supplement other spaceborne geo observatories
- Supporting/enhancing the FUEGO Data Cube

FUEGO Objectives :

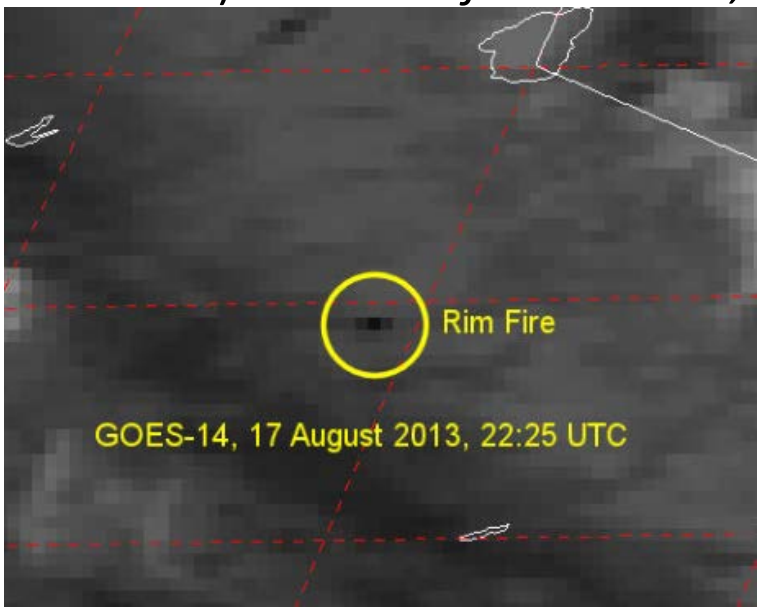
- Develop a Berkeley and International team of wildfire detection and suppression experts

- Play a role in helping to join/create a movement for state-of-the-art effective detection, modeling, suppression, and follow-up systems, based on modern remote sensing, satellite, computing, and modeling technology.

- Solicit input from potential users, benefactors, and collaborators of FUEGO.

Aspects of Rim Fire Story (1)

- Hunter's Campfire, 3:25 PM, August 17 (GOES saw it at 3:25), and "discovered/reported" after 4:30 pm (estimate)
- Reported/discovered by phone an hour or two later than expected FUEGO threshold
- Turned into California's 3rd biggest fire -- 260,000 square acres (400 square miles) *BTW: California is 100,000,000 acres area*



Aspects of Rim Fire Story (2)
Suppression $'s !!

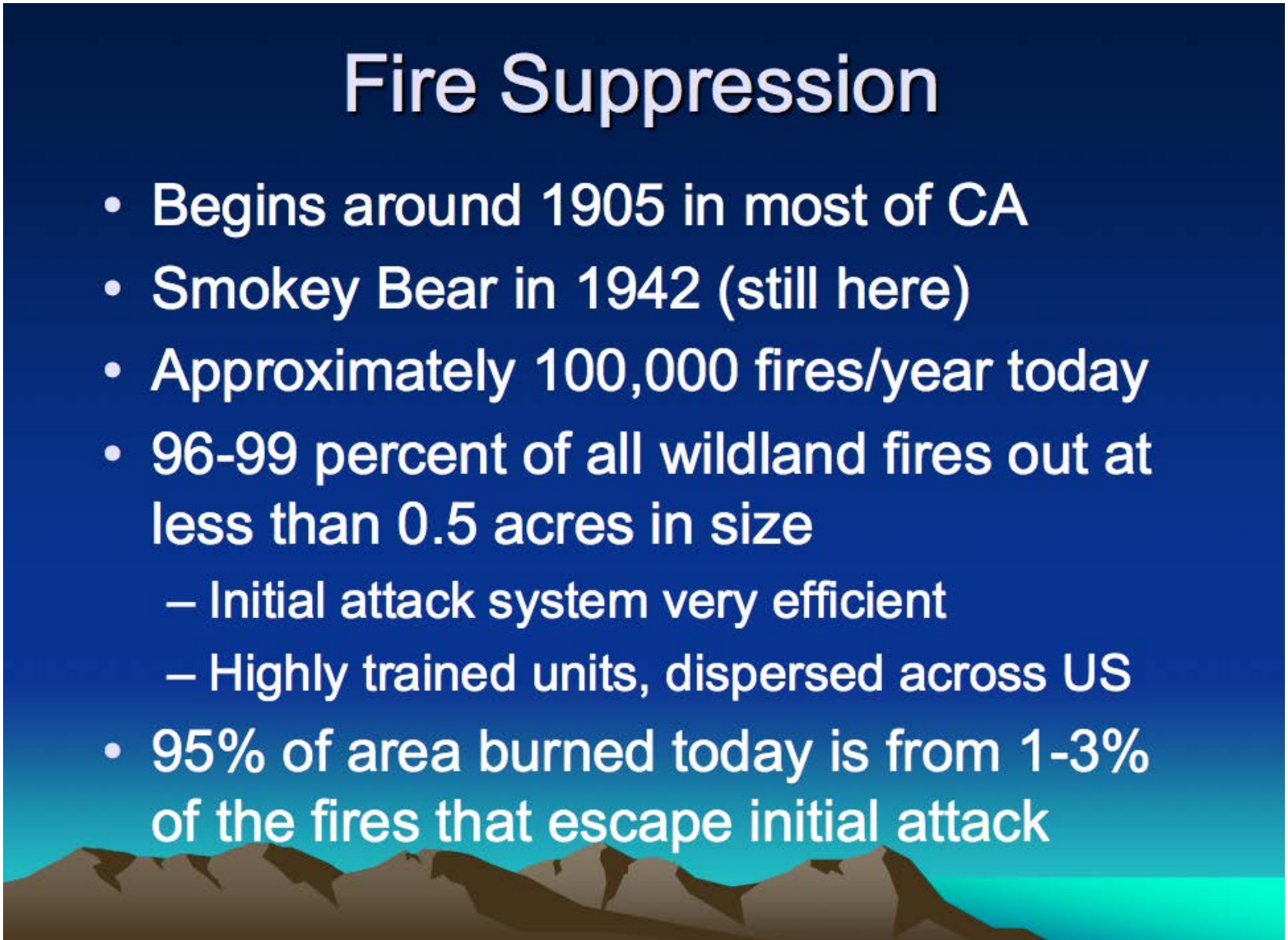
Aspects of Rim Fire Story (3)
Damage to Ecosystem $'s !!

The Modesto Bee
modbee.com

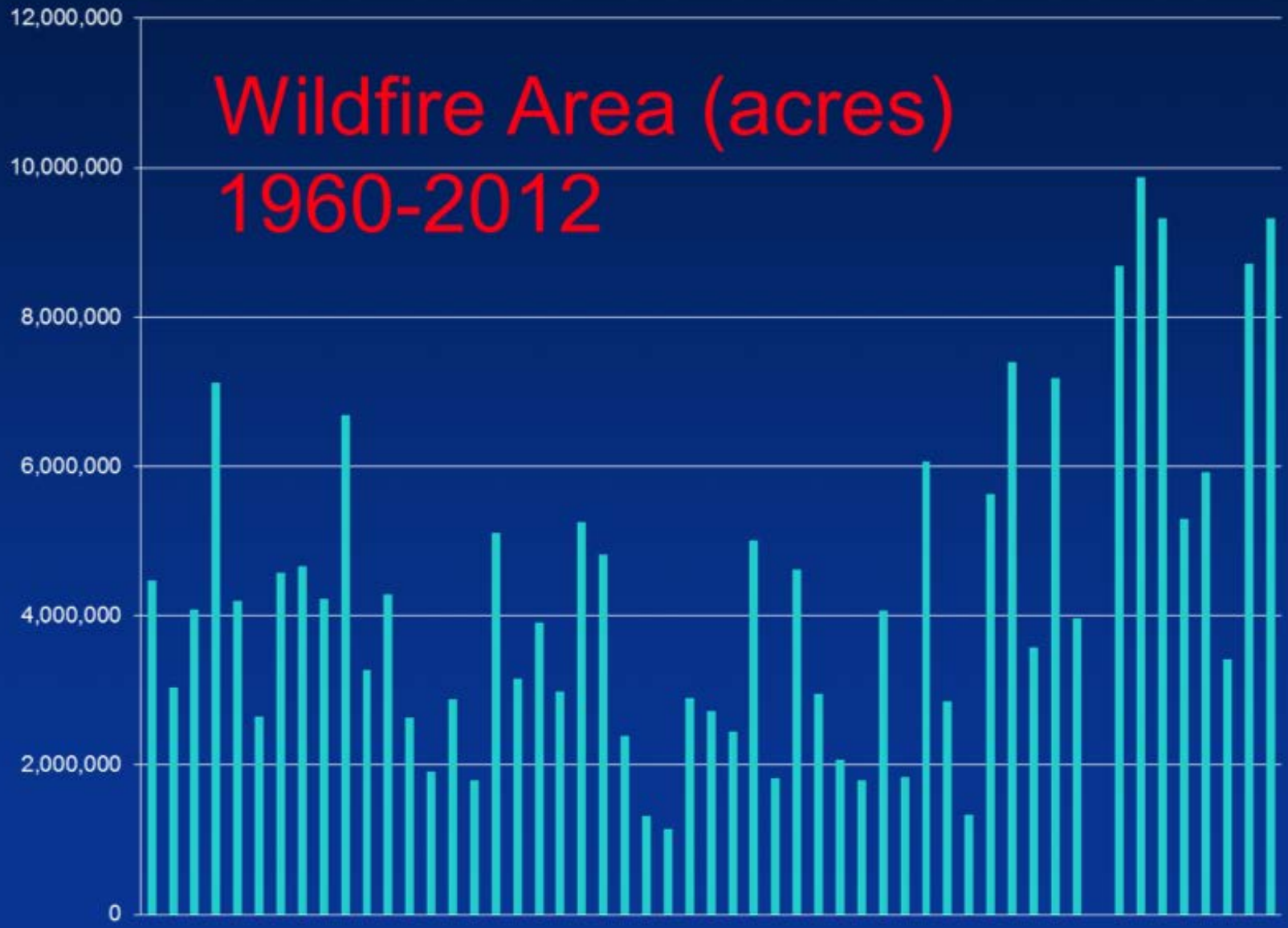
Report puts $797M price tag on Rim fire's damage to ecosystem

BY JOHN HOLLAND
jholland@modbee.com December 25, 2013

Following 5 Slides from ***Scott Stephens*** from our FUEGO Meeting, Dec, 2013



Federal Fire Area in US



Federal Fire Suppression Costs

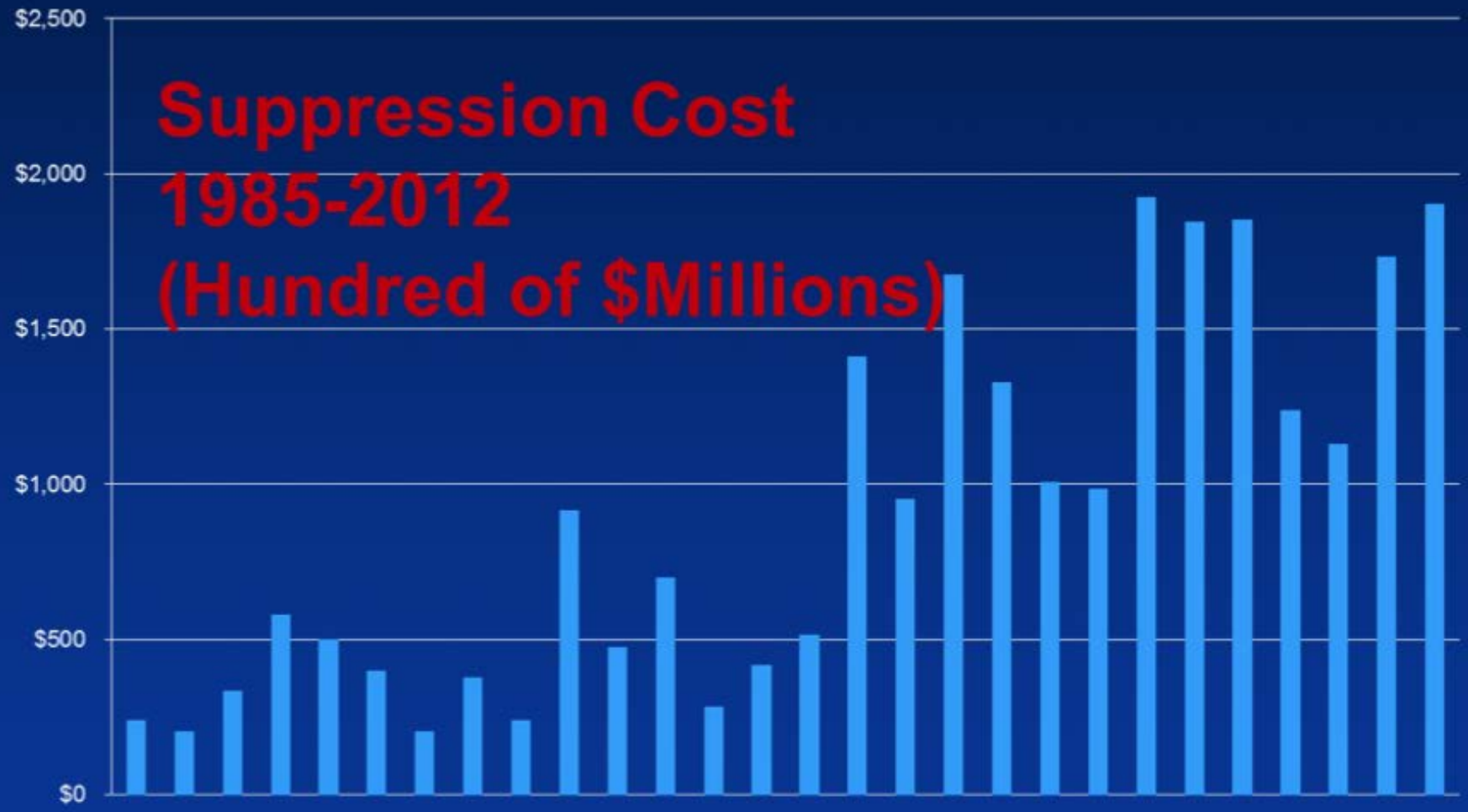
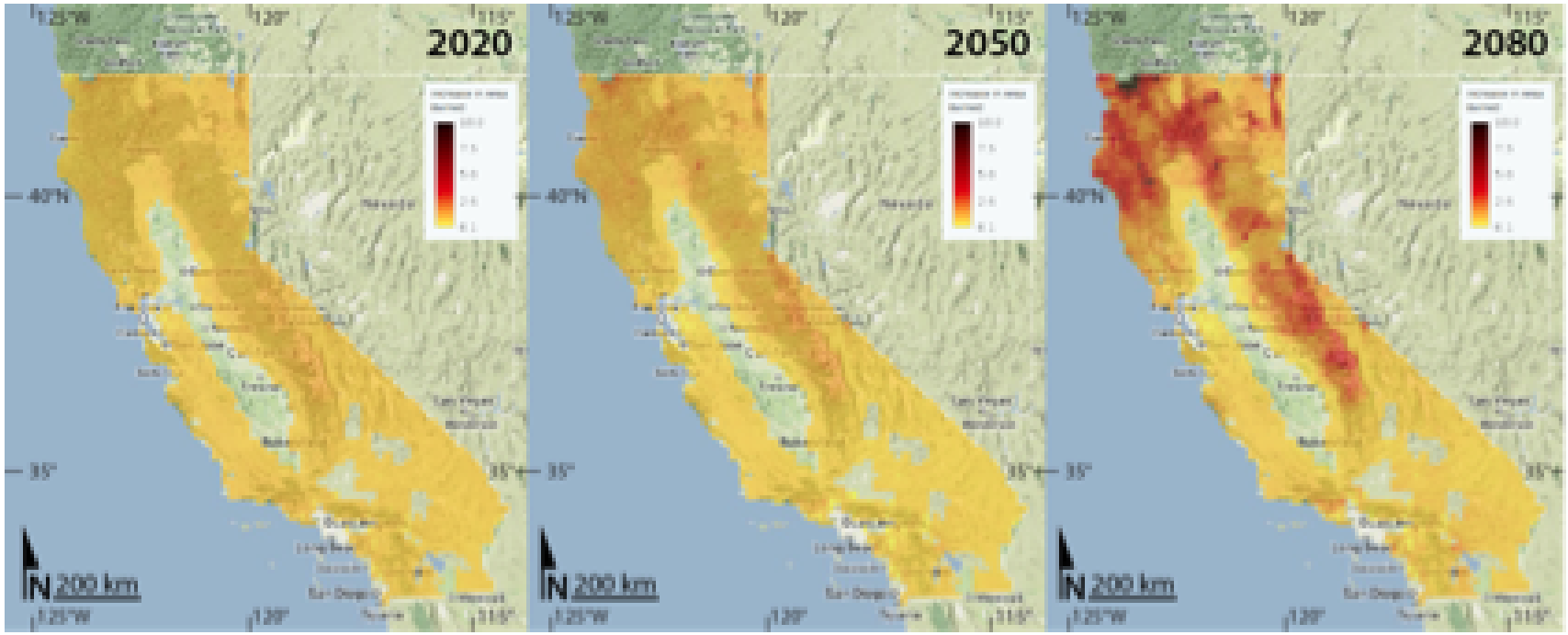


Figure 1. Projected ratio of additional fire risk for an area, as compared to the expected burned area for each grid cell. The ratio of additional risk was calculated for 30 year averaged periods ending 2020, 2050, and 2085, for one climate change model (GFDL) and one scenario (A2). Darker oranges and reds suggest up to a 10-fold increase in potential area burned in 2020, 2050 and 2085. Data source: http://cal-adapt.org. More detailed information about these data can be found in [2].



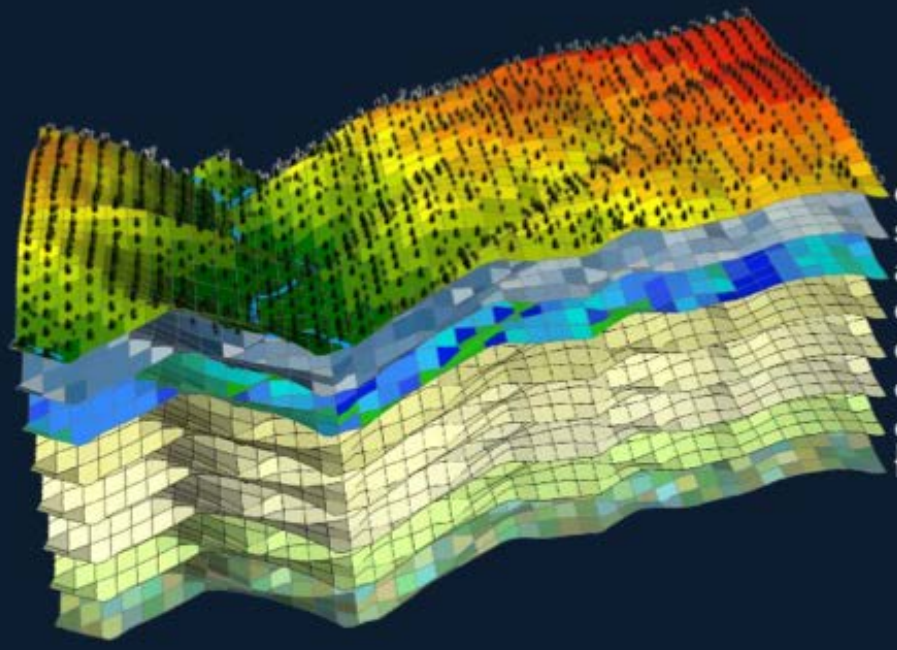
Wildfire Simulations

- **Fire behavior modeling:**
  - FARSITE (Fire Area Simulator by Mark Finney (UCB alumni))
    - Simulates an individual fire event based on a weather stream, topography, and fuels
    - Very good at predicting fire size and shape in wildland areas
      - Fires burning for months or a few days
      - Previous models were not spatial

- **Weather:**
  - Uses hourly wind velocity and
  - direction, max and min temp
  - and humidity

- **Analysis:**
  - Useful information for managers
  - Normally used on all large fires
  - today

GIS Fire Behavior Data Requirements for FARSITE



FARSITE

FlamMap

Eight layer sandwich of data

lidar basics

wildfire modeling { backgro und → meth od → resul ts }

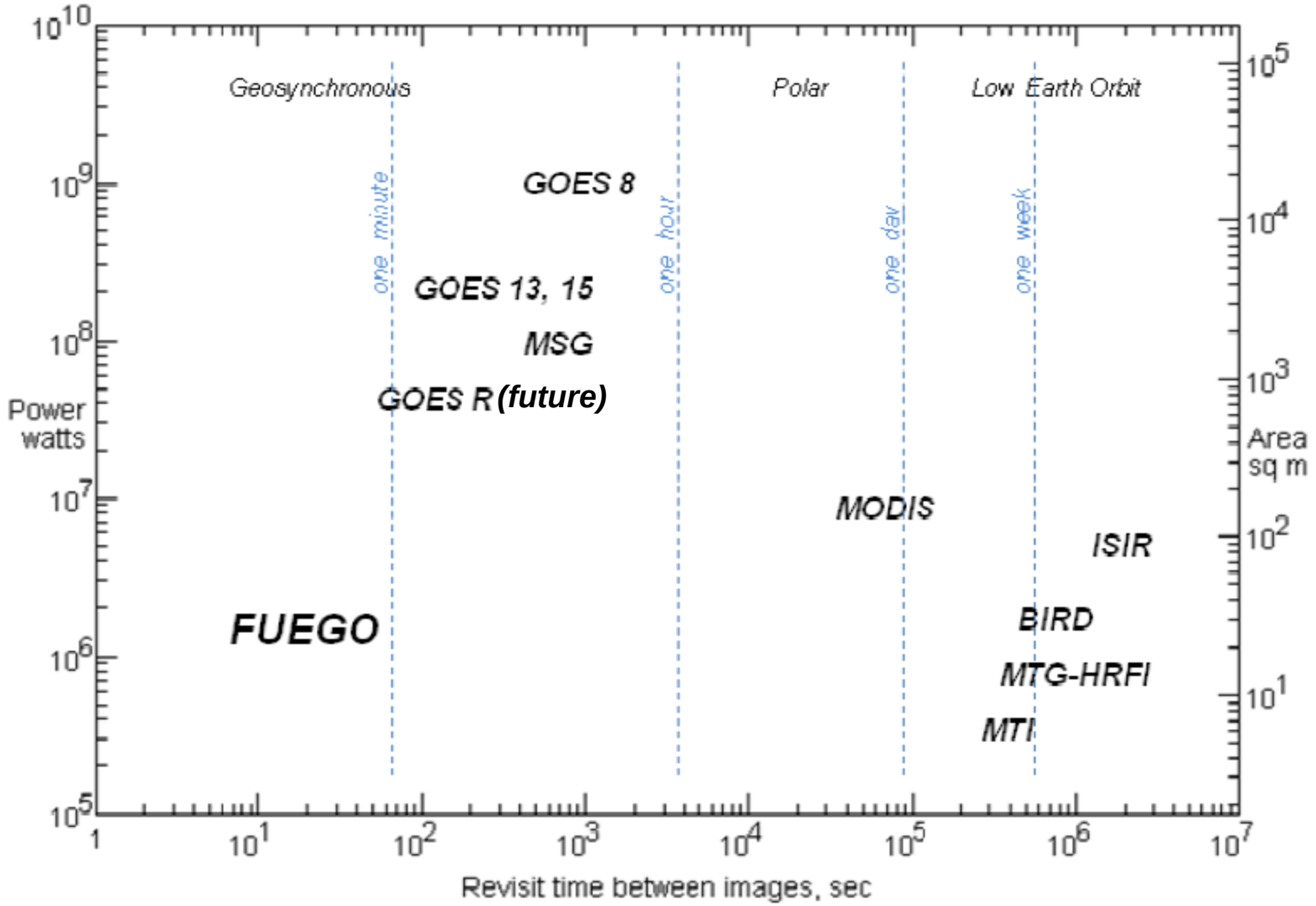
density { wh y → ho w → resul ts }

Problem Forest Fires

- Moonlight Fire
- Fall of 2007
- 65,000 acres in the Plumas National Forest east of Quincy
- Over 60% of the area burned at high severity (> 95% of trees killed)

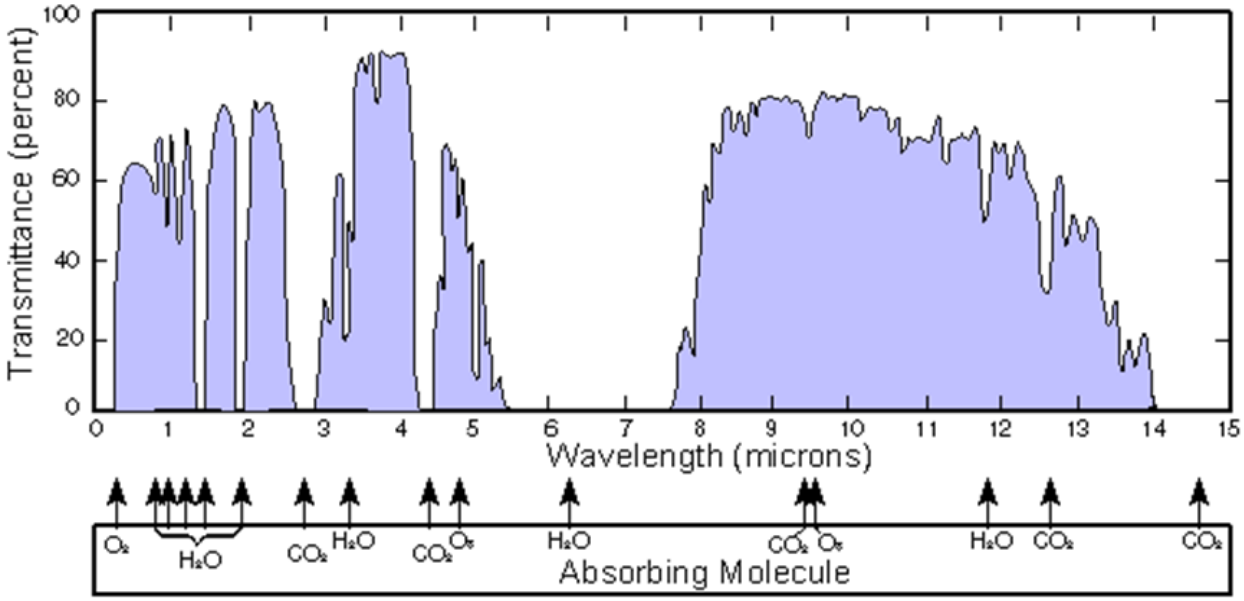
Detecting Fires from Space

Pennypacker C.R., et al., 2013, Fig 4



Fire Detection from Geosync Orbit (e.g. GOES-8):

Daytime: smoke
Nighttime: heat
Daytime: heat???
easy on big fires
poor S/N small fires
sensor overload limit



Noon Fluxes (electrons/sec) and Fire/NoonEarth
Fire: 1 sq meter BB at T=1100K

			TELESCOPE APERTURE METERS				
		PerPixel	0.20	0.30	0.40	0.50	0.60
λ, μm=	0.80	NoonFlux	1.66E+08	1.66E+08	1.66E+08	1.66E+08	1.66E+08
		Fire/Noon	4.5E-06	1.0E-05	1.8E-05	2.8E-05	4.0E-05
λ, μm=	1.30	NoonFlux	9.0E+07	9.0E+07	9.0E+07	9.0E+07	9.0E+07
		Fire/Noon	4.9E-04	1.1E-03	2.0E-03	3.1E-03	4.4E-03
λ, μm=	1.60	NoonFlux	8.6E+07	8.6E+07	8.6E+07	8.6E+07	8.6E+07
		Fire/Noon	2.5E-03	5.5E-03	9.9E-03	1.5E-02	2.2E-02
λ, μm=	2.20	NoonFlux	6.2E+07	6.2E+07	6.2E+07	6.2E+07	6.2E+07
		Fire/Noon	0.011	0.024	0.042	0.066	0.095
λ, μm=	3.80	NoonFlux	2.36E+07	2.36E+07	2.36E+07	2.36E+07	2.36E+07
		Fire/Noon	0.058	0.131	0.233	0.364	0.525
λ, μm=	4.80	NoonFlux	1.08E+07	1.08E+07	1.08E+07	1.08E+07	1.08E+07
		Fire/Noon	0.090	0.202	0.360	0.562	0.809

Unobscured “Fuego12” Optical Concept:

Provides clearances for baffling, esp. secondary and tertiary mirrors

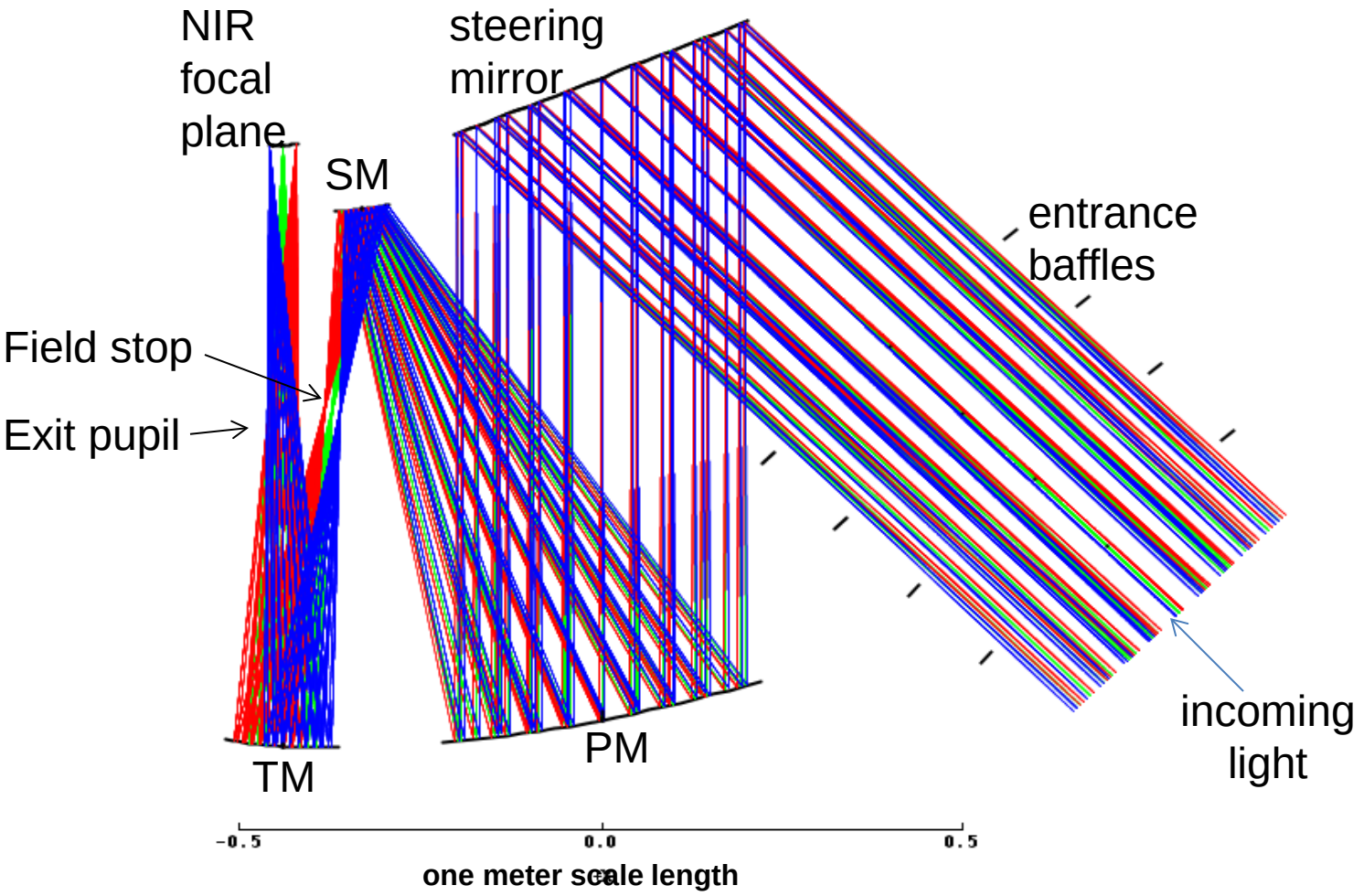
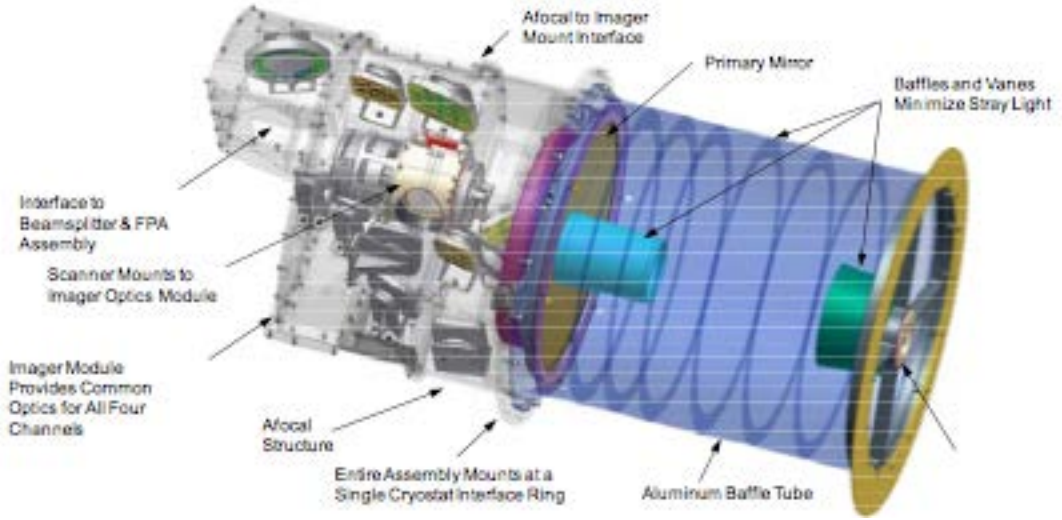


Table 1. FUEGO Parameters.

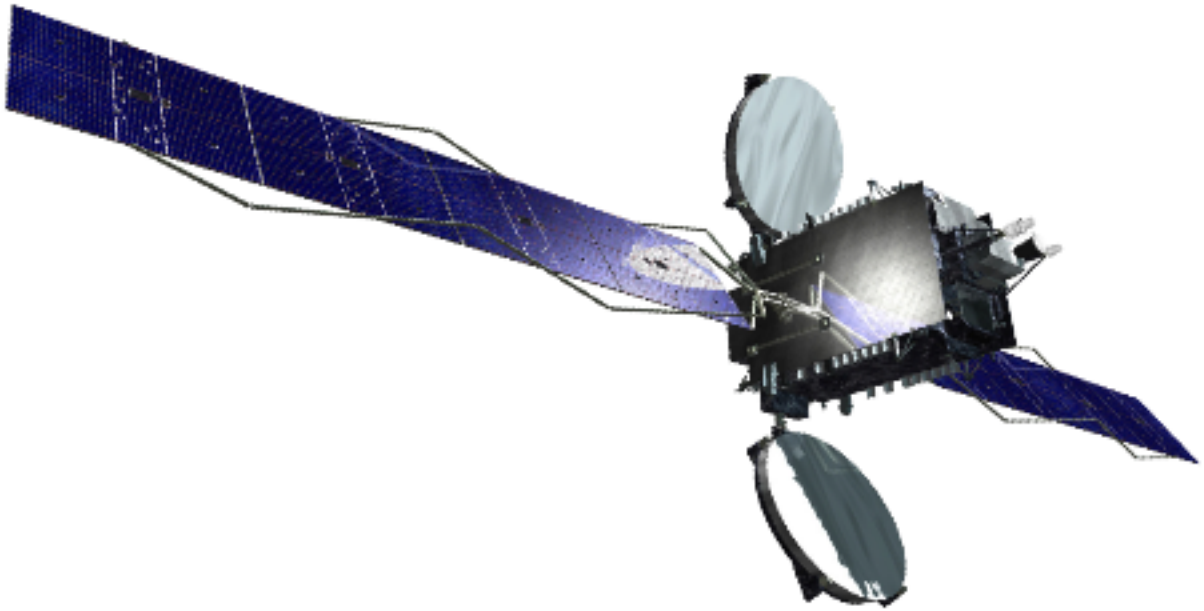
Proposed/Suggested System Parameter	Value
Wave Band	3.4 to 4 microns
Diameter of Primary Mirror	0.5 m
Infrared Detector and Pixels	Teledyne H4RGT 4,096 × 4,096 pixels^2
Areal Coverage in One Field	295 km × 295 km
Projected Pixel Size at Nadir Viewing	72 m
Projected Diffraction Diam @ 2 microns	72 m
Projected Diffraction Diam @ 4 microns	144 m
Signal detected from a 3 m × 3 m 1100 K fire (assume 10% system efficiency) at FUEGO	1.2×10^6 photons/second detected
Noon Background per Resolution Element (assume a 290 m resolution element)	4×10^7 photons/second detected
Noon Signal/noise in One second integration (assuming Poisson counting statistics)	387
Comments	Noise will almost certainly arise from artifacts of subtraction of image.

Part of FUEGO Predicate: WISE Satellite
-- BUT! We could probably build FUEGO for about $60M and put on “hosted geo-sync platform system” – (cheaper then $400M):



GEOStar™ Hosted Payloads

Hosted Secondary Payload Opportunities Provide Rapid/Low-Cost Access to Space



Encouraging Progress on Algorithms

- Subtract images with smaller time differences:

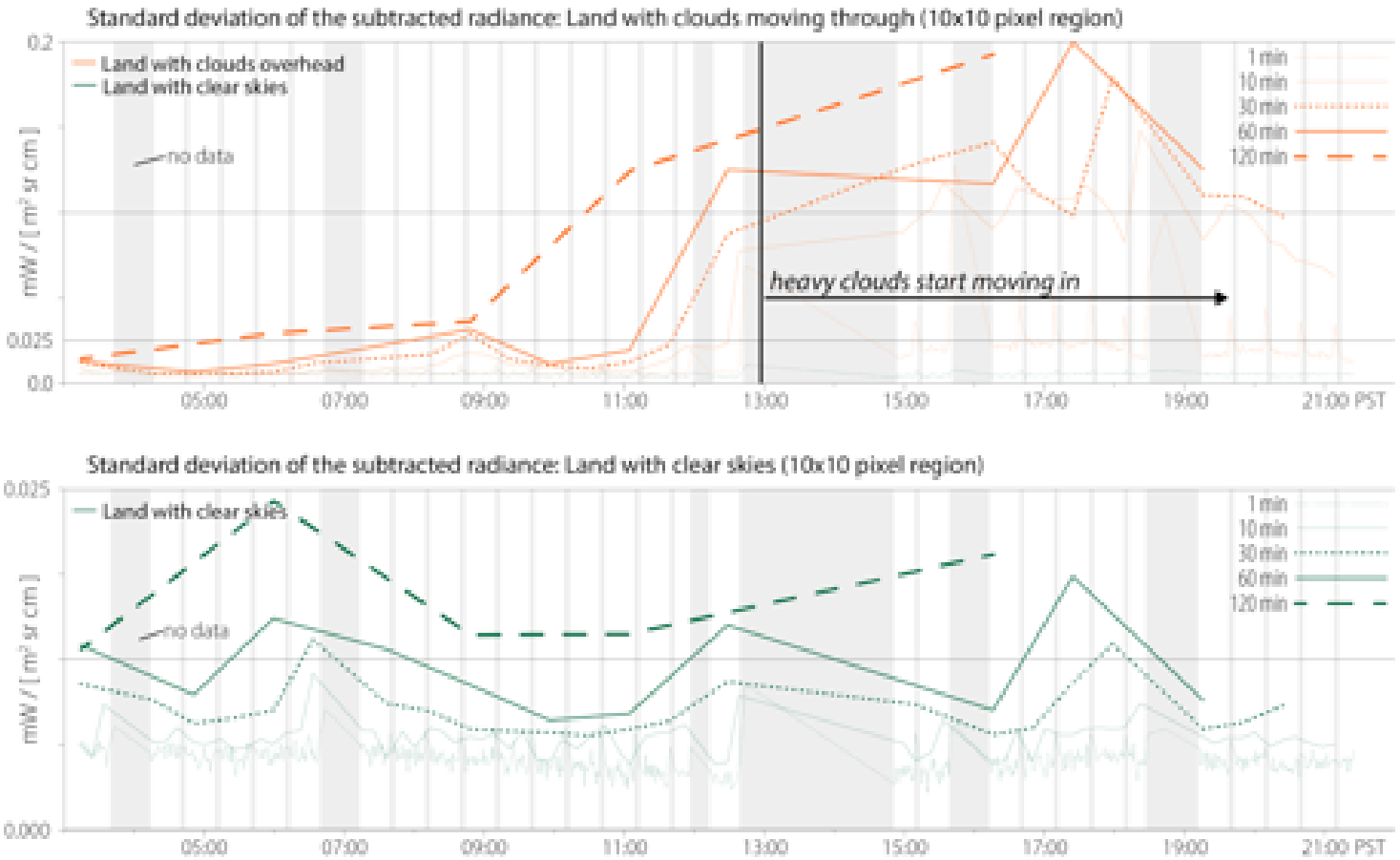


Figure 8. Standard deviation of the radiance (top) and radiance of sequentially subtracted images (bottom). The standard deviations were calculated for two small (3 × 3 pixels) regions: one directly over a fire (red) and another immediately adjacent with no fire (blue).

Boeing Phantom Eye Demonstrator

Second Flight: February 25, 2013, Edwards Air Force Base

Which leads us to……

Objective: Prove the technical readiness of the hydrogen propulsion system for operational development

FUEGO Airborne

A quick packaging study for a
low-cost airborne FUEGO Instrument

Next Steps
Developing the Plan*:*

- Test Fires and Background studies at UC's Hopland Field Station
- Build International collaboration
- International FUEGO Meeting April 10th or so
- Plan and implement UAV for Southern California Testbed
- Get some funding
- Build Camera for UAV
- Fly UAVfor Part of Fire Season – get data
- Plan and Build Satellite

Micro-Report on Aerial Tanker Conference*:*

(Sacramento, last month – Bill Derr and I spoke, Donn networked..)

- Growing numbers of Aerial Tankers, but probably far too few.
- Italy and Canada have great aerial tanker systems!
- Some areas have arguably urgent needs but needs cannot be met (LA). Putting Aerial tankers at the right spot at the right time I think is a challenge.
- Very innovative ideas – Big Russian troop plane->tanker, Canadian super-scoopers, etc. Fire retardent/water in little plastic bubbles.
- Distributed tanker basing is not obvious to plans
- Coordination and competition for resources is a big issue during fires.
- Some very nice planes – C130, but C130's cost ~$48M (new) or so, and you cannot pave the United States with these. (Feinstein and retro-fits of federal C-130's, etc.)