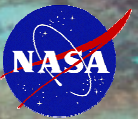


# Western States Ikhana UAV Fire Imaging Missions: 2008

TFRSAC Meeting;  
NIFC - Boise, ID  
4 November 2008





# ***“Turning Swords Into Plowshares”***

## **Adaptation of UAVs to Support Civilian Use**

### **NASA “Ikhana” UAV**

The *Ikhana* is a derivative of the Predator B (MQ-9) “*Reaper*” UAV, designed specifically as a NASA science and research platform.

*Ikhana* is a Native American Choctaw word meaning: Intelligence, Conscience or Aware

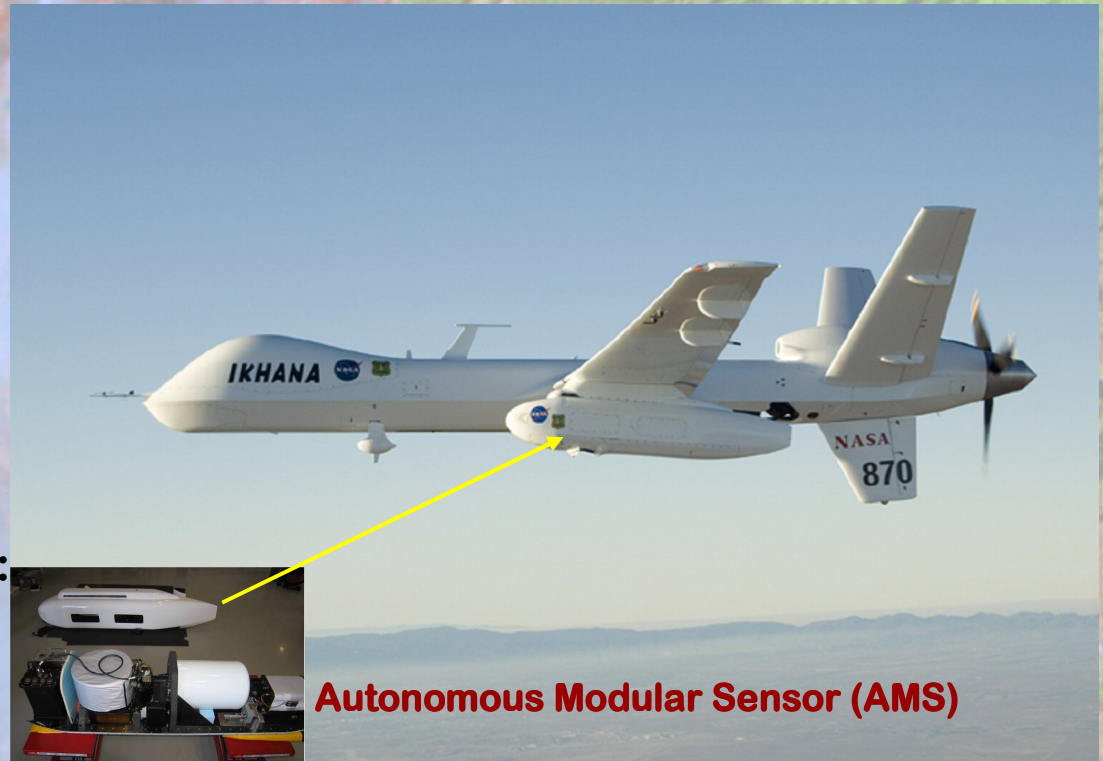
Capable of medium to high altitude operations for ~24-hour periods.

2400 lbs of instruments; Operations: ~50K ft; 170-200kts

Length: 36 feet, Wingspan: 66 feet

Max T/O weight: 10,500 pounds

Capable of autonomous payload operations and real-time sensor data delivery to anywhere in the world via an onboard satellite communications system.



**Autonomous Modular Sensor (AMS)**

**NASA Ikhana with Sensor Pod  
under-wing mount**



# Ground Systems

- **Mobile Ground Control Station**
  - Dual pilot control station
  - Electronic navigation charts
  - Weather
  - 6 Engineering/Science workstations
  - Range safety workstation
  - Intercom system throughout
  - Overhead mission displays
  - Telephones
  - Remote video from aircraft start-up/shut-down site
  - Downlink video and data recording
- **Mobile 2.4m Ku SatCom Antenna**
  - Dual redundant receiver/transmitters





# Sensor System: AMS-Wildfire Instrument

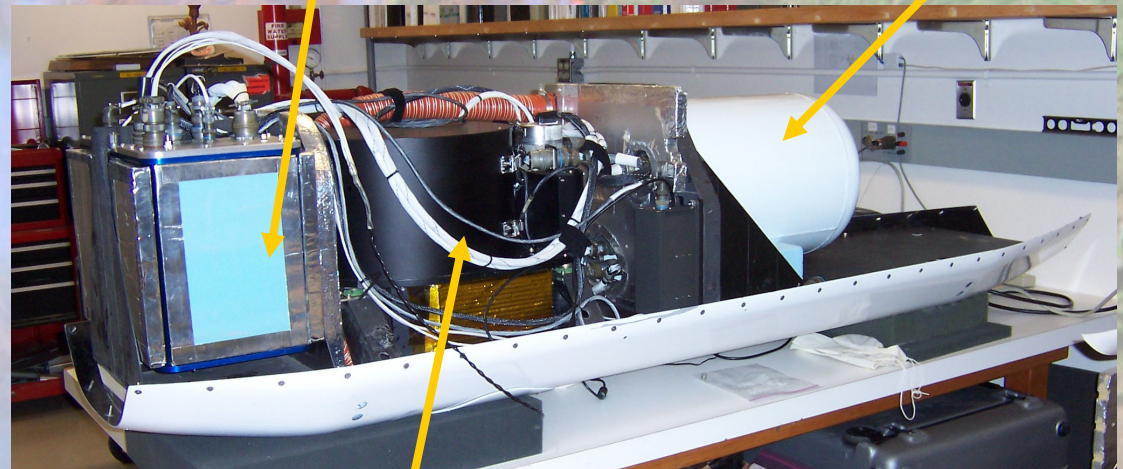
## AMS Wildfire Sensor

<u>Band</u>	<u>Wavelength <math>\mu\text{m}</math></u>	
1	0.42- 0.45	
2	0.45- 0.52	(TM1)
3	0.52- 0.60	(TM2)
4	0.60- 0.62	
5	0.63- 0.69	(TM3)
6	0.69- 0.75	
7	0.76- 0.90	(TM4)
8	0.91- 1.05	
9	1.55- 1.75	(TM5)
10	2.08- 2.35	(TM7)
11	3.60- 3.79	(VIIRS M12)
12	10.26-11.26	(VIIRS M15)

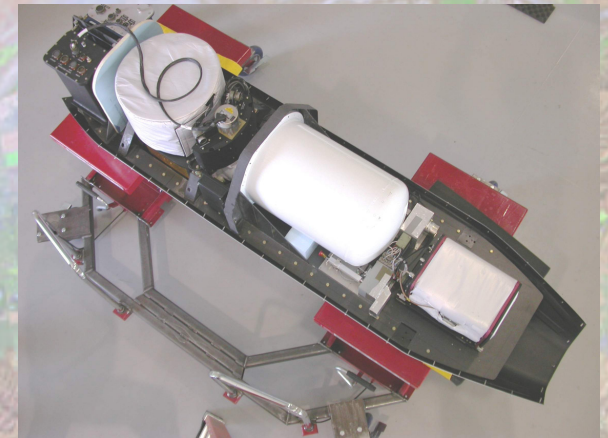
Total Field of View: 85.9 degrees  
IFOV: 2.5mrad  
Altitude: 25000'  
Spatial Resolution: 20m (at sea level)

Two environmental enclosures  
(data disks & GPS; and power  
supplies & controllers)

Data System  
Enclosure



Scan Head





An aerial photograph of a wildfire. Thick white and grey smoke rises from the fire, partially obscuring the landscape. A NASA aircraft is visible in the sky, flying over the fire. The ground is covered in green vegetation, with some areas appearing brown and charred. The title text is overlaid on the top half of the image.

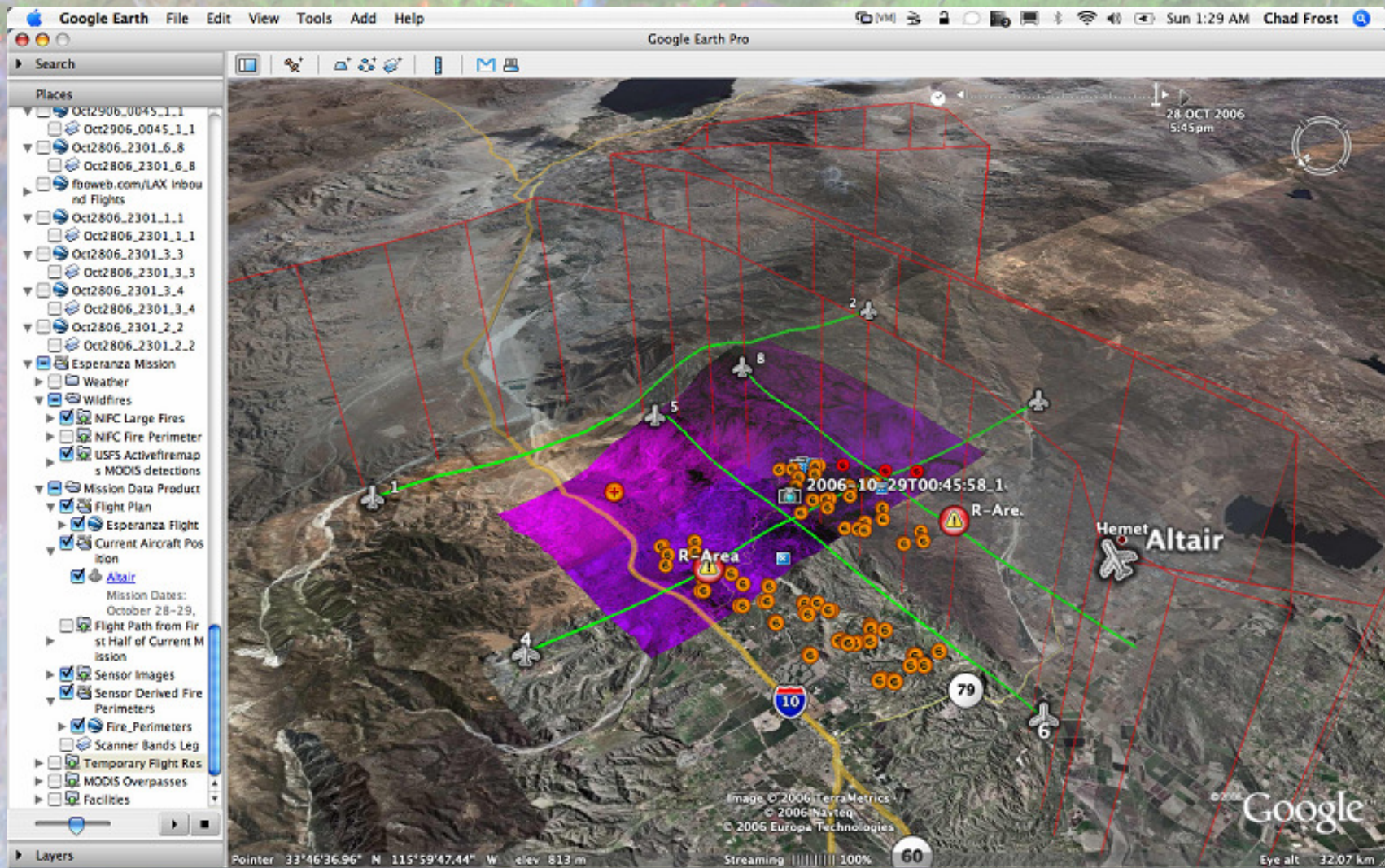
# **Wildfire - Collaborative Decision Environment (CDE): *Real-Time Information Sharing and Visualization***

## **The Wildfire-CDE Provides:**

- **Aggregation of disparate information sets into a Common Operating Picture (COP):**
  - **Real-Time Airborne sensor data from a multitude of Platforms**
  - **Real-Time Satellite Data Integration (MODIS Fire Detection Data)**
  - **Real-Time Weather Satellite Data**
  - **Real-Time Lightning Strike Detection Data**
  - **Ground-Based Measurement Data (RAWS weather data)**
  - **Mission Planning Tools (for Ikhana Mission Team)**
- **Analysis tools to observe, visualize, and interpret sensor and external data.**
- **Automated mechanisms to generate data products (e.g. GeoTIFF, vector shapes for fire perimeter).**
- **Groupware-like collaboration in communicating and sharing data products.**
- **All data visualized in a “freeware” visualization package---GoogleEarth**



# W-CDE: Google Earth Client



Real-time 3-D rendering and fly through of acquired fire imagery



# Wildfire - CDE

## Decision support tool for wildfire missions

- **Goals**

- Mission planning
- Situational awareness
- Data visualization
- Collaboration among distributed

- **Users**

- Mission Development Team
- Data Products Users

The screenshot displays the Google Earth Pro interface with several data layers loaded. Three blue boxes highlight specific sections of the 'My Places' list:

- Wildfires:**
  - ☐ Southern California 2007 Fire Perimeters  
Data provided by USFS
  - ☐ IncWeb National Incidents  
Points of origin of incidents nationally.
  - ☒ CONUS MODIS and Large Fires  
Data provided by [USFS Remote Sensing Applications Center](#)
  - ☒ CONUS Fire Perimeters  
Data provided by [USFS Remote Sensing Applications Center](#)
- Weather:**
  - ☐ GOES IR
  - ☒ NWS Fire Weather Forecast
  - ☐ NWS Radar Animation
  - ☐ RAWs
  - ☐ Global Cloud Top  
multiple satellites composite image from US Navy NRL Monterey
  - ☐ NWS Warning Products
  - ☐ Global Lightning  
lightning provided by [www.guiWeather.com](#)
- National Airspace:**
  - ☐ FAA ARTCC boundaries
  - ☐ Temporary Flight Restrictions
  - ☐ Special Use Airspace (near Edwards AFB)

The main map shows California with an orange boundary line and yellow dots representing wildfire locations. Labels on the map include San Francisco, San Jose, BIGHORN, Los Angeles, San Diego, Nevada, and Phoenix. The 'Layers' panel on the right shows the following structure:

- Search
- Places
- My Places
  - CDE
    - External Links
      - [launch video player](#)
      - [download CDE startup guide](#)
    - Wildfires
    - Weather
    - Western States Fire Mission
      - COA Boundaries
      - Routes
      - Keep Out Zones
      - Facilities
      - Edwards Weather Station
      - Mission Plans
      - Aircraft Position
    - Wildfire Sensor Data
      - Sensor Images
        - Current Mission
        - Previous Missions
      - Scanner Bands Legend
      - Sensor Derived Fire Perimeters
        - Current Mission
        - Previous Missions
      - sggate WMS
      - MODIS Overpasses
    - USA Shaded Relief Background
    - National Airspace
    - Temporary Places

- Layers

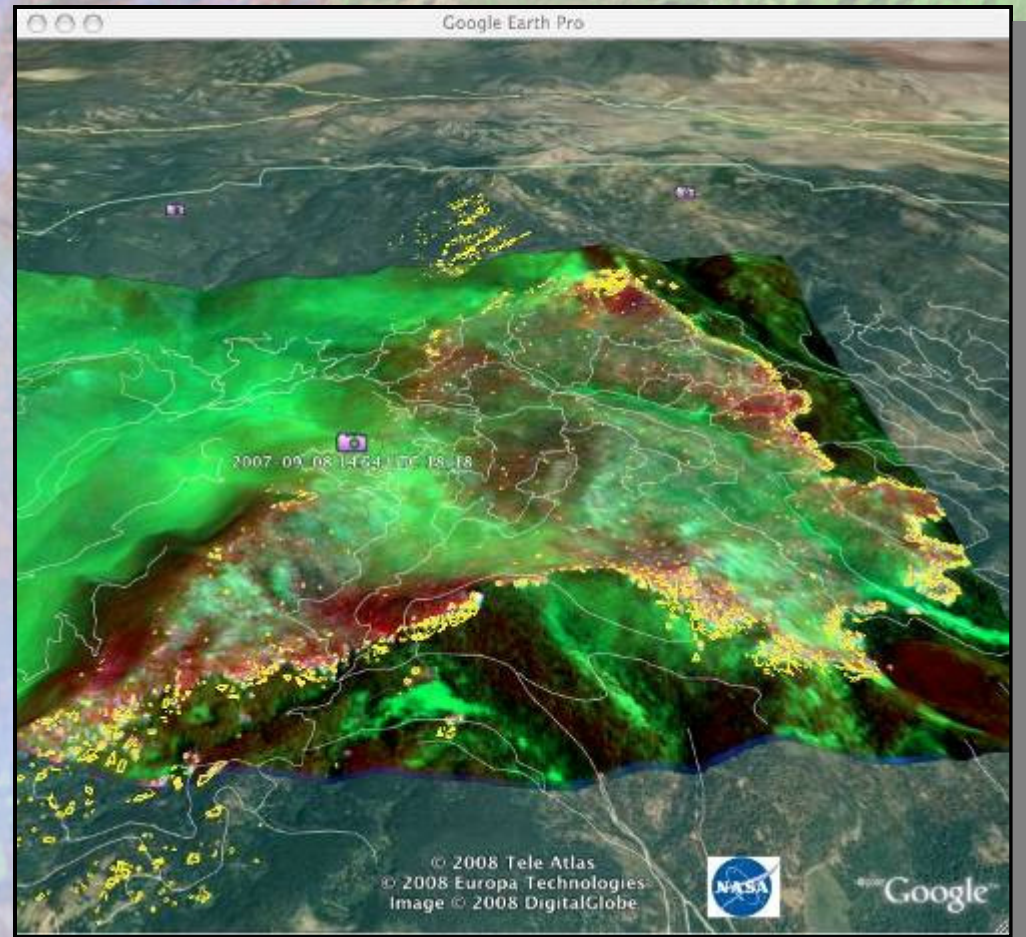
Image NASA  
© 2008 Tele Atlas  
© 2008 Europa Technologies  
Image © 2008 DigitalGlobe



# Sensor Data Visualization

## Procedure for viewing sensor data in CDE

- Camera placemarks appear when images are available
- Click on icon to display thumbnail image
- Download image from server
- “Hot Pixel” detections are available on separate layer
- Adjust 3D view of data draped on terrain





# Fires in California: NASA Support

**June 21st & 22nd:**

CA lightening storms, triple-digit temperatures spawn a few hundred fires.

CalFire calls NASA-Ames WRAP staff at 3:00 AM requesting Ikhana and sensor support (six weeks prior to WRAP team's planned fire missions).

**June 24<sup>th</sup> 9:00 AM**

NASA-ARC, NASA-DFRC, NASA-HQ and CalFire telecon: agree to accelerate mission series. Schedule plan drafted to "ready" all systems by 30 June. DFRC engages FAA for emergency "amendment" to COA start. Mission start-up by mid-week 30 June.

WRAP team anticipates 1-3 missions through 7/12. Missions anticipated to be 8-10 hours duration.

**July 7th**

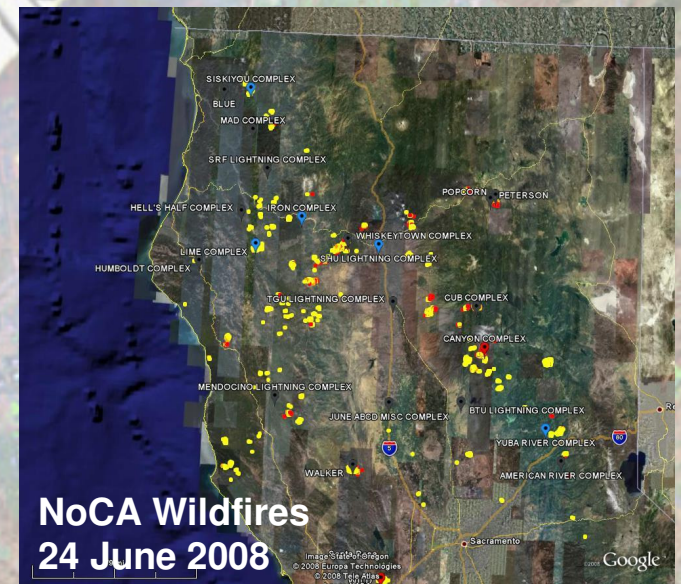
FAA approves emergency amendment to COA. Fires to be flown: Piute, Clover, American River Complex, Yuba River Complex, Canyon Complex, Cub Complex, Butte (BTU) Complex, Basin / Indians Complex, Gap Fire.

**July 8th**

0600 PDT: Pre-flight Brief

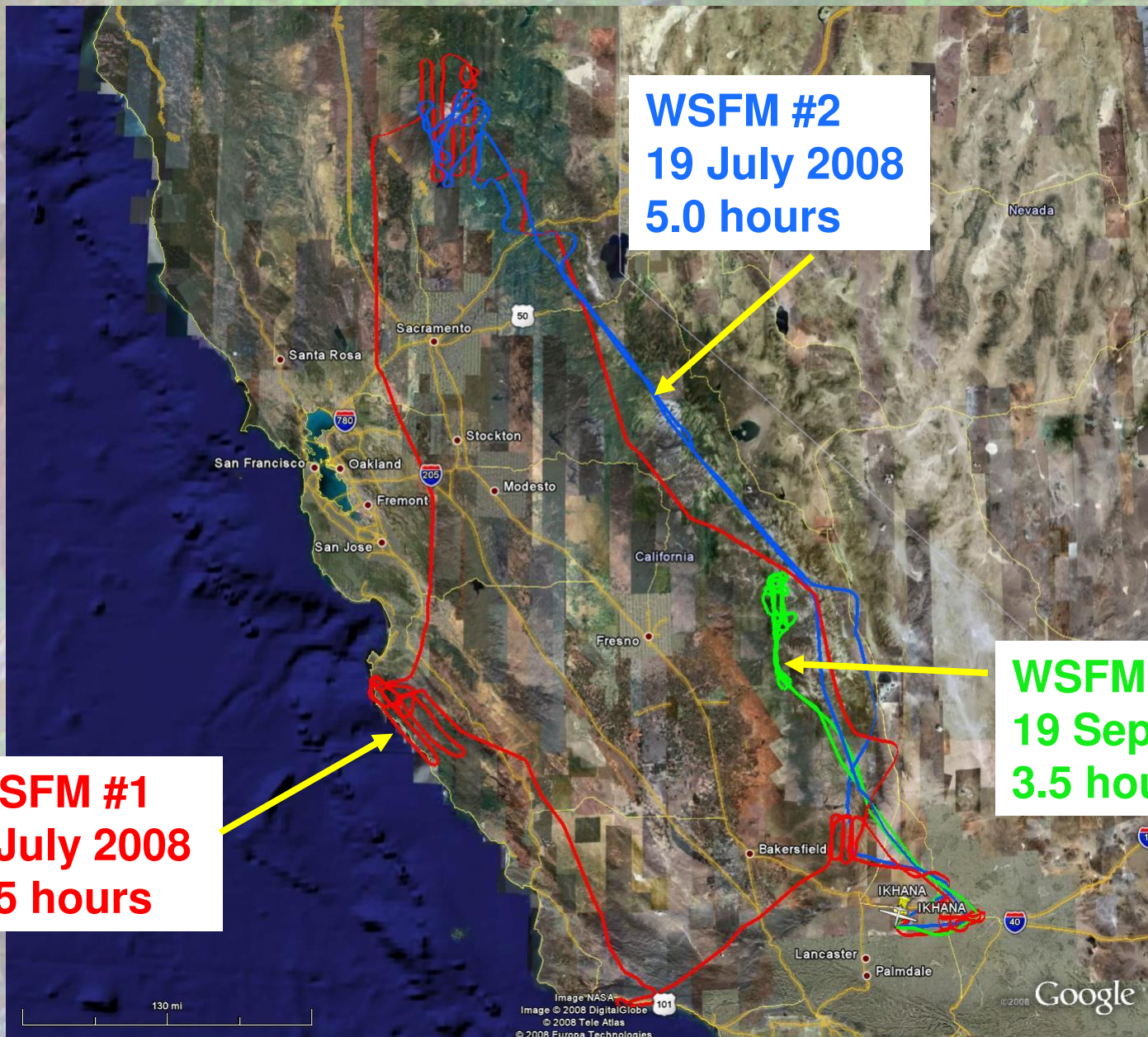
~0800 PDT: Ikhana T/O for mission

~1900 PDT: Post-mission debrief; Set schedule for First WSFM over No CA fires



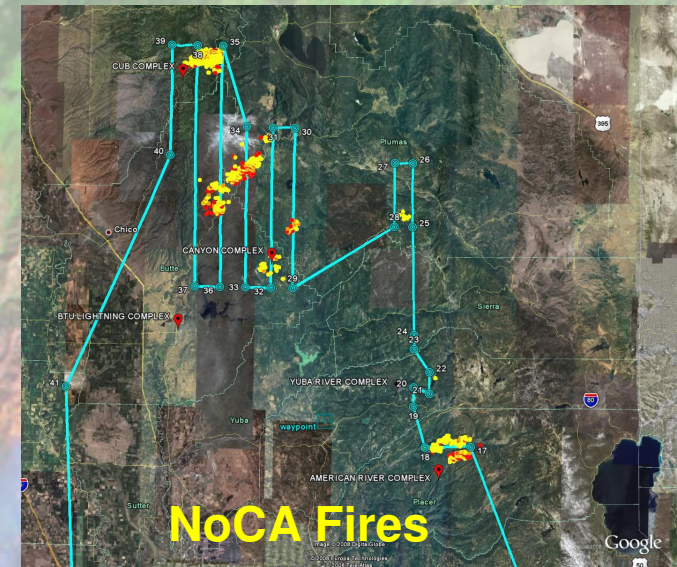
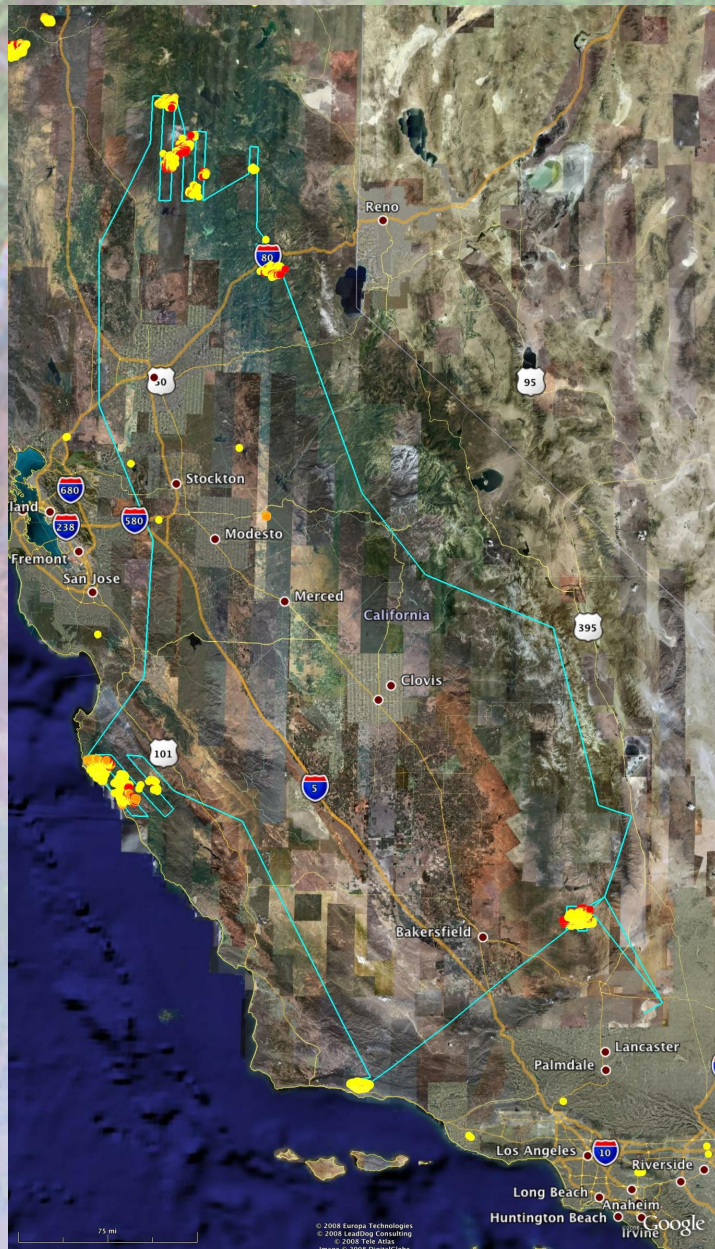


# WSFM – 2008 Flight Tracks



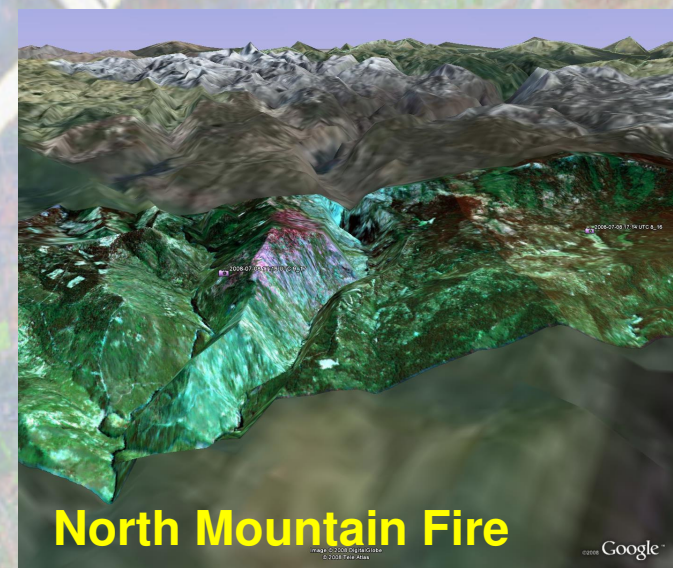


# WSFM-08 NoCA Mission 1: 8 July 2008



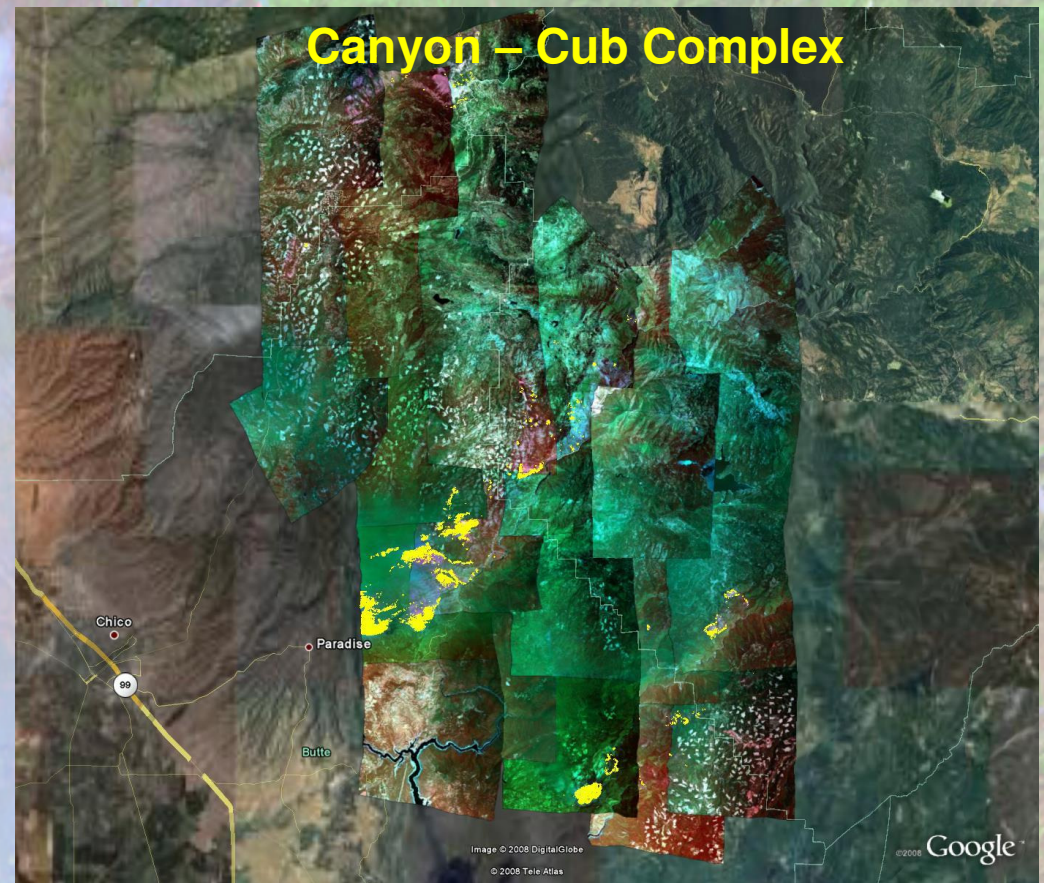


# WSFM-08 NoCA Mission 1: 8 July 2008



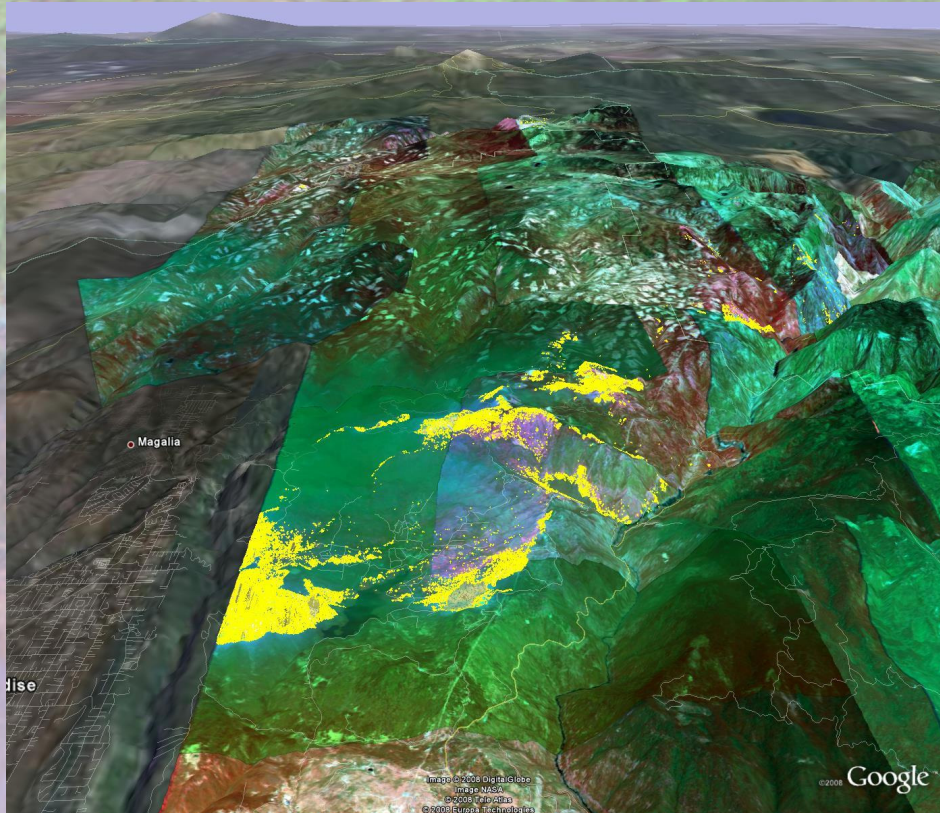


# WSFM-08 NoCA Mission 1: 8 July 2008

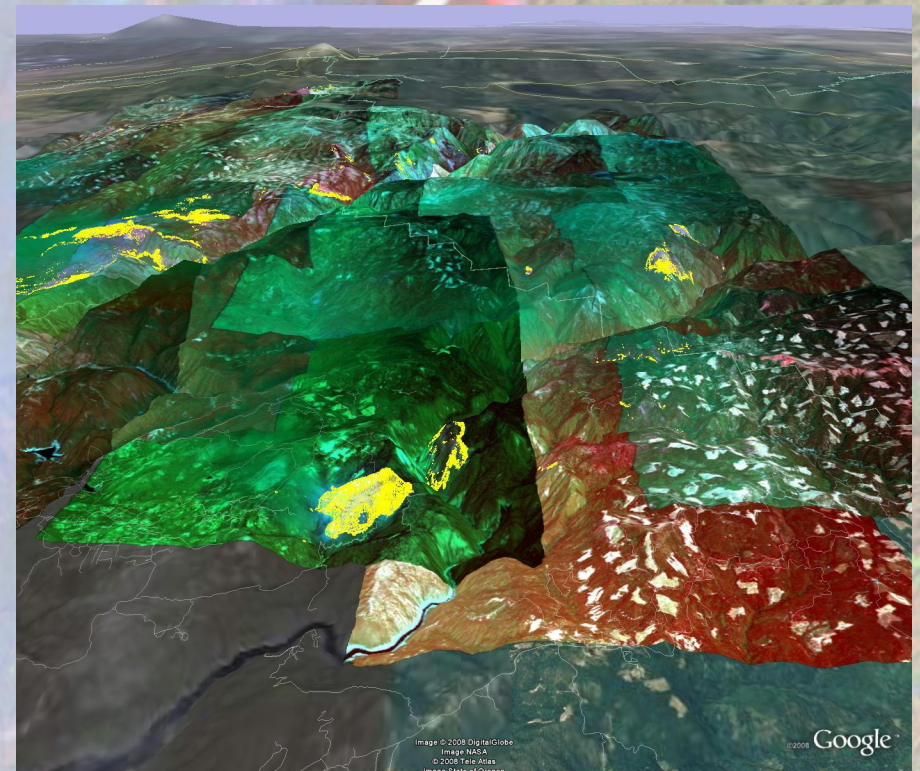




# WSFM-08 NoCA Mission 1: 8 July 2008



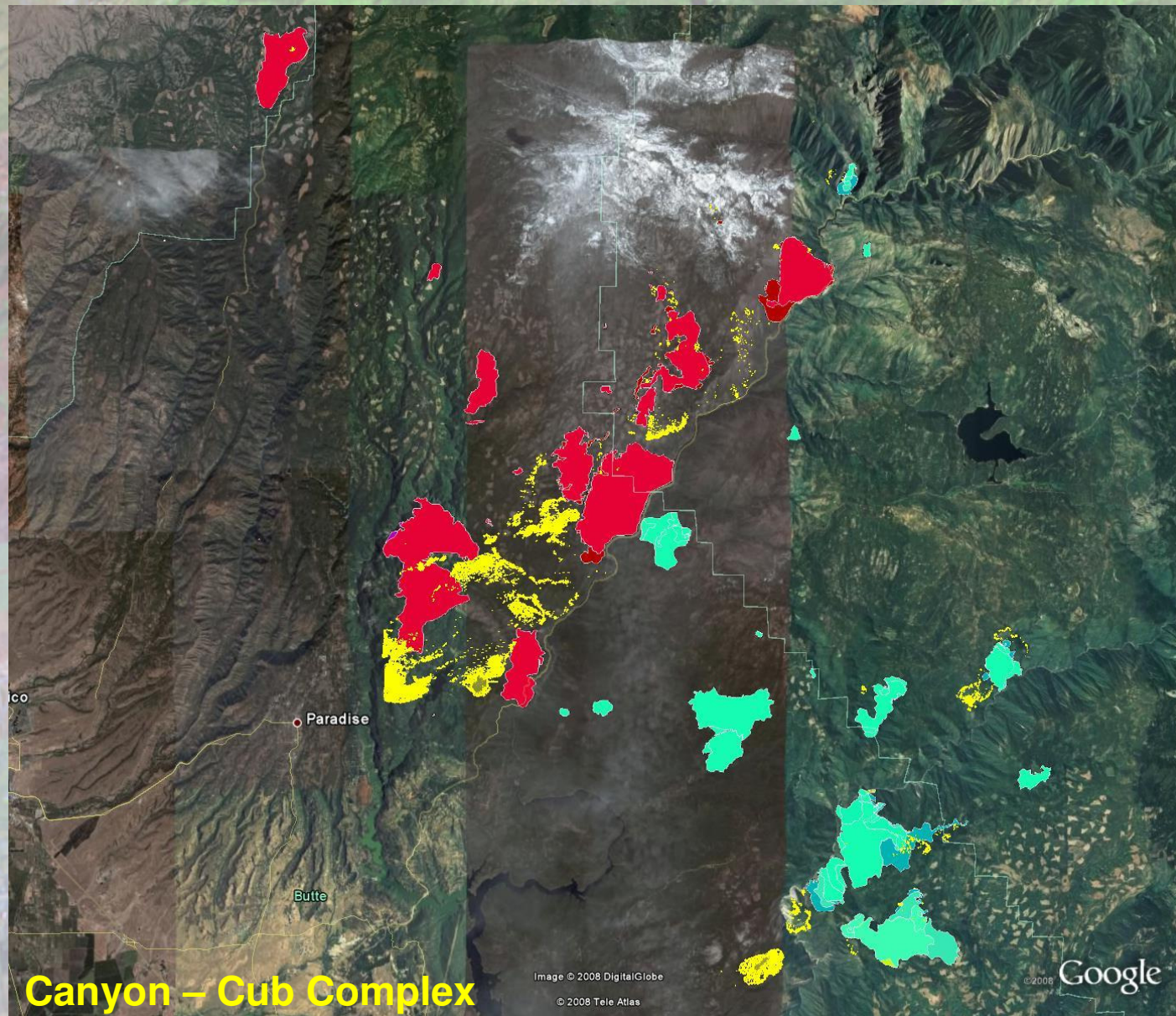
Canyon – Cub Complex



Canyon – Cub Complex

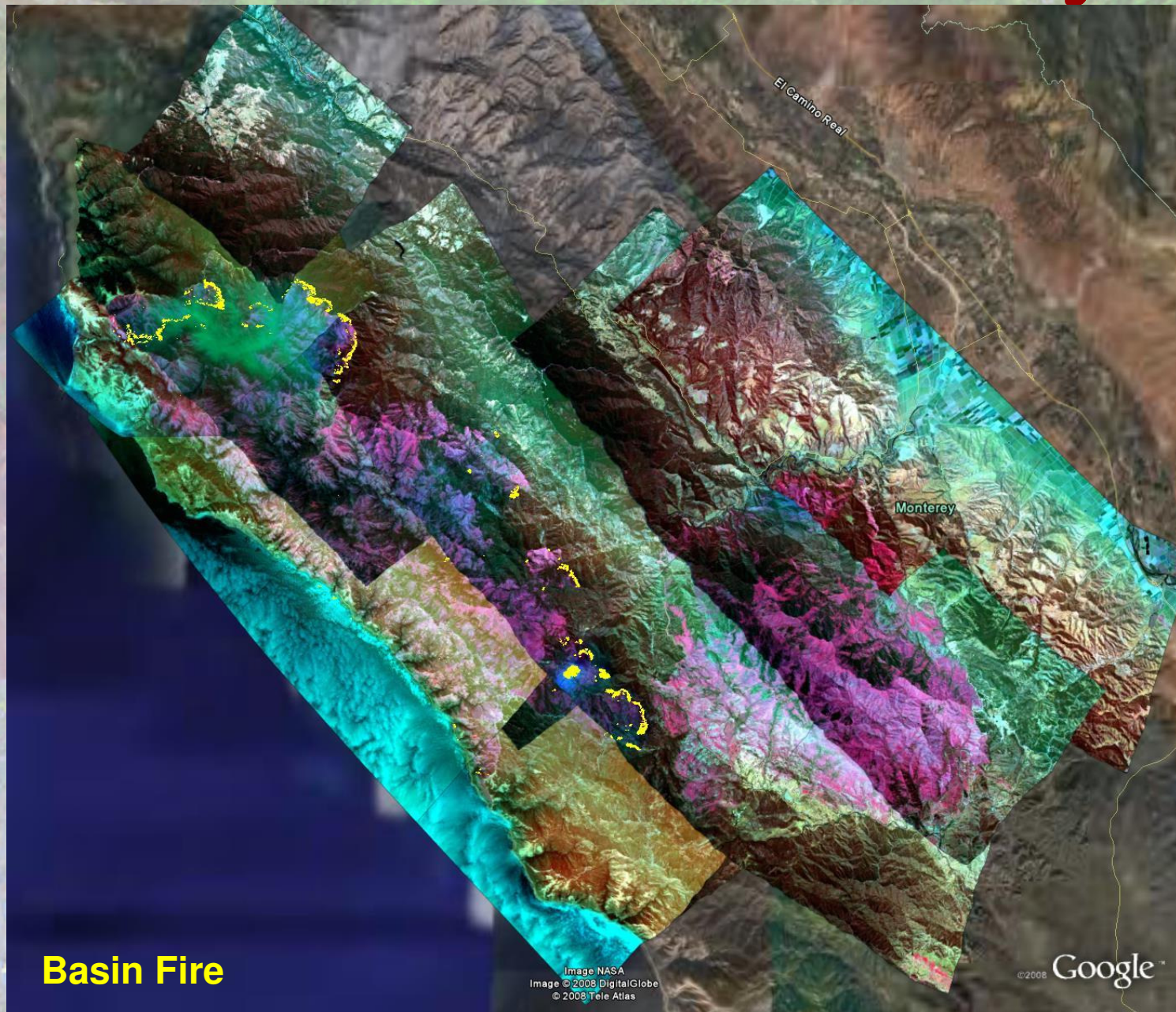


# WSFM-08 NoCA Mission 1: 8 July 2008



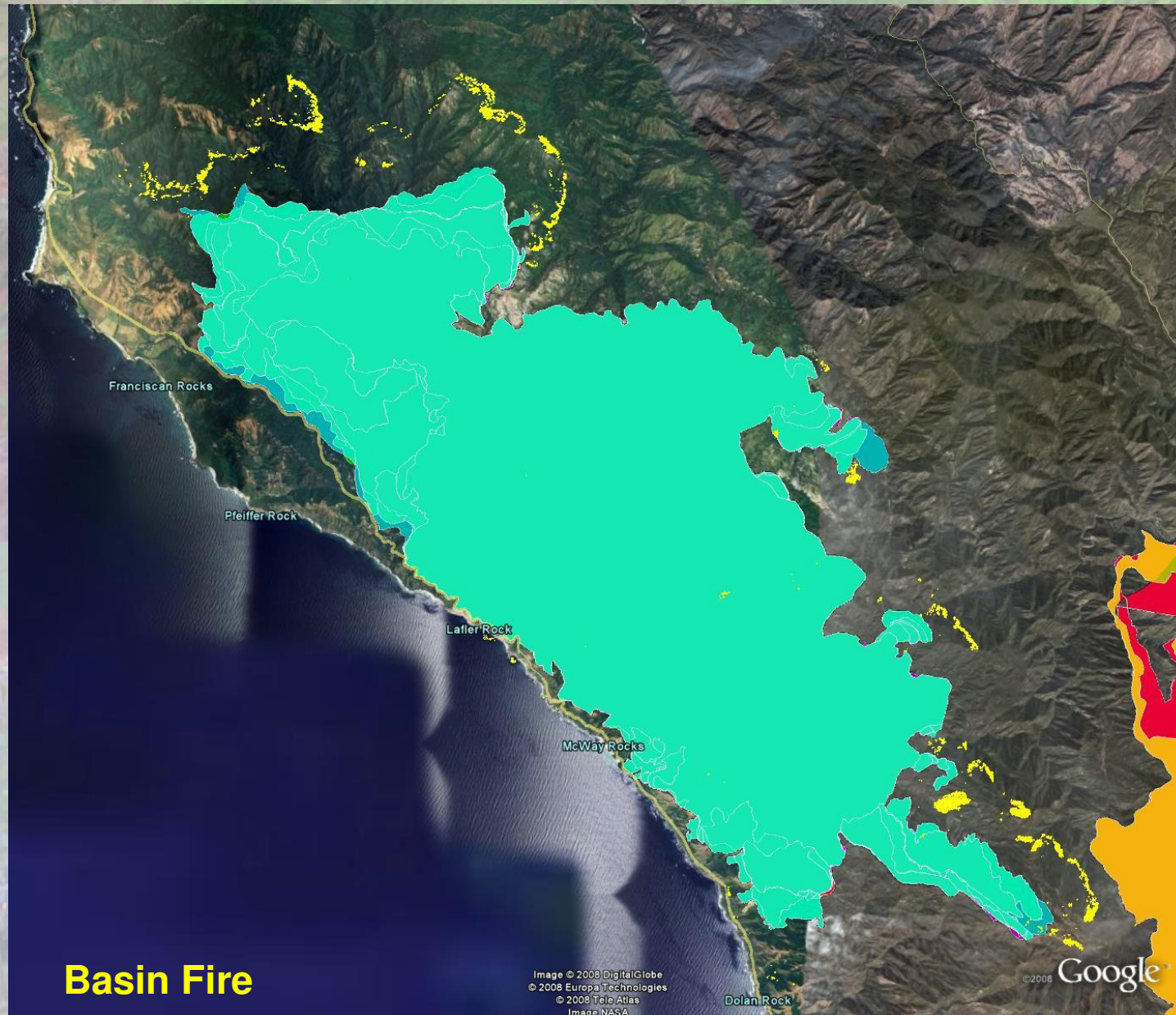


# WSFM-08 NoCA Mission 1: 8 July 2008



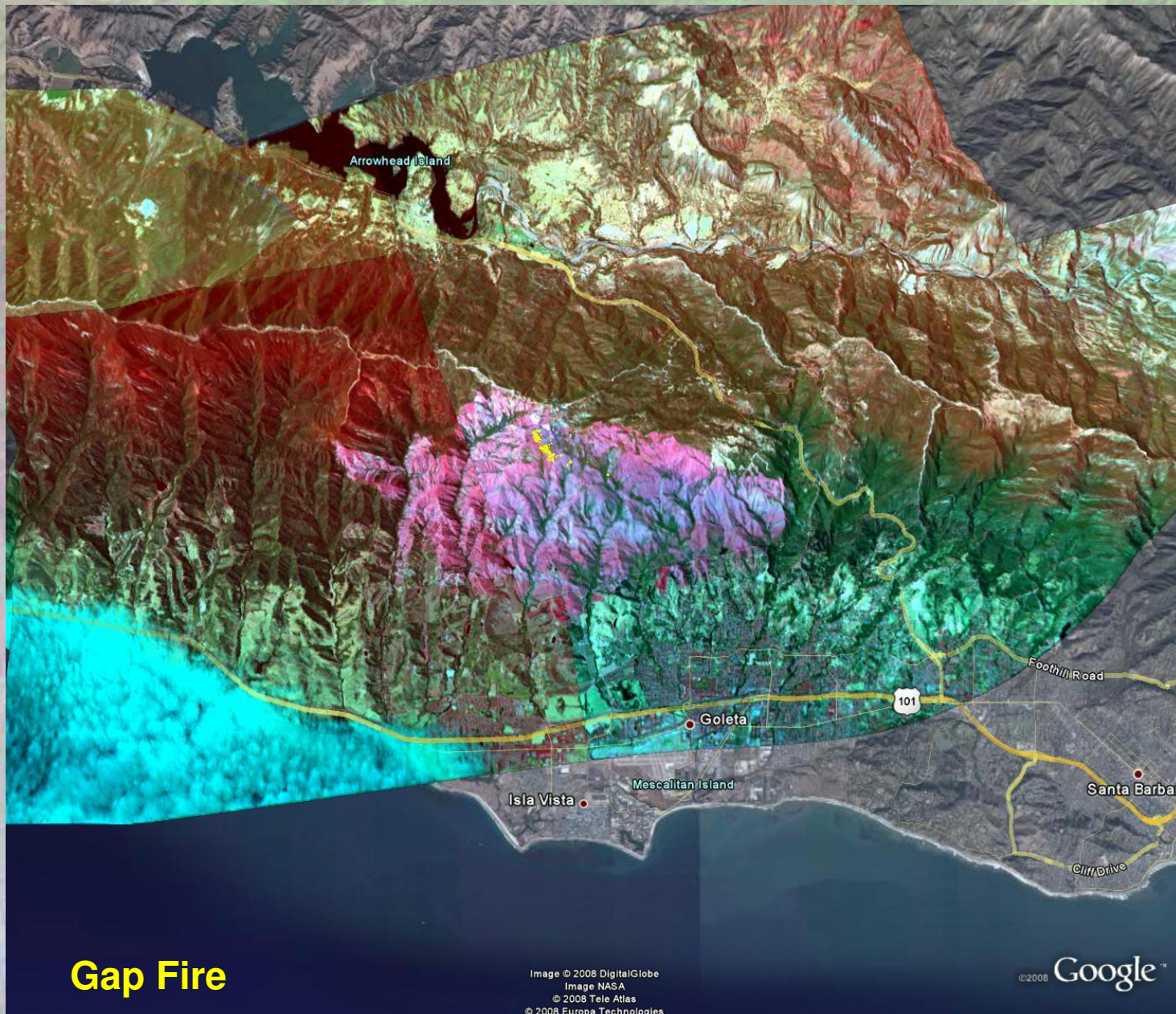


# WSFM-08 NoCA Mission 1: 8 July 2008



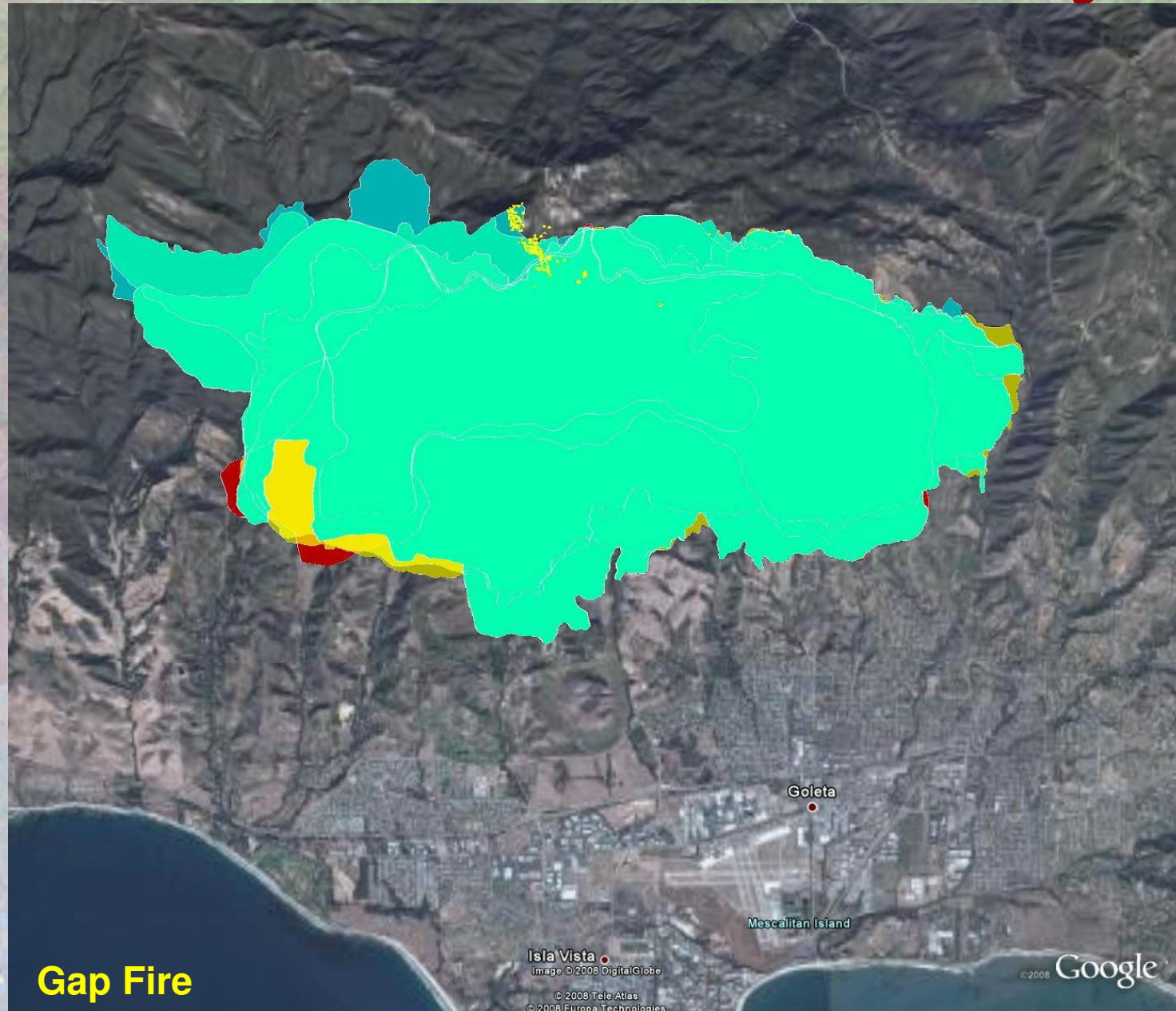


# WSFM-08 NoCA Mission 1: 8 July 2008





# WSFM-08 NoCA Mission 1: 8 July 2008

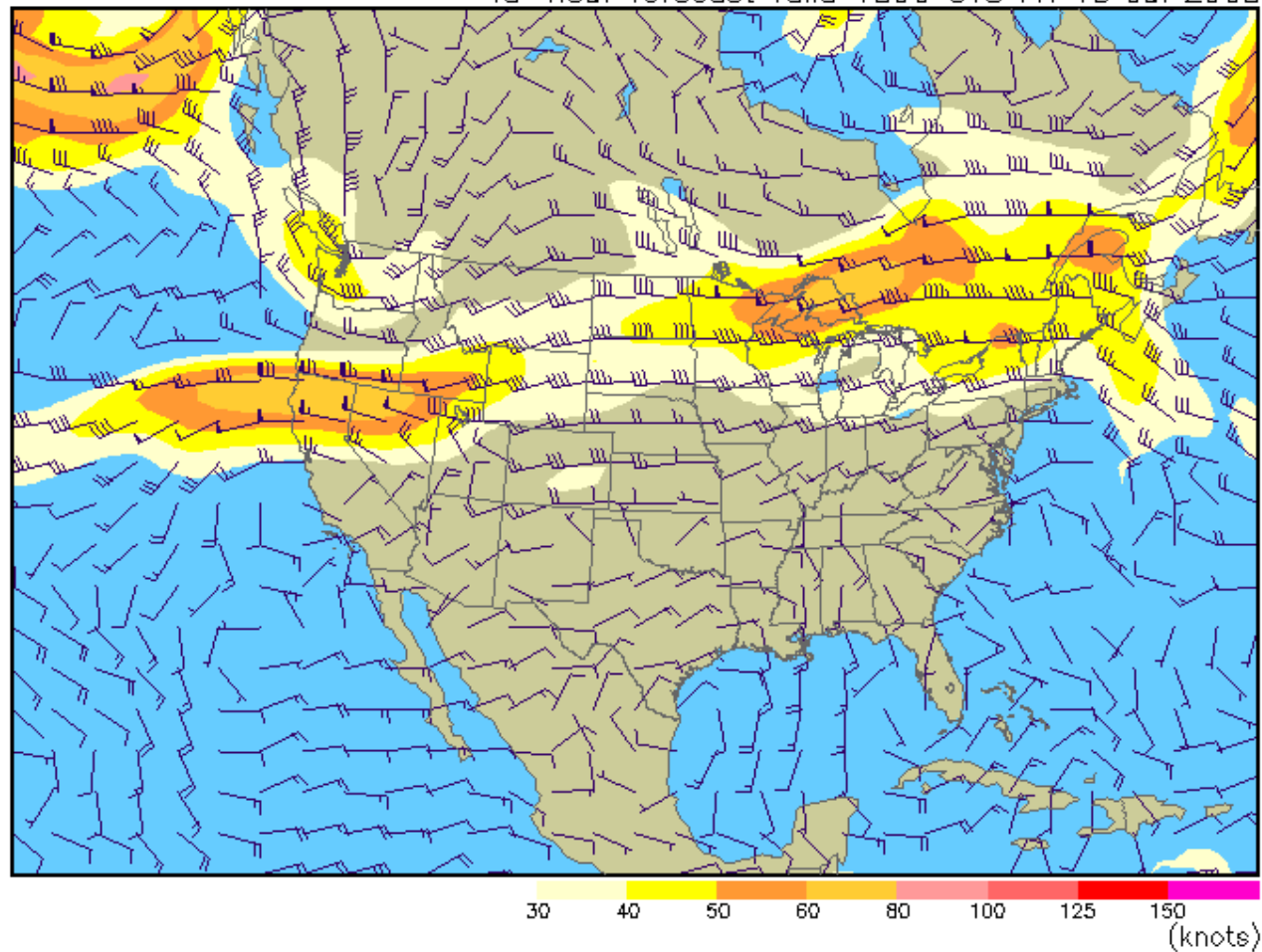




# WSFM-08 NoCA Mission 2: 19 July 2008

Wind speed (kts) at 24,000 ft MSL (400 mb)

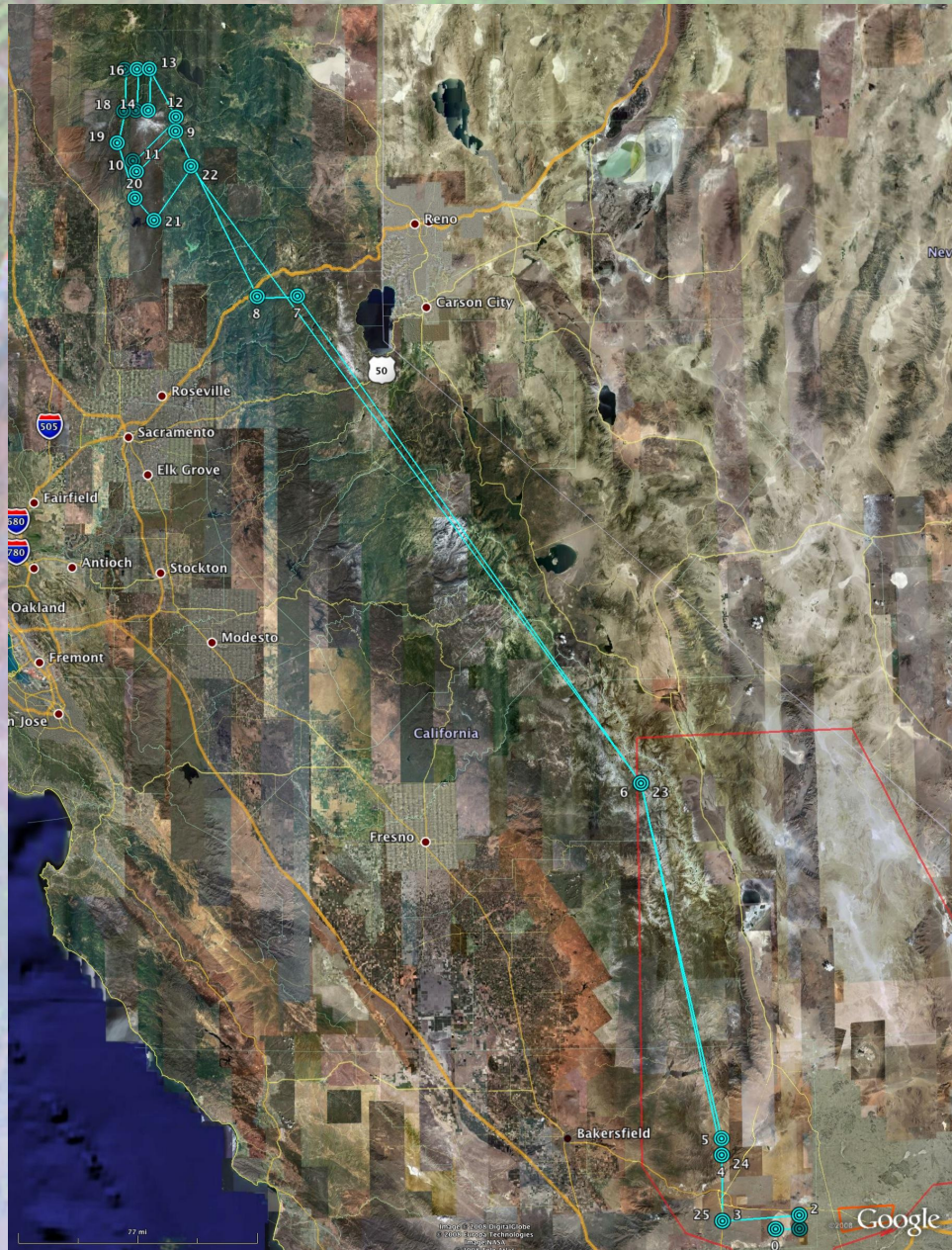
48-hour forecast valid 1800 UTC Fri 18 Jul 2008



ADDs temp/wind charts supplement, but do not substitute for, the official winds and temperatures aloft forecast contained in the FB product.



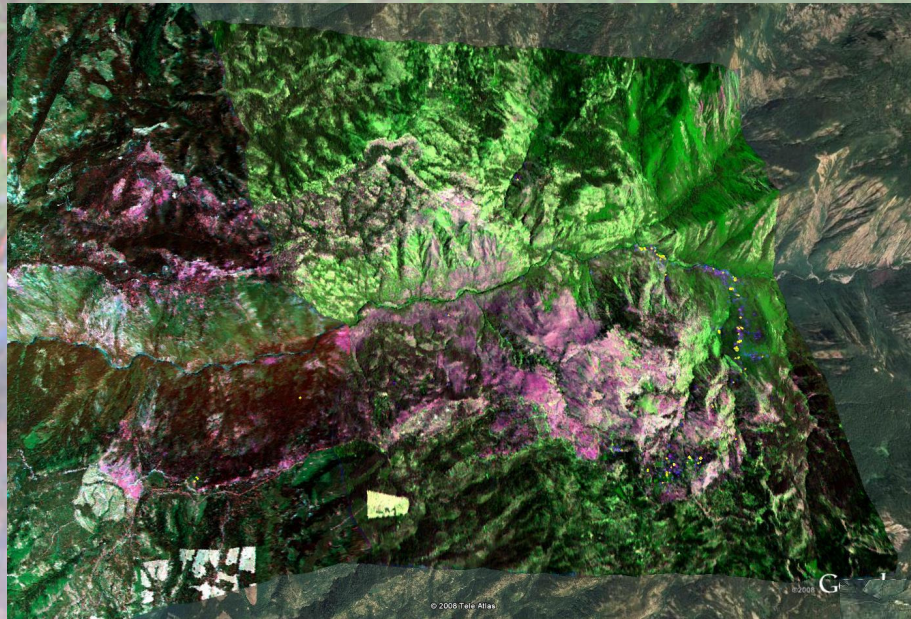
# WSFM-08 NoCA Mission 2: 19 July 2008



**American River,  
Canyon Complex and  
BTU Complex**

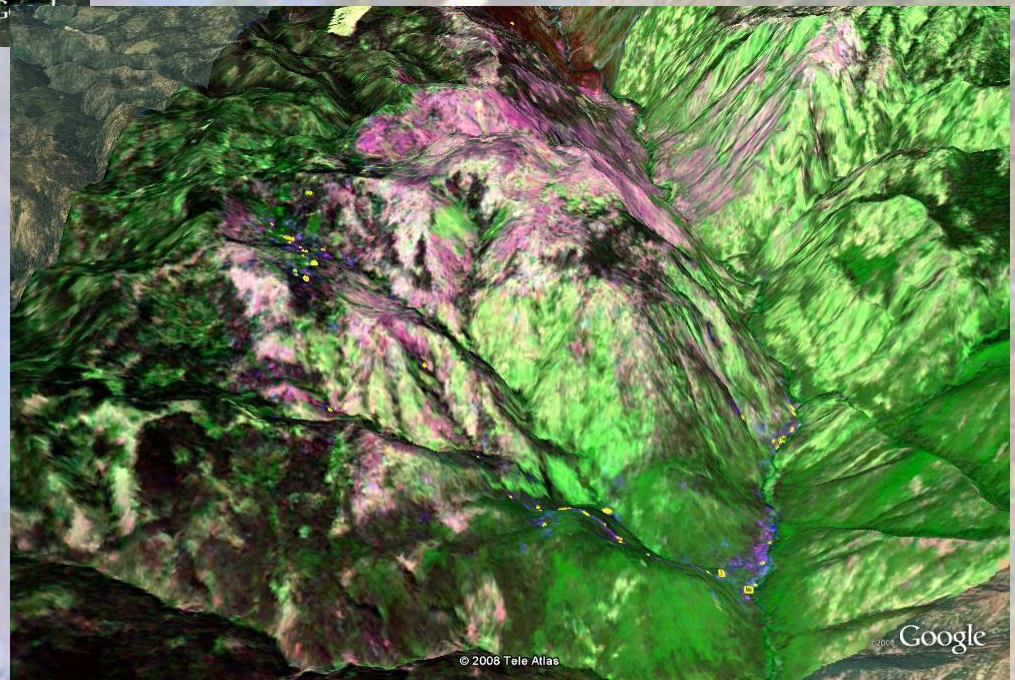


# WSFM-08 NoCA Mission 2: 19 July 2008



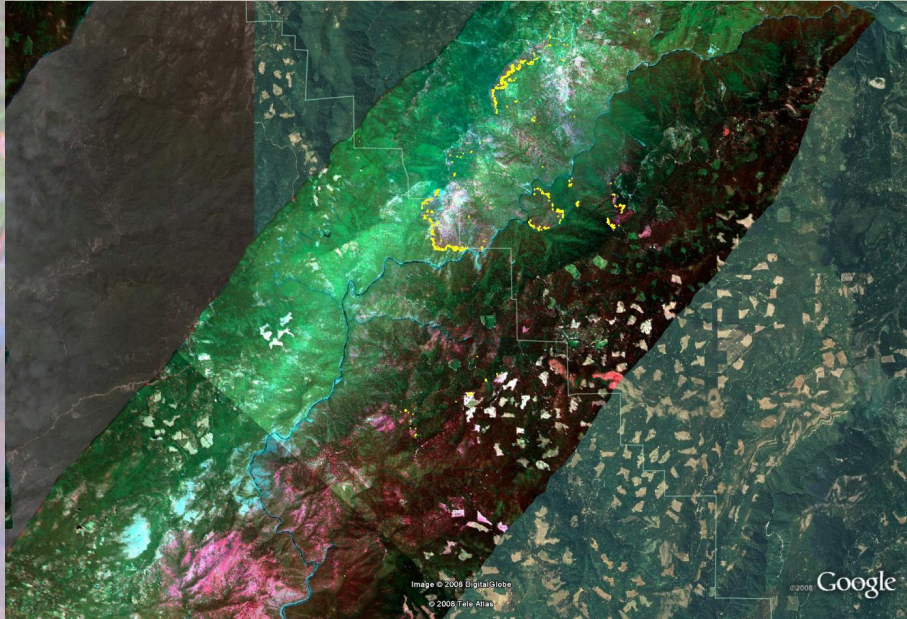
**American River  
Complex**

**3D Perspective  
West View**



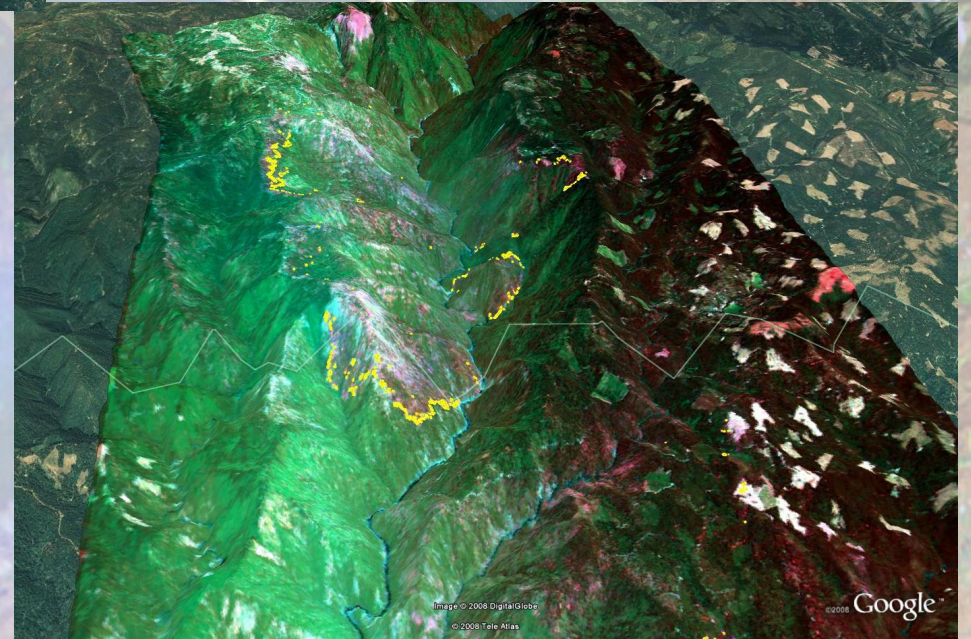


# WSFM-08 NoCA Mission 2: 19 July 2008



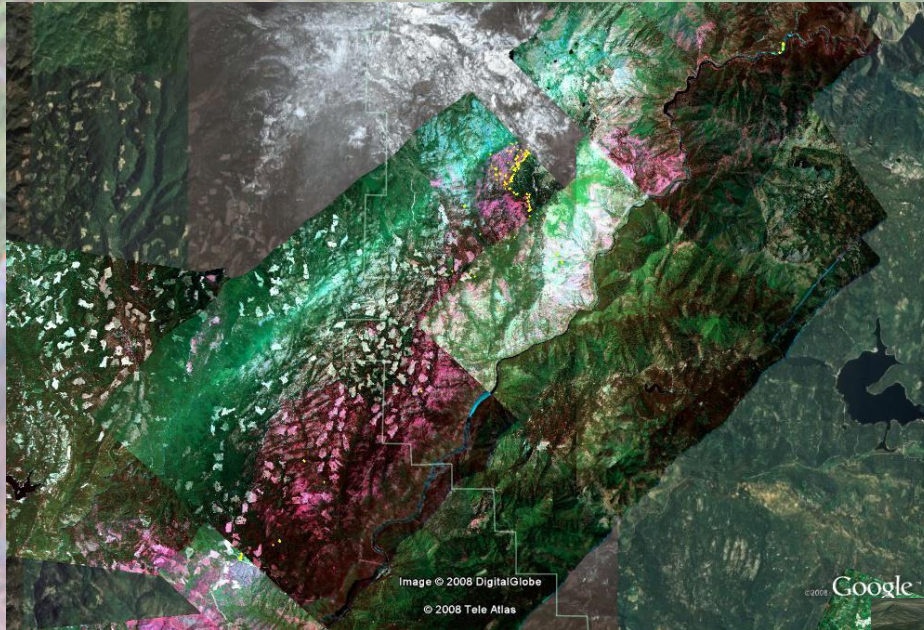
**Canyon Complex**

**3D Perspective  
Northeast View**



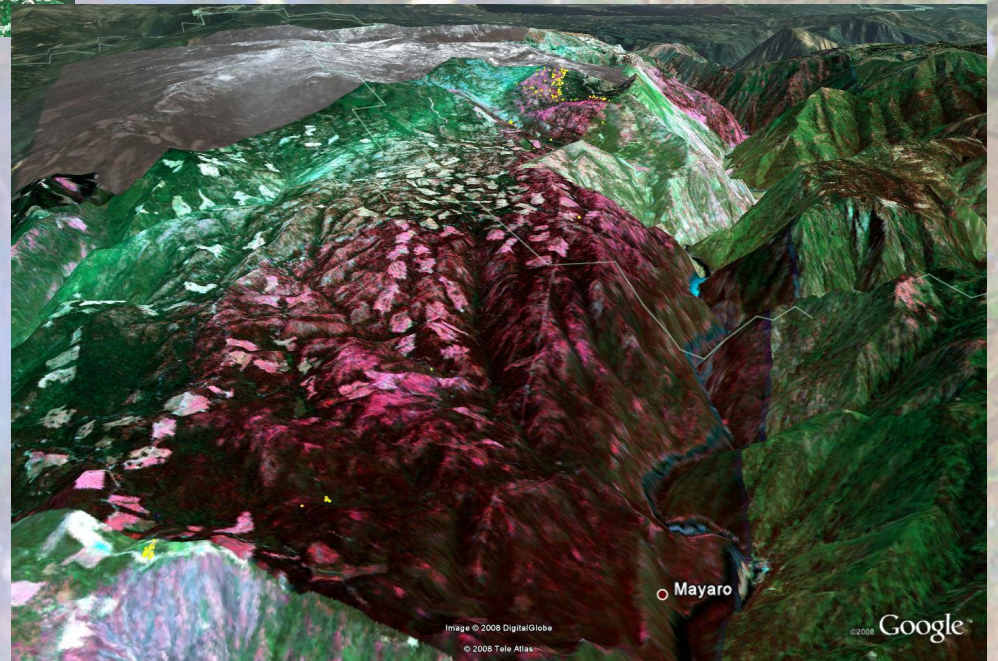


# WSFM-08 NoCA Mission 2: 19 July 2008



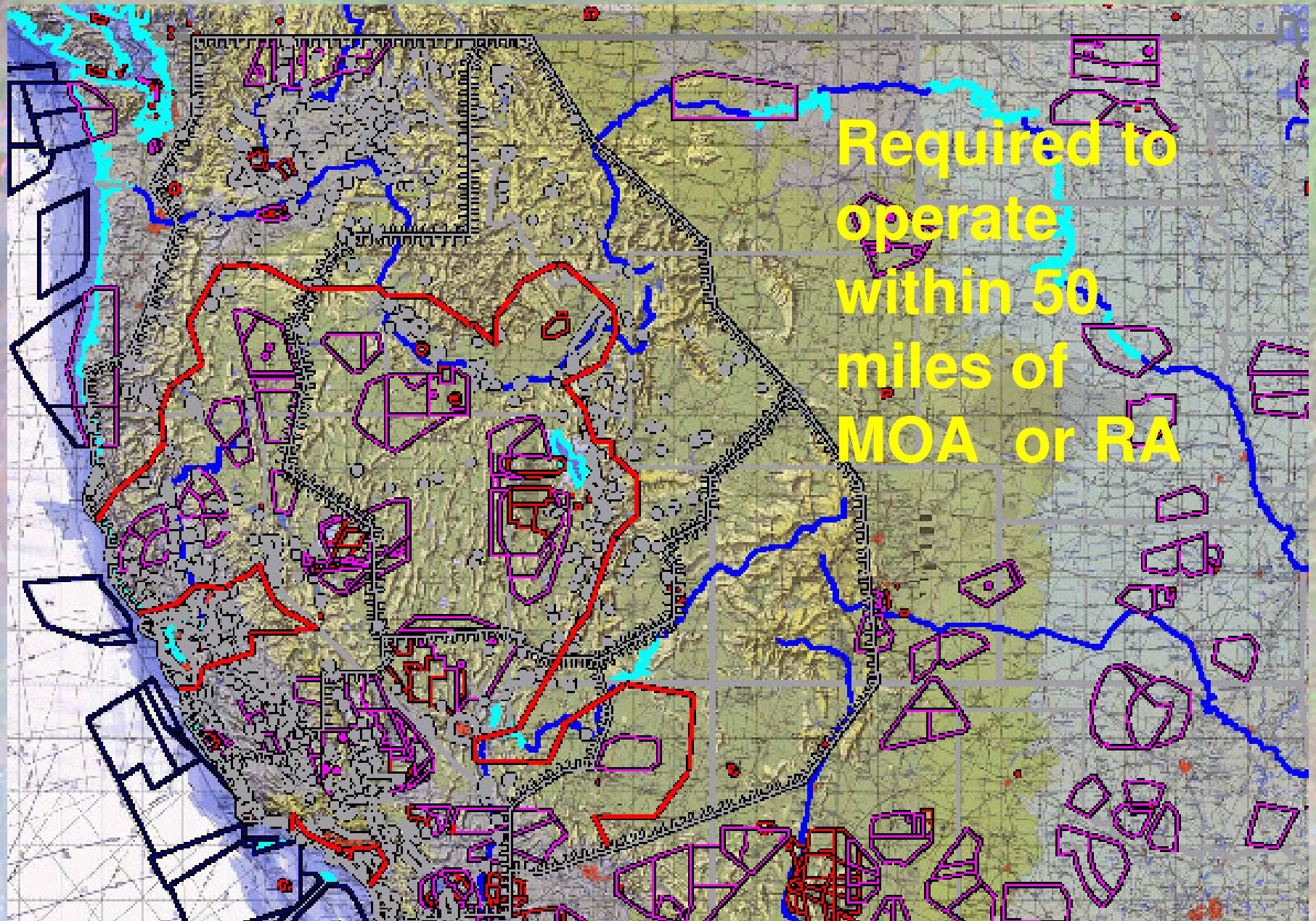
**BTU Complex**

**3D Perspective  
Northeast View**





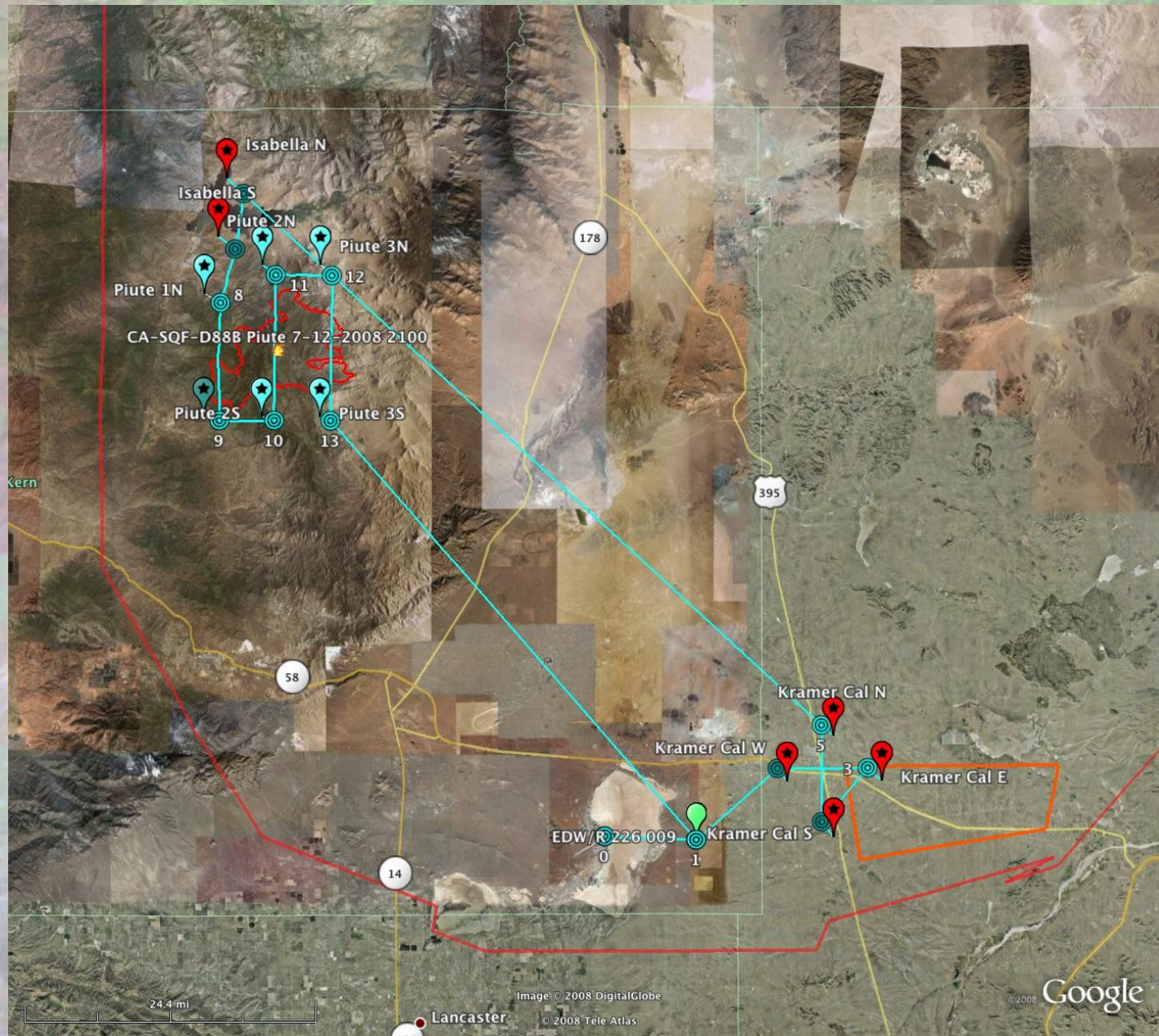
# August 2008: FAA COA Rules Change!!!



Required to  
operate  
within 50  
miles of  
MOA or RA



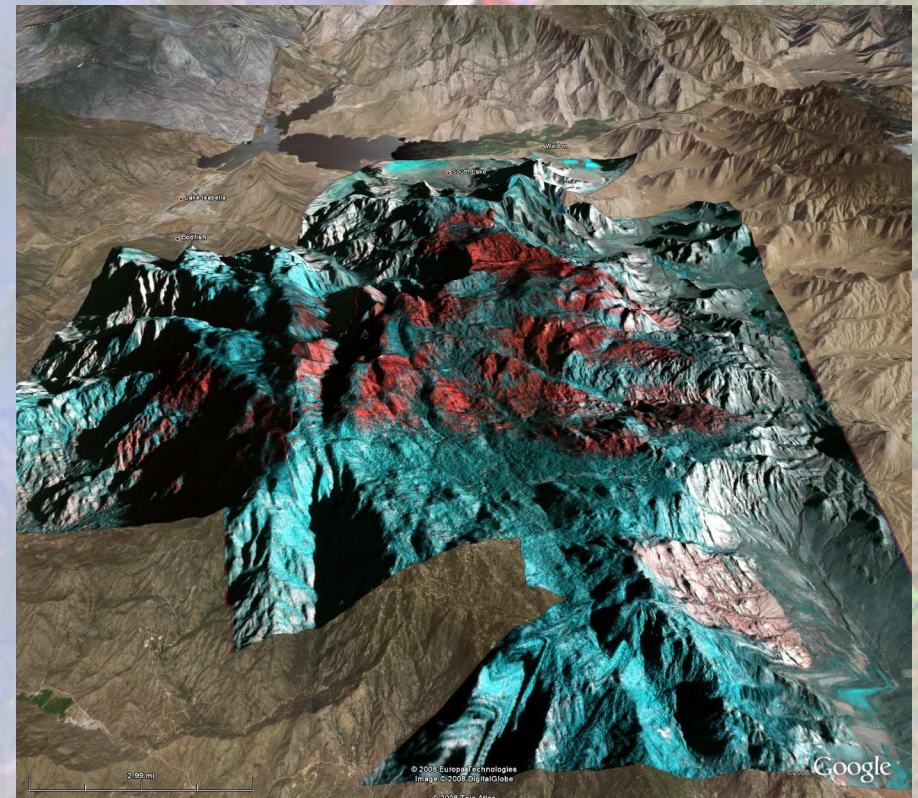
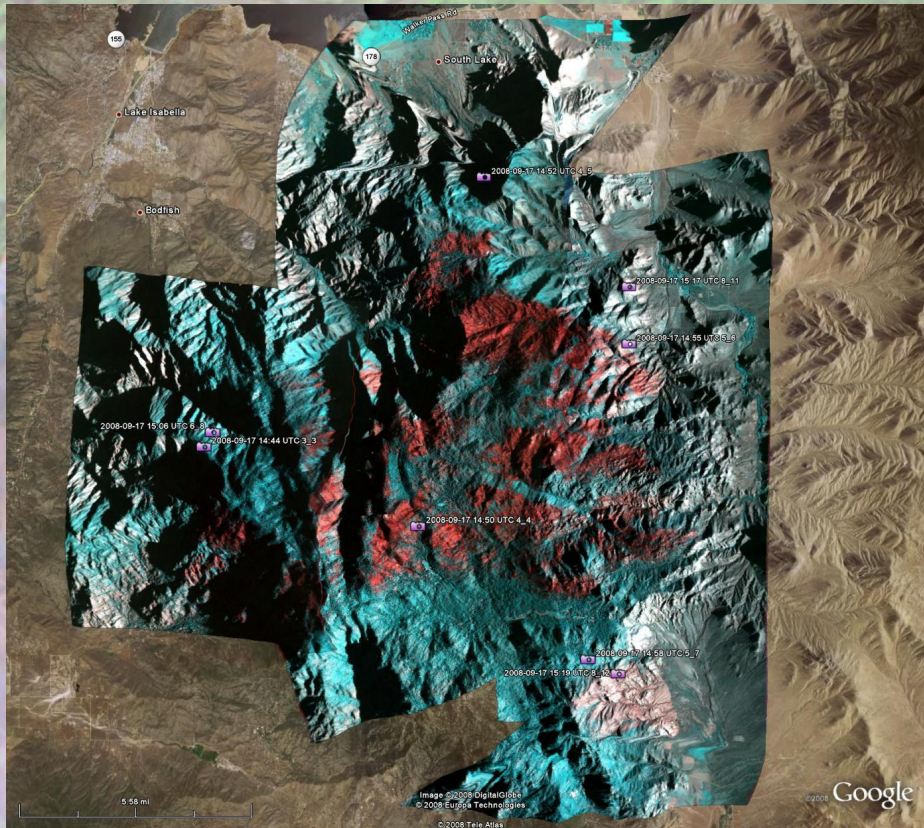
# WSFM-08 Test Mission: 17 Sept 2008





# WSFM-08 Test Mission: 17 Sept 2008

## Piute Fire BAER Data



### AMS Bands :

10: 2.08- 2.35 (TM7)

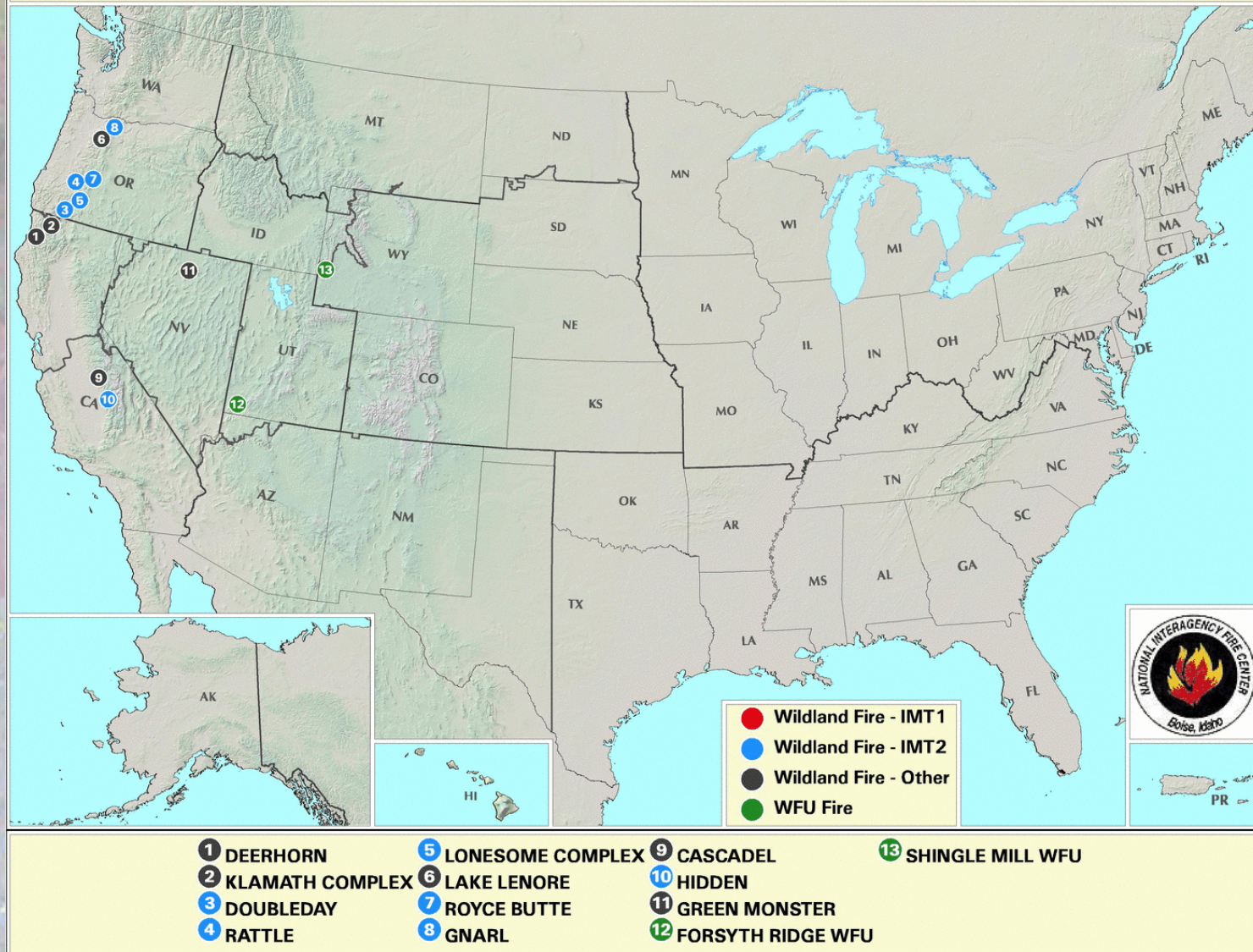
7: 0.76- 0.90 (TM4)

8: 0.91- 1.05



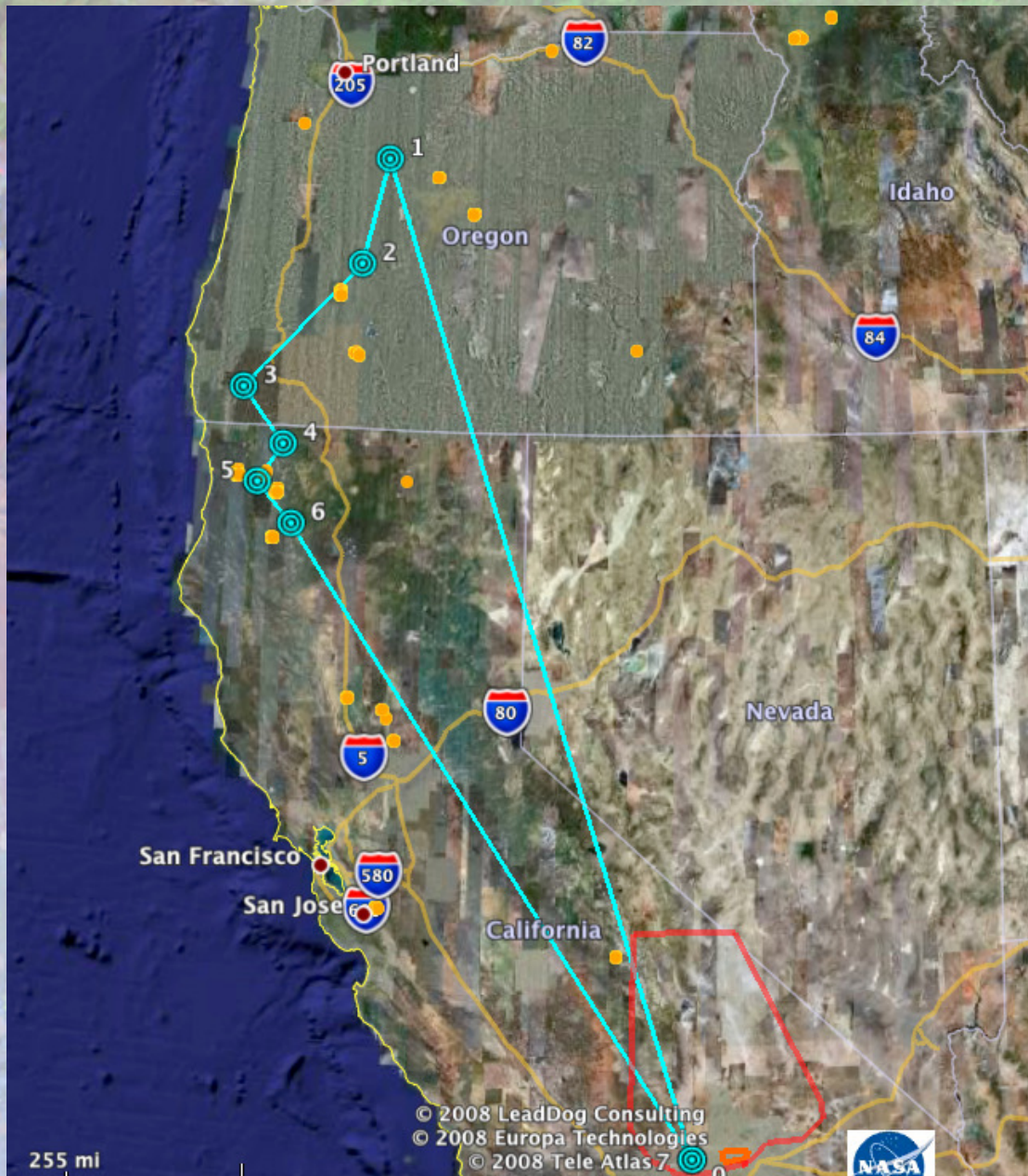
# WSFM-08; 18 Sept 2008

## Current Large Incidents September 18, 2008





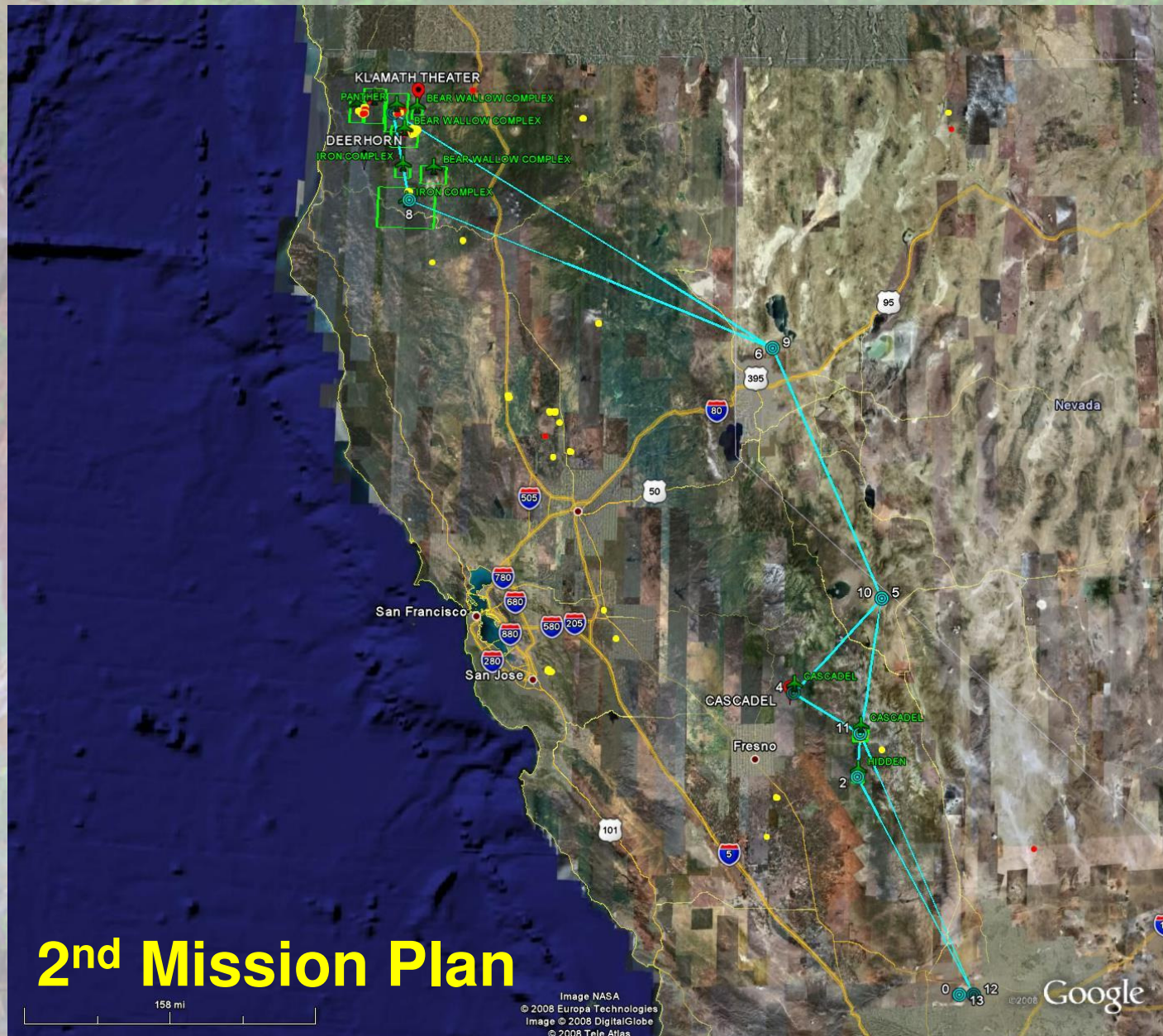
# WSFM-08 NoCA Mission 3: 19 Sept 2008



**Original  
Mission Plan**



# WSFM-08 NoCA Mission 3: 19 Sept 2008



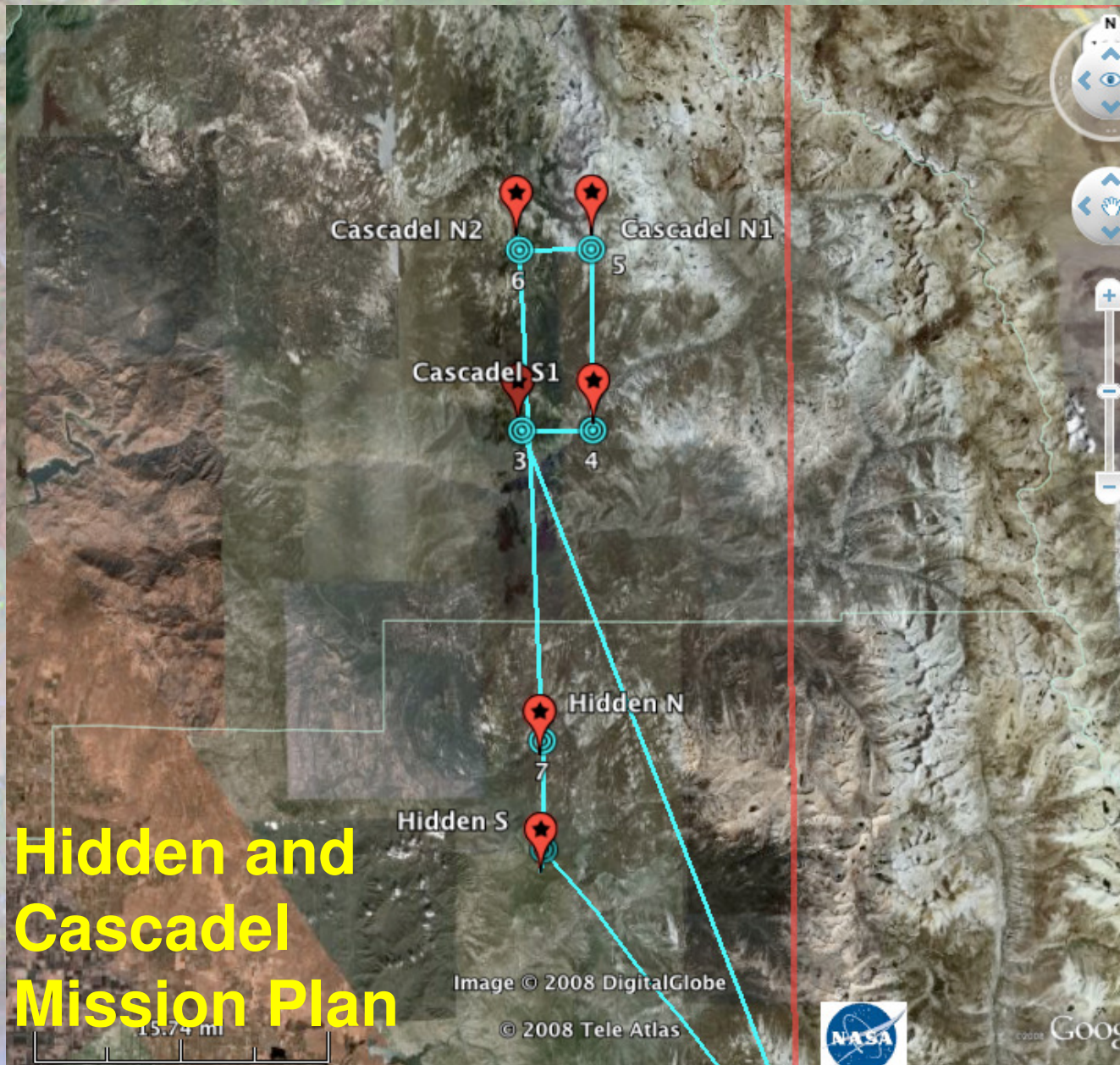


# WSFM-08 NoCA Mission 3: 19 Sept 2008





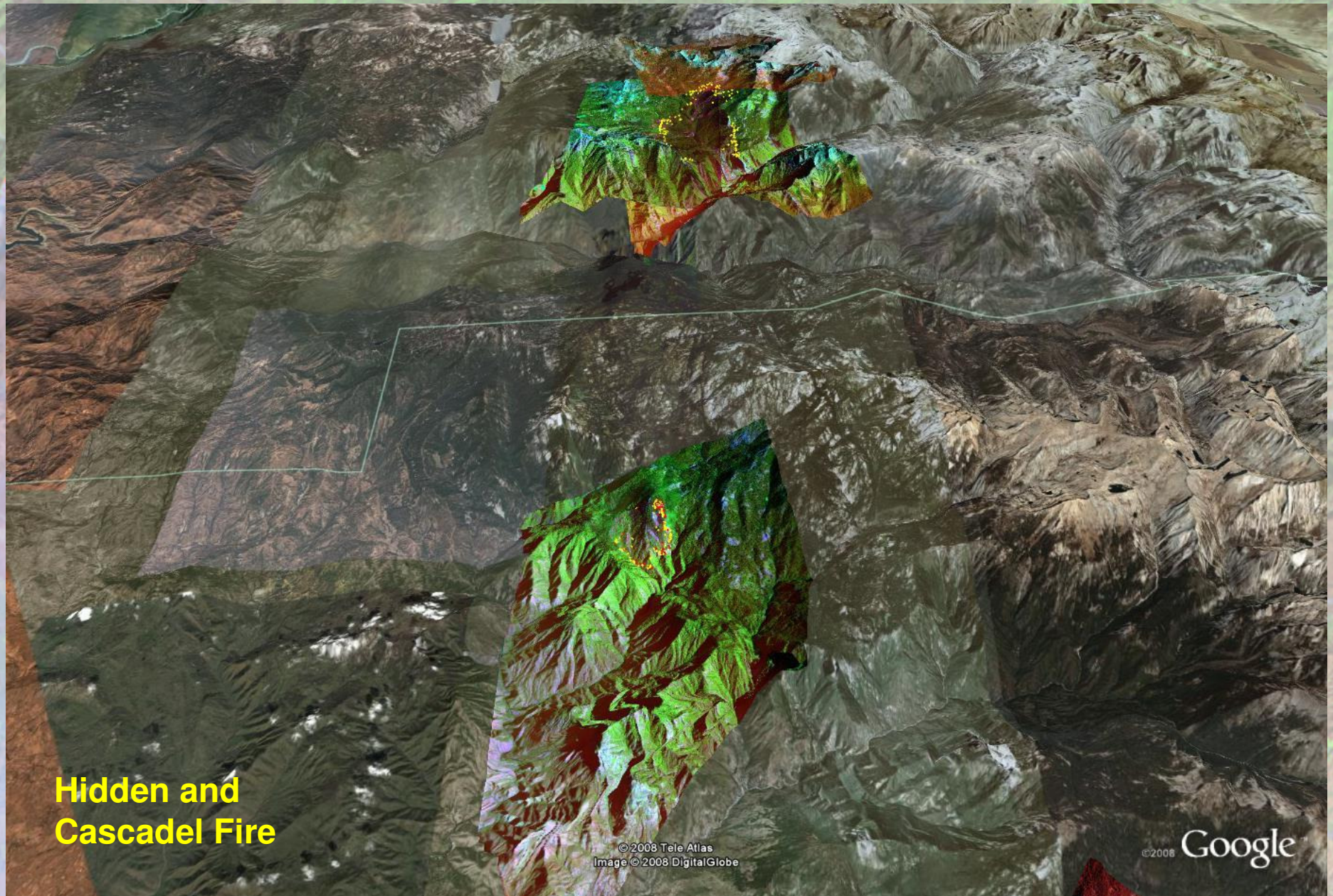
# WSFM-08 NoCA Mission 3: 19 Sept 2008



**Hidden and  
Cascadel  
Mission Plan**



# WSFM-08 NoCA Mission 3: 19 Sept 2008



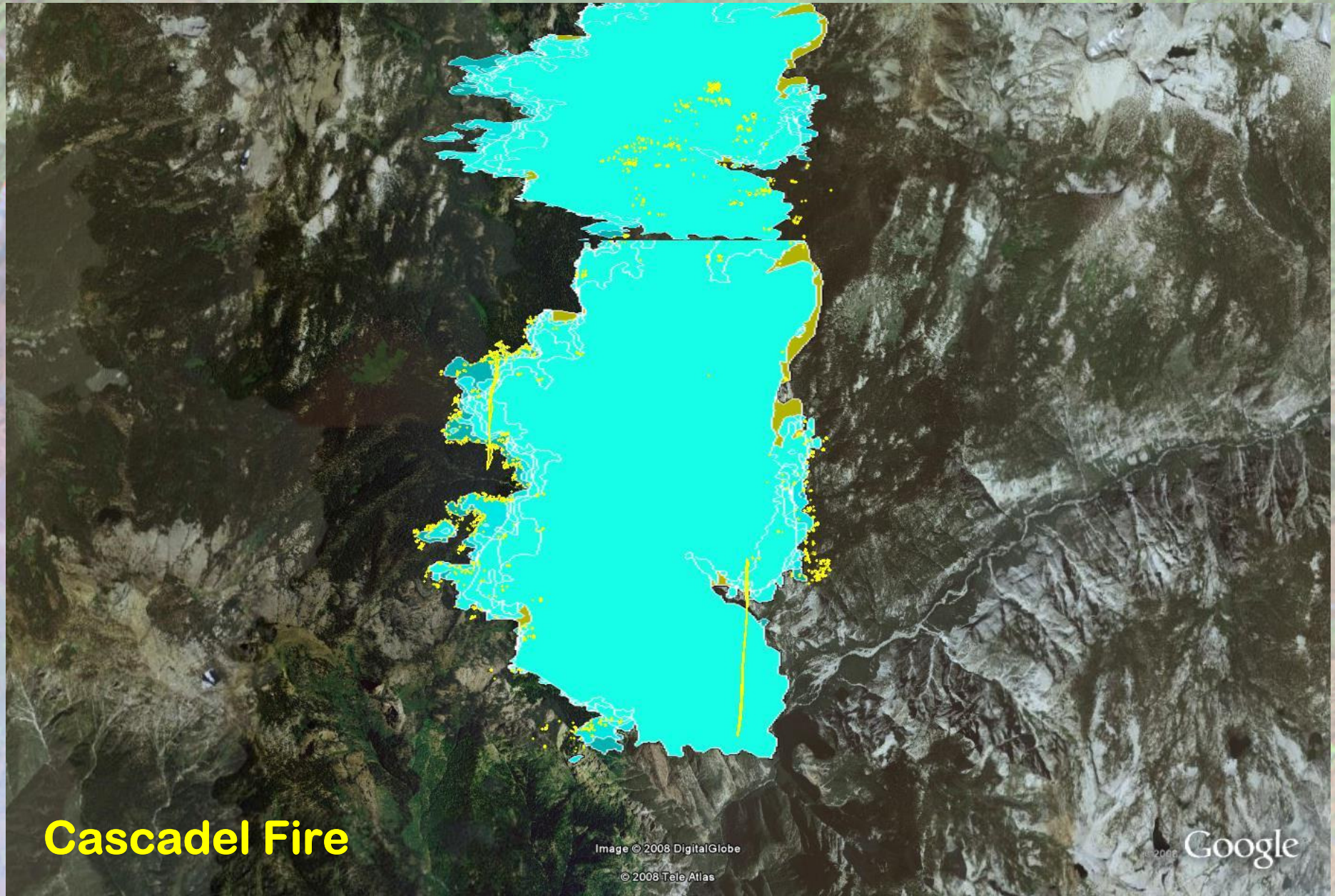
Hidden and  
Cascadel Fire

© 2008 Tele Atlas  
Image © 2008 DigitalGlobe

© 2008 Google



# WSFM-08 NoCA Mission 3: 19 Sept 2008



**Cascadel Fire**

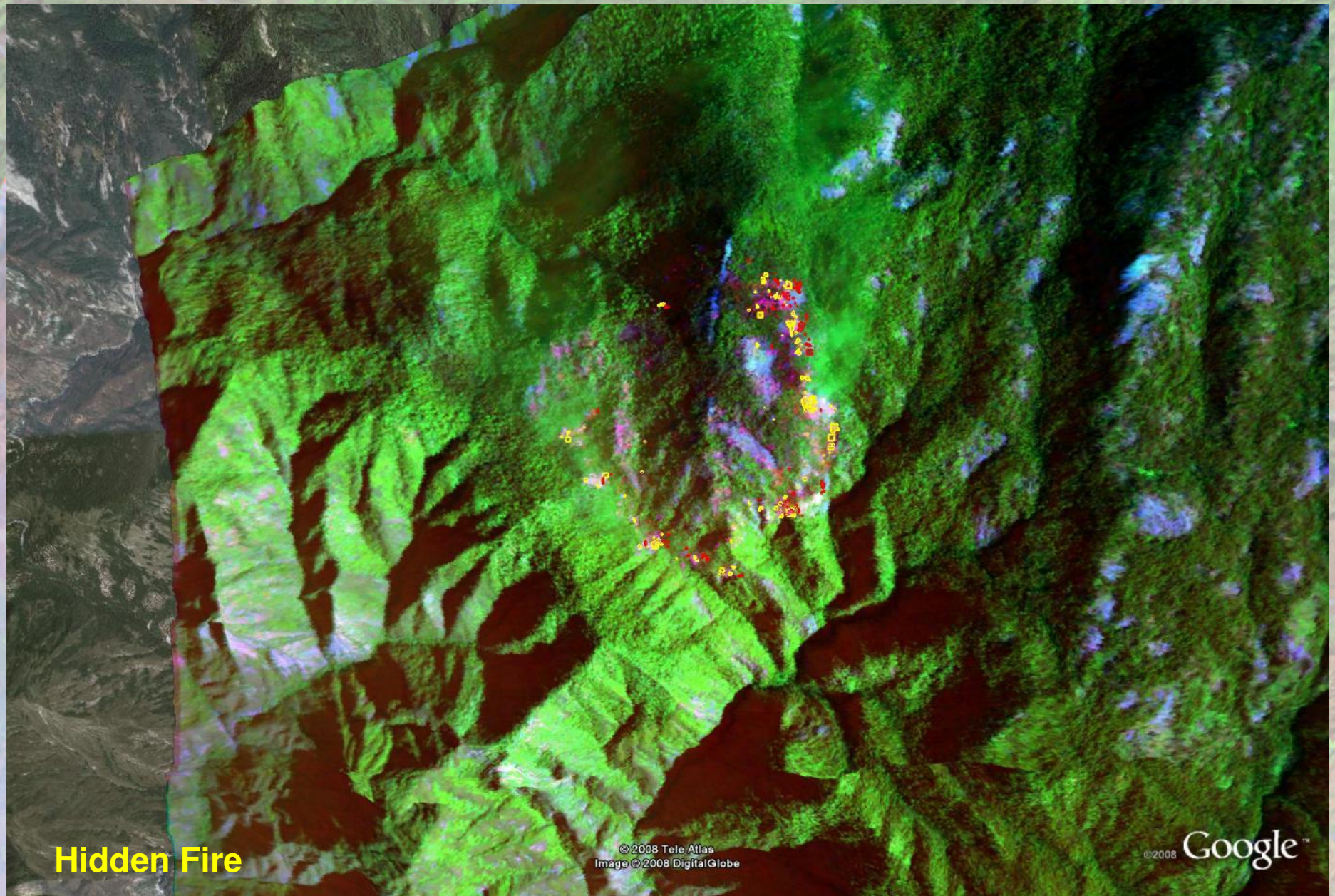
Image © 2008 DigitalGlobe

© 2008 Tele Atlas

© 2008 Google

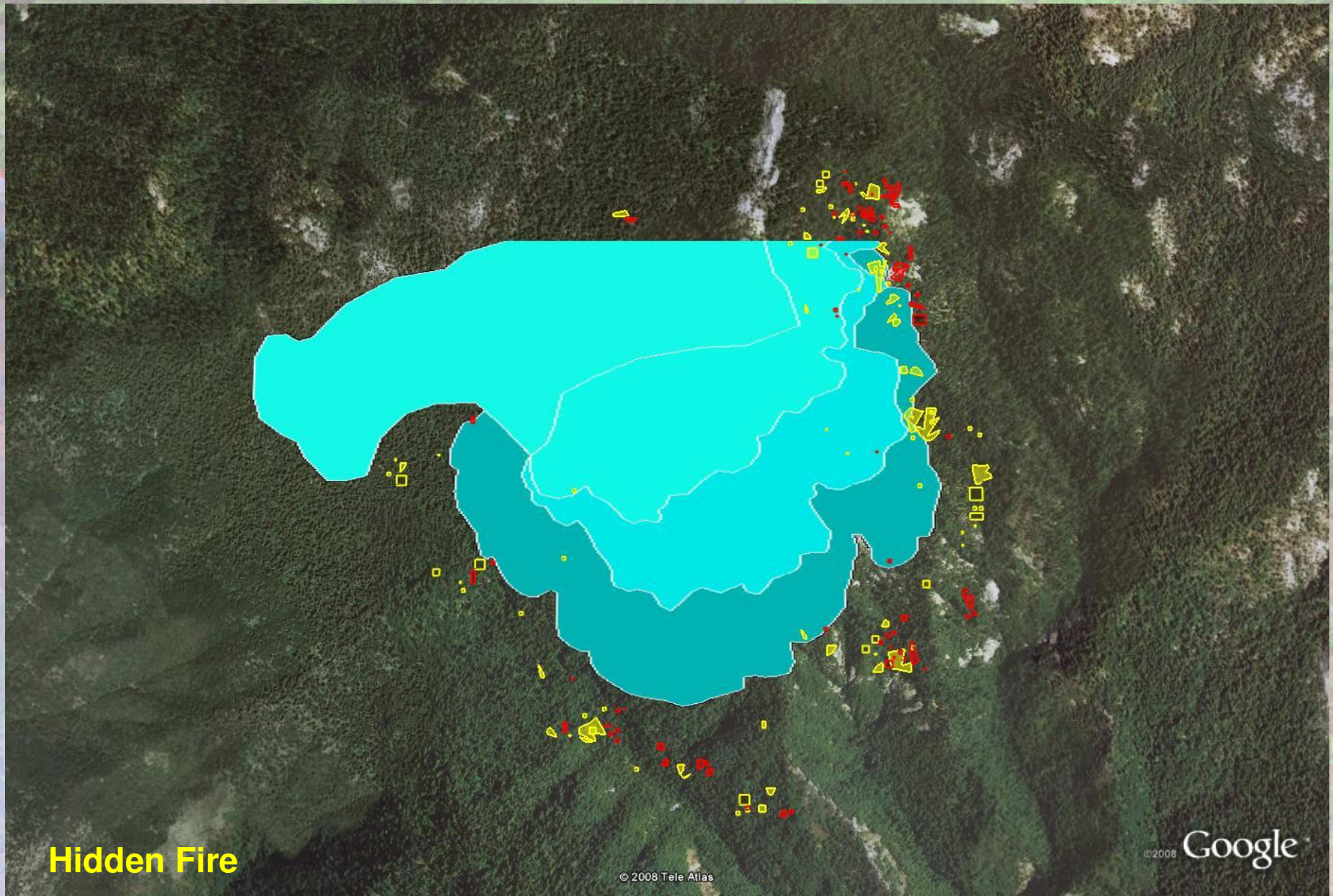


# WSFM-08 NoCA Mission 3: 19 Sept 2008



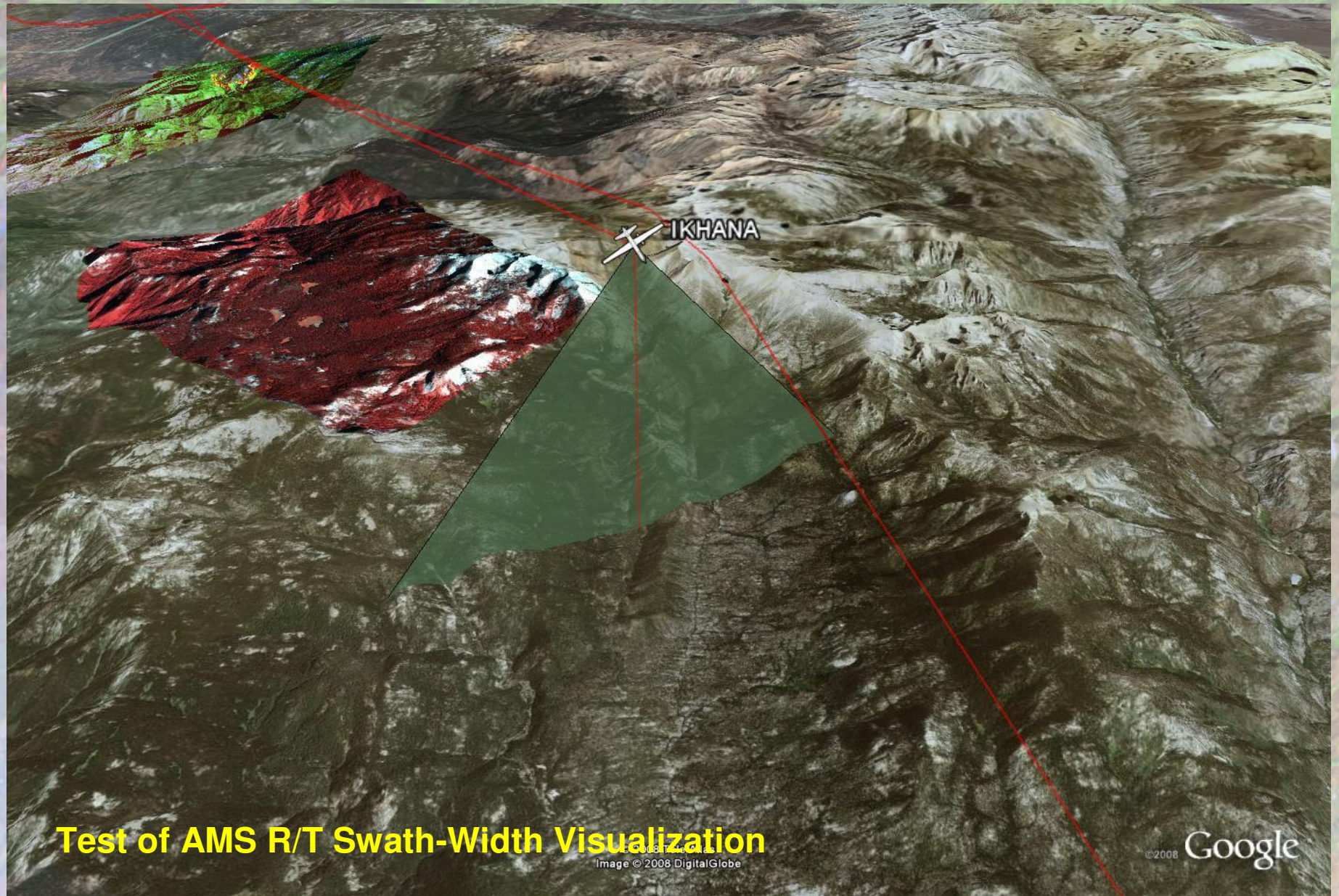


# WSFM-08 NoCA Mission 3: 19 Sept 2008



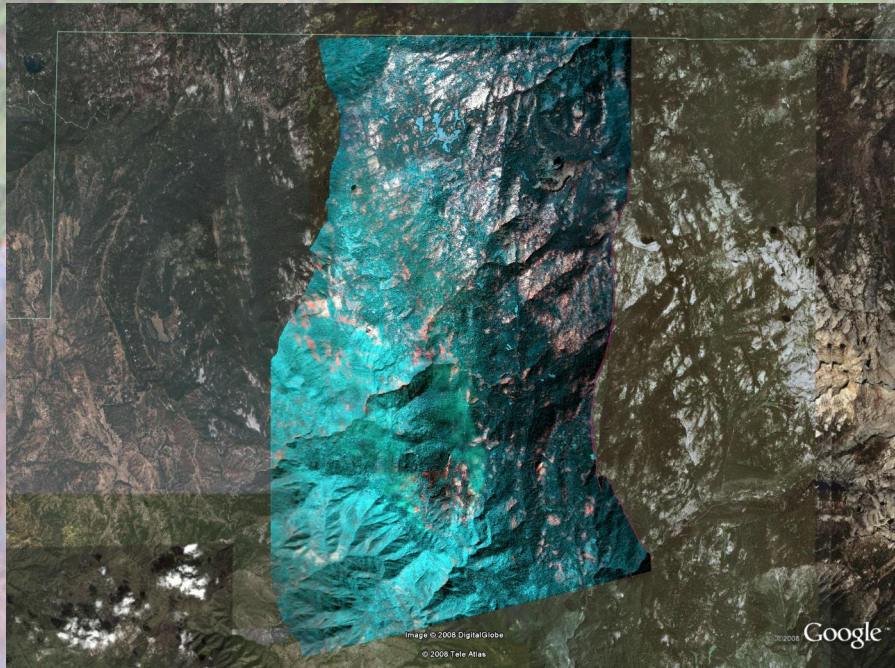


# WSFM-08 NoCA Mission 3: 19 Sept 2008





# WSFM-08 NoCA Mission 3: 19 Sept 2008



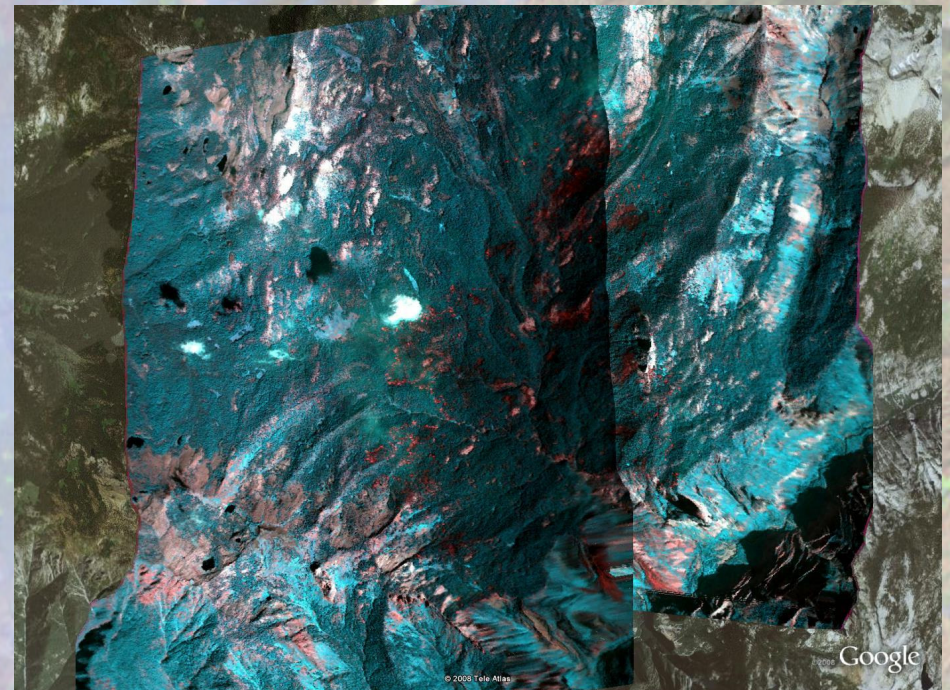
## Hidden and Cascadel BAER Data

### AMS Bands :

10: 2.08- 2.35 (TM7)

7: 0.76- 0.90 (TM4)

8: 0.91- 1.05





# Summary of WSFM - 2008

## No CA Fires Mission Summary 2008 (as of 10-17-08)

Mission Number	Mission Endurance	Date	Fire Imaged
NoCA #1	9.5 Hours	7/8/2008	Piute Clover Silver North Mountain American River Cub Complex Canyon Complex Basin Gap
NoCA #2	5.03 Hours	7/19/2008	American River Camp Cub Complex Canyon
Engineering Check	3.0 Hours	9/17/2008	Piute (BAER)
Mission #3	3.5 Hours	9/19/2008	Cascadel Hidden
Total Mission Time:	21.0		
Total Fires Flown:	16		



# WRAP 2009

- Integrate fire-critical model-derived data from NASA's Terrestrial Observation and Prediction System (TOPS) and scalable wind model data (NOGAPS) into the W-CDE.
- Mature and integrate new airborne sensor fire detection algorithm capabilities with the NASA-AMS-Wildfire sensor (atmos. correction).
- Develop new airborne post-fire burn severity indices data to feed directly into the W-CDE (post fire NBR data).

## ISSUES:

- Unsure of Ikhana use in '09; transitioned to NASA AERO, no longer supported by Airborne Sciences. Costs will go up dramatically.
- AMS-Wildfire is an institutional instrument, will be committed to other projects in spring and fall '09 (ARCTAS) on GH.
- Possible fire demo missions in EU (Greece) in summer '09.



# **Additional Information**

**Wildfire Research and Applications Partnership (WRAP)  
Web Site:**

**<http://geo.arc.nasa.gov/sge/WRAP>**

**Wildfire Collaborative Decision Environment (W-CDE):**

**Add following in GoogleEarth at: Add / Network Link**

**<http://sggate.arc.nasa.gov:9518/GoogleEarth/CDE.kml>**