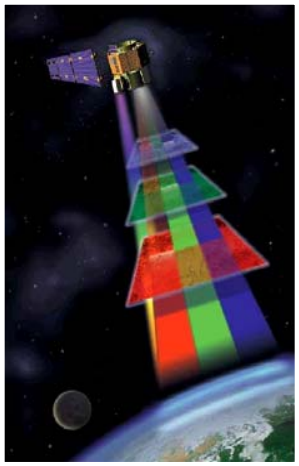

Integrating Orbital and Airborne Assets: SensorWeb Demonstrations During Western States Fire Mission 2007

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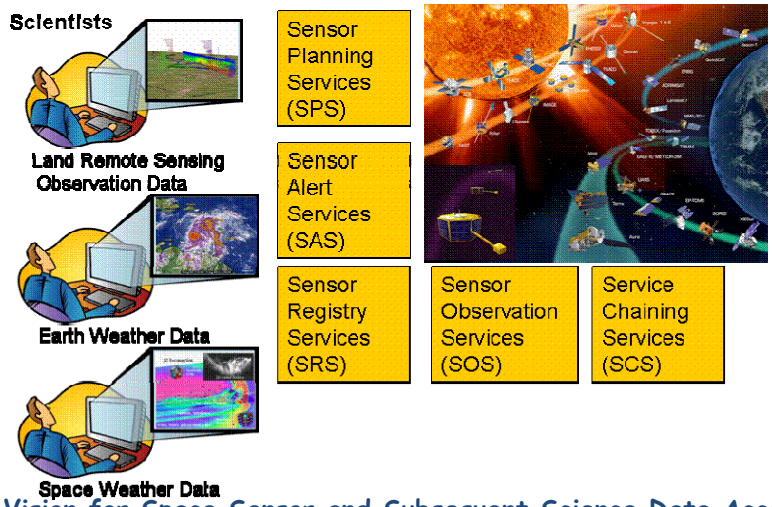
NASA ESTO Earth Science Technology Office | Goddard Space Flight Center | Ames Research Center | JPL | University of Maryland 1856

An Interoperable Sensor Architecture to Facilitate Sensor Webs in Pursuit of GEOSS

PI: Dan Mandl, GSFC

Objective

- Assist future Earth science needs for integrating multiple observations without requiring the end-user to have intimate knowledge of the sensors being used.
- Demonstrate and validate a path for rapid, low cost sensor integration, which is not tied to a particular system.
- Facilitate the United States contribution to the Global Earth Observation System of Systems by defining a common sensor interface protocol based upon emerging community standards.



Vision for Space Sensor and Subsequent Science Data AccessVia Generic Web Services to Form Sensor Web

Approach

- Experiment with interoperability standards
- Demonstrate and specify the discovery process for available sensor resources
- Demonstrate and specify the ability to direct other sensors
- Demonstrate and specify the ability to specify how the available data should be delivered and combined

Co-I's/Partners

- Robert Sohlberg, Dr. C. Justice, Dr. J. Townshend / UMD
- Dr. Jeffrey Masek, Stuart Frye / NASA-GSFC
- Dr. Stephen Ungar, Troy Ames / NASA-GSFC
- Dr. Steve Chien, Daniel Tran / NASA-JPL
- Pat Cappelaere / Vightel
- Don Sullivan, Vince Ambrosia / NASA-ARC

Key Milestones

- Development of relevant science & operations concepts and scenarios (Done) June 2007
- 1st demonstration EO-1 "discoverable"/taskable via Internet and the use of SensorML & EO-1 Autonomy SW Sept 2007
- Augment demonstration 1 with GMSEC framework in testbed for 2nd demonstration June 2008
- Integration of SensorML, IRC, GMSEC, cFE and CHIPS or testbed into 3rd demonstration Mar 2009
- Full capabilities demonstration, 4th demo Sept 2009
- Ident. of Earth Science mission infusion targets Ongoing

$TRL_{in} = 3$
$TRL_{9/30/07} = 4$

ESTO Earth Science Technology Office

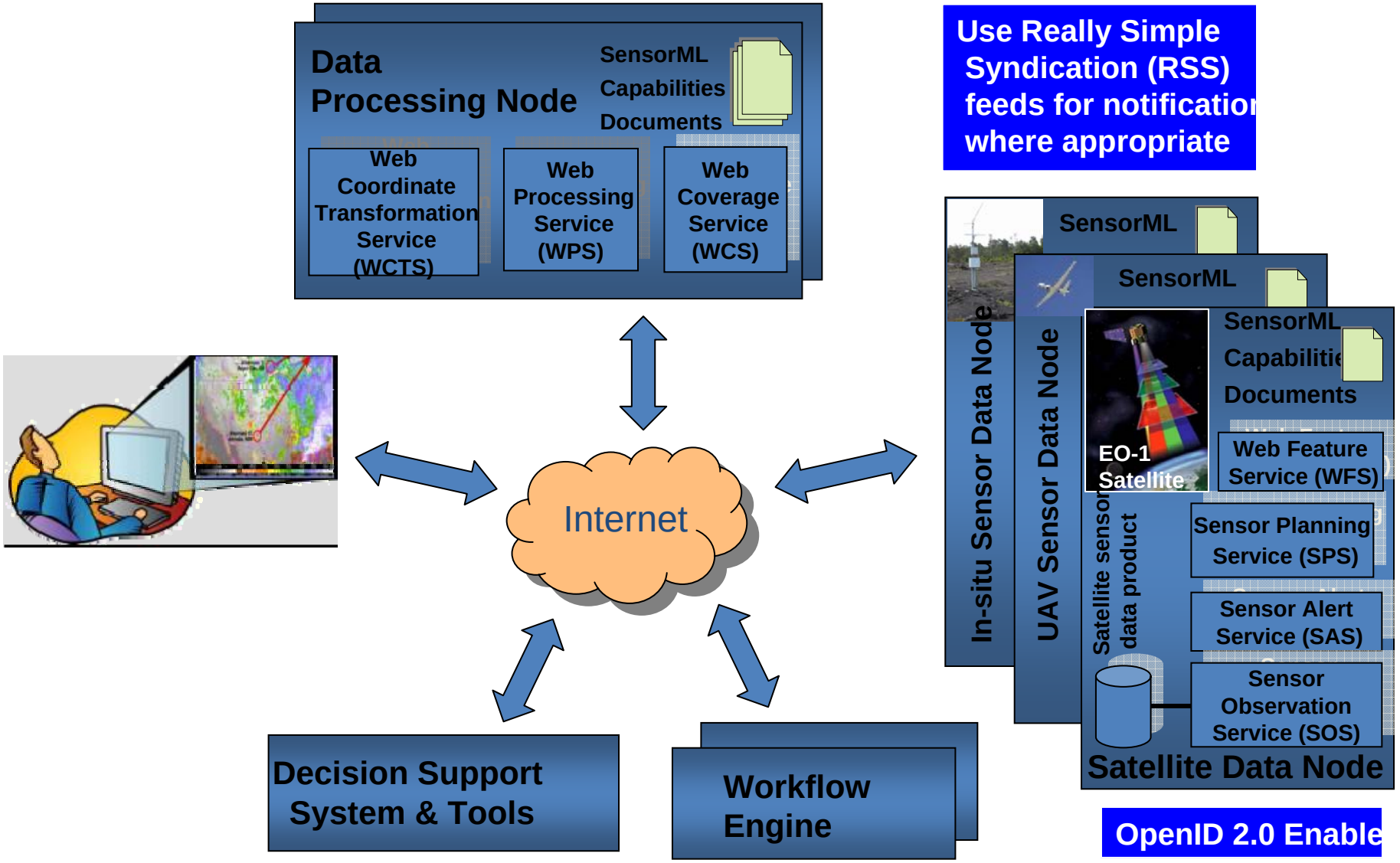
Overview

- Sensors are everywhere
- Disasters and natural phenomena can happen anywhere
- Develop process to interconnect world's sensors using the Internet, it's common tools such as browsers and the emerging Web 2.0 capabilities
- Facilitate cost reductions to produce customized science data products by an order of magnitude

Approach

- Identify investigation / potential targets
- Discover available sensor assets and algorithms over Internet
- Select or customize needed workflows and delivery methods
- Execute workflow automatically
- Making customized products via web “mash-ups”
- Deliver data to user desktop

Reference Architecture: Encapsulate Sensors and Data Processing with Web Services and OGC Standards



OGC Interface Terms

- SPS: Sensor Planning Service
- SOS: Sensor Observation Service
- WfCS: Workflow Chaining Service
- WPS: Web Processing Service
- WMS: Web Map Service
- WCS: Web Coverage Service
- WCS-T: Web Coverage Service - Transformation
- CSW: Catalog Services for the Web

Accomplishment Thus Far (1 of 2)

Sensor Web Services Established

JPL SPS
EO-1 Hyperion
EO-1 ALI

JPL SOS
EO-1 Hyperion L0
EO-1 Hyperion
EO-1 Hyperion
EO-1 Hyperion
EO-1 ALI L0
EO-1 ALI L1R
EO-1 ALI L1G

Geobliki WfCS
WfXML workflow engine

JPL WPS
Thermal classifier
Burn Index
Composite Browse
Fluvial classifier
Cloud classifier
Sulfur classifier
SWIL classifier
Fire fuel load classifier (various, future)

Geobliki WPS
Vegetation Index (future)
Burn scar
Water classifier (future)
Rhodamine dye (future)
Snow & Ice (future)

Geobliki SPS
EO-1 Hyperion
EO-1 ALI

Geobliki SOS
EO-1 Hyperion L0
EO-1 Hyperion
EO-1 Hyperion L1R
EO-1 Hyperion
EO-1 ALI L0
EO-1 ALI L1R
EO-1 ALI L1G

Geobliki WMS
Fire maps
KML transform for Google Earth

Accomplishment Thus Far (2 of 2)

Sensor Web Services Established

Draper WPS

AFWA Cloud Cover

Northrop Grumman

Smoke Model

WVHTF WfCS

Sensor Workflow Engine

AMES WCS

Ikhana UAS hot pixels

AMES SPS

Ikhana UAS Wildfire Instrument

AMES WMS

Ikhana UAS Wildfire Images & Fire location maps

KML transform for Google Earth

GMU WCS

Hot Pixels

GMU WCS-T

Transform Hot Pixels for Map production

GMU WfCS

BPEL engine to execute workflow

SPOT-5 SPS

SPOT-5

ASTER SPS

ASTER

ASTER SPS

ASTER

MODIS WFS

MODIS Hot Pixels

Earth Science Gateway CSW

NASA data

Global Change Management Directory CSW

NASA data

Summer 2007 Wildfire SensorWeb Scenario

Utilizing MODIS, ASTER, EO-1 (ALI / Hyperion), and Ikhana UAS

NIFC ICS-209

National Priority Wildfires

MODIS, ASTER Detection & Targeting

Air Force Weather Agency Cloud Prediction

EO-1 Acquisition & Detection

Ikhana UAS Tasking & Acquisition

Increasing Knowledge

Builds upon success of MODIS Rapid Response to provide coordinated data from multiple NASA sensors.

END USERS

Active & Post-Fire

High Level Architecture for Fall 2007 Fire SensorWeb Demo

First responder

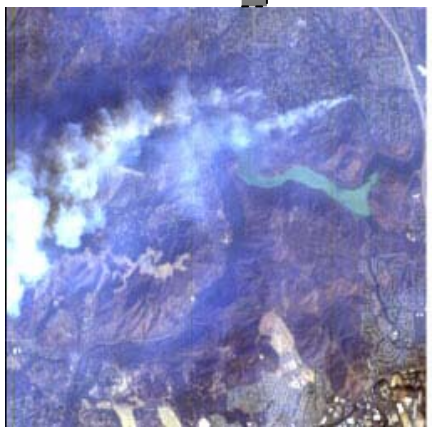
Theme Based Tasking Request

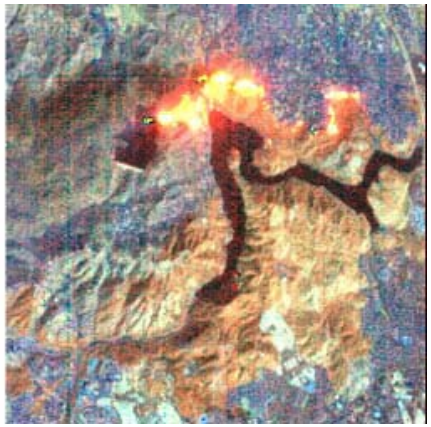
Theme:

Loc:

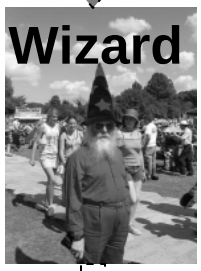
Priority:

Geo-Emergency





Wizard

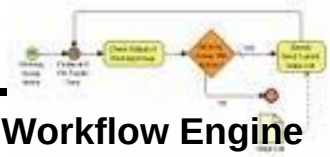


- Emergency
- Discover available sensor assets over Internet
- Wizard assembles possible workflows
- Workflow engine controls creation of multi-sensor products, processing and delivery to user desktop

Witch Fire (SoCal) Oct 23, 2007

EO-1 Fire Sensor Web Image

Published in CNN- Popular Science



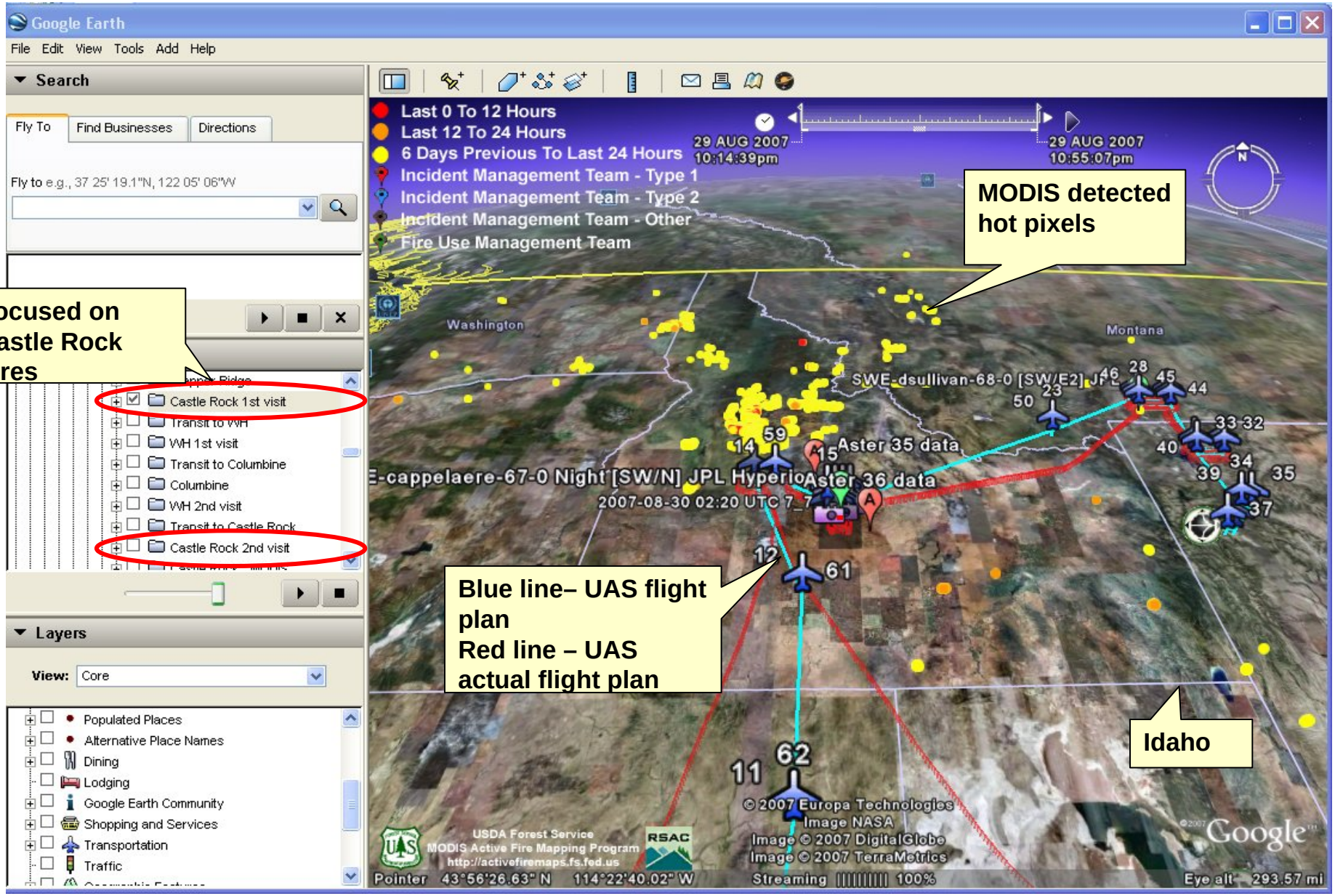
Workflow Engine

Result: Efficient / timely use of assets

Date/Time	OGC Services Used	Description of Demo step
1. Monday, August 27, 2007	SPS	Trigger ASTER image for Wed/Thurs of Castle Rock fire in Idaho if ASTER can see targets in that timeframe
2. Wed, August 29, 2007 morning(Pacific)		Steve Wegener posts final UAS flight plan to Ames Collaborative Decision Environment (CDE) web page
3. Wed, August 29, 2007 morning (Pacific)		EO-1 Geobliki (Cappelaere) and Draper (Kolitz) retrieve flight plan from CDE
4. Wed, August 29, 2007 morning (Pacific)	WFS	Geobliki computes targets from MODIS fire hot pixel map via the WFS interface and send targets to Draper (Kolitz)
5. Wed, August 29, 2007 afternoon (Pacific)		Draper (Kolitz) sends revised UAS flight plan to Ames (S. Wegener) - note: Draper sends update cloud predicts to Ames every 6 hours
6. Wed, August 29, 2007 afternoon (Pacific)		Draper send E-Mail to Geobliki with selected EO-1 target (screening for least cloudy) and occurring Wed night or Thurs morning
7. Wed, August 29, 2007 afternoon(Pacific)		EO-1 Geobliki SPS tasks EO-1 and bumps previously planned image for new image requested
8. Wed, August 29, 2007 2:00 pm (Pacific)		UAS takes off
9. Wed, August 29, 2007 evening (Pacific)	SPS	UAS detects first fire on way to Idaho and then automatically posts (D.Sullivan) new target request for EO-1 via Geobliki SPS
10. Thursday, August 30, 2007		EO-1 images target before UAS lands if selected targets are viewable in that time period
11. Aug 29 Sept 2	SOS, WPS, WCS-T, WMS, WFS	Post UAS and EO-1 Images

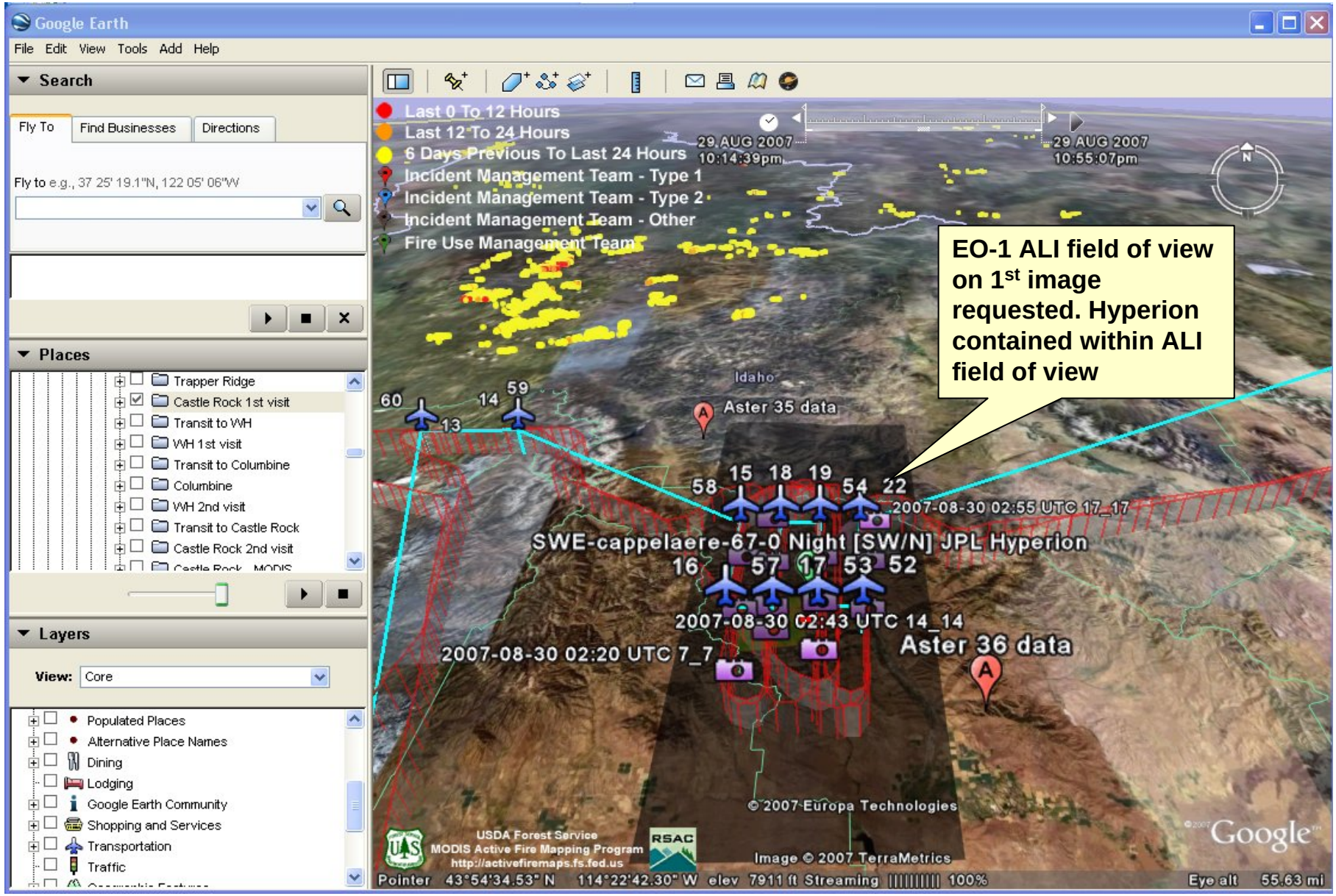
Fire Sensor Web Demo Aug 27-30 2007

Ikahana UAS, EO-1 (Hyperion & ALI), Terra/Aqua (MODIS & ASTER)



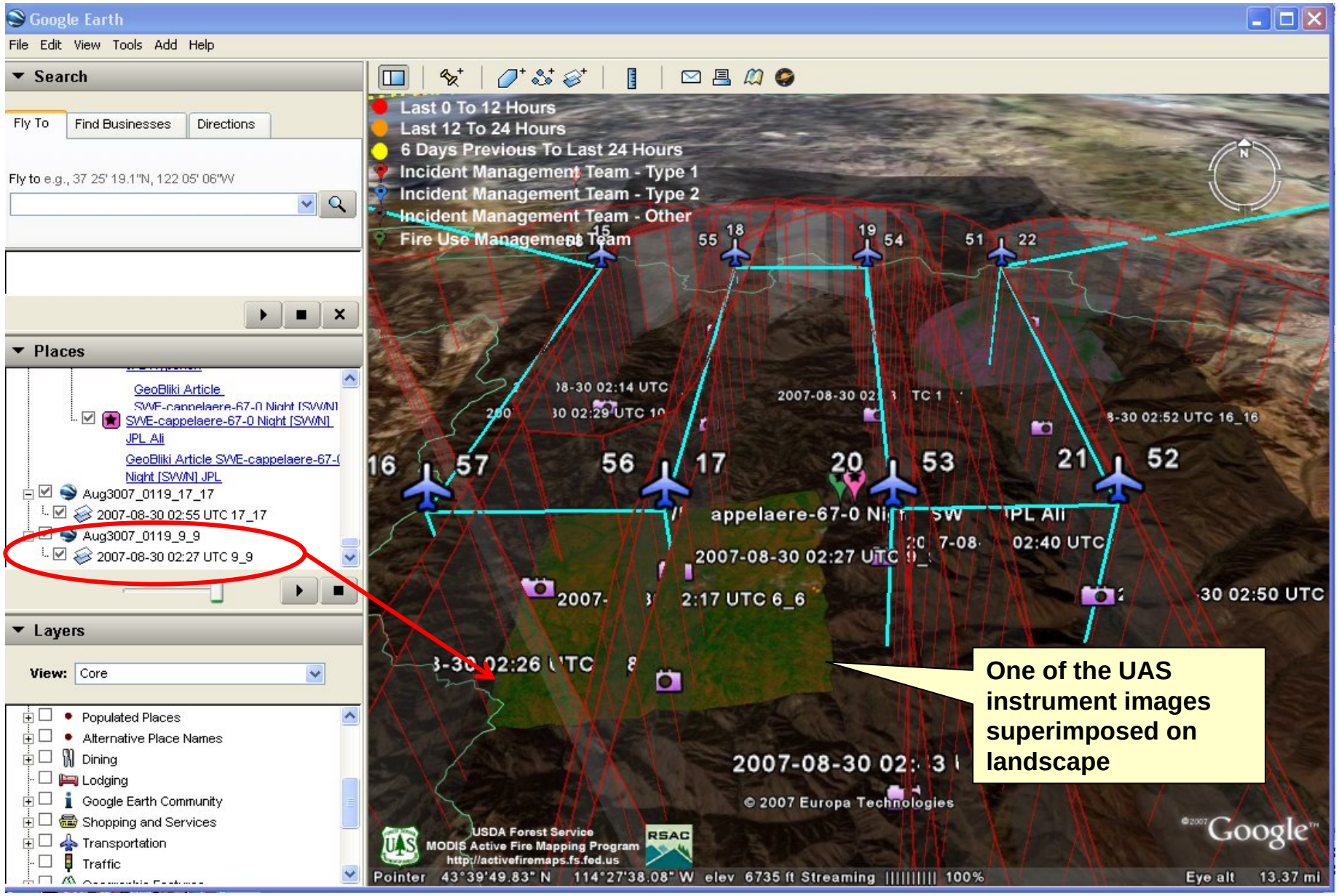
Fire Sensor Web Demo Aug 27-30 2007

Zoom in - 1



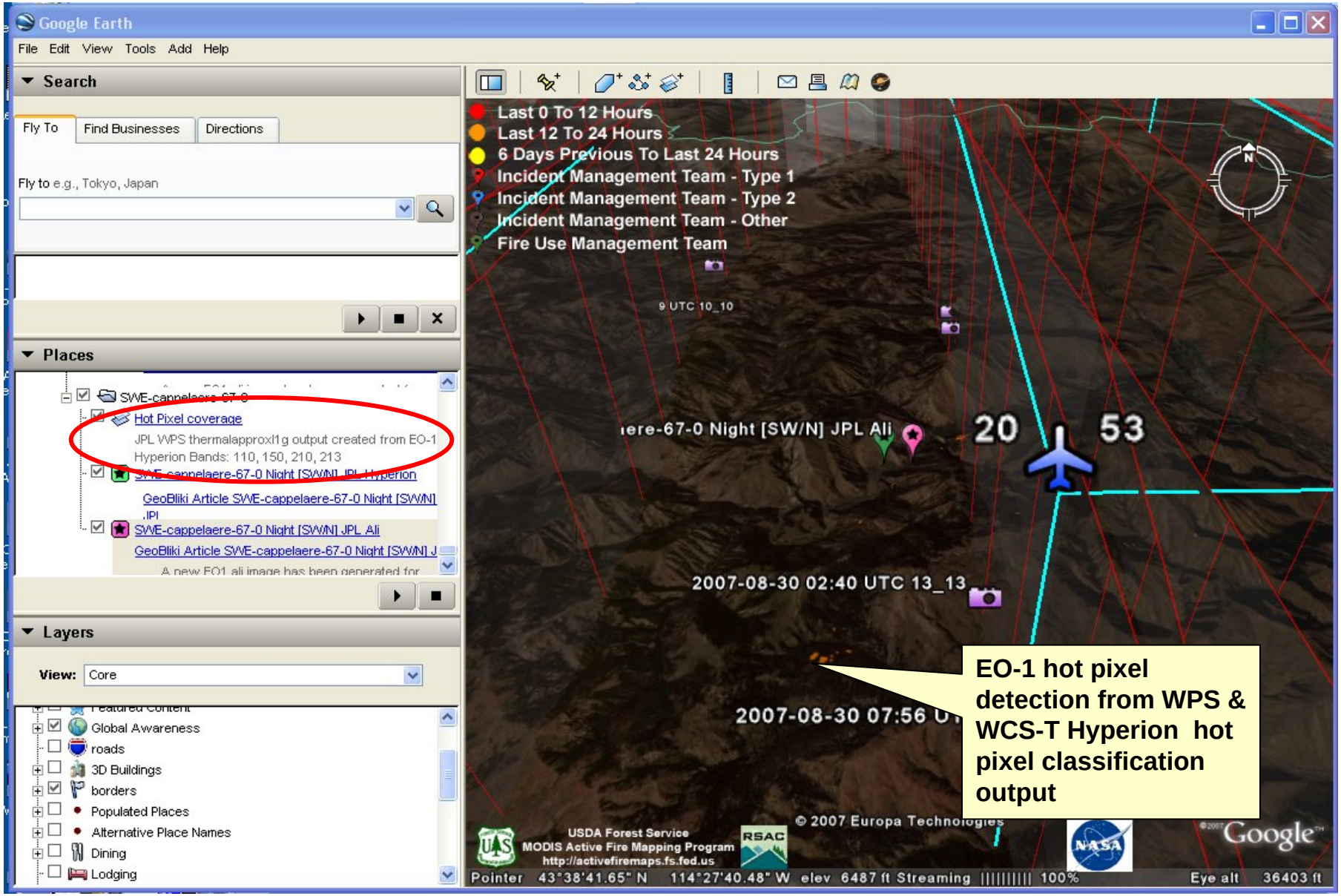
Fire Sensor Web Demo Aug 27-30 2007

Zoom in - 2



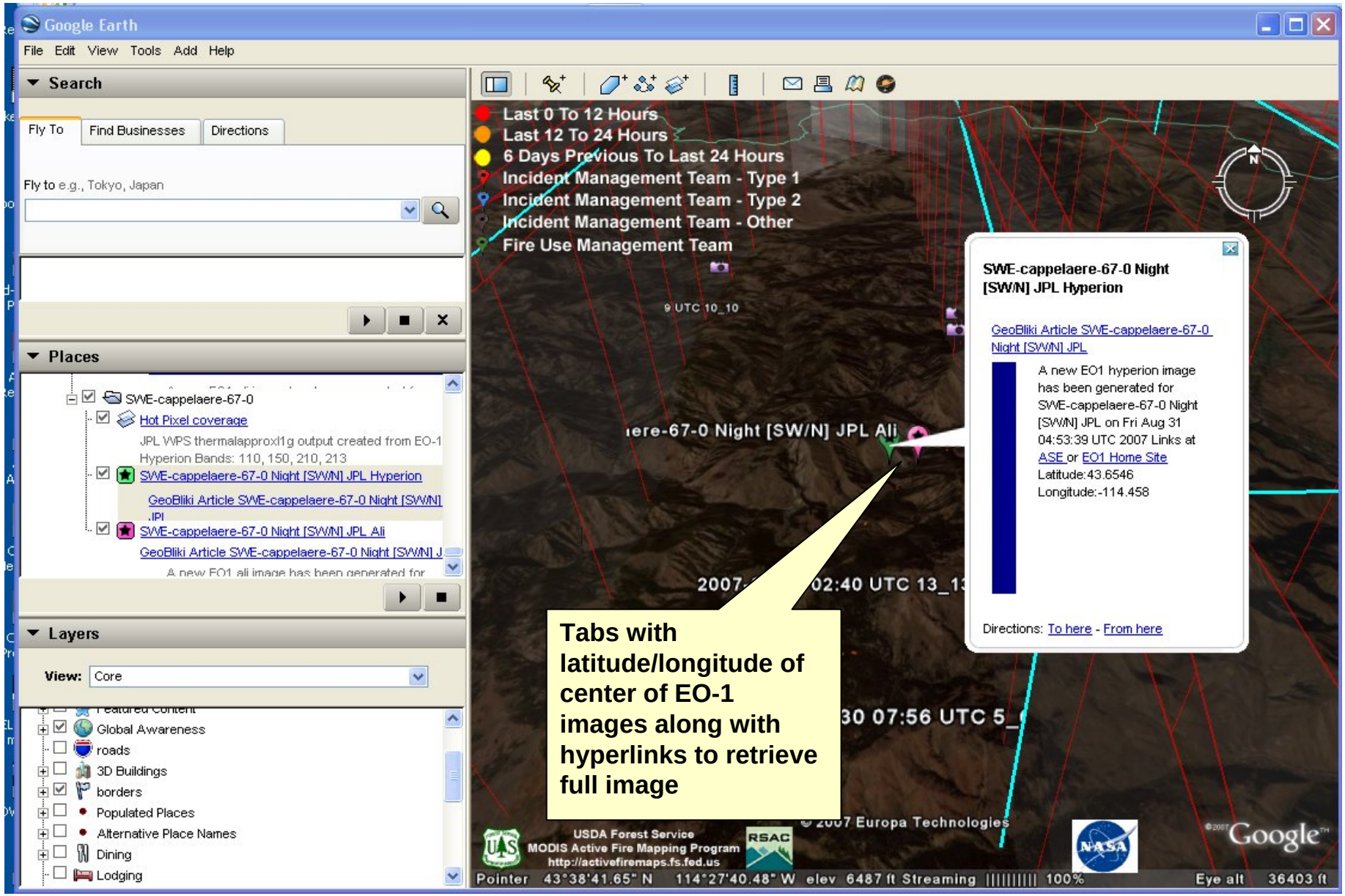
Fire Sensor Web Demo Aug 27-30 2007

Zoom in – 3 – Hyperion WPS & WCS-T hot pixel classification



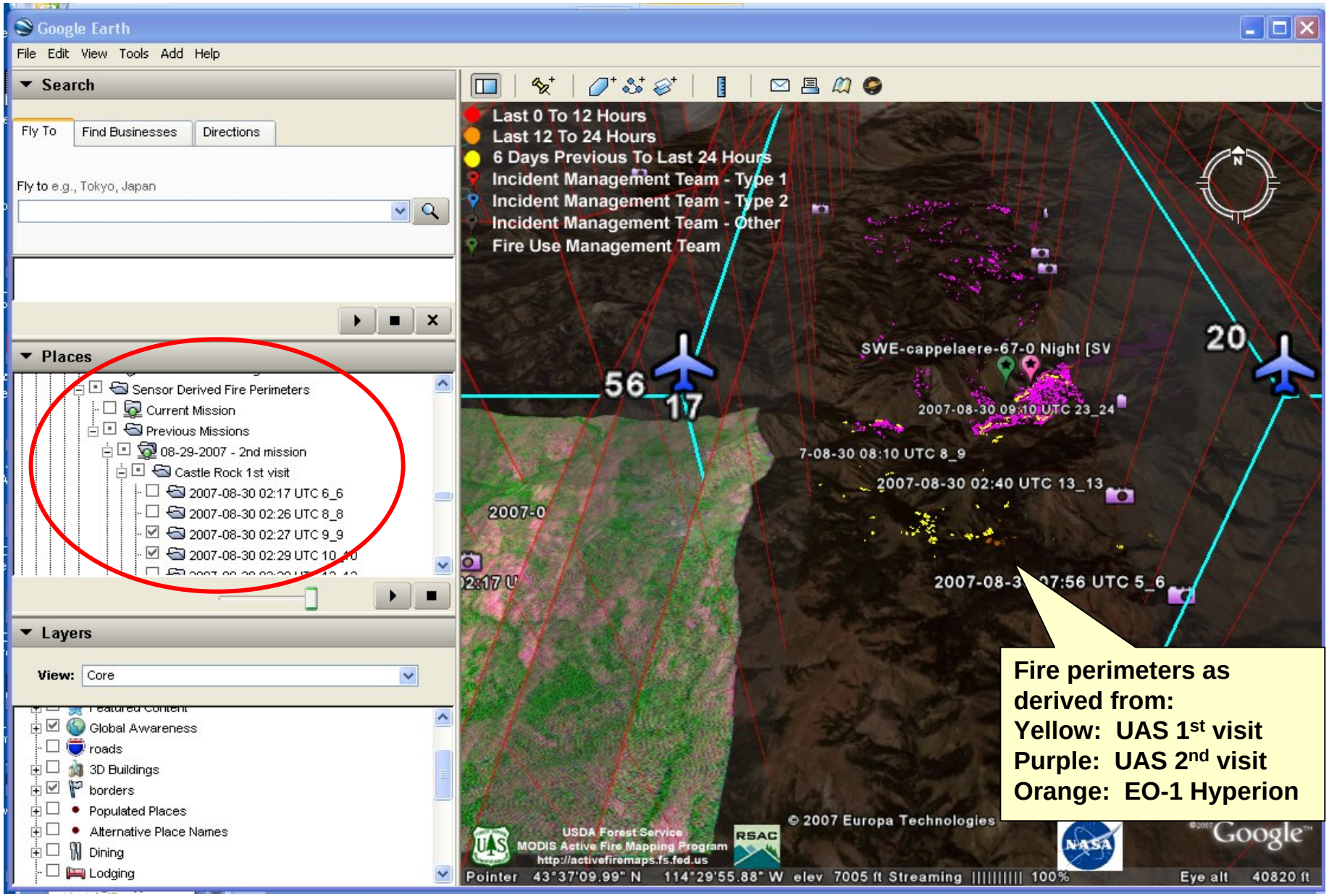
Fire Sensor Web Demo Aug 27-30 2007

Zoom in – 4 – Easy retrieval of actual Hyperion and ALI images



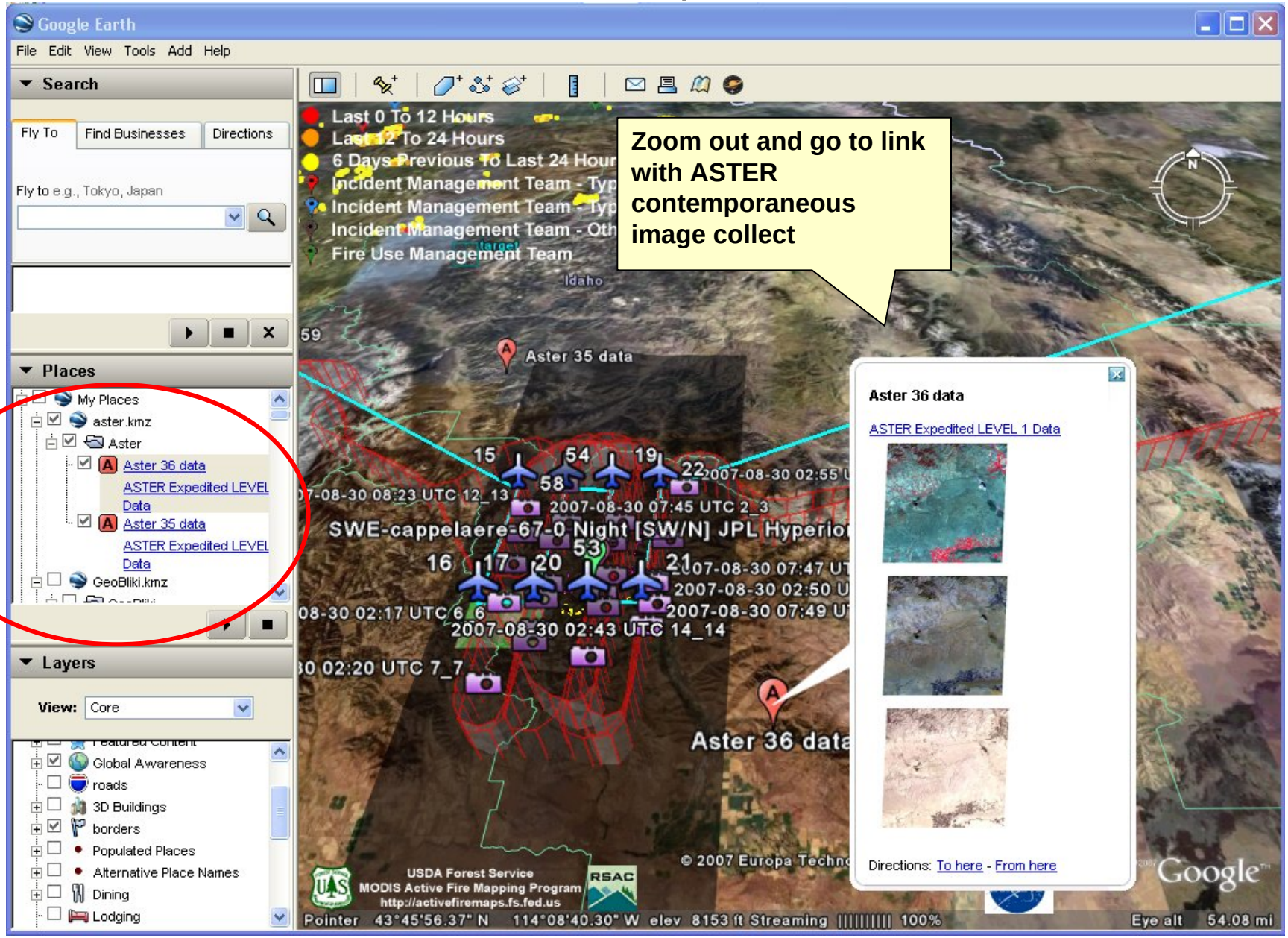
Fire Sensor Web Demo Aug 27-30 2007

Zoom in – 5 – Overlays of UAS & EO-1 fire perimeter classification



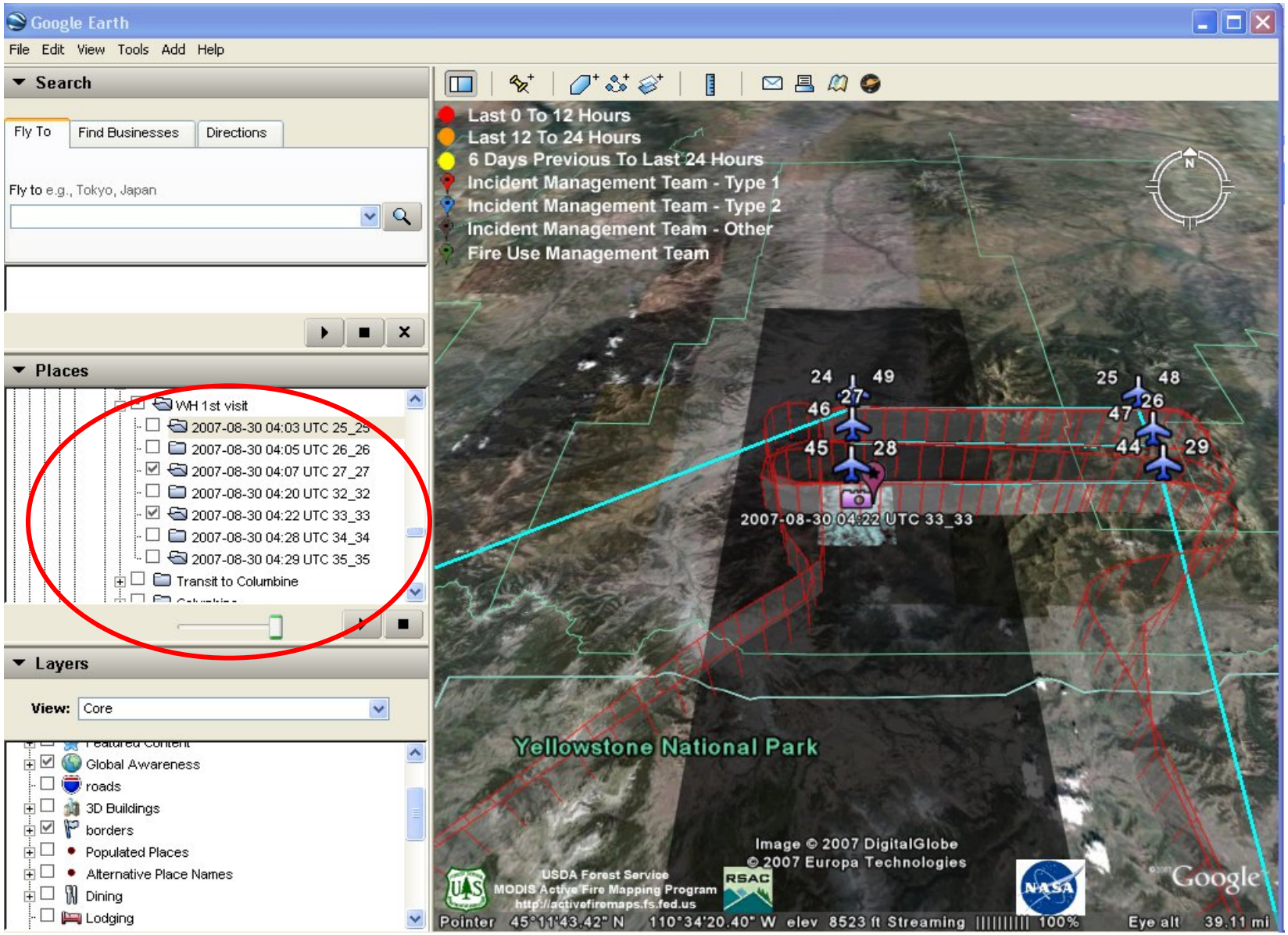
Fire Sensor Web Demo Aug 27-30 2007

Zoom out – 6 – Find contemporaneous ASTER data



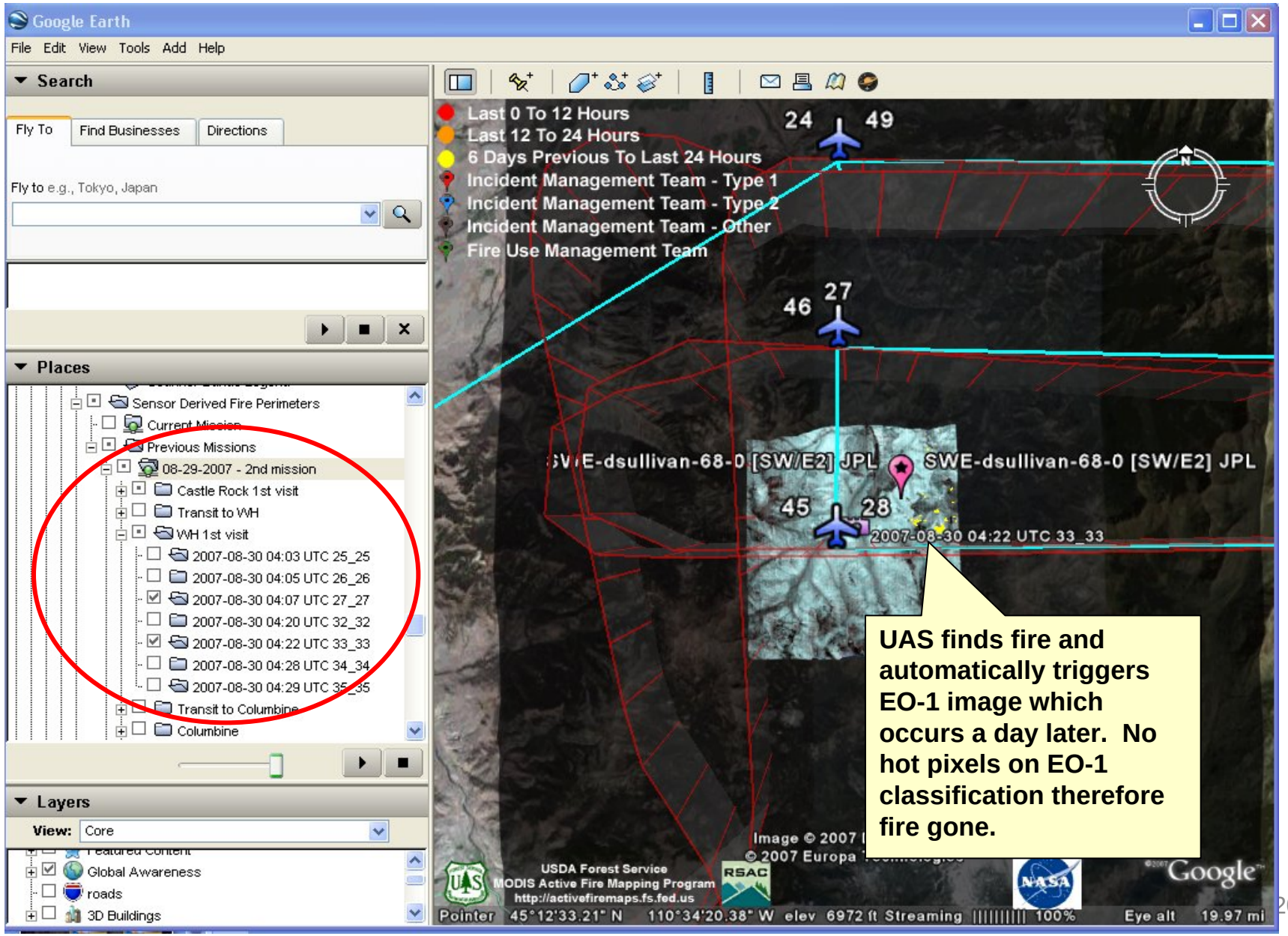
Fire Sensor Web Demo Aug 27-30 2007

Move to Yellowstone National Park – 7 – Find fire and trigger EO-1



Fire Sensor Web Demo Aug 27-30 2007

Zoom in – 8 – Find fire and trigger EO-1

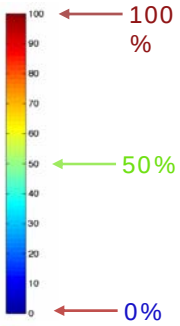


Sample cloud coverage prediction used to select least cloudy targets for EO-1 & UAS

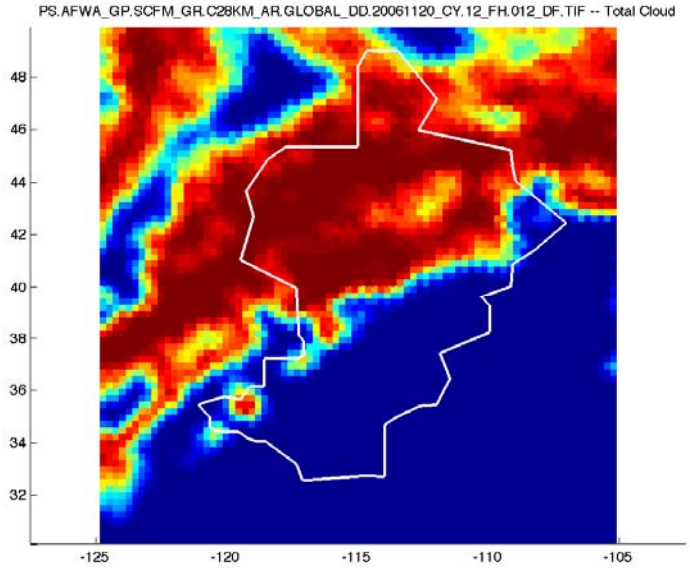
DRAPER LABORATORY

Flight Corridors with Predicted Total Cloud Cover Provided to UAS to Optimize Flight Path

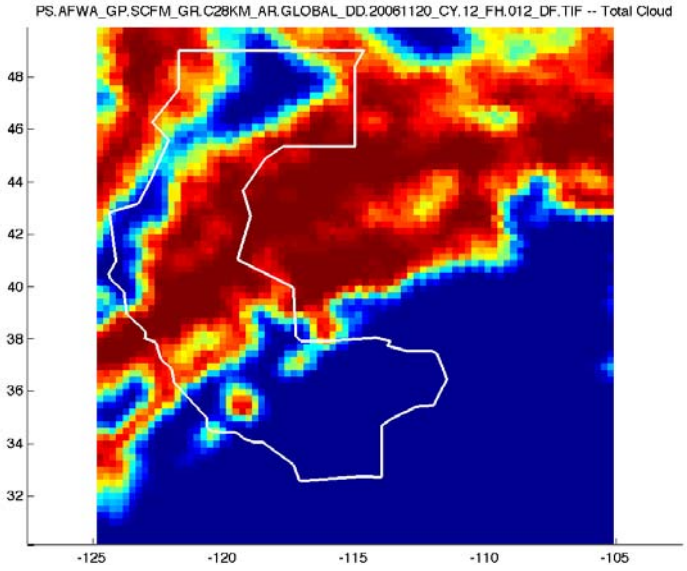
An Example using AFWA Stochastic Cloud Forecast Model Data converted to GeoTIFF



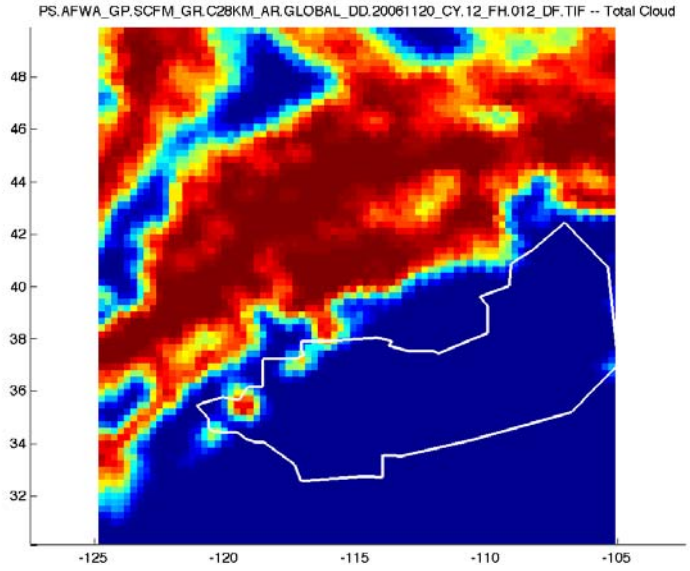
Corridor B



Corridor A



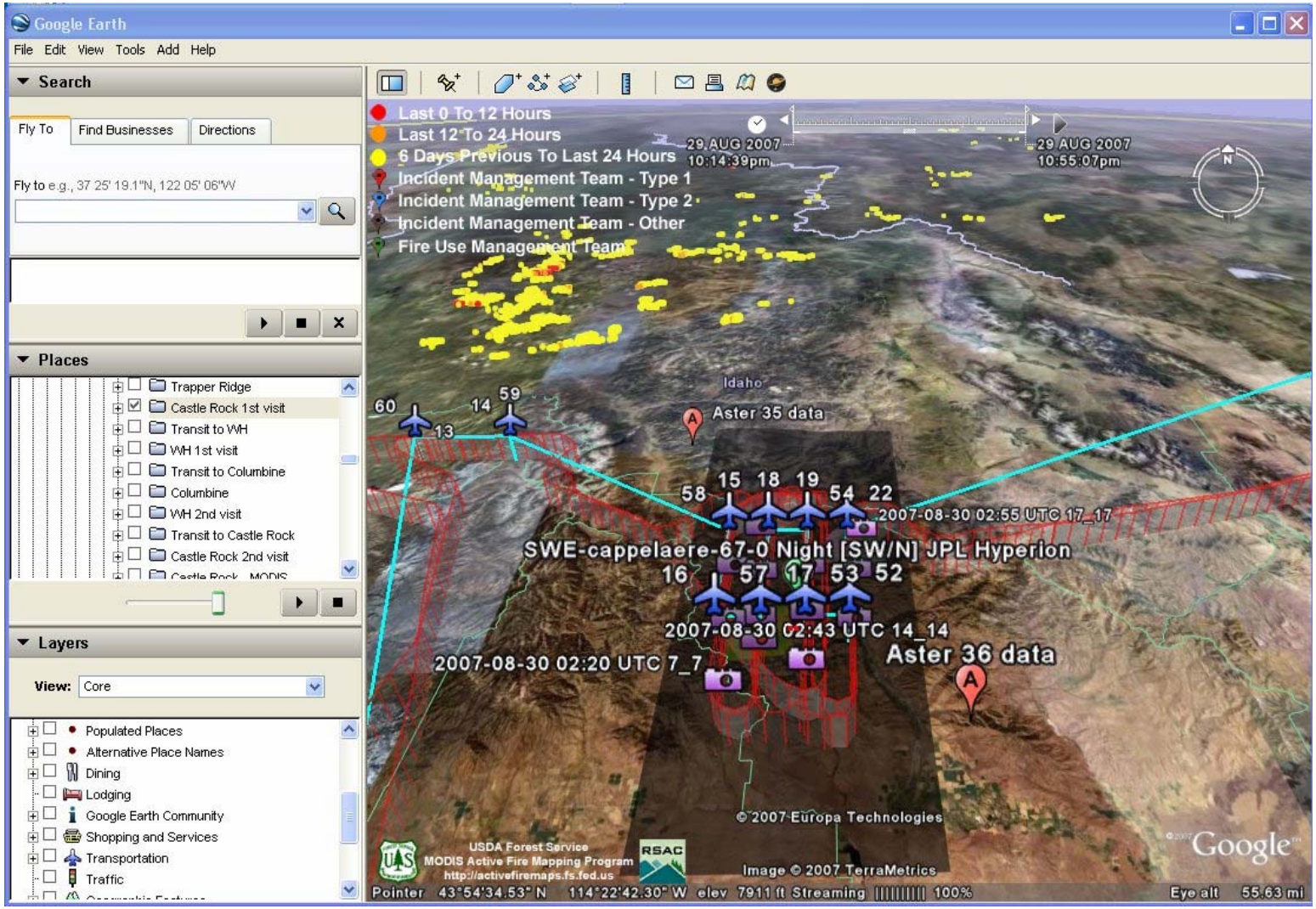
Corridor C



Wildfire SensorWeb: The Movie
3 minute version

Fire SensorWeb Experiments During 2007

- Funded by NASA Earth Science Technology Office AIST grant.
- Coordinated observations using ALI, Hyperion, MODIS, ASTER and Ikhana UAS.
- Delivery via an OGC compliant web interface.
- Deployed during South California Fire Siege.
- Planned deployments for 2008.



Future Plans in Fire Science and Applications

NASA LARGE FIRE CAMPAIGN 2009

Science Goals:

- Characterize the integrated release of energy from large fires.
- Quantify the effect of flaming vs. smoldering combustion on fluxes.
- Use ground based measurements to calibrate remote sensing data.
- Support validation of satellite fire products.
- Determine when fire becomes unstable and exhibits extreme fire behavior.
- Provide robust data set to community for subsequent analysis