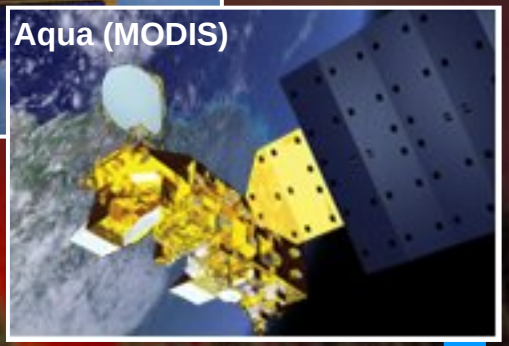
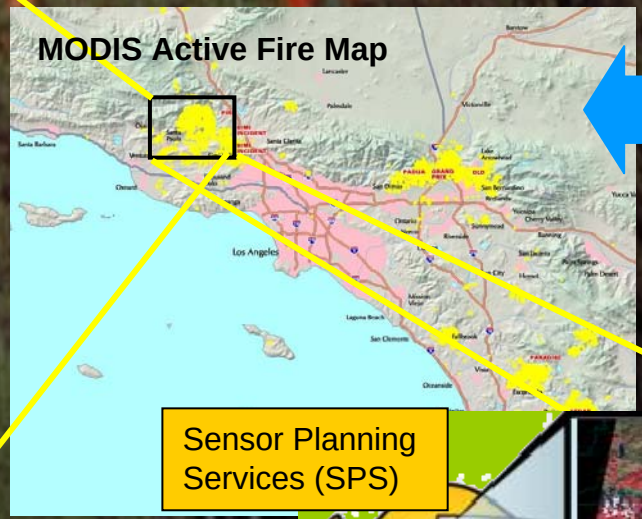
EO-1 Fire Sensor Web Evolution



- **2003 First EO-1 Fire sensor web demo**
  - **Controlled using ground automation**
  - **Data processing manual**
- **2004 Add automatic cloud screening**
- **2005 Add autonomous onboard planner to EO-1**
  - **Added matching ground planner**
  - **Added web portal for tasking requests**
- **2007 Add Web Services, OGC standards, workflow to EO-1**
- **2007/2008 Add Web Services, Models, OGC standards, workflows to other assets**

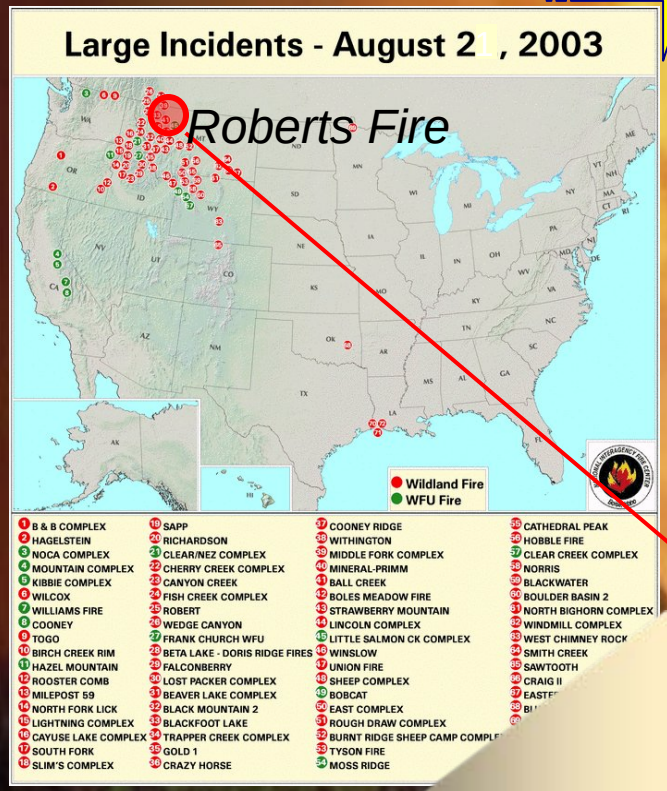


Aug 2003 - First EO-1 Fire Sensor Web Demo

Sensor Web

Identify NIFC-tracked Wildfire Incidents

1



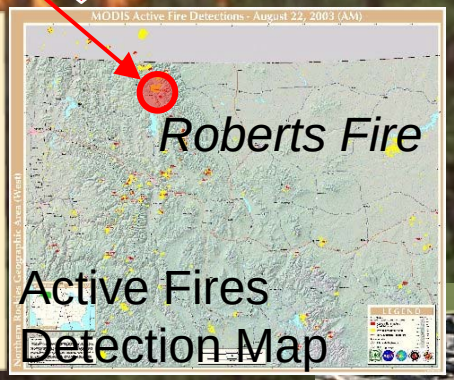
Science Goal Monitor(SGM)

3

SGM adds target to EO-1 ground & on-orbit planning & scheduling systems and tasks EO-1

2

Correlate latest fire location information with MODIS imagery

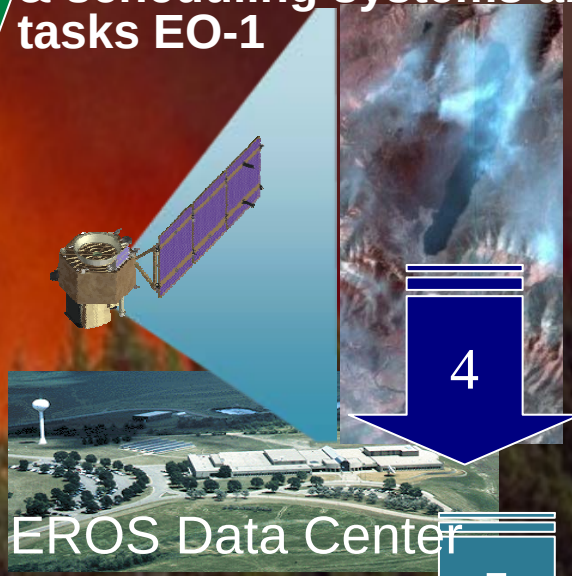


Active Fires Detection Map

Aqua or Terra MODIS data

Fire location confirmed and selected for imaging

3

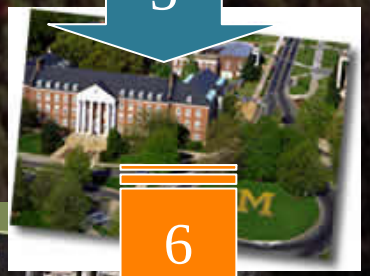


EROS Data Center

4

L1 Data

5

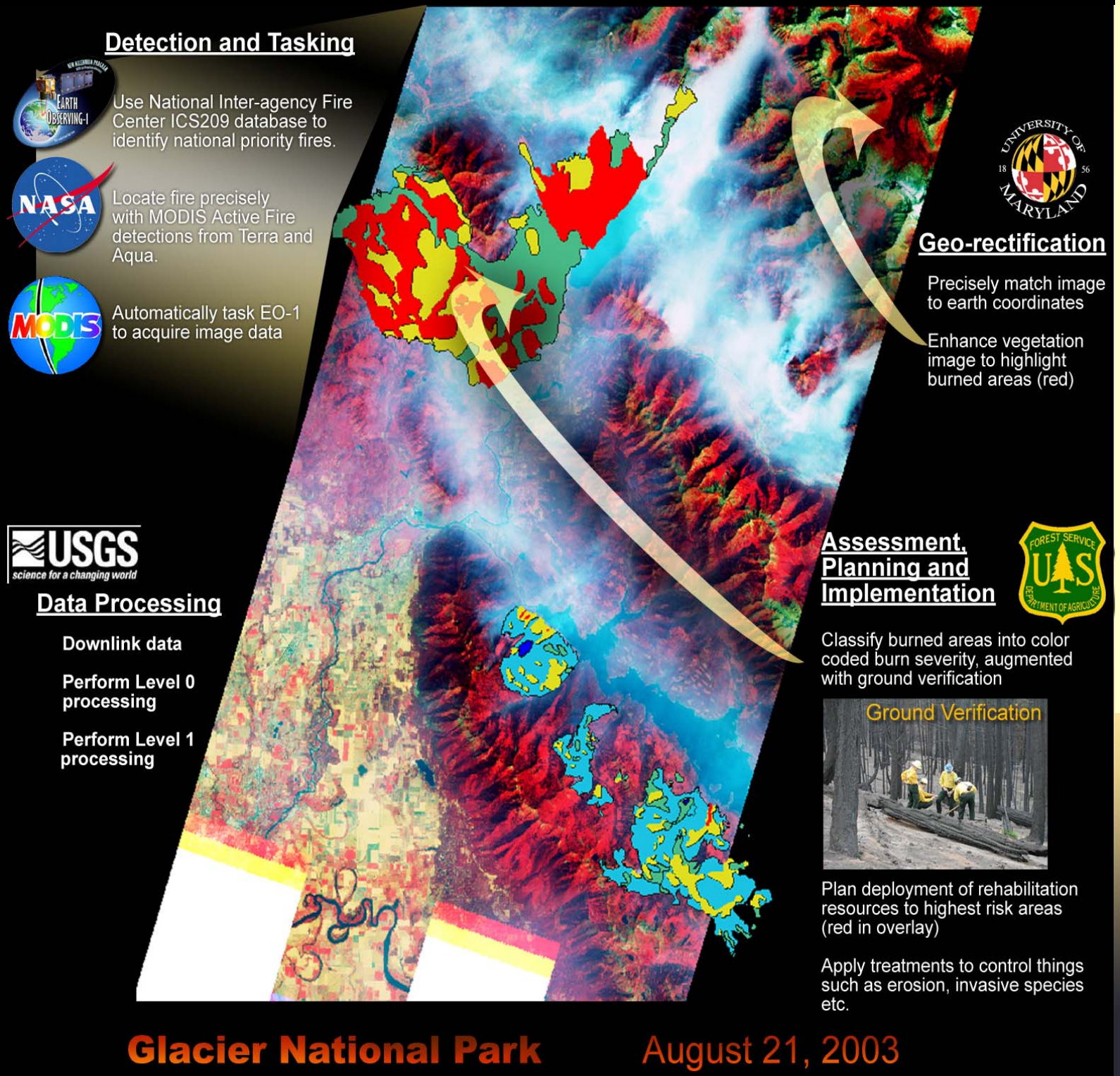


UMD Natural Hazards Investigation Team

6

Roberts Fire
USFS Burned Area Emergency Response (BAER) team

End product of 2003 Demo Sensor Web Workflow



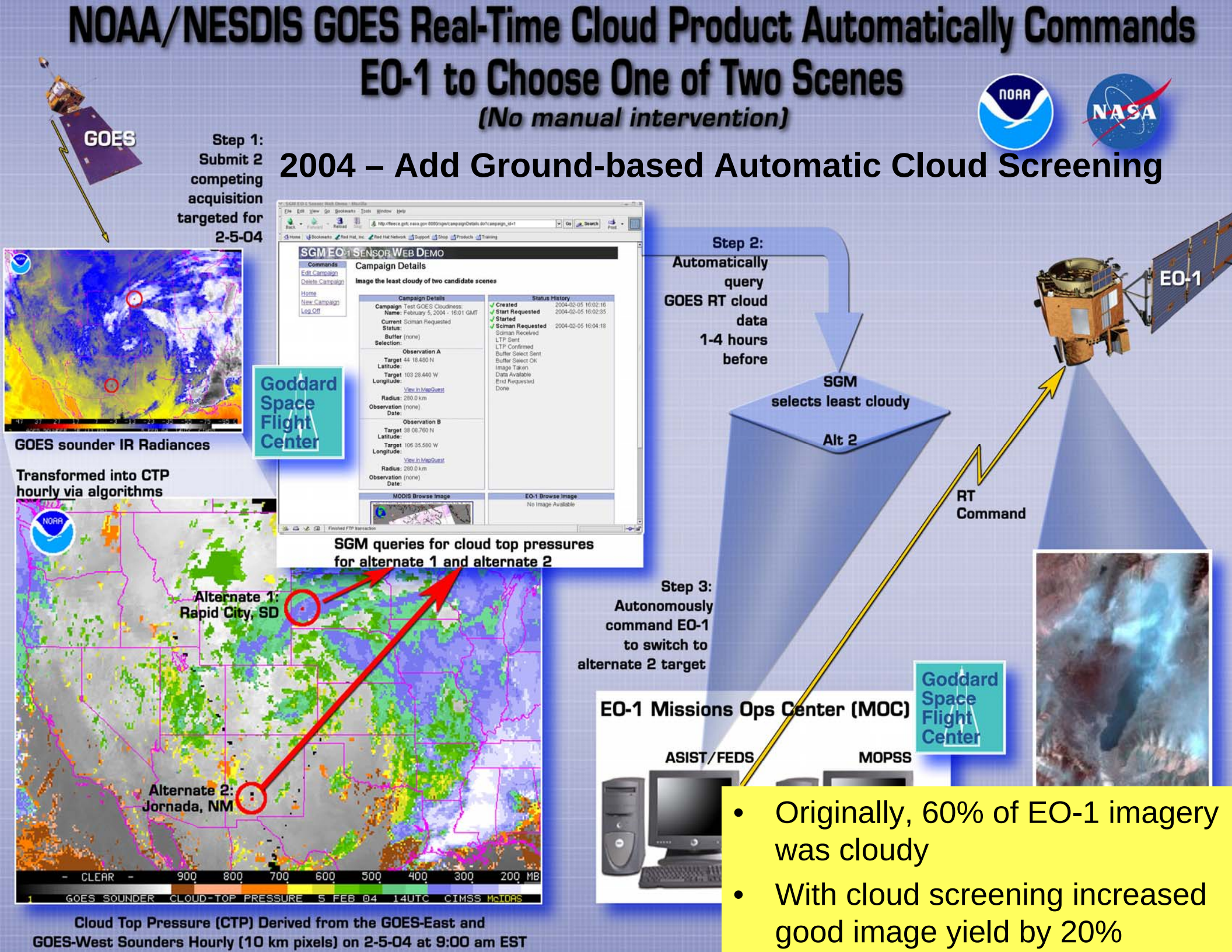
Burned Area Reflectance Classification (BARC) map -

used by Forestry Service to efficiently rehabilitate burned areas

NOAA/NESDIS GOES Real-Time Cloud Product Automatically Commands EO-1 to Choose One of Two Scenes

(No manual intervention)

2004 – Add Ground-based Automatic Cloud Screening

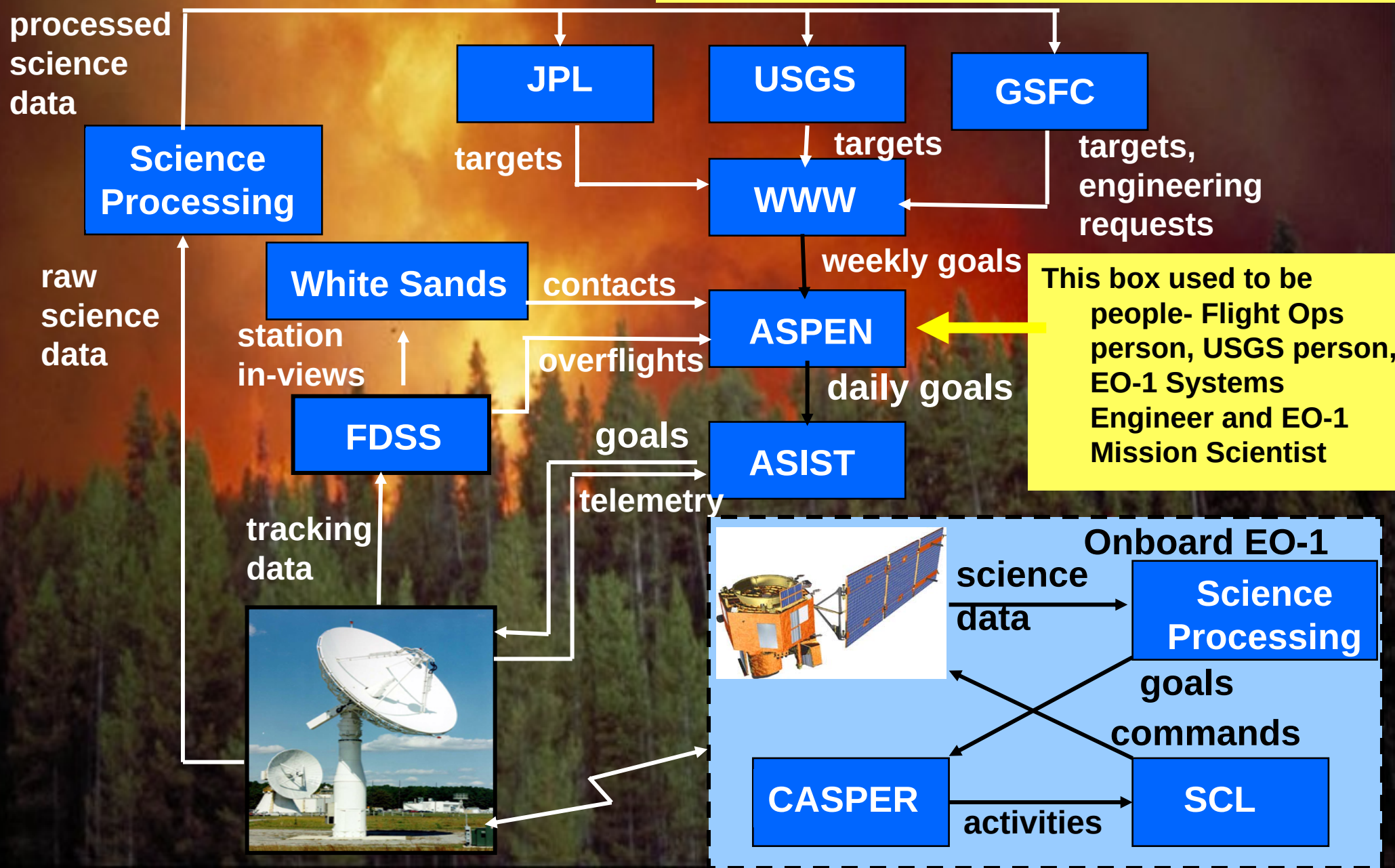


- Originally, 60% of EO-1 imagery was cloudy
- With cloud screening increased good image yield by 20%

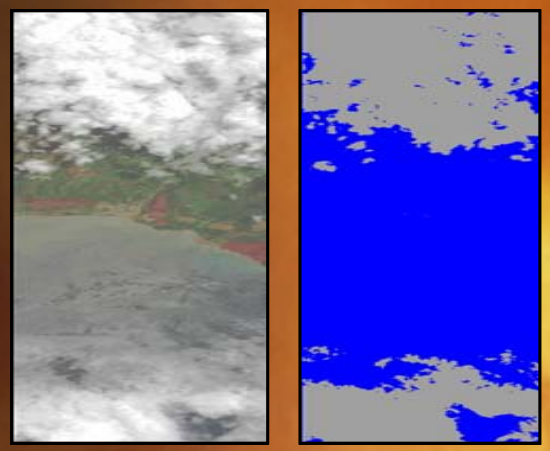
2005 – Added Autonomous Onboard Planner to EO-1

- Added onboard autonomous planner
- Added matched ground planner for screening goals
- Added web portal for tasking requests

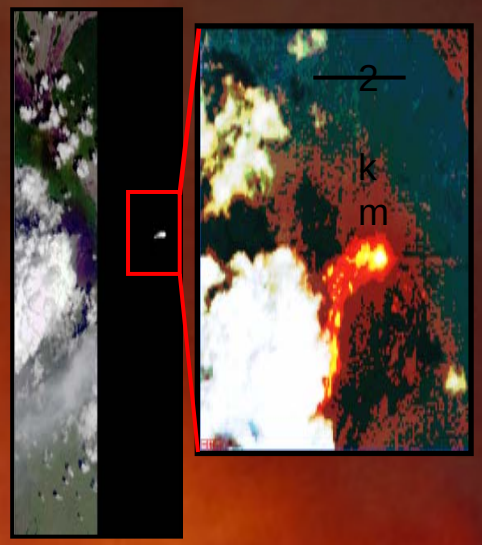
- Saving $1 million per year in ops costs
  - Reduce from 4 mission planners to 1 (savings $600K per year)
  - Automated selection of tasking requests versus manual process (savings $420K per year



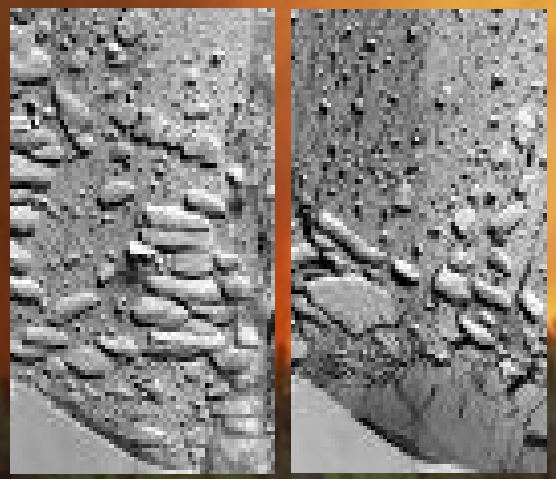
2005 – Added Onboard Classifiers to EO-1



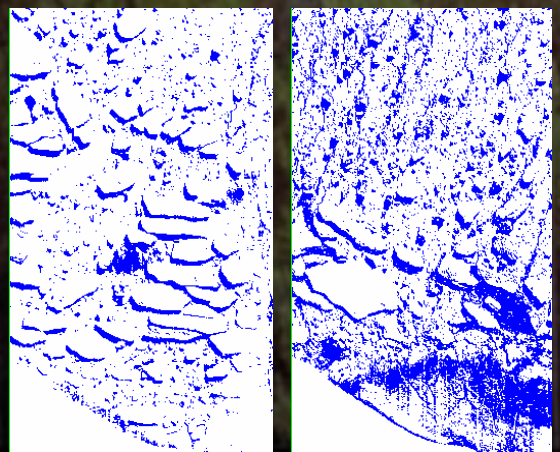
Cloud classifier



Thermal classifier for volcanoes and fires



Snow, water, ice, land (SWIL) classifier



Sulfur classifier added July 2007

As of July 20, 2007:

Total images taken for life of EO-1 mission = approx 35,000

STATUS of ASE initiated images

	Mission	Last Week	Yesterday	Upcoming
Images Taken	11621	79	2	48
Sensorweb	1637	6	0	5
Science Scenarios Executed	1251	2	0	1
Positive Triggers	236	0	0	
Ground Contacts	11222	84	10	43
X-Band	3870	28	1	13
S-Band	7352	56	9	30
Planner Goals	94020	555	33	291

2007 Add Web Services and OGC standards to EO-1

- Potential savings
  - Originally, USGS charged $2000 to task EO-1 and perform L0 and L1G data processing for customers ($1250 now)
  - Potential cost reduced to under $100 since tasking EO-1, L0 and L1G data processing automated

Sensor Planning Service (SPS)

Cappelaere/Vightel

Tran, Chien/JPL

Level 0 Science Process

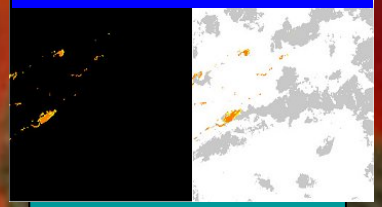
Tran, Chien/JPL

Level 0.5 Process

Tran, Chien/JPL

Level 1G Process

Classify hot pixels



Pixels and heat values

1

2

Sensor Observation Service (SOS)

Cappelaere/Vightel

Level 1G or Level 0.5

Web Processing Service (WPS)

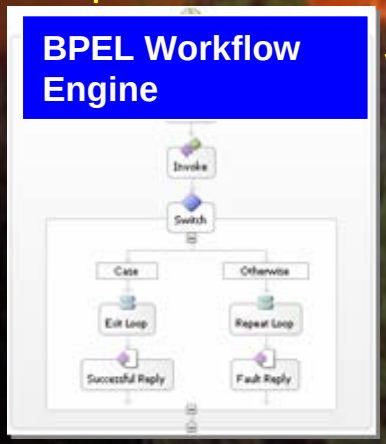
Tran, Chien/JPL

Web Coverage Service –Transformation (WCS-T)

Zhao/GMU

JPEG

BPEL Workflow Engine



L. Di, Zhao/GMUI

3

4

5

Publish composite JPEG map with data overlay (map with fire locations)

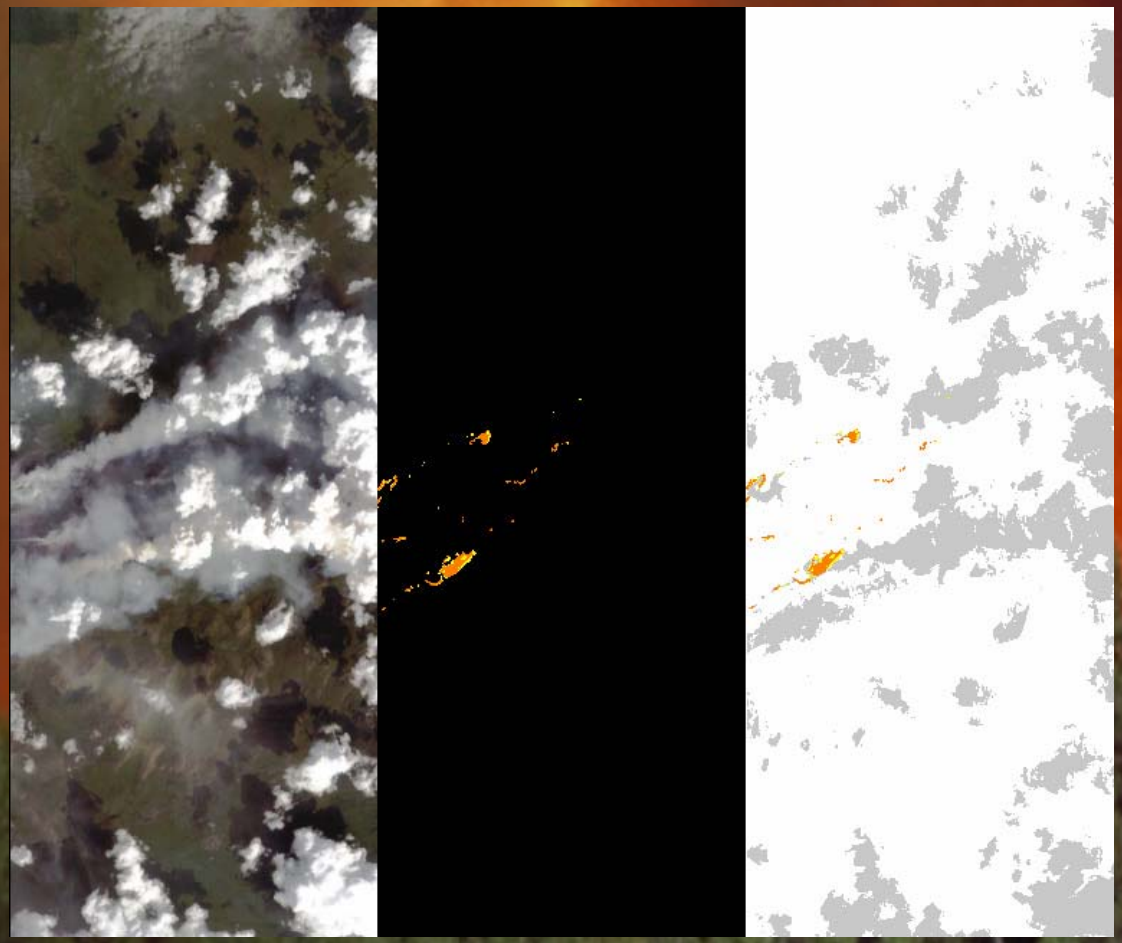
Community Map Builder client (on eo1.geobliki.com)

Web Map Service (WMS)

JPEG Map

Cappelaere/Vightel

Preliminary Test Product of Expected Output for Web Services and OGC standards Enabled EO-1 Fire Sensor Web



EO-1 Hyperion test image of wild fires in the Yukon in July 2004 (Image ID is EO1H0680132004192110KY.)

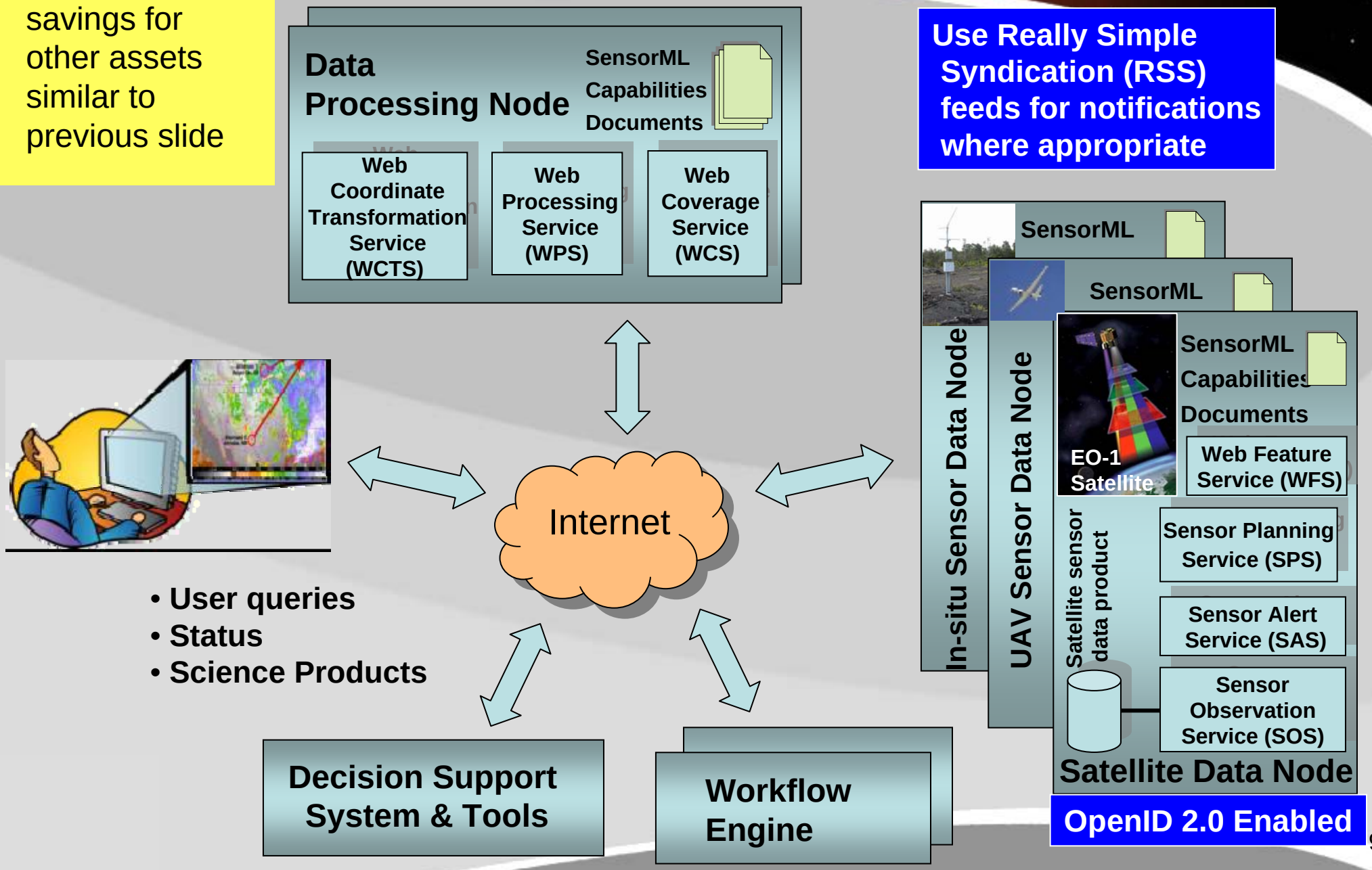
Final demonstration product to be superimposed on map

Left image: three-band visible image
Middle image: thermal classifier output (orange and yellow)
Right image: thermal (orange and yellow) + cloud (gray)

(Image produced by Ashley Davies and Daniel Tran/JPL)

2007/2008 Encapsulate Other Assets with Web Services and OGC Standards

- Potential savings for other assets similar to previous slide



Summer 2007 Wildfire Sensor Web Scenario

Utilizing MODIS, ASTER, EO-1, DMSP and Ikhana UAS

5 missions over 6 weeks
mid July – end of August 2007

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

Remote Automated Weather Station (RAWS) Local Weather

END USERS

Infrared Interpreter
Fire Behavior Analyst
Plans Chief
Command
PAO

2007 UAS Workflow

Updated flight plan

Sensor Planning Service (SPS)

Ambrosia, Sullivan/AMES

Sullivan/AMES

Web Coverage Service (WCS)

Web Map Service (WMS)

Web Feature Service (WFS)

Global cloud predicts

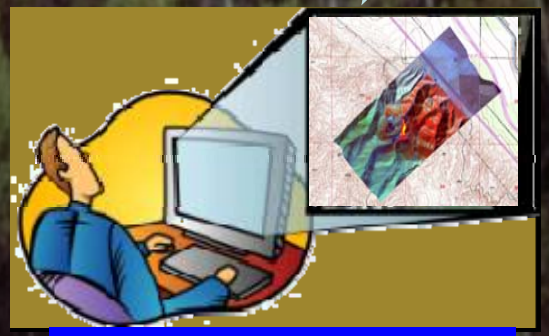
Air Force Weather Agency Global Cloud Predictions

Kolitz, Abramson/Draper

GeoTiff 3 bands

GeoTiff 3 bands

Sullivan/AMES



User-friendly Desktop Internet GIS (Udig)

Google Earth

GIS – Geographical Information System

2007/2008 Composite Sensor Web Demo

ICS209 National Fire Database

National Interagency Fire Center (NIFC)

Quayle/Remote Sensing Application Center (RSAC) - Forest Service

Kolitz, Abramson/Draper
Cappelaere/Vightel

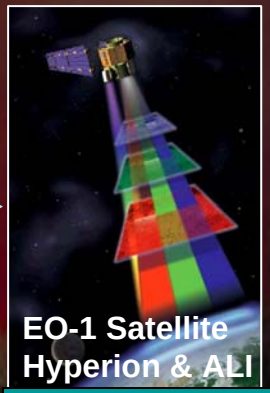
Decision Support System
- Cross correlate possible fire targets within flight path of UAS
- Get feasible assets
- Get feasible task allocations
- Allocate tasks to various assets

Ambrosia, Sullivan/AMES

Sensor Planning Service (SPS)

Get feasibilities & Task

Get feasibilities & Task



Sensor Planning Service (SPS)

Mandl/GSFC
Chien/JPL

Get feasibilities & Task

Get feasibilities & Task

Ambrosia, Sullivan/AMES

Internet

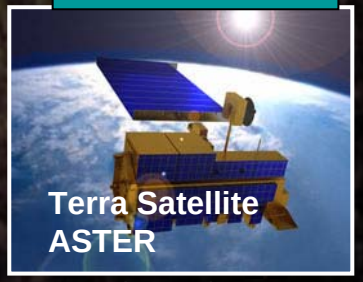
Air Force Weather Agency Global Cloud Predictions

Kolitz, Abramson/Draper

Remote Automated Weather Stations (RAWS)

Horel/ Univ. of Utah

Sensor Planning Service (SPS)



Abrams/JPL

2007/2008 Add Smoke Prediction Model with Auto-Tasking for EO-1 and UAS

National Interagency Fire Center (NIFC)

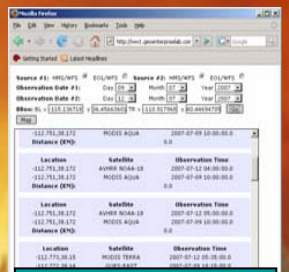
ICS209 National Fire Database

Quayle/Remote Sensing Application Center (RSAC) - Forest Service

Fire ID and general fire location

Web Feature Service (WFS)

Refined fire location



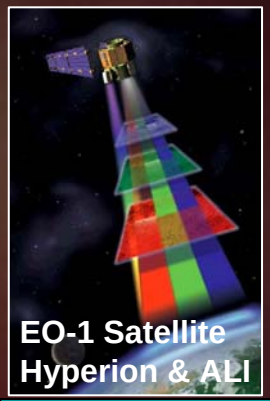
Web Processing Service (WPS)

S. Falke/NGC

2007 Table of Graphics Markup Language

Sensor Planning Service (SPS)

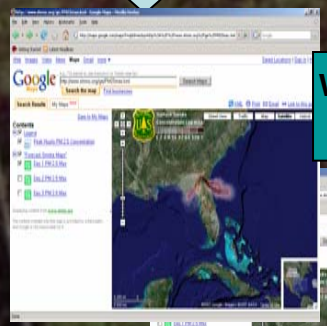
Ambrosia, Sullivan/AMES



Sensor Planning Service (SPS)

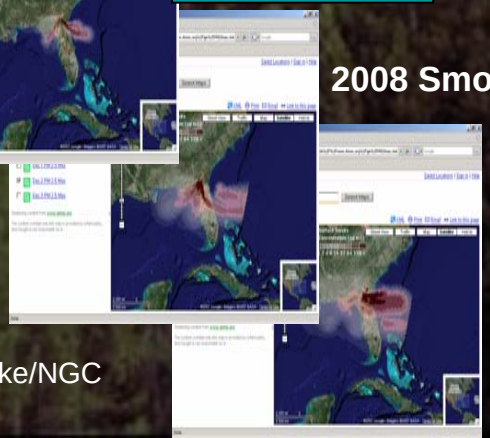
Mandl/GSFC
Chien/JPL

Automatic tasking requests based on model analysis



Web Processing Service (WPS)

2008 Smoke Model



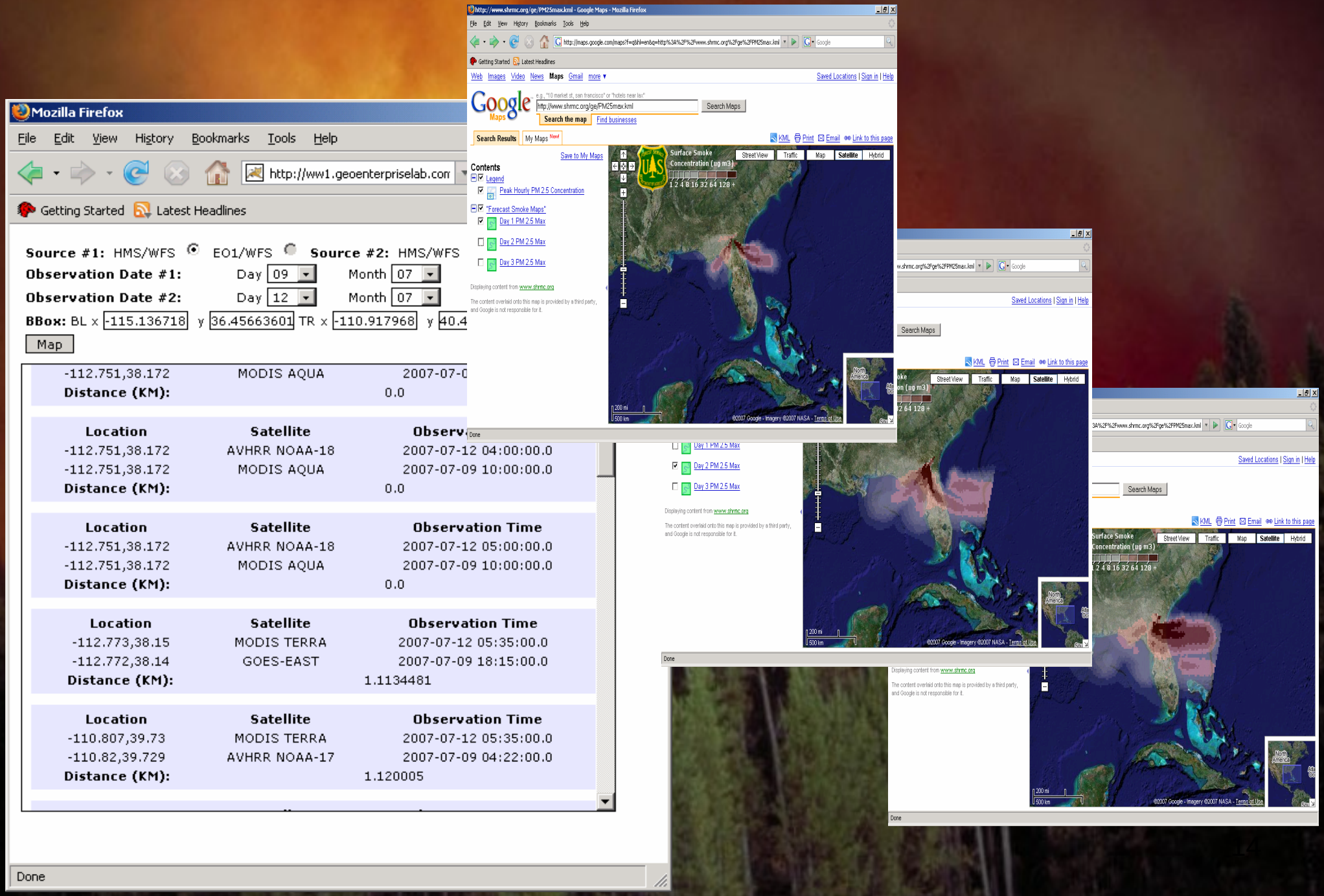
S. Falke/NGC

Web Feature Service (WFS)

Refined fire location

Ambrosia, Sullivan/AMES

Prototype Smoke Prediction Model Outputs by S. Falke



Partners and Collaborators

PI Dan Mandl NASA/GSFC Code 584 – daniel.j.mandl@nasa.gov

Co-I's: Rob Sohlberg, Chris Justice, John Townshend/Univ. of Md, Dept of Geography
Stephen Ungar, Dr. Jeffrey Masek NASA/GSFC Code 614
Steve Chien NASA/JPL
Troy Ames NASA/GSFC Code 588
Stuart Frye/Noblis

Partners:

Daniel Tran, Mark Johnston/JPL (programmer for EO-1 SOS, SPS and WPS)
Lawrence Ong/ SSAI/GSFC (EO-1 L0 Process, L1G Process, SensorML)
Robert Morris/ NASA Ames (Intelligent planner)
Pat Cappelaere/ Vightel (OGC compliant architect)
Linda Derezinski/ Innovative Solutions(EO-1 Geobliki programmer)
Vince Ambrosia, Don Sullivan, Steve Wegener/Ames (UAS & SPS, WCS, WPS))
S. Kolitz, M. Abramson/ Draper Labs (DSS, Optimizer/planner, global cloud predicts)
Stefan Falke/ NGC (smoke prediction model)
Dr. Michael Botts/ UAH (SensorML)
Everett Hinkley, Brad Quayle/Forest Service (MODIS Hot pixel data from RASC)
Nadine Alameh/ Geoscience Interoperability Office, GSFC
M. Abrams/ JPL (ASTER PI)
George Percivall/ OGC (OGC Architect)
David Smithbauer/ WVHTF (SensorML)
J. Dolan/ Carnegie Mellon, J. Moisan/ Wallops, J. Hosler/GSFC (Adaptive Sensor Fleet)
J. Horel/ Univ. of Utah (Remote Automated Weather Stations)