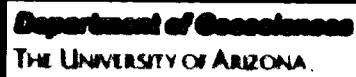


# Using Timely Satellite Data to Autonomously Trigger Science Observations

Presenter: Steve Chien, JPL

Portions of this work were performed by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.  
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# Timely Satellite Data

- Recent advances have made large amounts of timely satellite data readily available, e.g.

Satellite	Instrument	Frequency of Overflight	Timeliness
Terra, Aqua	MODIS	12 hours daylight, 12 hours night	several hours from acquisition (DAAC); near real-time (DB)
QuikSCAT	Scatterometer radar	~12 hours	daily
NOAA-POES	AVHRR	Frequent	< 1 hour
GOES	Infra-Red, visible	continuous	~25 minutes

# Resolution

- Unfortunately, for some applications higher resolution data or alternative instrumentation is needed to study science phenomena

Satellite	Resolution
MODIS - Terra, Aqua	250m-1km
QuikSCAT	km
NOAA/AVHRR	km
GOES	km

- Ideally high resolution data would be continuously available
- Typically high resolution assets must be pointed at specific targets

# Sensorweb

Sensorweb – a networked set of instruments in which information from one sensor is *automatically* used to reconfigure the remainder of the web

- In our application we use low resolution, high coverage sensors to trigger observations by high resolution instruments
- We describe preliminary work in demonstrating the Sensorweb concept to track
  - wildfires,
  - volcanos, and
  - floods





# Wildfires

- Leverage Rapidfire MODIS active fire alerts
- Rapidfire uses both absolute threshold and relative threshold thermal activities to develop fire alerts (Justice et al.)
- Uses data ~ 3 hours from acquisition

# Sensorweb Demo Scenario 1 Wild Fires 8-22-03

After ascertaining that the Robert fire is at lat 48,564 long -114,163, EO-1 is tasked to take closer high resolution look

SGM causes MOPSS, CMS, CASPER (ground version) to task EO-1 via command load

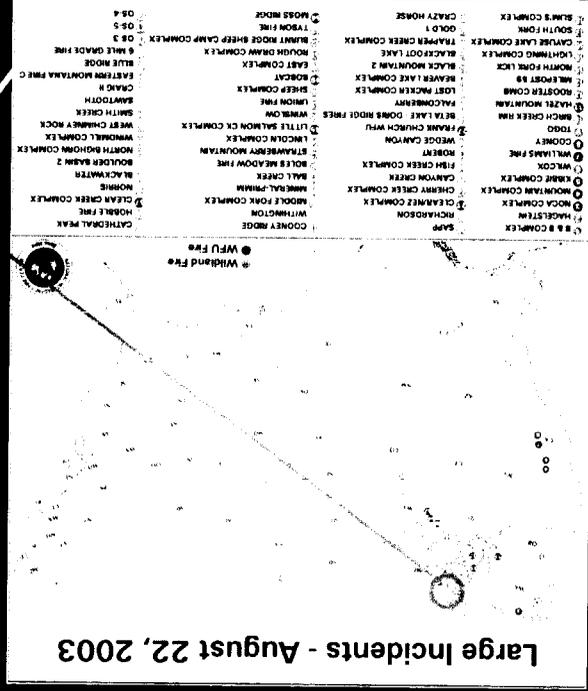
and causes EO-1 to download the image to EROS Data Center (EDC) at Sioux Falls

EDC performs L0

and L1 processing and FTP's image to Dr. Rob Sohberg, Univ. of Md.

Dr. Rob Sohberg transform image into ERDAS format and FTP's file to Forestry Service for evaluation

Large wild fires tracked by National Interagency Fire Center (NIFC)



**SENSORWEB DEMO**

Comments

Image the most recent significant fire

**Campaign Details**

Created: 2003-08-22 10:27  
 Started: 2003-08-22 10:27  
 Stopped: 2003-08-22 10:27  
 Campaign Requested: 2003-08-22 10:27  
 Campaign Approved: 2003-08-22 10:27  
 Campaign Name: Robert Fire

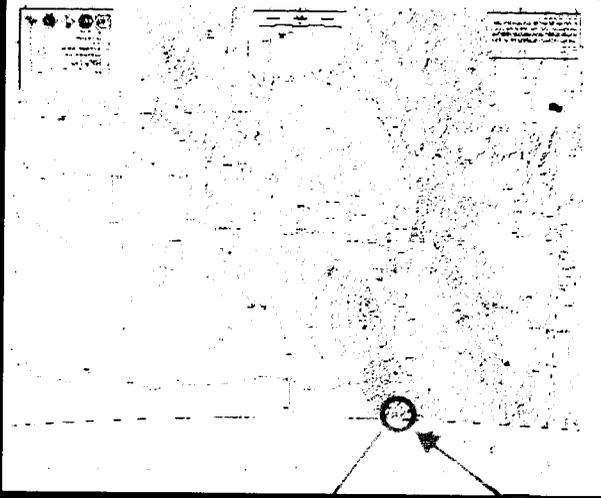
**Target Details**

Target Longitude: -114.163  
 Target Latitude: 48.564  
 Radius: 2000

**EO-1 Browse Image**

EO-1 Browse Image

SGM correlates selected wildfire (25 Robert) to exact present location using MODIS Instrument Center which is updated every 5 minutes



MODIS Instrument on Terra or Aqua

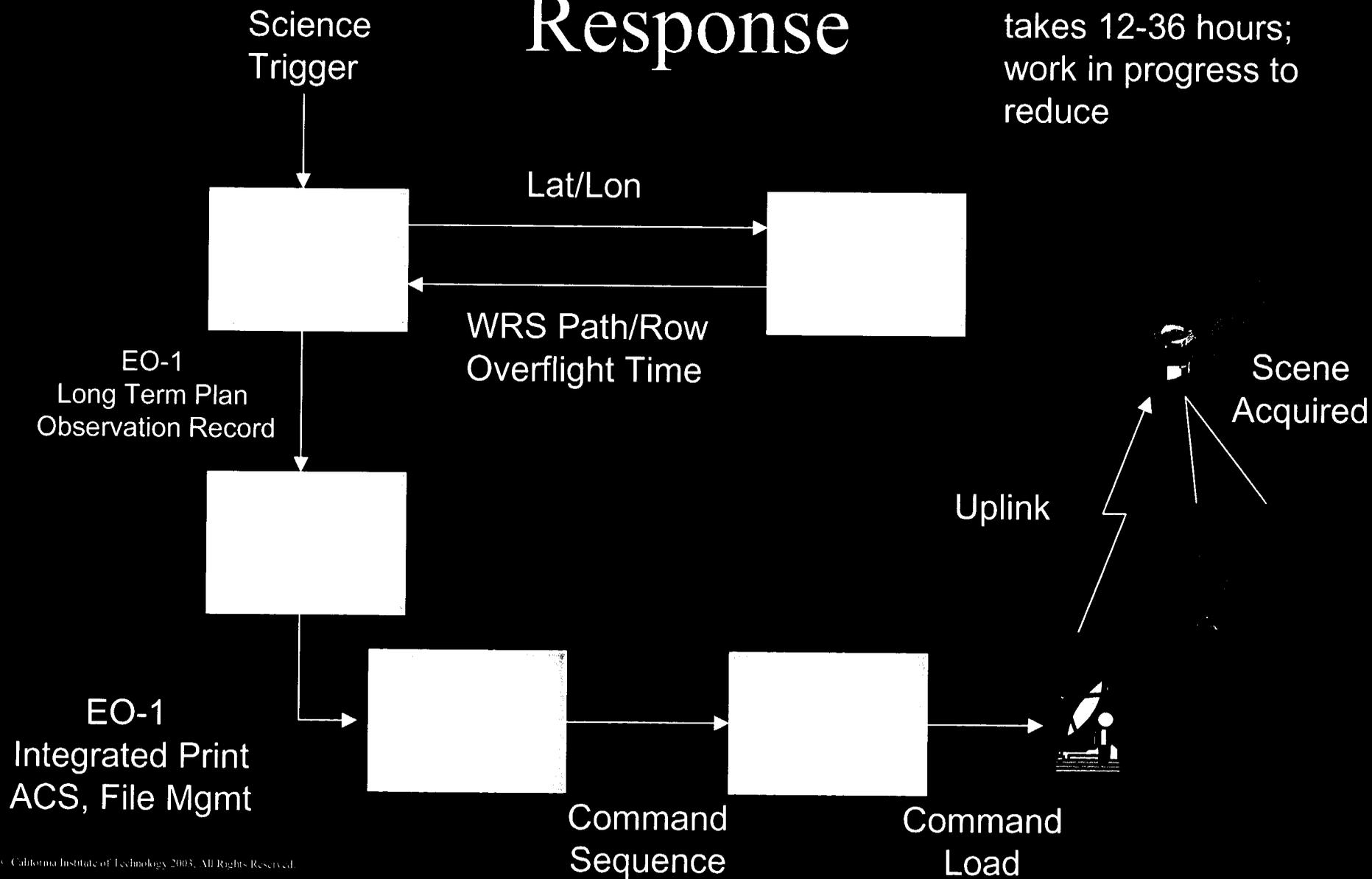
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# Details

- Trigger uses intersection of
  - NIFC major fires
  - Rapidfire active fires detection
  - User-defined area of interest
- Science Goal Monitor (Jones et al., GSFC)
  - Computes largest weight (activity) centroid of hotspots in the above intersection

# Response

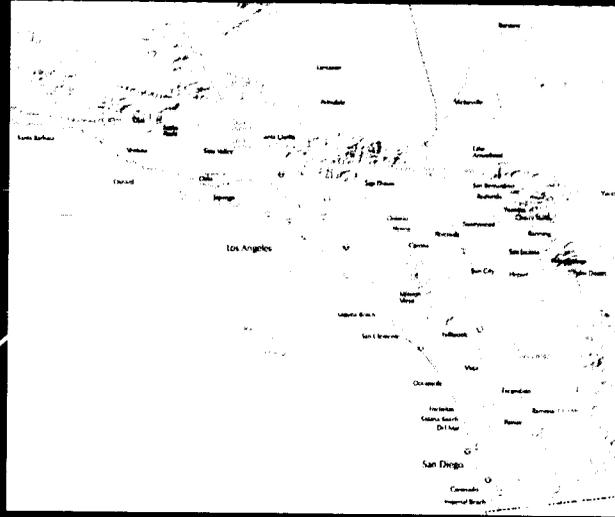
Currently this  
timeline  
takes 12-36 hours;  
work in progress to  
reduce



# Status - Wildfires

- End to end demonstrations
  - Robert Fire, August 2003, Montana
  - Simi/Val Verde Fire, October 2003, Southern CA
  - Old Fire, October 2003, Southern CA

# Wildfire SensorWeb



On 11-2-03, the NASA Wildfire SensorWeb was employed to collect data on the burn scars resulting from the Simi Valley, Val Verde and Piru fires in Southern California. MODIS active fire detections for the duration of the event were used to target an acquisition by the ALI and Hyperion instruments onboard EO-1. Such data are employed by the USDA Forest Service for Burned Area Emergency Rehabilitation mapping. BAER maps are used to target high risk areas for erosion control treatments. In this image, burned areas appear red while the unburned areas appear green. The blue burn perimeter vector is based on ground data.

# Floods

- Leverage Dartmouth Flood Observatory global flood atlas activities
- Identify floods in remote locations automatically based on satellite data
- MODIS, QuikSCAT both possible
  - QuikSCAT used to avoid cloud issues - more amenable to automation
- Active flooding triggers EO-1 observations at gauging reaches

# Floods - Detection



## Dartmouth-Flood Observatory QuikSCAT

- The DFO in collaboration with JPL/QuikSCAT processes QuikSCAT Scatterometer data to assess surface water conditions.
- VV/HH ratio is used to assess surface water properties of the areas in 0.25 lat/lon degree bins
- The 7 day running mean is used to dampen effects of short-duration rainfall over urban areas.
- This data is then compared to the seasonal (90 day) average of the previous year to screen out wetlands.

# Sample Detections - China

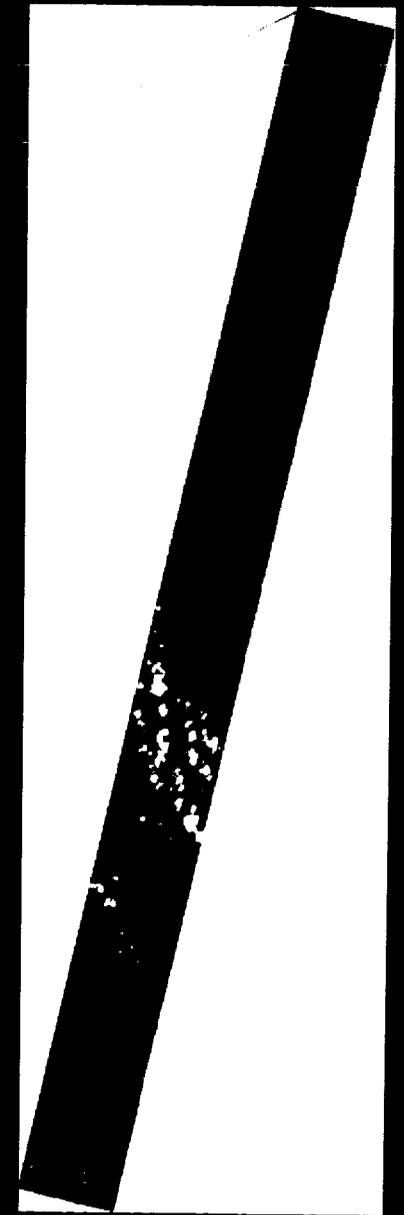
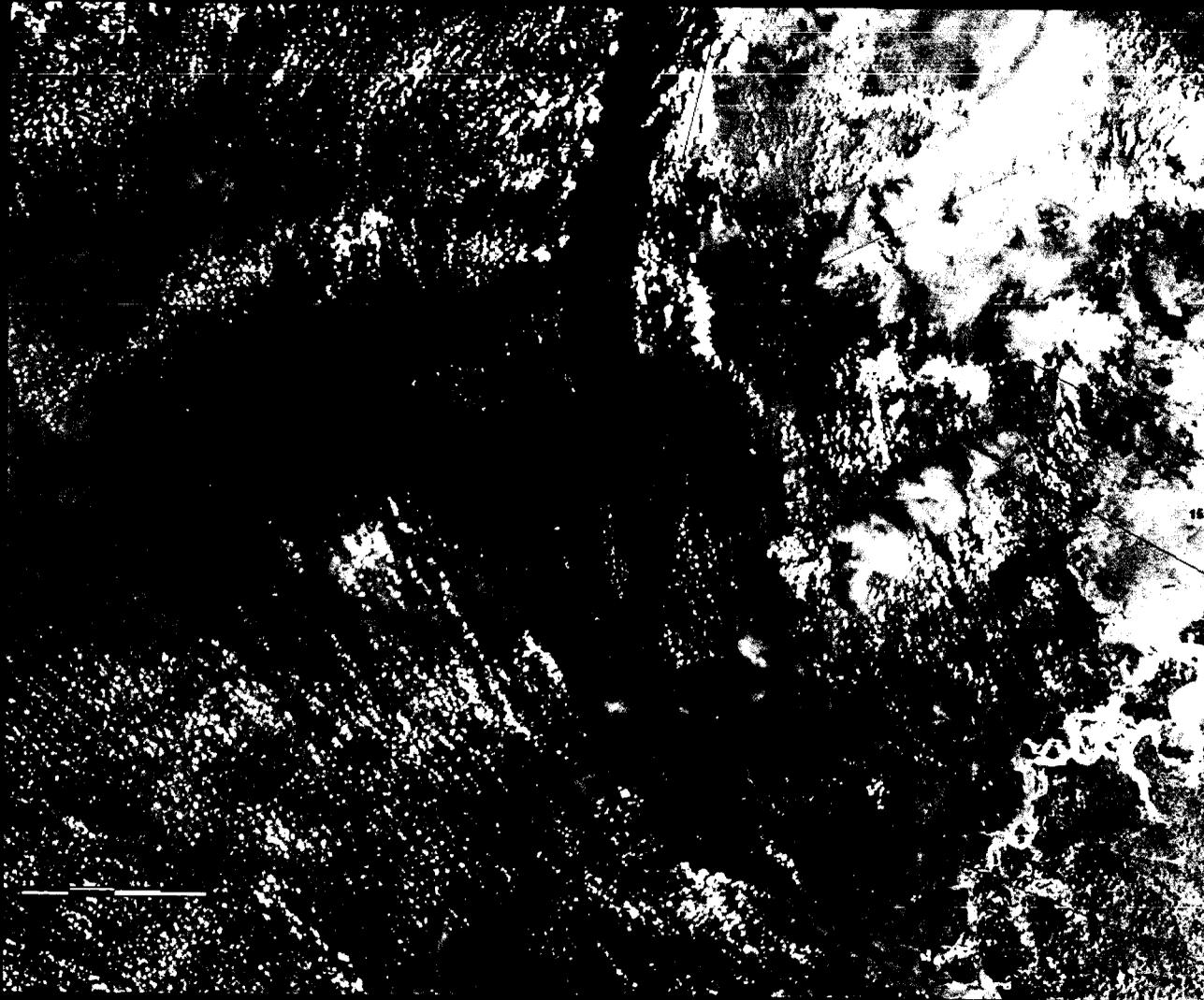
- QuikSCAT polarity ratio (“flood alert”) display for September 28, 2003.
- Blue and Yellow indicate increased and decreased surface water extent compared to September-October, 2002.



Flood alerts are then used to  
retask EO-1.

*EO-1 Hyperion Image Brahmaputra Aug 6, 2003*

*MODIS Image Brahmaputra Aug 6, 2003*



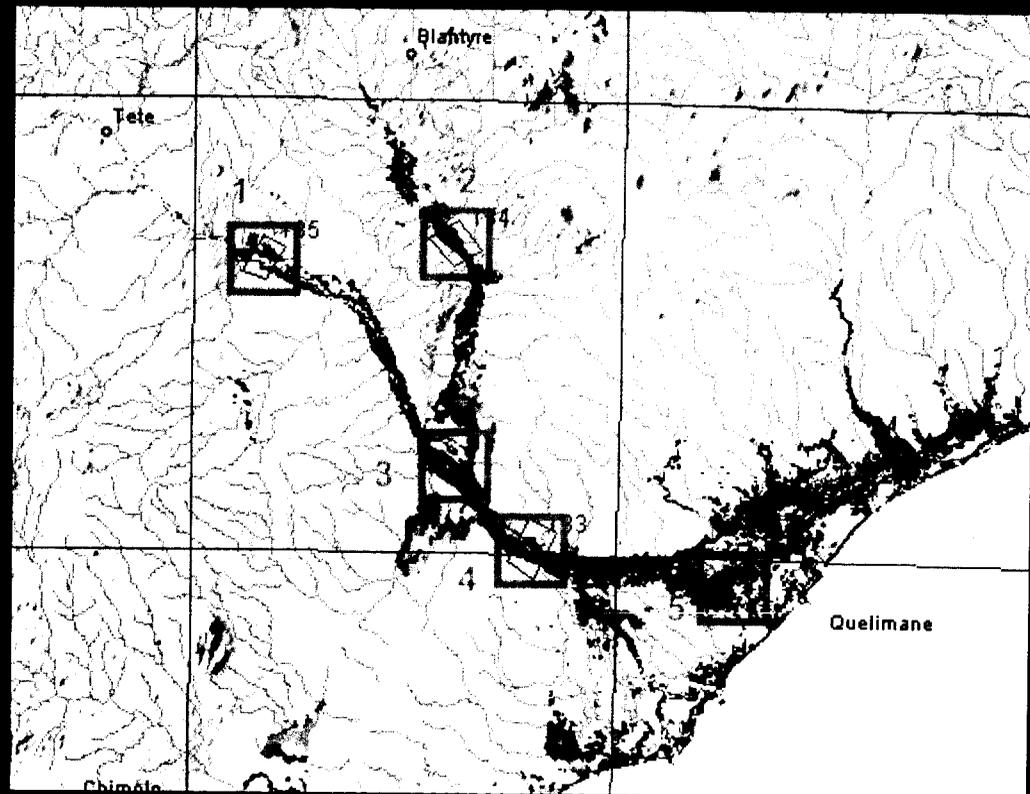
# Status - Floods

- Several demonstrations in September, October 2003 to track flooding in the Brahmaputra River basin, India

# And the Future...

- Use timely event detection and knowledge of topography to track event as progresses

proposed 4-week imaging campaign for the lower Zambesi river in Mozambique



# Volcanoes

- Many volcanoes are in remote, poorly monitored sites
- University of Hawaii, HIGP has implemented GOES, NOAA/AVHRR and MODIS-based detection systems
- Detection of volcanic activity triggers EO-1 observation

# GOES/AVHRR

- University of Hawaii has near real-time (< 1 hour) tracking of hotspots (volcanoes) in GOES & AVHRR data
- Low-resolution, but fast notification of new activity

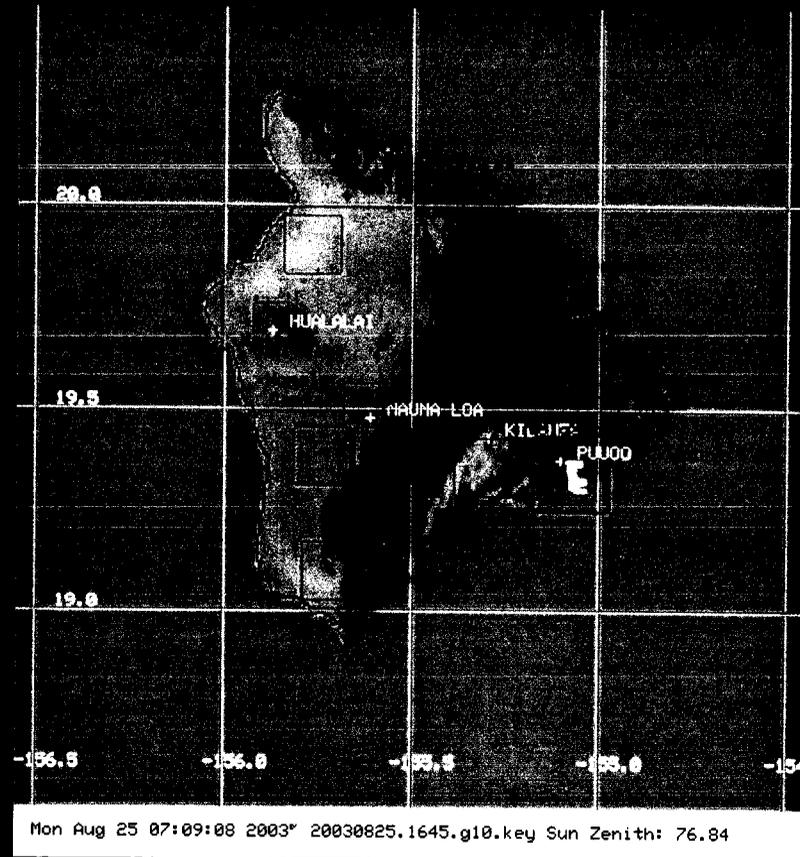
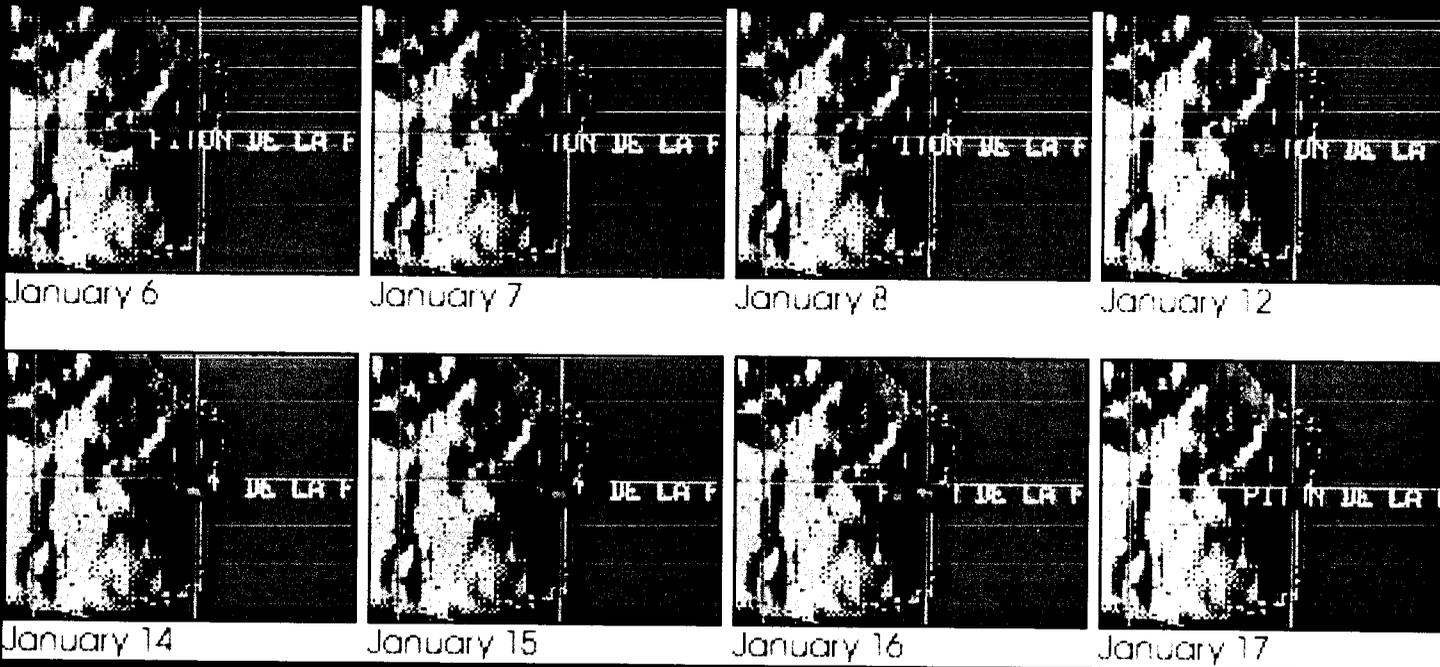


Image courtesy Hawaii Institute of Geophysics and Planetology.

# MODIS



[Images courtesy Peter Mouginis-Mark (University of Hawaii)]

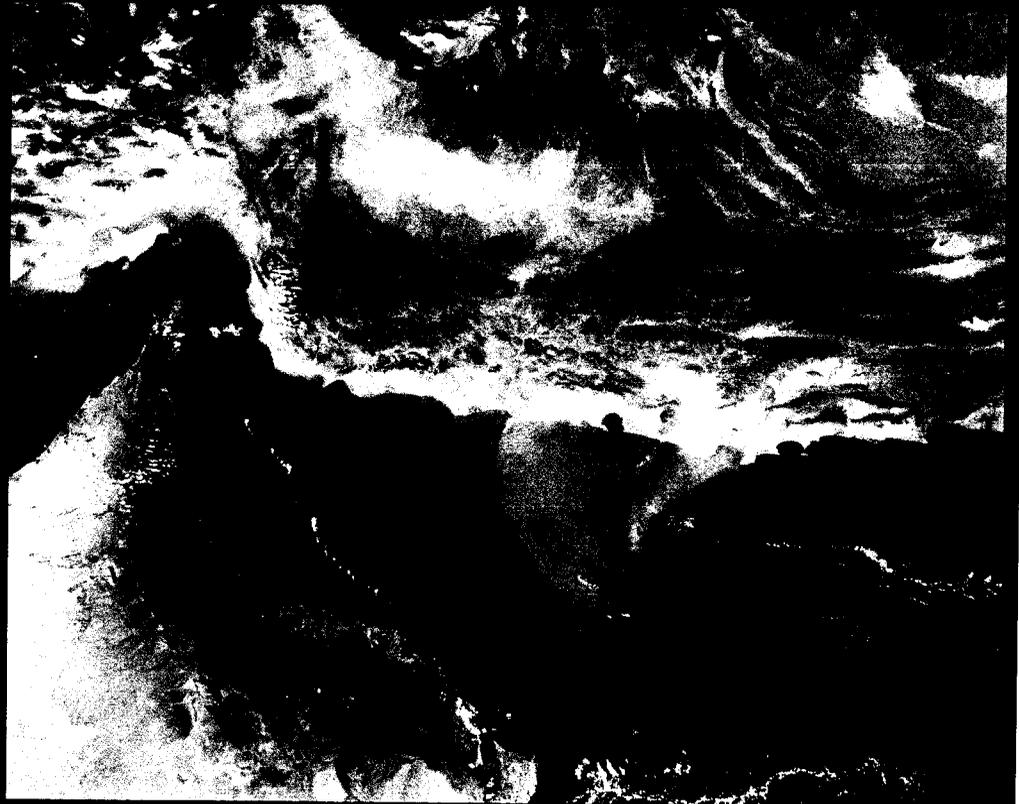
- U. Hawaii uses MODIS data to detect smaller scale volcanic activity.
- Four (4) overflights daily
- See below for MODIS monitoring of Piton de la Fournaise volcano on Reunion Island (21.2°S, 55.7°E) January 2002.
- Wright, R., Flynn, LP, Garbeil, H, Harris, AJL, and Pilger, E. (2002).  
*Remote Sensing of Environment*, 82, 135-155.
- Flynn, LP, Wright, R, Garbeil, H, Harris, AJL, and Pilger, E. (2002).  
*Advances in Environmental Monitoring and Modeling*, 1, 5-36.

# Status - Volcanoes

- Demonstrations in progress using MODVOLC
- Recent triggers of Kilauea, Belinda
- GOES & AVHRR linkup in progress

# Dust Storms - Future

- Large scale dust storms detectable in MODIS imagery
- Working with Naval Research Laboratory Monterey to utilize their MODIS, GOES systems to track large-scale dust storms
- EO-1 triggered to image dust storms
- Great Mars analogue



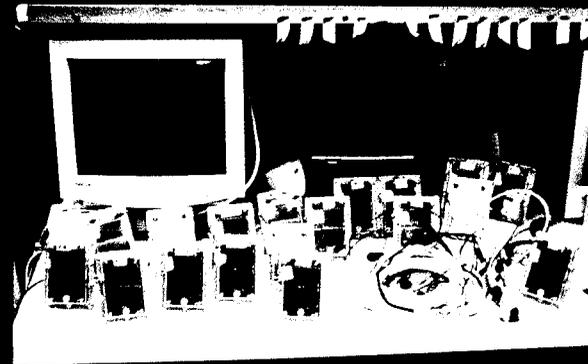
MODIS Image of the day for 19<sup>th</sup> November 2003.  
Images courtesy MODIS Rapid Response Team.

# In-situ Instrumentation

- Sometimes available to trigger or corroborate remote sensing detection
- Currently investigating use of such instruments for
  - Volcanoes – Kilauea, Etna
  - Flooding – Avra Valley, AZ
  - Dust Storms – Soda Lake, CA; Jornada, NM
  - Lake Freeze/thaw – Sparkling Lake, Trout Lake, WI

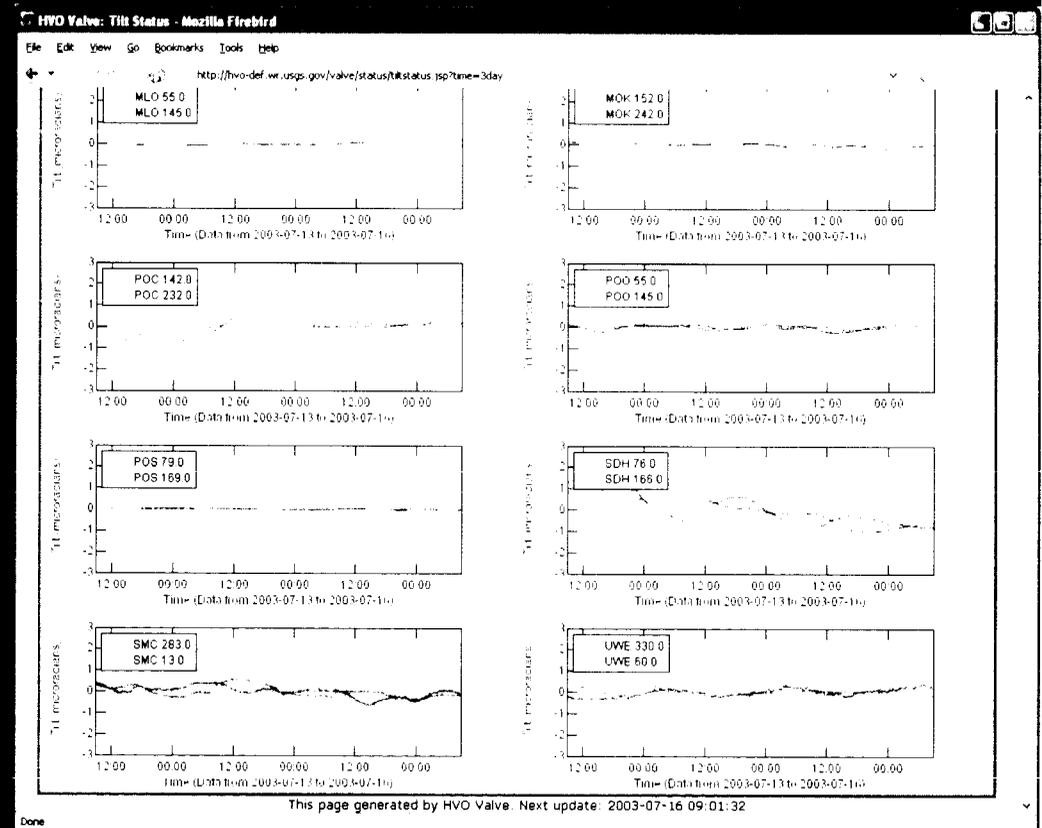
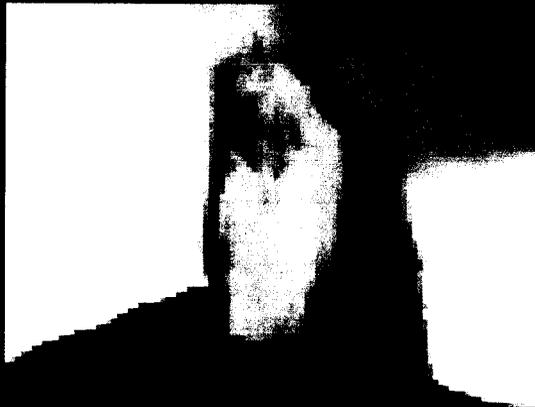
# Flooding

- USGS has several hundred in-situ gauging sites in the US
- Specific sensors deployed to Avra Valley, NM test site



# Kilauea

- HVO has numerous data streams (100+) from in-situ measurements on Kilauea
- Includes, temperature, pressure, seismographic, tilt,...
- Data accessible on SQL server
- Working with Peter Cervelli of HVO



# Conclusions

- Plethora of available timely satellite data can be used to automatically trigger followup observations
  - Partnerships with operational science tracking systems critical (Rapidfire, DFO, UH)
  - Automated response enables acquisition of followup data in timely fashion and in larger quantities (due to reduced ops cost for rapid response)
- 
- We are seeking collaborations with the Direct Broadcast community!

# Acknowledgements

- EO-1 Mission and Science Teams (Mandl, Frye, Ungar, Shulman, Brakke, et al.)
- Autonomous Sciencecraft Experiment Software and Science Teams (Chien, Davies, Castano, et al.)
- Rapidfire/MODIS Land Rapid Response Team (Justice, Sohlberg, DesCloitres et al.)
- Dartmouth Flood Observatory and QuikSCAT (Brakenridge, Andersen, Nghiem, Caquard et al.)
- University of Hawaii, HIGP (Flynn, Wright, Harris, et al.)
- Science Goal Monitor Team, GSFC (Jones, Grosvenor, et al.)

