# Low Latency Data/IPM Operations Concept and Applications

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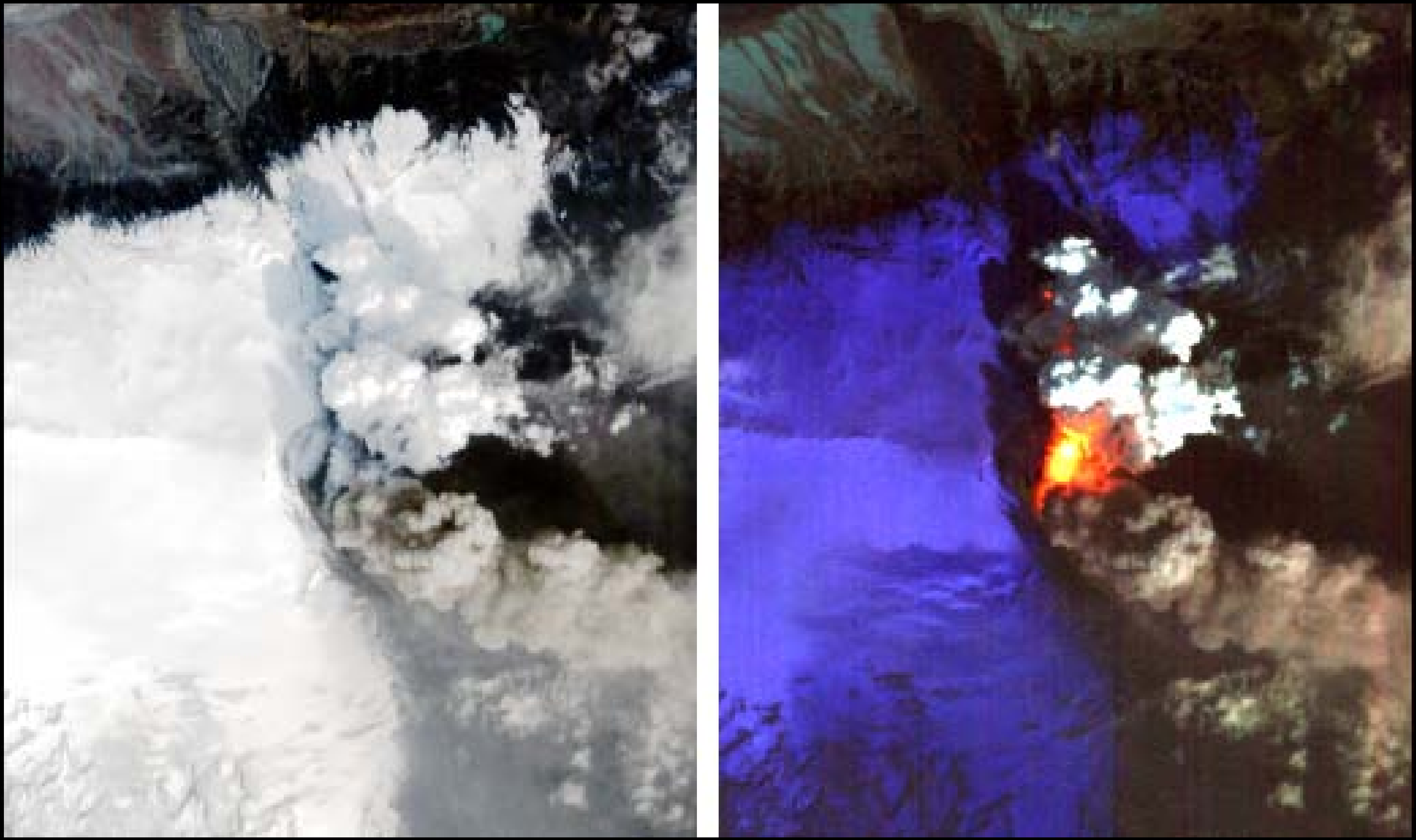
# Rapid Data delivery:
## 02 May 2010 Hyperion Imagery

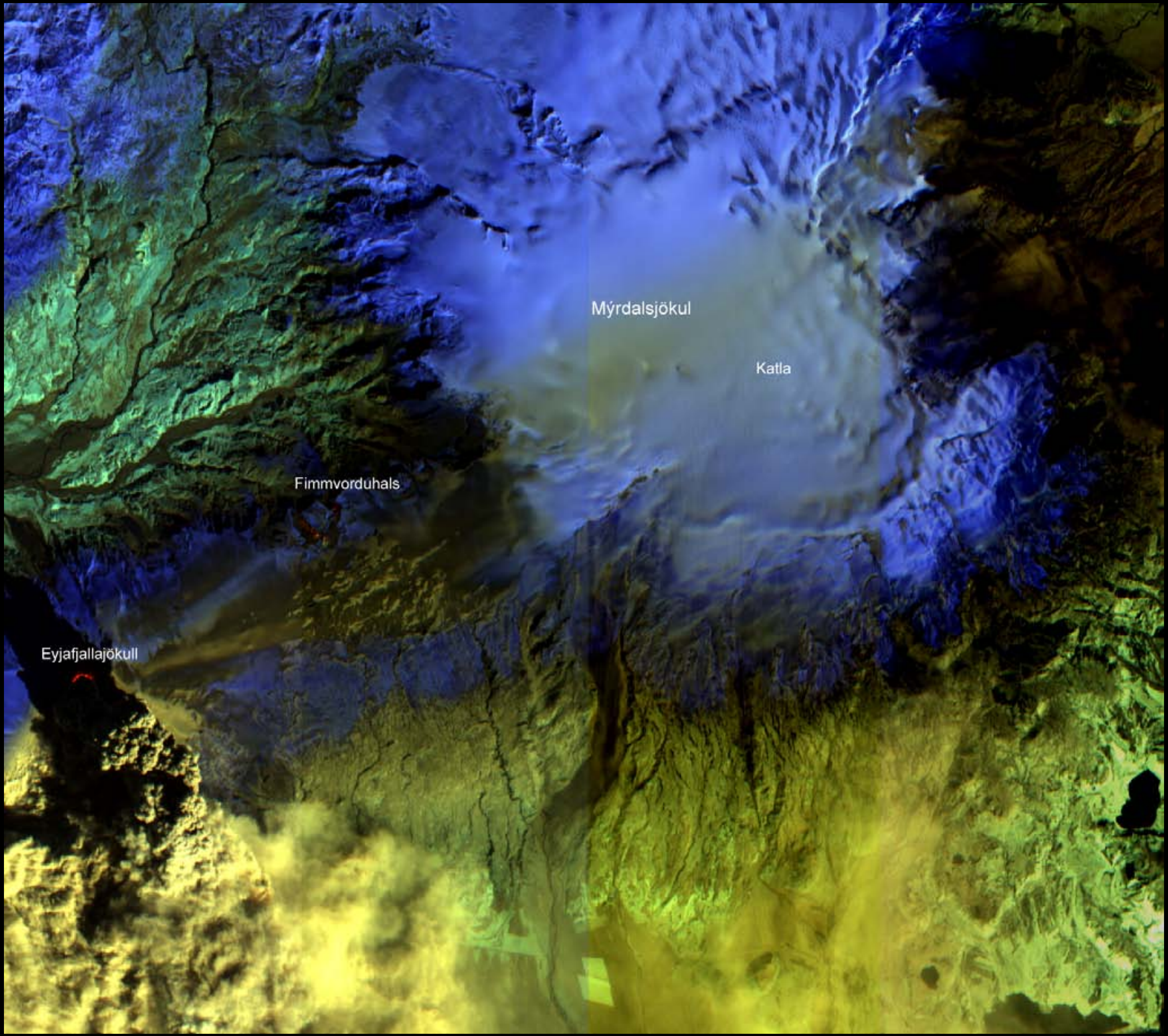


Left – True color   Right -  thermal false color
Image courtesy EO-1 Mission/GSFC,  Volcano Sensorweb/JPLA. Davies

# Recent: Iceland Volcano

False color Advanced Land Imager (ALI) from EO-1 acquired 17 April 2010

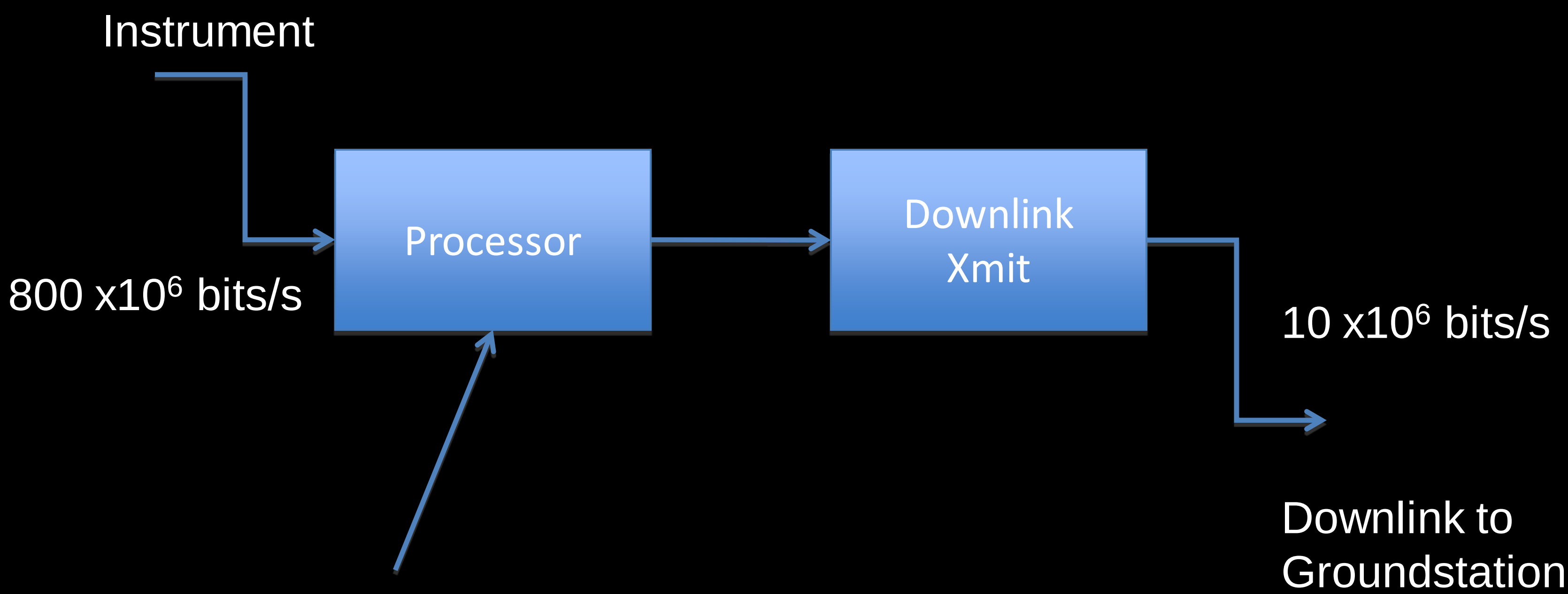
Image courtesy EO-1 mission NASA GSFC & Volcano Sensorweb Courtesy JPL/A. Davies



# HyspIRI Direct Broadcast

- HyspIRI TIR + VSWIR will produce 800 x $10^6$ bits per second (raw uncompressed)
- In order to use heritage technology groundstations HyspIRI DB will have an effective rate of 10 x $10^6$ bits per second (uncompressed)
  - Even assuming 4:1 compression we have a 20x oversubscription

# HyspIRI DB Concept

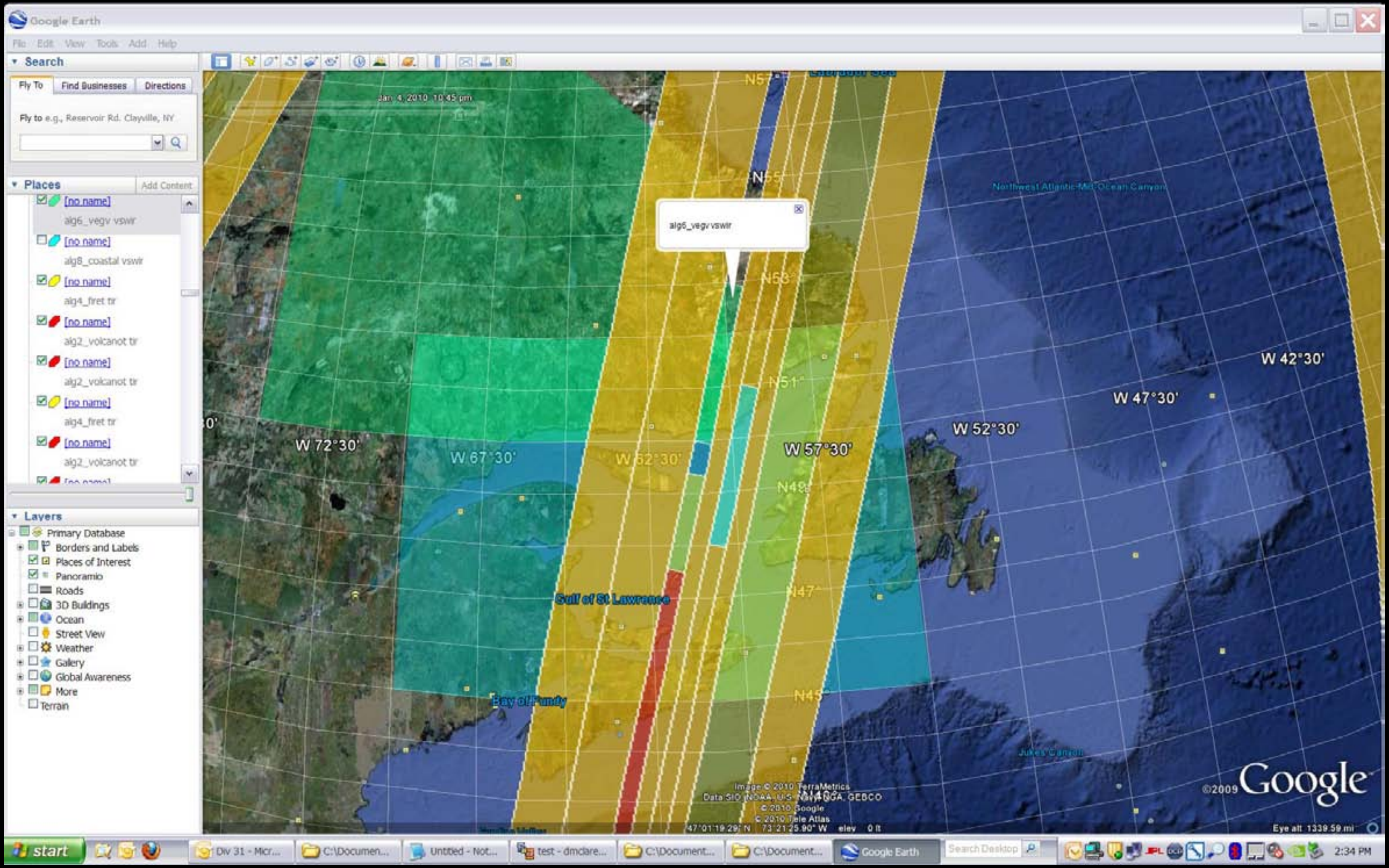



Powerful Space processor
currently evaluating
Spaceube 2.0, OPERA, I-Board

# Operations for HyspIRI DB

- Users specify “areas of interest” which are
  - geographical regions (polygon on surface of Earth)
  - product, (e.g. normalized burn index)
  - priority, (e.g. 50 on 1-100 scale)
  - Constraint (sun must be at least 20 degrees above horizon)
- In generic tool (e.g. Google Earth)
- DB can also be used to rapidly downlink “scenes”

# Instrument Swaths

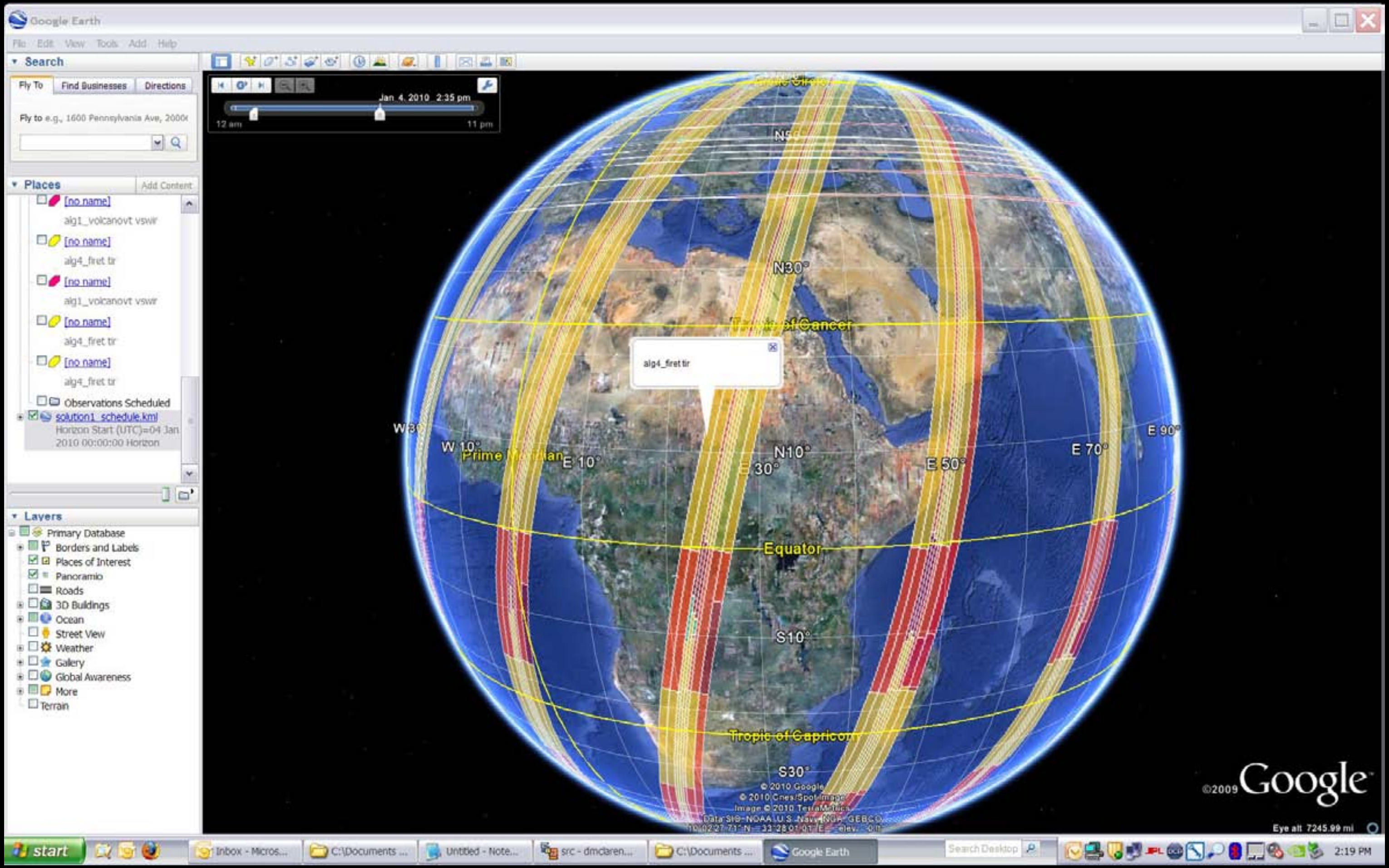


# Automated Operations Planning

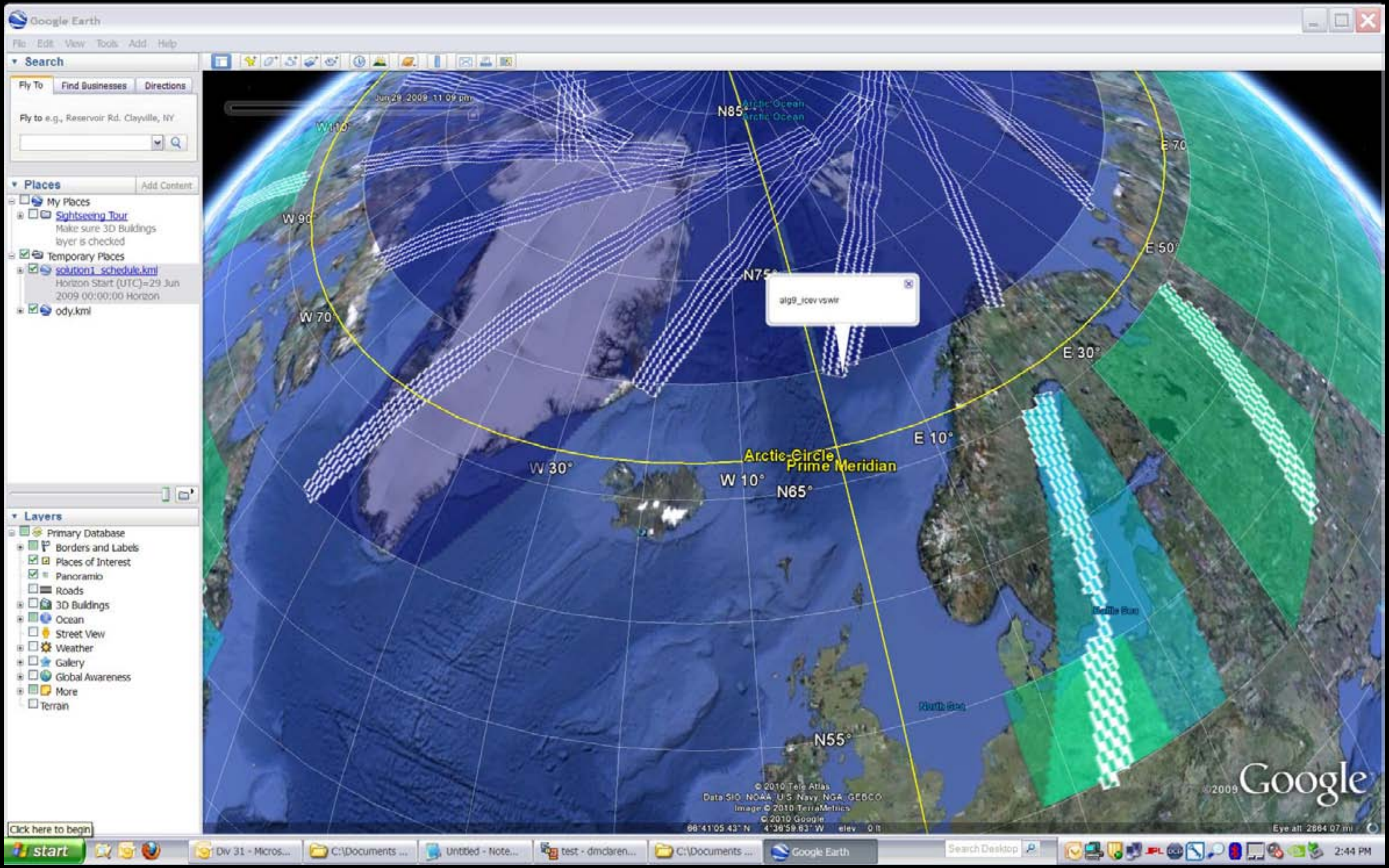
- Automated Planning tool selects highest priority products while respecting
  - Visibility (instrument swaths)
  - Onboard CPU limits
  - Downlink data limits

- Result is a time ordered sequence of commands to process instrument data from each of 8 instrument swaths

# Sample Plans



# More Plans



Google Earth
File Edit View Tools Add Help
Search
Fly To
Find Businesses
Directions
Fly to e.g., Reservoir Rd, Clayville, NY
Places
Add Content
My Places
Sightseeing Tour
Make sure 3D Buildings layer is checked
Temporary Places
solution1_schedule.kml
Horizon Start (UTC)=29 Jun 2009 00:00:00 Horizon
ody.kml
Layers
Primary Database
Borders and Labels
Places of Interest
Panoramio
Roads
3D Buildings
Ocean
Street View
Weather
Gallery
Global Awareness
More
Terrain
Click here to begin
N85°
Arctic Ocean
W 90°
W 70°
N75°
alg9_icev vswir
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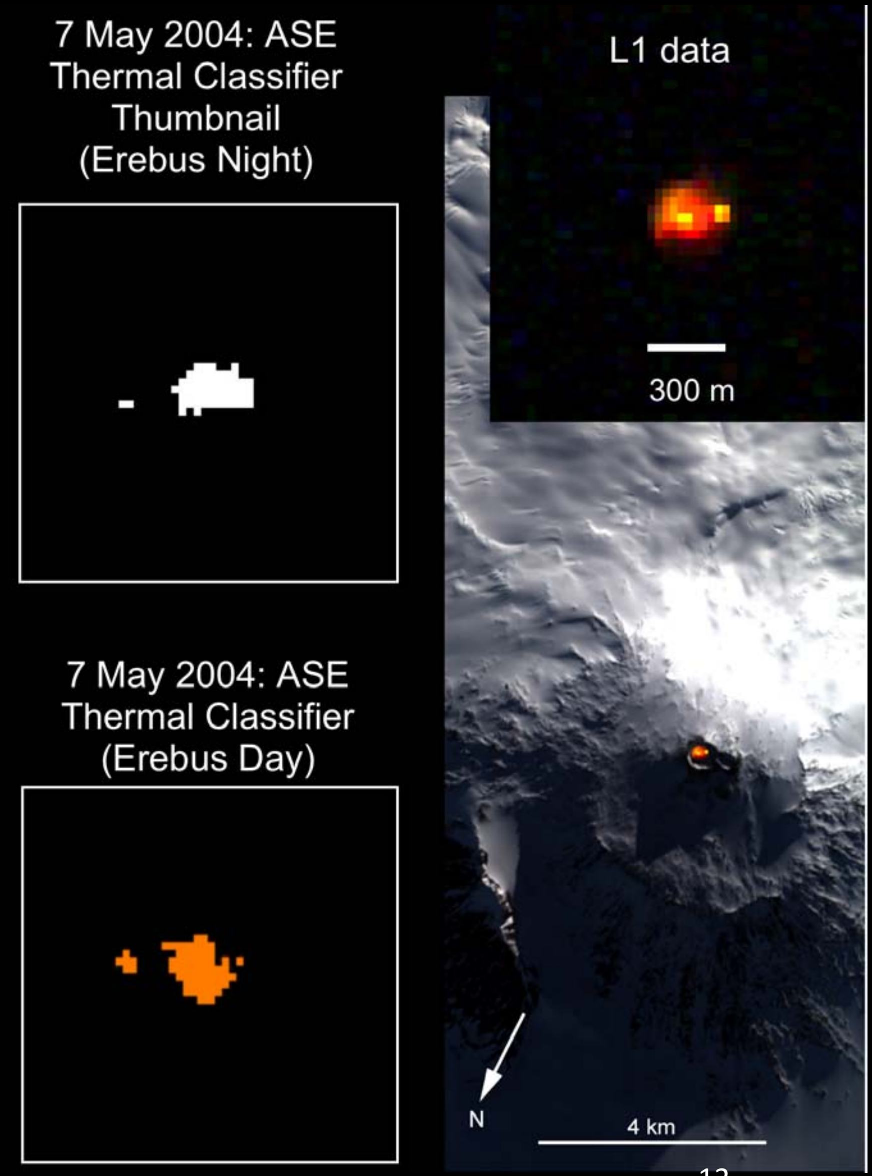
E 10°
Arctic Circle
Prime Meridian
W 30°
W 10°
N65°
North Sea
N55°
© 2010 Tele Atlas
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2010 TerraMetrics
© 2010 Google
©2009 Google
start
Div 31 - Micros...
C:\Documents ...
Untitled - Note...
test - dmclaren...
Google Earth
2:44 PM

# HyspIRI DB Applications

- Volcanos
- Fires
- Flooding
- Cryosphere
- Ocean

# Heritage (onboard) – EO-1/ASE Thermal Detection

- EO-1
  - Onboard thermal event detection in use since 2004 based on onboard Hyperion spectral signature
  - Uses spectral slope in 1.65-2.28μ
  - Onboard event detection can trigger:
    - Subsequent imaging
    - Alert Notices
    - Generation of thermal summary and quicklook context images
    - Ground-based automatic data product generation and distribution






Courtesy [Davies et al. 2006]

# Heritage – ground-based MODIS Active Fire Detection

- Detects hotspots using
  - absolute threshold
    - $T_4$>360K, 330K(night) or
    - $T_4$>330K, 315K(night)
      and $T_4$-$T_{11}$>25K(10K @ night)
  - and relative threshold
    - $T_4 > mean(T_4) + 3stddev(T_4)$
      and $T_4 - T_{11} > median(T_4-T_{11}) + 3stddev(T_4-T_{11})$

Looks for areas significantly hotter than surrounding area (requires 6 surrounding pixels cloud, water, fire free → 21x21)

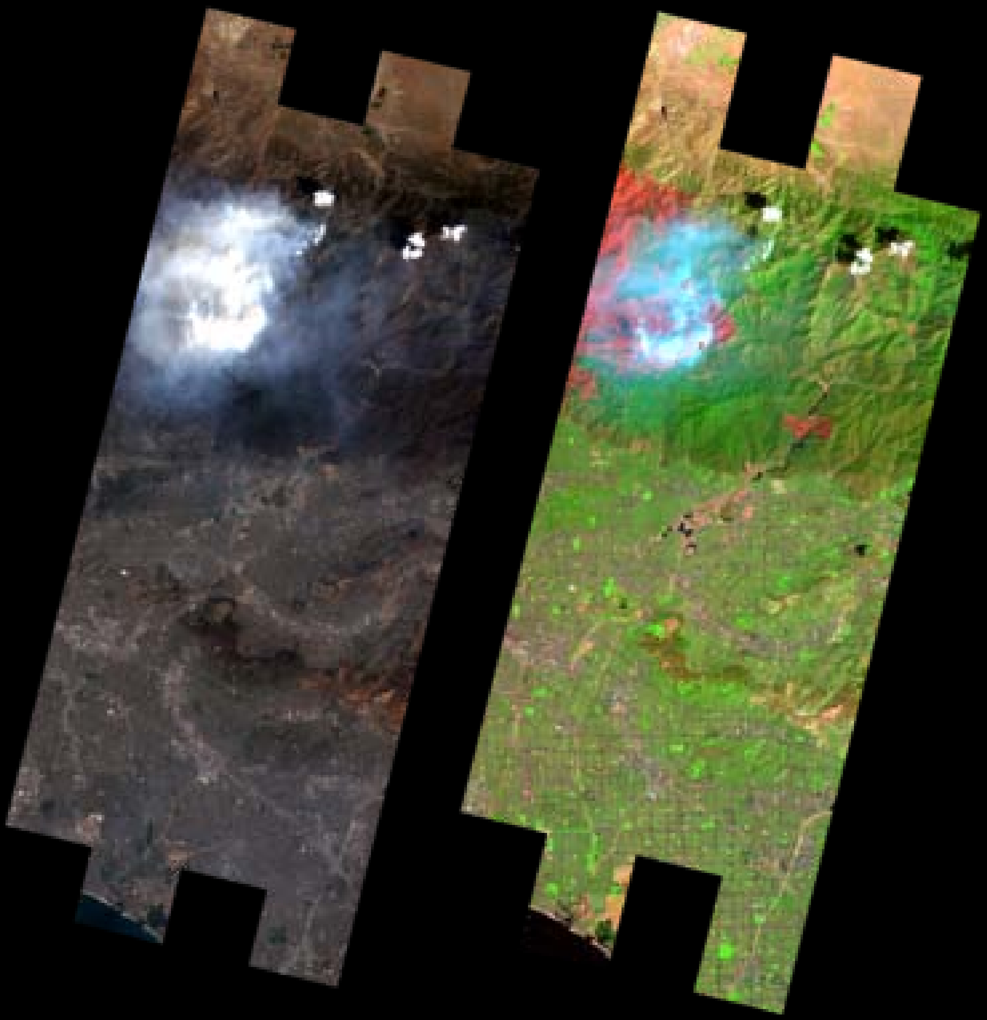


C. Justice et al.

# Fires – Burn Scar

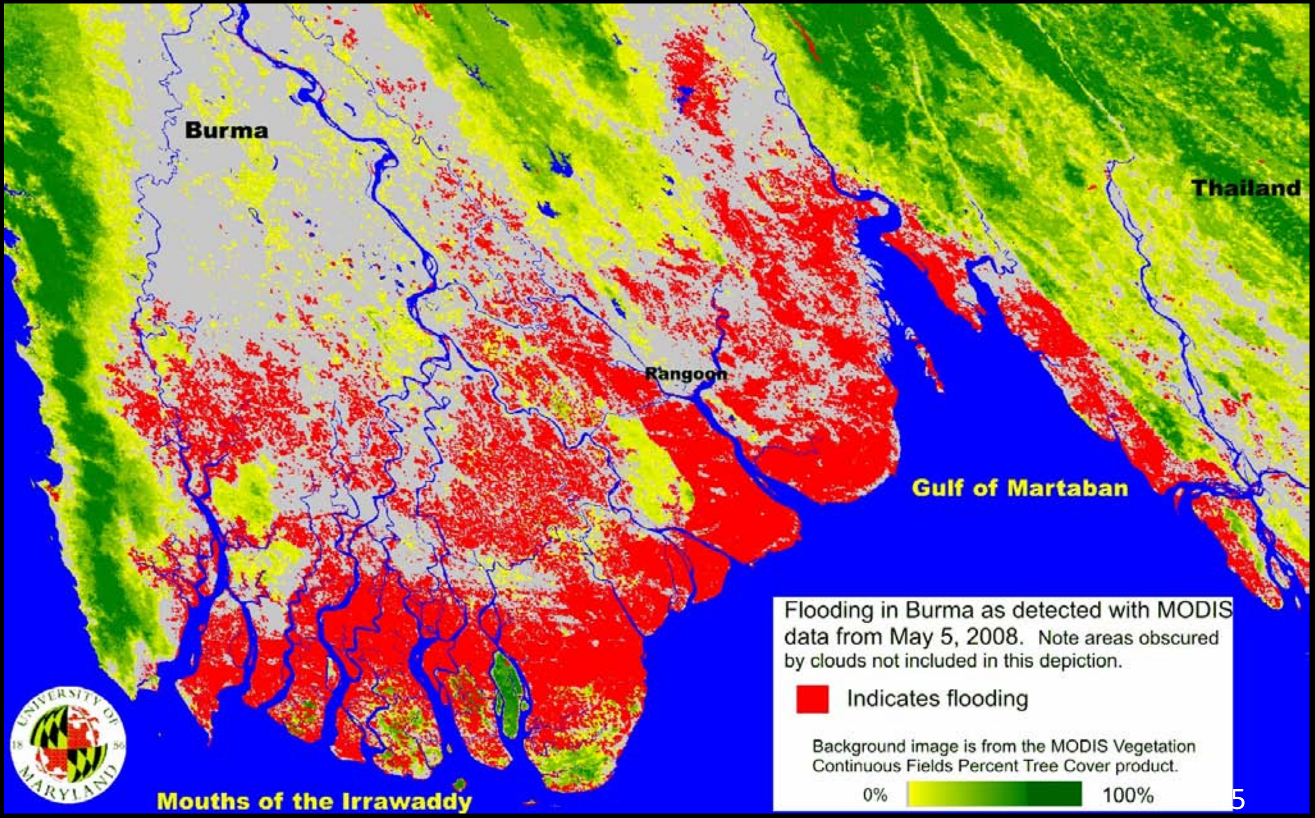
Visible and burn scar enhanced images from ALI instrument on EO-1 of Station Fire near Los Angeles 03 September 2009

Images courtesy EO-1 Mission NASA GSFC



# Flooding – Heritage (Ground) MODIS/UMD

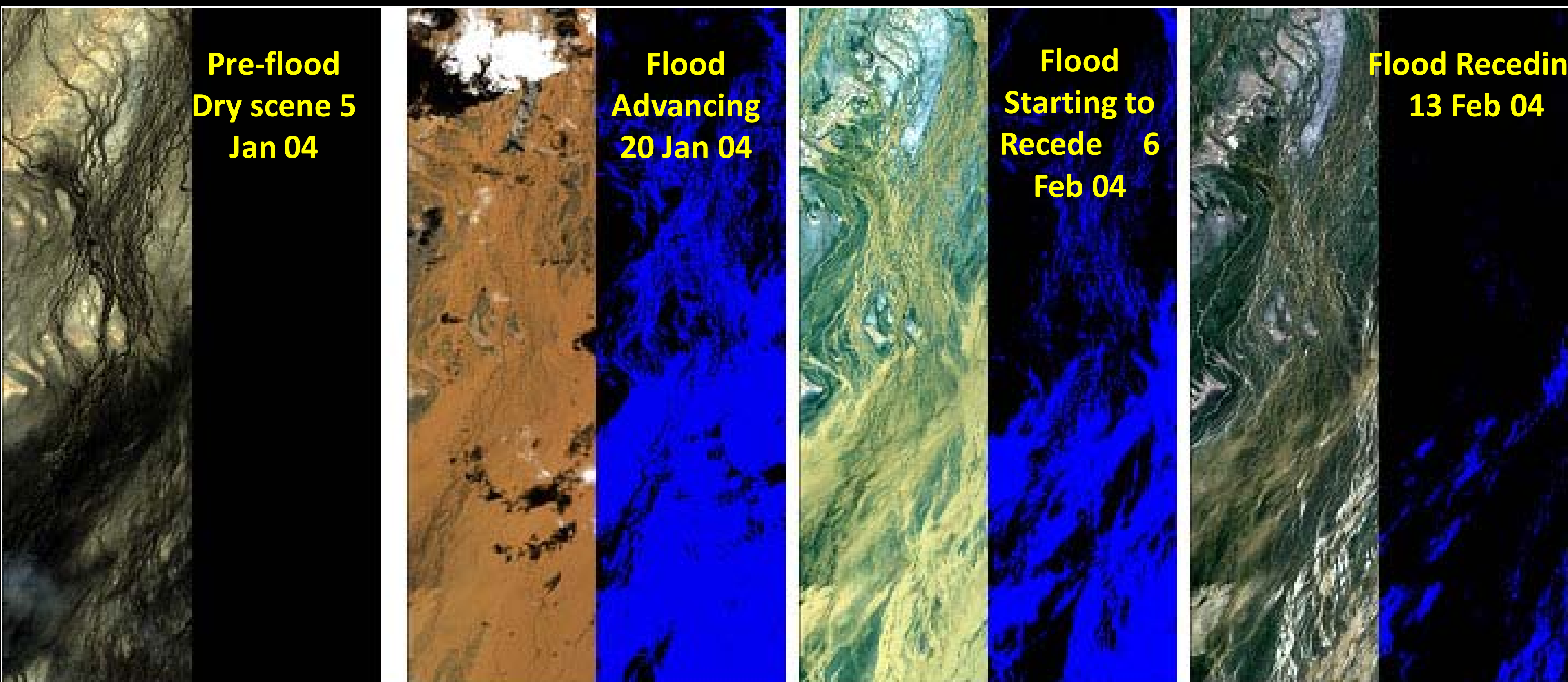
- UMD Flood tracking of Myanmar using MODIS bands 1,2,5,7 (620-2155 nm)




M. Carroll et al.

# Flooding - Heritage (Flight) – EO-1/ASE

## Onboard Detection of a Rare Major Flood on Australia’s Diamantina River




Cause of flooding: Monsoonal rain

EO-1 Hyperion. Wavelengths used: 0.86 μm and 0.99 μm

**F. Ip, V. Baker, et al., University of Arizona**

# Cryosphere (Ground)

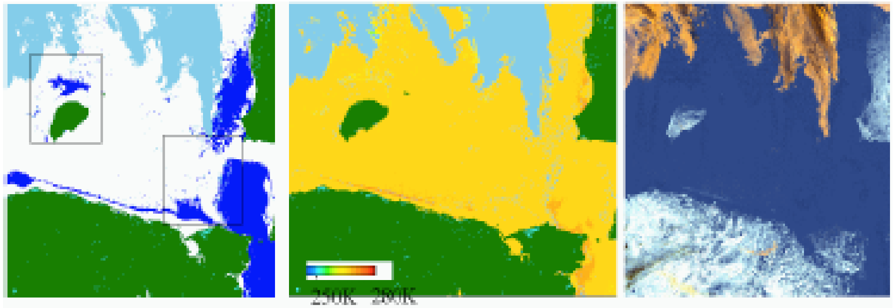



*Figure 4: MODIS sea ice product by NDSI method (left), IST method calculated temperatures (center), and a composite image made from MODIS Bands 20 (3.7µm), 22 (3.9µm) and 23 (4.0µm) to highlight clouds (right).*

Image courtesy of [Scharfen and Kalsa 2003]

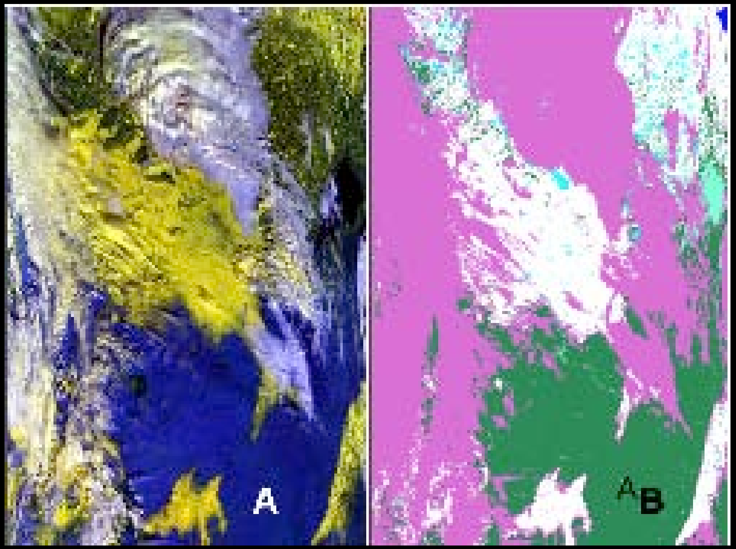


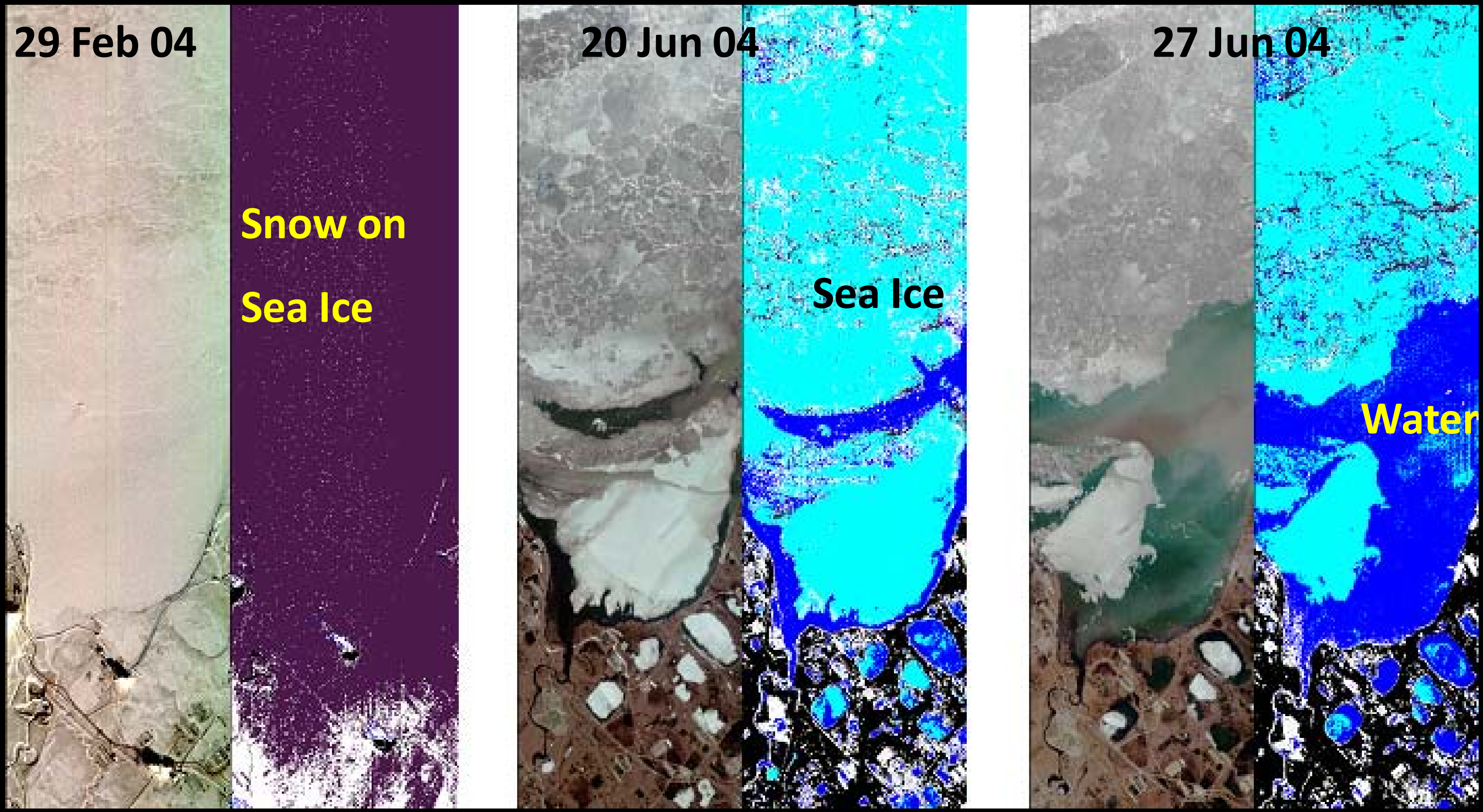


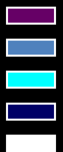
Figure 1 MODIS at-satellite reflectance image from swath of MOD02HKM for 3 January 2003 (A). Snow cover appears as yellow in this display of bands 1, 4 and 6. Snow cover map of the swath (B) and the snow cover map in sinusoidal projection (C).

Courtesy of *MODIS Snow Products User Guide*

# Heritage (onboard) EO-1/ASE Hyperion Cryosphere Classifier

Deadhorse (Prudhoe Bay), Alaska

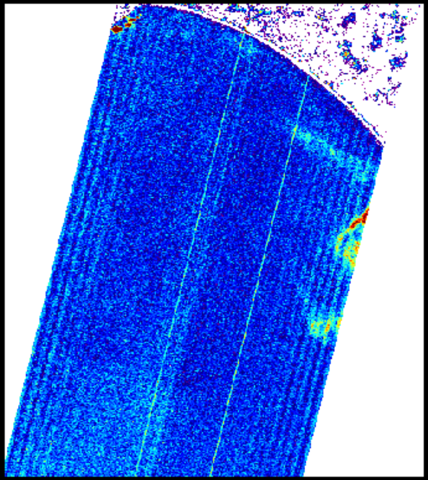


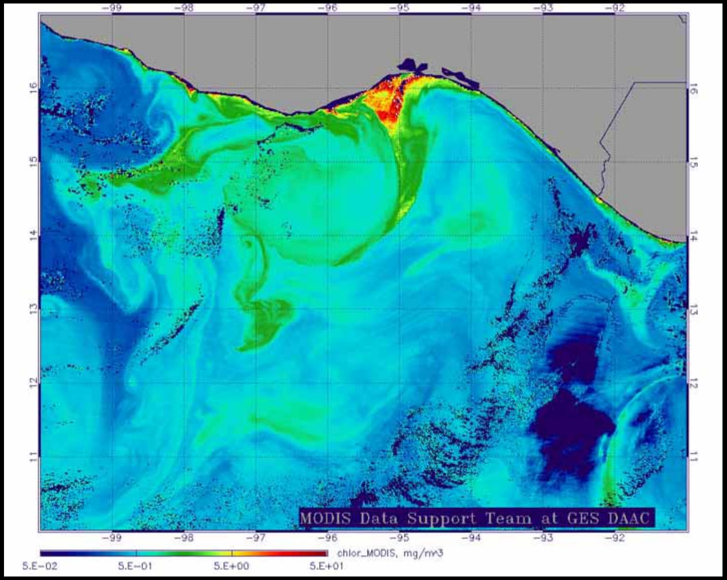

EO1/Hyperion data
Wavelengths used in classifier:
0.43, 0.56, 0.66, 0.86 and 1.65 μm

**Arizona State University**
**Planetary Geology Group**

# Coastal



Maximum Chlorophyll Index derived from Hyperion imagery acquired 21 October 2008 of Monterey Bay [Chien et al. 2009] using 660, 681, 711, 752, nm. (ack J. Ryan/MBARI)




Uses 490nm/555nm or 490nm/565 nm MODIS reflectance data Courtesy GSFC DAAC

# Dust

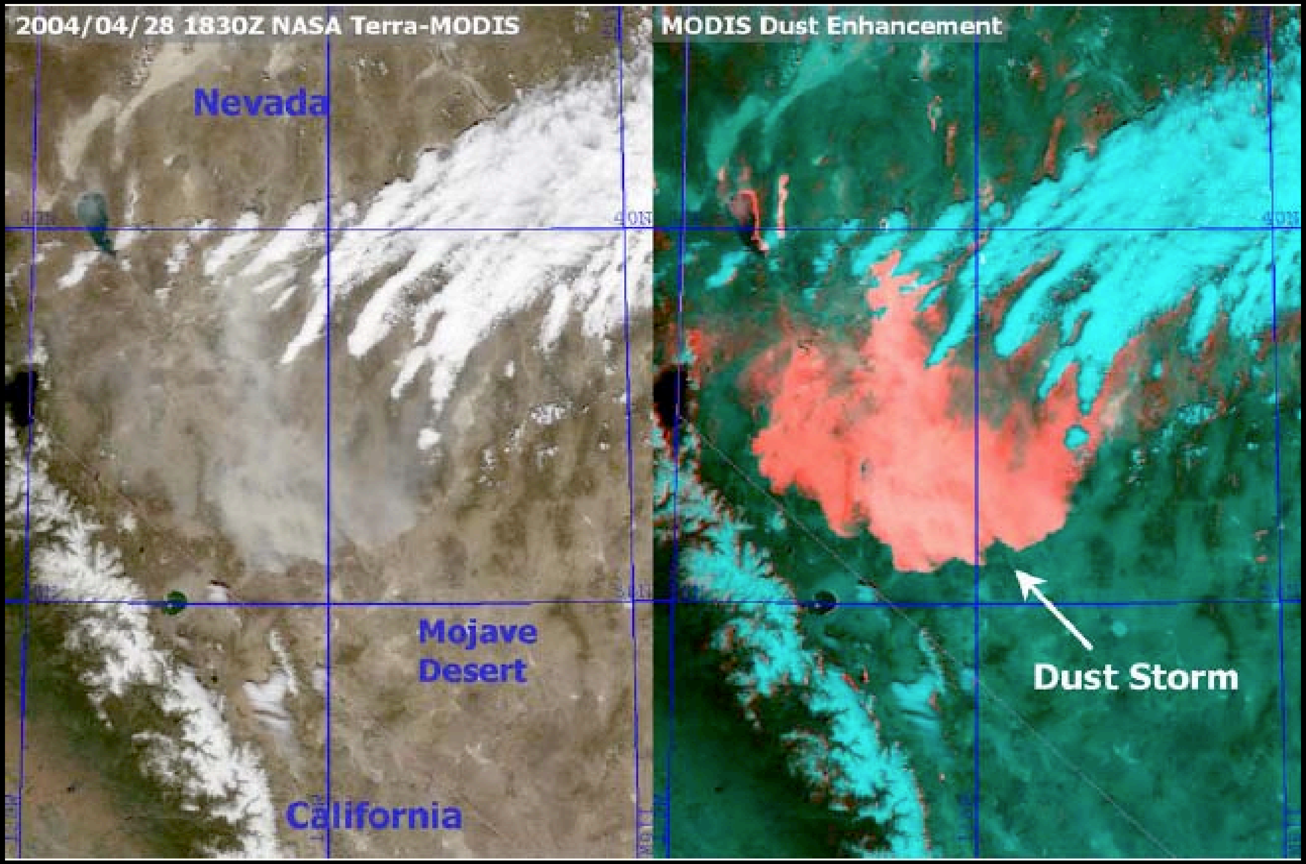



Image (processed MODIS) courtesy of *Satellite Product Tutorials: Desert Dust Storms, S. Miller et al.*

# Vegetation

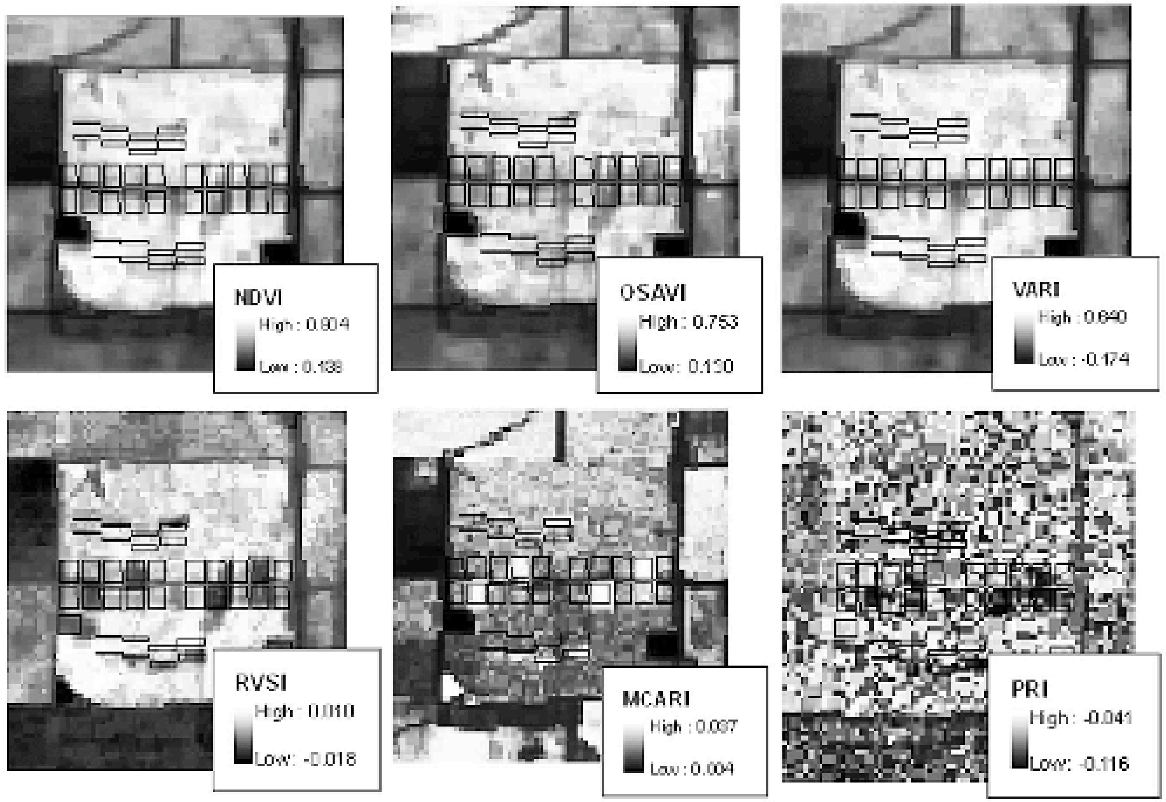



**Fig. 3. Comparison of selected indices derived from 6 July Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) imagery (18-m spatial resolution) with locations of N trial plots and subpixel plots shown. The corresponding classification accuracies are shown in Table 7. Note the differences between the appearance of the subpixel areas and the classification accuracies. For example, the subpixel stressed areas for the Normalized Difference Vegetation Index (NDVI) and the Modified Chlorophyll Absorption in Reflectance Index (MCARI) are quite apparent, although the classification accuracies (Table 7) for the Photochemical Reflectance Index (PRI) are generally higher.**

Aviris measurement of plant stress using NDVI, MCARI, and PRI [Perry & Roberts 2008]

# Conclusions

- Direct broadcast can provide key data at low latency
- Onboard computing can address issues to downselect data to fit within reduced downlink
- Operations can be simple and automated