Onboard Instrument Processing Concepts for the HyspIRI Mission

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Direct Broadcast Heritage

- Direct Broadcast is a technology which enables downlink of instrument data during acquisition (e.g., MODIS)

- In current use, DB downlinks all of the data acquired by the instrument

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

Instrument

800×10^6 bits/s

Processor

Downlink Xmit

10×10^6 bits/s

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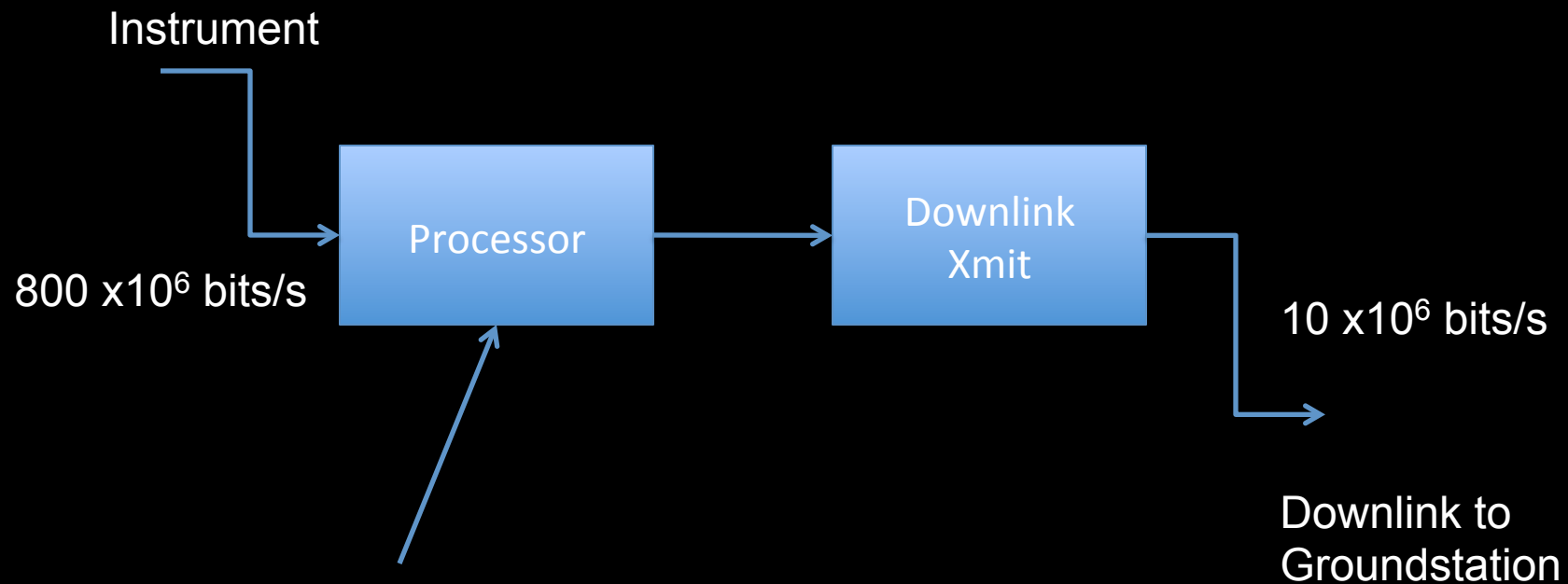
Powerful Space processor currently evaluating Spaceube 2.0, OPERA, I-Board

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)

Instrument Swaths
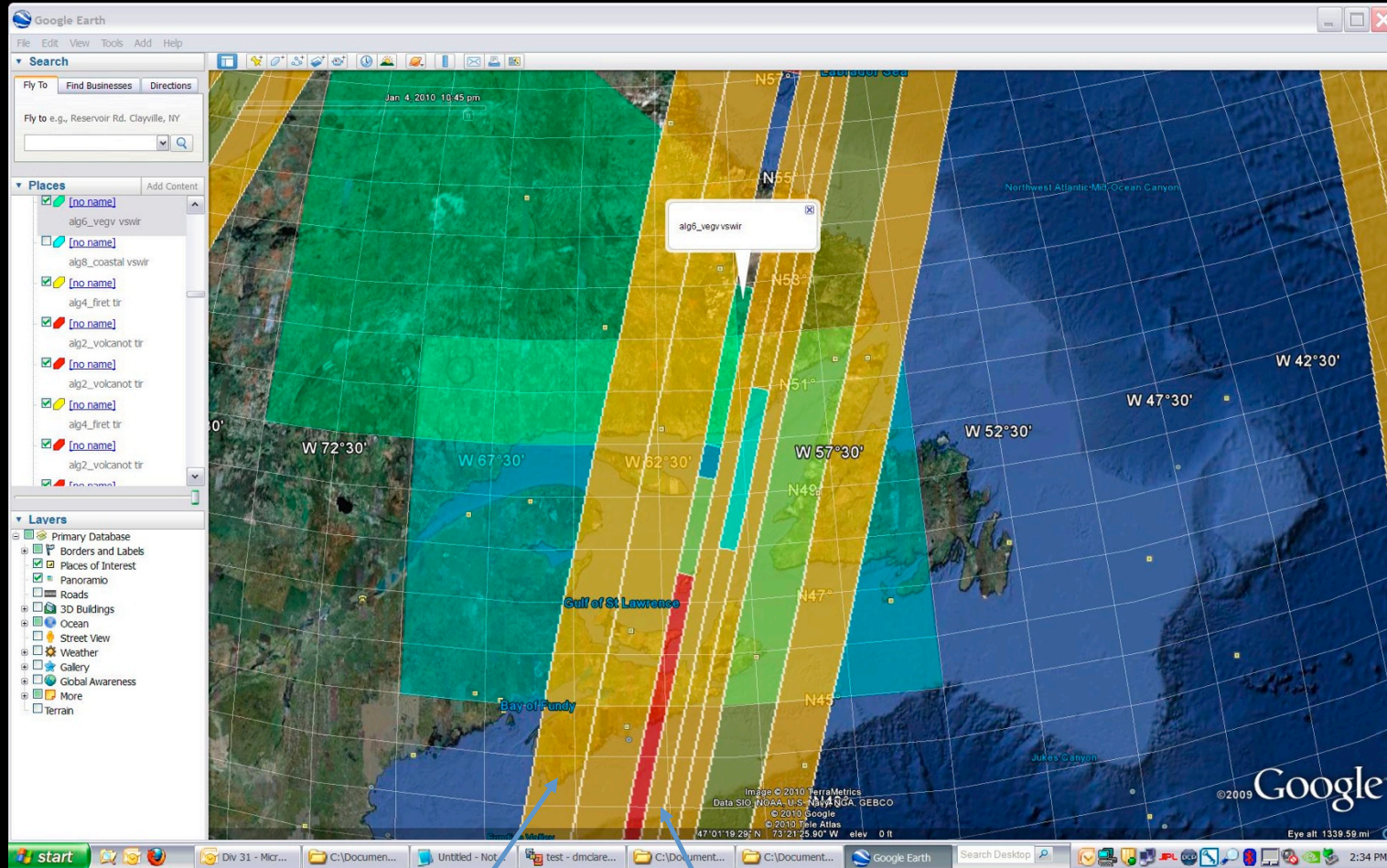
4 x 112.5.5 km wide –TIR only   4 x 37.5 km wide – VSWIR + TIR
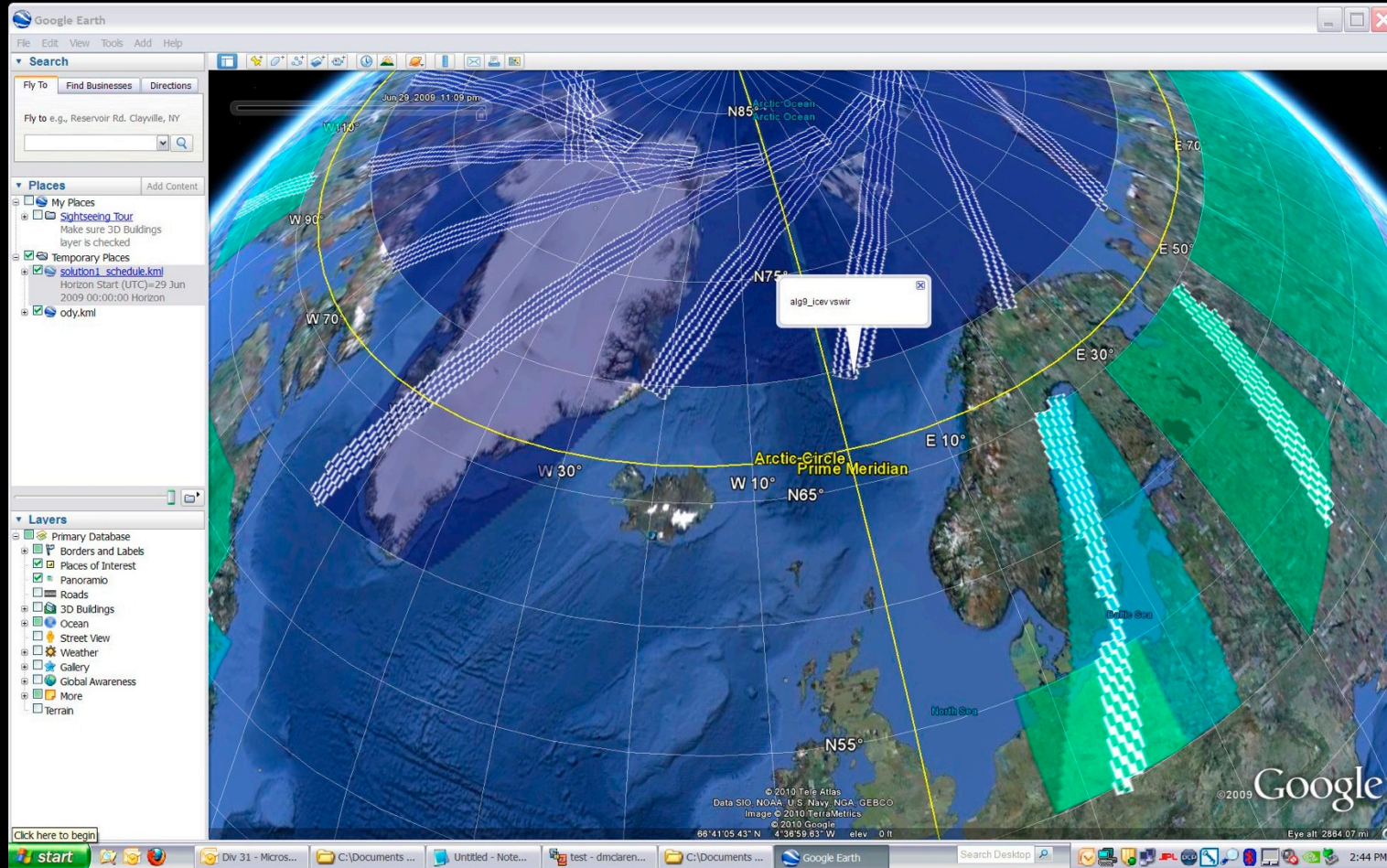
Automated Operations Planning

- 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
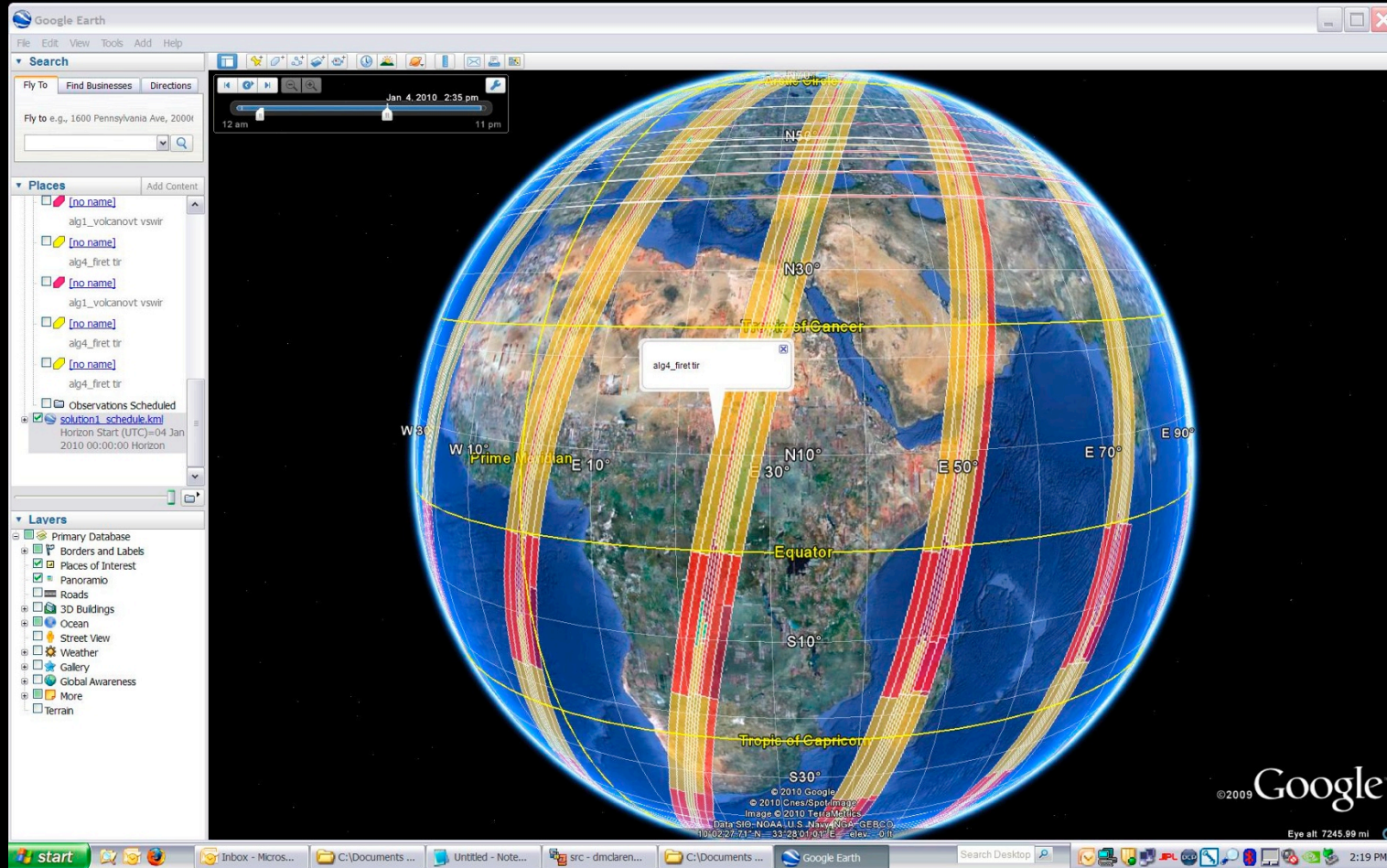
More Plans

HyspIRI DB Applications

- Volcanos
- Fires
- Flooding
- Cryosphere
- Ocean

- Applications allows spatial and spectral subsampling (bands and products) to reduce needed downlink volume, and prior heritage

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
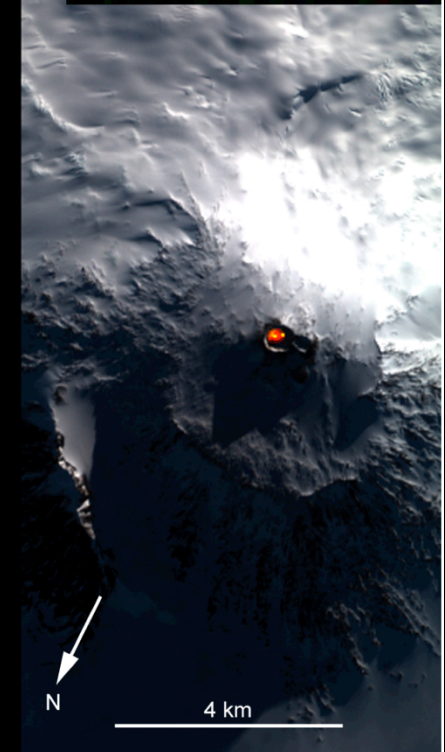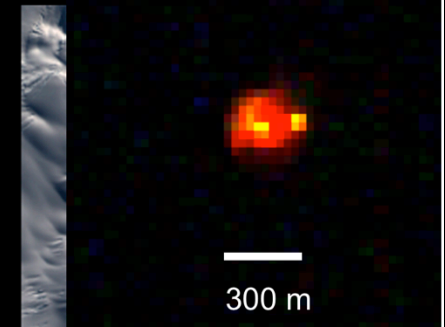   - Ground-based automatic data product generation and distribution

7 May 2004: ASE Thermal Classifier Thumbnail (Erebus Night)

L1 data

300 m
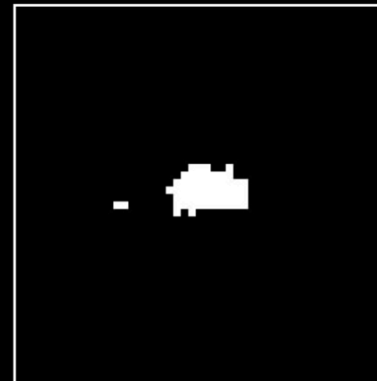
7 May 2004: ASE Thermal Classifier (Erebus Day)

N

4 km
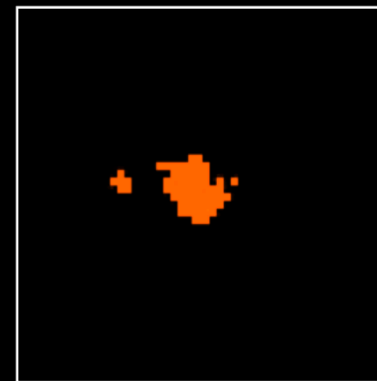
Courtesy [Davies et al. 2006]
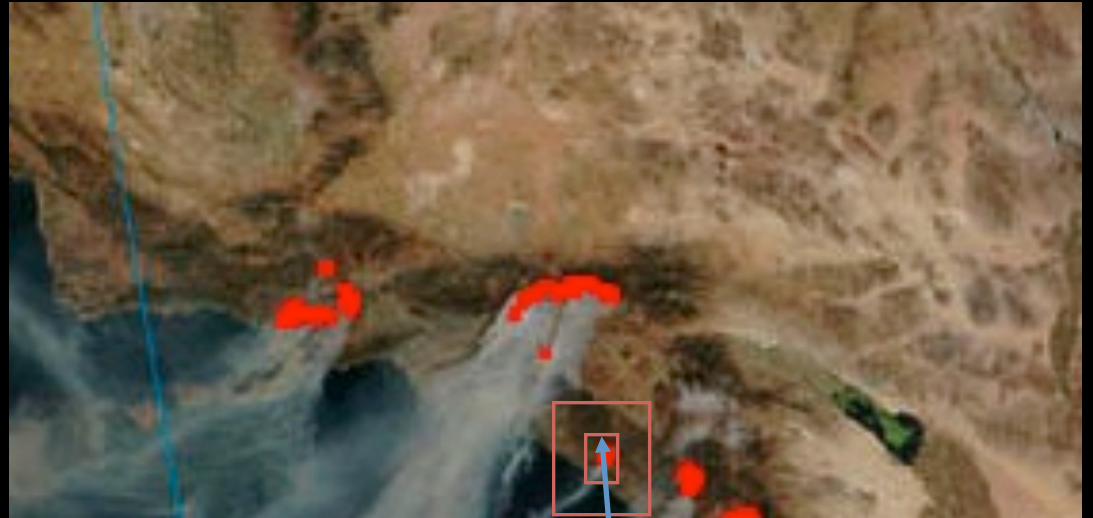
Heritage – ground-based MODIS Active Fire Detection

- 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 $T_4 - T_{11} > median(T_4 - T_{11}) + 3stddev(T_4 - T_{11})$

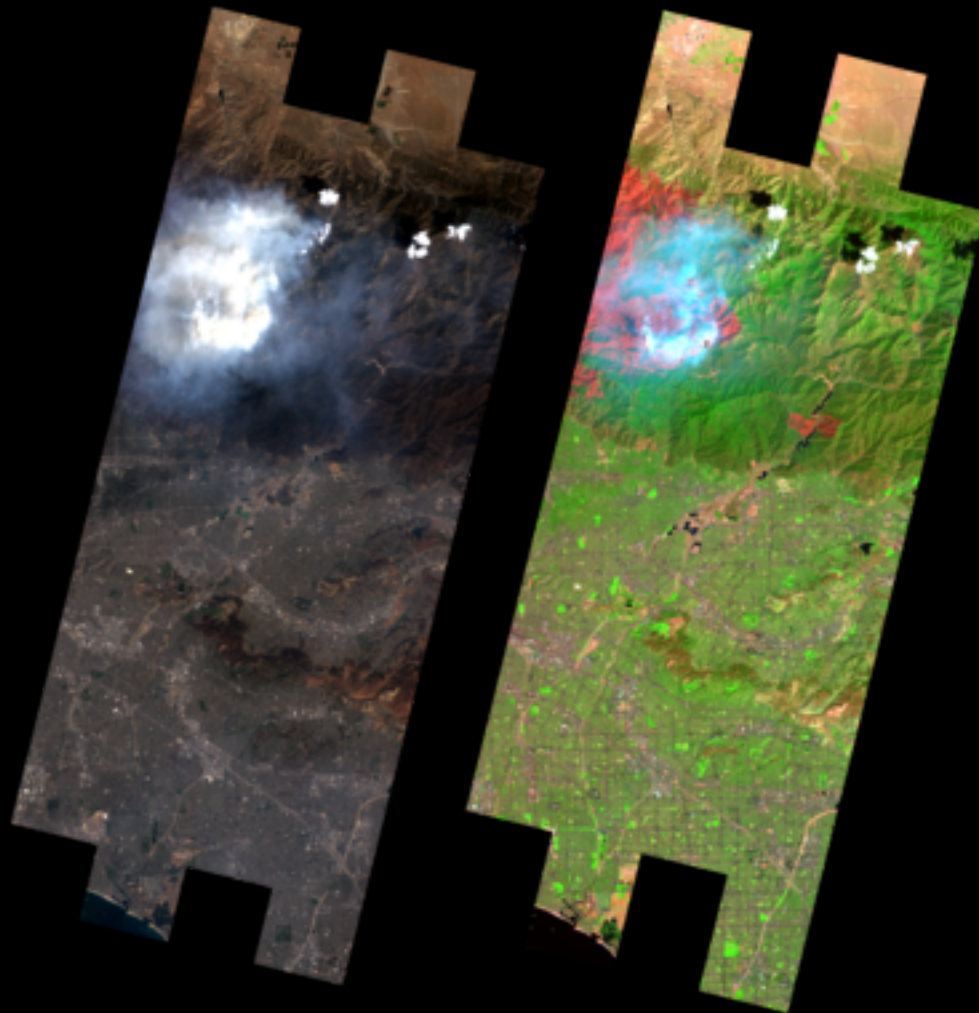Looks for areas significantly hotter than surrounding area (requires 6 surrounding pixels cloud, water, fire free → 21x21)

C. Justice et al.

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Fires – Burn Scar

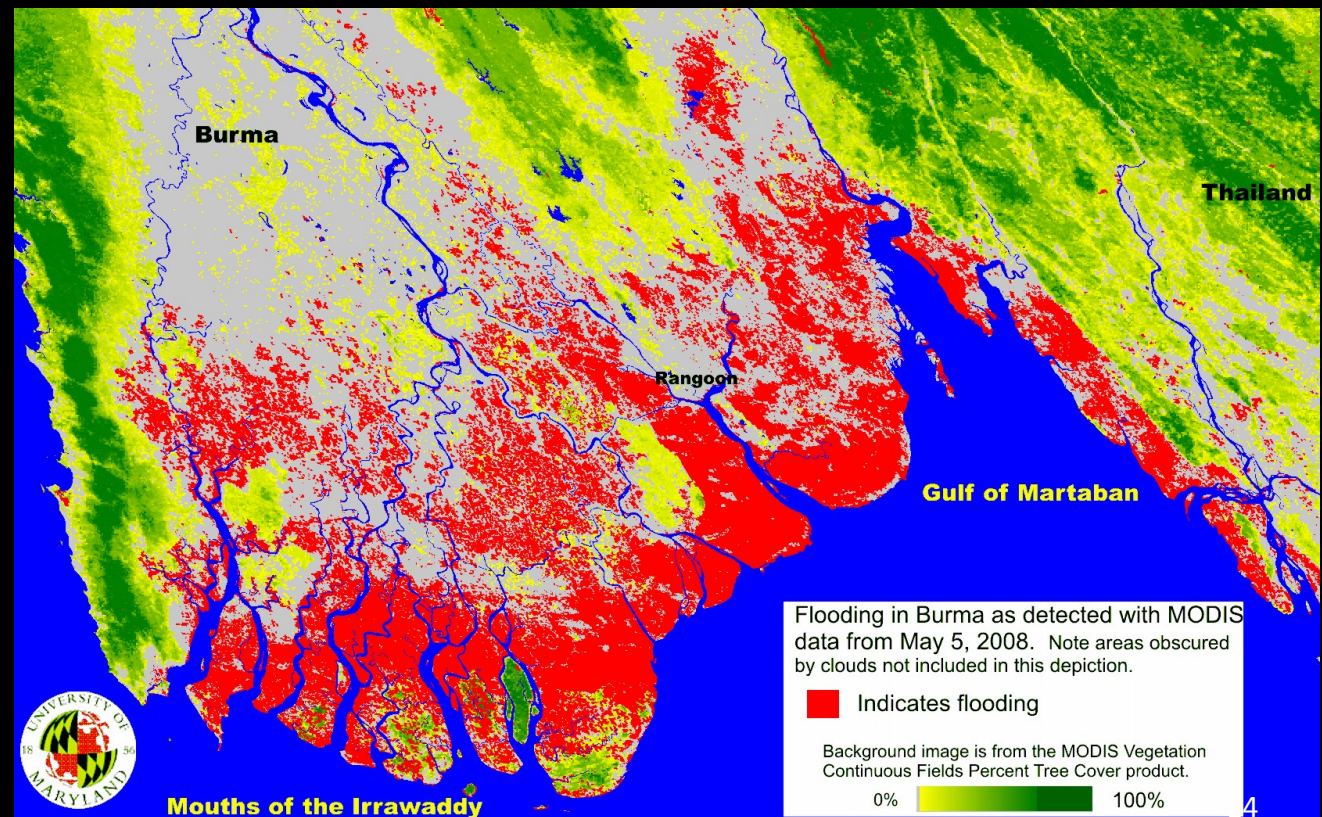Visible and burn scar enhanced images from ALI instrument on EO-1 of Station Fire near Los Angeles 03 September 2009

Images courtesy EO-1 Mission NASA GSFC

Burn scar:
0.76-0.90μm,
2.08-2.35μm
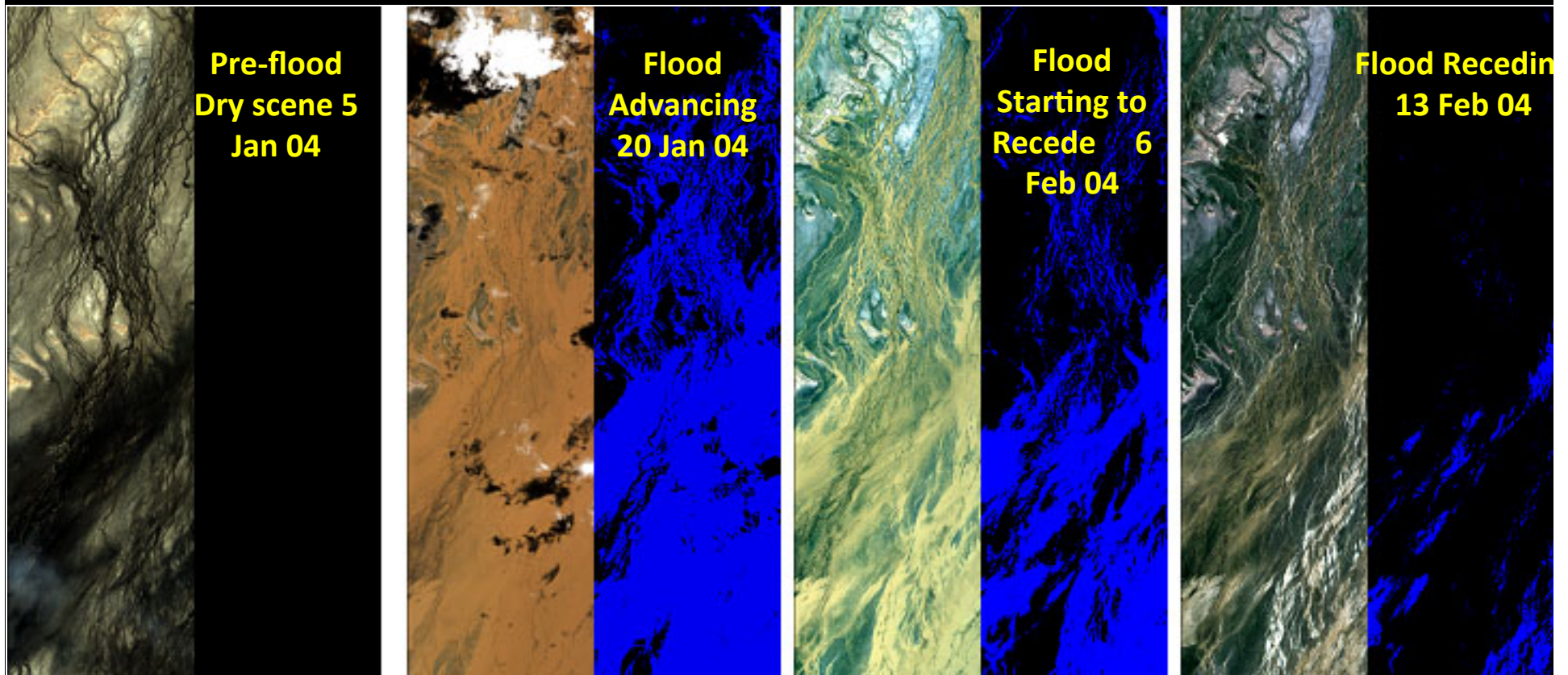
Flooding –
Heritage (Ground) MODIS/UMD

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

Flooding in Burma as detected with MODIS data from May 5, 2008. Note areas obscured by clouds not included in this depiction.

■ Indicates flooding

Background image is from the MODIS Vegetation Continuous Fields Percent Tree Cover product.

0% 100%

M. Carroll et al.

Flooding - Heritage (Flight) – EO-1/ASE
Onboard Detection of a Rare Major Flood on Australia's Diamantina River

Pre-flood Dry scene 5 Jan 04

Flood Advancing 20 Jan 04

Flood Starting to Recede 6 Feb 04

Flood Recedin 13 Feb 04

Cause of flooding: Monsoonal rain

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

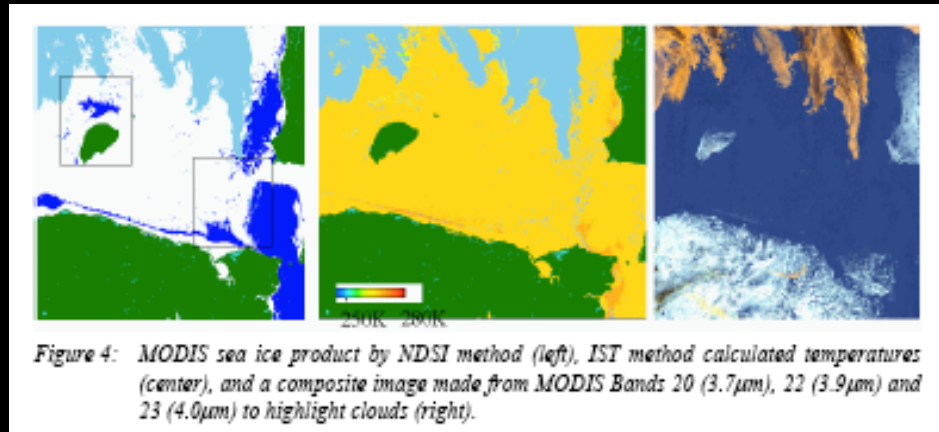**F. Ip, V. Baker, et al., University of Arizona**

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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]

Snow
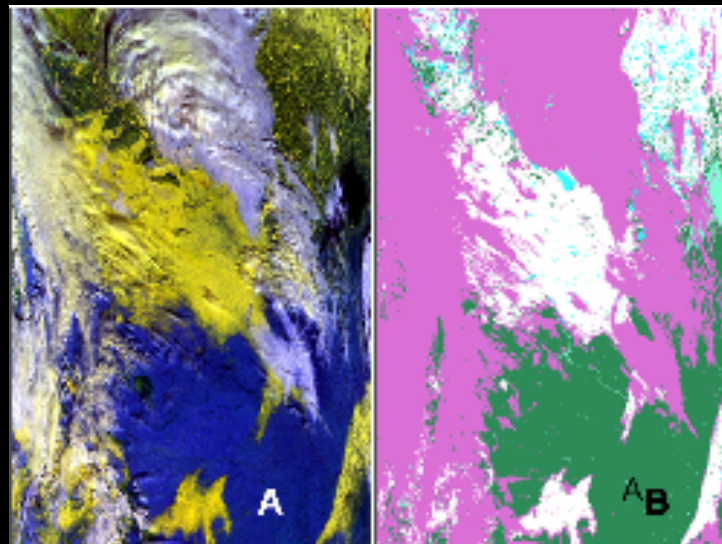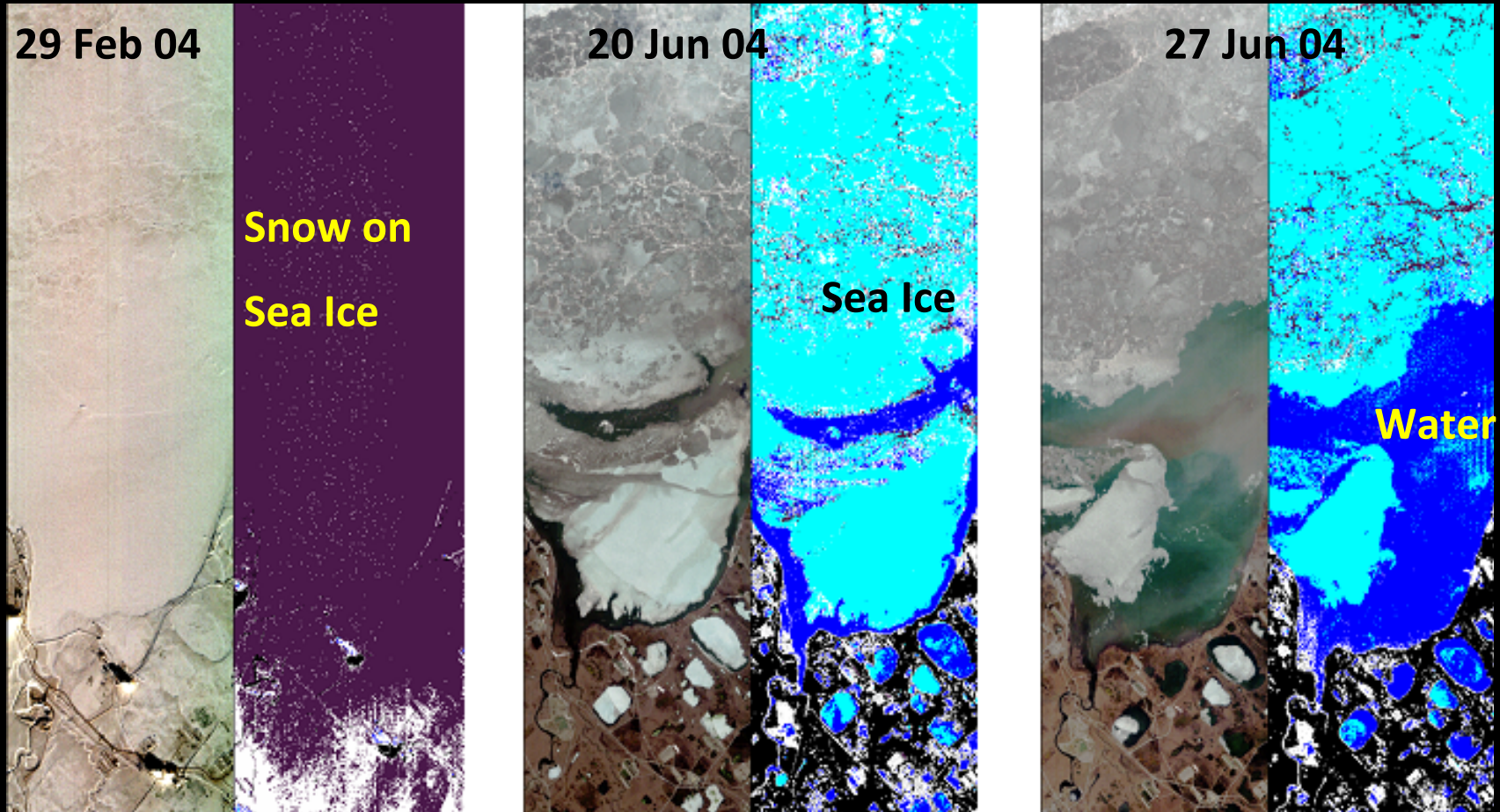Land
Water
Lake Ice
Cloud
Ocean
Night
No Decision

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
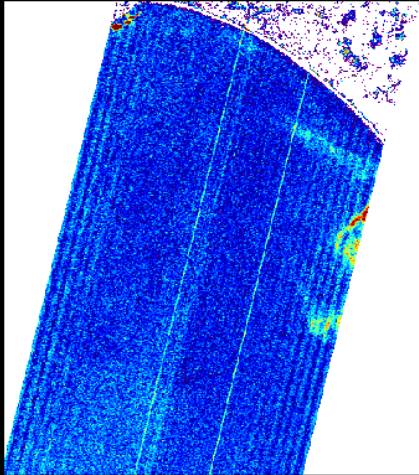## Deadhorse (Prudhoe Bay), Alaska

29 Feb 04

Snow on Sea Ice

20 Jun 04

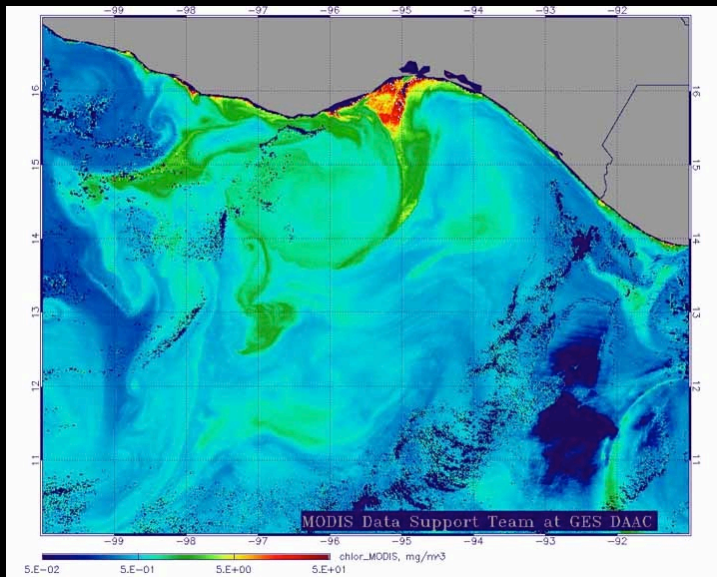Sea Ice

27 Jun 04

Water

Snow
Water
Ice
Land
Unclassified

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
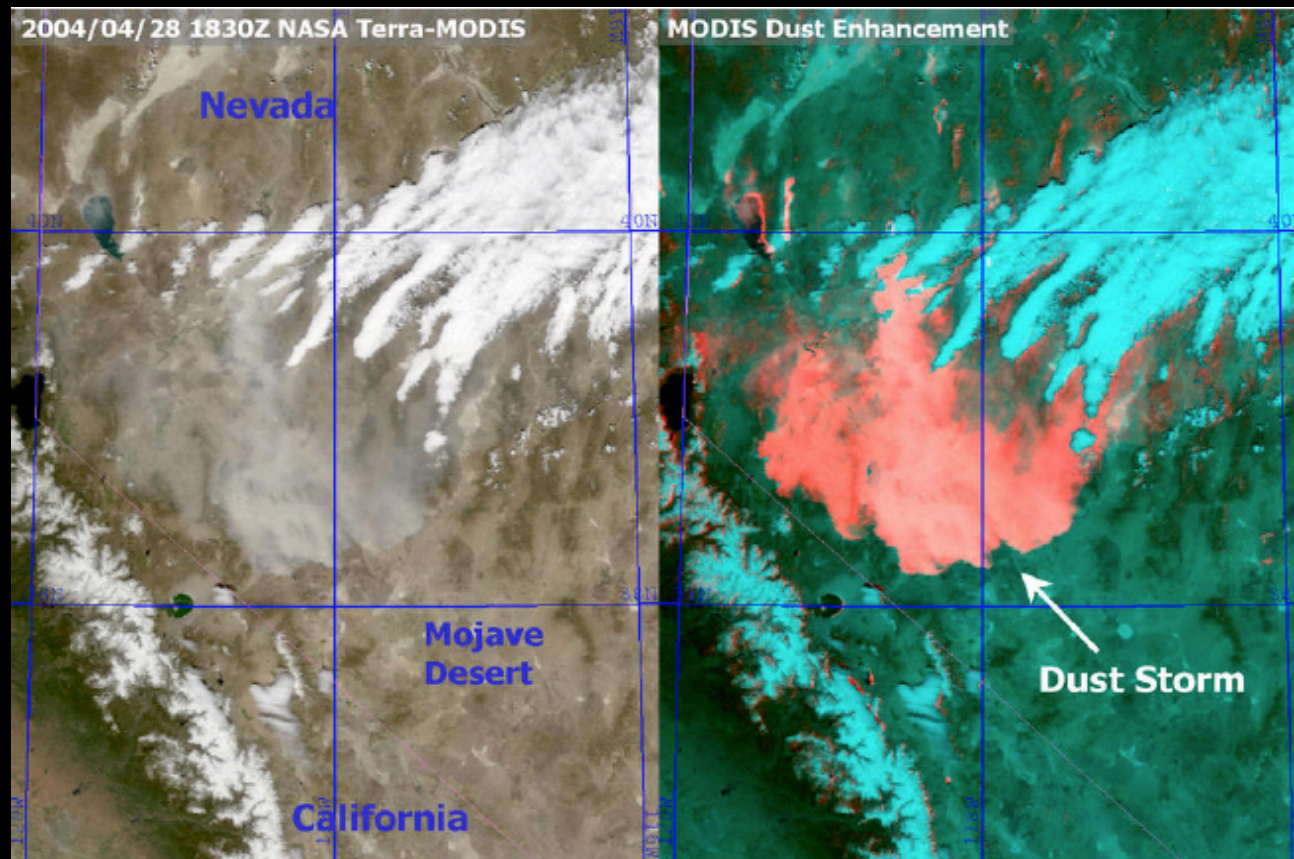Courtesy GSFC DAAC

Dust

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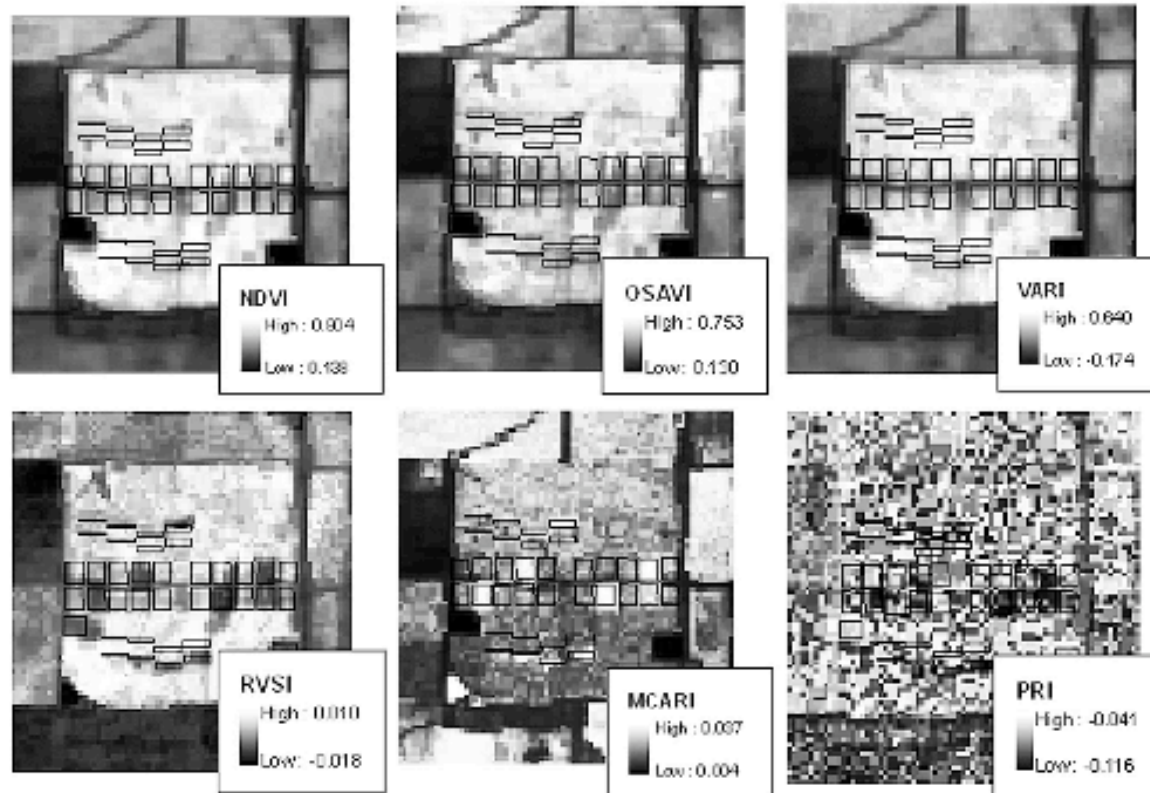
Vegetation

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] describes 22 measures using 500-1200 nm.

Conclusions

- Direct broadcast can provide key data at low latency
- Onboard computing can address issues to downselect and process data to fit within reduced downlink
- Operations can be simple, web-based and automated
- For further information see poster and refs IGARSS 2010, IEEE Int. Sys., and 2009/2010 HyspIRI workshops