Onboard Instrument Processing Operations 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)

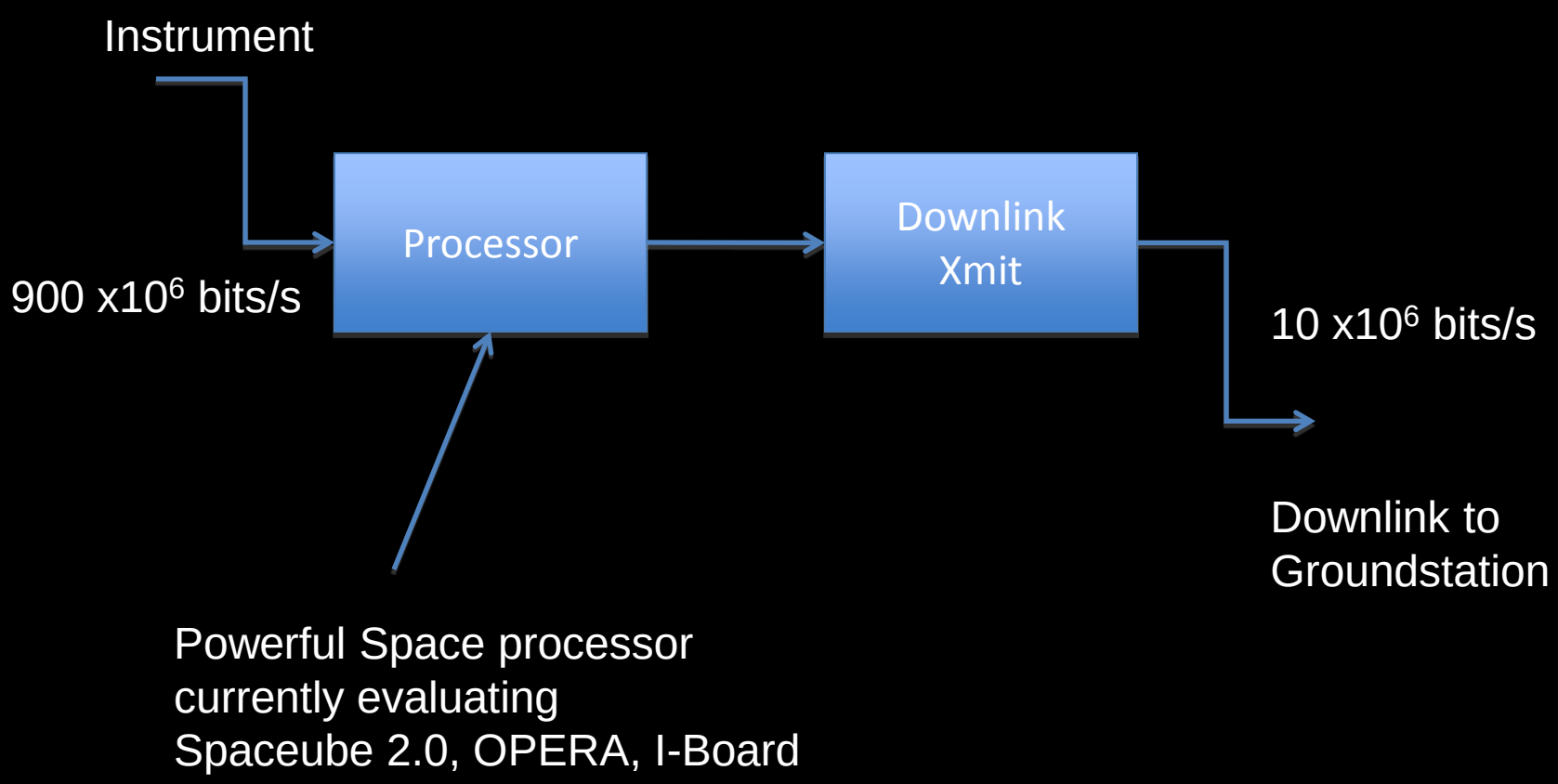
- In current use, DB downlinks all of the data acquired by the instrument

HyspIRI Direct Broadcast

- HyspIRI TIR + VSWIR will produce 900 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 2:1 compression we have a 45x oversubscription

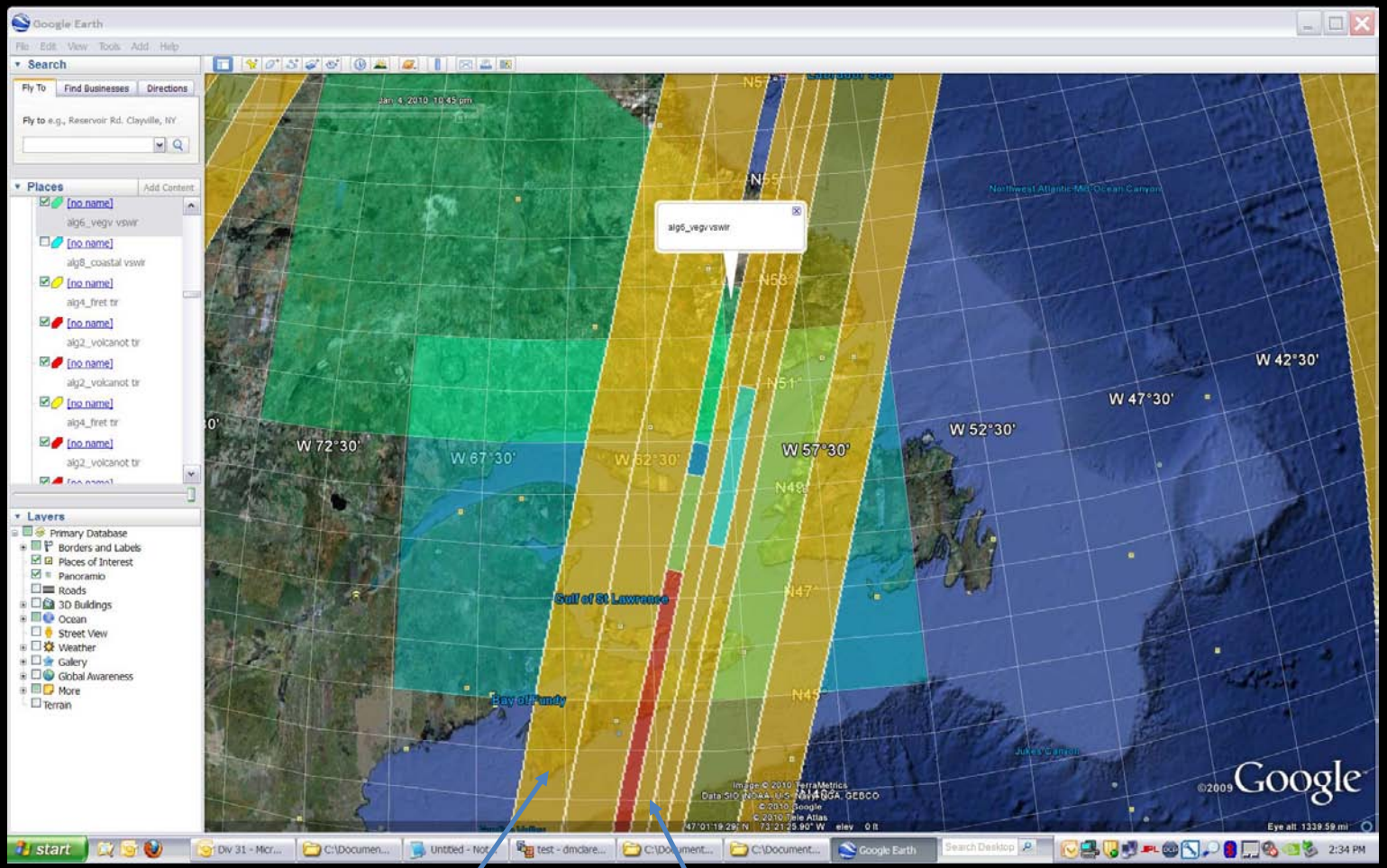
HyspIRI DB Concept



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)
- For each product, consider:dl bands, dl product
- 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

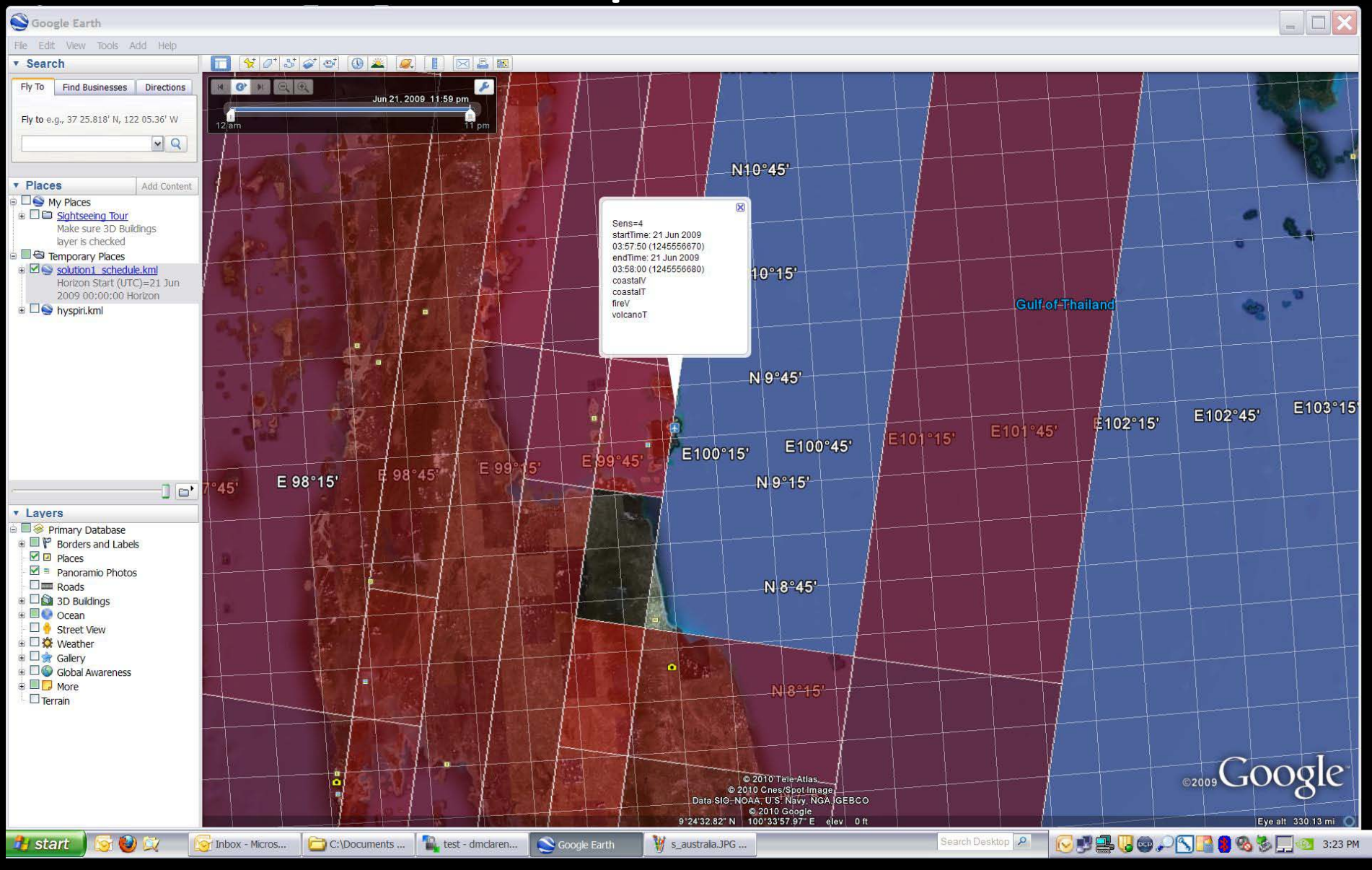
How much can we get down DB?

- 10 x 10^6 bits/s DB downlink = ?
- 1 band @ 14 bits (uncompressed) =
  - 3.2 x 10^6 bits/s 1 band 112.5km (unc)
  - 1.0 x 10^6 bits/s 1 band 37.5km (unc)
- Assuming 2:1 lossless comp
- ~20 small swaths bands or ~6 large
- Can also downsample spatially
- Considerable leverage from products

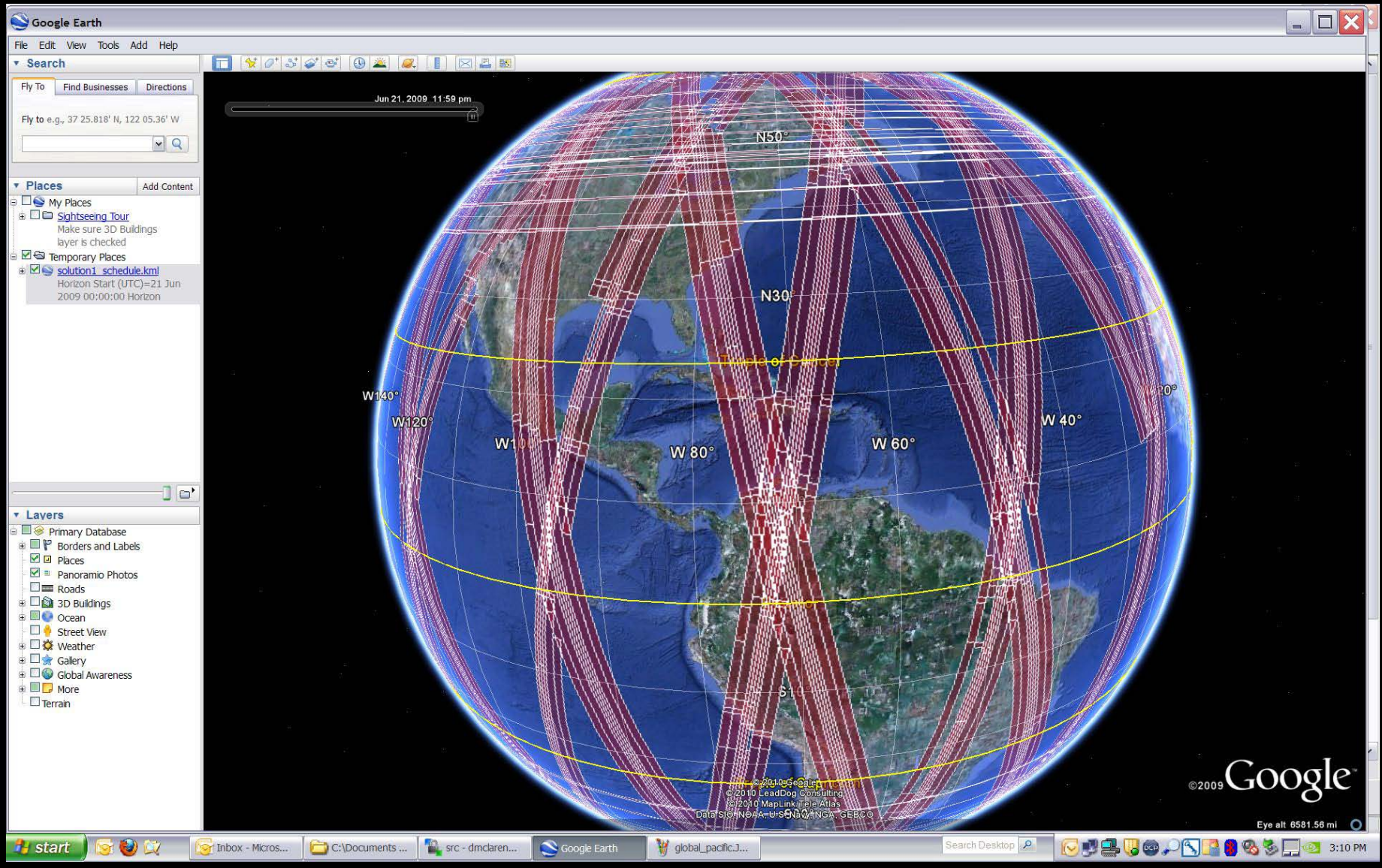
Automated Operations Planning

- 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., 37 25.818' N, 122 05.36' W
Places
Add Content
My Places
Sightseeing Tour
Make sure 3D Buildings layer is checked
Temporary Places
solution1_schedule.kml
Horizon Start (UTC)=21 Jun 2009 00:00:00 Horizon
Layers
Primary Database
Borders and Labels
Places
Panoramio Photos
Roads
3D Buildings
Ocean
Street View
Weather
Gallery
Global Awareness
More
Terrain
Jun 21, 2009 11:59 pm
N50°
N30°
W140°
W120°
W 80°
W 60°
W 40°
©2009 Google
Eye alt 6581.56 mi
start
3:10 PM

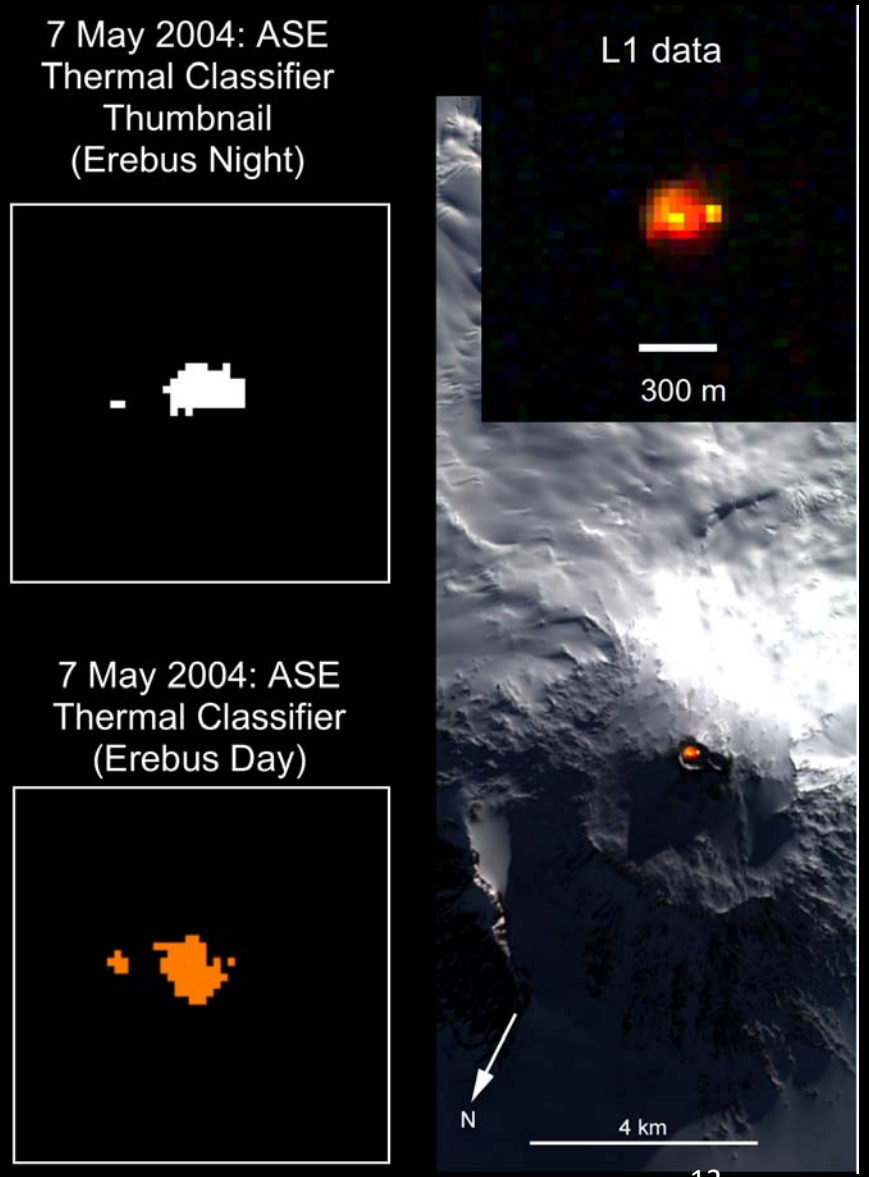
HyspIRI DB Applications

- Volcanos
- Fires
- Flooding
- Cryosphere
- Ocean

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

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

- EO-1
  - Onboard thermal event detection in use since 2004 using onboard Hyperion spectral signature
  - Uses spectral slope in 1.65-2.28μ (HyspIRI VSWIR)
  - 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]

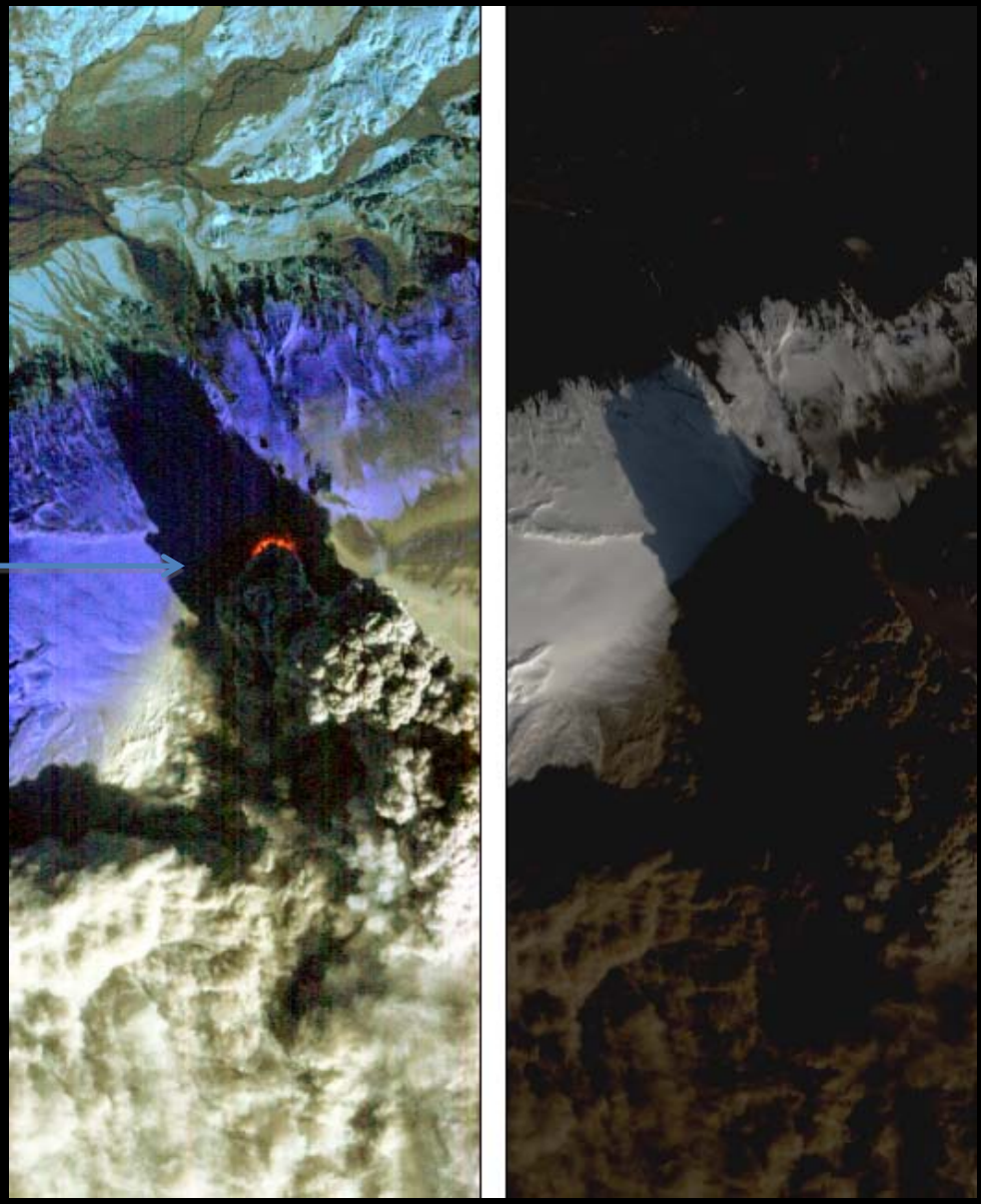
Iceland Imagery

Eyafallajökull

2 Giga Watt Thermal emission

Left – thermal false color
Right – True color

17 April 2010
Image credit:
NASA/JPL/EO-1
Mission/GSFC/Volcano
Sensorweb/Ashley
Davies



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})
  - 4μ and 11 μ available on HyspIRI TIR

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

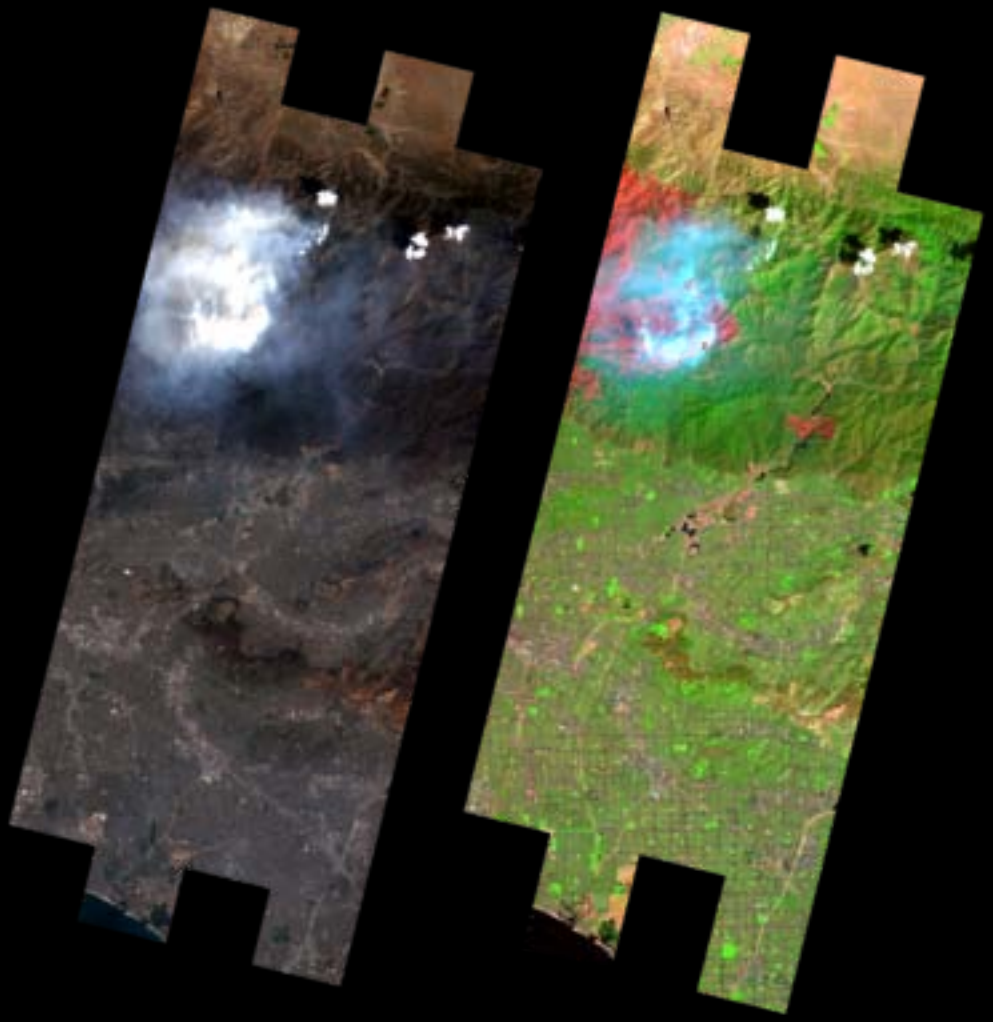
C. Justice et al.

Fires – Burn Scar

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

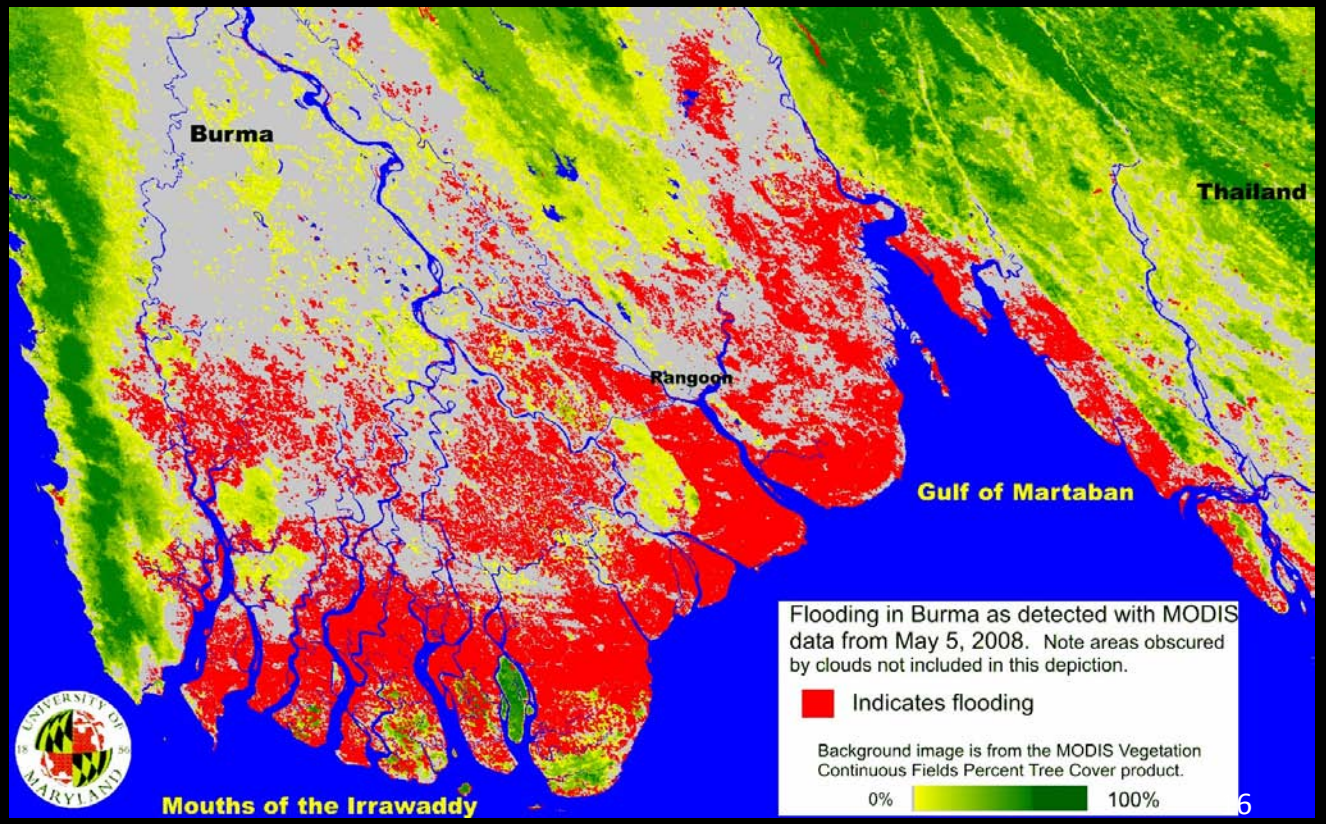
Images courtesy EO-1 Mission NASA GSFC

Burn scar:
0.76-0.90μm,
2.08-2.35μm
Both VSWIR



Flooding – Heritage (Ground) MODIS/UMD

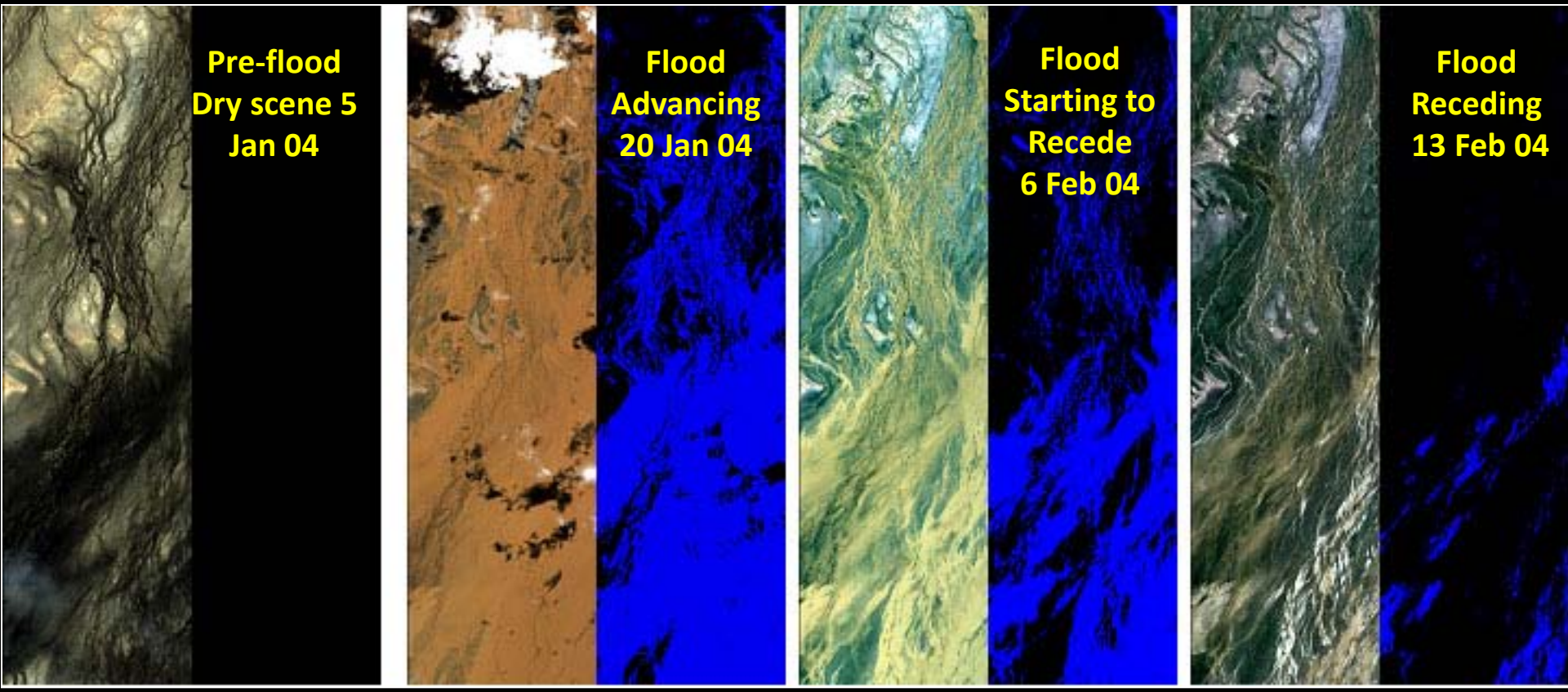
- UMD Flood tracking of Myanmar using MODIS bands 1,2,5,7 (620-2155 nm avail. on VSWIR)



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 (also 0.55 µm, 0.86 µm) available on VSWIR

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

Cryosphere (Ground)

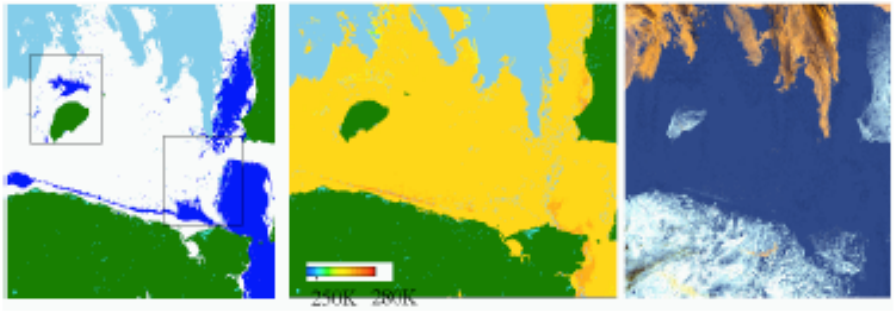


Figure 4: MODIS sea ice product by NDSI method (left), IST method calculated temperatures (center), and a composite image made from MODIS Bands 20 (3.7μm), 22 (3.9μm) and 23 (4.0μm) to highlight clouds (right).

Image courtesy of [Scharfen and Kalsa 2003]

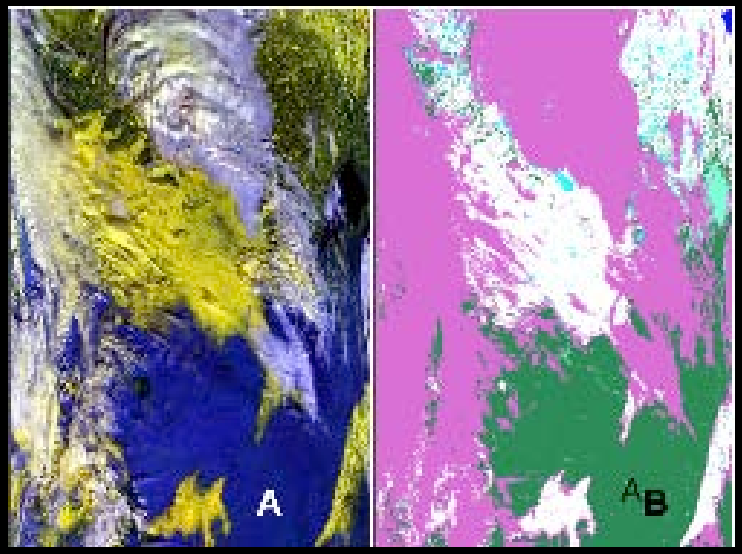


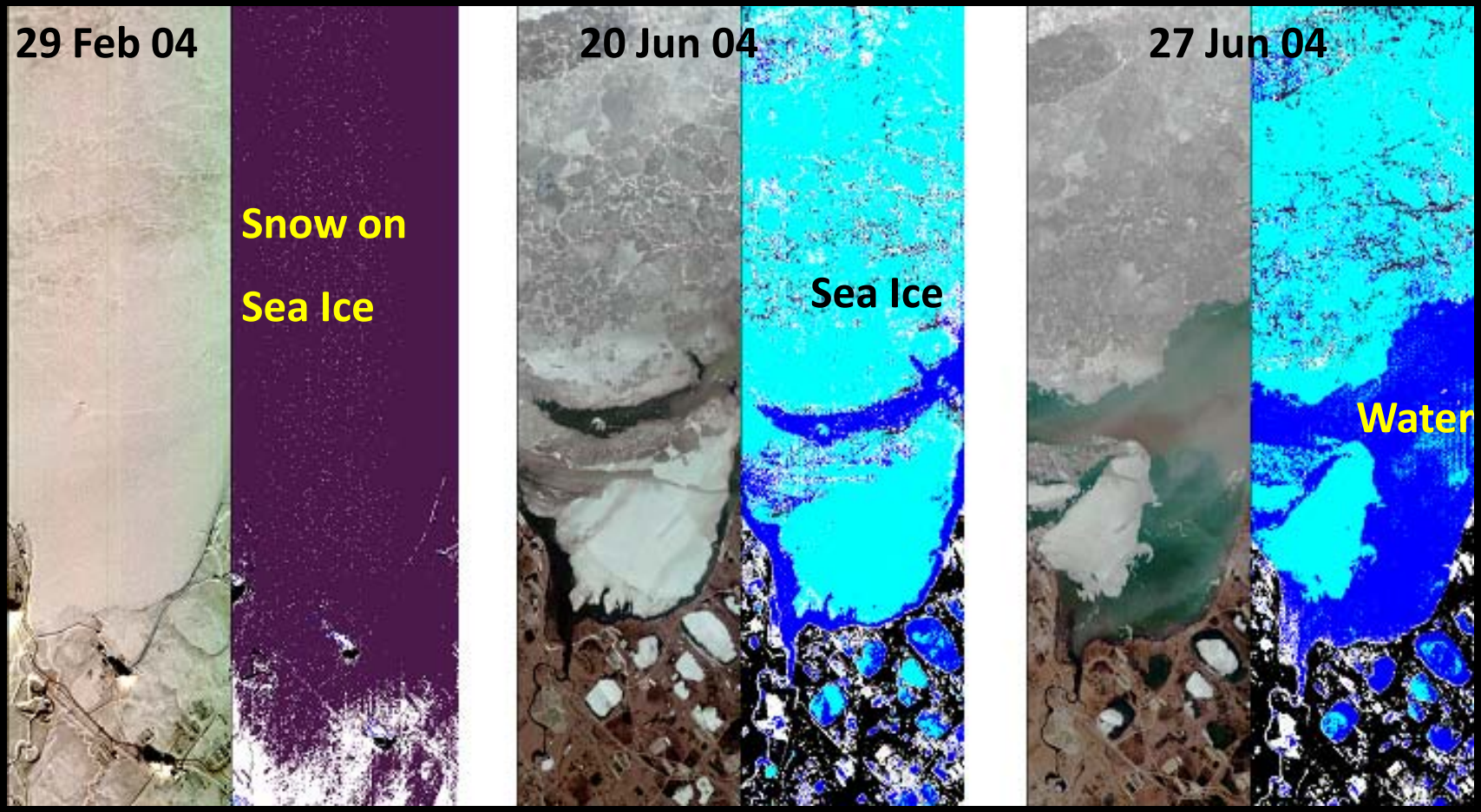
Figure 1 MODIS at-satellite reflectance image from swath of MOD02HKM for 3 January 2003 (A). Snow cover appears as yellow in this display of bands 1, 4 and 6. Snow cover map of the swath (B) and the snow cover map in sinusoidal projection (C).

Courtesy of *MODIS Snow Products User Guide*

MODIS Snow product algorithms will require both VSWIR and TIR

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

Deadhorse (Prudhoe Bay), Alaska

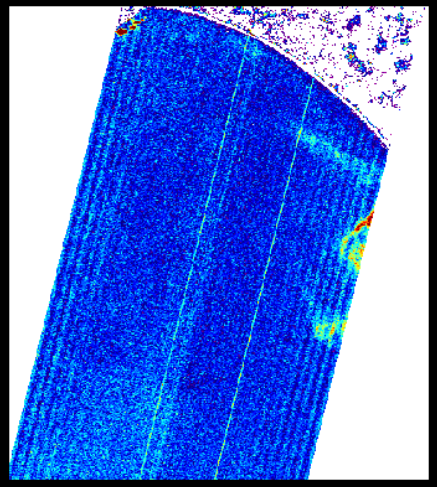


Snow
Water
Ice
Land
Unclassified

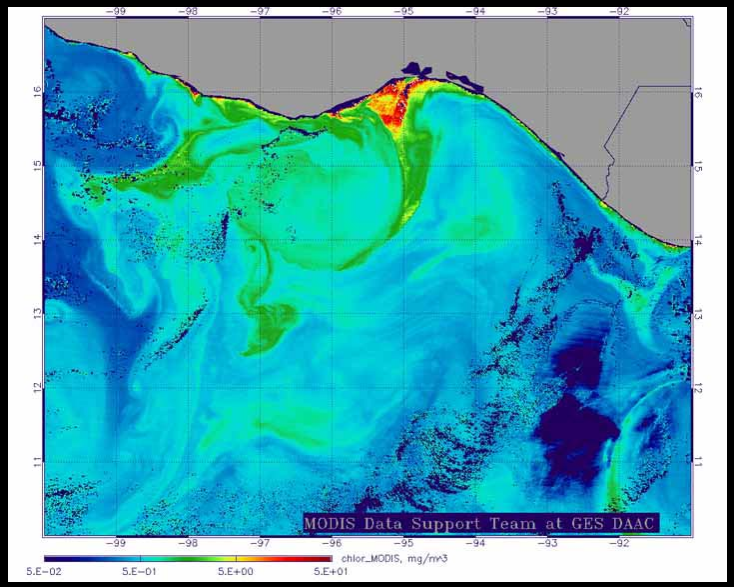
EO1/Hyperion data
Wavelengths used in classifier:
0.43, 0.56, 0.66, 0.86 and 1.65 µm (all avail. VSWIR)

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) These bands avail. VSWIR



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

Again avail. VSWIR.

Dust

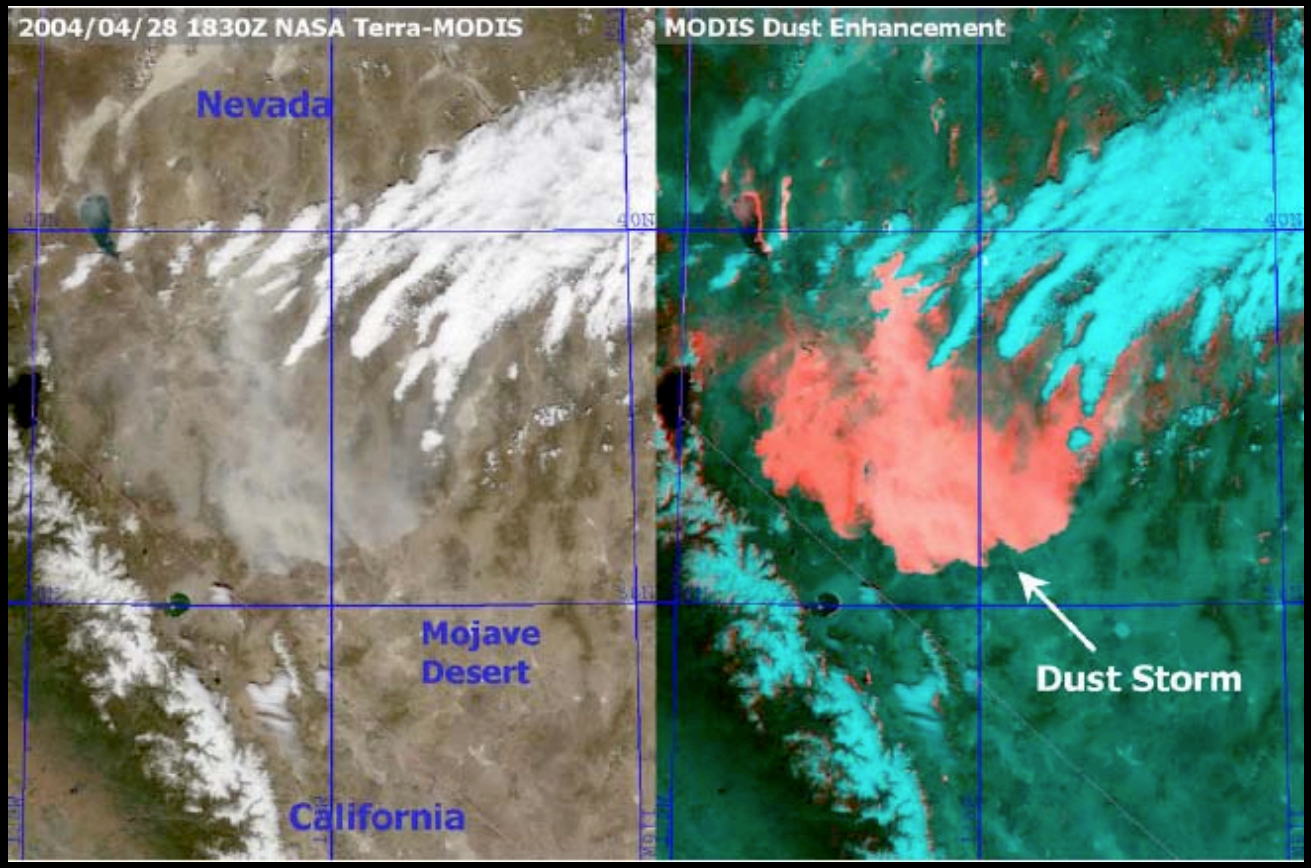


Image (processed MODIS) courtesy of *Satellite Product Tutorials: Desert Dust Storms, S. Miller et al.*
Algorithms would require both VSWIR and TIR bands.

Vegetation

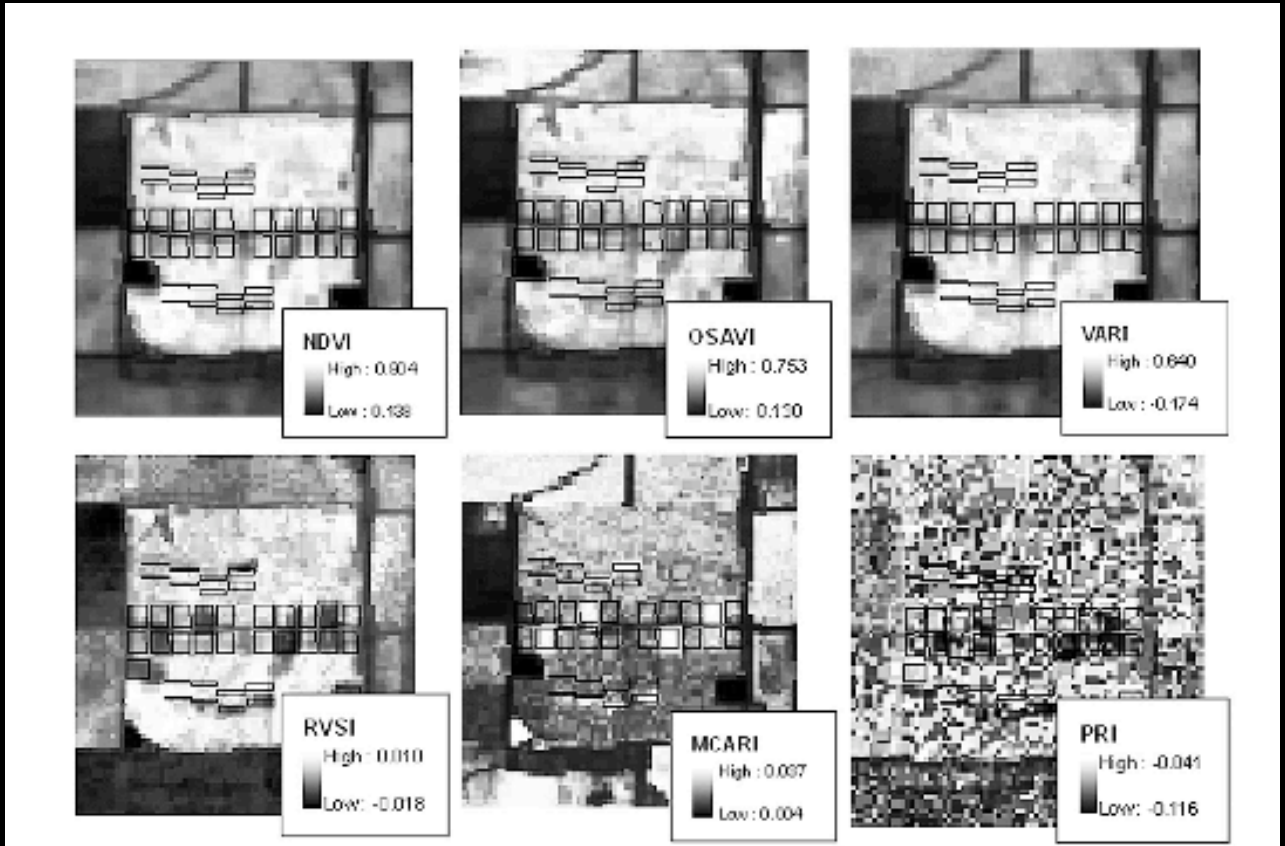


Fig. 3. Comparison of selected indices derived from 6 July Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) imagery (18-m spatial resolution) with locations of N trial plots and subpixel plots shown. The corresponding classification accuracies are shown in Table 7. Note the differences between 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. These bands are available in VSWIR data.

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 and automated