A Flight and Ground Operations Concept for the Intelligent Payload Module for the Proposed HyspIRI Mission

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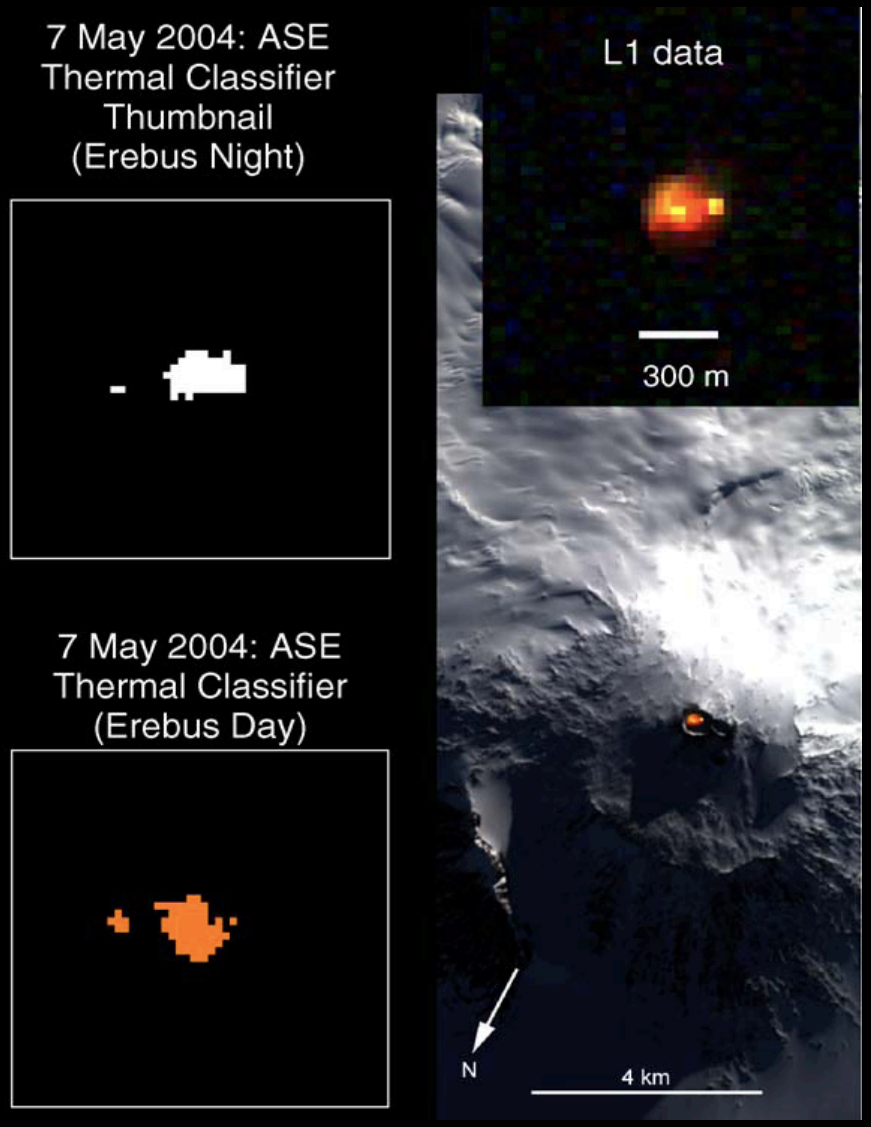
Intelligent Payload Module Summary

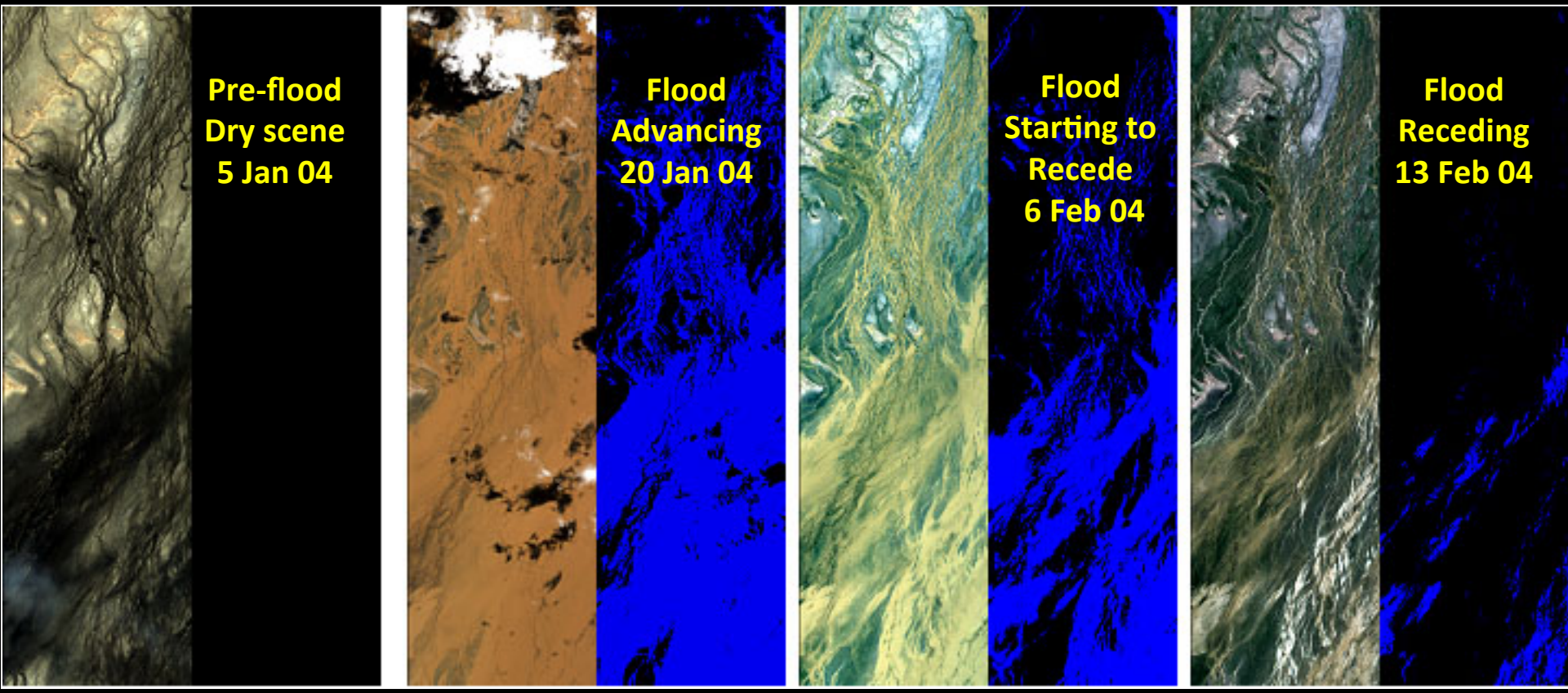
- The Intelligent Payload Module will enable near real-time downlink of selected subset (spatial, spectral, product) of VSWIR/TIR data using heritage Direct Broadcast/Direct Readout technology
- Direct Broadcast enables effective ~10 x 10^6 bits / sec out of VSWIR + TIR = ~ 800 x 10^6 bits/sec data stream

High Interest Heritage Products

Discipline	Products	Heritage (not exhaustive)	Interest
Cryosphere	Snow, Water, Ice Land	**Hyperion/EO-1 (onboard)**, MODIS, ASTER, AVHRR, Landsat (Ground)	High
Volcanology	Thermal emission	AVHRR, ASTER, MODIS (ground), **Hyperion (onboard)**	High
Hydrology	Surface Water Extent	MODIS, Landsat, WV2, Geo-Eye, Ikonos, ASTER (ground), **Hyperion (onboard)**	High
Wildfire	Thermal Mapping	MODIS, (Ground), **Hyperion (onboard)**	High
	Burn Scar	Landsat, AVHRR, Aviris, ALI, Hyperion, ASTER (ground)	High

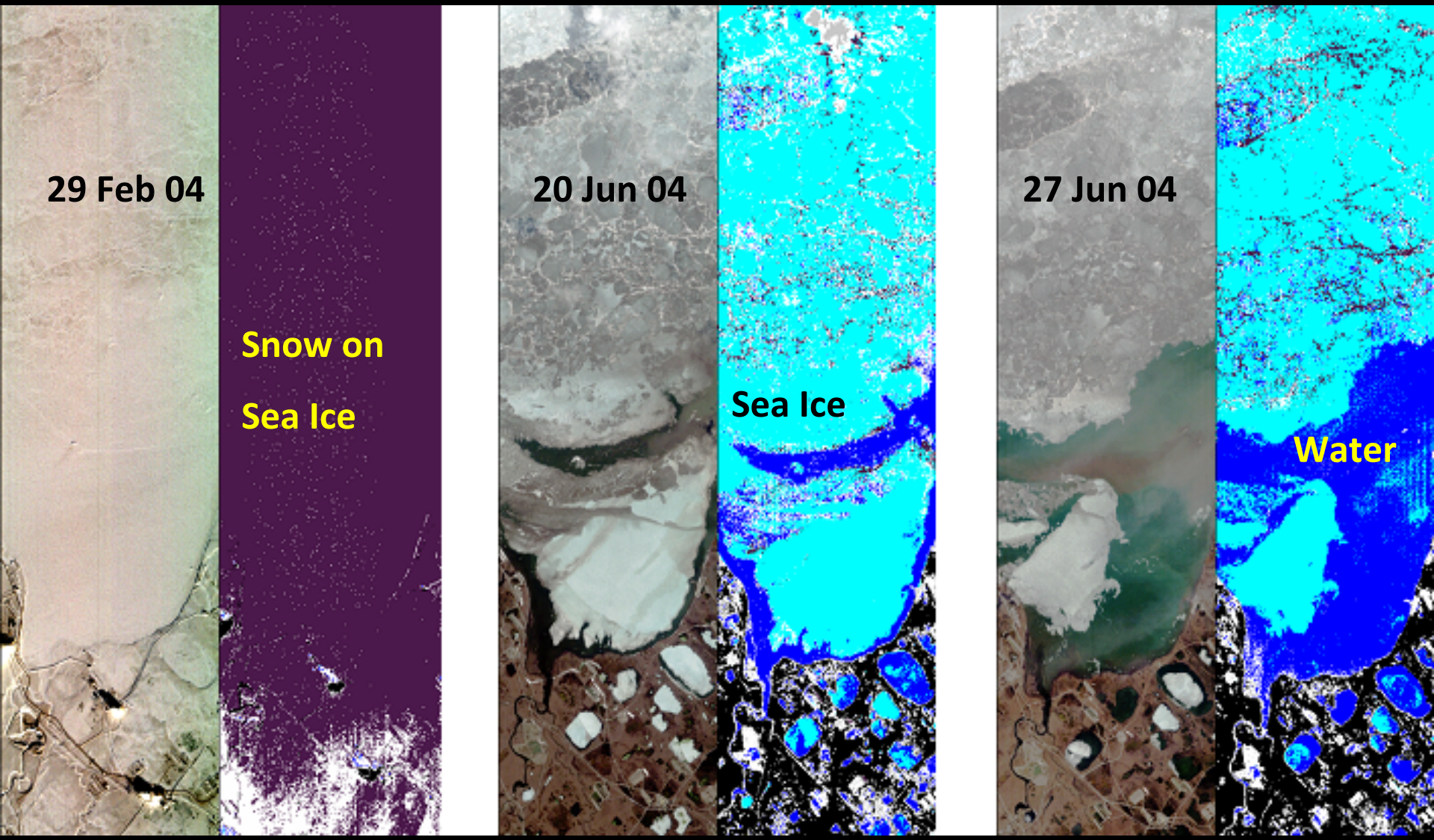


EO-1/ASE Onboard:
At left hot and extreme pixel classification maps developed onboard from Hyperion Data.
At right Level One full data downlinked and processed on ground. Both acquired of the Mount Erebus volcano 7th May 2004 on two overflights.
Courtesy NASA/GSFC/ EO-1, A. Davies.
For further information: [Davies et al. 2006, RSE]



EO-1: Onboard derived flood maps of Diamantina River, Australia, 2004.

For further information: [Ip et al. 2006, RSE] Courtesy NASA/GSFC/EO-1/U. AZ/JPL



Snow
Water
Ice
Land
Unclassified

EO-1 Onboard: Cryosphere Classifier

Deadhorse (Prudhoe Bay), Alaska

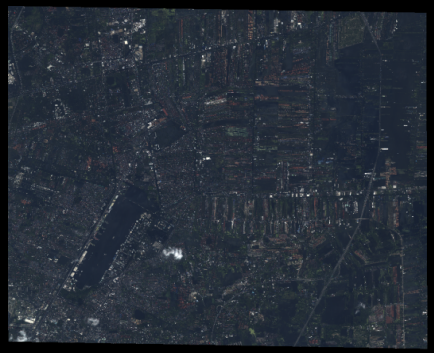
For further information: [Doggett et al. 2006 RSE]

Courtesy NASA/EO-1/GSFC/ASU

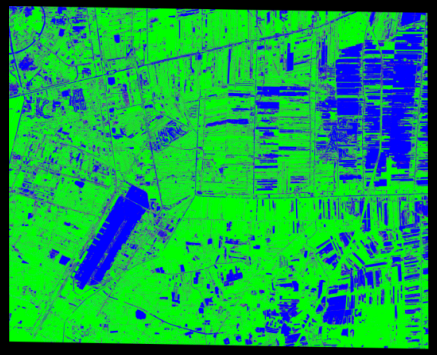
More Advanced Products

Flood Tracking

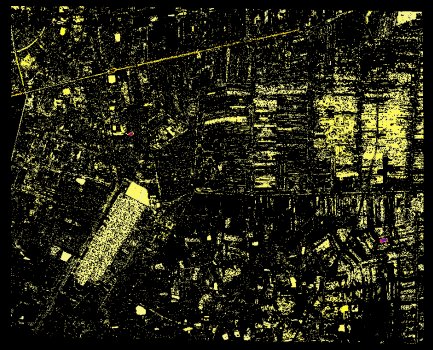
- Integrated WV-2 data (2m spatial resolution)
- Developed algorithms and workflows for water depth and volume estimation (incorporating DEM) – potential HyspIRI IPM algorithms



Reflectance of WV2 scene of Bangkok w/ flooded Don Muang Airport, acquired 11.3.2011



Surface water extent (blue) from SVM classifier using 5th degree polynomial kernel on 8 WV2 bands

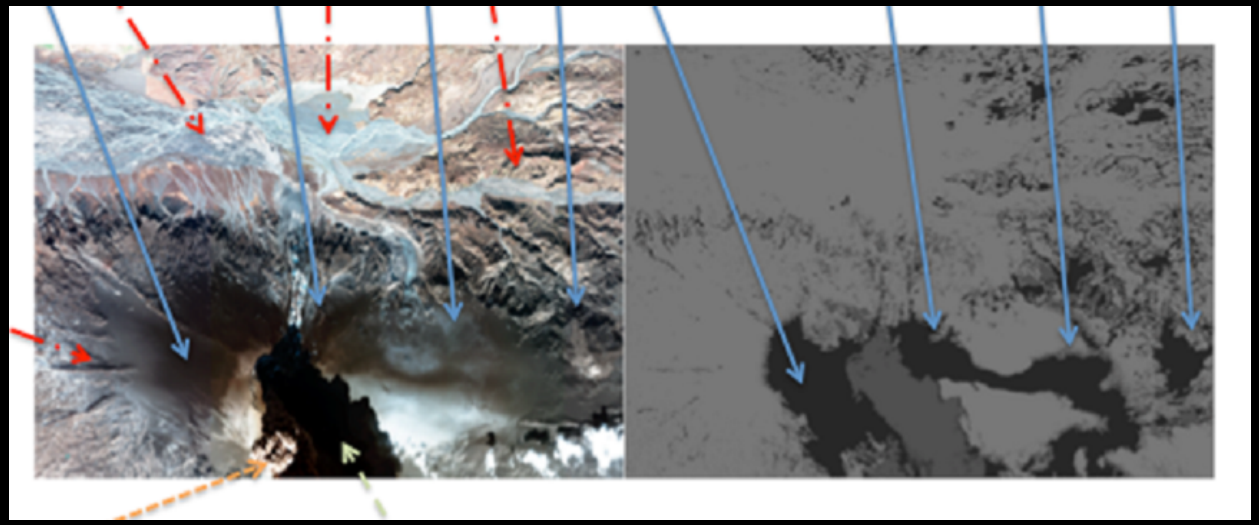


Resulting water depth map calculated using SVM-classified surface water extent map and DEM. Total water volume calculated: ~27,872,000 m^3; average flooded pixel depth: 0.64 m.

For further details see [Mclaren et al. 2012a, SPIE]

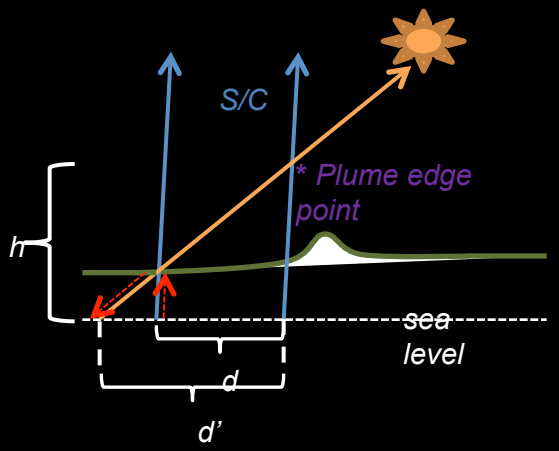
Volcanic Plume Height Estimation

ground as plume
shadow as shadow
plume as plume
ground, ice as ground



Histogram-equalized WV2 image, acquired May 17, 2011

Classification map: black = plume, grey = shadow, light = land



***d** : Initial shadow length*
***d'**: Shadow length after projecting up to DEM & down along sun vector*
***h** : Plume point height*

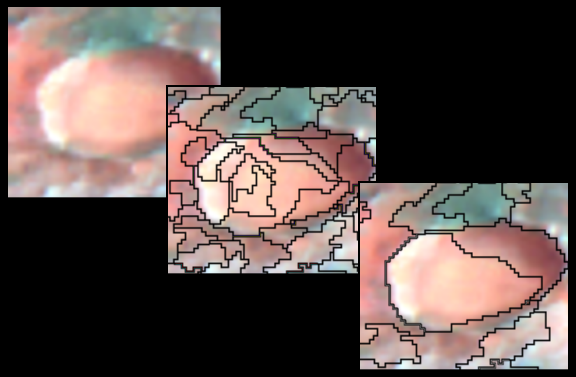
Plume & Shadow Classification using TextureCam Decision Forest Machine Learning [Thompson et al., LPSC, 2012]

Plume height calculation using classification, viewing and solar geometry, DEM.

Reasonable correlation with visual, radar based measurement from [Arason et al. 2011]

For further details see [Mclaren et al. 2012b, SPIE]

Onboard Hyperspectral Analysis

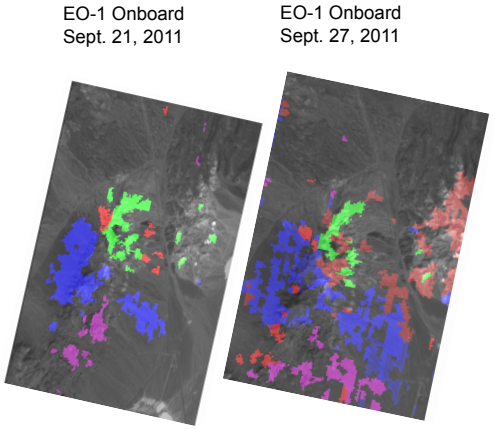


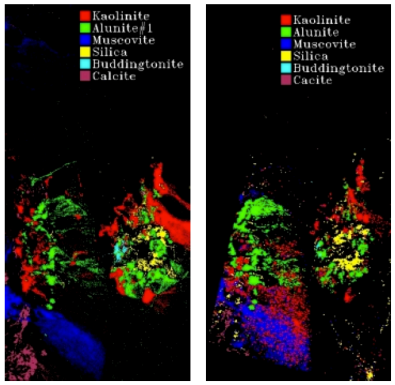
Superpixel segmentation
+
SMACC endmember extraction
=
onboard spectral search

Results from onboard EO-1 (9/2011)

For further details see
[Thompson et al 2009, TGARS]
[Thompson et al. 2012, i-SAIRAS]

Repeatability: maps

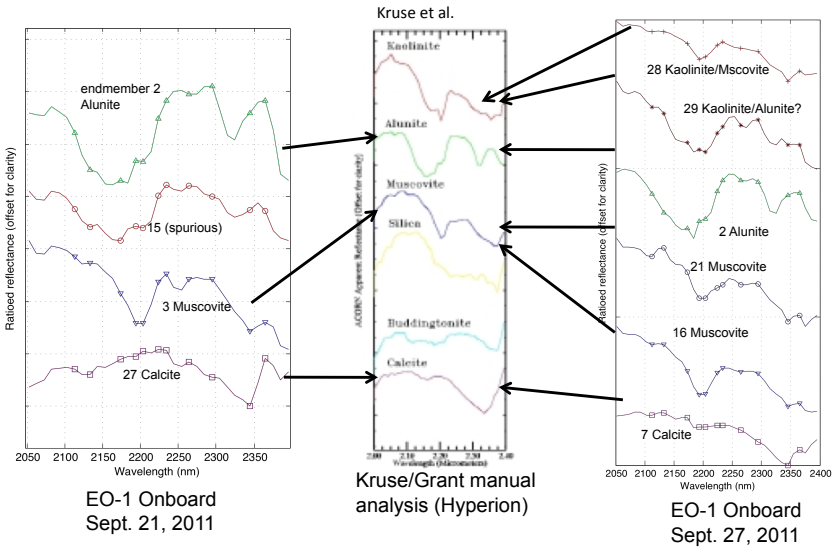




Kruse/Grant manual analysis (AVIRIS)

Kruse/Grant manual analysis (Hyperion)

Repeatability: detections



EO-1 Onboard
Sept. 21, 2011

Kruse/Grant manual analysis (Hyperion)

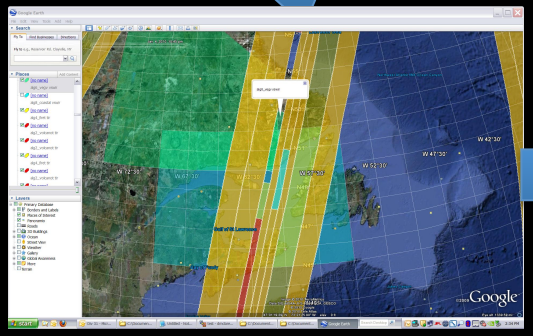
EO-1 Onboard
Sept. 27, 2011

Intelligent Payload Module Operations

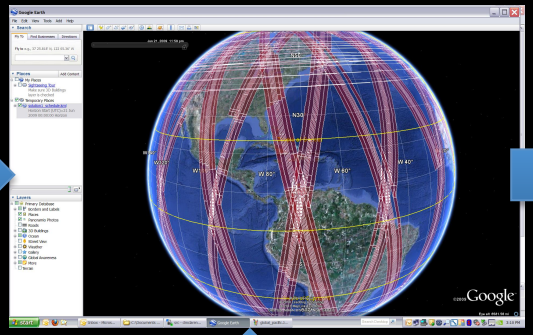
- How will Ground/Science/Applications team designate which data/products to downlink?

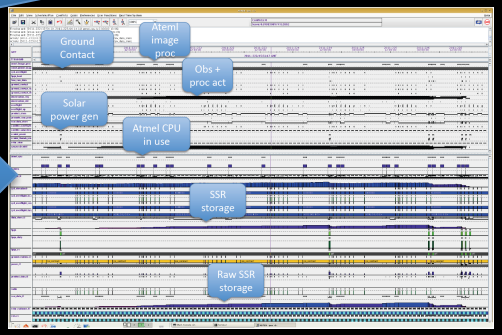
HyspIRI IPM Operations Concept

Users input product requests in Google Earth



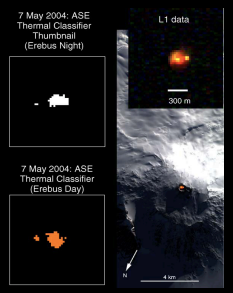
Planning system determines products based on overflights and resources (CPU, RAM downlink) CLASP+ ASPEN (ground), CASPER (onboard)





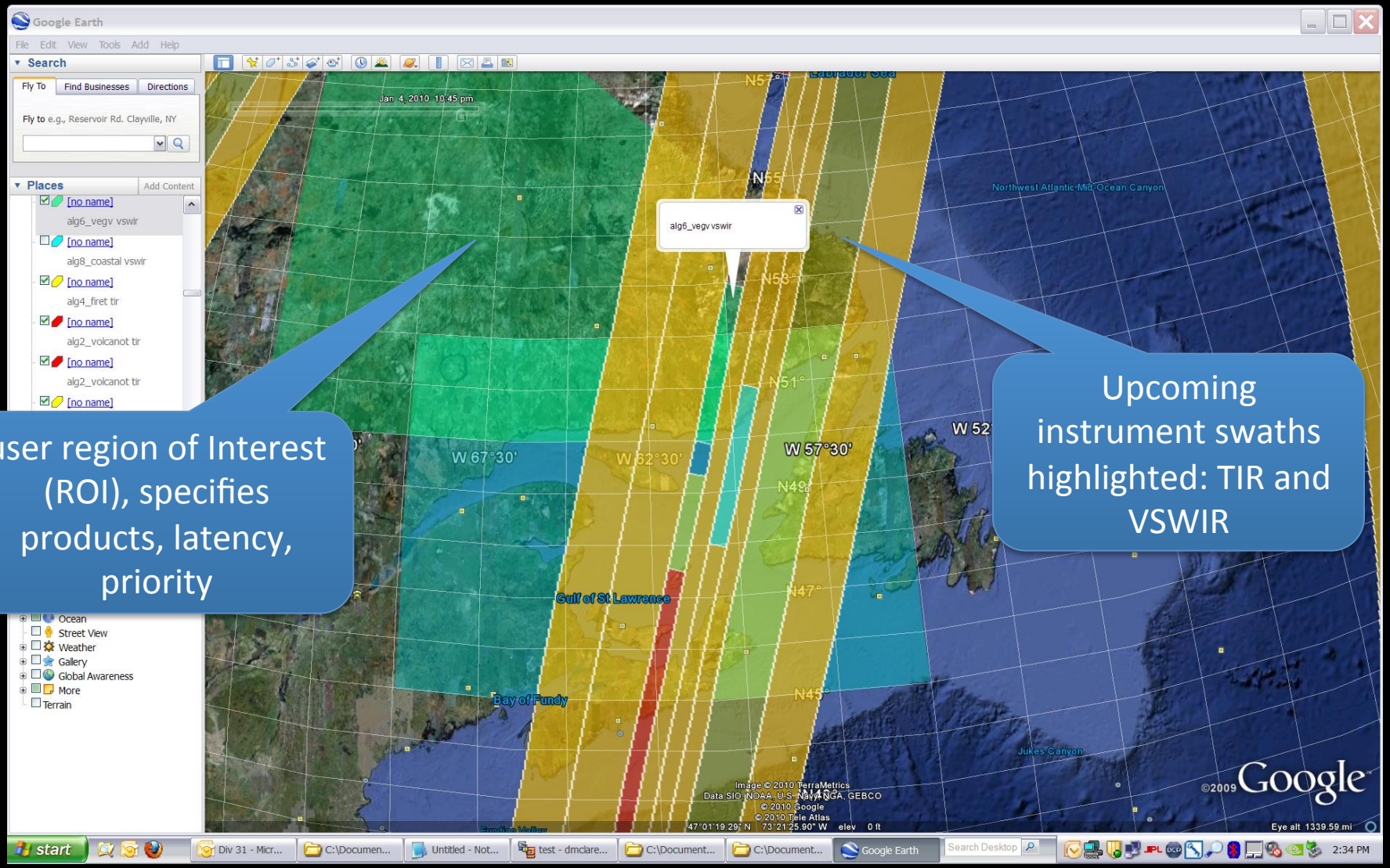
Electronic automatic tasking requests via Sensorwebs

Spacecraft acquires imagery, generates product onboard (including onboard event detection), downlinks product



"lights out" payload operations

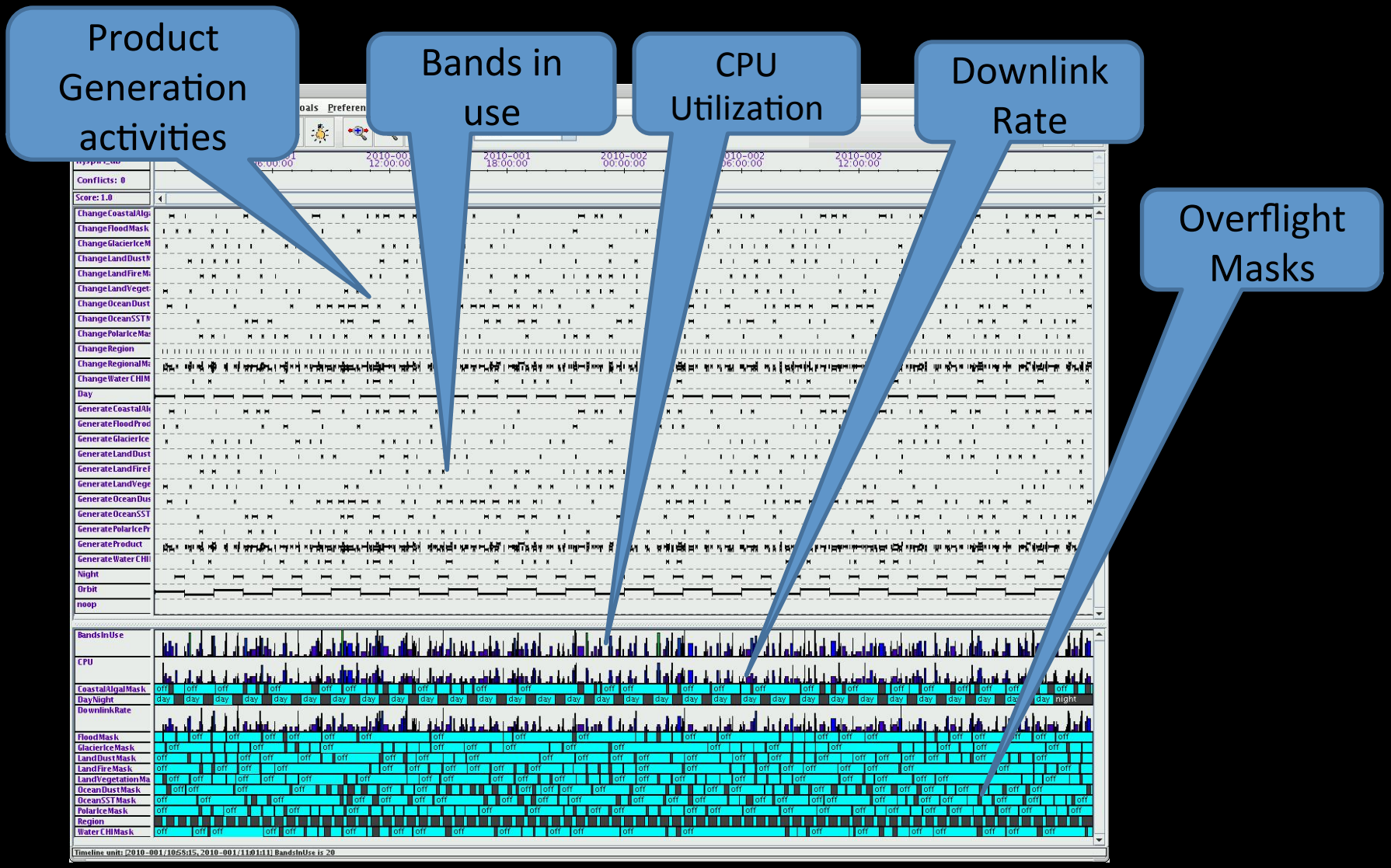
Input via Google Earth KML



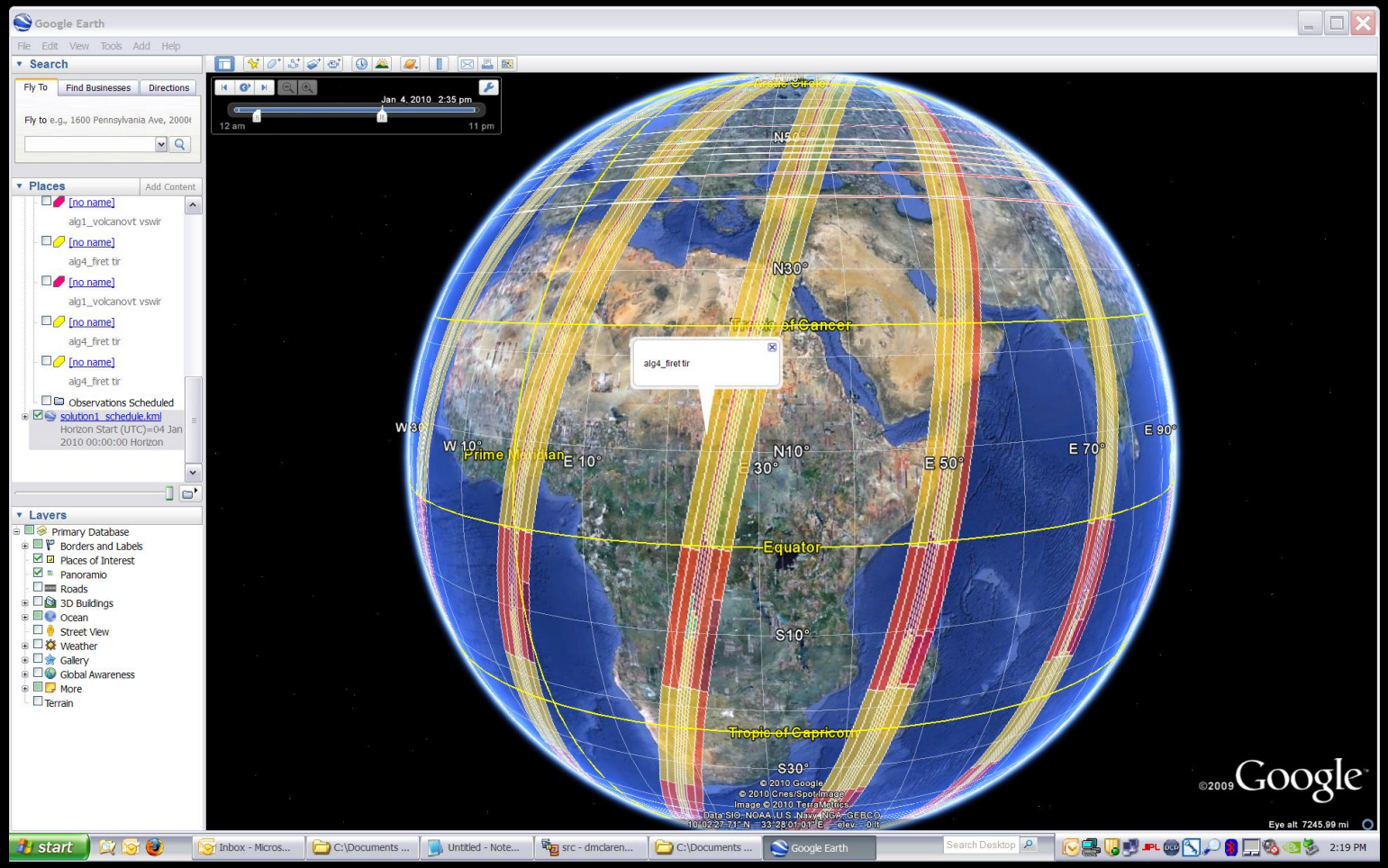
user region of Interest (ROI), specifies products, latency, priority

Upcoming instrument swaths highlighted: TIR and VSWIR

ASPEN Generated Processing + D/L Plan



Users can view upcoming acquisition and processing plans

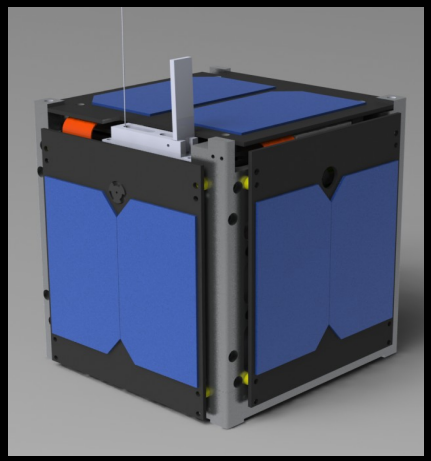


Operations Concept Maturity

- The software for this automated operations concept is *already implemented*.
- Software was first demonstrated in 2010, and has undergone minor enhancements since.
  - Enhancement: specification of latency so that products can be designated for later downlink over desired target ground stations.
  - Enhancement: enables dynamic across track swaths based on overlap with regions of interest

Intelligent Payload Experiment (IPEX)

- IPEX Cubesat will validate elements of HyspIRI IPM concept (launch scheduled 10/13)
  - IPEX will generate products onboard
    - Some based on onboard image analysis
  - IPEX will use proposed HyspIRI IPM web-based, automated operations concept



IPEX Model

Image from July 2012 balloon test flight

IPEX Acquisition Plan

Conclusions

- HyspIRI Intelligent Payload Module will enable delivery of low-latency products and data subsets (spectral, spatial)
  - Mature, heritage (minimal onboard computing required) and
  - More advanced products (enhanced onboard computing needed)
- Operations concept uses a *simple, web-based interface* to specify products, regions, priorities
- Operations concept is *fully automated* and *does not require dedicated operations staff*