GSFC Activities in Support of HyspIRI

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Petya Campbell (NASA/UMBC)
HyspIRI: Building on NASA Hyperion Technology Demonstration

SNR > 10X

Uniformity > 10X

Swath > 10X

Soil C:N Ratio
White Mountain National Forest, NH

Global Coverage >> 10X
Earth Observing-1 (EO-1) Mission

EO-1 was designed to flight validate technologies and operational approaches applicable to future Earth observing missions. Launched on November 21, 2000, it is currently in its 9th year, with more than 40,000 scenes in archive.

![Image of EO-1 satellite](http://eo1.gsfc.nasa.gov/)

### ALI

<table>
<thead>
<tr>
<th>Band designations</th>
<th>Band Names (wavelength, μm)</th>
<th>Hyperion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pan</td>
<td>Pan (0.48 – 0.69)</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>MS-1p (0.433 – 0.453)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MS-1 (0.450 – 0.515)</td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>MS-2 (0.525 – 0.605)</td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>MS-3 (0.633 – 0.690)</td>
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<tr>
<td>NIR</td>
<td>MS-4 (0.775 – 0.805)</td>
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<tr>
<td></td>
<td>MS-4p (0.845 – 0.890)</td>
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<tr>
<td>SWIR</td>
<td>MS-5p (1.20 – 1.30)</td>
<td>Continuous Spectra</td>
</tr>
<tr>
<td></td>
<td>MS-5 (1.55 – 1.75)</td>
<td>0.4 – 2.4 μm</td>
</tr>
<tr>
<td></td>
<td>MS-7 (2.08 – 2.35)</td>
<td>242 Bands</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>Pan: 10m, MS: 30m</td>
<td>Bandwidth: 10nm</td>
</tr>
<tr>
<td>Swath width</td>
<td>37km</td>
<td>7.5km</td>
</tr>
</tbody>
</table>

Heritage: EO-1 Hyperion Op’s/Analysis addresses a broad range of issues and world-wide sites.

- Forests
- Minerals
- Grasslands
- Glaciers
- Deserts
- Agriculture

- Canada
- United States
- Argentina
- Antarctica
- Sahara
- Australia
EO-1 2009 Goals towards enabling HyspIRI

• Providing spectroscopy data for sensors inter-calibration;
• Generating Validation Datasets – validation of other sensors response and for validation of science products;
• Developing new EO-1 MSO science level products;
• Automated Tools & Intelligent Payload Module (IPM)– related support for data throughput;
• Rapid Remote Sensing and SensorWebs for Disaster response – fire, flood, volcanoes;
• Sources of high spectral resolution data;
• Hyperion applications: Discrimination of land cover types and vegetation species composition (classifications), Spectral un-mixing, Canopy Water content and Foliar chemistry, etc.
To date, over 42,500 scenes have been acquired, 2001-2009
These acquisitions could be summarized into three main categories: Science and disaster response, Global Land Survey (GLS2005 and GLS2010), and Calibration/Validation collects
Calibration Efforts
sensor inter-comparisons

Validation Activities
evaluate products
Comparison of the Hyperion integrated lunar responses with the USGS ROLO Lunar model

The Hyperion response has remained stable over the last eight years.
Solar Panel Spectra

Spectra of the solar panel show large degradation in the shorter wavelengths.
Cal/Val Targets: Repeated Collections Coordinated by Committee on Earth Observing Satellites (CEOS/WGCV/IVOS)

CEOS/WGCV Calibration Sites

1. Tuz Golu, Turkey * (priority)
2. Frenchman Flat, USA
3. La Crau, France (only suitable for high resolution)
4. Dunhuang, China
5. Railroad Valley, USA
6. Ivanpah playa, USA
7. Negev, Israel
8. Libya 4
9. Mauritania 1
10. Mauritania 2
11. Algeria 3
12. Libya 1
13. Algeria 5

USGS: World-wide Test Sites for Sensor Characterization
FY2008, WGCV Pilot study for GEO Task DA-06-02: EO-1 participated by contributing data for inter-comparison of AVHRR, MODIS and SeaWiFS.

FY 2009, CEOS Dome C Instrument comparison underway: As part of this campaign, during the winter of 2008-2009 EO-1 collected a number of new images.
<table>
<thead>
<tr>
<th>Site name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>IGBP Cover Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1st priority</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BARC- USDA ARS</td>
<td>39.03</td>
<td>-76.85</td>
<td>Broadleaf Cropland</td>
</tr>
<tr>
<td>Barrow</td>
<td>71.322525</td>
<td>-156.625881</td>
<td>grassland</td>
</tr>
<tr>
<td>Bartlett Experimental Forest- New Hampshire</td>
<td>44.06464</td>
<td>-71.288077</td>
<td>Mixed forest</td>
</tr>
<tr>
<td>British Columbia, DF49</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>SERC</td>
<td>38.53°N</td>
<td>-76.33°W</td>
<td>Mixed Hardwoods</td>
</tr>
<tr>
<td>Bondville</td>
<td>40</td>
<td>-88.29154</td>
<td>BroadleafFLX Cropland</td>
</tr>
<tr>
<td>Vancouver Island, British Columbia, CA</td>
<td>49°52'7.8&quot;N</td>
<td>125°20'6.3&quot;W</td>
<td>Douglas fir</td>
</tr>
<tr>
<td>BOREAS/BERMS SSA</td>
<td>53.65</td>
<td>-106.2001</td>
<td>Southern Boreal Forest</td>
</tr>
<tr>
<td><strong>2nd priority</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvard Forest</td>
<td>42.53</td>
<td>-72.17</td>
<td>Northern Hardwoods</td>
</tr>
<tr>
<td>Howland Forest (main tower)- Maine</td>
<td>45.20407</td>
<td>-68.740278</td>
<td>Mixed forest</td>
</tr>
<tr>
<td>Jornada</td>
<td>32.6</td>
<td>-106.86</td>
<td>Shrubland/Woodland</td>
</tr>
<tr>
<td>Konza Prairie</td>
<td>39.08</td>
<td>-96.56</td>
<td>Grassland/Cereal Crop</td>
</tr>
<tr>
<td>Sevilleta</td>
<td>34.344</td>
<td>-106.671</td>
<td>Grassland/Cereal Crop</td>
</tr>
<tr>
<td>Wisc: NTL LTER - Park Falls</td>
<td>45.9454</td>
<td>-90.27248</td>
<td>Needle leaf Forest</td>
</tr>
<tr>
<td>ARM/CART Ponca City (28/34 Landsat)</td>
<td>36.77</td>
<td>-97.13</td>
<td>Agriculture (Wheat)</td>
</tr>
<tr>
<td>Duke Forest-hardwoods- North Carolina</td>
<td>35.973582</td>
<td>-79.10043</td>
<td>Mixed forest</td>
</tr>
<tr>
<td>Metolius/Cascades OR (Landsat 45/29)</td>
<td>44.452432</td>
<td>-121.557166</td>
<td>Evergreen needle leaf forest</td>
</tr>
<tr>
<td>Virginia (costal reserve)</td>
<td>37.42</td>
<td>-75.7</td>
<td>Broadleaf Cropland</td>
</tr>
<tr>
<td>ARM/CART SGP</td>
<td>36.64</td>
<td>-97.5</td>
<td>Grassland/Cereal Crop</td>
</tr>
<tr>
<td>ARM/CART Shider</td>
<td>36.93</td>
<td>-96.86</td>
<td>Grassland</td>
</tr>
<tr>
<td>Cascades, Springfield, IL</td>
<td>44.25</td>
<td>-122.25</td>
<td>forest</td>
</tr>
<tr>
<td>Walker, Oak Ridge, Tennessee, USA</td>
<td>35.96</td>
<td>-84.31</td>
<td>forest</td>
</tr>
<tr>
<td>WindRiverCraneSite, Washington</td>
<td>45.82049</td>
<td>-121.95191</td>
<td>forest</td>
</tr>
<tr>
<td>Québec, CA</td>
<td>49.69247</td>
<td>-74.34204</td>
<td>Mature site</td>
</tr>
<tr>
<td>Krasnoyarsk</td>
<td>57.27</td>
<td>91.6</td>
<td>Deciduous needleleaf</td>
</tr>
<tr>
<td>Yakutsk-Larch Russia</td>
<td>62.255</td>
<td>129.618889</td>
<td>Larix gmelinii (100-160 yrs.)</td>
</tr>
<tr>
<td>Zotino Russia</td>
<td>60.8007972</td>
<td>89.350806</td>
<td>Coniferous forest, central Siberia</td>
</tr>
<tr>
<td>Shortandy, Kazhstan</td>
<td>51.5736111</td>
<td>71.259722</td>
<td>dry step (short grass, wheat and hey)</td>
</tr>
<tr>
<td>St. Petersburg, Russia</td>
<td>59°56'N</td>
<td>30°18'E</td>
<td>Deciduous/conifer mixed forest</td>
</tr>
<tr>
<td>Changbaishan, China</td>
<td>42.4025</td>
<td>128.095833</td>
<td>Deciduous/conifer mixed forest</td>
</tr>
<tr>
<td>Hyytiala, Finland</td>
<td>61.847415</td>
<td>24.29477</td>
<td>Evergreen needleleaf forest</td>
</tr>
<tr>
<td>Sodankyla, Finland</td>
<td>67.3618611</td>
<td>26.637833</td>
<td>Evergreen needleleaf forest</td>
</tr>
<tr>
<td>Avignon, France</td>
<td>43.9163889</td>
<td>4.879167</td>
<td>Cropland and deciduous broadleaf</td>
</tr>
<tr>
<td>La Crau, France</td>
<td>43.9163889</td>
<td>4.879167</td>
<td>cropland (wheat, rice, corn, meadow)</td>
</tr>
<tr>
<td>Barrax, Spain</td>
<td>39°3'44&quot; N</td>
<td>2°6'10&quot; W</td>
<td>various crops</td>
</tr>
</tbody>
</table>
EO-1 ALI data for reefs and islands are used in the Mid-Decadal Global Land Surveys 2005 and 2010 (±2 yr)

EO-1 scenes used in the Mid-Decadal Global cover 56% of the island content of the GLS2005

Quality
- Acceptable/Close: 21%
- Close: 15%
- Marginal: 4%
- Not Good: 20%
- Not Acquired: 23%
- Cancelled: 3%
Plant Growth Experiment Site at USDA Beltsville Agricultural Research Center

The EOS Validation Site - Located at the USDA Beltsville Agricultural Research Center is part of an intensive multi-disciplinary project entitled Optimizing Production Inputs for Economic and Environmental Enhancement (OPE).

The site has four hydrologically bound watersheds, about 4 ha each labeled as A through D which feed a wooded riparian wetland and first-order stream.

Carbon and nitrogen cycle dynamics - are being probed with a hybrid fluorescence and reflectance remote sensing approach. An intensive ground sampling protocol was initiated in 2001.
Remotely Sensed Reflectance Indices
Tracking Corn Grain Yield
Canopy Optical Properties

**Canopy Reflectance**
The ASD FieldSpec-Pro radiometer was used to measure radiance 1 m above plant canopies with a 22° field of view and a 0° nadir view zenith angle. The radiometer has 3 nm Full-Width at Half Maximum (FWHM) spectral resolution at a 1 nm sampling resolution.

**Leaf Area Index**
LAI was determined using the LI-2000 Plant Canopy Analyzer with a single above canopy and four below canopy data points at each *in situ* measurement location.
Reflectance and reflectance derivative spectra (x100) for high N (solid) and low N (dashed) field corn at five observation levels

A) leaf integrating sphere with ASD spectral radiometer,
B) above canopy at 1m with ASD spectral radiometer,
C) AISA aircraft multispectral sensor,
D) AVIRIS aircraft hyperspectral imager,
E) EO-1 Hyperion orbital hyperspectral imager.
Prototyping & Evaluating
Science Products
Level 2-3
EO-1 Hyperion Science Products & Tools

1. Reflectance (%) **
2. Vegetation spectral bio-indicators (VIs) **
3. LAI (MODIS C4, SPOT/Veg, AVHRR, MERIS, other) *
4. fPAR (MODIS, AVHRR, other) *
5. Total chlorophyll (modeled Cab) **
6. Albedo (MOD43) *
7. LUE **
8. Landsat - greenness, wetness *
9. Canopy chemistry (WGCV/LPV!)**
Modeling Products (Maps of LAI, fAPAR, fCover, Chlorophyll, Albedo)

Spectral Products (Maps of Vis, Vegetation condition, Chemistry, APAR)

Reflectance Means and Variation

EO-1 Hyperion Images (Level 1, Radiance)

Assessment of Atmospheric Correction and R% stability

Reflectance (R%)

FLAASH
ACORN
ATREM

Others (MODIS based)

VIS
VIS & NIR
VIS & NIR refined
<table>
<thead>
<tr>
<th>Products</th>
<th>Approach</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflectance</td>
<td>ACORN, ATREM and FLAASH</td>
<td>Seasonal and long term trends in spectra, basis for sensors inter-comparison</td>
</tr>
<tr>
<td>LAI, fAPAR, fCover</td>
<td>Spectral approaches, Modeling, In collaboration with OLIVE (WGCV/LPV, F. Baret)</td>
<td>Seasonal trends, variation by land cover, Validate/Confirm by comparison to field data and estimates from other sensors</td>
</tr>
<tr>
<td>Foliar pigments (total chlorophyll)</td>
<td>Testing spectral approaches and models, OLIVE</td>
<td>Local variability, Seasonal and long term trends</td>
</tr>
<tr>
<td>LUE</td>
<td>Spectral and Modeling approaches</td>
<td>Seasonal dynamics, Variation by cover type</td>
</tr>
<tr>
<td></td>
<td>Adjusted to 10 nm spectral trends, classifiers, un-mixing, derivatives; Approaches for confirmation / validation</td>
<td>Monitoring of seasonal and long term trends in foliar water, pigments and other, Monitoring of ecosystem function</td>
</tr>
</tbody>
</table>
Seasonal Dynamics at 30 m for Major Land Cover Types
Greenbelt, MD

Subset of the mid summer radiance image, used in the aggregations to a larger pixel size (from 30 to 60, 90 and 240 m).
Seasonal Dynamics in VIs for Major Land Cover Types
Greenbelt, MD

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Hyperion, 2008</th>
<th>V1</th>
<th>PRI</th>
<th>REIP</th>
<th>Dmax</th>
<th>WBI</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>13-Jun</td>
<td>1.03</td>
<td>-0.04</td>
<td>712</td>
<td>0.36</td>
<td>0.96</td>
<td>0.461</td>
</tr>
<tr>
<td></td>
<td>18-Aug</td>
<td>1.81</td>
<td>-0.06</td>
<td>722</td>
<td>0.75</td>
<td>1.09</td>
<td>0.197</td>
</tr>
<tr>
<td></td>
<td>3-Oct</td>
<td>1.15</td>
<td>0.04</td>
<td>721</td>
<td>0.51</td>
<td>0.98</td>
<td>0.155</td>
</tr>
<tr>
<td>Forest</td>
<td>13-Jun</td>
<td>1.12</td>
<td>-0.06</td>
<td>712</td>
<td>0.89</td>
<td>1.00</td>
<td>0.257</td>
</tr>
<tr>
<td></td>
<td>18-Aug</td>
<td>1.56</td>
<td>-0.03</td>
<td>722</td>
<td>0.51</td>
<td>1.01</td>
<td>0.140</td>
</tr>
<tr>
<td></td>
<td>3-Oct</td>
<td>1.61</td>
<td>-0.10</td>
<td>712</td>
<td>0.42</td>
<td>0.94</td>
<td>0.127</td>
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<tr>
<td>Water</td>
<td>13-Jun</td>
<td>0.15</td>
<td>0.01</td>
<td>712</td>
<td>0.16</td>
<td>1.23</td>
<td>0.058</td>
</tr>
<tr>
<td></td>
<td>18-Aug</td>
<td>0.52</td>
<td>0.02</td>
<td>712</td>
<td>0.10</td>
<td>1.46</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>3-Oct</td>
<td>0.62</td>
<td>-0.07</td>
<td>712</td>
<td>0.08</td>
<td>0.93</td>
<td>0.036</td>
</tr>
</tbody>
</table>
Reflectance Characteristics of Major Cover Types at 30 and 60 m pixel size
<table>
<thead>
<tr>
<th>Pixel size</th>
<th>Vegetation Indices for Corn*</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V1</td>
<td>PRI</td>
</tr>
<tr>
<td>30 m</td>
<td>1.81a</td>
<td>-0.056a</td>
</tr>
<tr>
<td>60 m</td>
<td>1.84a</td>
<td>-0.051a</td>
</tr>
<tr>
<td>240 m</td>
<td>1.71b</td>
<td>-0.040b</td>
</tr>
</tbody>
</table>

* different letters indicate statistically significant differences
The Global Semivariance (describes the spatial autocorrelation within a spectral band) is quite similar for 30 m and 60 m pixels, and significantly different for the 240 m.
FAPAR_{chl} image extracted from atmospherically corrected EO-1 Hyperion data for the Harvard Forest area on DOY 159, 2008 (water bodies are set to be 0)
EVI                                FAPARchl
159, 2008  251, 2002
EO-1 support of HyspIRI

Sun glint off coast of Belize and BRDF effects

Insert from Francois Roget & Rob Greene, JPL
Color composites using Hyperion VIs

Beltsville area in 2008

- Exploring the potential of using Hyperion VIs for terrestrial ecology studies
- R: PRI ; G: NDVI ; B: NDII
- Non-vegetated area showed steady pattern through the season
  - Implication: steady reflectance values
- Phenological cycle: green-up (April-June) and senescence (August-October) were observed.
- During senescence, NDII (water) dropped faster than NDVI (greenness)
- The table shows VI values (top to bottom: PRI, NDVI, NDII) in the Greenbelt Park area (circle on images)
<table>
<thead>
<tr>
<th>Date</th>
<th>April 18</th>
<th>June 21</th>
<th>July 8</th>
<th>August 18</th>
<th>October 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.002</td>
<td>-0.049</td>
<td>-0.016</td>
<td>-0.010</td>
<td>-0.095</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>0.82</td>
<td>0.78</td>
<td>0.80</td>
<td>0.076</td>
</tr>
<tr>
<td></td>
<td>0.11</td>
<td>0.37</td>
<td>0.35</td>
<td>0.34</td>
<td>0.21</td>
</tr>
</tbody>
</table>

R: PRI, G: NDVI, B: NDII
Comparisons between *in situ* and Hyperion observations

**USDA Cornfield in Beltsville, MD in 2008**

<table>
<thead>
<tr>
<th>In situ</th>
<th>Hyperion</th>
<th>VIs</th>
<th>OOptics</th>
<th>Sim_HYP</th>
<th>HYP</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 19</td>
<td>August 18</td>
<td>PRI</td>
<td>-0.03</td>
<td>-0.026</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NDVI</td>
<td></td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>October 2</td>
<td>October 3</td>
<td>PRI</td>
<td>-0.04</td>
<td>-0.05</td>
<td>-0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NDVI</td>
<td></td>
<td></td>
<td>0.66</td>
</tr>
</tbody>
</table>

OOptics: values derived from Ocean Optics measurements (~1.5 nm FWHM)

Sim_HYP: values derived from simulated Hyperion bands (~ 10 nm FWHM) using Ocean Optics measurements

HYP: values derived directly from EO-1 Hyperion imagery
Automated Tools and Applications
HyspIRI simulation using Hyperion data

Goals: To test a) data streaming & b) data compression

- 20 random Hyperion L1R scenes were stitched together to match HyspIRI swath
- At 30m and 60m spatial resolution
# Earth Observing 1 (EO-1) Campaign Manager on-line Tool

### Scenario/Campaign Tasking Requests for UAV 3

<table>
<thead>
<tr>
<th>Title</th>
<th>Content</th>
<th>Geolocation</th>
<th>Scenario Feasibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAFRICOM</td>
<td>USAFRICOM Testing</td>
<td>flooding cappelle a</td>
<td>Zimbabwe</td>
</tr>
</tbody>
</table>

**Title:** California  
**Description:** California  
**Category:**  
**Latitude:** 41.2  
**Longitude:** -123.8  
**Country Code:** US  
**County:** United States  
**Name:**  
**Zone Number:** 36  
**Zone Name:** Northern California  
**Region:**  
**Region Name:** Oregon, California and Nevada  
**Admin Code:** CA  
**Admin Name:** California  
**Nearby:** Hatch, Sogoro, Shire of (historical), Tattah, Tplu (historical), Monterey, Johnson, Napa, Napa Valley, Napa Plaza, Napa Park (historical)  
**Created At:** Fri, 19 Sep 2008 02:58:22 -0700  
**Updated At:** 2008-09-19  

**Feasibilities:**

1 Found  
USAFRICOM  
**USAFRICOM Testing**  
flooding cappelle a  
**Zimbabwe**  
06/19/2008 02:58 PM  
06/19/2008 02:58 PM  

EO-1 L2 Tools and Prototype Reflectance Products
albedo; fAPAR; LAI; spectrum derivatives; chlorophyll, N, water content ...

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**Goals**: To enable the conventional users to apply corrections and develop products and applications
EO-1 serves as a Pathfinder for SensorWebs and Enabling of Rapid Response Remote Sensing
The SensorWeb architecture was developed on EO-1 as a pathfinder effort to encapsulate sensors and data processing algorithms with Open Geospatial Consortium standardized Web 2.0 Service interfaces. Thus future missions, especially HyspIRI, will be able to significantly lower the cost of interoperating, automating procedures and enable rapid customization of data products.
Disaster Monitoring/Sensor Webs
Disasters: ALI Imagery of Australian Flood (March 2009)

March 12, 2009
True-Color Image
EO-1 ALI Image

In this true-color image, note how the water color is so muddy that it makes discerning the extent of the flooding difficult.

March 12, 2009
False-Color Image
EO-1 ALI Flood Product

This false-color image combines infrared and visible light, which makes the extent of the flooding far more obvious. Water is dark blue, while plant-covered land is green, and bare earth is rosy tan.

March 25, 2009
False-Color Image
EO-1 ALI Flood Product

Two weeks later, the flood waters have receded even more, which the EO-1 Flood Product makes evident.
10/23/07
EO-1 Hyperion and ALI View
Witch Wildfire
Disasters: EO-1 ALI images of New Orleans after Hurricane Katrina

ALI pan-sharpened images acquired just two days apart, clearly showing the receding flood waters from Hurricane Katrina.

Ungar (2005)
Disasters: La Plata, MD Tornado after-effects still visible one year later

EO-1 ALI Pan-sharpened images (Ungar, 2003)

April 24, 2002  May 1, 2002  April 27, 2003

Tornado Track

Tornado Track
Instrument Characteristics and Data Availability can be found at the following URLs

AVIRIS: http://aviris.jpl.nasa.gov/

MASTER: http://masterweb.jpl.nasa.gov/


ASTER: http://asterweb.jpl.nasa.gov/
### Recent ER-2 flights carrying both AVIRIS and MASTER

<table>
<thead>
<tr>
<th>Flight</th>
<th>Date</th>
<th>Area</th>
<th>Flight</th>
<th>Date</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-115</td>
<td>10 Aug 2001</td>
<td>Vancouver Island, Canada/Hoquiam, WA</td>
<td>02-914</td>
<td>02 Nov 2001</td>
<td>Big Island/Maui/Molokai, HI</td>
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<tr>
<td>01-123</td>
<td>01 Aug 2001</td>
<td>Mono Lake/Lake Tahoe, CA</td>
<td>02-915</td>
<td>04 Nov 2001</td>
<td>Big Island/Oahu/Maui, HI</td>
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<tr>
<td>01-124</td>
<td>17 Aug 2001</td>
<td>Death Valley/Mono Lake/Walker Lake, CA &amp; NV</td>
<td>02-916</td>
<td>05 Nov 2001</td>
<td>Big Island/Oahu, HI</td>
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<tr>
<td>01-125</td>
<td>18 Aug 2001</td>
<td>Mono Lake/Fort Irwin/Pinto Basin, CA &amp; NV</td>
<td>02-917</td>
<td>06 Nov 2001</td>
<td>Big Island/Oahu, HI</td>
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<tr>
<td>02-602</td>
<td>02 Oct 2001</td>
<td>Santa Monica/Santa Barbara, CA</td>
<td>02-918</td>
<td>07 Nov 2001</td>
<td>Ferry Honolulu, HI to Dryden, CA</td>
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<tr>
<td>02-902</td>
<td>14 Oct 2001</td>
<td>Lake Tahoe/Mono Lake, CA</td>
<td>04-601</td>
<td>03 Oct 2003</td>
<td>Ivanpah, CA &amp; NV</td>
</tr>
<tr>
<td>02-903</td>
<td>15 Oct 2001</td>
<td>Ferry to Hawaii from Dryden, CA</td>
<td>06-626</td>
<td>19 Sep 2006</td>
<td>Sheely Farm/Mono Lake, CA</td>
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<tr>
<td>02-904</td>
<td>16 Oct 2001</td>
<td>Big Island of Hawaii</td>
<td>06-627</td>
<td>20 Sep 2006</td>
<td>Cuprite, NV</td>
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<tr>
<td>02-905</td>
<td>19 Oct 2001</td>
<td>Big Island/Maui/Molokai, HI</td>
<td>06-628</td>
<td>22 Sep 2006</td>
<td>Jasper Ridge/Monterey Bay, CA</td>
</tr>
<tr>
<td>02-906</td>
<td>20 Oct 2001</td>
<td>Big Island of Hawaii</td>
<td>06-629</td>
<td>25 Sep 2006</td>
<td>Yellowstone National Park, WY, MT, &amp; ID</td>
</tr>
<tr>
<td>02-908</td>
<td>24 Oct 2001</td>
<td>Big Island/Kahoolawe, HI</td>
<td>06-630</td>
<td>26 Sep 2006</td>
<td>Mono Lake/Lake Tahoe, CA</td>
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<tr>
<td>02-910</td>
<td>26 Oct 2001</td>
<td>Big Island/Maui/Kaunai, HI</td>
<td>07-601</td>
<td>02 Oct 2006</td>
<td>Minnesota/Wisconsin</td>
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<td>02-911</td>
<td>29 Oct 2001</td>
<td>Big Island/Molokai/Kaunai, HI</td>
<td>08-627</td>
<td>11 Jun 2008</td>
<td>Jasper Ridge/Moffett/Santa Monica/Big Sur Fire, CA</td>
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<tr>
<td>02-912</td>
<td>30 Oct 2001</td>
<td>Kahoolawe/Big Island, HI</td>
<td>08-629</td>
<td>19 Jun 2008</td>
<td>Coal Oil Point, CA</td>
</tr>
</tbody>
</table>

**NASA/ROSES A.29: HyspIRI preparatory activities using existing imagery**
EO-1 Data

• Hyperion and ALI archived and newly acquired data are now provided as L1G at no cost by EROS/USGS
• Hyperion L1R archived data can be obtained by special request through the GSFC MSO
• New data acquisition requests are funneled through EROS/USGS
Application Examples
Automatic mineral mapping algorithm creates, in 30 seconds, a quick-look mineral map (left & centre). More precise detail is on right.

Colours to the right indicate the relative abundance of talc/tremolite. Red shows areas of greatest abundance and blue gives the least.

(Courtesy of CSIRO Australia)
Hyperion Maps Mt. Fitton Geology

Hyperion-based apparent reflectance compares with library reference spectra

(1) Published Geologic Survey Map
(2) Hyperion three color image (RGB) showing regions of interest
(3) Hyperion surface composition map using SWIR spectra above

Hyperion surface composition map agrees with known geology of Mt. Fitton in South Australia

Hyperion Spectra
Reference Spectra

(a) (b)

Courtesy of CSIRO, Australia
Mapping land cover and vegetation diversity in a fragmented ecosystem

Ability to map up to the 4th level of the CORINE legend (CORINE Land Cover 2000)

(Pignatti et al., 2009)
Evaluation of Hyperion and ALI for Forest Classification

Goodenough et al. 2003
Detection of Invasive Plants in the Galapagos National Park and Archipelago, Ecuador by merging Hyperion and *QuickBird*

Classification of guava (blue) and other land cover types

Spectral un-mixing of Hyperion data for the characterization of guava (%)

Walsh et al., 2008
Composition of Inland Tropical Amazon Floodplain Waters Using Hyperion Derivative Analysis

Hyperion end-members spectra of waters dominated by optically active substances

(Rudorff et al., 2007)
Detection of mountain pine beetle red attack damage, using Hyperion moisture stress indices (MSI)

(White et al. 2007)

Individual tree crowns with mountain pine beetle red attack damage were identified using the Hyperion spectra then overlaid on a QuickBird image and are delineated in red.
Forest structure, biomass and species richness maps estimated from Hyperion

- a) canopy height (m)
- b) Shannon species richness
- c) biomass (kg/0.1 ha)
- d) basal area (m²/ha)

(Kalacska et al. 2007)
Desertification in Central Argentina

Hyperion MC Unmixing

AVIRIS-30m MC Unmixing

PV  NPV  Soil

Asner et al.
Predicted Canopy Nitrogen

Field Sampling for Canopy Structure, Canopy Chemistry & Wood Growth

Ollinger et al. (2003)
4-way model validation, Bartlett Experimental Forest

Field-Measured %N

AVIRIS % N

Hyperion % N

Mean % N from Broadband Cover Type Map

R² = 0.77
SEE = 45.6

R² = 0.73
SEE = 48.2

R² = 0.63
SEE = 50.3

R² = 0.20
SEE = 57.6

Ollinger et al. (2003)
**Tropical Forest NPP from Field, Remote Sensing and Modeling Combinations**

Ratio of net primary production in dry-down and control forest stands \((\text{NPP}_{\text{dry,c}})\) for the year 2001, simulated using satellite data and the CASA model (Field et al. 1995).

<table>
<thead>
<tr>
<th>Scenario</th>
<th>(\text{NPP}_{\text{dry,c}}(2001))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) NDVI</td>
<td>0.98</td>
</tr>
<tr>
<td>(2) NDVI, PRI</td>
<td>0.85</td>
</tr>
<tr>
<td>(3) SWAM</td>
<td>0.69</td>
</tr>
<tr>
<td>(4) SWAM, PRI</td>
<td>0.67</td>
</tr>
<tr>
<td>(5) LAI</td>
<td>0.99</td>
</tr>
<tr>
<td>(6) LAI, PRI</td>
<td>0.84</td>
</tr>
<tr>
<td>(7) Field measurements</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Asner et al.
• We continue to utilize EO-1 assets to evaluate and plan HyspIRI products and algorithms.

Betsy Middleton
Petya Campbell
Qingyuan Zhang
Yen-Ben Cheng
Larry Corp
Lawrence Ong
Stu Frye
Dan Mandl
Nathan Pollack

Steve Ungar
Kurt Thome
Bob Knox
Fred Huemmrich
The Global Semivariance provides a single value that describes the spatial autocorrelation of the data within a spectral band.

The Geary's C index provides a measure of dissimilarity within the data.
The Global Semivariance (describing the spatial autocorrelation of the data within a spectral band) is quite similar for 30 m and 60 m pixels, and significantly different for the 240 m.
Developing Higher level EO-1 Hyperion Science Products

Vegetation Indices and Albedo for major Crops and Land Cover Types (example for Greenbelt, MD)

<table>
<thead>
<tr>
<th>Pixel size</th>
<th>Vegetation Indices*</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V1</td>
<td>PRI</td>
</tr>
<tr>
<td>30 m</td>
<td>1.81</td>
<td>-0.14</td>
</tr>
<tr>
<td>60 m</td>
<td>1.88</td>
<td>-0.15</td>
</tr>
</tbody>
</table>

* Reported means, no statistically significant differences established

- Enabling conventional users to conduct their own assessments, using software such as ENVI (Agricultural stress and Red edge Greenbelt, MD)
• Dome C
  75°S, 123°E, 3250 m
• Very small surface slope results in light winds and small surface roughness
• Cold, fine-grained snow all year
• Similar surface to most of East Antarctic Plateau above 3000 m