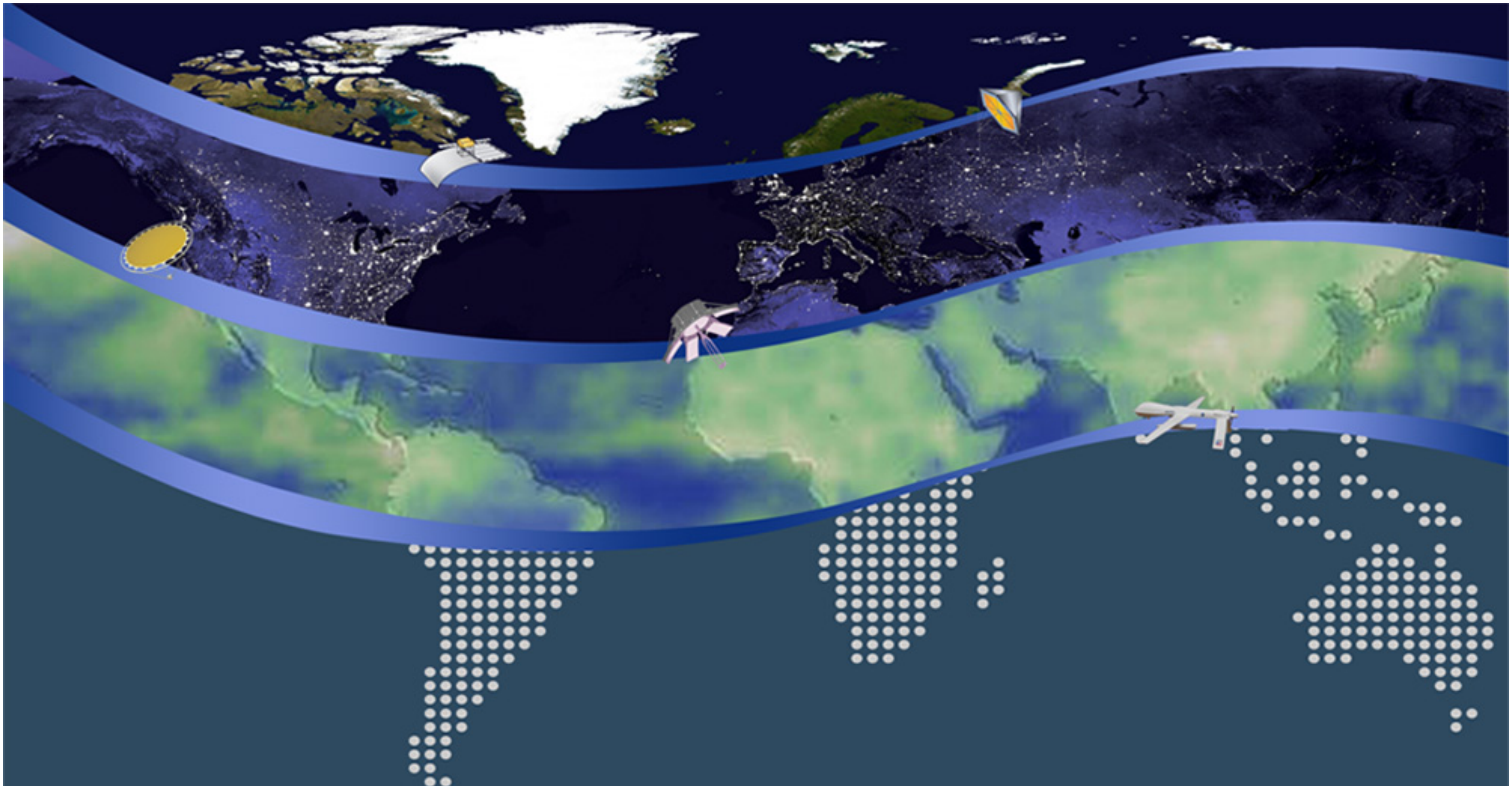


HyspIRI Technology Investment Overview

August, 2009

Janice L. Buckner
NASA Earth Science Technology Office

Future Directions for NASA Earth Science and Technology

- Advances in Earth science are often enabled by advances in technology

- In many cases, fundamentally new tools and techniques are needed before a measurement can be made or significantly improved

- NASA's Earth Science organization places a high priority on developing new technologies to meet present and future scientific challenges

- The Earth Science Technology Office (ESTO) was formed to address these technology challenges

Earth Science Technology: A Flexible, Science-Driven Approach

Competitive, peer-reviewed proposals enable selection of best-of-class technology investments

Risks are retired before major dollars are invested: a *cost-effective approach* to technology development and validation

This approach has resulted in:

- a portfolio of emerging technologies that will enhance and/or enable future science measurements

- a growing number of infusion successes:

  - technologies are infused into: science campaigns, instruments, ground systems and missions

    - infusion is by competitive selection by science investigators or mission managers, not the technology program

Technology Product Lines

Advanced Component Technology (ACT) Program - development of component and subsystem technologies for instruments and platforms

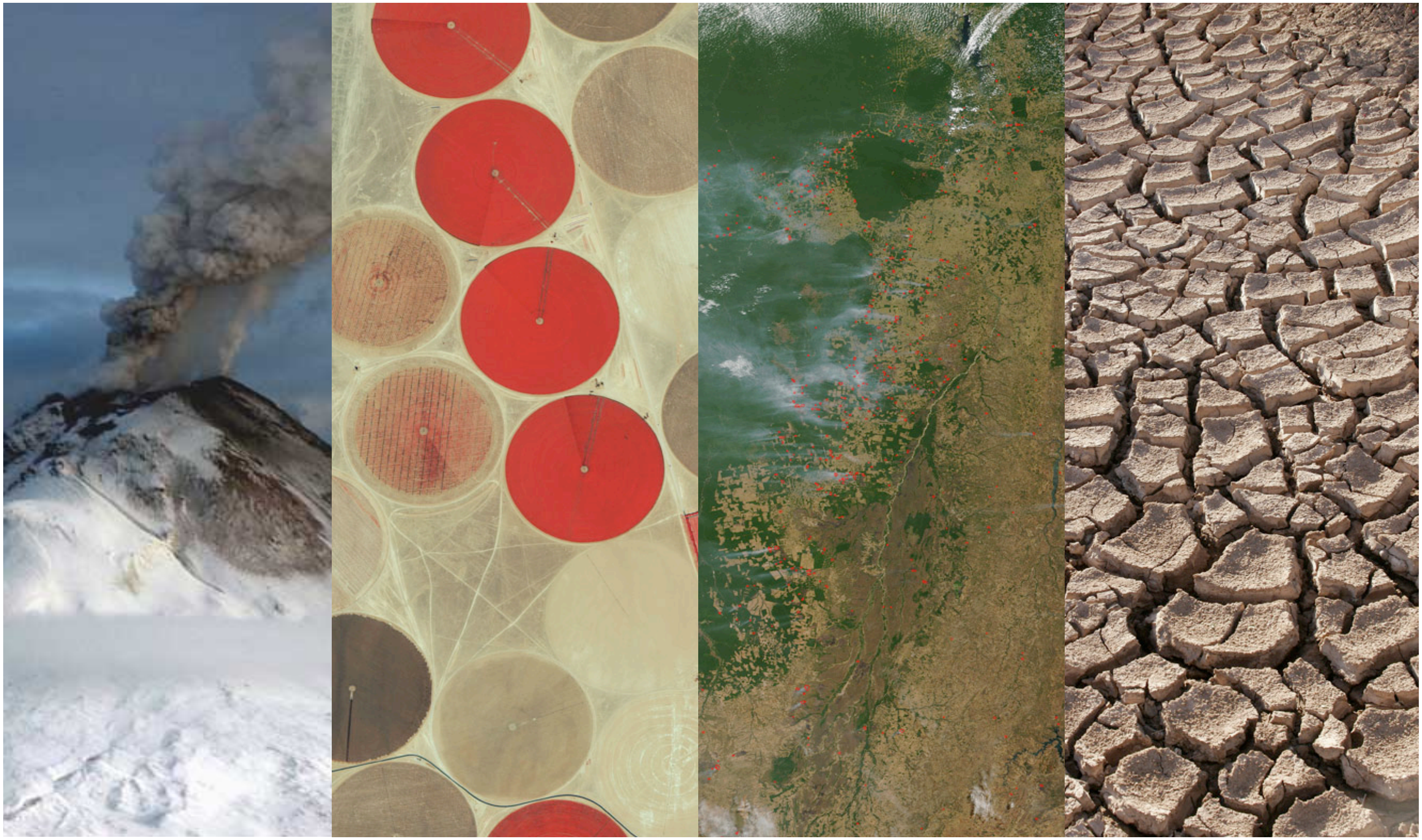
Instrument Incubator Program (IIP) - new instrument and measurement techniques, including laboratory development and airborne validation

Advanced Information Systems Technologies (AIST) - innovative on-orbit and ground capabilities for the communication, processing, and management of remotely sensed data and the efficient generation of data products and knowledge. Includes data manipulation, and visualization of very large, highly distributed remotely sensed data sets consistent with modeling needs

Presentation Outline

- Outline
  - Mission description and payload highlights
  - Observation technologies
  - Information system technologies
- Most tasks initiated before Decadal Survey was released!
- Some tasks have broad mission relevancy
- Some tasks have relevancy to the application of the science to societal benefits

HyspIRI - Technology Investments



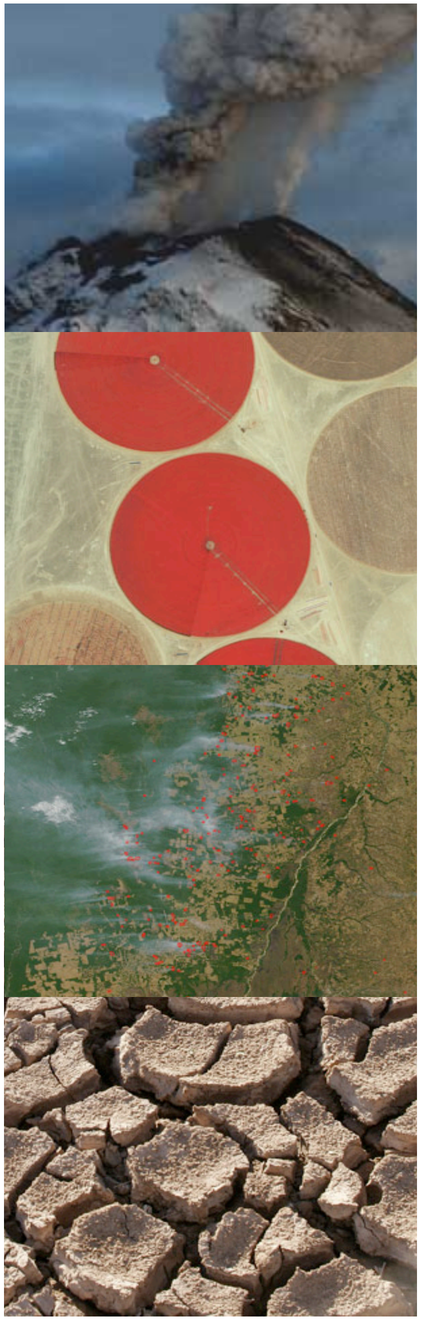
Earth Science Technology Office

Mission and Payload

The HyspIRI mission uses imaging spectroscopy (optical hyperspectral imaging at 400–2500 nm and multispectral IR at 8–12 μm) of the global land and coastal surface. The mission would obtain global coverage from LEO with a repeat frequency of 30 days at 45-m spatial resolution. A pointing capability is required for frequent and high-resolution imaging of critical events, such as volcanoes, wildfires, and droughts.

The payload consists of a hyperspectral imager with a thermal multispectral scanner, both on the same platform and both pointable. Given recent advances in detectors, optics, and electronics, it is now feasible to acquire pushbroom images with 620 pixels cross-track and 210 spectral bands in the 400- to 2,500-nm region. If three spectrometers are used with the same telescope, a 90-km swath results when Earth's curvature is taken into account. A multispectral imager similar to ASTER is required in the thermal IR region. For the thermal channels (five bands in the 8- to 12-μm region), the requirements for volcano-eruption prediction are high thermal sensitivity of about 0.1 K and a pixel size of less than 90 m. An optomechanical scanner, as opposed to a pushbroom scanner, would provide a wide swath of as much as 400 km at the required sensitivity and pixel size. The HyspIRI mission has its heritage in the imaging spectrometer Hyperion on EO-1 launched in 2000 and in ASTER, the Japanese multispectral SWIR and thermal IR instrument flown on Terra. The hyperspectral imager's design is the same as the design used by JPL for the Moon Mineralogy Mapper (M3) instrument on the Indian Moon-orbiting mission, Chandrayaan-1, and so will be a proven technology.

From Decadal Survey



Mission Overview

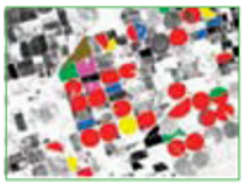
- Mission Description:
  - This mission provides the surface temperature and emissivity from LEO at high spatial resolution (45m) and high temporal resolution (monthly) for studies at the local, regional and global scale.
- Instruments:
  - Visible ShortWave InfraRed (VSWIR) Imaging Spectrometer
    - Push broom images with 620 pixels cross-track and 210 spectral bands in the 400 to 2,500-nm region
  - Thermal InfraRed (TIR) Multispectral Scanner
    - Five bands in the 8–12 um region

From Decadal Survey

HYPERSPECTRAL INFRARED IMAGER (HYSPIRI)

Launch: 2013-2016 Mission Size: Medium

Processes indicating volcanic eruption



Nutrients and water status of vegetation; soil type and health

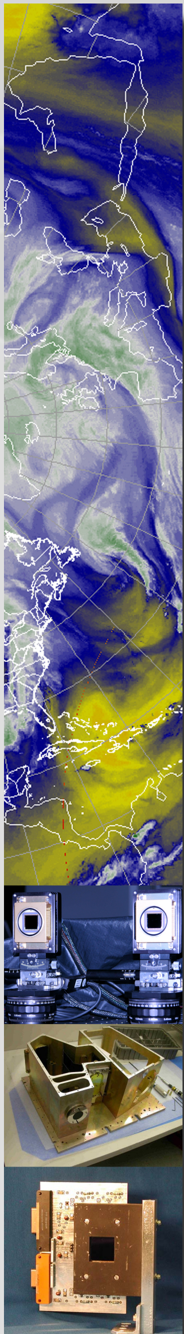
Spectra to identify locations of natural resources

Changes in vegetation type and deforestation; drought early warning

Improved exploration for natural resources

Forecasts of likelihood of volcanic eruptions and landslides

From Decadal Survey



ESTO Technology Development in Support of an

Advanced Remote-Sensing Imaging Emission Spectrometer

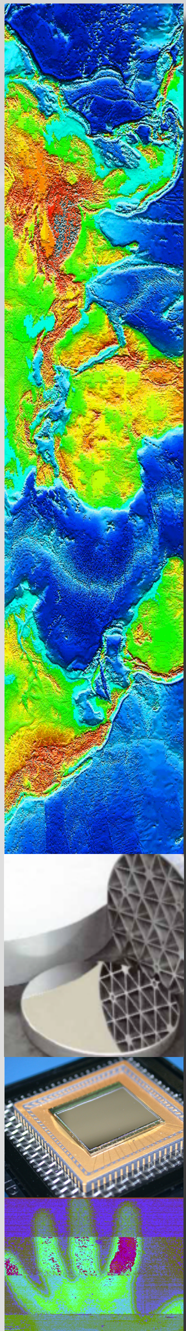
Missions Supported: HyspIRI

Measurement Approach

Hyperspectral, high-resolution imager sounder

Earth Science Technology Office (ESTO) Investments

- Development and airborne demonstration of a thermal infrared imaging spectrometer with high spatial and spectral resolution to support the HyspIRI mission (Hook/JPL-IIP07)
- Development and airborne demonstration of a high-performance thermal imager for HyspIRI-type measurement applications (Hall/The Aerospace Corp.-IIP-07)
- Completed second instrument technology advancement of SIRAS-G, a WFOV, multi-grating/channel IR spectral imager concept designed to accurately measure atmospheric temperature and water vapor from LEO or GEO. Lab demonstrated fully functional imaging MWIR spectrometer (3.35-4.8 µm) operating at cryogenic temperatures (Kampe/Ball Aerospace - IIP-02)
- Designed and lab demonstrated a proof-of concept Hyperspectral imager that is suitable for area coverage from GEO orbit. The instrument design concept is a dual spectrograph covering the UV/VIS wavelength region of 310-481 nm and the VIS/NIR wavelength region of 500-900nm. GeoSpec is designed to take space based measurements of environmentally important trace gases, coastal and oceanic pollution events, and measure the origin and evolution of aerosol plumes. (S. Janz/GSFC-IPP-02)
- Reconfigurable Computing Based Compression for Spaceborne Hyperspectral Imaging Processing (S. Hauck/U Washington- AIST-02)
- A Reconfigurable Computing Environment for On-Board Data reduction and Cloud Detection (J. LeMoigne/GSFC AIST-02)
- A tunable high performance compression scheme suitable for push-broom sensors for quick-look and direct broadcast applications. (P. Yeh/GSFC AIST-02)
- An Inter-operable Sensor Architecture to Facilitate Sensor Webs in Pursuit of GEOSS (D. Mandl/GSFC AIST-05)



ESTO Technology Development in Support of

Land Surface Imaging

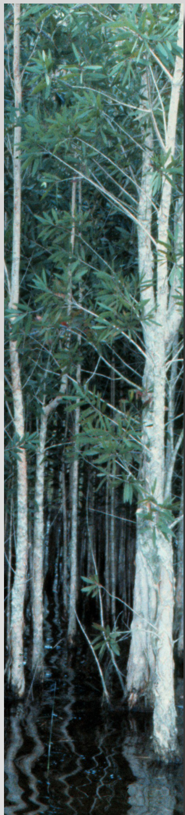
Missions Supported: HyspIRI

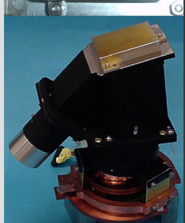
Measurement Approach

Spectrometers UV/VIS, near-IR, thermal IR

Earth Science Technology Office (ESTO) Investments

- Development and airborne demonstration of a thermal infrared imaging spectrometer with high spatial and spectral resolution to support the HyspIRI mission (Hook/JPL-IIP07)
- Development and airborne demonstration of a high-performance thermal imager for HyspIRI-type measurement applications (Hall/The Aerospace Corp.-IIP-07)
- Designed and lab demonstrated a proof-of concept Hyperspectral imager that is suitable for area coverage from GEO orbit. The instrumetn design concept is a dual spectrograph covering the UV/VIS wavelength region of 310-481 nm and the VIS/NIR wavelength region of 500-900nm. GeoSpec is designed to take space based measurements of environmentally important trace gases, coastal and oceanic pollution events, and measure the origin and evolution of aerosol plumes. (S. Janz/GSFC-IPP-02)
- Designed, fabricated, hybridized and fully characterized a 1,024 x 1,024 (1K x 1K) GaAs Quantum Welled Infrared Photodetector (QWIP) array sensitive to the 8-14 µm infrared spectral region. (M. Jhabvala/GSFC -ATIP-99 and ACT-02)
- Land Information System (C. Peters-Lidard/GSFC AIST-02) and Land Information Sensor Web (P. Houser/ IGES AIST-05)
- Data Mining for Understanding the Dynamic Evolution of Land-Surface Variables (P. Kumar/U Illinois AIST-05)
- Science Model Driven Autonomous Sensor Web (A. Davies/JPL AIST-QRS-07)
- Optimized Autonomous Space – In-situ Sensorweb (W. Song/Washington State AIST-05)



ESTO Technology Development in Support of

Physiology & Functional Group Measurements

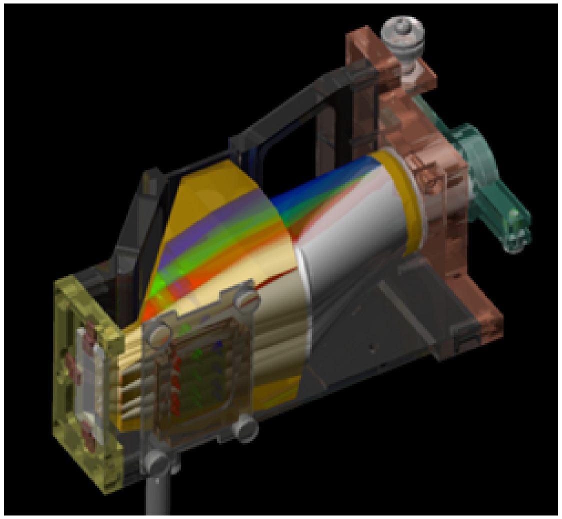
Missions Supported: ACE, **HyspIRI**

Measurement Approach

Polar-orbiting imaging spectrometer(s) (~350-2500 nm); **Multi-Spectral imager in the Thermal IR**; High spectral resolution aerosol lidar (SP) for atmospheric correction over oceans

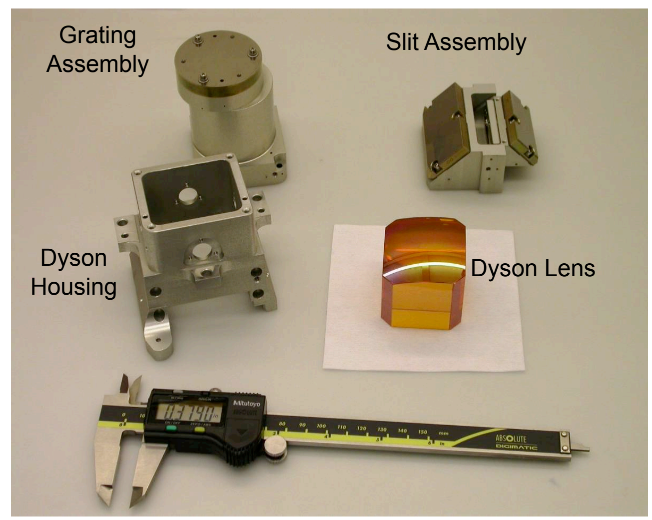
Earth Science Technology Office (ESTO) Investments

- Developed a large format (256X256) array VIS-NIR bland Aluminum Gallium Nitride (AlGaN) UV imager designed for 310-365 nm operation (Mott/GSFC-ACT-02)
- **Developed ultra-narrow UV and visible interference filters that demonstrated a 100%improvement in transmission over previously available filters (Potter/Barr Associates – ACT 02)**
- **Demonstrated a full-scale dual spectrograph breadboard instrument capable of the required sensitivity to enable future geostationary instrumentation. The instrument design concept is a dual spectrograph covering the UV/VIS wavelength region of 310-481 nm and the VIS/NIR wavelength region of 500-900 nm (S. Janz - IIP-02)**
- Developing an autonomous diode-pumped UV laser system for High Spectral Resolution (HSRL) Aerosol Lidar measurements. Proposed flight demonstration of autonomous joint Ozone and aerosol performance. (Hostetler/ LaRC – IIP 04)
- **Developed an on-board data compression tool for scientist to maximize science return despite scarce downlink resources (S. Dolinar/JPL AIST-02)**
- **MATLAB-BASED Adaptive Comuting for NASA Image Processing Applications (S. Hauck/U Washington AIST-02)**



Instrument Technologies

(Current and Completed ESTO Investments)

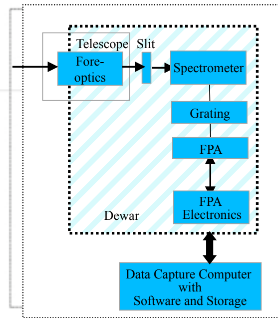


HyTES: Hyperspectral Thermal Emission Spectrometer for HyspIRI-TIR Science

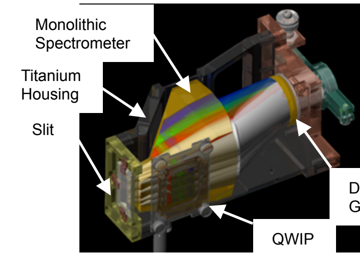
PI: Simon Hook, JPL

Objective

- Develop , This mission will address key science questions related to the Solid Earth and Carbon Cycle and Ecosystems focus areas .
  - The instrument will use at its base a cooled Dyson spectrometer that acquires 256 spectral channels of image data between 7.5 and 12 μm when used in conjunction with a Quantum Well Infrared Photodetector (QWIP) array
- Verify the performance in the laboratory as well as on an airborne platform.

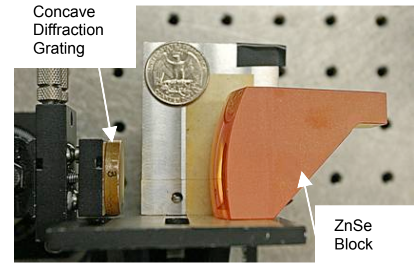


1) Block Diagram Concept



2) Graphical Concept

3) Concave Diffraction Grating



4) Dyson Spectrometer

Approach

- Develop opto-thermo-mechanical system design requirements.
- Develop analytical system model and design for a cryocooler Dyson spectrometer.
- Fabricate/procure spectrometer system (QWIP, grating, optics, thermal and mechanical components, test equipment).
- Integrate and test in the laboratory and on an airborne platform to verify performance.

Co-Is/Partners:

Bjorn T. Eng, Sarath D. Gunapala, Cory J. Hill, William R. Johnson, Pantazis Mouroulis, Vincent J. Realmuto, Daniel W. Wilson, JPL

Key Milestones

• Complete science and prelim. instrument design requirement	11/08
• Complete Optical Design Review	01/09
• Complete Thermal/Mechanical Design Review	05/09
• Complete Preliminary Design Review (PDR)	06/09
• Complete Critical Design Review (CDR)	08/09
• Complete critical component procurement	01/10
• Complete fabrication	08/10
• Complete static, dynamic and force tests	01/11
• Complete calibration I&T	01/11
• Complete performance and science verification	07/11

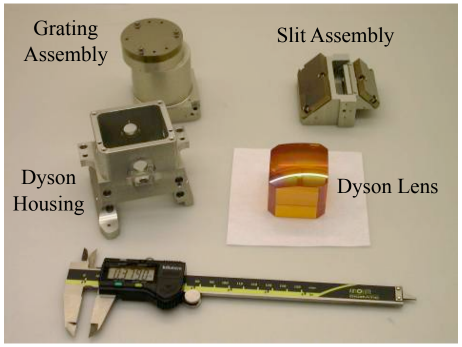
TRL_{in} = 4 $TRL_{current}$ = 4

Mineral and Gas Identification Using a High-Performance Thermal Infrared Imaging Spectrometer

PI: Jeff Hall, The Aerospace Corp.

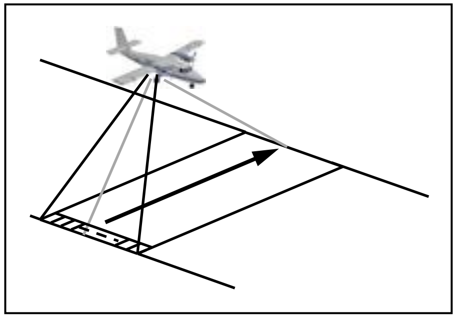
Objective

- Design and build an airborne demonstrator version of a high-performance thermal imager for HyspIRI-type measurement applications.
  - The instrument will use a cooled, optically fast Dyson spectrometer that acquires 28 spectral channels of image data between 7 and 12 microns
- Demonstrate the feasibility of a two-detector-module design for increased swath width.
- Demonstrate the new sensor's performance using airborne field trials.
- Develop LEO implementation concept



Dyson Spectrometer Components

Whiskbroom Scanning



Approach

- Examine trade-offs between spectral resolution, spectral range, area coverage rate, and sensitivity for a satellite version of the airborne instrument.
- Incorporate a Dyson spectrometer mated to a high-frame-rate 2D focal plane array.
- Use Fiber Support Technology for thermal isolation of components.

Key Milestones

• Requirements Definition Completion	01/09
• Conceptual Design Completion	01/09
• Preliminary Design Completion	09/09
• Critical Design Completion	05/10
• System Fabrication & Integration	12/10
• System Test - Laboratory	02/11
• System Test – Aircraft Flights	04/11

Co-Is/Partners:

David Tratt, David Warren, Stephen Young, The Aerospace Corp.; Michael Ramsey, Univ. of Pittsburgh

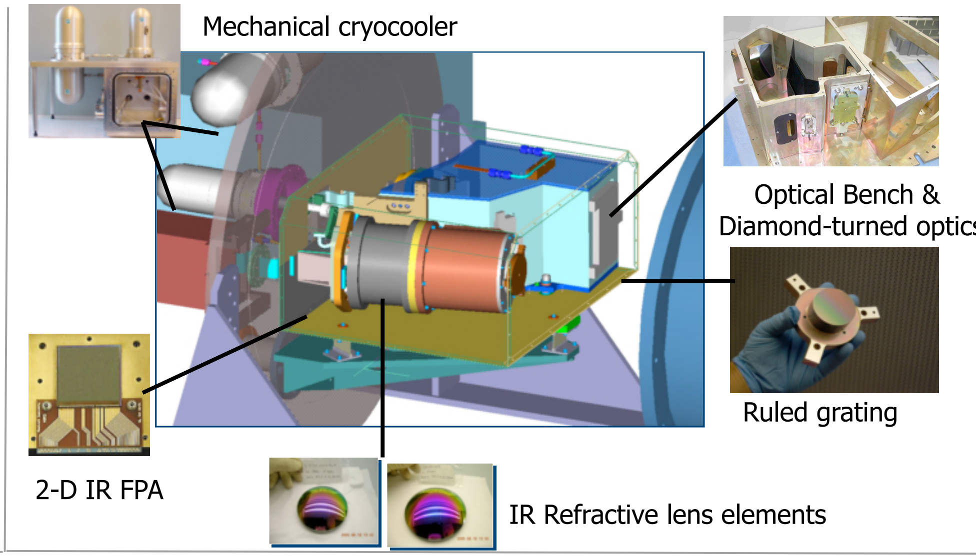
TRL_{in} = 3 $TRL_{current}$ = 3

SIRAS-G, the Spaceborne Infrared Atmospheric Sounder for GEO

PI: Thomas Kampe, Ball Aerospace & Technologies Corp. (BATC)

Objective

- Develop instrument technology for IR atmospheric sounding from GEO and LEO
- Validate operational performance in a laboratory demonstration
- Generate a design recommendation for space flight instrument



Accomplishment

- Developed single-channel MWIR lab demo that integrates flight-like spectrometer, active cooling, flight-like IR Focal Plane Arrays and electronics
- Spectrometer design developed for low distortion (spectral smile & keystone) & excellent image quality. Design form is extendable to multi-leg configuration (3-15 μm spectral coverage)
- Advanced technology multi-stage warm shield concept demonstrated
- Tested demo instrument in cryogenic environment using test methodology and apparatus developed at BATC (keystone distortion, smile, MTF, SRF, dispersion)

Technology Development Partners

Bill Folkner/Jet Propulsion Laboratory

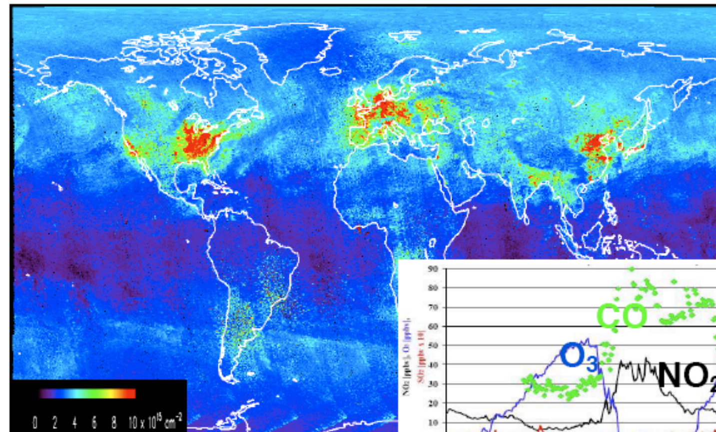
TRLin= 2 TRLout= 4

Geostationary Spectrograph (GeoSpec) for Earth and Atmospheric Science Applications

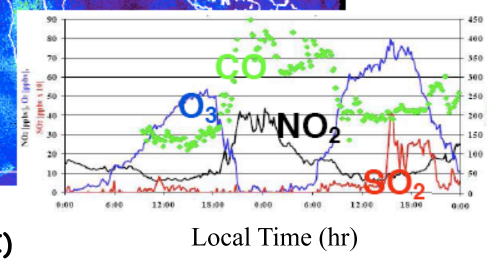
PI: Dr. Scott Janz / GSFC

Objective

- Demonstrate the feasibility of future Geostationary Earth Science missions using hyperspectral UV/VIS/NIR instrumentation.
- Geostationary orbit allows the measurement of the diurnal evolution of physical processes.
- Breadboard demonstration of a dual spectrograph instrument with UV/VIS and VIS/NIR channels using hybrid PIN/CMOS detectors.
- Target Earth Science Products: Coastal and ocean pollution events, tidal effects, origin and evolution of aerosol plumes, and trace gas measurements of O3, NO2, CH2O, and SO2.



NO_2 column density: Ozone Monitoring Instrument (OMI)



Accomplishments:

- Completed GeoSpec instrument design and system performance studies including polarization sensitivity, spectral sampling/sensitivity trades, image quality, and detector packaging/thermal control.
- Completed design, testing, fabrication and coating of all system optics including convex holographic gratings and new technology single crystal silicon (SCS) mirrors.
- Completed design and fabrication of optical bench mechanical structure.
- Completed optical alignment and end-to-end testing of breadboard including atmospheric retrievals.
- Completed both ISAL and IMDC studies of flight instrument concept.

CoIs:

- Pennsylvania State University
- Washington State University
- Research Support Instruments/Ball Aerospace

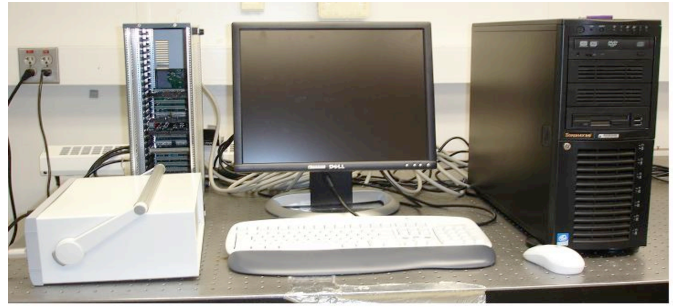
TRL_{in} = 3 **TRL_{out}** = 4

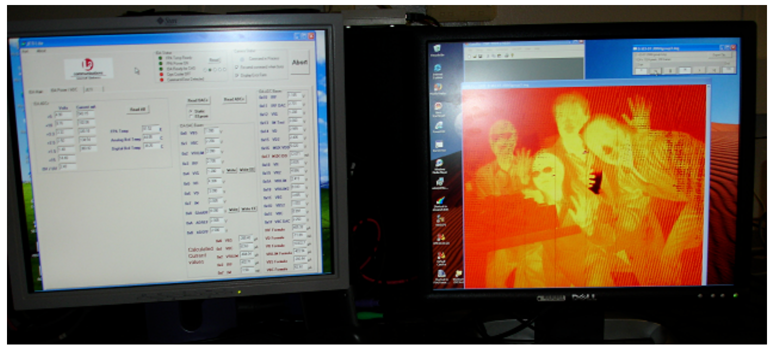
Development of a 1K x 1K GaAs QWIP Far Infrared Detector Array

PI: Dr. Murzy Jhabvala

Objective

- Design and fabricate a broadband 8-14 um infrared 1Kx1K, GaAs Quantum Well Infrared Photodetector (QWIP) imaging array.
- Develop the readout integrated circuit (ROIC)
- Design/build the electronics and camera system to perform imaging
- Perform Earth observing airborne experiments





QWIP Camera And Electronics System

Accomplishments

- Designed QWIP Array
- Successfully completed QWIP array fabrication
- Developed Rockwell based hybrid camera
- Flew QWIP on airborne experiment in Thailand (BASE-ASIA)
- First demonstration of 1Kx1K, 8-12 micron array
- Tested and characterized QWIP camera and completed Final Report

CoIs: Si-Chee Tsay, Dennis Reuter-NASA/GSFC,
Sarath Gunapala-NASA/JPL, K.K. Choi/Army Research Lab

TRLin= 2 TRLout= 6

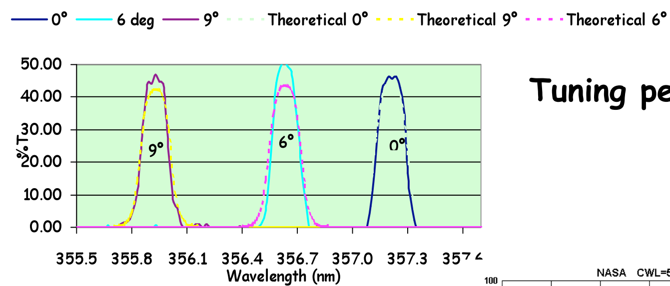
Advanced UV and Visible Ultra-narrow Interference Filter Technology Development

PI: John Potter, Barr Associates Inc.

Objective

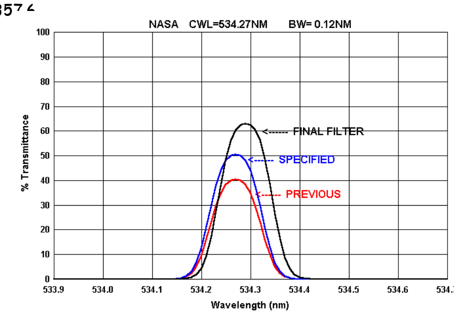
- 3 year effort to conduct research to build interference filters with up to twice the transmission of current filters while maintaining other specifications in the UV. Technology can also be applied to Vis and UV areas of the spectrum.
- Demonstrate filter performance using a Raman LIDAR.
- Transfer research result to space optics.

Co-I's: David Whiteman (NASA –Goddard SFC), Igor Veselovskii/UMBC, Ms. Rebecca Tola, Barr Associates Inc. , Martin Cardirola / Ecotronics



Tuning performance

Transmission



Accomplishment

- **UV Band-pass filter fabrication and testing:** More than a factor of 2 improvement in transmission versus previous capability. Manufactured Angle tunable Ultra-Narrow band filter.(0-9°)
- **Impact:** Techniques and filters developed here have been used to improve upper tropospheric measurements of water vapor for Aqua satellite validation.
- **Enables:** Improvements in the transmission of these filters while maintaining other required specifications such as blocking permits higher sensitivity measurements of water vapor, temperature, ozone, etc. than is currently being accomplished by these systems with no increase in size, weight or power consumption. Only the interference filter in use would need to be changed.

TRL_{in} =3, TRL_{out} =5

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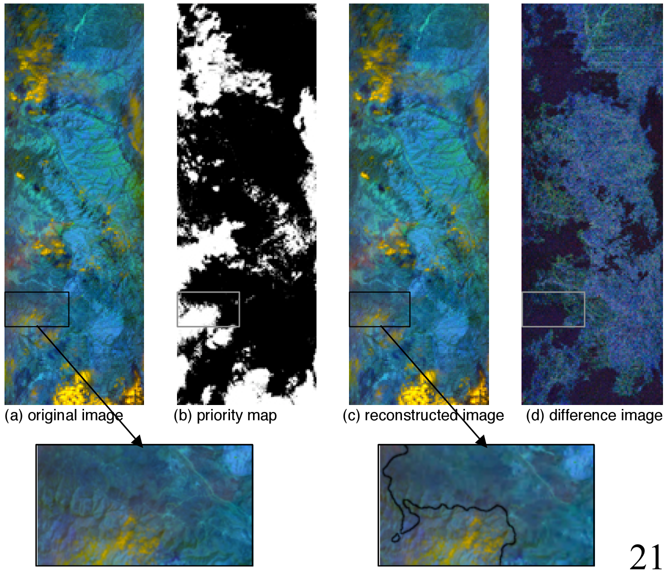
Information Systems Technologies

(Current and Completed ESTO Investments)

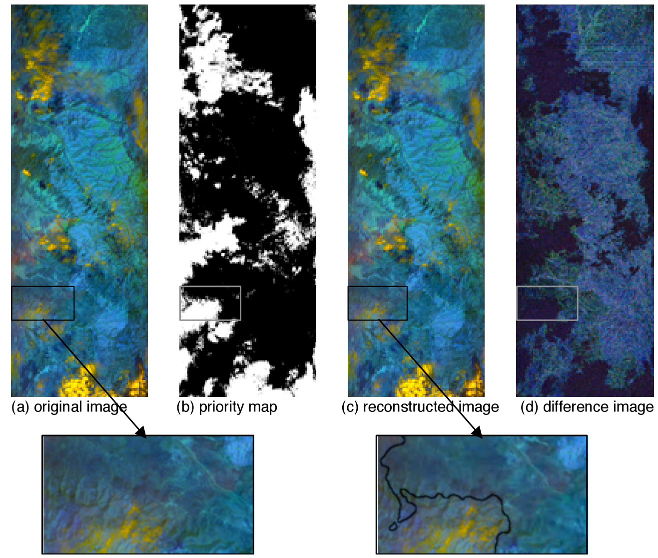


Region-of-Interest Data Compression with Prioritized Buffer Management

PI: Sam Dolinar at JPL

Objectives

- Create an onboard priority-oriented data compression tool for scientists to maximize science return despite scarce downlink resources
- Obtain test images and multi-spectral datasets, and develop algorithms for assigning priorities
- Develop a Web-accessible testbed for active experimentation by scientists
- Measure the gain in science return versus the required processing speed, memory, and storage of onboard computer



Accomplishments

- Developed region-of-interest (ROI) compression algorithms and software (ROI-ICER)
- Developed prioritized buffer management algorithms and software (PBM)
- Developed classification/prioritization algorithms for specific realistic scenarios
- Developed Web-accessible testbed for the ROI-ICER & PBM software
- Performed doctoral-level research on further improvements to the algorithms for classification/prioritization, ROI compression, and prioritized buffer management, leading to four Ph.D. theses at USC
- Some "so whats" E.G.:
  - Enables efficient use of limited communication resources by allocating scarce bits to the most important sections of images (both within images and across images). See example of prioritized bit allocation in image above.

CoIs: Matt Klimesh and Aaron Kiely at JPL,
Antonio Ortega at USC, and Roberto Manduchi at UCSC

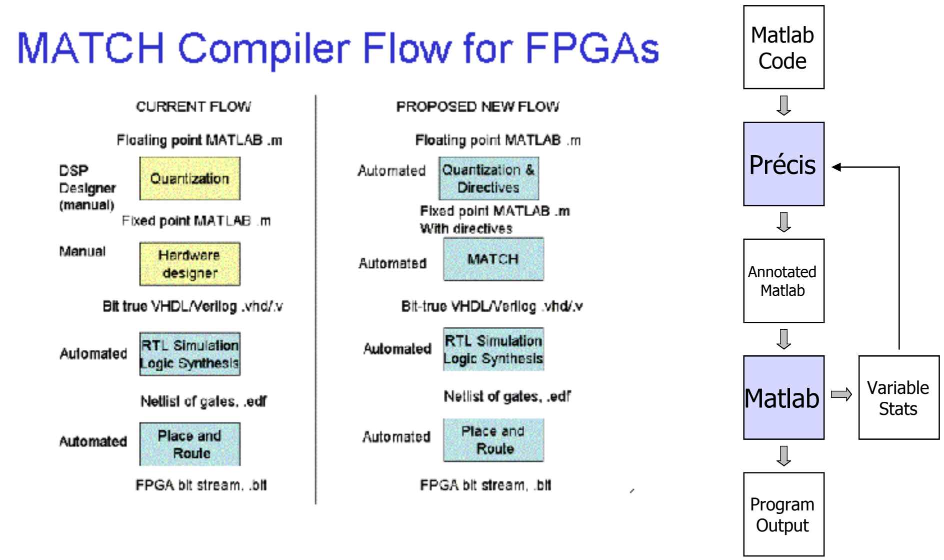
TRL_{in} = 1; TRL_{out} = 3

MATLAB-Based Adaptive Computing for NASA Image Processing Applications

PI: Scott Hauck, University of Washington

Objective

- Reduce code development times for adaptive applications from weeks to hours using compiler tools
- Produce efficient codes that optimize resources under performance constraints, or optimize performance under resource constraints
- Enable Adaptive (Field Programmable Gate Array (FPGA) based) Computing for NASA scientists via
    - MATLAB to FPGA Compiler (MATCH)
    - Automatic Variable Precision Support
    - Multi-spectral Image Classification Example



Accomplishments

- Reduced code development times for adaptive applications from weeks to hours using compiler tools
    - Developed compiler for automatic translation of MATLAB programs to Register Transfer Level (RTL) Very High Speed Integrated Circuit (VHSIC) Hardware Desciption \Language (VHDL) for mapping to FPGAs on reconfigurable hardware
    - Developed a set of variable precision tools to aid NASA developers in trading off quantization errors and fidelity for resources on an FPGA
    - Produced efficient codes that optimize resources under performance constraints, or optimize performance under resource constraints
- Transferred MATCH compiler technology to Accelchip, Inc. for commercialization
    - Developed an experimental prototype of the MATCH compiler on commercial FPGAs
    - Developed real-world applications to drive research on optimizations

CoIs: Prithviraj Banerjee, Northwestern University

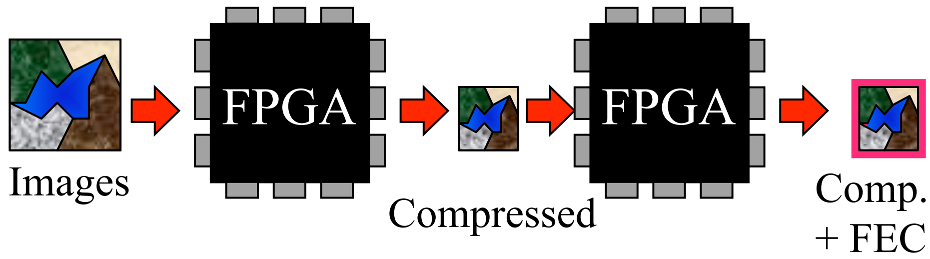
TRL_{in} =3; TRL_{out}=4

Reconfig. Computing Based Compression for Hyperspectral Images

PI: Scott Hauck/University of Washington

Objective

- Enable fast, efficient compression of NASA hyperspectral data via:
    - Linear prediction
    - Set Partitioning in Hierarchical Trees (SPIHT) lossy image compression
    - Region-of-Interest-SPIHT based on cloud cover detection
    - Unequal loss protection/forward error Correction (FEC)
    - FPGA-based computation



Accomplishments

- Enabled fast, efficient compression of NASA hyperspectral data; a compression ratio of 3.11:1 was achieved for lossless data compression
- Optimized SPIHT for hyperspectral images & mapped algorithms to FPGA hardware
    - Significantly reduced bandwidth requirements while retaining important image data
    - Reduced the impact of transmission errors
    - Simplified predictive encoder for FPGA implementation

CoIs: Eve Riskin, Richard Ladner/Univ. of Washington

TRL_{in} = 2; TRL_{out} = 4

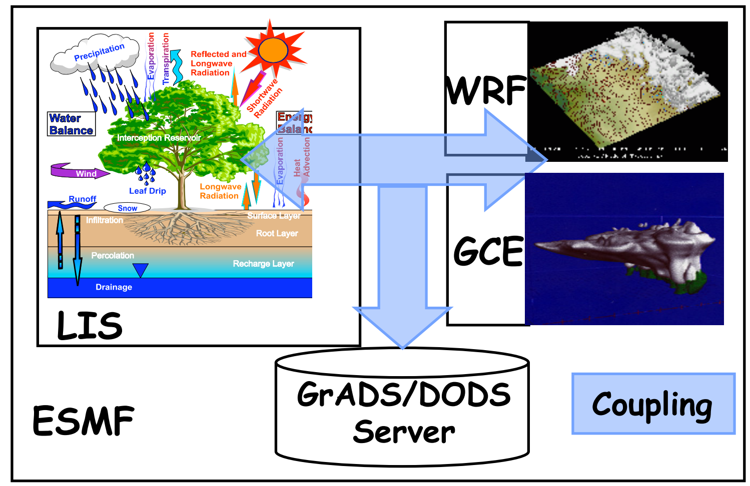
Coupling High-Resolution Earth System Models Using Advanced Computational Technologies

Christa Peters-Lidard, GSFC

Objectives

- Apply advanced computational technologies to the problem of coupling high-resolution Earth system models

- Combine the emerging technologies of the Earth System Modeling Framework (ESMF), the Land Information System (LIS) and the Grid Analysis and Display System (GrADS)/Distributed Oceanographic Data System (DODS) and couple them to the Weather Research and Forecasting (WRF) model and the Goddard Cumulus Ensemble (GCE) model to enable high-resolution modeling



Accomplishments

- Successfully coupled LIS to GCE and WRF with ESMF
- Populated LIS GrADS/DODS Server (GDS) with data for the 2002 International H2O Project (IHOP) experiment
- Completed ESMF-compliant and non ESMF-compliant coupling of LIS and WRF and LIS and GCE
- Completed IHOP synthetic and real cases with WRF and GCE that show significant impact on radiation coupling timestep, length of spin-up, type of data used in spin-up, and horizontal heterogeneity

CoI: Wei-Kuo Tao, GSFC
Paul Houser, GMU/IGES

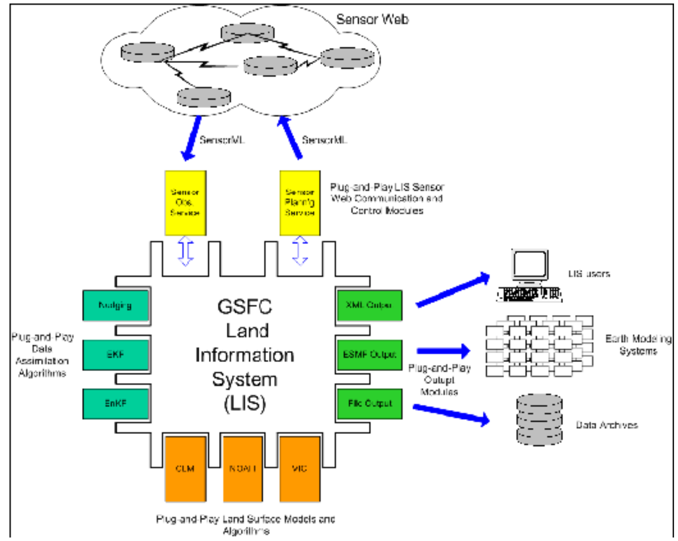
TRL_{in} = 3; TRL_{out} = 5

Land Information Sensor Web

PI: Hongbo Su, Institute of Global Environment and Society, Inc.

Objective

- Develop a prototype Land Information Sensor Web (LISW) by integrating the Land Information System (LIS) in a sensor web framework
- Enable real-time sensor web reconfiguration to optimize the changing needs of science and solutions using continuous automatic calibration techniques and data assimilation methods
- Exercise and optimize the sensor web – modeling interfaces using the simulated interactive sensor web on which LISW will be based
- Demonstrate LISW capabilities using Soil Moisture and Latent Heat Flux use cases



Enabling LIS to interact with sensor webs with open protocols and web

Approach

- Create a synthetic global land truth data set
- Develop a model of future land sensors
- Develop sensor web communication, reconfiguration and optimization techniques
- Establish various land surface uncertainty, prediction and decision support metrics
- Exercise and evaluate the system using LISW experiments
- Identify trade-offs for sensor web design

Co-Is/Partners:

James Geiger, GSFC; Sujay Kumar, Yudong Tian, UMBC

Key Milestones

• Scenario development	03/07
• Sensor simulation	09/07
• Sensor web framework	03/08
• Evaluation and optimization metrics	09/08
• LISW experiments	03/09
• Sensor web design implications	08/09

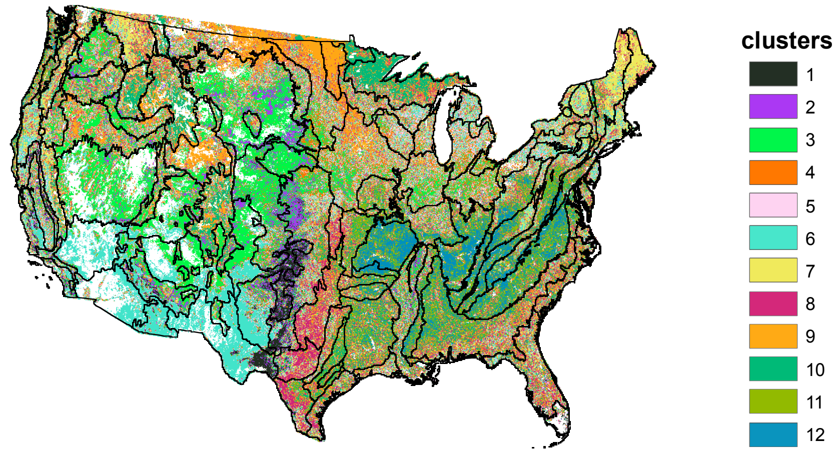
TRL_{in} = 4 **$TRL_{current}$ = 5**

Data Mining for Understanding the Dynamic Evolution of Land-Surface Variables: Technology Demonstration using the D2K Platform

PI: Praveen Kumar, University of Illinois

Objective

- Develop data mining techniques, using the Data to Knowledge (D2K) platform of NCSA, to facilitate analyses, visualization and modeling of terrestrial variables obtained from the TERRA and AQUA platforms, in support of scientific investigations for climate and weather applications.
  - MODIS terrestrial products to be supported include NDVI, EVI, LAI, FPAR, NPP, LST, and snow and ice cover.



Clustering analysis of MODIS Terrestrial data at 1km for May 2004. Clusters identified by different colors are overlaid with ecoregion boundaries.

Accomplishments

- Developed GeoLearn which supports processing, data mining, and visualization based on various data products
  - Terrestrial products (NDVI, EVI, LAI, FPAR, LST, Albedo, snow/ice cover (HDF-EOS files)
  - SRTM elevation
  - GIS coverage (vector and raster)
- GeoLearn provides data processing and mining support for very large data sizes (out of core processing capability)
- GeoLearn provides scientific analyses at regional and continental scales

CoI: Peter Bajcsy, NCSA, Univ. of Illinois

TRL_{in} = 4; TRL_{out} = 6

Science Model Driven Autonomous Sensor Web

PI: Ashley Davies, JPL

Objective

- To maximize science data return and optimize asset and resource use of an existing sensor web by including volcanic process models in the control loop.
- We have modified an existing sensor web that has a simple trigger-reaction mode, to one that uses a volcanic process model to guide the reaction. For example: a ground sensor detects increasing activity, causing the sensor web to seek additional key data as input for a model of a volcanic process to determine volcano state.
- This effort integrated automated retasking and science process modeling to enable true science-driven sensor web operations.

Applications for Monitoring Volcanoes, Forest Fires, Snow/Ice Cover and Flooding

Accomplishments

- Volcano sensor web detected activity at Nyamulagira in the Democratic Republic of Congo and rescheduled satellite observations faster than the alternative system which incorporates human decision-making in the loop. Sensor Web-generated data and products were used to direct mitigation efforts around the town of Sake.
- Have defined and set up Web Services for the Model-based Sensor Web (a major step towards universal accessibility). Using web services automates complex coordination and analysis of data for multiple users. Data are automatically produced and disseminated to experts in the field.
- Volcano sensor web includes ground based sensors (tilt, seismic, acoustic, gas) and algorithms for sunlight removal, saturation detection, temperature fitting, and calculation of thermal emission and effusion rate.
- Developed a ground sensor package for two-way communication with satellites, allowing autonomous analysis-driven two-way triggering (spacecraft by ground sensor-derived trigger; ground sensor by spacecraft-derived trigger).
- Sensor web was expanded to sea ice and flood applications using other satellites and ground sensors.

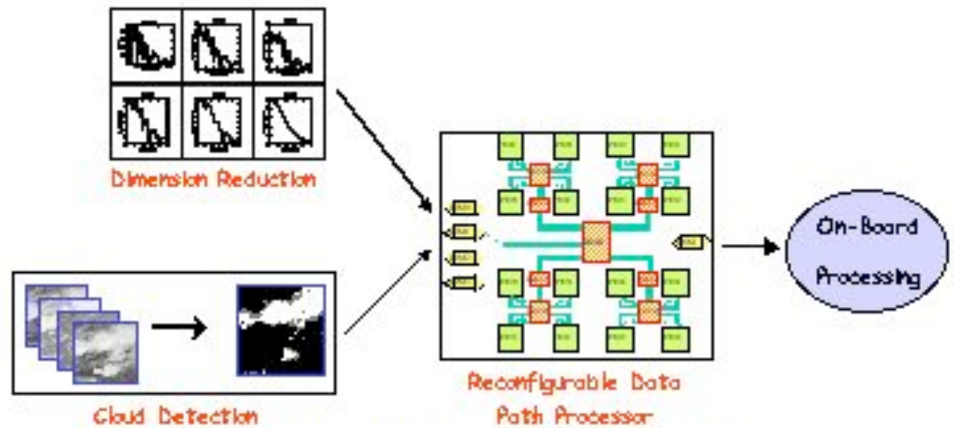
TRL_{in} = 3 TRL_{out} = 5

A Reconfigurable Computing Environment for On-Board Data Reduction and Cloud Detection

PI: Jacqueline Le Moigne, GSFC

Objective

- Investigate the use of reconfigurable computing for on-board automatic processing of remote sensing data.
- Use Reconfigurable Data Path Processor/Field Programmable Path Array (RDPP/FPPA), a radiation tolerant alternative to Field Programmable Gate Arrays, developed at NASA/Goddard and U. of Idaho as the computation engine of our study.



Reconfigurable Data Processing

Accomplishments

- Performed Algorithms Tradeoff Studies
- Applied and Validated Dimension Reduction to Hyperspectral AIRS Data
- Designed a Flexible FPPA Reconfigurable Processing Testbed ; Designed FPPA Graphical Design Environment
- Performed Algorithm implementation study
- Developed New FPPA Technology Advances/Method &Pilot Software for Accurate Mathematical Computing on Integer Hardware
- Implemented Wavelet-Based Hyperspectral Dimension Reduction on SRC-6: 32X Speedup
- Implemented Automatic Cloud Cover Assessment (ACCA) on SRC-6: 28X Speedup and less than 1% Error Over Water
- Implemented Automatic Image Registration in SRC-6: 4X Speedup

CoIs: P.S. Yeh, J. Joiner, GSFC. W. Xia, GS&T
G. Donohoe & Team, U. Idaho, T. El-Ghazawi & Team, GWU

TRL_{in} = 3; TRL_{out}= 5

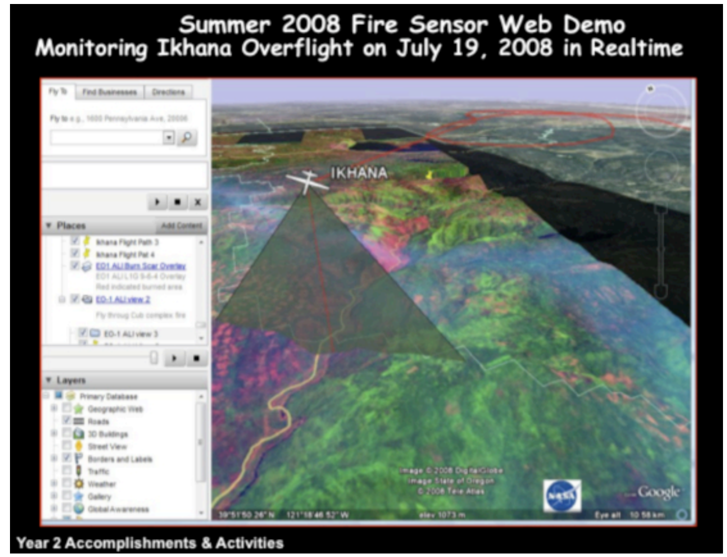
An Expanded Interoperable Sensor Architecture to Facilitate Sensor Webs in Pursuit of GEOSS

PI: Dan Mandl, NASA GSFC

Objective

Augment existing EO-1 Sensor Web effort to make the demonstrations more robust by adding:

- Security on open Internet (OpenID/OAuth) for Open Geospatial Consortium (OGC) compliant web services
- OGC compliant cloud Web Coverage Service (WCS)
- OGC compliant WCS for Ikhana Unmanned Aerial System to be used by smoke model
- Publish/subscribe capability for alerts
- Decision Support System to allocate resources



Accomplishments

- Developed integration software to enable automated sensor web operations via:
  - Workflow Chaining Service (WfCS), and GEOSS Campaign Manager
  - OpenID/OAuth security protocols
  - Web Notification Service (WNS), GeoRSS data feeds
  - Draper Cloud Coverage predictions as Web Processing Services (WPS)
  - Web Mapping Service (WMS) for visualization via Google Earth
  - Web Coverage Service (WCS) for fire, smoke products
- Supported several sensor web demonstrations:
  - OGC Web Services Testbed 5 (OWS-5) and the Empire Challenge (National Geospatial-Intelligence Agency)
  - Global Earth Observing System of Systems (GEOSS) fire sensor web experiment in Kenya
  - International Red Cross emergency response demos in Mozambique and Myanmar (floods), and China (earthquake)
  - California 2008 Wildfire campaign

Co-Is/Partners: Pat Cappelaere, Vightel; Don Sullivan, NASA ARC; Stefan Falke, Northrop Grumman; Steve Kolitz, Draper Lab

TRL_{in} = 4; TRL_{out} = 5

For more information on these and other Earth Science technologies, go to :

http://esto.nasa.gov

Or contact :

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