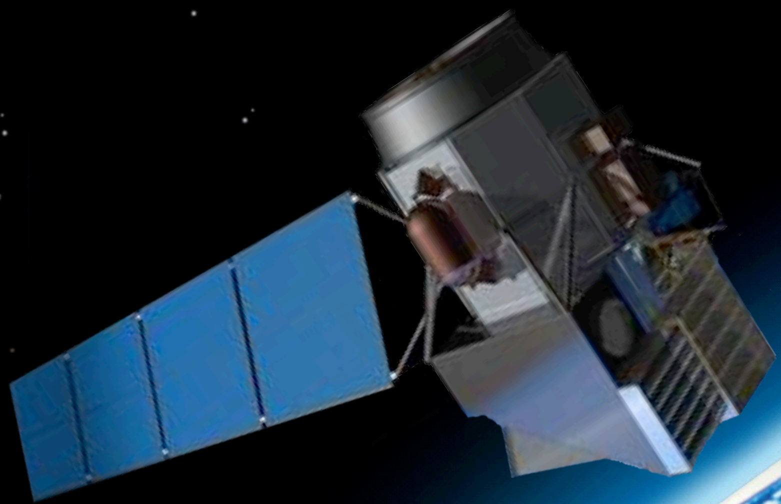
Overview of the 2016 HyspIRI Symposium at NASA's Goddard Space Flight Center June 1-3, 2016



Elizabeth M. Middleton
EO-1 Mission Scientist
2007- present
Biospheric Sciences Laboratory
NASA GSFC, October, 2016

HyspIRI Workshop
Pasadena, CA
October 2016

2016 HyspIRI Mission and Products Symposium:
Evolving the HyspIRI Mission and Products: The Amazing Possibilities with Imaging Spectroscopy & Thermal Observations from Space

NASA/GSFC, June 1 and 2, 2016
Building 33, Conference Room H114

Wireless internet connection:
Choose "Guest-CNE" network

GSFC EO-1/HyspIRI Team

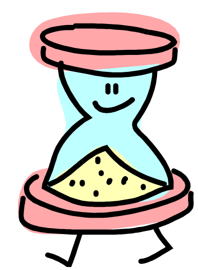
Betsy Middleton, Dan Mandl, Chris Neigh, NASA GSFC
Steve Ungar, USRA

Lisa Henderson, SSAI
Petya Campbell, UMBC
Kevin Turpie, UMBC

David Landis, GST
Fred Huemmrich, UMBC
Qingyuan Zhang, USRA
Larry Corp, SSAI
Lawrence Ong, SSAI
Dan Mandl, NASA
Stu Frye, SGT
Pat Cappelaere, Vightel Corp
Kevin Mitchell, SSAI

Wed/Thurs Lunches: Boxed Lunches are for Pre-Purchases Only
If pre-purchased, please pay at Registration Desk ($10)

Thursday Dinner: Sign up at Registration Desk



2016 HyspIRI Mission and Products Symposium

Day One: Wednesday, June 1

- Session I: Missions [Chair, Betsy Middleton, GSFC] HyspIRI Mission Update Overviews
- Session II: Terrestrial Ecosystem Priorities [Chair, Woody Turner, NASA HQ]
- Session III: Cal/Val Activities [Chair, Chris Neigh, GSFC]
- Session IV: HyspIRI Science Preparatory Activities: Applications [Chair, Jeff Luvall, MSFC]
- Session V: HyspIRI Science Preparatory Activities: New Technologies & Products [Chair, Dan Mandl, GSFC]

Day Two: Thursday, June 2

- Session VI: HyspIRI Preparatory Activities: Airborne Campaigns [Chair, Simon Hook, JPL]
- Session VII: Addressing International Space Station Related Mission Activities [Chair, Steve Ungar, USRA]
- Session VIII: HyspIRI Science Preparatory Activities: Carbon & Water Science (Chair, Petya Campbell, UMBC]

Day 3: Friday, June 3

HyspIRI Aquatic Studies Group (HASG), 4th Annual Aquatic Forum [Chair, Kevin Turpie]

- Session XI: Aquatic Airborne Campaigns
- Session XIII: Aquatic Missions


2016 HyspIRI Mission and Products Symposium
Evolving the HyspIRI Mission and Products: The Amazing Possibilities with Imaging Spectroscopy & Thermal Observations from Space
HyspIRI
NASA/GSFC June 1-3, 2016
Building 33, Conference Room H114 (June 1-2)
Building 34, Conference Room W150 (June 3)

7th HyspIRI Data Product Symposium, GSFC, Greenbelt, MD

HyspIRI Update

Woody Turner
HyspIRI co-Program Scientist
Earth Science Division
NASA Headquarters

June 1, 2015

HyspIRI Guidance for FY2016

(Per 10/30/2015 Guidance Memo from Eric Ianson)

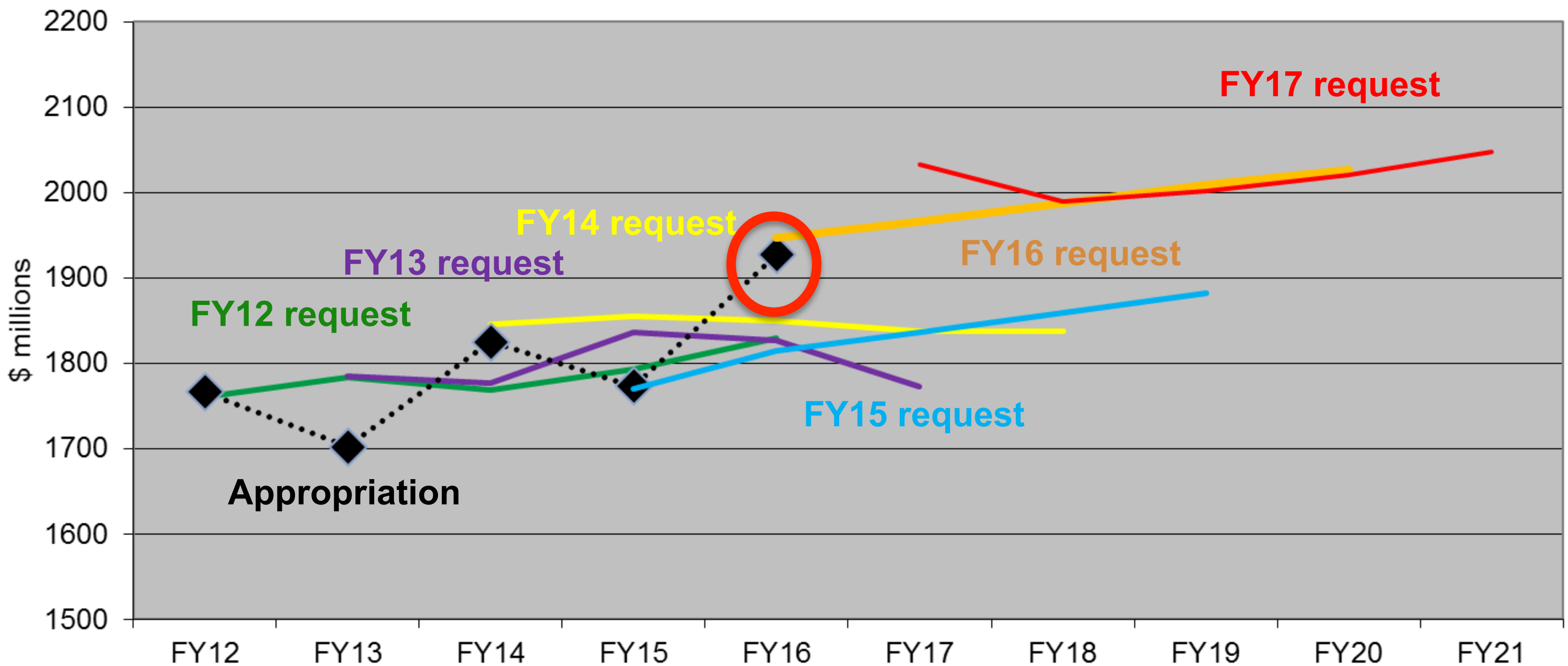
1. Continue to build broad community understanding via workshops/symposia
2. Continue to conduct HyspIRI data product generation and benchmarking with airborne and satellite data
3. Continue to carry out instrument mission trade studies, including smallsat and ISS opportunities, to provide lower cost and more adaptable instrument and/or mission approaches, including risk reduction and IPM for throughput/low latency
4. Continue to explore options to ensure the HyspIRI VSWIR and TIR instruments meet the Sustainable Land Imaging measurement requirements, including compatibility with heritage data product resolutions, inter-sensor band synthesis
5. Utilize the ECOSTRESS mission development for HyspIRI risk reduction
6. Continue to engage potential international and domestic partners in addressing opportunities to lower mission cost while maintaining Level 1 mission requirements, and strengthen synergies with upcoming international missions
7. Prepare materials updating the NRC 2017 Decadal Survey on status and value of HyspIRI and provide NRC with options for accomplishing the mission
8. Refine and update the HyspIRI comprehensive development report

FY16 Funding = $2M + $360,000 over guide

ESD Budget: FY17 Request/Appropriation

ESD Total						
$M	FY16 (op plan)	FY17	FY18	FY19	FY20	FY21
FY16 PBS	$ 1,927	$ 1,966	$ 1,988	$ 2,009	$ 2,027	
FY17 PBS		$ 2,032	$ 1,990	$ 2,001	$ 2,021	$ 2,048

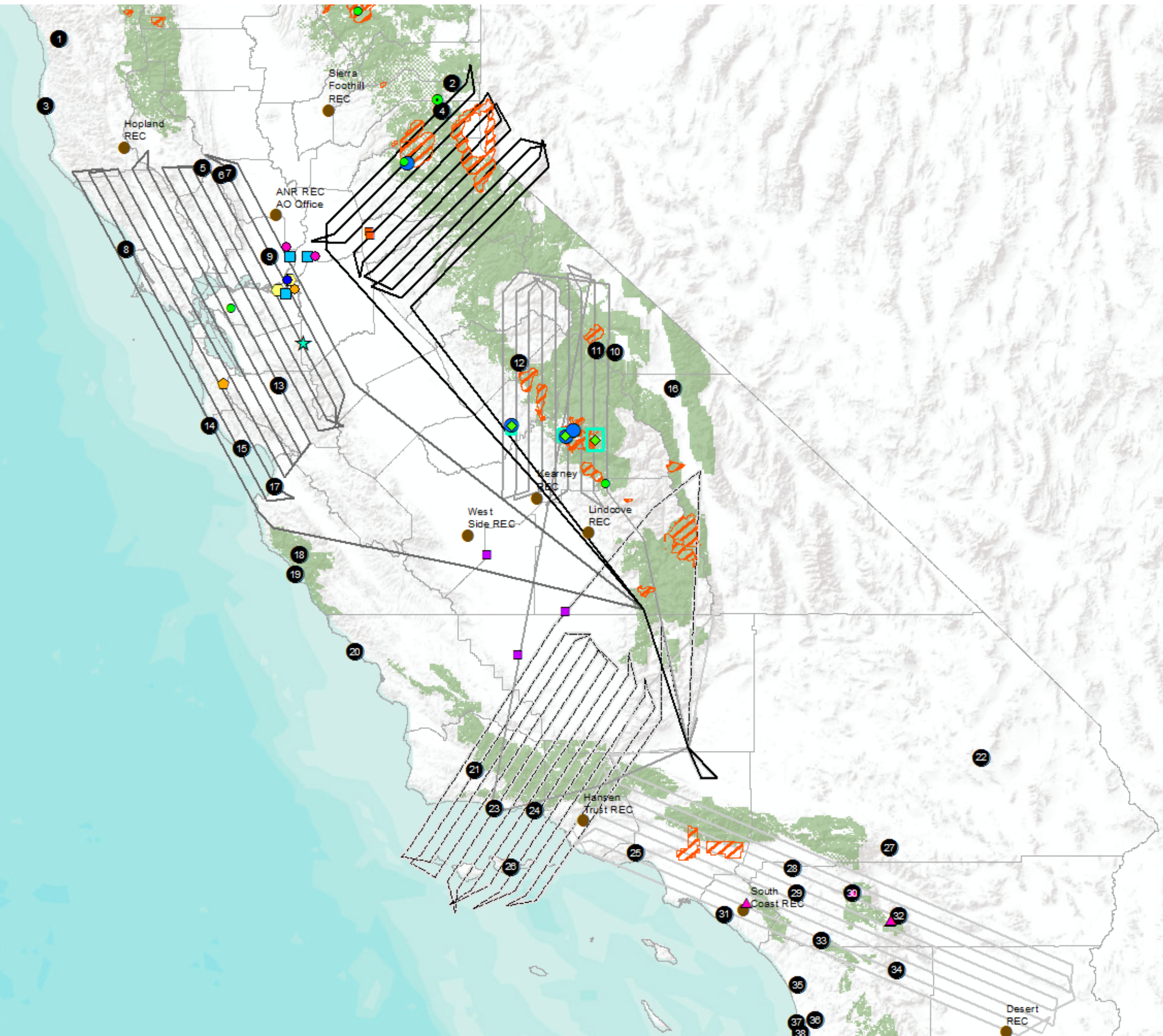
- *ESD budget jumps significantly in FY17 – then becomes consistent with FY16 PBR for the out years*

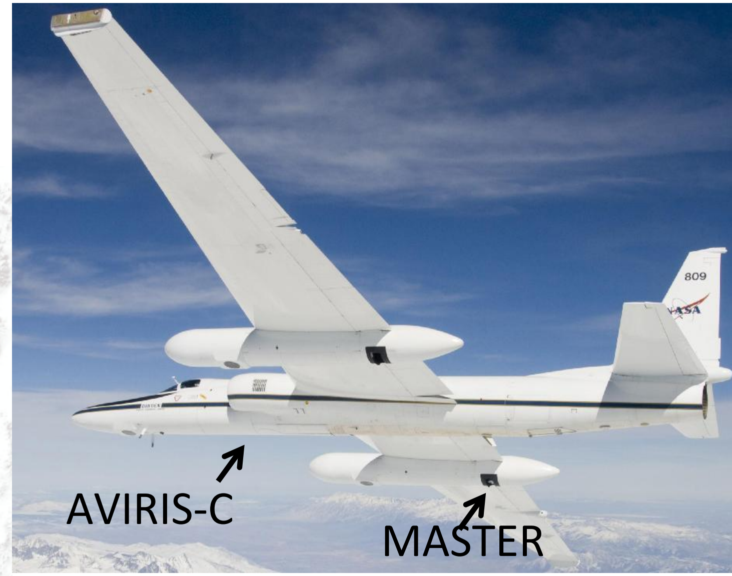


HyspIRI Airborne Preparatory Mission - CA

Summer 2016 Acquisition

ER-2 Altitude	*AVIRIS Resolution*	*AVIRIS Swath*	*MASTER Resolution*	*MASTER Swath*
65,000 ft	*20 m*	*12 km*	*50 m*	*35 km*

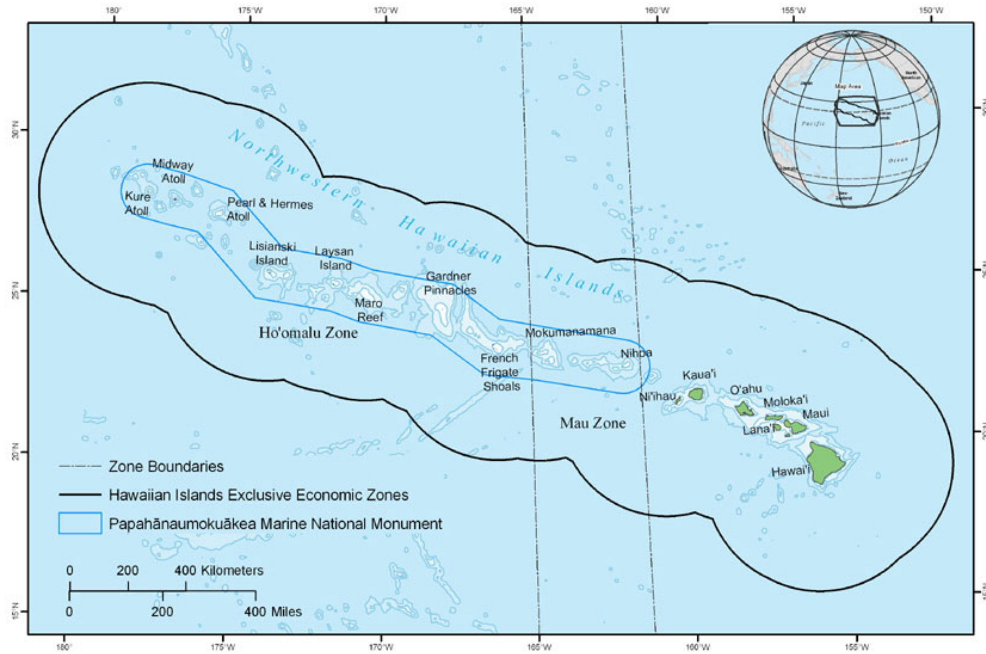




PI TEAM:

Wendy Calvin/University of Nevada - Reno
Matthew Clark/Sonoma State University
Bo-Cai Gao/Naval Research Laboratory
Bernard Hubbard/USGS
George Jenerette/University of California, Riverside
Thomas Kampe/NEON
Raphael Kudela/University of California, Santa Cruz
Ira Leifer/University of California, Santa Barbara
Paul Moorcroft/Harvard University
Dar Roberts/University of California, Santa Barbara
Philip Townsend/University of Wisconsin-Madison
Susan Ustin/University of California, Davis
Jan van Aardt/Rochester Institute of Technology
Dongdong Wang/University of Maryland

HyspIRI Preparatory Airborne Hawaii Campaign for Coral Reefs and Volcanoes



Coral Reef Investigators

- Steve Ackleson/NRL
- Kyle Cavanaugh/UCLA
- Heidi Dierssen/UCONN
- Paul Haverkamp/Cramer Fish Sciences
- Eric Hochberg/BIOS
- ZhongPing Lee/UMASS Boston

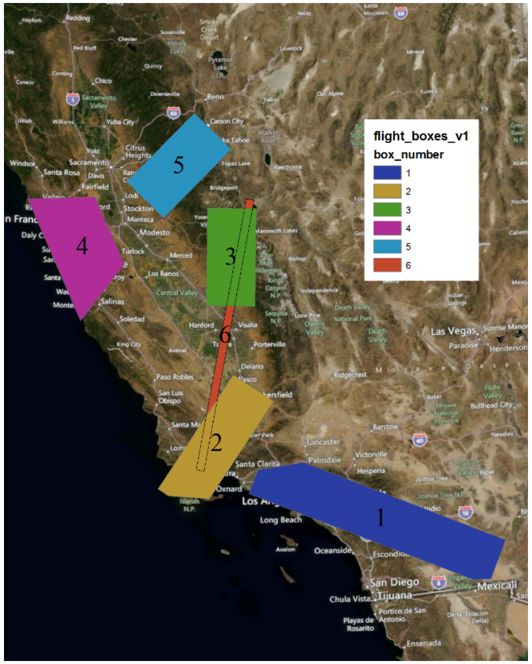
Volcano Investigators

- Chad Deering/Michigan Tech
- David Pieri/JPL
- Michael Ramsey/University of Pittsburgh
- Vincent Realmuto/JPL
- Greg Vaughan/USGS Flagstaff

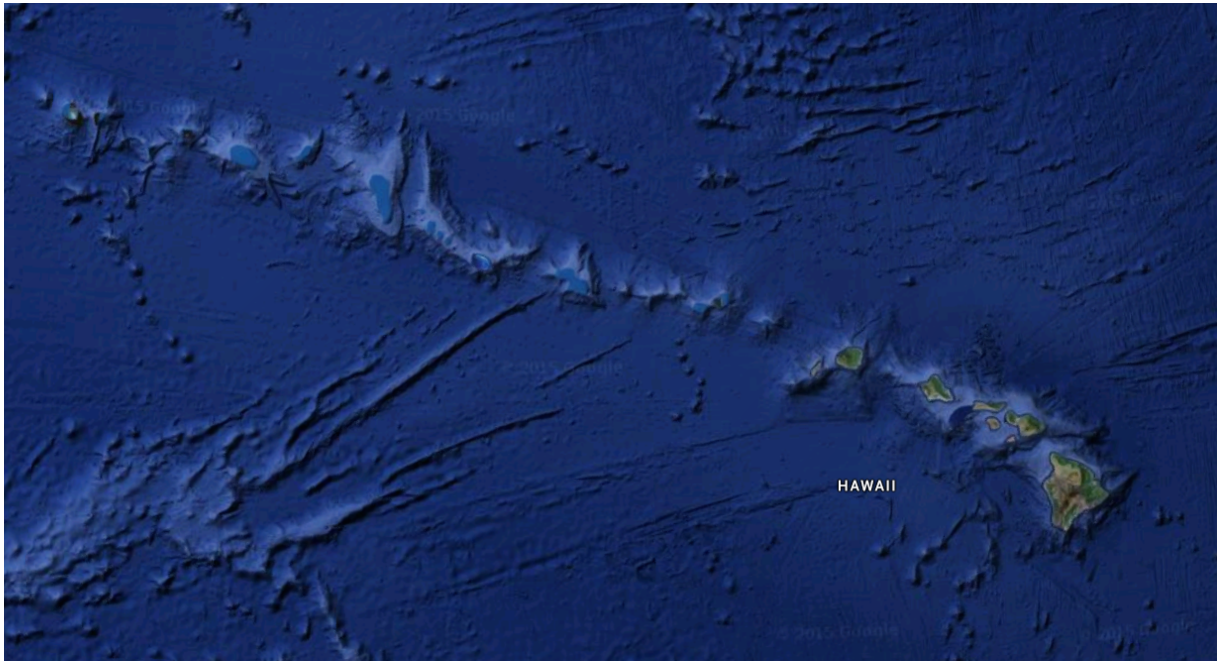
Flights planned for mid January to early March 2017

HyspIRI Preparatory Airborne Campaigns

Western US: Diversity



Hawaii: Volcanoes and Coral Reefs

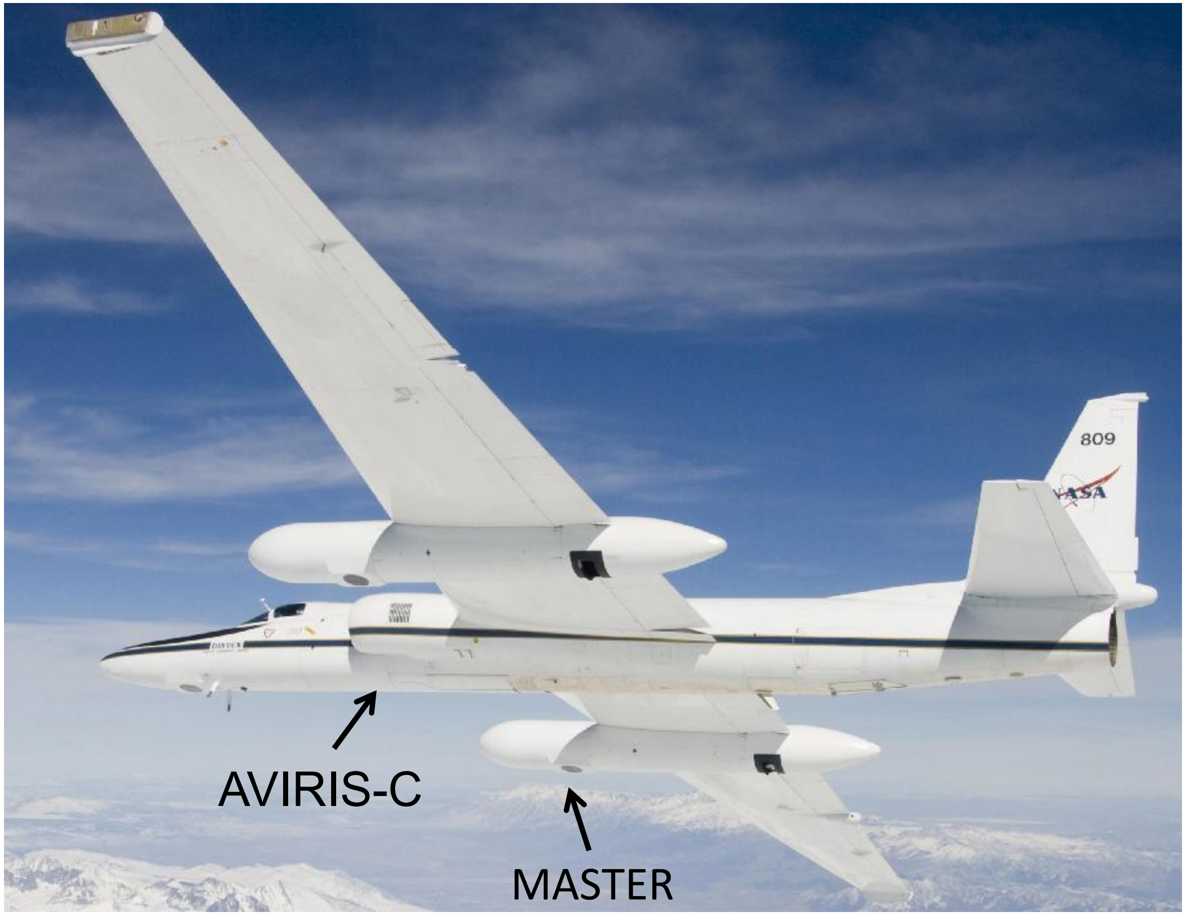


Robert O. Green[1] and The HyspIRI Community

[1]Jet Propulsion Laboratory, California Institute of Technology

Preparatory Measurements to Simulate HyspIRI Flights Over California Based from NASA Armstrong

ER-2 Altitude	*AVIRIS Resolution*	*AVIRIS Swath*	*MASTER Resolution*	*MASTER Swath*
65,000 ft	*20 m*	*12 km*	*50 m*	*35 km*



AVIRIS (VSWIR)

- 10 nm spectral resolution
- 224 bands
- 400-2500 nm
- 1 mrad IFOV
- 34 degree FOV

MASTER (TIR)

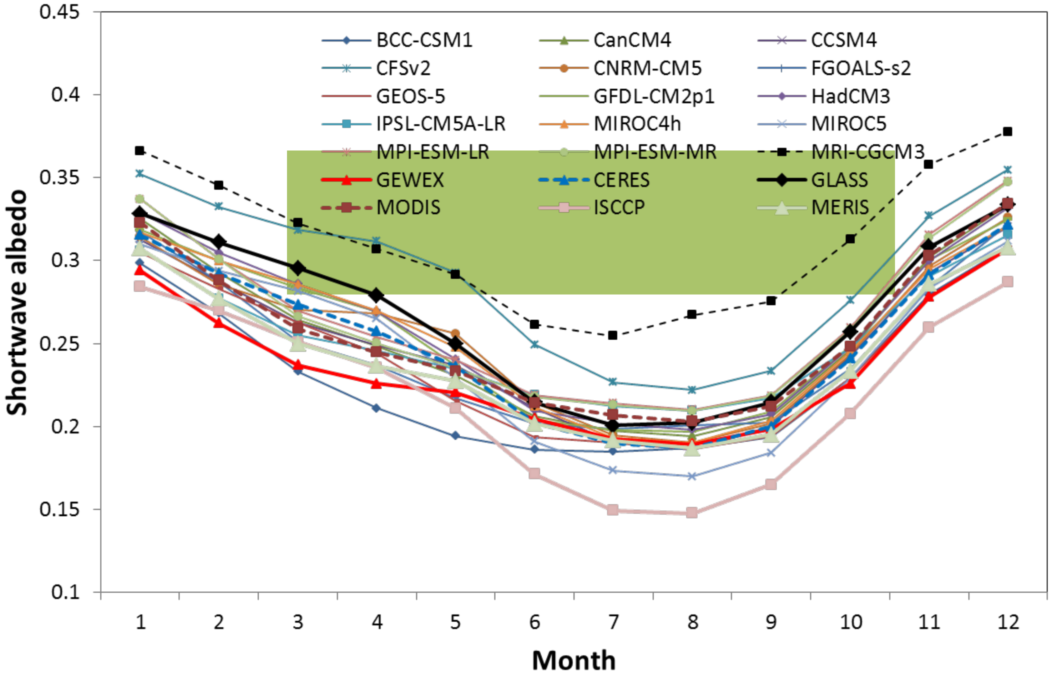
- 50 bands
- 0.4-13 um
- 2.5 mrad IFOV
- 85.92 degrees FOV

Mapping land surface radiation and energy budget from the AVIRIS and MASTER data

Dongdong Wang, Shunlin Liang, Tao He, Qinqing Shi

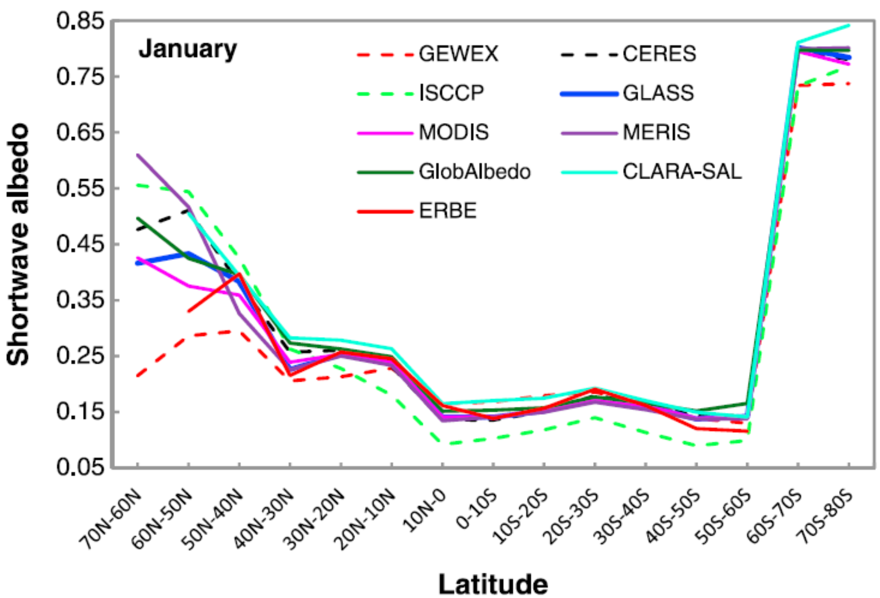
Department of Geographical Sciences

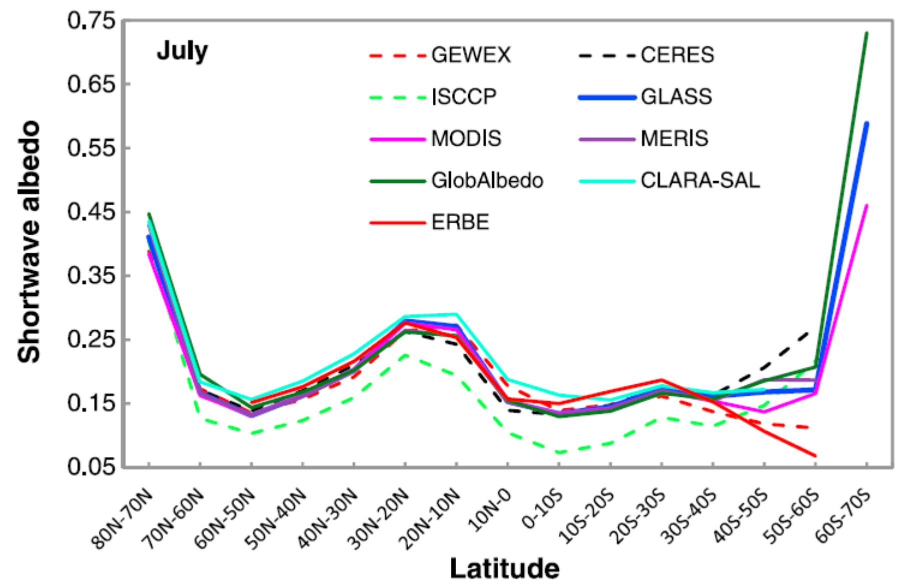
University of Maryland, College Park



Inter-comparison of 30-year global albedo climatology derived from satellite products and CMIP5 model outputs.

Model mean: 0.21
Standard dev.: 0.02
MODIS: 0.24

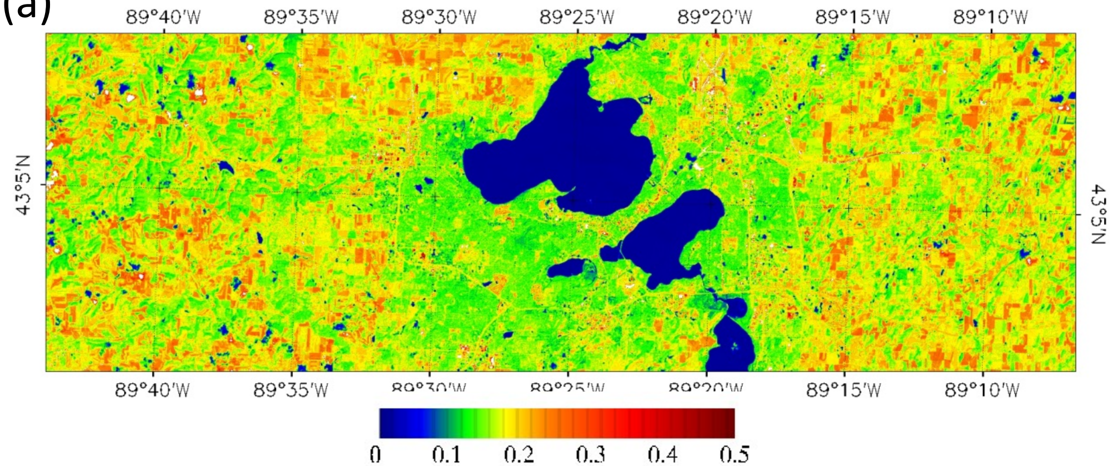




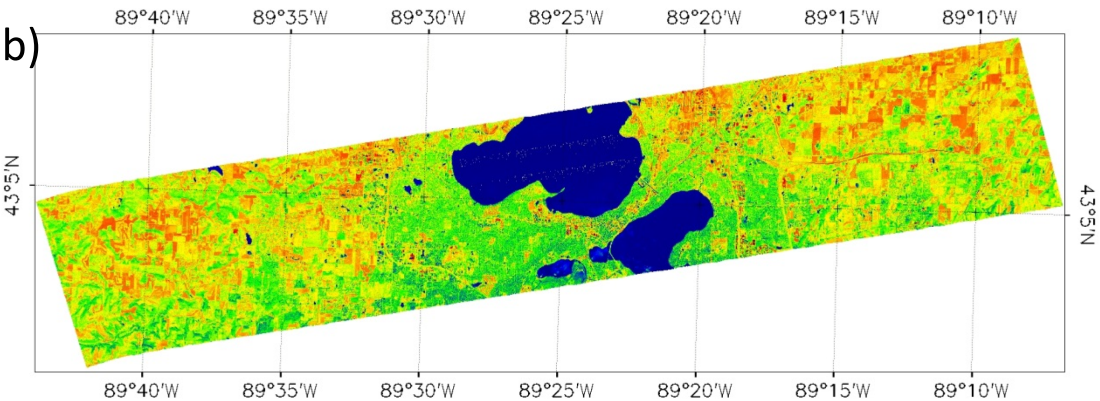
He, et al, (*2014*). Analysis of global land surface albedo climatology and spatial-temporal variation during 1981-2010 from multiple satellite products. *Journal of Geophysical Research: Atmospheres, 119, 10281-10298*

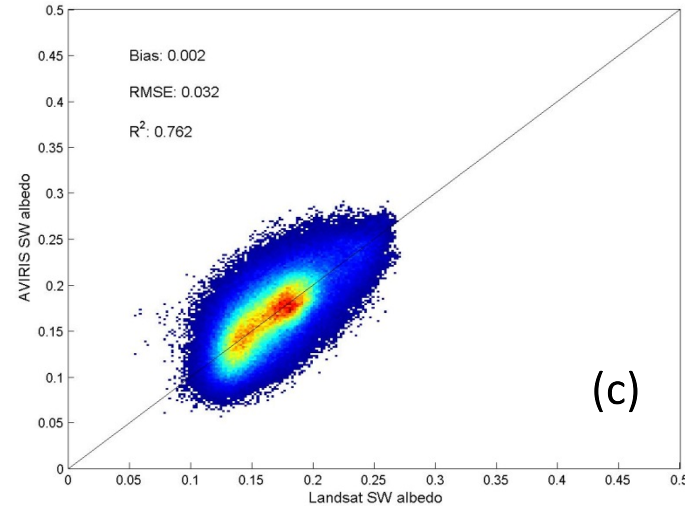
Mapping surface albedo: AVIRIS vs. Landsat

(a)



(b)





(c)

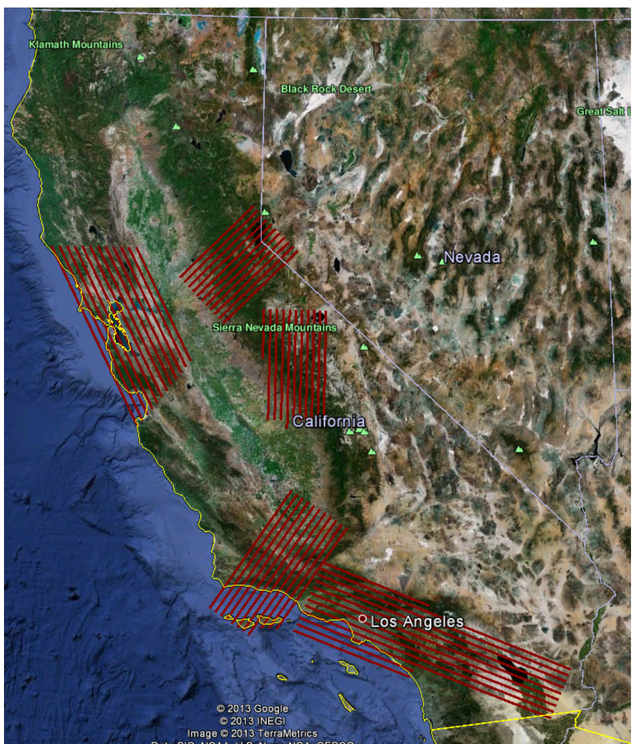
Shortwave albedo estimations from: (a) Landsat TM on Aug 18th, 2010; (b) AVIRIS on Aug 26th, 2010 using the stepwise regression algorithm; and (c) scatter plot. Image is centered at 43.08°N, 89.41°W in Madison, WI, USA.

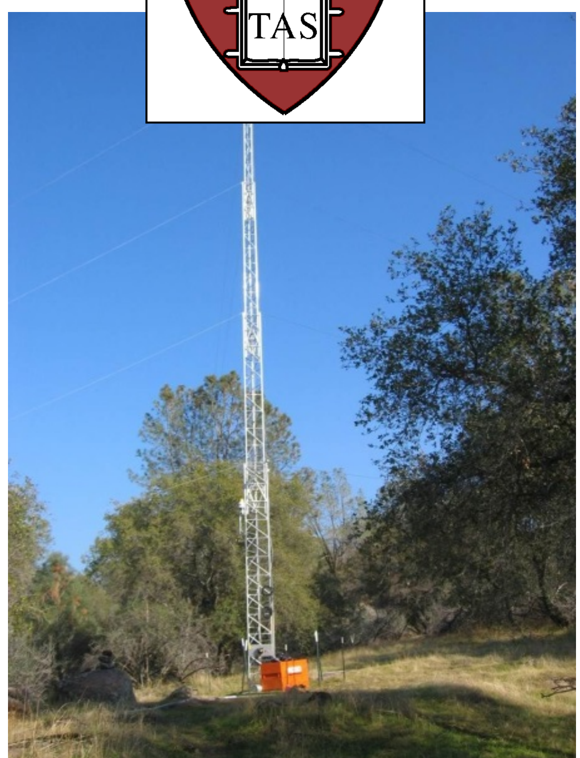
He et al. 2013

Using Imaging Spectrometry Measurements of Ecosystem Composition to Constrain Terrestrial Biosphere Model Predictions of Carbon, Water and Energy Fluxes

Paul R. Moorcroft[1], Alexander Antonarakis[1,2], Stacy Bogan[1]

1Harvard University
2 University of Sussex





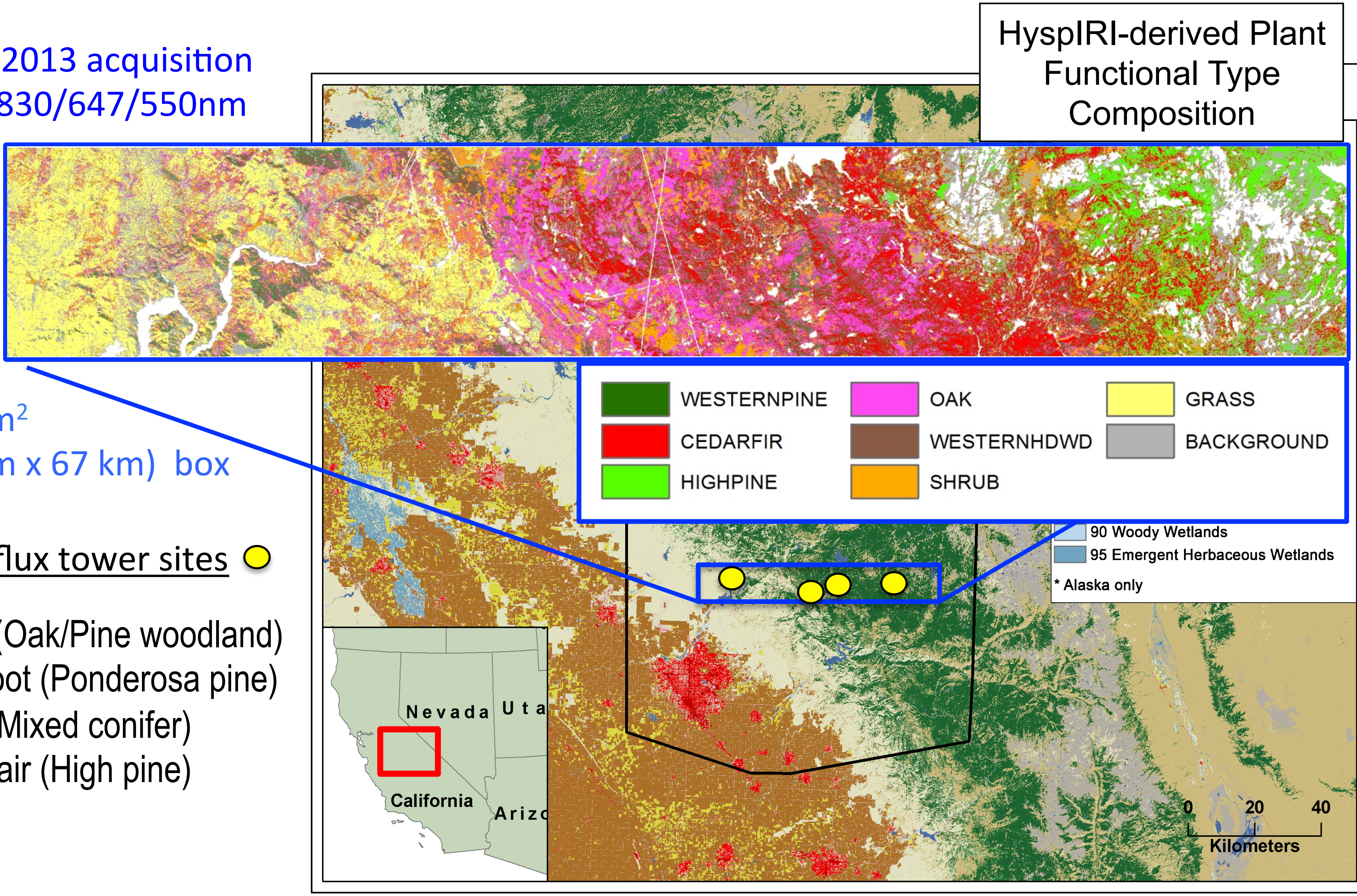
HyspIRI-Derived Composition Estimates for the Yosemite/NEON Flight Box

June 2013 acquisition
RGB 830/647/550nm

737km²
(11 km x 67 km) box

CZO flux tower sites

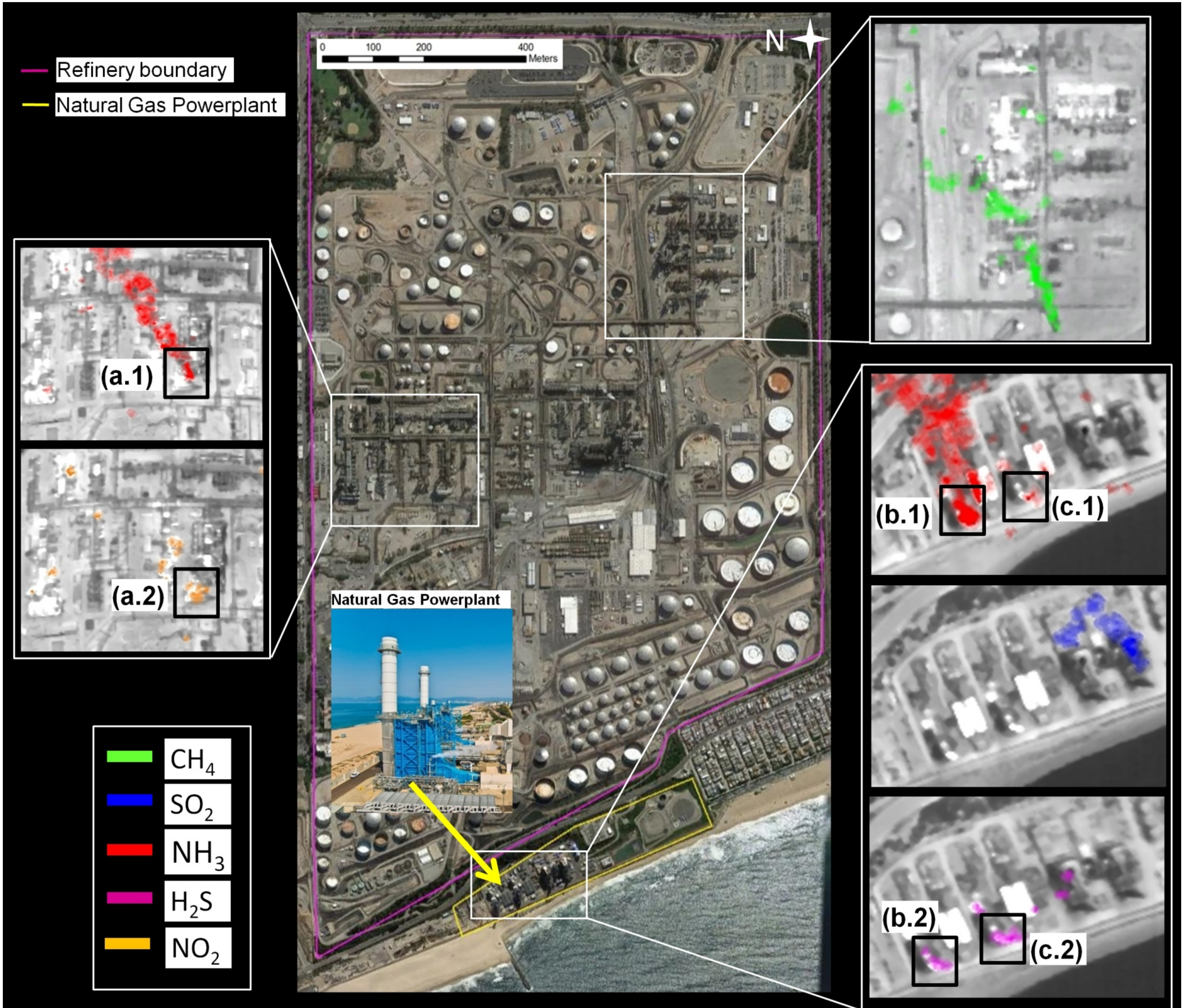
SJER (Oak/Pine woodland)
Soaproot (Ponderosa pine)
P301 (Mixed conifer)
Shorthair (High pine)



High spatial resolution imaging of methane and other trace gases with HyTES

Glynn Hulley, Le Kuai, Francesca Hopkins, Riley Duren
Jet Propulsion Laboratory, California Institute of Technology

<u>PI:</u> Simon Hook
<u>Mission Manager:</u> Seth Chazanoff
<u>Project Manager:</u> Bjorn Eng, Pierre Guillevic
<u>Optics:</u> Zakos Mouroulis, William Johnson
<u>Geo-correction and Image Orthorectification:</u> Veljko Jovanovic, Nick Vance
<u>Detectors:</u> Sarath Gunapala, Alex Soibel, David Ting
<u>Gratings:</u> Dan Wilson
<u>Thermal/Mechanical:</u> Jonathan Mihaly, Chris Paine, Andy Lamborn, Kevin Knarr, William Johnson
<u>Science, Data Reduction, Quality Control:</u> Glynn Hulley, Pierre Guillevic, Riley Duren, Simon Hook, Andrew Aubrey, William Johnson
<u>Data recording and storage:</u> Nick Vance, Bjorn Eng


Refinery boundary
Natural Gas Powerplant
0
100
200
400
Meters
N
(a.1)
(a.2)
Natural Gas Powerplant
(b.1)
(c.1)
(b.2)
(c.2)
CH_4
SO_2
NH_3
H_2S
NO_2

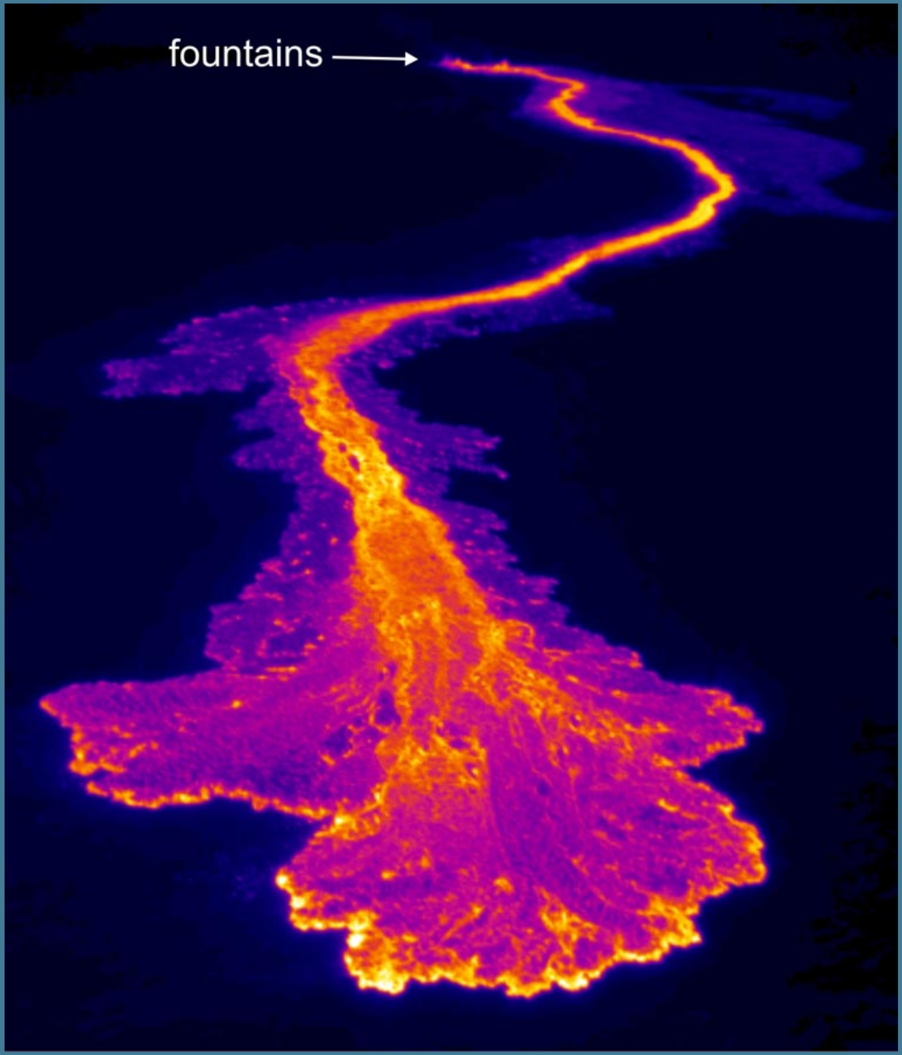
Quantifying Active Volcanic Processes and Mitigating their Hazards with HyspIRI Data

Michael Ramsey, University of Pittsburgh

Andrew Harris, Univesité Blaise Pascal (France)

I. Matthew Watson, University of Bristol (UK)

Matthew Patrick, USGS Hawaiian Volcano Observatory

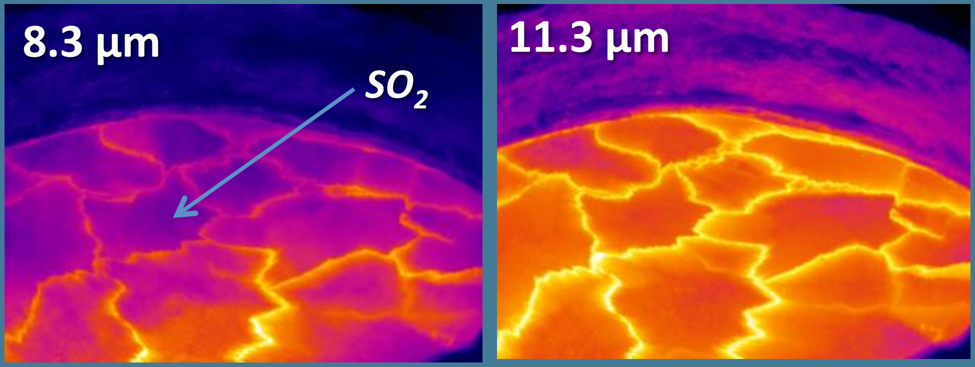


IR image of Kilauea flow: Matt Patrick (HVO)

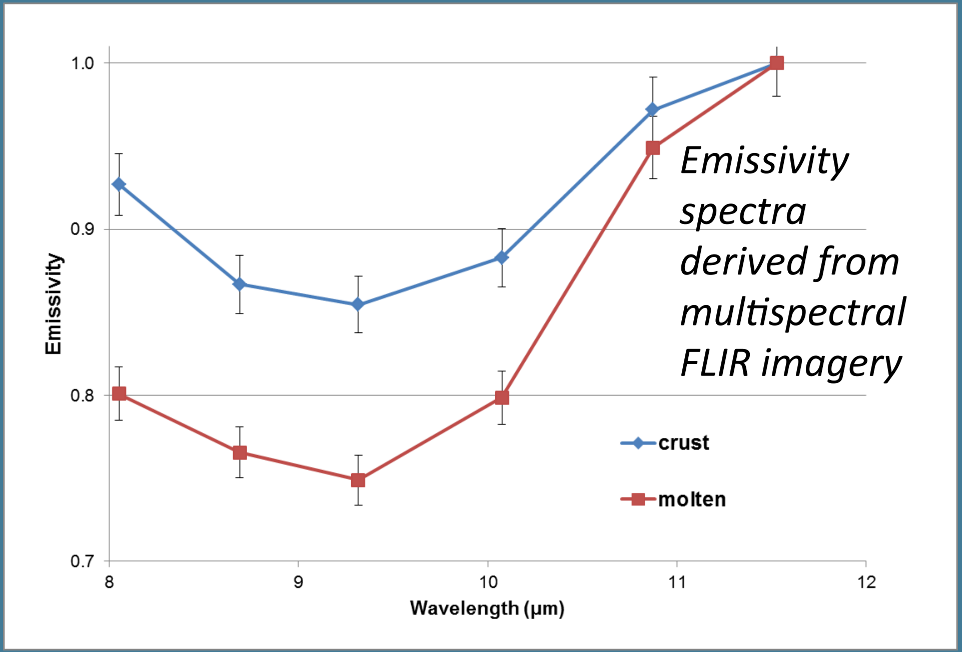
Quantifying Active Volcanic Processes and Mitigating their Hazards with HyspIRI Data

Approach:

- The airborne data will be forward-modeled using a quantitative resampling methodology
- Ground-based multispectral TIR data will be acquired with new FLIR-based instrument
- The combined data will be used to validate a correction approach for thermally-mixed HyspIRI data using VSWIR and TIR data
- Results will be input into flow modeling to better monitor and predict future volcanic hazardous phenomena



FLIR filter images of Halemaumau Crater lava lake



Emissivity spectra derived from multispectral FLIR imagery

HyspIRI Related Inputs to Decadal RFI2 Many Tied to Airborne Campaigns

Wendy	Calvin	Earth Surface Geochemistry and Mineralogy: Processes, Hazards, Soils, and Resources
Philip	Dennison	Global Measurement of Non-Photosynthetic Vegetation
Heidi	Dierssen	Assessing Transient Threats and Disasters in the Coastal Zone with Airborne Portable Sensors
Riley	Duren	Understanding anthropogenic methane and carbon dioxide point source emissions
Joshua	Fisher	Evapotranspiration: A Critical Variable Linking Ecosystem Functioning, Carbon and Climate Feedbacks, Agricultural Management, and Water Resources
Robert	Green	Science and Application Targets Addressed with the 2007 Decadal Survey HyspIRI Mission Current Baseline
Eric	Hochberg	Coral Reefs: Living on the Edge
Simon	Hook	Carbon Emissions from Biomass Burning
Luvall	Jeffrey	A Thermodynamic Paradigm For Using Satellite Based Geophysical Measurements For Public Health Applications
Natalie	Mahowald	Measuring the Earth's Surface Mineral Dust Source Composition for Radiative Forcing and Related Earth System Impacts
Frank	Muller-Karger	Monitoring Coastal and Wetland Biodiversity from Space
Thomas	Painter	Understanding the controls on cryospheric albedo, energy balance, and melting in a changing world
Ryan	Pavlick	Biodiversity
Dale	Quattrochi	High Spatial, Temporal, and Spectral Resolution Instrument for Modeling/Monitoring Land Cover, Biophysical, and Societal Changes in Urban Environments
E. Natasha	Stavros	The role of fire in the Earth System
Philip	Townsend	Global Terrestrial Ecosystem Functioning and Biogeochemical Processes
Kevin	Turpie	GLOBAL OBSERVATIONS OF COASTAL AND INLAND AQUATIC HABITATS
Robert	Wright	PREDICTING CHANGES IN THE BEHAVIOR OF ERUPTING VOLCANOES, AND REDUCING THE UNCERTAINTIES ASSOCIATED WITH THEIR IMPACT ON SOCIETY AND THE ENVIRONMENT

Decadal Survey 2017

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The National Academies of
SCIENCES • ENGINEERING • MEDICINE

DECADAL SURVEY FOR EARTH SCIENCE AND APPLICATIONS FROM SPACE
Division on Engineering and Physical Sciences

- ESAS 2017 HOME
- ABOUT THE SURVEY
- STEERING COMMITTEE
- PAST MEETINGS AND EVENTS
- COMMUNITY INPUT
- SSB HOME
- DEPS HOME

Community Input and White Papers

ESAS 2017 Request for Information (RFI #2)

In late September 2015, the Committee on Earth Science and Applications from Space requested community input (RFI #1) to help understand the role of space-based observations in addressing the key challenges and questions for Earth System Science in the coming decade. The responses to this RFI are available at the survey website. The responses guided the since-appointed steering committee's initial discussions on survey organization; in particular, regarding the structure of its supporting study panels. The responses will also continue to inform the work of the committee and will be made available to the soon to be formed study panels.

By design, the initial RFI did not ask the community for ideas on how to address an identified challenge/question in Earth System Science. Building on RFI #1, the committee now requests ideas for specific science and applications targets (i.e., objectives) that promise to substantially advance understanding in one or more of the Earth System Science themes associated with the survey's study panels:

I. Global Hydrological Cycles and Water Resources
The movement, distribution, and availability of water and how these are changing over time

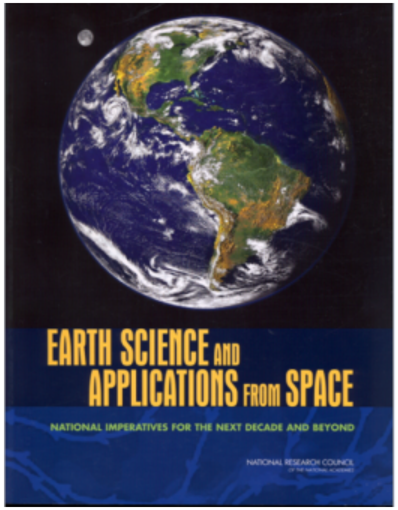
II. Weather and Air Quality: Minutes to Subseasonal
Atmospheric Dynamics, Thermodynamics, Chemistry, and their interactions at land and ocean interfaces

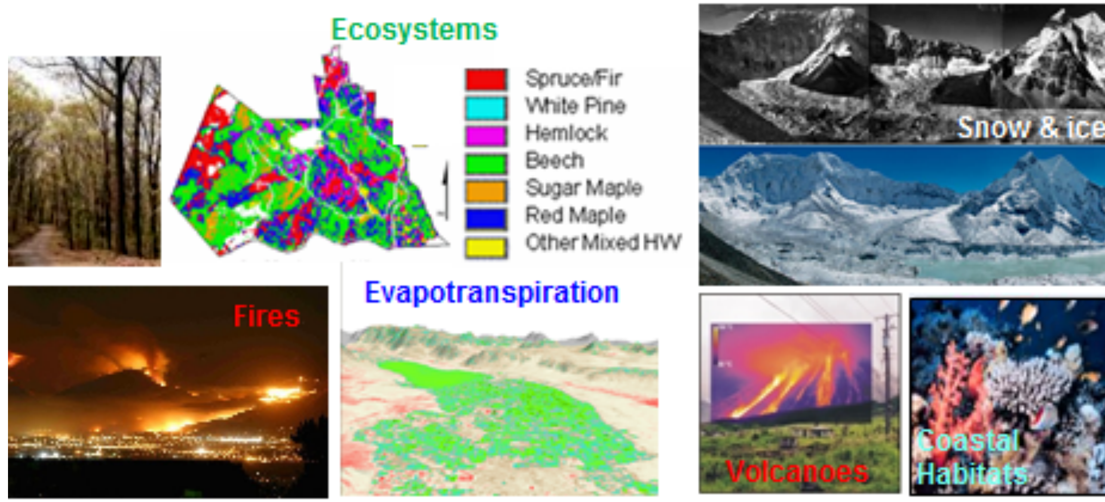
III. Marine and Terrestrial Ecosystems and Natural Resource Management
Biogeochemical Cycles, Ecosystem Functioning, Biodiversity, and factors that influence health and ecosystem services

IV. Climate Variability and Change: Seasonal to Centennial
Forcings and Feedbacks of the Ocean, Atmosphere, Land, and Cryosphere within the Coupled Climate System

V. Earth Surface and Interior: Dynamics and Hazards
Core, mantle, lithosphere, and surface processes, system interactions, and the hazards they generate

18 white papers submitted in response to the 2nd Request for Information!
Available online at http://hyspiri.jpl.nasa.gov/nrc-decadal-survey





Decadal Survey Status & HyspIRI Inputs

Robert O. Green[1] and The HyspIRI Community

[1]Jet Propulsion Laboratory, California Institute of Technology

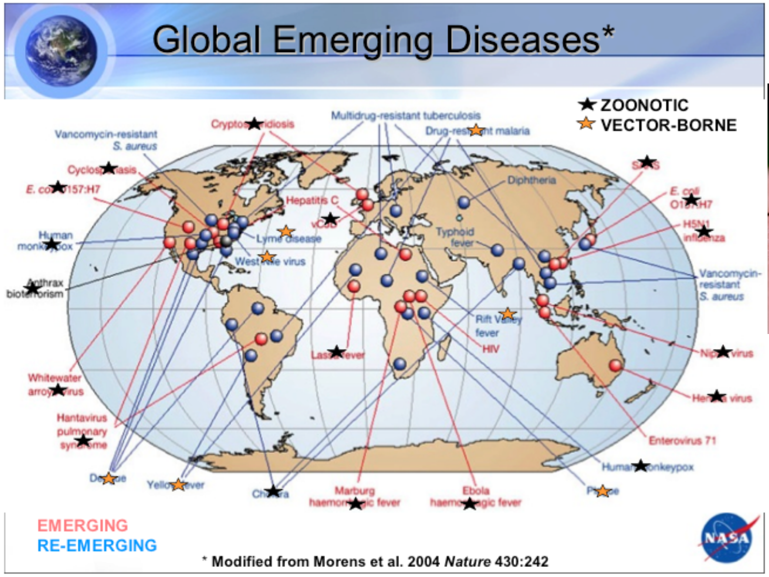
NASA Science Mission Directorate
Earth Science Division
Applied Sciences Program

HyspIRI

Missions Applications

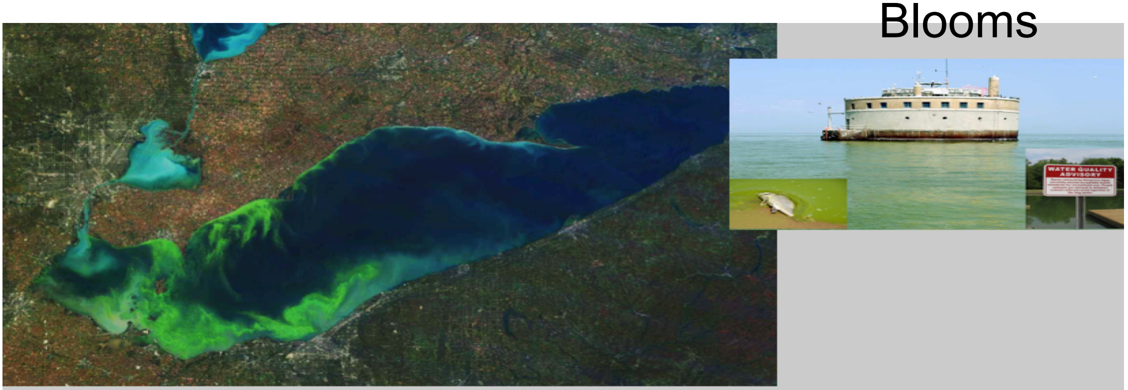
Jeffrey C. Luvall, MSFC, and Christine Lee, Simon Hook, JPL

HyspIRI Mission Applications



Vector Borne Diseases

Harmful Algal Blooms



Dust

Middle East Dust – Trace Composition

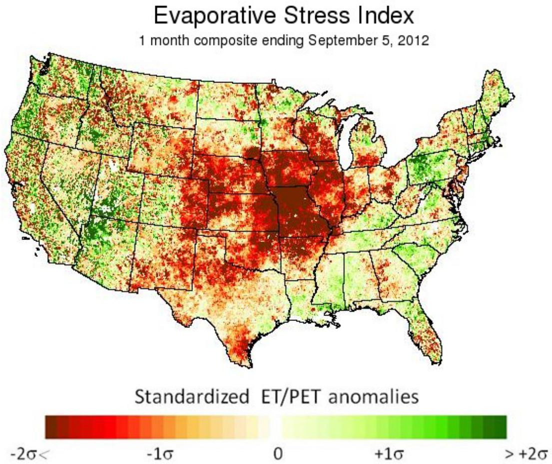
Links between selected elements and some known lung function conditions and diseases

	Desert Dust <10 µm	Desert Dust 20-40 µm
Mn (ppm)	450	331.98
Fe (ppm)	25500	18111.61
Co (ppm)	11.72	8.24
Pb (ppm)	17.22	9.45
Cu (ppm)	220	152.64
Cd (ppm)	1.24	0.70
Mg (ppm)	13230.49	10572.70
Al (ppm)	15912.39	13154.60
Ca (ppm)	139577.64	140250.15
Na (ppm)	1098.28	1476.86
Cr (ppm) [but species critical]	181.32	187.36
Zn (ppm)	105.18	72.30
Ni (ppm)	93.28	60.44
Ti (ppm)	1095.52	539.81

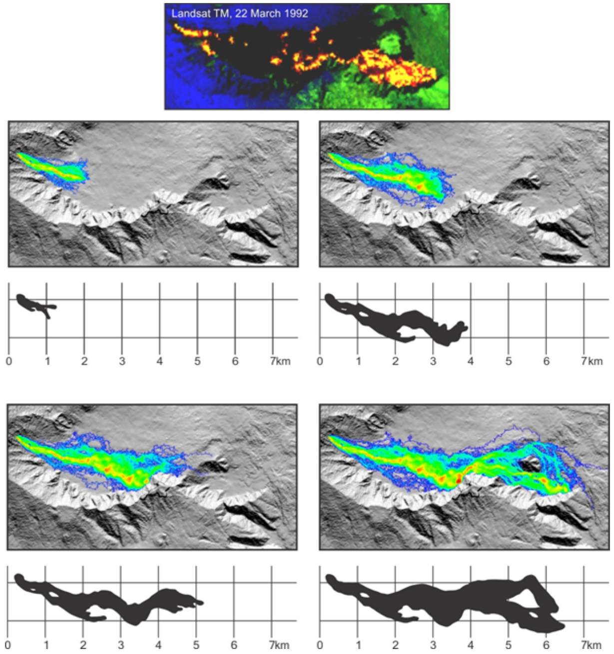
Cancer | Cancer suspected | Cancer & asthma | Emphysema | Asthma

HyspIRI Mission Applications

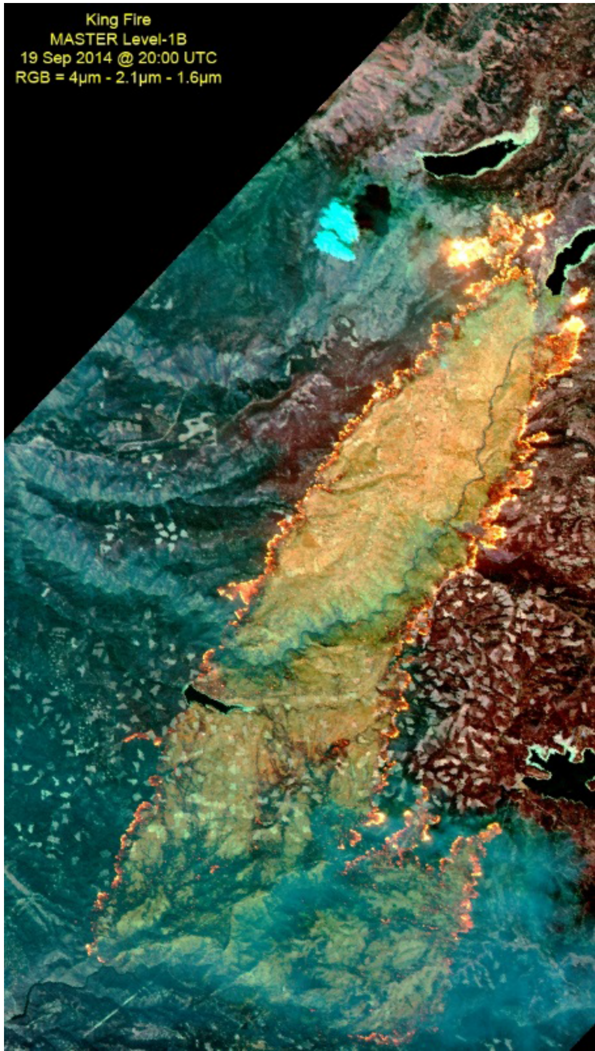
Eco-Forecast
Ecological
Forecasting



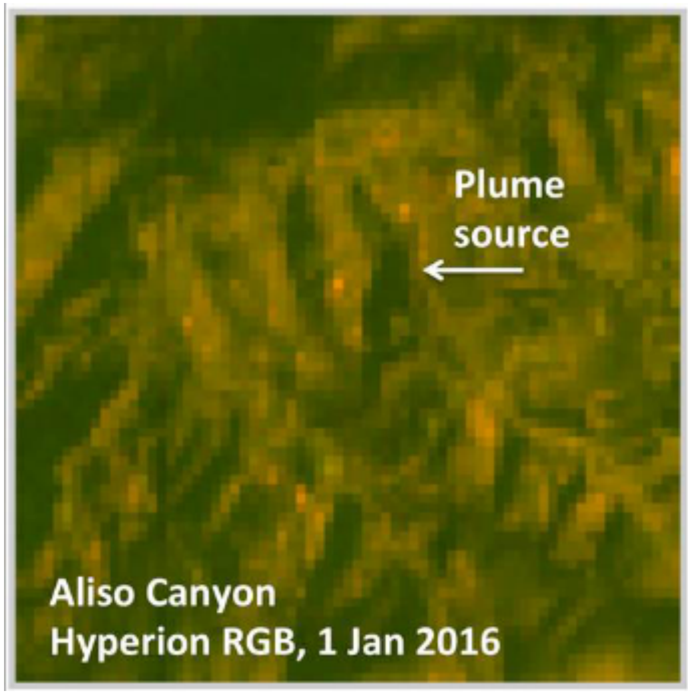
Disasters
Volcanos

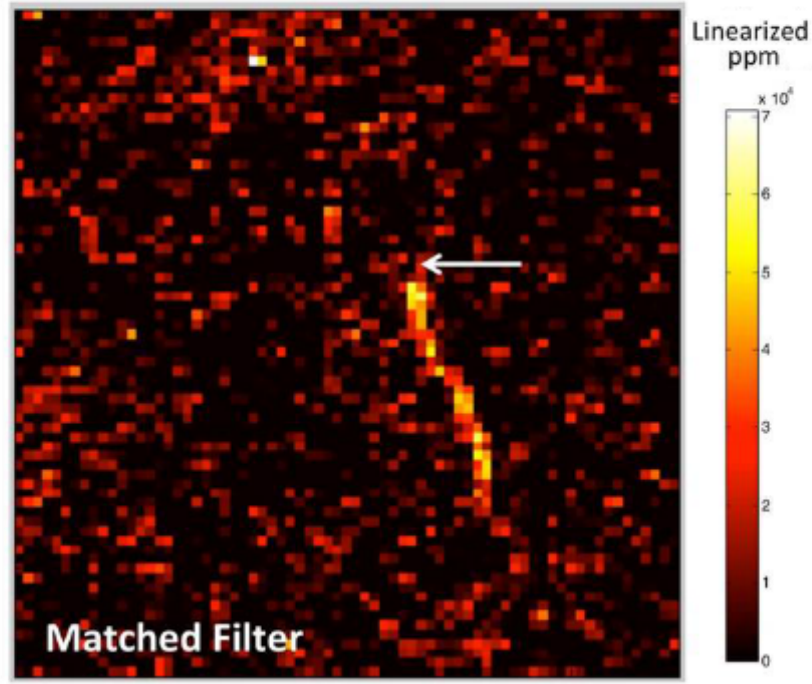


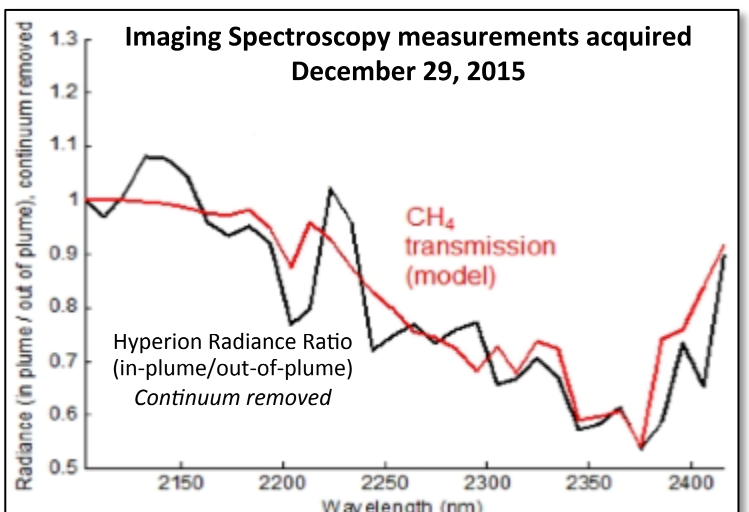
Fire
Behavior



Hyperion Detects the California Methane Leak







On January 1, 2016, Hyperion imaged the massive methane leak in the Aliso Canyon region of California. David Thompson's (JPL) algorithm detected the methane leak within the Hyperion data and showed a pronounced plume trending to the south. Since then, six additional acquisitions have been made, thanks to EO-1's ability to rapidly schedule, reorient satellite attitude, and quickly process and distribute the data.

Hyperion Matched Filter Detection Technique Provided by
D. Thompson, A. Thorpe, R.O. Green and The Imaging Spectroscopy Team, JPL, CalTech

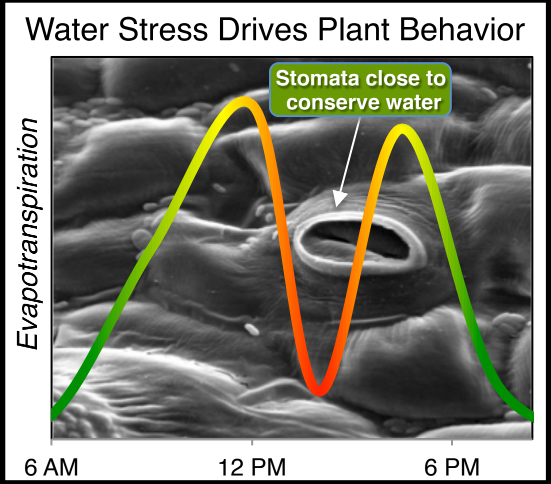
ECOSTRESS

ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

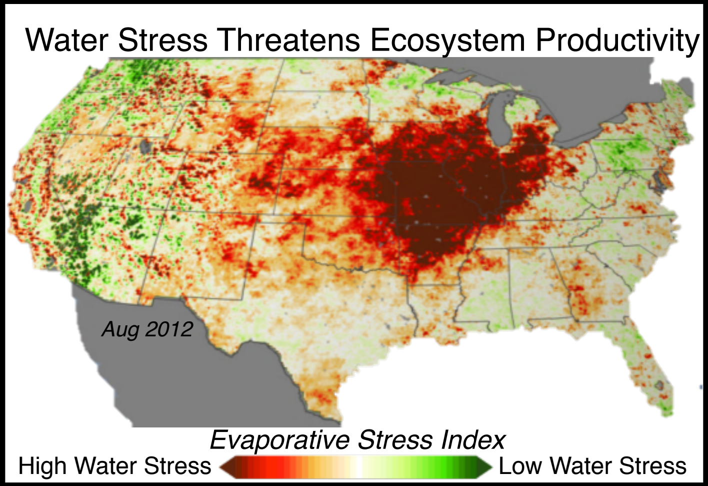
Dr. Simon J. Hook, JPL, Principal Investigator

Science Objectives

- Identify **critical thresholds of water use and water stress** in key climate-sensitive biomes
- Detect the timing, location, and predictive factors leading to plant **water uptake decline** and/or cessation over the **diurnal cycle**
- Measure **agricultural water consumptive use** over the contiguous United States (CONUS) at spatiotemporal scales applicable to improve drought estimation accuracy



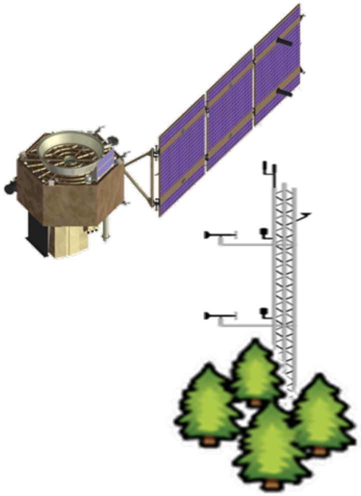
When stomata close, CO_2 uptake and evapotranspiration are halted and plants risk starvation, overheating and death.



Water stress is quantified by the Evaporative Stress Index, which relies on evapotranspiration measurements.

*ECOSTRESS will provide critical insight into **plant-water dynamics** and how **ecosystems change with climate** via **high spatiotemporal** resolution thermal infrared radiometer measurements of evapotranspiration from the International Space Station (ISS).*

Hyperion Time Series for GPP…Petya Campbell et al.

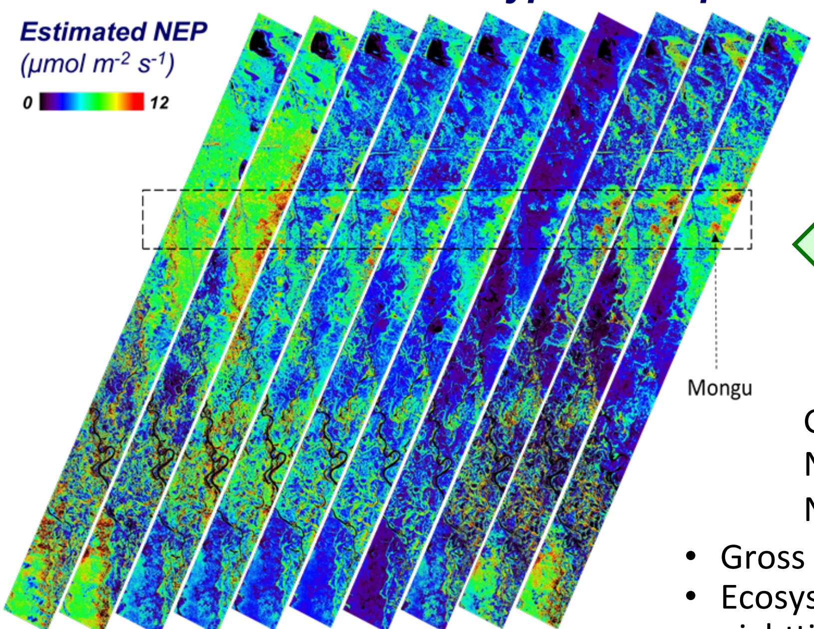


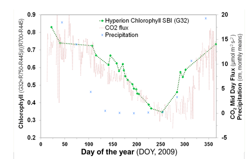
EO-1 Hyperion seasonal time series (TOA rad) → Atmospheric correction, Pre-processing (TOC reflectance) → Hyperion Spectral Bio-Indicators (SBIs)

FLUX tower measurements (CO_2 flux, µmol m^{-2} s^{-1}) → CO_2 FLUX parameters (**NEP**, GEE, etc.)

EO-1 Hyperion: Spectral Time Series for Mongu, Zambia

Estimated NEP
(µmol m^{-2} s^{-1})
0 ***12***





Relationship between CO_2 FLUX parameters & Hyperion SBIs

GEE = gross ecosystems exchange

NEP = GEE – Re

NEE = -NEP

- Gross Primary Production (GPP = GEP, µmol m^{-2} s^{-1})
- Ecosystem Respiration (Re) -calculated from relationships between nighttime Net Ecosystem Exchange (NEE) and air temperature
- Net Ecosystem Production -> from the observed GEE and Re

Cross-calibration of Terra MODIS and Landsat 7 ETM+ using EO-1 Hyperion

Amit Angal[a], Xiaoxiong (Jack) Xiong[b] and Dennis Helder[c]

[a] *Science Systems and Applications Inc. Lanham, MD 20706*

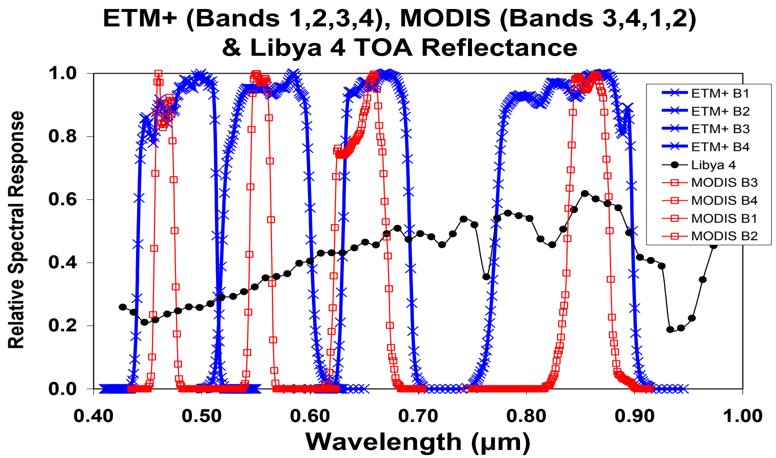
[b] *NASA Goddard Space Flight Center*

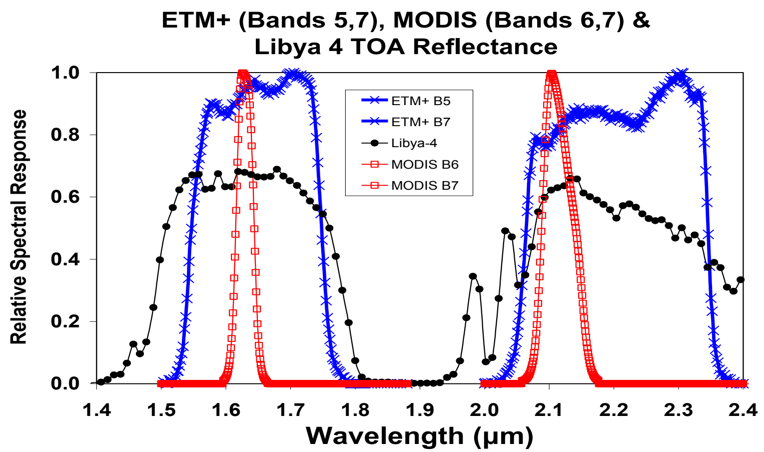
[c] *Image Processing Lab, South Dakota State University, Brookings, SD, 57006*

Acknowledgements: Previous members of MCST and SDSU's IPlab

Sensor Overview

Platform	Terra	Landsat 7	EO-1
Sensor	MODIS	ETM+	Hyperion
Number of bands	36	8	220
Spatial resolution	250 m, 500 m, 1 km	15 m, 30 m, 60 m	30 m
Swath	2330 km	187 km	7 km
Spectral coverage	0.4~14 µm	0.4~12.5 µm	0.4~2.5 µm (10 nm)
Launch date	Dec 18, 1999	April 15, 1999	Nov 21, 2000
Altitude	705 km	705 km	705 km at launch





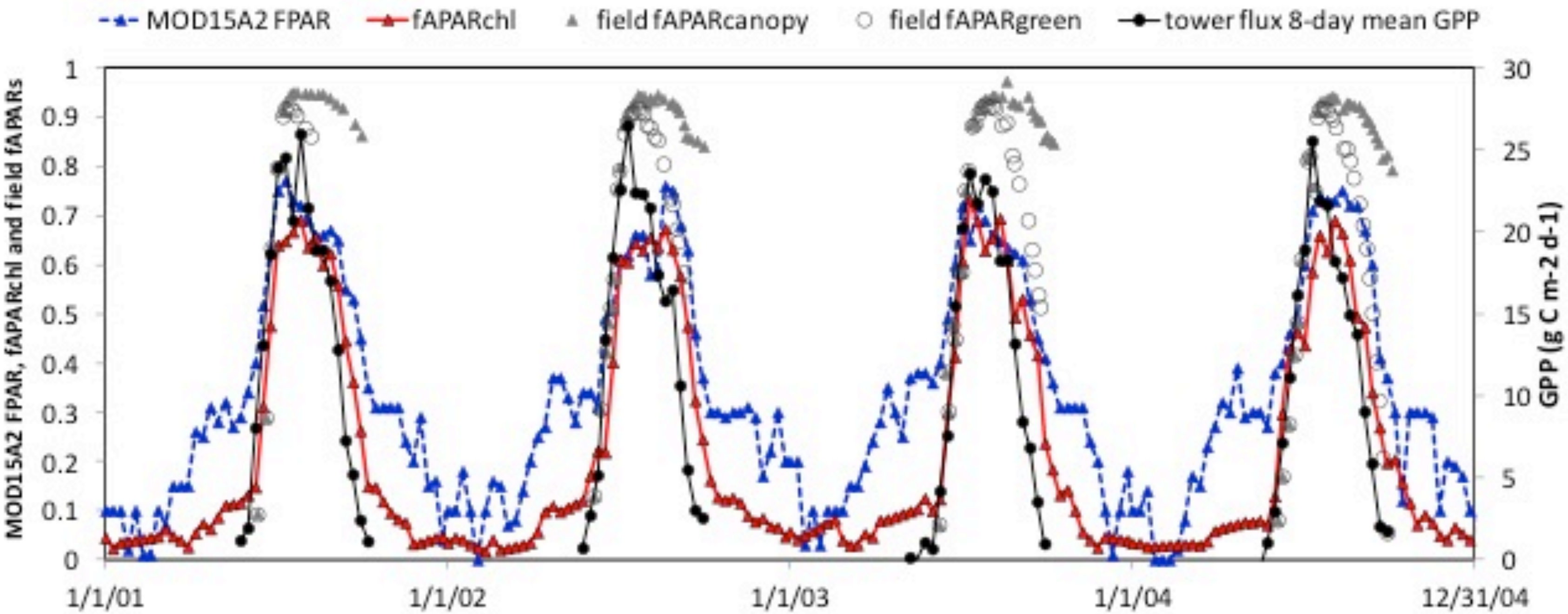
Uncertainties in estimates of fAPAR for photosynthesis ($fAPAR_{PSN}$) when approximated with $fAPAR_{canopy}$, NDVI and EVI

Qingyuan Zhang[1,2]
Tian Yao[1,2]
Alexei I. Lyapustin[3]
Yujie Wang[3,4]
Elizabeth M. Middleton[1]
Karl F. Huemmrich[1,4]

[1]NASA/GSFC, code 618; [2]USRA;
[3]NASA/GSFC, code 613;[4]UMBC;

6th HyspIRI Product Symposium, NASA's GSFC, June 1-3, 2016

US-Ne1: field measurements, RTM retrievals and tower GPP from 2001 – 2004



- Retrieved $fAPAR_{chl}$ matches well with tower GPP while MOD15A2 FPAR does not.
- MOD15A2 FPAR does not agree well with field fAPARcanopy. It has earlier green-up and late fall-off, compared to tower GPP, fAPARchl, and field fAPARcanopy. It overestimates fAPARcanopy in spring and fall, but underestimates fAPARcanopy in summer.

FUSION: a GSFC Prototype for Field Spectroscopy Cal/Val

FUSION

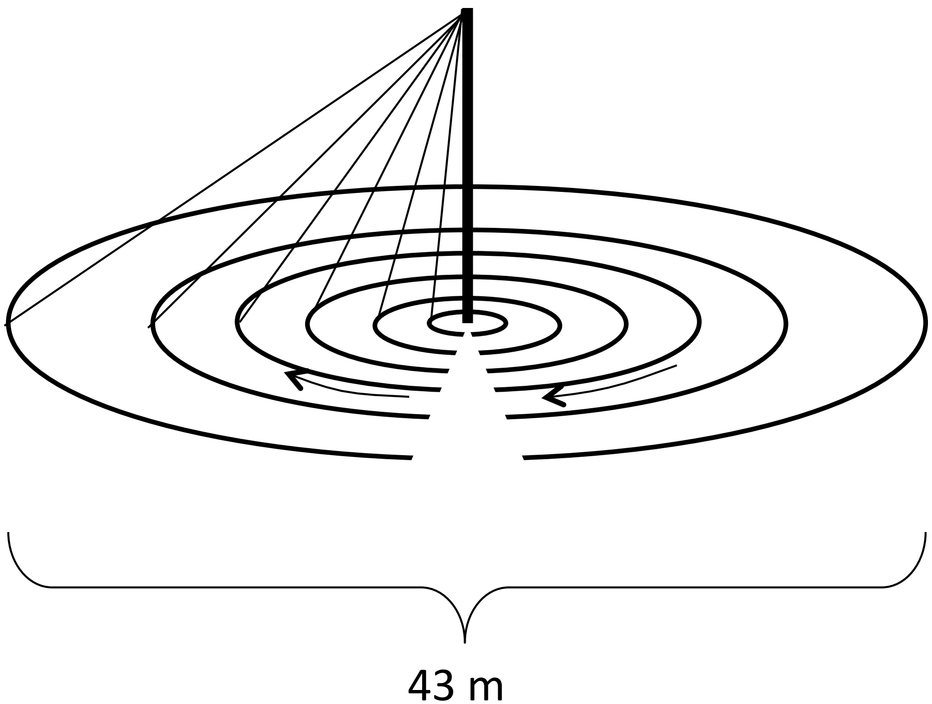
To provide optical measurements of vegetation

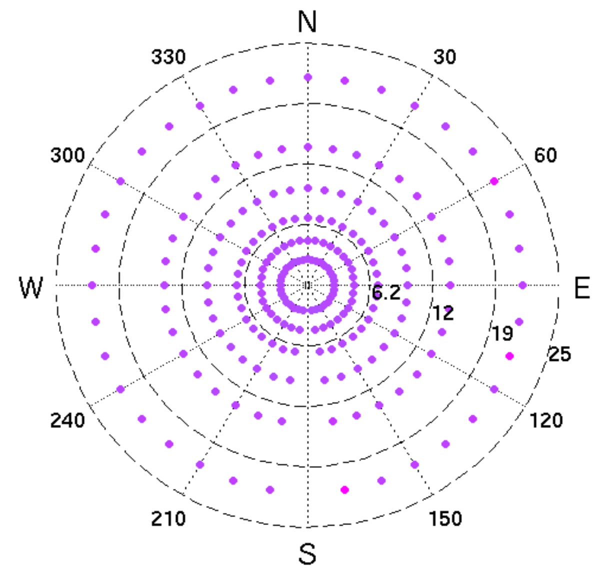
- Describe diurnal and seasonal dynamics
- Describe bidirectional reflectance/emission
- Sense hyperspectral reflectance and fluorescence
- Provide measurements that could scale to satellite observations
- Make measurements with spatial and temporal resolution that can be linked to carbon/water fluxes measured by flux towers

FUSION Operations

FUSION is mounted atop a 10 m tall tower in a cornfield

- Makes 350° azimuth angle scans
- At six zenith angles (15°,25°,35°,45°,55°,65°)
- Takes about 25 minutes for a full set





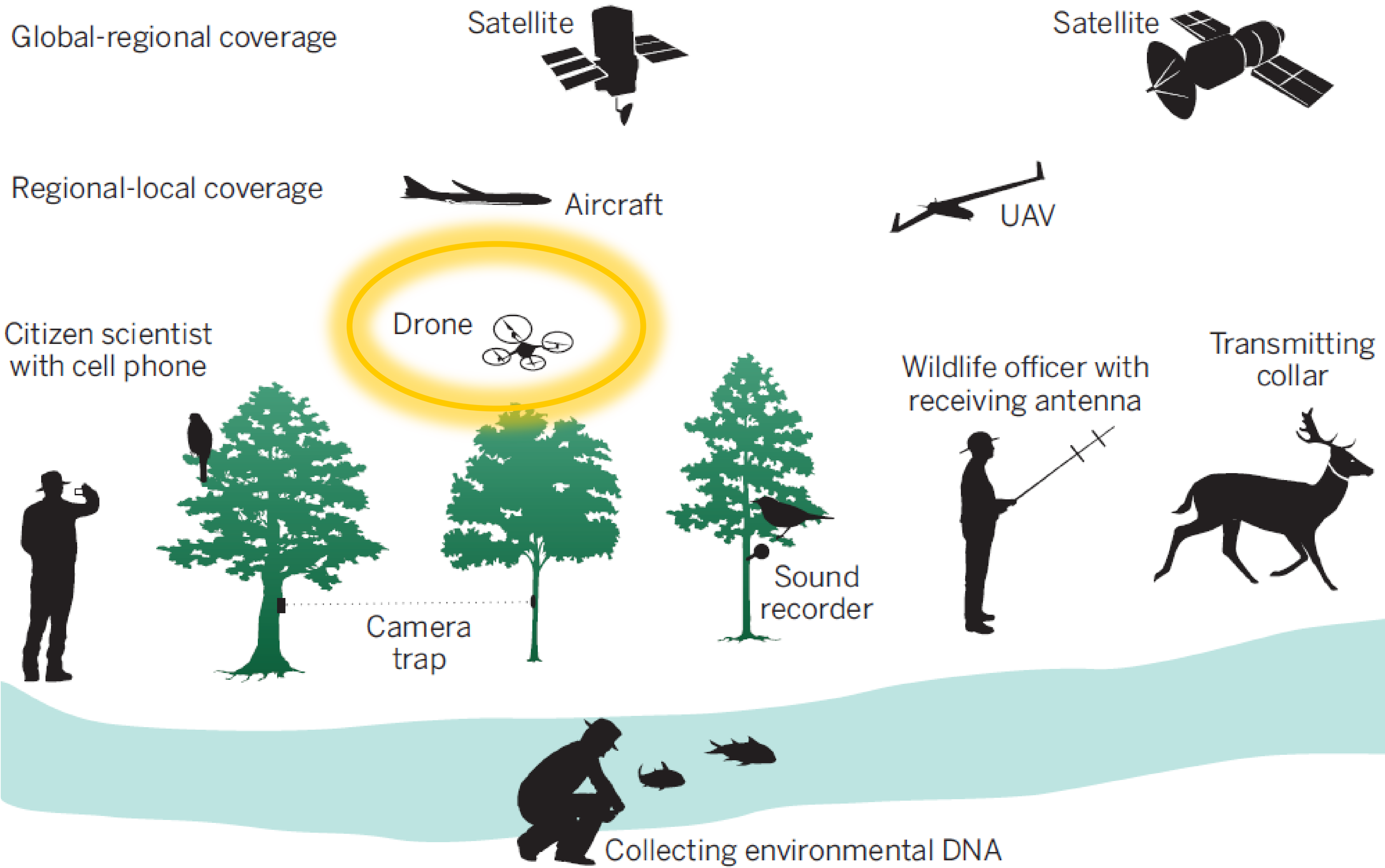
Locations of FOV center points

Next Generation UAS Based Spectral Systems for Environmental Monitoring

PIs: Petya Campbell – Presenter, UMBC; Phillip Townsend - Science Lead, UW; Daniel Mandl -Technology Lead, NASA/GSFC

Co-Is: C. Kingdon , V. Ly, L. Corp, R. Sohlberg, L. Ong , P. Cappelaere, S. Frye, M. Handy, J. Nagol and V. Ambrosia

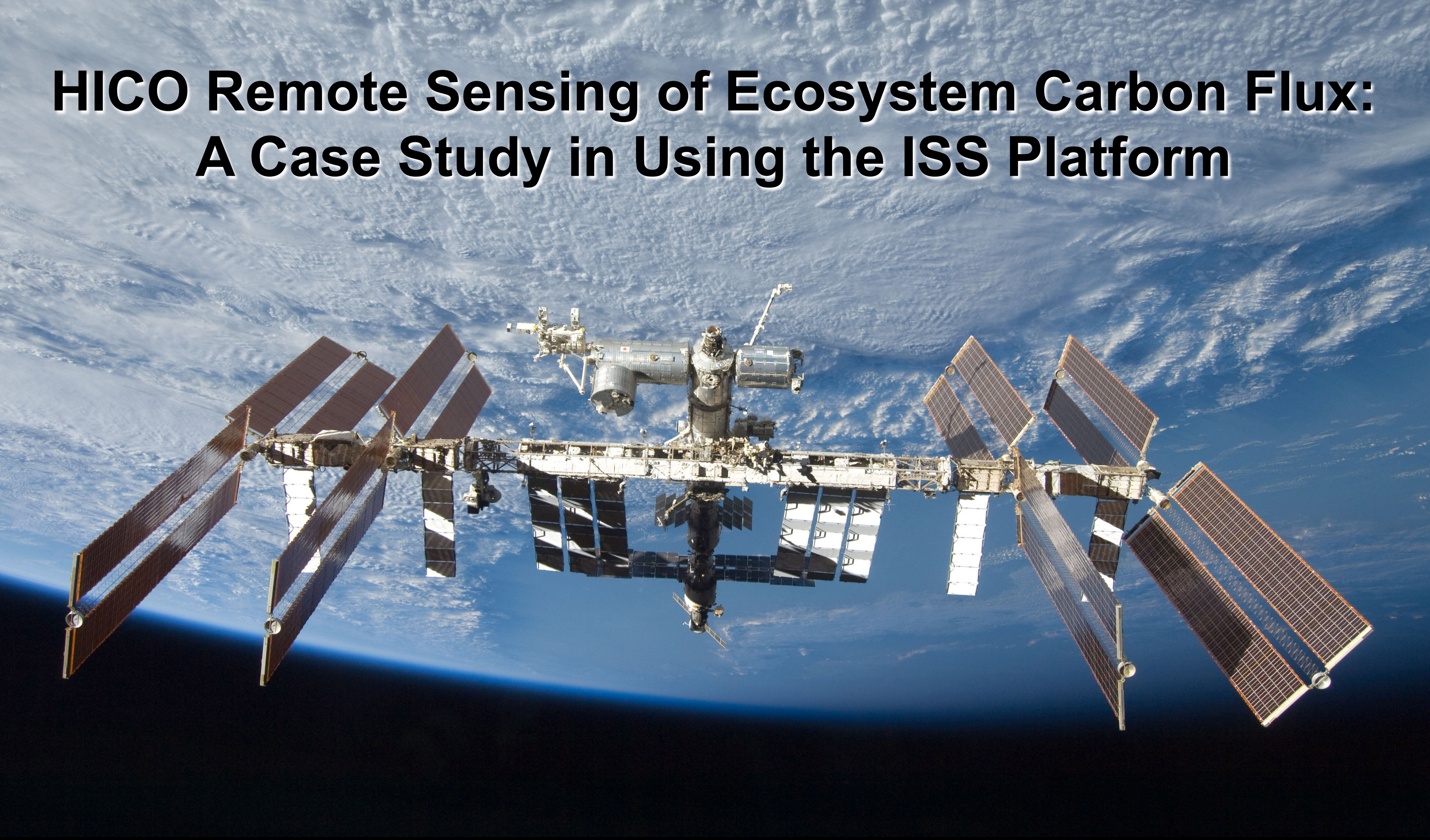
Tested Piccolo & Nano-Hyperspec with Combination of Tram and Tractor



Sensor power. Networking satellite and airborne remote sensing with in situ sensing will allow changes in many elements of biodiversity to be tracked over time.

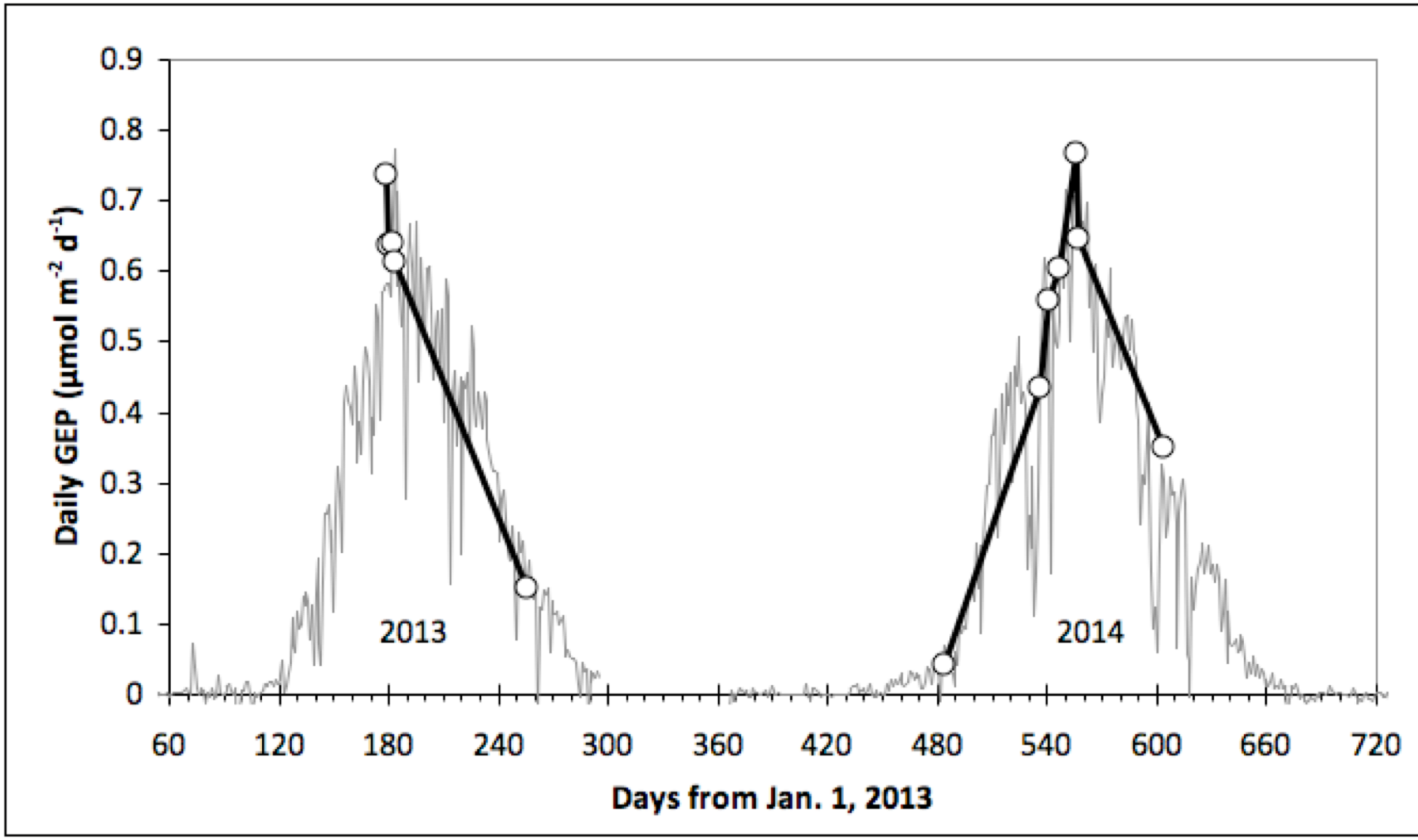
Sensing biodiversity
Woody Turner (October 16, 2014)
Science **346** (6207), 301-302. [doi: 10.1126/science.1256014]

HICO Remote Sensing of Ecosystem Carbon Flux: A Case Study in Using the ISS Platform



K. Fred Huemmrich
Petya Campbell
University of Maryland Baltimore County

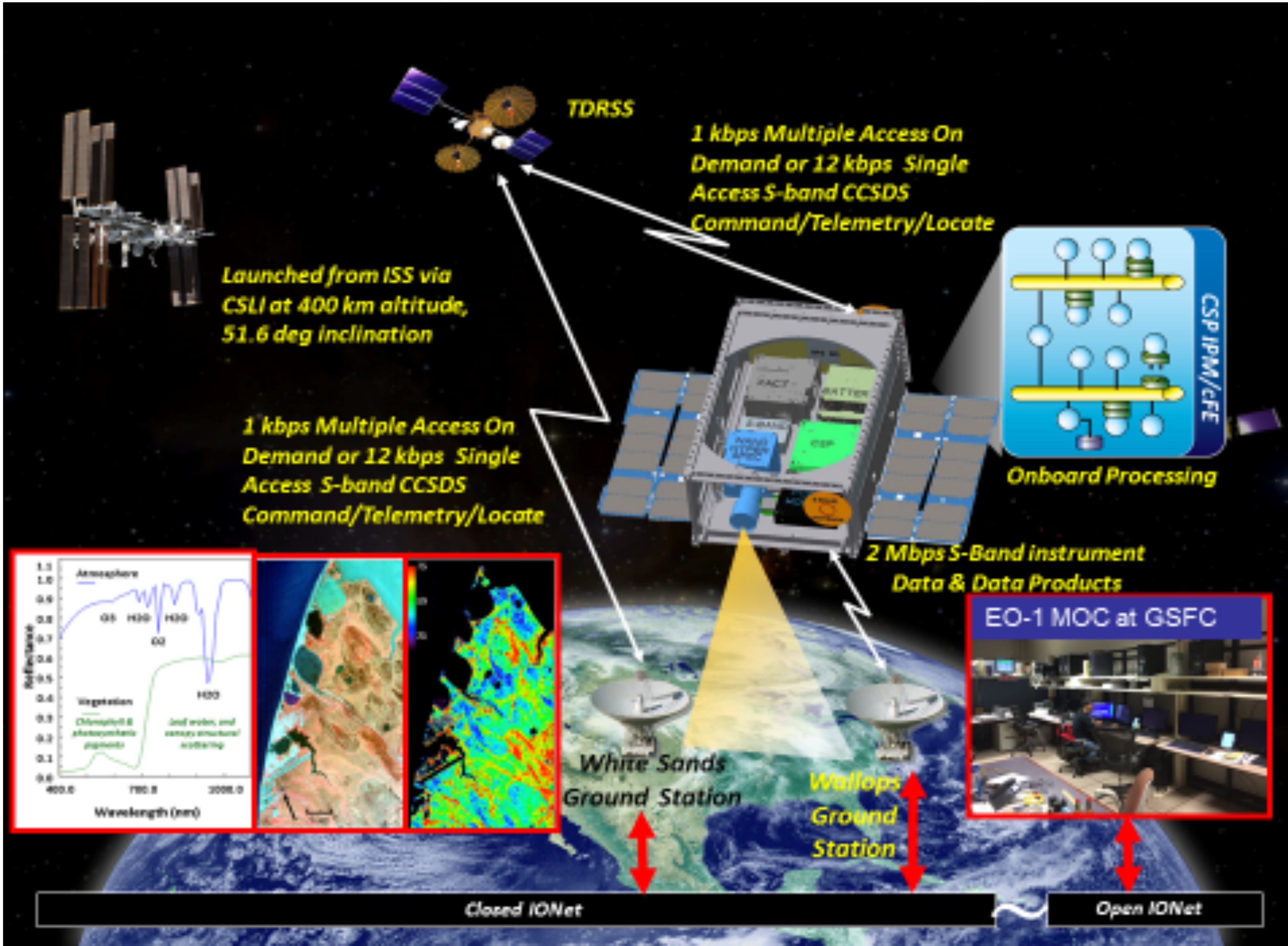
Estimation of Seasonal GEP



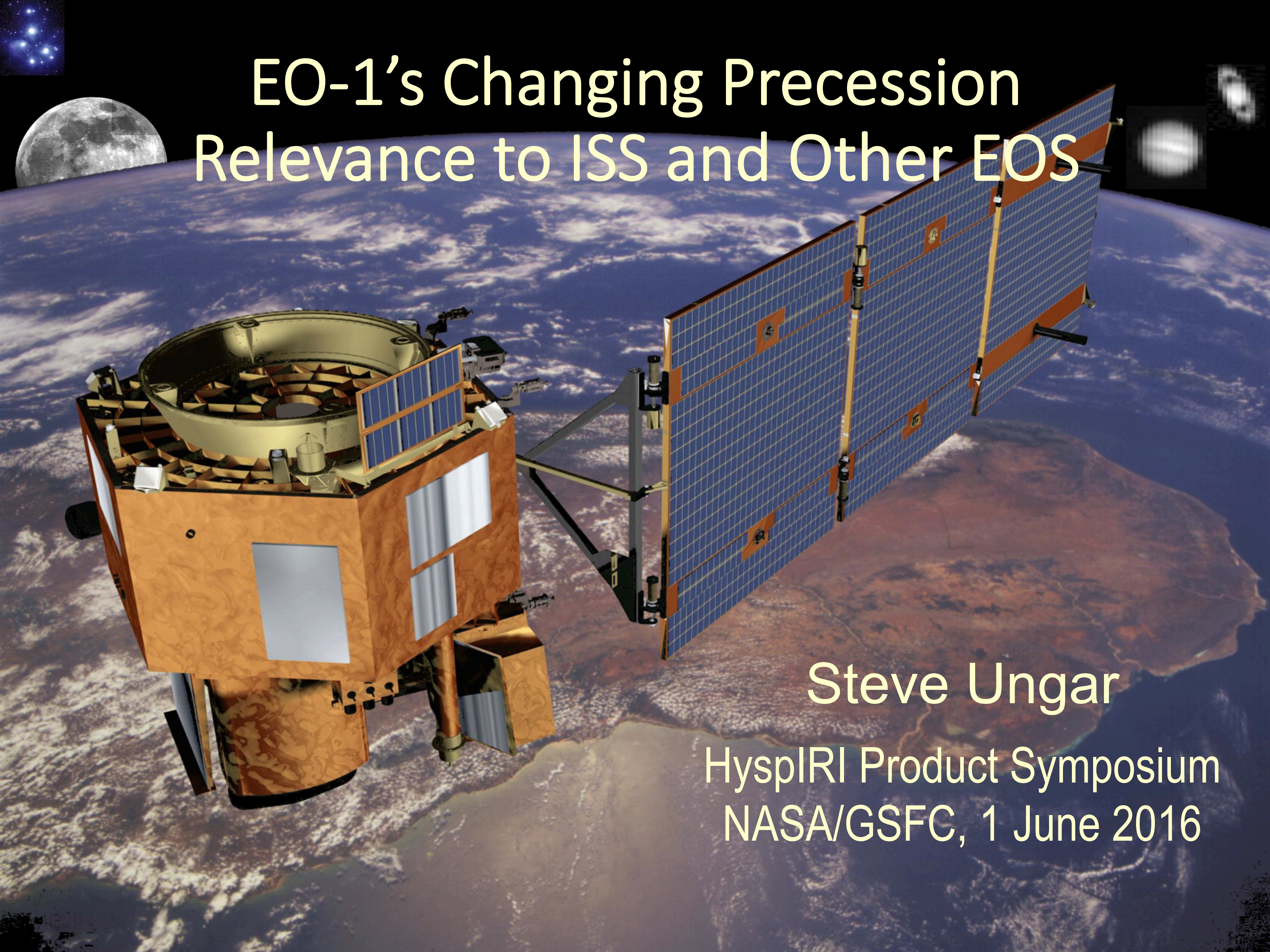
- Points are HICO estimations of daily GEP compared with flux tower measurements

Hyperspectral Cubesat Constellation (HCC)

Dan Mandl, GSFC



EO-1's Changing Precession Relevance to ISS and Other EOS



Steve Ungar

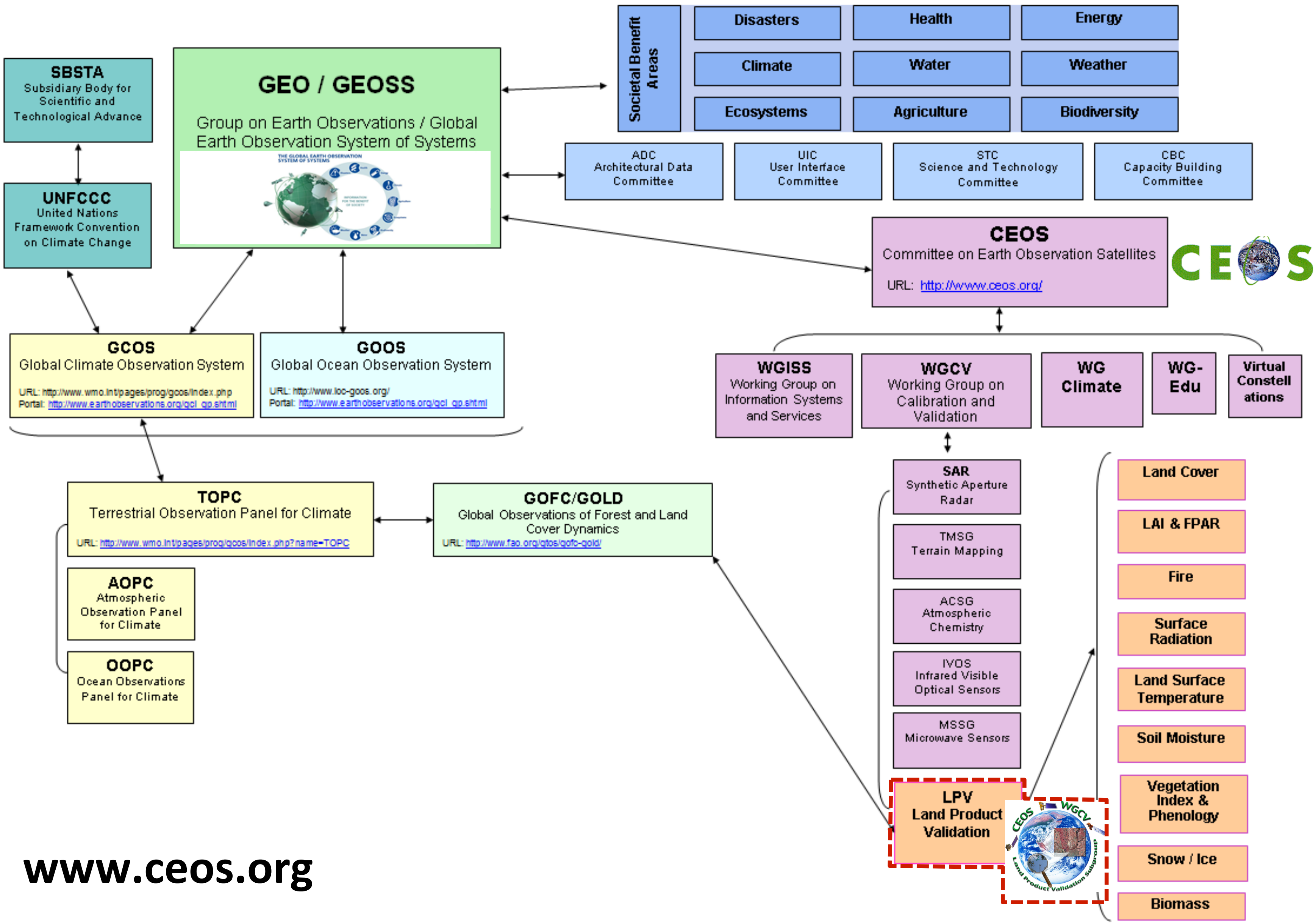
HyspIRI Product Symposium
NASA/GSFC, 1 June 2016

Linkages between HyspIRI Science & International EO Programs

Miguel Román, Pierre Guillevic, Jaime Nickeson, Zhuosen Wang
with contributions from the CEOS-LPV Focus Area Leads

6th Annual HyspIRI Data Product Symposium and Aquatic Forum: June 1-3, 2016

International Programs concerned with Terrestrial Earth Observations



www.ceos.org

19 Essential Climate Variables

A key TOPC activity is to identify measurable terrestrial key variables that control the physical, biological and chemical processes affecting climate and are indicators of climate change.

Biological/Ecological (6)

Land cover
FAPAR
Leaf area index
Above ground biomass
Soil carbon
Fire disturbance

Hydrological (5)

River discharge
Water use
Ground water
Lakes
Soil moisture

Cryospheric (4)

Snow cover
Glaciers ~~and ice caps~~
Ice sheets and ice shelves
Permafrost

Surface Properties (4)

Albedo
Land surface temperature
Energy fluxes
Anthropogenic greenhouse gases

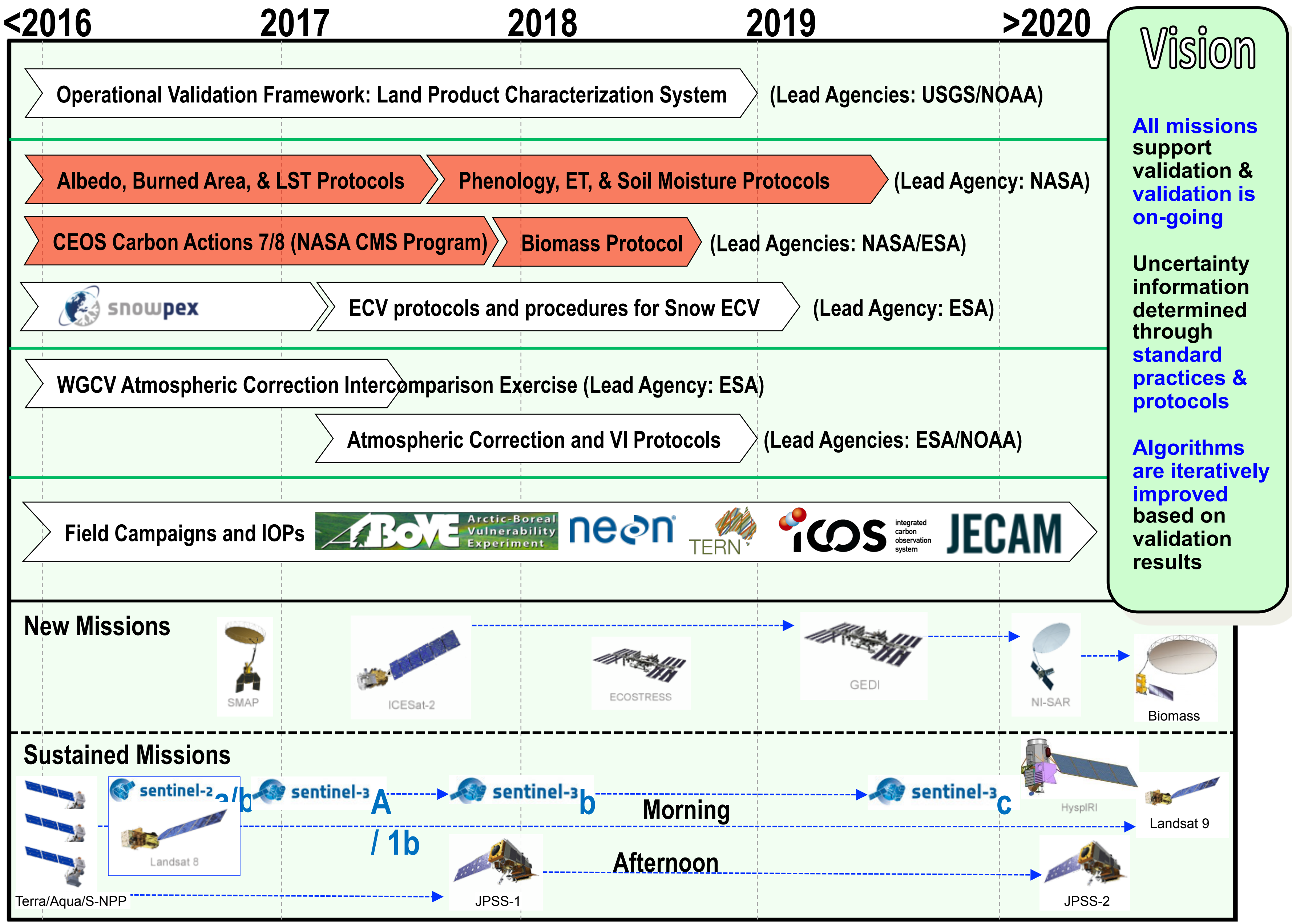
New GCOS Terrestrial ECVs

‘Pairing’ of GCOS-ECVs with HyspIRI Products

LPV Focus Group / Product	VSWIR L 2/ 3	VSWIR L4	VSWIR Global	TIR L4	SWIR / TIR
LAND COVER					
Fractional land cover / veg. cover		Existing Val Methods	Existing Val Methods		
Disturbance, PFT, hazard susceptibility		Research Required			
SURFACE RADIATION					
Surface Reflectance	Existing Val Methods				
Surface Albedo	Existing Val Methods				
BIOPHYSICAL					
Gross / Net Primary Production		Existing Val Methods	Existing Val Methods		
fPAR		Existing Val Methods	Existing Val Methods		
LAI		Existing Val Methods	Existing Val Methods		
Water content, LUE, Pigments		Research Required			
FIRE					
Detection of Fire events				Existing Val Methods	Existing Val Methods
Fire fuel loads		Research Required			
LAND SURFACE TEMPERATURE					
LST				Existing Val Methods	Existing Val Methods
Emissivity				Existing Val Methods	Existing Val Methods
Evapotranspiration				Research Required	

Existing Val Methods **Research Required**

CEOS-LPV 5-Year Roadmap



Takeaways: HyspIRI Science Needs for in-situ data

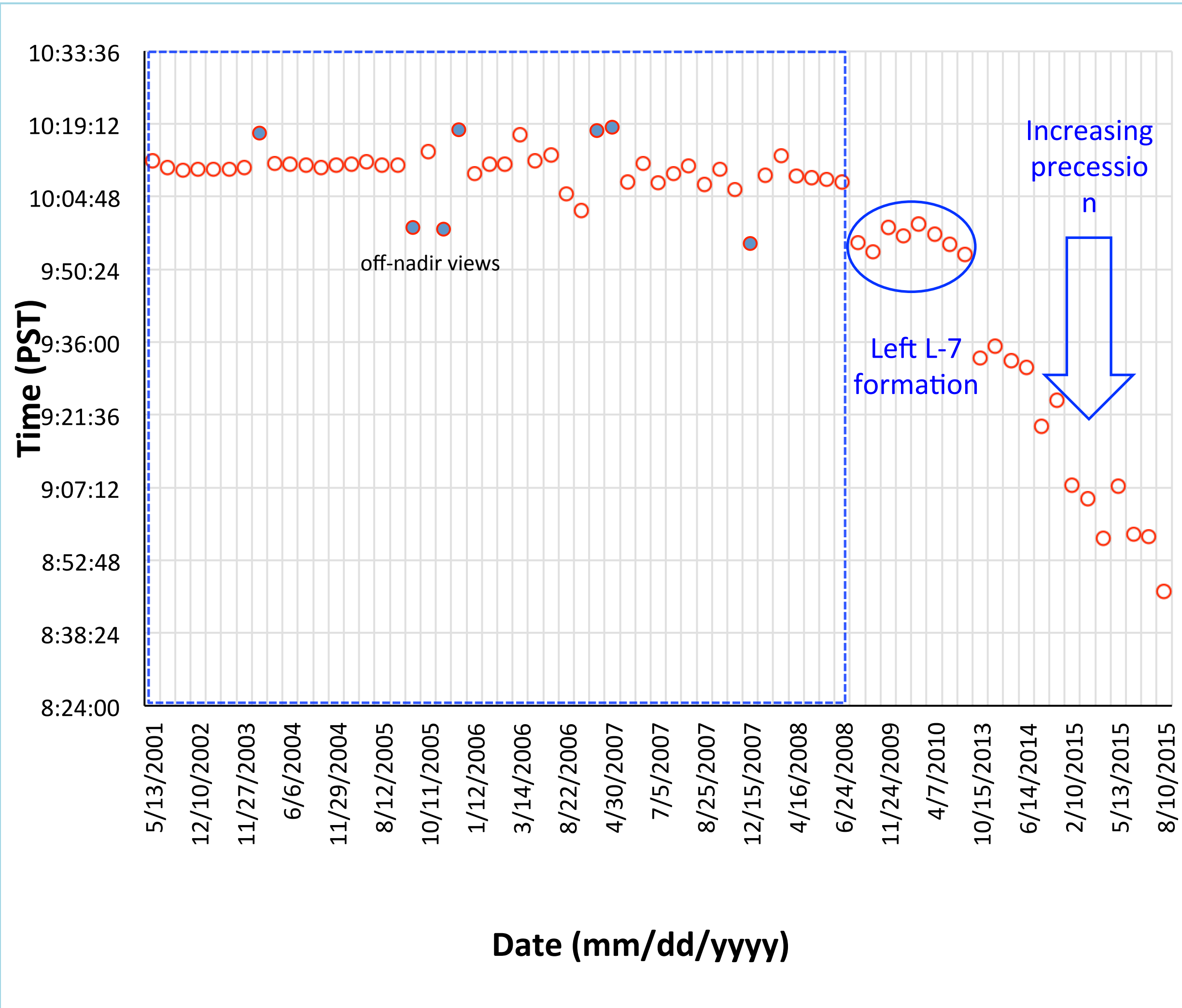
- Ensemble of sites representative of diverse land cover types and climates.
- Expand ground-based measurements of 'essential' biophysical variables: fAPAR, LST, Biomass, ??? **Chloropyll content??**
- Prepare for validation of 'higher level' products and climate adaptation indicators: e.g., crop yield, evapotranspiration, land/ water use efficiency.
- Collect ancillary information about energy, water, carbon and nitrogen cycles
- Uncertainty estimates of field data
- Spatial representativeness of in situ measurements
- Optimize data processing and reduce latency

Summary and Future Work

- Cross-calibration of Terra MODIS and Landsat-7 ETM+ was performed over the Libya 4 ground target using two different approaches
  - MCST's approach uses multi-year same-day Libya 4 acquisitions from Terra MODIS and L7 ETM+ with corrections for BRDF, SBAF and water-vapor impacts
  - SDSU's approach involves formulating an empirical absolute calibration model for the Libya 4 site, using Terra MODIS as a reference, and EO-1 Hyperion used to derive the spectral dependence
  - The long-term drift is less than 1% using both approaches for VIS and SWIR bands
  - MODIS-ETM+ calibration differences are less than 5% using either approach
- Future work
  - Investigate the uncertainties involved with each approach and how they influence the results
  - Extend the MCST approach to other desert sites and eventually alternate surface types (i.e. ice/snow targets, dark oceans, boreal forests)
  - Comparison using these approaches extended to other sensors (i.e. Landsat-8 OLI and Aqua MODIS)

EO-1: EOM

Orbital Precession & local crossing times



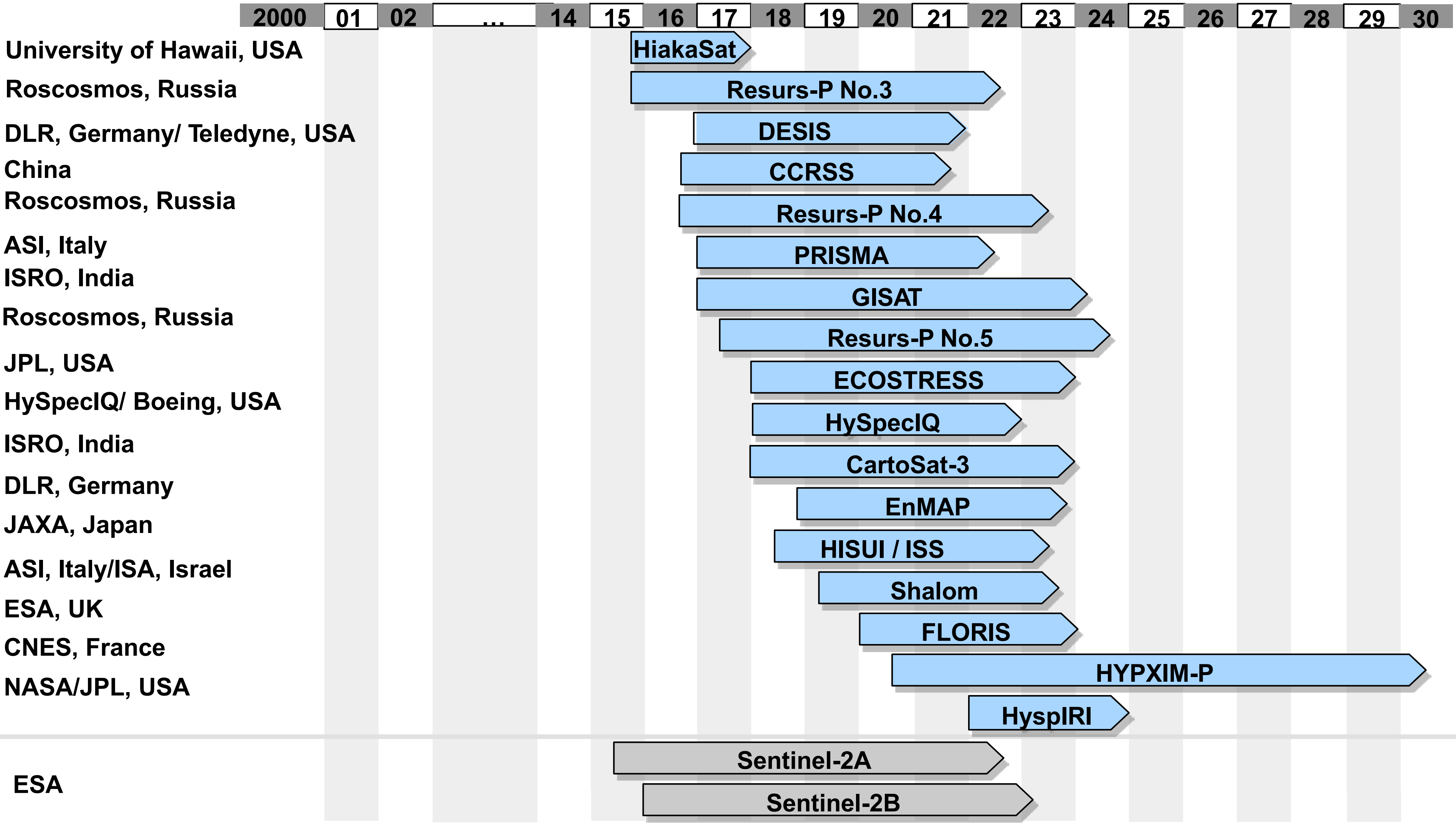
- Left A-train formation in 2008
- Completely ran out of fuel in 2011 and precession increased
- Our results are current up to crossing times around 8:40am
- Will reach 8am equatorial crossing times in October, 2016
- Satellite will be decommissioned in early 2017

Applications of Hyperspectral Imaging for Terrestrial Environmental Monitoring

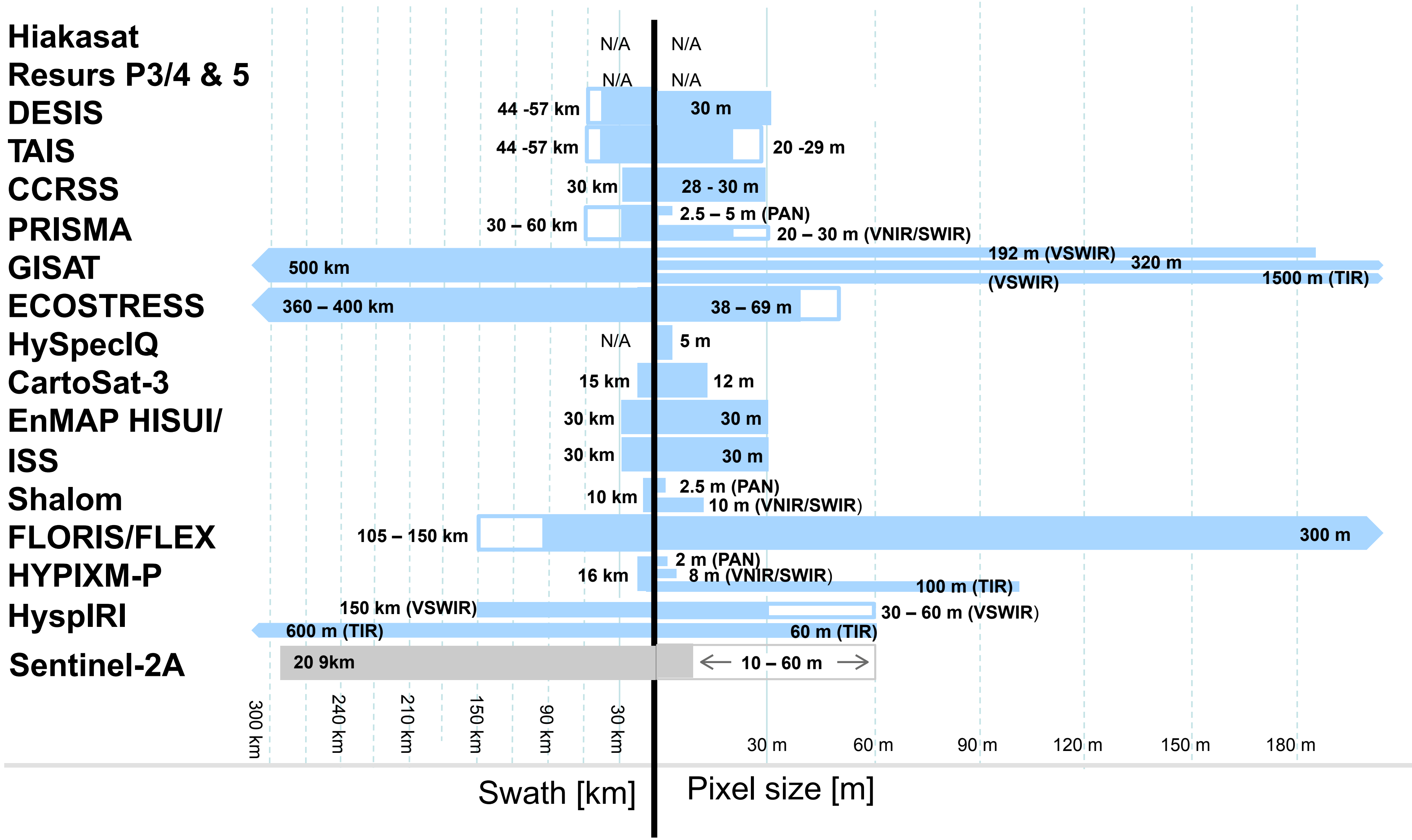
Andreas Müller, DLR, Earth Observation Center
Luis Guanter, GFZ, GeoResearch Center Potsdam

DLR

Future spaceborne imaging spectroscopy EO missions – Launch and life time



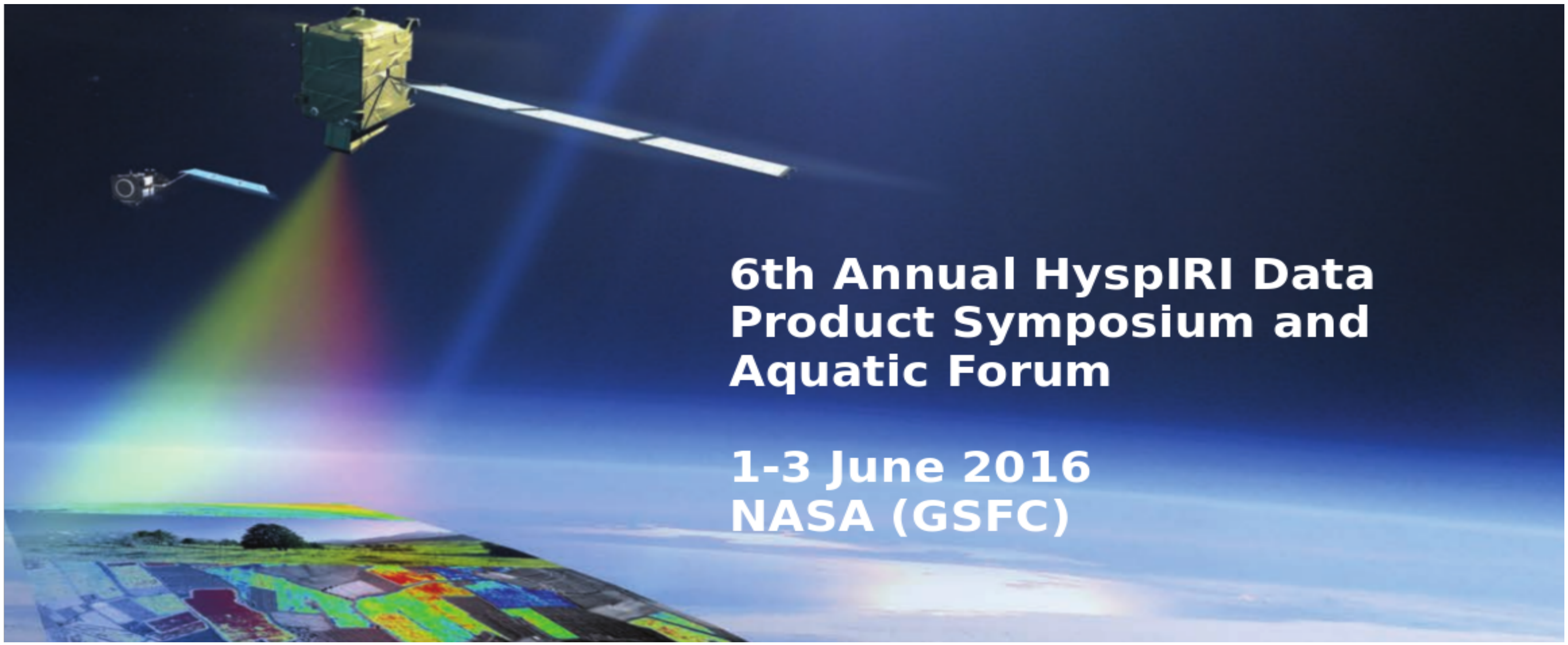
Spaceborne imaging spectroscopy future missions – Spatial characteristics



Concluding Thoughts

- Imaging Spectroscopy is maturing rapidly
- Space Technology at high TRL
- No computational limitations
  - Cloud Services, GPU, …
- Community is organized
  - IEEE GRSS TC GSIS & Whispers , EARSeL SIG IS
- Added Value has been demonstrated
- Service Providers ready to take up new products in their portfolio
- Demand for sustainable long term data provision

The FLuorescence EXplorer (FLEX) space mission



Neus Sabater (1) Jose F Moreno[1] and Elizabeth Middleton [2] on behalf of the FLEX team.

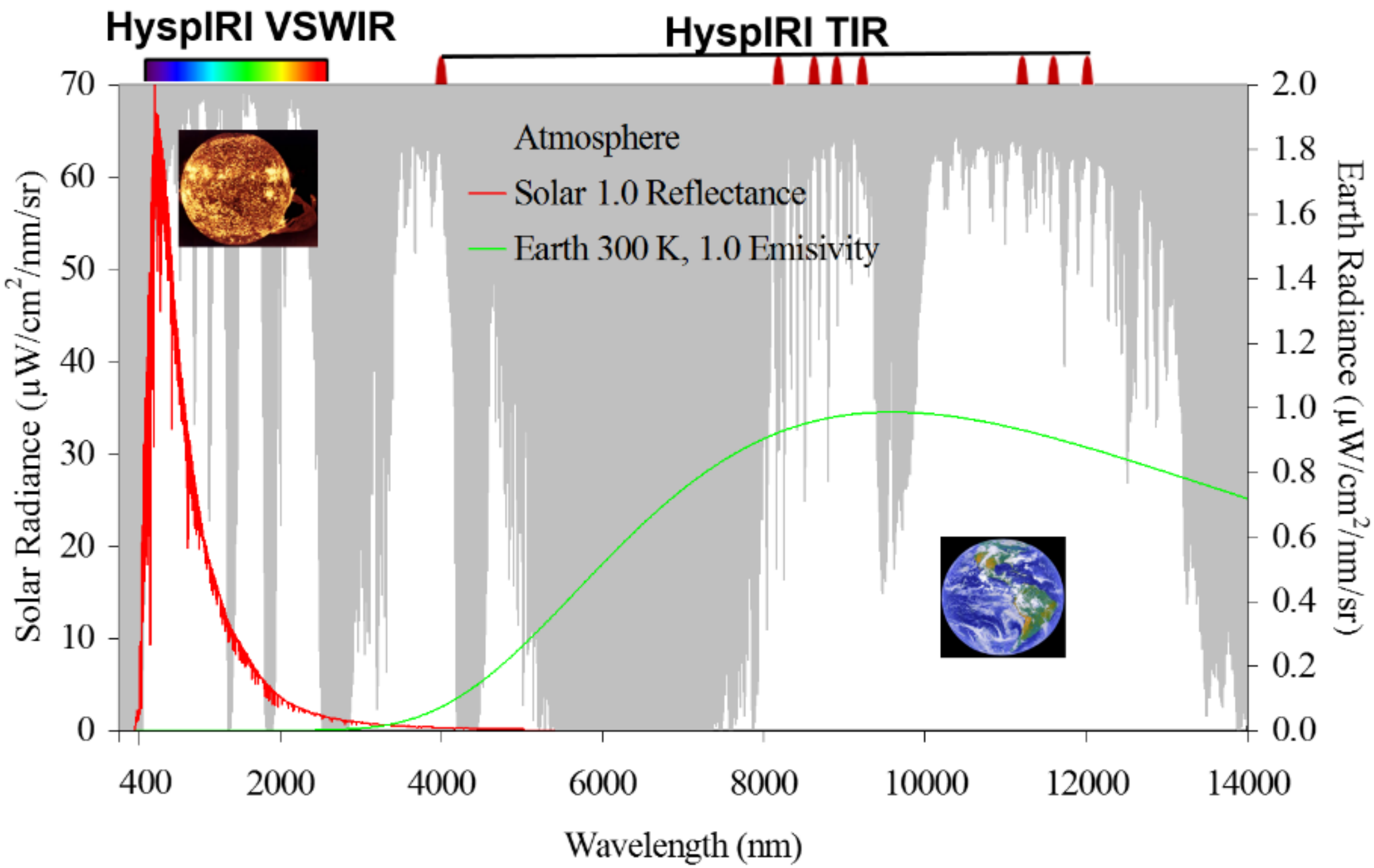
(1) Faculty of Physics, University of Valencia, Spain

(2) Laboratory for Biospheric Sciences, NASA/Goddard Space Flight Center, Greenbelt, Maryland

ESA's 8^{th} Earth Explorer FLuorescence EXplorer (FLEX) mission will be the first space mission specially dedicated to map sun-induced chlorophyll fluorescence (SIF) of the terrestrial vegetation at a global scale.

HyspIRI Measurements

- Global terrestrial and coastal VSWIR spectroscopy at 30 m, 16 days and multispectral TIR at and 60 m, 4 days with real-time downlink of selected products.



Update on SLI, Landsat, & Sentinel-2

Bruce Cook, NASA GSFC
Jeffrey Masek, NASA GSFC

HyspIRI Science Symposium, 1 June 2016

Landsat-9

- Landsat-9 will rebuild Landsat-8, but with upgraded TIRS
  - Capitalizes on design heritage and minimizes time to next mission
  - TIRS upgraded to Class B
  - Stray light issue in TIRS Band 11 corrected
- Interagency Partnership between NASA & USGS with same roles as Landsat-8
- Launch in 2020/21
- Current Status
  - Ball Aerospace under contract to build OLI-2 sensor
  - TIRS-2 being built at GSFC
  - Spacecraft RFO issued

Landsat-10 and Beyond

- USGS assessing **user needs** for future land imaging
  - Requirements Capabilities & Analysis for Earth Observations (RCA-EO)
    - Documents land imaging user requirements across Federal Agencies
  - Additional input from Landsat Science Team and User Workshops

- NASA Earth Science Technology Office (ESTO) managing **technology** developments for SLI
  - Reduce the risk, cost, size, volume, mass, and development time for the next generation SLI instruments, while still meeting or exceeding the current land imaging program capabilities.
  - NASA SLI-T ROSES proposal opportunity recently closed

- The FY 2016 Appropriations provides funding for satellite servicing to continue the pathfinder mission [RESTORE–L] to refuel Landsat-7 or another U.S. Government-owned satellite in low-Earth orbit, potentially extending Landsat-7 life.

Future Architecture Options

- ***All options are on the table***

- More compact Landsat-type systems?
  - Smaller systems => Lower cost => More frequent launches
  - NASA Reduced Envelope Study
    - Designs <100kg, <1m^3 feasible
    - Instrument optics & PSF drive instrument size (SWIR, TIR)

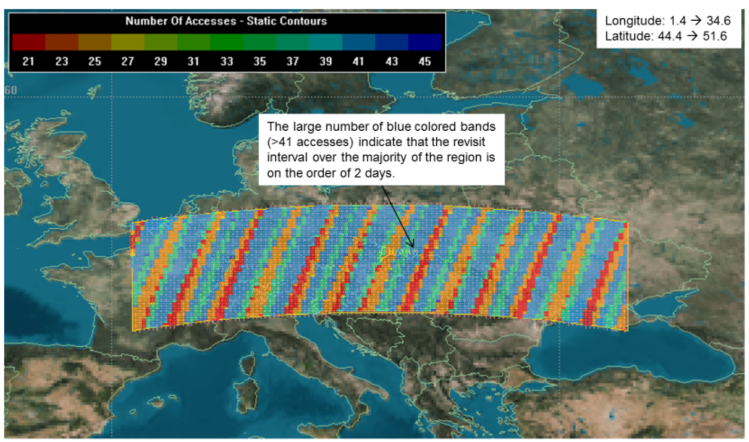
- Greater reliance on International systems for core multispectral data?
  - May require additional platforms to fill gaps (eg. TIR)

- Imaging Spectrometer data?
  - Imaging spectrometer that could provide both hyperspectral and multispectral data (spectral aggregation)

Harmonized Landsat Sentinel-2 (HLS) Project

- Merging Sentinel-2 and Landsat data streams can provide 2-3 day coverage
- Goal is "seamless" near-daily 30 m surface reflectance record including cross-calibration, atmospheric corrections, spectral and BRDF adjustments, regridding
- Project initiated as collaboration among GSFC, UMD, NASA Ames

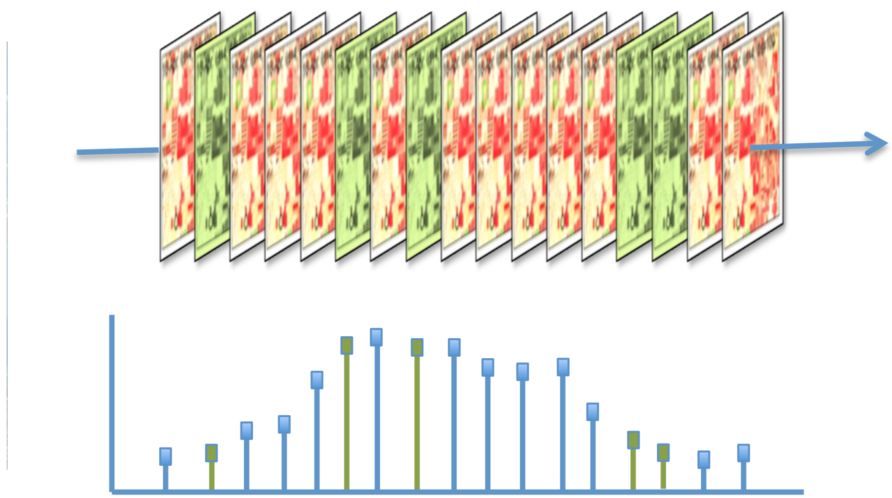
Sentinel 2A and B - LDCM Europe



- The picture shows the number of times LDCM and the Sentinel 2 satellites accessed areas on the ground over an 80 day period of time.
  - 21 accesses indicates a maximum revisit interval of ~3 days 19 hours
  - 46 accesses indicates a minimum revisit interval of ~1 day 18 hours

7

Courtesy Brian Killough, NASA LARC



Conclusion

- Future land imaging is focusing on advancing the measurement capability while preserving continuity and constraining program costs
  - Capability enhancements could include spectral, spatial, and temporal domains
- We are seeing a new emphasis on using time domain to analyze moderate-resolution imagery as we have done for years with AVHRR, MODIS, and other ~1km systems
- Using observations from multiple, international systems (e.g. Landsat + Sentinel) provides a cost effective approach toward this goal
  - MuSLI Program is one effort to advance community capabilities