CEOS Land Product Validation Update (and other housekeeping items…)

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

MODIS/VIIRS Science Team Meeting: June 6-10, 2016

CEOS > WGCV > LPV

CEOS - Committee on Earth Observation Satellites

31 CEOS Members (e.g. space agencies, research centers)

24 Associate Members (e.g., UNEP, WMO, GCOS)

CEOS coordinates civil space-based EO to benefit society

The **Working Group on Calibration and Validation** (WGCV) is one of 5 CEOS working groups.

Land Product Validation (LPV) is one of 6 WGCV subgroups

Current LPV Officers:

Chair	Miguel Román	NASA GFSC
Vice-Chair	Fernando Camacho	EOLAB/U. of Valencia
Secretariat	Jaime Nickeson	SSAI/NASA GSFC
Protocol Dev.	Pierre Guillevic	UMD/NASA GSFC
LPCS Liaison	Zhuosen Wang	ESSIC/ NASA GSFC

+ 11 Focus Areas with ~2 co-leads each

LPV Focus Areas and Co-leaders

*ECV

Snow Cover*, Sea Ice	Thomas Nagler (ENVEO, Austria)	Tao Che (Chinese Academy of Sciences)
Surface Radiation (Reflectance, BRDF, Albedo*)	Crystal Schaaf (U Mass Boston)	Alessio Lattanzio (EUMETSAT)
Land Cover * and Land Use Change	Pontus Olofsson (Boston University)	Martin Herold (Wageningen University, NL)
Biomass*	**Vacant**	**Vacant**
FAPAR*	Arturo Sanchez (University of Alberta)	Nadine Gobron (JRC, IT)
Leaf Area Index*	Oliver Sonnentag (University of Montreal)	Stephen Plummer (Harwell, UK)
Fire* (Active Fire, Burned Area)	Luigi Boschetti (University of Idaho)	Kevin Tansey (University of Leicester, UK)
Land Surface Temperature* (LST and Emissivity)	Simon Hook (NASA JPL)	Jose Sobrino (University of Valencia, SP)
Soil Moisture*	Tom Jackson (USDA ARS)	Wolfgang Wagner (Vienna Univ of Technology, AT)
Land Surface Phenology	Matt Jones (Oregon State University)	Jadu Dash U Southhampton
Vegetation Index	Tomoaki Miura and Marco Vargas (University of Hawaii / NOAA/STAR)	**Vacant**

LPV's Core Mission

Instrument Teams

Discipline Teams

CEOS Member Agencies and Affiliates

To integrate across LPV Focus Areas, CEOS Space Agencies, and the Land Discipline & Instrument Teams.

MODIS land team

Status for: BRDF/Albedo (MCD43)

General Accuracy Statement

Validation at stage 3 has been achieved for the surface reflectance product (MCD43). The accuracy of the high quality 500m MODIS operational albedo is well less than 5% albedo at the majority of the validation sites studied thus far, and even those albedo values with low quality flags have been found to be primarily within 10% of the field data. Data for solar zenith angles greater than 70 degrees should be considered suspect.

While the daily algorithm has been shown to capture rapid changes well, such as snow melt and greenup, the values associated with rapid change may be flagged with lower quality flags and the algorithm can lag abrupt reactions in the field data.

Product status updated: November 2015
Product version: Collection 5/6

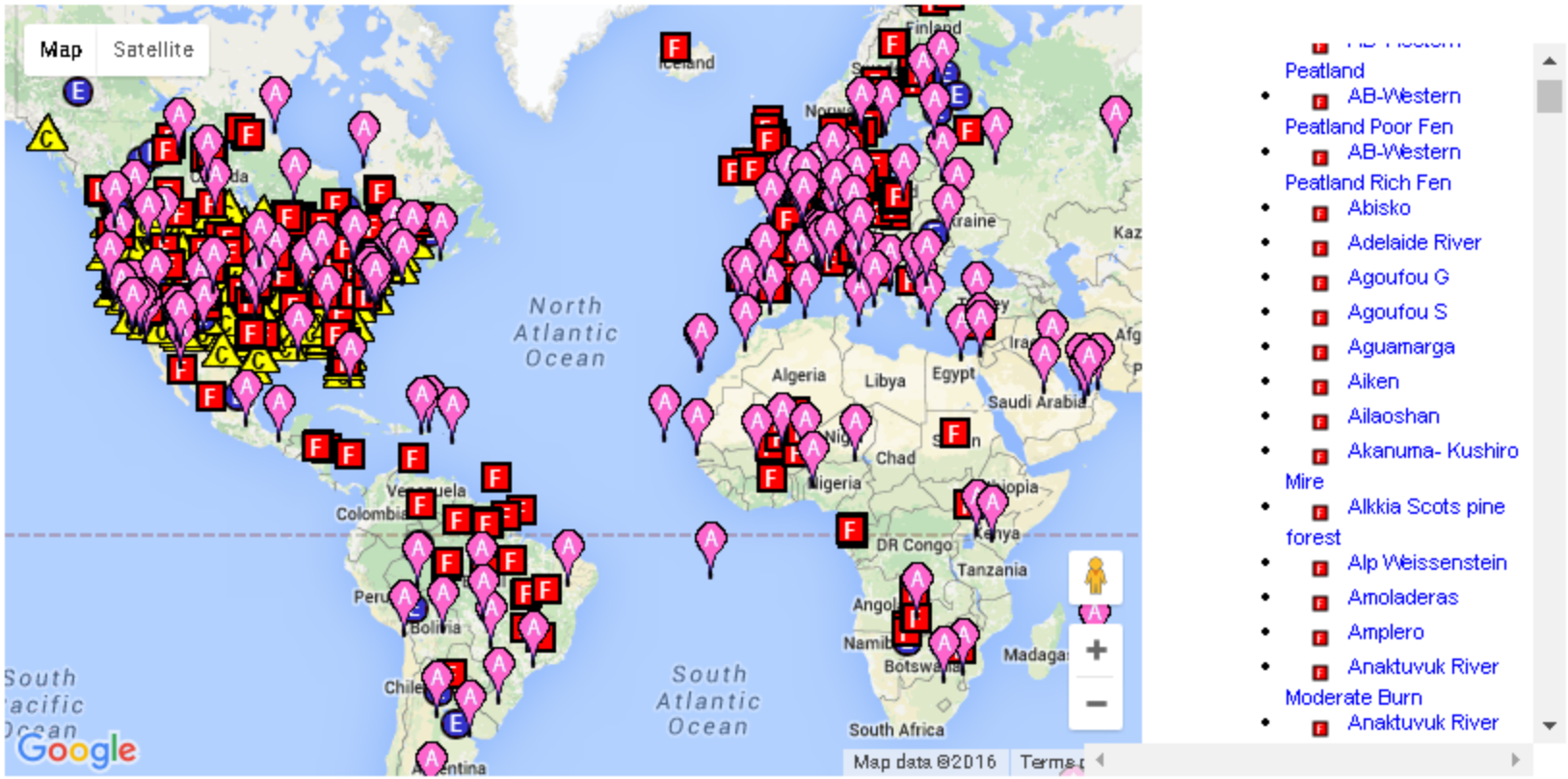
Supporting Studies:

Title: Evaluation of MODIS albedo product (MCD43A) over grassland, agriculture and forest surface types during dormant and snow-covered periods
Author: Wang, Z., C.B. Schaaf, A.H. Strahler, M.J. Chopping, M.O. Román, Y. Shuai, C.E. Woodcock, D.Y. Hollinger, D.R. Fitzjarrald
Source: Remote Sensing of Environment, 140, 60-77, 2014.
View Summary Results From This Document

Title: Re-evaluation of MODIS MCD43 Greenland albedo accuracy and trends
Author: Stroeve,J., J. E. Box, Z. Wang, C. Schaaf, A. Barrett
Source: Remote Sensing of Environment, 138, 199-214, 2013
View Summary Results From This Document

MODIS Maintenance PIs: Need to keep your val status pages updated!!

MODIS/VIIRS Subsets FTP Access Page

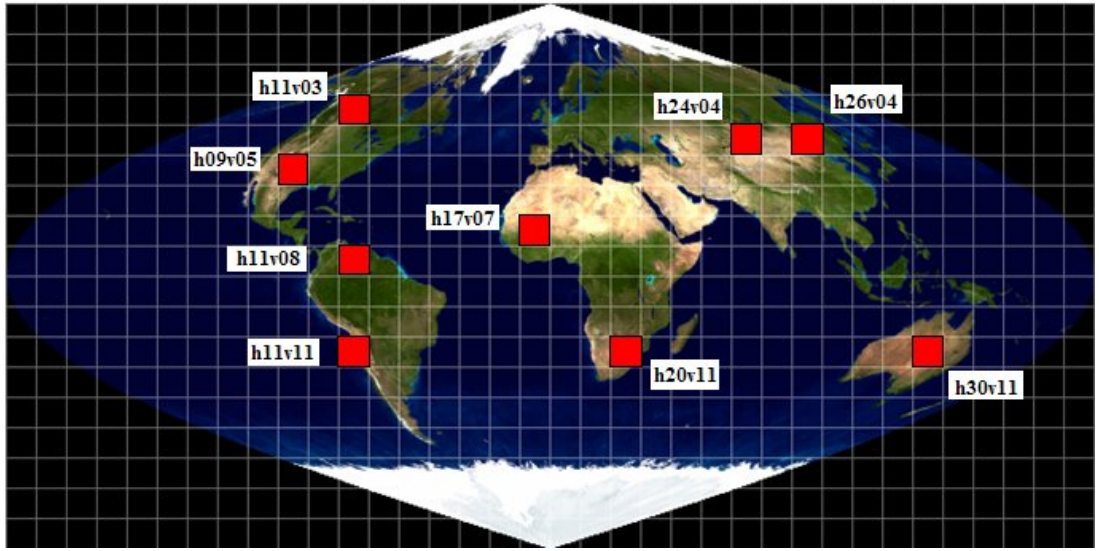


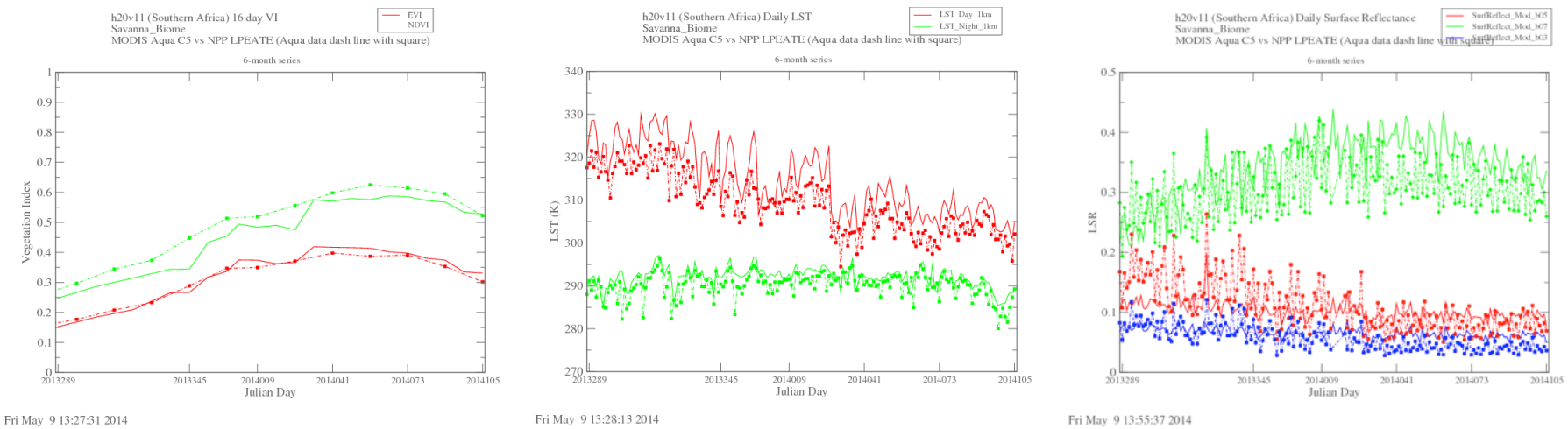
Product Short Name	Product Description
NPS_CMIP_L2	VIIRS/NPP Cloud Mask 5-Min L2 Swath IP 750m - Subset
NPS_IMFT_L1	VIIRS/NPP Imagery Resolution 5-Min Swath SDR 375m - Subset
NPS_QMMVIIP_L2	VIIRS/NPP Gridded Annual Min/Max Vegetation Index Quarterly 5 Min Swath IP 750m Granulation - Subset
NPS_QSIP_L2	VIIRS/NPP Gridded Surface Types Quarterly 5-Min L2 Swath IP 750m Granulation - Subset
NPS_QSLWMIP_L2	VIIRS/NPP Gridded Surface Types Land Water Mask Quaterly 5-Min L2 Swath IP 750m Granulation - Subset

Used by multiple teams (VIIRS ST, VCST, LPDAAC, ORNL, NOAA/STAR)

Land Product Quality Assessment
Golden Tile Time Series

Approach:
Summary statistics for (10° X 10°) SIN golden tiles.





Early VIIRS (solid lines) vs. Aqua MODIS C6 (dashed-dot lines) **Vegetation Index** (left), **LST** (center), and **Surface Reflectance** (right). 6-month trending shown for observations from savanna class (tile h20v11).

Instrument Teams

VIIRS Land

MODIS Land

Discipline Teams

NOAA

NASA

USGS

esa

EUMETSAT

CEOS Member Agencies and Affiliates

CEOS WGCV Land Product Validation Subgroup

http://ceos.org/about-ceos/agencies/

Lead Coordinating Agency: NASA

The LPV Validation Framework

Validation Good Practice Document

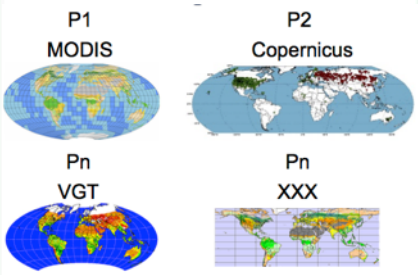
Fernandes et al., (2014). Global LAI Product Validation Good Practices. doi:10.5067/doc/ceoswgcv/lpv/lai.002

Fiducial Reference Data Sets

Example of fiducial reference data for soil moisture.

Lead Agencies: Various

Global Satellite Product Subsets

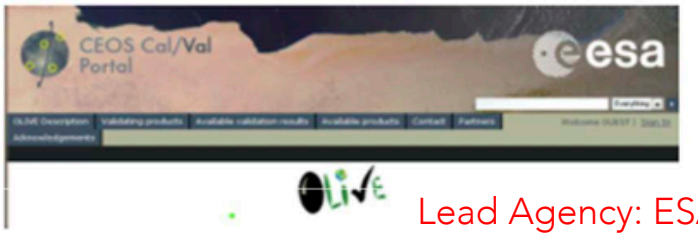


Subsets over fiducial reference data sites for each product automatically delivered.

Lead Agency: NASA

Lead Agencies: USGS/NOAA

Online Validation Tool

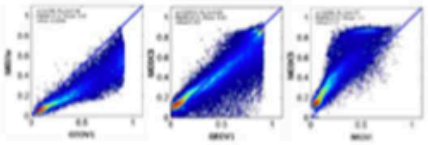


Lead Agency: ESA

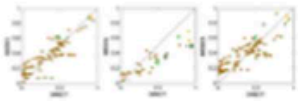
Example of OLIVE validation tool for LAI and FAPAR [3].

Lead Agency: ESA

Standardized Intercomparison Report

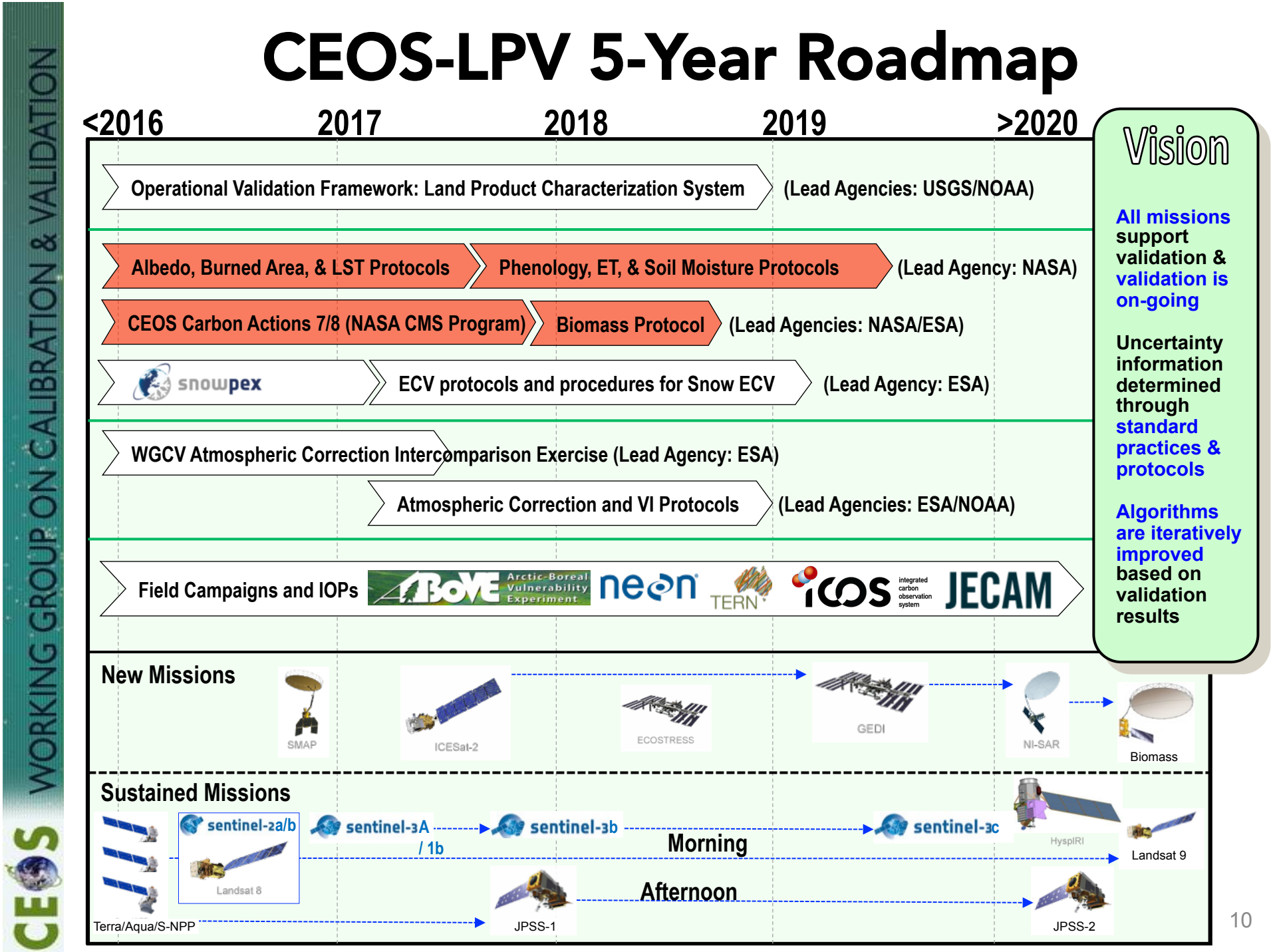


Standardized Validation Report

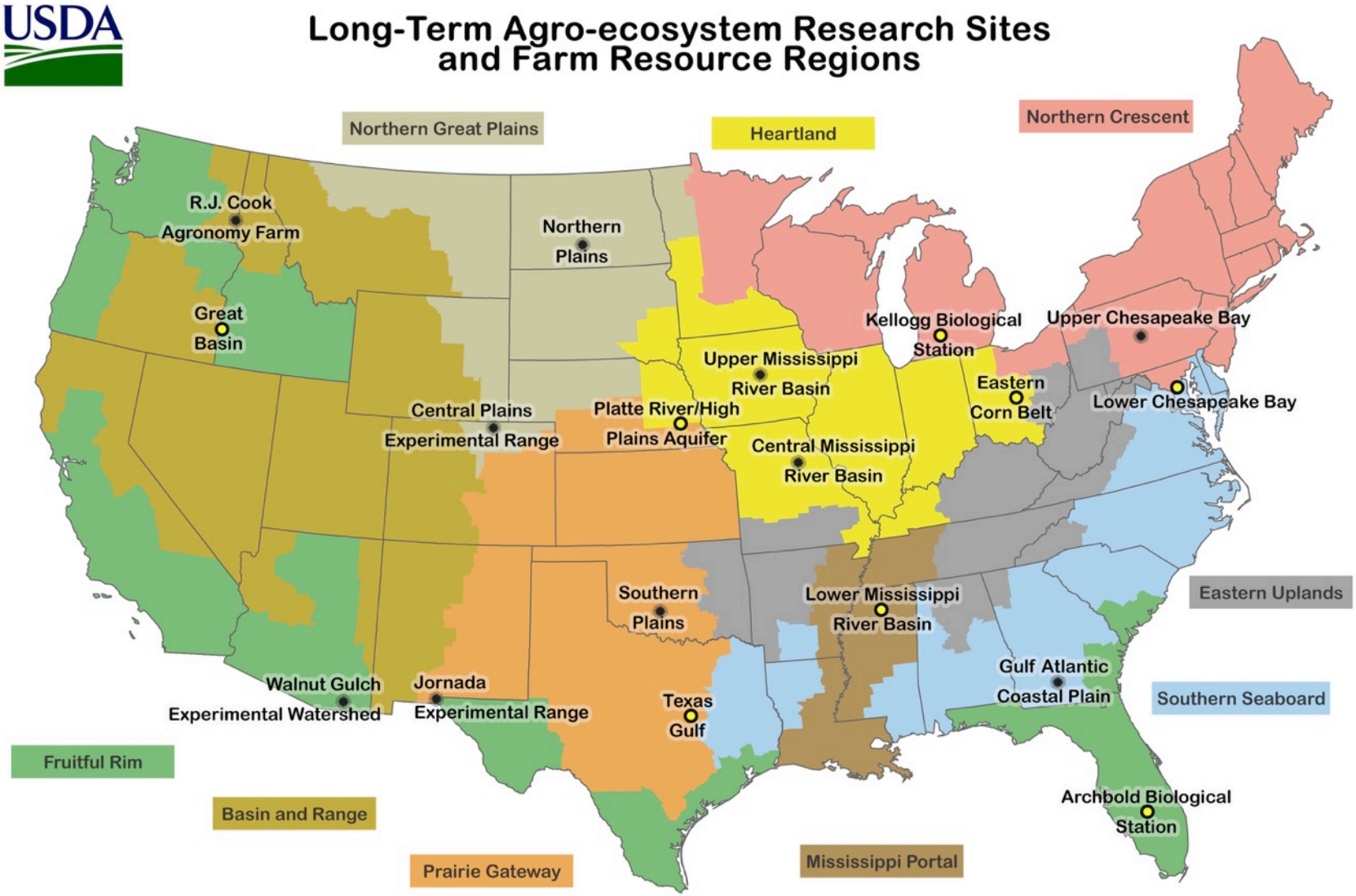


FAPAR	GEOV1		MOD15		MODIS	
	Closest	Interpolated	Closest	Interpolated	Closest	Interpolated
N	85	86	18	40	88	91
R^2	0.78	0.80	0.68	0.84	0.56	0.67
RMSE	0.12	0.12	0.12	0.24	0.17	0.14
Slope	0.71	0.77	0.55	0.47	0.51	0.60
Intercept	+0.14	+0.10	+0.04	+0.08	+0.21	+0.18

CEOS-LPV 5-Year Roadmap

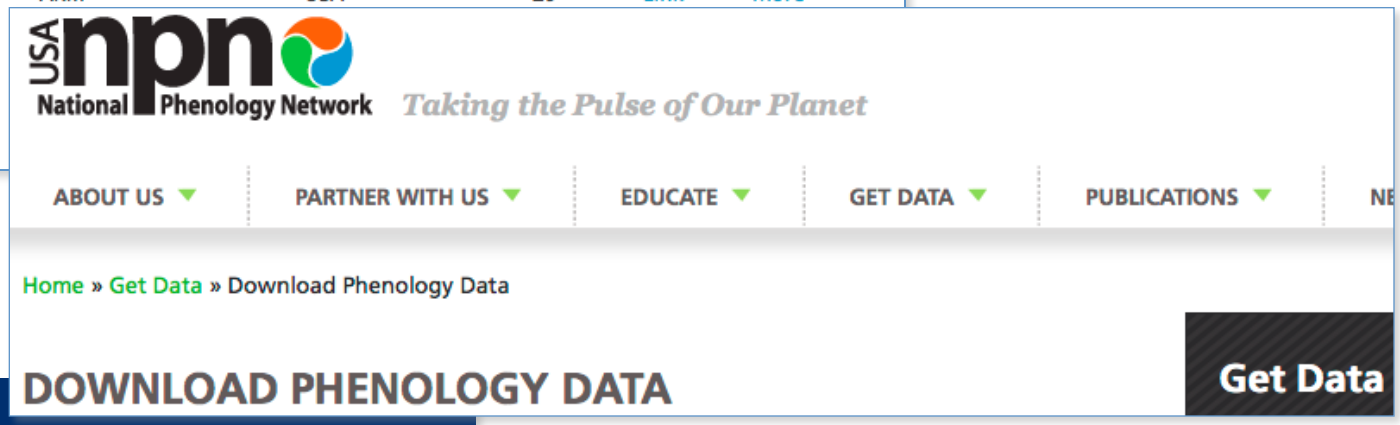


Fiducial Reference Data Sets: Key Players



NASA POCs (Pierre Guillevic, Brad Doorn, Chris Justice)
Full List of Organizations: *http://www.ars.usda.gov/SP2UserFiles/Program/211/LTAR%20Collaborators%20alphbetical%20FINAL.pdf*

Fiducial Reference Data Sets

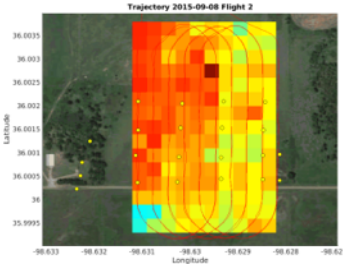


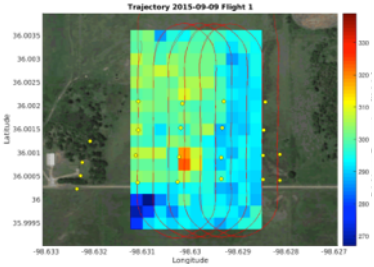
NASA small-UAS Partnerships:

GSFC, ARC and *BlackSwift Technologies LLC*

Two Instrument Systems

Soil Moisture (w/ L-Band Radiometer - SBIR)



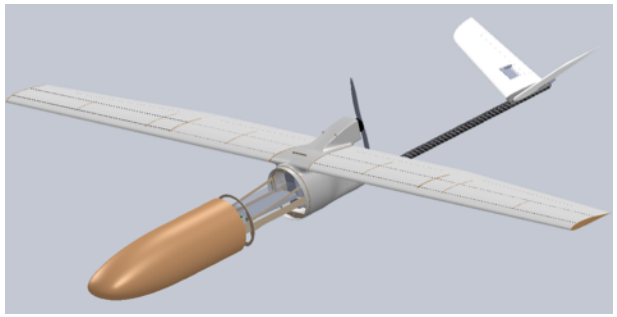


MultiAngle, MultiSpectral Imagers (Román, et al - IRAD)

Two Types of s-UAS

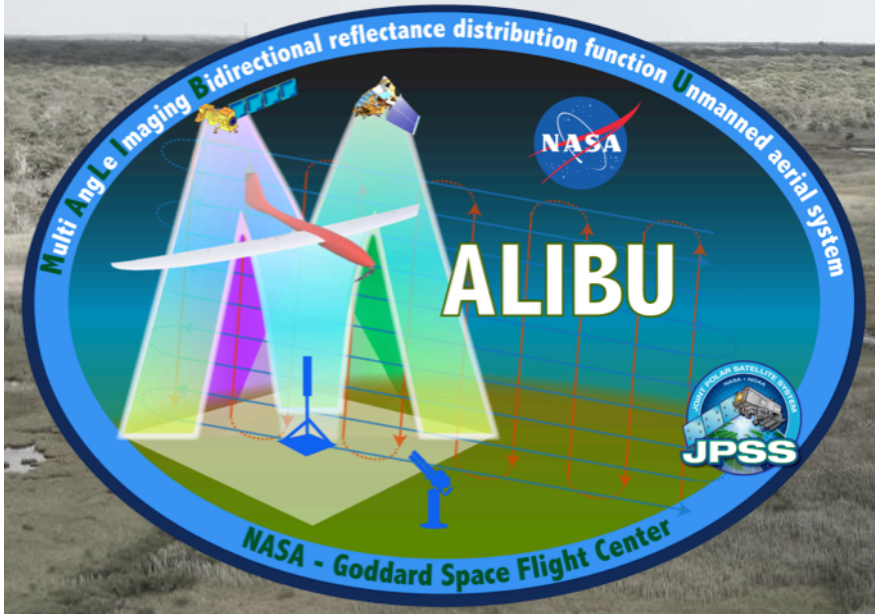
Tempest (Established Platform)

SuperSwift (New, GeoScience Tailored Platform)



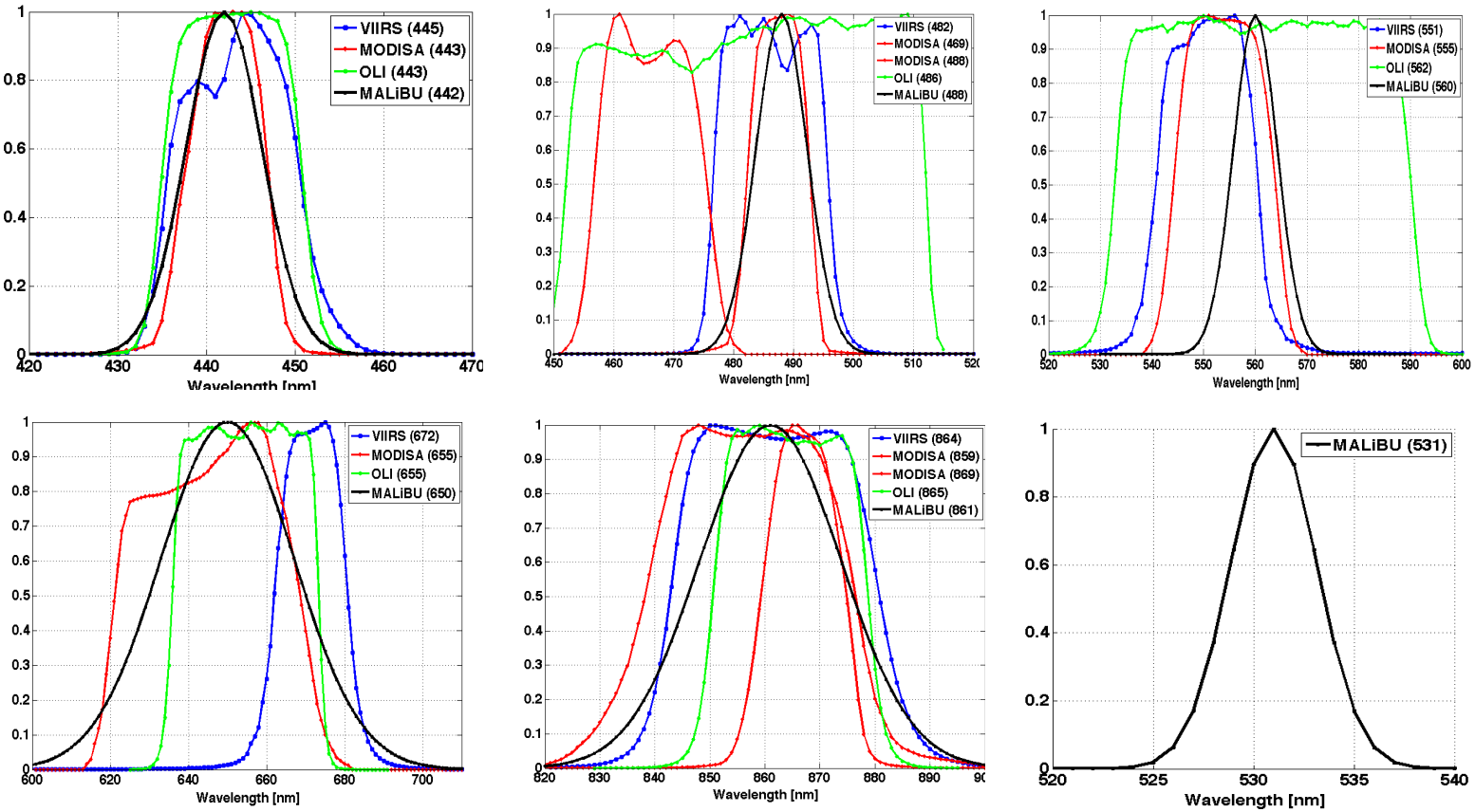
Electric s-UAS (both):
Max Wt. ~15 lbs
P/L Wt. ~5 lbs
Endurance~1 Hr

MALIBU (Multi AngLe Imaging Bidirectional Reflectance Distribution Function sUAS)

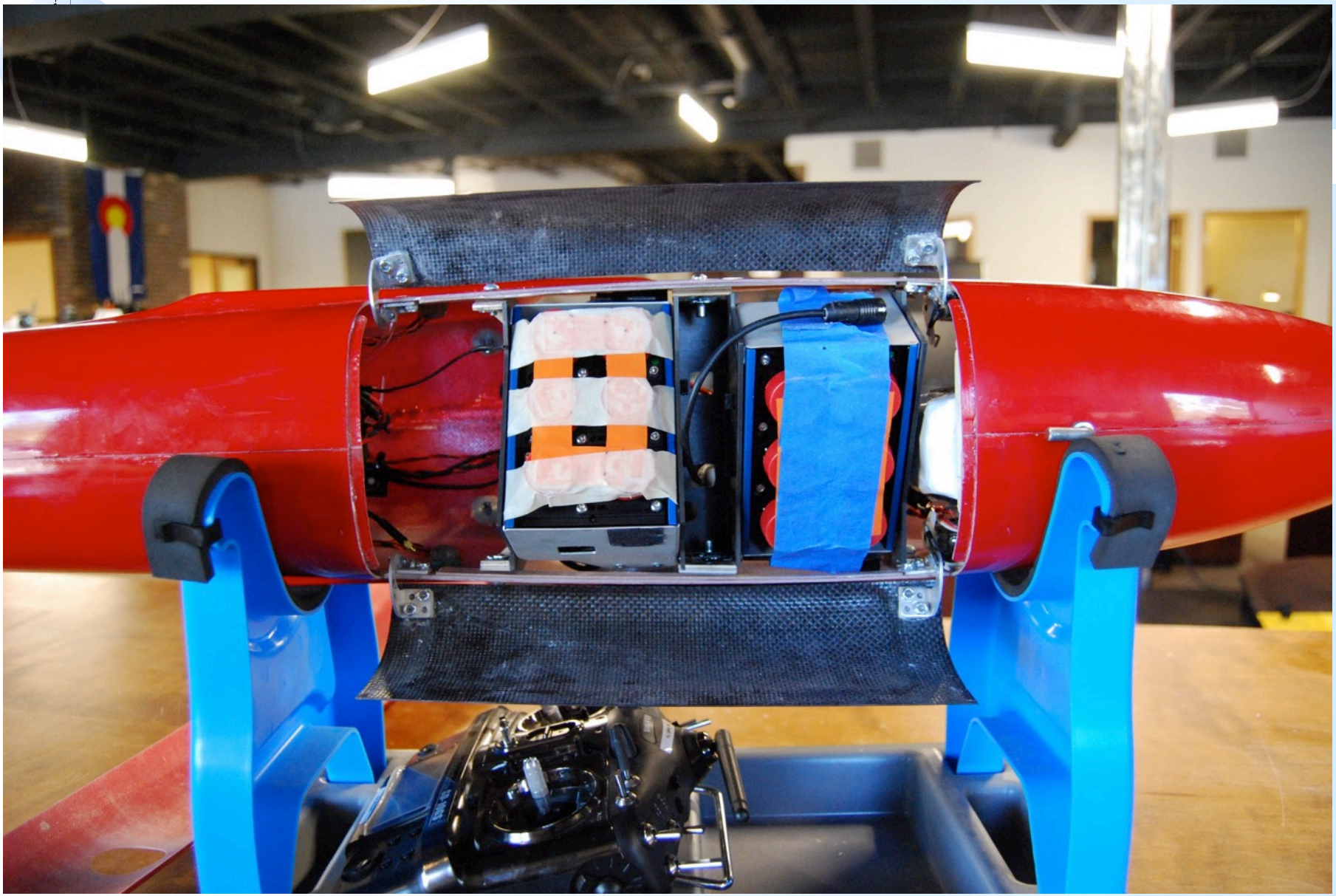


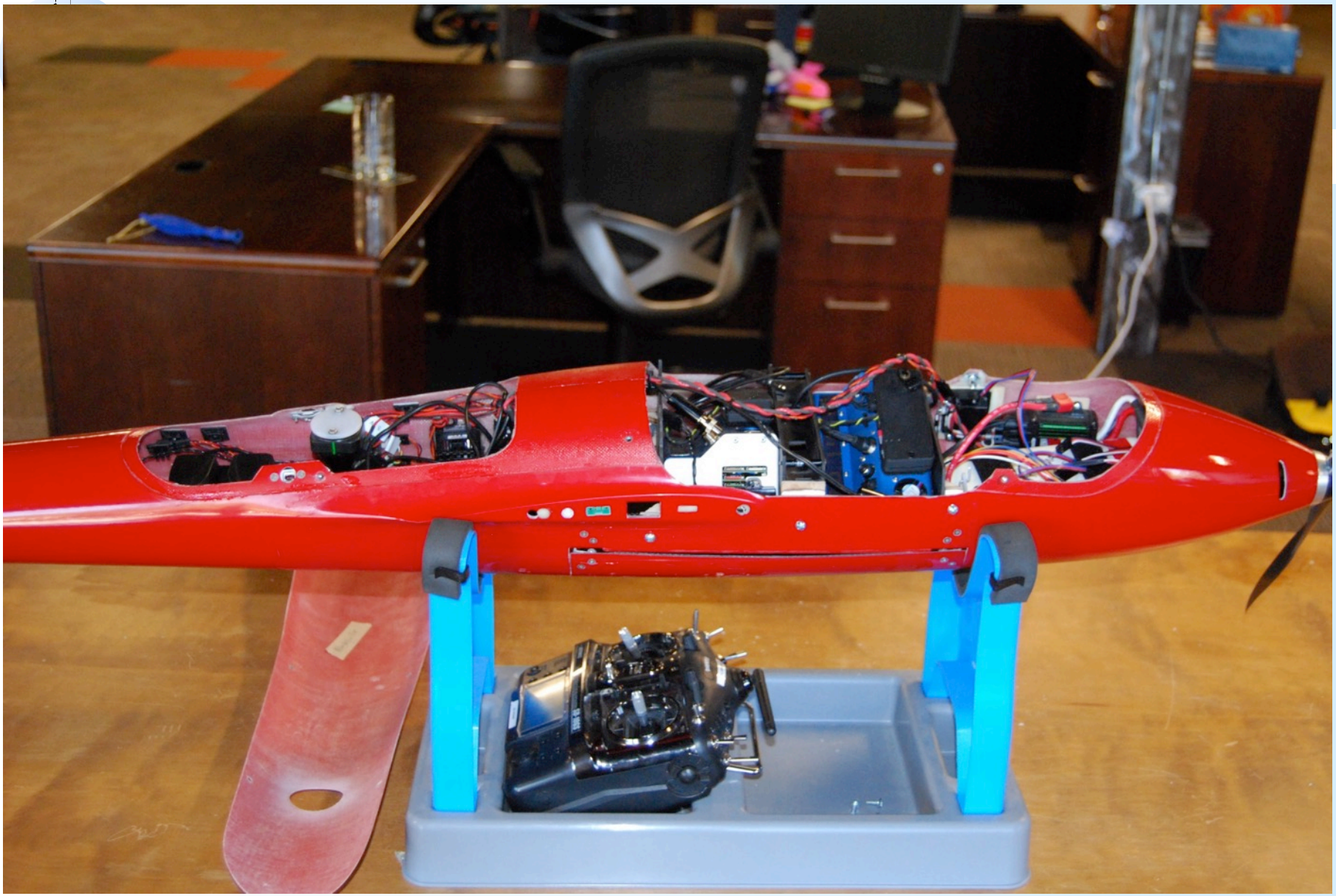
- *MALIBU* is a pathfinder concept funded through NASA's Internal Research and Development Program (IRAD) to develop a multi-angle remote sensing technique using small Unmanned Aircraft Systems (sUAS).
- The instrument package includes two multispectral imagers, oriented at two different viewing angles, to capture key surface radiation and biophysical parameters.
- GSFC instrument system is packaged in a Black Swift Technologies LLC *Tempest* aircraft (seen deployed here).

MALIBU Spectral Response



The MALIBU instrument design includes two Tetracam optical units matching the optical Land channels of key Land sensors such as Landsat-8 OLI, Sentinel-2 MSI, Terra/Aqua MODIS, Terra MISR, and Suomi-NPP/JPSS VIIRS.





Six types of drone concepts 'crazier' than MALIBU…

Package Delivery

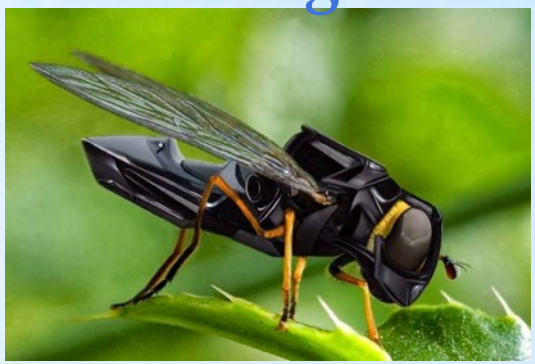
IED Detection

Hurricane Drone

Food Delivery

Wildfire Drone

Pollinating Drone



NASA Flight Readiness Review Approval
COA-Gov't

National Aeronautics and
Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia 23337-5099

Reply to Attn. of: Code 830 / AFSRB Chairman April 20, 2016

TO: 840/PM, Tempest UAS

FROM: 830/Chairman, Airworthiness and Flight Safety Review Board (AFSRB)

SUBJECT: Flight Release for the Tempest UAS

REF:
(a) FRR Meeting Minutes. March 25, 2016.
(b) UAS FOM, March 2016
(c) Tempest UAS Pilot Operating Handbook (Flight Manual)
(d) NPR 7900.3, "Aircraft Operations Management Manual", July 15, 2011

1. In accordance with the recommendations of the AFSRB in Reference (a), the Tempest UAS is certified for flight under the sUAS Provisions of the UAS FOM, Reference (b). All flights shall be flown in accordance with the Tempest UAS pilot operating handbook, Reference (c), UAS FOM and NPR7900.3, Reference (d). In the event of conflicting guidance, the more restrictive policy shall be used.

FAA Section 333 and Transport Canada Full Blanket Exemptions

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

December 11, 2015

Exemption No. 13967
Regulatory Docket No. FAA–2015–1684

Mr. Jack Elston
Black Swift Technologies
2100 Central Avenue
Boulder, CO 80301

Dear Mr. Elston:

This letter is to inform you that we have granted your request for exemption. It transmits our decision, explains its basis, and gives you the conditions and limitations of the exemption, including the date it ends.

BlackSwift TECHNOLOGIES
2100 CENTRAL AVE STE 102
BOULDER, CO 80301
(720)638-9656

This document is concerned with operations of UAS in Canada for commercial use weighing less than 25 kg (55 lbs). More specifically, this document is concerned with operations of UAS that do NOT require a Special Flight Operations Certificate (SFOC). To operate a UAS that is exempt from an SFOC, this falls into 2 categories, sub 2 kg and 2 kg to 25 kg. The requirements and operational limitations for each class are listed below in the following two sections. The infographic outlining these rules is attached in the Appendix. However, the detailed requirements listed in the following two sections are taken from the more detailed Advisory Circular (AC) No. 600-004 [1]. Note that Transport Canada can issue a fine of up to $25,000 to a company not following these rules.

The operator must have the following 4 things in their possession, ready to show to any Transport Canada representative:

	Copy of UAS Exemption (i.e., this document with all provisions in the previous section followed)
	Proof of liability insurance
	Contact Information
	Aircraft System Limitations (i.e. manuals)

MALIBU Test Flight – (6/28/16 – 7/1/16) (Pawnee National Grasslands, CO)

Pawnee NGL flight area

NASA-FAA Approved MALIBU Sites

MODIS/VIIRS Team Member Discount! ~ $350/flight hour

Meeting COA-Gov't and FAA Section 333 requirements

Instrument Teams

VIIRS Land

MODIS Land

Discipline Teams

NOAA

NASA

USGS

esa

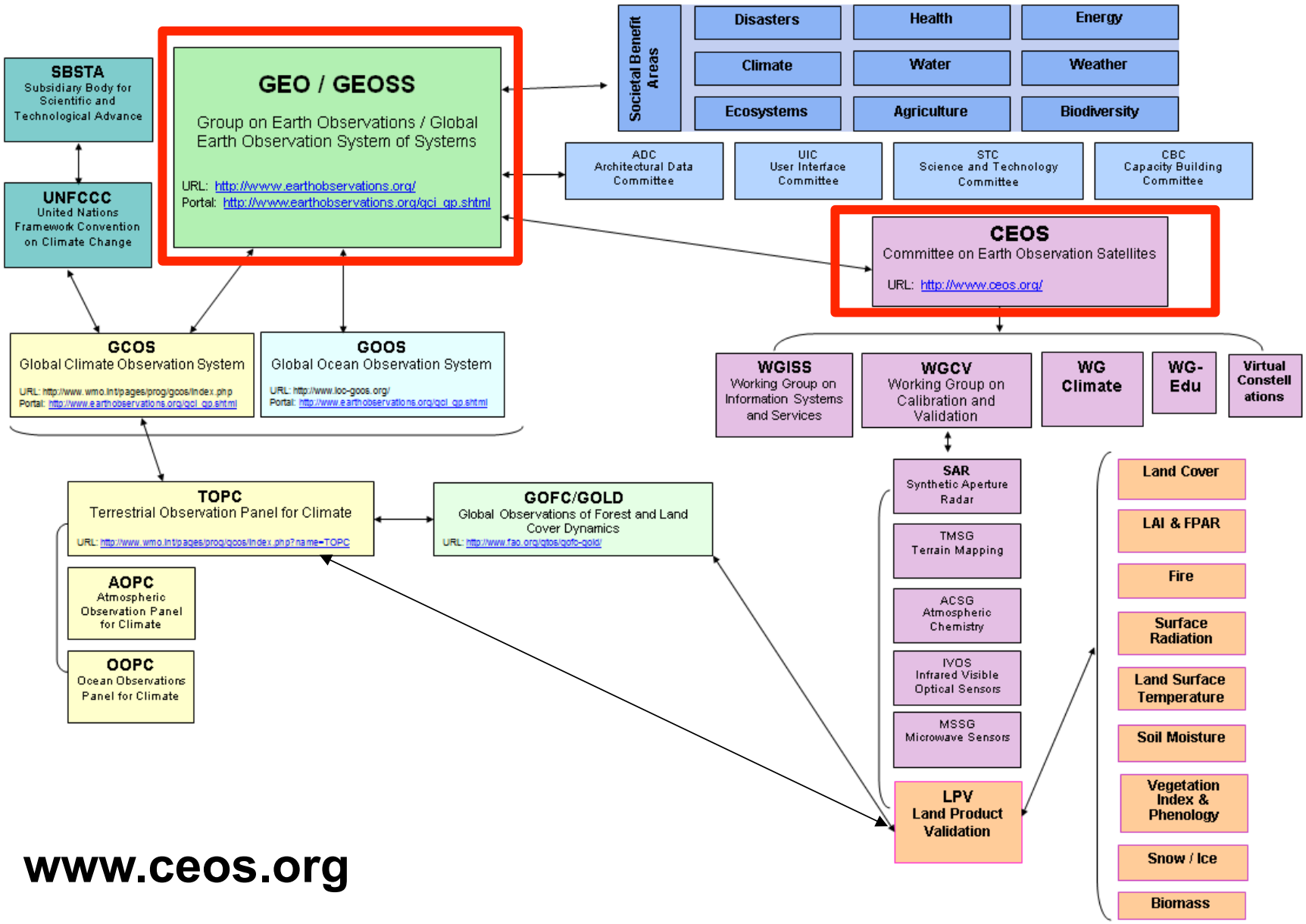
EUMETSAT

CEOS Working Groups and Associates

CEOS WGCV

Land Product Validation Subgroup

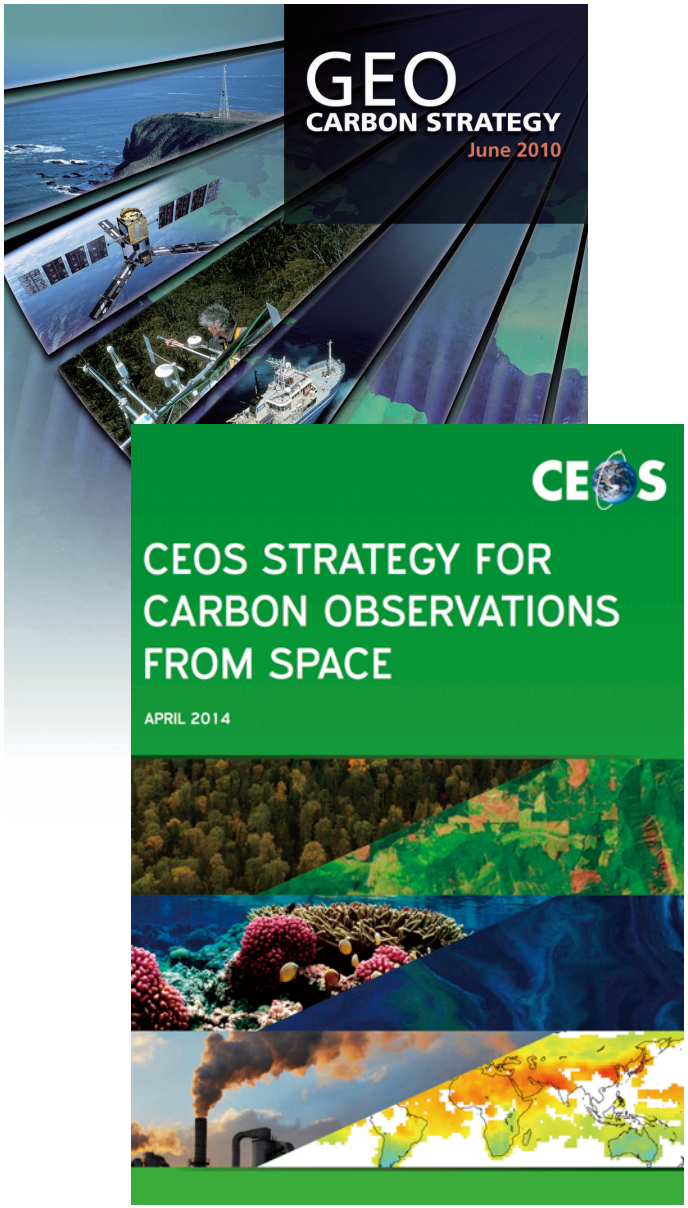
International Programs concerned with Terrestrial Earth Observations



www.ceos.org

CEOS Carbon Activity: History and Background

- GEO Carbon Report developed in June 2010.
- *CEOS Strategy for Carbon Observations from Space* – written in response to above, completed in March 2014 – *Wickland et al.*
- 42 Actions identified in the report for specific response– first discussed at SIT Technical Workshop in September 2013
- April 2014: Proposed establishment of a study team to take forward the Actions and also identify formal CEOS mechanism to manage Actions.



Mark Dowell (EC-JRC)
mark.dowell@jrc.ec.europa.eu
Stephen Plummer (ESA)
stephen.plummer@esa.int

CEOS WORKING GROUP ON CALIBRATION & VALIDATION

LPV Biomass Focus Area Goals:

Validation protocols **focusing on core site selection, field sampling using Terrestrial and Airborne LIDAR Systems, and spatial representativeness and uncertainty quantification of in situ measurements.**

Practicality Optimizations:

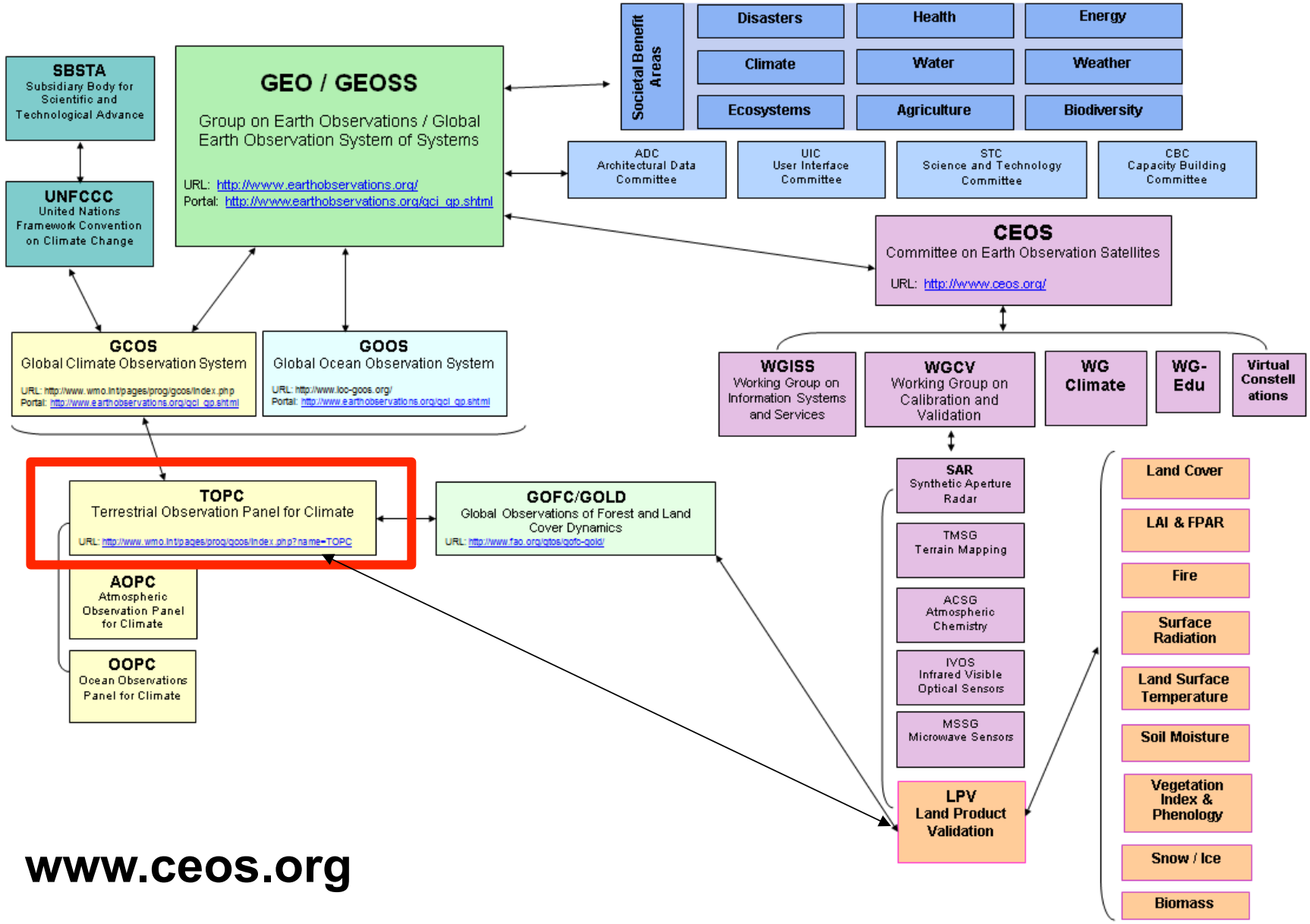
- 3.4 kg
- 33 second scan
- IP68 waterproof
- Wireless operation

UMB CBL (RIT SICK)	Instrument	RIEGL VZ400
Time-of-flight	Ranging Technique	Time-of-flight
1st and 2nd discrete return	Recorded Data	Multiple discrete return Waveform
0-135 zenith 0-360 azimuth	Scan Configuration	30-130 zenith 0-360 azimuth
905 nm	Wavelengths	1550 nm
0.25 deg 0.50 deg	Angular Resolution	0.04-5.03 mrad zenith 0.04-8.73 mrad azimuth
15 mrad	Beam Divergence	0.35 mrad
1	Laser Class	1
50 Hz	Pulse Rate	100 kHz 300 kHz
3.4 kg	Weight	9.6 kg
40 m	Max. Range	200 m 120 m

Capability Optimizations:

- 0.04 mrad max resolution
- 200 m max range
- Multiple return / waveform

International Programs concerned with Terrestrial Earth Observations



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TOPC-18 Panel & Experts

TOPC/USA Delegation

Miguel Román (CEOS/NASA)

Sassan Saatchi (JPL)

Tom Painter (JPL)

Jeff Key (NOAA)

GCOS Land Surface Temperature (LST) Status

LST to become ECV!!

(Just in time for inclusion in the new GCOS-IP due for UNFCCC COP 22.)

- Process ***took years*** since initial inquires. LPV LST & Emissivity focus area leads first made a strong case for inclusion and pushed the case forward.
- Key players (Hook, Sobrino, Hulley, Guillevic, Warren, Remedios) iterated on variable definitions, requirements for satellite/reference/climate, and completed a Draft IP section: ***Not easy!***
- Proposal presented by the CEOS-LPV Chair (Román) and endorsed by the TOPC-18 Panel in April, 2017.

Driving the Global Climate Observation Agenda

Identify/Review Essential Climate Variables (ECVs) through science panels → Regular review of how these ECV are observed → Develop plans to ensure continuity and improvement of observations

- GCOS follows a 3 phase approach driven by users
- 2015 Status Report started the 3rd assessment cycle with a new Implementation Plan due in 2016 for UNFCCC COP 22

(1st cycle: 1995-1998)

(2nd cycle: 2003-2004-2010)

(3rd cycle: 2015-2016)

WMO IOC UNEP ICSU International Council for Science

CEOS WORKING GROUP ON CALIBRATION & VALIDATION

CEOS Working Group on Calibration and Validation

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Land Product Validation Subgroup

Focus Areas: Biophysical | Fire/Burn Area | Land Cover | LST/Emissivity | Phenology | Snow Cover | Soil Moisture | SurfRad/Albedo

Focus Area on Land Surface Temperature and Emmissvity Product Validation

Simon Hook, NASA Jet Propulsion Laboratory, USA
Jose Sobrino, University of Valencia, Spain

Meetings

The Earthtemp initiative 35th EARSeL Symposium Stockholm, Sweden, June 15 to 19. Abstract Deadline is February 2015.

ISRSE36, Berlin, Germany, 11-15 May.

Land Surface Temperature Definition

Land surface temperature (LST) is defined as the temperature derived from a radiative energy balance of a surface and provides the best approximation to the surface skin thermodynamic temperature based on a measure of radiance (Norman and Becker, 1995). LST is also called (directional) radiometric temperature or skin temperature.

Units: The unit of LST is Kelvin [K]. Degree Celsius [°C] is also commonly used.

Land Surface Emissivity Definition

The emissivity of an isothermal, homogeneous emitter is defined as the ratio of the actual emitted radiance to the radiance emitted from a black body at the same thermodynamic temperature (Norman and Becker 1995).

Units: Dimensionless.

Norman, G., and Becker, F. (1995). Terminology in thermal infrared remote sensing of natural surfaces. Agricultural and Forest Meteorology, Volume: 77, Issue: 3-4, Pages: 153-166, DOI: 10.1016/0168-1923(95)02259-Z

Highest Validation Stage Currently Reached for Satellite-Derived Land Surface Temperature and Emissivity Products

Validation stage 1 (LPV validation stage hierarchy) - The highest LPV validation stage reached for satellite-derived land surface temperature and emissivity products. For reaching validation stage 3 and higher, an increased number of global validation sites, covering all surface types, with extended temporal coverage, as well as intercomparison of different LST products are needed.

Land Surface Temperature Validation Methods

Four different methods have been widely used to validate and determine the uncertainties in LST products derived from satellite measurements (Schneider et al., 2012; Guillevic et al., 2014):

Factors that helped 'seal the deal' for LST at TOPC-18:

-- Community Consensus

GLOBTEMPERATURE

esa

University of Leicester

University of Reading | ipma | KIT | ACRI-ST | Met Office | Estellus | University of Copenhagen | Met Office

ILSTE WG

NASA

JPL Jet Propulsion Laboratory

-- Housekeeping of LPV LST&E Section!

19 Essential Climate Variables

Current focus of TOPC 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 **and Land Use Change**
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, Revised, and Proposed

11 ECVs are directly linked to MODIS/VIIRS Land Products

http://lpvs.gsfc.nasa.gov