CEOS/WGCV/LPV
2015 Report:
Validation Datasets and Interagency/International Coordination

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Committee on Earth Observation Satellites (CEOS)
Working Group on Calibration and Validation (WGCV)
Land Product Validation (LPV)

2015 JPSS Annual Science Team Meeting: August 24-28, 2015
CEOS - Committee on Earth Observation Satellites

31 CEOS Members
24 Associate Members (eg UNEP, GTOS, IGBP, WMO, GCOS)

CEOS coordinates civil space-based observations of the Earth

This is achieved through its working groups and virtual constellations. 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       Gabriela Schaepman-Strub       University of Zurich
Vice-Chair  Miguel Román                  NASA/GFSC/JPSS
LPV Support Jaime Nickeson                NASA/GSFC/SSAI

9 Focus Areas with 2 co-leads each
Linkages between International Programs concerned with Terrestrial Earth Observation

GEO / GEOSS
Group on Earth Observations / Global Earth Observation System of Systems

GCOS
Global Climate Observation System

GOOS
Global Ocean Observation System

GTOS
Global Terrestrial Observation System

TOPC
Terrestrial Observation Panel for Climate

AOPC
Atmospheric Observation Panel for Climate

OOPC
Ocean Observations Panel for Climate

TCO
Terrestrial Carbon Observations

C-GTOS
Coastal GTOS

GT-NET
Global Terrestrial Observing Network

GOFC/GOLD
Global Observations of Forest and Land Cover Dynamics

Land Cover
Fire
Biomass

Disasters
Climate
Water

Energy
Weather

Societal Benefit Areas

ADC
Architectural Data Committee

UIC
User Interface Committee

STC
Science and Technology Committee

CBC
Capacity Building Committee

CEOS
Committee on Earth Observation Satellites
URL: http://www.ceos.org/

WGCI
Working Group on Information Systems and Services

WGCV
Working Group on Calibration and Validation

WG Climate
WG Edu
Virtual Constellations

SAR
Synthetic Aperture Radar

TMSG
Terrain Mapping

ACSG
Atmospheric Chemistry

IVOS
Infrared Visible Optical Sensors

MSSG
Microwave Sensors

LPV
Land Product Validation

Land Cover
Biophysical
Fire
Surface Radiation
Land Surface Temperature
Soil Moisture
Phenology
Snow / Ice

www.ceos.org
1. To **foster and coordinate quantitative validation** of higher level global land products derived from remotely sensed data, in a traceable way, and to relay results to users.

2. To increase the quality and efficiency of global satellite product validation by developing and promoting **international standards and protocols** for
   - Field sampling
   - Scaling techniques
   - Accuracy reporting
   - Data and information exchange

3. To provide **feedback to international structures** for
   - Requirements on product accuracy and quality assurance
   - Terrestrial ECV measurement standards
   - Definitions for future missions
### Focus Areas and Co-leaders

- **Snow Cover (T5)\(^*\), Sea Ice**
  - North America: Thomas Nagler (ENVEO, Austria)
  - EU / China: Tao Che (Chinese Academy of Sciences)

- **Surface Radiation (Reflectance, BRDF, Albedo [T8]\(^*\))**
  - North America: Crystal Schaaf (U. Massachusetts Boston)
  - EU / China: Alessio Lattanzio (EUMETSAT)

- **Land Cover (T9)\(^*\)**
  - North America: Pontus Olofsson (Boston University)
  - EU / China: Martin Herold (Wageningen University, NL)

- **FAPAR (T10)\(^*\)**
  - North America: Arturo Sanchez-Azofeifa (University of Alberta)
  - EU / China: Nadine Gobron (JRC, IT)

- **Leaf Area Index (T11)\(^*\)**
  - North America: Oliver Sonnentag (University of Montreal)
  - EU / China: Stephen Plummer (Harwell, UK)

- **Fire (T13)\(^*\)**
  - North America: Luigi Boschetti (University of Idaho)
  - EU / China: Kevin Tansey (University of Leicester, UK)

- **Land Surface Temperature (LST and Emissivity)**
  - North America: Pierre Guillevic (University of Maryland)
  - EU / China: Jose Sobrino (University of Valencia, SP)

- **Soil Moisture\(^*\)**
  - North America: Tom Jackson (USDA ARS)
  - EU / China: Wolfgang Wagner (Vienna Univ of Technology, AT)

- **Land Surface Phenology**
  - North America: Matt Jones (University of Montana)
  - EU / China: Jadu Dash (University of Southampton, UK)
<table>
<thead>
<tr>
<th>Innovation Driver</th>
<th>Impact to Product Utilization</th>
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<tr>
<td>Product Development and Cal/Val</td>
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**PGRR Initiatives Integrate across all drivers**
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JPSS Land Cal/Val Team Contributions to LPV

- JPSS Land cal/val team has adopted the CEOS/WGCV LPV framework & validation stages.
- Key JPSS (FY16) contributions:
  1. Tower-based reference data (CRN, BSRN-SURFRAD)
  2. Airborne-UAV reference data (MALIBU: Román et al.)
  3. Land Product Characterization System (LPCS: K. Gallo)
- Participating CEOS member agencies: NOAA-STAR, NOAA-NCDC, USGS-EROS, NASA-GSFC, ESA-ESRIN.

CEOS/WGCV/LPV subgroup has developed a framework for land product intercomparison and validation based on: (1) a citable protocol, (2) fiducial reference data, and (3) automated subsetting. These components are integrated into an online platform where quantitative tests are run, and standardized intercomparison and validation results reported.
Validation of Land Surface Temperature products derived from the Visible Infrared Imaging Radiometer Suite (VIIRS) using ground-based and heritage satellite measurements


- V1 LST Protocol Published!
- Uses VIIRS as case study
- Interagency Collaboration has been key to CEOS-LPV team’s success. Major players:
  - NOAA (STAR/NCDC)
  - NASA (JPL/GSFC)
  - INRA
Validation of Land Surface Reflectance

Description of Surface Reflectance Validation Protocol

Aerosol models for each AERONET site can be defined using new regressions with optical properties (i.e., $\tau_{440}$ and $\alpha$) as standardized parameters. For the aerosol models, the aerosol microphysical properties provisioned by AERONET, including size-distribution ($%C_t, %C_c, r_t, r_c, a_t, \sigma_t$), complex refractive indices and sphericity, can also be used as standardized protocol measures.

Comparisons with AERONET indicate that parameter standardization produces Accuracy-Precision-Uncertainty (APU) metrics up to 20% lower than the current baseline (Dubovik et al., 2002).

Uncertainties on the retrieved surface reflectance for 40 AERONET sites

MODIS band 1 (red) – synthetic input surface reflectance = 0.05

Team Response: Further classification of errors requires the adoption of consistent and agreeable protocols across MODIS/VIIRS land surface reflectance products. This is also crucial to enable objective assessment and characterization of downstream product impacts (e.g., NDVI/EVI, LAI/FPAR, BRDF/Albedo/NBAR).
Fiducial Reference Data Sets
Relaying Validation Results to our Users

LPV Web Site
15 years and running..

Established in 2000

Subscribed member list has grown to nearly 700 members over the years.

Each focus area (ECV) has pull down menu of links to

- Home page
- References
- Collaboration
- Products

http://lpvs.gsfc.nasa.gov
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How About This Driver?
A Land Validation Framework

Validation Good Practice Document


Fiducial Reference Data Sets

Example of fiducial reference data for soil moisture.

Global Satellite Product Subsets

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

Online Validation Tool

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

Standardized Intercomparison Report

Standardized Validation Report
Scaling Phenology (USGS)
A Land Validation Framework

Validation Good Practice Document

Example of fiducial reference data for soil moisture.

Fiducial Reference Data Sets

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

Standardized Intercomparison Report

Standardized Validation Report
Fiducial Reference Data Collection: Challenges

– **CEOS/WGCV/LPV Goal**: To characterize land product uncertainties in a statistically rigorous way (i.e., over multiple locations and time periods representing global conditions).

– **Our Challenge**: To work within the constrains of NOAA/NASA missions, programs, and airborne assets (e.g., deployments costs on P3-B: ~$4000/flight hour).

– **Our Strategy to-date**: “Piggy-backing” has brought us some gains; but it requires a lot of:

  1. Patience (work with lead PIs and identify common goals),
  2. Good Luck (e.g., nominal operations + clear skies),
  3. Hard Work (countless hours of mostly unfunded effort; esp. for post-processing and science data analysis).
Description and Objectives:
• Design a low-cost imaging approach to validate critical land climate data records
• Radiometric/Spectral calibration of dual Tetracam cameras at GSFC calibration facility
• Platform integration and Field Deployment
• Subpixel (10 meter) land biogeophysical product retrieval (PRI, NDVI, BRDF/Albedo, Reflectance) and validation efforts (MODIS/MISR, VIIRS, Landsat/OLI, and GOES-R).

Key challenge(s)/Innovation:
• Accurate earth gridding & geo-location of the collected images.

Approach:
• Specify/Study camera specifications
• Work closely with the camera vendor during the fabrication
• In-house camera calibration
• Work closely with platform vendor during integration phase
• Test flights and geo-location tests
• Design flight plans and data collection procedure
• Data processing and product generation

Application / Mission:
• Develop international protocols for assessment of terrestrial essential climate variables.

Key Members: Geoff Bland (610W), Joel McCorkel (618), Zhuosen Wang (ORAU), Ed Masuoka (619), Robert Wolfe (619), Jack Elston (Black Swift), John Augustine (NOAA), and Ivan Csiszar (NOAA).

Milestone and Schedule:
- Start of the project: 10/2014
- Camera procurement: 11/2014
- Camera characterization: 12/2014
- System Integration: 03/2015
- Test flights: 04/2015
- Data collection: 06/2015
- Post-deployment calibration: 07/2015
- Data processing: 09/2015

MALIBU Platform and Payload:
- Tempest Blackswift UAS
  - Two six-channel cameras
  - Irradiance sensor
  - FOV ~ 50deg
  - Weight 0.7kg (each)
- Programmable flight path
- Endurance (~60-90 min)
- Altitude: 100-500 m
- Cruise speed: 50 km/h
- Weight: 3 kg

Mini-MCA6 Equipped with Incident Light Sensor

TA-08; New Tools of Discovery; TRL_{in} = 4
Task Objective

- Objective: To deploy an Unmanned Aircraft System (UAS) that can enable high spatial and angular resolution mapping of terrestrial essential climate variables.

- MALIBU sensor suite performance metrics:
  - Two Tetracam optical units
  - Combined FOV ~ 100° (50° x camera)
  - GIFOV < 10 meters
  - Geolocation accuracy < 0.7 pixel*
  - Signal to Noise > 300
  - Radiometric uncertainty < 5% attained through frequent GSFC in-house calibration

*Challenges: All-of-the-Above Strategy: Onboard IMU (Uncertainty = 0.1 deg) + Onboard GPS (Uncertainty < 1 m) + Ground Control Points (image-based geolocation).
Six types of drone concepts ‘crazier’ than MALIBU...

Package Delivery

IED Detection

Hurricane Drone

Food Delivery

Wildfire Drone

Pollinating Drone
MALIBU Imaging Geometry

- Camera mounts
MALIBU Spectral Response

442, 488, 531, 560, 650, 861nm + Tetracam’s Incident Light Sensor
Viewing Geometry: Cross-track

- Dual Tetracam cameras (with non-overlapping swaths) mounted on the platform across-track

Coverage ~ 600 m

- $H \sim 200$ m
- $\alpha \approx 20^\circ$
- $FOV \approx 50^\circ$
- $\sim 75$ m
- $\sim 250$ m
- Coverage $\sim 600$ m
• $5 \times 5 \ km^2$ is covered during two-day deployment
• Requires visible line-of-sight less than 5 km
Overlapping scenes along-track provide multi-angular retrievals.
Overlapping Regions

Impact of changes in attitude

Target of interest

20 frames

Flight lines

Secondary

Primary

Along-track

Across-track
First MALIBU Test Site: NOAA-SURFRAD
Table Mountain, CO

- Located ~8 miles north of Boulder, CO.
- John Augustine (NOAA/ESRL, Site PI) is MALIBU team collaborator.

- In-situ measurements include: MFRSR, LI-COR PAR, Yankee UVB-1 Ultraviolet Pyranometer, ventilated Eppley pyrgeometer and ventilated Spectrosun pyranometers.
- Blackswift Tempest has been deployed extensively at this site (69 flights completed since 2010).

Latitude: 40.12498
Longitude: -105.23680
Elevation: 1689 m
Installed: July 1995
How About J2 Cal/Val??

(2020 and beyond...)
ConOps

- **18,500 nm** range, **10 day** endurance, with 30 pound payload
- 2 aircraft could keep a payload on-station indefinitely

Contours of on-station endurance with launch and recovery from the eastern United States
TetraCam Micro MCA-6

- Multi-spectral imaging, two systems each 45° from nadir
If you want to go fast, go alone.
If you want to go far, go together.

African Proverb