Summary of MODIS Maintenance Activities (Senior Review Summaries)

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with inputs from the Terra/Aqua MODIS Maintenance PIs
GSFC Code 619 MODAPS support teams
These are updated annually, so users know the current validation status of the MODIS and VIIRS products.

Statements do not have to be updated annually, but the PIs need to verify the status information posted on their status pages are current.

### Status of MODIS / VIIRS Land Product Validation Statements

<table>
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<tr>
<th>Product</th>
<th>PI</th>
<th>Sensor</th>
<th>Last Review/Update</th>
<th>Input/Review rec’d</th>
<th>URL for validation statement page</th>
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<tr>
<td></td>
<td>Giglio</td>
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<td>Lyapustin</td>
<td>VIIRS</td>
<td>NA</td>
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</table>
Transition of validation status information from LandVal to MODLAND – Deprecation of LandVal

Background

• MODIS Land Validation (LandVal) and MODLAND web sites evolved separately, both active since 2000 with stable URLs.
• MODIS Land Validation was a large concerted effort post-launch, web site served primarily as a link to many different data sets collected at the EOS Core Sites (including MODIS subsets) and to MODIS product validation status information.
• LandVal site now operates almost solely as a source for the Product validation status information (per web site traffic monitoring)
• Most of the core site validation data were collected in the 2000-2010 time frame, most were stored at the LPDAAC and are no longer available there (as noted on the web site home page)

Plan

• To move the product validation status pages from LandVal into the MODLAND web site. Will provide redirects for the many unknown links out there to the site for a time, but will notify the LP and NSIDC DAACS of the new links.
• LandVal web site will be deprecated at some point which has yet to be determined. If anyone has any needs to retain information hosted there, please contact Jaime Nickeson (jaime.nickeson@nasa.gov).
Very high-resolution commercial imagery available for NASA-funded research

- The National Geospatial-Intelligence Agency’s extensive archive of commercial satellite data are available to NASA investigators free of cost
- Licensed under NextView contract (can be shared with those supporting USG interests)
- 4 active sensors available, plus historical IKONOS and QB. MS and Pan (0.5 to 5 m resolution), as well as SWIR w WV3, some CAVIS (MODIS bands), extensive global coverage.
- GSFC already has over 7M high res scenes and 3.5 Pb of these data in house, and access to future collections.
- Go to [http://cad4nasa.gsfc.nasa.gov](http://cad4nasa.gsfc.nasa.gov) to register and submit requests. Non-NASA need grant number to register.
MODIS SR Product suite

Collection 6: (Released in 2015)

Bands 1 through 7
250m, 500m, 0.05 deg.

Daily, 8 days

Status and Updates:

- MODIS SR collection 6 (LaSRC: Land Surface Reflectance Code) is the basis for a variety of SR product (VIIRS, AVHRR, Landsat, Sentinel 2) assuring consistency and traceability in the SR products from multiple satellites/instruments.
- Validation stage IV (AERONET) and cross-comparison with MODIS is on-going. ACIX-II (Landsat 8/ S2) is on-going.

Recent Publications:


Google scholar citations containing MODIS surface reflectance (as of November 13, 2019) about 63000 total.
MODIS VI Suite (in its 19th year)
Collection 6: (Released in 2015)
Collection 7: (Many changes)

VIIRS VI Suite (in its 7th year)
Collection 1: (Released in 2018)
Consistent with MODIS product suite
Collection 2: (Changes and possible 375m product)

Status and Updates:
- Improved QA-driven compositing algorithm
- Improved QA and View Angle compositing scheme
- Ongoing Algorithms enhancement to address upstream changes and/or issues
- Regular and opportunistic validation (using NEON and Drone Data)
- Time series fully characterized with explicit MODIS T/A continuity transfer functions
- VIIRS VI product orphaned and no longer funded, the PI/SCF continues to support the Algorithm/product suite due to its critical value to the science community (thousands of users and tens of agencies and private companies depend on this effort).

Known Issues:
- The use of pre-composited 8-day surface reflectance inputs continues to cause consistency issues that will be addressed in C7 (back to daily inputs)

Recent Publications:
Status and Long-term plans for the VI Time Series

For the most part VIIRS is almost identical to MODIS (not withstanding resolution) with $R^2 > 96\%$. Differences between VIIRS and MODIS are minor averaging around 2% and 1.7% VI units for NDVI and EVI respectively. Diff. standard deviation (a measure of the Time Series continuity error) is around 0.057 for NDVI and 0.0386 EVI. There are still some challenges that we plan to address with later collections (clouds, WL mask, etc.).

Future plans
- A robust and Internal LW mask to avoid current problems (near shores land)
- Internal cloud mask and finer resolution (375 m, requested by some of our users) for VIIRS
- Newer long-term CMG databases
- Back to daily for MODIS
- Prototyping an experimental ZERO CLOUD product suite with Gap filling
- Aiming at Validation Stage 4 for MODIS and 2/3 for VIIRS

Online platform for VI Validation and Across sensor continuity
https://vip.arizona.edu/tools/NEON/

Opportunistic validation and continuity analysis with NEON
Status of MODIS MCD19

MCD19 Product Suite
Collection 6: (Since May, 2018)
- MCD19A1: Surface Reflectance
  - Daily L3 1 km: BRF in bands 1-12; Snow grain size and snow fraction;
  - Daily L3 500 m: BRF in bands 1-7;
- MCD19A2: Atmospheric properties
  - Daily L3 1 km: CM, AOD, CWV, Plume Injection Height (for detected smoke)
- MCD19A3: BRDF/Albedo
  - 8-Day L3 1 km: RTLS BRDF, instantaneous albedo in bands 1-8;

Status and Updates for C6.1:
- Daily gap-filled 250m BRF in bands 1-2 (Red-NIR);
- CMG (0.05° products)

Known Issues:
- NA

Selected Recent Publications:
MODIS MAIAC Algorithm

A 25% increase in rice production in Punjab and post-harvest fires during 2002-2016 result in dramatic deterioration of air quality in populous Indo-Gangetic plane with associated 43% growth in aerosol loading and near 60% rise in ground particulate matter (in New Delhi)


MAIAC AOD shows best correlation and lowest rmse against AERONET among operational aerosol products (Schutgens et al., 2019; climate modeling community)

Pollution in Dehli from agricultural residue burning in upwind states of Punjab and Haryana (for ref. the US AQ standard is 35 µg/m³)

Chowdhury, S., S. Dey, L. Di Girolamo, K.R. Smith, A. Pillarisetti, A. Lyapustin, Tracking ambient PM2.5 build-up in Delhi national capital region during the dry season over 15 years using a high-resolution (1 km) satellite aerosol dataset, Atm. Environ., 204, 142-150, 2019.
MODIS Burned Area Product Collection 6: (released 2017)
- MCD64A1: Monthly L3 500 m SIN Grid
- MCD64CMH: Monthly CMG (released 2018)

Status and Updates:
- Stage-3 validation complete.

Known Issues:
- None.

Recent Publications:
MODIS Active Fire Products
Collection 6: (released 2015)
• MOD14/MYD14: Terra/Aqua L2 Swath
• MOD14A1/MYD14A1: L3 Daily 500-m SIN Grid
• MOD14A2/MYD14A2: L3 8-day 500 m SIN Grid
• MCD14ML: Monthly fire locations

Status and Updates:
• Widely used mature product.
• Stage-2 validated.

Known Issues:
• None.

Recent Publications:

Congo’s rainforest is getting smaller.
*The Economist*, 19 Oct. 2019
MODIS Snow-Cover Product
Collection 6.1:
• New -- M*D10A1F: Daily Cloud-gap-filled product MODIS/Terra/Aqua L3 500 m SIN Grid
  • M*D10_L2 revised algorithm and data content, improved snow cover detection

Status and Updates:
• Snow cover algorithm: revised low visible reflectance screen and added two algorithm QA bit flags
• Product user guides updated for C6.1

Known Issues:
• Investigating cloud/snow confusion and effect of aerosols on the snow cover algorithm

Recent Publications:
• O’Leary, Donal, Dorothy Hall, Michael Medler, and Aquila Flower, 2018: Quantifying the early snowmelt event of 2015 in the Cascade Mountains, USA by developing and validating MODIS-based snowmelt timing maps, Frontiers of Earth Science 12(4):693-710.
Cloud-Gap-Filled (CGF) MODIS Product is Now in Production

Dorothy Hall\textsuperscript{1,2} and George Riggs\textsuperscript{1,2}
\textsuperscript{1}ESSIC / University of Maryland, \textsuperscript{2}NASA/GSFC Cryospheric Sciences Lab, \textsuperscript{3}SSAI

The cloud-gap filled (CGF) MODIS product provides a time series of daily cloud-free snow-cover maps at 500-m resolution from both Terra and Aqua.

The MODIS Terra CGF time series shows a trend of \(~4\) fewer days of snow cover for this part of the western U.S. over 18 years.
MODIS Cloud-Gap-Filled (CGF) Snow-Cover Maps Show a Trend of ~11 Fewer Days of Snow Cover in the Great Salt Lake Basin, 2001 – 2018

Trend of number days of snow cover per pixel (Feb – May) over 18 years

* basins of the Weber, Bear and Jordan rivers

Hall et al., in preparation
Status of MODIS LST&E

Status and Updates:
• MODIS LST&E swath (L2) and sinusoidal (A1/A2) products released in Collection 6 (Fall 2018).
• MODIS LST&E gridded products (C1,C2,C3) in processing and released with Collection 6.1 (Fall 2019)

MOD21 LST&E Products:
Collection 6: (Released Fall 2018)
• MxD21 L2: Daily 5-min L2 Swath 1km
• MxD21A1: Daily L3 Global 1km
• MxD21A2 8-day L3 Global 1km

Collection 6.1: (in processing)
• MxD21C1: Daily 0.05 degree Climate Modeling Grid (CMG)
• MxD21C2: 8-day 0.05 degree Climate Modeling Grid (CMG)
• MxD21C3: Monthly 0.05 degree Climate Modeling Grid (CMG)

Known Issues and Concerns:
• MOD21 Terra products only produced until 2005 in Collection 6 due to issues with band 29 calibration.
• Currently two different product streams (MxD11/MxD21) with a total of 10 different product types
• No current plan forward to retire MxD11 suite of products
• Validation shows MxD21 product addresses cold LST bias of MxD11 over arid regions, with products having similar accuracy over vegetated regions.

Publications/Documentation:
• User guide and ATBD available at: https://modis.gsfc.nasa.gov/data/dataprod/mod21.php
New MODIS MYD21 LST detects rising extreme temperature trends and heat vulnerability in Los Angeles, CA

New MYD21 LST product pinpoints hotspots and regions most vulnerable to heat stress in urban areas. Heat vulnerability index (HVI) maps are currently used by the LA county sustainability office to advise on implementing effective climate adaption and mitigation strategies.

[Hulley et al. 2019, Rem. Sens.]

Lower income communities are disproportionately affected by the effects of extreme heat in L.A.
History Status of MODIS LAI/FPAR

✓ All are in nominal operation

✓ Status of MODIS LAI/FPAR Product

Collection 3: November 2000 – December 2002 / OBSOLETE!
Collection 4: March 2000 – December 2006 / OBSOLETE!
Collection 5: February 2000 – March 2017 / OBSOLETE!
Collection 6: February 2000 – Present (Released since 2015)

MOD15A2H: MODIS/Terra 8-Day L4 Global 500 m SIN Grid V006
MYD15A2H: MODIS/AQUA 8-Day L4 Global 500 m SIN Grid V006
MCD15A2H: MODIS/Terra+Aqua 8-Day L4 Global 500 m SIN Grid V006
MCD15A3H: MODIS/Terra+Aqua 4-Day L4 Global 500 m SIN Grid V006

• L2G–Lite surface reflectance at 500m resolution as MOD09GA input instead of reflectance at 1km resolution MODAGAGG
• New multi-year land cover product at 500m resolution in place of the 1km resolution static land cover product
MODIS LAI/FPAR Product suite
- Collection 6: (Released in 2015)
- Terra (MOD), Aqua (MYD), and Terra and Aqua (MCD)
- 8 days for MOD/MYD, 4 days for MCD
- 500m

Status and Updates:
- MODIS LAI/FPAR collection 6 uses 500m Surface Reflectance and land cover instead of 1km in collection 5.
- New 3 or 4 years land cover instead of static land cover
- Validation at stage 2 has been achieved for the MODIS collection 6 LAI product.

Known Issues:
- None

Recent Publications:

"One-third of the global vegetated area is greening and 5% is browning... Two-thirds of this greening is from croplands and forests in about equal measure ...The greening is most notably in China and India, which together account for nearly one-third of the observed total net increase in green leaf area globally."
MODIS GPP/NPP and ET/PET products.

Collection 6:
- MXD17A3H: MODIS/Terra-Aqua Annually L4 500 m SIN Grid
- MXD17A2H: MODIS/Terra-Aqua 8-day L4 500 m SIN Grid
- MXD16A3: MODIS/Terra-Aqua Annually L4 500 m SIN Grid
- MZD16A2: MODIS/Terra-Aqua 8-day L4 500 m SIN Grid

Status and Updates:
- The collection 6 products are not available due to cloud contamination problems.
- The new Gap filled GPP/NPP and ET/PET products (collection 6.1) are going to be available soon.
- A comparison and validation of the method will be carried out with the new data.

Known Issues:
- Important gaps due to cloud contamination in heavily clouded areas in (collection 6).

Recent Publications:
Improvements on MODIS Evapotranspiration (MOD16) and GPP/NPP (MOD17) Operational Data Sets Using Gap-filled Climatological FPAR/LAI

Maosheng Zhao, Alvaro Moreno, Sudipta Sarkar, Sadashiva Devadiga and Steven W. Running

- Cloud cover and aerosols difficult obtaining valid retrievals in 8-day operational FPAR/LAI which in turn create “gaps” in MOD17 and MOD16 products (A).
- Collection 6.1 MOD16 and MOD17 products use a back up enhanced climatological FPAR/LAI (EHCFL) when unreliable FPAR/LAI estimates are present.
- The pre-computed EHCFL improves standard mean/median climatologies approaches.
- EHCFL maximizes global MOD16 and MOD17 usefulness and reduce drastically the errors due to cloud contamination (B).
Plant traits are an important part of the MODIS GPP/NPP and ET/PET algorithms (MOD17 and MOD16). But also in most of DGVMs, ESMs and GCMs. Their contribution in all these models is over simplified (one value per PFT) and constitutes a significant source of uncertainties (A). We present and validate a combined remote sensing and biogeographic approach to spatializing estimates of key leaf traits (B) and their respective uncertainties (C).
Satellite data-driven modeling of field scale evapotranspiration in croplands using the MOD16 algorithm framework


- We refined the MOD16 ET algorithm to better represent C3 and C4 croplands.
- Enhancements include refined model, dynamic land cover and 30-m vegetation inputs (Landsat based).
- Results show enhanced ET accuracy and lower bias over diverse CONUS crop types.
- Improved representation of field scale (30-m) ET heterogeneity (A), (B)
MODIS BRDF Albedo NBAR Products

The MODIS products rely on high quality multi-date, multi-angle surface reflectances to retrieve a daily surface BRDF for each pixel. This BRDF is then used to produce White Sky Albedo (bihemispherical albedo under isotropic illumination), Black Sky Albedo (directional hemispherical albedo under local solar noon illumination), and Nadir BRDF-Adjusted Reflectance (NBAR). Extensive QA fields are provided. Albedo is retrieved as either a snow albedo or a snow-free albedo depending on the condition of the daily day of interest.

Collection V006:
- MCD43A: 500 m SIN grid
- MCD43A1: BRDF/Albedo Model Parameters
- MCD43A2: BRDF/Albedo Quality
- MCD43A3: Albedo
- MCD43A4: NBAR
- MCD43C: 0.05 degree CMG
- MCD43C1: CMG BRDF/Albedo Model Parameters
- MCD43C2: CMG BRDF/Albedo Model Snow-Free Parameters
- MCD43C3: CMG Albedo
- MCD43C4: CMG NBAR
- MCD43D: 30 Arc-Second CMG (1 – 40)
- MCD43GF: CMG Gap-Filled Snow-Free

Status and Updates:
- Due to the detector failures in MO/YD09 Bands 5 and 6, new mandatory QA values have been created for the products, indicating whether or not these bands could be used in processing. New narrow-to-broadband coefficients have been calculated for such cases.
- Snow free Gap Filled V006 products (MCD43GF) are available from the LP DAAC for years 2001-2017.
Vicarious calibration of BRF in Railroad Valley Playa was performed with MCD43 BRDF values. A specially modified MCD43 code was used due to compensate for underlying MOD/YD09 reflectance values mistaking exceptionally bright surfaces for aerosol.

The special MODIS product, which is produced ignoring the aerosol QA flag, is found to agree with in situ measurements within 4%.

Broadband white-sky albedo in these images, derived from the Moderate MCD43A3, shows the rapid darkening of the western edge of the ice sheet during spring/summer 2019. The recent extensive melt event exacerbated early melting in the ablation area, where bare ice becomes exposed by early warming.

MCD43 products featured on ‘Greenland Today’ blog over the summer, helping highlight the exceptional melt season. Future work will explore melt-related albedo consequences over Greenland for the entire MODIS time series.

MODIS MOD44B Vegetation Continuous Fields: A Functional Baseline for Biogeochemical Parameterizations
Charlene DiMiceli, John Townshend, Robert Sohlberg
University of Maryland

- Sub-pixel estimates of landscape components.
- Annual results for 2000 – present.
- Nominal spatial resolution of 250 m.
- Derived with daily L2G data and machine learning.
- Fully automated with embedded error estimates.
- Algorithm can be applied to other sensor systems.
- Popular use within the carbon community.
- Improves spatial estimates of productivity, roughness, disturbance, surface water, etc.
- 2400 unique user citations since 2000.
- 1040 citations in the past five years.
- **420 citations in just the past two years.**
**Recent Maintenance Activity**

- Routine production of C6 annual products released each April.
- User’s Guide and ATBD up-to-date.
- Available via the LP-DAAC.
- Several code updates to accommodate changes in meta data and upstream surface reflectance input products.
- All code currently accepted in the production system.
- Standing by for C6.1 reprocessing and quality assurance checks.
- Product quality remains stable.

**New Science Activity**

- Work underway to use VCF capabilities to estimate global disturbance.
- Forest degradation and fragmentation resulting in adverse impact on provision of ecological goods and services.
- **Fragmentation hotspots where >30% of 25 km² tiles have changed from interior forest (>1 km from forest edge) to edge-impacted forest (<1 km from forest edge):**

Charlene DiMiceli  
cdimicel@umd.edu  
tel: 301-780-3967
MODIS MOD44B Vegetation Continuous Fields: A Functional Baseline for Biogeochemical Parameterizations

Future Needs & Opportunities

- Extensive use by climate and carbon modeling communities demonstrates the unique contribution of fractional cover products.
- The product would benefit from use of newly available Lidar data. Canopy height and structure data would improve training and allow retrieval of a much requested “shrubs” layer.
- New machine learning techniques are available to provide a dynamic water layer which captures the seasonal signal.
- The current code could expand the VCF record to VIIRS with minimal new investment, primarily QA/QC and validation.
- We plan to develop ecological applications in concert with the land management community.
- As illustrated below, afforestation is more complicated than is currently understood. Fragmentation and edge effects – both anthropogenic and climate-driven – degrade ecological services even as total forest area remains stable.

A. Logging and regrowth. Oregon.

B. Many roads and small clearings break up interior forest into smaller patches. West Virginia.

C. Forests in the Far North are naturally fragmented.

D. Patches of forest are surrounded by agricultural clearings. Nicaragua.
MODIS DSR and PAR Products added in 2017

Collection 6:
- MCD18A1: MODIS/Terra+Aqua Daily L3 5km DSR SIN Grid
- MCD18A2: MODIS/Terra+Aqua Daily L3 5km PAR SIN Grid

Collection 61:
- Under processing
- MCD18A1, MCD18A2: 1km
- MCD18C1, MCD18C2: CMG, 0.05°

Known Issues:
- Programming errors in C6 overestimating DSR and PAR

Status and Updates:
- C61 codes fixed the programming errors
- Spatial resolution was improved from 5km to 1km
- Added new 0.05 degree CMG products of DSR and PAR
- Improved LUT with better representation of clouds
- Adding VIIRS as additional data to better capture diurnal changes

Recent Publications:
Field data collection
- Starting with data of 2018
  - BSRN, AmeriFlux, European Flux, OzFlux 119 stations

Other products for intercomparison
- Clouds and the Earth’s Radiant Energy System (CERES)
- Global LAnd Surface Satellite (GLASS)

Validation approaches
- Temporal and spatial aggregation
- Effects of input surface reflectance data
- Effects of daily overpass counts

Top figures: scatter plots between MCD18 data and in situ measurements for instantaneous DSR, daily DSR, instantaneous PAR and daily PAR.

Right figure: Accuracy of MODIS daily DSR product (MCD18A1) as functions of the counts of daily MODIS overpass.
Radiometric Calibration

Surface Reflectance Validation
NOAA-20 VIIRS: no imagery

Status and Updates:
• Radiometric Calibration Test Site (RadCaTS) operational since ~2013.
• RadCaTS currently one of five RadCalNet sites (www.radcalnet.org).
• Routine daily download and weekly processing of data.

Known Issues:
• RadCaTS bias with MODIS Band 3 (466 nm).

Recent Publications:
**Radiometric Calibration**

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<th>Time Period</th>
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<td>(2000–2019)</td>
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**Land Surface Temperature and Emissivity Validation**

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<th>Collection</th>
<th>Time Period</th>
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**Status and Updates:**

- Lake Tahoe Site operational since 1998
- Salton Sea Site operational since 2008
- Collection 6.0 Terra thermal bands 31, 32 and Aqua thermal bands 29, 31, 32 within +/- 0.25 (Top Figure). Terra band 29 steady drift since 2009 in Collection 6.0 (Bottom Figure).
- Collection 6.1 will require calibration of MODIS and VIIRS mid and thermal infrared data and products (02, 11, 21).
- Collection 6.1 includes MOD/MYD21 LST&E product for first time.
- MOD21 will be affected by drift and only Collection 6.1 should be used.
- VIIRS thermal bands within 0.25 K

**Known Issues:**

- Cross talk in MODIS Terra Band 29. May be fixed in Collection 6.1
- Bias in MODIS Terra mid infrared bands