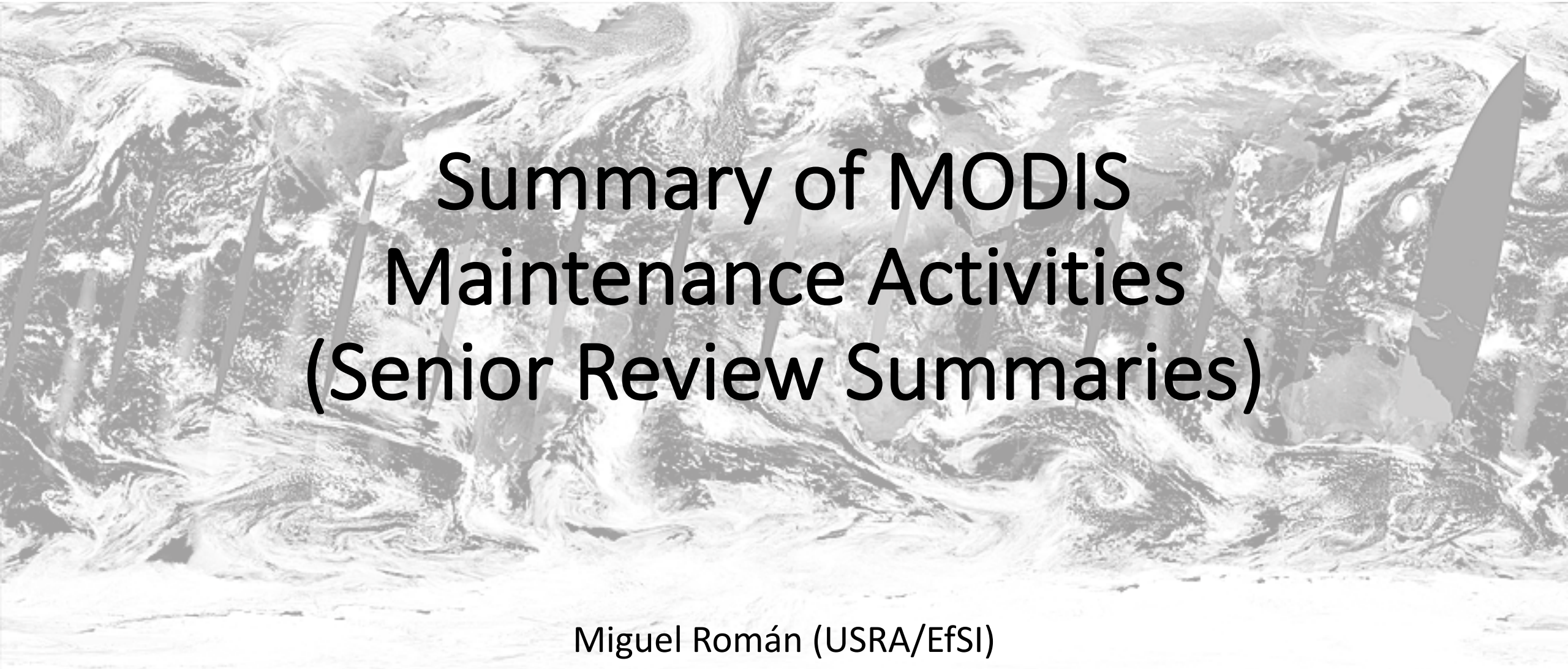


# Summary of MODIS Maintenance Activities (Senior Review Summaries)

Miguel Román (USRA/EfSI)

MODIS/VIIRS Measurement Team Co-Lead

with inputs from the Terra/Aqua MODIS Maintenance PIs
GSFC Code 619 MODAPS support teams

# Status of MODIS / VIIRS Land Product Validation Statements

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.

| Product | PI | Sensor | Last Review/ Update | Input/Review rec'd | URL for validation statement page |
|---|---|---|---|---|---|
| Surf Refl | Vermote | MODIS | Aug-2018 | Nov-2019 | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD09 |
| | Vermote | VIIRS | Oct-2017 | Nov-2019 | https://viirsland.gsfc.nasa.gov/Val/LSR_Val.html |
| LST2 | Hulley | MODIS | Sep-2017 | Nov-2019 | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD21 |
| | Hulley | VIIRS | Oct-2019 | Oct-2019 | https://viirsland.gsfc.nasa.gov/Val/LST_Val.html |
| LST1 | Wan | MODIS | Jul-2018 | | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD11 |
| BRDF/Albedo | Schaaf | MODIS | Oct-2019 | Oct-2019 | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD43 |
| | Schaaf | VIIRS | Sep-2019 | Sep-2019 | https://viirsland.gsfc.nasa.gov/Val/Albedo_Val.html |
| LAI/Fpar | Myneni | MODIS | Oct-2019 | Oct-2019 | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD15 |
| | Myneni | VIIRS | Oct-2019 | Oct-2019 | https://viirsland.gsfc.nasa.gov/Val/LAI_Fpar_Val.html |
| Fire | Giglio | MODIS | Jun-2018 | | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD14 |
| | Schroeder | VIIRS | Oct-2017 | Nov-2019 | https://viirsland.gsfc.nasa.gov/Val/Fire_Val.html |
| Burned Area | Boschetti | MODIS | Jun-2018 | Nov-2019 | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MCD64 |
| | Giglio | VIIRS | NA | | |
| Land Cover/Dynamics | Friedl | MODIS | Oct-2018 | Nov-2019 | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD12 |
| Snow Cover (Sea Ice) | Riggs | MODIS | Oct-2019 | Oct-2019 | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD10/29 |
| | Riggs | VIIRS | Oct-2019 | Oct-2019 | https://viirsland.gsfc.nasa.gov/Val/Snow_Val.html |
| Sea Ice Cover | Tschudi | VIIRS | | Nov-2019 | https://viirsland.gsfc.nasa.gov/Val/SeaIce_Val.html |
| Ice Surface Temp | Tschudi | VIIRS | | Nov-2019 | https://viirsland.gsfc.nasa.gov/Val/IST_Val.html |
| GPP/NPP | Running | MODIS | Nov-2015 | Aug-2019 | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD17 |
| Veg Indices | Didan | MODIS | Jul-2018 | Nov-2019 | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD13 |
| | Didan | VIIRS | Mar-2018 | Nov-2019 | https://viirsland.gsfc.nasa.gov/Val/VI_Val.html |
| Veg Cont Fields | Dimicelli/Sohlberg | MODIS | Jul-2018 | | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD44 |
| Evapotranspiration | Running | MODIS | Nov-2015 | Aug-2019 | |
| MAIAC | Lyapustin | MODIS | Jun-2018 | | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MCD19 |
| | Lyapustin | VIIRS | NA | | |
| DSR/PAR | Wang/Liang | MODIS | Jun-2018 | | https://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD18 |
| Black Marble | Kalb | VIIRS | | Nov-2019 | https://viirsland.gsfc.nasa.gov/Val/BM_Val.html |
| Land Surface Phenology | Zhang | VIIRS | NA | Nov-2019 | https://viirsland.gsfc.nasa.gov/Val/Pheno_Val.html |

# 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 to register and submit requests.  Non-NASA need grant number to register.

# Status of MODIS Surface Reflectance (MOD09)

## MODIS SR Product suite

Collection 6: (Released in 2015)
Bands 1 through 7
250m, 500m, 0.05 deg.
Daily, 8 days

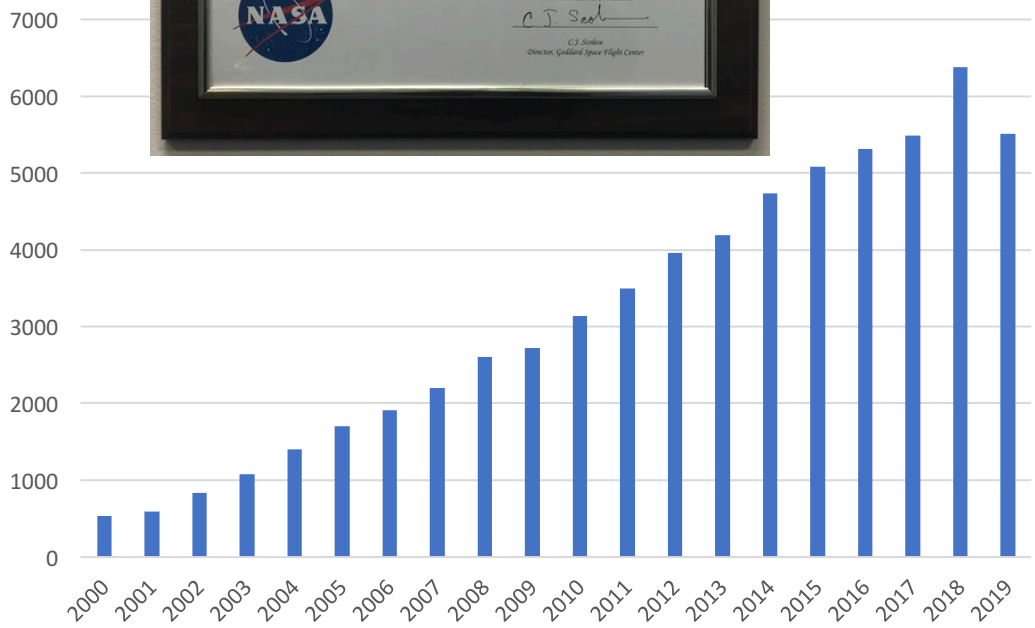
## Status and Updates:

- 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:


- Guillevic, P.C., et al., 2019. **Impact of the Revisit of Thermal Infrared Remote Sensing Observations on Evapotranspiration Uncertainty—A Sensitivity Study Using AmeriFlux Data.** Remote Sensing, 11(5), p.573.
- Santamaría-Artigas, A.E., et al., 2019. **Evaluation of Near-Surface Air Temperature From Reanalysis Over the United States and Ukraine**: Application to Winter Wheat Yield Forecasting. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.
- Villaescusa-Nadal, J.L., et al., 2019. **Spectral Adjustment Model's Analysis and Application to Remote Sensing Data.** IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.
- Franch, B., et al., 2019. **Remote sensing based yield monitoring:** Application to winter wheat in United States and Ukraine. International Journal of Applied Earth Observation and Geoinformation, 76, pp.112-127.
- Becker-Reshef, I., et al. , 2018**. Prior Season Crop Type Masks for Winter Wheat Yield Forecasting**: A US Case Study. Remote Sensing, 10(10), p.1659.






Google scholar citations containing MODIS surface reflectance (as of November 13, 2019) about 63000 total.

# Status of the MODIS and VIIRS VI Time Series

Kamel Didan[1], Armando Barreto[1], Compton Tucker[2], Jorge Pinzon[3]
[1]University of Arizona, [2]Goddard Space Flight Center, [3]SSAI/GSFC

## 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:

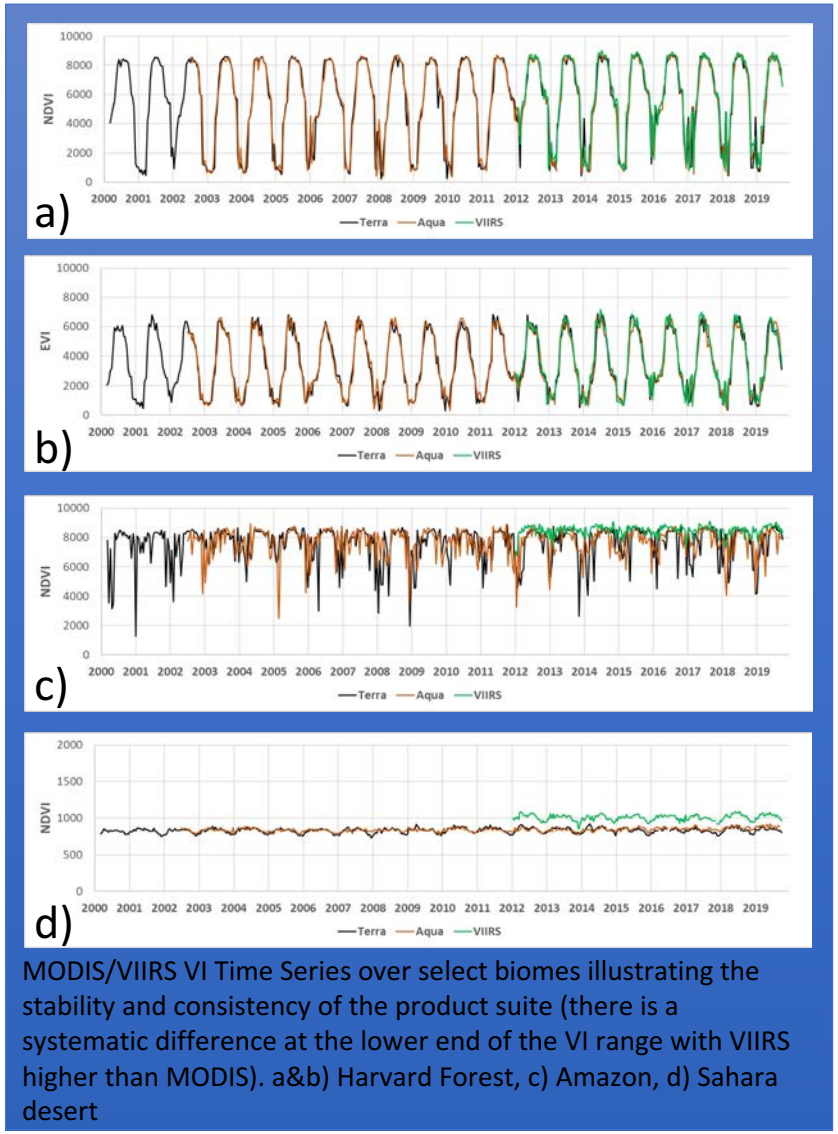
- Improved QA-driven compositing algorithm
- *Improved QA and View Angle compositing scheme*
- *Ongoing Algorithms enhancement to address upstream changes and/or issues*
- *Regular and opportunistic validation (using NEON and Drone Data)*
- Time series fully characterized with explicit MODIS T/A continuity 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:

- Jarchow, C. J., Didan, K., Barreto-Muñoz, A., Nagler, P. L., & Glenn, E. P. (2018). Application and Comparison of the MODIS-Derived Enhanced Vegetation Index to VIIRS, Landsat 5 TM and Landsat 8 OLI Platforms: A Case Study in the Arid Colorado River Delta, Mexico. *Sensors*, *18*(5), 1546.

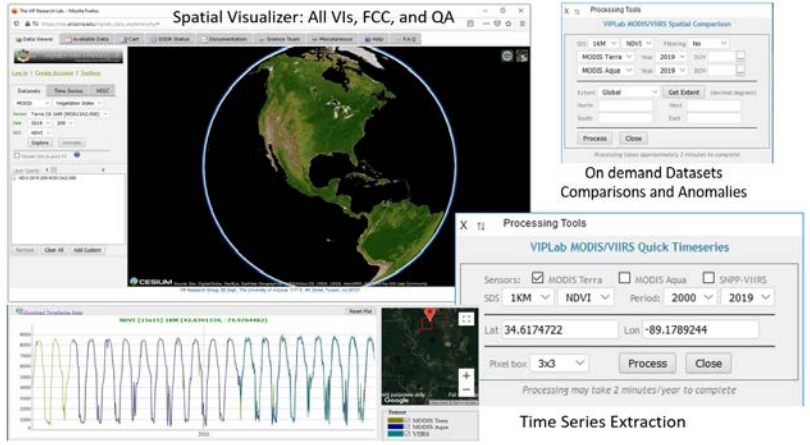



MODIS/VIIRS VI Time Series over select biomes illustrating the stability and consistency of the product suite (there is a systematic difference at the lower end of the VI range with VIIRS higher than MODIS). a&b) Harvard Forest, c) Amazon, d) Sahara desert

# Status and Long-term plans for the VI Time Series

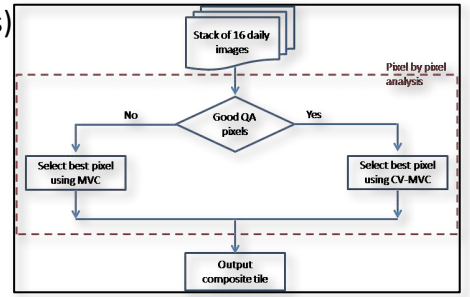
## Global VI Time Series Multi-sensor Online Platform

https://vip.arizona.edu/viplab_data_explorer.php



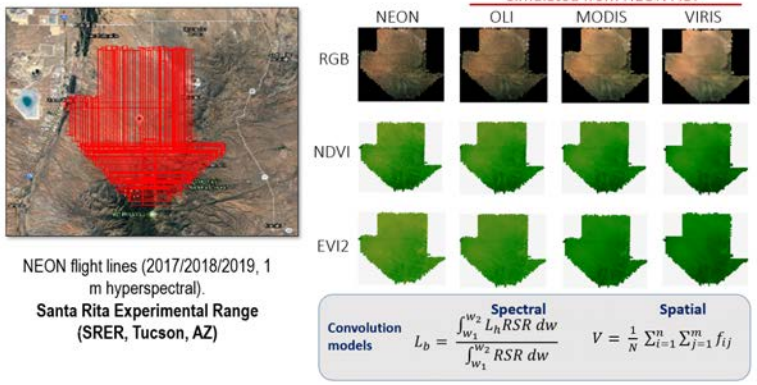

## Future plans

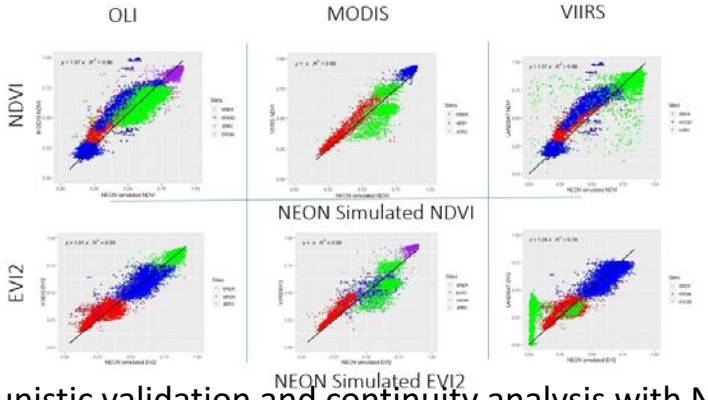
- A robust and Internal LW mask to avoid current problems (near shores land)
- Internal cloud mask and finer resolution (375 m, requested by some of our users) for VIIRS
- Newer long-term CMG databases
- Back to daily for MODIS
- Prototyping an experimental **ZERO CLOUD** product suite with Gap filling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

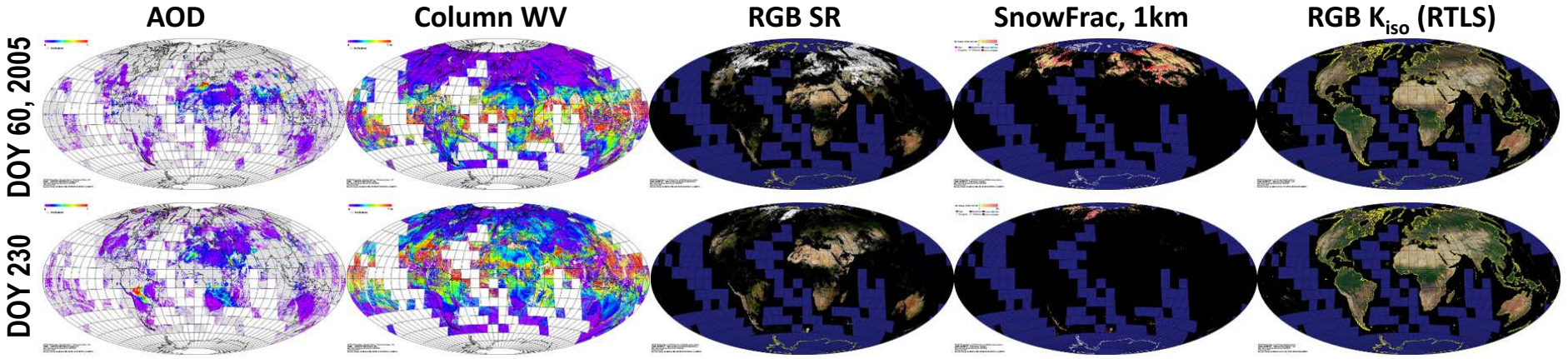



Opportunistic validation and continuity analysis with NEON

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..)

# 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)

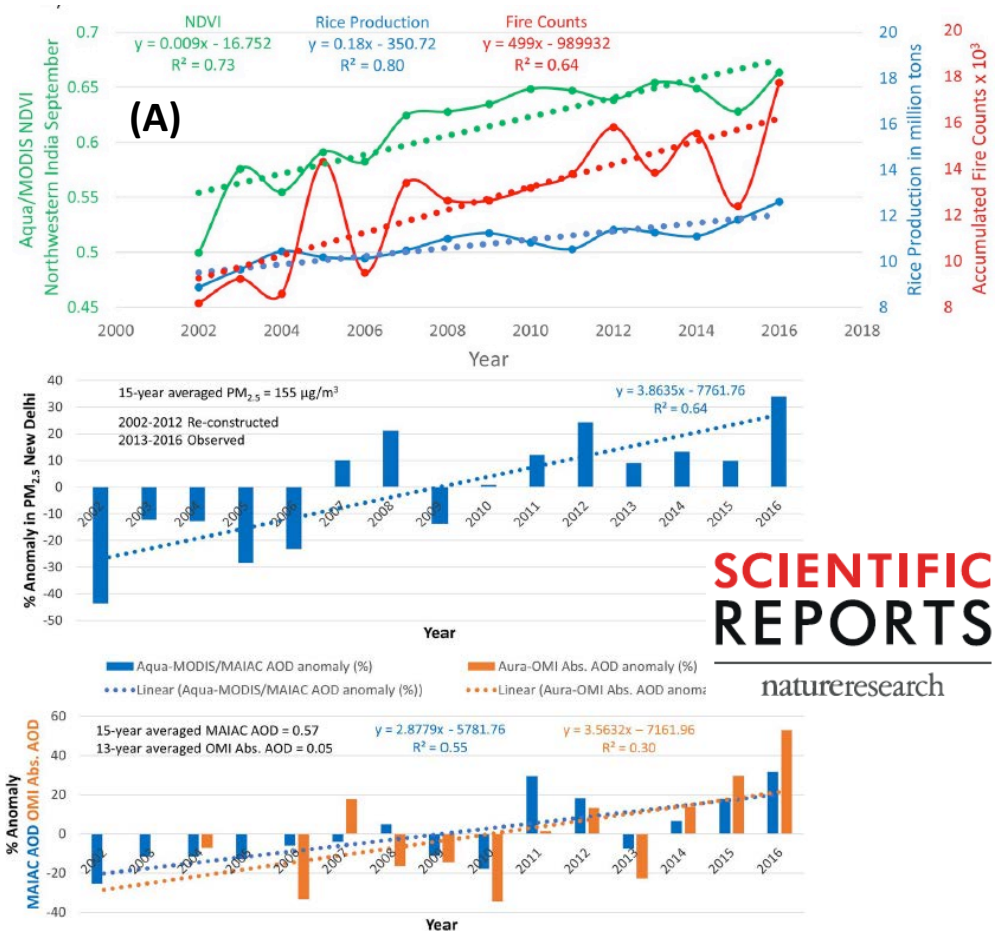
## Known Issues:

- NA

### Selected Recent Publications:


- Lyapustin et al., 2018. MODIS Collection 6 MAIAC Algorithm, ***Atm. Meas. Techniques,*** doi:10.5194/amt-2018-141.
- Lyapustin et al., 2019, MAIAC Thermal Technique for Smoke Injection Height From MODIS, ***IEEE Geosci. Rem. Sens. Lett***., pp. 1-5, 2019 doi: 10.1109/LGRS.2019.2936332.
- H. Jethva, O. Torres, R.D.Field, A. Lyapustin, R. Gautam, V.Kayetha, Connecting Crop Productivity, Residue Fires, and Air Quality over Northern India, ***Scientific Reports***, 9:16594, 2019.
- Q. Di, H. Amini, L. Shi, I. Kloog, R. Silvern, J. Kelly, M.B. Sabath, C. Choirat, P. Koutrakis, A. Lyapustin, Y. Wang, L.J. Mickley, J. Schwartz. An ensemble-based model of PM2.5 concentration across the contiguous United States with high spatiotemporal resolution, ***Environ. Int***., 130 (2019).

# MODIS MAIAC **Algorithm**

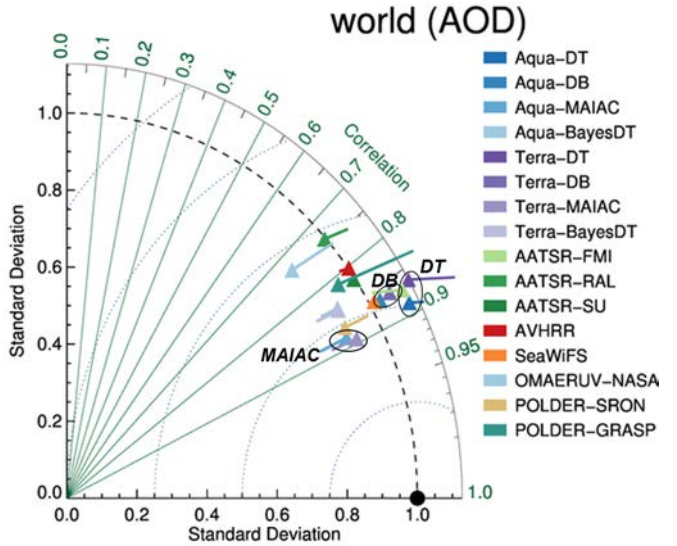



SCIENTIFIC REPORTS
nature research

**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 Dehli)**

H. Jethva, O. Torres, R.D.Field, A. Lyapustin, R. Gautam, V.Kayetha, Connecting Crop Productivity, Residue Fires, and Air Quality over Northern India, ***Scientific Reports***, 9:16594, 2019.

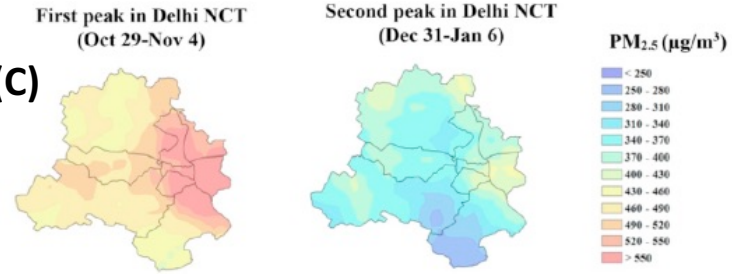
**(B)**




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 35µg/m³)**

**(C)**




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.

# Status of MODIS Burned Area

## MODIS Burned Area Product

Collection 6: (released 2017)

- MCD64A1: Monthly L3 500 m SIN Grid
- MCD64CMH: Monthly CMG (released 2018)

## Status and Updates:

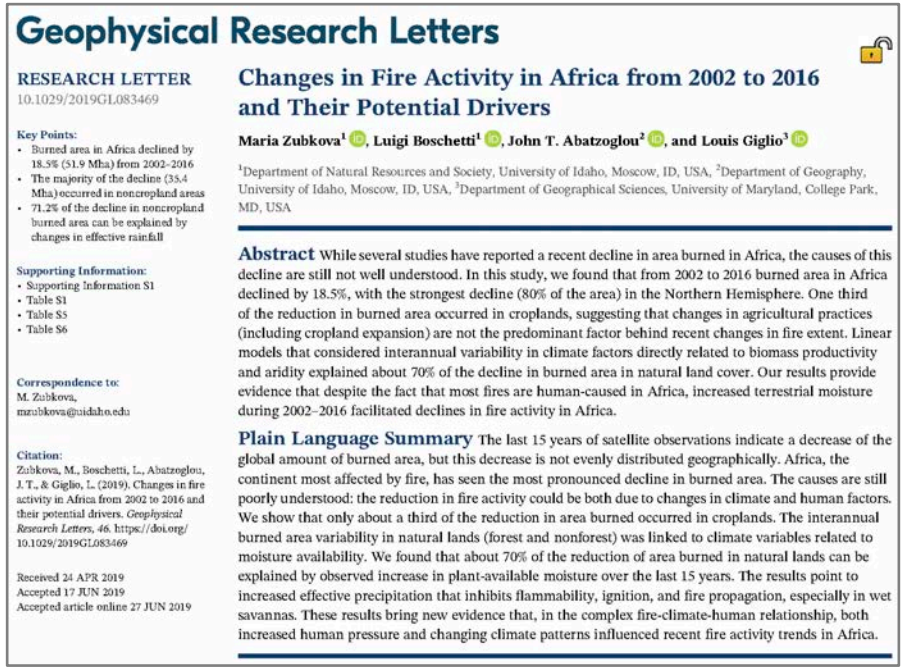
- Stage-3 validation complete.

## Known Issues:

- None.

## Recent Publications:


- Boschetti, L., Roy, D. P., Giglio, L., Huang, H., Zubkova, M., and Humber, M. L., 2019, Global validation of the collection 6 MODIS burned area product. *Remote Sensing of Environment*, 235:111490.
- Zubkova, M., et al., 2019, Changes in fire activity in Africa from 2002 to 2016 and their potential drivers. *Geophysical Research Letters*, 46, 1-11.
- Giglio, L., Boschetti, L., Roy, D. P., Humber, M. L., and Justice, C. O., 2018, The Collection 6 MODIS burned area mapping algorithm and product. *Remote Sensing of Environment*, 217:72–85.

Geophysical Research Letters

RESEARCH LETTER
10.1029/2019GL083469

Changes in Fire Activity in Africa from 2002 to 2016 and Their Potential Drivers

Maria Zubkova[1], Luigi Boschetti[1], John T. Abatzoglou[2], and Louis Giglio[3]

[1]Department of Natural Resources and Society, University of Idaho, Moscow, ID, USA, [2]Department of Geography, University of Idaho, Moscow, ID, USA, [3]Department of Geographical Sciences, University of Maryland, College Park, MD, USA

Key Points:
- Burned area in Africa declined by 18.5% (51.9 Mha) from 2002–2016
- The majority of the decline (35.4 Mha) occurred in noncropland areas
- 71.2% of the decline in noncropland burned area can be explained by changes in effective rainfall

Supporting Information:
- Supporting Information S1
- Table S1
- Table S5
- Table S6

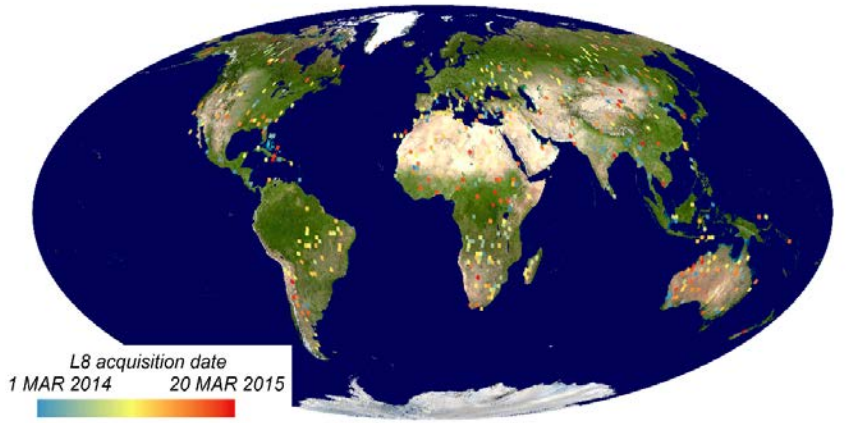
Correspondence to:
M. Zubkova,
mzubkova@uidaho.edu

Citation:
Zubkova, M., Boschetti, L., Abatzoglou, J. T., & Giglio, L. (2019). Changes in fire activity in Africa from 2002 to 2016 and their potential drivers. *Geophysical Research Letters*, *46*. https://doi.org/10.1029/2019GL083469

Received 24 APR 2019
Accepted 17 JUN 2019
Accepted article online 27 JUN 2019


**Abstract** While several studies have reported a recent decline in area burned in Africa, the causes of this decline are still not well understood. In this study, we found that from 2002 to 2016 burned area in Africa declined by 18.5%, with the strongest decline (80% of the area) in the Northern Hemisphere. One third of the reduction in burned area occurred in croplands, suggesting that changes in agricultural practices (including cropland expansion) are not the predominant factor behind recent changes in fire extent. Linear models that considered interannual variability in climate factors directly related to biomass productivity and aridity explained about 70% of the decline in burned area in natural land cover. Our results provide evidence that despite the fact that most fires are human-caused in Africa, increased terrestrial moisture during 2002–2016 facilitated declines in fire activity in Africa.

**Plain Language Summary** The last 15 years of satellite observations indicate a decrease of the global amount of burned area, but this decrease is not evenly distributed geographically. Africa, the continent most affected by fire, has seen the most pronounced decline in burned area. The causes are still poorly understood: the reduction in fire activity could be both due to changes in climate and human factors. We show that only about a third of the reduction in area burned occurred in croplands. The interannual burned area variability in natural lands (forest and nonforest) was linked to climate variables related to moisture availability. We found that about 70% of the reduction of area burned in natural lands can be explained by observed increase in plant-available moisture over the last 15 years. The results point to increased effective precipitation that inhibits flammability, ignition, and fire propagation, especially in wet savannas. These results bring new evidence that, in the complex fire-climate-human relationship, both increased human pressure and changing climate patterns influenced recent fire activity trends in Africa.


Stage-3 Validation Voxels

# Status of MODIS Active Fire

## 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:


- Vadrevu, K. P., Lasko, K., Giglio, L., Schroeder, W., Biswas, S., and Justice, C. O., 2019, Trends in vegetation fires in south and southeast Asian countries. *Scientific Reports*, 9:7422, 1-13.
- Giglio, L., Schroeder, W., and Justice, C. O., 2016, The collection 6 MODIS active fire detection algorithm and fire products. *Remote Sensing of Environment*, 178, 31-41.



Congo's rainforest is getting smaller.
*The Economist*, 19 Oct. 2019

# Status of MODIS Cryosphere Products

Dorothy Hall[1] and George Riggs[2]
[1]ESSIC / University of Maryland, [2]SSAI

## 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

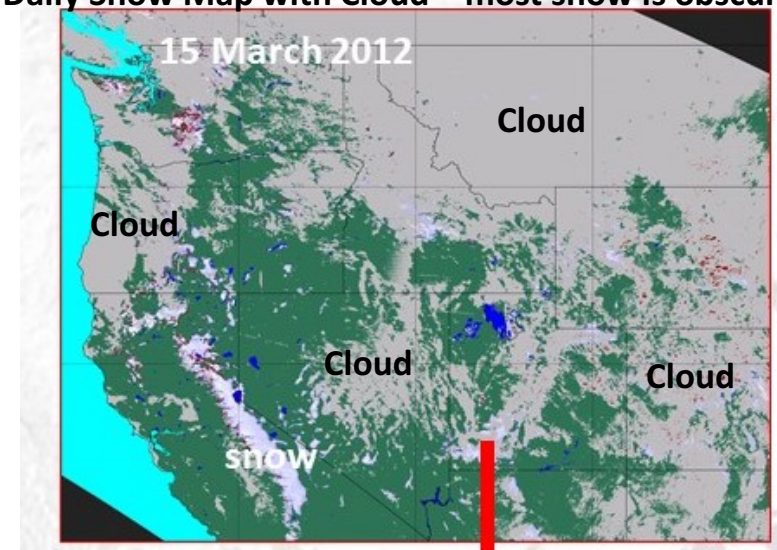
## Recent Publications:

- Hall, D.K., G.A. Riggs, Nicolo E. DiGirolamo and Miguel O. Román, 2019: Evaluation of MODIS and VIIRS Cloud-Gap Filled Snow-Cover Products for production of an Earth Science Data Record, *Hydrology and Earth System Sciences* (accepted following minor changes).
- 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.

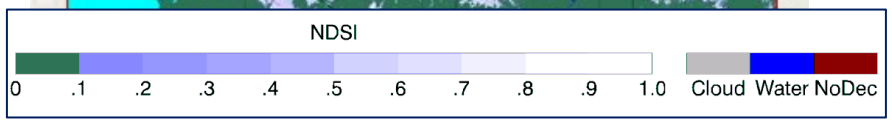
# MODIS Cloud-Gap-Filled (CGF) Product is Now in Production

**Dorothy Hall[1,2] and George Riggs[3,2]**
[1]ESSIC / University of Maryland, [2]NASA/GSFC Cryospheric Sciences Lab, [3]SSAI

**Daily Snow Map with Cloud – most snow is obscured**

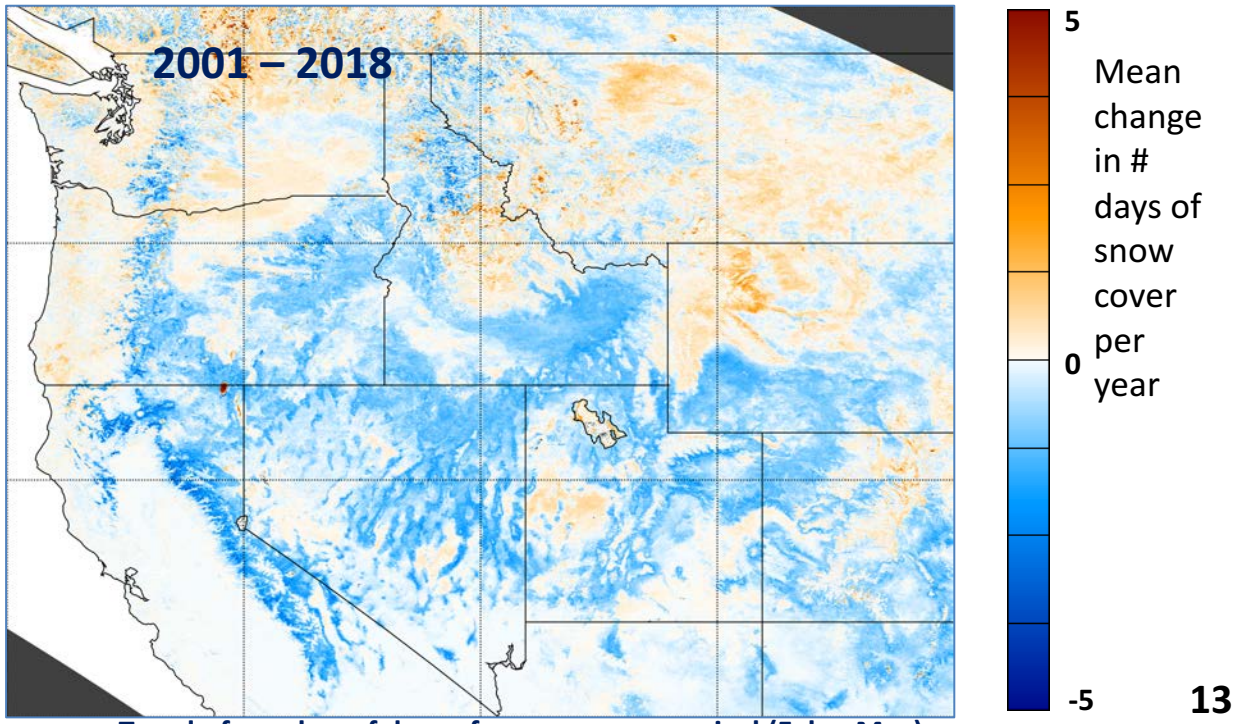



**Cloud-Gap Filled Daily Snow Map – no clouds**


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

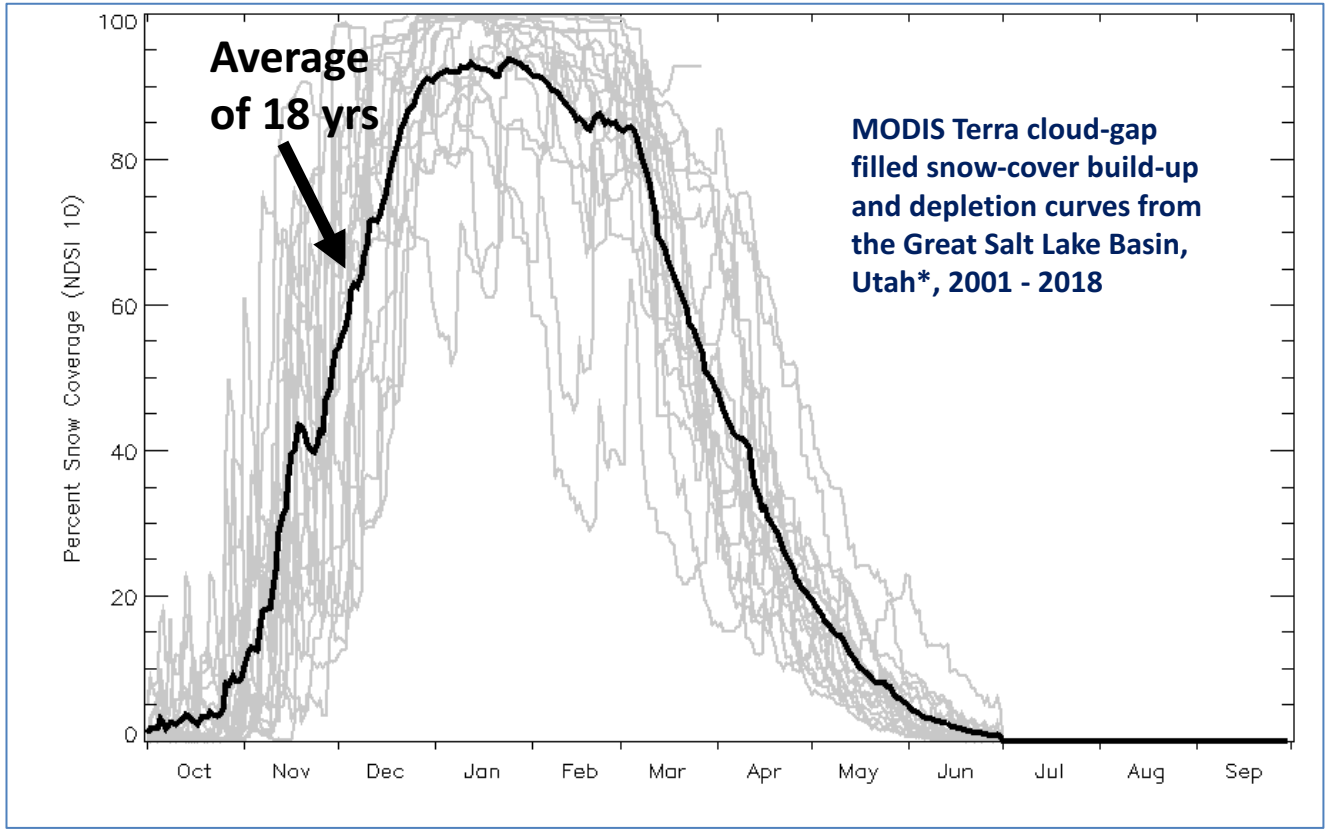
**The MODIS Terra CGF time series shows a trend of ~4 fewer days of snow cover for this part of the western U.S. over 18 years**



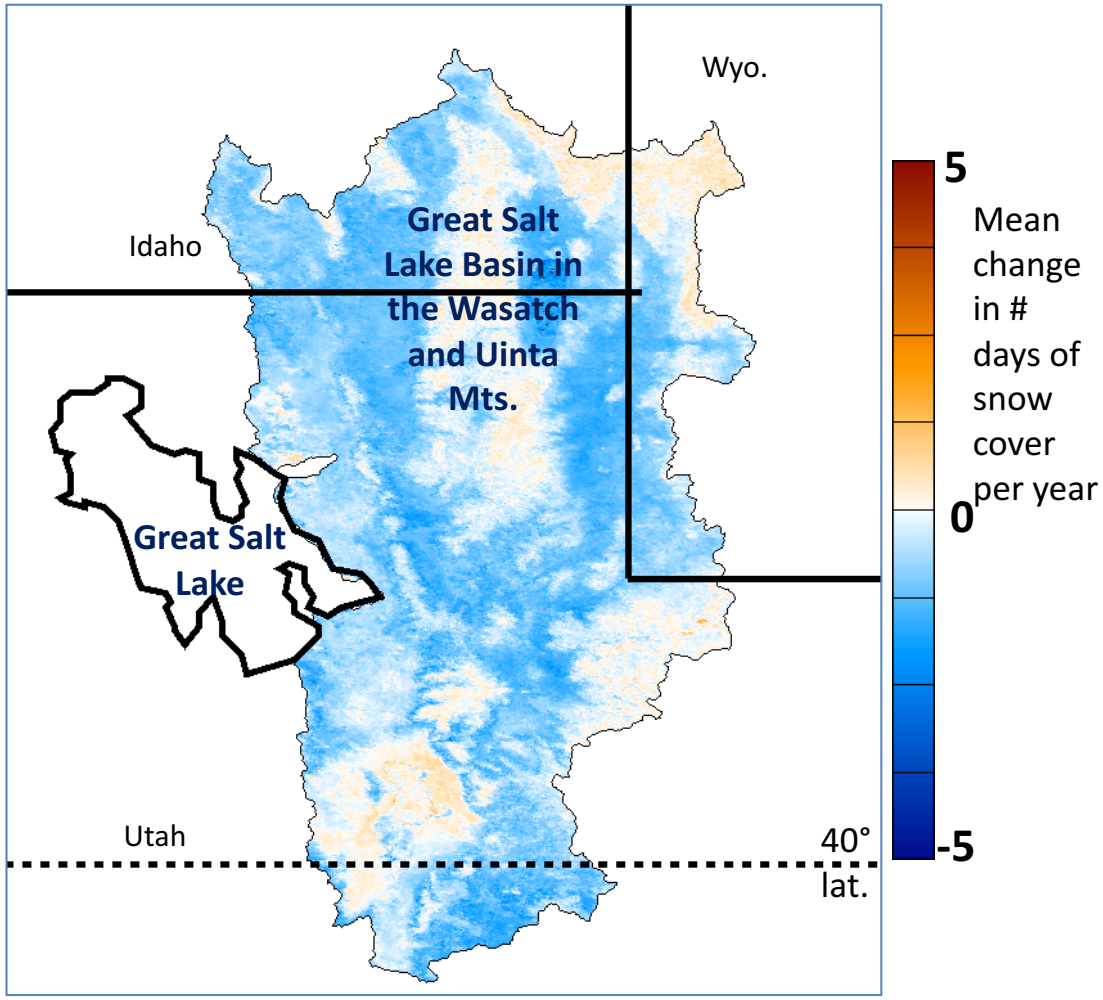

**Trend of number of days of snow cover per pixel (Feb – May)**

Hall et al., in preparation

# 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




* basins of the Weber, Bear and Jordan rivers




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

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)

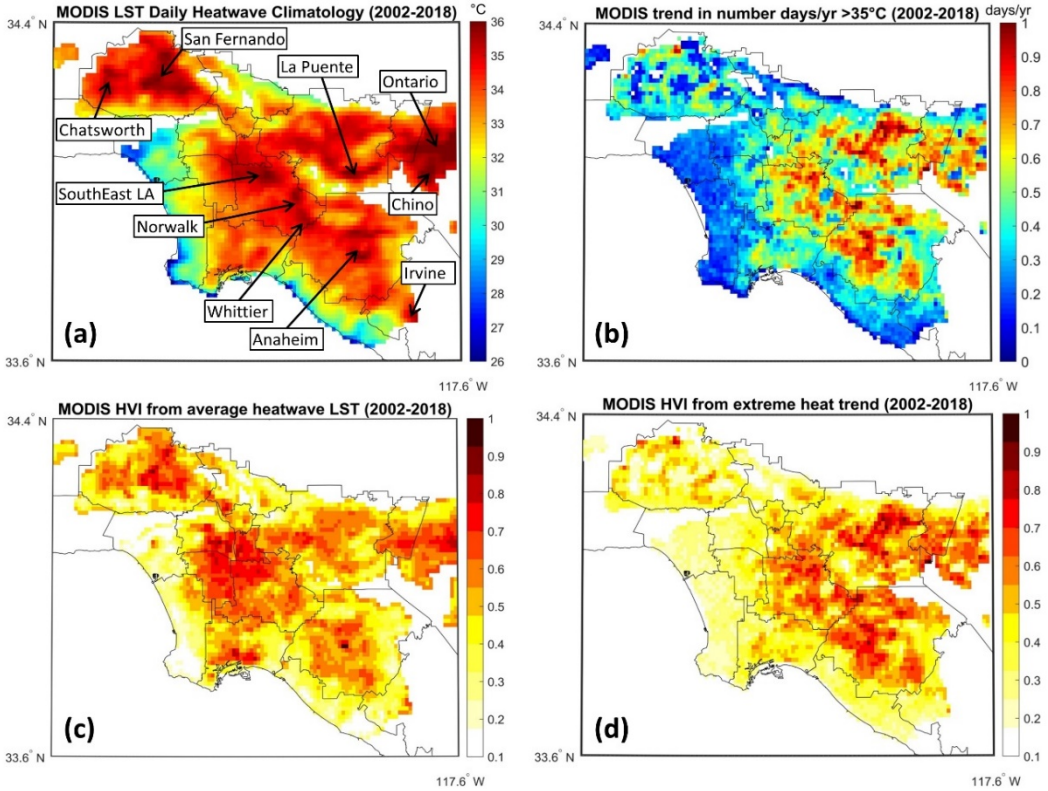
## Known Issues and Concerns:

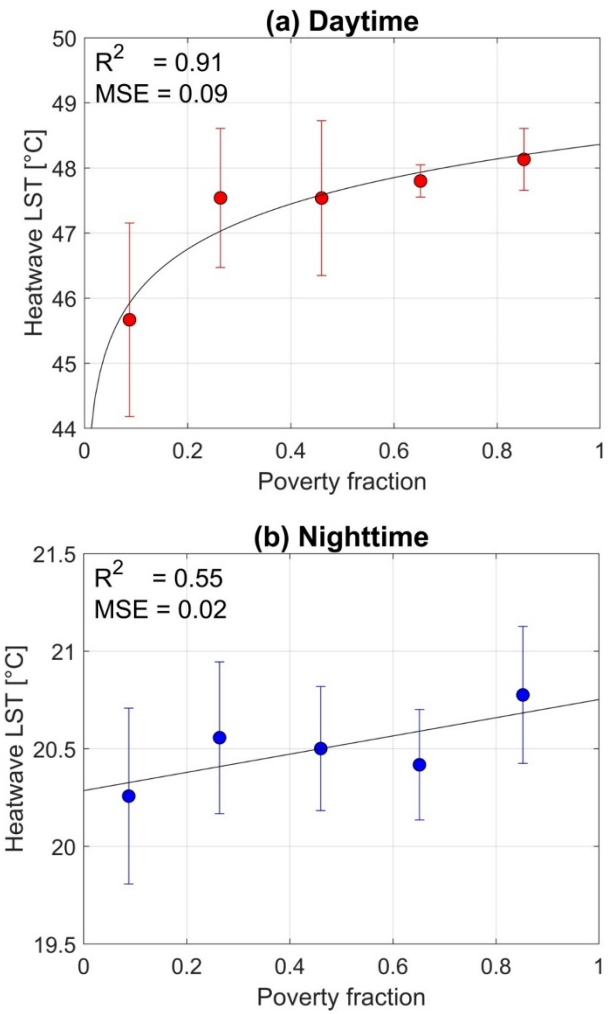
- MOD21 Terra products only produced until 2005 in Collection 6 due to issues with band 29 calibration.
- Currently two different product streams (MxD11/MxD21) with a total of 10 different product types
- No current plan forward to retire MxD11 suite of products
- Validation shows MxD21 product addresses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

## Publications/Documentation:


- *Hulley, G., Shivers, S., Wetherley, E., & Cudd, R. (2019). New ECOSTRESS and MODIS Land Surface Temperature Data Reveal Fine-Scale Heat Vulnerability in Cities: A Case Study for Los Angeles County, California. Remote Sensing, 11(18).*
- *Hulley, G. C., Malakar, N., Islam, T., Freepartner, R, (2017), NASA's MODIS and VIIRS Land Surface Temperature and Emissivity Products: A Consistent and High Quality Earth System Data Record, IEEE TGRS, DOI: 10.1109/JSTARS.2017.2779330.*
- *Malakar, N. K., and G. C. Hulley (2016), A water vapor scaling model for improved land surface temperature and emissivity separation of MODIS thermal infrared data, Remote Sensing of Environment, 182, 252-264*
- *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 disproportionality 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

# Status of MODIS LAI/FPAR

**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:**

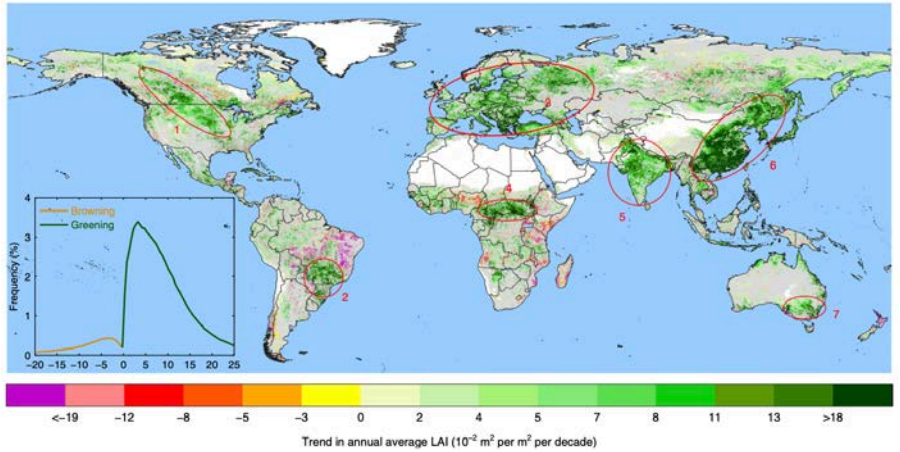

- Chen et al., 2019. China and India lead in greening of the world through land-use management. Nature Sustainability 2, 122–129. https://doi.org/10.1038/s41893-019-0220-7
- Xu et al., 2018. An integrated method for validating long-term leaf area index products using global networks of site-based measurements. Remote Sens. Environ., doi:10.1016/j.rse.2018.02.049
- Chen et al., 2017. Prototyping of LAI and FPAR Retrievals from MODIS Multi-Angle Implementation of Atmospheric Correction (MAIAC) Data. Remote Sensing, doi:10.3390/rs9040370
- Yan et al., 2016. Evaluation of MODIS LAI/FPAR Product Collection 6. Part 1: Consistency and Improvements, Remote Sensing, doi:10.3390/rs8050359
- Yan et al., 2016. Evaluation of MODIS LAI/FPAR Product Collection 6. Part 2: Validation and Intercomparison, Remote Sensing, doi:10.3390/rs8060460



ARTICLES
https://doi.org/10.1038/s41893-019-0220-7
nature sustainability


## China and India lead in greening of the world through land-use management


Chi Chen[1*], Taejin Park[1], Xuhui Wang[2], Shilong Piao[2], Baodong Xu[1,3], Rajiv K. Chaturvedi[4], Richard Fuchs[5], Victor Brovkin[6], Philippe Ciais[7], Rasmus Fensholt[8], Hans Tømmervik[9], Govindasamy Bala[10], Zaichun Zhu[11], Ramakrishna R. Nemani[12] and Ranga B. Myneni[1]


*"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."*

# Status of MODIS GPP/NPP and ET/PET products.

## 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:

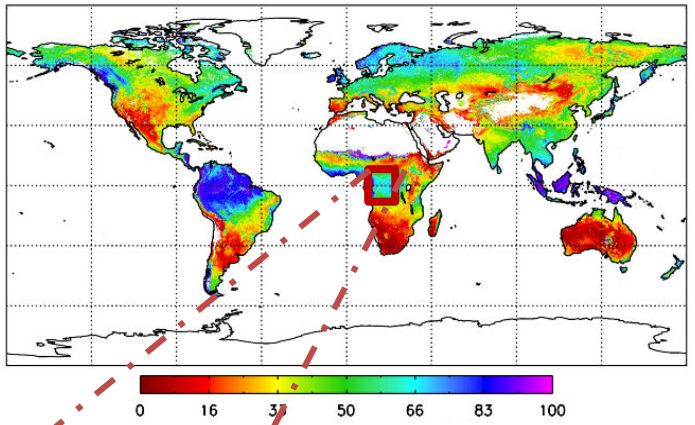
- *The collection 6 products are not available due to cloud contamination problems.*
- *The new Gap filled GPP/NPP and ET/PET products (collection 6.1) are going to be available soon*.
- *A comparison and validation of the method will be carried out with the new data.*

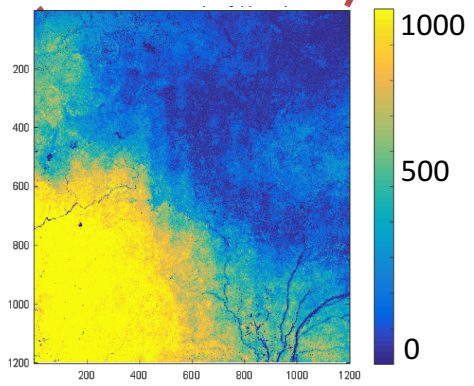
## Known Issues:

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

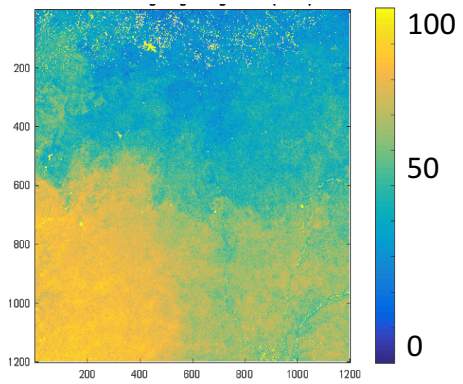
## Recent Publications:


• Sánchez-Ruiz, S., Moreno-Martínez, Á., Izquierdo-Verdiguier, E., Chiesi, M., Maselli, F., & Gilabert, M. A. (2019). Growing stock volume from multi-temporal landsat imagery through google earth engine. **International Journal of Applied Earth Observation and Geoinformation**, 83, 101913.
• He, M., Kimball, J. S., Yi, Y., Running, S., Guan, K., Jensco, K., ... & Maneta, M. (2019). Impacts of the 2017 flash drought in the US Northern plains informed by satellite-based evapotranspiration and solar-induced fluorescence. **Environmental Research Letters**, 14(7), 074019.
• He, M., Kimball, J. S., Yi, Y., Running, S. W., Guan, K., Moreno, A., ... & Maneta, M. (2019). Satellite data-driven modeling of field scale evapotranspiration in croplands using the MOD16 algorithm framework. **Remote Sensing of Environment**, 230, 111201.
• Robinson, N. P., Jones, M. O., Moreno, A., Erickson, T. A., Naugle, D. E., & Allred, B. W. (2019). Rangeland Productivity Partitioned to Sub-Pixel Plant Functional Types. **Remote Sensing**, 11(12), 1427.


**Absolute error (mm/y) in MOD16 (ET) due to cloud contamination**



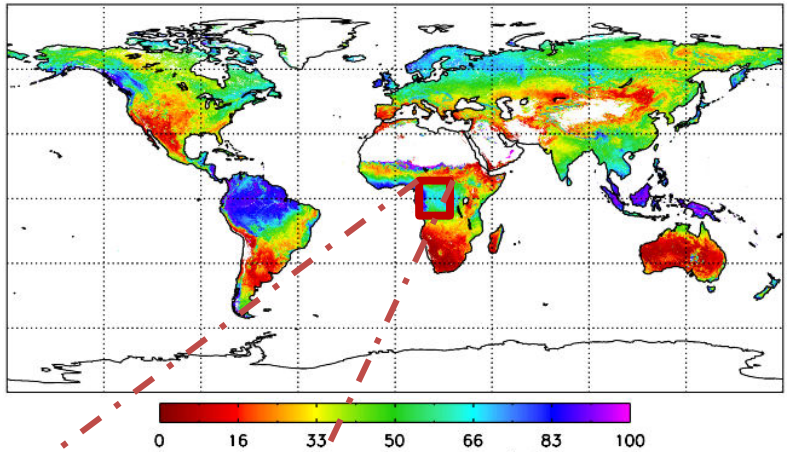

**% Gaps during the growing season**

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

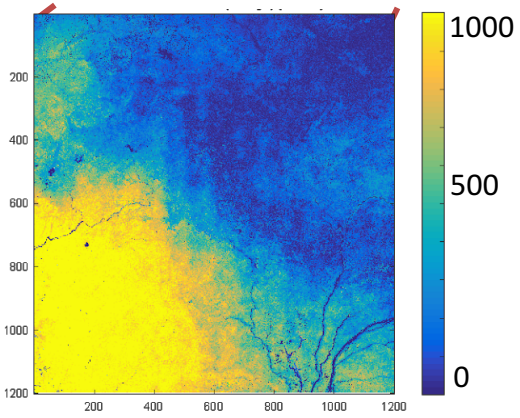
Maosheng Zhao, Alvaro Moreno, Sudipta Sarkar, Sadashiva Devadiga and Steven W. Running

(A)

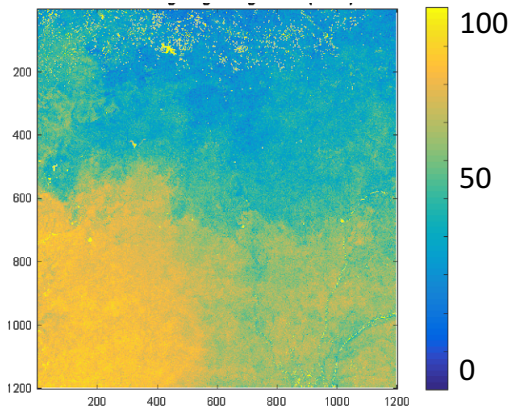
Mean annual data gaps in MOD17/MOD16 (%)




(B)




Absolute error (mm/y) in MOD16 (ET) due to cloud contamination




% Gaps during the growing season

- 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)** .

# A methodology to derive global maps of plant traits using remote sensing and climate data

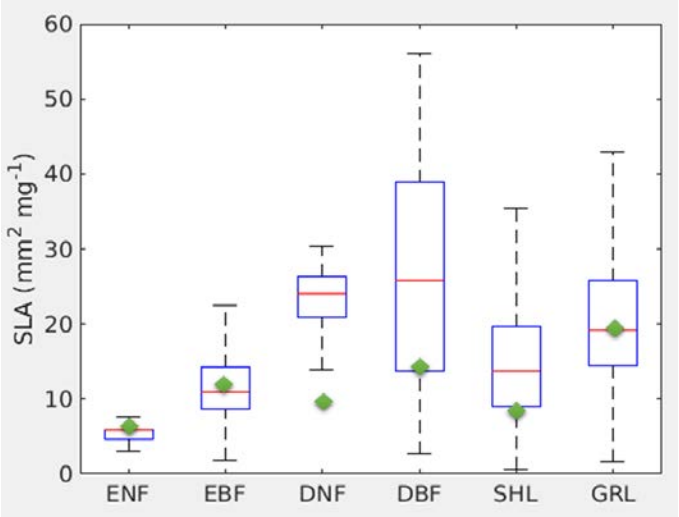
Alvaro Moreno, Gustau Camps-Valls, Jens Kattge, Nathaniel Robinson, Markus Reichstein, …, Steven W. Running (2018).
Remote Sensing of Environment, 218, 69-88

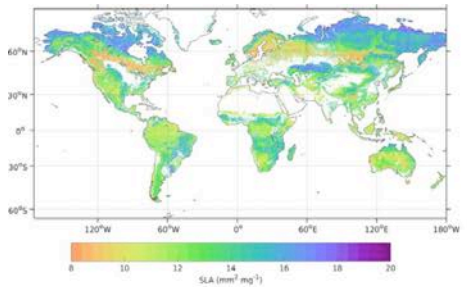
Plant traits are an important part of the MODIS GPP/NPP and ET/PET algorithms (MOD17 and MOD16) . But also in most of DGVMs, ESMs and GCMs.

Their contribution in all these models is over simplified (one value per PFT) and constitutes a significant source of uncertainties **(A)**.

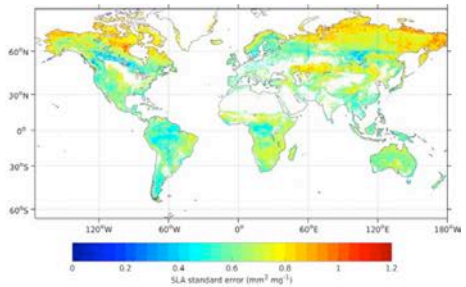
We present and validate a combined remote sensing and biogeographic approach to spatializing estimates of key leaf traits **(B)** and their respective uncertainties **(C).**

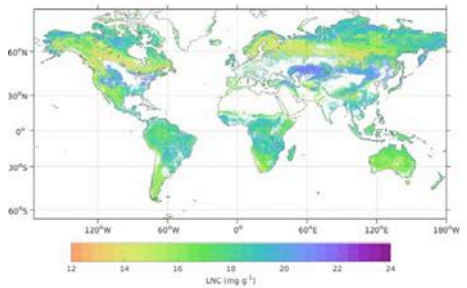
**(A)**



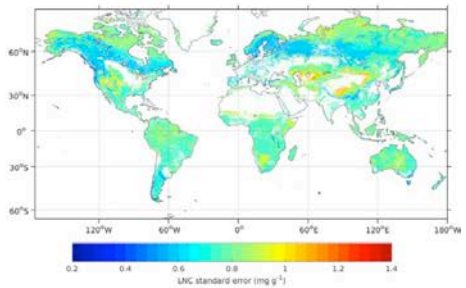



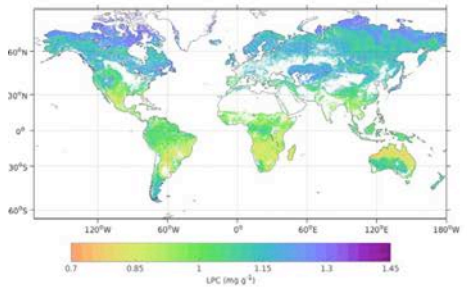
**SLA**



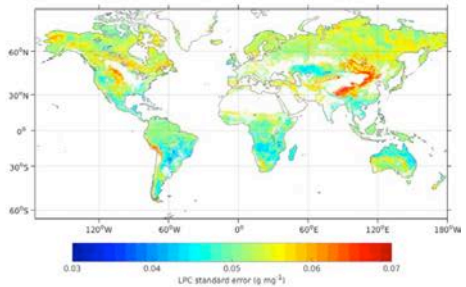


**LNC**





**LPC**

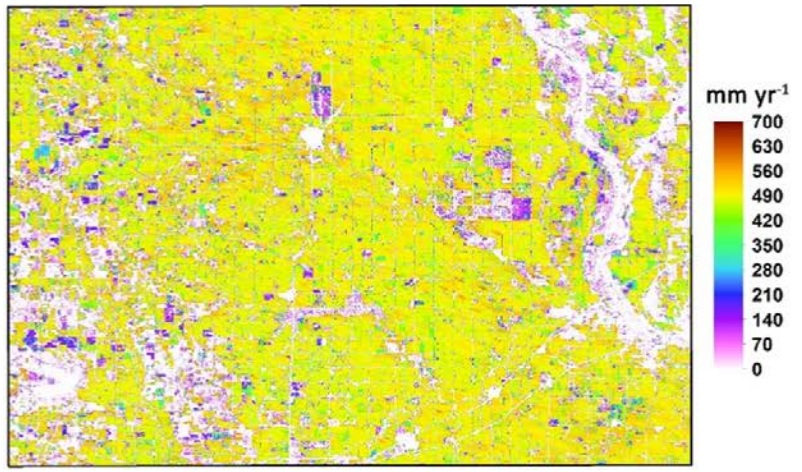


**(B)** **(C)**

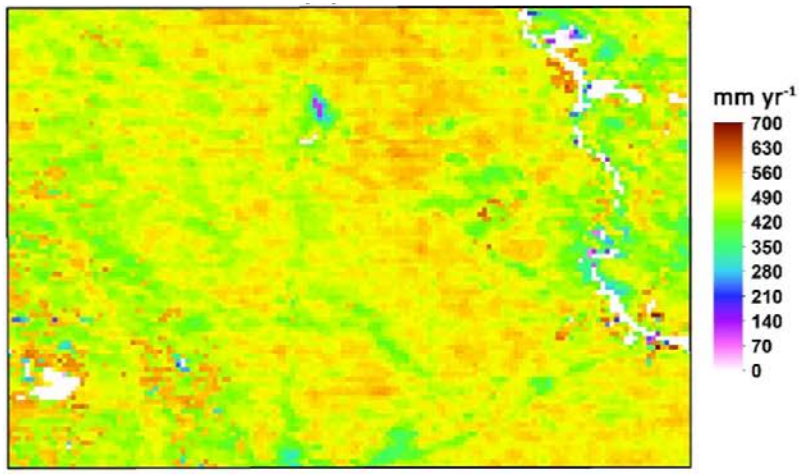
# Satellite data-driven modeling of field scale evapotranspiration in croplands using the MOD16 algorithm framework

MingzhuHe, John S.Kimball, Yonghong Yic, Steven W. Running ,Kaiyu Guan, Alvaro Moreno, Xiaocui Wue, MarcoManet (2019). Remote Sensing of Environment.

**(A)** Refined Landsat 30 m MOD 16 algorithm




**(B)** Original 500m MOD16 algorithm




- 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)**

# MCD43 BRDF, Albedo, and NBAR products from Terra/Aqua MODIS

Crystal Schaaf[1], Zhuosen Wang[2,3] Qingsong Sun[2], Yan Liu[1], Zhan Li[1], Angela Erb[1], Arthur Elmes[1], Charlotte Levy[1]

[1] School for the Environment, University of Massachusetts Boston, Boston MA, USA
[2] Terrestrial Information Systems Lab, NASA Goddard Space Flight Center, Greenbelt, MD, USA
[3] Earth System Science Interdisciplinary Center, University of Maryland, College Park, MD, USA

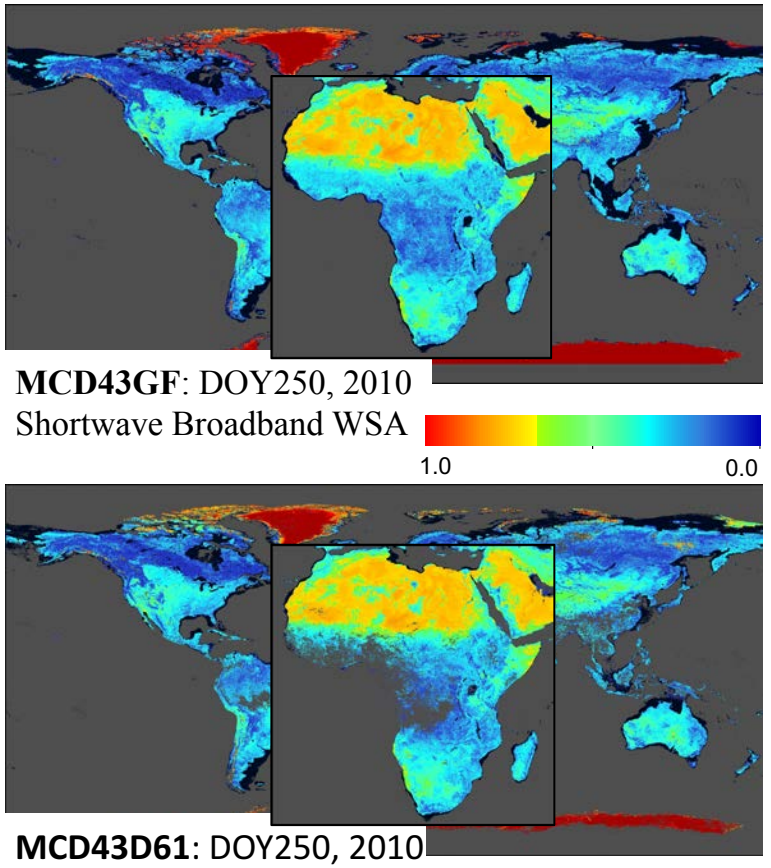
## MODIS BRDF Albedo NBAR Products

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 **W**hite **S**ky **A**lbedo (bihemispherical albedo under isotropic illumination), **B**lack **S**ky **A**lbedo (directional hemispherical albedo under local solar noon illumination), and **N**adir **B**RDF-**A**djusted **R**eflectance (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

**Gap-Filled vs Standard CMG Product**




**MCD43GF**: DOY250, 2010
Shortwave Broadband WSA

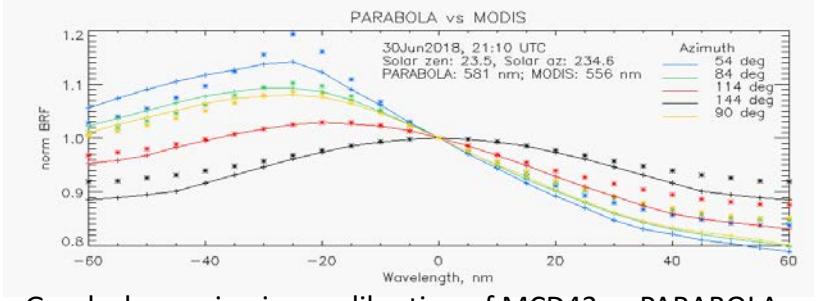
**MCD43D61**: DOY250, 2010
Shortwave Broadband WSA

## 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

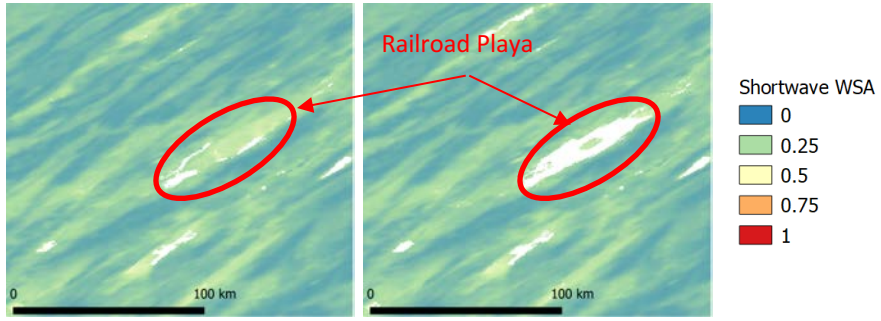
# Status of Terra/Aqua MODIS BRDF, Albedo and NBAR

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.




Graph shows vicarious calibration of MCD43 vs PARABOLA instrument in situ

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




'Special' Product Operational Product

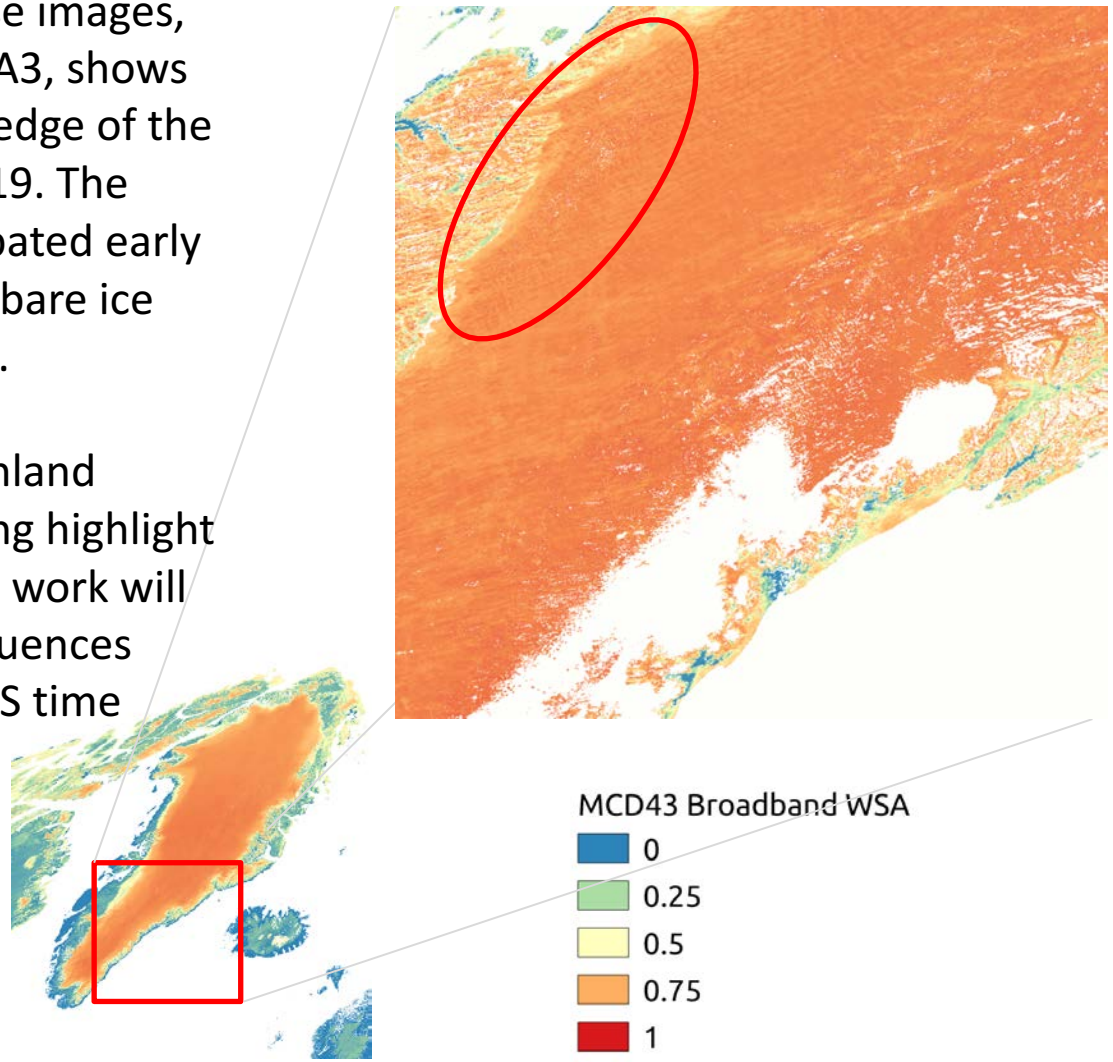
| PARAB band, nm | MODIS band, nm | FracDiff 30 W | FracDiff 20 E |
|---|---|---|---|
| 444 | 446 | 0.023 | −0.053 |
| 551 | 556 | −0.002 | −0.009 |
| 860 | 862 | 0.016 | −0.037 |
| 1650 | 1631 | 0.011 | −0.029 |


Bruegge, C., Coburn, C., **Elmes A.**, Helmlinger, M., Kataoka, F., Kuester, M., Kuze, A., Ochoa, T., **Schaaf, C.**, Shiomi, K. and Schwandner, F. (2019). Bi-Directional Reflectance Factor Determination of the Railroad Valley Playa. Remote Sensing, *in press.*

# Greenland Ice Sheet Melt Albedo

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.

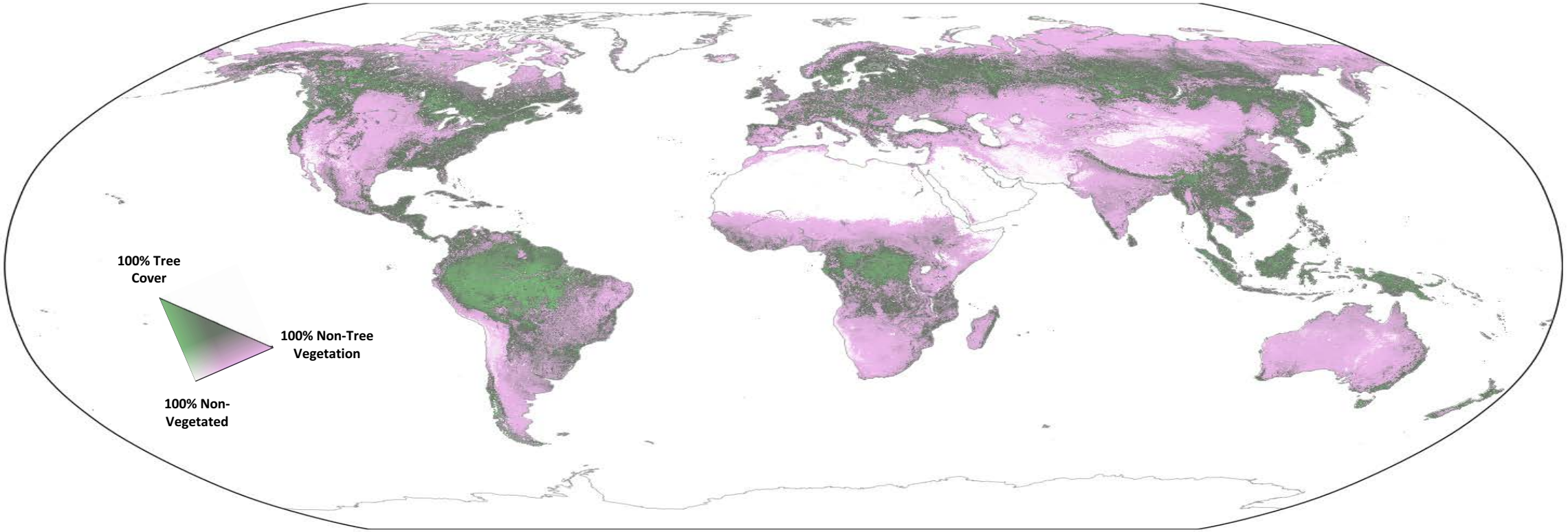



https://nsidc.org/greenland-today/2019/07/a-record-melt-event-in-mid-june/

# 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.**

# MODIS MOD44B Vegetation Continuous Fields: A Functional Baseline for Biogeochemical Parameterizations

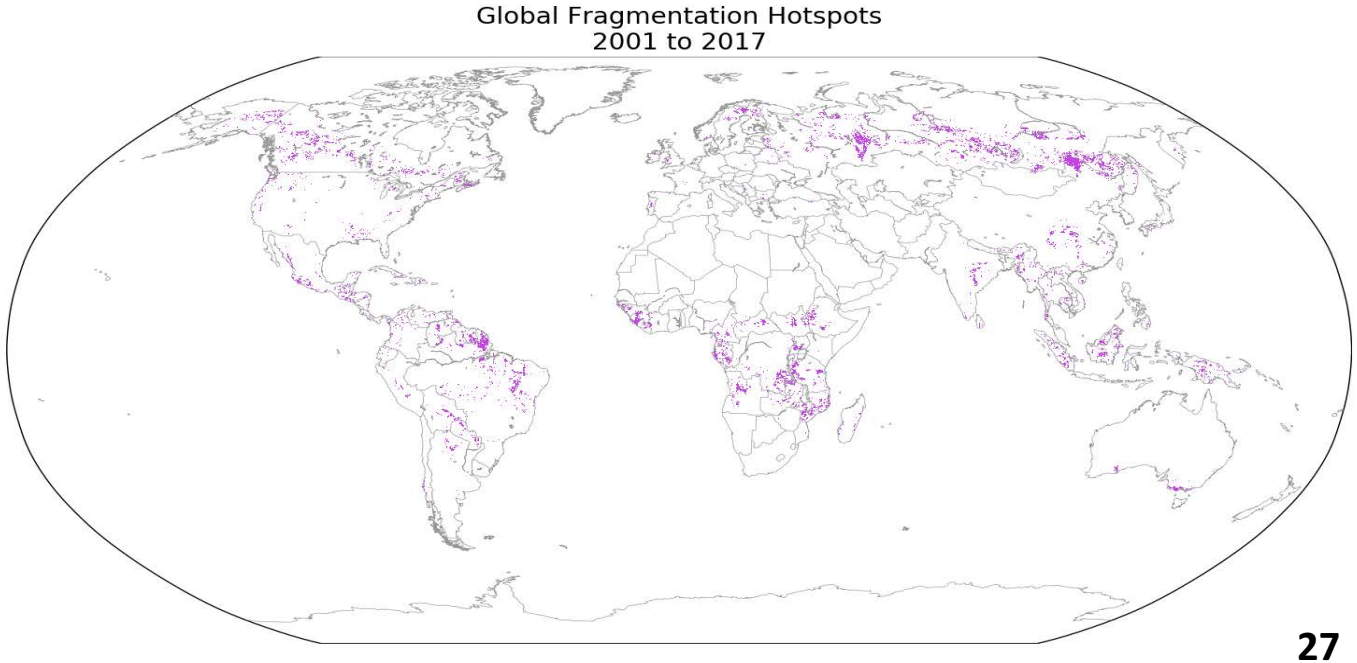
## Recent Maintenance Activity

- ✓ 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.

Charlene DiMiceli
cdimicel@umd.edu
tel: 301-780-3967

## 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 km$^2$ tiles have changed from interior forest (>1 km from forest edge) to edge-impacted forest (<1 km from forest edge):**



# MODIS MOD44B Vegetation Continuous Fields: A Functional Baseline for Biogeochemical Parameterizations

## Future Needs & Opportunities

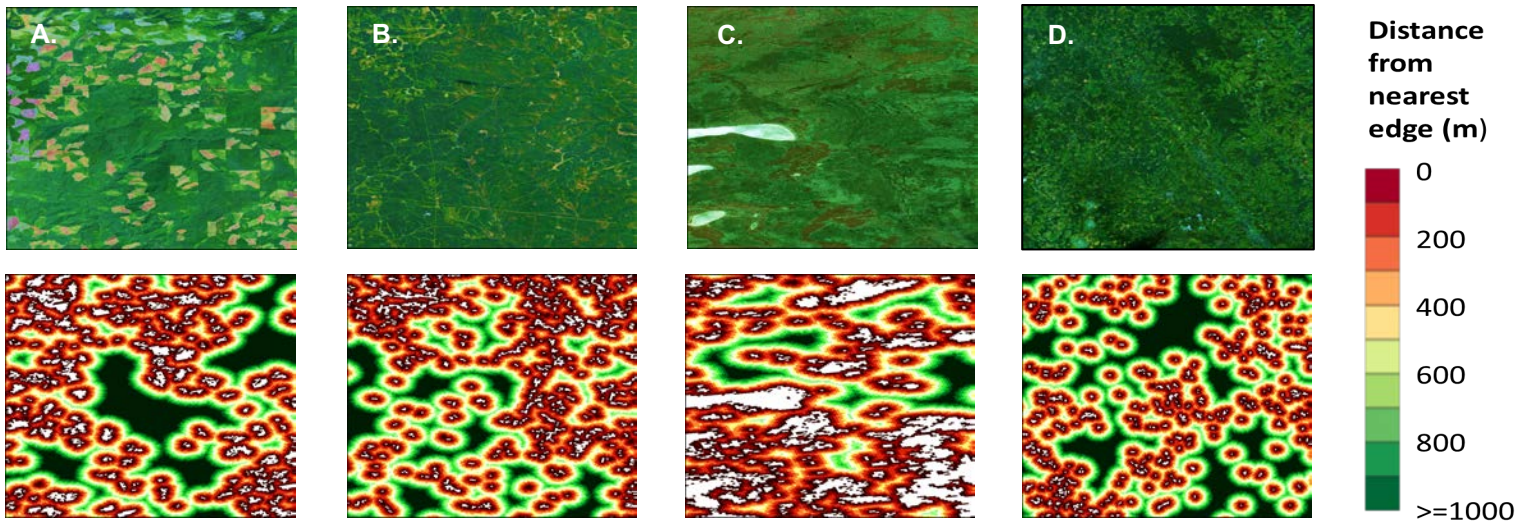
- ✓ Extensive use by climate and carbon modeling communities demonstrates the unique contribution of fractional cover products.
- ✓ **The product would benefit from use of newly available Lidar data. Canopy height and structure data would improve training and allow retrieval of a much requested "shrubs" 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.



# Status of MODIS DSR and PAR (MCD18)

## 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:

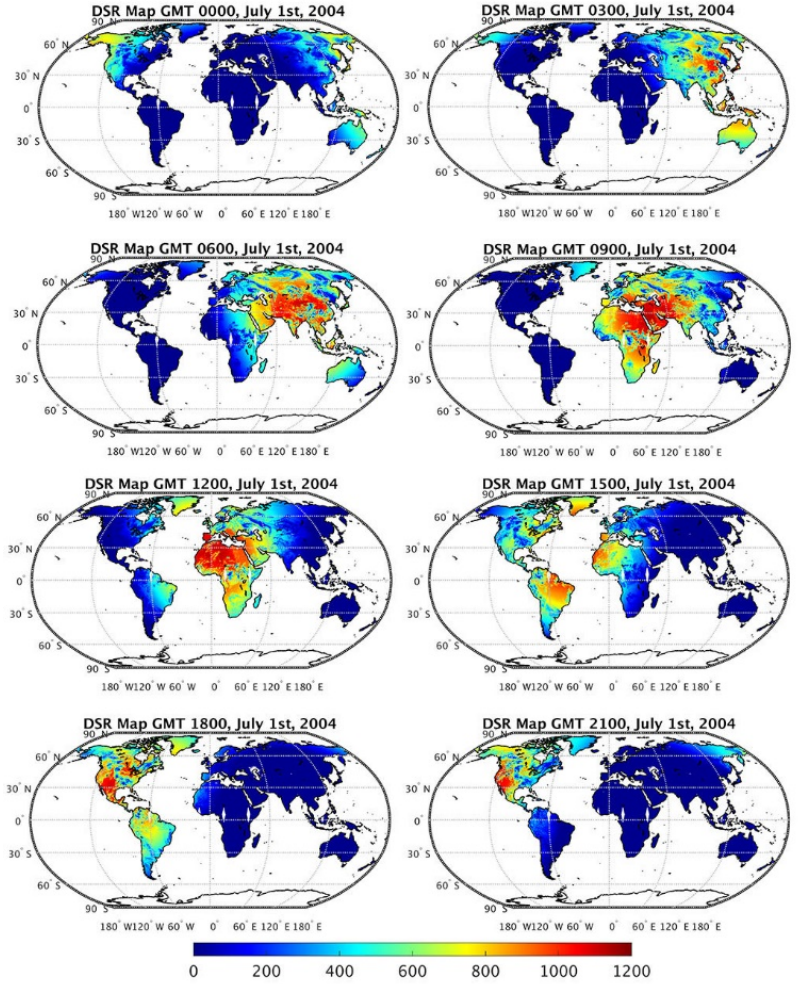
- Programming errors in C6 overestimating DSR and PAR

## 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:


- Wang, D., Liang, S., Zhang, Y., Gao, X., Brown, M., & Jia, A. (2019). A new set of MODIS land products (MCD18): downward shortwave radiation and photosynthetically active radiation. *Science of Remote Sensing*, submitted
- Huang, G., Li, Z., Li, X., Liang, S., Yang, K., Wang, D., & Zhang, Y. (2019). Estimating surface solar irradiance from satellites: Past, present, and future perspectives. *Remote Sensing of Environment*, 233, 111371
- Zhang, Y., He, T., Liang, S., Wang, D., & Yu, Y. (2018). Estimation of all-sky instantaneous surface incident shortwave radiation from Moderate Resolution Imaging Spectroradiometer data using optimization method. *Remote Sensing of Environment*, 209, 468-479

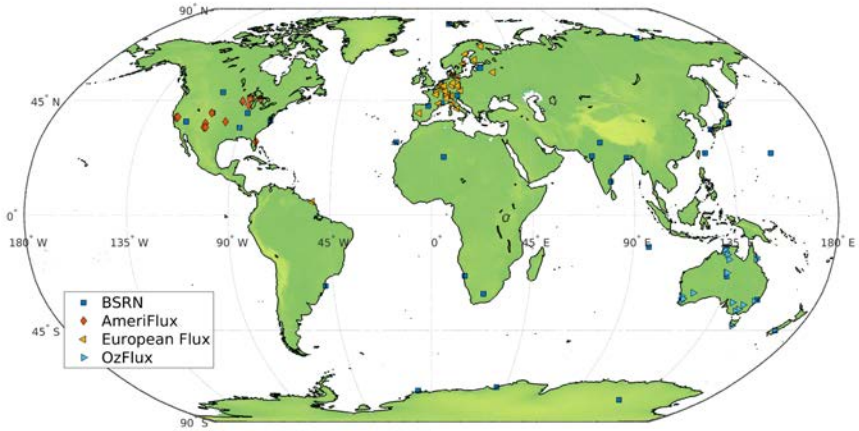



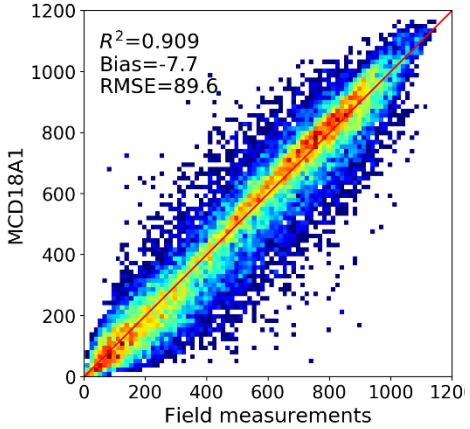
# Extensive validation of MCD18 C6

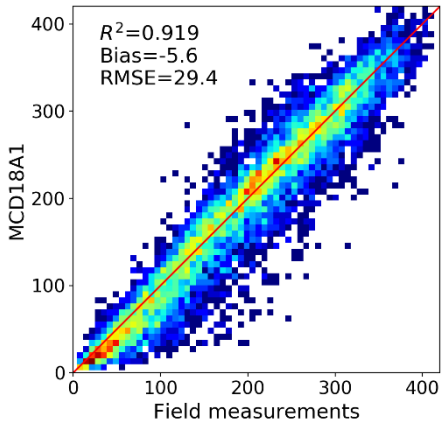
## Field data collection
- Starting with data of 2018
- BSRN, AmeriFlux, European Flux, OzFlux 119 stations

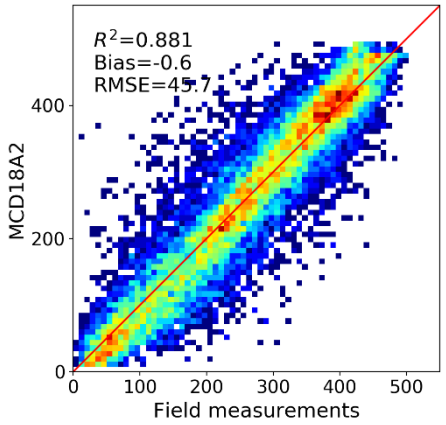
## Other products for intercomparison
- Clouds and the Earth's Radiant Energy System (CERES)
- Global LAnd Surface Satellite (GLASS)

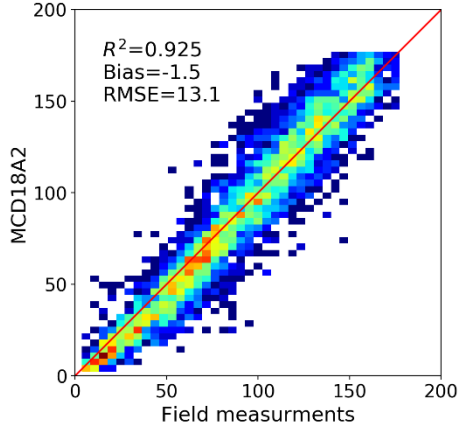
## Validation approaches
- Temporal and spatial aggregation
- Effects of input surface reflectance data
- Effects of daily overpass counts



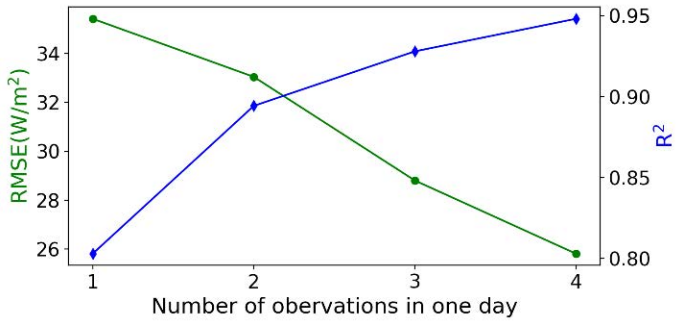




**Top figures:** scatter plots between MCD18 data and in situ measurements for instantaneous DSR, daily DSR, instantaneous PAR and daily PAR.

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



# Status of MODIS and VIIRS Surface Reflectance Validation

J. Czapla-Myers, University of Arizona

## Radiometric Calibration

| | | |
|---|---|---|
| Terra & Aqua MODIS: | Collection 6.1 | (2013–2019) |
| SNPP VIIRS: | Collection 1 (Archive 5110) | (2013–2019) |
| NOAA-20 VIIRS: | Collection 2 (Archive 5200) | (2018–2019) |

## Surface Reflectance Validation

| | | |
|---|---|---|
| Terra & Aqua MODIS: | Collection 6 | (2013–2019) |
| SNPP VIIRS: | Collection 1 (Archive 5000) | (2013–2019) |
| NOAA-20 VIIRS: | no imagery | |

## Status and Updates:

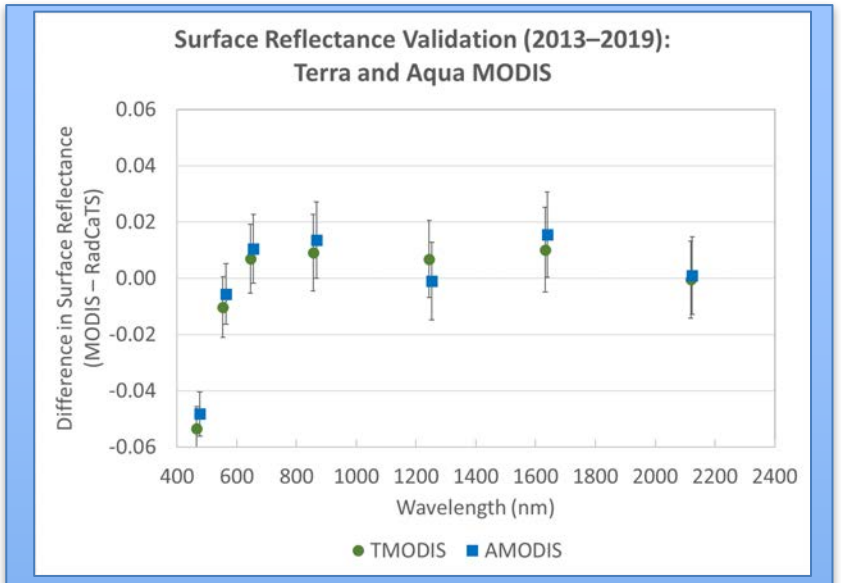
- *Radiometric Calibration Test Site (RadCaTS) operational since ~2013.*
- *RadCaTS currently one of five RadCalNet sites (www.radcalnet.org).*
- *Routine daily download and weekly processing of data.*

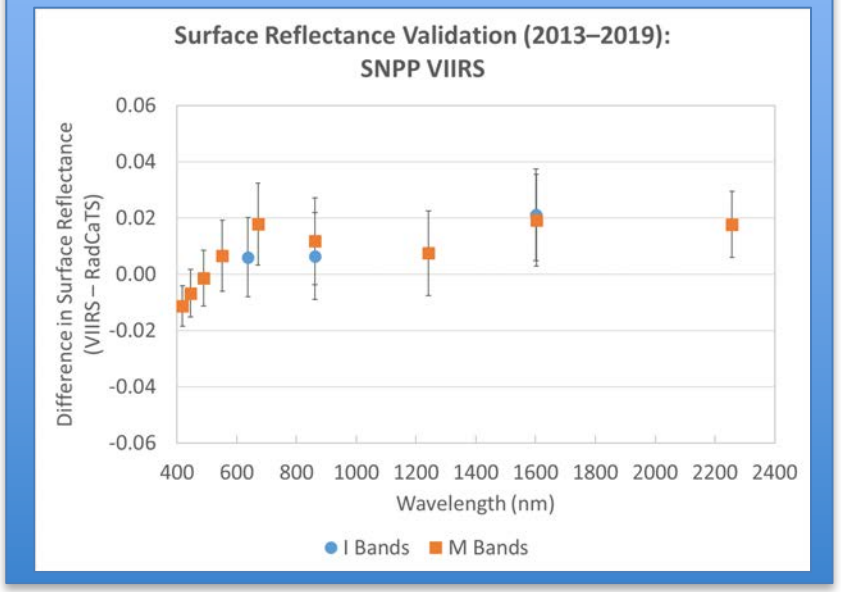
## Known Issues:

- RadCaTS bias with MODIS Band 3 (466 nm).

## Recent Publications:


- Czapla-Myers, J. S., and Anderson, N. J., "Intercomparison of the GOES-16 and -17 Advanced Baseline Imager with low-Earth orbit sensors." Proc. SPIE 11127 (2019).
- Bouvet, M., Thome, K., Berthelot, B., Bialek, A., Czapla-Myers, J., Fox, N. P., Goryl, P., Henry, P., Ma, L., Marcq, S., Meygret, A., Wenny, B. N., and Woolliams, E. R., “RadCalNet: A Radiometric Calibration Network for Earth Observing Imagers Operating in the Visible to Shortwave Infrared Spectral Range,” Remote Sensing, 11(20), 2401 (2019).
- Czapla-Myers, J. S., Coburn, C. A., Thome, K. J., Wenny, B. N., and Anderson, N. J., "Directional reflectance studies in support of the Radiometric Calibration Test Site (RadCaTS) at Railroad Valley." Proc. SPIE 10764, 9 (2018).

# Status of MODIS and VIIRS Land Surface Temperature and Emissivity Validation

Simon J. Hook, NASA/JPL

## Radiometric Calibration

| | | |
|---|---|---|
| Terra & Aqua MODIS (02): | Collection 6.0 | (2000–2019) |
| SNPP VIIRS: | Collection 1 (Archive 5110) | (2012–2019) |

## Land Surface Temperature and Emissivity Validation

| | | |
|---|---|---|
| Terra & Aqua MODIS (11): | Collection 6.0 | (2000–2019) |

## 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