MODIS – SNPP VIIRS Land Discipline Overview

Chris Justice

Miguel Román, Sadashiva Devadiga

Land Discipline Leads

Status of MODIS/S-NPP Land Team Activities

- **MODIS (14 products) Maintenance Mode**
  - Collection 6 and C6.1 processing underway, C7 in the planning stage
  - Senior Review - waiting for information on what products are supported and at what level – lack of communication with Discipline Leads

- **SNPP-VIIRS (12 Land Products) Evaluation and Refinements**
  - Collection 1 reprocessing proceeding, C2 improvements ready to start

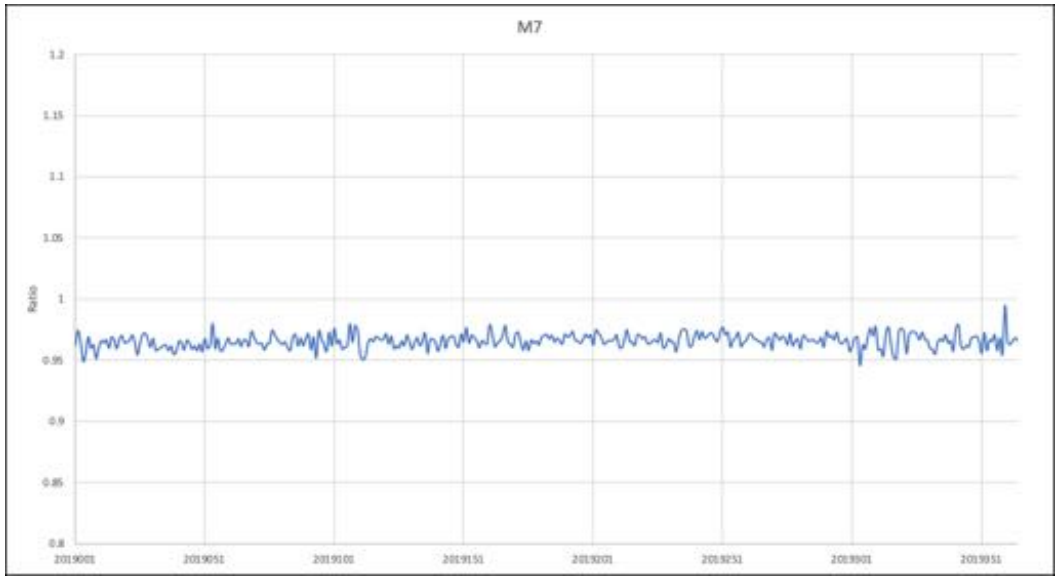
- **J1 (10 products) Experimental Status Evaluation Underway**
  - Difference between SNPP and J1 L1B Calibration (same for NOAA SDRs)- investigation of impact on continuity product underway (Vermote/Devadiga)

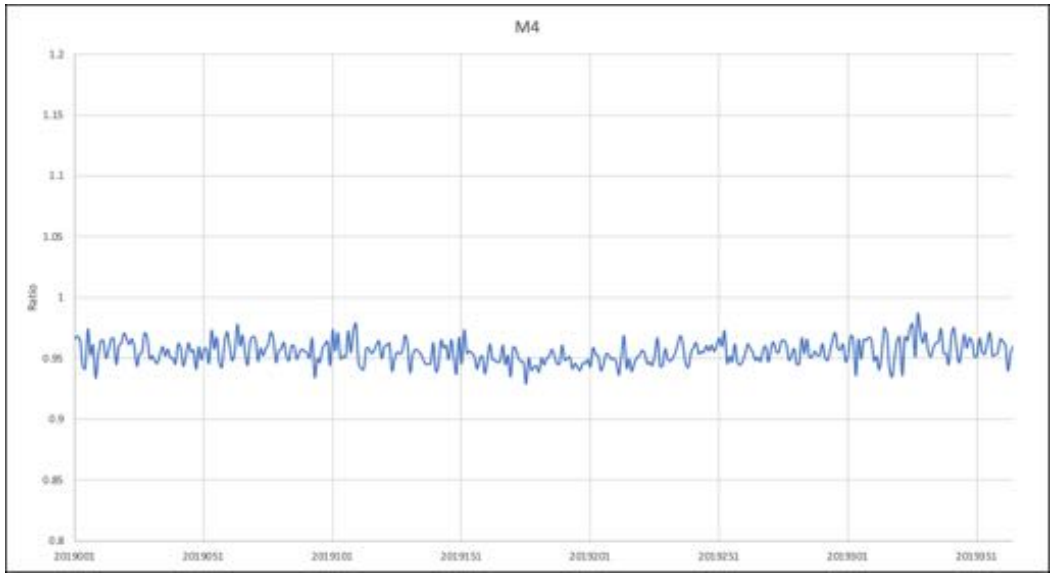
Table 1. N20 and S-NPP VIIRS RSB and TEB comparison. Results are provided in percentage difference (S-NPP-N20)/S-NPP (%) for RSB and in Kelvin (K) (N20 – S-NPP) for TEB. Values in parentheses are the standard error. Those marked n/a are either not applicable or are excluded due to saturation.

Method	Period	M1	M2	M4	M7	I1	I2	M13	M14	M15	M16	I5
SNO	2018-2020	6.3 (1.8)	5.2 (1.6)	3.4 (1.6)	3.5 (1.8)	3.8 (1.6)	3.6 (1.8)	0.12 (0.22)	n/a	0.02 (0.20)	0.10 (0.15)	0.10 (0.16)
Desert	2018-2020	7.0 (1.3)	6.1 (1.2)	3.7 (1.2)	2.8 (0.9)	3.7 (1.1)	3.1 (1.1)	n/a	n/a	n/a	n/a	n/a
Dome C	2018-2019	6.7 (1.4)	4.7 (1.4)	5.2 (2.9)	2.9 (2.9)	3.8 (2.7)	3.3 (3.0)	-0.15 (1.96)	0.23 (2.09)	0.70 (2.17)	0.64 (2.19)	n/a
Ocean	2018-2020	n/a	n/a	n/a	n/a	n/a	n/a	0.01 (4.72)	0.60 (5.46)	0.11 (6.04)	-0.07 (6.41)	n/a

Source VCST

J1-SNPP Reflectance Ratio from operational L1 products





Source LDOPE

Status of MODIS/S-NPP Team Activities

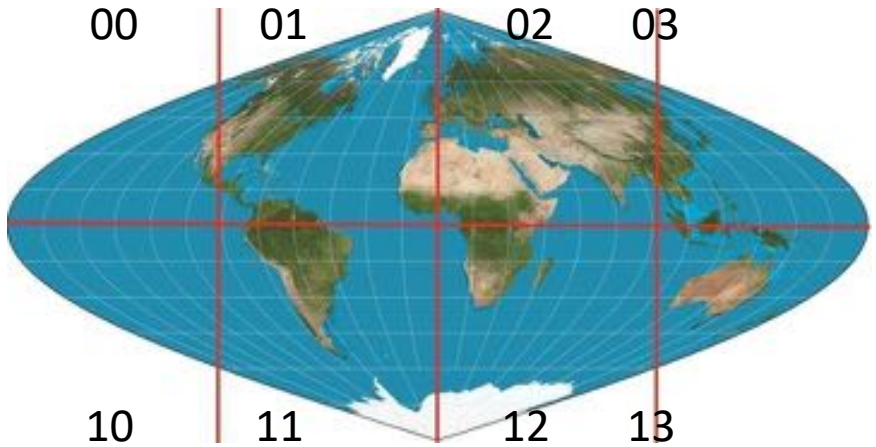
- **4 New MODIS/VIIRS Land Products in various stages of development**
  - Night Lights Product – in operational production (by Dec will be caught up to leading edge)
  - Global Reservoir Product – MODIS delivered, VIIRS in development
  - Volcanic Heat Flux Product – in development
  - Sea Ice Leads – in development

- **2 Multi-source Land Data Fusion Research Activities**
  - Soil Moisture and Evapotranspiration
  - Snow Water Equivalent

Issues raised at recent Land Discipline Meetings

- Annual Land Water Mask (*funding needed/recompete*)
- Orphaned Land Cover options inc. re-purposing NOAA VIIRS Land Cover (*funding needed/recompete)*
- Phasing out MOD 11 (3rd most downloaded) suggested replacement by MOD 21
  - LAND SIPS Maintaining MOD 11
  - C7 plan needed w. Science Team, SIPS, LPDAAC
- Improving Google Earth Engine Metadata Documentation (*in process*)
- Recent Discussions
  - Sinusoidal Projection limitations – (*Tiger team planning session needed for C7*)
  - August 2020 Aqua Anomaly and Direct Broadcast Gap Filling

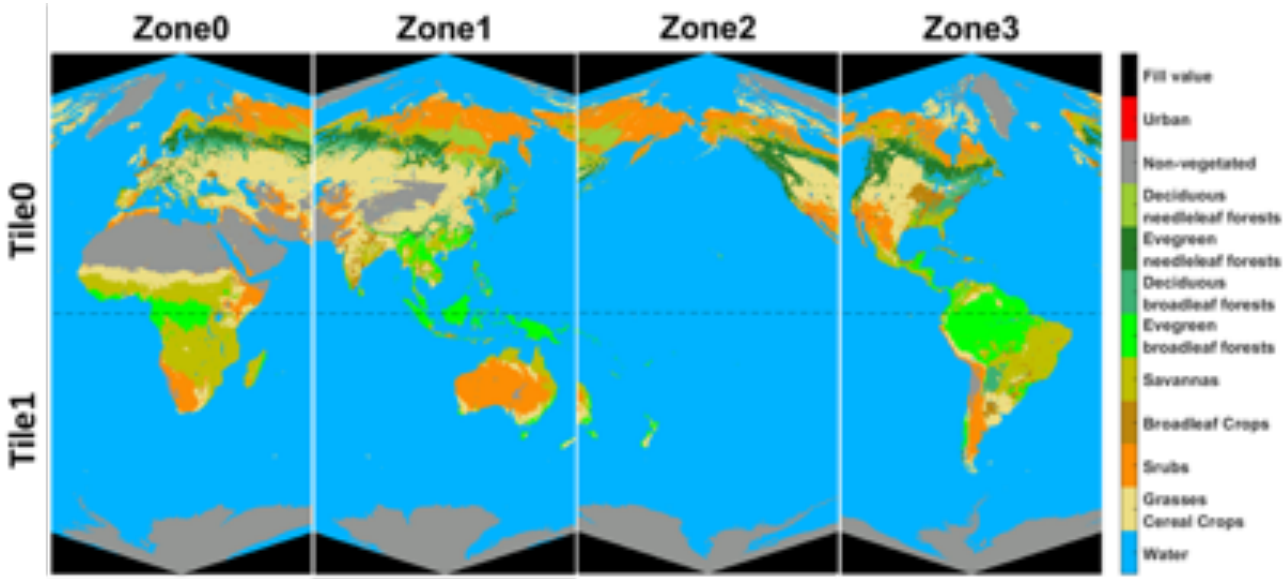
A C7 additional Projection Option: MAIAC suggestion



v1 Global Sinusoidal Projection

- Equal Area
- The same # pixels
- Some limited oversampling
- Almost undistorted compared to global Sinusoidal
- Can be re-projected in global projection without loss of information

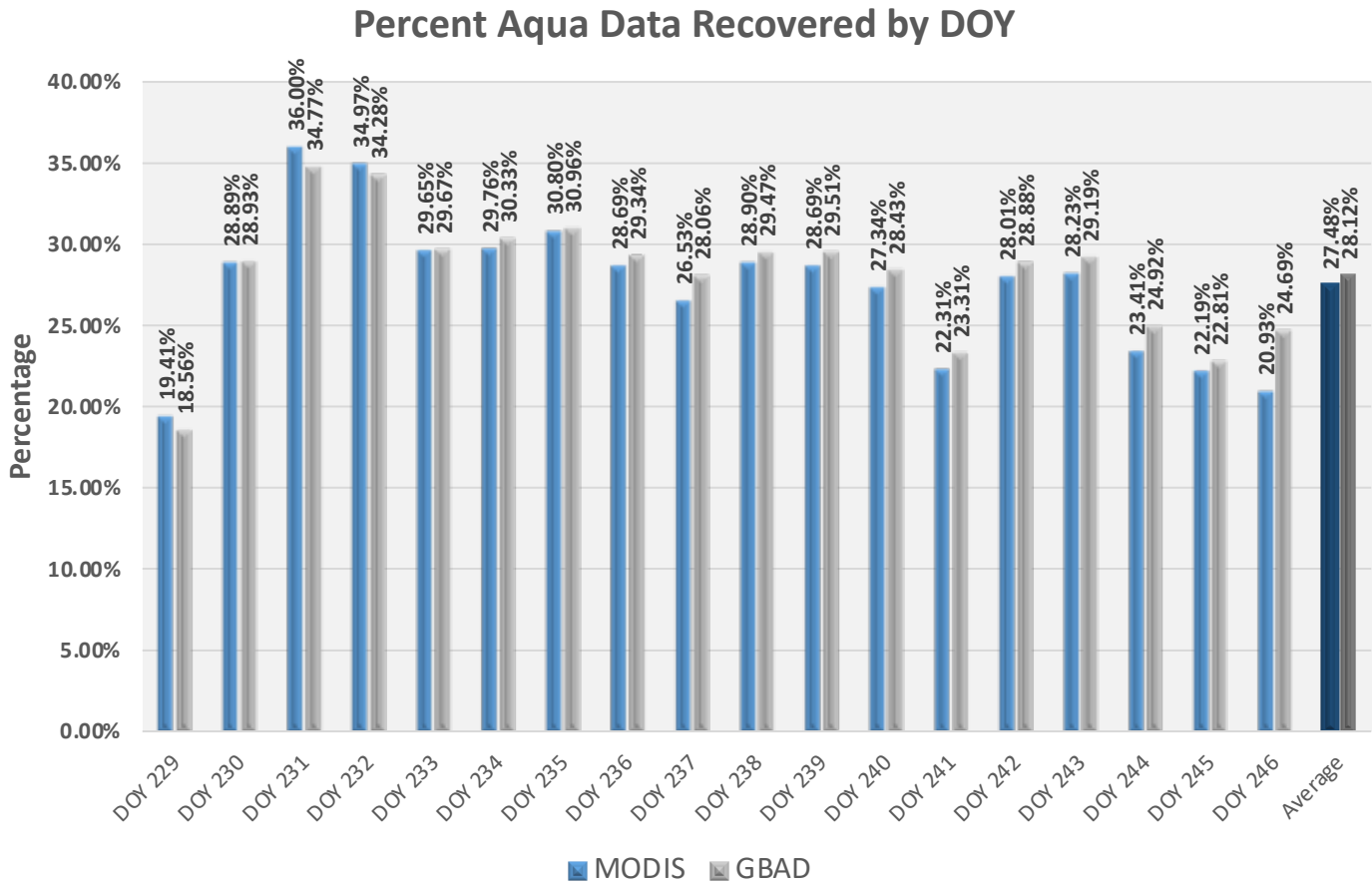
v2 Regional Sinusoidal Projection



(from Yuri Knyazikhin)

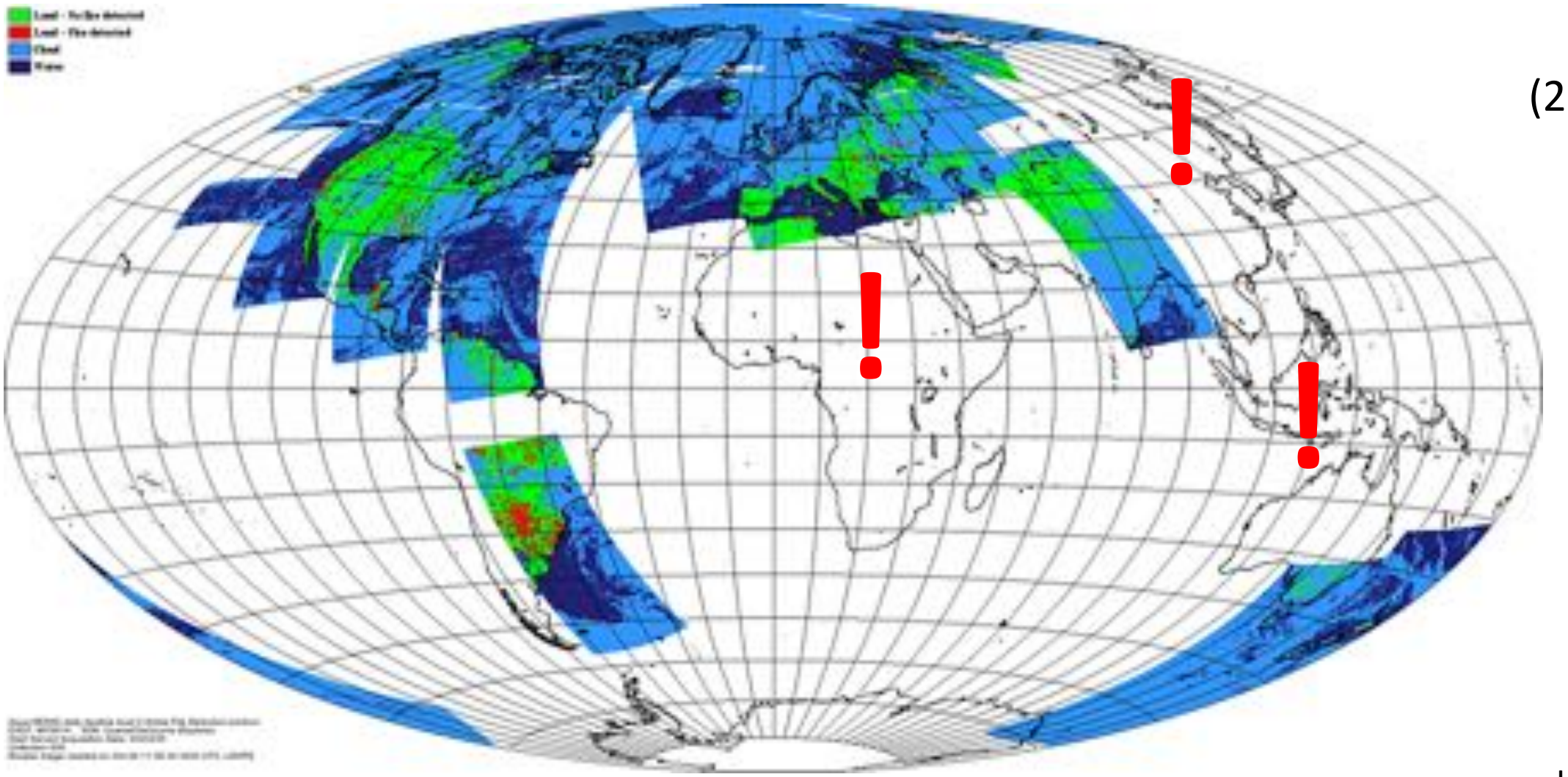
Aqua FMU Anomaly Processing

- Aqua experienced Formatter-Multiplexer Unit (FMU) anomaly on Aug 16, 2020 (2020229)
- FMU recovered through software reset on Sept 2, 2020 (2020246) – kudos to ESMO
- MODIS suffered science data outage for the period 2020229 9:26:25 through 2020246 20:12:00
- **MODAPS processed the L1, atmosphere and land products for the anomaly period (8/16 – 9/02) using the data received from various Direct Broadcast (DB) stations via EDOS**
  - Processing includes L1, L2 and L3 daily atmosphere and land products, and L3 n-day composite land products.



LDOPE

Typical Direct Broadcast Coverage During Outage



2020 235
(22 August)

LDOPE Daytime
Global Browse

Aqua August 2020 Anomaly Experience

- NASA requested raw Aqua DB data + PDS files from ground-station network (19 August)
  - Upload data to NASAs ftp server
- DB data provides coverage for only up to 25 - 30% of the globe each day.
- Response to NASA call for Aqua DB data during outage was surprisingly poor – not sure why?
- *Suggestion:*
  - *We need a NASA concerted DB data soliciting effort next time,*
  - *Ground stations need to be encouraged to step up*
  - *The DRL needs to be actively involved in soliciting for data, given their strong DB connections*

Approx. 165 DB Stations worldwide

Ed Masuoka retiring after 40 years

- Recognize the outstanding contribution of Ed Masuoka, Chief Terrestrial Information Systems Laboratory (Code 619) - an excellent colleague and the quintessential civil servant
- Responsible for processing EOS Terra, Aqua and Aura, Suomi NPP and JPSS data – setting the gold standard for NASA land data products

MODIS and VIIRS Land Processing Status

Sadashiva Devadiga

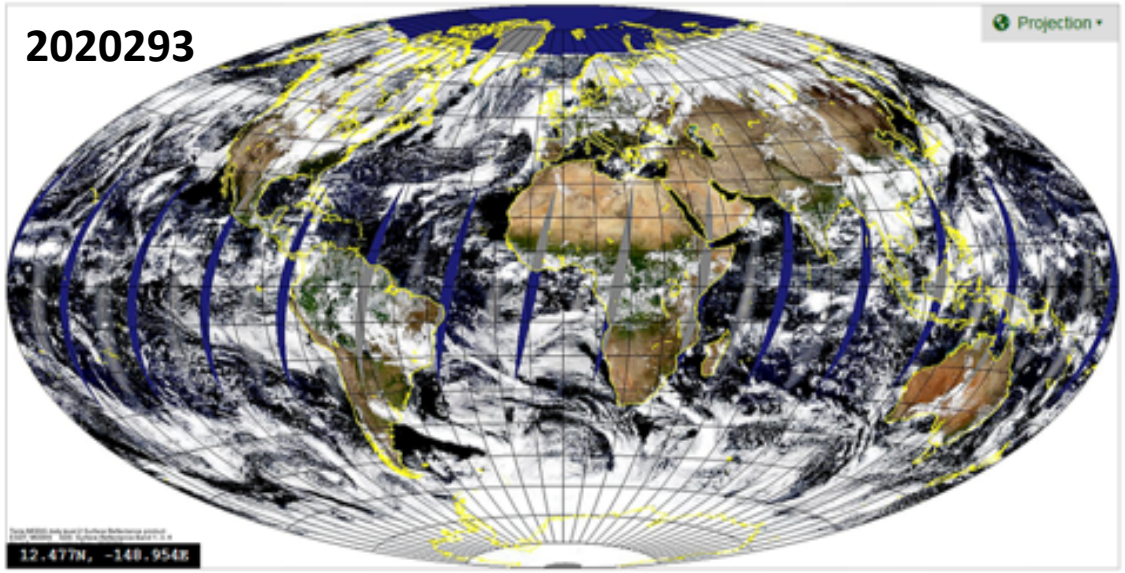
MODIS Land Processing Status

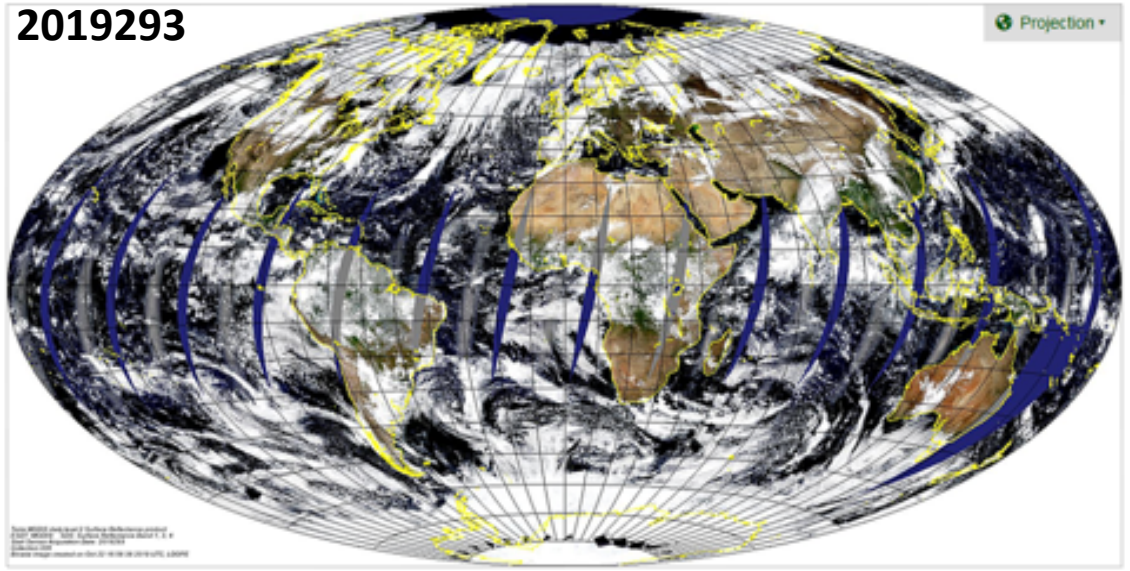
- **C6 Land forward processing**
  - Standard products are generated within a day or two after the data acquisition, NRT products are generated within two hours after the acquisition.
  - Processing of maneuver days in standard processing are delayed for Land Data Operational Product Evaluation (LDOPE) to complete evaluation of data for geolocation error from Loss of Pointing Accuracy (LOPA)

- **C61 Land reprocessing**
  - Main objective is to correct known issues and inconsistencies in the calibration
  - Completed processing the early mission period, beginning of mission through year 2006, for both missions.
  - Reprocessing switched to process year 2019 and forward.
  - Reprocessing will switch back to process the period 2007 – 2018 after the C61 forward processing has caught up to the leading edge of the ongoing C6 forward processing.
  - **Product to be released to public starting Jan 2021.**
  - **Reprocessing expected to complete by summer 2021.**

Terra PWA Anomaly

- On 10/05/2020 (2020279) Terra MODIS experienced a Printed Wire Assembly (PWA) failure. There has been 14 such anomalies prior to this since launch.
- On day 2020280, the Field Operation Team (FOT) moved the two corrupt Super Sets (SS) to the bad SS list, and re-enabled the science recording with 28 SS assigned to MODIS.
- This is below the minimum number of SS required to operate MODIS without frequent buffer overflow scenario.
- On day 2020281 MODIS acquisition ratio was changed to 40/60 day night rate (option 1) to avoid unplanned buffer overflow. This would result in less day time coverage towards the pole.
- Acquisition plan changed to option 2 on 11/8/2020, acquiring additional 10mins of data at north and south pole on alternate orbits.





C7 Reprocessing

- **All products to be produced in netCDF4/HDF5-EOS5 format**
- **Operational C61 PGEs will be updated to pre-C7 version to generate products in netCDF4**
  - C61 PGEs to be seamlessly transitioned to early C7 version using the APIs developed in-house at LDOPE replacing the current SDP Toolkit.
  - Science teams to use these PGEs to implement C7 specific changes
- **Additional projection for C7 in discussion**

- **Tentative Schedule**
  - **Spring 2021:** Initial delivery of C7 L1B with changes to calibration by MCST for evaluation by discipline teams
  - **Summer 2021:** Delivery of C7 operational versions of Geolocation and L1B
  - **Fall 2021:** Start of C7 L1 reprocessing
  - **Mid 2022:** Start C7 reprocessing of Atmosphere and Land

C1 SNPP VIIRS L1 and Land Reprocessing

- L1 products and all Land products planned for C1 reprocessing available for the mission period except the L3 DNB night light product (VNP46A2) which is currently processing year 2018.
- Leading edge of forward processing lags current day by a day or two except for maneuver days or satellite/instrument anomaly.
- NASA L1B and geolocation products are generated using the NASA VCST delivered Calibration algorithm and LUT (AS 5110)
- Land products are generated using the Mx8 version of the operational IDPS L1B SDR algorithm and the NASA VCST delivered calibration LUTs. (AS 5000)

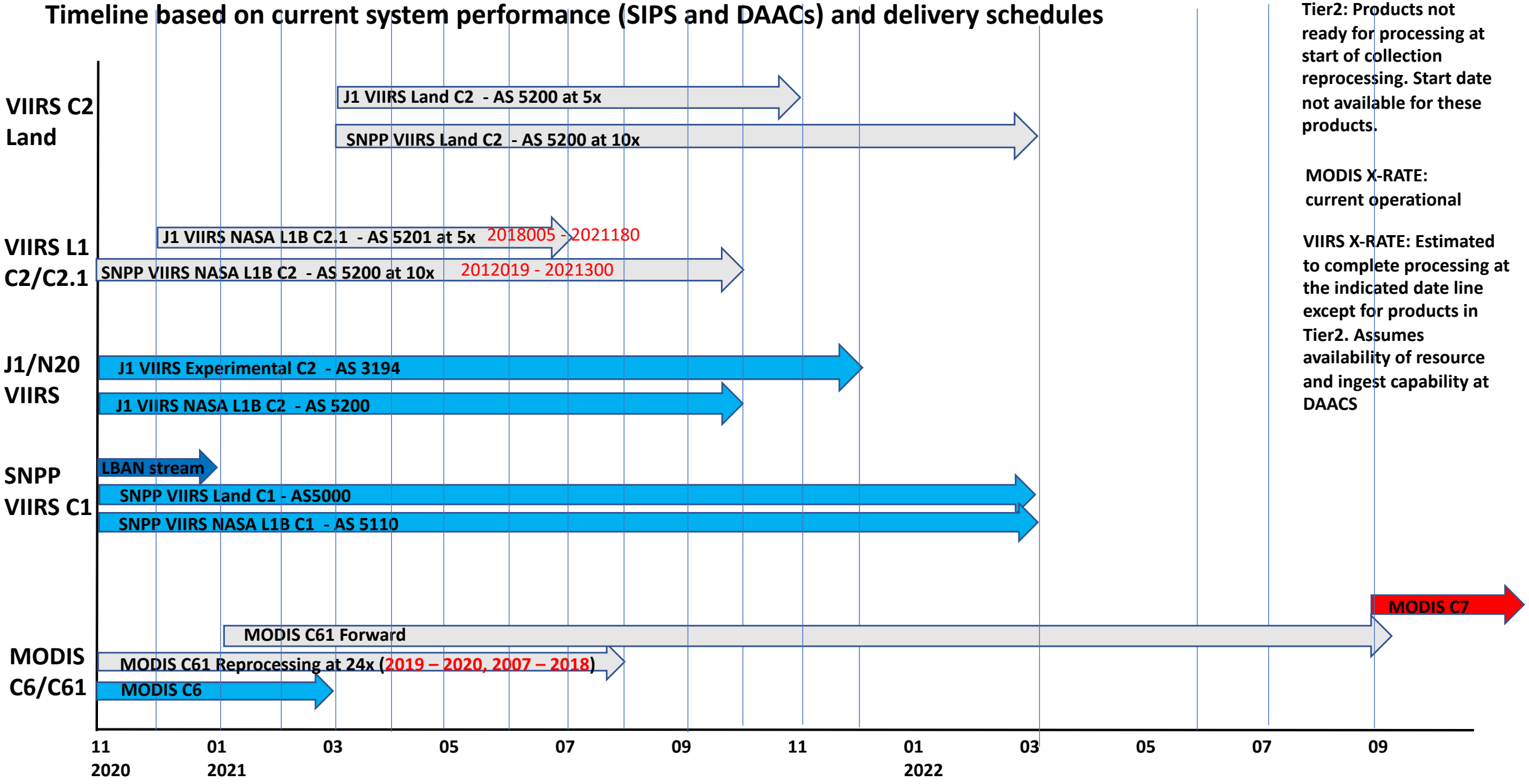
C2 SNPP and J1 VIIRS L1 and Land Reprocessing

- **C2 SNPP VIIRS L1 Reprocessing**
  - **Reprocessing of SNPP VIIRS L1 currently in progress - uses the latest version of the VCST delivered calibration algorithm and LUT**

- **C2/C2.1 J1/NOAA-20 VIIRS L1 Reprocessing**
  - **C2 reprocessing of L1B and geolocation products for the mission period completed in Aug 2019 (AS 5200)**
  - **C2.1 reprocessing of L1B and geolocation product using the latest version 3.1 algorithm and calibration LUT is expected to start late Nov 2020**
  - **J1 VIIRS experimental land products generated using the NASA J1 VIIRS L1B and C2 VIIRS land algorithms are made available to science teams only (AS 3194).**

- **C2 VIIRS SNPP and J1/NOAA-20 Land reprocessing**
  - **Expected to start early 2021 pending resolution to the cross calibration of SNPP and J1**

Timeline based on current system performance (SIPS and DAACs) and delivery schedules



Tier2: Products not ready for processing at start of collection reprocessing. Start date not available for these products.

MODIS X-RATE: current operational

VIIRS X-RATE: Estimated to complete processing at the indicated date line except for products in Tier2. Assumes availability of resource and ingest capability at DAACS

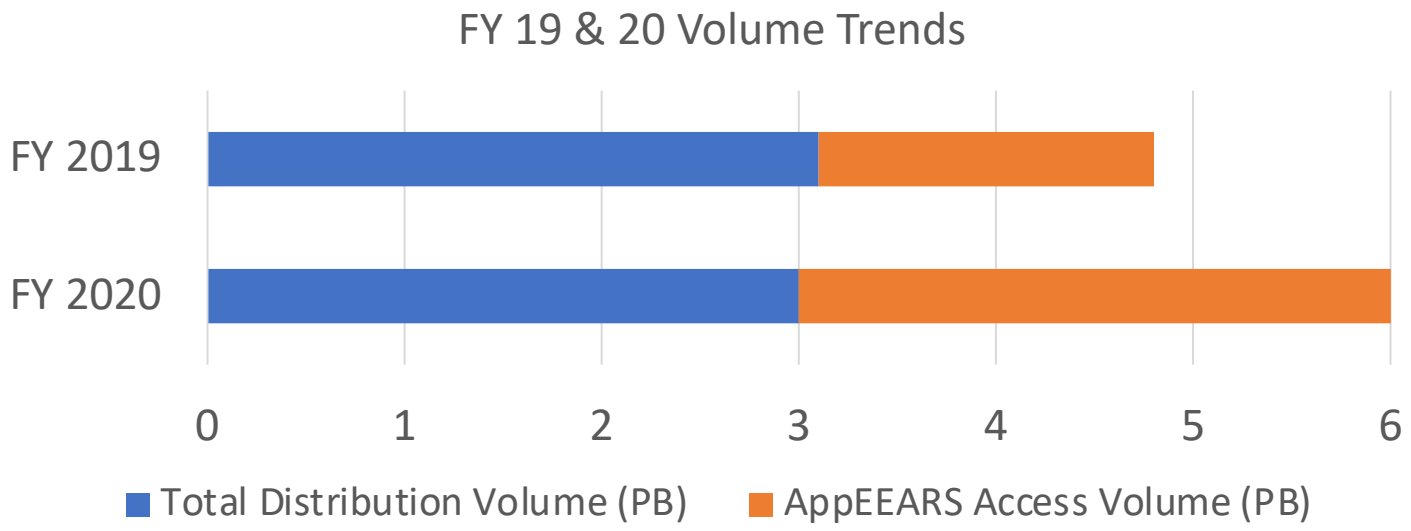
MODIS & VIIRS Land Data Metrics (LP DAAC)

All-time Distribution Metrics

MODIS – 1.2 Billion Files; 24.4 Petabytes
VIIRS – 20.1 Million Files; 510 Terabytes

FY 2019 + FY 2020 Detail

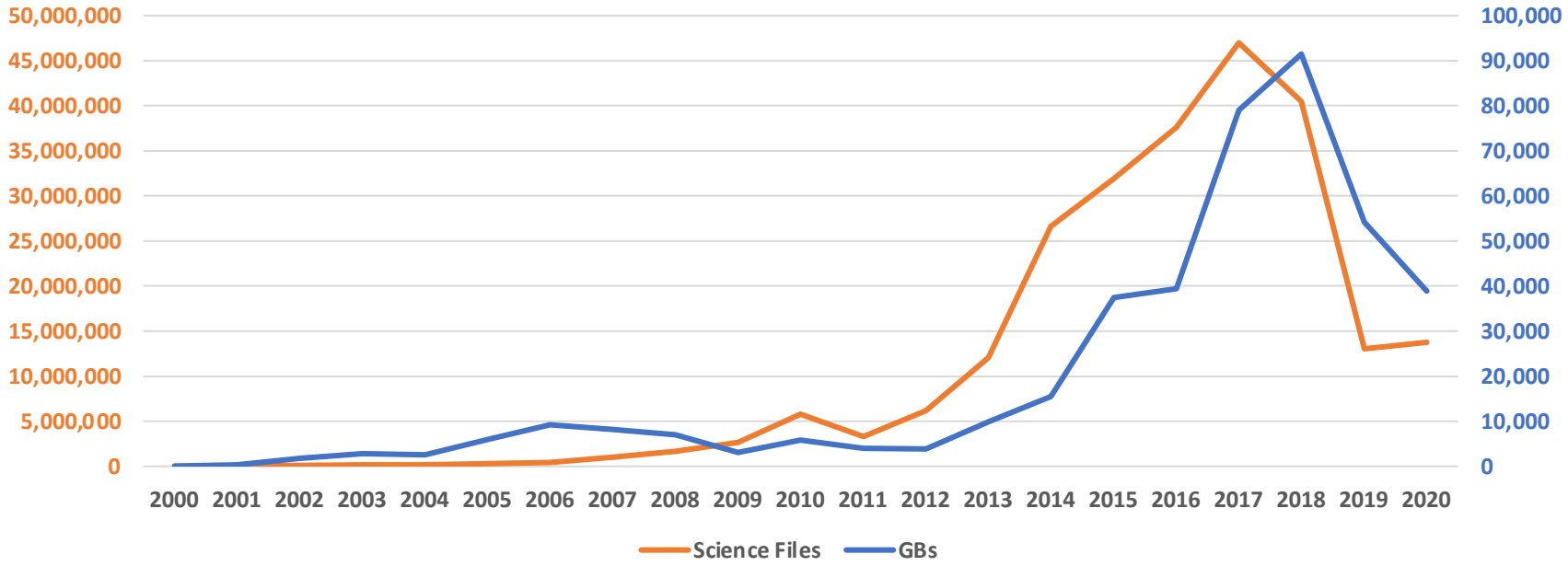
MODIS – 81,536 Unique Users
VIIRS – 2,636 Unique Users



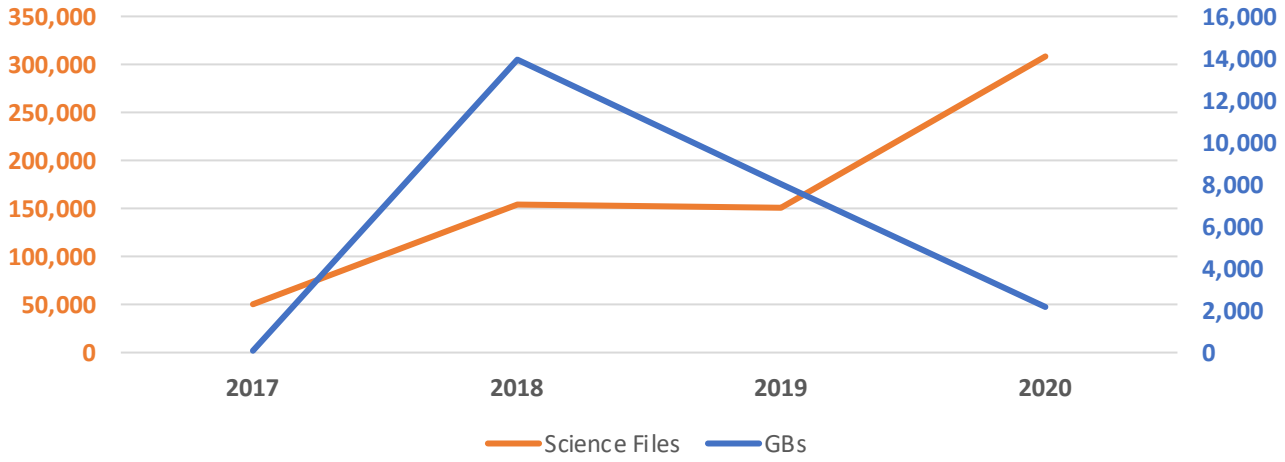
LP DAAC Updates

- **On-prem capabilities**
  - LP DAAC continues to work with MODAPS and LandSIPS to maximize ingest rates into the legacy ECS system (for MODIS v6.1 and VIIRS v2 rproc & fproc)
- **Cloud capabilities**
  - LP DAAC has successfully instantiated operational cloud systems for ingest, archive and distribution (i.e., NASA Cumulus in AWS)
  - Goal is for all holdings to migrate from ECS to Cumulus (a multi-year transition)
    - To date, only provisional HLS v1.5 data (Masek et al.) have been made publicly available from LP DAAC Cumulus
    - The next dataset publishing priority for LP DAAC Cumulus is ASTER GDEM
    - The next cloud migration priority is ECOSTRESS
- **Timing of MODIS and VIIRS Land data migration to LP DAAC Cumulus is TBD**

MODIS Distribution from NSIDC DAAC (Since 2000)



VIIRS Distribution from NSIDC DAAC (Since 2017)



NSIDC Updates

- Internal testing of cloud systems in progress.
- Will be launching an entirely new website in the Spring of 2021.
- Converting all User Guides to PDF. They will still be managed and updated like the html based User Guides.

MODIS – SNPP VIIRS Land Science Highlights

Miguel Roman

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)
Terra & Aqua MODIS (02):	Collection 6.1	(2000–2020)
SNPP VIIRS:	Collection 1 (Archive 5110)	(2012–2019)

Land Surface Temperature and Emissivity Validation

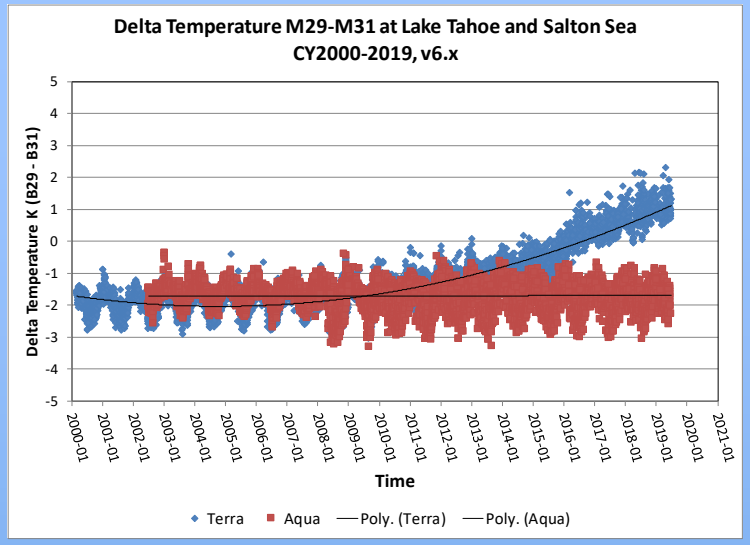
Terra & Aqua MODIS (11):	Collection 6.0	(2000–2019)

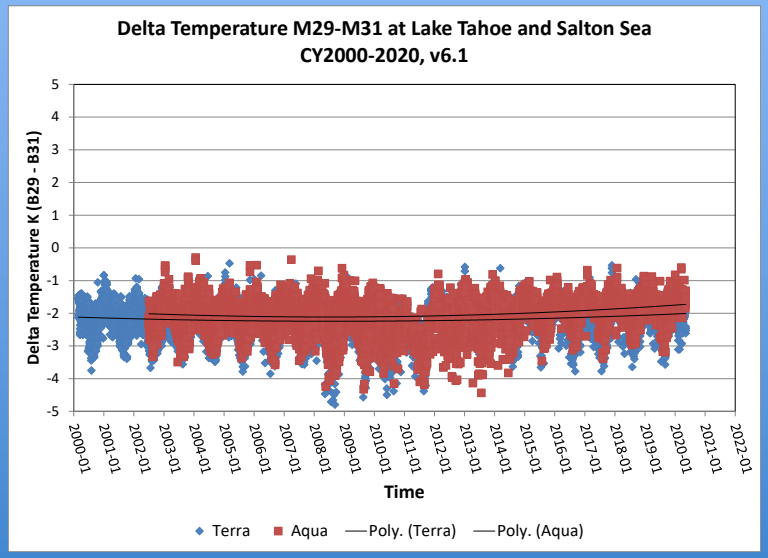
Status and Updates:

- *Lake Tahoe Site operational since 1998*
- *Salton Sea Site operational since 2008*
- *Collection 6. 0 Terra band 29 steady drift since 2009 in Collection 6.0 (Top Figure).*
- *Collection 6.1 Terra band 29 drift has been corrected. Now possible to acquire LST data for full record with MOD21.*
- *Collection 6.1 Includes MOD/MYD21 LST&E product for first time.*
- *VIIRS thermal bands within 0.25 K*

Key Take Home:

- Cross talk in MODIS Terra Band 29 has been fixed in Collection 6.1. Collection 6.1 should be used for any studies using MOD/MYD21 LST&E
- MOD11 does not use Band 29 and Collection 6.0 can be used. However, MOD11 does have other problems and recommend using MOD/MYD21 LST&E going forward.

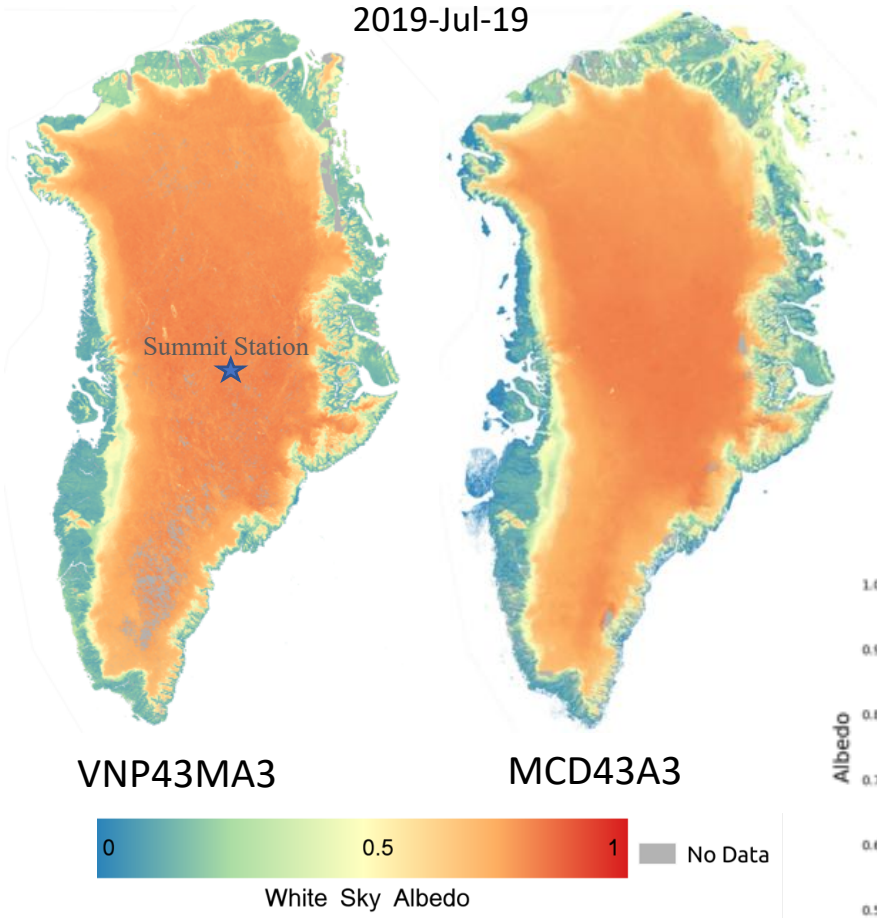




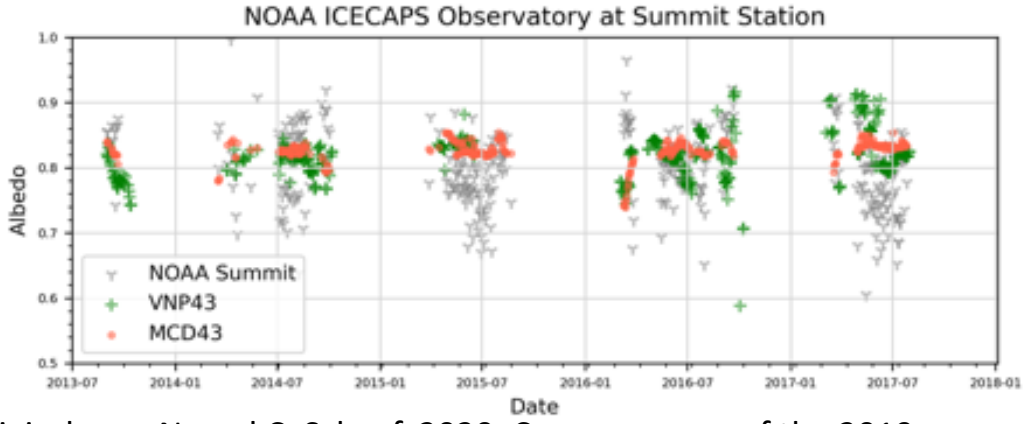
Consistent BRDF, Albedo, and NBAR products from Suomi-NPP VIIRS and Terra/Aqua MODIS

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



The MODIS and VIIRS BRDF/Albedo products rely on high quality multi-date, multi-angle surface reflectances to retrieve daily gridded surface **BRDF models**, **W**hite **S**ky **A**lbedo (**WSA** - bihemispherical albedo under isotropic illumination), **B**lack **S**ky **A**lbedo (**BSA** - directional hemispherical albedo under local solar noon) and Nadir BRDF-Adjusted Reflectance (**NBAR**) gridded at 500 m for MCD43 and 1 km for VNP43, and with detailed QA fields. The consistency of daily snow albedo is demonstrated during the **2019 Greenland Ice Sheet Melt Event** (particularly in the southwest), with a further comparison of satellite derived products with field data at Summit Station (72.57375, -38.4698).



Elmes, A., Levy, C., Erb, A., Hall, D. K., Scambos, T.A, Digirolamo, N. and C. Schaaf, 2020, Consequences of the 2019 Greenland Ice Sheet Melt Episode on Albedo, Remote Sensing, in review.

Declining Snow Cover in the Western U.S. Promotes Desiccation of the Great Salt Lake

Dorothy K. Hall[1,2], Donal S. O'Leary III[3], Nicolo E. DiGirolamo[4,2], Woodruff Miller[5] and Do Hyuk Kang[1,2]

[1]ESSIC/UMD, [2]Cryospheric Sciences Lab, NASA/GSFC, [3]Department of Geographical Sciences, UMD, [4]SSAI, [5]Civil and Environmental Engineering, Brigham Young University

MODIS daily snow-cover products show earlier snowmelt in the Great Salt Lake (GSL) basin since 2000. This contributes to a reduction in streamflow from the major tributaries to the lake and thus to lower lake levels and higher salinity in this terminal lake.

In addition, air & surface temperatures and evaporation are increasing, and snow depth is decreasing in the basin, leading to warmer and drier conditions*.

A shallower lake is associated with negative (and sometimes catastrophic) effects on wildlife, recreation and air quality.

Fig 1 Location of the Great Salt Lake Basin

Orange pixels show a trend of earlier snowmelt by ~9.5 days

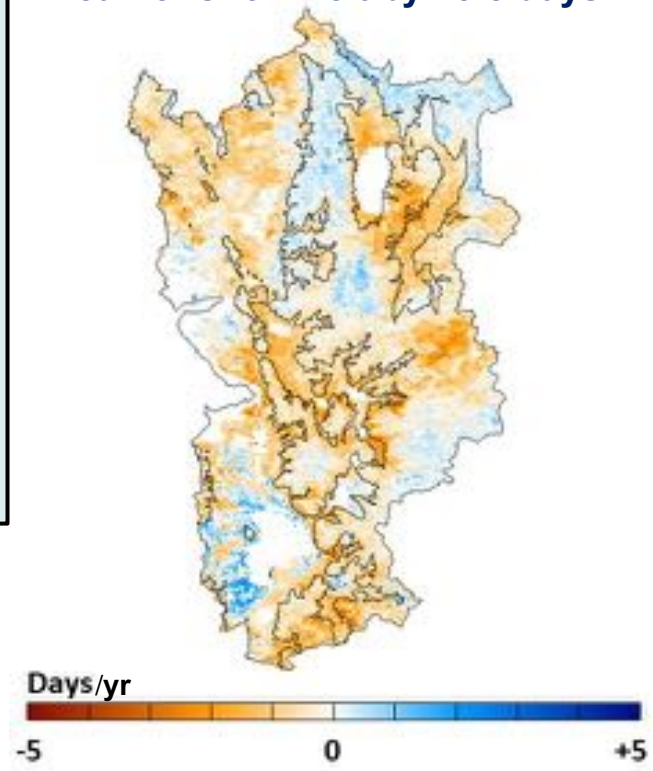


Fig 2 Trends in snowmelt timing** for the GSL basin, 2000–2018. Blue indicates later snowmelt. Source: MOD10A1F data products.
**O'Leary et al. (2018)

Orange pixels show a trend of higher LST by~2.1 °C

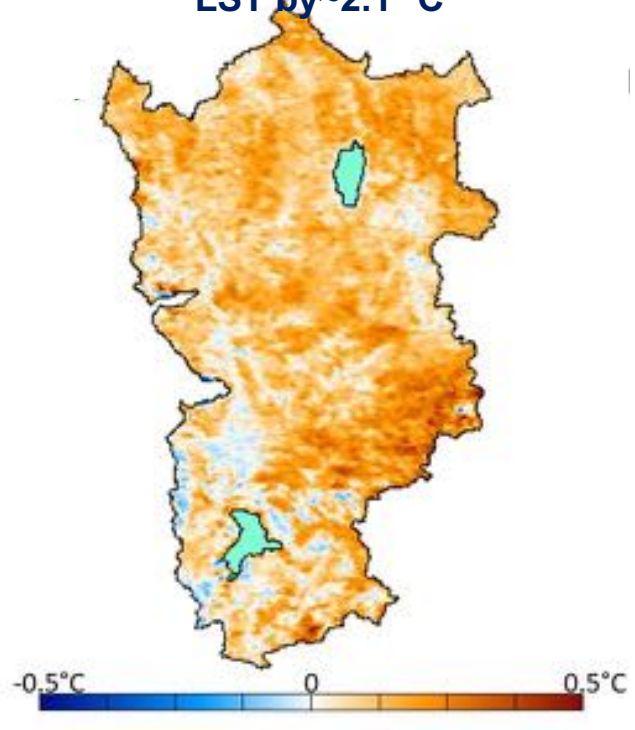


Fig 3 Trends in daytime surface temperature (°C) in the GSL basin, 2000–2018; blue indicates cooling. Source: M*D21 LST data products.

***Hall, D.K., D.S. O'Leary III, et al., 2021: The Role of Declining Snow Cover in the Desiccation of the Great Salt Lake, Utah, using MODIS Data, *RSE*, Special issue on Terra@20.**

A greening Earth dampens global warming trends

Chen et al. (2020). *Sci. Adv. 6, eabb1981*

Scientific Question:

- What is the impact of greening Earth on land surface temperature (LST)?

Analysis:

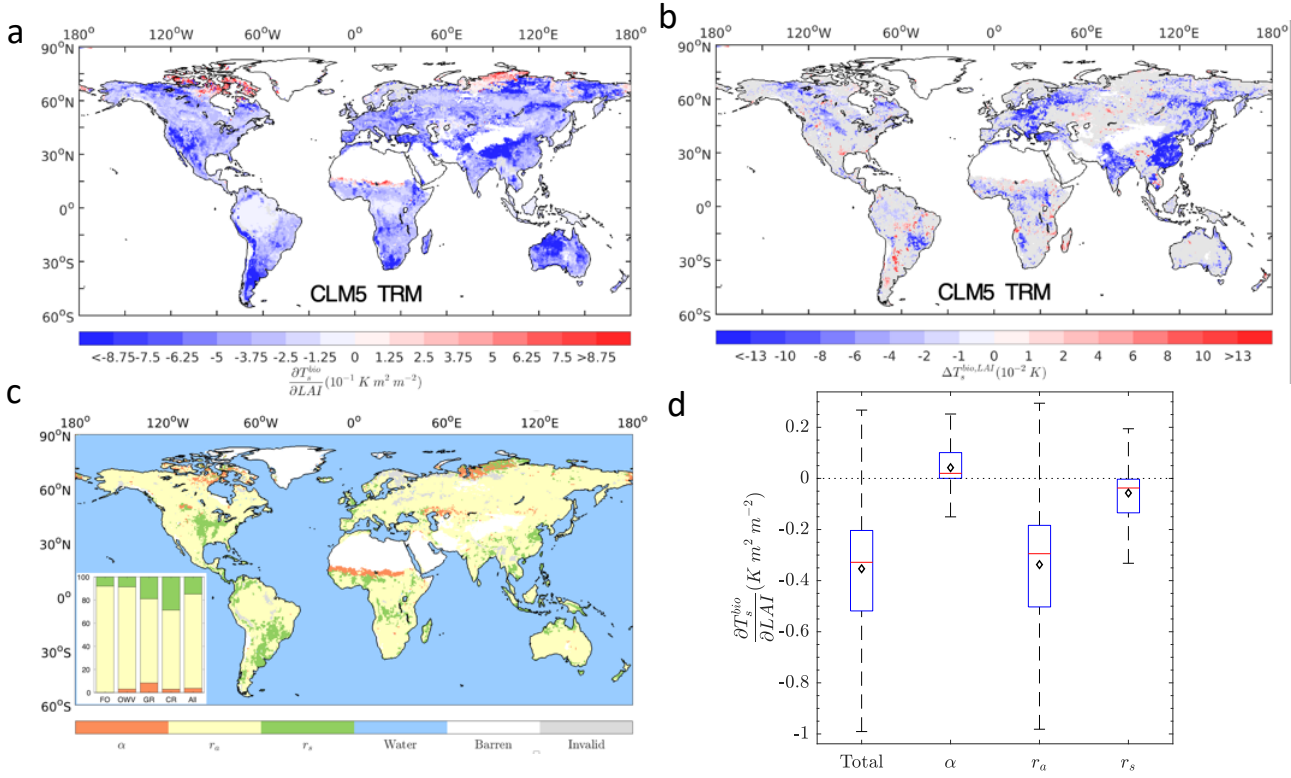
(1) Use the two-resistance mechanism (TRM) method to build an attribution framework for LST change; (2) use NASA's MODIS LAI; (3) Run NCAR's CLM5; (4) use MERRA-2 and seven CMIP5 model outputs.

Results:

- 93% of the global vegetated area shows negative sensitivity of LST to changes in LAI.
- The sensitivity of LST to LAI is strongest in semi-arid woody vegetation, and it decreases as LAI or precipitation increases.
- 30% of the global vegetated area is cooled by increasing LAI trends and 5% is warmed.
- Change in aerodynamic resistance from changing LAI is the dominant mechanism in controlling LST.

Significance:

The observed changes in LST are compound effects of Earth greening and large-scale climate change. The greening of the lands during the first fifteen years in the 21st century represented an additional heat dissipation (2.97×10^{21} J) from the surface equivalent to five times the total energy produced and used by humans in 2015 (5.71×10^{20} J). This greening-induced cooling effect was twenty-five times stronger than the warming effect caused by tropical deforestation



a. Sensitivity of LST to LAI. **b.** Changes in LST due to LAI change. **c.** Dominant factor in controlling LST change due to the Earth greening. **d.** Attribution of sensitivity of LST to LAI to albedo (α), aerodynamics resistance (r_a), and surface resistance (r_s).

Clarifying the influence of soil moisture on ET over the continental USA using the MOD16 framework

Brust, Kimball, Maneta, Jencso, He, Reichle, 2020. *RSE*. (in press)

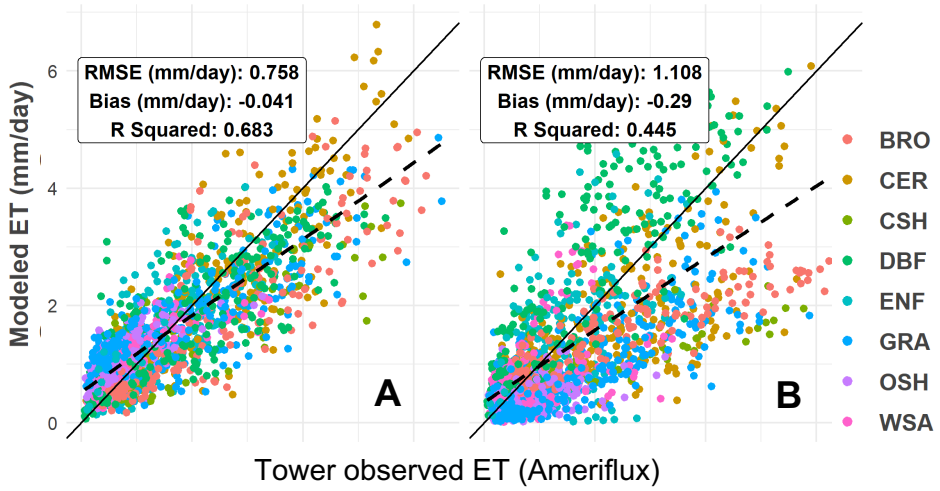
Problem: MOD16 uses Atm. vapor pressure deficit to define moisture related controls on transpiration & evaporation, while soil water supply controls affecting ET are lacking, which can lead to model errors.

Methods: **SMAP** daily surface & root zone (0-1m) soil moisture (L4SM) used to define new **MODIS** MOD16 water supply controls. Model sensitivity analysis used to clarify soil moisture (SM) influence on ET over the continental USA. ET results corroborated against tower ET observations from major regional biomes & MOD16 baseline (no SM control) calculations.

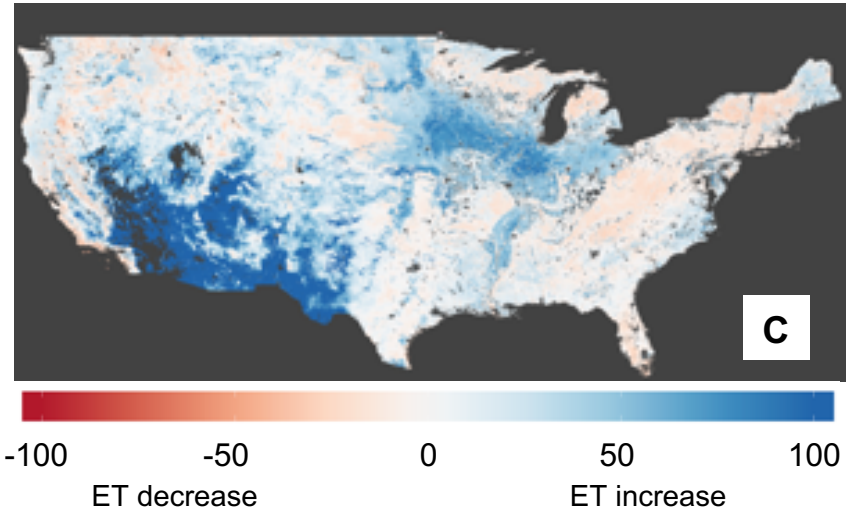
Finding: Soil moisture improves MOD16 ET accuracy by >31% (**A**) over baseline (**B**). Model ET improvements & associated SMAP influence is larger in more arid climates (**C**).

Impact: New framework for understanding soil & atmospheric moisture controls on ET.

MOD16 accuracy with (**A**) & without (**B**) SM control



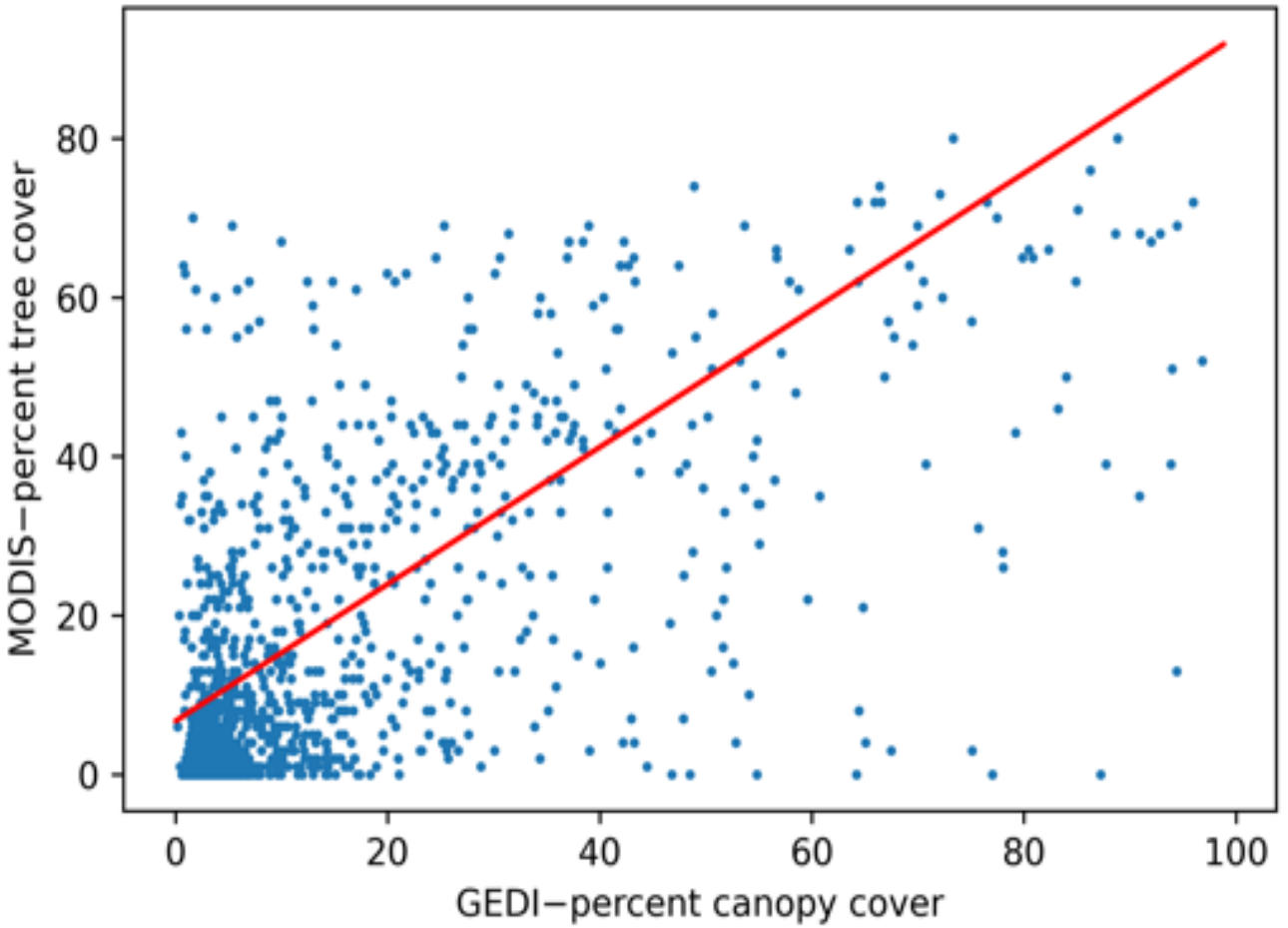
Soil Moisture Impact on MOD16 Annual ET (%)



MODIS Vegetation Continuous Fields Validation using GEDI Data

Charlene DiMiceli, Robert Sohlberg
University of Maryland, Geographical Sciences

- To evaluate MODIS Vegetation Continuous Fields (VCF—MOD44B) product accuracy, we compared VCF tree cover outputs with canopy cover from the GEDI L2B products.
- We restricted the validation dataset to MODIS pixels containing five or more high quality GEDI retrievals, then averaged the canopy cover samples falling into each MODIS pixel. This resulted in validation data > 1.5 million pixels.
- Linear regression comparing MODIS canopy cover values with those from GEDI gives an R^2 value of 0.53. Bias in the higher values is partially due to GEDI retrievals over buildings, which we have not yet eliminated from the data. Variability about the regression line is also expected since GEDI footprints cover approximately 1% of each MODIS pixel in the validation dataset.

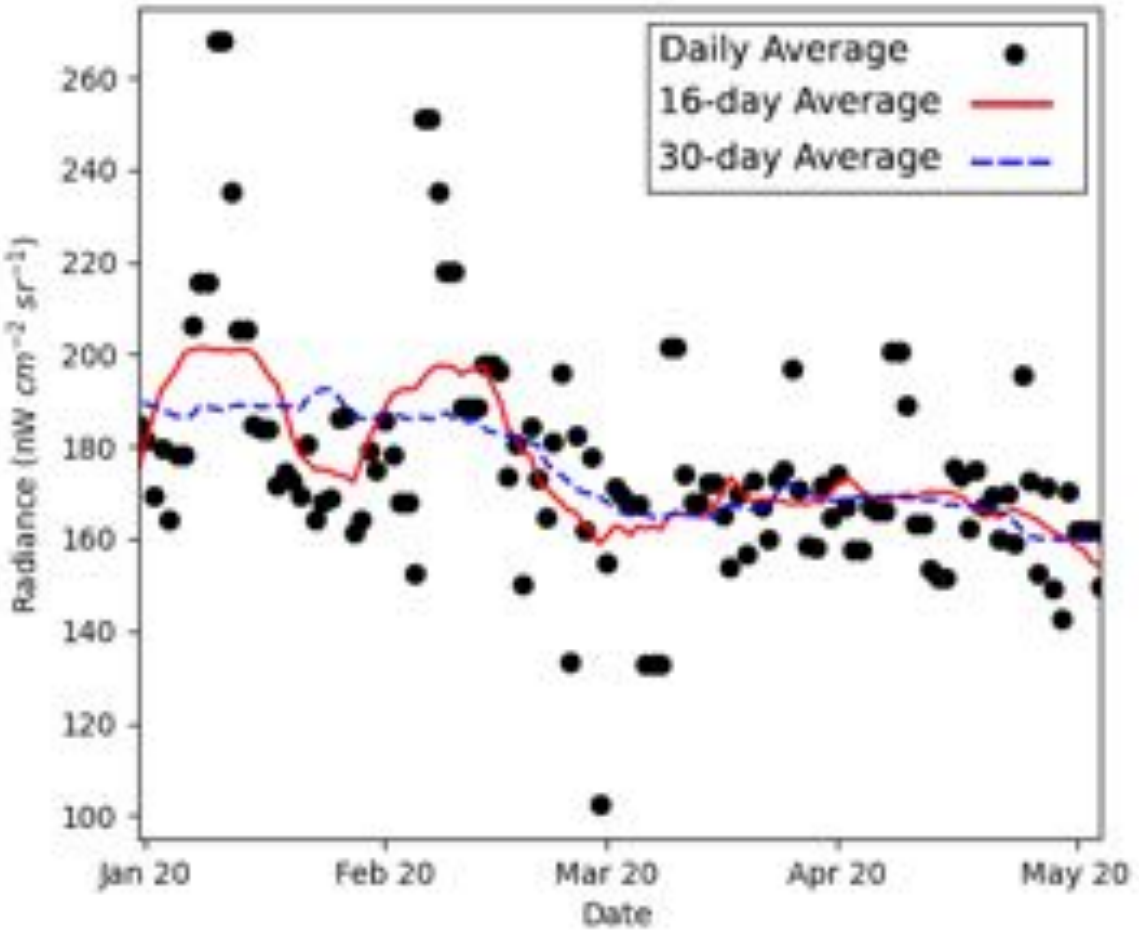


EARTHDATA
COVID-19 Dashboard BETA

INDICATOR
Nighttime Lights

NASA's Black Marble Product (VNP46)

Beijing, China



https://earthdata.nasa.gov/covid19/indicators/bm

ARSET Training: Introduction to NASA's Black Marble

Key Objectives:

- Understand the new capabilities of NASA's Black Marble product suite.
- Learn the basics of how to acquire information in Black Marble nighttime lights data.
- Interpret Black Marble science data sets (SDS), quality flags, and create time-series results.
- Apply products in topics relevant to the UN Sustainable Development Goals (SDGs), e.g. : tracking urbanization, disaster recovery, and electrification.

https://appliedsciences.nasa.gov/join-mission/training/english/introduction-nasas-black-marble-night-lights-data

Summary

- **NASA Earth Sciences has a unique global reputation for science quality instruments, data and products**
  - The MODIS/VIIRS Land continuity products contribute to this reputation for science quality time-series data records.
- **The Land Science Investigator-led Processing System model is robust and sustainable**

  Peer Reviewed Products, Peer Reviewed Algorithms, Production and QA Team, Science Team Coordination

  I. Open communication and coordination among the instrument, science, and data processing teams;
  II. A commitment to on-orbit calibration and instrument characterization, including spacecraft maneuvers, incorporated into continual Level-1 algorithm updates;
  III. Evolving science-driven algorithms with full-record data reprocessing collections;
  IV. Agility for reconfiguration and redirection of resources; and
  V. A capacity for generating of experimental research products, recognizing and responding to the diversity of users and their needs.
- **There is a strong case for NASA to continue to provide Data Continuity stewardship for a Long-Term record of daily coarse resolution science-quality data products**
- **A long-term affordable implementation strategy needed to sustain the NASA coarse resolution data records using the JPSS instruments (>2038)**
  - Discussion needed with NASA Program Management on the strategy