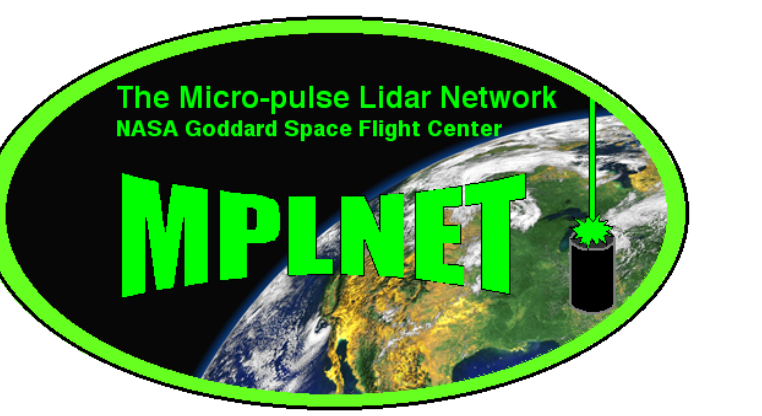


The NASA Micro Pulse Lidar Network (MPLNET): Introduction of the new Version 3 release



Ellsworth J. Welton¹, J. R. Campbell², J. Lewis Jr.³, S. Lolli⁴, S. Stewart⁵, and L. R. Belcher⁵

Abstract:

The NASA Micro-Pulse Lidar Network (MPLNET) is a global federated network of polarized Micro-Pulse Lidar (MPL) systems running continuously. MPLNET began in 2000, and there have been over 70 sites deployed worldwide, with 24 sites currently active and a few more planned over the next year. Seven of the long-term sites have 10+ years of data, and many more have 5+ years. Most sites are co-located with AERONET providing joint data on column and vertically resolved aerosol and cloud information. This presentation will introduce our new Version 3 MPLNET data. All sites in the network now feature eye-safe polarized backscatter MPL instruments, providing information on attenuated backscatter and particle shape. In addition to change with our signal data, we have an enhanced cloud product suite, a new PBL height product, and inclusion of the new AERONET lunar aerosol optical depth into MPLNET aerosol retrievals. A new quality flag process will be used to better describe all data products. Finally, a new data portal will provide near-real-time (NRT) access to all data products, including new quality assured NRT L1.5 products. Custom products developed for model specific applications will also be provided.

Version and Product Descriptions:

There have been three Versions of MPLNET data. Detailed information is available on our website.

- Version 1: 2000 – 2006. MPL Model 2 & 3
- Version 2: 2006 – 2015. MPL Model 3 & 4
- Version 3: 2015 – current. MPL Model 4 (Polarized), limited support for the miniMPL

Each successive Version has introduced new MPL models and data products. All older data are reprocessed in new Version releases, ensuring continuity in the multi-decadal data set. Table 1 lists the Version 3 Product Suite.

Table 1: MPLNET V3 Product Suite

V3 Product	Descriptions
NRB	Lidar signals; volume depolarization ratios; diagnostics
CLD	Cloud heights; thin cloud extinction and optical depths; cloud phase
AER	Aerosol heights; extinction, backscatter, and aerosol depolarization ratio profiles; lidar ratio
PBL	Surface-Attached Mixed Layer Top and estimated AOD
Product File Formats	
Formats	MPLNET V3 products are NETCDF 4, CF compliant files. Subsets for each product may be selected to reduce file sizes.

MPLNET products follow the modified EOS convention originated by AERONET: Level 1, Level 1.5, and Level 2. Contrary to standard EOS conventions, our Level 1 data contain both calibrated-measured and retrieved variables. Our product levels are abbreviated as L1, L1.5, and L2. Table 2 describes our product levels in detail. L1 and L1.5 are all available in near real time (NRT).

Table 2: MPLNET V3 Product Levels

Product Levels	Availability	Calibration	QA Screen	Ancillary Input
L1_NRB	Automated Browse: Near Real Time Download: Next Day *	initial, ongoing field calibrations	none	GEOS5 Forecast NRT, reprocessed next day with GEOS5 Assimilated, AERONET L15 AOD
L1_CLD				
L1_PBL				
L1_AER	Automated Browse: Near Real Time Download: Next Day *	initial, ongoing field calibrations	L1.5	GEOS5 Forecast NRT, reprocessed next day with GEOS5 Assimilated, AERONET L15 AOD
L1.5_NRB				
L1.5_CLD				
L1.5_PBL	upon request †	initial, ongoing field calibrations, post calibration, additional‡	L2	GEOS5 Assimilated, AERONET L2 AOD
L1.5_AER				
L2_NRB				
L2_CLD	upon request †	initial, ongoing field calibrations, post calibration, additional‡	L2	GEOS5 Assimilated, AERONET L2 AOD
L2_PBL				
L2_AER				

* Near real time data can be provided to site partners and forecasting/modeling centers
 † L2_AER products subject to availability of L2 AERONET data
 ‡ Additional L2 calibrations may include corrections for instrument temperature and manual inspection of data

MPLNET Levels are differentiated by the application of quality assurance (QA) screens. Product specific QA Flag variables are present in all products and are used to determine the QA criteria to pass each level QA screen. Level 1 products have no QA screen applied, and all data are provided. QA screens are applied for all products at Level 1.5 and 2. A summary of the QA Flags and screening criteria are provided in Table 3. All products have three potential QA confidence levels: high, moderate, and low. Data that fail a given product QA screen are replaced with NaN. Detailed descriptions of the QA criteria and process are available on our website under the Product Information link.

Table 3: MPLNET V3 QA Confidence Levels

QA Confidence Level	Value	Descriptions
n/a	0	Only set if variable has no QA inspection applied.
High	1	Long history with variable and QA procedures results in high confidence
Moderate	2	Lower confidence in an ancillary data input results in lower overall QA confidence
Low	4	Reserved for variables that are new and require more study to elevate confidence
Fail	8	Data fail QA screen, variable data replaced with NaN

Figure 1 shows the primary MPLNET instrument: the polarized MPL and its deployment containers. The provisional polarized miniMPL is also shown, but only supported for Level 1 and 1.5 data at this time.

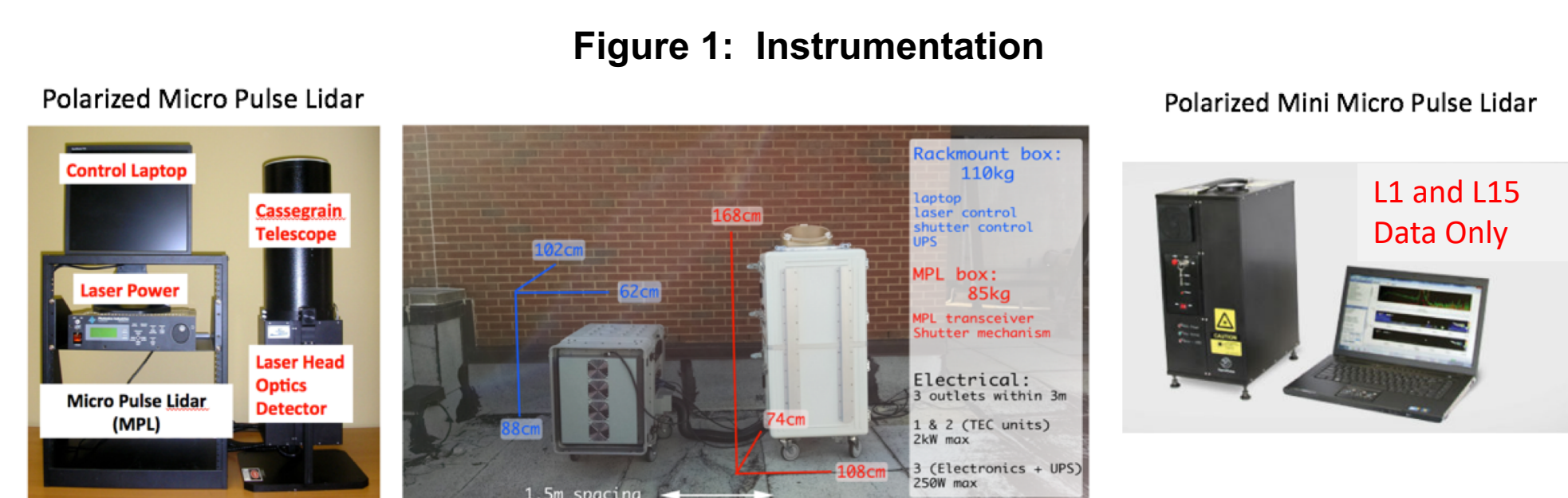
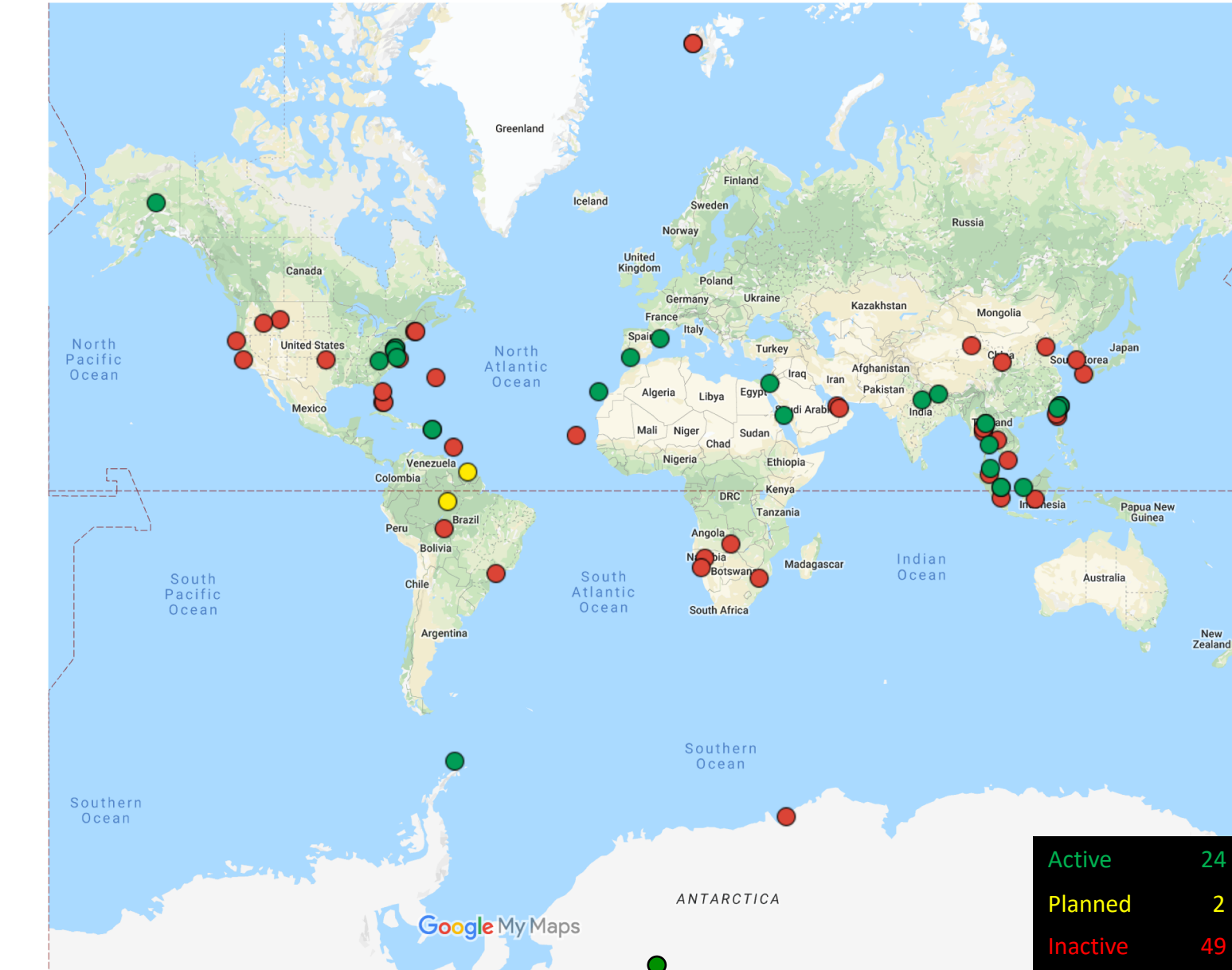
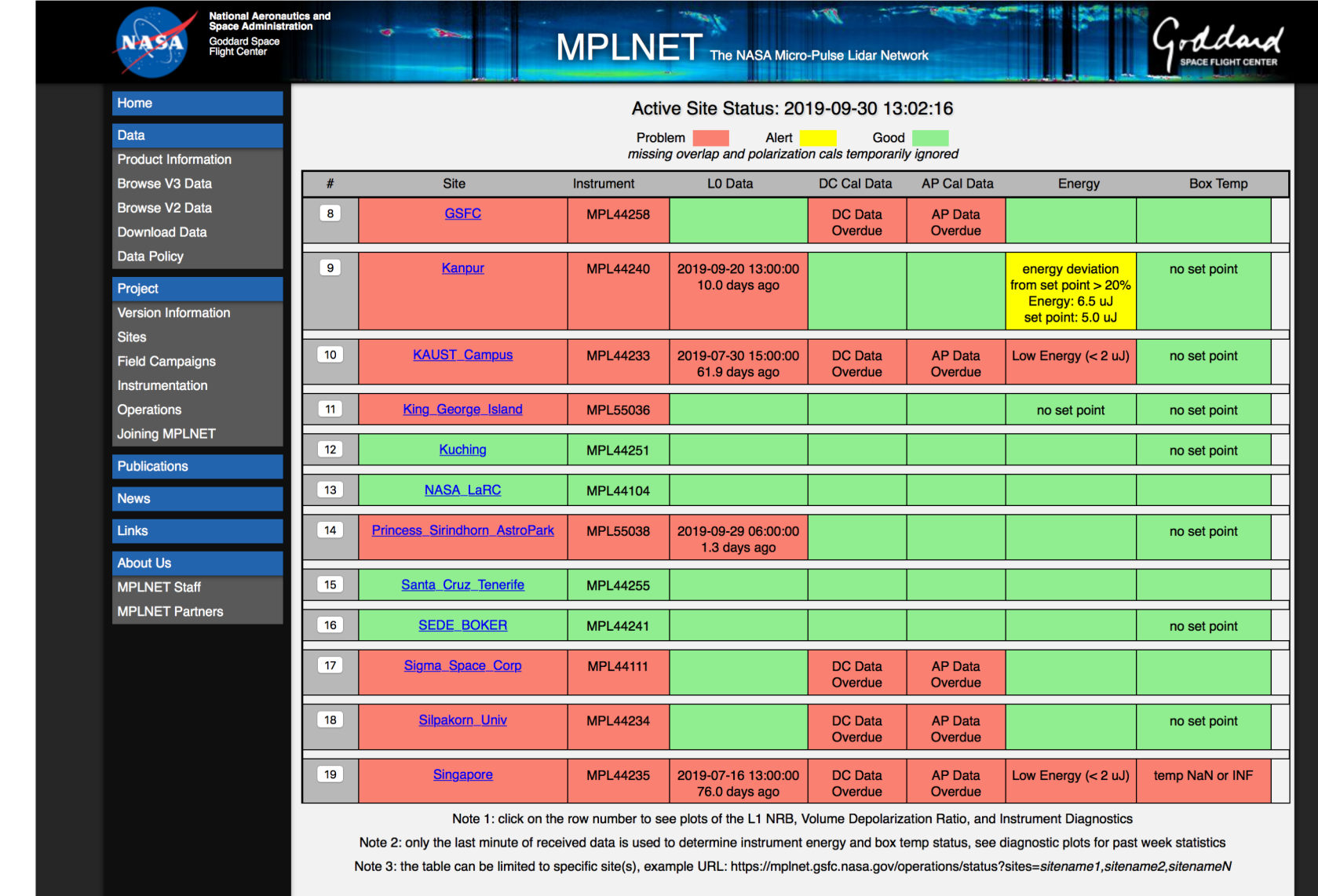


Figure 2: MPLNET Sites 2000 - Current



MPLNET Website: mplnet.gsfc.nasa.gov

Figure 3: MPLNET Site Status & Alert System



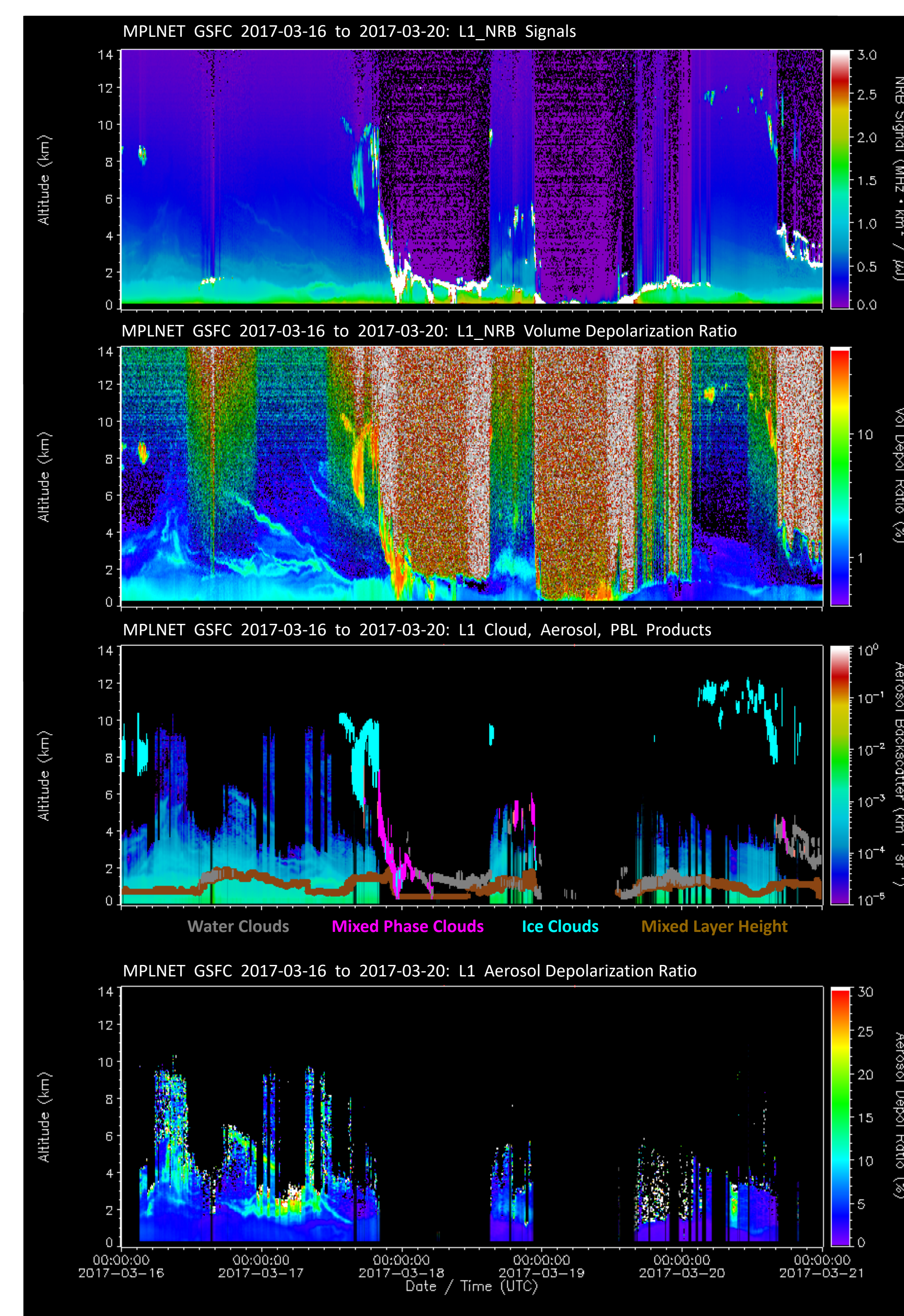
The MPLNET data center is configured for interoperability with other data centers, including linkable real-time data plotting, and an online data file portal for manual or automated data file downloads (wget/curl accessible). Files are NETCDF-4 and contain all necessary metadata, product variables, diagnostics, and QA flags.

Network:

Figure 2 displays all network sites from 2000 to current. The exact number of active, planned, and inactive sites changes over time (sites shown may not be current). A typical year has ~20 sites running concurrently, including both long-term and field experiment sites. MPLNET is a member of the WMO GAW Aerosol Lidar Observation Network (GALION), and any apparent observation gaps in Europe, East Asia, and South America in particular are covered by other regional networks in GALION (with some overlap).

MPLNET V3 introduces a new automated site status and alert system to monitor instrument health, data communications, and data quality parameters (Fig 3). In addition, all automated real-time processing and reprocessing tasks are tracked and controlled via a multi-threaded processing system with online monitoring and logging to ensure our hourly NRT schedule is maintained.

Figure 4: MPLNET V3 Product Examples



Data Product Examples and Results:

MPLNET has produced and contributed to over 100 peer reviewed publications in the fields of aerosol and lidar research, lidar instrumentation and techniques, boundary layer studies, satellite cal/val, and a few other diverse areas such as blowing snow and cloud screening for neutrino detectors (see our website for citations). The new V3 products provide an enhanced data set for future research. Notable new product variables include: cloud phase, nighttime aerosol profiles from lunar AOD constraints (considered provisional from AERONET), and mixed layer height (~boundary height). Finally, many of our sites now have 10+ years of data (or are approaching this milestone), which will allow us to provide climatological data sets.

Figure 4 displays examples of MPLNET V3 L1 data products from a GSFC from March 16-20, 2017. GSFC is a mid-latitude site along the US Eastern coast and represents a typical mid-latitude continental data set. The top two panels show the NRB lidar signal and volume depolarization ratio (VDR) profiles. The VDR provides a measure of particle shape, with low VDR indicating more spherical particles and high VDR non-spherical. Ice cloud layers are routinely detected in the mid to upper troposphere from winter to summer. GSFC is not along strong dust advection pathways but does see some dust during summer. Smoke from North American fires is fairly routine outside winter, and during recent years increasing occurrences of intercontinental smoke have been detected in the mid-troposphere. Other sites in the network are routinely impacted by dust, smoke, and turbid urban environments, in addition our sites span from the tropics to the South Pole providing an expansive latitudinal cloud data set.

Figure 5 displays an example of the usefulness of diurnal climatologies available from MPLNET. The evolution of the surface mixed layer from winter to summer at GSFC is shown, along with the corresponding trends in total column vs mixed layer AOD. There is a residual free tropospheric AOD of about ~0.05 due to transported aerosols during winter. Such information is valuable for air quality studies and assessments.

Figure 5: MPLNET V3 Diurnal Climatologies

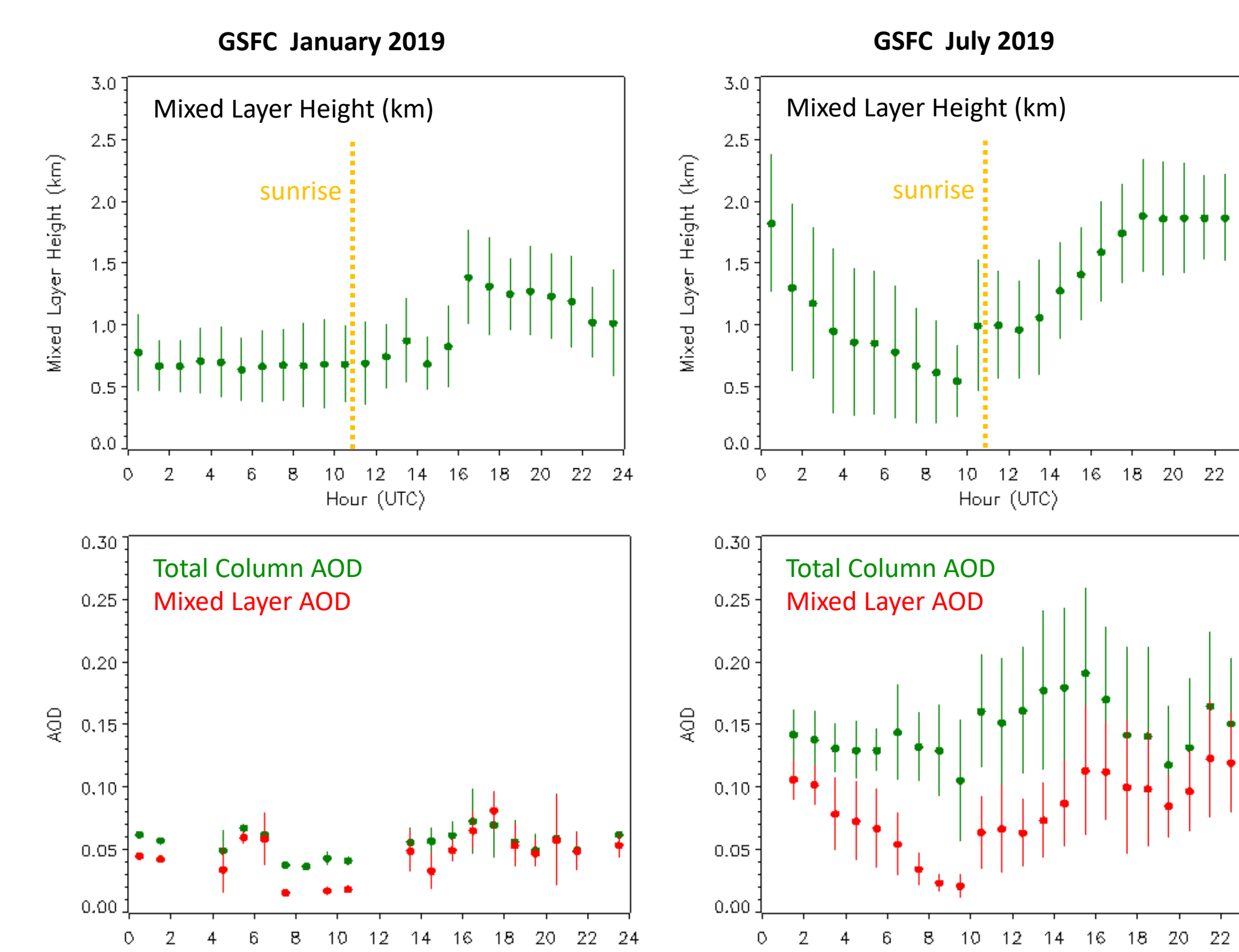


Figure 6: MPLNET V3 Example of L15 QA and use of new Lunar AOD. GSFC 2019 Aerosol Product L1 vs L1.5 Sun vs Lunar AOD Results

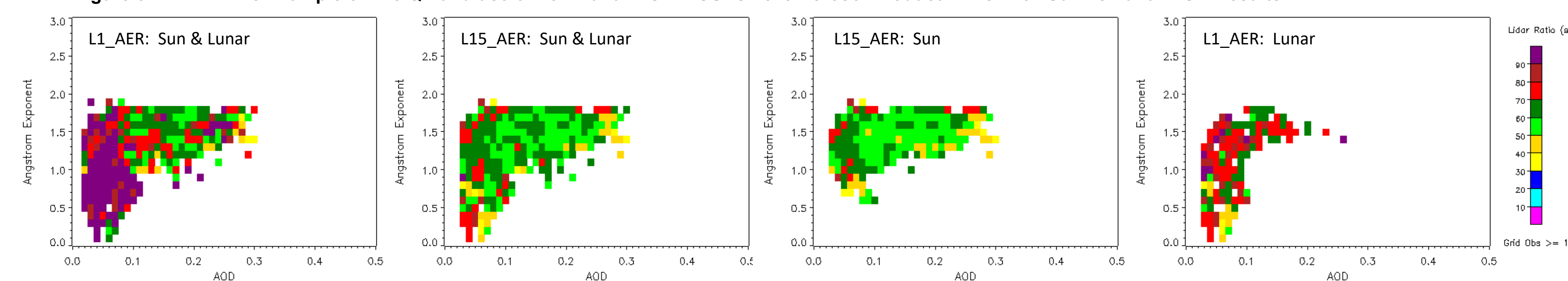
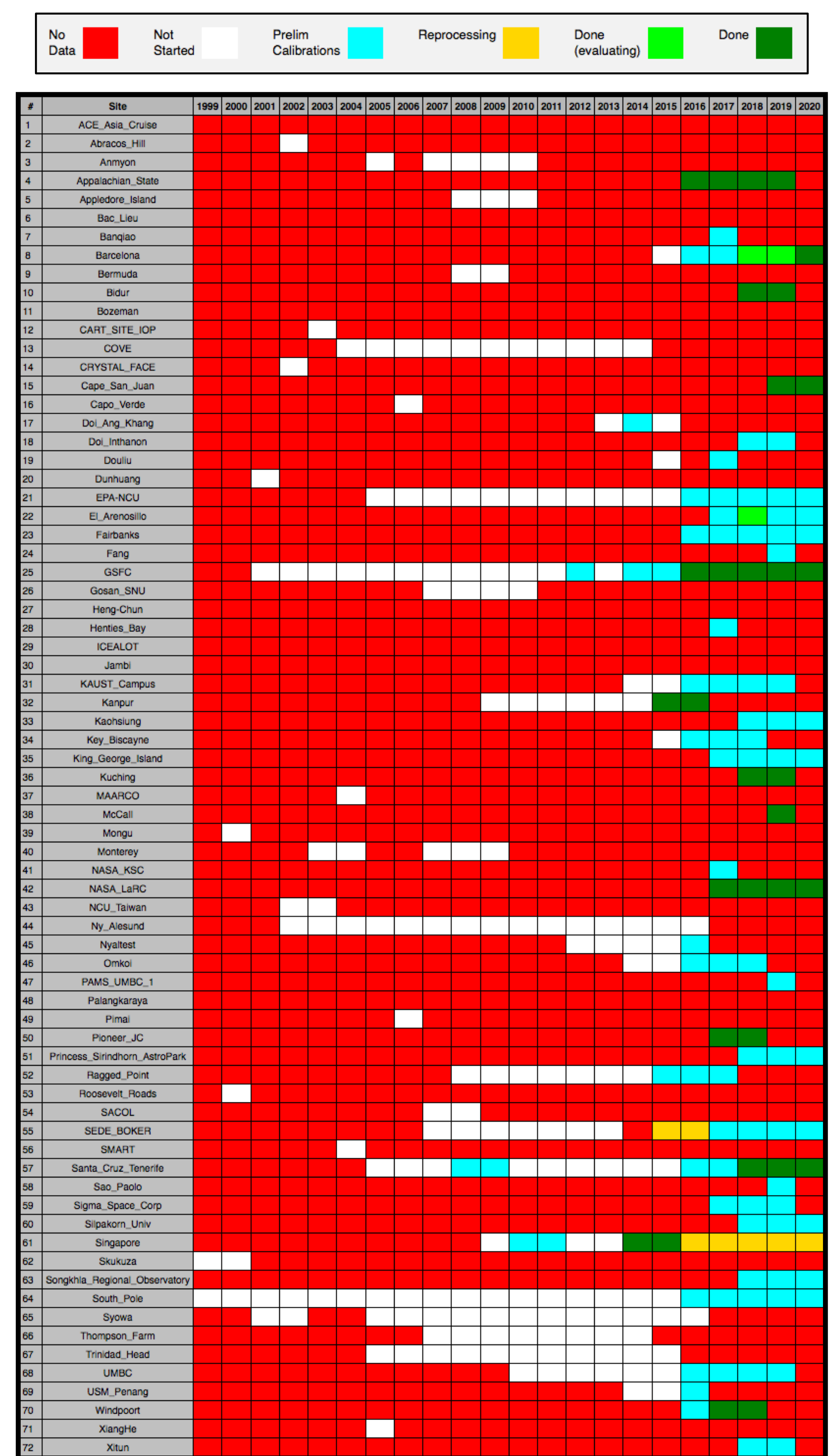


Figure 6 shows the results of the aerosol L1.5 QA screen. Lidar ratios above 90 sr usually indicate failed retrievals (outside cases of very strong smoke). The L1.5 aerosol data are typical for a mid-latitude continental site.

The new sun vs lunar photometer derived data indicate that more work is needed to understand the (provisional) lunar results. The differences could be calibration related or indication of strong day/night aerosol changes.

Table 4: V3 Reprocessing Status (as of Jan 6, 2020)



Version 2 Era: 44,431 days (files) of data
V2 Data Products Available on website

V3 Reprocessing Status:

Development of all V3 data products was completed in December 2019, and Version 3 reprocessing started on Dec 18, 2019. Table 4 displays the status of reprocessing as of January 6, 2020.

Data from 1999 to 2015 were acquired during the V2 era. Most of the data were processed and the older V2 product files are available for download on our website. This data will be easily reprocessed in V3 since the calibrations and evaluations are already done.

The V3 data portal on our website will open to the public in January 2020, in the meantime all data are viewable using our online browsing tools. Only final data will be available for download (not those in evaluation or prelim calibration status). The reprocessing of all 20 years of MPLNET data will be completed later in 2020.

Contacts: Ellsworth.J.Welton@nasa.gov

1. NASA Goddard Space Flight Center, Code 612, Greenbelt, MD, 20771
2. Naval Research Laboratory, Code 7544, Monterey, CA, 93943
3. University of Maryland Baltimore County JCET, GSFC Code 612, Greenbelt, MD, 20771
4. CNR, Istituto di Metodologie per l'Analisi Ambientale, 85050 Tito Scalo, Potenza, Italy
5. SSAI, Goddard Space Flight Center, Code 612, Greenbelt, MD, 20771

Acknowledgements:

The MPLNET project is funded by the NASA Earth Observing System and Radiation Sciences Program. Additional support is provided by the institutions and funding agencies of our international partners.