



# Evaluation of AERONET AOD Measurements in the Version 3 Database

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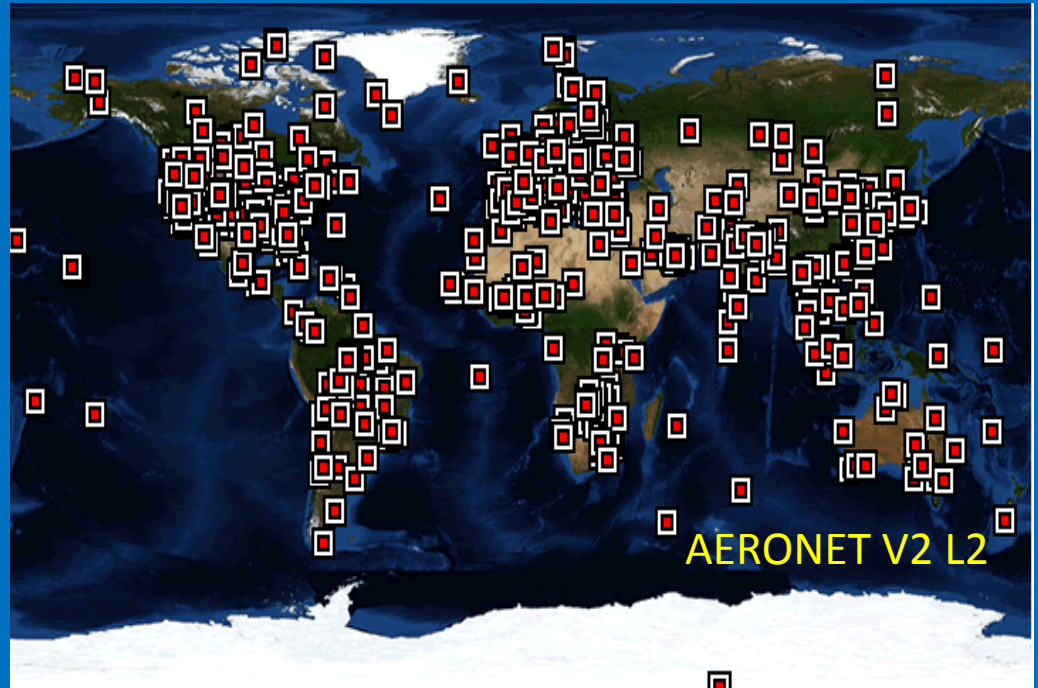
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<sup>3</sup> Universities Space Research Association

Yoram Kaufman Memorial Symposium  
NASA GSFC

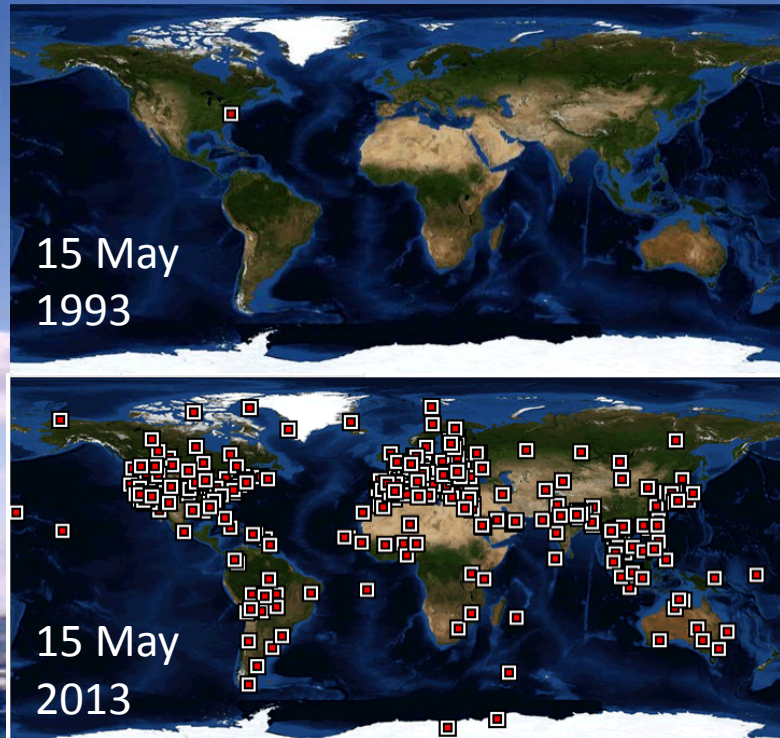
# Outline

- Need for Higher Quality NRT AOD
- Cloud Screening
- Quality Controls
- NRT AOD Results
- Outlook and Summary



<http://aeronet.gsfc.nasa.gov>

# AERONET Aerosol Robotic Network-Twenty Years of Observations and Research



The **AERONET program** is a federation of ground-based remote sensing aerosol networks established by NASA and LOA-PHOTONS (CNRS) and has been expanded by collaborators from international agencies, institutes, universities, individual scientists and partners.

**AERONET** provides a long-term, continuous public database of aerosol optical, microphysical, and radiative properties for aerosol research and characterization, validation of satellite measurements, and synergism with other databases.

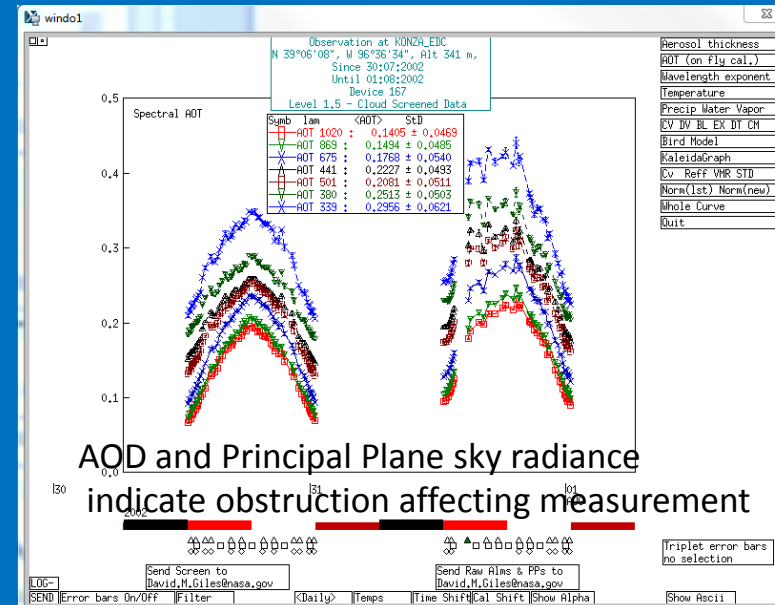
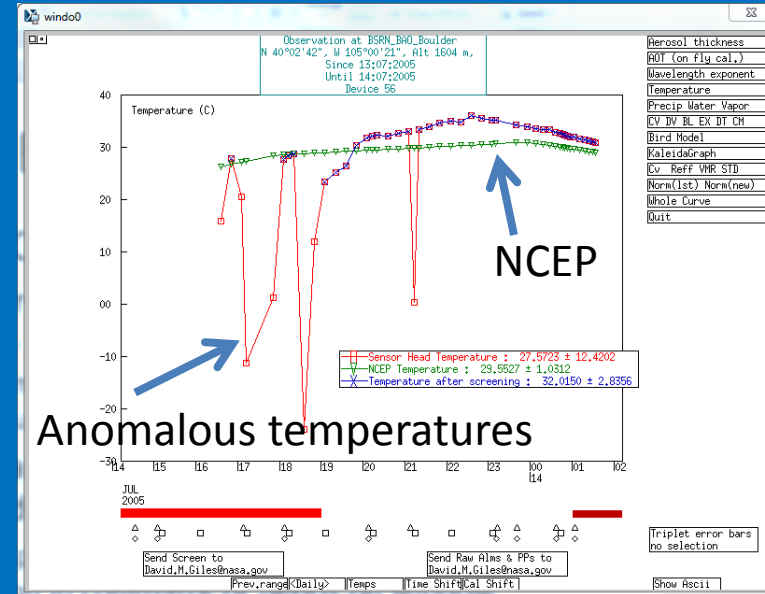
- >7000 citations
- >400 sites
- Over 80 countries
- <http://aeronet.gsfc.nasa.gov>

# Growing Need for Higher Quality NRT AERONET Data

- Satellite evaluation
  - VIIRS, MODIS, MISR, OMI, GOES, Himawari-8, Sentinel 3, GOCI
- Data synergism
  - MPLNET, SPARTANS, GreenNet
- Aerosol forecast models and reanalysis
  - GOCART, ICAP, NAAPS, MERRA-2
- Meteorological models
  - NCEP, ECMWF, GEOS-5
- Field Campaign Support
  - KORUS-AQ, ORACLES, FIREX, CAMPex

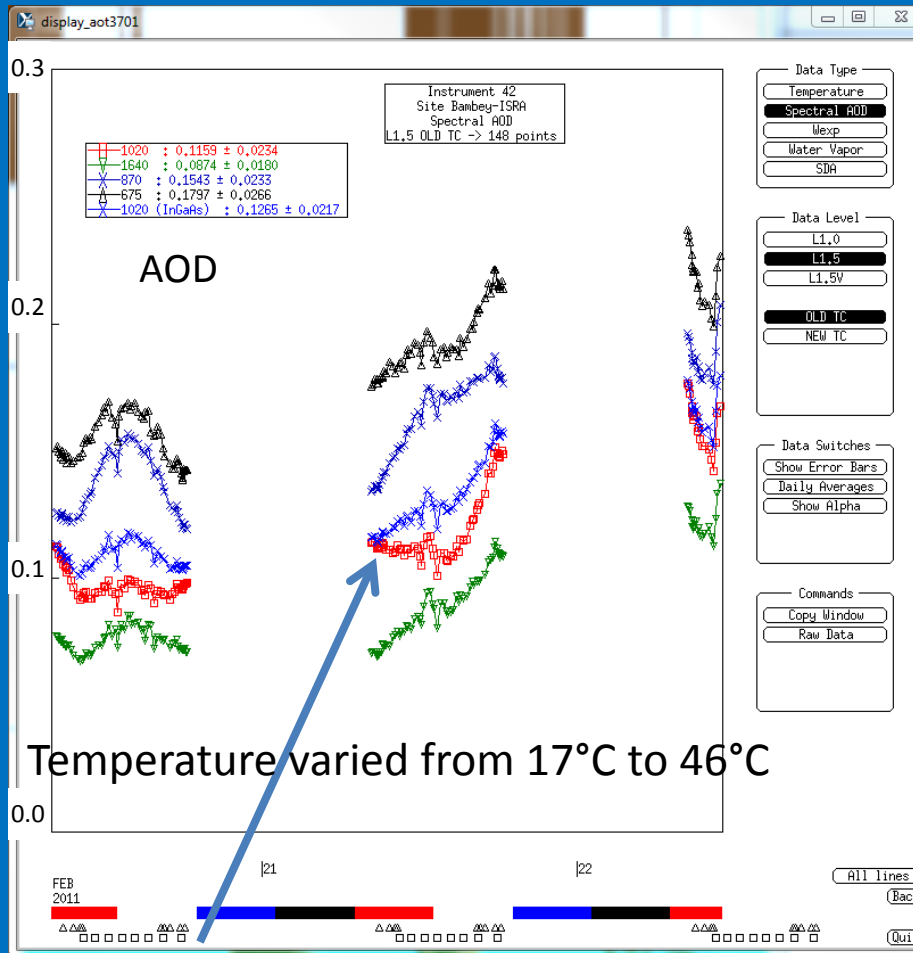
# AERONET Version 3: AOD

- V3 Level 1.0: Unscreened data (NRT)
  - Applies new temperature characterizations
  - Applies NO2 OMI L3 climatology (2004-2013)
- V3 Level 1.5: Based on Level 1.0 and uses new automatic quality controls (NRT)
  - Cloud Screening
    - Improves removal of optically thin cirrus contamination
    - Preserves more highly variable smoke
    - Compares well to Version 2 Level 2
  - Quality Controls
    - Removes sensor temperature artifacts
    - Removes AOD affected by solar eclipses
    - Removes AOD impacted by window obstructions
    - Removes AOD with poor spectral dependence
- V3 Level 2.0: Based on Level 1.5 with pre- and post-calibration applied and minimal manual intervention
  - Significantly improves timeliness of Level 2.0 data availability
  - Applies more objective removal scheme
  - Requires minimal manual analysis to remove uncommon data anomalies



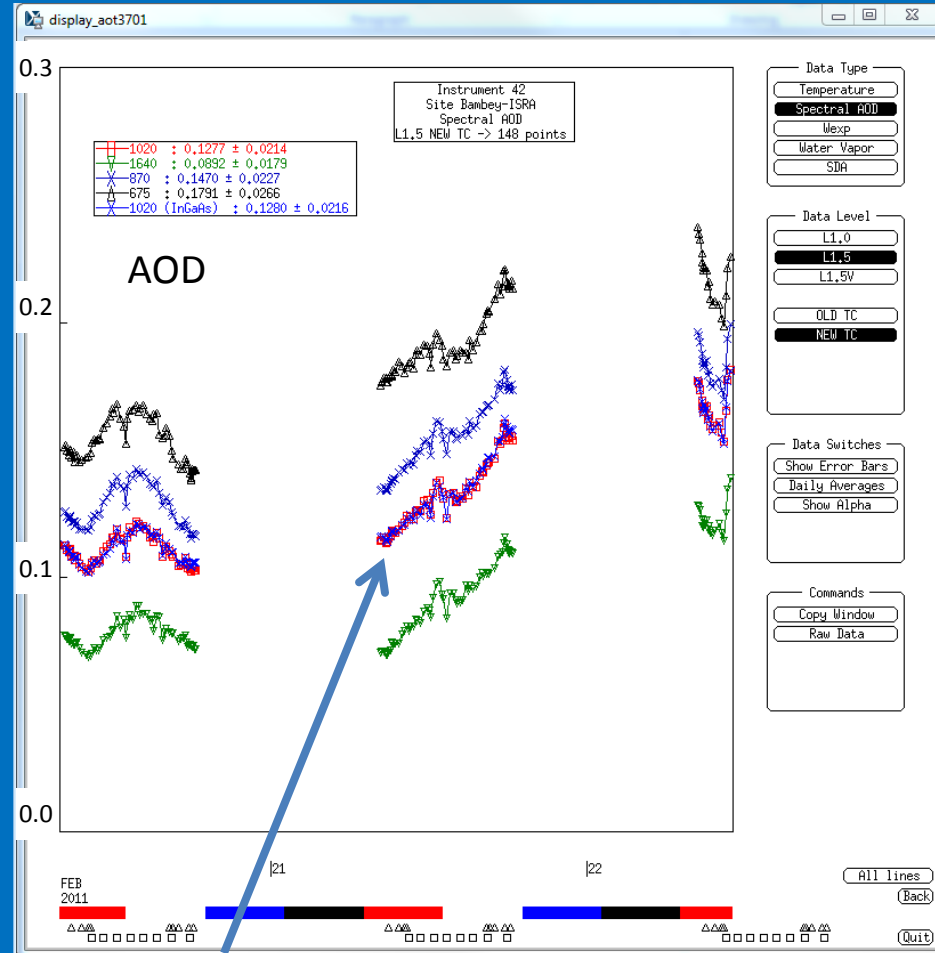
# AERONET V3: Spectral Temperature Characterization

## V2 Temperature Correction



AOD 1020nm for Silicon and InGaAs detectors do not match

## V3 Temperature Correction



AOD 1020nm Silicon matches 1020nm InGaAs after V3 temperature correction

# V2 vs. V3 Cloud Screening

Algorithm/Parameter	Version 2	Version 3
<b>Air Mass Range</b>	5 to 5	7 to 7
<b>Remaining Measurements</b>	$N < 3$ , reject day	After all checks applied, reject day if $N_{\text{remain}} < \text{MAX} \{3 \text{ or } <10\% \text{ of } N\}$
<b>Low Count Restoration</b>	N/A	If Digital Count $< 5$ , $\tau_{870\text{nm}} > 0.5$ , $\alpha_{675-1020\text{nm}} > 1.2$ or $\alpha_{870-1020\text{nm}} > 1.3$ , then restore measurement for evaluation
<b>Triplet Criterion</b>	All $\lambda$ s; AOD range $> \text{MAX}$ {0.02 or $0.03 * \tau_a$ }	$\lambda = 675, 870, 1020\text{nm}$ AOD range $> \text{MAX}\{0.01 \text{ or } 0.015 * \tau_a\}$
<b>AOD Stability Check</b>	Same as V3	Daily Averaged AOD 500nm (or 440nm) has $\sigma$ less than 0.015, then do not perform <b>3-Sigma Check</b>
<b>3-Sigma Check</b>	Same as V3	AOD 500nm and $\alpha_{440-870\text{nm}}$ should be within $\text{MEAN} \pm 3\sigma$ ; otherwise reject point(s)

# V2 vs. V3 Cloud Screening

Algorithm/Parameter	Version 2	Version 3
<b>Smoothness Check</b>	D<16	For AOD 500nm (or 440nm) $\Delta\tau_a > 0.01$ per minute, remove larger $\tau_a$ in pair
<b>Standalone Points</b>	N/A	No data $\pm 1$ hour of point, then reject it unless $\alpha_{440-870\text{nm}} > 1.0$ , then keep point
<b>Solar Aureole Radiance Curvature Check</b>	N/A	Compute curvature ( <b>k</b> ) for 1020nm aureole radiances from 3.2°-6.0° $\phi$ . If <b>k</b> < 2.0E-5, compute a slope of $\ln \mathbf{k}$ vs $\ln \phi$ . If slope is greater than 4.3 (empirically derived), then point is “cloud contaminated.” For ALM, PP, and HYB, all $\tau_a$ points will be removed in the $\pm 30$ minutes period from sky measurement.
<b>Low Count Restoration</b>	N/A	If Digital Count < 5, $\tau_{870\text{nm}} > 0.5$ , $\alpha_{675-1020\text{nm}} > 1.2$ or $\alpha_{870-1020\text{nm}} > 1.3$ , then restore measurement for evaluation
<b>Very High AOD Restoration</b>	N/A	$\tau_{870} > 0.5$ ; $\alpha_{675-1020} > 1.2$ or $\alpha_{870-1020} > 1.3$ , restore if eliminated by cloud screening

Algorithm Step Change Summary: 2 same, 4 modified, and 5 new

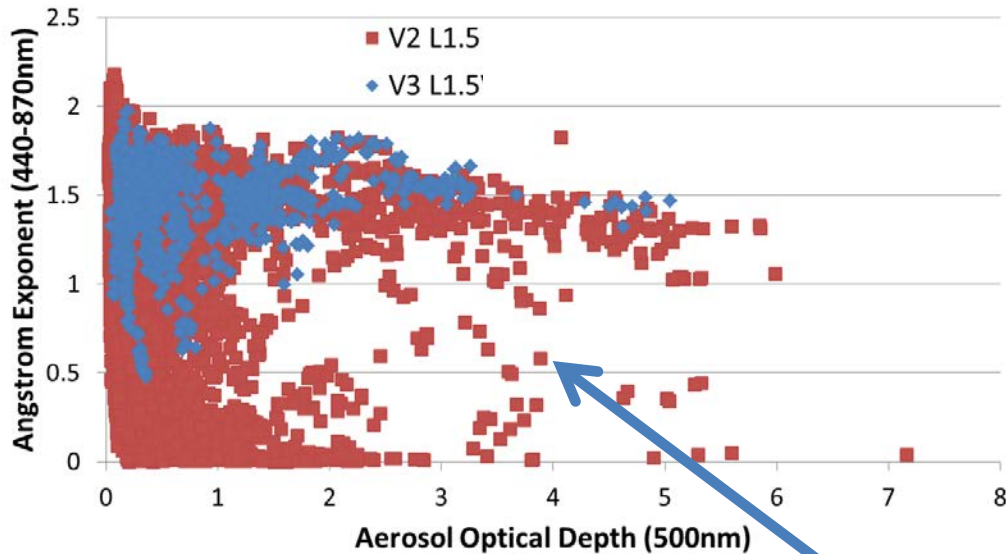


# AERONET V3 L1.5 (Cloud Screening Only)

Palangkaraya

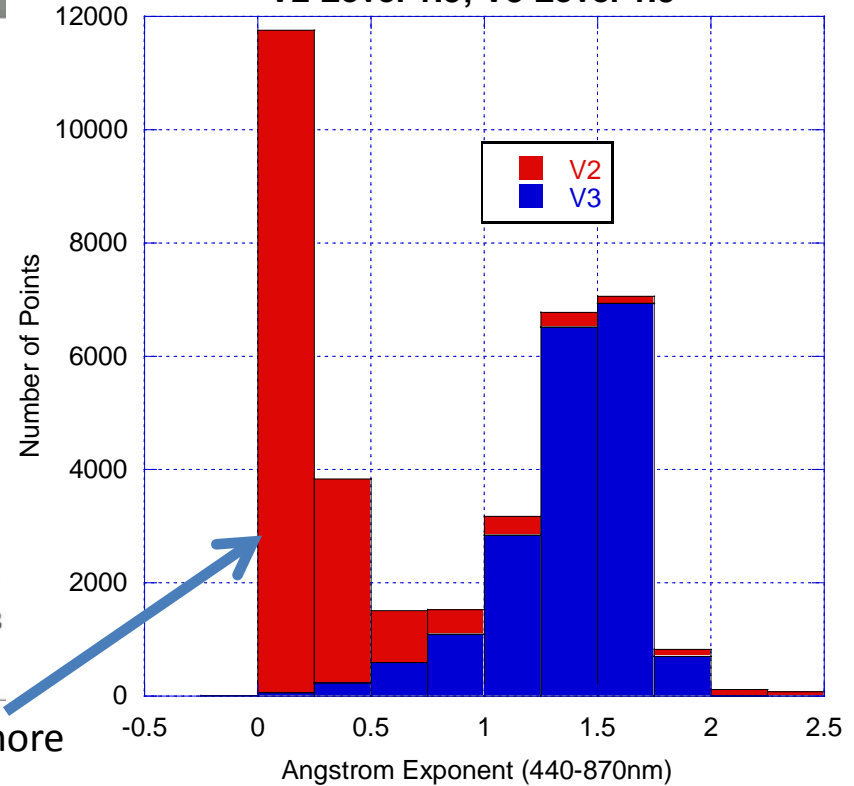


V2 vs V3: Level 1.5  
Palangkaraya, Indonesia (2012-2015)



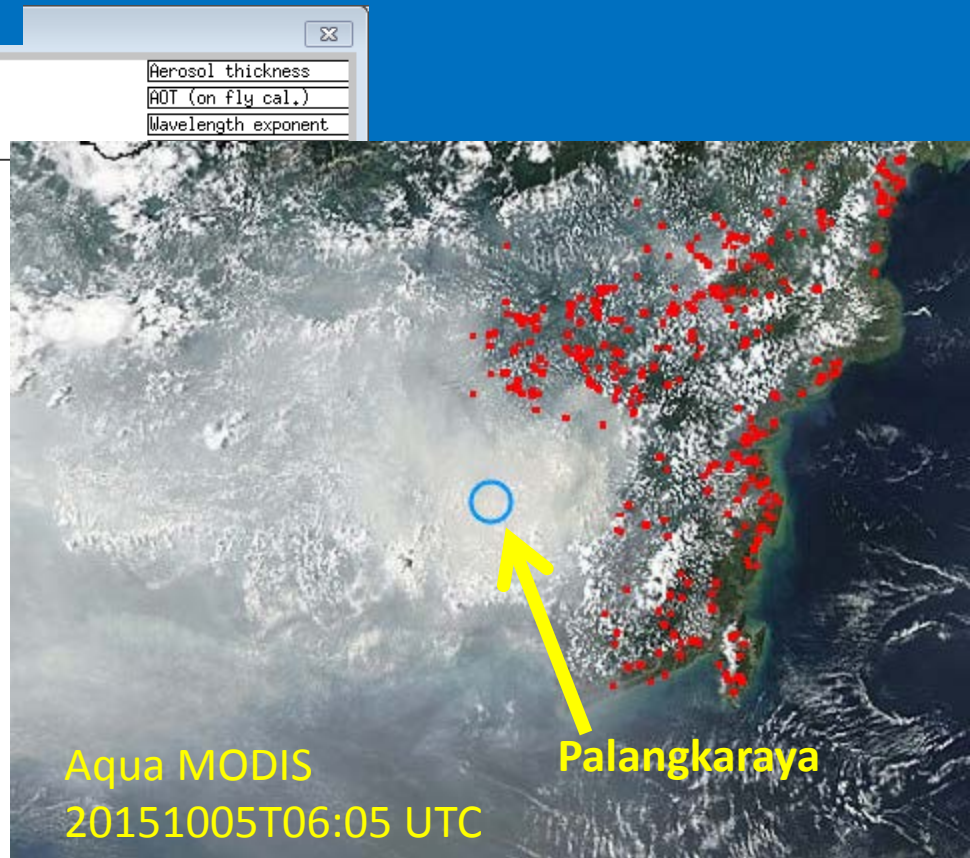
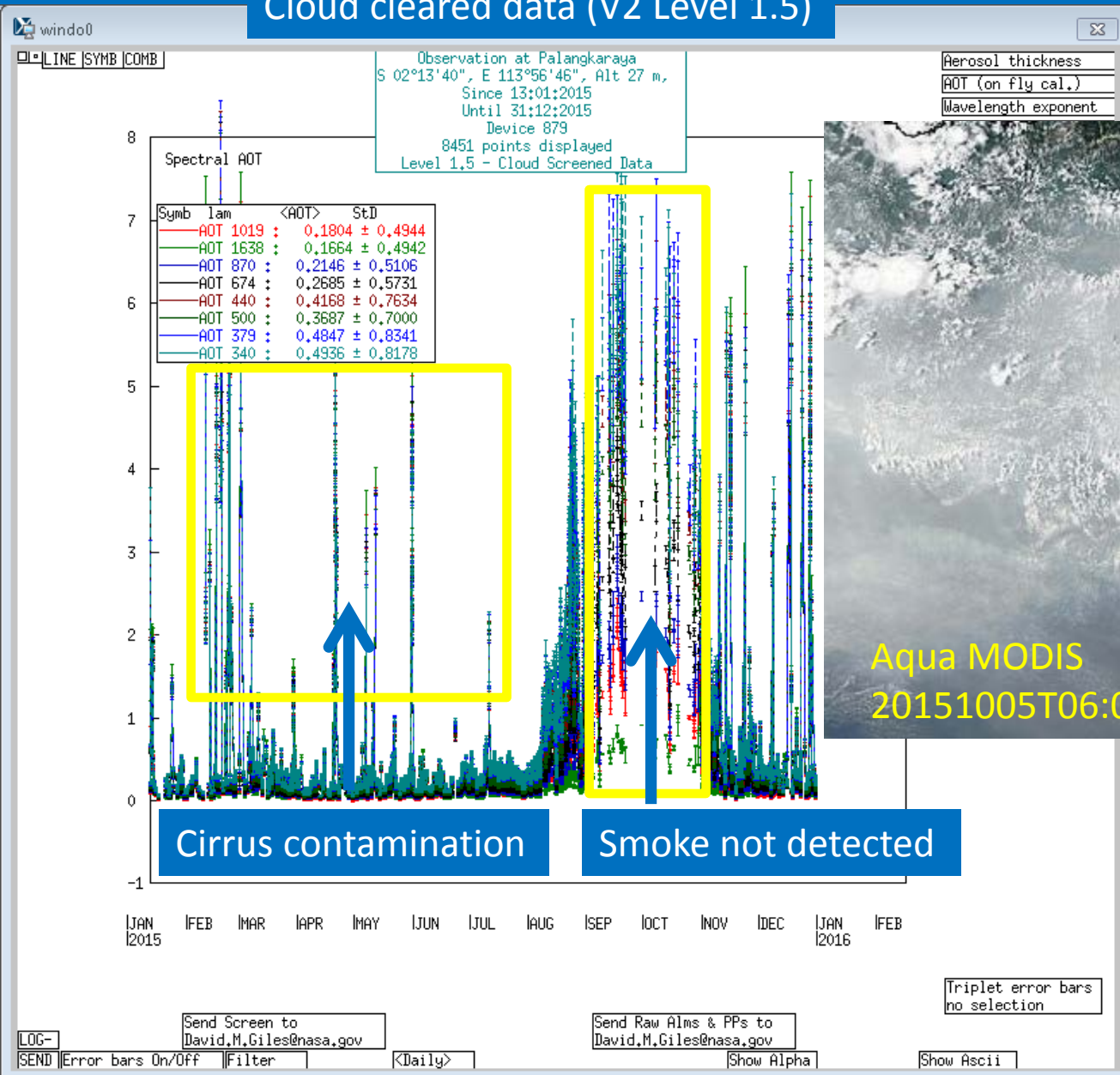
V3 removes more  
cirrus clouds

Palangkaraya, Indonesia (2012-2015)  
V2 Level 1.5; V3 Level 1.5



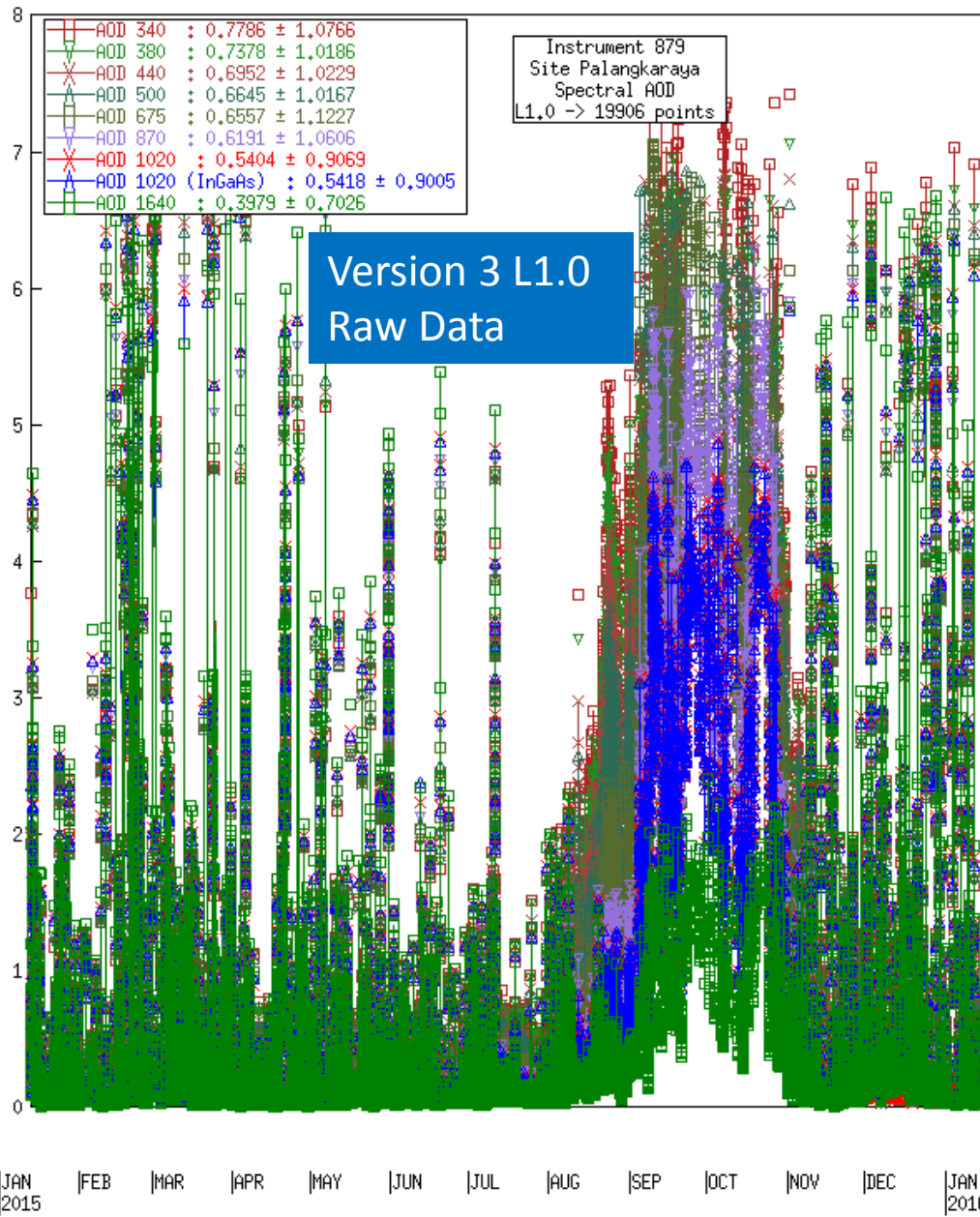
# Indonesian Fires 2015 (Palangkaraya) – Current V2

Cloud cleared data (V2 Level 1.5)



Cirrus contamination

Smoke not detected



Data Type

Spectral AOD

Wexp

Water Vapor

SDA

Data Level

L1.0

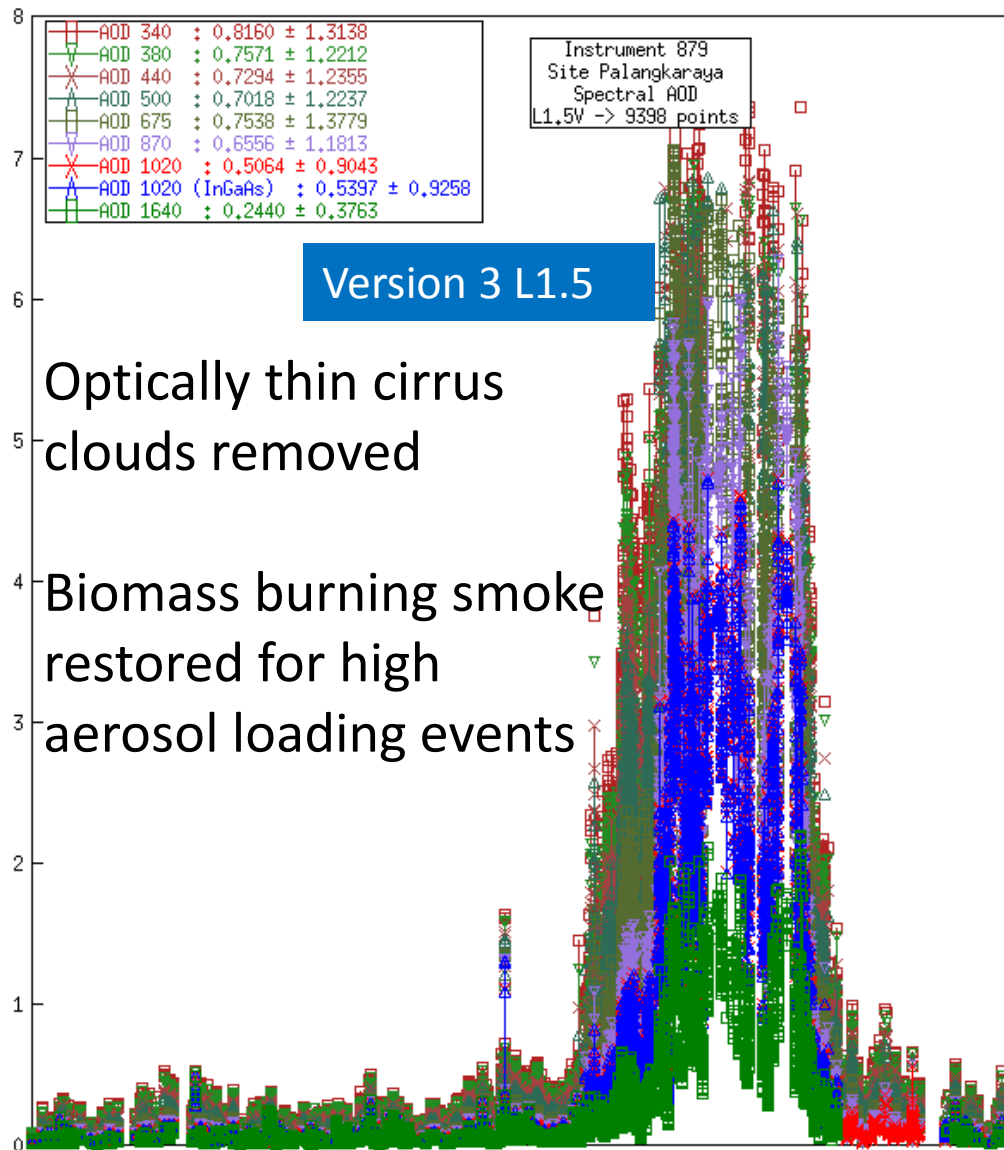
L1.5

L1.5V

Data Switches

Commands

JAN 2015 | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN 2016



Version 3 L1.5

Optically thin cirrus  
clouds removed

Biomass burning smoke  
restored for high  
aerosol loading events

Data Type

 Spectral AOD Wexp Water Vapor SDA Temp Pres Ext V PWR BLK

Data Level

 L1.0 L1.5 L1.5V

Data Switches

 Show Error Bars Daily Averages Show Alpha

Commands

| JAN  
2015

| FEB

| MAR

| APR

| MAY

| JUN

| JUL

| AUG

| SEP

| OCT

| NOV

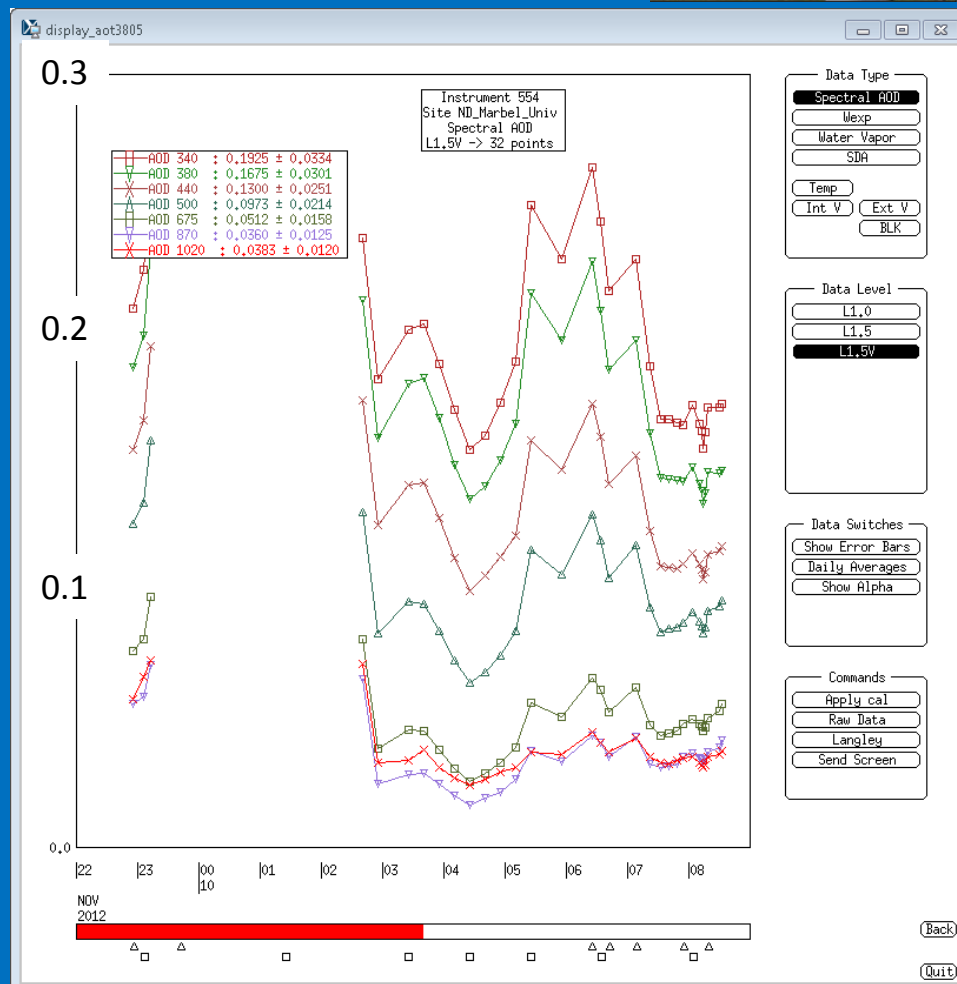
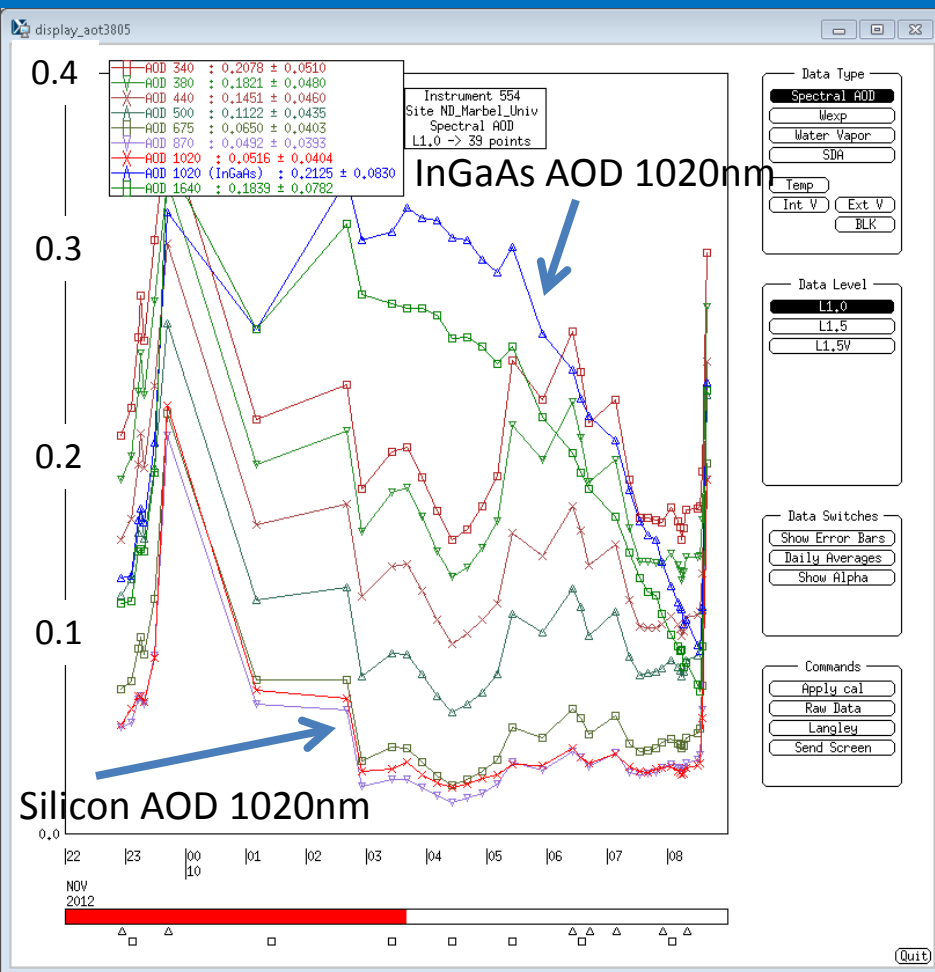
| DEC

| JAN  
2016

# Level 1.5 Quality Controls

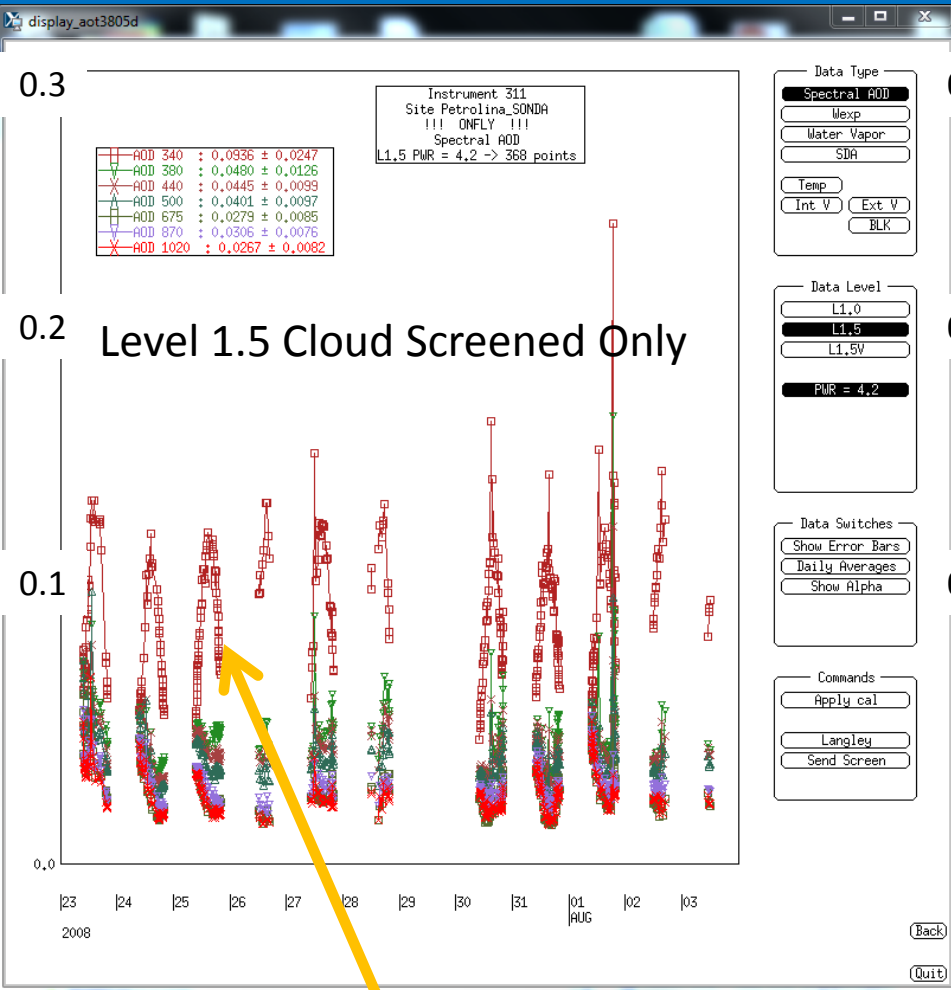
- Raw Data Checks – sensor temperature, digital counts, clock shift, etc.
- Collimator consistency checks
- AOD diurnal dependence checks
- AOD spectral dependence checks
- Solar eclipse screening

# AERONET V3 L1.5: Collimator Consistency Check

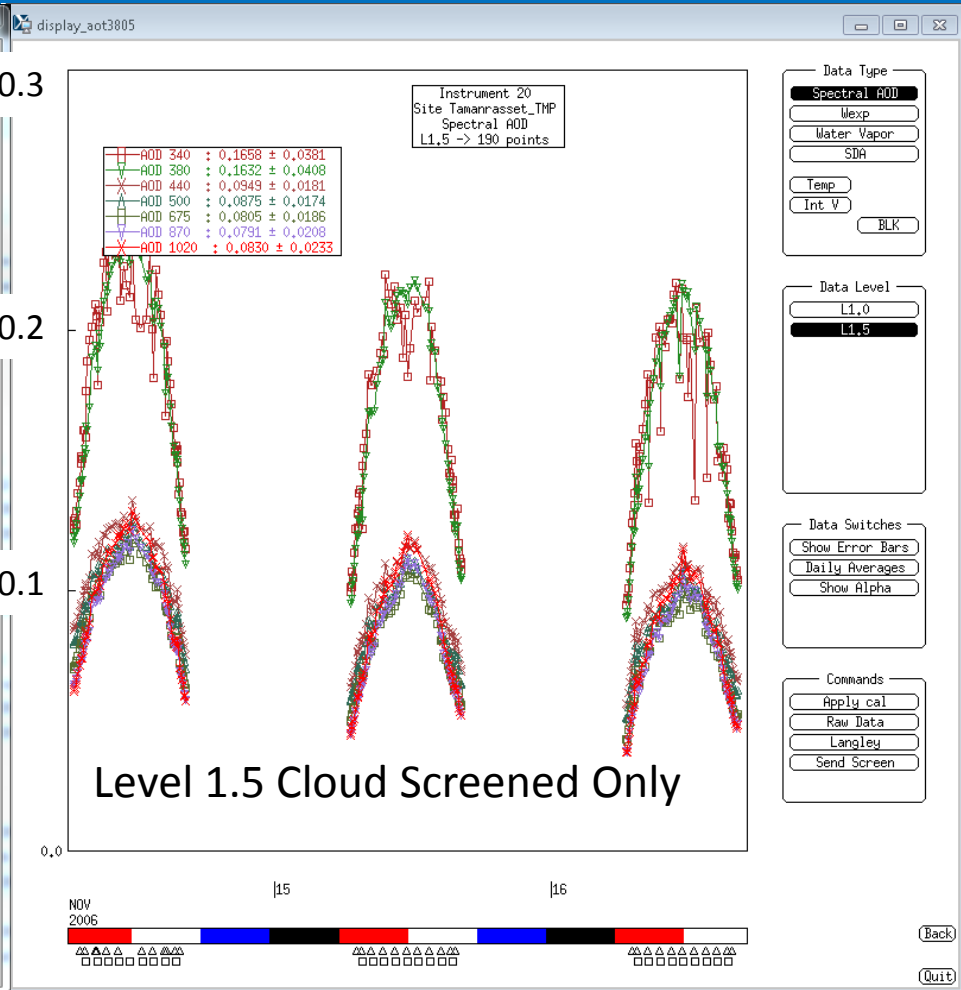


\* InGaAs Channels Removed: 1020nm and 1640nm

# AERONET V3 L1.5: AOD Diurnal Dependence



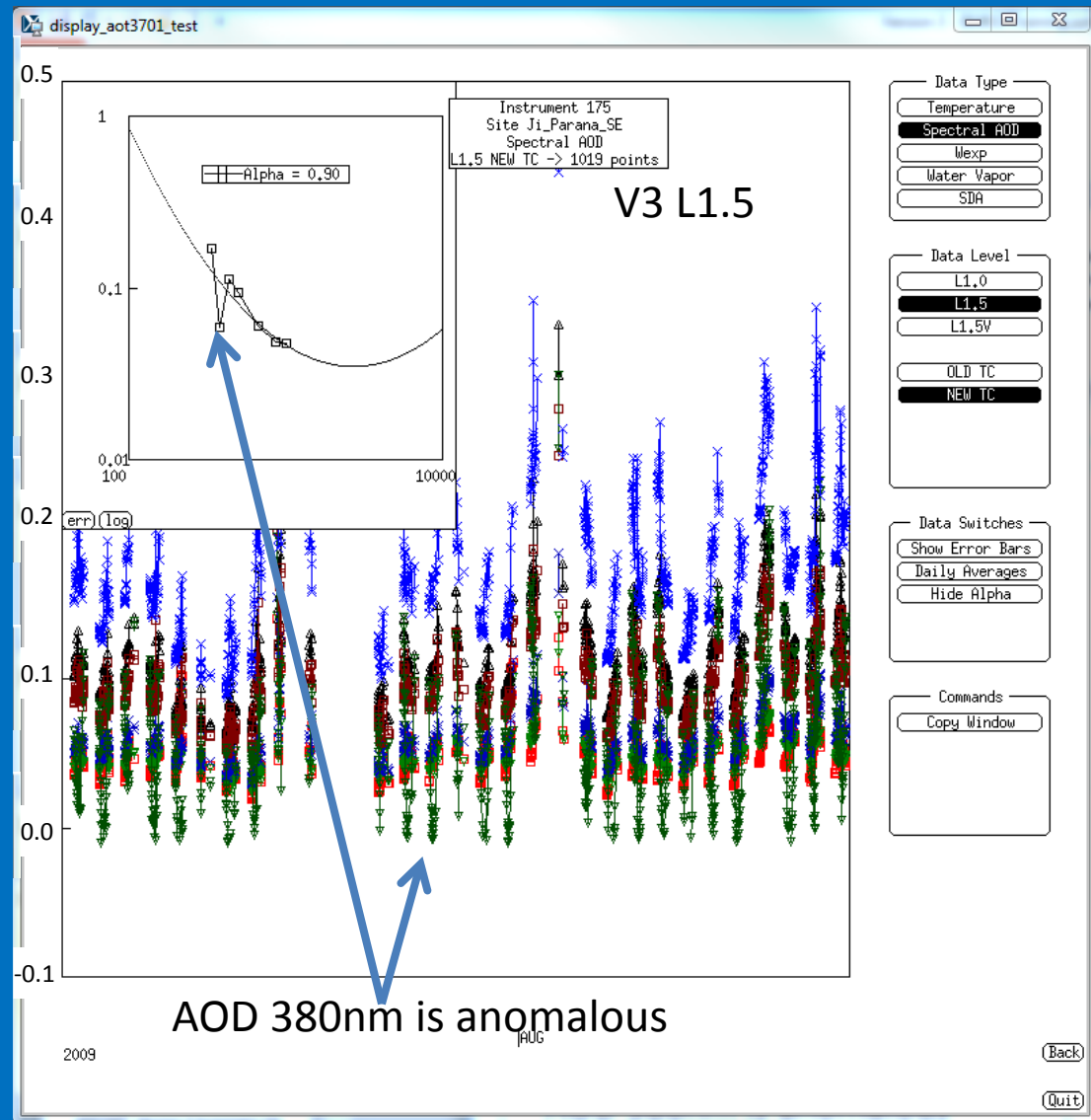
Only AOD 340nm data removed



All spectral measurements removed

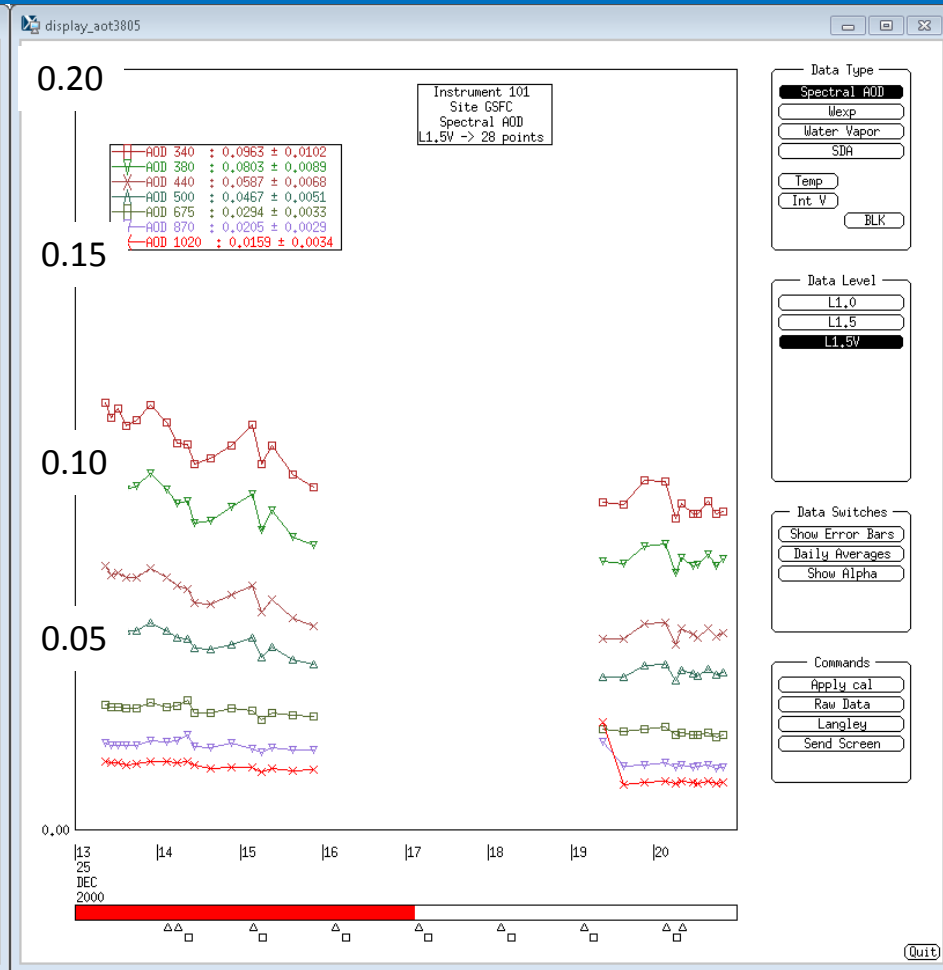
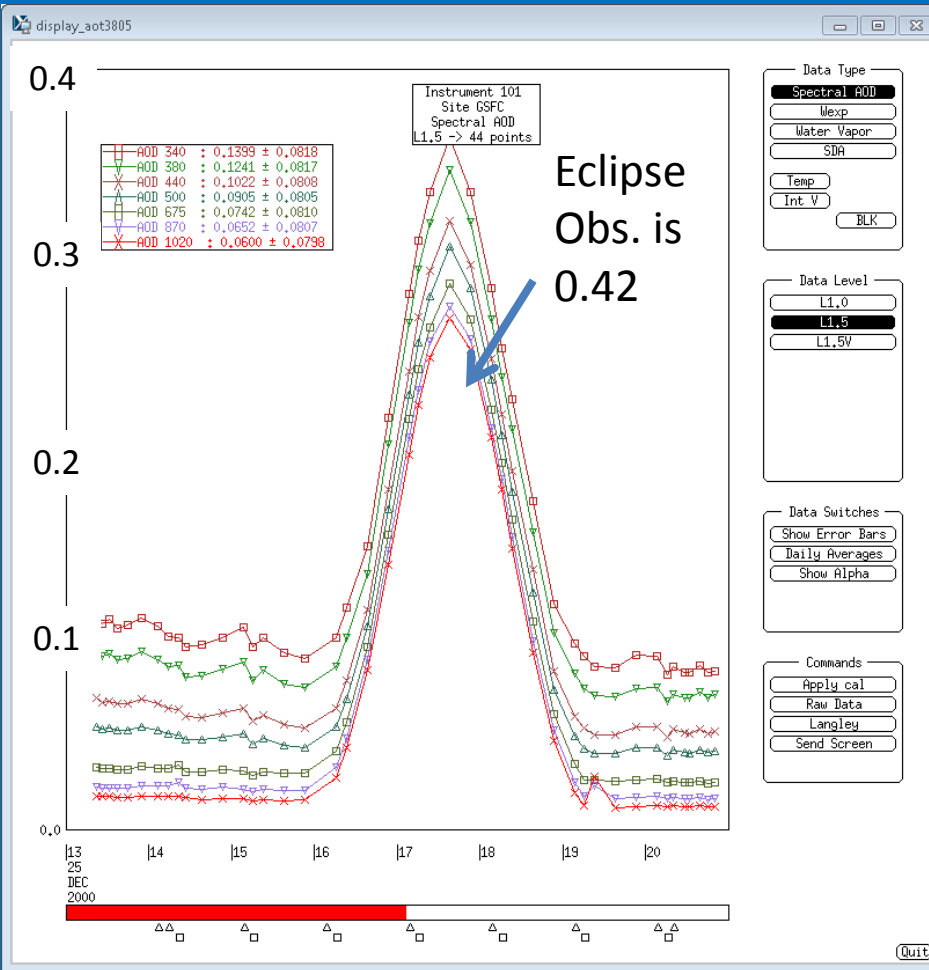
# AERONET V3 L1.5: AOD Spectral Dependence

- Utilize mainly 1<sup>st</sup> or 2<sup>nd</sup> order fit
  - Number of wavelengths
  - AOD magnitude
- Employ iterative approach to remove outliers based on fit (fit-measurement)
- Combine with other screening techniques





# AERONET Version 3 L1.5: Solar Eclipse Screening



- \* Uses NASA Eclipse database: <http://eclipse.gsfc.nasa.gov>
- \* AOD correction may be implemented

# AERONET V3 Level 1.5

**Nauru, #168, 2000-2005, 2010**

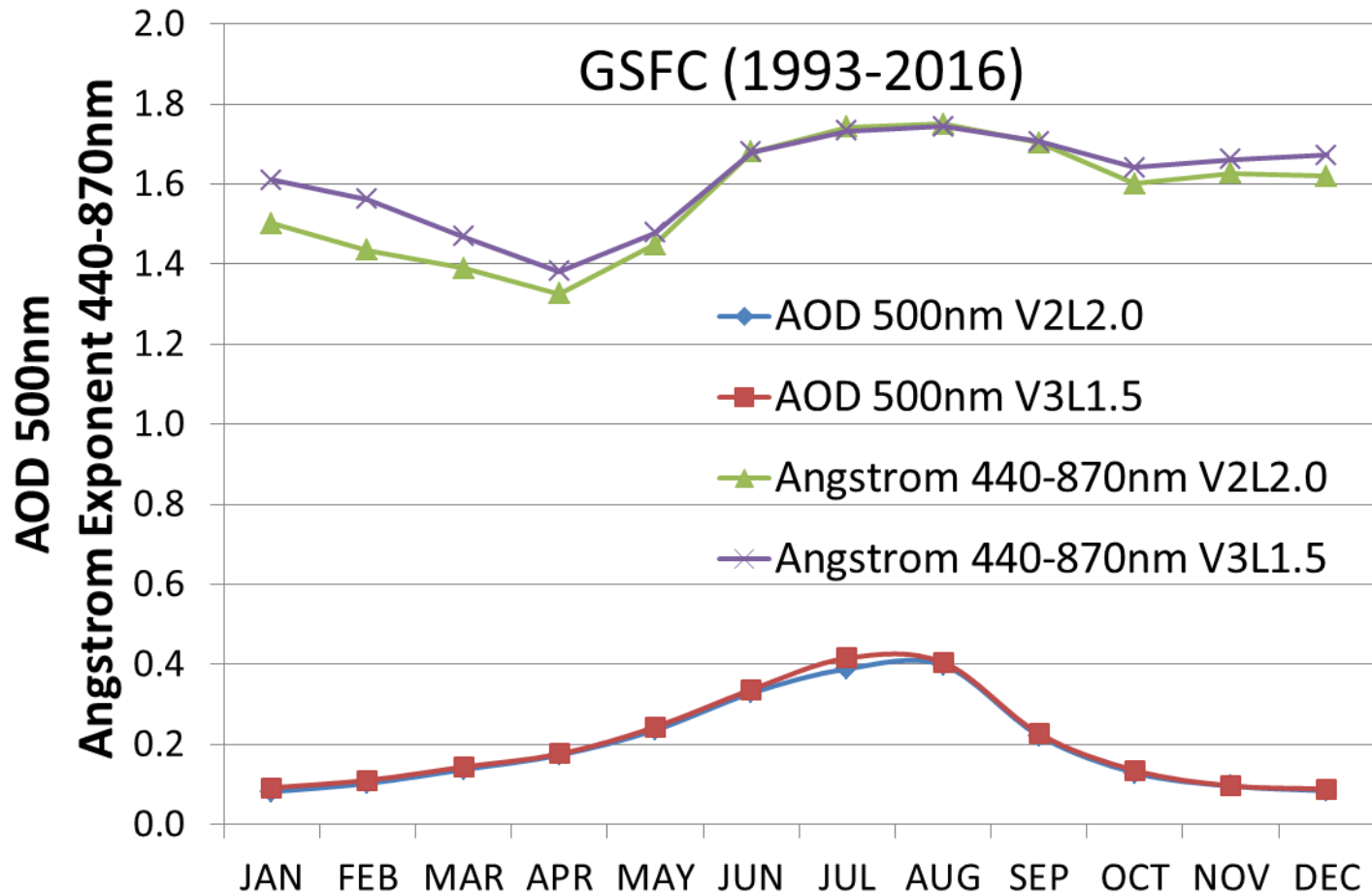
Level	N	AOD	$\alpha$
V2 L1.0	25579	0.23	0.31
V2 L1.5	13326	0.11	0.47
V2 L2.0	9371	0.08	0.54
V3 L1.5 CldScr	10385	0.07	0.48
V3 L1.5	9702	0.07	0.51

- New Level 1.5  $AOD_{500nm}$  and  $\alpha_{440-870nm}$  statistically very close to V2 Level 2.0
- Improperly filtered highly variable AODs (dominated by fine aerosols) may be restored in the V3 database
- Stable thin cirrus becomes less of an issue (less residual contamination)

**Singapore, #22, 2007-2011**

Level	N	AOD	$\alpha$
V2 L1.0	25500	0.61	0.86
V2 L1.5	8680	0.46	1.03
V2 L2.0	6920	0.35	1.20
V3 L1.5 CldScr	6794	0.34	1.53
V3 L1.5	6534	0.35	1.52

# Climatology





## AERONET AEROSOL ROBOTIC NETWORK



+ AEROSOL OPTICAL DEPTH

+ AEROSOL INVERSIONS

+ SOLAR FLUX

+ OCEAN COLOR

+ MARITIME AEROSOL

Web Site Feature

[AERONET Data Synergy Tool](#) - Access Earth Science data sets for AERONET sites

-Home

15 January 2014 - MODIS Rapid Response images are not available between January 2011 and mid-December 2013 ([More Information](#))

Home

### MISSION

The AERONET (AErosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks established by NASA and PHOTONS (PHOTométrie pour le Traitement Opérationnel de Normalisation Satellitaire; Univ. of Lille 1, CNES, and CNRS-INSU) and is greatly expanded by networks (e.g., RIMA, AeroSpan, AEROCAN, and CARsNET) and [collaborators](#) from national agencies, institutes, universities, individual scientists, and partners. The program provides a long-term, continuous and readily accessible public domain database of aerosol optical, microphysical and radiative properties for aerosol research and characterization, validation of satellite retrievals, and synergism with other databases. The network imposes standardization of [instruments](#), [calibration](#), [processing](#) and [distribution](#).

AERONET collaboration provides globally distributed observations of spectral aerosol optical depth (AOD), inversion products, and precipitable water in diverse aerosol regimes. Aerosol optical depth data are computed for three data quality levels: Level 1.0 (unscreened), Level 1.5 ([cloud-screened](#)), and Level 2.0 ([cloud-screened and quality-assured](#)). Inversions, precipitable water, and other AOD-dependent products are derived from these levels and may implement additional quality checks.

The processing algorithms have evolved from Version 1 to Version 2.0 (fully released in July 2006) and are available from the AERONET and PHOTONS web sites. Version 1 data may be downloaded from the web site through 2006 and thereafter upon [special request](#). New AERONET products will be released as new measurement techniques and algorithms are adopted and validated by the AERONET research community. The AERONET web site also provides AERONET-related news, a description of research and operational activities, related Earth Science links, and an AERONET staff directory.

[+ Read More](#)



### NEWS

10 May 2016

- The Distributed Regional Aerosol Gridded Observation Networks ([DRAGON](#))-KORUS-AQ instrument deployment has been established in South Korea, Japan, and China from 1 April to 31 July 2016. The network will be strategically located to take advantage of [KORUS-AQ](#) in situ and airborne resources from mid-June 2016.

[+ Read More](#)

### AERONET DATA ACCESS

#### DATA SYNERGY TOOL

+ Data Display

#### AEROSOL OPTICAL DEPTH (V3)

+ Data Display

+ Download Tool

+ Web Service

#### AEROSOL OPTICAL DEPTH (V2)

+ Data Display

+ Download Tool

+ Download All Sites

+ Climatology Tables

+ Climatology Maps

+ Data Availability (L2.0)

V3 NRT

