AERONET overview and Update of AEROENT V3 Products as it relates to 7-SEAS

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Thursday, Sept 21, 2016 10th 7-SEAS Workshop

Outline

- AERONET Background
- New Database Processing (moving from Ver2 to Ver3)
- V3 Level 1.5 NRT Quality Controls
- New Measurements (hybrid scans to retrieve intensive properties)
- Summary

AERONET- The Ground-Based Satellite

Mission Objectives:
- Characterize aerosol optical properties
- Validate Satellite & model aerosol retrievals
- Synergism with Satellite obs., ESS and CC

- Internationally Federated
  - GSFC & PHOTONS (Fr)
  - Spain, Australia, Brazil, Russia
  - Canada, Italy, China, SE Asia…
- ~600 instruments
- ~450 Operational sites
- >5. x 10^8 AOD obs since 1993
- Expansion to Asia, Africa high latitudes and over water sites
- Support NASA ESS activities

Parameters measured: τ, ω_o, Θ, size, n, k and WV, clds, L_{wn}

Open data access via website: http://aeronet.gsfc.nasa.gov/

Growing Need for Higher Quality NRT AERONET Data

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

New Version 3 AERONET Algorithm Advances

- AOD is less contaminated by optically thin cirrus clouds
- AOD is available for high aerosol loading biomass burning smoke events previously removed by Version 2
- Improved corrections including temperature
- AOD products are automatically controlled in NRT using new algorithms derived from manual QA methods (Level 1.5)

AERONET V3 L1.5: Cloud Screening

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

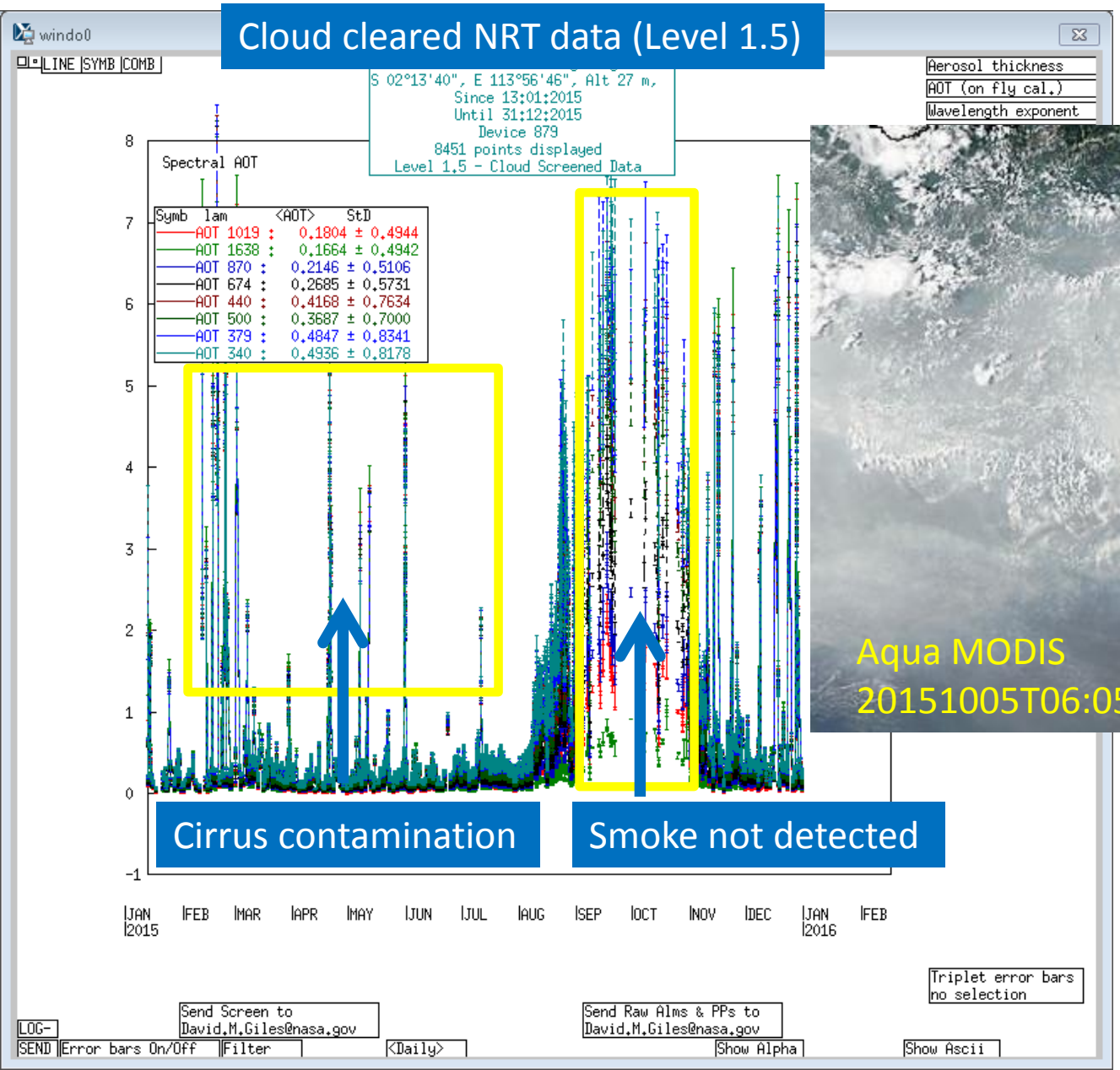
Nauru, #168, 2000-2005, 2010

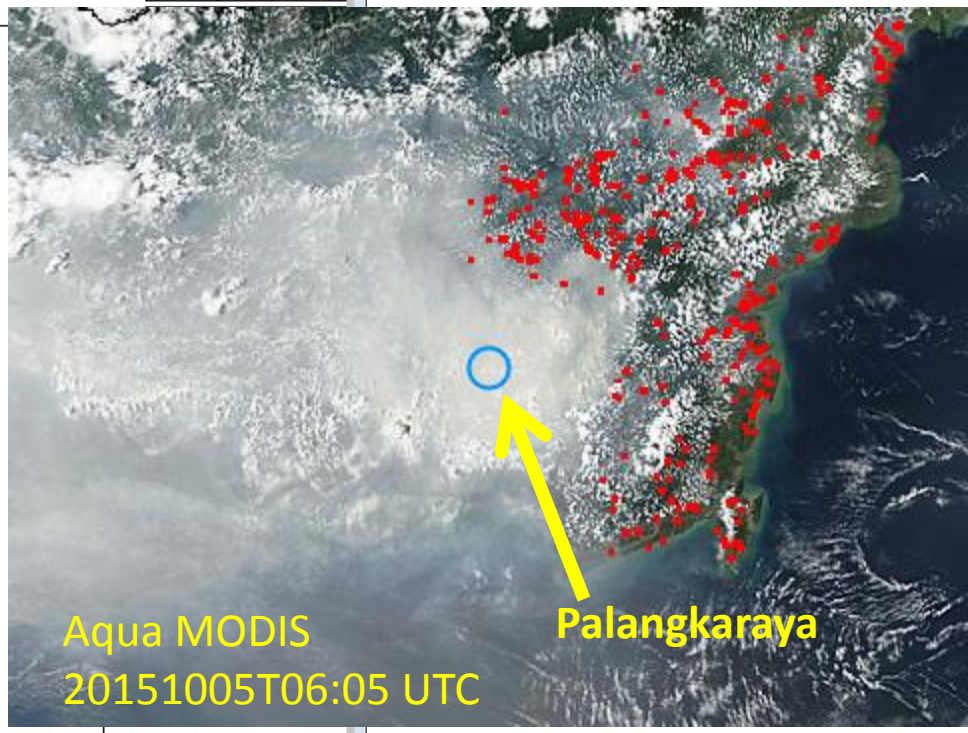
	N	AOD	α
Lev 1.0	25579	0.23	0.09
Lev 1.5	13326	0.11	0.33
Lev 2.0	9371	0.08	0.58
V3 Lev 1.5	9167	0.07	0.40

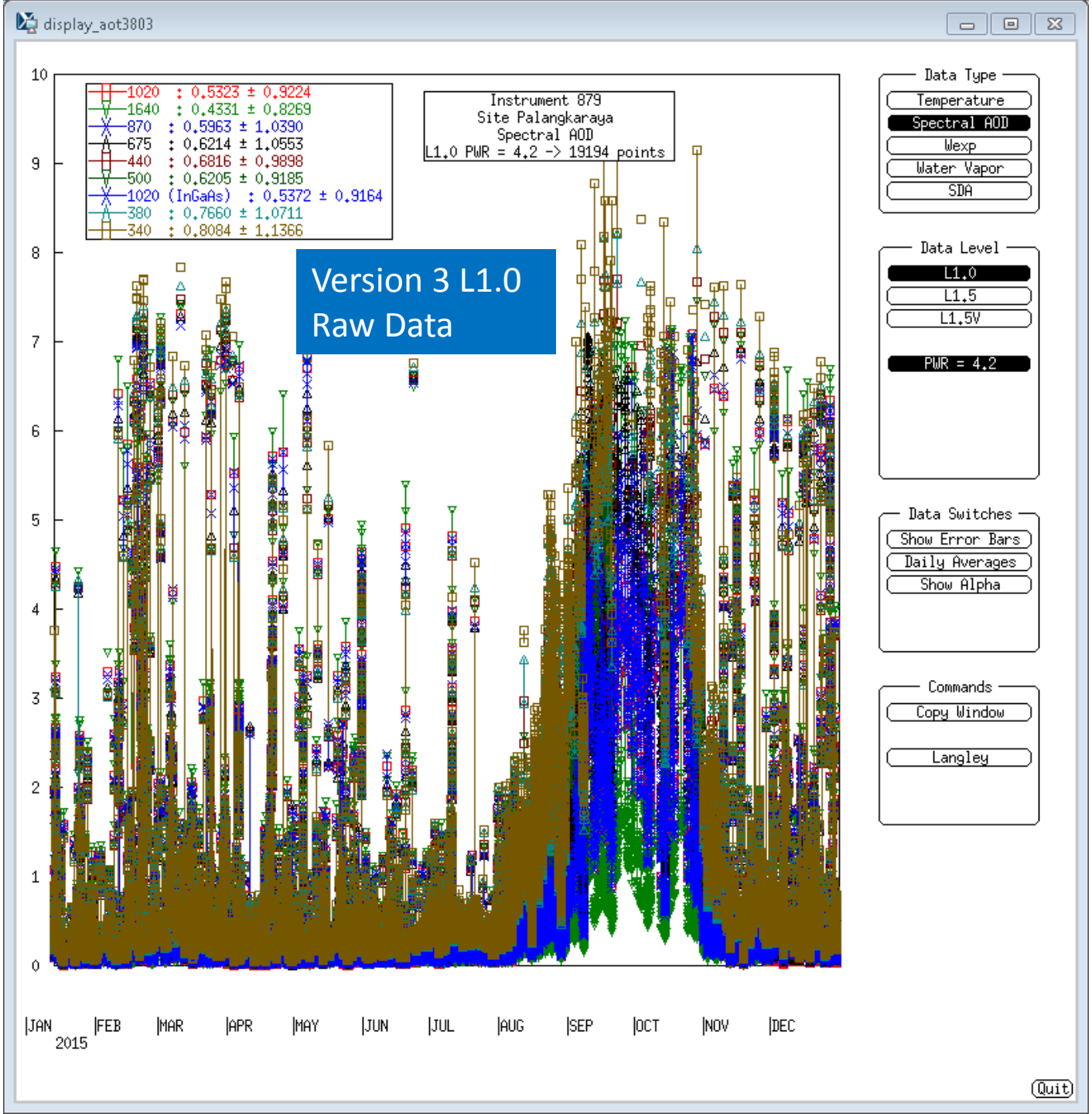
Singapore, #22, 2007-2011

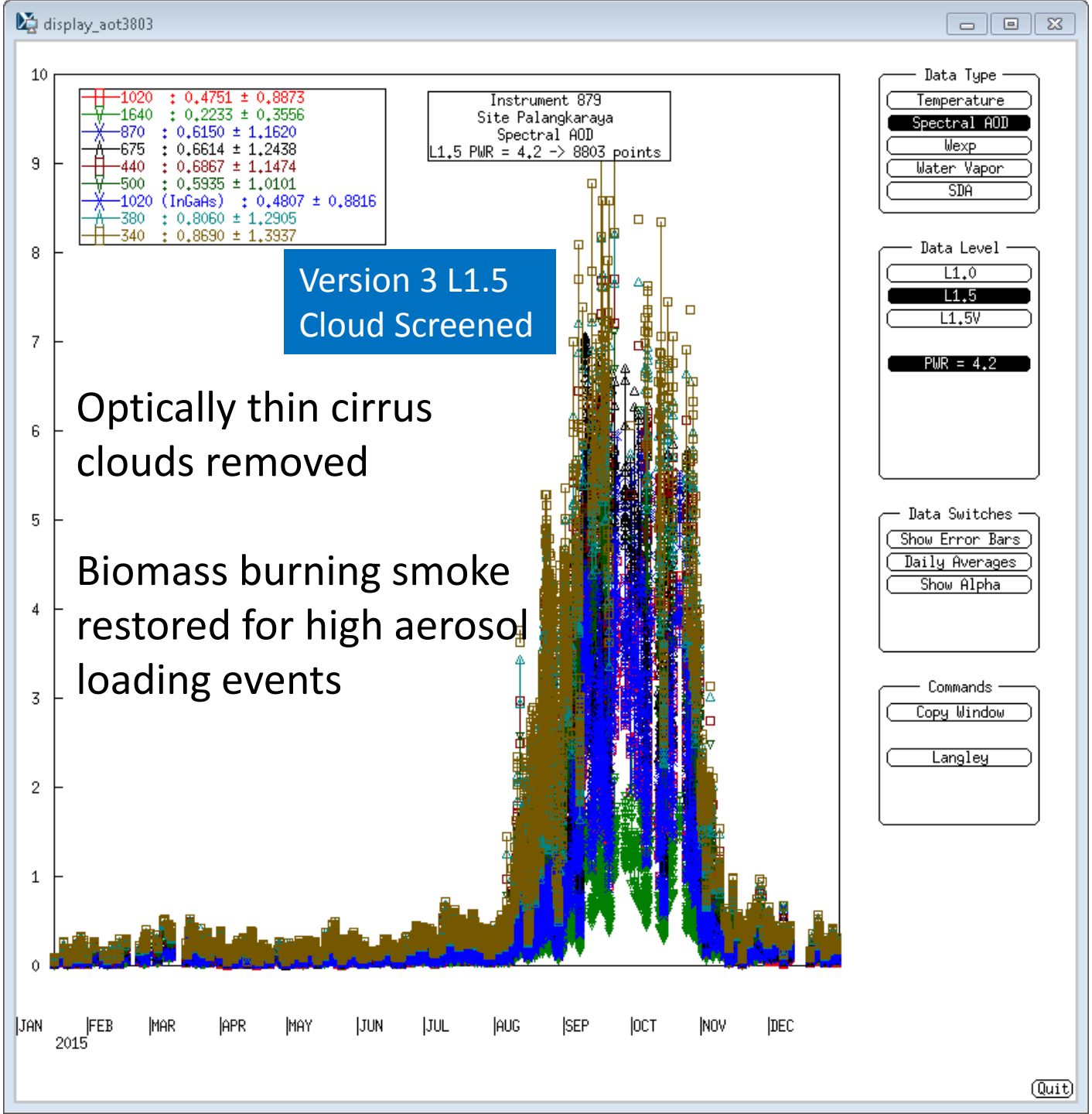
	N	AOD	α
Lev 1.0	25500	0.61	0.58
Lev 1.5	8680	0.45	0.79
Lev 2.0	6920	0.34	1.21
V3 Lev 1.5	5029	0.33	1.40

Indonesian Fires 2015 (Palangkaraya) – Current V2






display_aot3803
1020 : 0.5323 ± 0.9224
1640 : 0.4331 ± 0.8269
870 : 0.5963 ± 1.0390
675 : 0.6214 ± 1.0553
440 : 0.6816 ± 0.9898
500 : 0.6205 ± 0.9185
1020 (InGaAs) : 0.5372 ± 0.9164
380 : 0.7660 ± 1.0711
340 : 0.8084 ± 1.1366
Instrument 879
Site Palangkaraya
Spectral AOD
L1.0 PWR = 4.2 -> 19194 points
Version 3 L1.0
Raw Data
Data Type
Temperature
Spectral AOD
Wexp
Water Vapor
SDA
Data Level
L1.0
L1.5
L1.5V
PWR = 4.2
Data Switches
Show Error Bars
Daily Averages
Show Alpha
Commands
Copy Window
Langley
Quit
JAN
2015
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

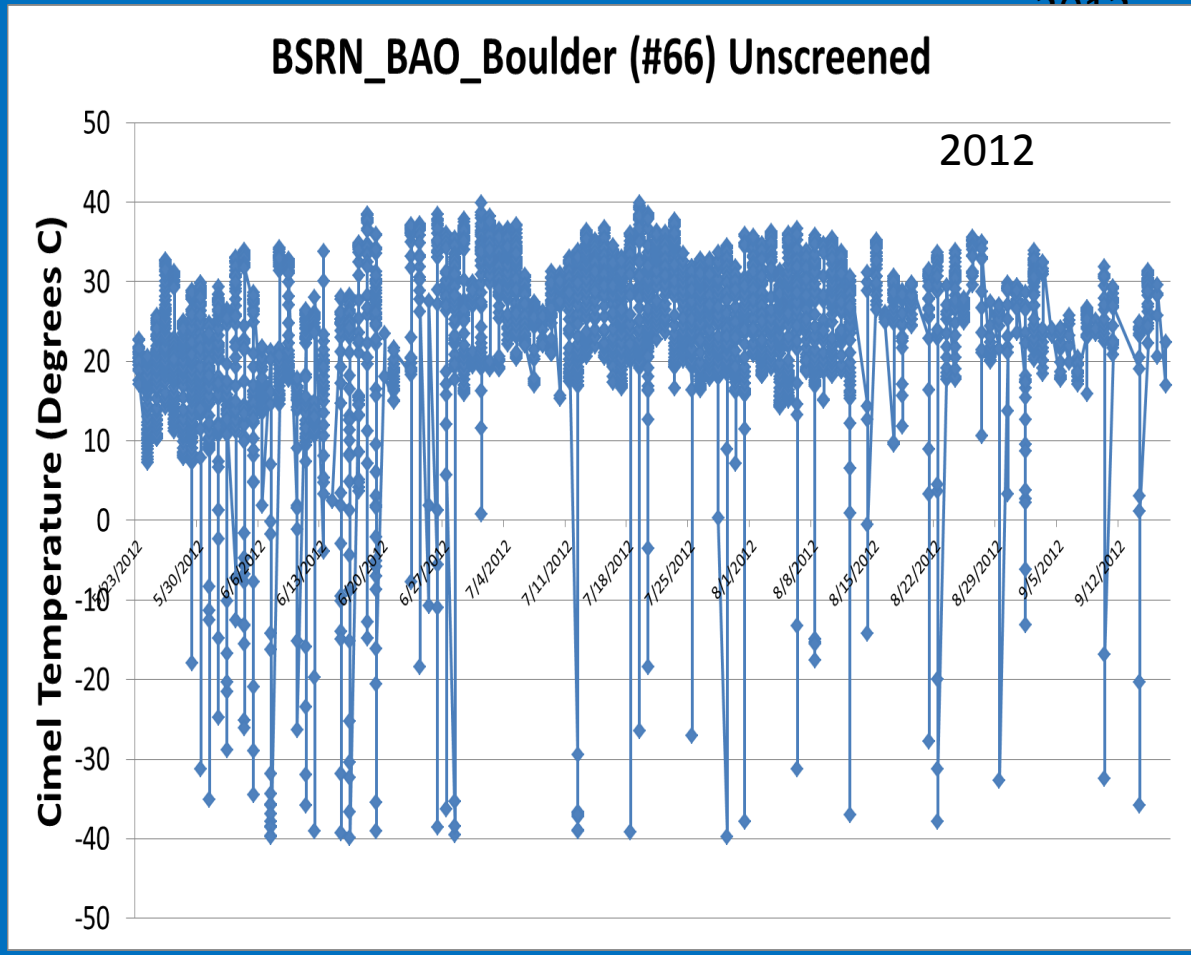

display_aot3803
1020 : 0.4751 ± 0.8873
1640 : 0.2233 ± 0.3556
870 : 0.6150 ± 1.1620
675 : 0.6614 ± 1.2438
440 : 0.6867 ± 1.1474
500 : 0.5935 ± 1.0101
1020 (InGaAs) : 0.4807 ± 0.8816
380 : 0.8060 ± 1.2905
340 : 0.8690 ± 1.3937
Instrument 879
Site Palangkaraya
Spectral AOD
L1.5 PWR = 4.2 -> 8803 points
Version 3 L1.5
Cloud Screened
Optically thin cirrus clouds removed
Biomass burning smoke restored for high aerosol loading events
Data Type
Temperature
Spectral AOD
Wexp
Water Vapor
SDA
Data Level
L1.0
L1.5
L1.5V
PWR = 4.2
Data Switches
Show Error Bars
Daily Averages
Show Alpha
Commands
Copy Window
Langley
Quit
10
9
8
7
6
5
4
3
2
1
0
JAN
2015
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Level 1.5 Quality Control Algorithm

- Constant Digital Count Removal: Remove constant voltage digital counts
- Temperature Screening: Remove anomalous temperatures and channels significantly affected by temperature dependence
- Solar Eclipse Screening: Determine the existence of solar eclipse events and remove data affected by them
- Temporal Shift Screening: Evaluate data for overlap of UV channels only during one period during the day in the early AM or late PM
- AOD 1020nm Difference Check: If an extended instrument with InGaAs detector, check for good AOD 1020nm

AERONET V3 L1.5: Sensor Head Temperature Screening

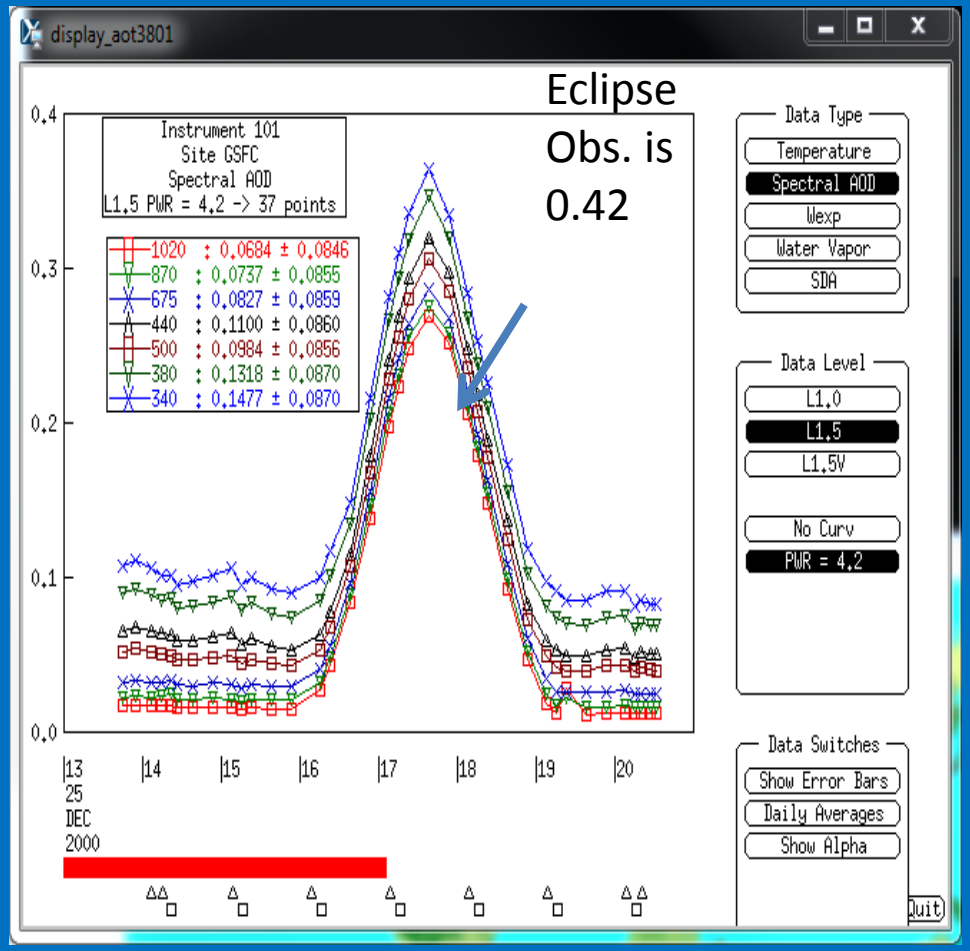
- Sensor Head Temperature Anomalies
  - Erroneous sensor temperatures adversely affect the magnitude of AOD for temperature sensitive channels



Utilizes NCEP temperature as ambient baseline

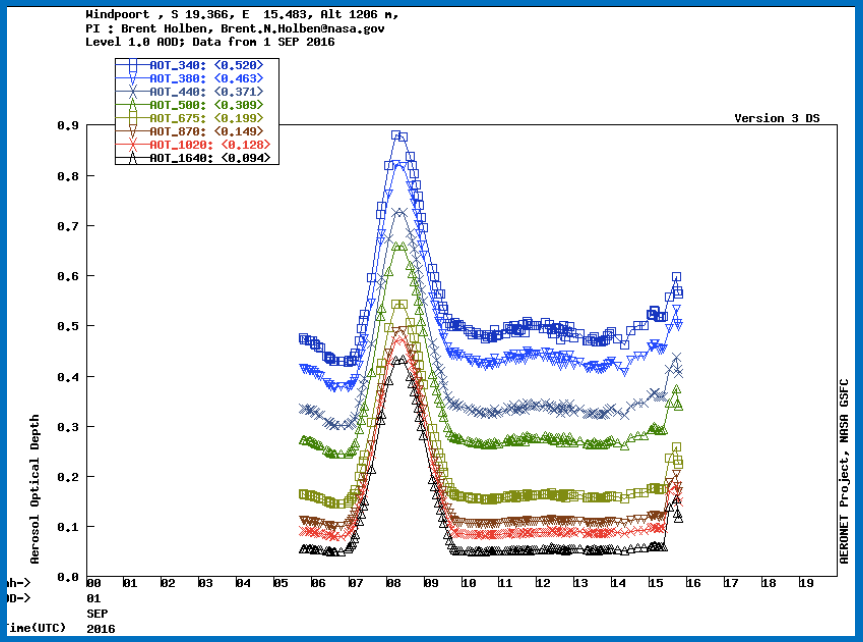
AERONET Version 3 L1.5: Solar Eclipse Screening

- Various solar eclipses affect AOD by changing incident extraterrestrial radiation
- AOD is maximum at maximum obscuration of the Sun
  - AOD calculation uses calibration coefficient that is not adjusted for eclipse
- NASA eclipse database utilized for screening: http://eclipse.gsfc.nasa.gov

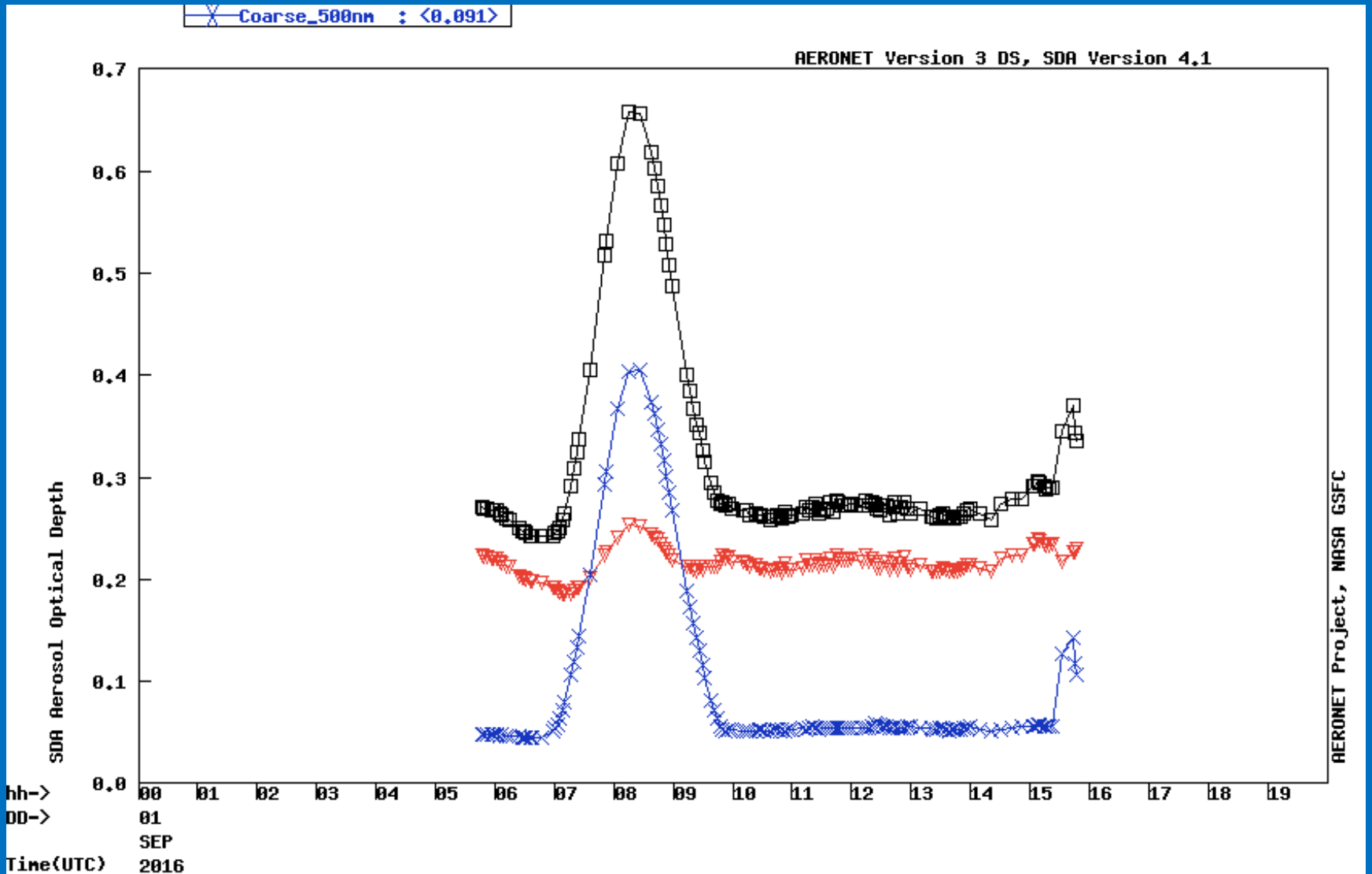


* AOD correction may be implemented

Eclipse Namibia Sept 1, 2016



SDA Eclipse


Coarse_500nm : <0.091>
AERONET Version 3 DS, SDA Version 4.1
SDA Aerosol Optical Depth
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
hh->
DD->
Time(UTC)
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19
01
SEP
2016
AERONET Project, NASA GSFC

Level 1.5 Quality Control Algorithm

- AOD1640nm Check: Evaluate whether AOD 1640nm is too high when AOD 870nm is determined to be good
- A and K Principal Plane Check: For non-InGaAs instruments, check the A and K difference is more than 10% in the principal plane and flag for use with AOD diurnal dependence
- AOD Diurnal Dependence: Evaluate the AOD diurnal dependence independently for each wavelength and day and include with other checks such as AOD 1020nm difference and A and K principal plane difference for AM, PM, and the full day.

AERONET V3 L1.5V: AOD Diurnal Dependence Check

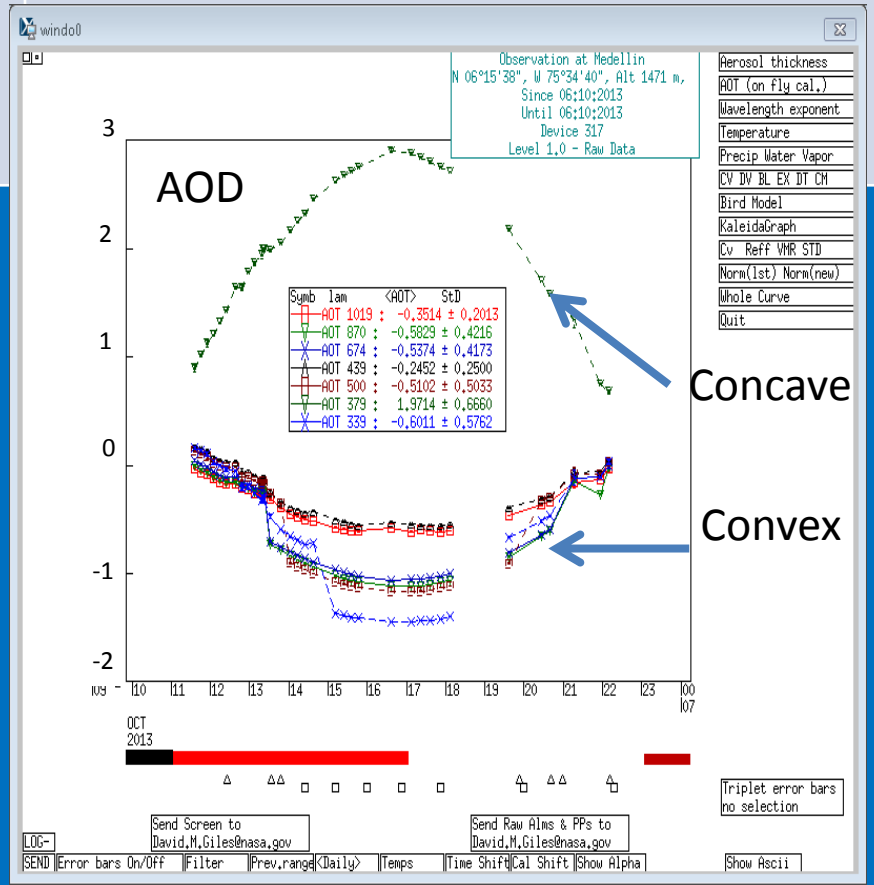
Concave	Convex
-- Decreased filter transmittance -- Obstruction in collimator or on sensor head lens -- Filter dust or broken desiccant pack inside the sensor head -- Incorrect gain setting	-- Increased filter transmittance -- Filter degradation -- Incorrect gain setting

- Error in AOD is dependent on the c.a. cosine of the solar zenith angle

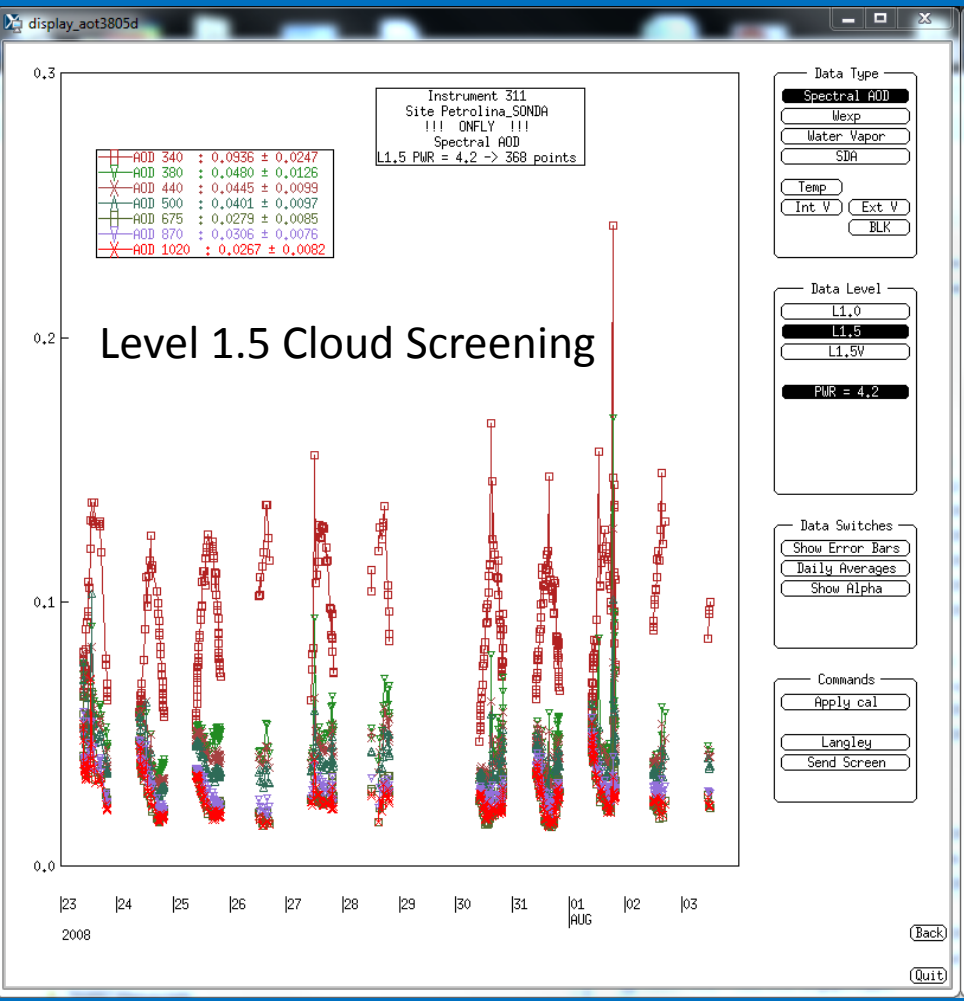
  $\delta\tau = 1/m * \delta Vo/Vo$

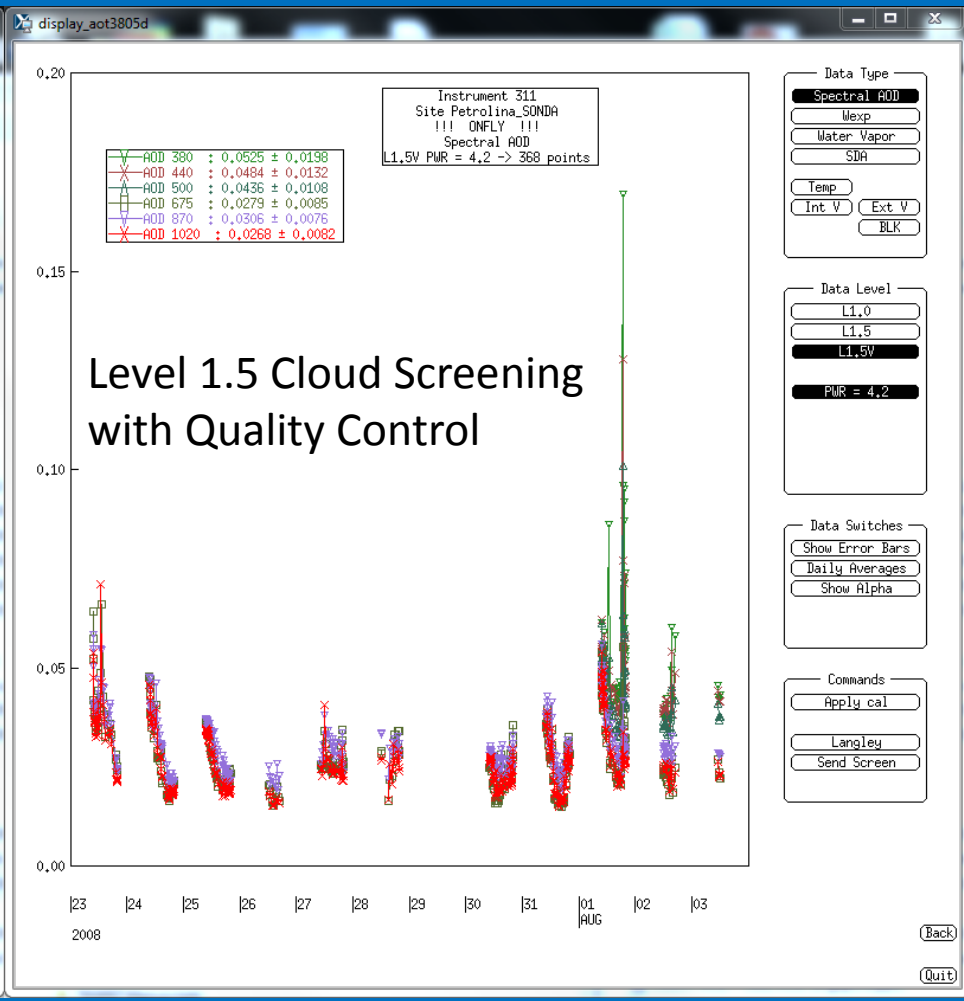
  ***1/m* ~ cosine of solar zenith angle**

- For the AM, PM, or day and AOD versus the cosine of the solar zenith angle relationship, calculate slope, correlation coefficient, and rms



AERONET V3 L1.5V:
AOD Diurnal Dependence Check

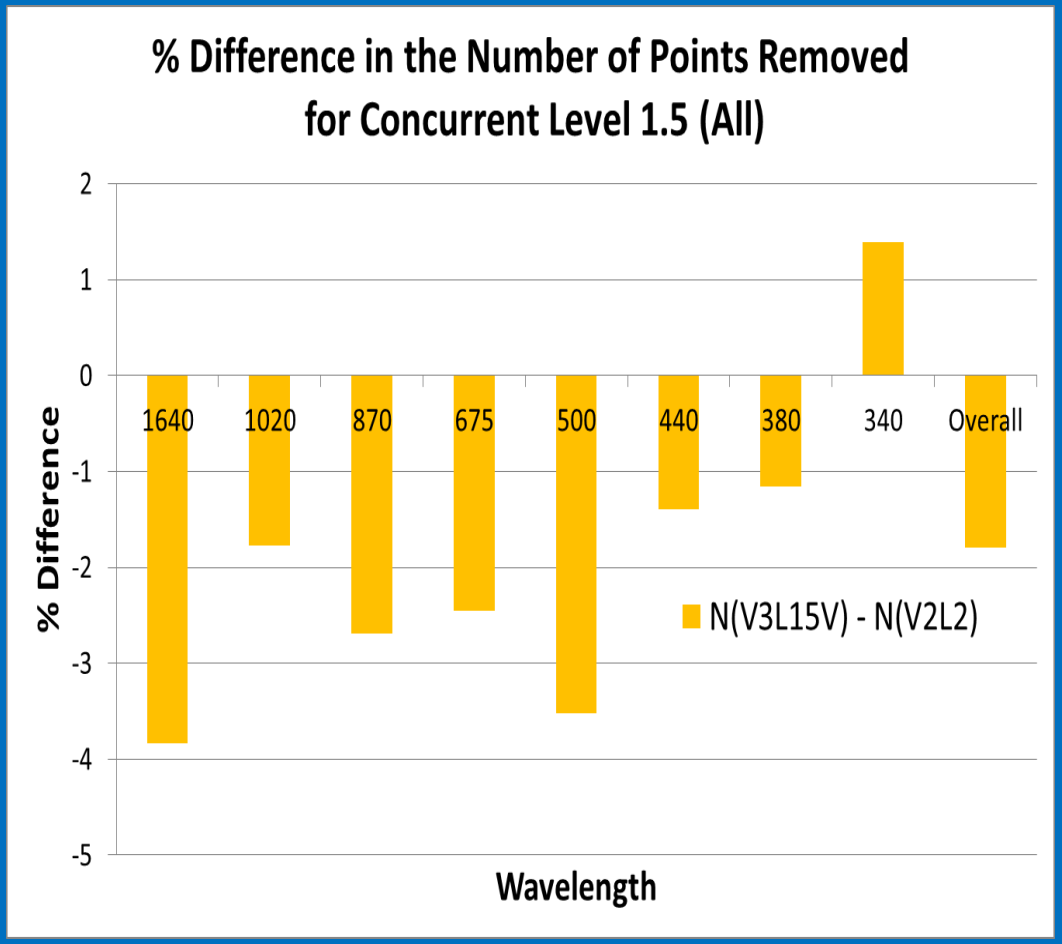




Removal of AOD diurnal dependence of 340nm

V2 L2 vs. V3 L1.5
All Instruments (1993-2015)

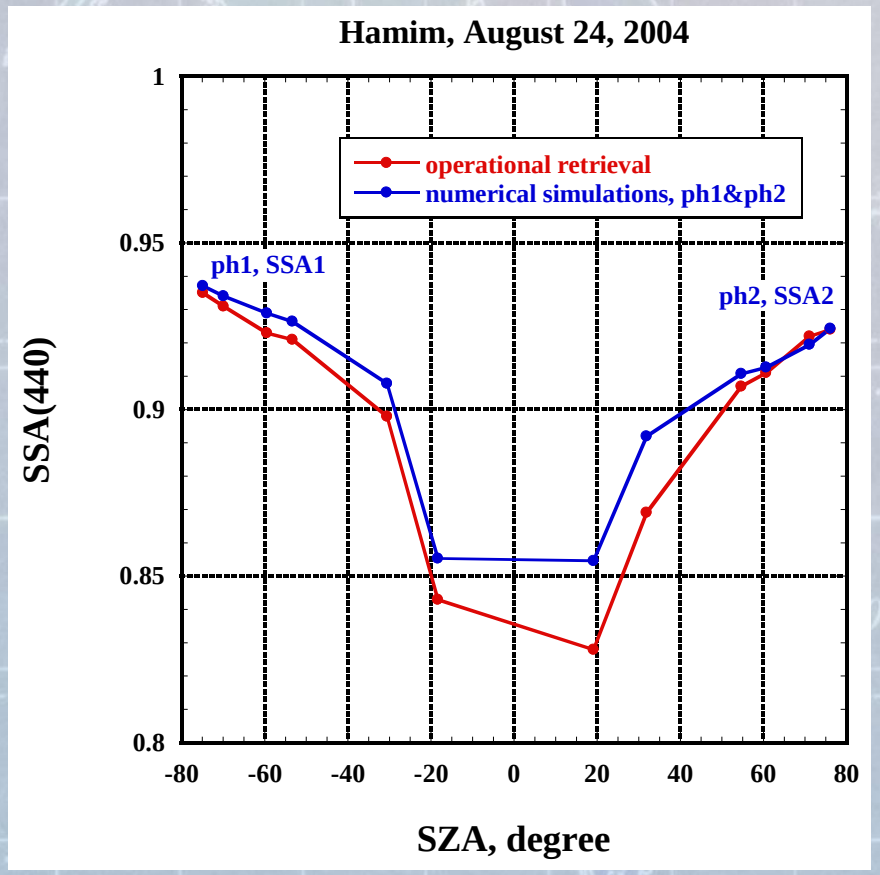
- V2 and V3 compared for the same L1.5 points
- V3 L1.5 point removal is comparable to V2 L2
- V3 L1.5 retained ~2% more data overall

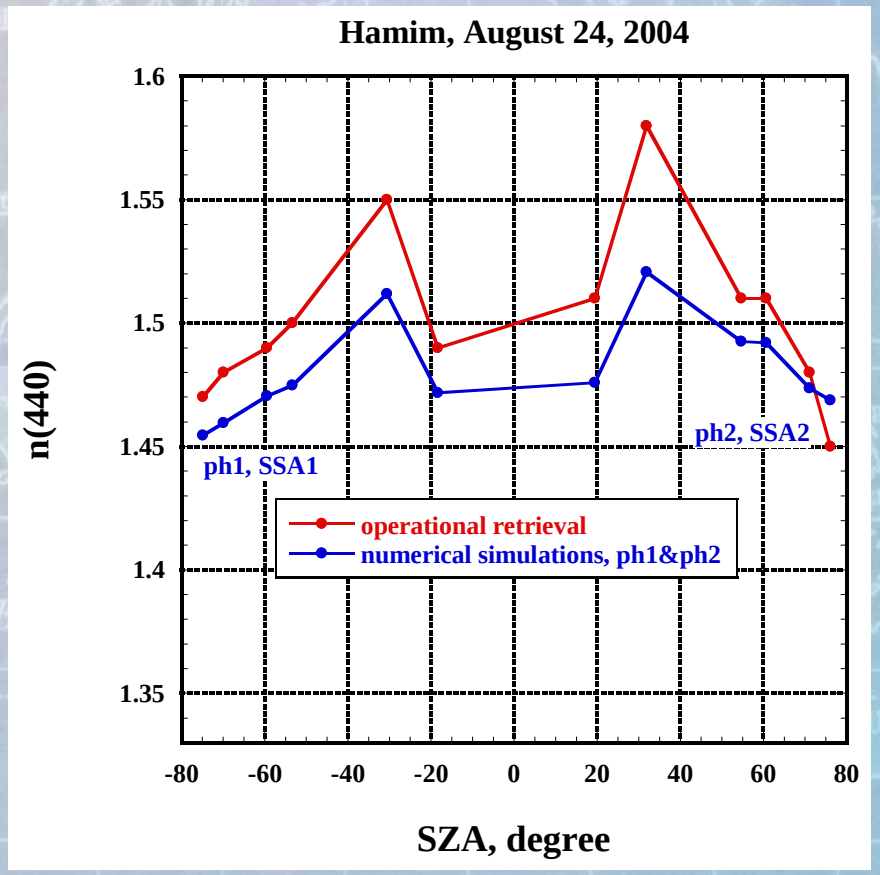


%Diff<0: V3 L1.5 retained more than V2 L2
%Diff>0: V3 L1.5 removes more than V2 L2

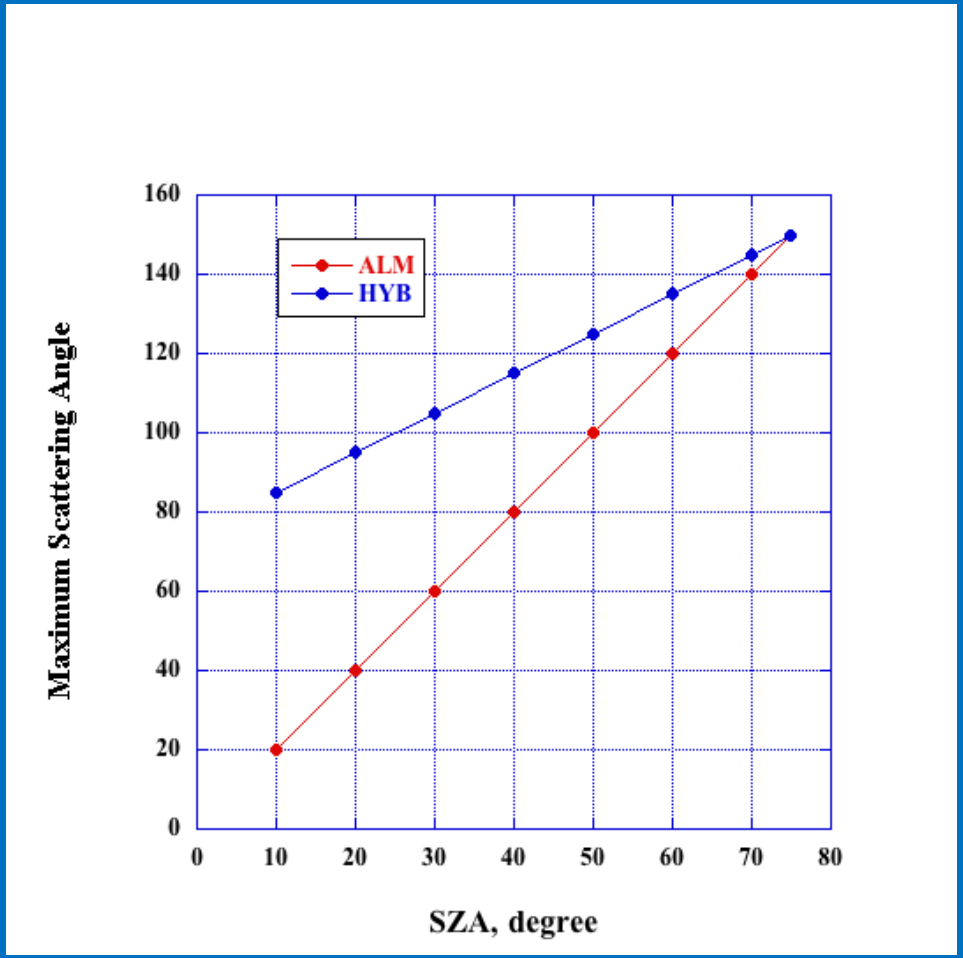
Numerical tests (1, SSA & n)

Both simulations and actual observation shows the same variability of SSA and n retrievals with SZA.

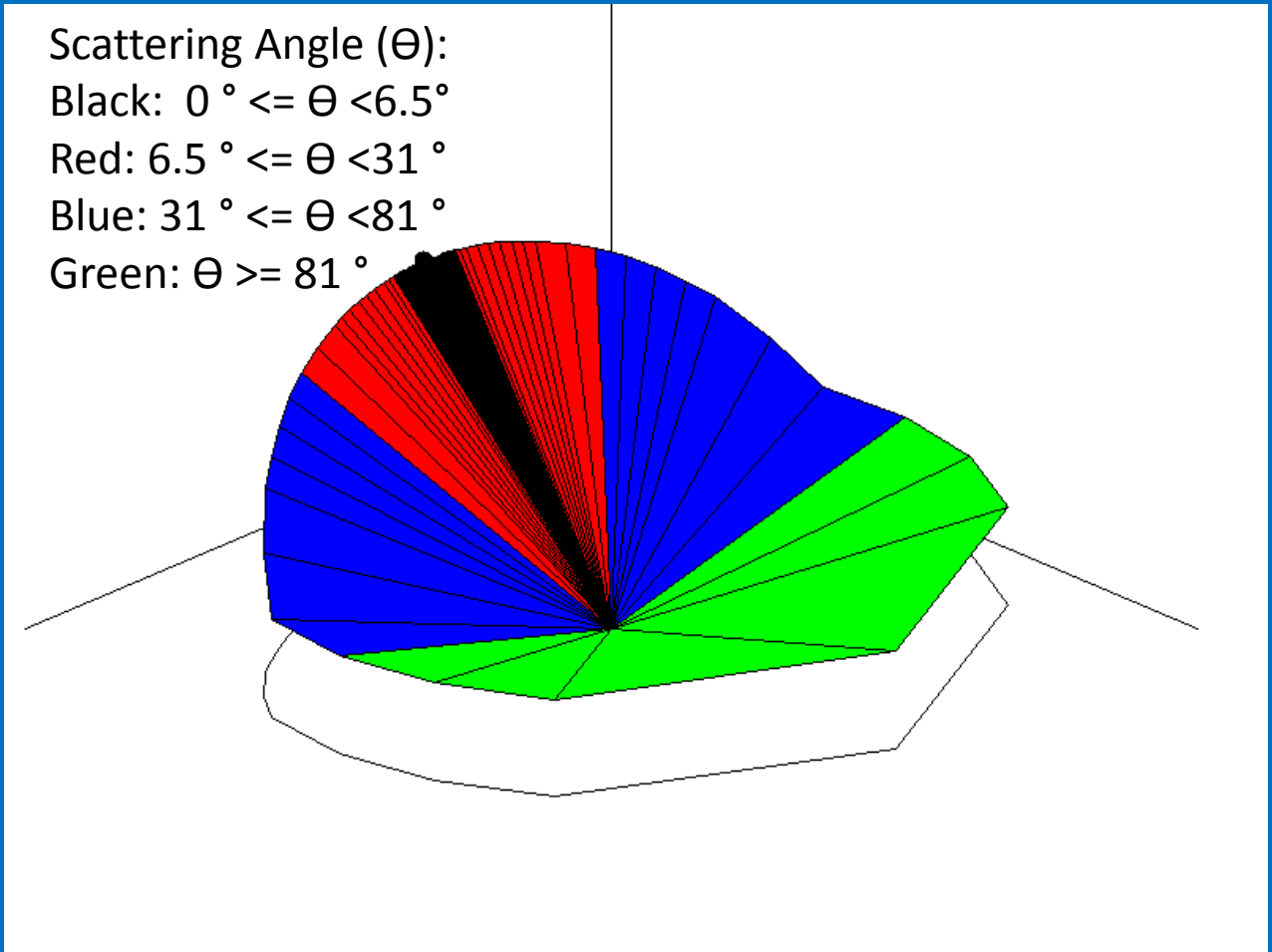




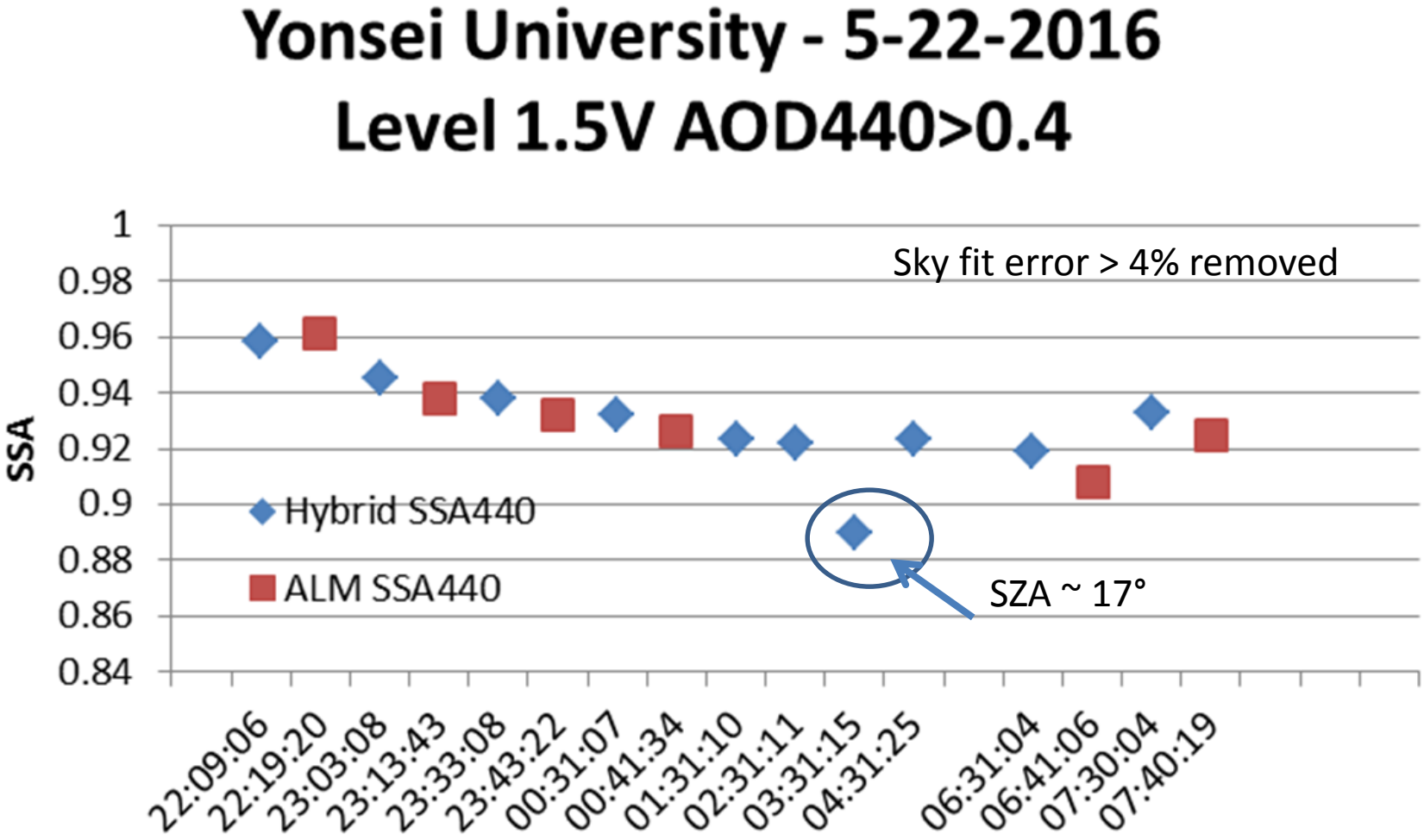
Scattering angles vs Solar zenith Angles for Hybrid and Almucantar scans



Hybrid Animation 30° SZA

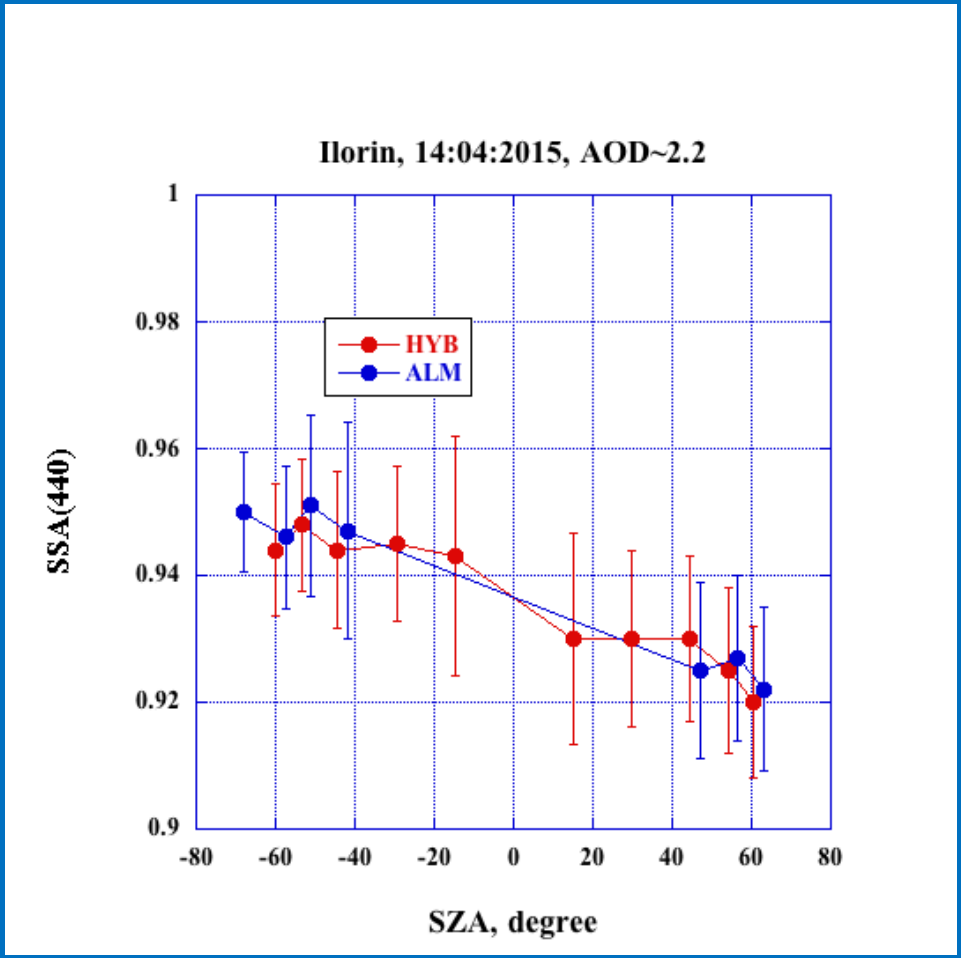


Initial Beta V3 SSA



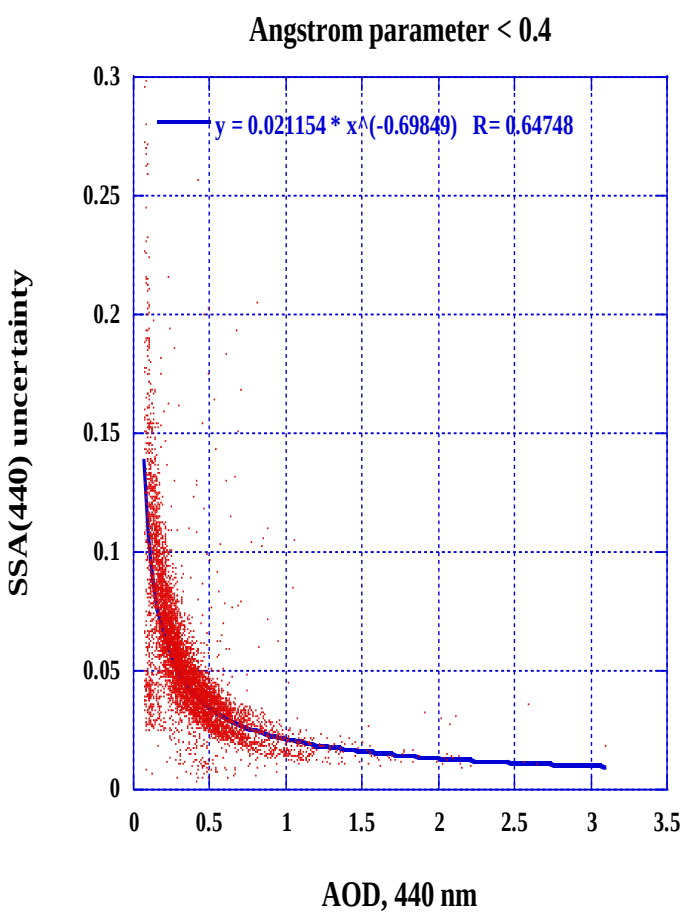
- Provide greater temporal coverage of inversion aerosol properties
- Hybrid important especially for polar orbiting satellite overpass

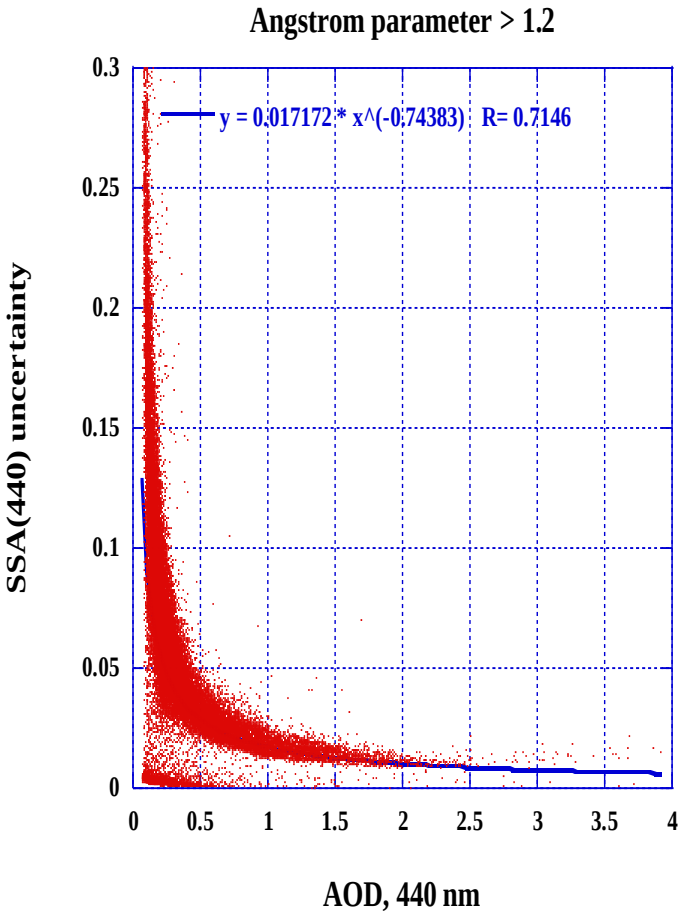
Hybrid vs Almuc SSA retrievals with error bars, Coarse mode aerosol

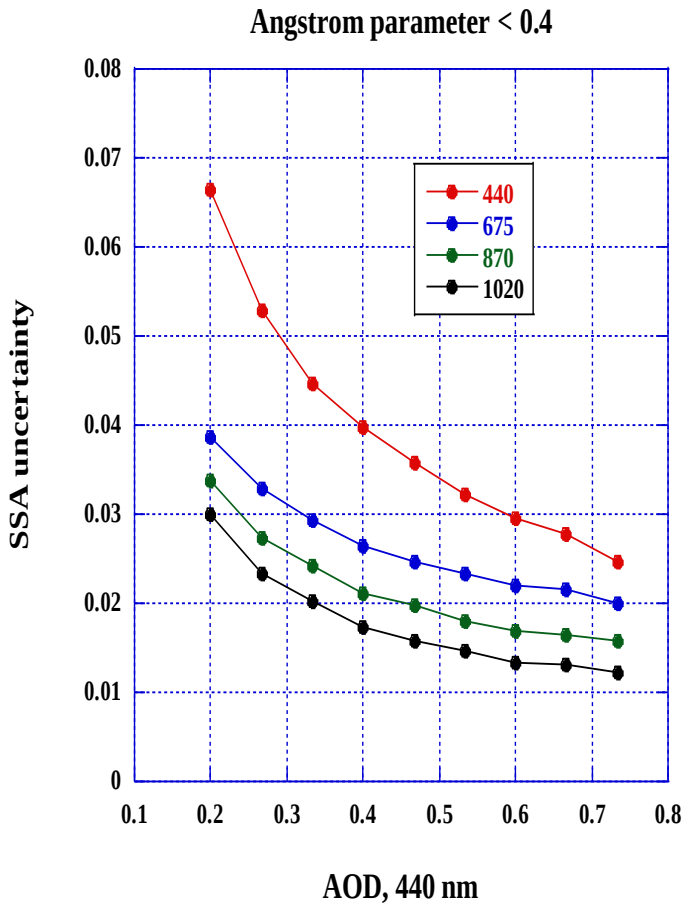


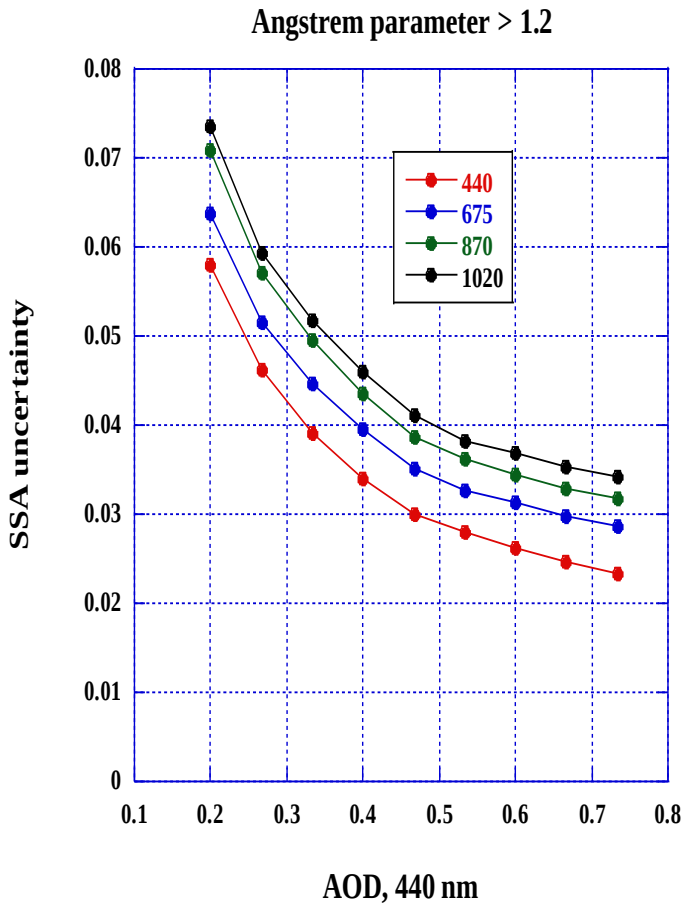
So what about uncertainty estimates under Ver. 3, level 2.0?

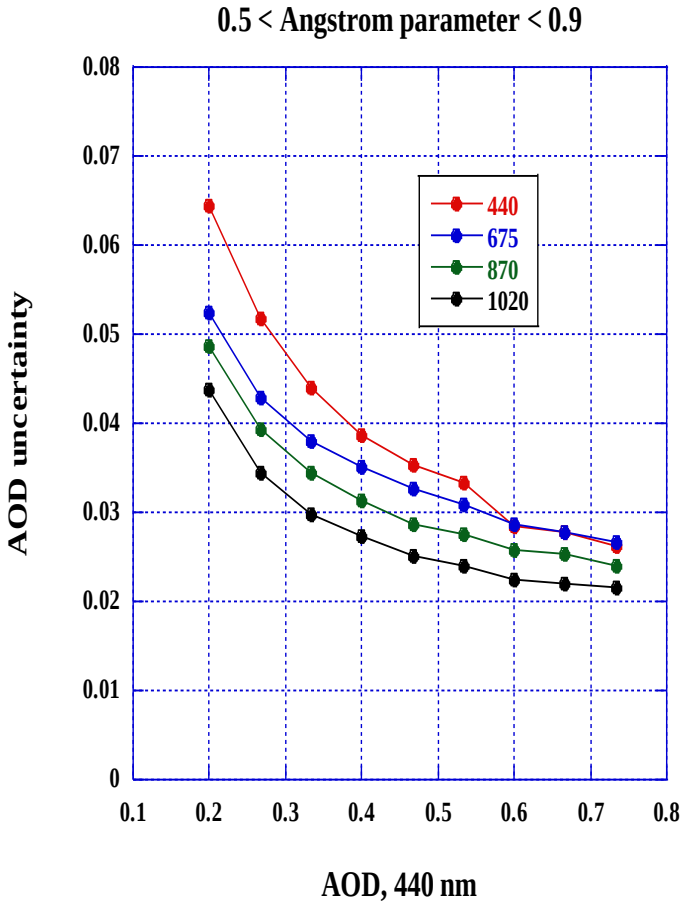
- AOD- Basically unchanged: VIS & near IR ± 0.01, UV ± 0.02 at the time of calibration, conservative number ±0.02
- Inversion products (retrieved/derived):
  - SSA ~ 0.03
  - Size dist.-TBD
  - Imaginary index of refraction-TBD
  - Real part of the Index of refraction- TBD


Angstrom parameter < 0.4
y = 0.021154 * x^(-0.69849) R= 0.64748
SSA(440) uncertainty
AOD, 440 nm
0
0.05
0.1
0.15
0.2
0.25
0.3
0.5
1
1.5
2
2.5
3
3.5


Angstrom parameter > 1.2
y = 0.017172 * x^(-0.74383) R= 0.7146
SSA(440) uncertainty
AOD, 440 nm
0
0.05
0.1
0.15
0.2
0.25
0.3
0.5
1
1.5
2
2.5
3
3.5
4


Angstrom parameter < 0.4
SSA uncertainty
AOD, 440 nm
440
675
870
1020
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8


Angstrem parameter > 1.2
SSA uncertainty
AOD, 440 nm
440
675
870
1020
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8


0.5 < Angstrom parameter < 0.9
AOD uncertainty
AOD, 440 nm
440
675
870
1020
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
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0.1
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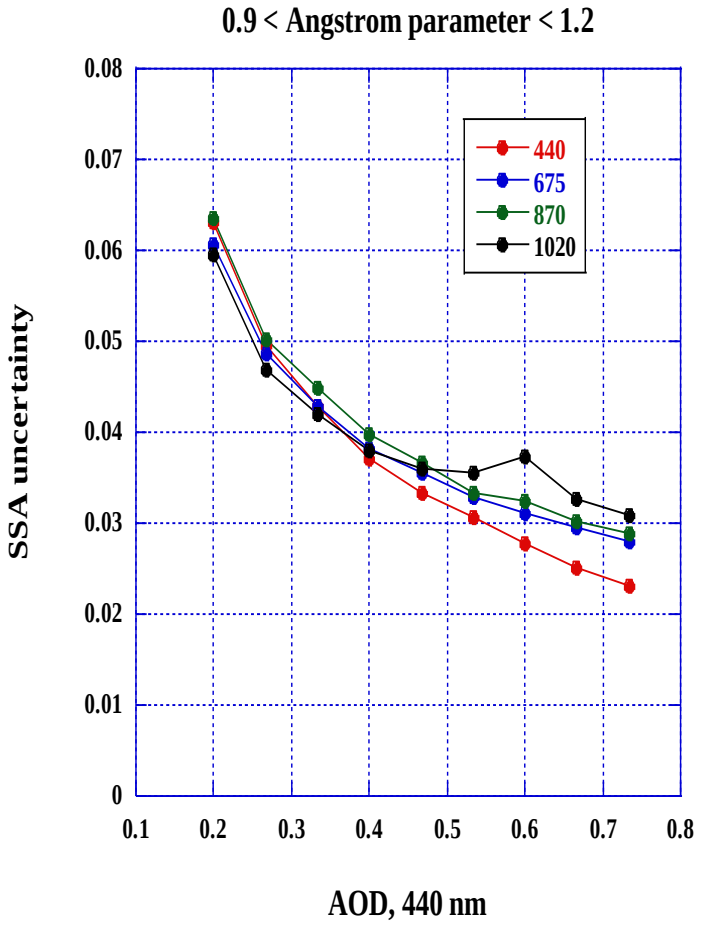
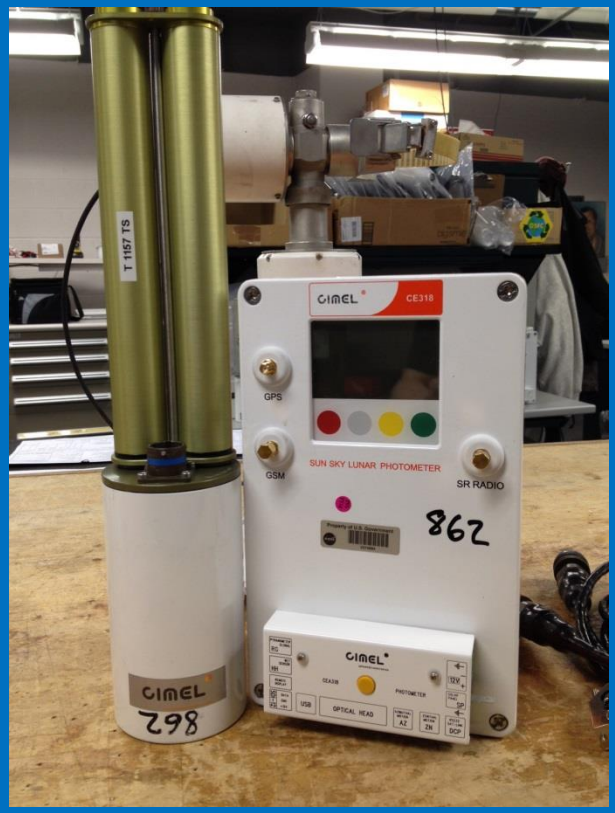
0.4
0.5
0.6
0.7
0.8


0.9 < Angstrom parameter < 1.2
SSA uncertainty
AOD, 440 nm
440
675
870
1020
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

AERONET
New Instrumentation/Enhancements

- Greater control over instrument measurement scenarios (e.g., **Hybrid**)
- Additional capabilities such as SD card storage, GPS, USB, and Zigbee
- Lunar measurements
  - 1st to 3rd quarter lunar phase (waxing to waning gibbous)
  - Processing for lunar measurements (e.g., ROLO, Tom Stone)
- Development toward attachment for CO2 measurements (Emily Wilson)
- Synergism with MPLNET, PANDORA, and in situ measurements



Cimel Sun/Sky/Lunar Radiometer

Summary

- Automatic quality controls perform objective assessments throughout the entire database and provide comparable results to manual screening
- Higher quality AOD data is available in V3 NRT
  - Due to temperature characterization, improved cloud screening, and quality controls
- High aerosol loading is characterized under Ver. 3

➢ Version 3 NRT AOD is released

Summary

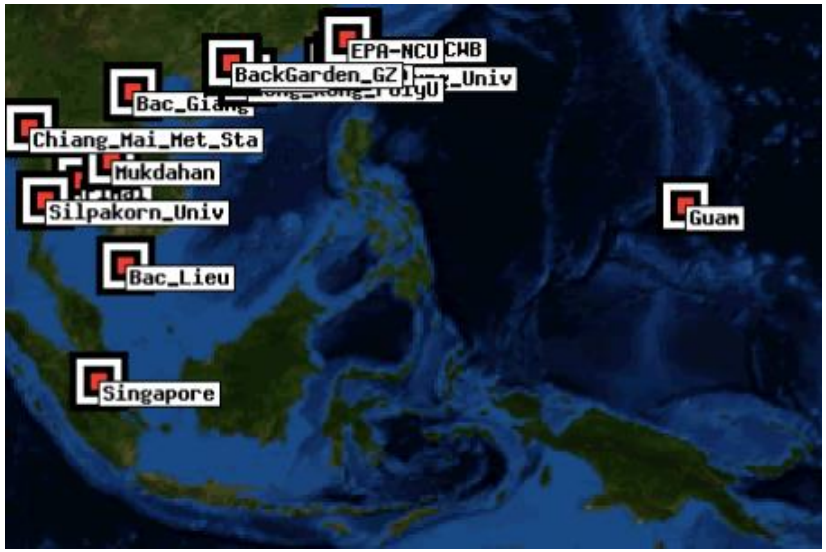
- New Cimel T instrument control boxes will provide enhance capabilities (e.g., Hybrid, Lunar)
- V3 inversions will utilize new radiative transfer, ancillary data sets, and provide new products
- Hybrid scenario will improve temporal coverage of aerosol characteristics
- Lunar AOD is coming
- Uncertainty estimates for each L 2.0 retrieval product

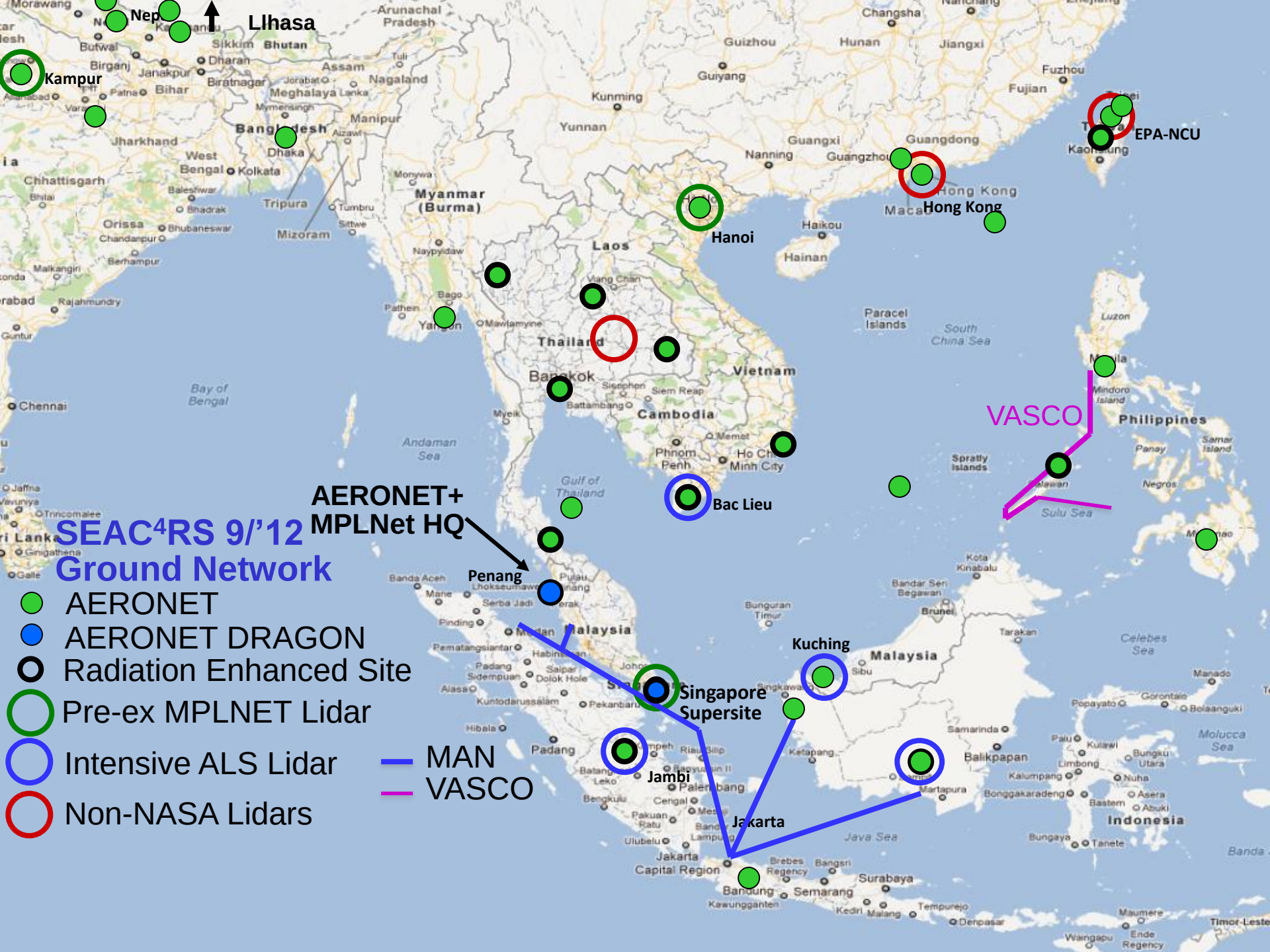
➢ Full V3 QA AOD and inversions expected release: **~Dec 2016**

Early AERONET distribution

2003

2006




Lhasa
Kampur
Hanoi
Hong Kong
EPA-NCU
VASCO
AERONET+
MPLNet HQ
Penang
Bac Lieu
Singapore
Supersite
Kuching
Jambi
Jakarta
SEAC⁴RS 9/'12
Ground Network
AERONET
AERONET DRAGON
Radiation Enhanced Site
Pre-ex MPLNET Lidar
Intensive ALS Lidar
Non-NASA Lidars
MAN
VASCO

AERONET's Regional Development 2012 and 2016

7-SEAS AERONET Milestones

- Greatly facilitated Regional expansion and diverse spatially distributed sites
- Improved our understanding of the SDA fine mode AOD retrievals under thin Ci contamination
- Facilitated Satellite and Model validation studies
- Provided critical data sets for AERONET Ver. 3 algorithm development and assessments
- Continues to contribute to regional AQ assessments
- Continues to support regional RS field campaigns

7-SEAS/AERONET way forward

- Sustain existing network thru collaborative measurements and data analysis (7-SEAS yields stakeholders)
- Fill the gaps: SE China, Myanmar, Laos, E. Indonesia
- Support joint field campaigns
- Federate/collaborate with other networks: MPLNET, GAW, SPARTAN, PANDORA