



Strive toward data harmony of
multi-sensor aerosol data -
Tribute to Dr. Gregory Leptoukh

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NASA/GES DISC Team



Dr. Gregory Leptoukh (GES DISC) Years of effort to provide a tool for harmonizing data

Step1 - Archiving data from multiple sensors.

Step2 - Harmonizing metadata.

Step3 - Accessing data from remote locations.

Step4 - Harmonizing data formats for joint
processing (Giovanni)

Step5 - Serving multi-sensor data via common protocols.

Step6 - Scale harmonization (Giovanni) – regriding (*horizontal only*)

Step7 - Harmonizing visualization (Giovanni, ACP).

Step8 - Joint analysis (Giovanni) → *Always Improving*

Step9 - Merging similar parameters (Giovanni). *Prototype for Level 3.*

Step10 - Merging L2 data. Adjusting bias using Neural Network approach

Step11 - Harmonizing quality.

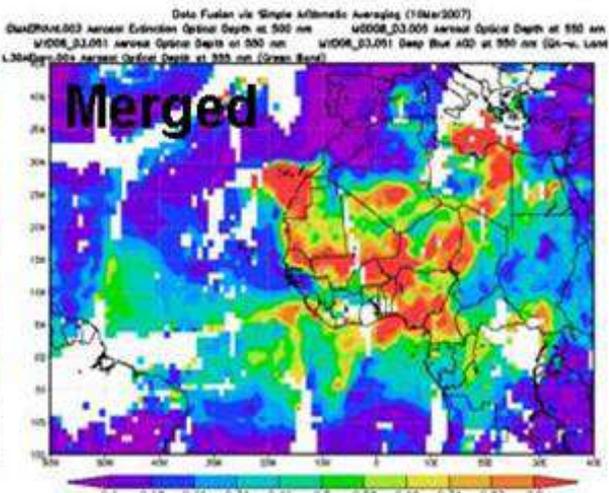
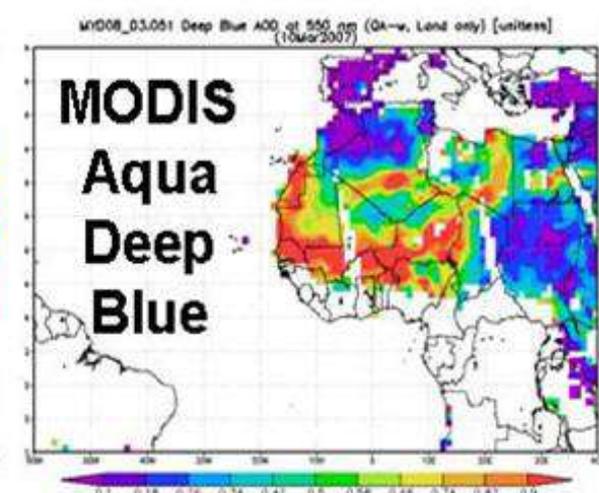
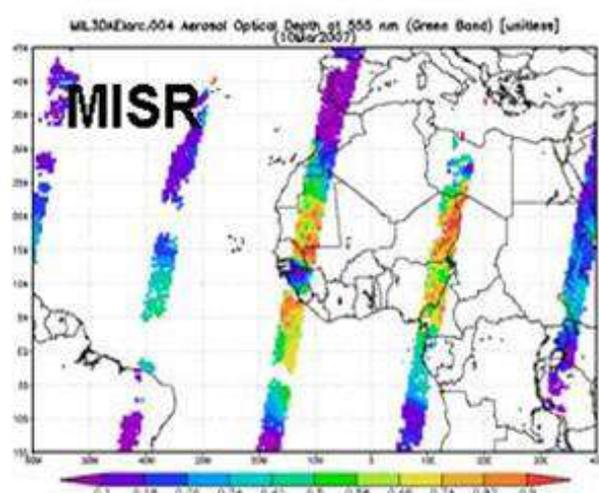
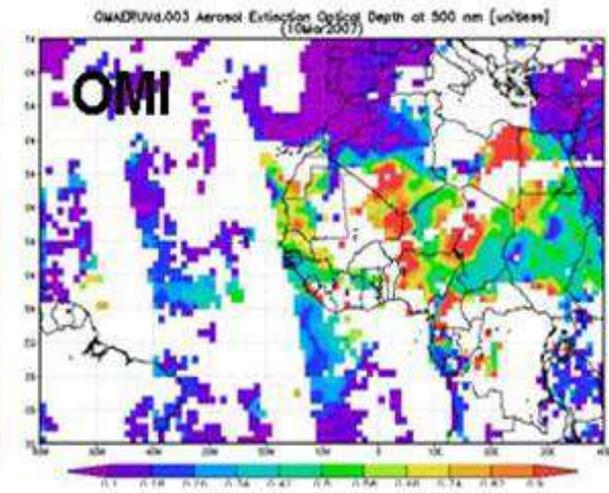
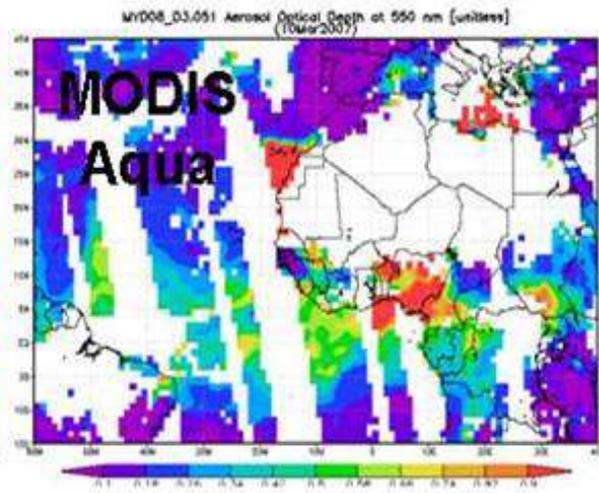
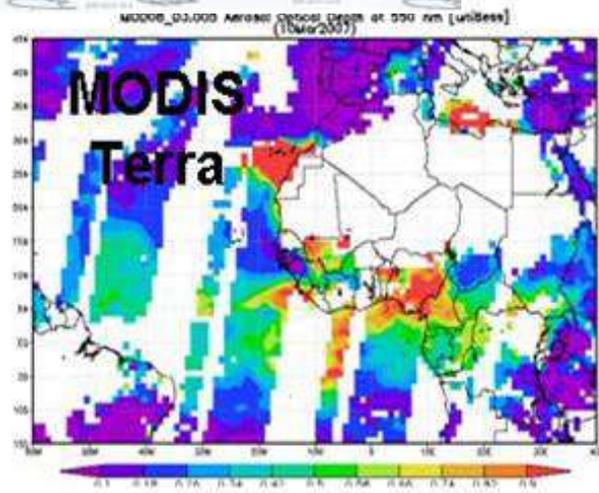
Step12 - Harmonizing provenance

Step13 - Fusing complementary geophysical variables



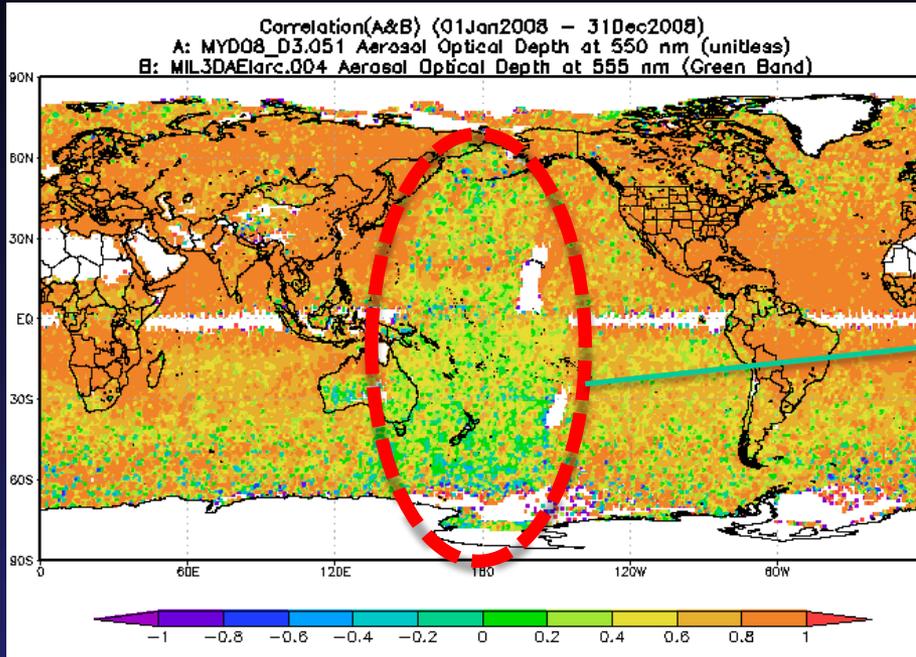


Why not use Level 3 gridded data to harmonize?



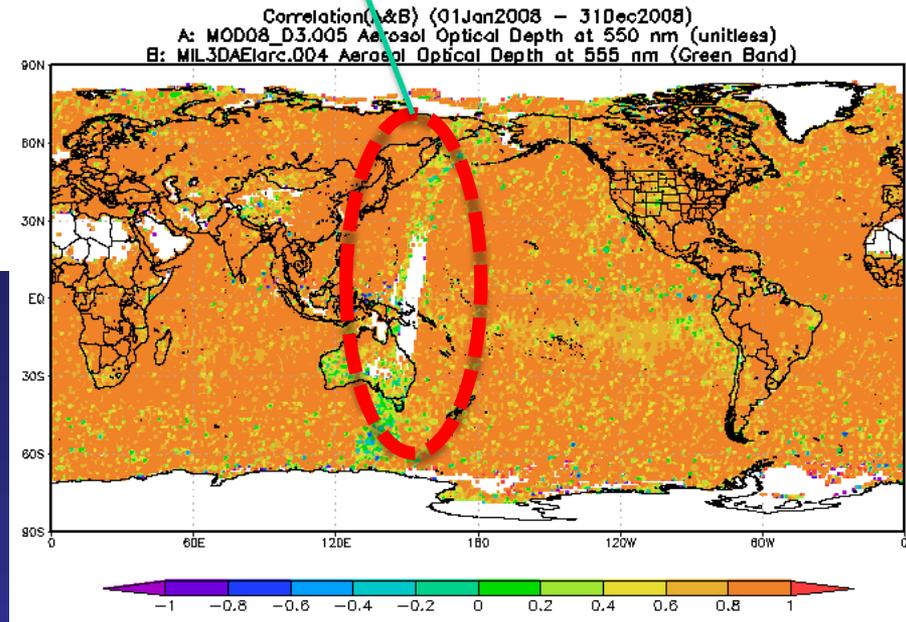


Challenges using Level-3 data



<<< AOD Aqua MODIS vs MISR correlation map for 2008

Decorrelation, why?



MODIS-Terra vs. MISR-Terra: Map of AOD temporal correlation >>>



Another challenge among aerosol measurements

- Different instruments and algorithms have different measurement characteristics
 - Spatial coverage
 - Spatial consistency
 - Temporal consistency
 - Diurnal coverage
 - Vertical sensitivity
 - Sensitivity to sunglint, clouds, surface reflectance, aerosol types, ...



Harmonization

To be able to compare and/or merge data from multiple sources, we need to harmonize:

- Quality Control flags
- Provenance
- Bias adjustment

→ **AeroStat (Online Platform for the Statistical Intercomparison of Aerosols)**

- Statistical analysis on stationary data
- Merging satellite L2 data
- Adjusting bias using Neural Network approach
- Many more...



What is Aerostat ?

- Aerostat is an environment for aerosol **comparison and collocation** with supporting documentation
- Read **essential documentation**:
 - Read Me First, quality statements, disclaimers, processing documentation, lineage/provenance,
- Compare satellite w/ground-based aerosol measurements (AERONET→MAPSS)
 - Scatterplot
 - Time Series
- Explore aerosol phenomena by **merging** multi-sensor data
- Experiment with quality filter settings and bias adjustment
- **Save and share** findings (and questions)



Giovanni-AeroStat

<http://giovanni.gsfc.nasa.gov/aerostat/>

AeroStat Online Platform for Statistical Inter-comparison of Aerosols

Version 1.2 Release Notes Browser Compatibility

AeroStat Giovanni offers statistical analysis, visualization and downloadable products from aerosol data measured by satellites and Aeronet stations.

READ ME FIRST!!

Data Selection Results

Plot Data

Reset

Clear

Send Us Feedback!

Help

Select Plot

Satellite Colocated with AERONET

Time Series - Multiple Y-variables vs Time

Scatter Plot - Multiple Y-variables vs the same X-variable

Satellite Only

Lat-Lon Map - Map of daily data

Merged Lat-Lon Map - Merged Map of daily data

Select Station

Kandahar

Browse

Select Measurements

Click each list below (beginning with the left-most list) to show the set of fully qualified measurements. Select a measurement and then click 'Add'. Repeat for additional measurements.

Product

AERONET L2 AOD, ver. 2

MISR L2 AOD, ver. 0022

MODIS Aqua L2 AOD, ver. 051

MODIS Terra L2 AOD, ver. 051

More about MODIS Aqua L2 AOD, ver. 051

Selected Measurements

AERONET L2 AOD, ver. 2 : Interpolated AOD : 550nm : mean

No. of Pixels Not Filtered >= 2

MODIS Aqua L2 AOD, ver. 051 : AOD Deep Blue at 550nm : 550nm : mean

No. of Pixels Not Filtered >= 5

QA Not Filtered =3 (Good)

Bias Adjustment None Neural Network

Select Date Range

Date Picker Seasonal Search

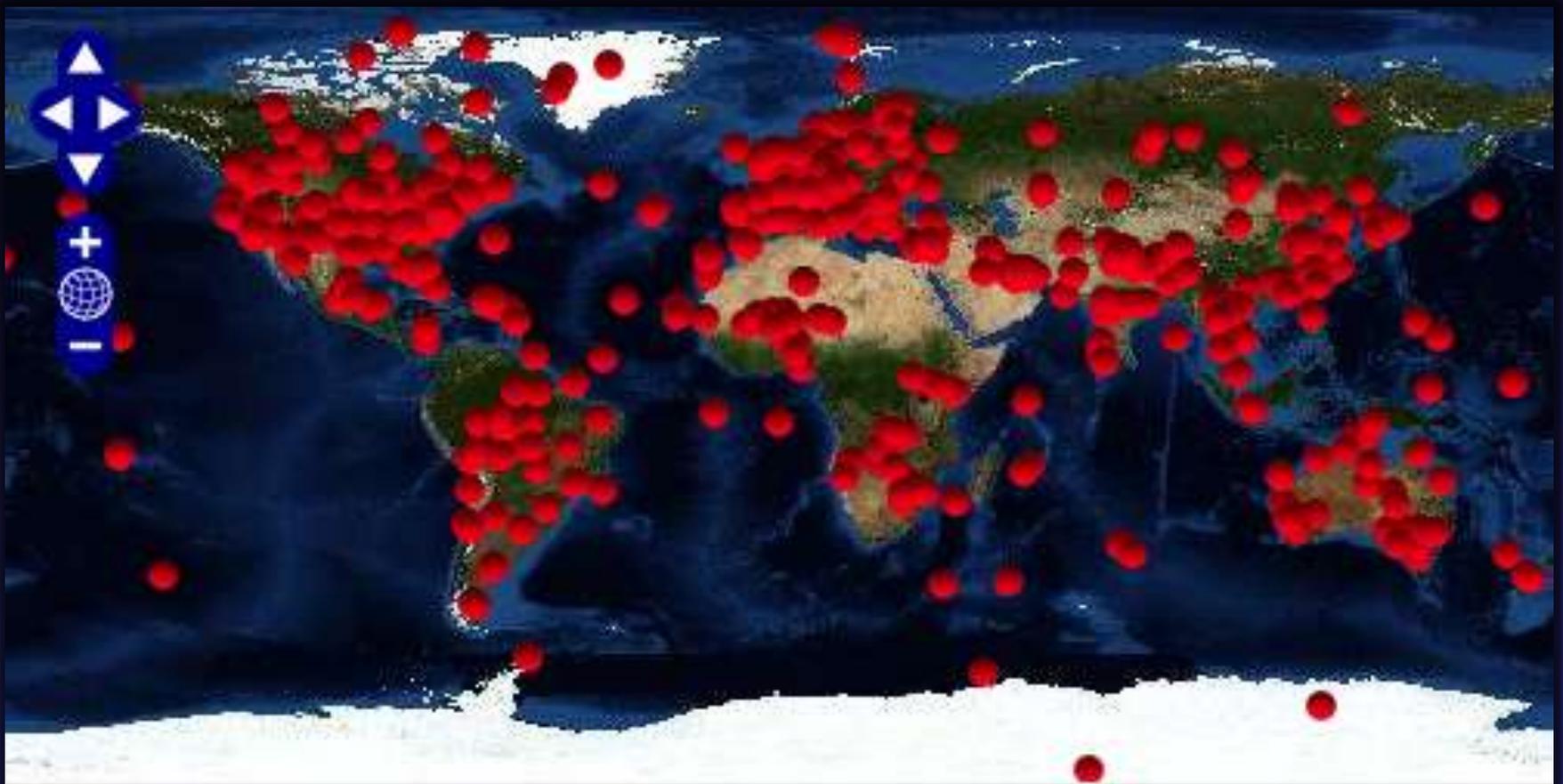
- Provide an effective tool for comparing satellite and ground-based aerosol **Level 2 data**
- Provide an environment for **colocation and comparison** methods with detailed documentation
- Provide aerosol **bias adjustment** to satellite **data** based on ground-based measurement
- Explore aerosol phenomena by **merging** multi-sensor data
- Enable easy **sharing** of results

Show Data Temporal Coverage



Multi-sensor Aerosol Products Sampling System (MAPSS)

- 659 sampling locations
 - 540 AERONET locations





READ_ME_FIRST

Aerostat - Read Me First!

A guide to essential documentation about the aerosol datasets offered in Aerostat.

A caution before using Giovanni-AeroStat

For many purposes, especially scientific research, ***it is critical*** to read key background articles describing each satellite data set before drawing conclusions based on results obtained from Giovanni-AeroStat.

MODIS Level 2 Aerosols:

- [General information on the MODIS L2 Aerosols](#)
- [Known Problems in the MODIS L2 Aerosols](#)

MISR Level 2 Aerosols

- [MISR Level 2 Aerosol Quality Statement](#)

Note that particular observing conditions may degrade the accuracy of remotely-sensed data products, which may cause processing algorithms to fail and result in missing data. Other types of conditions may make a data product less accurate, even though the data values may appear valid. **Thus, all remotely-sensed data products should be evaluated with caution, and with respect to conditions that may cause them to be incomplete or inaccurate.** Below we list several papers that address some of the challenges in working with and comparing remotely sensed aerosol data products.

AERONET aerosol products

- Version 2 AERONET direct sun algorithm: [Download PDF](#)
- Level 2 Quality Control: [Download PDF](#)

In summary, we encourage the use of Giovanni for research, and we are continually striving to make it an excellent tool for that purpose. Successful research investigations, however, require that researchers fully understand the characteristics and limitations of the data they are using, as well as the characteristics and limitations of the tools they utilize to analyze such data.



Extended Document on QA and Bias Adjustment

QA: Quality Control/Qualify Assurance Confidence flags.

In MAPSS data, this QA represents the "mode of QA flags" in the sample space.

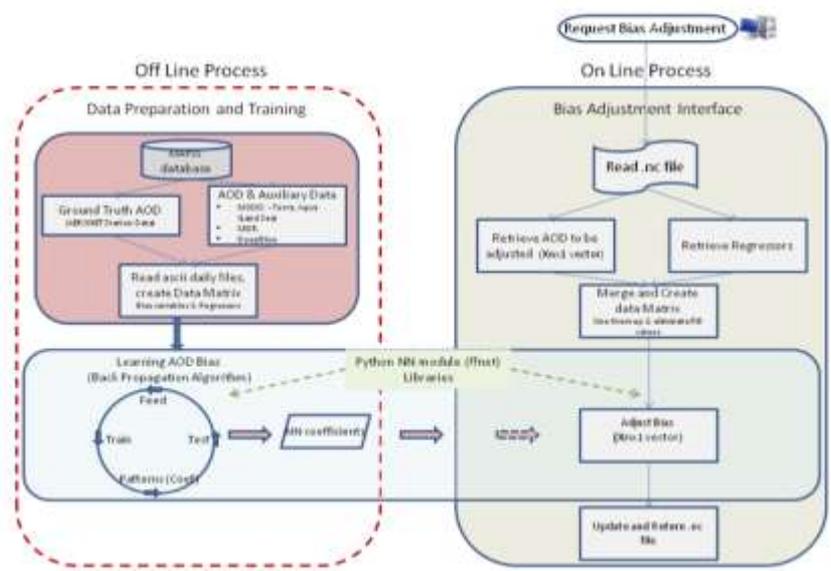
In Satellite Only data, we have decoded the original bit mask flags and reported as plain numbers.

In AeroStat Giovanni, we provide preset values for QA filtering option, and the default setting is following science teams recommendations.

| | | (Science Team Recommendation) |
|---|--|-------------------------------|
| MODIS Terra/Aqua Dark Target Ocean (470 nm, 550 nm, 660 nm, 870 nm, 1200 nm, 1600 nm) | <ul style="list-style-type: none"> Not Filtered QA>=1 (QAC=1,2,3) | QA >= 1 (i.e., QAC=1, 2, 3) |
| MODIS Terra/Aqua Dark Target Land (470 nm, 550 nm, 660 nm) | | |
| MODIS Terra/Aqua Deep Blue Land at 550 nm | | |
| MISR AOD (446 nm, 558 nm, 672 nm, 866 nm) | | |

Machine-learning approach (currently, Neural Networks (NN)) is used to persistently adjust bias between aerosol optical depth from MODIS Terra, MODIS Aqua, MISR, and the ground-based AERONET. We have seven training data sets, MODIS Terra Land, MODIS Terra Ocean, MODIS Terra Deep Blue over Land, MODIS Aqua Land, MODIS Aqua Ocean, MODIS Aqua Deep Blue over Land, and MISR. Since Neural Networks (NN) are multivariate non-parametric "learning" algorithms, it is better to include variables that contain related information about the retrieved AOD during the training process as well as applying the bias adjustment process. We refer these additional information as "Regressors". The processing diagram/flowchart is shown in the following figure.

Figure: Flowchart of Neural Networks Bias Adjustment in AeroStat



Albayrak, A., J. Wei, M. Petrenko, C. Lynnes, and R. C. Levy, Global Bias Adjustment for MODIS Aerosol Optical Thickness using neural network, submitted to SPIE JARS 2012.



Extras

History, Criteria, Save/Share, Disclaimer, Lineage

Data Selection

Results

History ▾

Criteria

Save/Share

Problem? Send a report!

Result 1 - Scatter Plot

Plots

Downloads

Lineage



AERONET Download Site

NOTICE TO USERS:

The public domain data you International AERONET Federated (PI), responsible priority use of the informed of any other

GSFC (Latitude

Recommended guidelines

Although journal paper senior author and not ask that every practical guidelines.

Using AERONET data:

| Step 1. | Search for and retrieve data |
|-------------------------------|---|
| Input | |
| data | AERONET_AOD_L2.2:AOD0550intrap:mean[nval >= 2] |
| data | MOD04_L2.051:AOD0550corr-l:mean[nval >= 5,QAavg-l = 3,None] |
| start time in ISO 8601 format | 2005-01-01 |
| location | GSFC |
| portal | AEROSTAT |
| service | AEROSTAT_SCATTER_PLOT |
| annual | |

| Step 4. | Search using time and location constraints. (completed at 09:57:55Z) |
|--|---|
| Input | |
| Data Start Time | 2004-03-31T10:00:00Z |
| Data End Time | 2004-04-03T13:59:59Z |
| Data set | MIL2ASAE.002 |
| Bounding box in 'west, south, east, north' order | -36.641000,-9.570000,38.047000,38.398000 |
| Output | |
| data file | ftp://4ft01.larc.nasa.gov/misr/213/MISR/MIL2ASAE.002/2004.03.31/MISR_AM1_AS_AEROSOL_P188_O022791_F12_0022.hdf |
| data file | ftp://4ft01.larc.nasa.gov/misr/213/MISR/MIL2ASAE.002/2004.03.31/MISR_AM1_AS_AEROSOL_P204_O022792_F12_0022.hdf |
| data file | ftp://4ft01.larc.nasa.gov/misr/213/MISR/MIL2ASAE.002/2004.03.31/MISR_AM1_AS_AEROSOL_P220_O022793_F12_0022.hdf |
| data file | ftp://4ft01.larc.nasa.gov/misr/213/MISR/MIL2ASAE.002/2004.03.31/MISR_AM1_AS_AEROSOL_P003_O022794_F12_0022.hdf |
| data file | ftp://4ft01.larc.nasa.gov/misr/213/MISR/MIL2ASAE.002/2004.03.31/MISR_AM1_AS_AEROSOL_P019_O022795_F12_0022.hdf |
| data file | ftp://4ft01.larc.nasa.gov/misr/213/MISR/MIL2ASAE.002/2004.03.31/MISR_AM1_AS_AEROSOL_P035_O022796_F12_0022.hdf |
| data file | ftp://4ft01.larc.nasa.gov/misr/213/MISR/MIL2ASAE.002/2004.03.31/MISR_AM1_AS_AEROSOL_P051_O022797_F12_0022.hdf |

I AGREE

I DO NOT AGREE



gSocial (Giovanni Social Network)

AeroStat Online Platform for Statistical Inter-comparison of Aerosols

Version 1.2 [Release Notes](#) [Browser Compatibility](#)

[AeroStat Giovanni](#) offers statistical analysis, visualization and downloadable products from aerosol data measured by satellites and stations.

READ ME FIRST!!

Data Selection

Results

History ▾

Load Data Selections

Save/Share

Send Us Feedback!

Help

NASA National Aeronautics and Space Administration

Global Earth Sciences Data and Information Services Center

+ ATMOS COMPOSITION

+ HYDROLOGY

+ A-TRAIN

+ AIRS

+ HURRICANES

+ NEESPI

+ PRECIPITATION

Social Giovanni

Home

You Must Register First!

In order to share on Social Giovanni, you must be on track to share this result.

If you are already registered, you may register.

If you have not registered, you may register.

User login

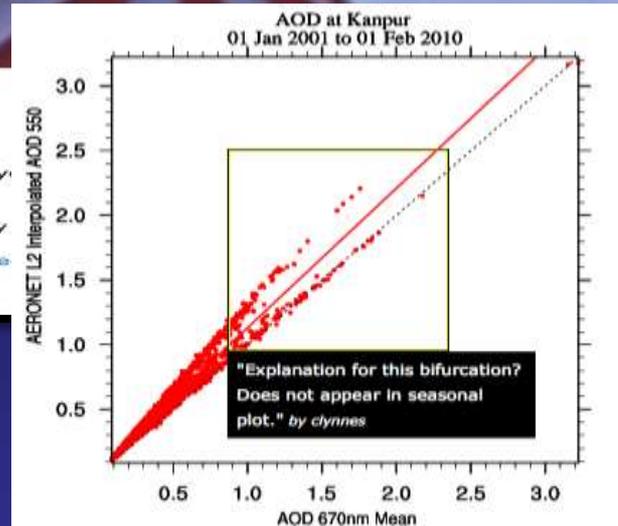
Username: *

Password: *

Log In

- Create new account
- Request new password

gSocial participants can save results, annotate plots, share with others, reproduce their and others' results (!), and continue sharing.



· AERONET L2 Interpolated AOD 550 Mean (nval >= 2)

— $y=1.078x+0.054, \text{RMS}=0.071, \text{R}^2=0.948, \text{N}=2209$

--- 1:1

... and free, and you will be kept

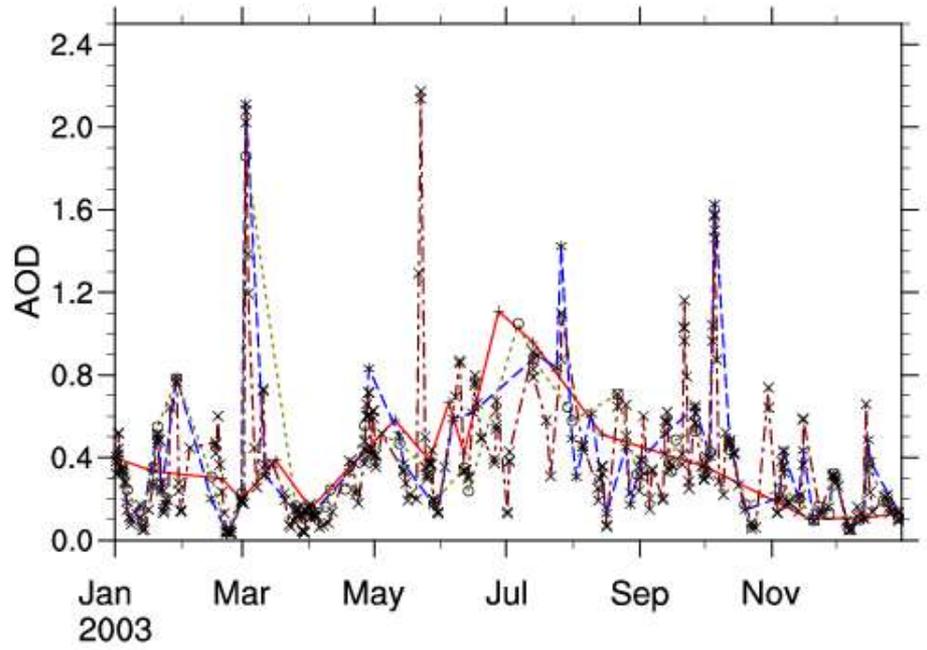
logged in.



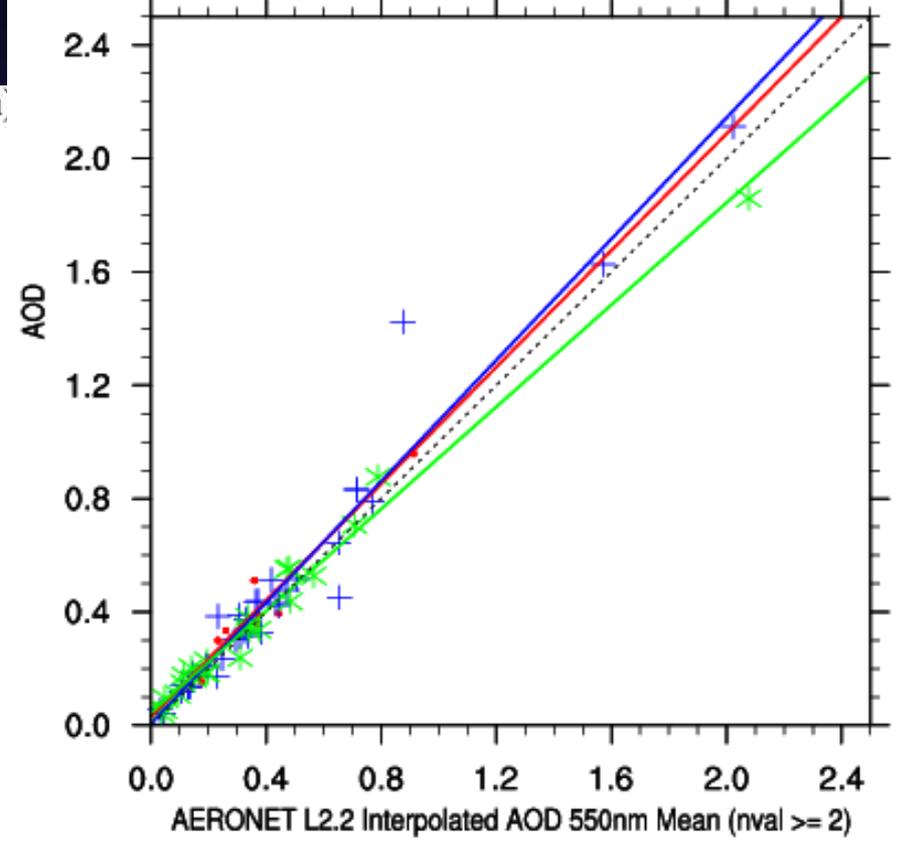
PROVIDE AN EFFECTIVE TOOL FOR COMPARING SATELLITE AND GROUND-BASED AEROSOL LEVEL 2 DATA

Cape Verde

AOD at Capo_Verde (Lat=16.733 Lon=-22.935 Alt=60m), 01 Jan 2003 to 31 Dec 2003



AOD at Capo_Verde (Lat=16.733 Lon=-22.935 Alt=60m) 01 Jan 2003 to 31 Dec 2003

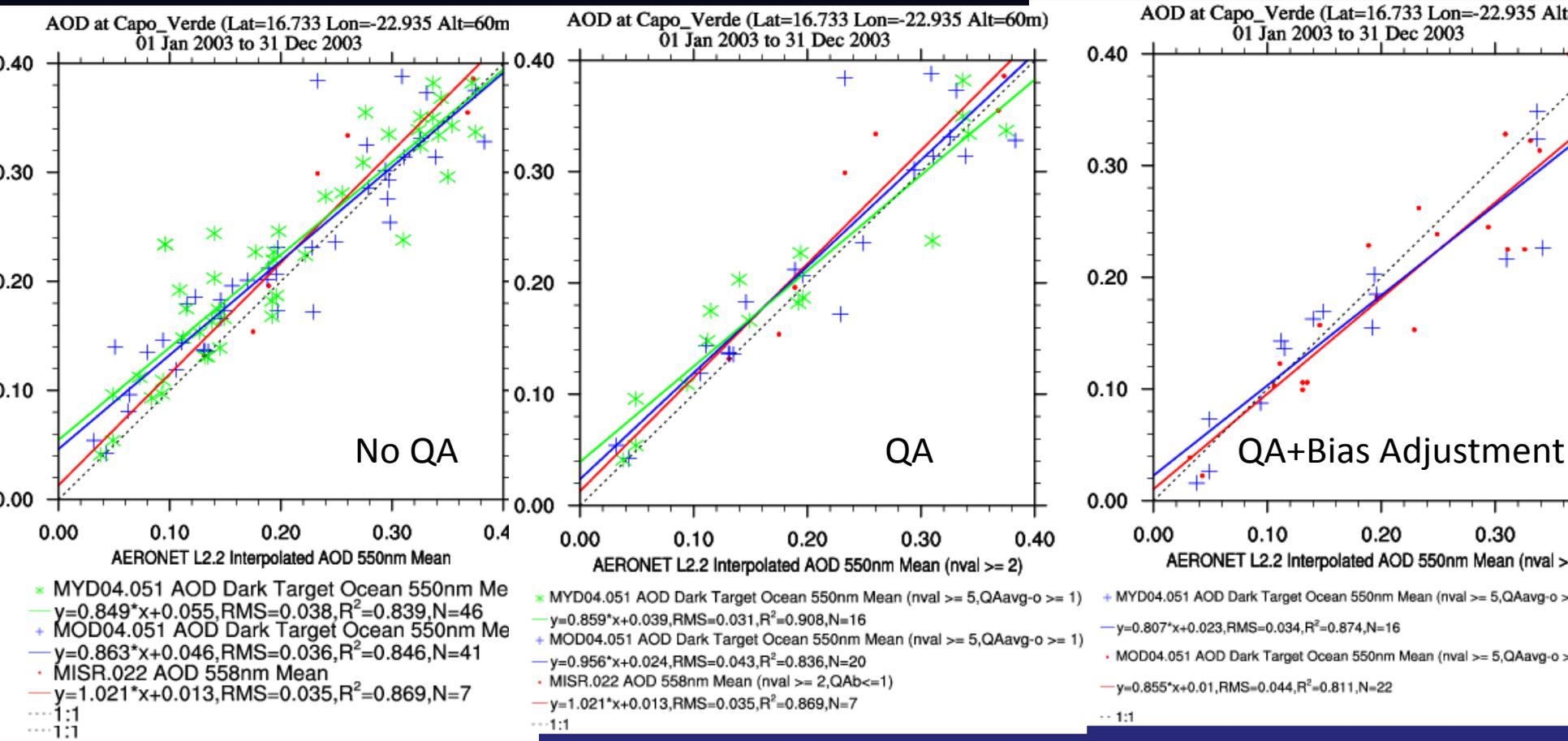


- x --- AERONET L2.2 Interpolated AOD 550nm Mean (nval >= 2)
- o --- MYD04.051 AOD Dark Target Ocean 550nm Mean (nval >= 5, QAavg-o >= 1)
- * --- MOD04.051 AOD Dark Target Ocean 550nm Mean (nval >= 5, QAavg-o >= 1)
- + --- MISR.022 AOD 558nm Mean (nval >= 2, QAb<=1)

- * MYD04.051 AOD Dark Target Ocean 550nm Mean (nval >= 5, QAavg-o >= 1)
- $y=0.901*x+0.043, \text{RMS}=0.047, \text{R}^2=0.984, \text{N}=23$
- + MOD04.051 AOD Dark Target Ocean 550nm Mean (nval >= 5, QAavg-o >= 1)
- $y=1.069*x+0.005, \text{RMS}=0.103, \text{R}^2=0.945, \text{N}=35$
- MISR.022 AOD 558nm Mean (nval >= 2, QAb<=1)
- $y=1.029*x+0.029, \text{RMS}=0.063, \text{R}^2=0.915, \text{N}=11$
- 1:1



QA filters and Bias Adjustment

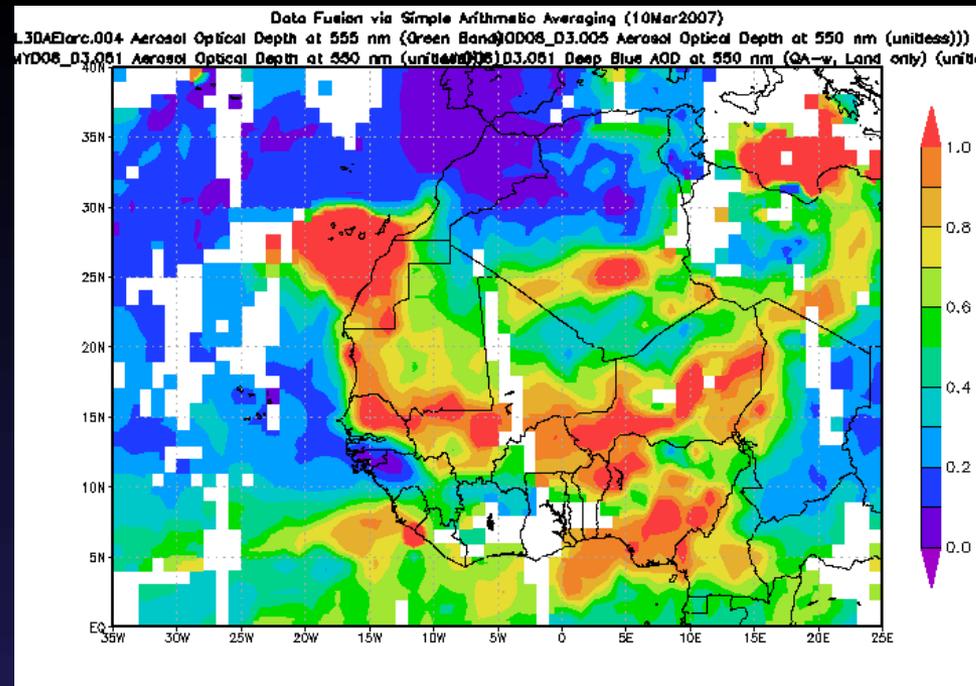


*** MODIS Aqua
 +++ MODIS Terra
 MISR

+++ MODIS Aqua
 MODIS Terra



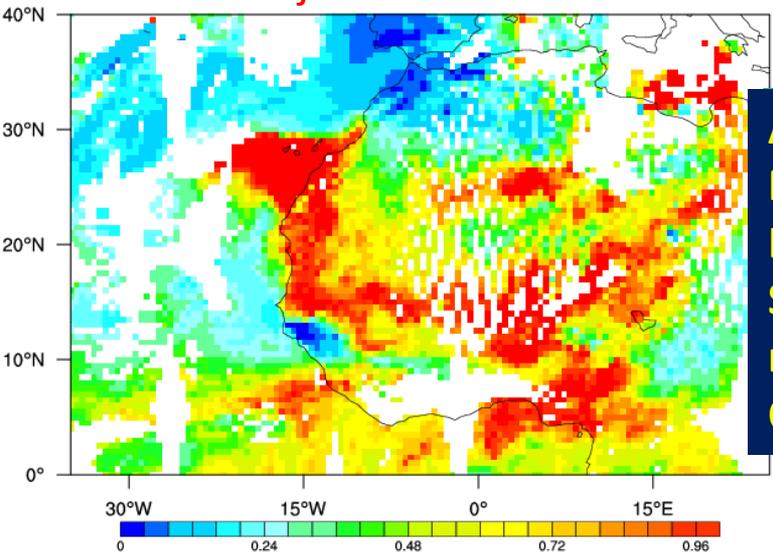
Merge from L3 data
No QA Filter
No Bias Adjustment



AOD Giovanni 0.50x0.50 deg for 10 Mar 2007

Merged AOD from MISR_AM1_AS@558nm, MYD04 Deep Blue@550nm*, MYD04 Dark Target Land@550nm*, MYD04 Dark Target Ocean@550nm, MOD04 Dark Target Ocean@550nm, MOD04 Dark Target Land@550nm*, MOD04 Deep Blue@550nm* (*=filtered)

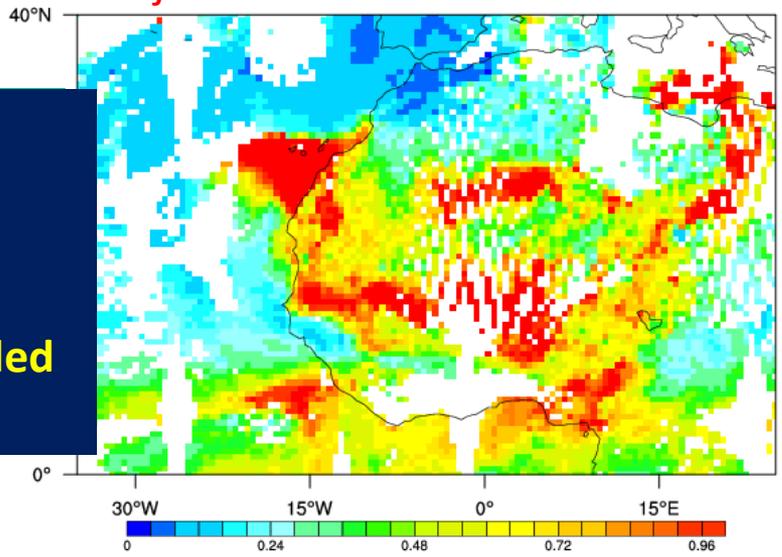
No Bias Adjustment



AOD Giovanni 0.50x0.50 deg for 10 Mar 2007

Merged AOD from MISR_AM1_AS@558nm, MYD04 Deep Blue@550nm*, MYD04 Dark Target Land@550nm*, MYD04 Dark Target Ocean@550nm, MOD04 Dark Target Ocean@550nm, MOD04 Dark Target Land@550nm*, MOD04 Deep Blue@550nm* (*=filtered, #=bias-adjusted)

Bias Adjustment



AeroStat
Merge from
L2 data
Science
recommended
QA Filter



Acknowledgement

- Dr. Gregory Leptoukh
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 - Martha Maiden.
 - Steve Berrick.
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 - AERONET: Brent Holben, David Giles, IlyaSlutsker
 - MODIS: Lorraine Remer, Rob Levy
 - MISR: Ralph Kahn
 - OMI: Omar Torres
 - POLDER: Didier Tanre, FabriceDucos, Jacques Descloitres
 - CALIOP: Dave Winker, Ali Omar
 - SeaWiFS Deep Blue: Christina Hsu, Andy Sayer, Corey Bettenhausen
- G – Team (GES DISC, GIOVANNI, gSocial, GMU)



MORE GIOVANNI FEATURES AND APPLICATIONS

→ EXHIBIT NASA BOOTH ON THURSDAY (DEC. 6TH) AT 9:30 AM