Level-2 AOD median from multiple satellite sensor retrievals

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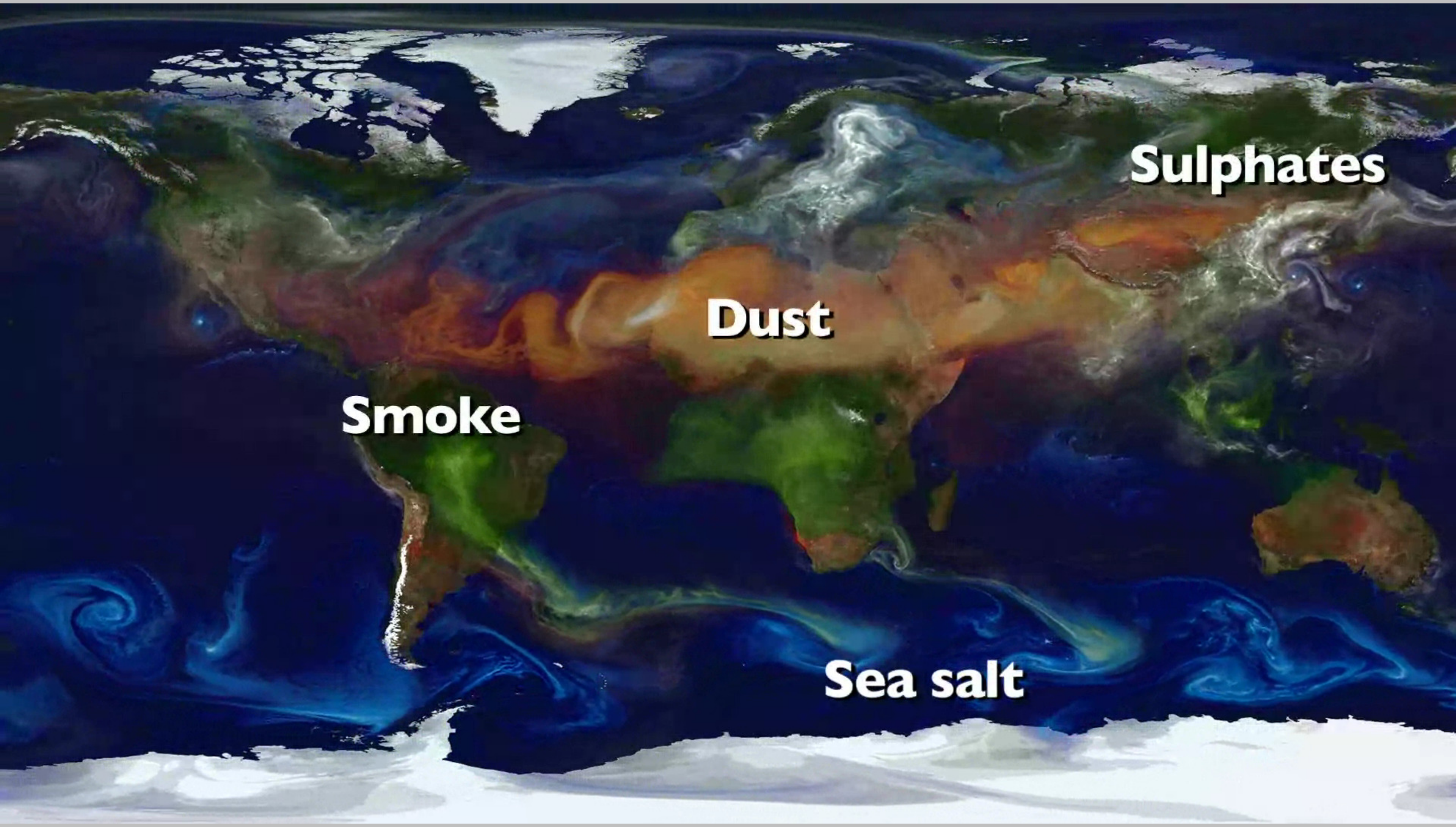


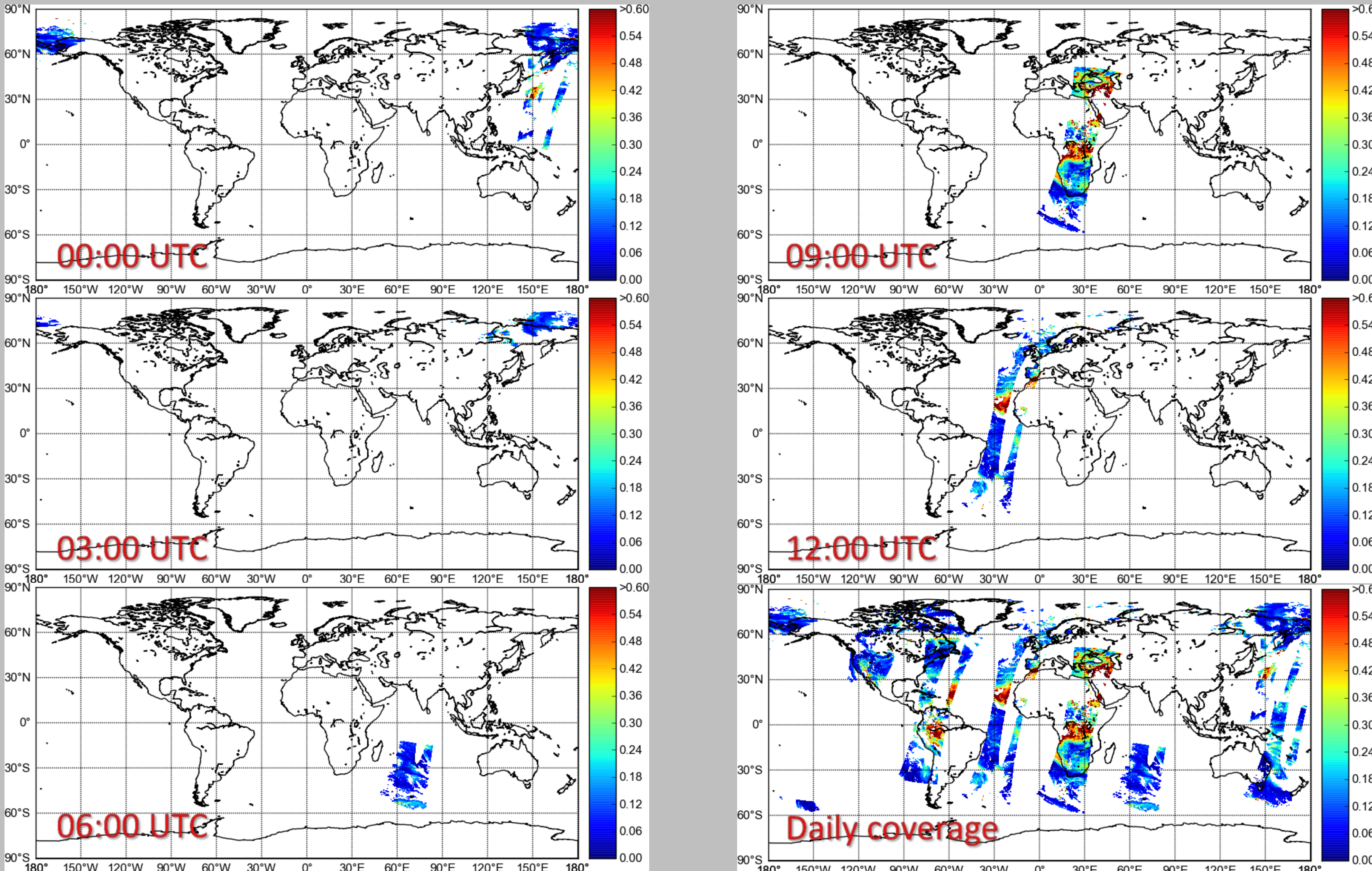
GEOS5 nature run for a given time, depicting different aerosol types with different colors

Presented at the 14th AEROCOM/3rd AEROSAT Workshop, 5-9 October 2015, ESA-Esrin, Frascati, Italy

Outline

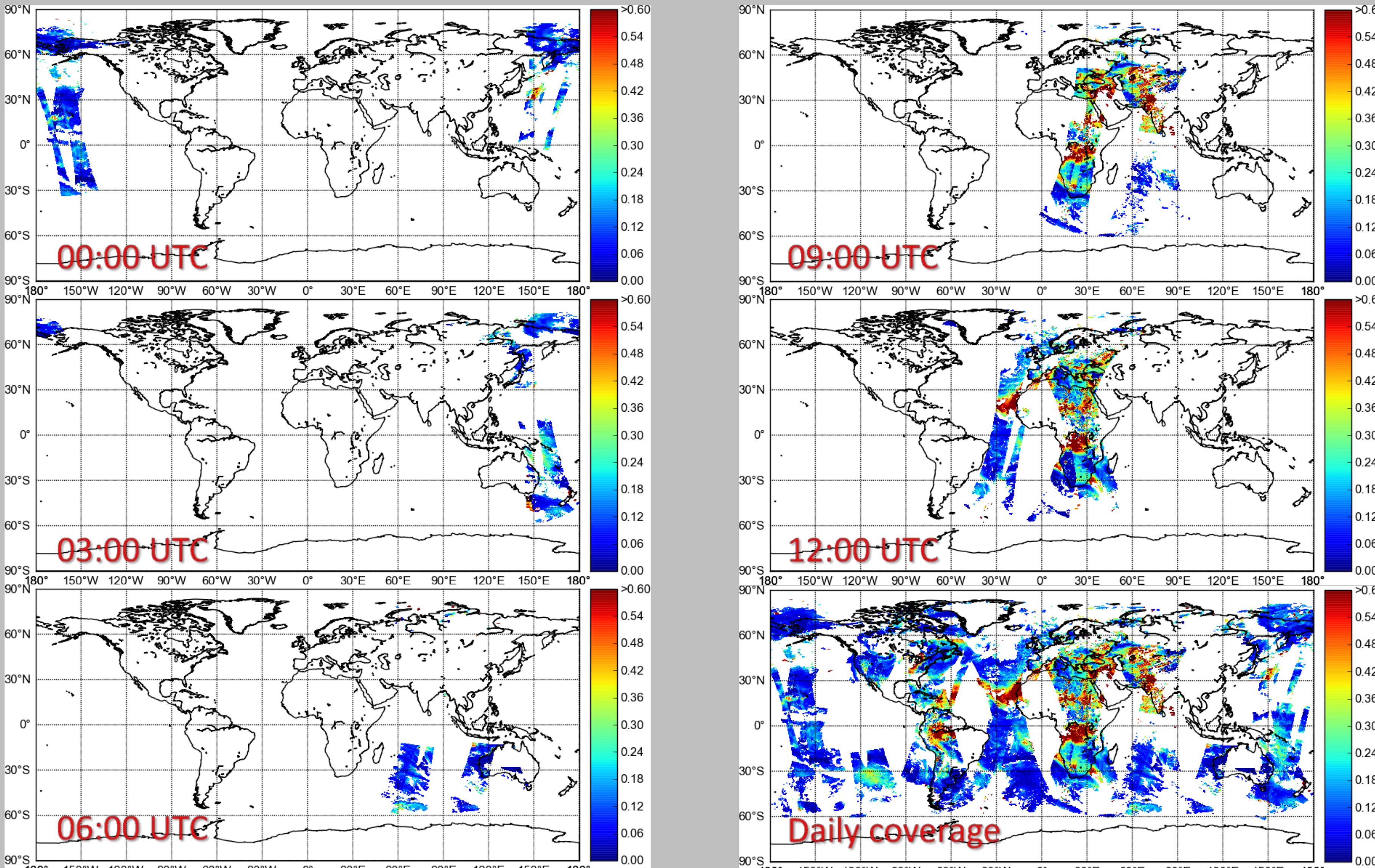
- **Spatio-temporal Challenges of Aerosol Inter-comparison between Satellite observations and Model simulations**
- **The MAPSS aerosol data sampling/analysis system**
- **Lessons from Multi-sensor Coherent Uncertainty Analyses**
- **Toward Multi-sensor Data Synergy: Level 2 AOD Median**
- **Future Possibilities (Suggestions very welcome)**

±30 minute MODIS Terra swath cutouts for evaluation of 3-hour model snapshots on 2008-08-22



Single product poor coverage, even whole day is not optimal spatially/temporally

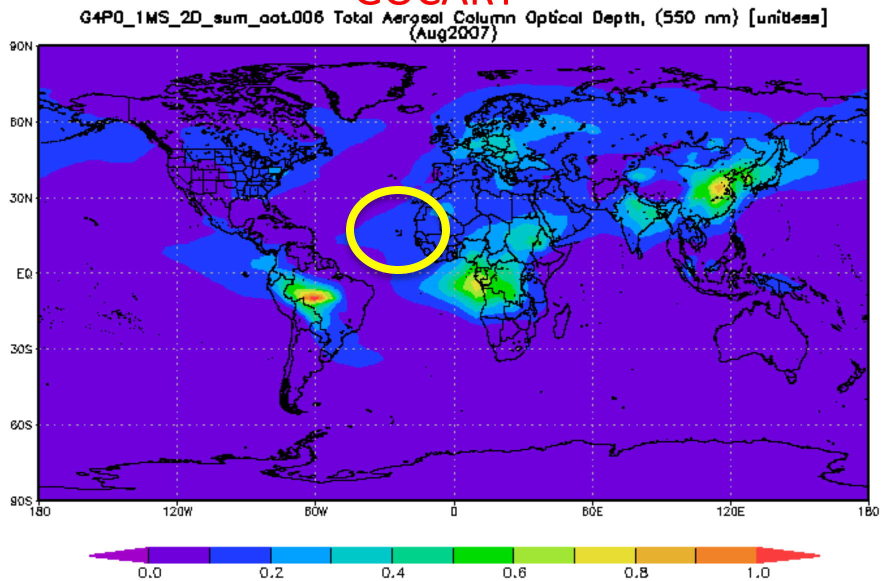
Combined swath cutouts from MODIS Aqua&Terra, MISR, OMI, SeaWiFS, and POLDER



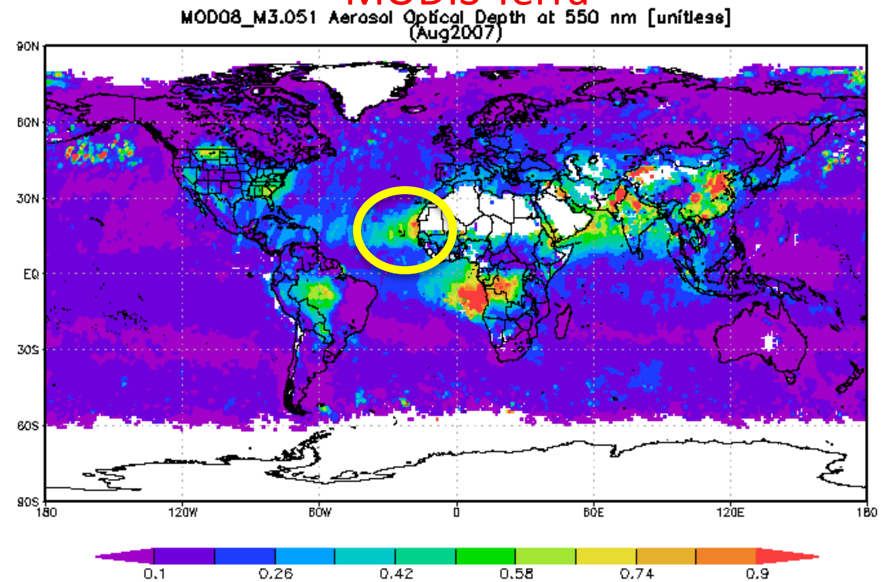
Combined product, a little improved, but still same issues, plus sampling dilemma

Global monthly AOD for August 2007

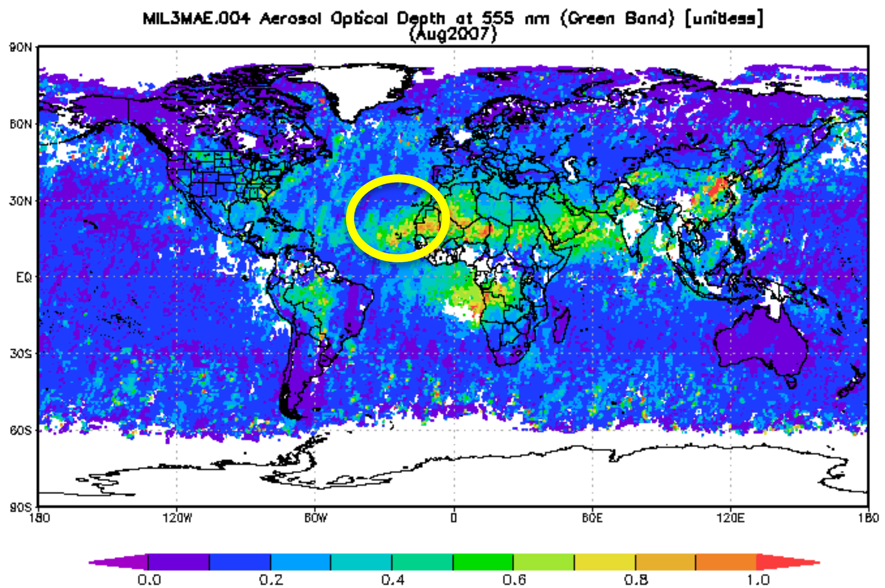
GOCART



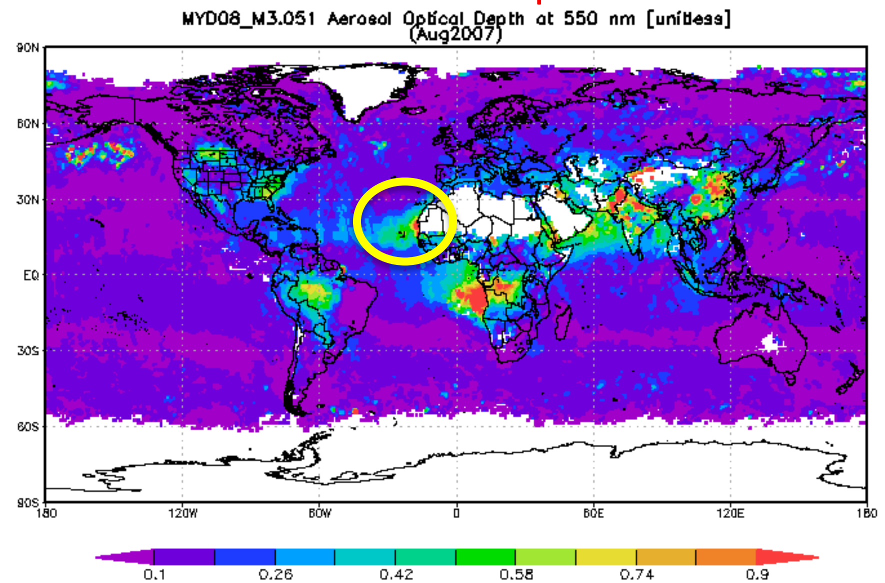
MODIS Terra



MISR

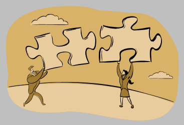


MODIS Aqua

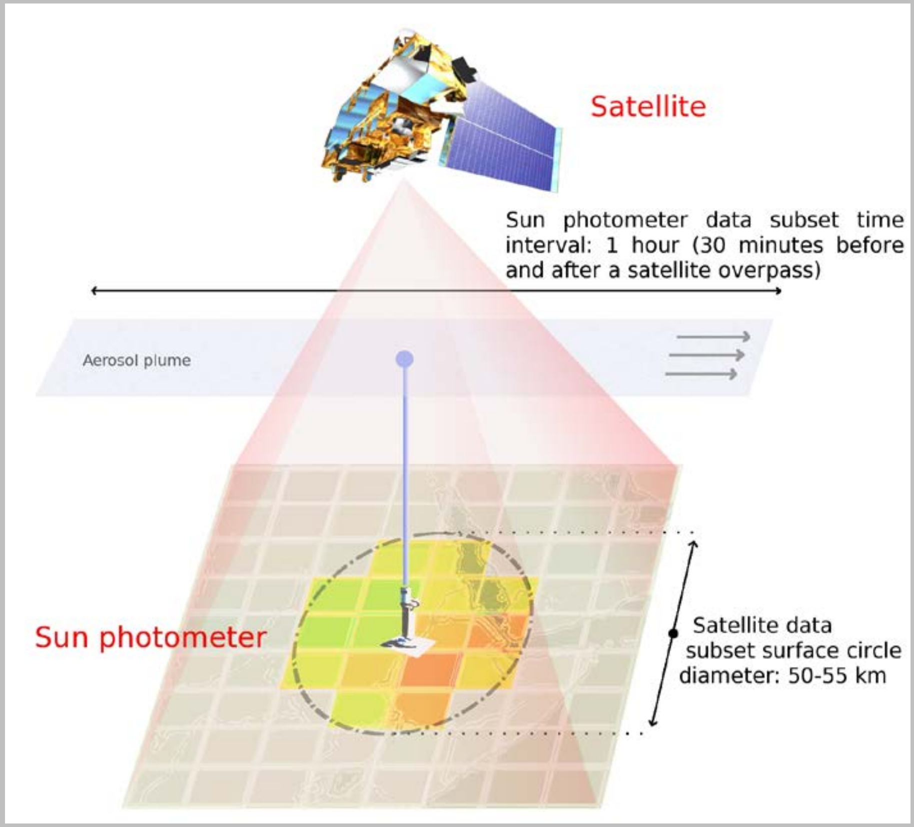


Monthly averages, improved coverage, but less useful for diagnosing models

MAPSS: Multi-sensor Aerosol Products Sampling System



- Aerosol data are available from different sensors
  - AERONET
  - MODIS
  - MISR
  - OMI
  - POLDER
  - CALIOP
  - SeaWiFS
  - VIIRS
- Hard to compare and inter-validate
  - Different spatial and temporal resolution
  - Different data access strategies

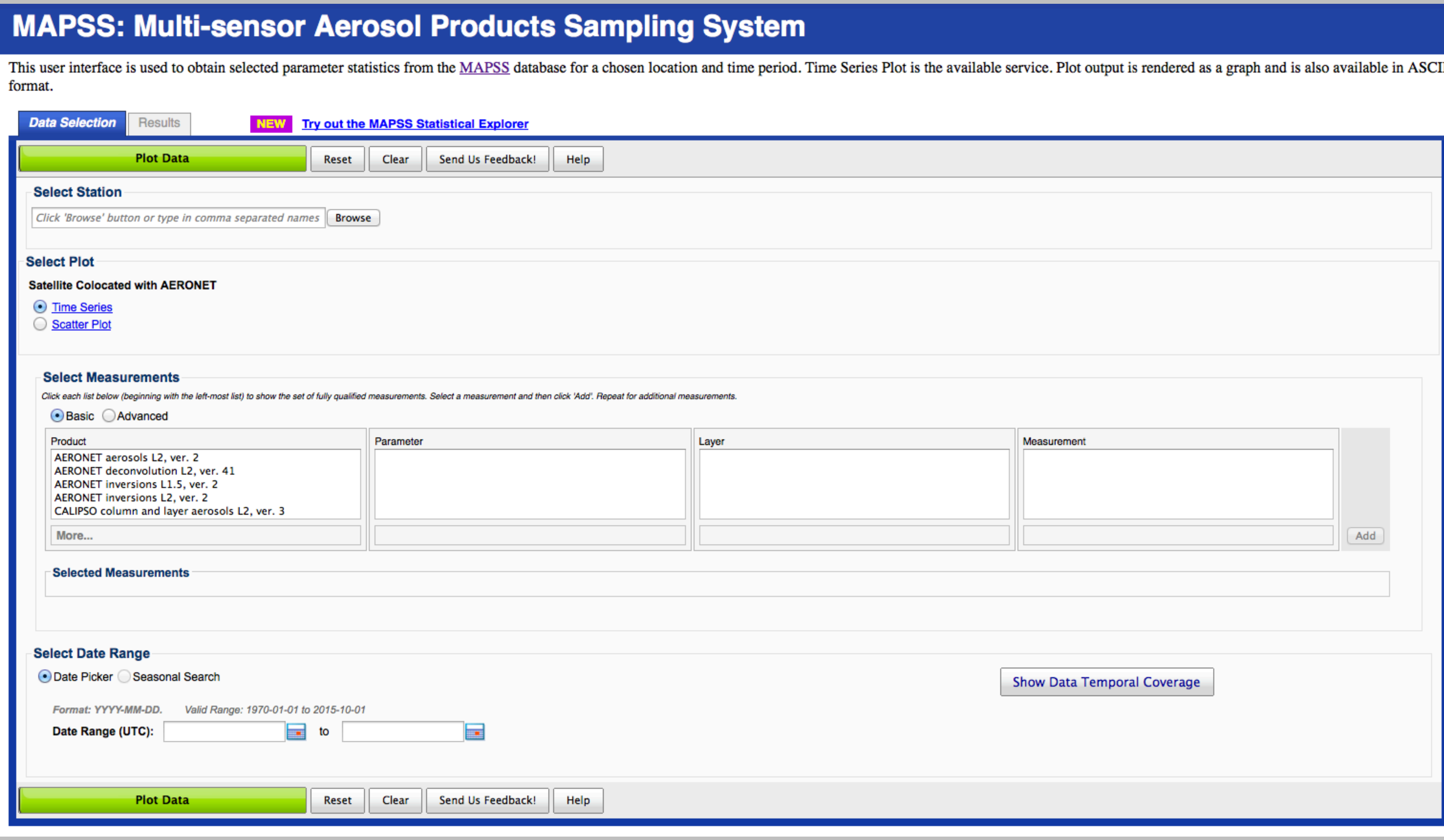


Petrenko et al., 2012, AMT

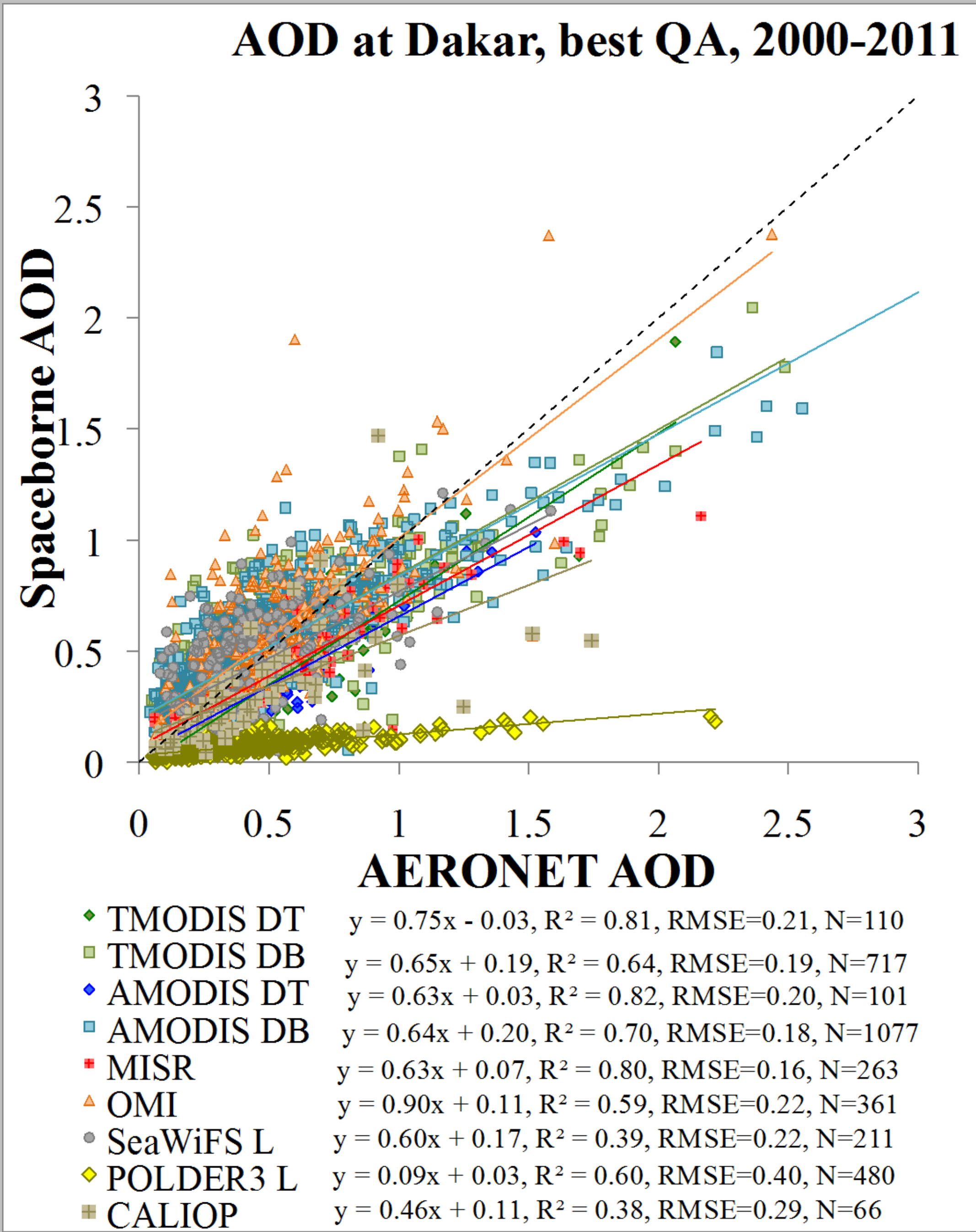
- MAPSS uniformly samples Level-2 aerosol products and stores resulting statistics in simple CSV files
- Giovanni-based WEB interface for MAPSS provides a convenient customized access to the data, with on-line plotting and data export capabilities

MAPSS (Multi-sensor Aerosol Products Sampling System)

http://giovanni.gsfc.nasa.gov/mapss/



Comparative Accuracy of spaceborne AOD retrievals

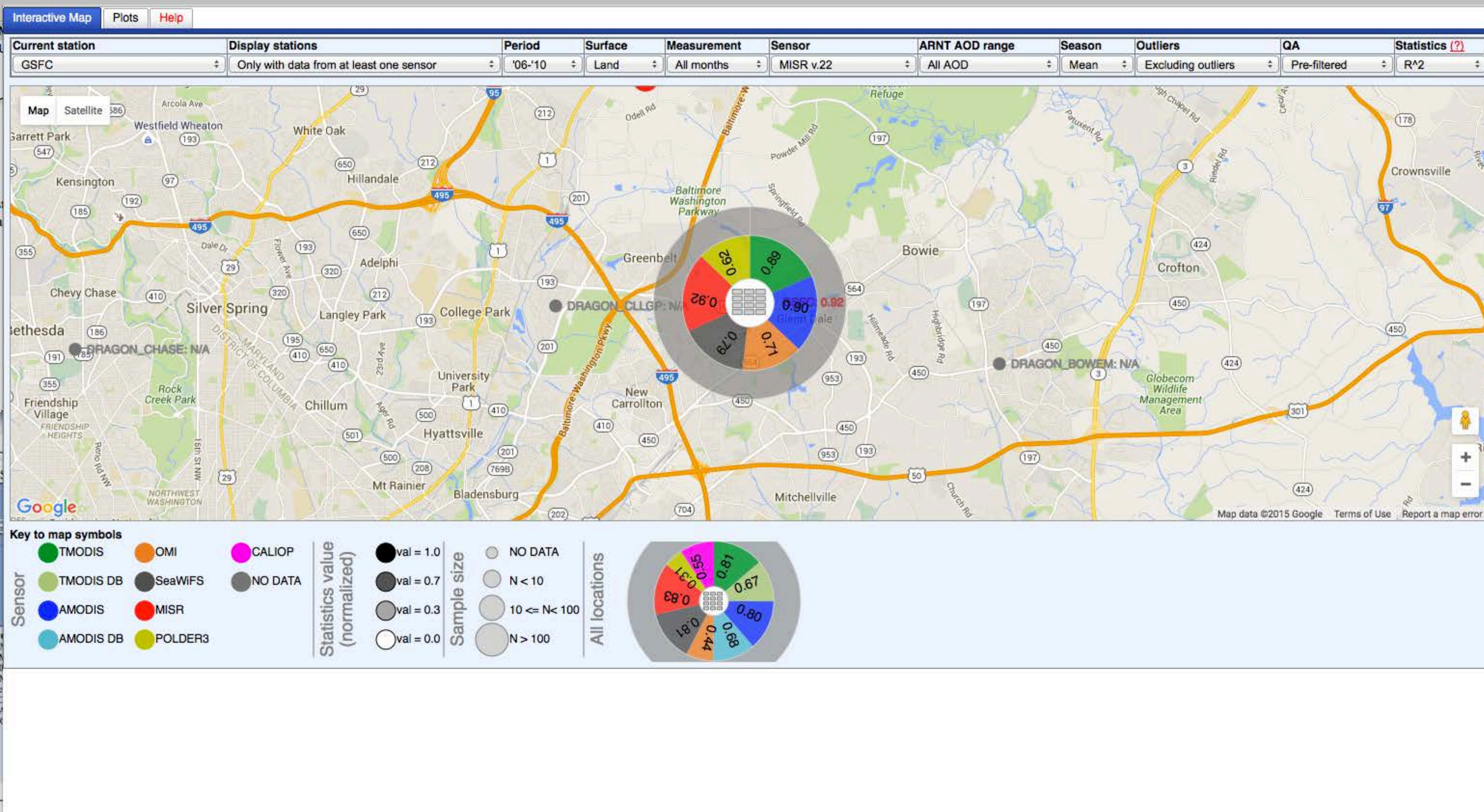


- Satellite data sampled within 55-km diameter circles centered over AERONET stations
- AERONET data sampled within ±30 minutes of each overpass of the satellites
- Space-borne AOD uncertainty metrics computed on the basis of comparison with AERONET data

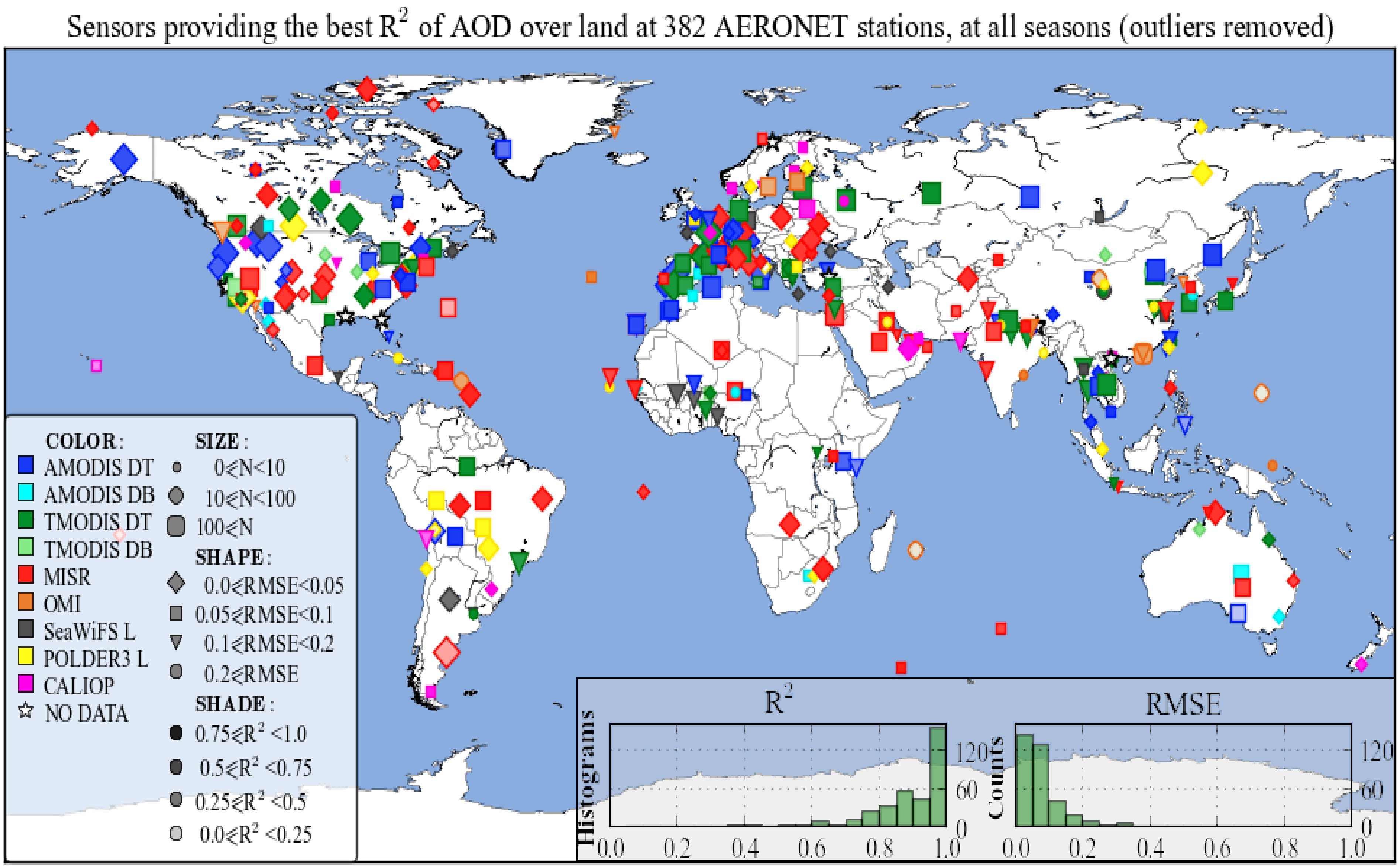
Reference: Petrenko, M. and Ichoku, C.: Coherent uncertainty analysis of aerosol measurements from multiple satellite sensors, Atmos. Chem. Phys., 13, 6777-6805, doi:10.5194/acp-13-6777-2013, 2013.

MAPSS-Explorer

http://giovanni.gsfc.nasa.gov/mapss_explorer/



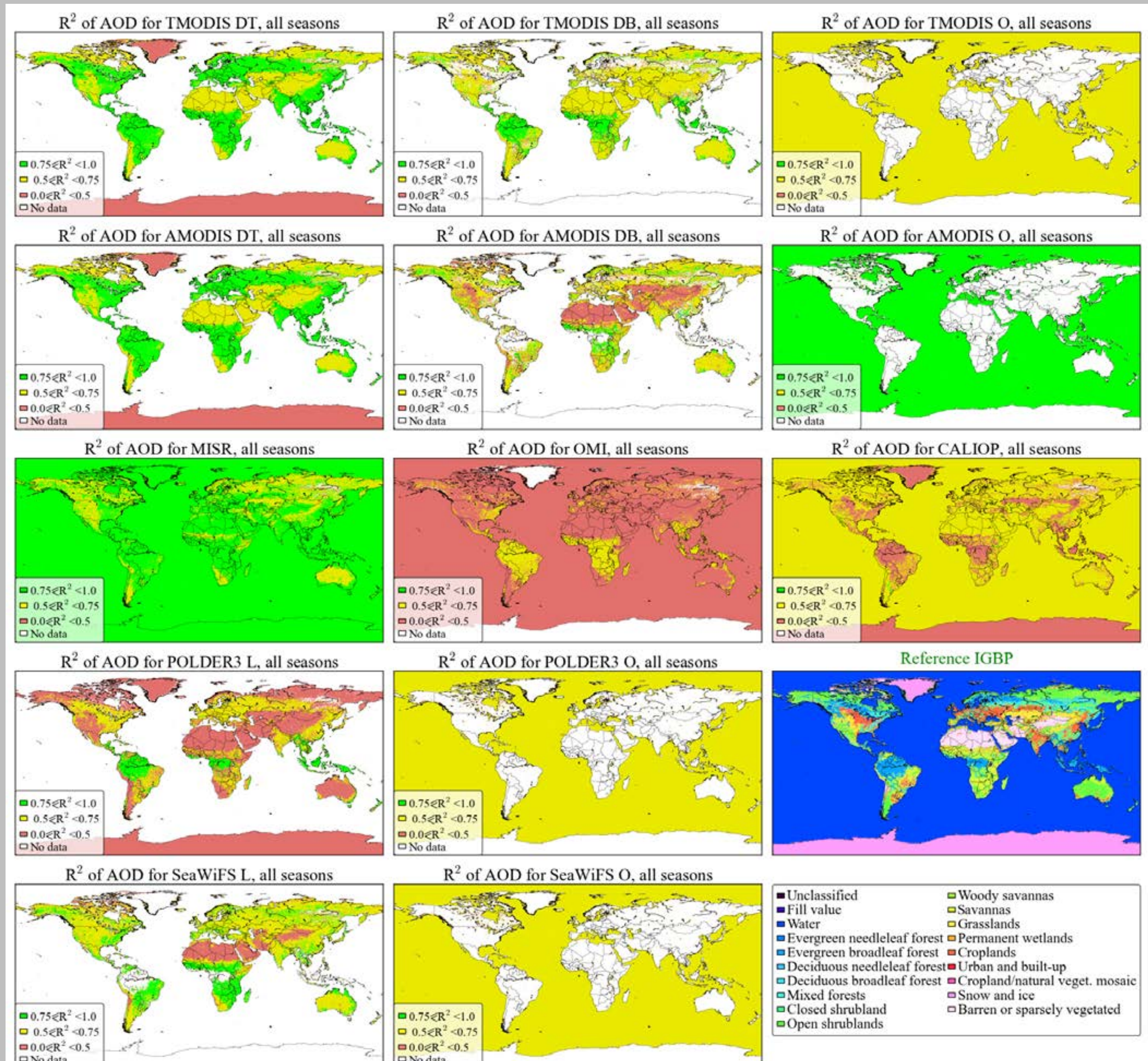
Relative Performance of Satellite Aerosol Products at AERONET locations



Reference: Petrenko, M. and Ichoku, C.: Coherent uncertainty analysis of aerosol measurements from multiple satellite sensors, Atmos. Chem. Phys., 13, 6777-6805, doi:10.5194/acp-13-6777-2013, 2013.

Relative Performance of Satellite Aerosol Products by Landcover Type

Measures of accuracy (e.g. R^2) by Land-cover Type



Reference: Petrenko, M. and Ichoku, C.: Coherent uncertainty analysis of aerosol measurements from multiple satellite sensors, Atmos. Chem. Phys., 13, 6777-6805, doi:10.5194/acp-13-6777-2013, 2013.

Lessons from coherent uncertainty analysis

Results and Summary

IGBP land cover type	Most adapted products
Water	MODIS, MISR, and SeaWiFS
Evergreen needleleaf forest	MODIS and MISR
Evergreen broadleaf forest	POLDER, MISR, and MODIS
Deciduous broadleaf forest	MODIS and MISR
Mixed forests	MODIS and MISR
Closed shrubland	MISR, CALIOP, MODIS Deep Blue
Open shrublands	All sensors have R^2<0.7
Woody savannas	MODIS Dark Target, MODIS Deep Blue, MISR, SeaWiFS
Savannas	MODIS, SeaWiFS, MISR, POLDER
Grasslands	All sensors have R^2<0.7
Permanent wetlands	MODIS and MISR
Croplands	MODIS and MISR
Urban and built-up	MISR
Cropland / natural veget. mosaic	MODIS, MISR, and SeaWiFS
Snow and ice	MISR
Barren or sparsely vegetated	MISR

- Accuracy varies with land-cover type, but no product is accurate across all regions
- Each product has unique features that make it advantageous in certain regions
- Certain land-cover types are problematic for all products, e.g., open shrublands and grasslands

Reference: Petrenko, M. and Ichoku, C.: Coherent uncertainty analysis of aerosol measurements from multiple satellite sensors, Atmos. Chem. Phys., 13, 6777-6805, doi:10.5194/acp-13-6777-2013, 2013.

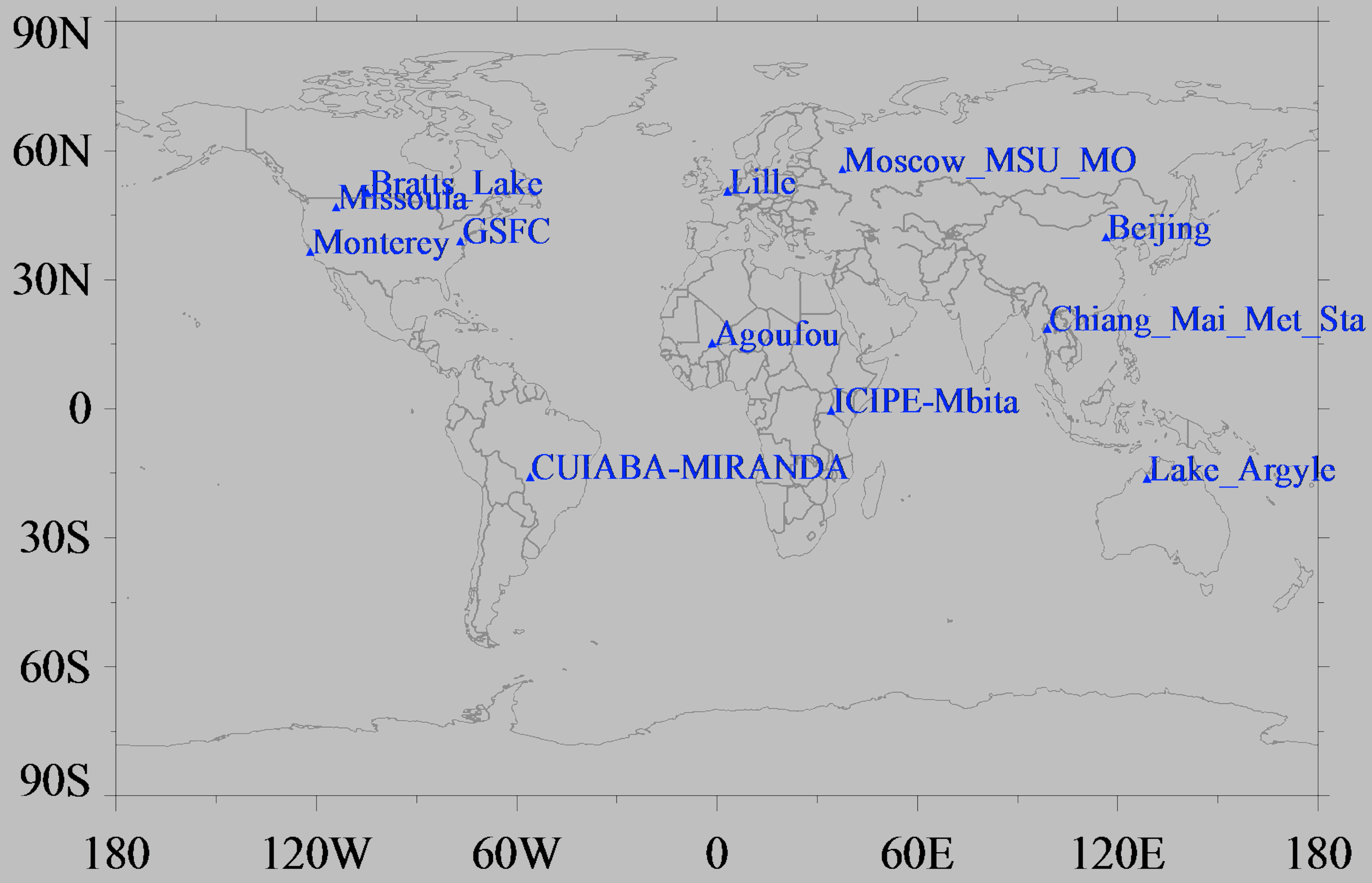
What satellite aerosol product to use for modeling and other Applications?

One that combines the best of all available aerosol products wherever and whenever they occur.

Challenge

How to derive a unique product that is an embodiment of the best the satellites can offer?

Exploring AOD Median at Selected Locations



Preliminary Method for Median Estimation

- **Step 1: Extract spatial mean or median of each satellite product from MAPSS:**

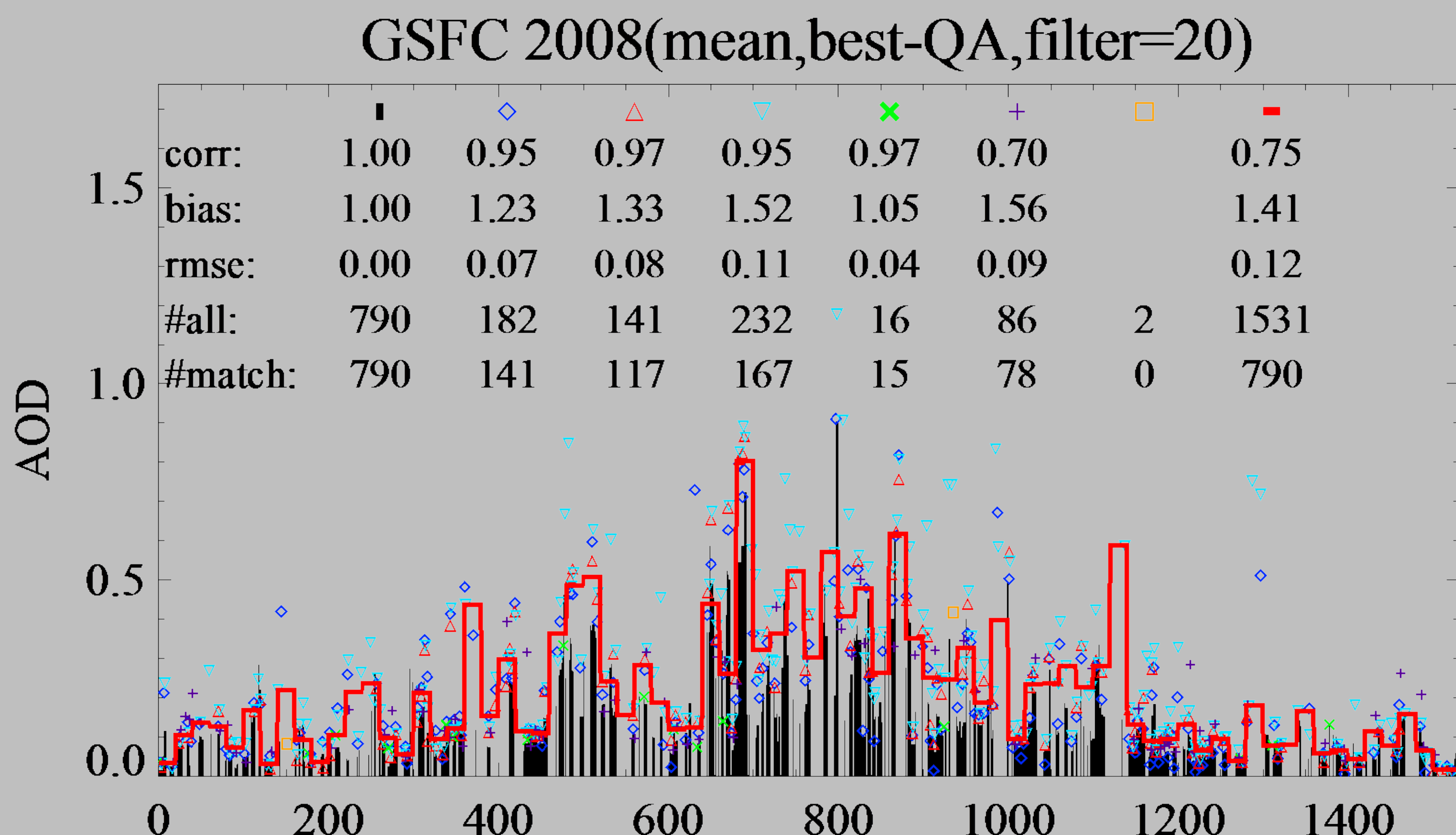
This is mean or median of pixels within the 55-km diameter sample space centered at each AERONET station.

- **Step 2: Determine the median of the above parameters for all available satellite AOD products:**

This is median of all available satellite AOD spatial mean or median values within a pre-determined sample bin size (e.g. 20), which is adjustable.

Using MAPSS mean, bin size = 20

GSFC



corr: correlation

bias: relative bias. Σsatellite > ΣAERONET, if > 1.

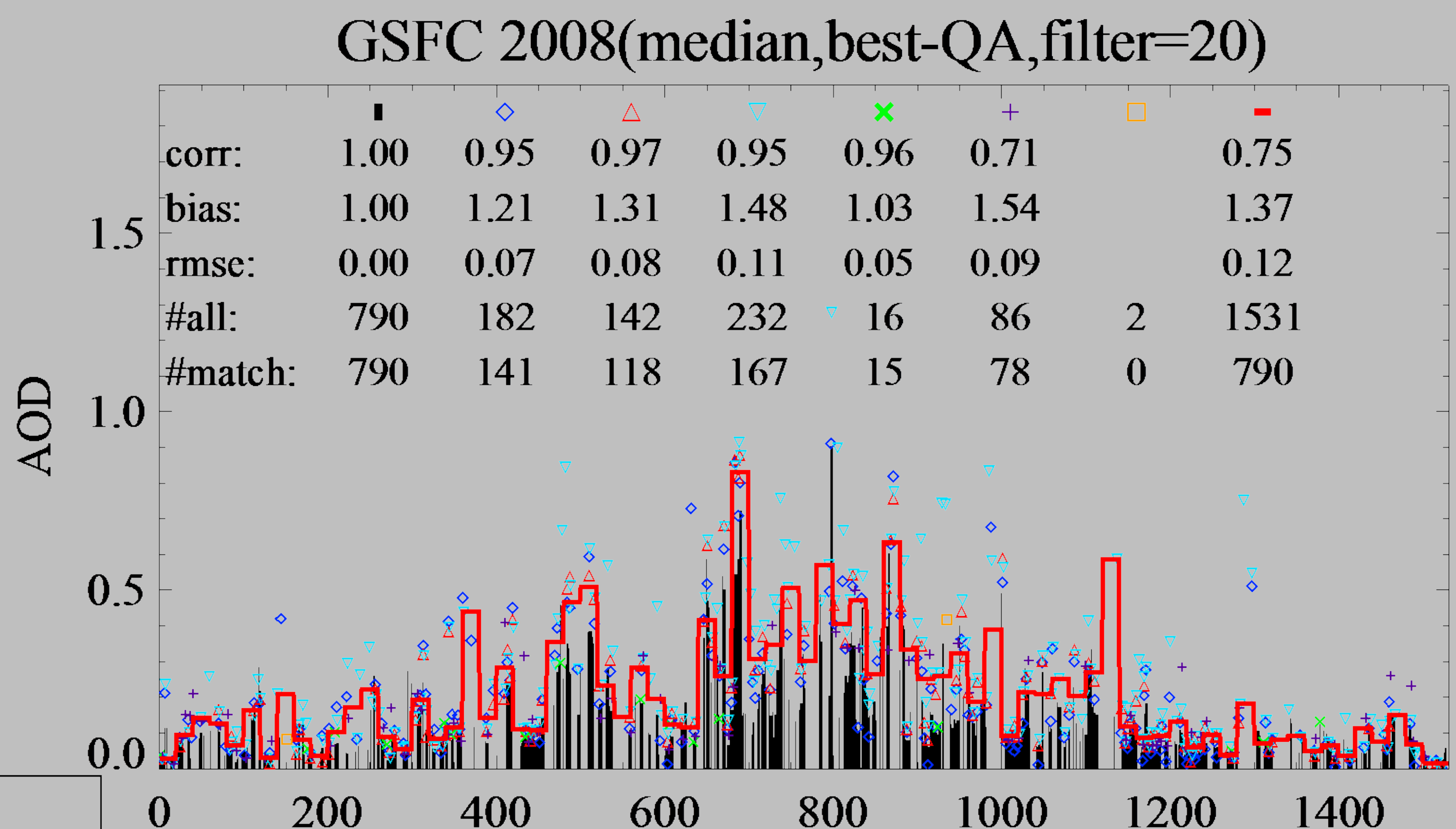
rmse: root mean square error

#all: number of points with valid data

#match: number of points when both satellite and AERONET have valid data

Using MAPSS median, bin size = 20

GSFC



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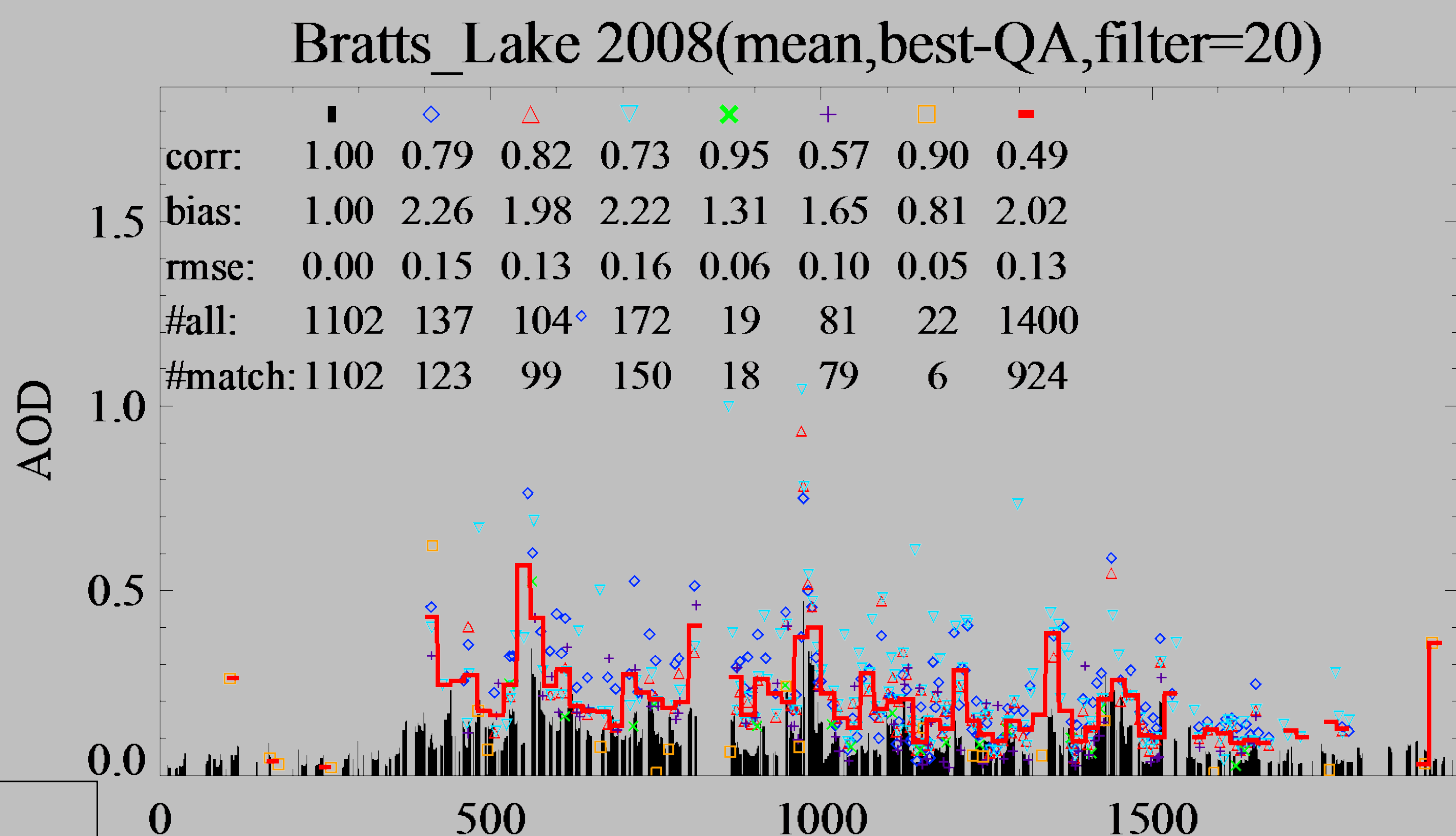
Using MAPSS mean, bin size = 20

Bratts_Lake



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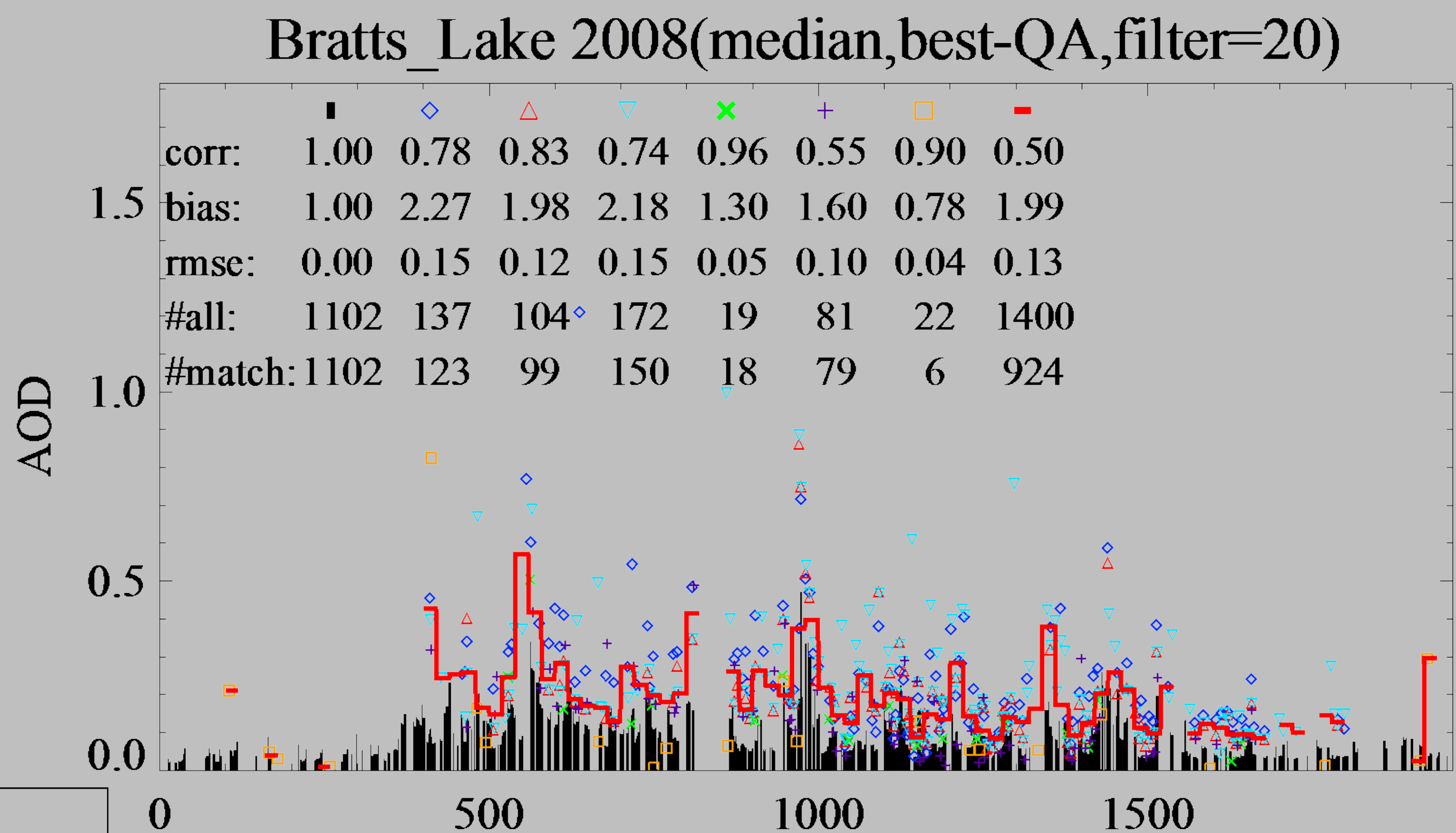

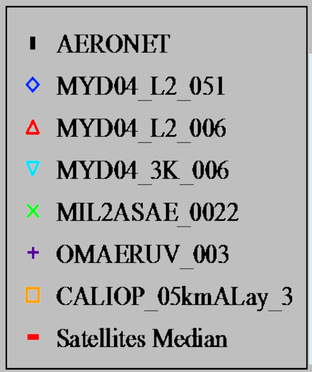

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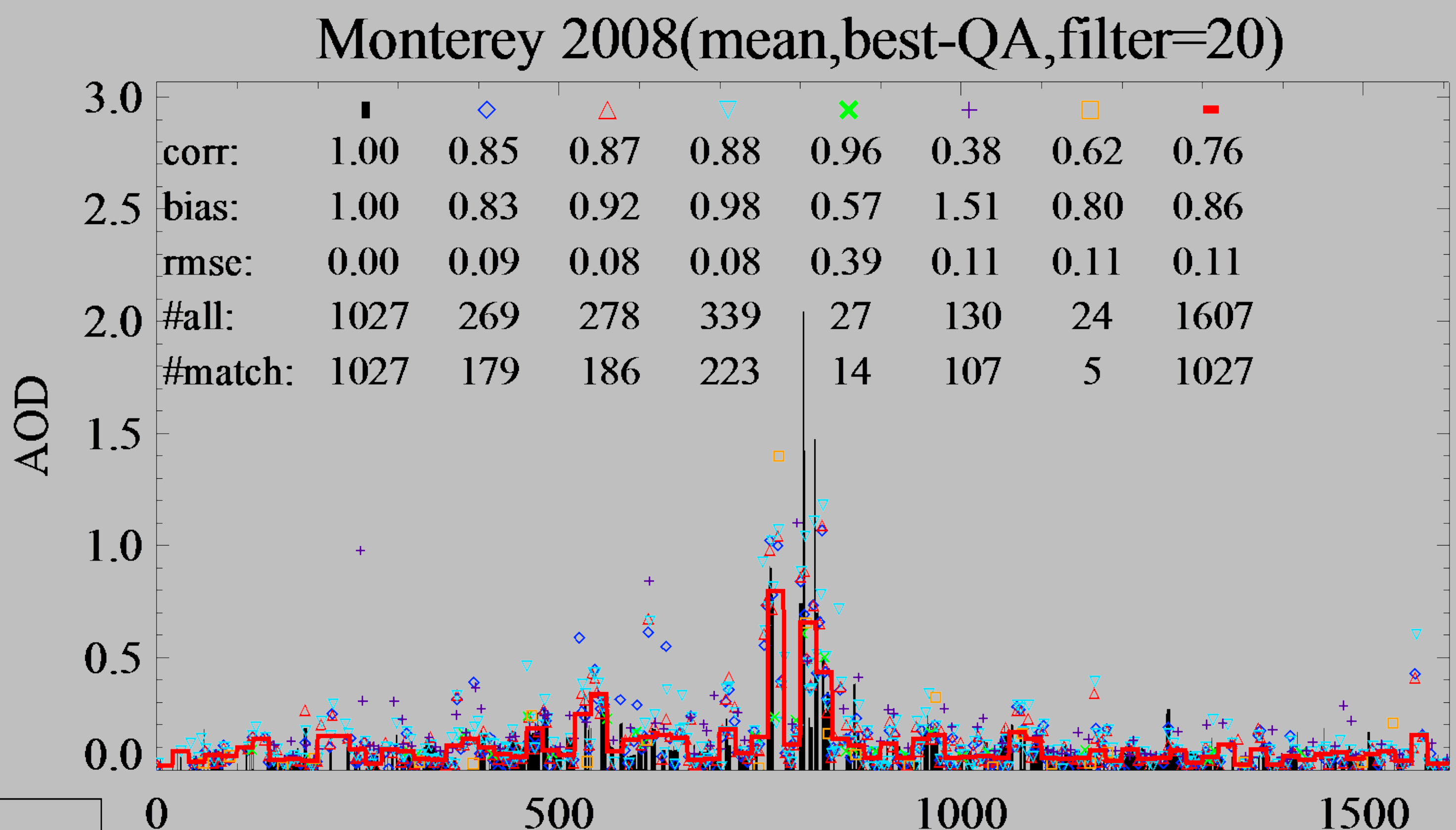
Using MAPSS mean, bin size = 20

Monterey



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Using MAPSS median, bin size = 20

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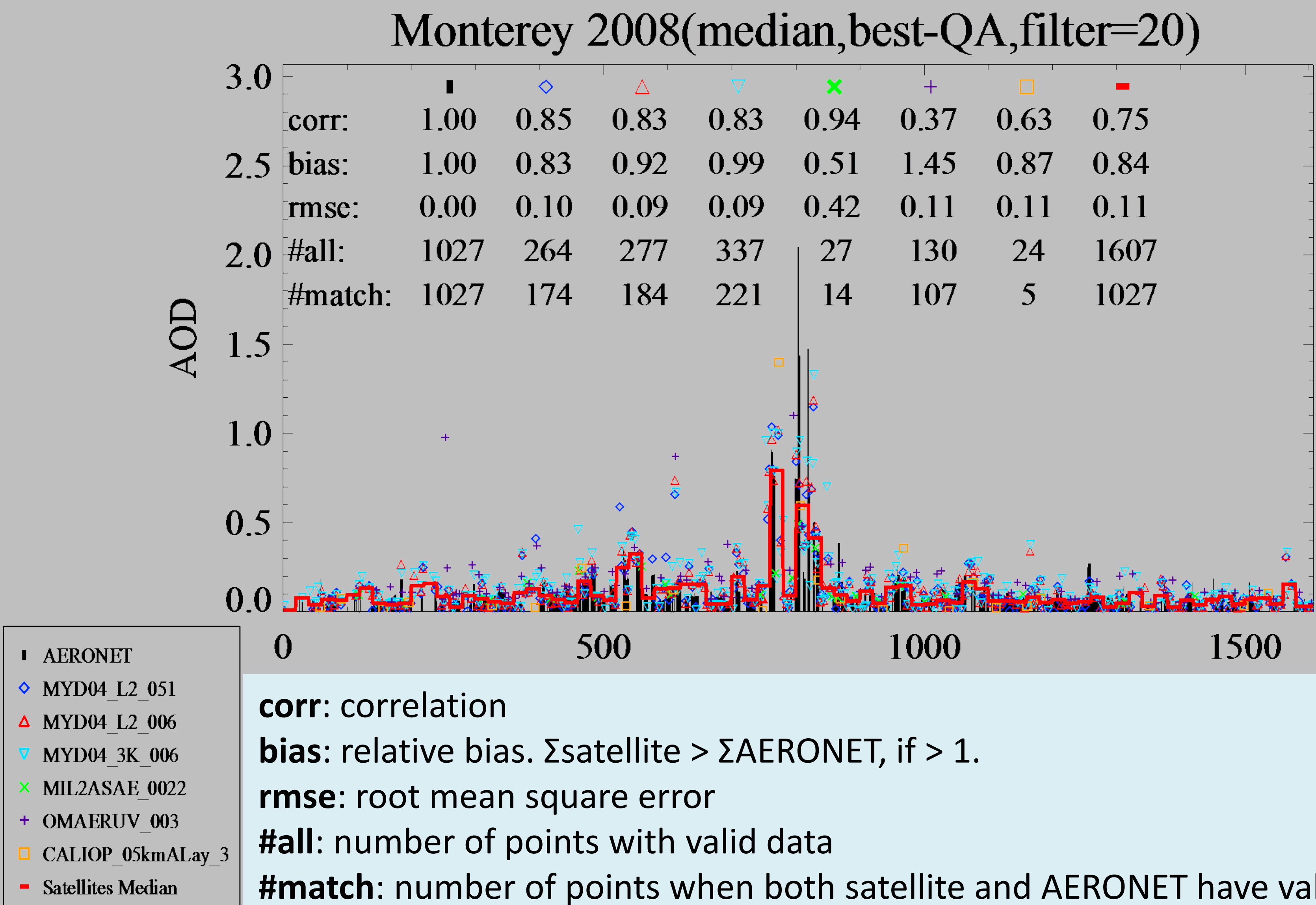

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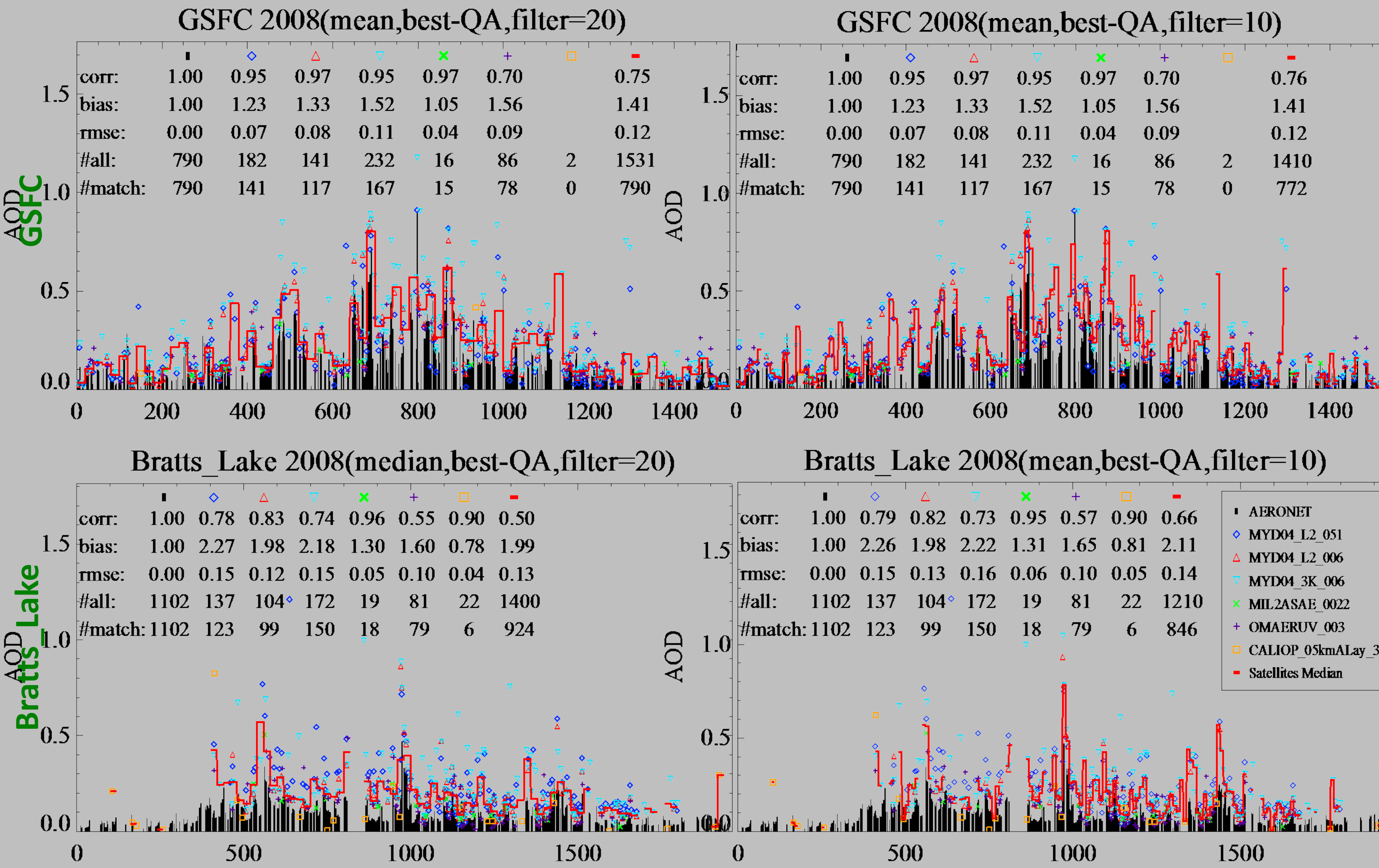
Filter_width = 20

Filter_width = 10



Conclusions

- There is considerable disagreement in AOT (level 2) between different satellite sensors/algorithms

- Multi-sensor synergy can help restore harmony and improve understanding in aerosol loading and impacts

- We are currently evaluating viable options for combining different products to get the best consensus satellite-based AOT

- Such consensus product can be of significant benefit for model evaluation, and hopefully provide a consistent satellite-based long-term aerosol climate data record across multiple satellite generations.

Acknowledgement

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  - Hal Maring
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  - Steve Berrick
  - Kevin Murphy

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- Aerosol PI Teams

  - AERONET: Brent Holben, David Giles, Ilya Slutsker
  - MODIS: Lorraine Remer, Rob Levy
  - MISR: Ralph Kahn
  - OMI: Omar Torres
  - POLDER: Didier Tanre, Fabrice Ducos, Jacques Descloitres
  - CALIOP: Dave Winker, Ali Omar
  - SeaWiFS: Christina Hsu
  - GOCART Model: Mian Chin
  - GEOS-5: Arlindo da Silva

Functions and Web Sites

GIOVANNI – Level 3 Earth Science Data Visualization and Analysis

http://giovanni.gsfc.nasa.gov/giovanni/

MAPSS – Level 2 Aerosol Point Sampling: Timeseries & Spreadsheet

http://giovanni.gsfc.nasa.gov/mapss/

MAPSS_Explorer – Level 2 Aerosol uncertainty analysis over AERONET sites

http://giovanni.gsfc.nasa.gov/mapss_explorer/

AeroStat – Level 2 Aerosol Point Sampling: Scatterplots & Statistics

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