Dancing together:
The symbiotic relationship between aerosol satellite remote sensing and AERONET

Lorraine Remer

UMBC and
GRASP-Earth

If there were no AERONET,
satellite aerosol remote sensing would have failed to thrive

If there were no satellite aerosol remote sensing,
there would not have been AERONET

Yoram Kaufman

Yoram Kaufman's Proposal to be a MODIS team member 1988

195 11

MODIS Team Member

GLOBAL MONITORING OF AEROSOLS PROPERTIES -
AEROSOL CLIMATOLOGY, ATMOSPHERIC CORRECTIONS, BIOMASS BURNING,
AND AEROSOL EFFECT ON CLOUDS AND RADIATION

A Proposal to be a MODIS team member

Submitted By:

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Volume 1

June, 1988

Yoram Kaufman
Principal Investigator

Om P. Bahethi
Om P. Bahethi, President

Yoram Kaufman's Proposal to be a MODIS team member

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MODIS SCIENCE TEAM MEETING

MINUTES

24 -26 SEPTEMBER, 1990

MODIS Science Team Meeting
1992

Atmospheric Corrections

Gordon's and Kaufman's presentations encouraged more open and direct communication of scientific ideas and concepts among the Discipline Groups. Gordon reviewed the first order correction algorithm and noted its shortcomings. He proposed a second-order algorithm, to be used by both SeaWiFs and MODIS, which employs a term for Rayleigh aerosol scattering. He reviewed plans for testing and improving the algorithm.

Kaufman reported that calculating the atmospheric correction over land is more difficult than for over oceans because there is more and highly variable surface reflectance over land—especially when the effects of vegetation are factored into the equation. He discussed molecular scattering, vegetation indices, effects of aerosols, and methods for deriving path radiance.

Eric Vermote discussed the codes whereby radiative transfer is used to apply atmospheric correction. Brent Holben detailed experiments in which his group used sun photometers to measure aerosol properties, precipitable water, ozone, and sky radiance. He presented data collected at GSFC, stations in Africa, the Amazon Basin, and the Dead Sea.

Israel 1992

Lorraine,
Yoram,
Anatoly
Gitelson,
Brent,
Arnon Karnieli,
Bill Lazenby

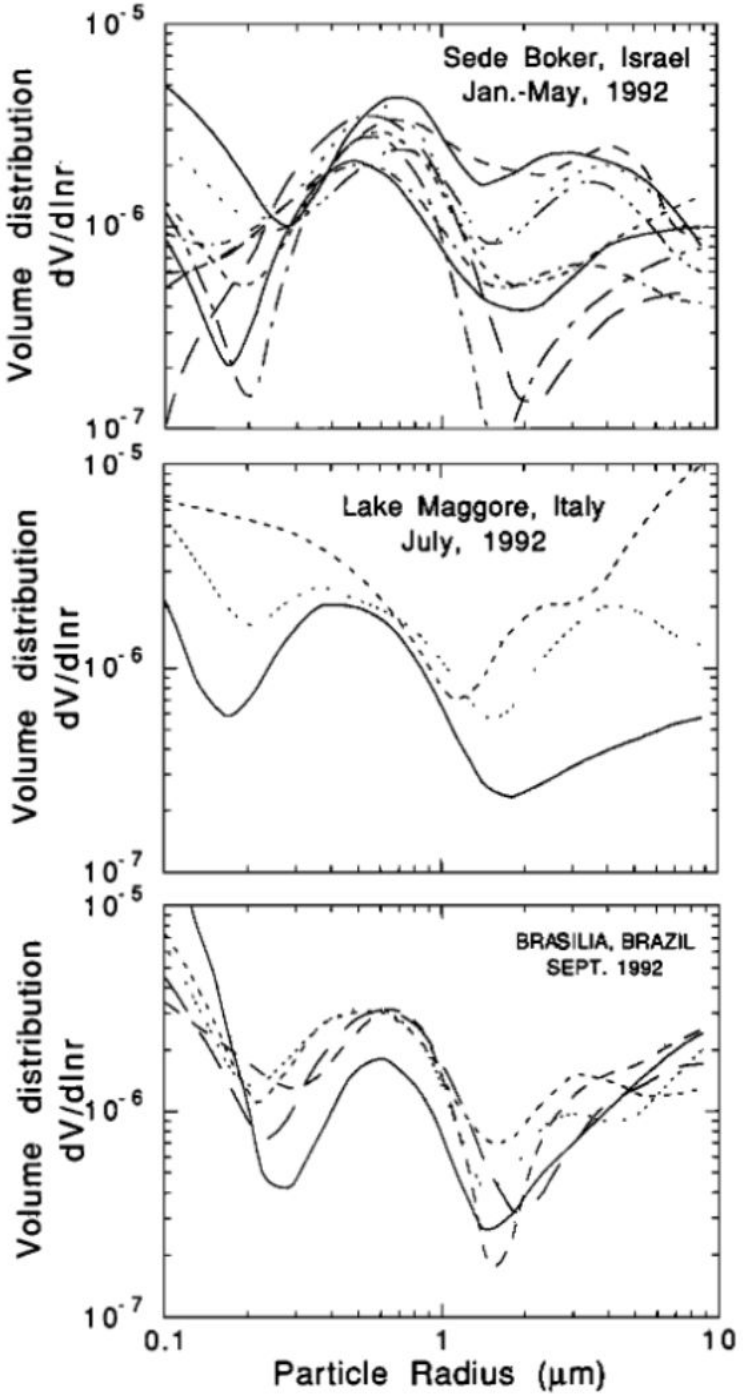
We brought a lot of stuff

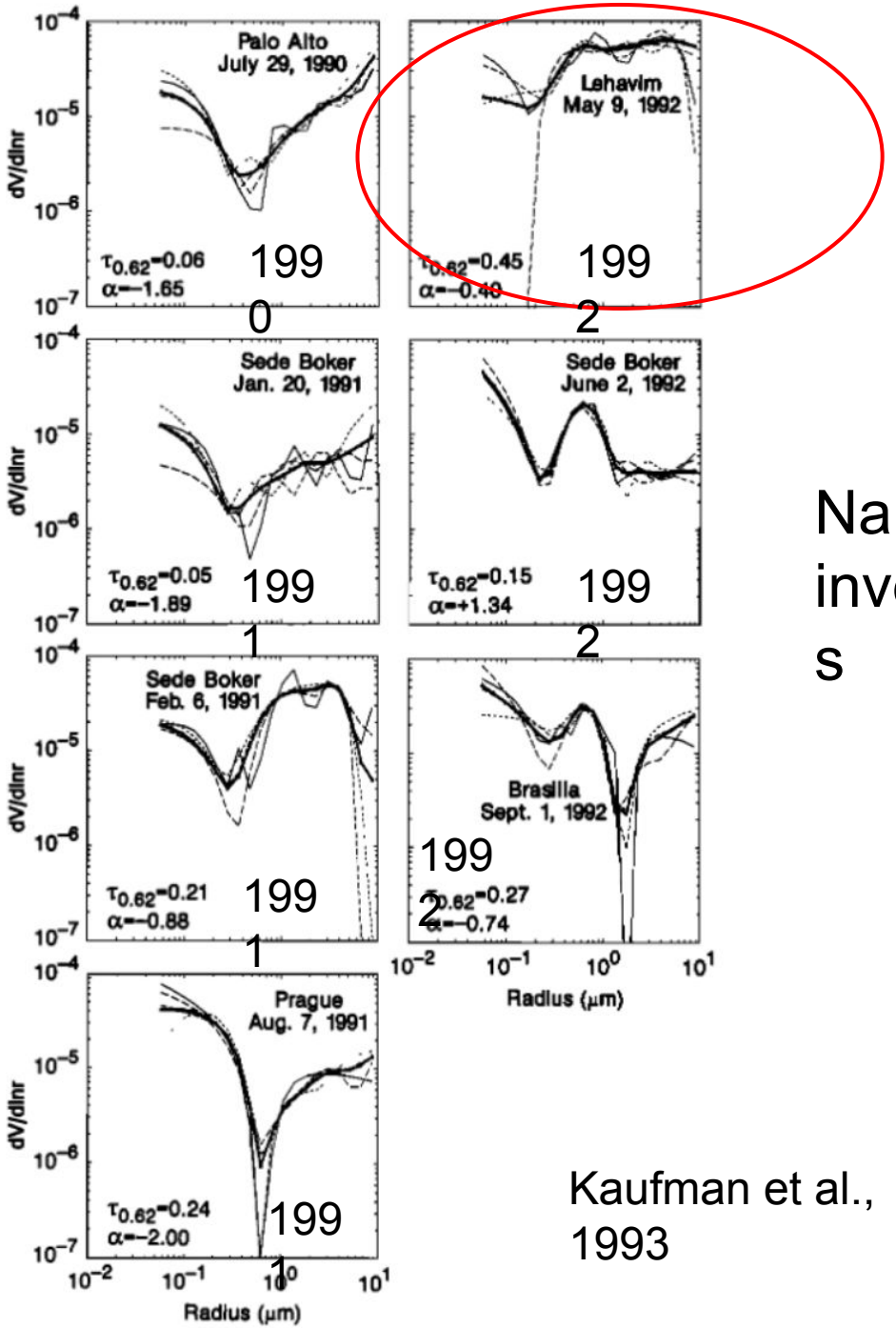
There was a prototype Cimel sunphotometer

Looked like one of the white control boxes
With colored buttons
Except it had a tube to point at the sun

Brent set it up on a tripod

Brent Holben and Lorraine Remer, 1992 in Israel with the pre-AERONET sky photometer





Nakajima inversions

Kaufman et al., 1993

MODIS Science Team Minutes March 1993

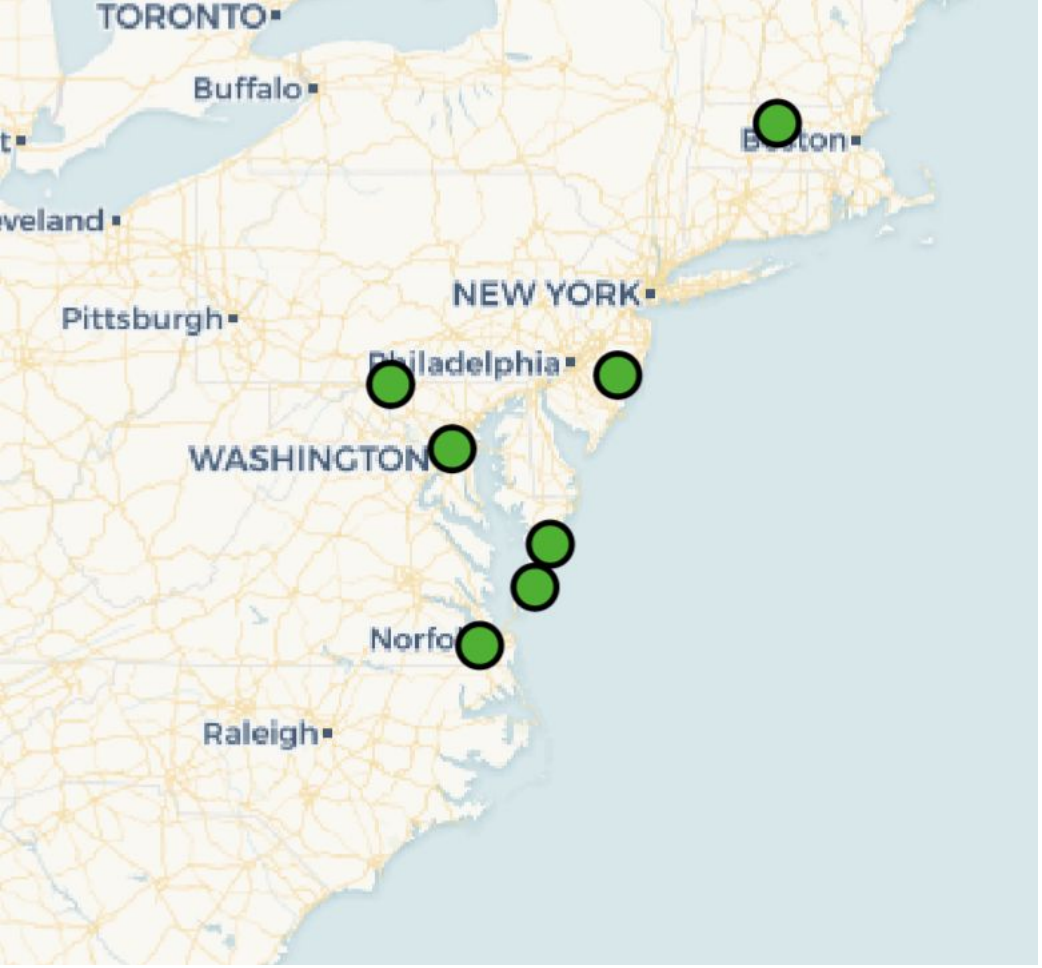
1.9 Smoke, Cloud, and Radiation (SCAR) Experiment

Yoram Kaufman reported on his plans to conduct SCAR experiments in 1993 and 1994, leading to the collection of data pertaining to deforestation and biomass burning in Brazil. Kaufman would like to conduct a pre-SCAR experiment in the Eastern United States in July, 1993. He invited anyone interested to participate. SCAR will provide

4.3 SCAR Workshop

Mike King, Yoram Kaufman, and David McDougal summarized plans for the Smoke, Cloud, and Radiation (SCAR) experiment for the eastern United States in 1993, and for Brazil in 1994 or 1995. The overall objective of the experiment is to study the radiative and physical effects of biomass burning on the atmosphere, and to prepare a comprehensive data set for the evaluation of remote sensing procedures from aircraft and satellites. The eastern U.S. plans include use of the MODIS Airborne Simulator (MAS) and Airborne Visible-Infrared Imaging Spectrometer (AVIRIS). There is a possibility that a MISR simulator may be placed in the nose of the plane. Chris Justice wants to obtain flight plans for the eastern United States in 1993 for possible modification to cover MODLAND or LTER sites. MODLAND has particular interest with the Harvard Forest and Virginia LTER. Additionally, further coordination for 1993 is needed with the Sun photometer network managed by Brent Holben. The Brazilian SCAR experiment is planned for 1994 or 1995. Additional work has to be conducted to secure funds and international arrangements with the Brazilian scientists. Kaufman will keep MODLAND informed.

AERONET in 1993



SCAR-A (1993)

GSFC(39.0N, 76.8W) [GSFC, Greenbelt, MD]	Hagerstown(39.7N, 77.7W)	Hampton_Roads(36.8N, 76.4W)
Harvard_Forest(42.5N, 72.2W) [Petersham, MA]	Hog_Island(37.5N, 75.7W)	Kolfield(39.8N, 74.5W)
Wallops(37.9N, 75.5W) [Wallops Island, Virginia]		

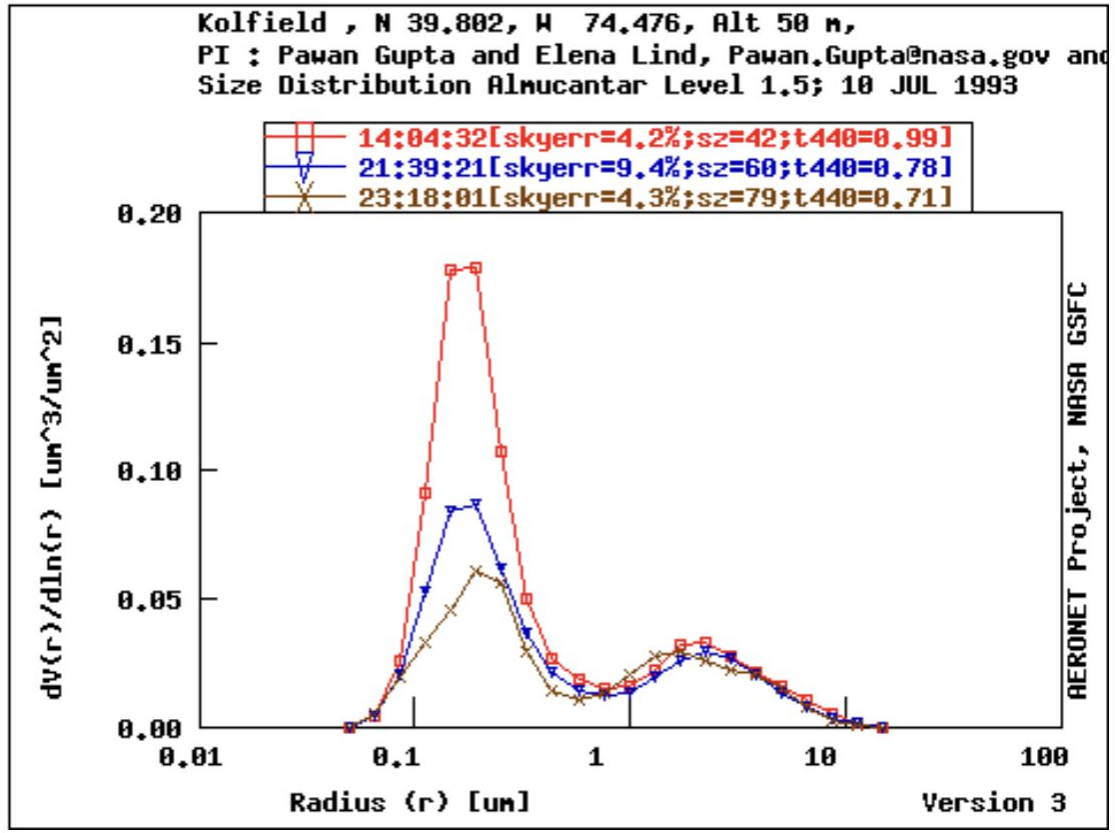
Kolfield (Coyle Field) during SCAR-A

JUL
AUG

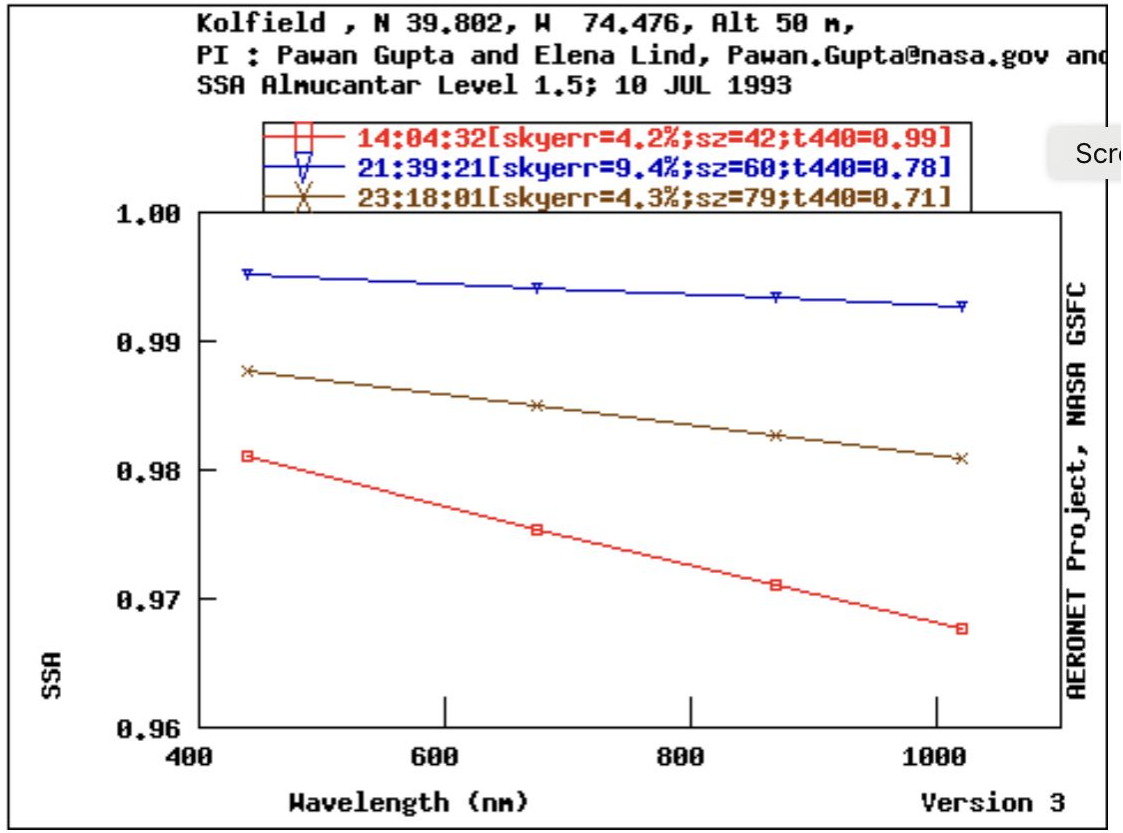
Choose day of JUL 1993

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31					

Almucantar Level 1.5 data from JUL 10 of 1993



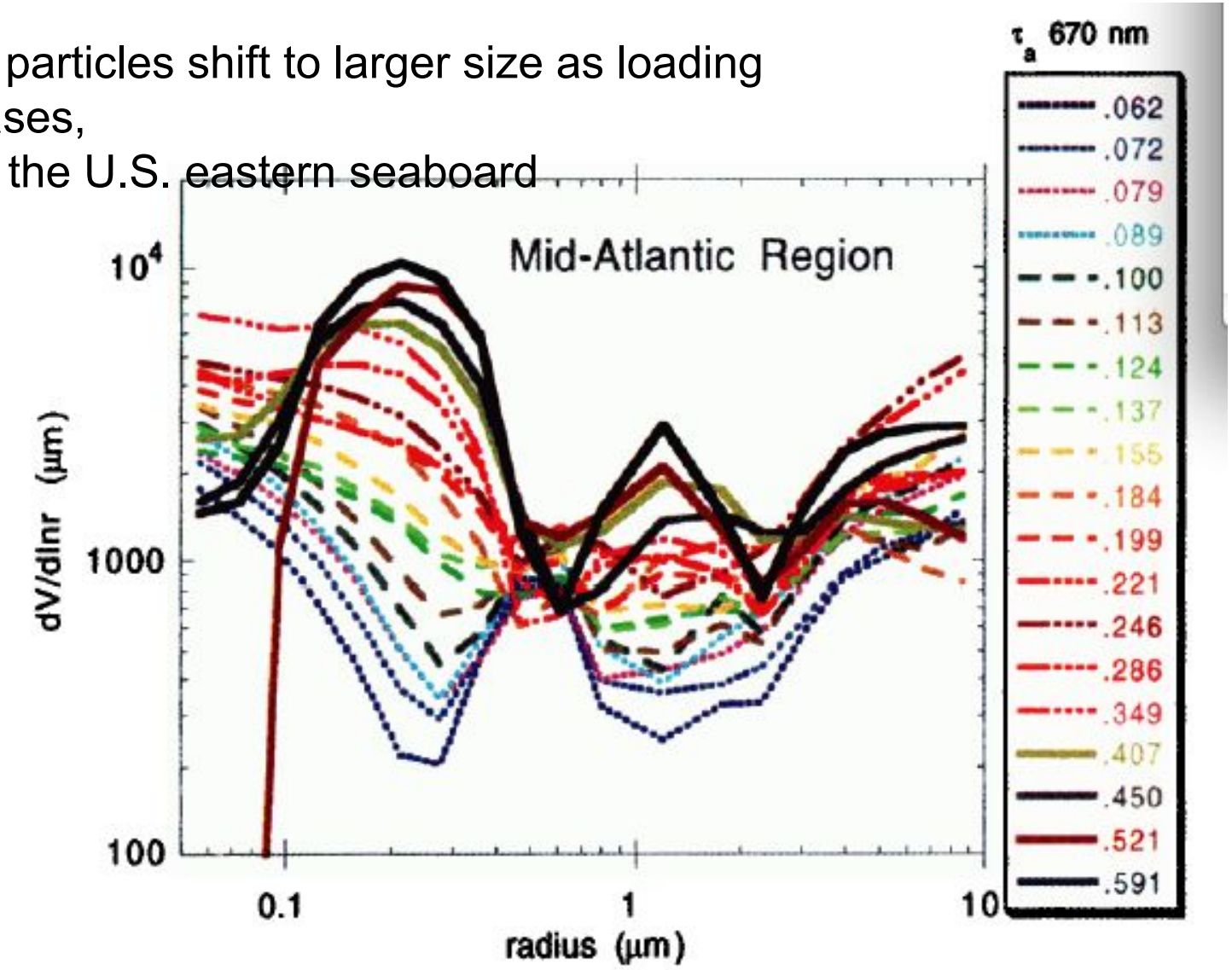
Almucantar Level 1.5 data from JUL 10 of 1993



AERONET DOWNLOAD

AERONET DOWNLOAD

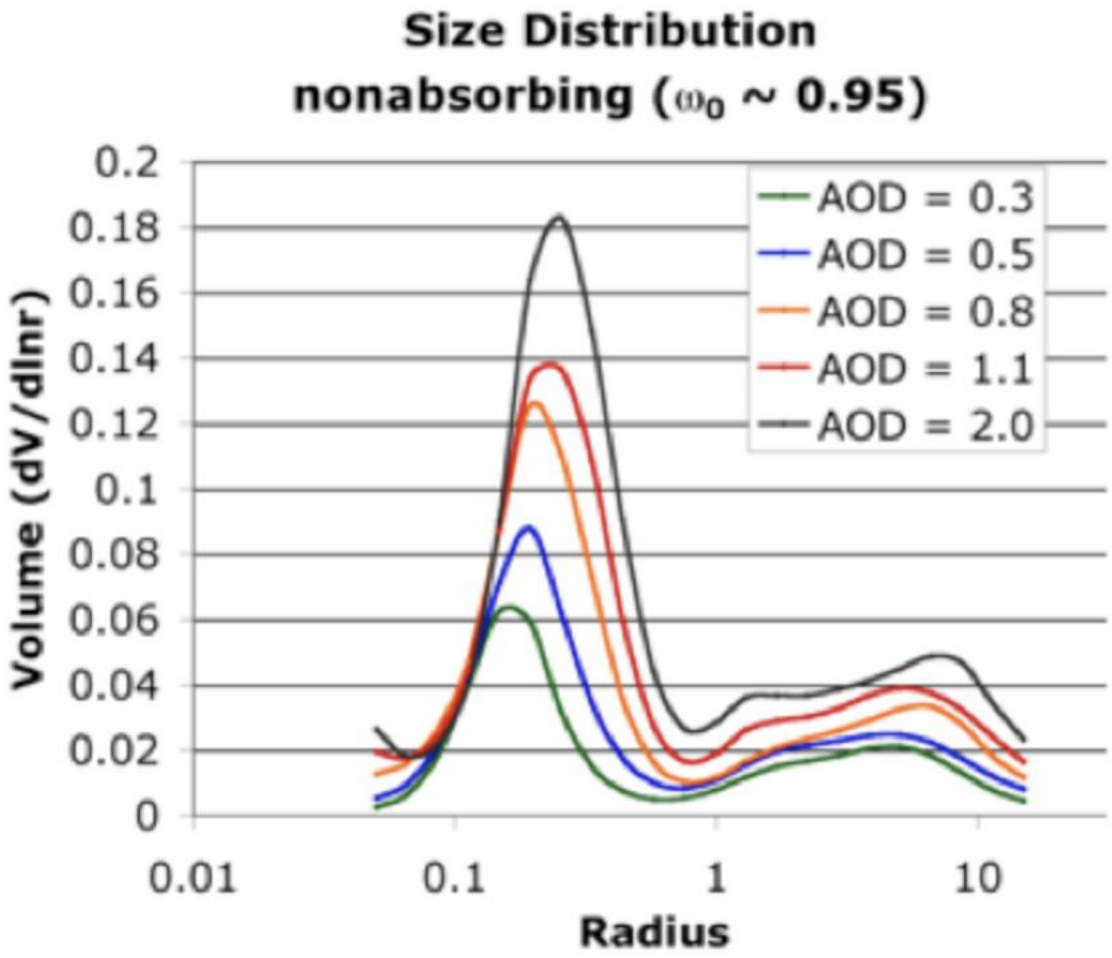
Small particles shift to larger size as loading increases,
Along the U.S. eastern seaboard



Remer and Kaufman (1998)

Dark Target ATBD

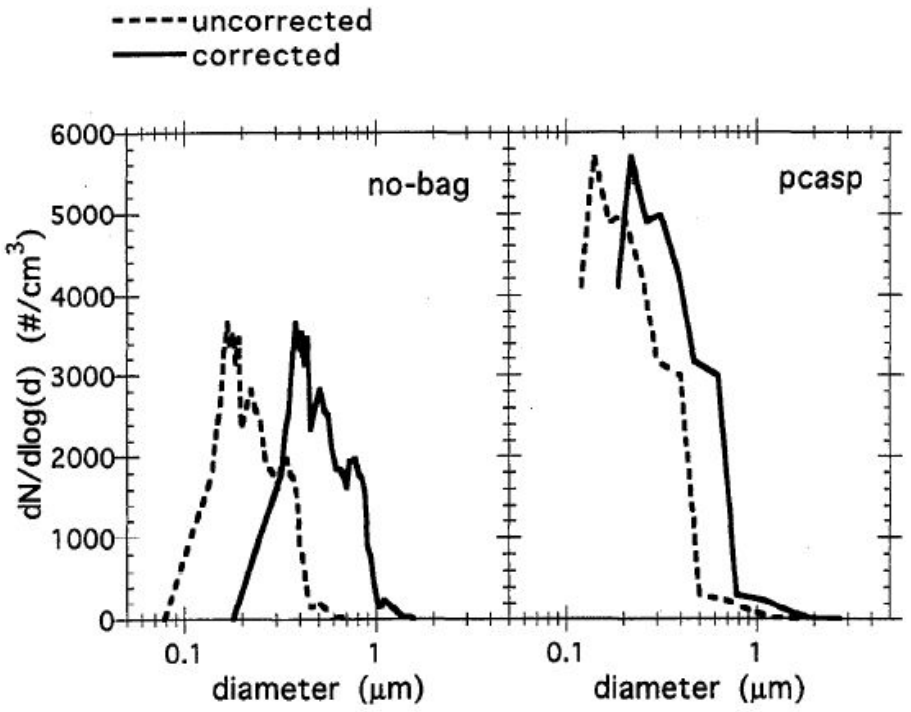
Non absorbing aerosol model over land

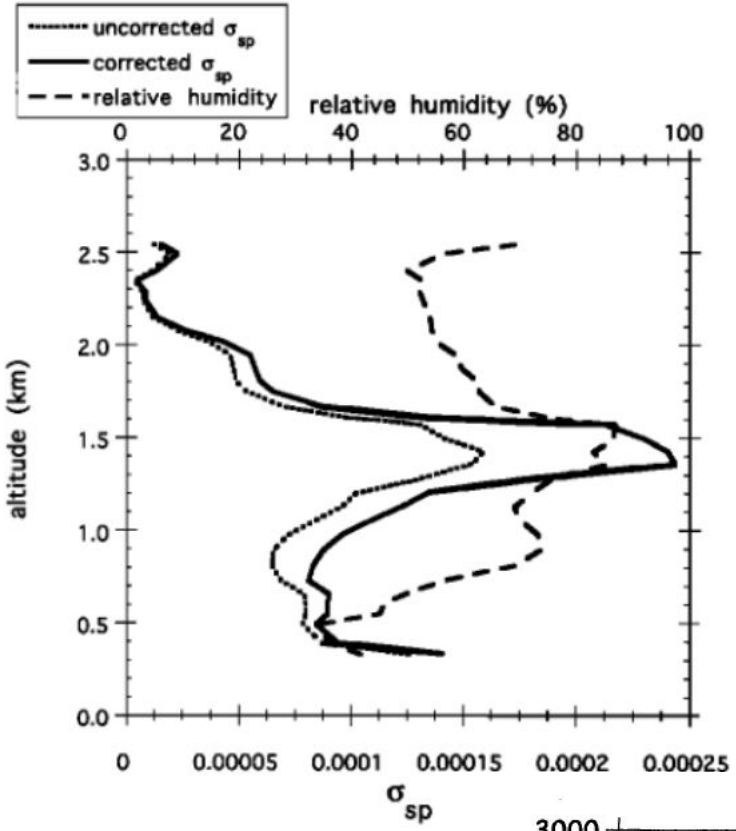


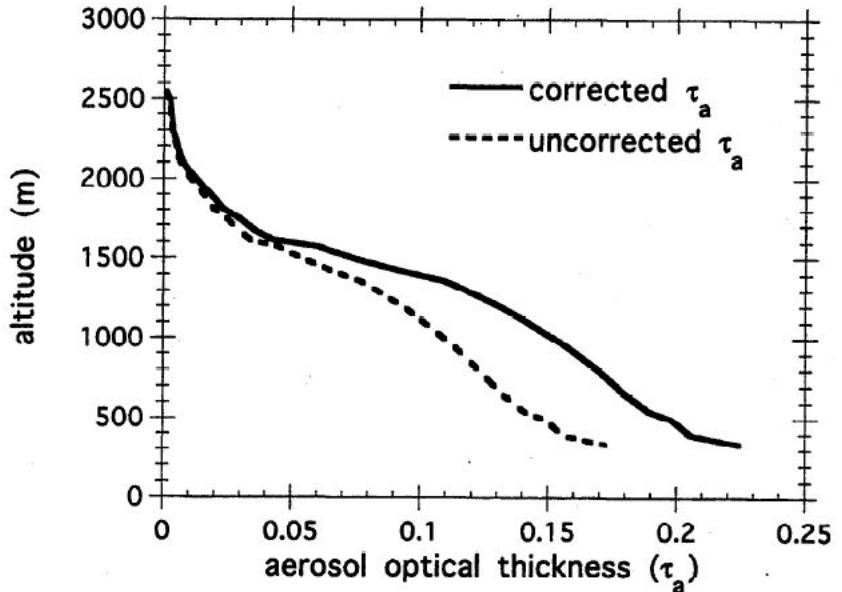
Mode	r_v (μm)	σ	V_0 ($\mu m^3/\mu m^2$)	Refractive Index: k
Accum	$0.0434\tau + 0.1604$	$0.1529\tau + 0.3642$	$0.1718\,\tau^{0.8213}$	$1.42 - (-0.0015\tau+0.007)i$
Coarse	$0.1411\tau + 3.3252$	$0.1638\tau + 0.7595$	$0.0934\,\tau^{0.6394}$	$1.42 - (-0.0015\tau+0.007)i$

Q: Why aren’t you using the in situ measurements to define your aerosol models?

A: AERONET inversions give total column, ambient aerosol properties.





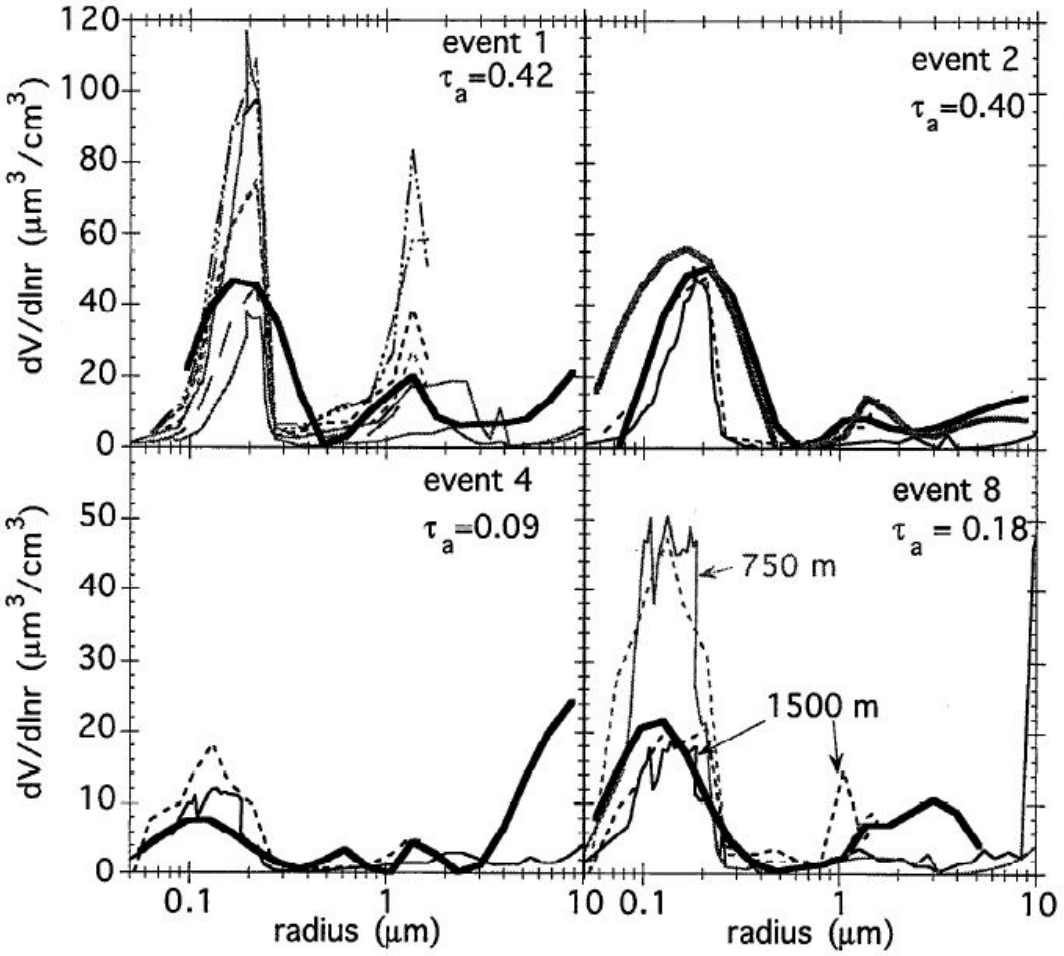


Torturing in situ measurements

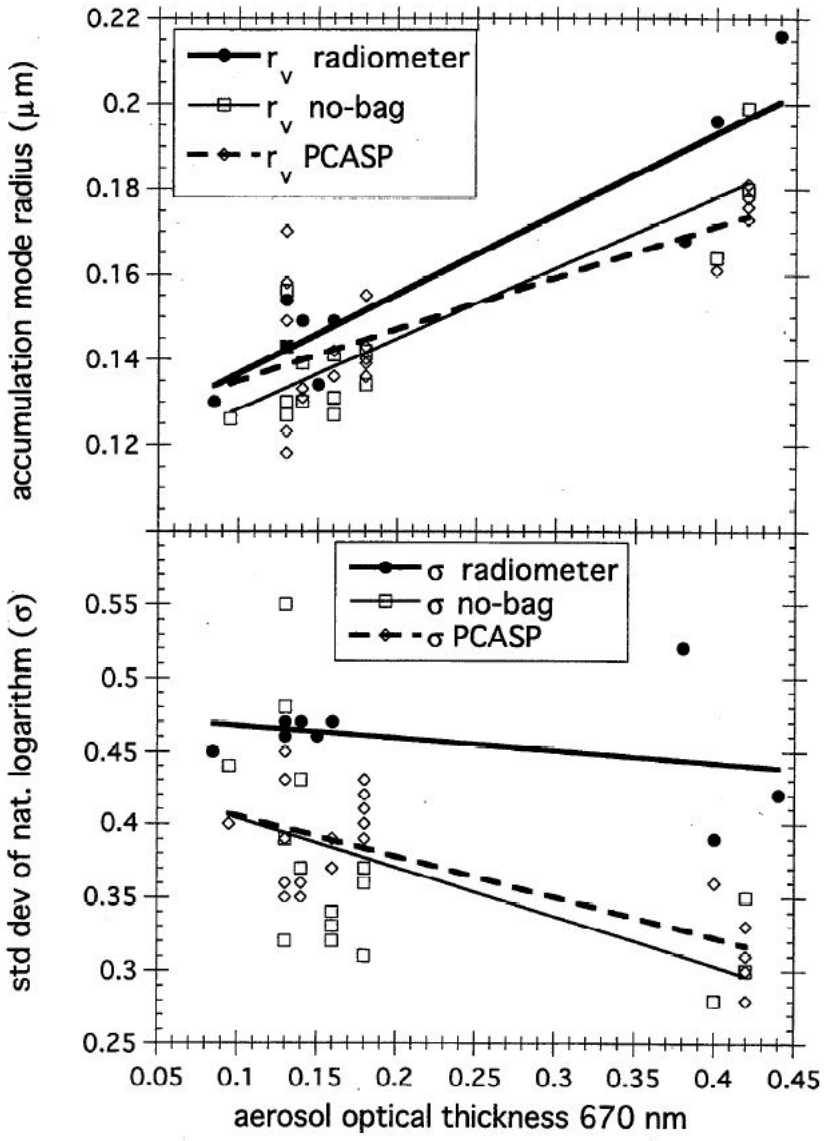
To get them back to ambient

Remer, Gassó et al. (1997)

Yet, if you do all that torturing, on both sides,
we could get the size distributions and trends to match.



Remer, Gassó et al. (1997)



The at-launch MODIS aerosol algorithm over land was dependent on:

1. Dynamic aerosol models (changing with aerosol loading)

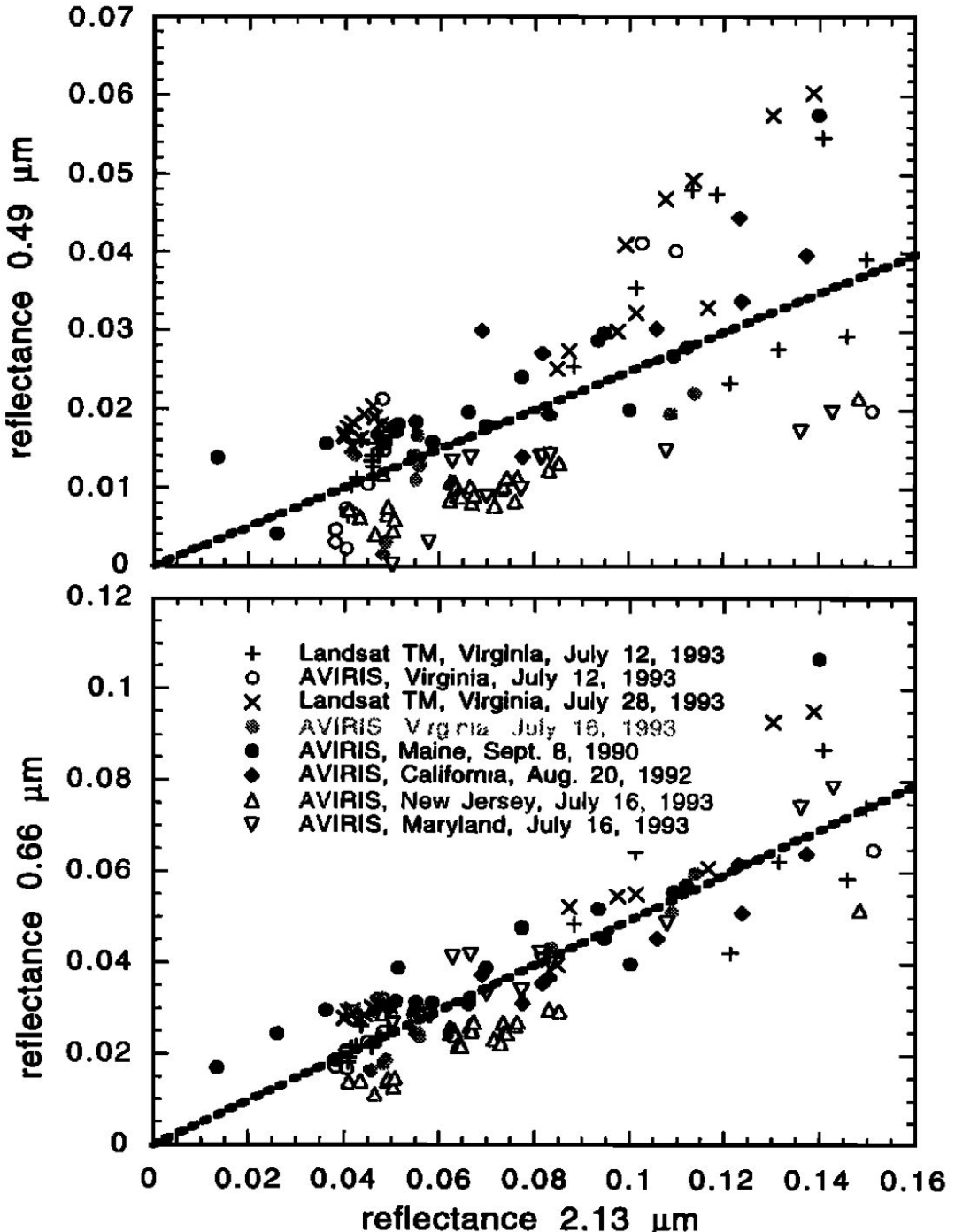
2. Surface reflectance spectral relationships

"Surface reflectance"

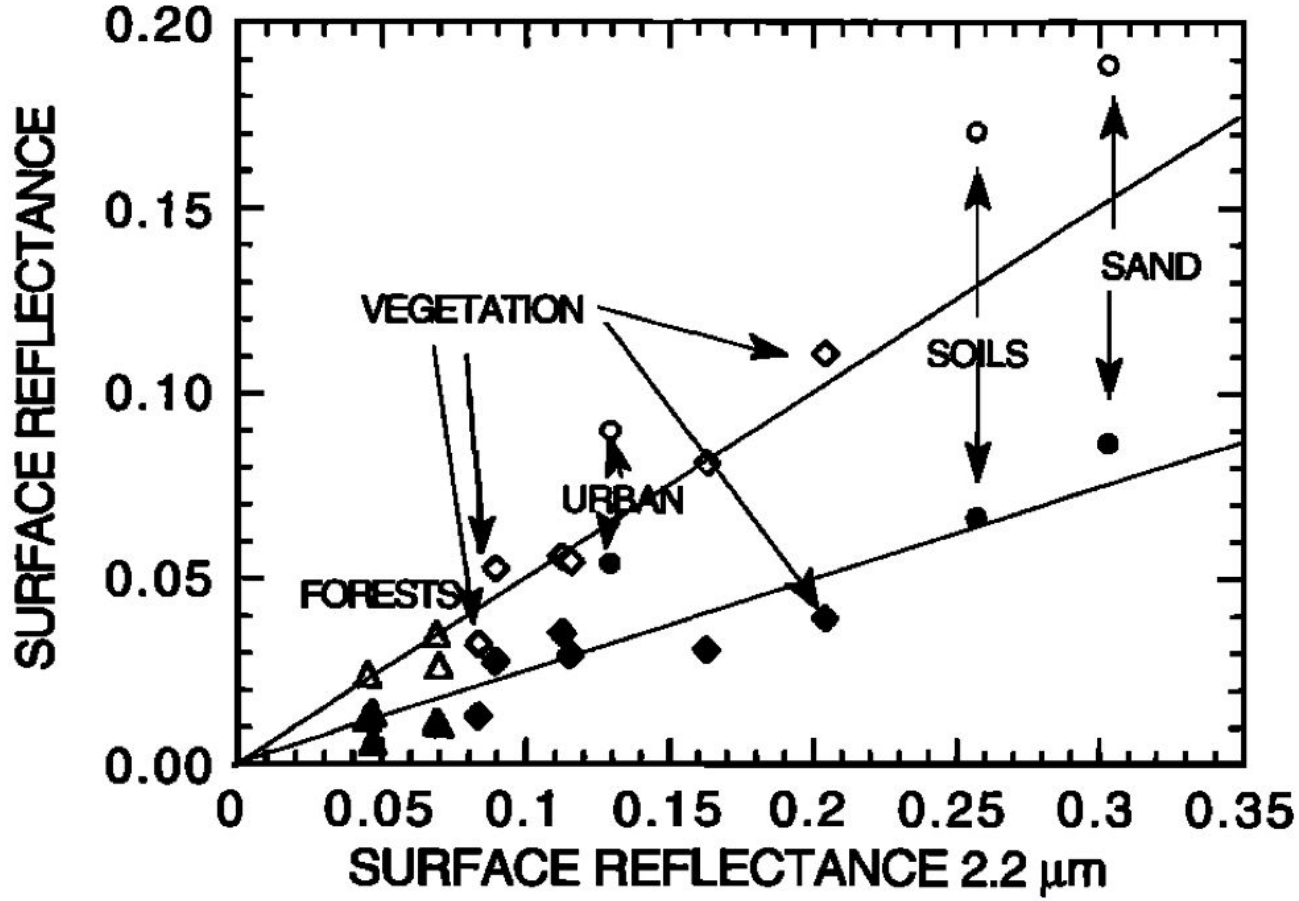
Meaning atmospherically-corrected

Meaning some sunphotometer was there to
Provide a measure of aerosol loading.

Those July 1993 dates were SCAR-A and AERONET
Allowed for the atmospheric correction



Kaufman et al. 1997



$$\rho_{0.49}/\rho_{2.2} = 0.25 \text{ and } \rho_{0.66}/\rho_{2.2} = 0.5$$

Kaufman et al., 1997

So we danced together right up to Terra launch….

…. And beyond

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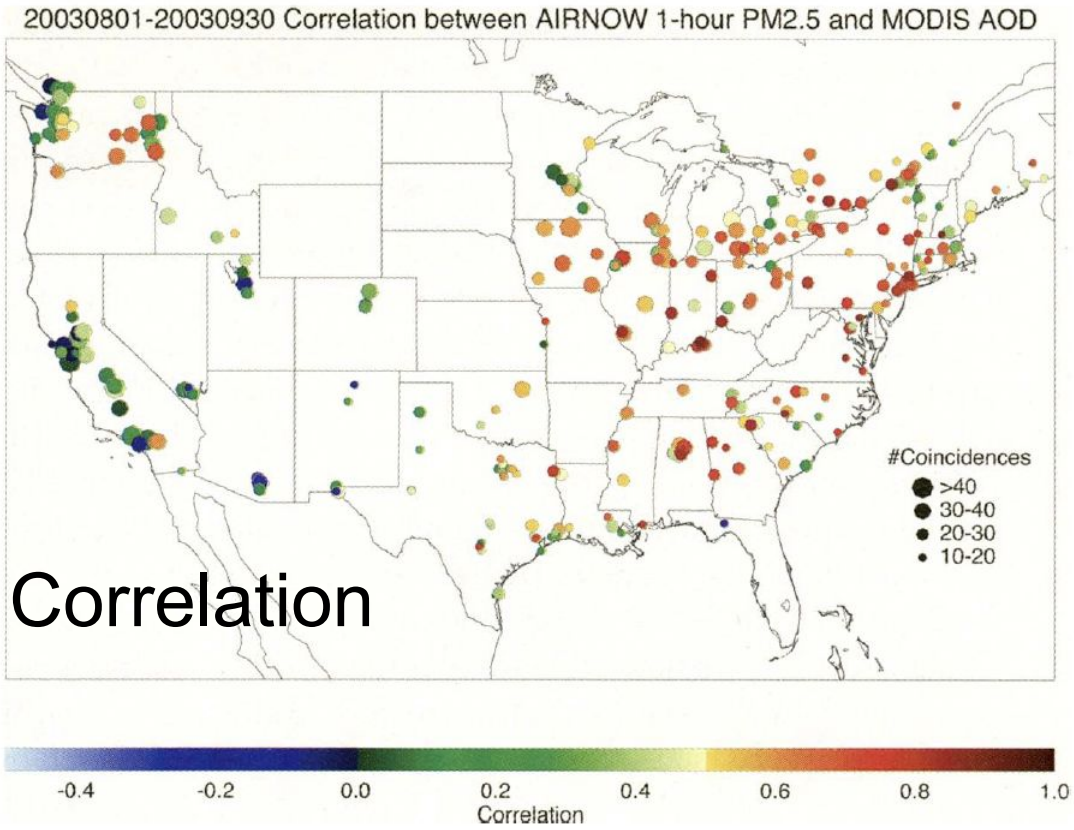
AND AEROSOL EFFECT ON CLOUDS AND RADIATION

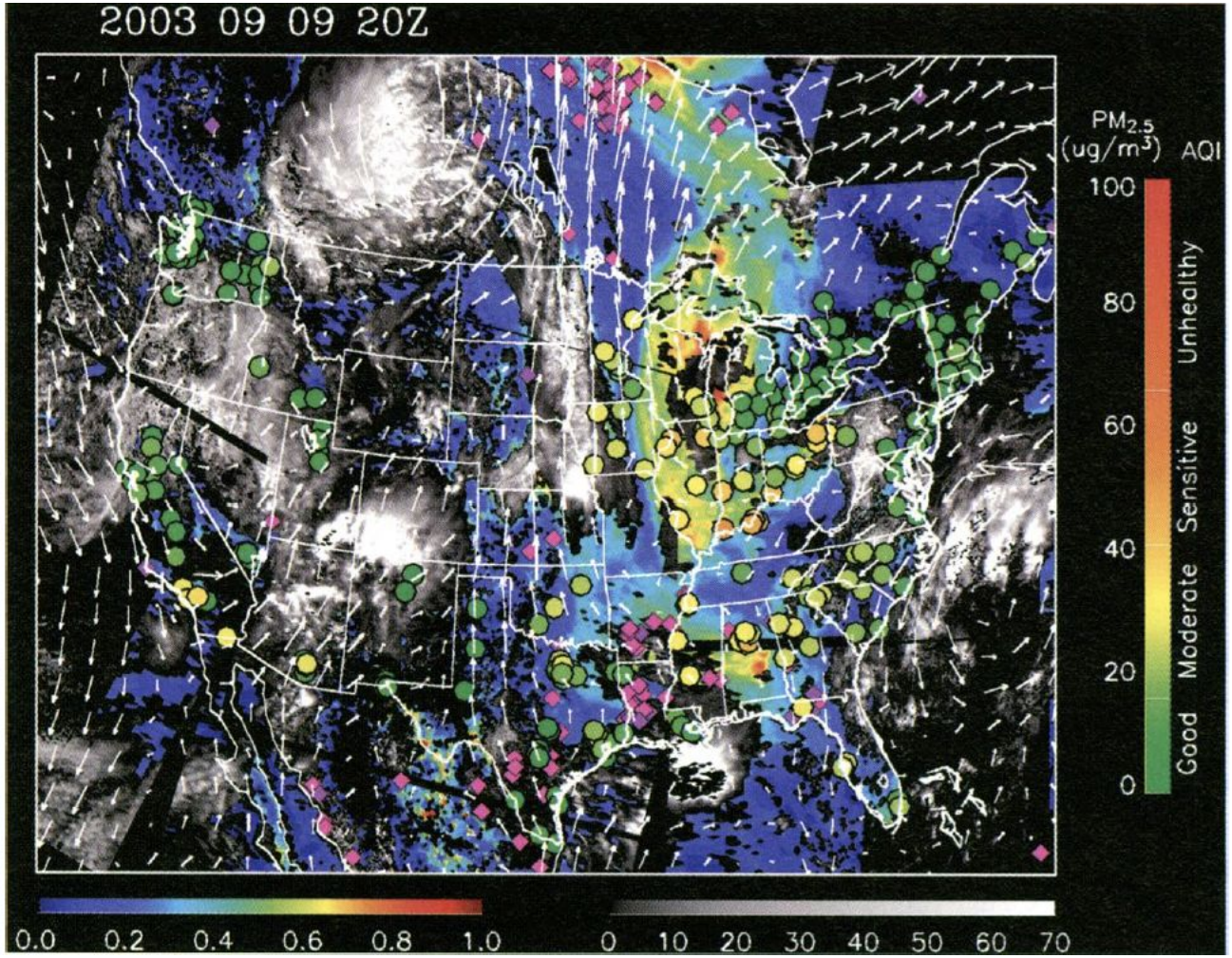
I don’t see any reference to Air Quality here

IMPROVING NATIONAL AIR QUALITY FORECASTS WITH SATELLITE AEROSOL OBSERVATIONS

BY JASSIM AL-SAADI, JAMES SZYKMAN,* R. BRADLEY PIERCE, CHIEKO KITTAKA, DOREEN NEIL, D. ALLEN CHU, LORRAINE REMER, LIAM GUMLEY, ELAINE PRINS,+ LEWIS WEINSTOCK, CLINTON MACDONALD, RICHARD WAYLAND, FRED DIMMICK, AND JACK FISHMAN



Correlation



Al-Saadi et al. (2005)

Total column, ambient doesn’t work as well for Air Quality applications.

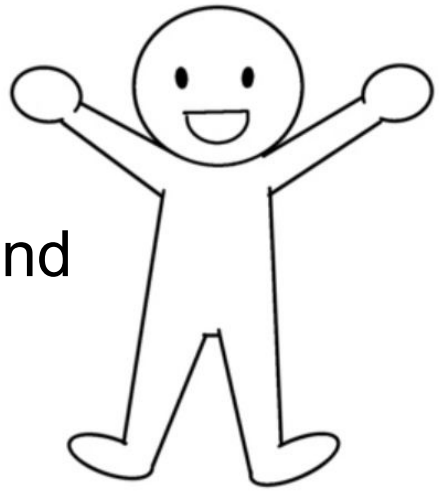
What are we breathing?

Total column looking up

From each you derive:

Aerosol size distributions
And a lot of other parameters

Total column looking down



What if we had an instrument on the ground
Measuring photons with spectral and angular
signatures?

AIRPHOTON

Innovative Technology for Earth and Space

The IMAP 100

Inverse Multi-Angle Polarimetric Nephelometer With GRASP Data Retrieval

The IMAP measures scattering by particles as a function of scattering angle, wavelength, linear polarization in up to 4 distinct size bins.

GRASP

Using the GRASP retrieval algorithm, the IMAP 100 can provide:

- Particle mass using a derived particle density
- A complete size distribution every 5 minutes
- The real refractive index of the particles for each size distribution
- Sphericity factor
- Full phase function

AIRPHOTON

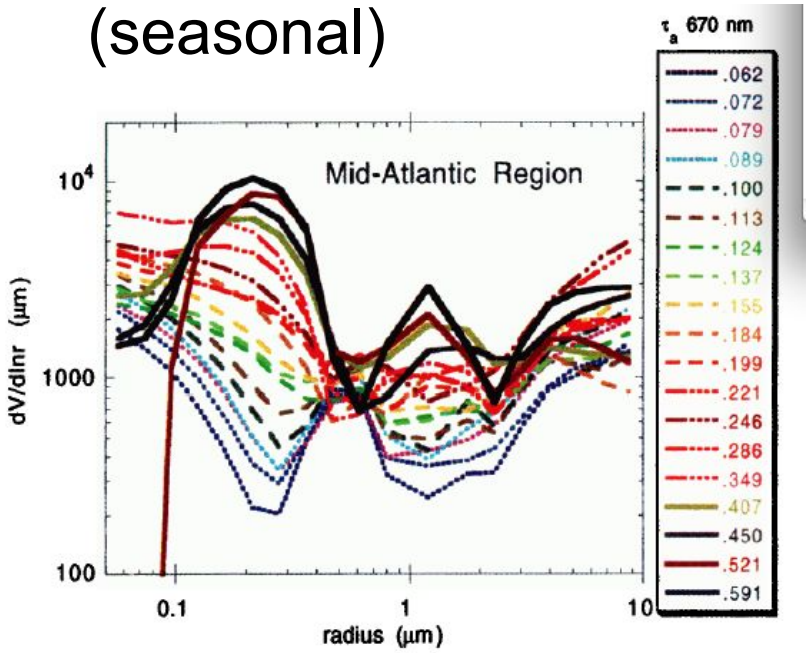
Innovative Technology for Earth and Space

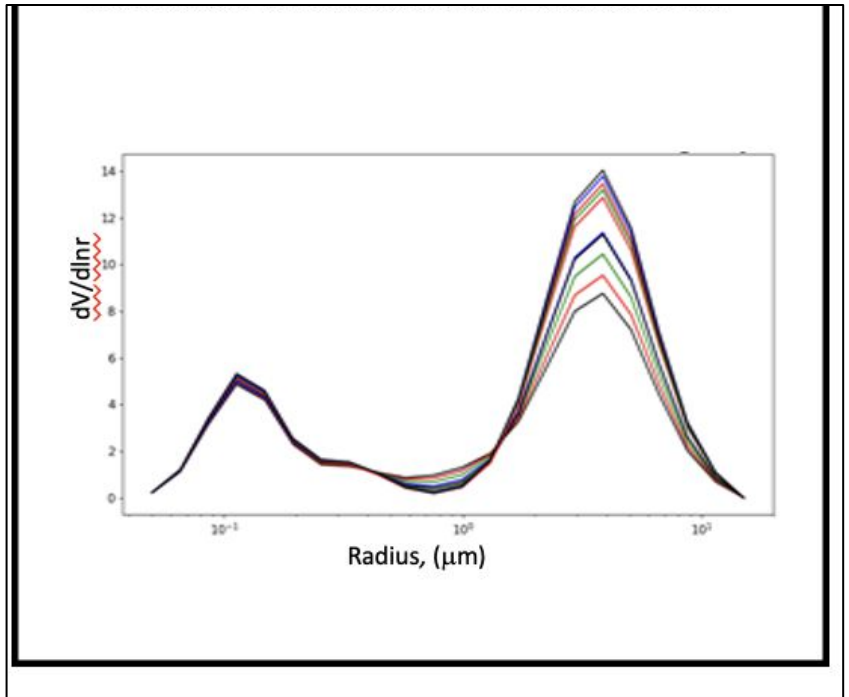
GRASP

Same information
Same inversion process
One is total column
One is breathing level

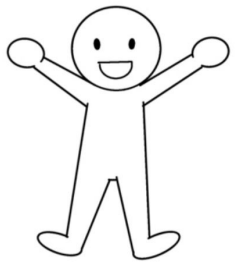
Let's move satellite remote sensing of Air Quality forward

Total column (seasonal)



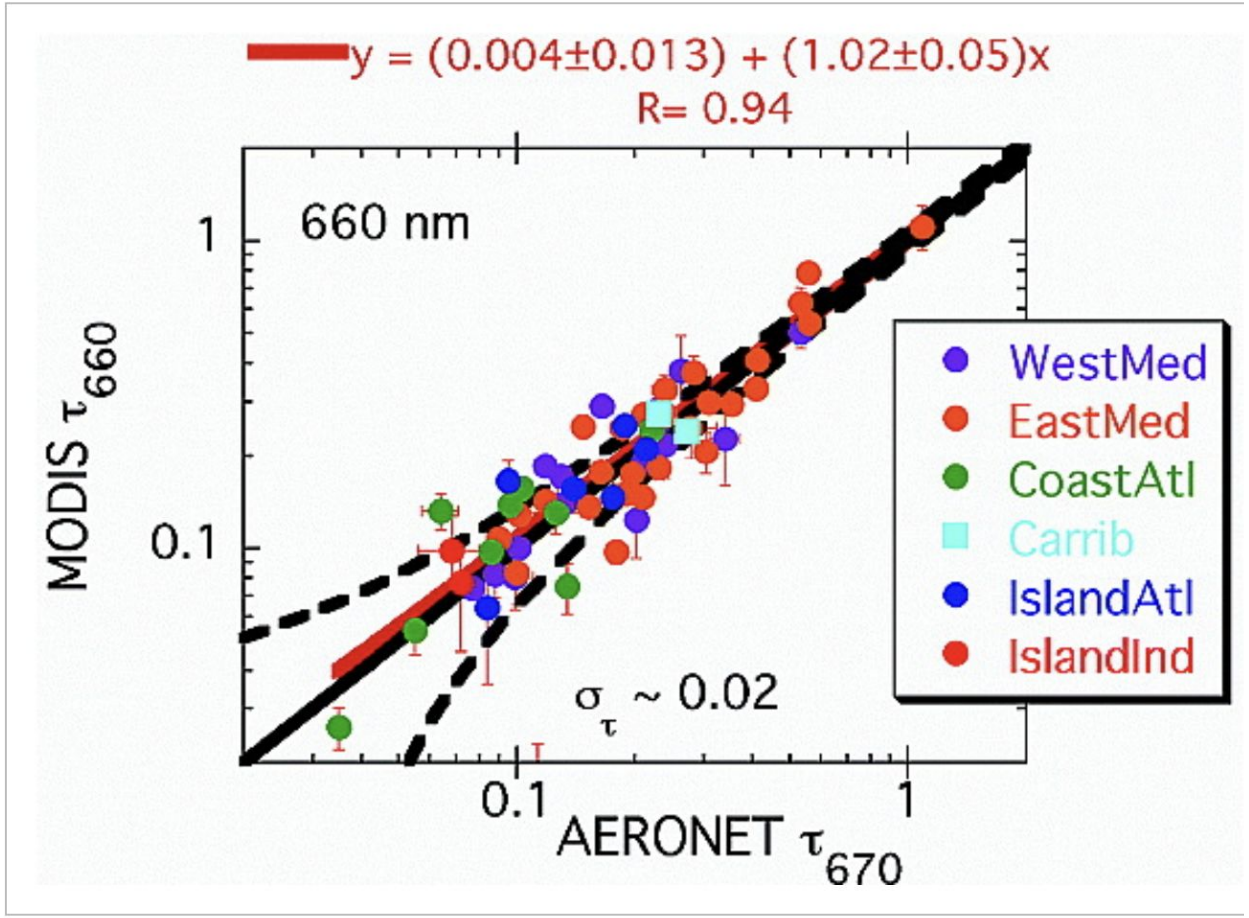


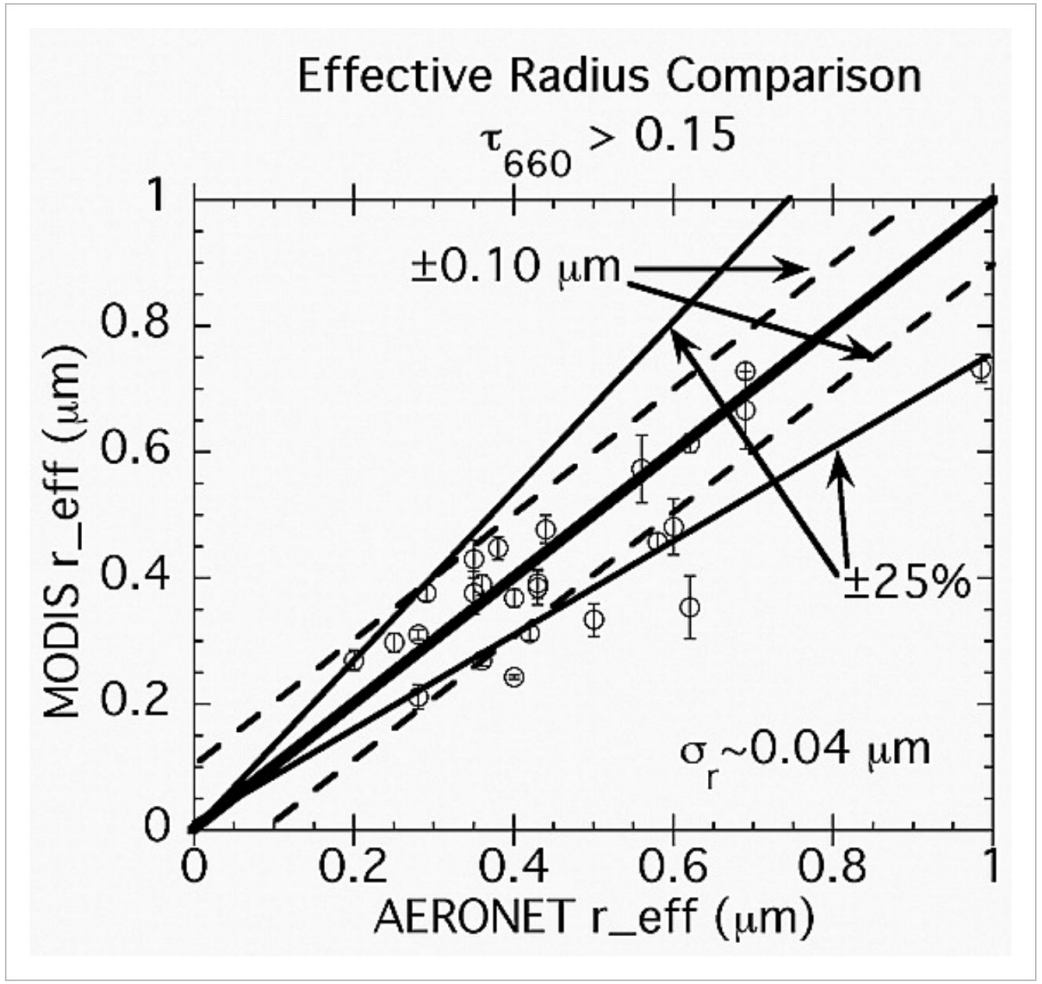
Breathing level (afternoon)



Moving Forward: Dancing Together will be a group affair,
and much more colorful

Preliminary validation (after 2 months of data collection)





Remer et al. (2002)