The MODIS Aerosol Products:

What are they?

How good are they?

Issues

Validation

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With thanks to Doug Westphal of NRL and
Chuck McClain, Christophe Pietras of SIMBIOS

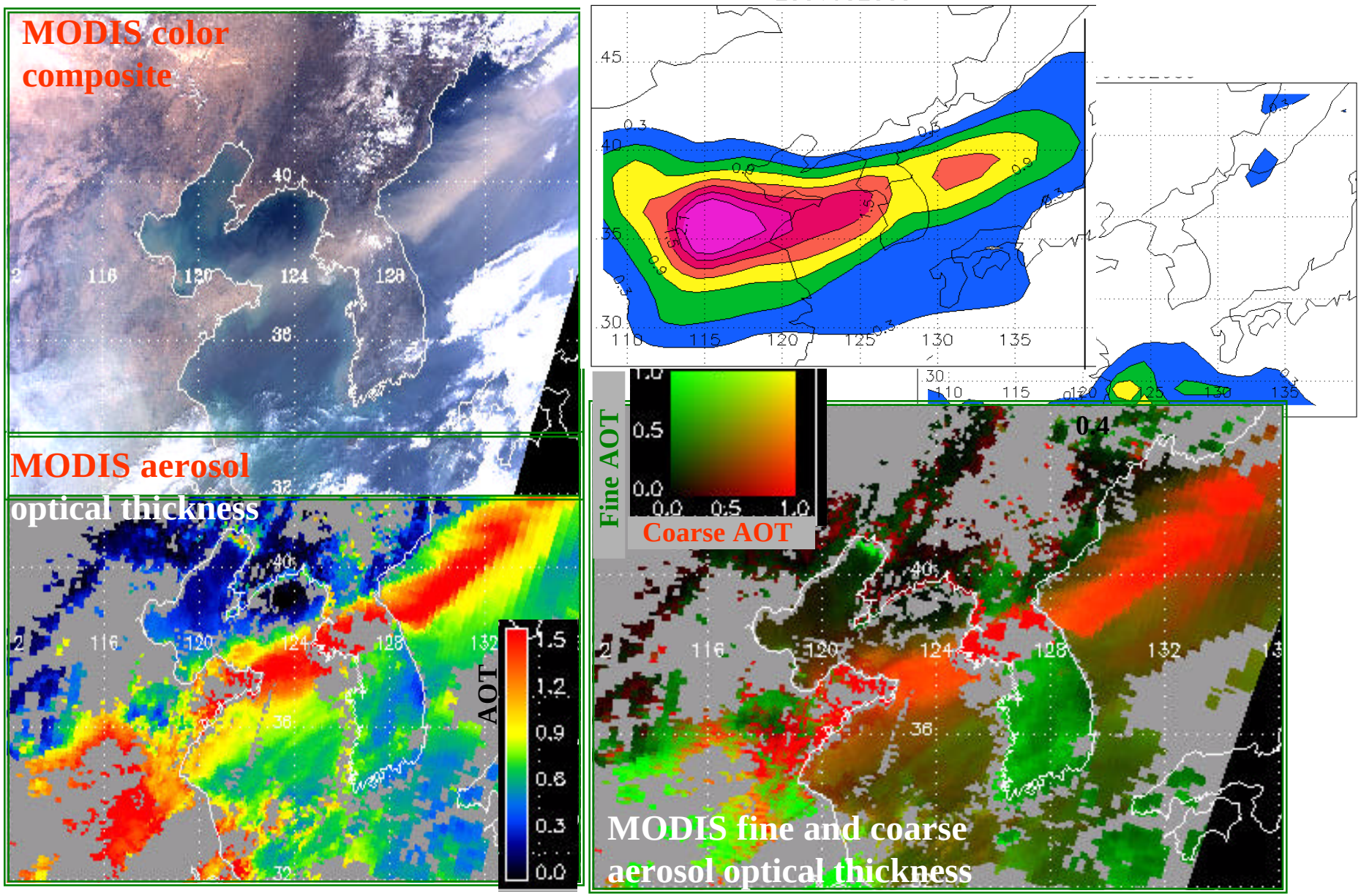
NO CARTOONS!

What are the MODIS aerosol products?

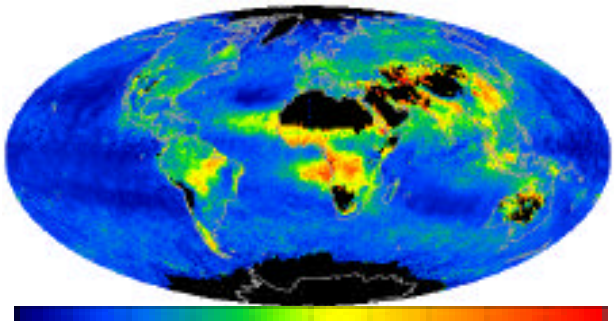
Aerosol optical thickness (7 wavelengths over ocean
3 wavelengths over land)
Size information (r_eff, fine and coarse mode τ)

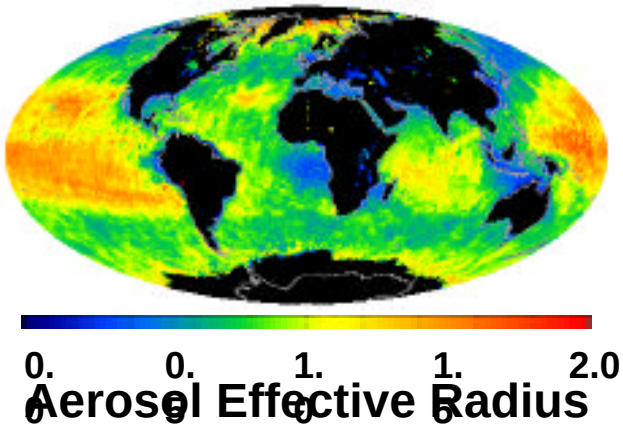
Aerosol spectral flux at TOA (7 or 3 wavelengths)
CCN
Solution index, number pixels etc.

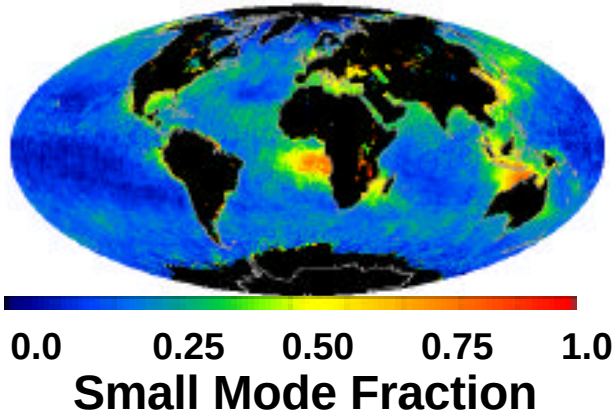
MODIS: Dust and pollution in East Asia, March 20, 2001



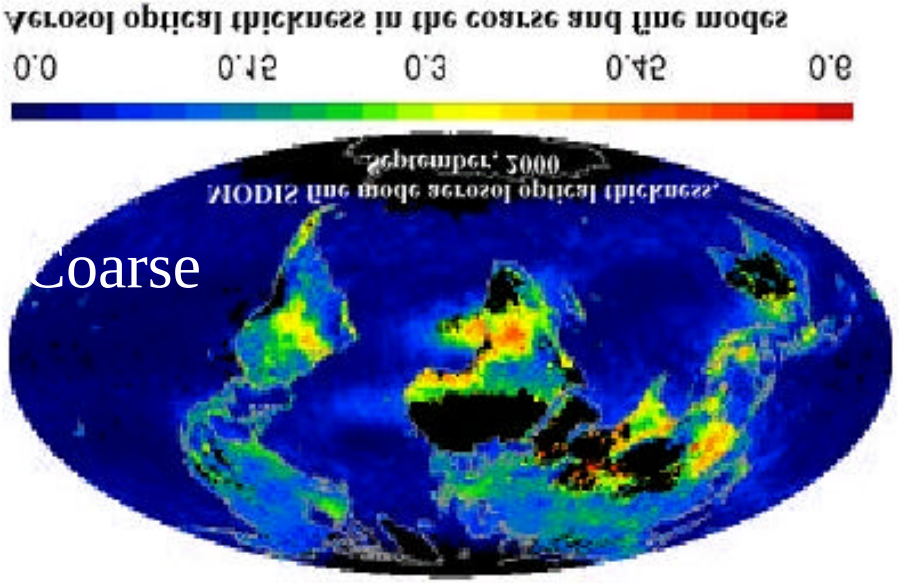
Plots by Y.Kaufman, R-R. Li and D. Westphal

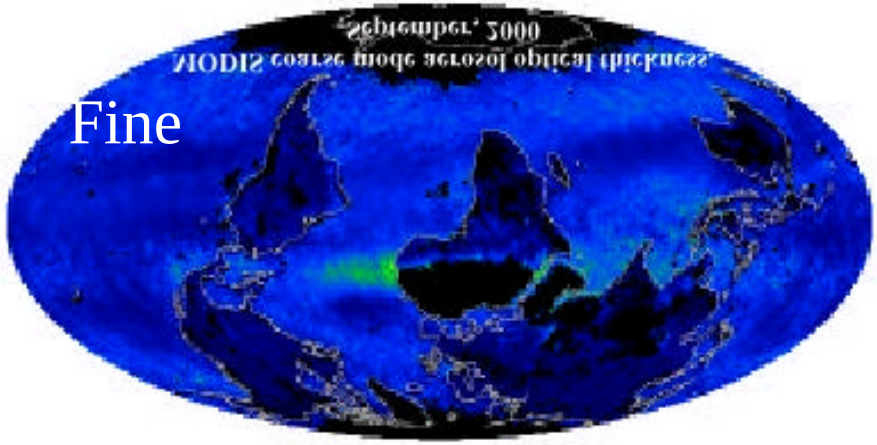






What is meant by size information?



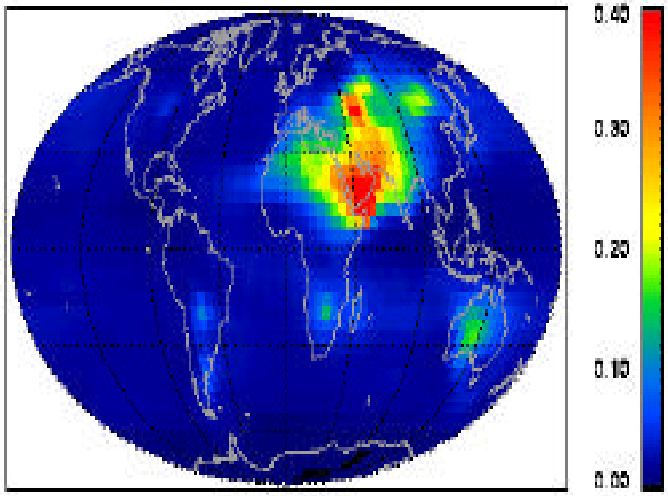


Plots by D.A. Chu

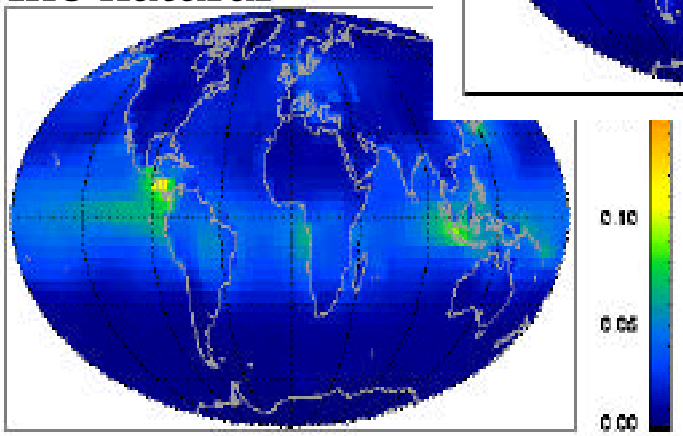
Coarse

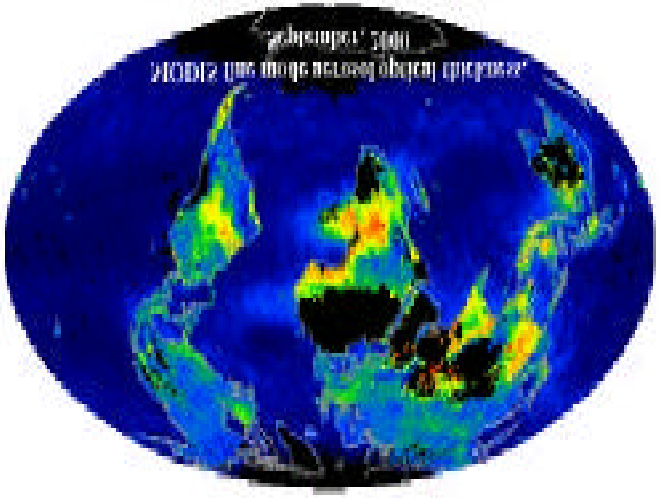
MODIS results

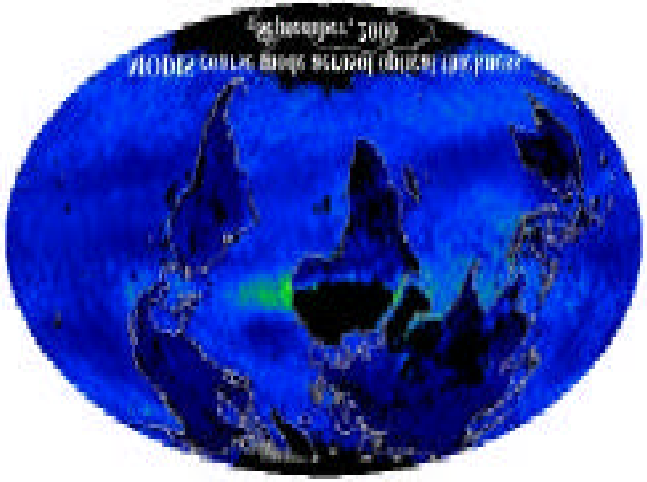
Model results
Tegen et al.
(1997; 2000)



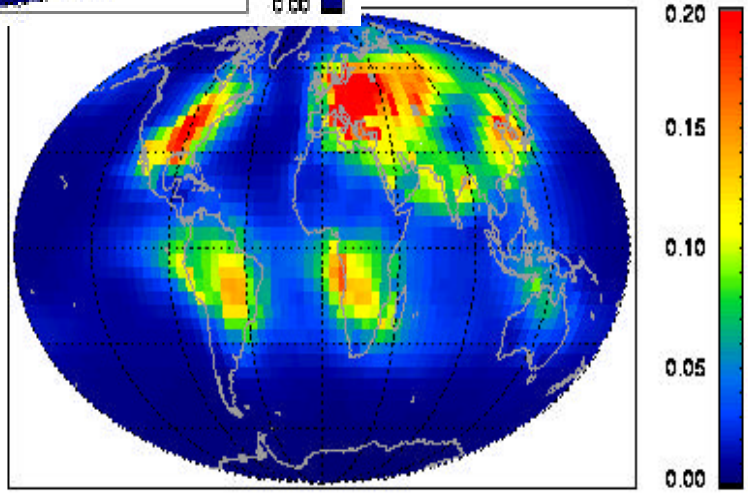
Fine natural





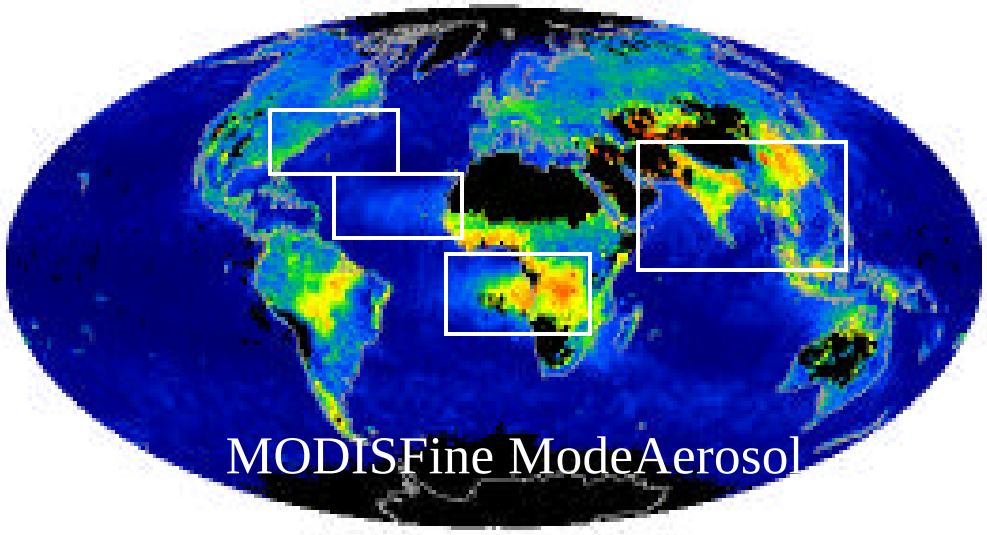


Fine anthro



Fine mode is proxy for human produced aerosol

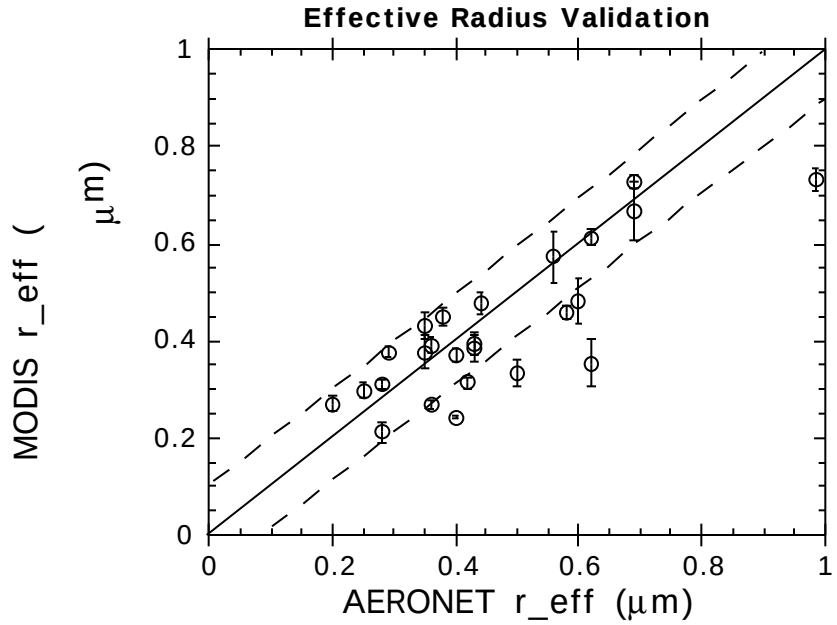
MODIS + AERONET = forcing

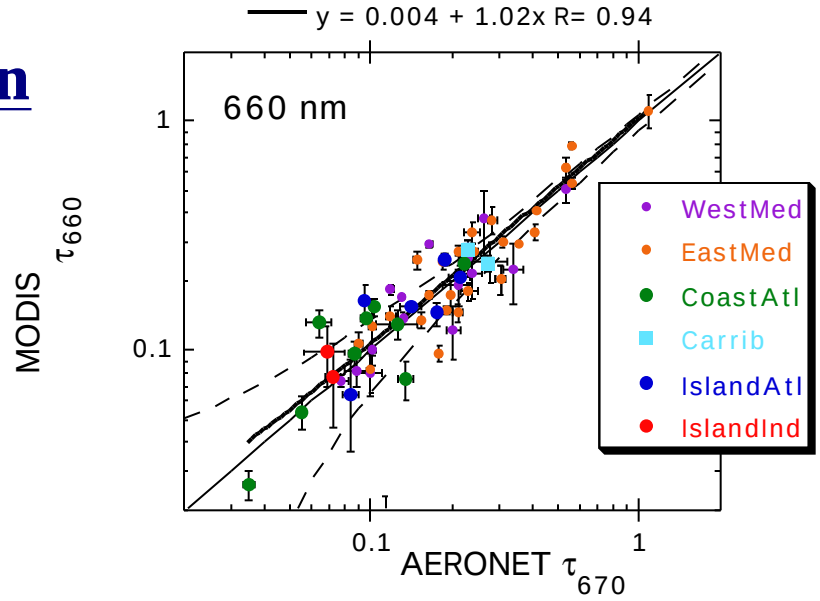


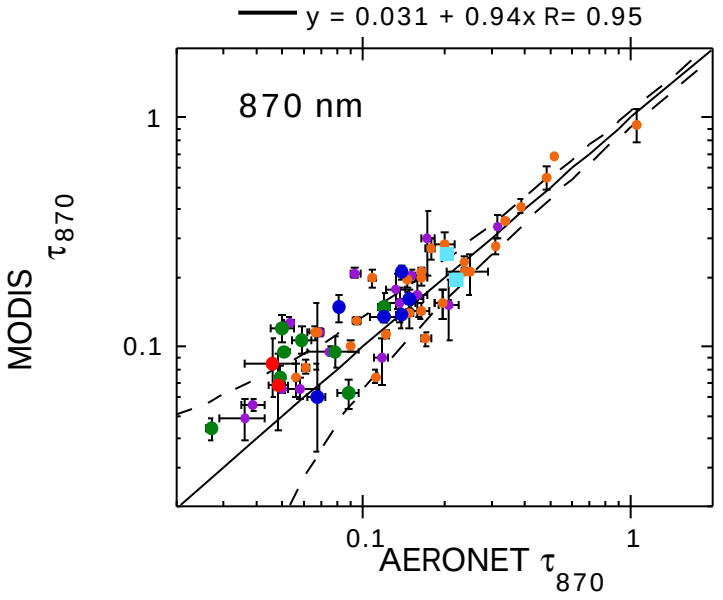
Aerosol type	Urban / industrial pollution		Biomass Burning Savanna from South Africa	Dust from West Africa
Location	East US	S-E Asia		
Area	60-105W 20-45N	70-140E 5-40N	15W-30E, 0-20S	15-50W, 10-25N
Area (million km^2)	9.8	22	9	5
Average $AOT_{0.55}$	0.18	0.24	0.31	0.30
Coarse AOT / total	0.59	0.56	0.34	0.67
R_{eff} (μm) - fine	0.15	0.2	0.2	0.2
R_{eff} (μm) - coarse	1.5	1.6	1.0	1.5
TOA forcing (W/m^2)	-8	-10	-10	-17
Surface forcing (W/m^2)	-10	-23	-30	-23

How good are the MODIS Aerosol Products?

MODIS validation: Ocean







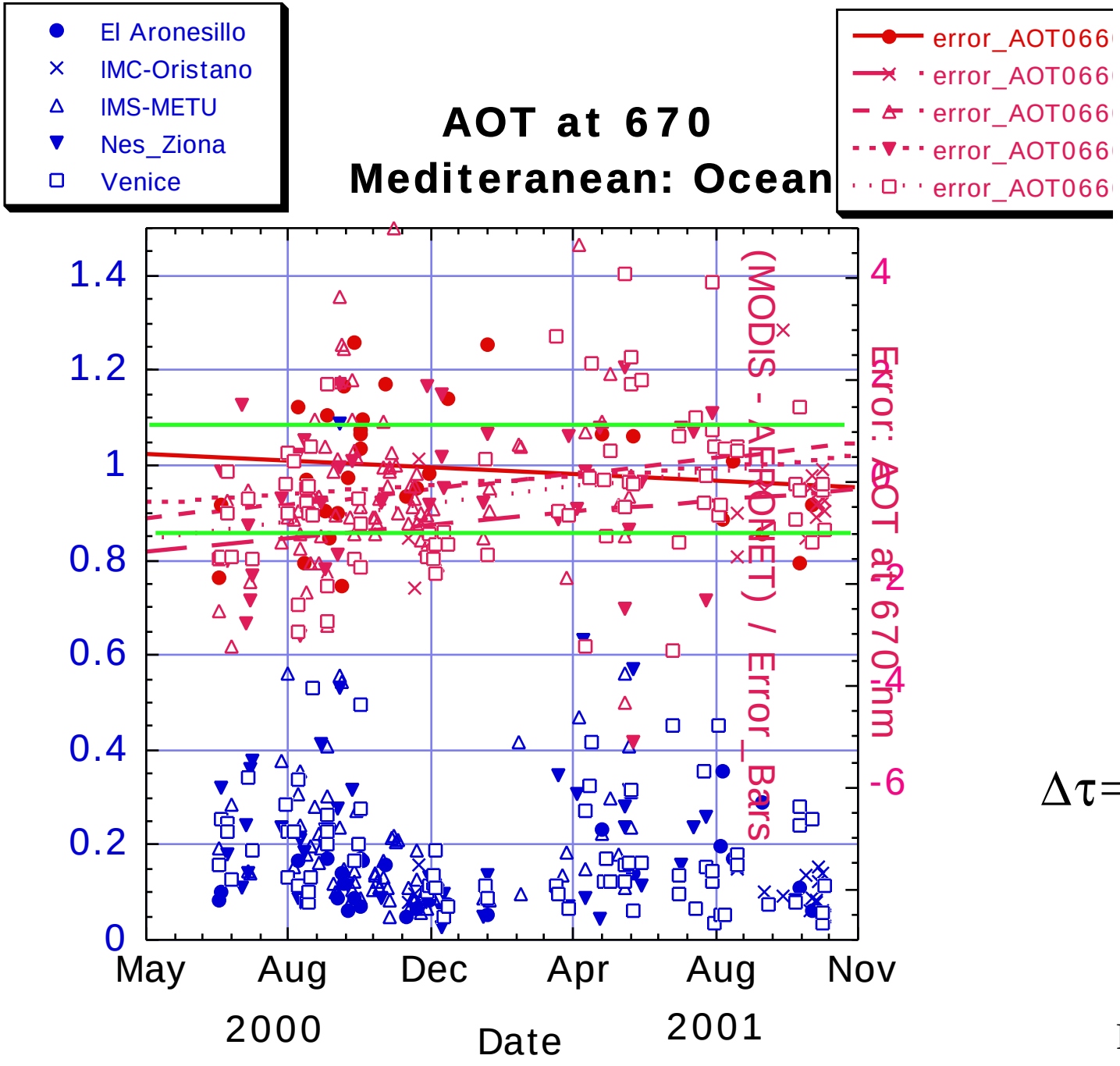
64 co-located measurements during 2 months representing 11 stations.

Lorraine Remer et al 2001

fraction

τ

e mode



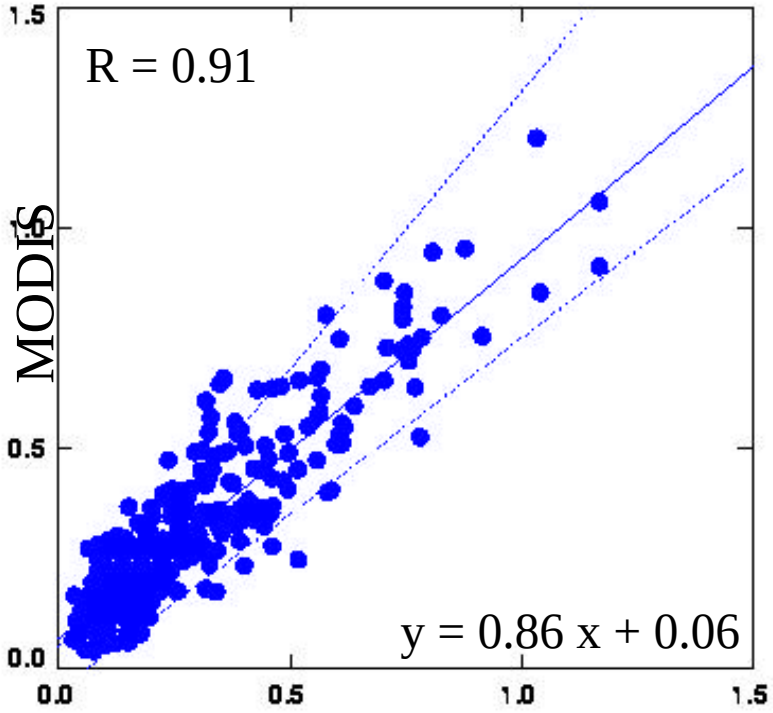
Estimated uncertainty Over ocean

$\Delta\tau = \pm 0.03 \pm 0.05\tau$

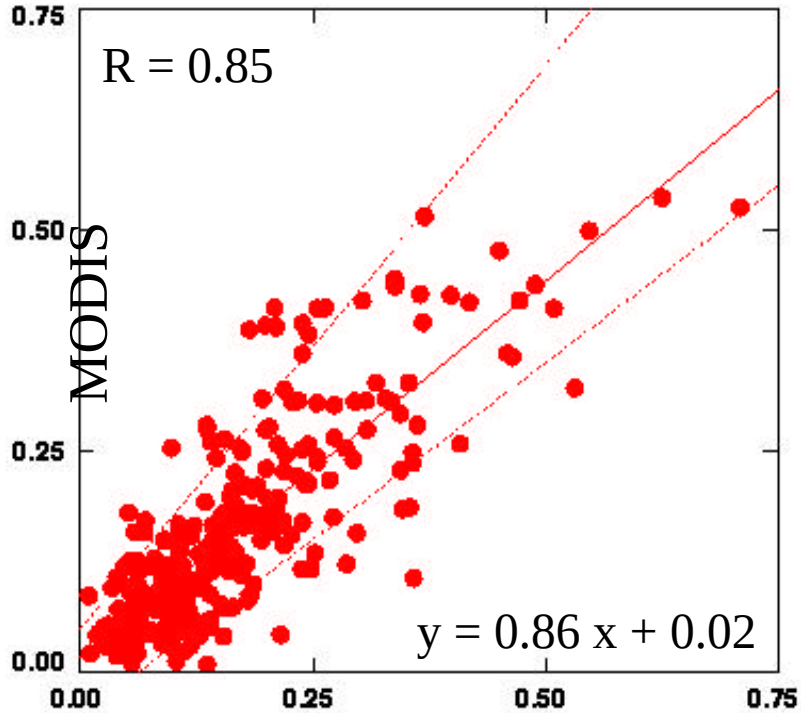
Plot by R. Levy

MODIS Validation: land

At 0.47 μm



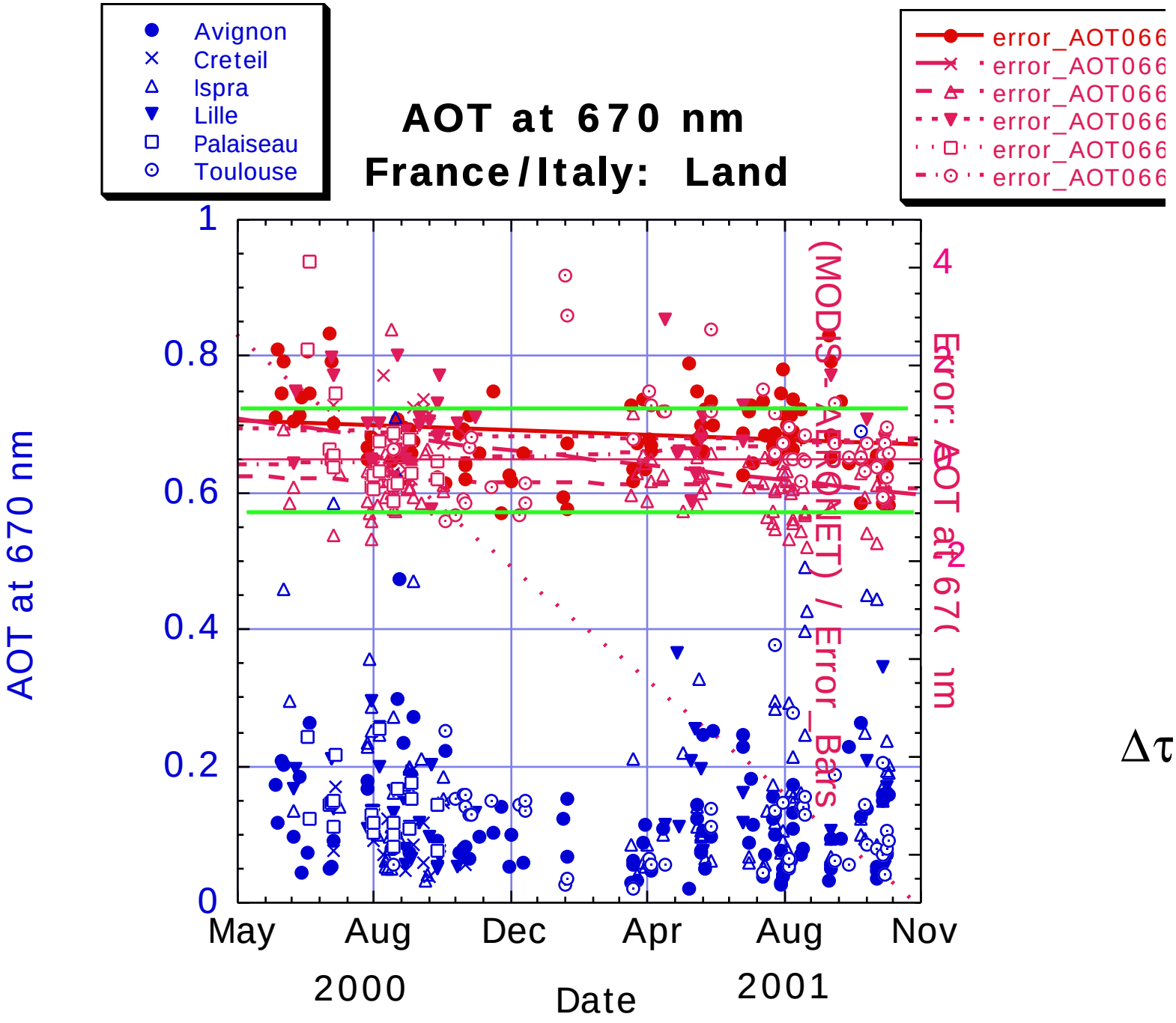
At 0.66 μm



Total points = 315

Allen Chu et al 2001

Note: excluding Venice and El Arenosillo sites

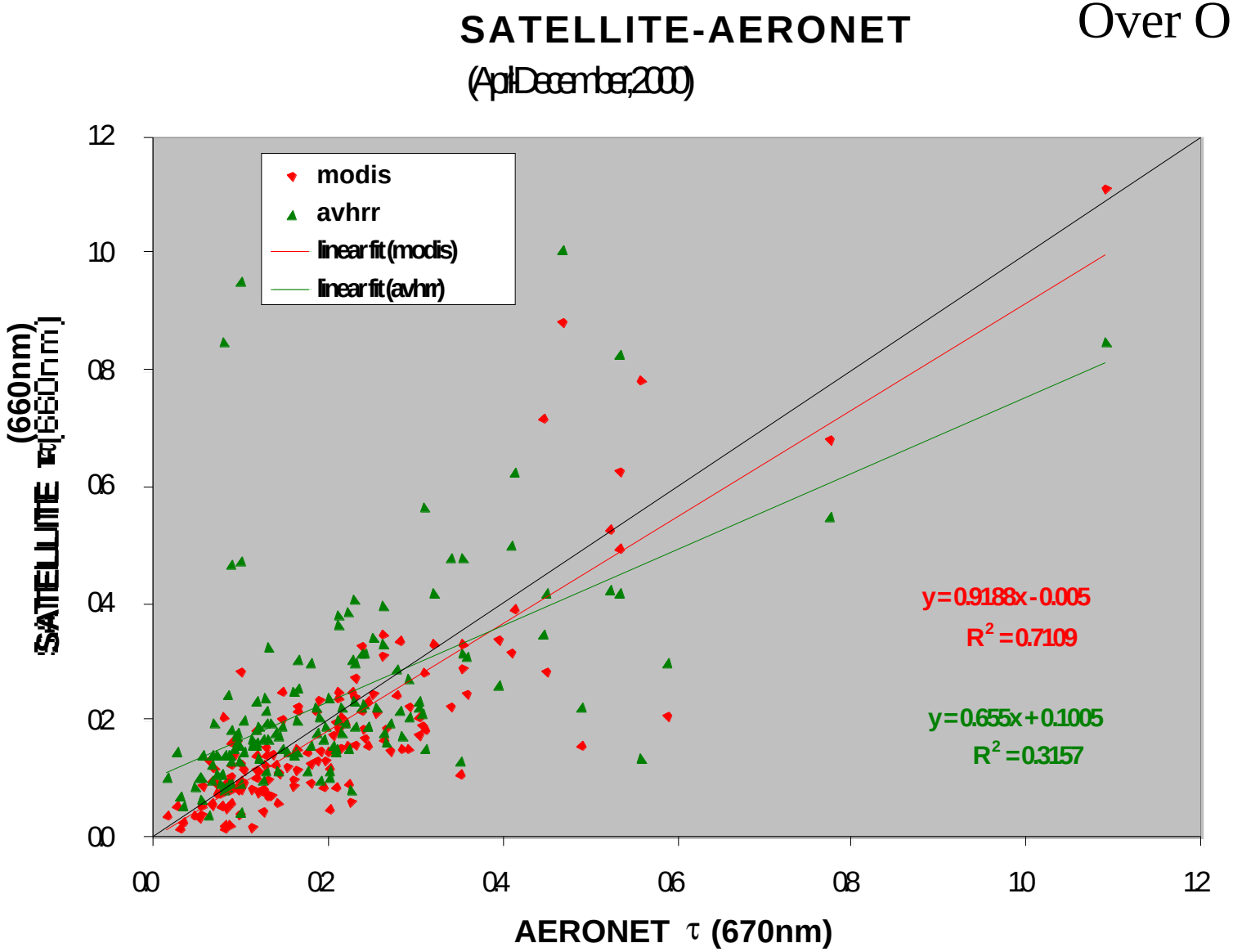


Estimated Uncertainty Over land

$\Delta\tau = \pm 0.05 \pm 0.20\tau$

Plot by R. Levy

Over Ocean



Courtesy of Xuepeng (Tom) Zhao, CIRA/NOAA

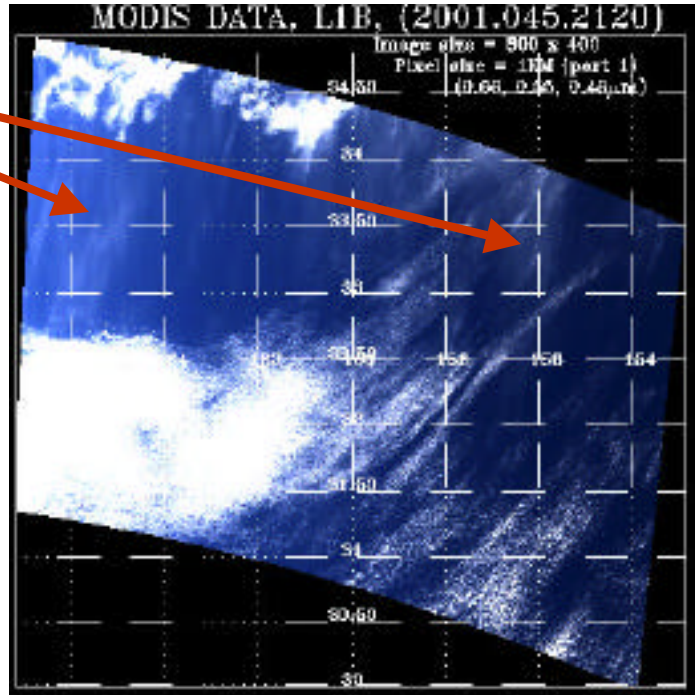
Issues

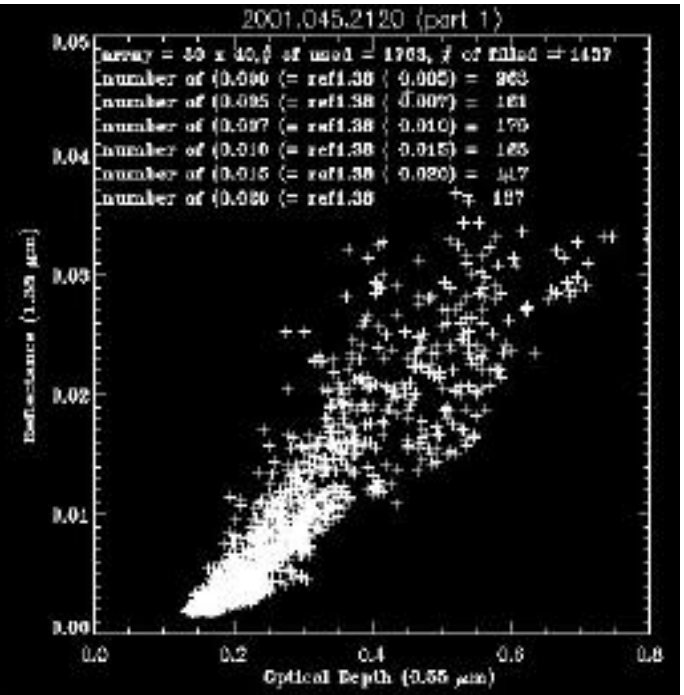
Residual cloud contamination (cirrus)

Nonsphericity

Marshes and swamps

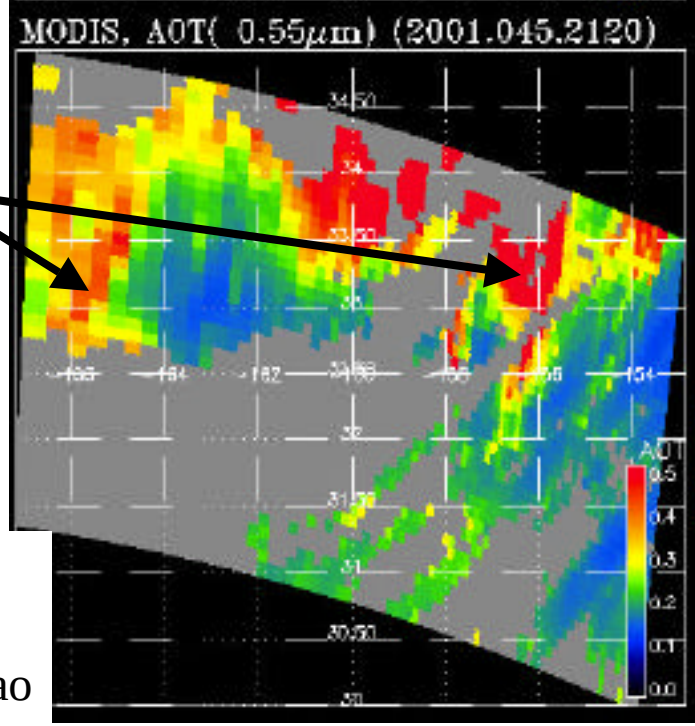
Cirrus

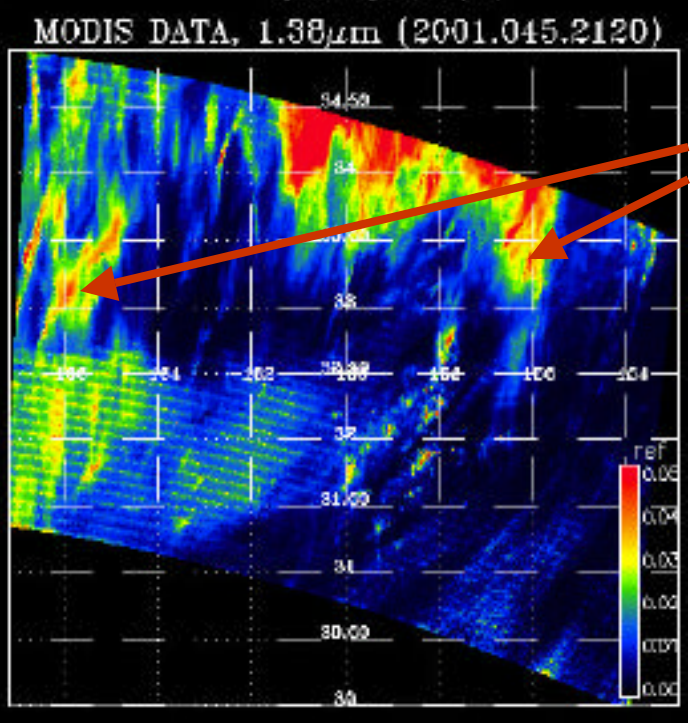




τ correlated with 1.38 reflectance

MODIS aerosol retrieval τ>0.5

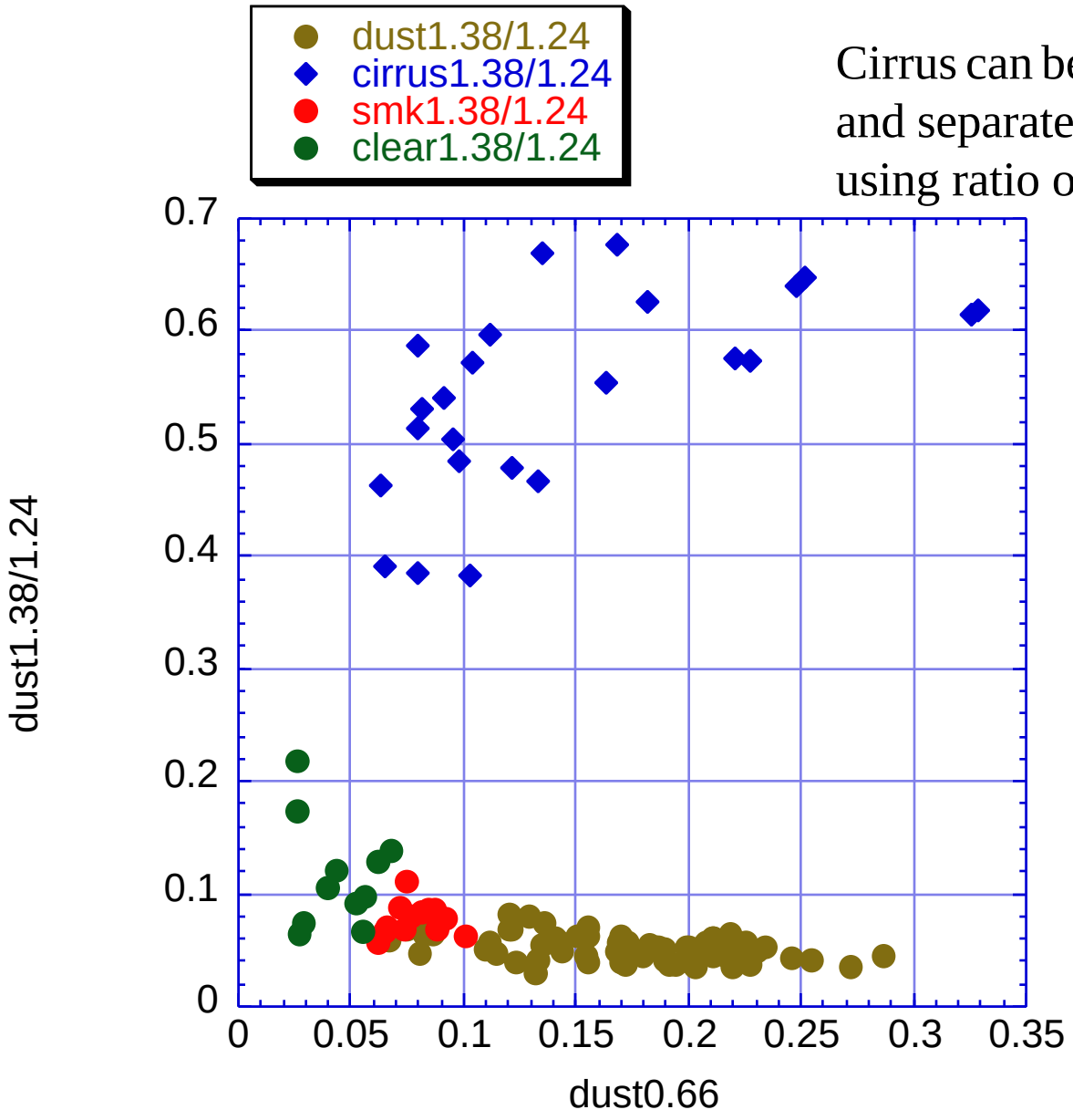




ρ1.38 > 0.03 where τ>0.5

Issue spotted by B-C. Gao

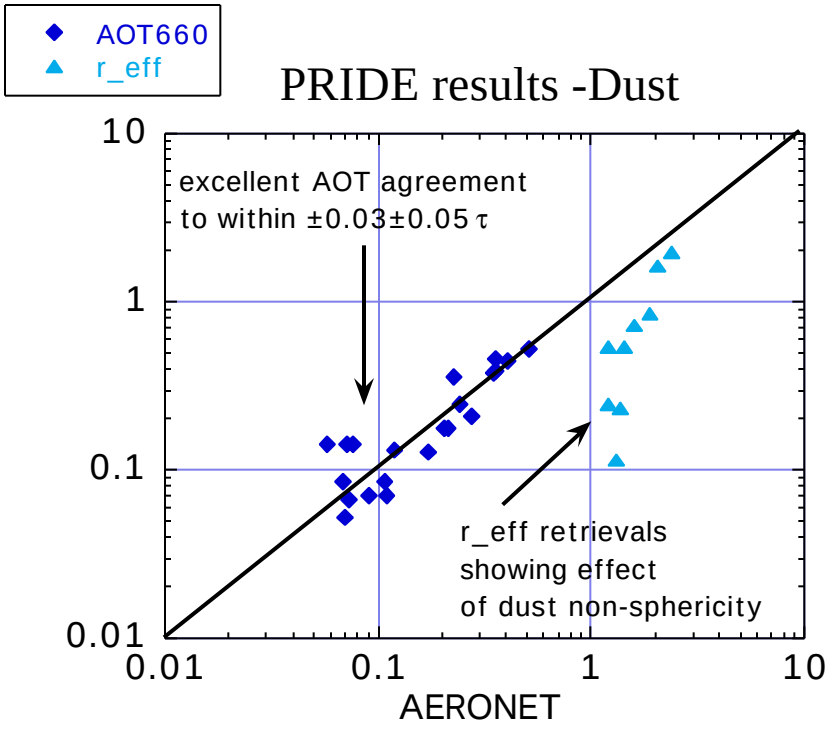
Images By R-R Li



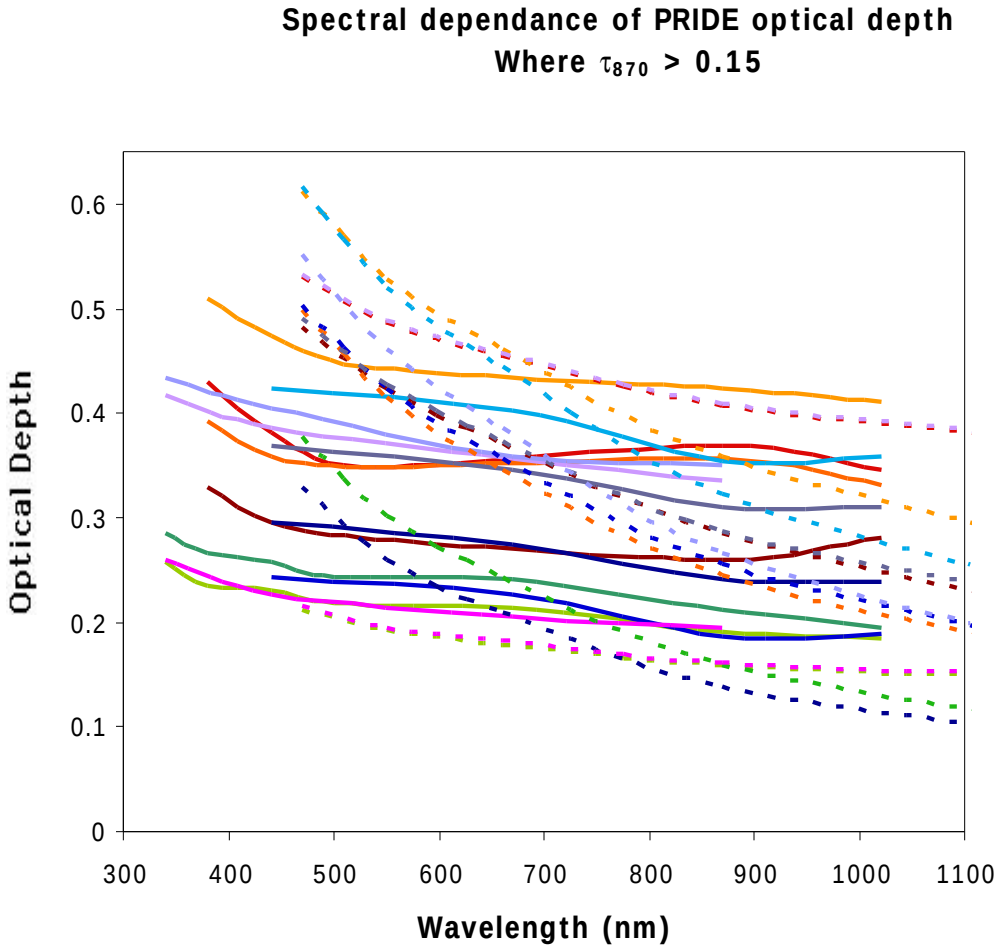
Cirrus can be identified and separated from aerosol using ratio of 1.38/1.24.

D. Tanré
R-R Li
B-C Gao

Dust nonsphericity issue

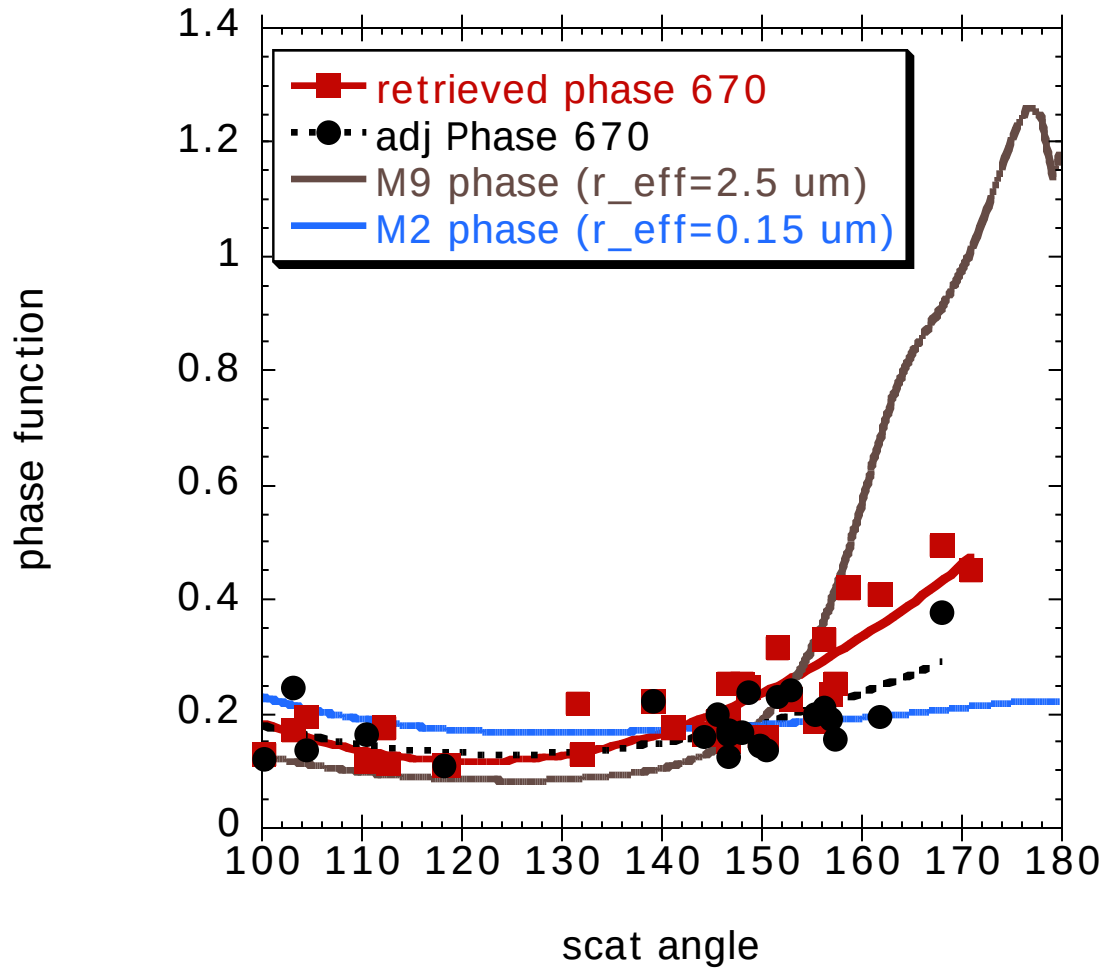


Retrievals are matching sunphotometer optical depth in the 600-800 nm range, but are finding greater spectral dependence and therefore smaller particles.



Moving towards deriving full column, ambient phase function for dust aerosol

Phase function used in retrieval.
Adjusted by ratio of τ_{sp}/τ_{MOD}



Issue: Marshes and swamps interfere with our assumptions about land surface properties.

Result: Optical thickness retrievals are too high in geographically isolated areas.

Are the Products Validated?

That depends on what the meaning of “is” is…

What is meant by “validated”?

What is meant by “products”?

What is meant by “validated’?

- The Ackerman tomato test of validation
- The Menzel $5 method of validation
- Know that every retrieval is exactly correct

  (Then why have a satellite?)

- Know with confidence what uncertainties exist

1 sigma (66%) of individual retrievals are accurate to within
$\pm 0.03 \pm 0.05\tau$ over ocean, to within $\pm 0.05 \pm 0.20\tau$
over land or to within 0.10 μm for r_eff.
No systematic bias so that ensemble means and climatic averages
will fall within the above stated uncertainties. (Level 3)

Optical thickness at 550 nm, land and ocean - VALIDATED Sept 2000
Ocean optical thickness (660, 870 nm) - VALIDATED Sept 2000
Land optical thickness (440, 670 nm) - VALIDATED Sept 2000

Other wavelengths, size information validated for non-dust
Globally validation expect Spring 2002

Summary: The MODIS Aerosol Products

What are they?

Aerosol spectral optical thickness and size information
R_eff or alternatively, fine and coarse mode AOT
Proxy for natural and human produced aerosol

How good are they?

1 σ within prelaunch estimates of uncertainty

Issues

Residual cloud contamination - improvement underway
Dust size and AOT in the mid-IR - improvement underway
Swamps and marshes

Validation

Aerosol optical thickness VALIDATED for 4 λs
r_eff and additional AOT at 3 λs validated for non-dust (PROVISIONAL)
Spring 2002 target date for completion of validation for all AOT and size