The Operational MODIS Aerosol Products

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And the MODIS aerosol team:
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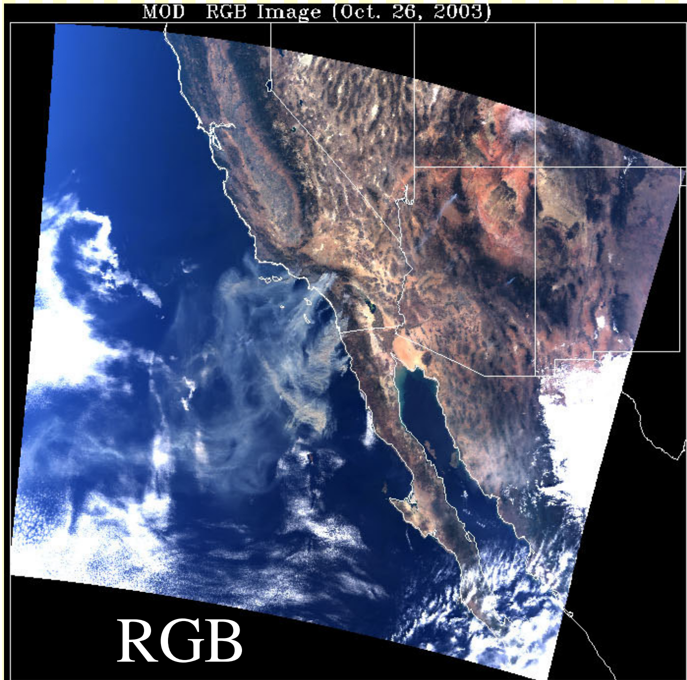
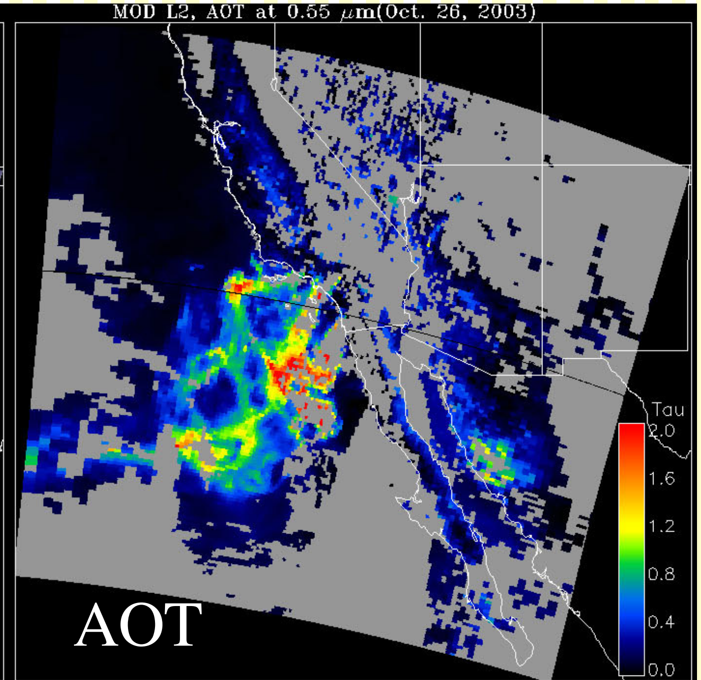
We’ve been extremely productive!

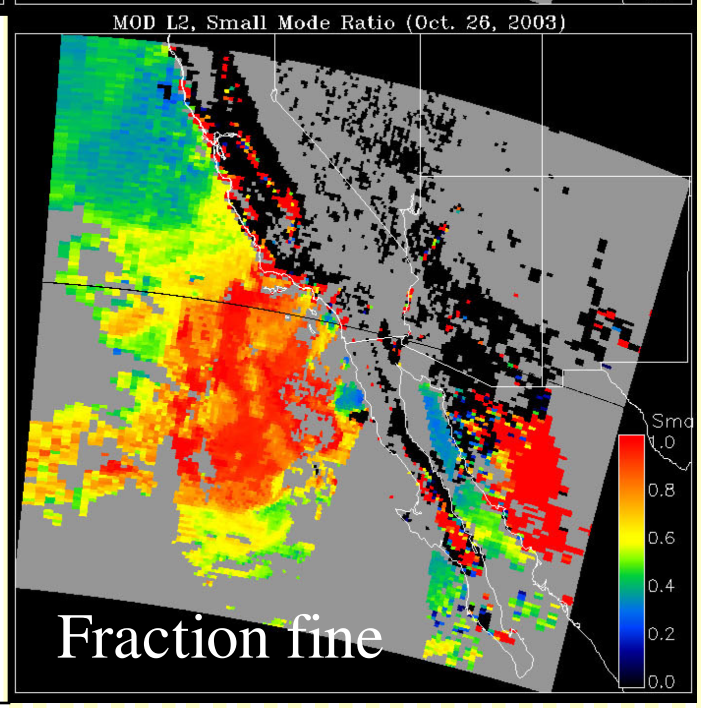




California
Wildfires
Oct. 26, 2003

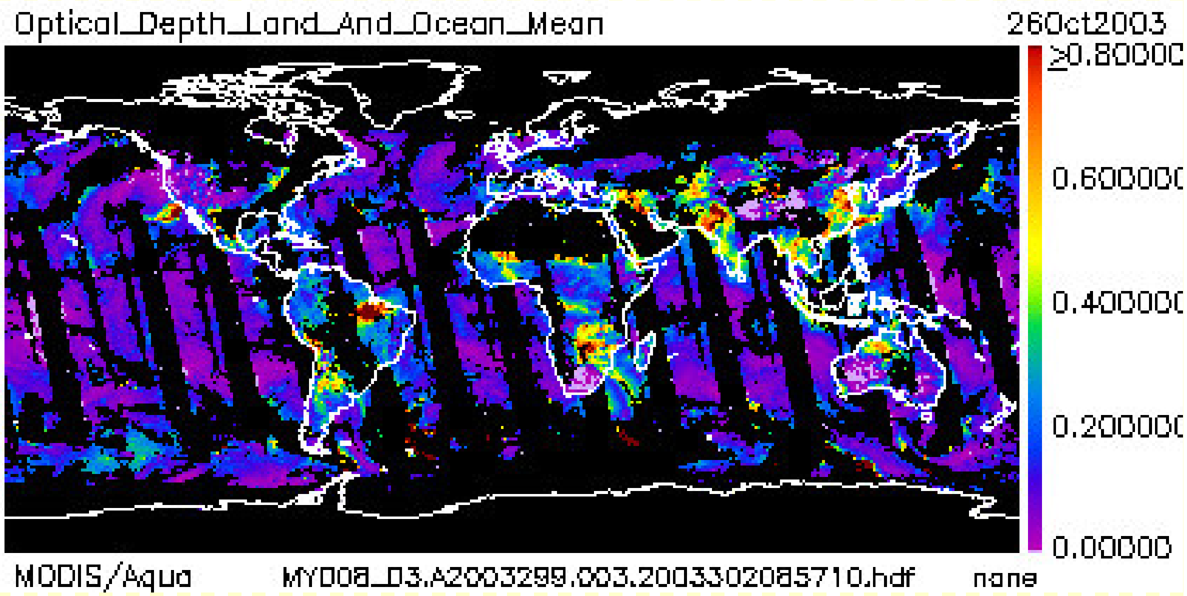
From Terra-MODIS

MOD04

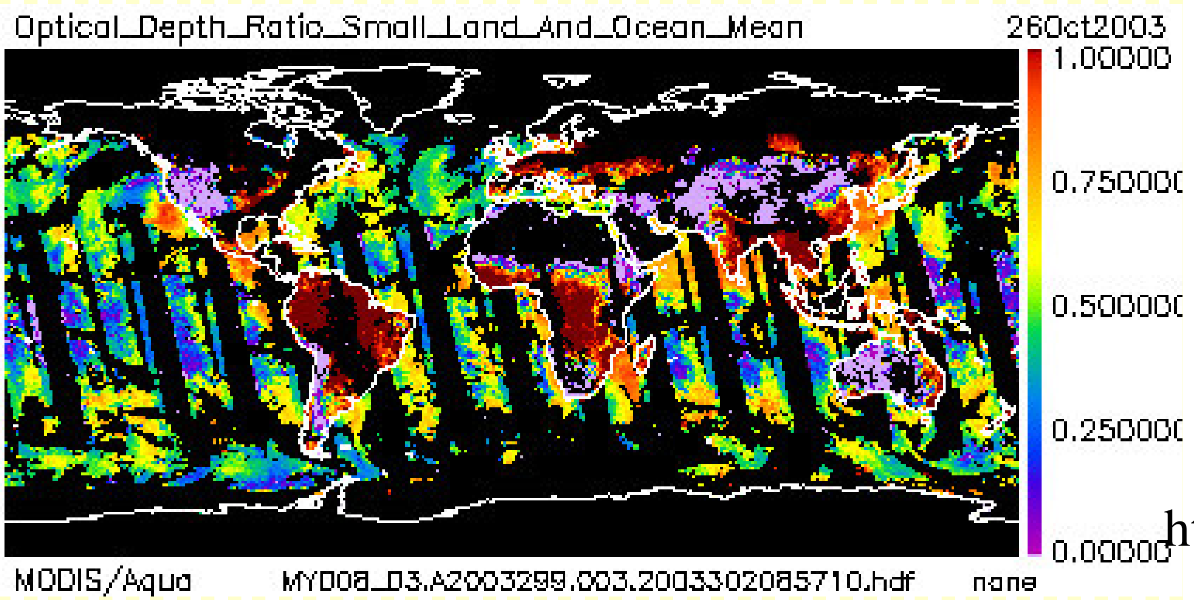


Rong-Rong Li

Aerosol Optical Thickness



Fine mode fraction



The global aerosol

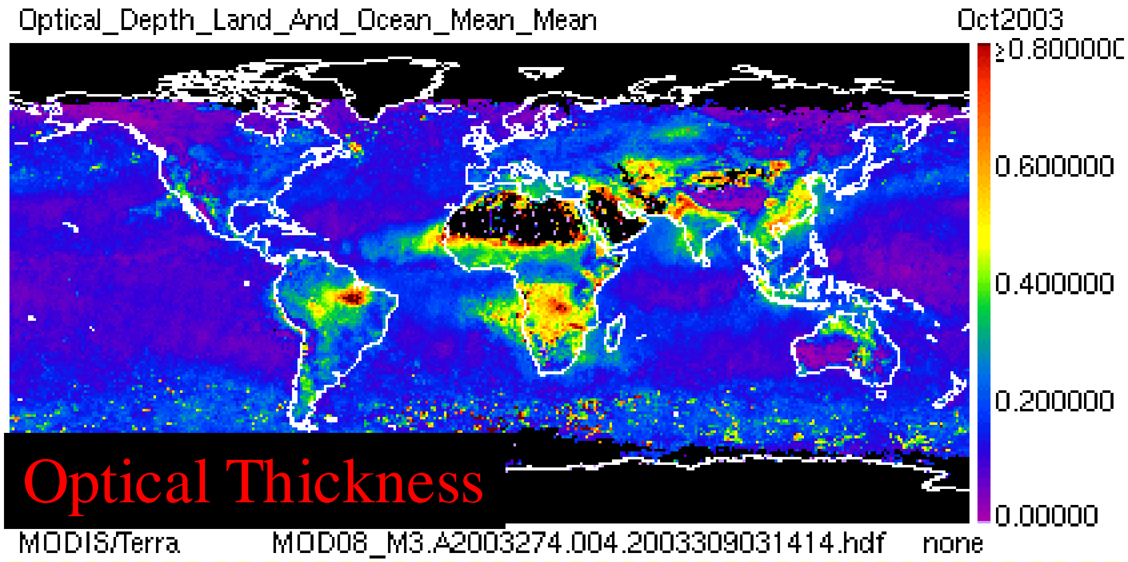
MOD08_D3

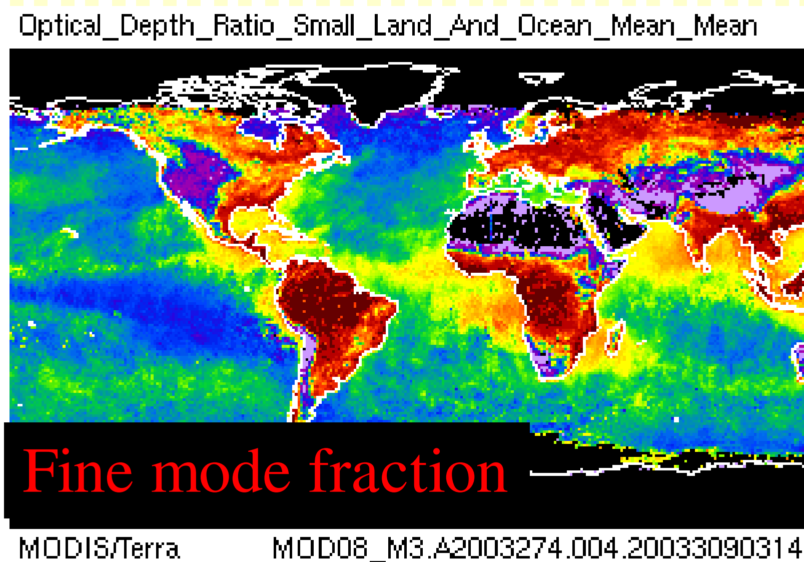
Daily Level 3
1 degree data

October 26, 2003

http//:modis-atmos.gsfc.nasa.gov

Paul Hubanks



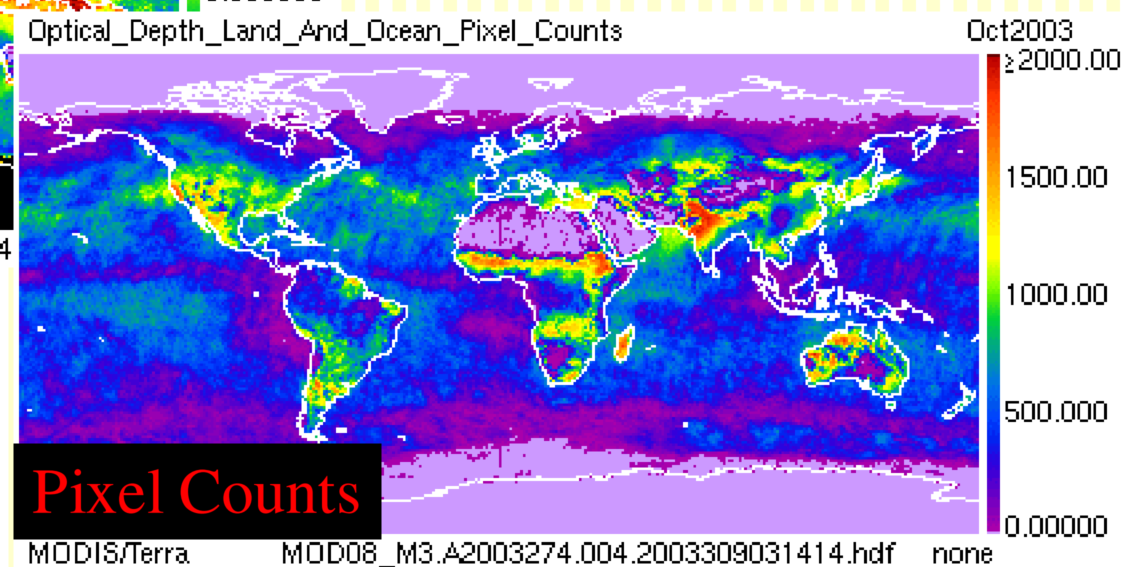


MOD08_M3

Monthly mean global data

1 degree grid

Oct. 2003



http//:modis-atmos.gsfc.nasa.gov

Paul Hubanks

Deriving aerosol properties over land and ocean

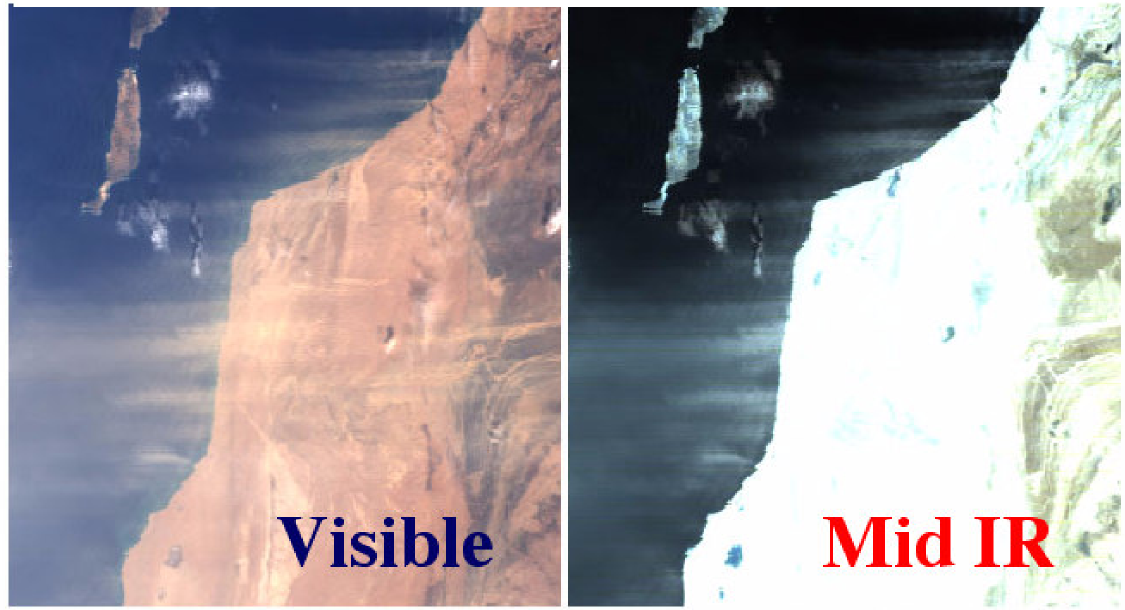
Examples:

MODIS wide spectral range:

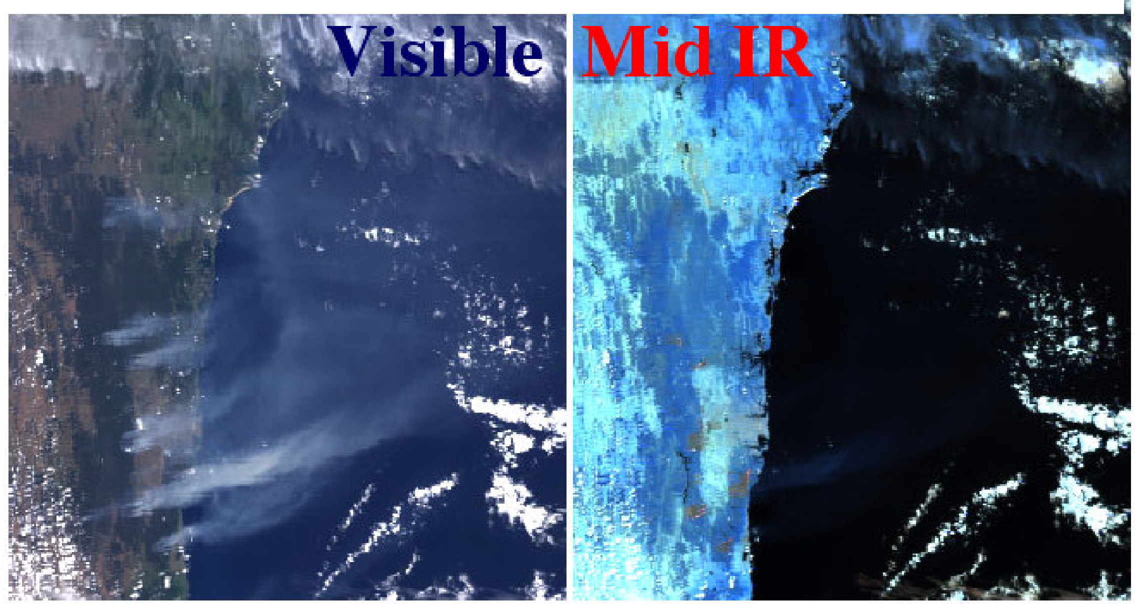
- **Distinguish dust from smoke / pollution aerosol**

- **Distinguish aerosol from land reflectance**

MODIS: Saharan dust, Jan. 2002



Fires in Australia, Dec 2001

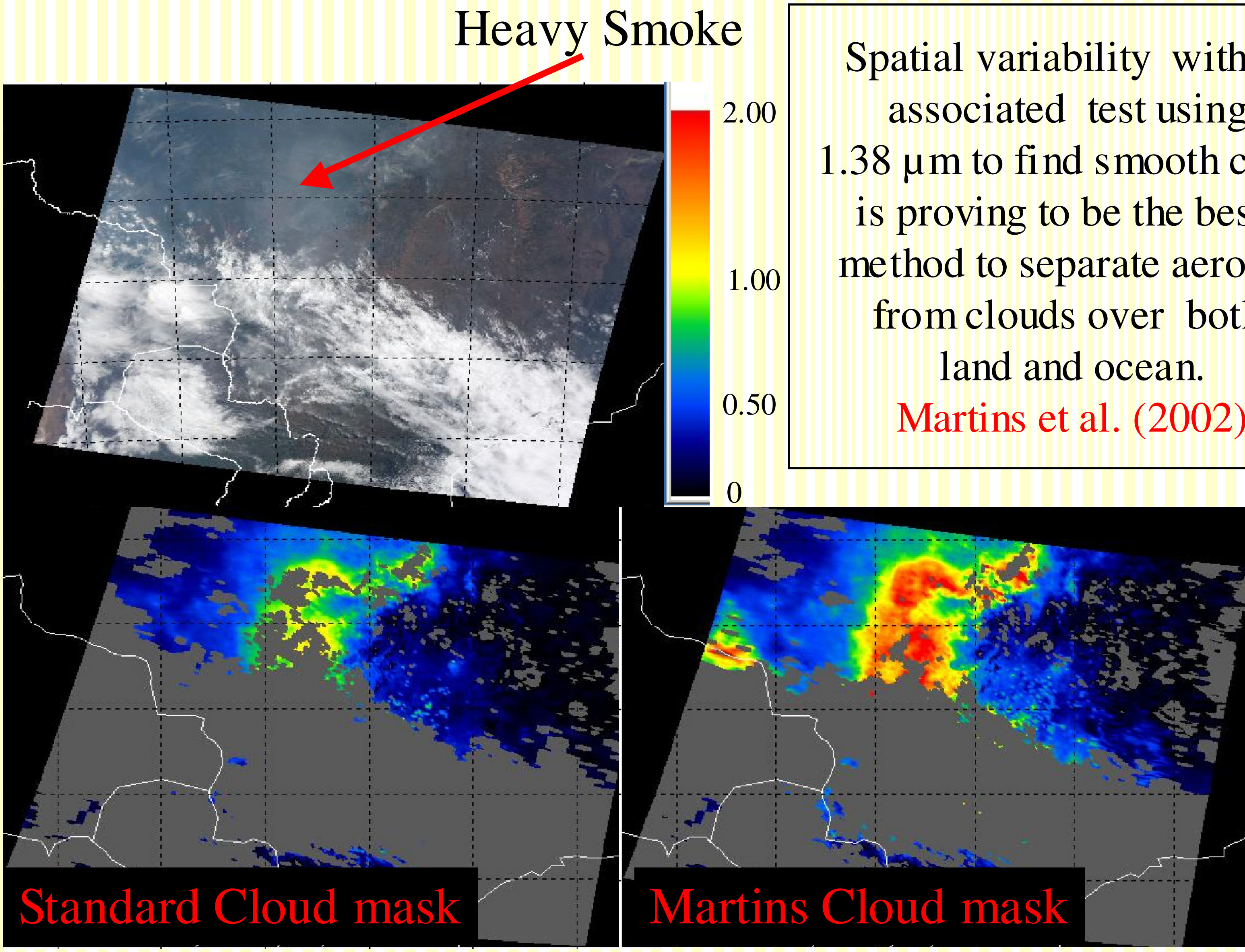


But, before we can begin to derive aerosol...

We need to find the right pixels.

Welcome to:
The Data Discarding Business

Cloud Masking



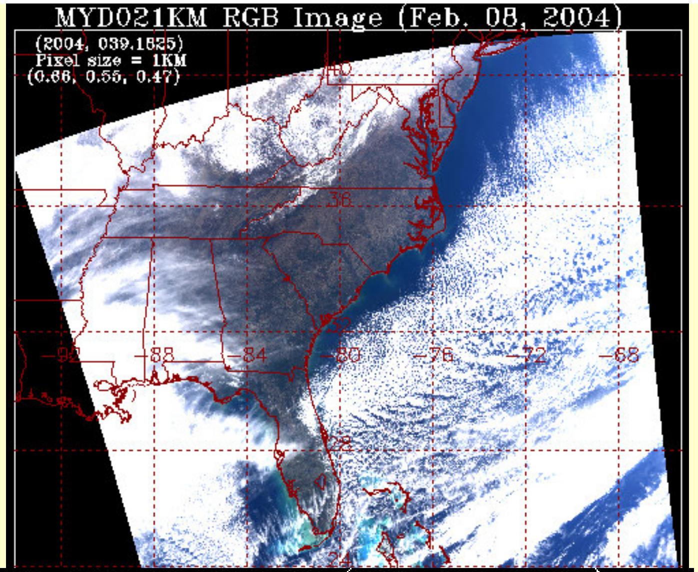
Spatial variability with an associated test using 1.38 μm to find smooth cirrus is proving to be the best method to separate aerosol from clouds over both land and ocean.
Martins et al. (2002)

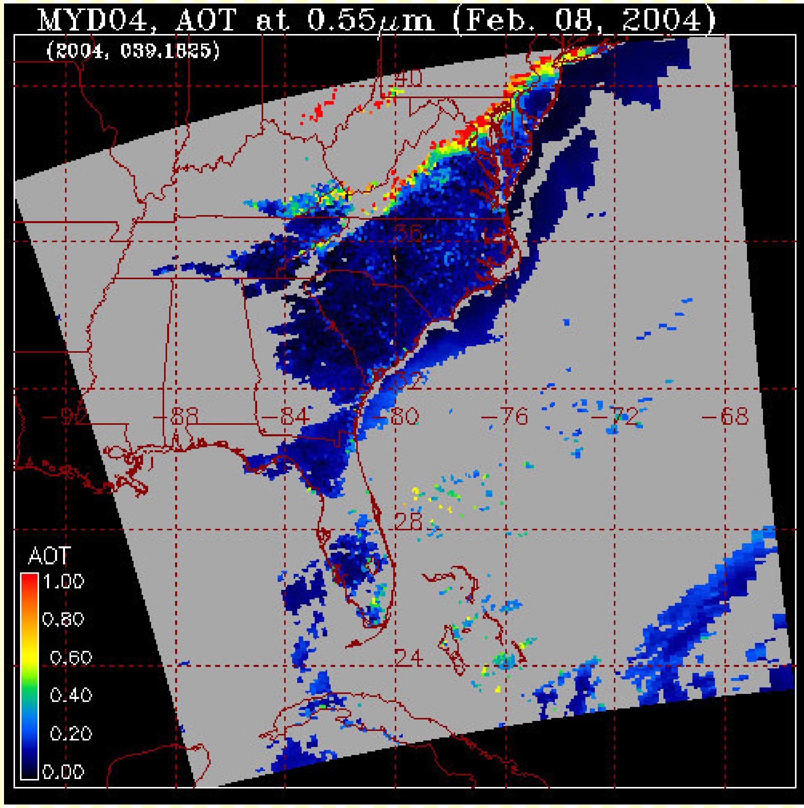
Example from the Amazon

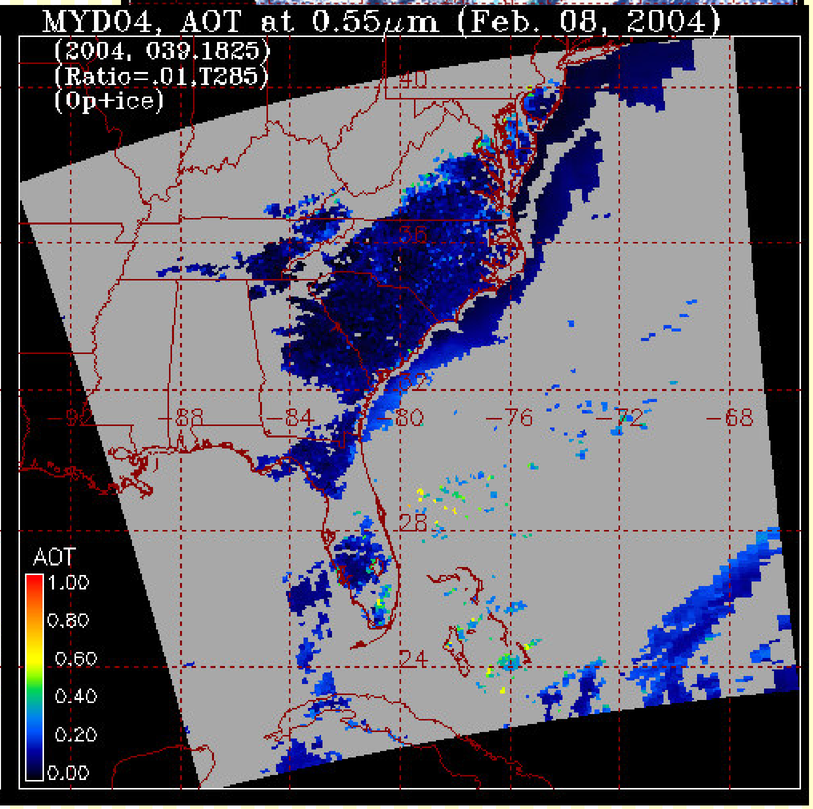
Snow Masking

Li et al. (2005)

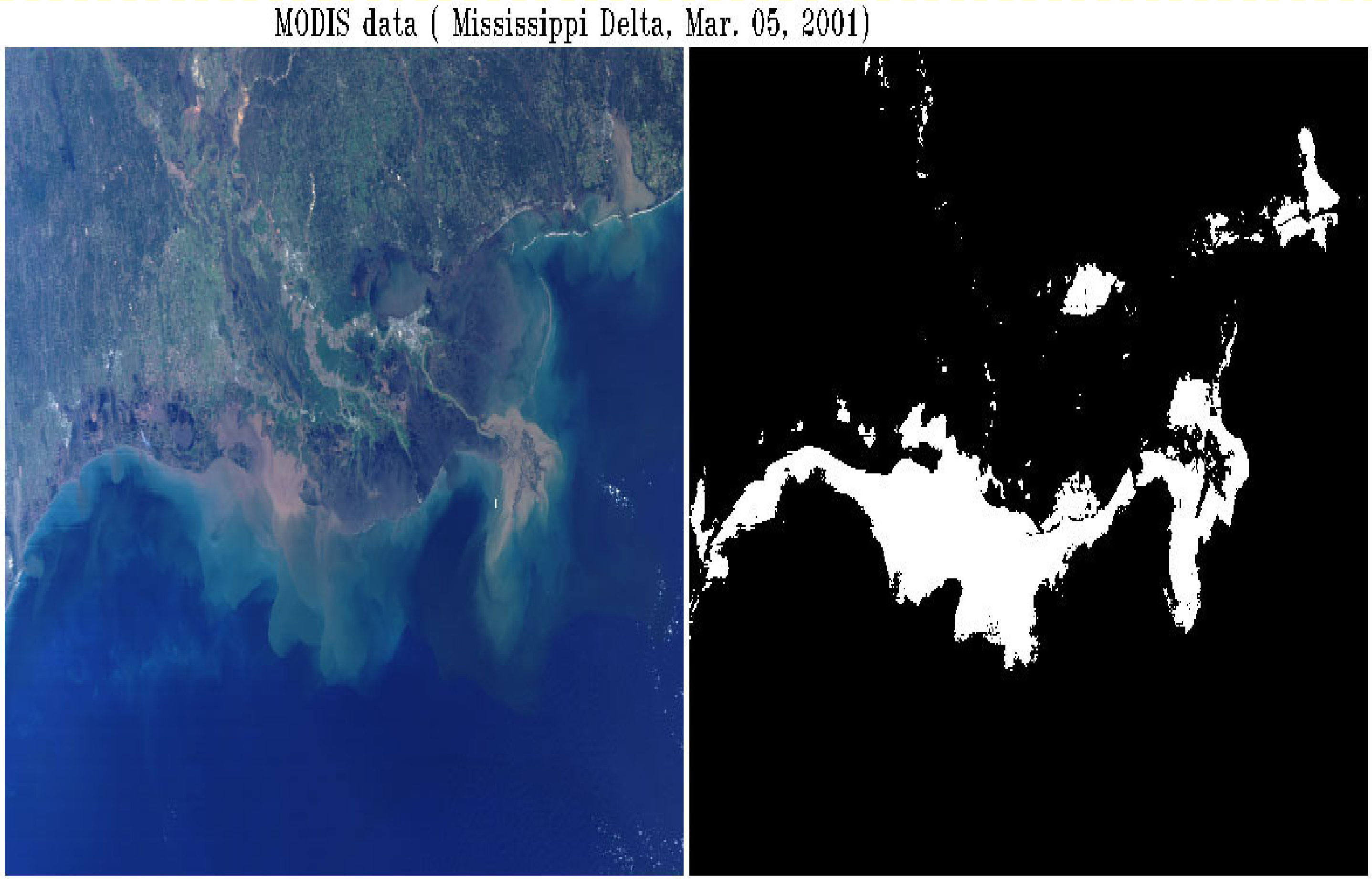
$(\rho^{0.86} - \rho^{1.24})/(\rho^{0.86} + \rho^{1.24}) > 0.01$
And $T_{11} < 285K$ then SNOW







Sediment Masking

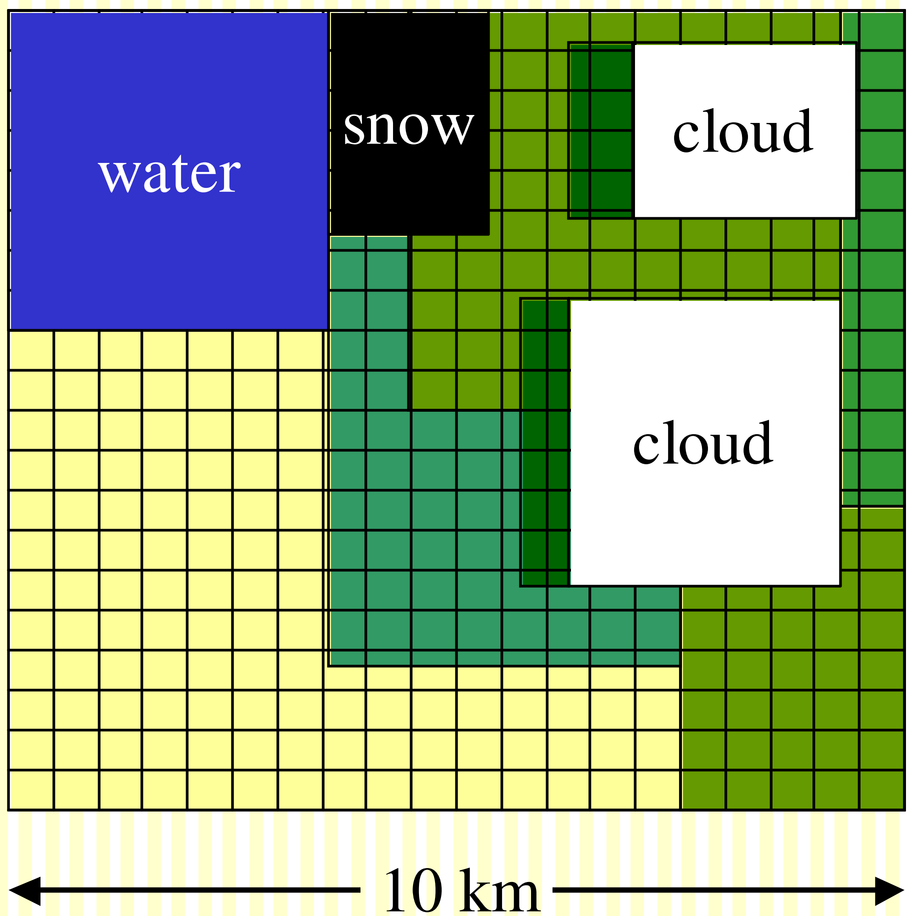


Li et al. (2003)

	ocean		land	
	now	soon	now	soon
Spatial variability Cloud mask	X			X
Internal spectral Snow mask				X
Sediment mask	X			

Now = Collection 004
Soon = Collection 005

MODIS Over Land Algorithm
20 x 20 pixels at 500 m resolution
(10 km at nadir)



400 total
- 56 water

344
- 24 snow

320
- 55 cloud

265
-116 "bright"

149 "good"

Discard brightest 50% and darkest 20% of the 149 good pixels.

→ 44 pixels

Remer et al. (2004)

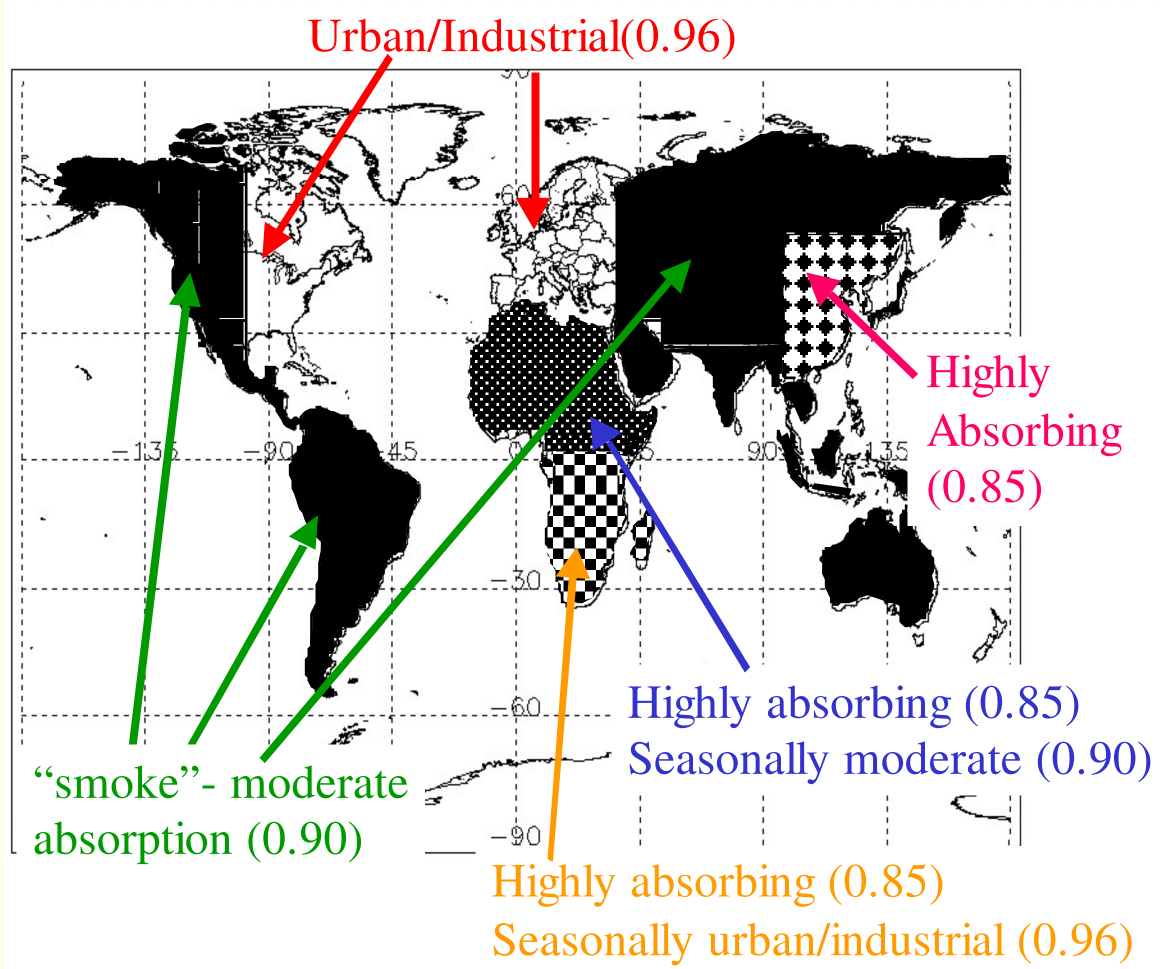
How to derive aerosol products from satellite (in 3 easy steps…)

1. Create a Look-Up Table with expected aerosol properties

2. Estimate surface reflectance (to separate signal from the atmosphere from signal from the ground).

3. Match the satellite-observed reflectances to the output of the Look-Up Table

Step 1: Create a LUT with expected aerosol properties… LAND



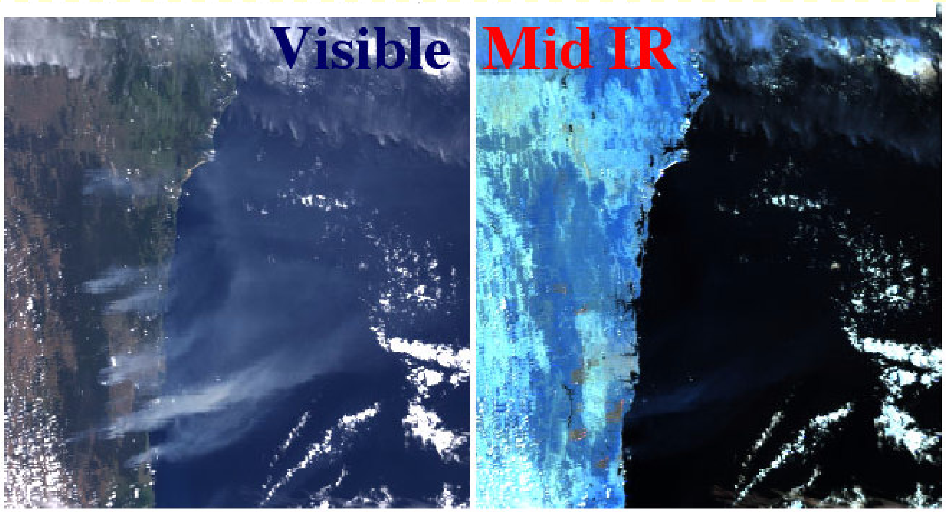
3 non-dust models plus dust

Set by geography and season

Models are dynamic f(τ)

All aerosol models and seasonal/geographical distributions are currently being re-evaluated.

Step 2: Estimate surface reflectance LAND

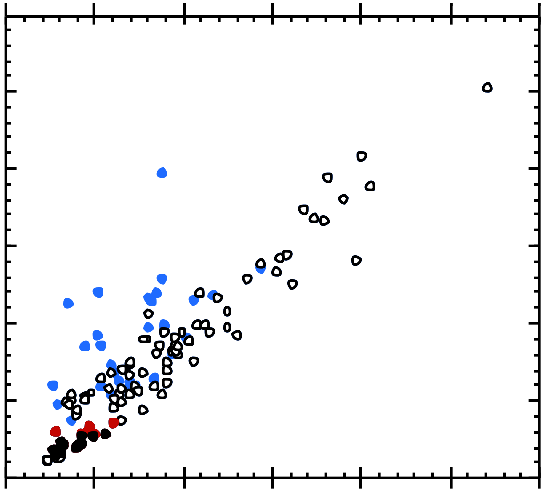


Current

Assume $\rho^{s}_{2.1} = \rho^{m}_{2.1}$

Assume $\rho^{s}_{0.47} = 0.25\rho^{s}_{2.1}$

Assume $\rho^{s}_{0.66} = 0.50\rho^{s}_{2.1}$



Planned

Assume $\rho^{s}_{0.47} \sim 0.35\rho^{s}_{2.1}$

Assume $\rho^{s}_{0.66} \sim 0.60\rho^{s}_{2.1}$

Step 3: Match the satellite-observed reflectances to the output of the Look-Up Table LAND

Current:

Individual channel retrievals:
0.47 µm and 0.66 µm

Fine model ratio = η = $f(\rho_o^{0.66}/\rho_o^{0.47})$

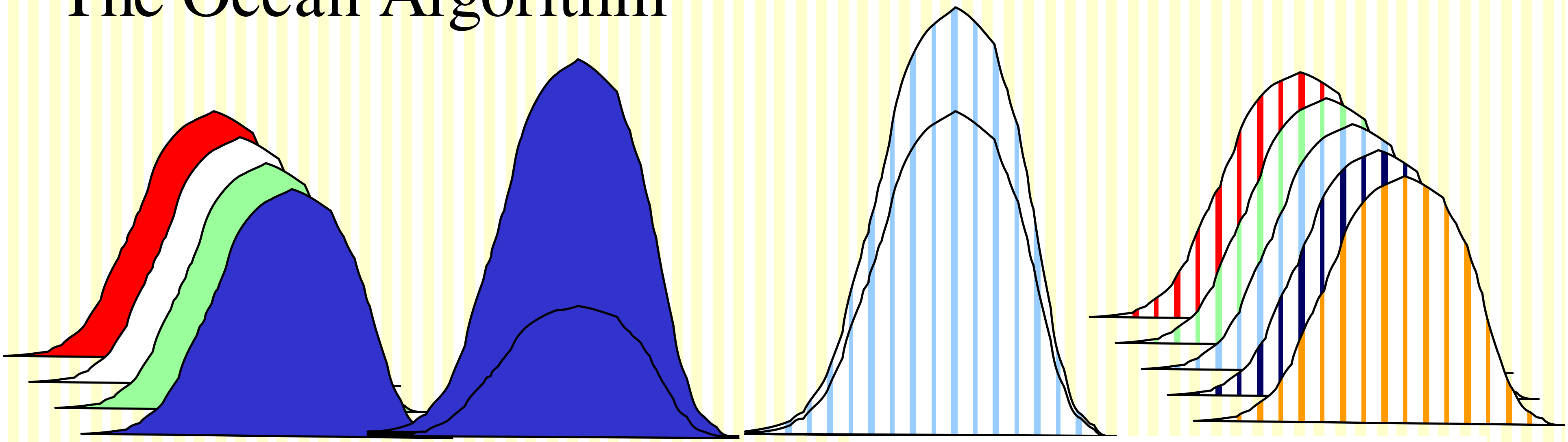
Remer et al. (2004)

Planned:

True inversion:
3 pieces of information = $\rho_m^{0.47}\ \rho_m^{0.66}\ \rho_m^{2.1}$
will yield three quantities = $\tau^{0.47}$, η, $\rho_s^{2.1}$
and for a given aerosol model the spectral dependence will automatically yield $\tau^{0.55}$ and $\tau^{0.66}$

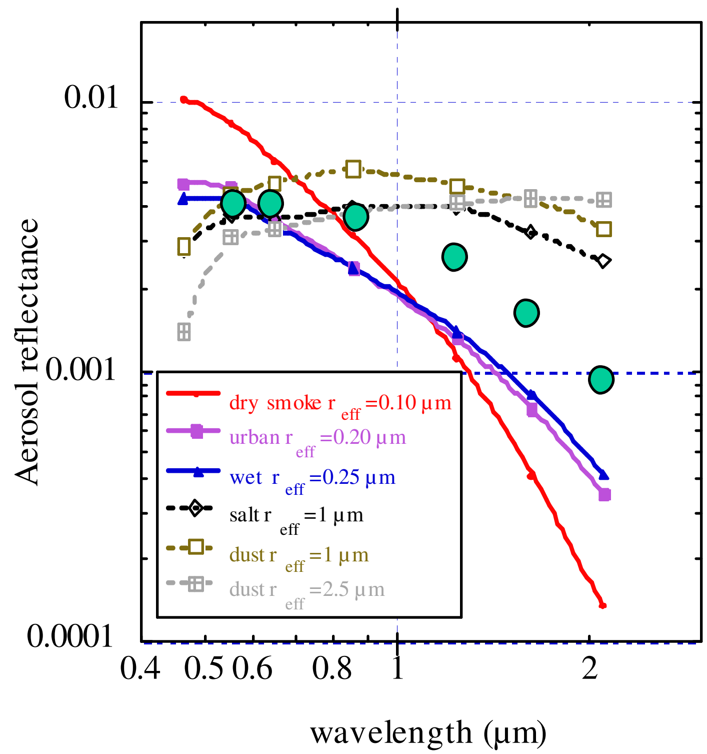
No longer assume $\rho_s^{2.1} = \rho_m^{2.1}$

The Ocean Algorithm



Choice of 4 fine modes
and 5 coarse modes

In order to minimize
(ρ_{meas} - ρ_{LUT}) over 6 wavelengths

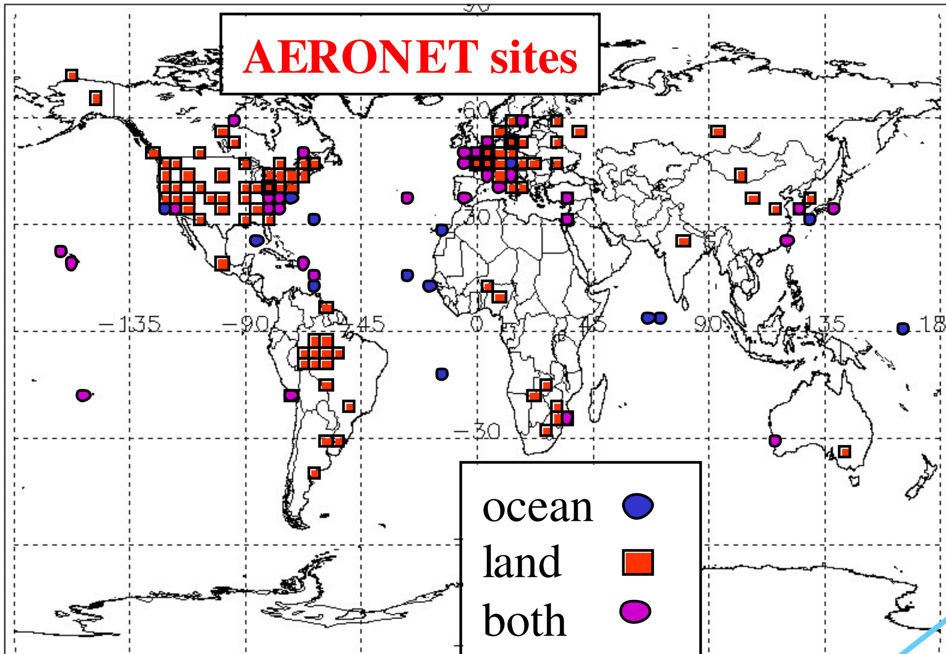


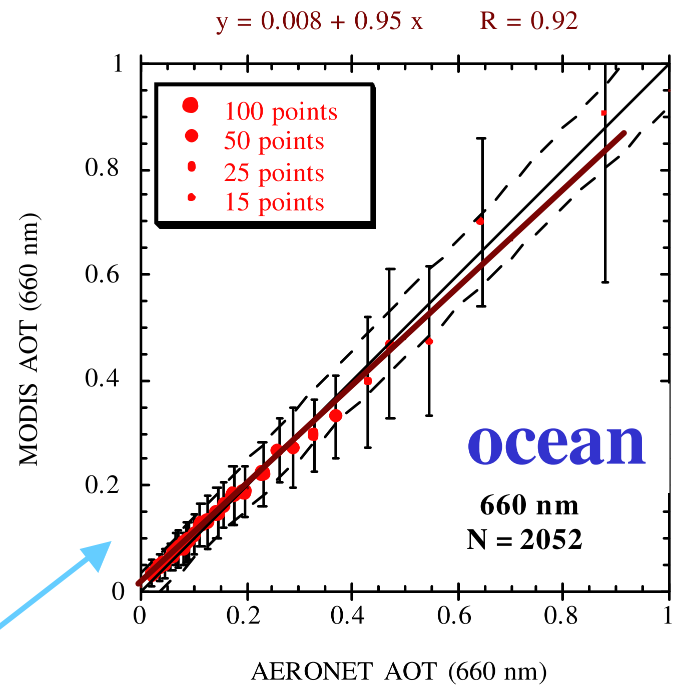
s

Remer et al. (2004)

Validation

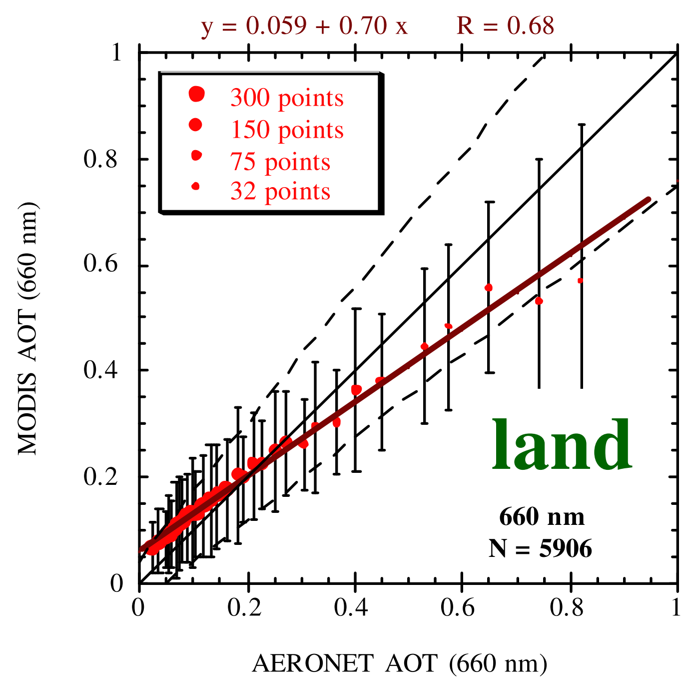
MODIS aerosol validation 2000-2002



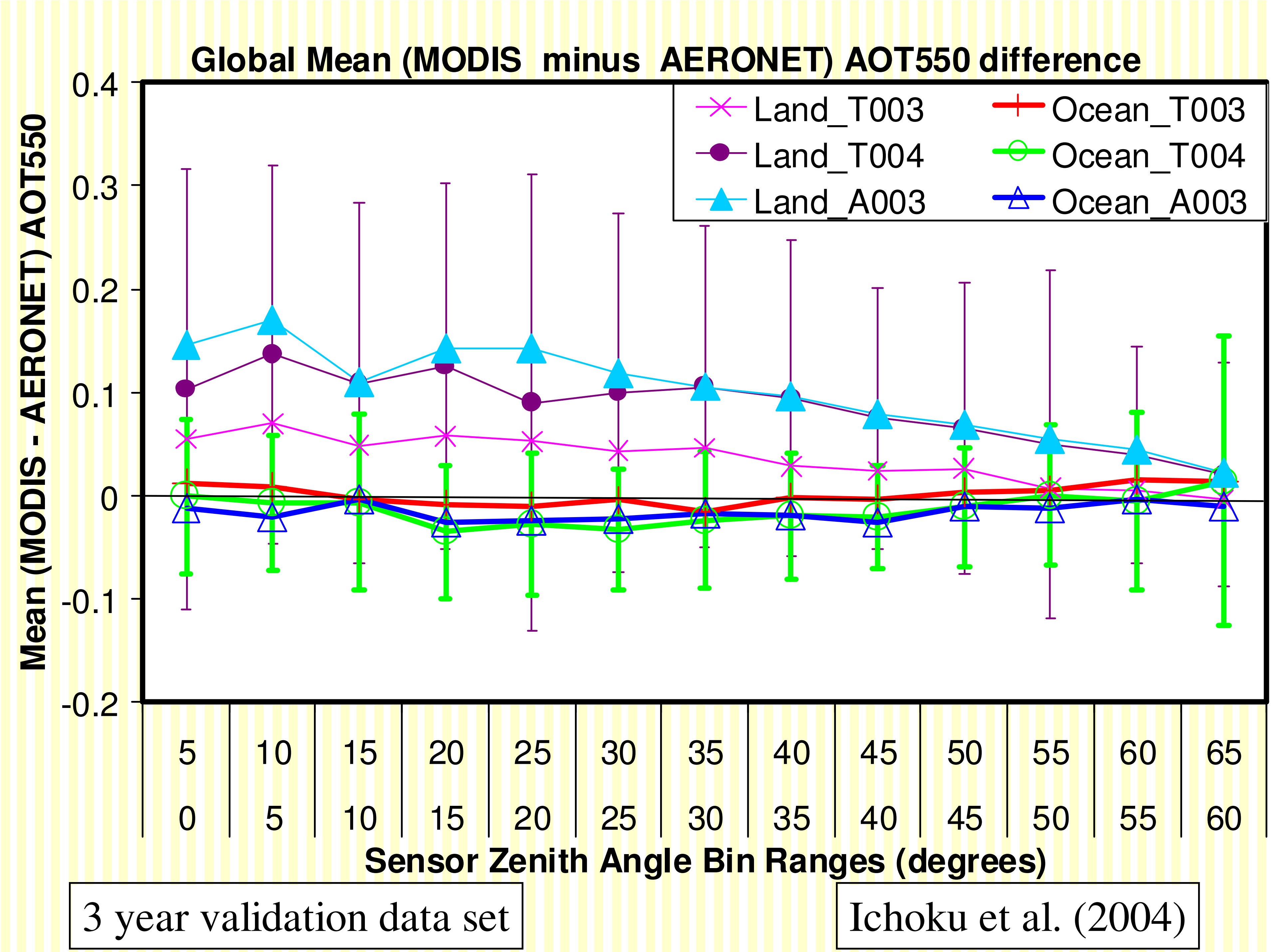


66% of MODIS aerosol retrievals over ocean fall within expected uncertainty

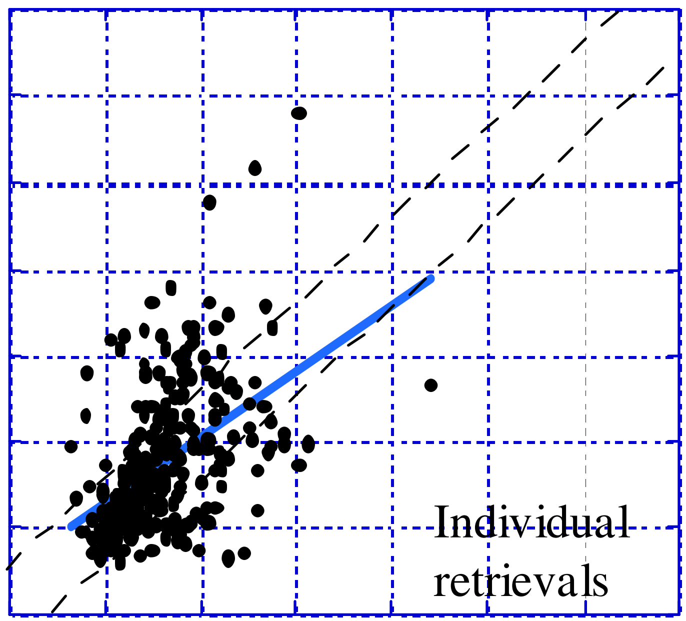
71% of MODIS aerosol retrievals over land fall within expected uncertainty



Remer et al. (2004)

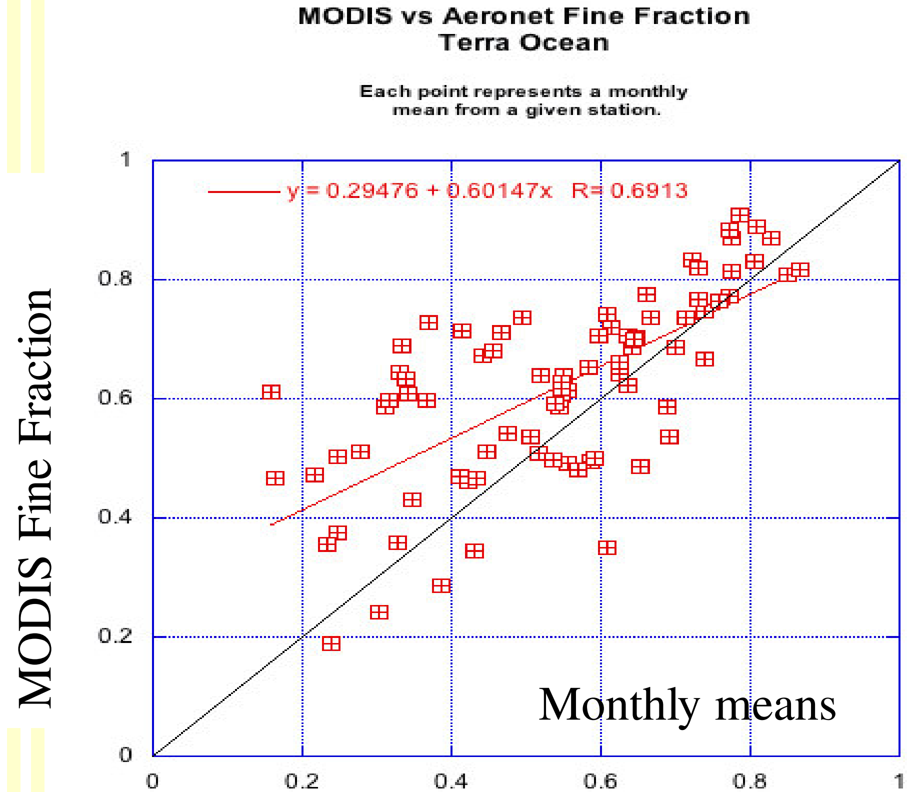


Global Mean (MODIS minus AERONET) AOT550 difference
Mean (MODIS - AERONET) AOT550
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Land_T003
Land_T004
Land_A003
Ocean_T003
Ocean_T004
Ocean_A003
5 10 15 20 25 30 35 40 45 50 55 60 65
0 5 10 15 20 25 30 35 40 45 50 55 60
Sensor Zenith Angle Bin Ranges (degrees)
3 year validation data set
Ichoku et al. (2004)



Dubovik inversion

Remer et al. (2004)

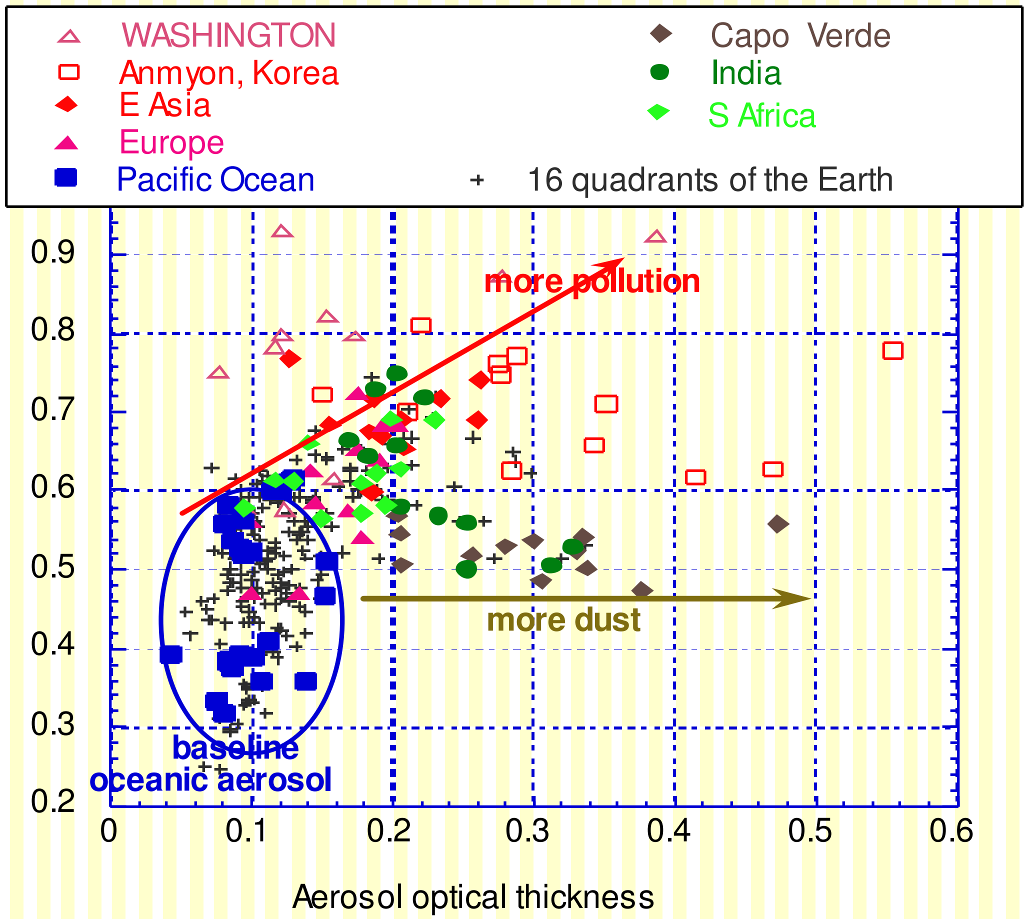


AERONET Fine Fraction
O'Neill's method from sun data

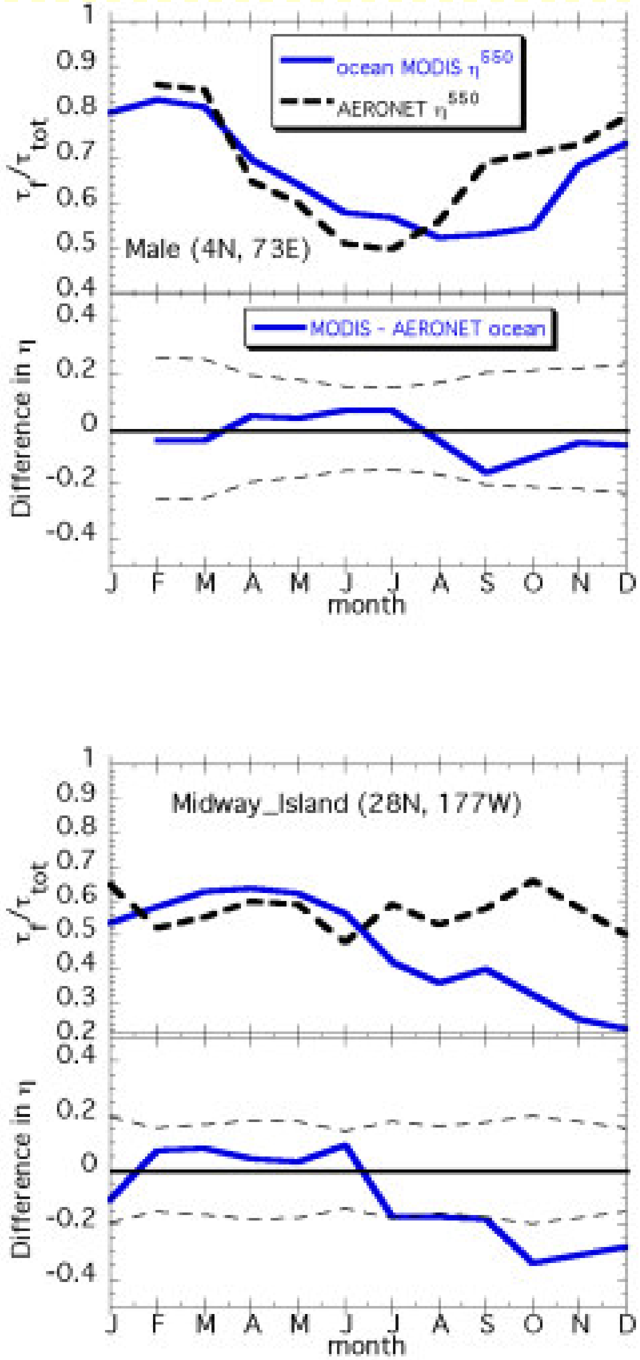
Kleidman et al. (2005)

<u>Over Ocean</u>: Validating Size Parameters

Non-sphericity of dust causes MODIS to under estimate size (over estimate fine fraction.)



Yoram Kaufman



Monthly mean fine fraction 2001

$\tau \sim 0.2$

The switch from Side B to Side A electronics in June 2001, creates a small calibration shift that affects aerosol size parameters but not optical thickness.

$\tau \sim 0.1$

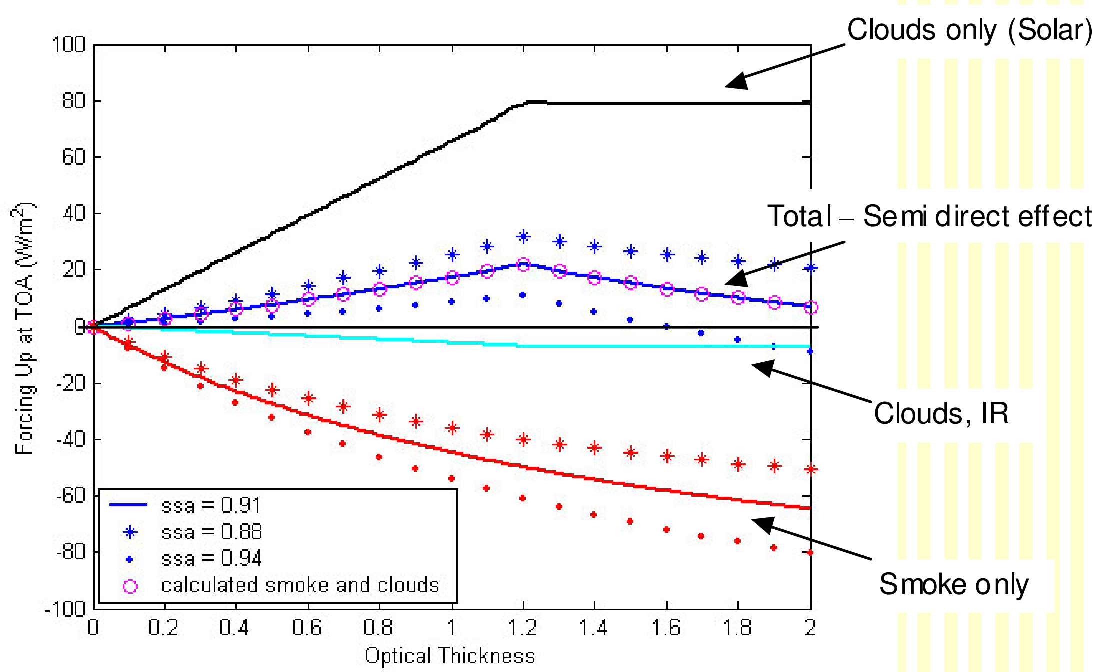
The effect is magnified when when τ is low.

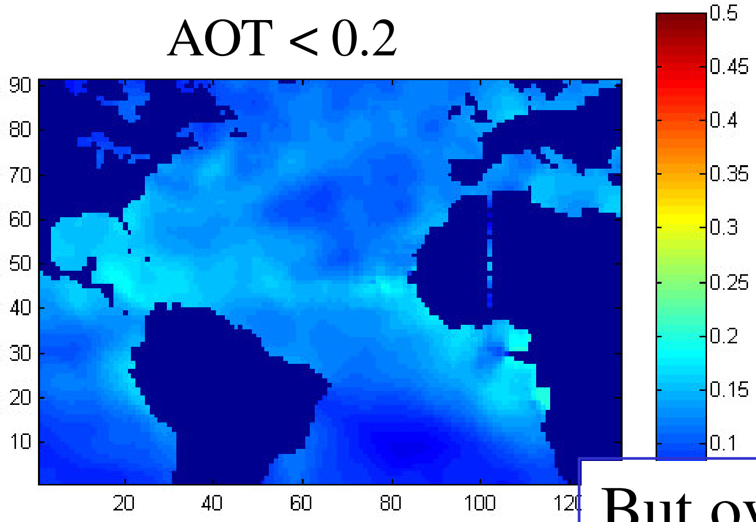
Applications

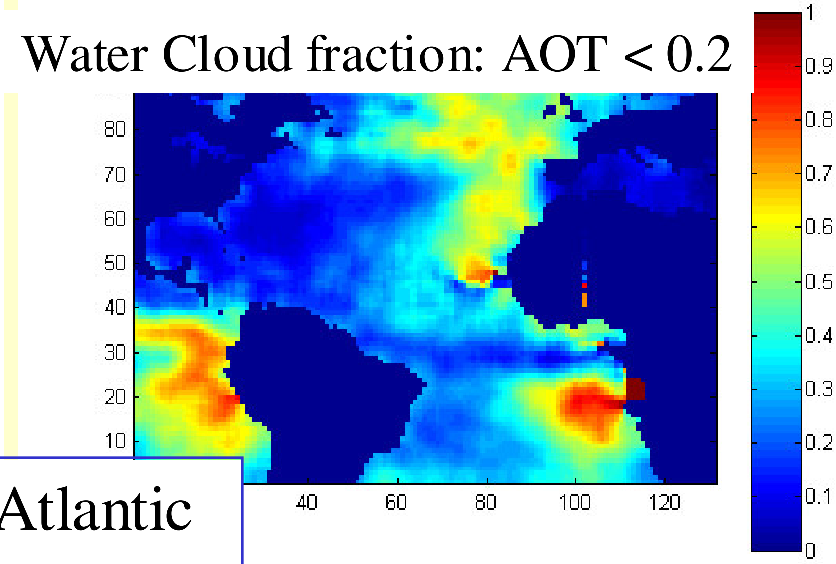
Direct and indirect radiative effects and forcing,
Aerosol effects on clouds,
Air quality,
Quantitative estimate of dust transport over ocean,
Estimates of biomass burning emissions at fire sources

Semi-direct Forcing
(Heavy smoke in the Amazon kills the clouds)

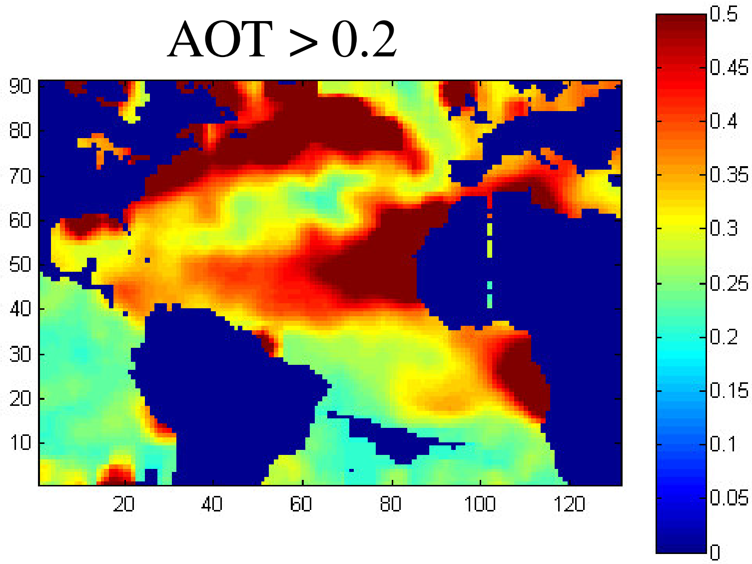
Koren et al. (2004) in Science

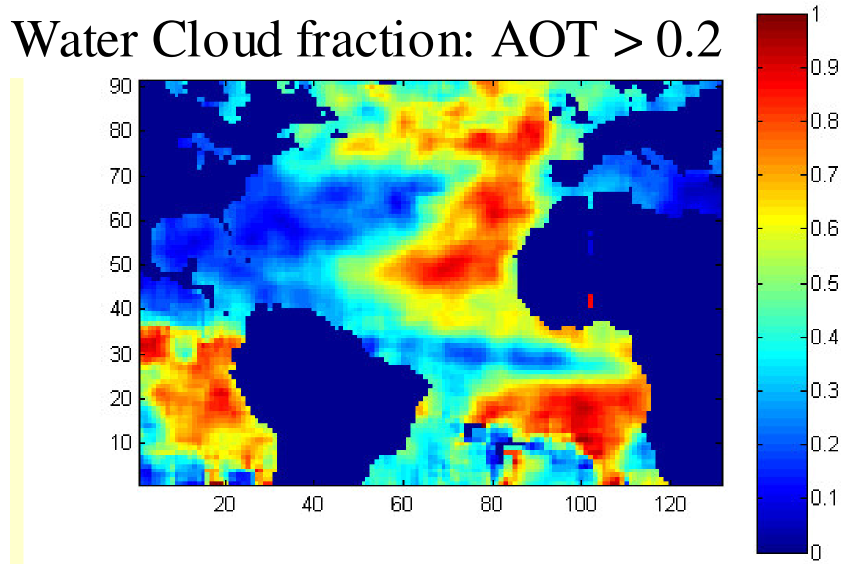






But over the Atlantic aerosols appear to increase cloudiness!





July 2002

Koren, Kaufman, Rosenfeld, Remer, Rudich

Collection 005 and Beyond….

Collection 005

1. Spectral snow mask
2. Land Cloud Mask
3. Remove Flux products
4. Corrected mistakes in the land retrieval over bright surfaces

Future plans

1. Dust nonsphericity
2. True inversion for land retrievals
3. Include polarization over land
4. Evaluating and updating aerosol models and surface assumptions.
5. Better masking

Acknowledgements

MODIS Aerosol Team: D.A. Chu, C. Ichoku, R. Kleidman, I. Koren, R. Levy, R-R. Li, J.V. Martins, S. Mattoo, Z. Ahmad

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