Spectral single scattering albedo retrievals with MODIS and its applications to direct radiative forcing calculations :

J. Vanderlei Martins[1,2], Li Zhu[1], Lorraine Remer[3]

martins@umbc.edu

1 - Department of Physics and JCET, University of Maryland Baltimore County, USA

2 - NASA Goddard Space Flight Center, Climate and Radiation Branch, USA

Atmospheric Absorption by Aerosols

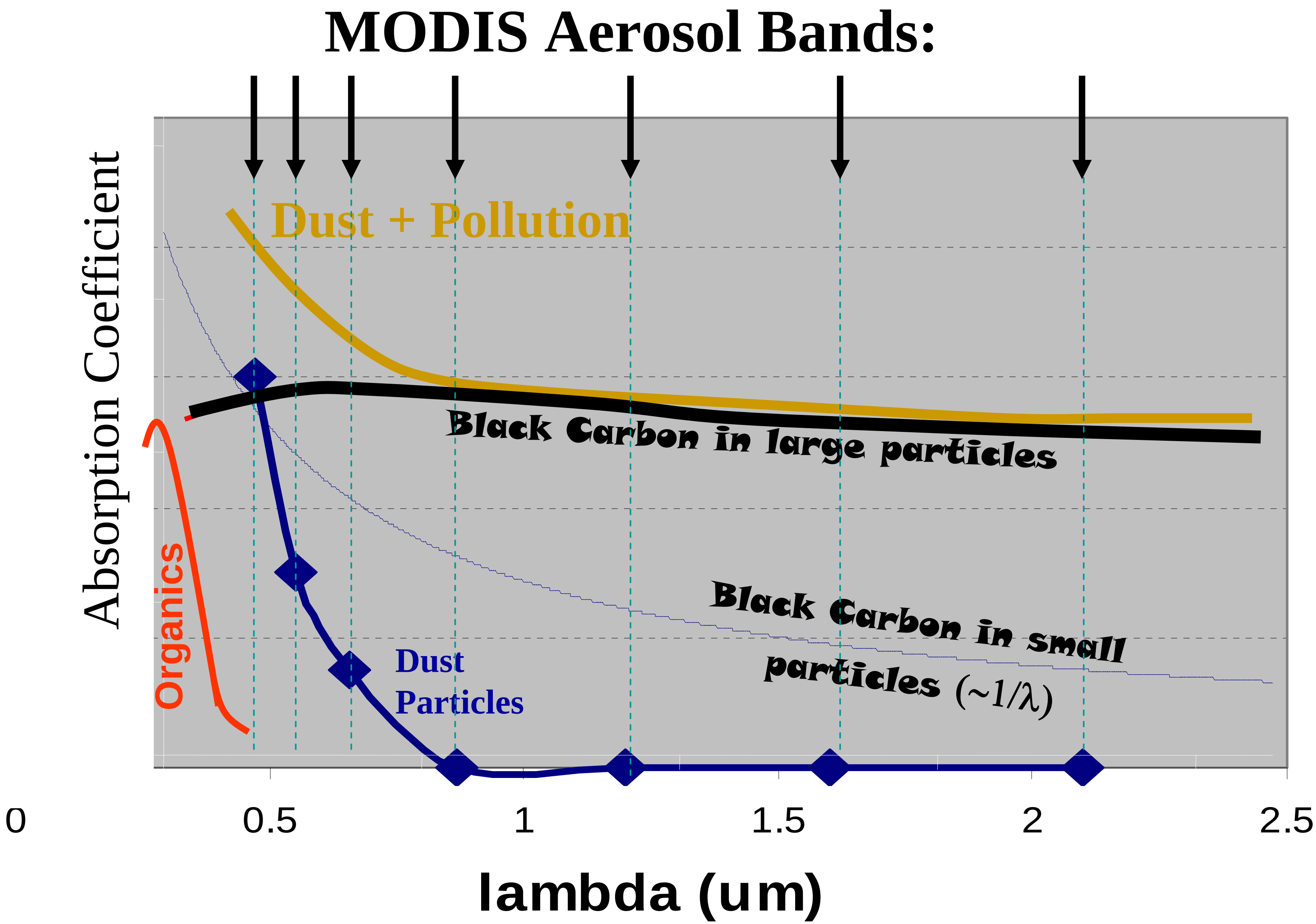
- Heats the atmosphere/Cools the surface
- Changes atmospheric stability
- Affects Cloud Formation and Destruction

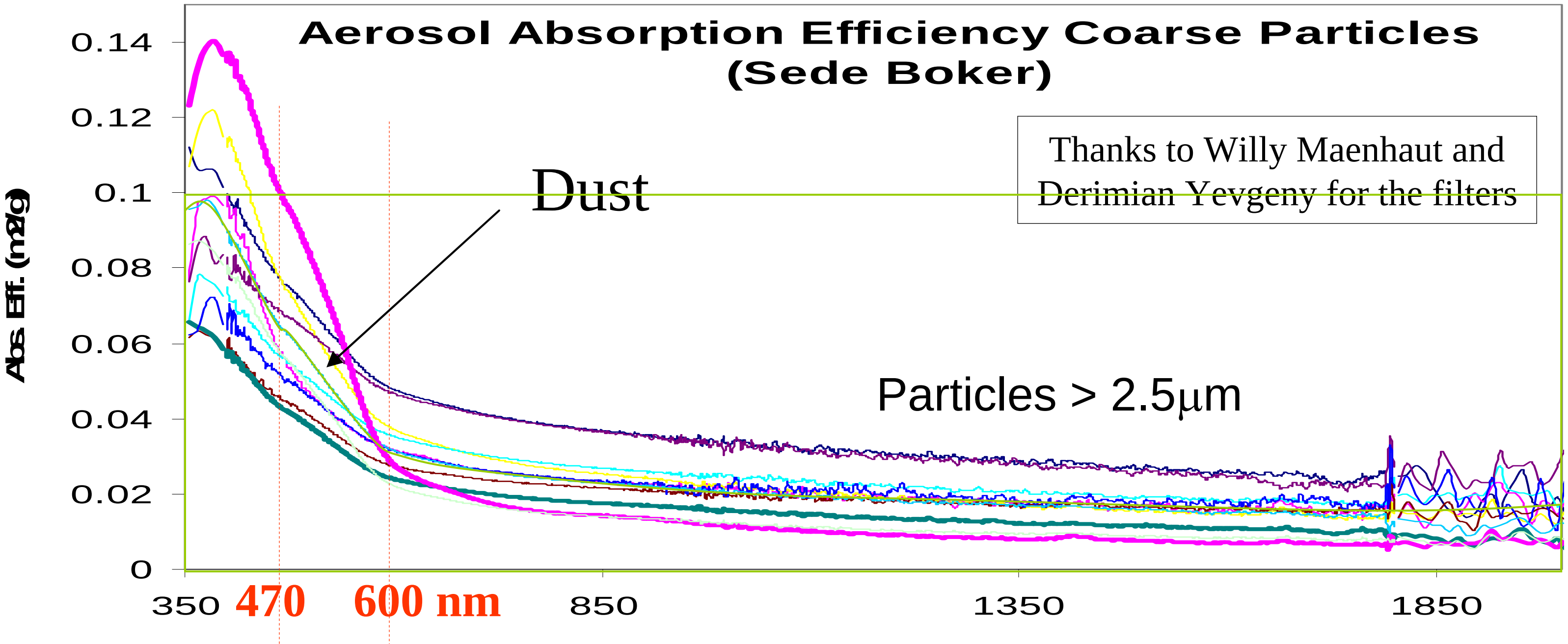
- Spectral dependence ←→ Chemical composition, size and mixture

Aerosol refractive index contain important information on aerosol composition and type:

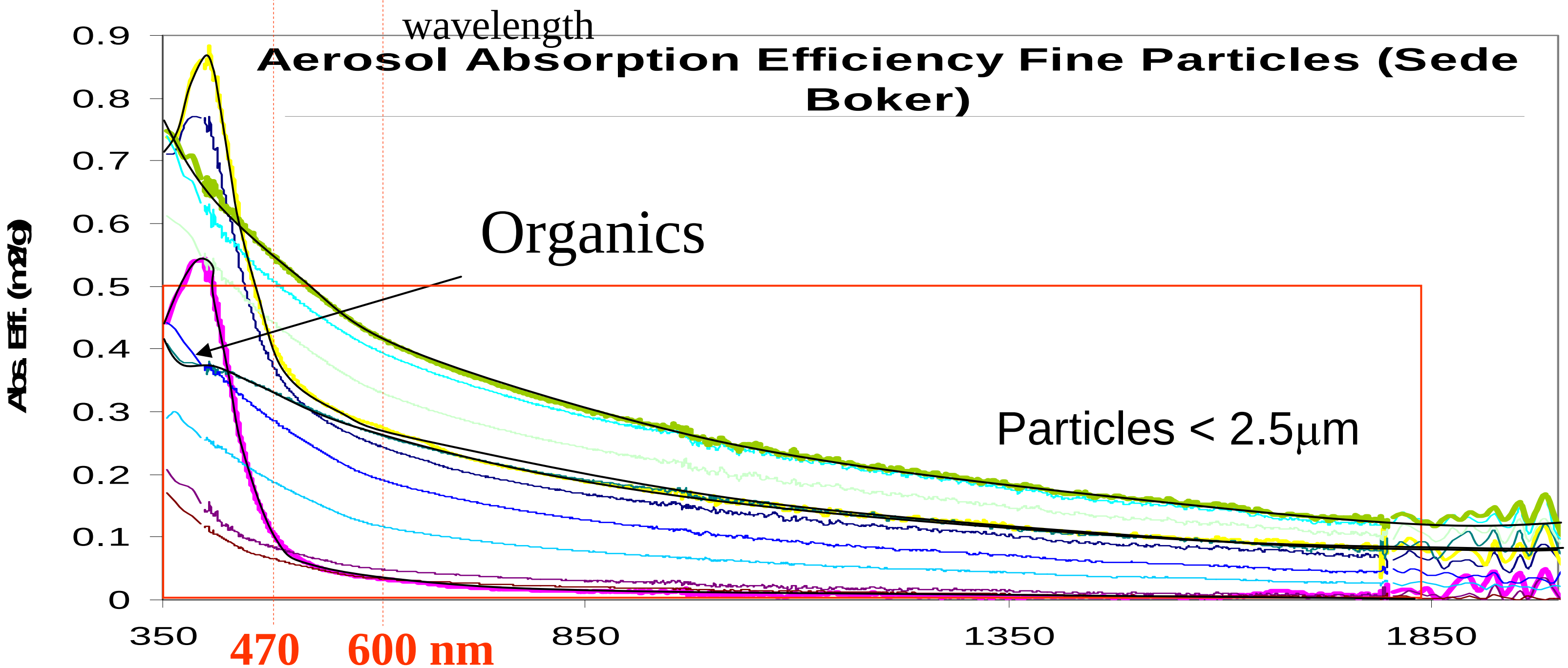
- Real part
  - Small variation; difficult to measure
  - Very sensitive to aerosol hydration
    - Aerosols: ~1.55
    - Water: 1.33
- Imaginary part
  - Large variations
  - Mainly driven by black carbon, iron oxides, and organic brown carbon
  - Also difficult to measure but can be inverted from absorption efficiency or absorption optical thickness measurements.

Aerosol Spectral Absorption





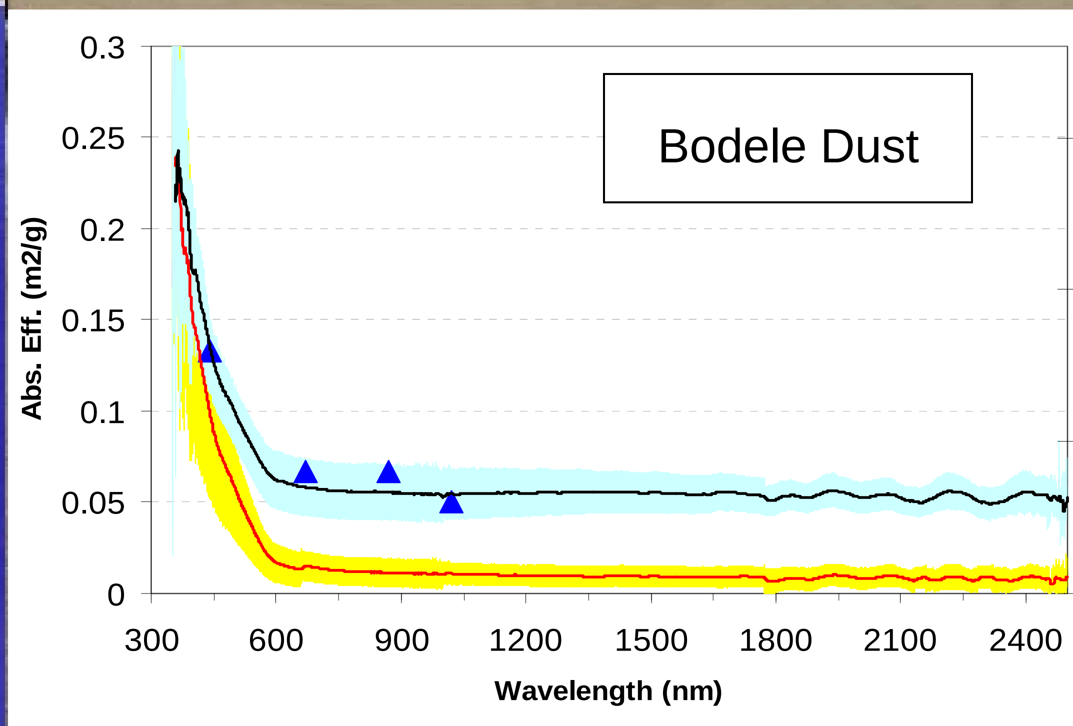
Aerosol Absorption Efficiency Coarse Particles (Sede Boker)
Thanks to Willy Maenhaut and Derimian Yevgeny for the filters
Dust
Particles > 2.5μm
Abs Eff. (m2/g)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
350
470
600 nm
850
1350
1850
wavelength



Aerosol Absorption Efficiency Fine Particles (Sede Boker)
Organics
Particles < 2.5μm
Abs Eff. (m2/g)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
350
470
600 nm
850
1350
1850

Pictures from the Bodele Dust Experiment (BoDEx) 2005

by: Martin Todd, Gill Lizcano (UCL)

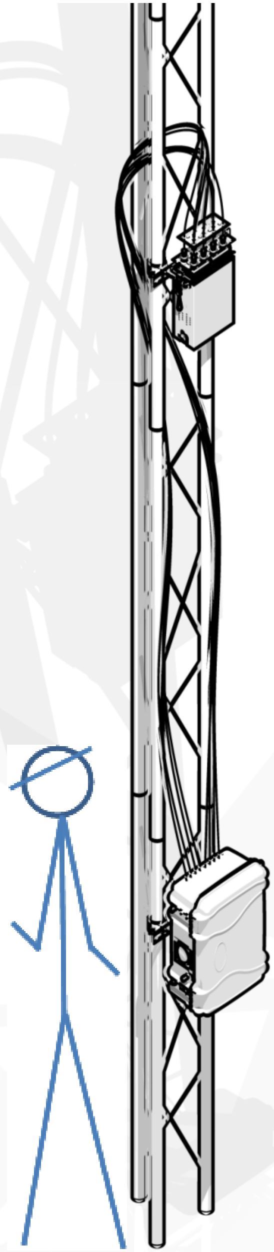


LACO
Laboratory for Aerosol, Clouds and Optics

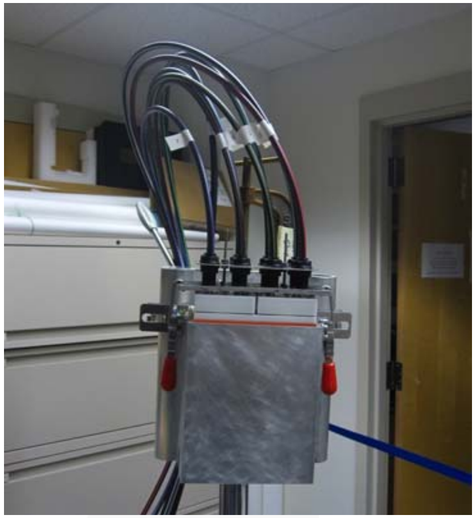
UMBC
AN HONORS UNIVERSITY IN MARYLAND

Automatic Aerosol Sampling Station for Fennec Experiment in the Sahara June 2011.

- Aerosol filter collection
- Spectral Absorption
- Scattering Coefficient

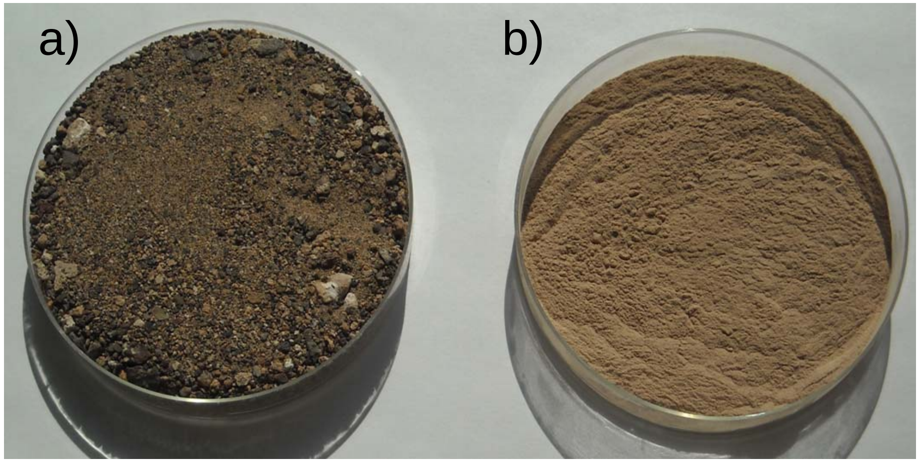


Multi-filter Inlet



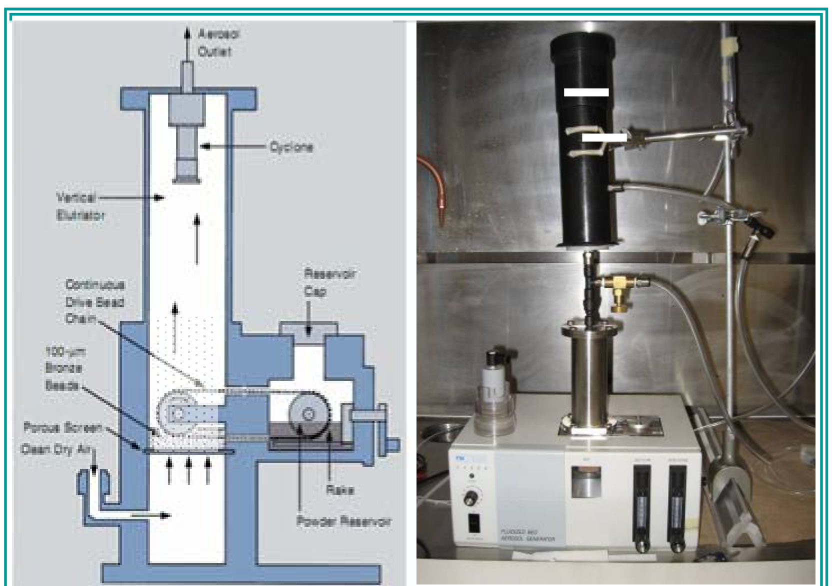
Automatic Controller

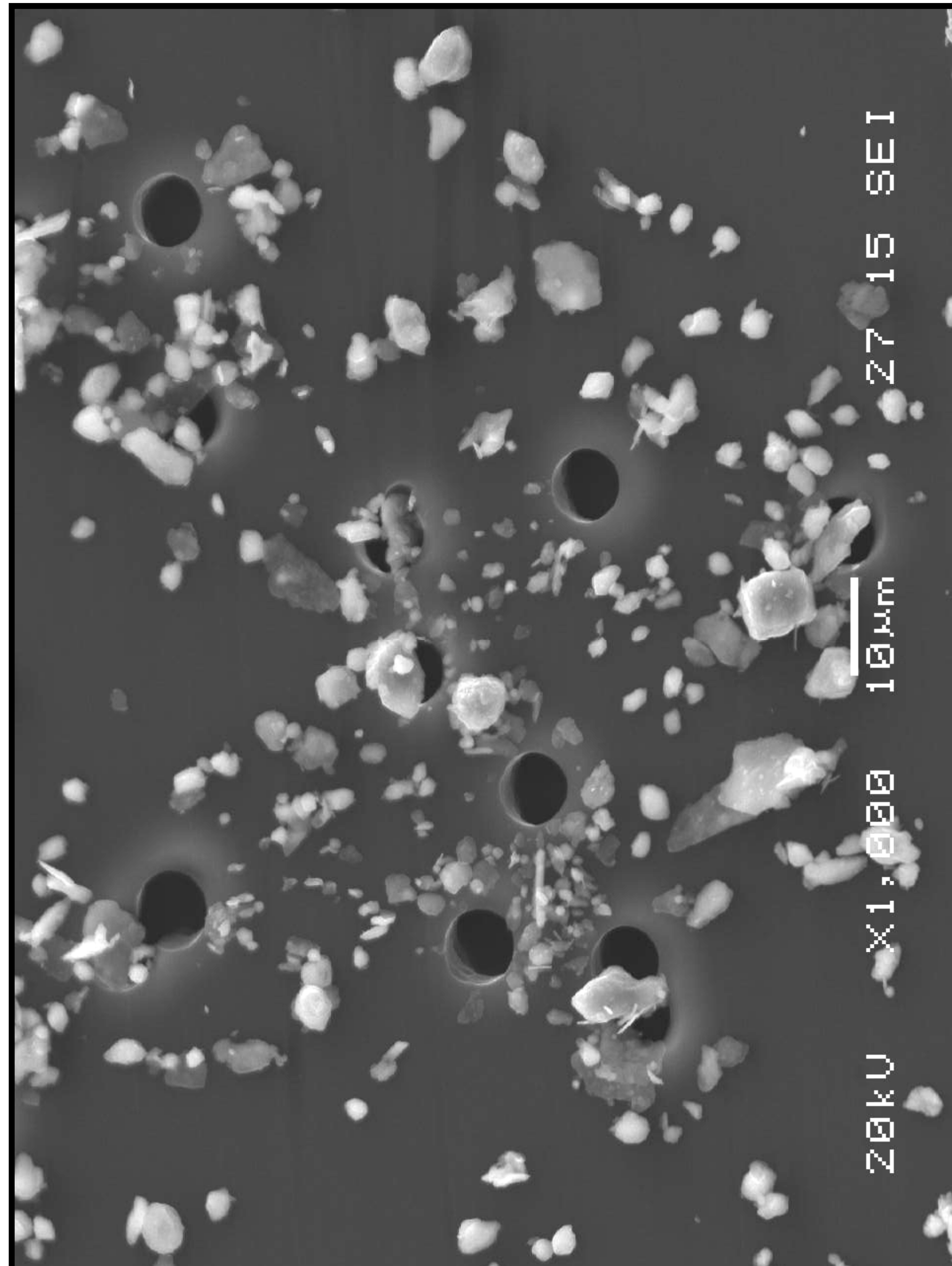
Dust – Collected at UMBC.



Before a) and after b) sieving: particles < 43mm.

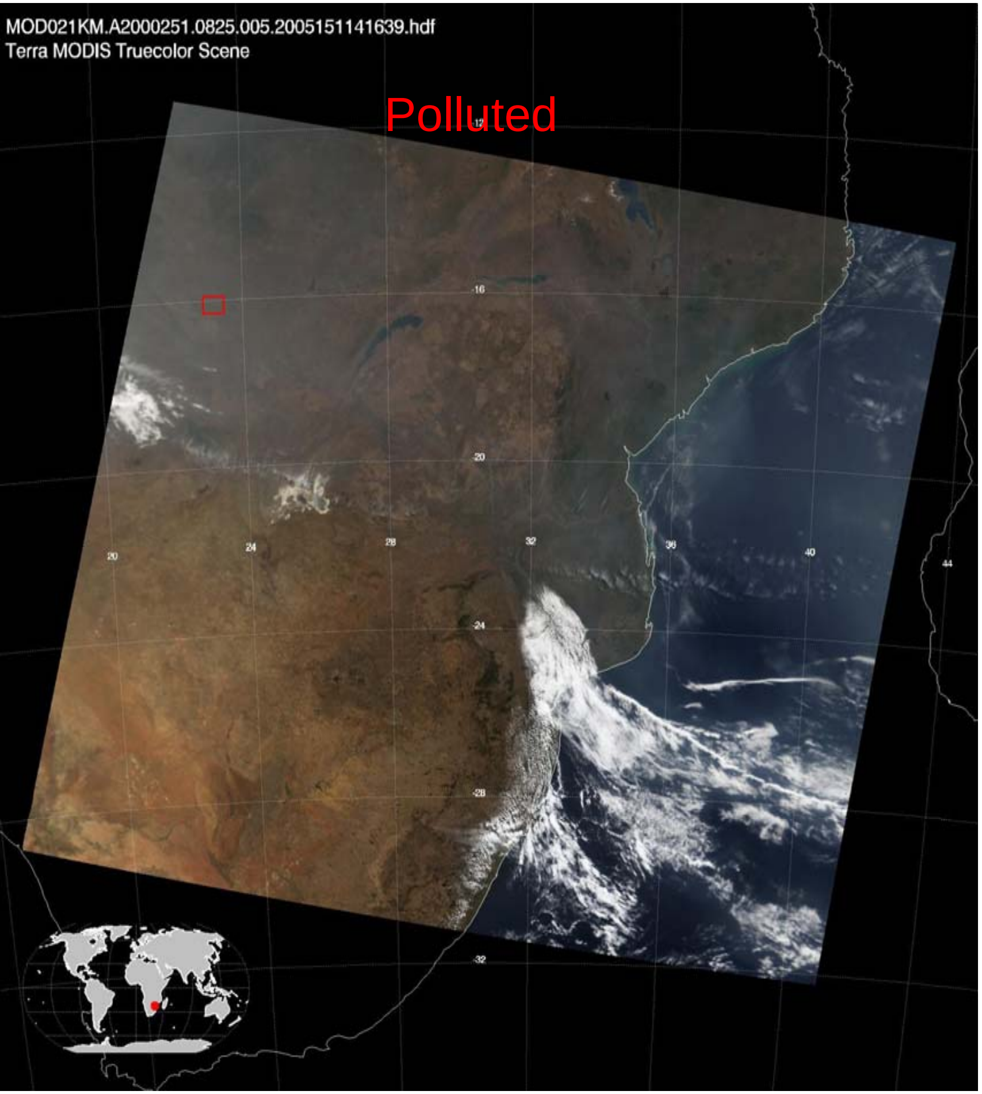
FBAG – Fluidized Bed Aerosol Generator

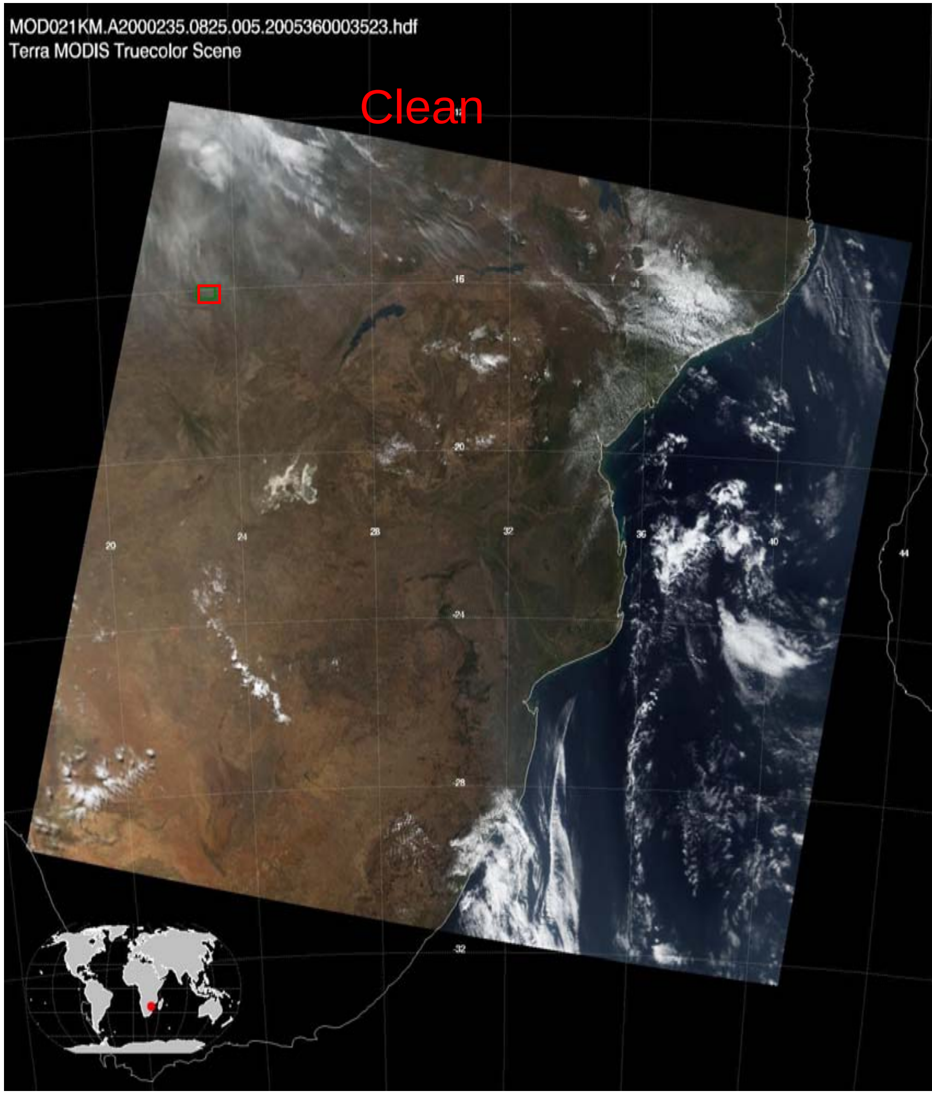


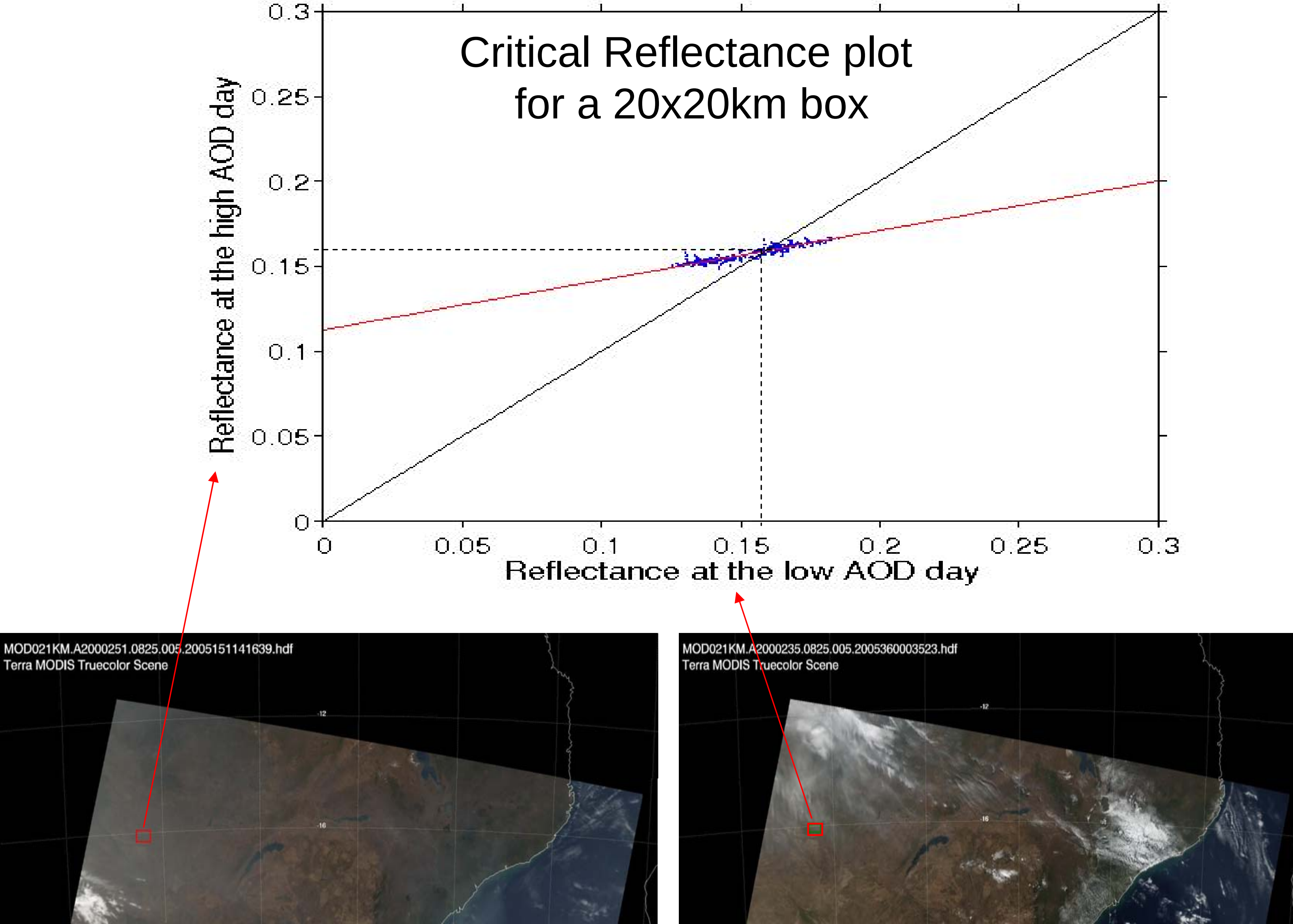


Using MODIS to retrieve aerosol Absorption:

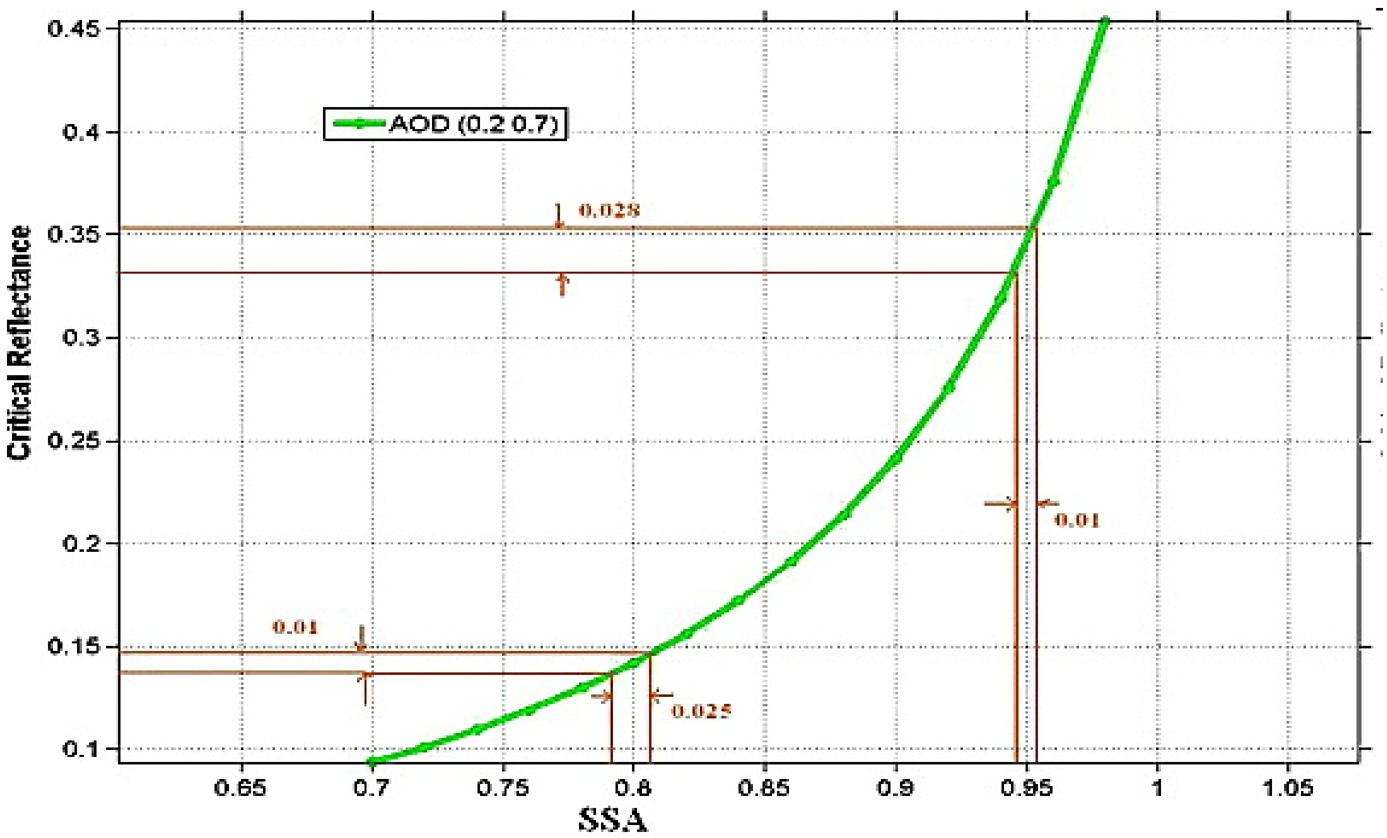
Images 16 days apart – Same viewing/solar geometry

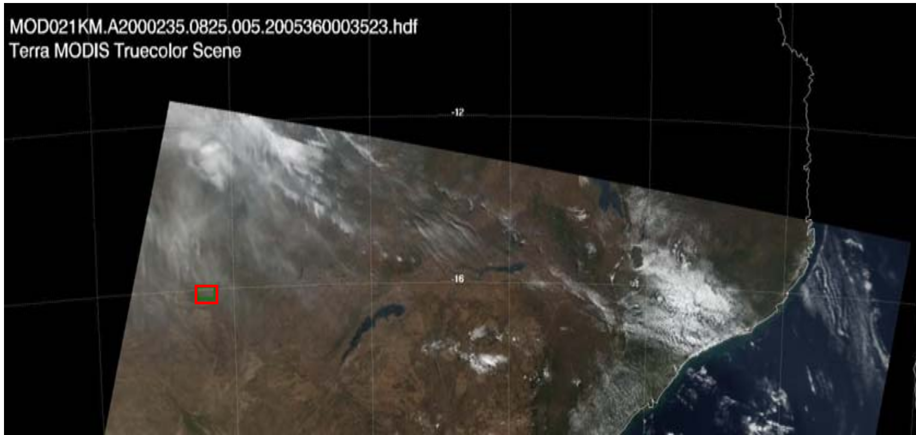





Critical Reflectance plot
for a 20x20km box
Reflectance at the high AOD day
Reflectance at the low AOD day
0
0.05
0.1
0.15
0.2
0.25
0.3
MOD021KM.A2000251.0825.005.2005151141639.hdf
Terra MODIS Truecolor Scene
MOD021KM.A2000235.0825.005.2005360003523.hdf
Terra MODIS Truecolor Scene

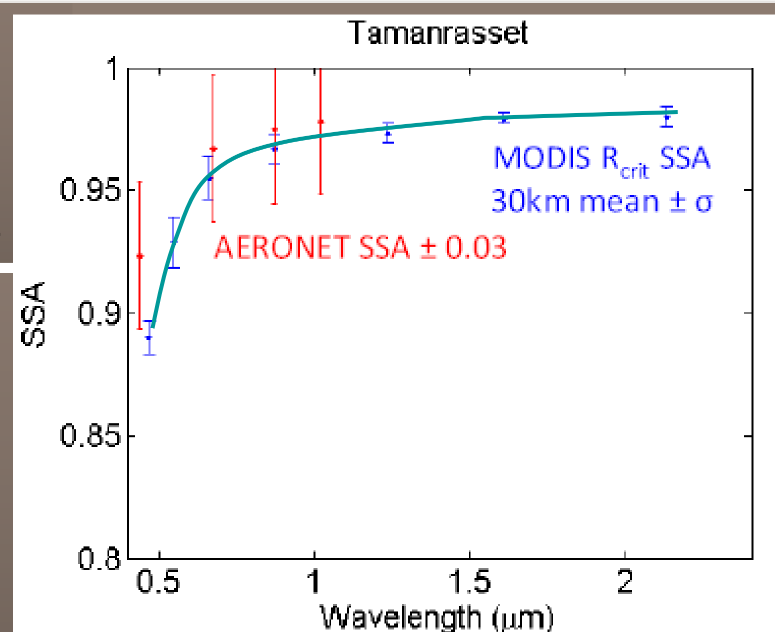
Critical Reflectance X Single Scattering Albedo

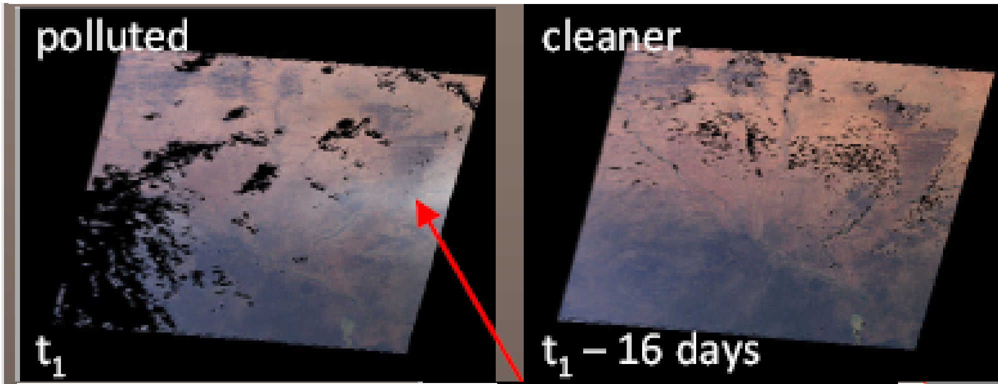


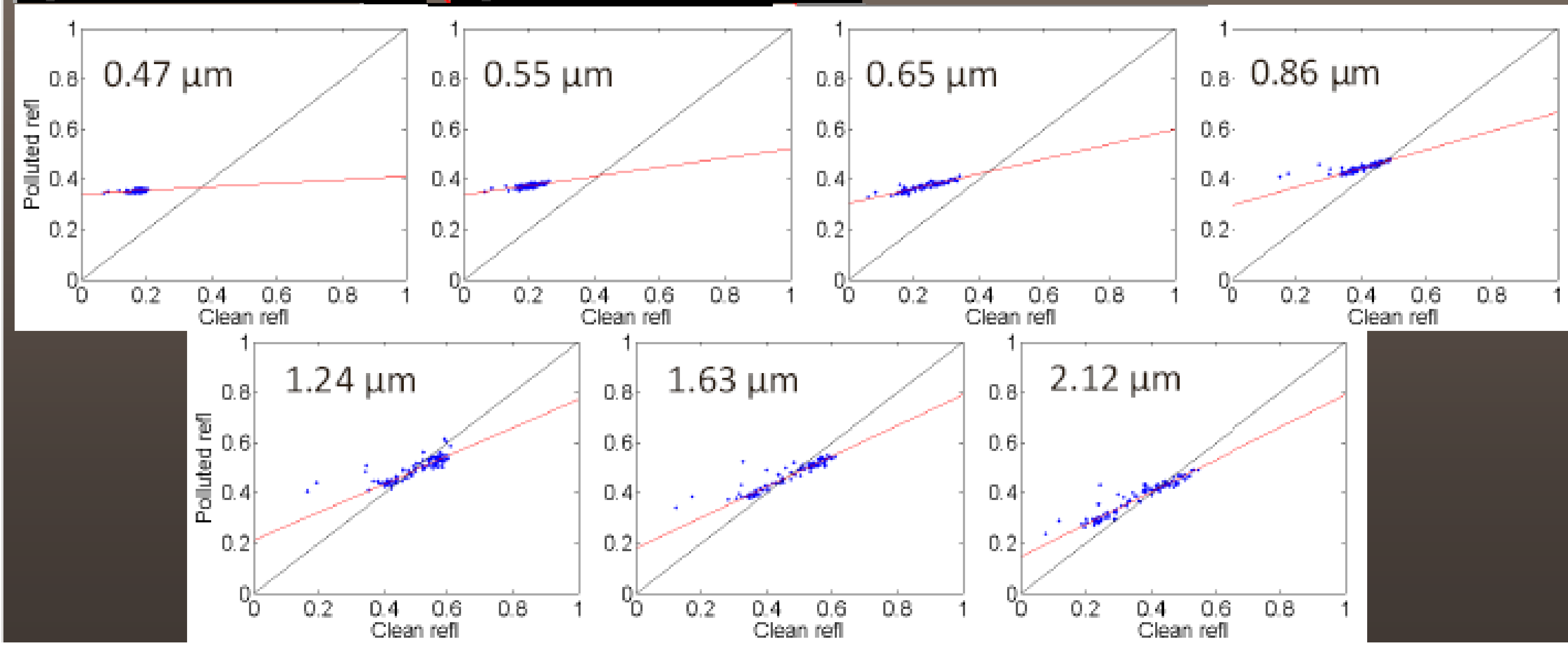


Single Scattering Albedo retrievals of Dust Aerosols

Kelley Wells, CSU – now at U. Minnesota

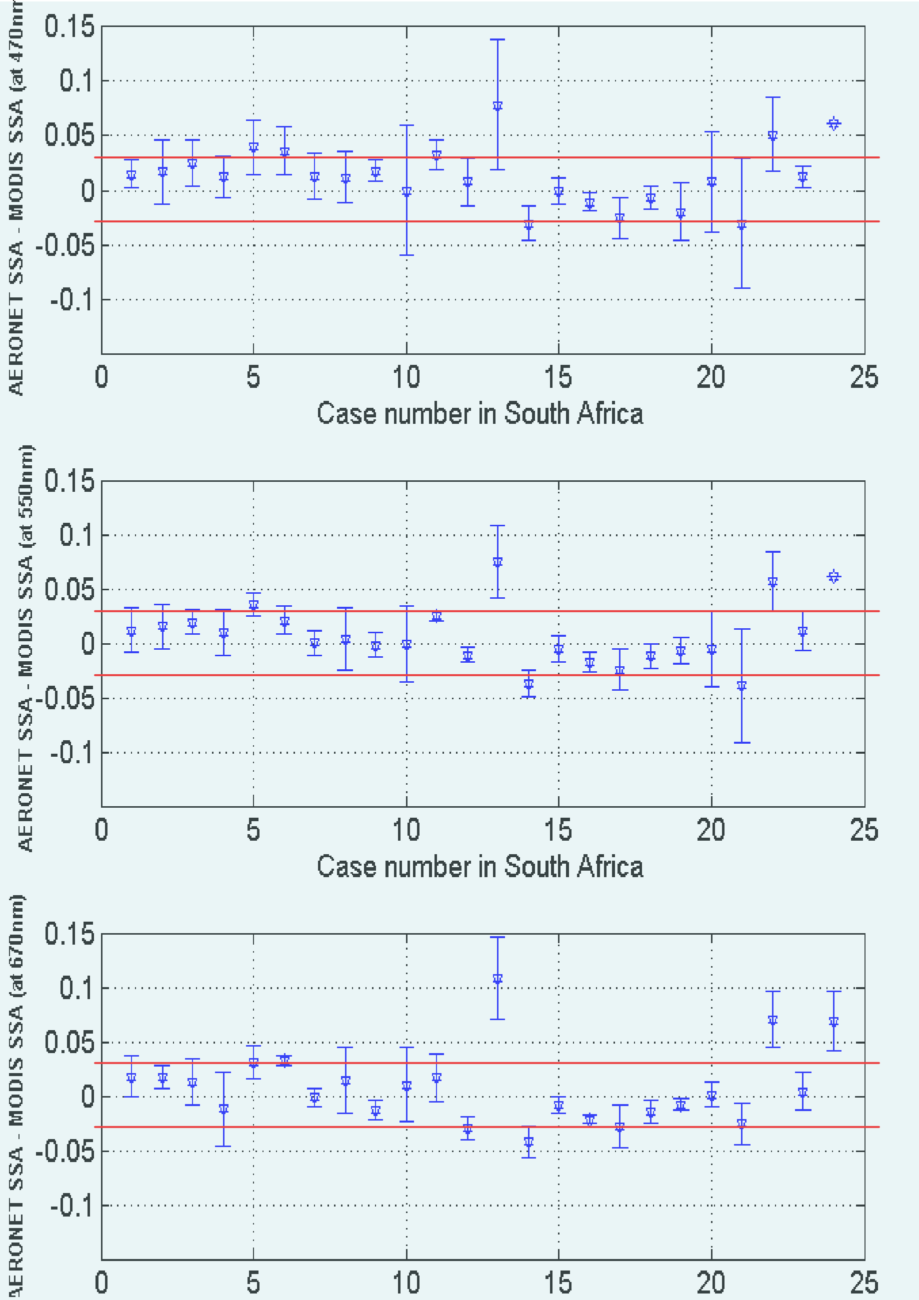




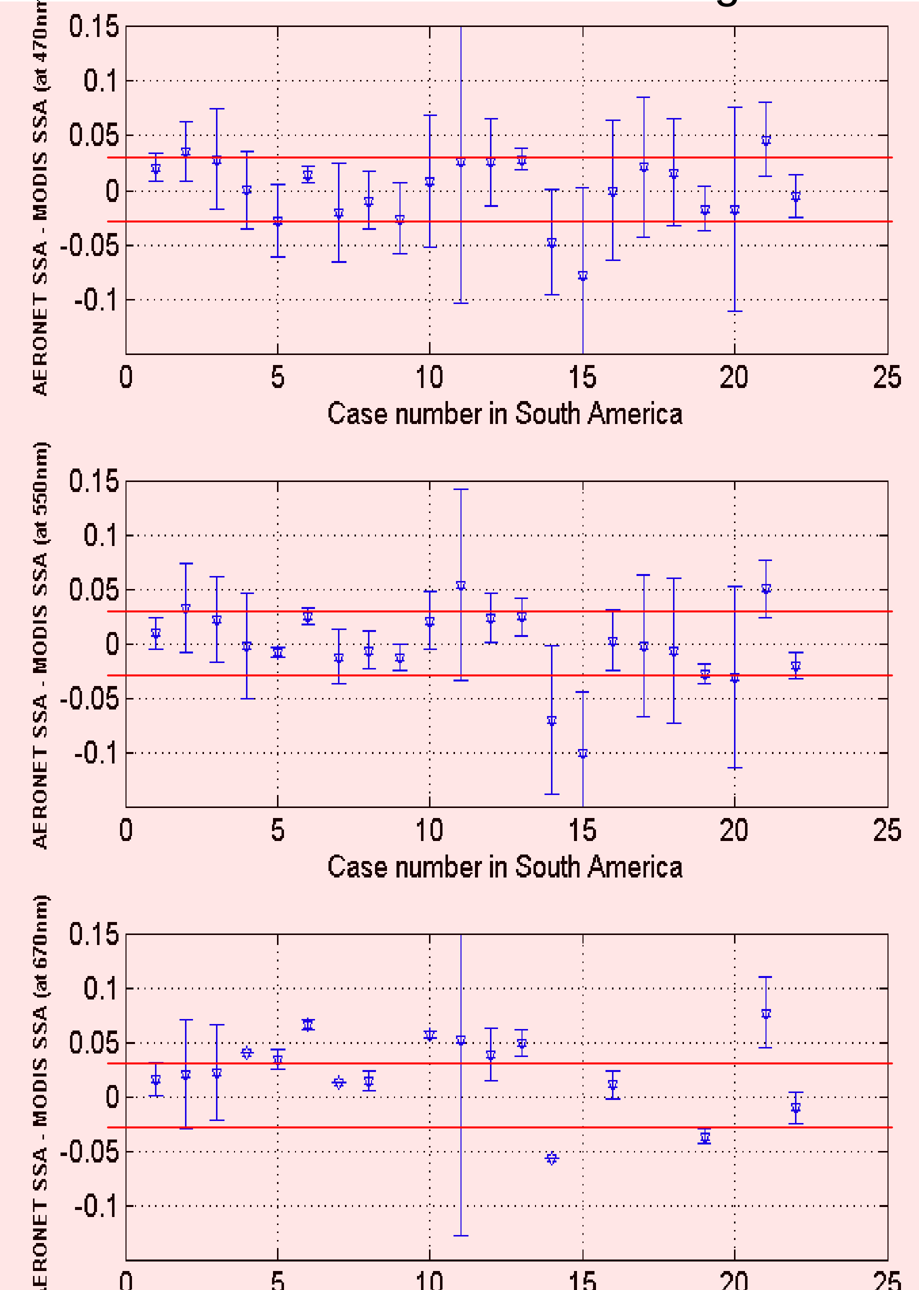


Differences with Aeronet SSA

Africa



Amazon Region



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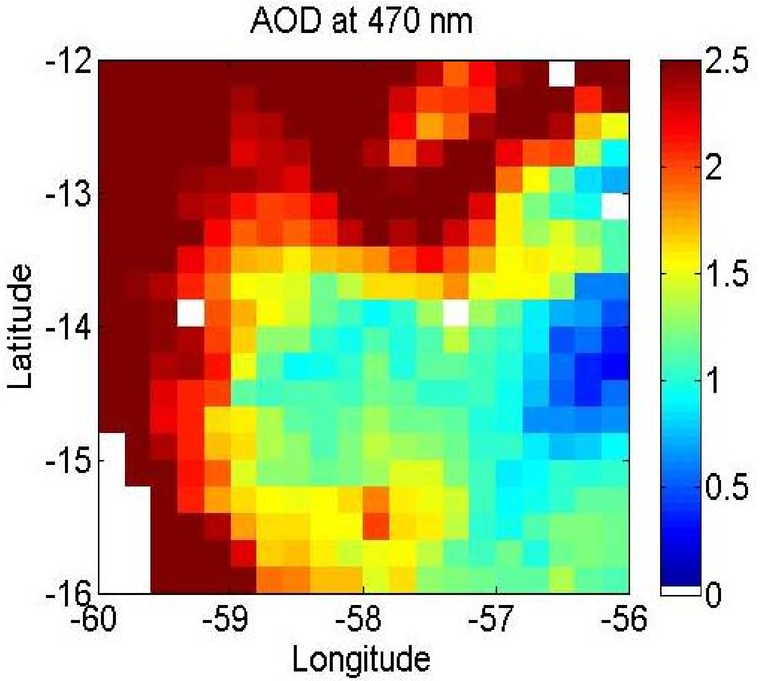
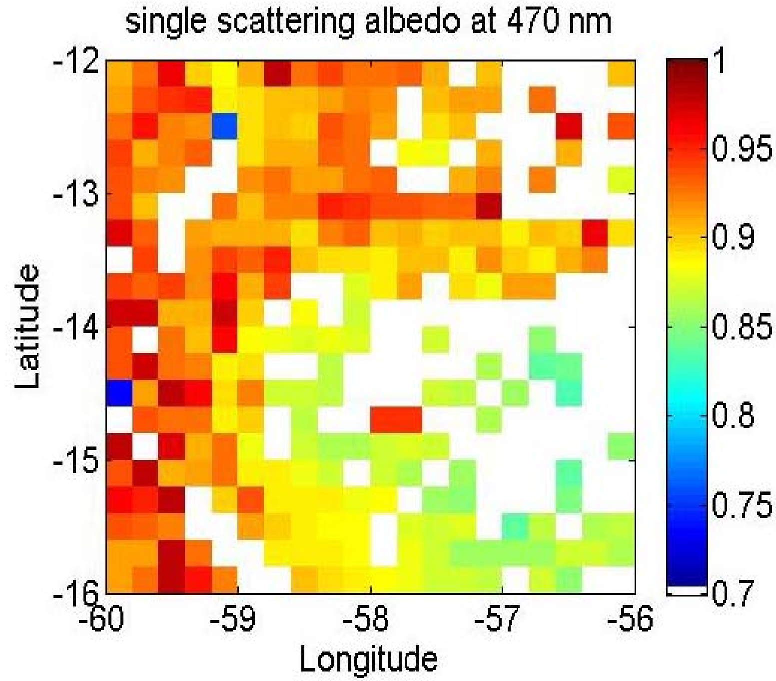
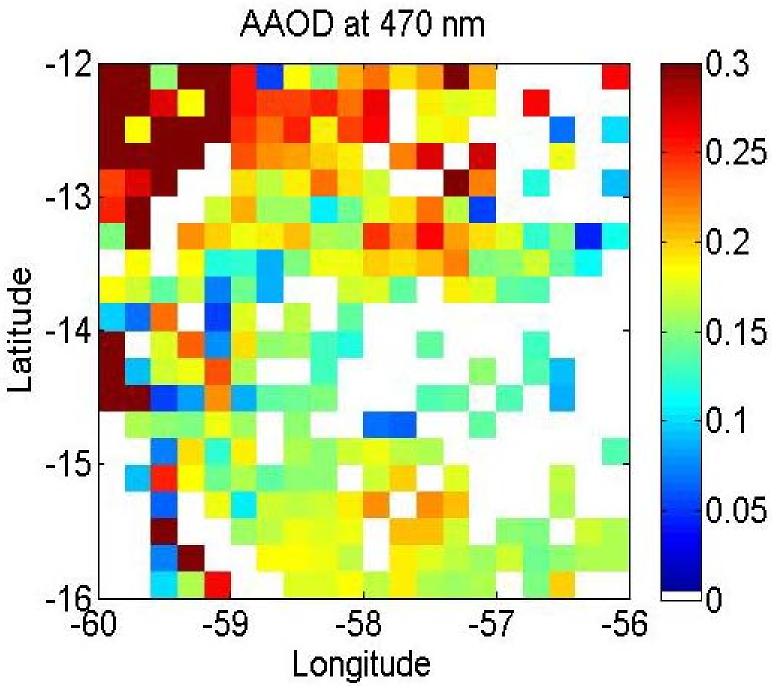
±

Average SSA over 60x60km

AERONET sites	SSA (at 470 nm)		SSA (at 550 nm)		SSA (at 670 nm)	
	AERONET	MODIS	AERONET	MODIS	AERONET	MODIS
Alta Floresta	0.92±0.02 (22 cases)	0.92±0.03	0.91±0.03 (22 cases)	0.92±0.03	0.92±0.03 (18 cases)	0.90±0.03
Senanga	0.86±0.01 (7 cases)	0.87±0.01	0.85±0.01 (7 cases)	0.87±0.01	0.84±0.01 (7 cases)	0.86±0.01
Mongu	0.88±0.02 (14 cases)	0.86±0.02	0.87±0.03 (14 cases)	0.86±0.02	0.86±0.03 (14 cases)	0.84±0.02
Mwinilunga	0.90±0.02 (3 cases)	0.86±0.01	0.90±0.02 (3 cases)	0.85±0.01	0.89±0.03 (3 cases)	0.84±0.01







Maps – AOD, SSA, AAOD
(on day 252 in 2004)

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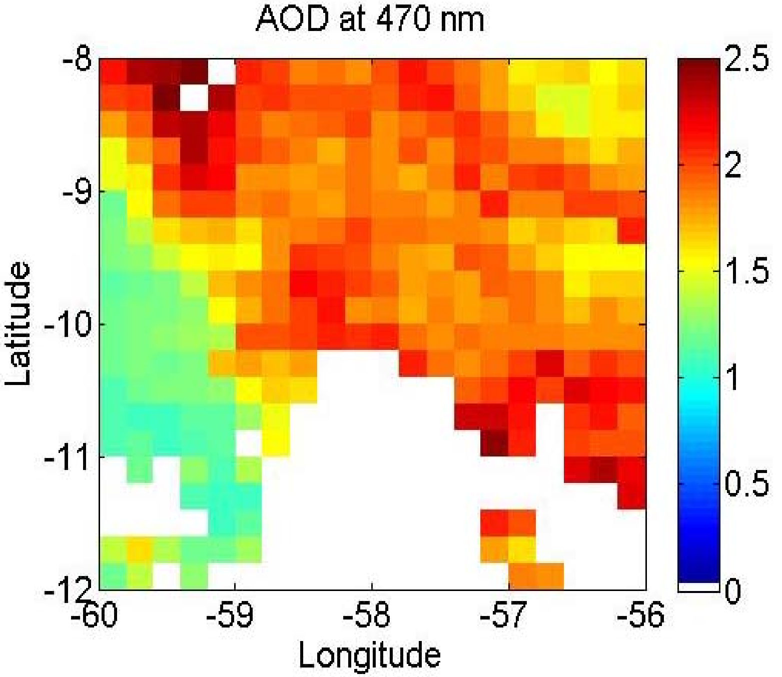

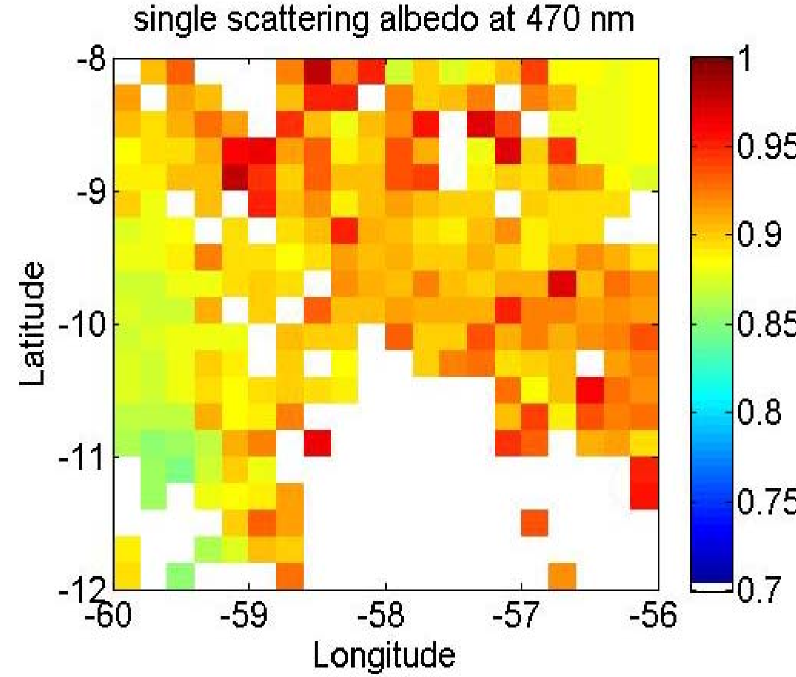

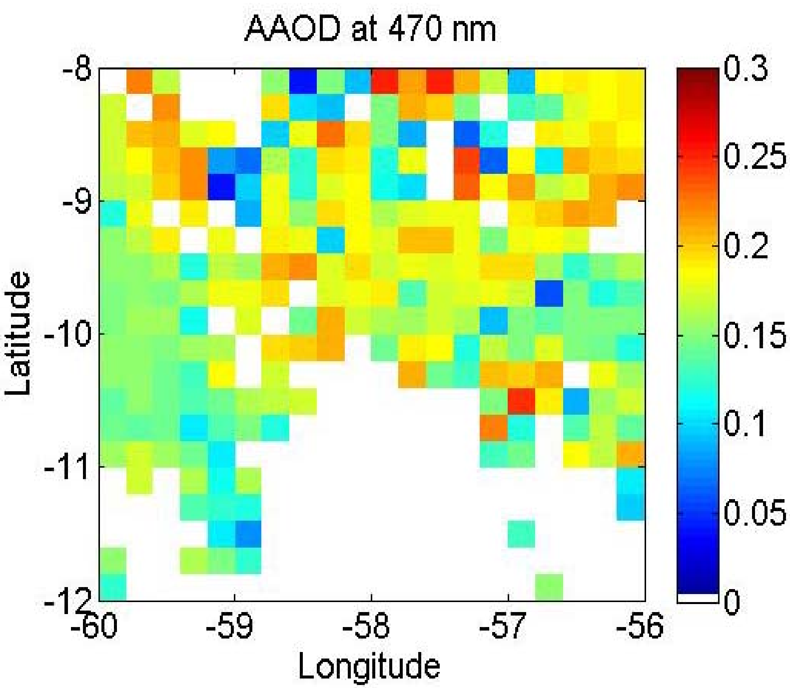

Maps – AOD, SSA, AAOD (on day 241 in 2006)

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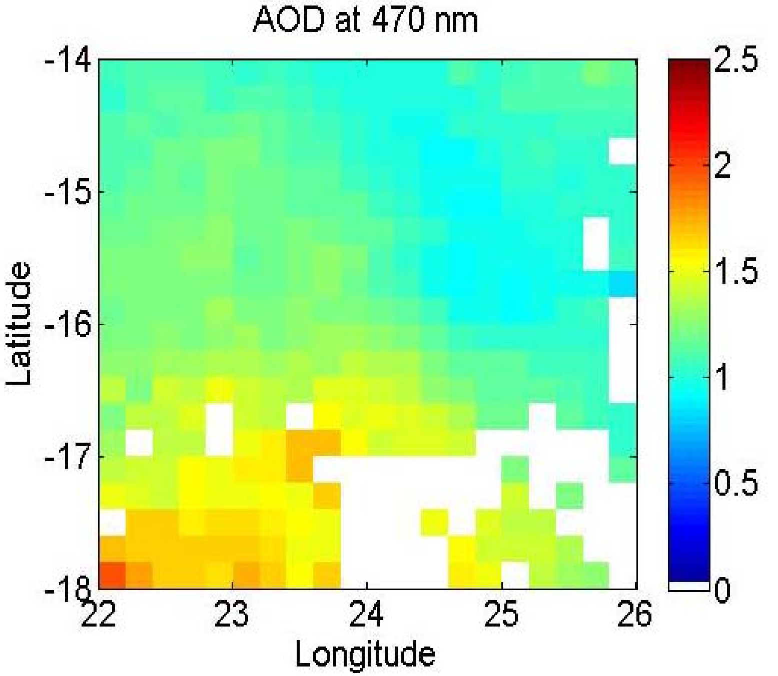
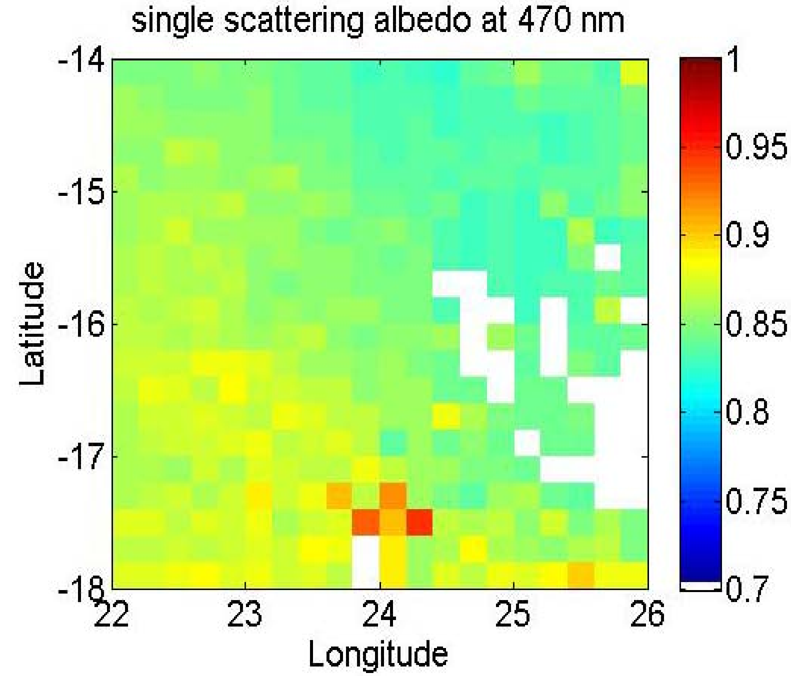
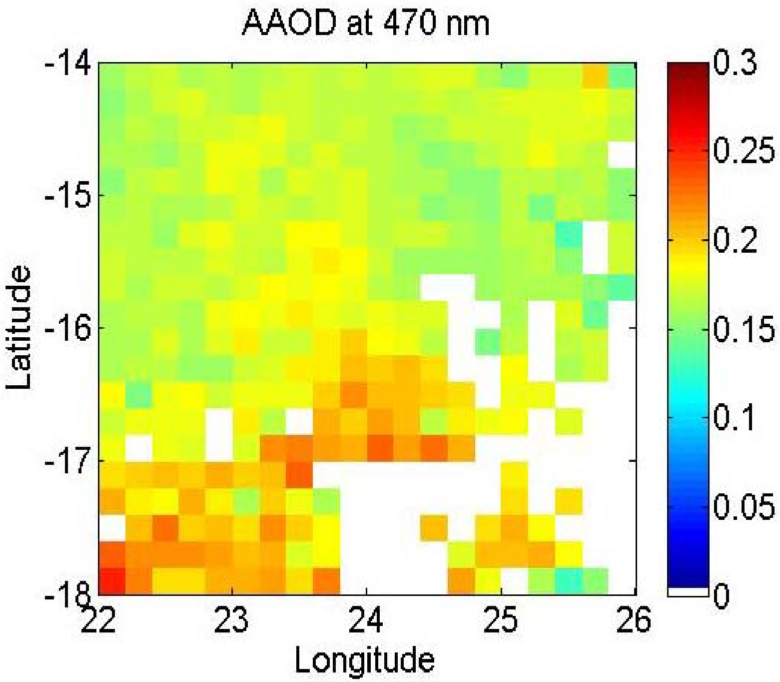
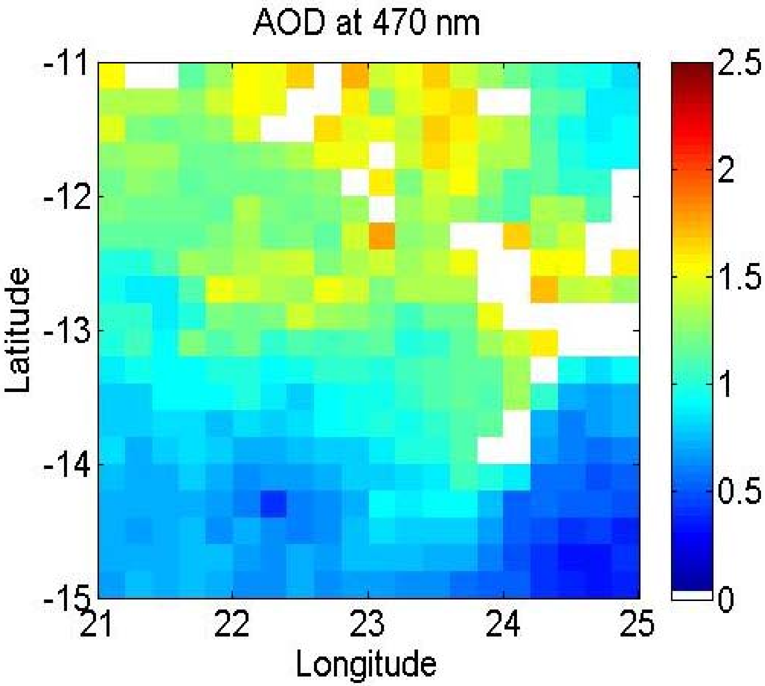


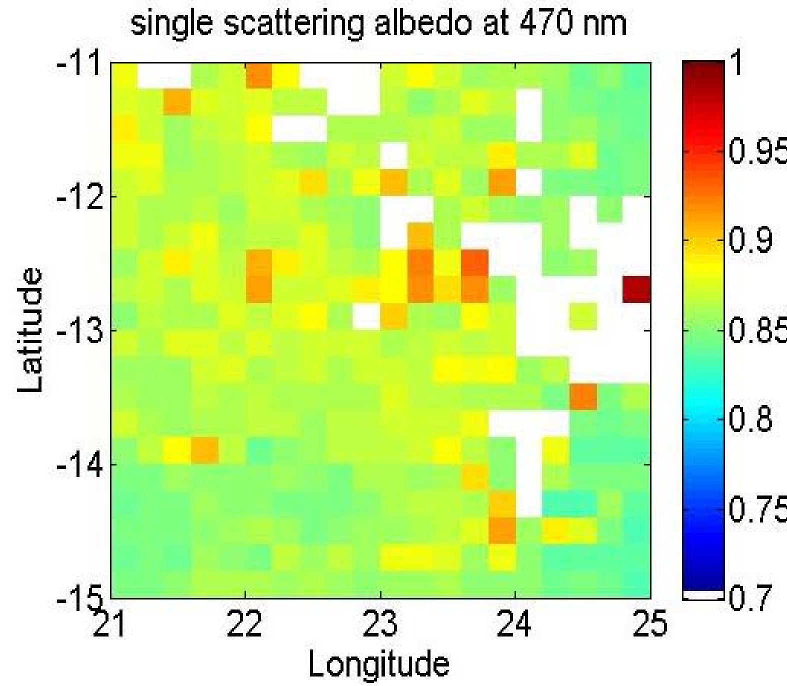


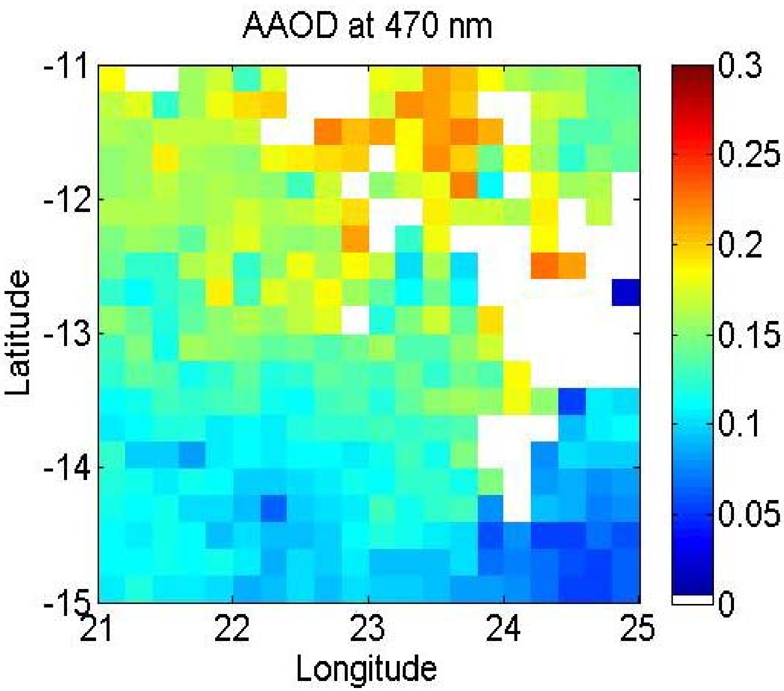


Maps – AOD, SSA, AAOD
(on day 250 in 2000)

Zhu, Martins, and Remer, 2011







Maps – AOD, SSA, AAOD (on day 254 in 2000)

Zhu, Martins, and Remer, 2011

Spatial Variability of SSA – (Zhu, Martins, and Remer, JGR 2011)

Case Information	AAOD: mean ± standard deviation			Aerosol SSA: mean ± standard deviation		
	470 nm	550 nm	670 nm	470 nm	550 nm	670 nm
latitude = [-15 to -11]; longitude = [21 to 25] over South Africa; on day 254 in 2000	0.13 ± 0.04	0.11 ± 0.04	0.10 ± 0.03	0.86 ± 0.02	0.84 ± 0.02	0.82 ± 0.02
latitude=[-18 to -14]; longitude=[22 to 26] over South Africa; on day 250 in 2000	0.18 ± 0.02	0.15 ± 0.02	0.14 ± 0.02	0.86 ± 0.02	0.84 ± 0.02	0.81 ± 0.02
latitude =[-12 to -8]; longitude = [-60 to -56] over South America; on day 241 in 2006	0.16 ± 0.04	0.13 ± 0.04	0.14 ± 0.04	0.90 ± 0.03	0.90 ± 0.03	0.87 ± 0.04
latitude=[-16 to -12]; longitude=[-60 to -56] over South America; on day 252 in 2004	0.20 ± 0.12	0.14 ± 0.05	0.14 ± 0.06	0.91 ± 0.04	0.92 ± 0.03	0.91 ± 0.03

Shortwave radiative forcing at TOA from CERES results:
by Elisa T. Sena/University of Sao Paulo

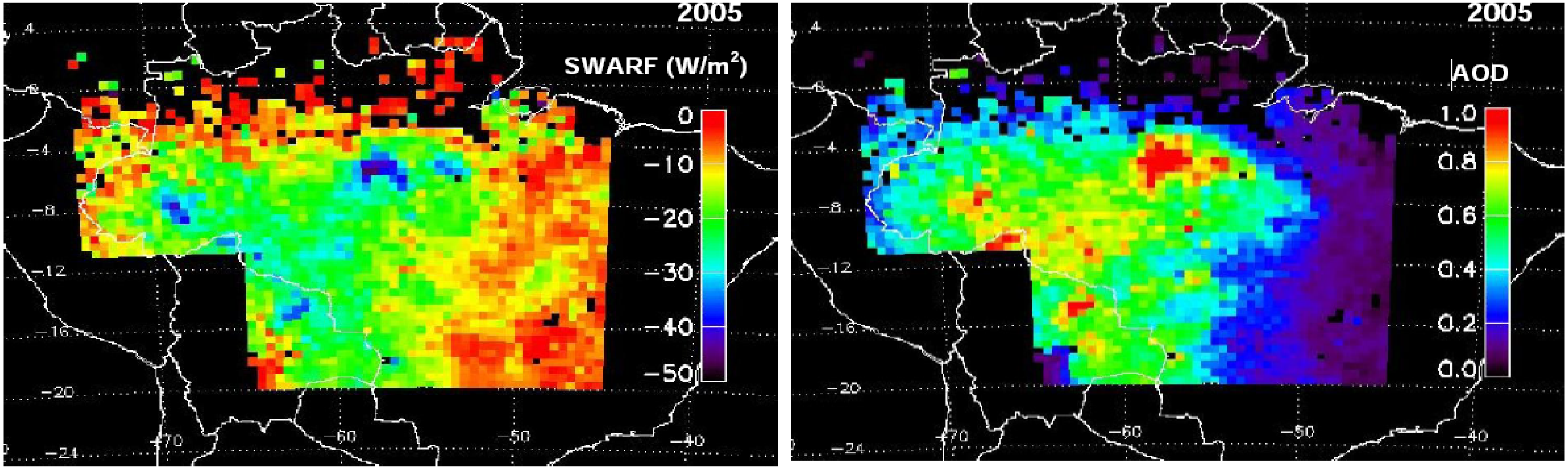


Figure 4: Spatial distribution of the shortwave radiative forcing at the TOA and aerosol optical depth over the Amazon during the biomass burning season of 2005.

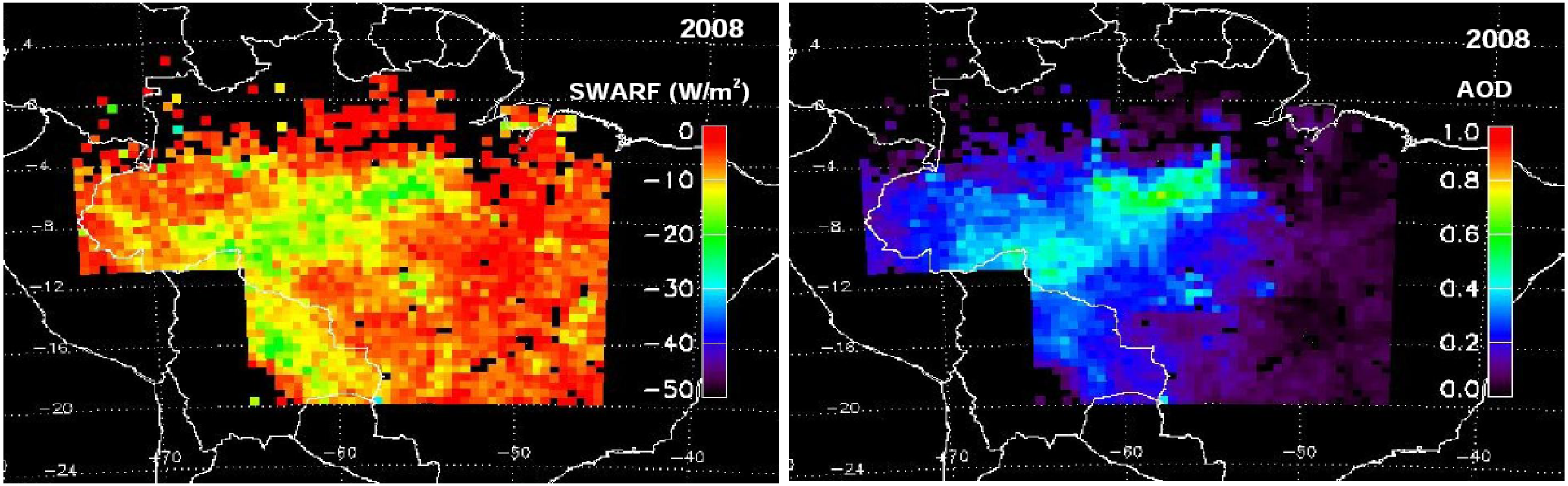


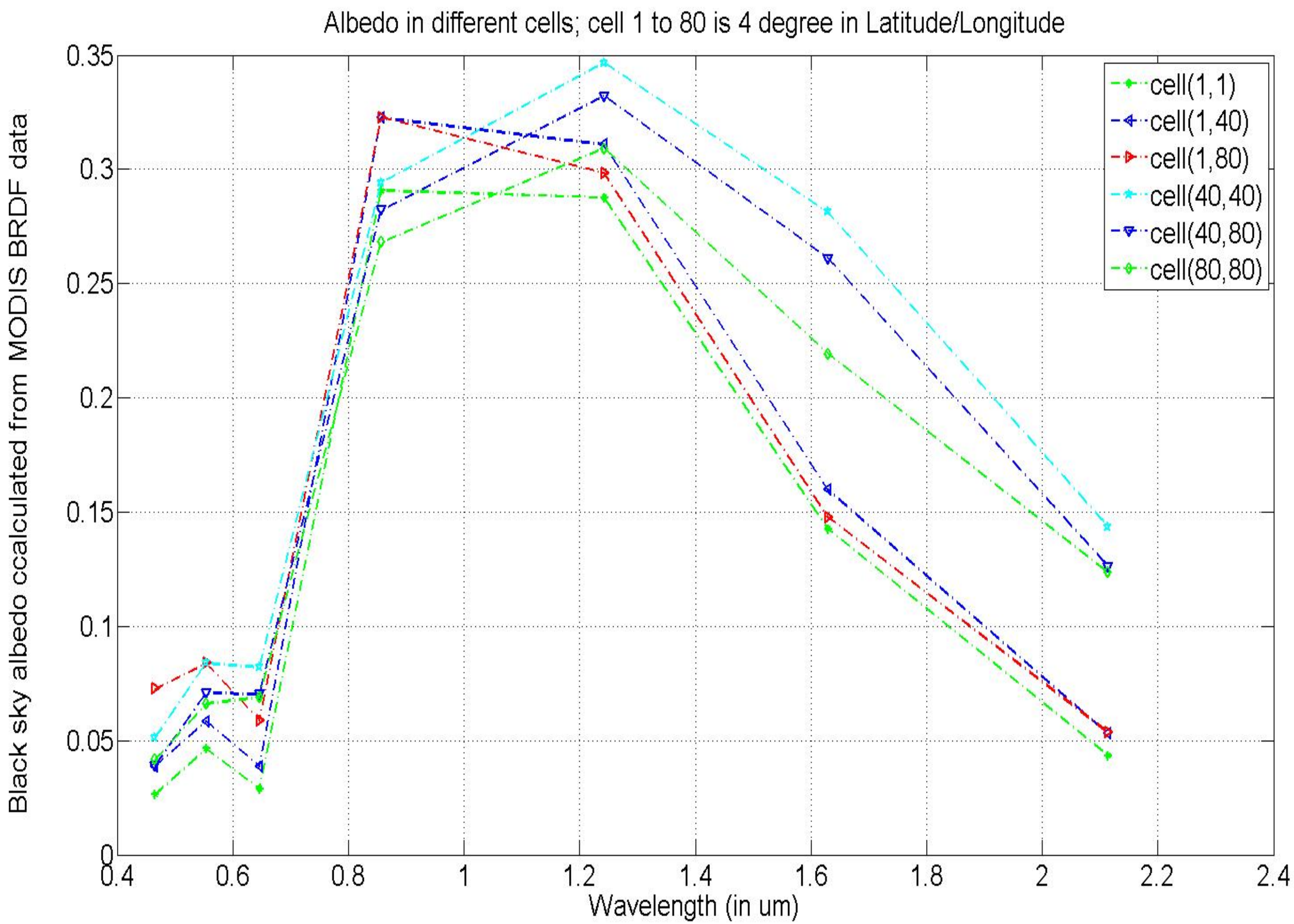
Figure 5: Spatial distribution of the shortwave radiative forcing at the TOA and aerosol optical depth over the Amazon during the biomass burning season of 2008.

Main Missing piece for Aerosol Forcing Calculations (after SSA):

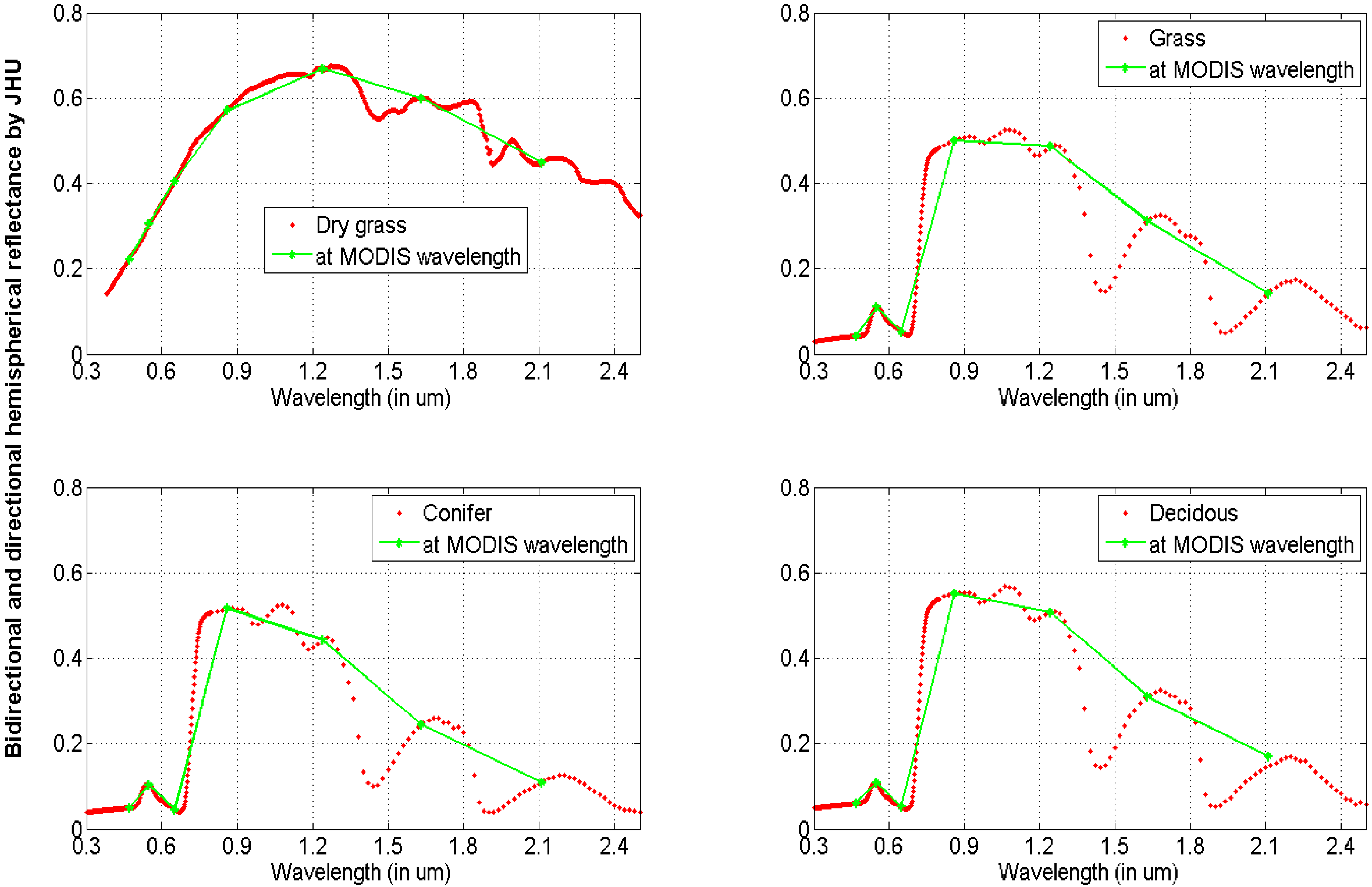
Spectral Surface Albedo/BRDF properties

- Use MODIS surface BRDF product to calculate surface albedo
- Produce surface albedo (from 0.3 to 2.5 um continuously) by interpolating albedo product in MODIS 7 channels (0.47, 0.55, 0.65, 0.86, 1.24, 1.63, and 2.11 um)
- Combine MODIS Aerosol forcing with CERES results

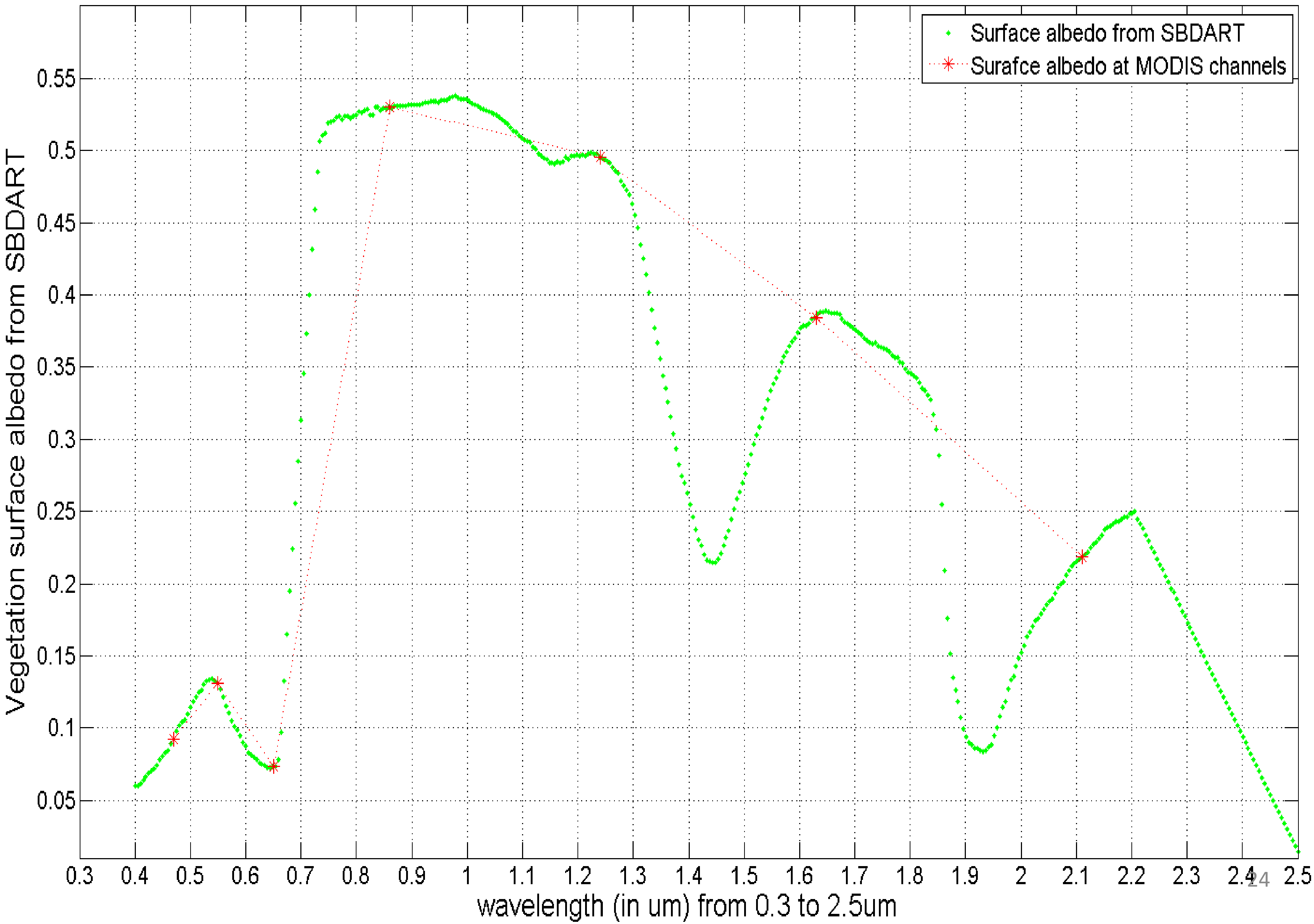
Spatial Variation of Surface Albedo



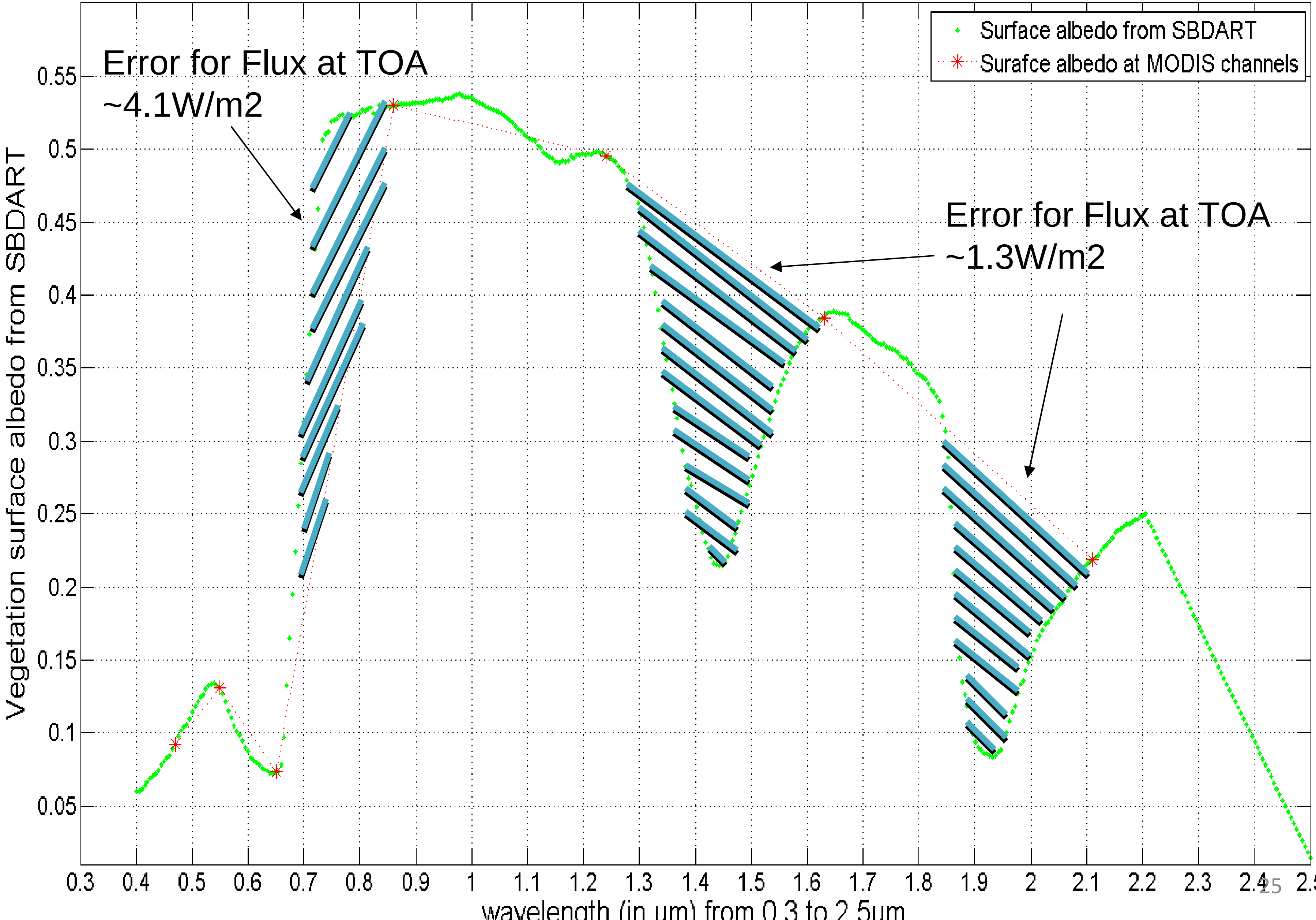
Typical Vegetation Surface Albedo
three missing features based on linear interpolation data from MODIS 7 channels



Three Missing Features

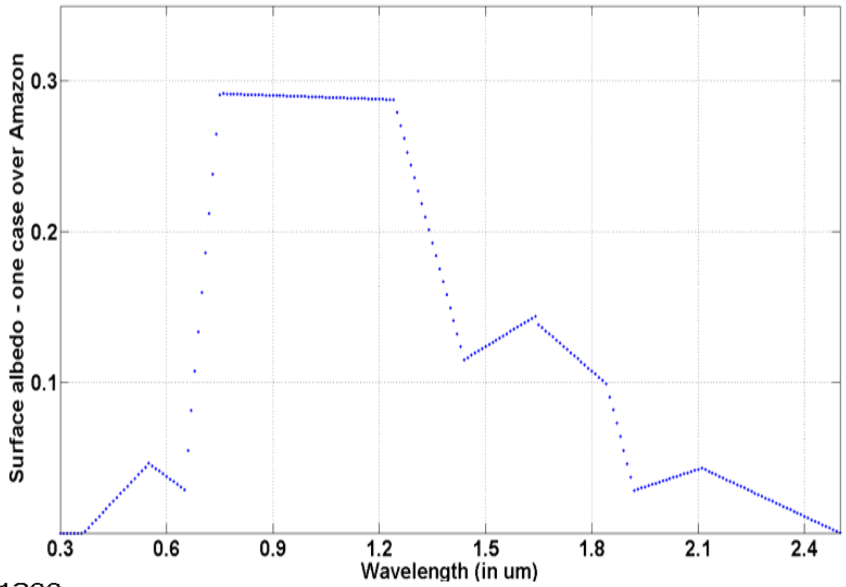


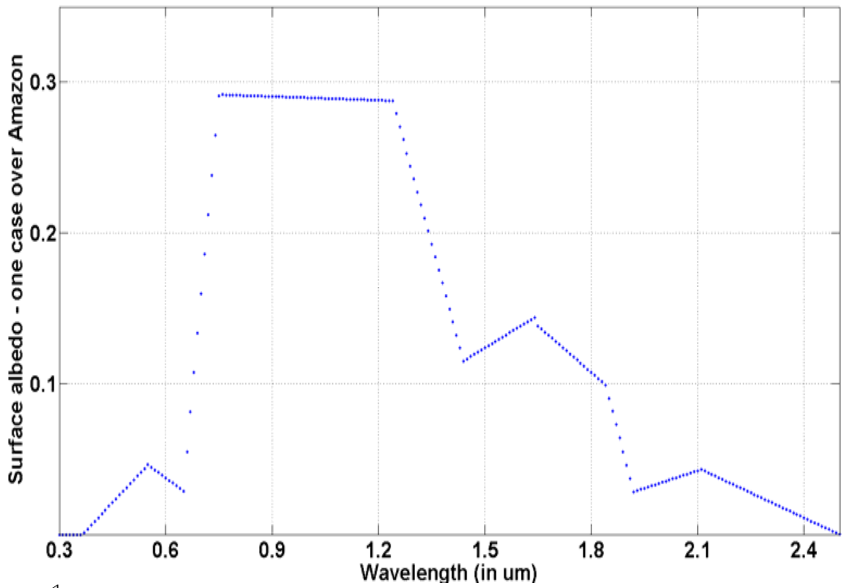
Impact in TOA Flux

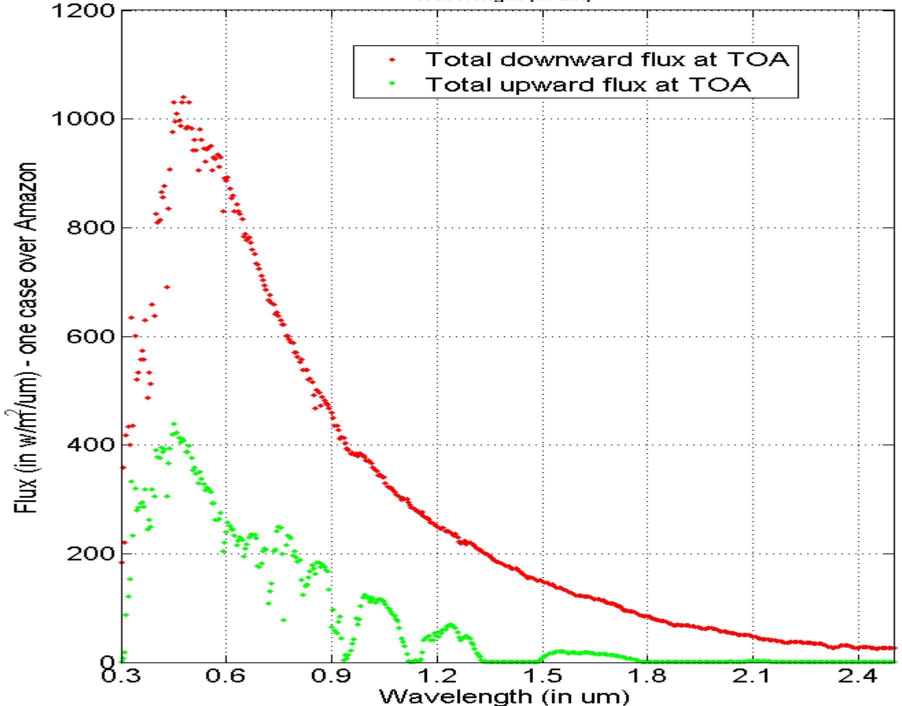


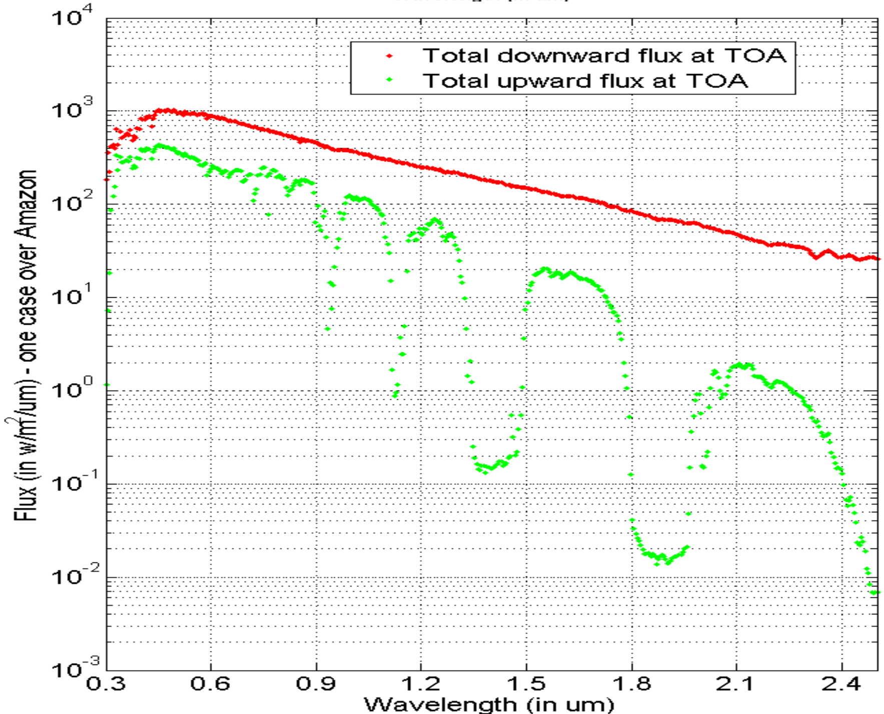
Thank you.

Explanation – Flux Difference at TOA









Defining Surface Albedo for Forcing Calculations: ***work in progress***