LibRadTran – PGF5349

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Motivation

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Observations of Manaus urban plume evolution and interaction with biogenic emissions in GoAmazon 2014/5

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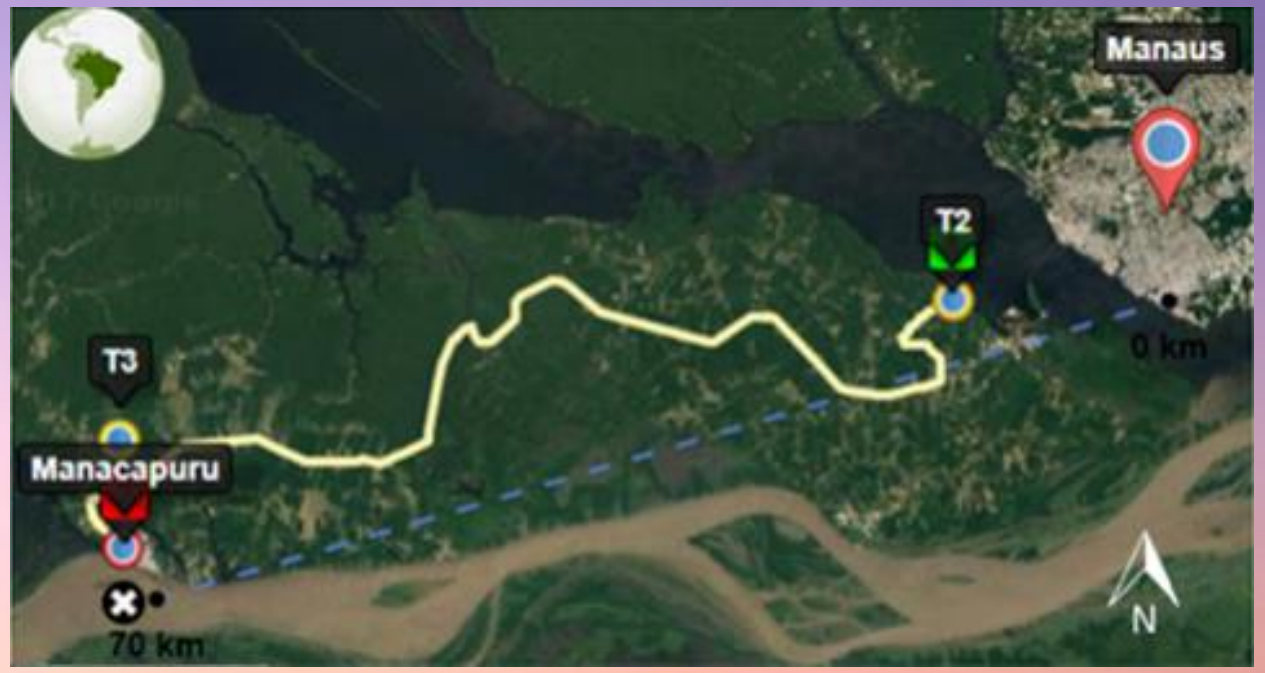
Course on Applications of LibRadtran for Studying Interactions of Radiation with Aerosols and Clouds

Main idea: understanding the factors that control the evolution of the size distribution by comparing properties of the aerosol size distribution at different locations and over different timescales.

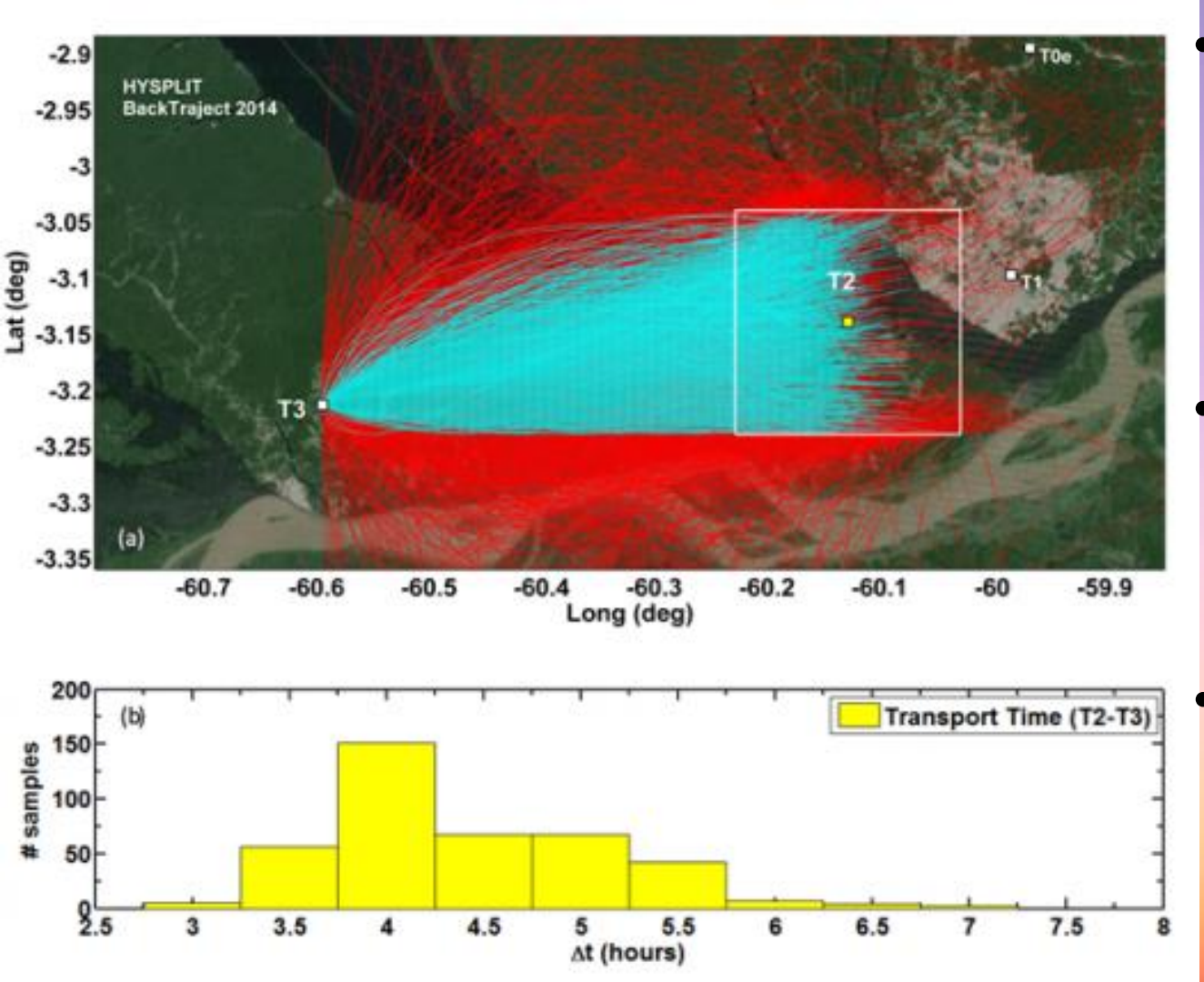
Properties of the aerosol size distribution as observed in two GoAmazon sites (T2 and T3)

T2 and T3

One year of aerosol number size distribution data (2014, continuous 5-min resolved data) from two different stations around Manaus, namely T2-Tiwa (5km downwind from Manaus) and T3-Manacapuru (80km downwind from Manaus). T2 site receives the fresh Manaus plume, while a more aged plume reaches the T3 site

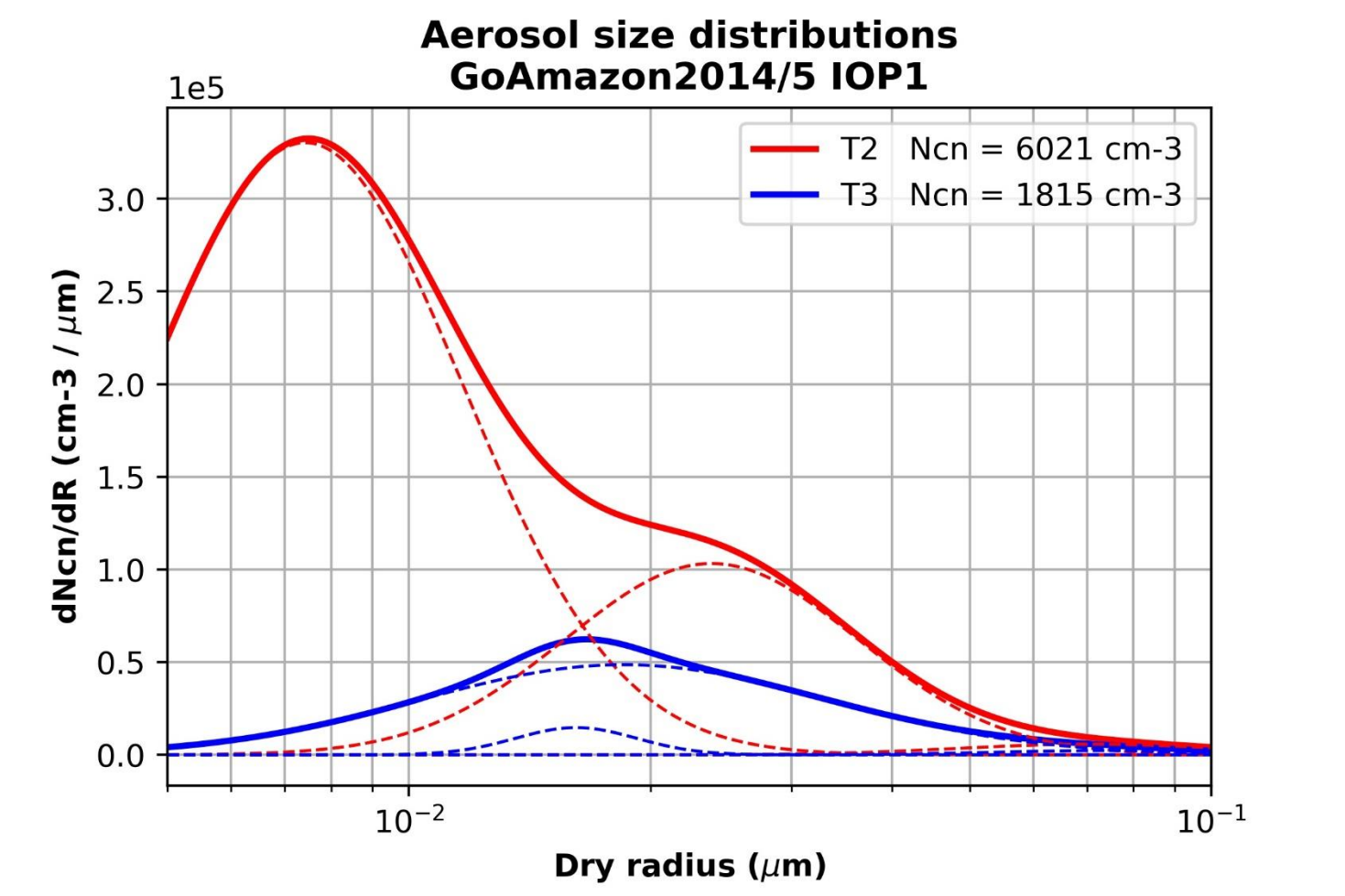


Back trajectories calculated for studying the plume evolution



- All trajectories eastward from T3 (70 km downwind) inside the boundary layer (h < 1000 m) and reaching a 20x20 km box around T2 (8 km downwind) are represented in red.
- A subset of direct trajectories without precipitation is represented in cyan. The trajectories were simulated as arriving 100 m above T3.
- Panel **b** shows the histogram of air mass transport time between T2 and T3 based on the trajectories shown in cyan

Aerosol particle size distributions



IOP1					
T2			T3		
N (cm^{-3})	GSD	D_g (nm)	N (cm^{-3})	GSD	D_g (nm)
3070	1.57	18.2	105	1.19	33.3
2818	1.52	56.8	1576	1.80	52.3
416.1	1.46	163.7	138	1.37	162.4

Measurements reported by Cirino et al

Optical Properties	Departure from T2	Arrival at T3
–	IOP 1	IOP1
SCAT (Mm^{-1})		
Median	9.2	6.8
Average	9.9	6.6
Std. Deviation (±)	4.1	2.1
SCAT/CN $(Mm^{-1}cm^{-3})$		
Median	1.6	2.6
Average	1.8	2.7
Std. Deviation (±)	1.2	0.9
ABS (Mm^{-1})		
Median	5.8	1.8
Average	6.8	1.9
Std. Deviation (±)	4.0	1.4
ABS/ΔCO $(Mm^{-1}ppb^{-1})$		
Median	0.1	0.0
Average	0.2	0.1
Std. Deviation (±)	0.1	0.0
SSA		
Median	0.6	0.8
Average	0.6	0.8
Std. Deviation (±)	0.1	0.1
SAE		
Median	1.4	1.6
Average	1.4	1.6
Std. Deviation (±)	0.3	0.4

ABS (Mm^{-1})	T2	T3
Median	5.8	1.8
Average	6.8	1.9
Std. Deviation (±)	4.0	1.4

SSA		
Median	0.6	0.8
Average	0.6	0.8
Std. Deviation (±)	0.1	0.1

Why so different?'

All the optical properties were measured at 637 nm.

Calculation of optical properties – mie (LibRadTran)

libRadtran includes the tool mie to calculate optical properties of spherical particles.

mie < input_file > output_file

Input file for calculation, given the size distribution

```
mie_program MIEV0           # Select Mie code by Wiscombe
refrac_user 1.001 0.05      # Specify refractive index
size_distribution_file t3iop1_enter_model.txt
wavelength 637. 637.        # Define wavelengths
output_user lambda refrac_real refrac_imag qsca omega
```

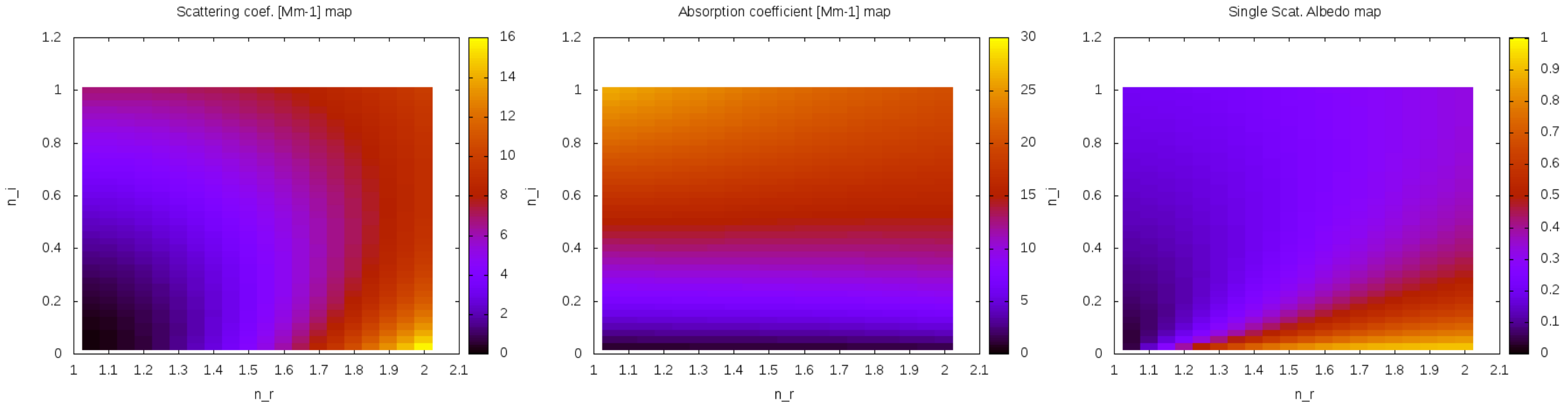
A routine was written to run mie for a range of values of `refrac_real` and `refrac_imag` and gather the results on a single output file

Optical Properties - Fundamentals

- $q_{scat}\ [Mm^{-1}]/[\frac{cm^3}{m^3}]$: scattering coefficient returned by the Mie Code
- $\omega_0 = \frac{q_{scat}}{q_{abs}} = \frac{\sigma_{scat}}{\sigma_{scat}+\sigma_{abs}}$: Single Scattering Albedo;
- $\sigma_{scat} = q_{scat} \times \int_0^\infty \pi r^3 \frac{dn(r)}{dr} dr\ [Mm^{-1}]$: scattering coef. measured by the nephelometer
- $\sigma_{abs} = \frac{\sigma_{scat}(1-\omega_0)}{\omega_0}$: absorption coef. measured by the aethalometer
- Refractive index: $m = n - ik$, where n is the real part and k is the imaginary part

With those values we can simulate and compare optical properties for both sites T2 and T3!

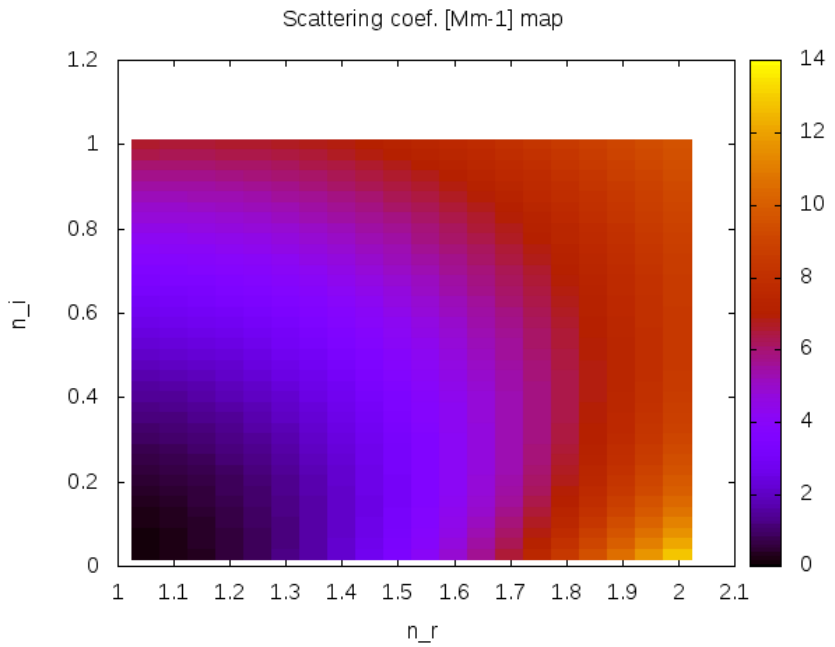
Results – T2 site

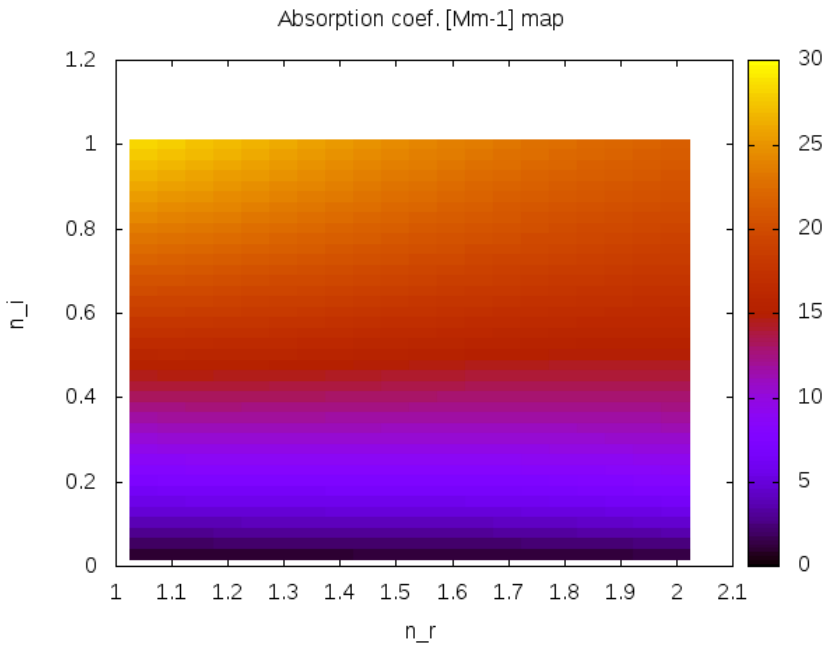


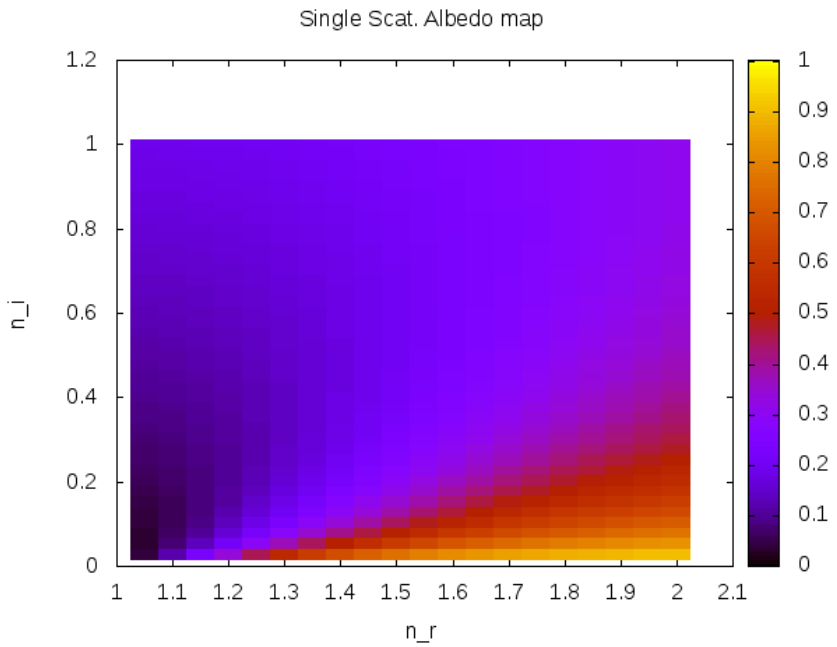
Intersection that approximately reproduces the values of the paper is:

- **n_real = 1.850 ; n_i = 0.150 with $\sigma_{scat} = 9.420, \sigma_{abs} = 6.38, \omega_0 = 0.596$**
- **Real values are: $< \sigma_{scat} >= 9.9$ (median = 9.2); $< \sigma_{abs} >= 6.8$ (median = 5.8) and $< \omega_0 >= 0.6$**

Results – T3 site







Intersection that approximately reproduces the values of the paper is:

- **n_real = 1.700 ; n_i = 0.05 with $\sigma_{scat} = 6.27, \sigma_{abs} = 2.15, \omega_0 = 0.75$**
- **Real values are: $< \sigma_{scat} >= 6.6$ (median = 6.8); $< \sigma_{abs} \geq 1.9$ (median = 1.8) and $< \omega_0 >= 0.8$**

Comparison between T2 and T3

Refraction index:

Site	n_r	n_i
T2	1.850	0.150
T3	1.700	0.050

Optical parameters:

Site	$\sigma_{scat,real}$	$\sigma_{scat,Mie}$	$\sigma_{abs,real}$	$\sigma_{abs,Mie}$	$\omega_{0,real}$	$\omega_{0,Mie}$
T2	9.90	9.24	6.8	6.38	0.600	0.596
T3	6.60	6.27	1.90	2.15	0.80	0.75

Conclusions

- Optical properties of the aerosols are different in both sites;
- Refraction index seems to be compatible with the parameters observed and possible can explain the differences;
- The model seems to return values a little underestimated in comparison with those obtained by the in situ measurements. But, even though, the results are really close to the real.

Thank you for listening