Aerosol impacts on cloud dynamics

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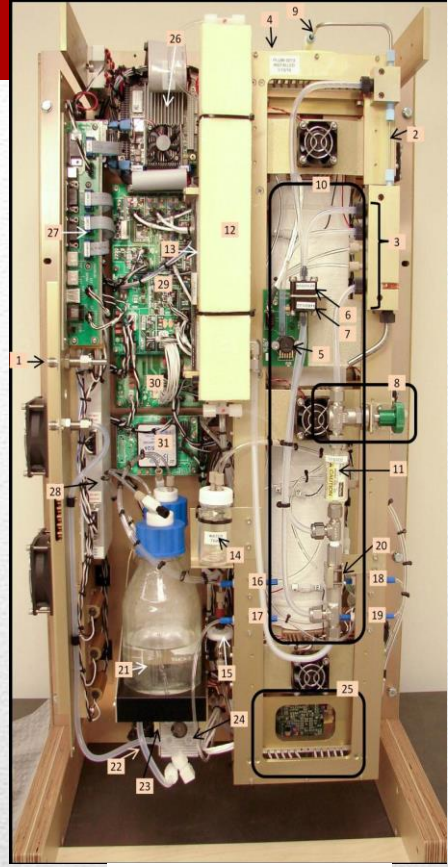
Objectives

- Assess if it's possible to observe aerosols impacts on precipitation characteristics through ground based measurements
- Analyze its significance

Instrumentation

- Measurements site: CHUVA container at IEAv, Vale do Paraíba
- CCNC
- CPC
- Joss
- Meteorological station



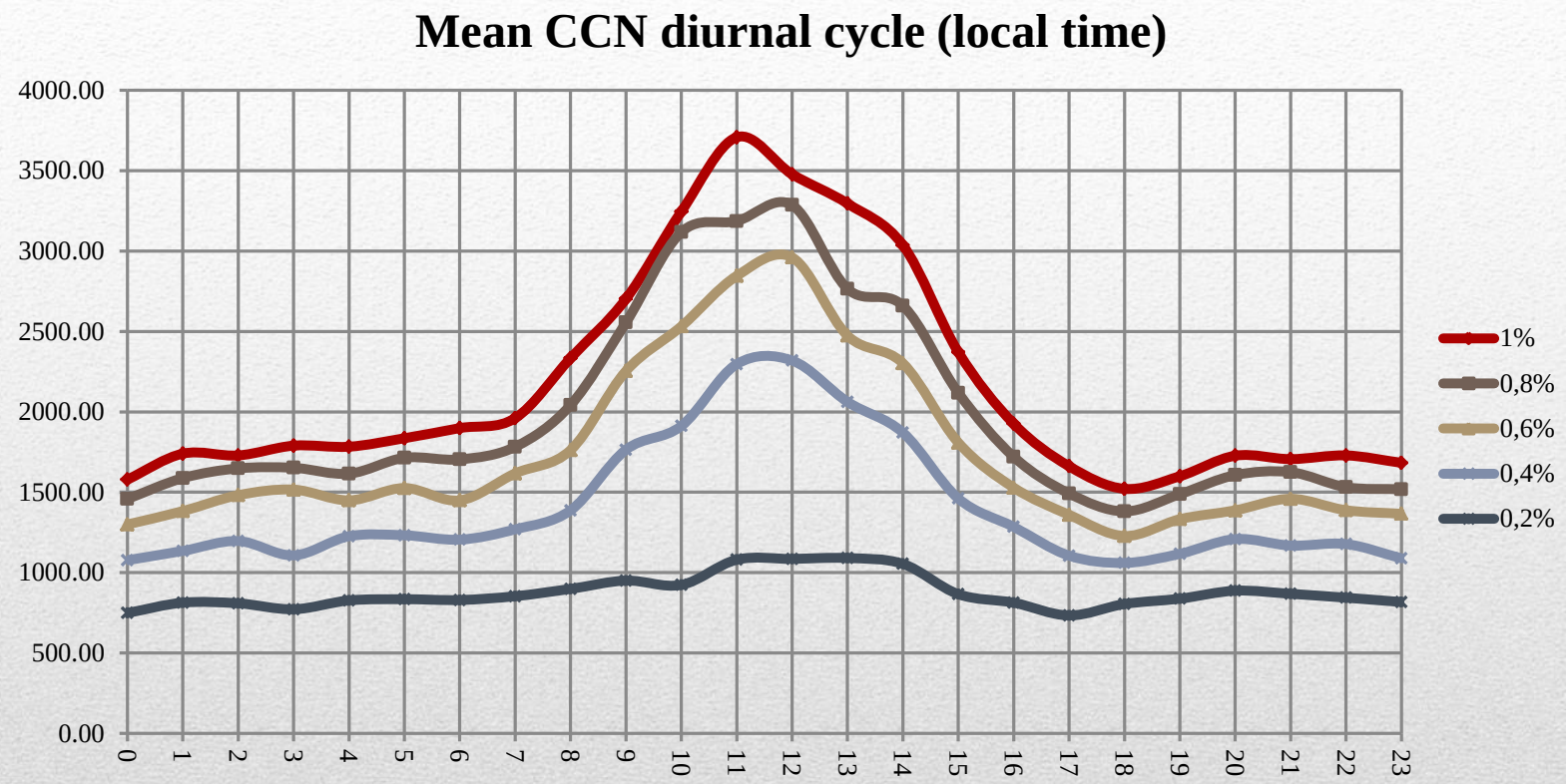
Methodology

- Measurement period -> Nov/22/2011 through Jan/10/2012
- DSD parameterization -> Tokay and Short (1996) and Tokay et al. (2001):
- $N(D) = N_0 D^m \exp(-\Lambda D)$
- $m = \frac{11G-8+[G(G+8)]^{1/2}}{2(1-G)}, G = \frac{M_4^3}{M_3^2 M_6}$
- $N_0 = \frac{\Lambda^{m+4} M_3}{\Gamma(m+4)}$
- $\Lambda = \frac{(m+4)M_3}{M_4} = \frac{(m+4)}{D_m}, D_m = \frac{M_4}{M_3}$
- Where $M_x = \int_0^\infty D^x N(D) dD$

$[N_0] = mm^{-1-m}m^{-3}$
$[m] = []$
$[\Lambda] = mm^{-1}$

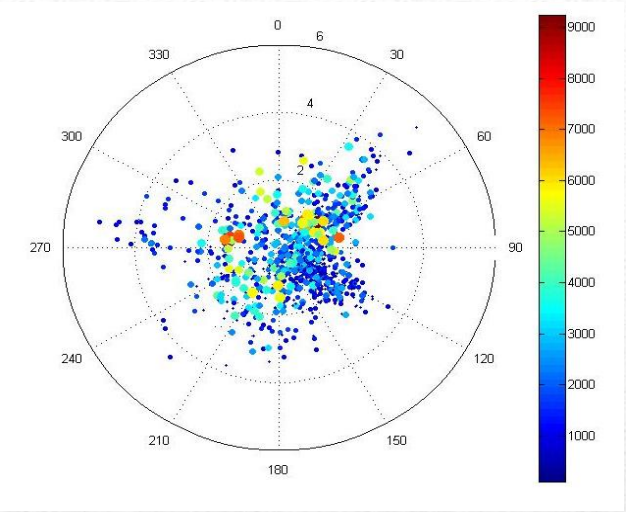
Methodology

- Rain Intensity:
- $RI = 6\pi \times 10^{-6} \int_0^{\infty} V(D) D^3 N(D) dD$
- Total droplet concentration:
- $\mathrm{TDC} = \int_0^{\infty} N(D) dD$
- Cluster analysis applied to m, N_0 and Λ
  - *k-means* method - Kanungo et. al (2002)



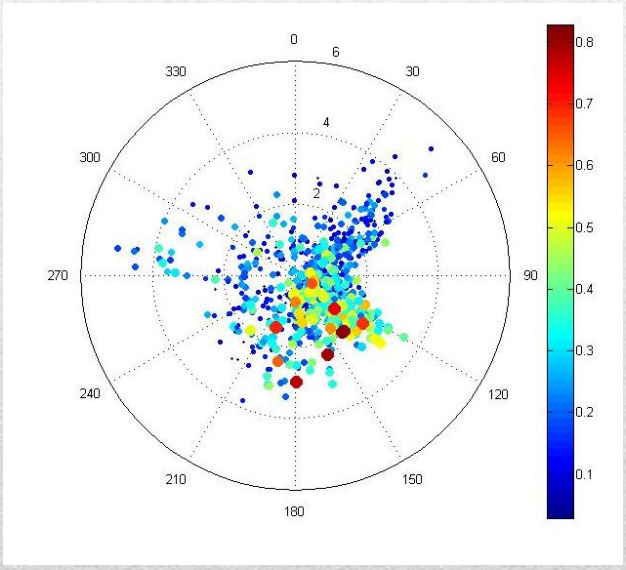
$CCN_{1.0}$ ~200 to ~10.000 cm^{-3}
CN ~400 to 70.000 cm^{-3}

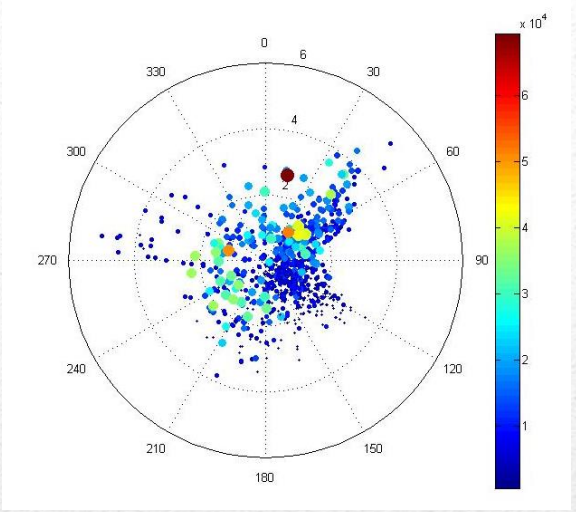
Results



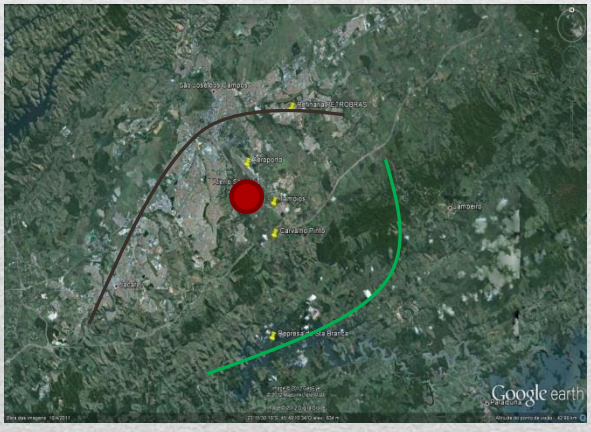
CCN

CCN/CN



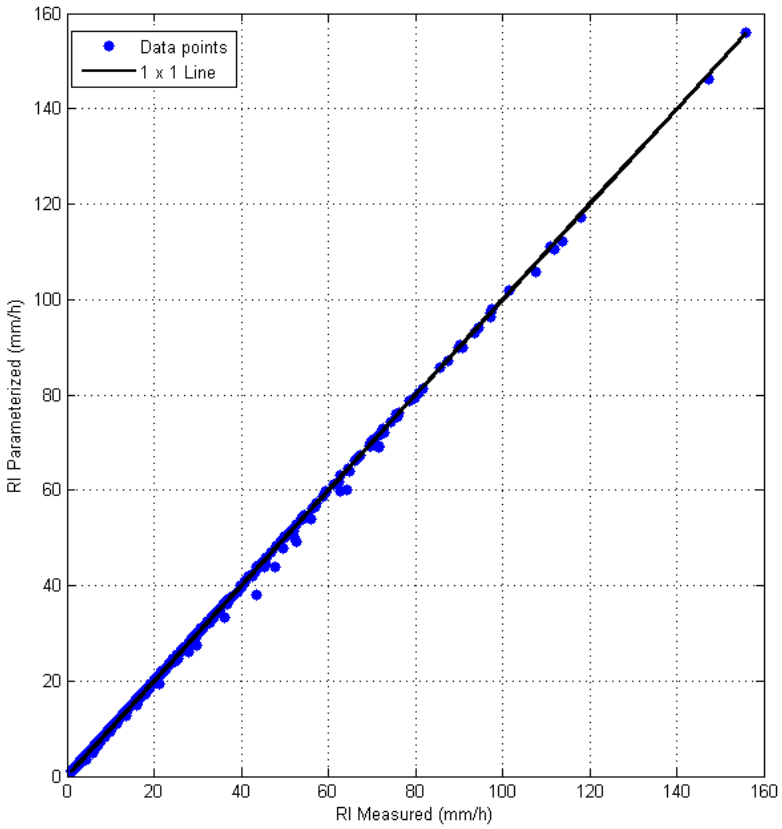


CN



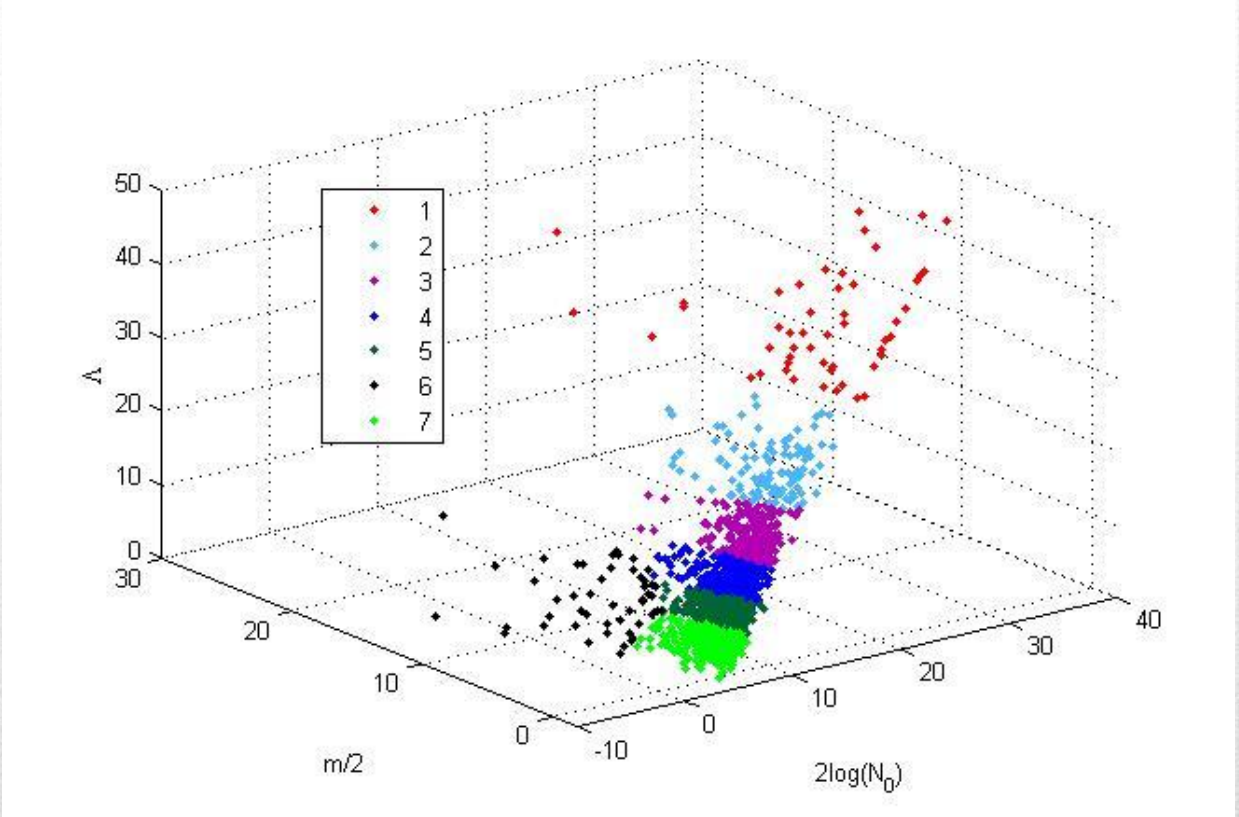
Results

$R^2 = 0{,}9996$



Results

-> Adjustments to parameters values (m/2 and 2*log(N_0))
-> supervised *k-means*
-> Centroid number chosen to best represent DSD data

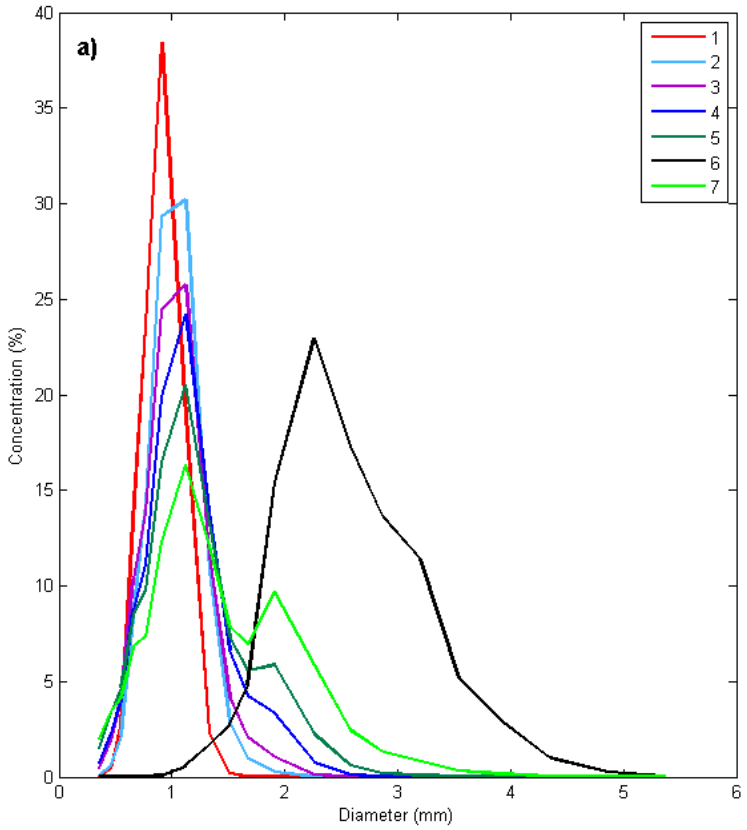


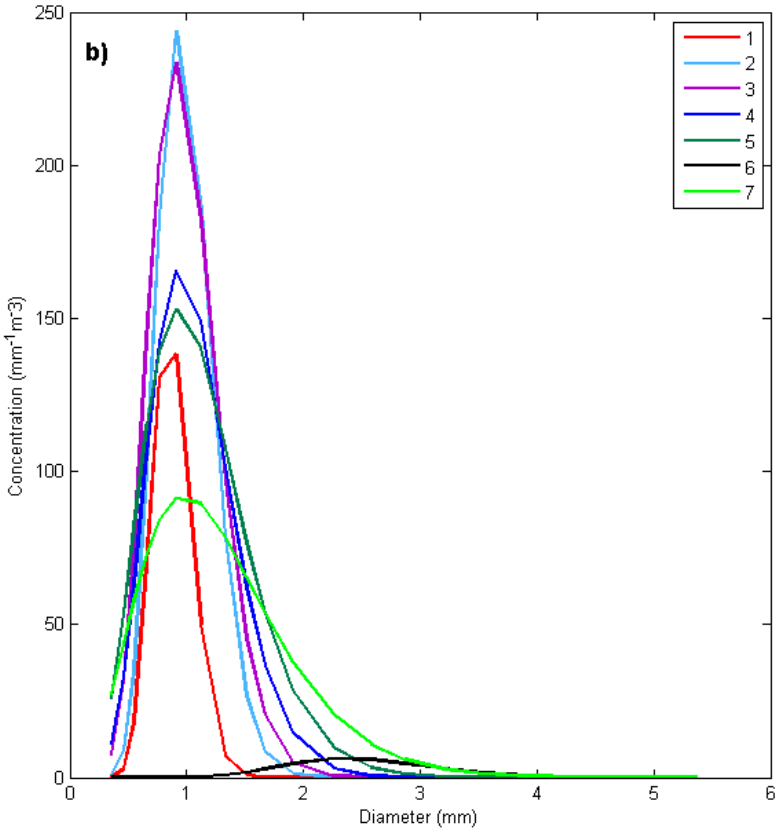
Results

# Cluster	N_0 ($mm^{-1-m}m^{-3}$)	m	Λ (mm^{-1})	RI (mm/h)	Rain Accum. (mm)	Frequency (%)
1	1.31E+15	25.63	30.18	0.35	1.62 (0.62%)	2.83
2	9.64E+09	16.40	17.52	1.39	4.59 (1.75%)	5.94
3	2.66E+07	10.63	11.69	1.81	11.21 (4.28%)	13.49
4	6.03E+05	7.78	8.20	2.33	29.14 (11.14%)	21.32
5	3.77E+04	5.18	5.52	3.70	82.38 (31.48%)	30.15
6	4.85E+01	14.65	6.20	2.81	5.87 (2.24%)	2.78
7	2.49E+03	3.25	3.30	6.28	126.86 (48.48%)	23.49

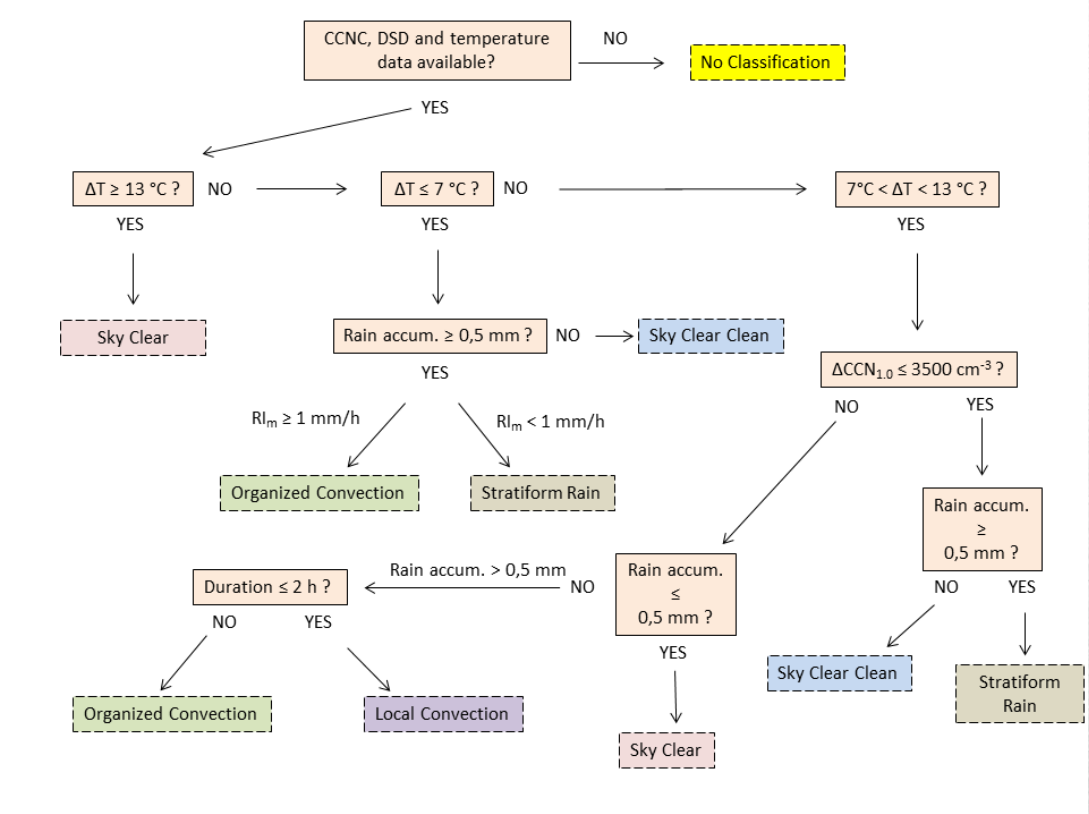
1,2,3 -> Stratiform clusters
4 -> Transition cluster
5,6,7 -> Convective cluster

Results


a)
1
2
3
4
5
6
7
Concentration (%)
Diameter (mm)
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6


b)
1
2
3
4
5
6
7
Concentration (mm-1 m-3)
Diameter (mm)
0
50
100
150
200
250
0
1
2
3
4
5
6

Results



-> Daily pattern classification based on ΔT, $\Delta CCN_{1.0}$, rain accumulated, Ri_m and duration

-> Local Convection, Stratiform Rain and Organized Convection

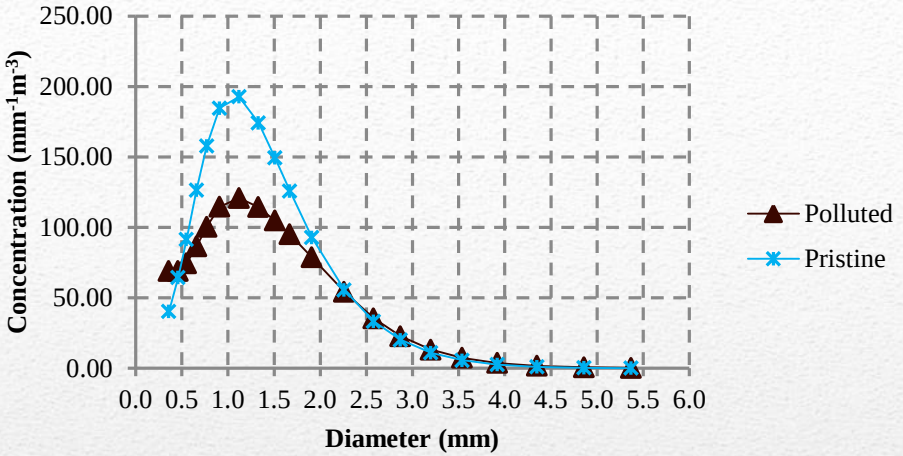
Results

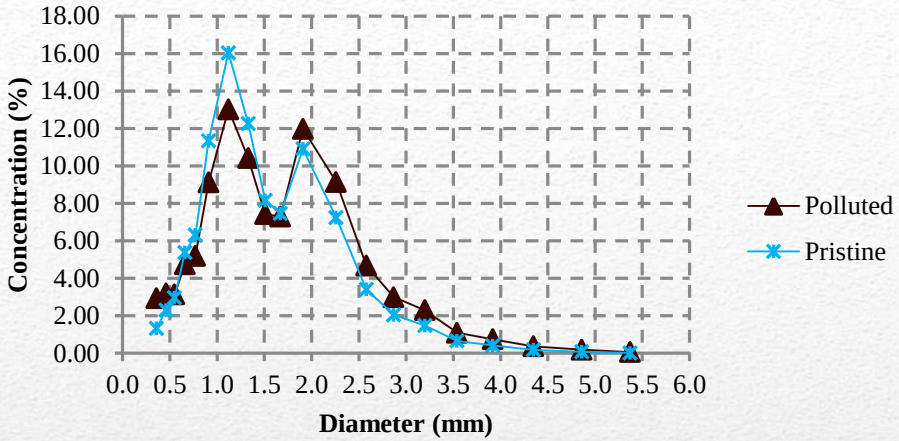
Daily Pattern	Cluster Frequency (%) ± Standard Deviation (%)						
	Stratiform Clusters			Transition Cluster	Convective Clusters		
	1	2	3	4	5	6	7
Stratiform Rain	21 ± 29	24 ± 11	19 ± 8	13 ± 11	12 ± 12	0 ± 0	11 ± 12
Local Convection	1 ± 2	3 ± 4	11 ± 8	13 ± 8	22 ± 13	7 ± 9	43 ± 17
Organized Convection	4 ± 8	7 ± 7	19 ± 16	19 ± 11	24 ± 15	8 ± 11	19 ± 15

Results

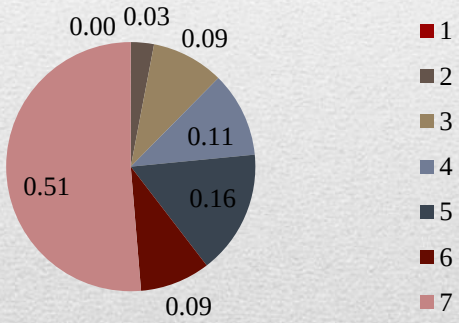
- Events separation:
  - Interval $\geq$ 20 min between two DSD data
  - CCN: 2 hours means, 30 minutes before rain starts
  - Mean DSD calculated for each event
  - Only the first event on each day was selected, avoiding *rainout* and *washout* effects
- 16 events, total
- 5 Local Convection, 5 Stratiform Rain, 6 Organized Convection
- Polluted X pristine pairs

Results





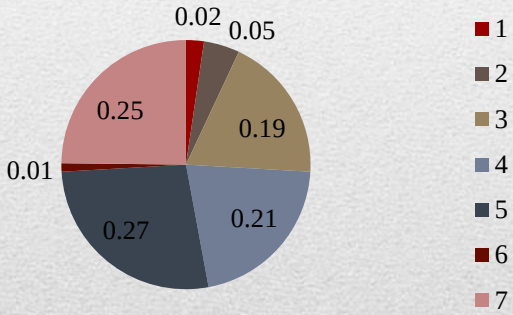
Polluted



CCN=4156 cm^{-3} RI=20.34 mm/h

D_m=2.69 mm **TDC=216 m^{-3}**

Pristine

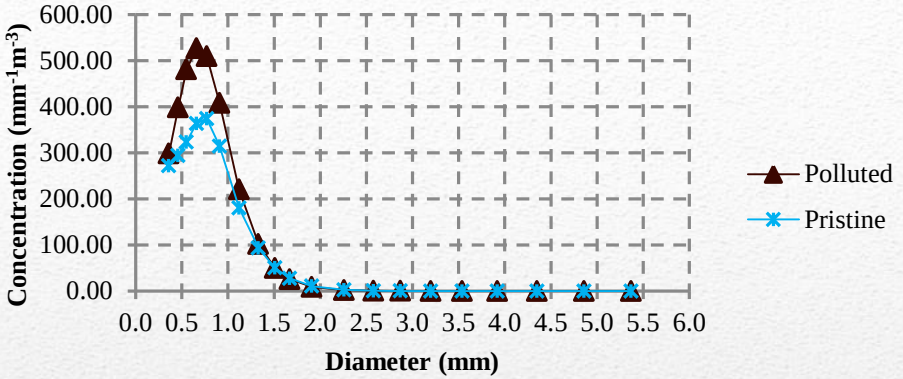


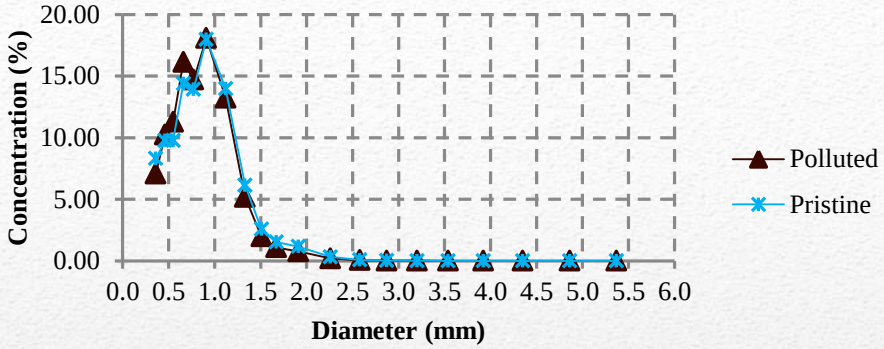
CCN=1849 cm^{-3} RI=19.20 mm/h

D_m=2.44 mm **TDC=280 m^{-3}**

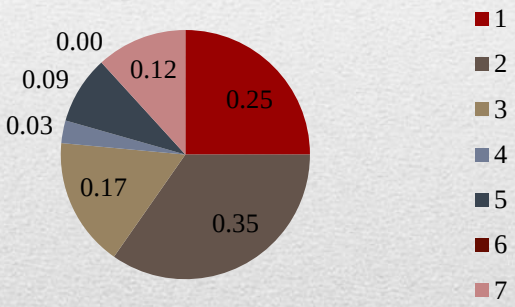
Results

Bold - Significant (T-Student)





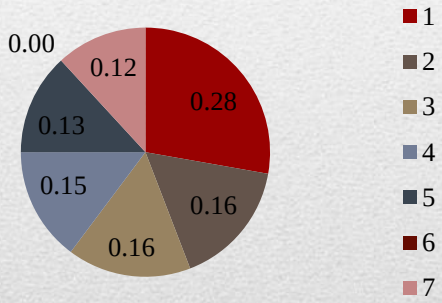
Polluted



CCN=2012 cm^{-3} RI=2.65 mm/h

D_m=1.22 mm **TDC=388 m^{-3}**

Pristine



CCN=668 cm^{-3} RI=2.45 mm/h

D_m=1.30 mm **TDC=301 m^{-3}**

Results

Conclusions

- CCN concentrations between rural and urban levels
  - Mean $CCN_{1.0}$ ~ 2000 cm^{-3}
- Clear diurnal cycle and dependent on local circulation
- Effective momentum DSD parameterization
- Cluster analysis – DSD patterns identification
- Stratiform rain: ↑CCN (201%) -> ↓D_m (6%);↑ TDC (29%)
- Local Convection:↑ CCN (125%) -> ↑ D_m (10%); ↓ TDC (23%)
- CCN favored convective characteristics on Local Convection cases and stratiform features on Stratiform Rain
- CCN x DSD -> restrictive analysis, more data needed!