Relationship between aerosols and precipitation chemistry in remote Amazonian

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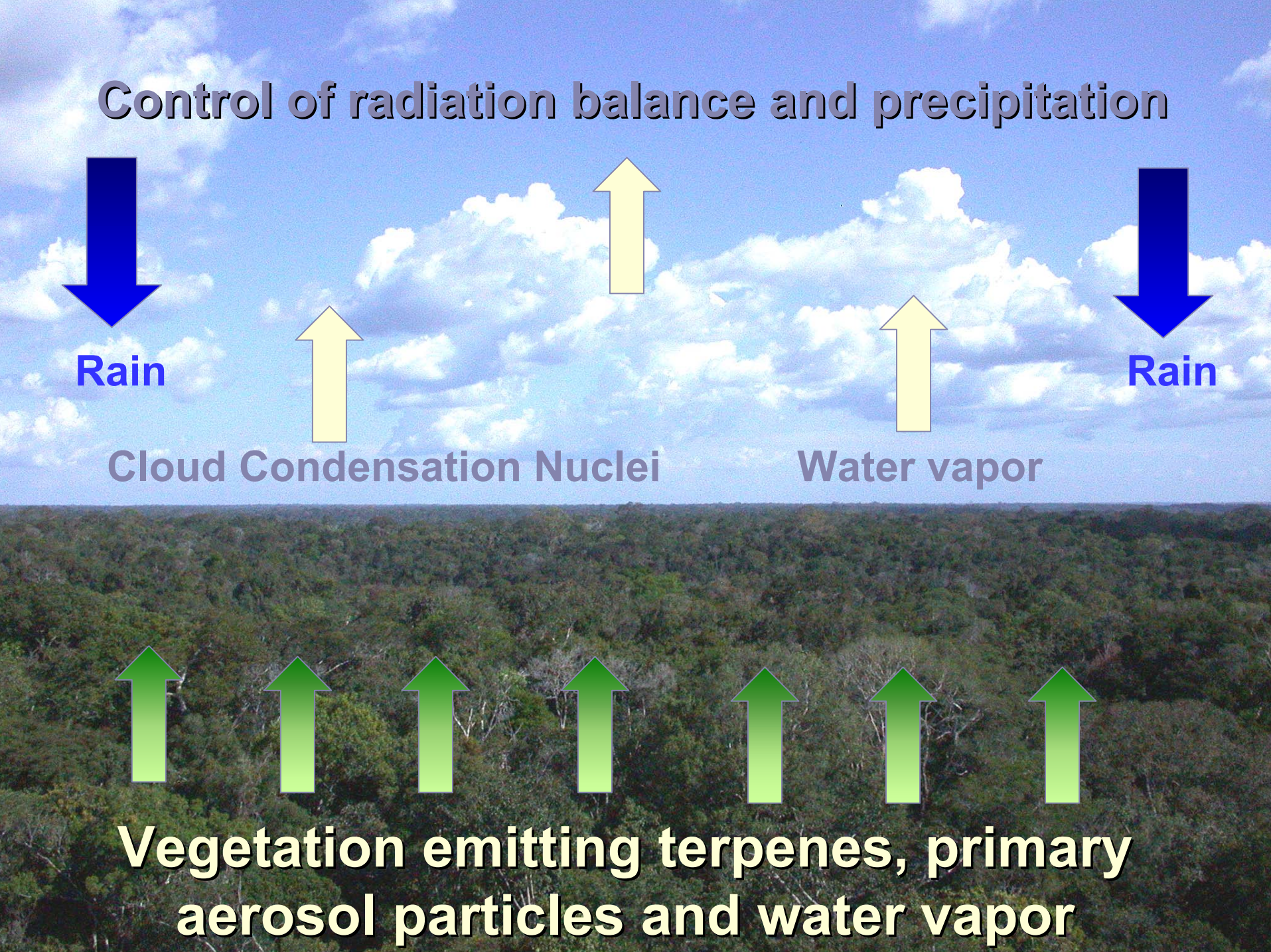
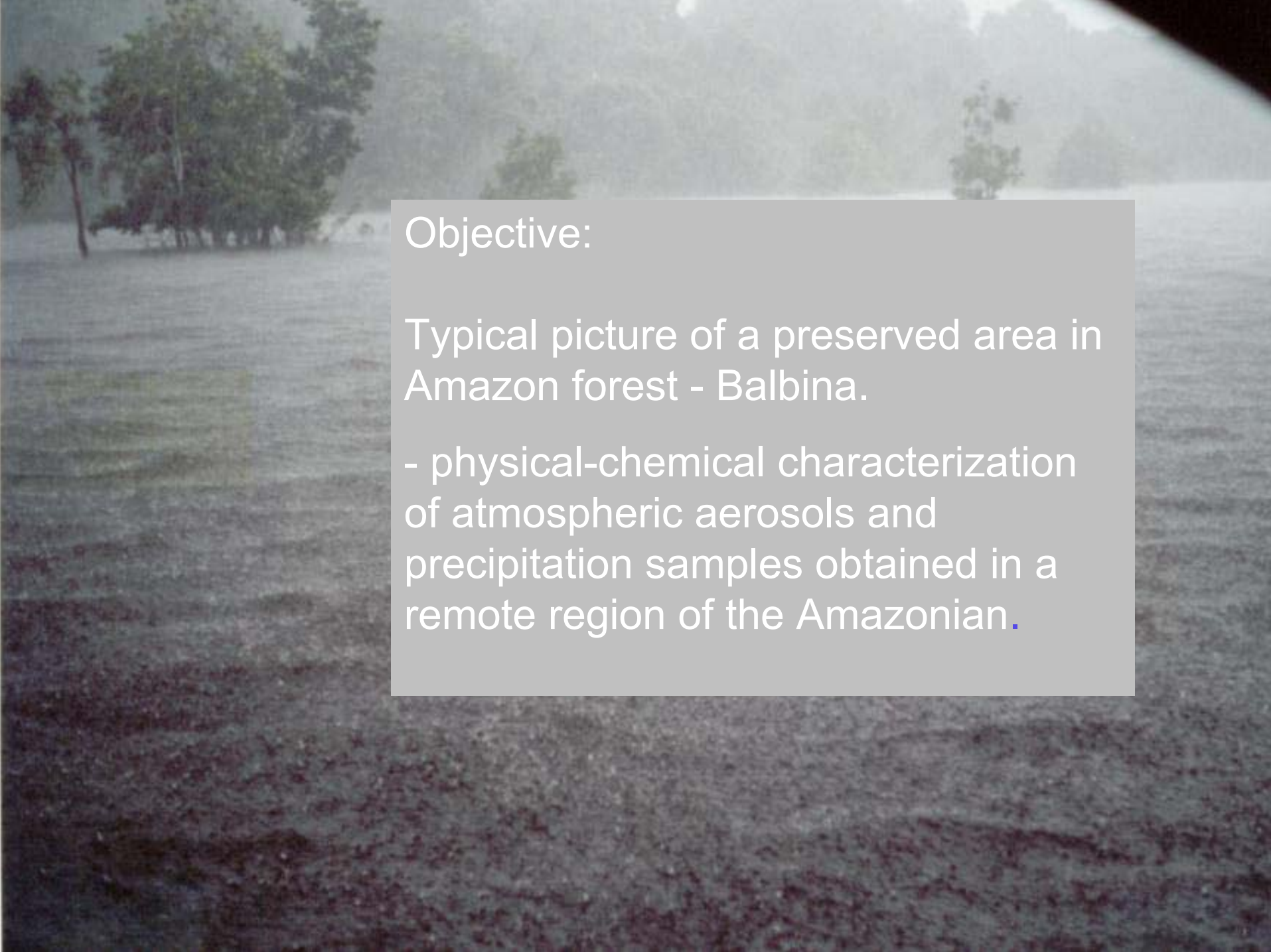
Tropical Forests
⇓
Survival Mechanisms:
-Nutrients recycling;
- Nutrients present in the rain;
- Nutrients transported from far regions.
Aerosol

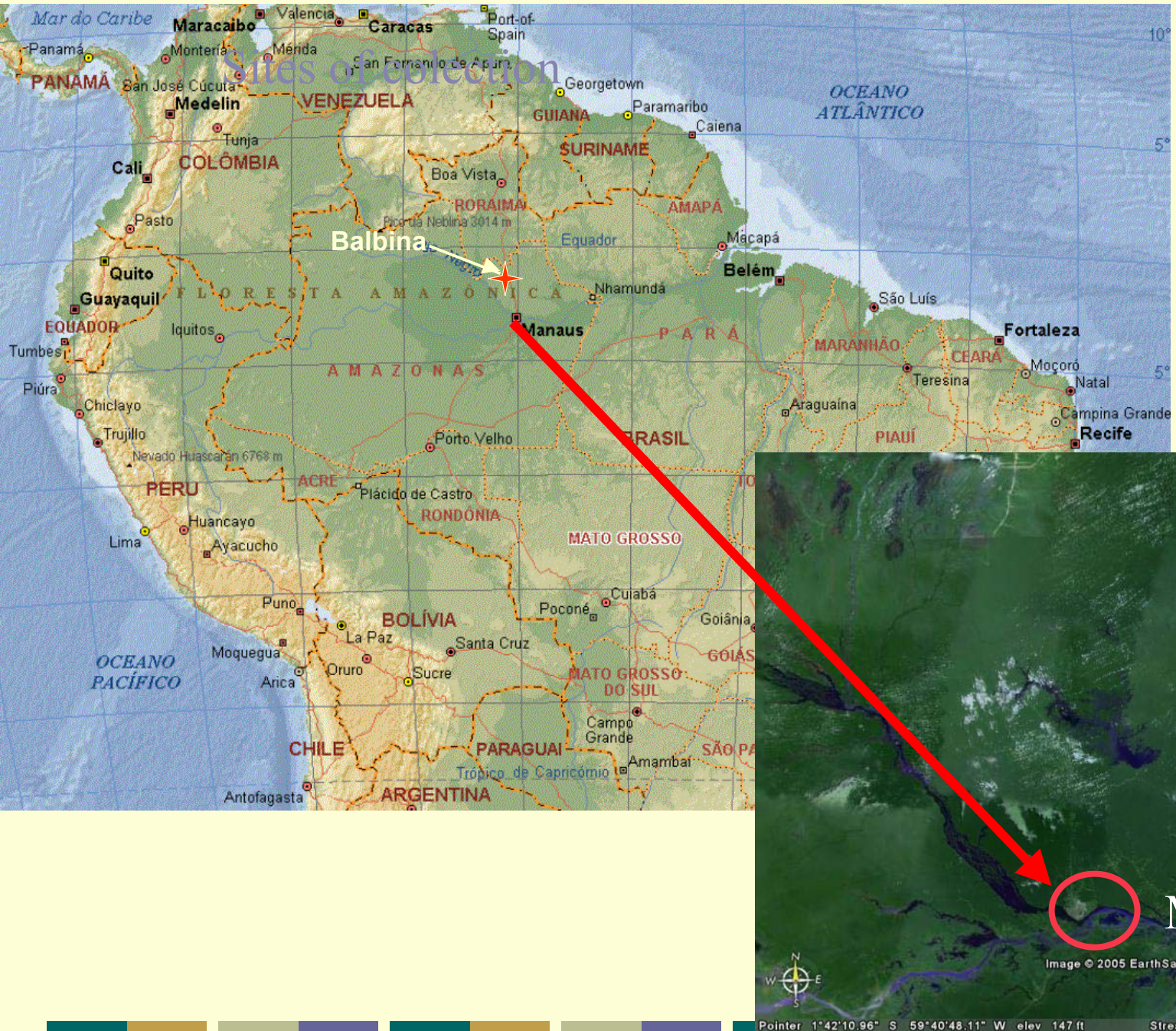

Control of radiation balance and precipitation
Rain
Cloud Condensation Nuclei
Water vapor
Rain
Vegetation emitting terpenes, primary aerosol particles and water vapor



Objective:

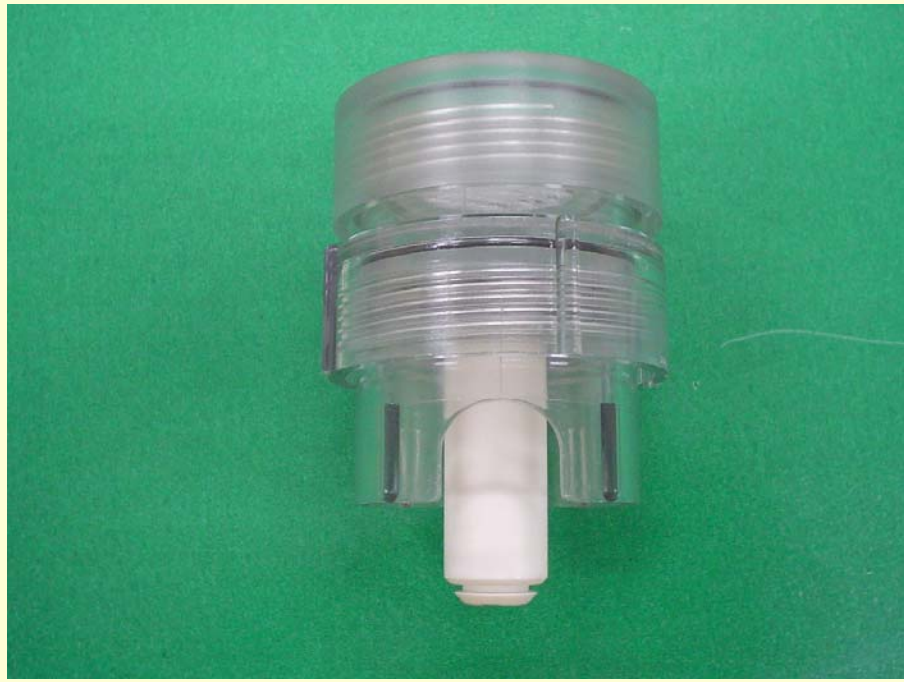
Typical picture of a preserved area in Amazon forest - Balbina.

- physical-chemical characterization of atmospheric aerosols and precipitation samples obtained in a remote region of the Amazonian.


Sites of Collection
Balbina
Manaus
Balbina dam
Manaus
Image © 2005 EarthSat
Google
Mar do Caribe
Maracaibo
Caracas
Port-of-Spain
Panamá
Montería
Mérida
PANAMÁ
San José Cúcuta
Medelín
VENEZUELA
Georgetown
Paramaribo
Caiena
GUIANA
SURINAME
OCEANO ATLÂNTICO
Tunja
Cali
COLÔMBIA
Boa Vista
RORAIMA
AMAPÁ
Pasto
Equador
Macapá
Belém
Quito
Guayaquil
FLORESTA AMAZÔNICA
Nhamundá
São Luís
EQUADOR
Iquitos
Manaus
PARÁ
Fortaleza
MARANHÃO
CEARÁ
Tumbes
AMAZONAS
Teresina
Moçoró
Natal
Piúra
Chiclayo
Araguaína
Campina Grande
Trujillo
Porto Velho
BRASIL
PIAUÍ
Recife
Nevado Huascarán 6768 m
PERU
ACRE
Plácido de Castro
RONDÔNIA
Huancayo
Lima
Ayacucho
MATO GROSSO
Cuiabá
Puno
Poconé
Goiânia
BOLÍVIA
La Paz
Santa Cruz
Moquegua
GOIÁS
OCEANO PACÍFICO
Oruro
Sucre
Arica
MATO GROSSO DO SUL
Campo Grande
CHILE
PARAGUAI
Amambai
Trópico de Capricórnio
Antofagasta
ARGENTINA

Aerosol Samples

Stacker Filter Unit



Sampling Period:

- Aerosols: October/1998-
  September/2004

PIXE – Particle Induced X-Ray emission

IFUSP – University of São Paulo

Precipitation samples

Automatic precipitation collector

Sampling Period:

- Years:

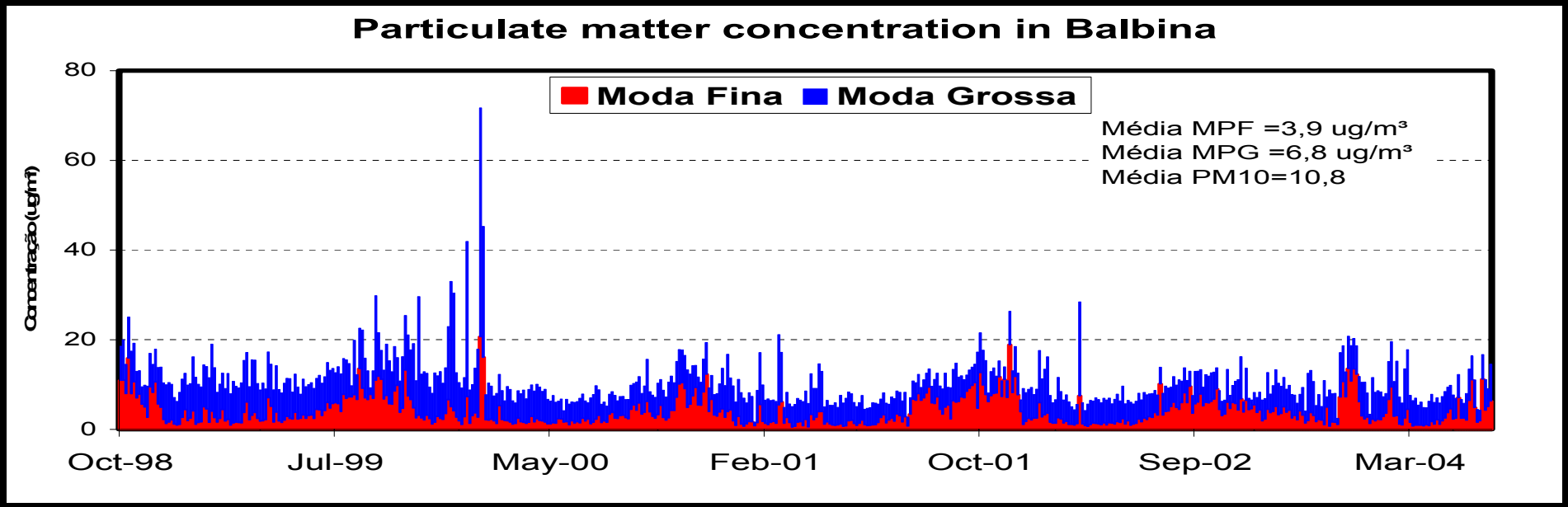
2001 - 2002

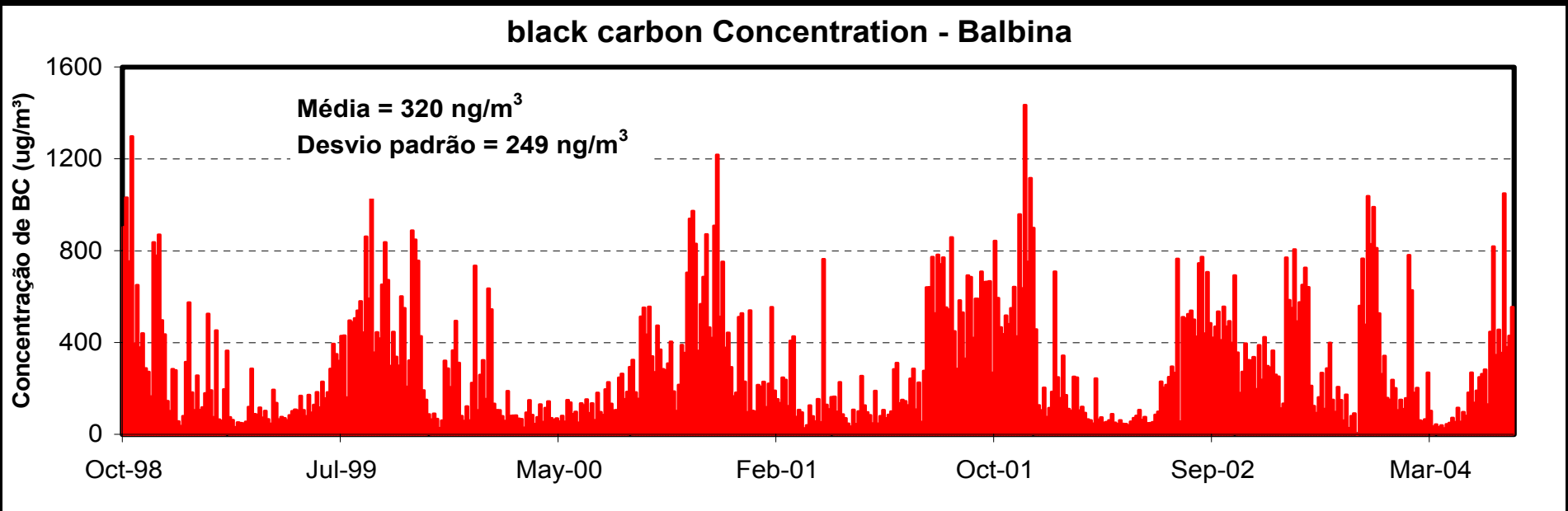
Ionic Chromatography:

CENA – USP

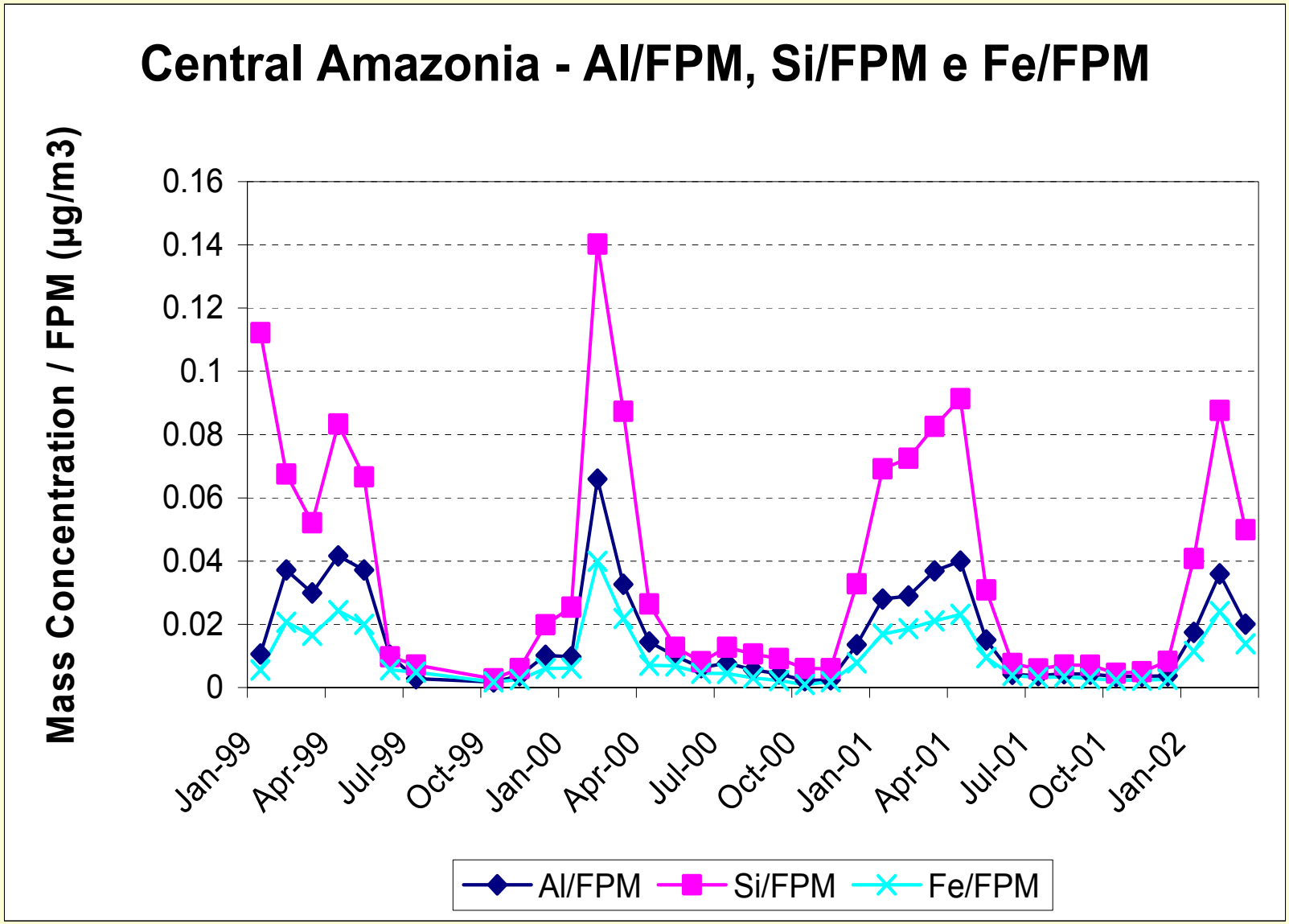
Lab. Ecologia Isotópica

Results – Balbina

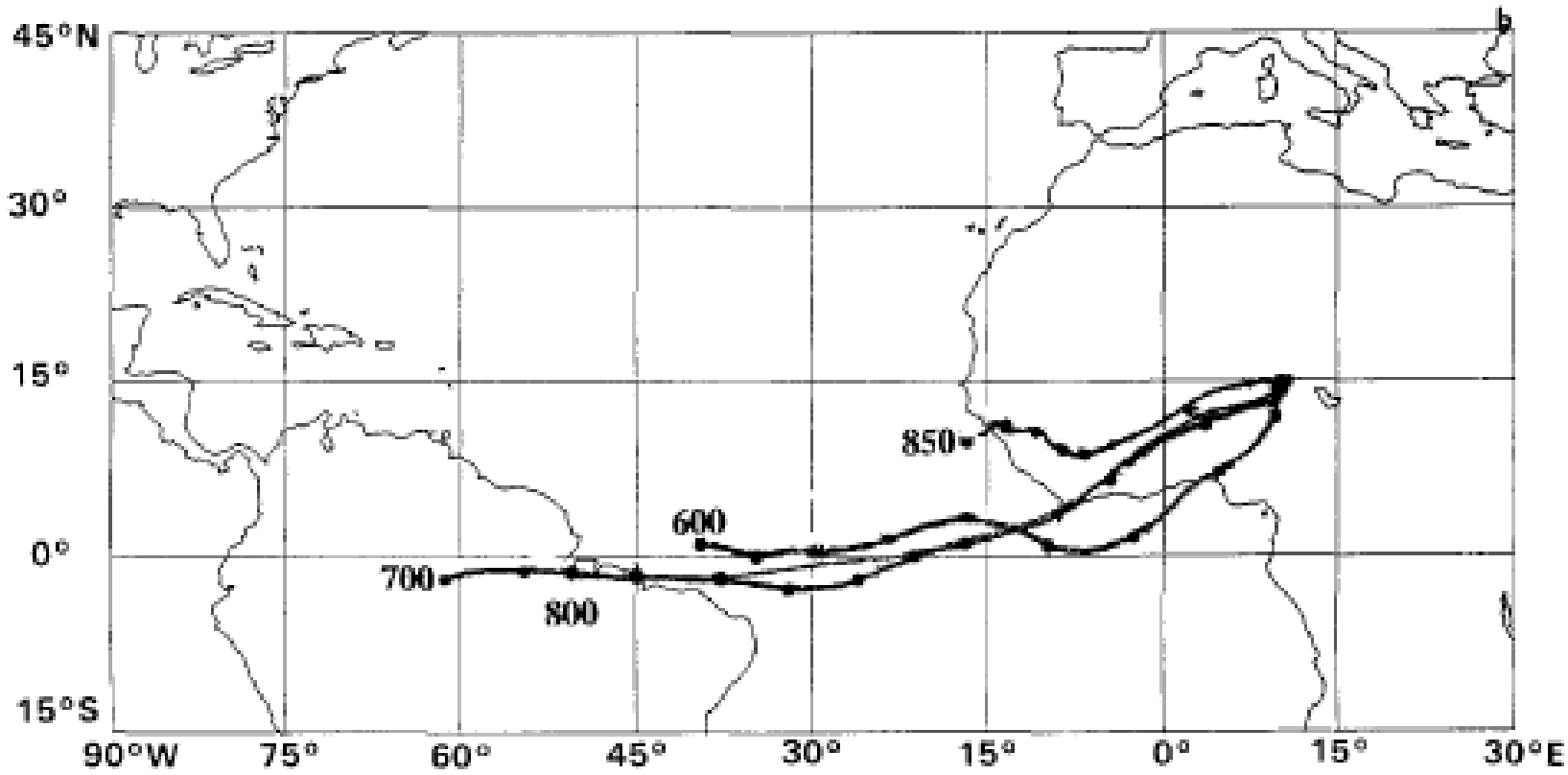




	Coarse fraction of aerosol (ng/m^3)		Fine fraction of aerosol (ng/m^3)	
	Dry Season	Wet season	Dry season	Wei season
MP	7200 ± 2100	6600 ±´2900	6200 ± 3100	2200 ± 1300
BC	48 ±19	53 ± 16	490 ± 260	161 ± 129
Mg	32 ± 19	24 ± 16	25 ± 14	20 ± 20
Al	55 ± 50	48 ± 71	32 ± 32	61 ± 84
Si	88 ± 82	110 ± 170	58 ± 72	130 ± 190
P	25 ± 13	35 ± 11	6 ± 3	4.2 ± 2.2
S	54 ± 22	37 ± 17	310 ± 180	100 ± 63
Cl	75 ± 73	73 ± 77	10 ± 8	10 ± 13
K	77 ± 29	93 ± 27	140 ± 88	40 ± 35
Ca	26 ± 16	26 ± 28	13 ± 9	15 ± 17
Ti	5.6 ± 5.7	5.3 ± 6.8	3.4 ± 3.2	5.3 ± 6.7
V	0.80 ± 0.63	0.51 ± 0.34	1.4 ± 0.9	0.82 ± 0.38
Cr	2.3 ± 1.9	2.1 ± 1.7	1.6 ± 1.6	1.3 ± 0.8
Mn	0.85 ± 0.61	1.0 ± 0.9	0.59 ± 0.49	0.91 ± 0.95
Fe	40 ± 30	34 ± 50	20 ± 19	36 ± 50
Ni	0.33 ± 0.36	0.38 ± 0.55	1.1 ± 1.0	0.77 ± 0.74
Cu	0.30 ± 0.32	0.34 ± 0.49	0.44 ± 0.53	0.55 ± 0.60
Zn	0.92 ± 0.48	0.95 ± 0.42	1.5 ± 1.1	0.70 ± 0.63
Br	0.38 ± 0.12	0.39 ± 0.28	2.5 ± 2.4	2.7 ± 1.6
Pb	0.30 ± 0.13	0.19 ± 0.12	0.36 ± 0.20	0.24 ± 0.16



Monthly average



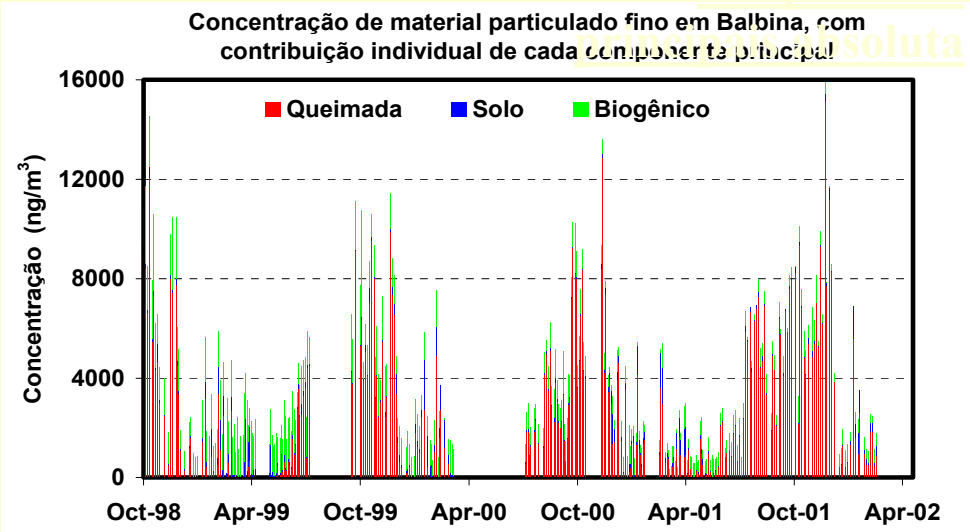
Swap,R. et al, Tellus(1992) 44B – 133-149

During this period ITCZ inject the dust from Sahara region to Central Amazonian.

Receptor Model Methodology – Factor Analysis

	Biomass Burning	Soil Dust	Biogenic Aerosol	
	Queimada	**Solo**	**Biogênico**	**COM**
BC	**0.97**	0.04	0.02	*0.95*
K	**0.95**	0.12	0.21	*0.95*
MPF	**0.94**	0.10	0.20	*0.93*
S	**0.86**	0.01	0.39	*0.89*
Zn	**0.65**	0.11	**0.50**	*0.69*
Al	0.02	**0.99**	0.03	*0.98*
Fe	0.04	**0.99**	0.00	*0.98*
Si	0.01	**0.99**	-0.06	*0.98*
Ca	0.23	**0.91**	0.08	*0.88*
P	0.37	-0.03	**0.89**	*0.94*
Variância (%)	41	38	13	

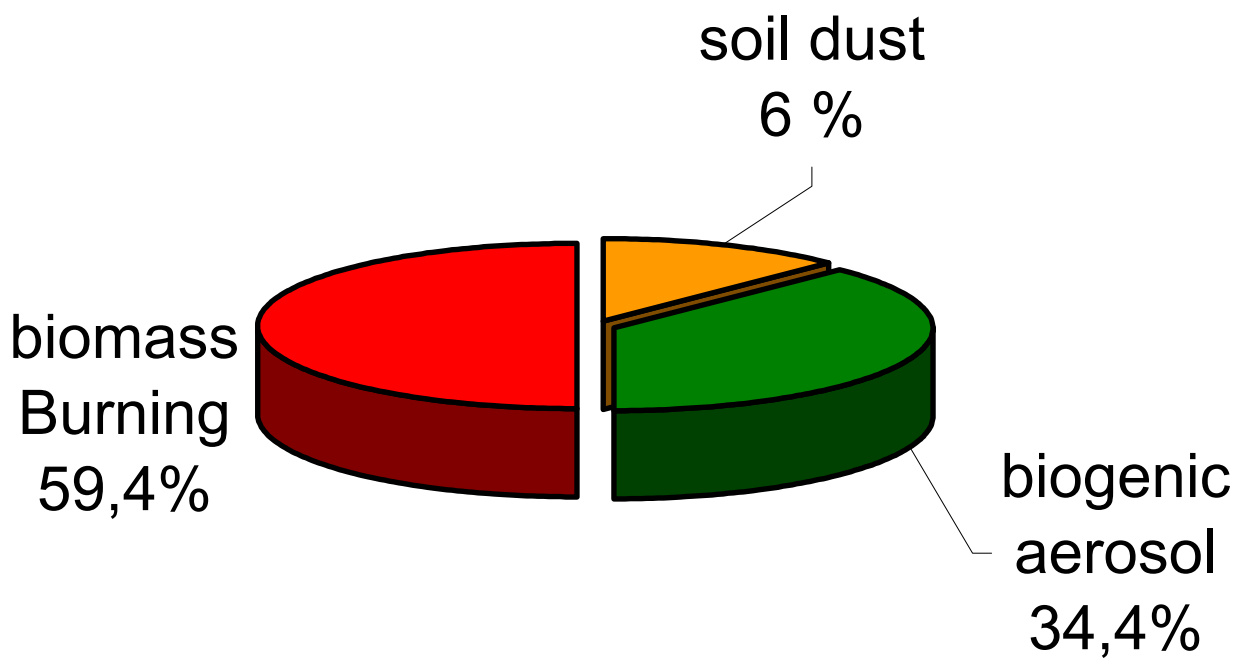
Balbina – Fine Mode



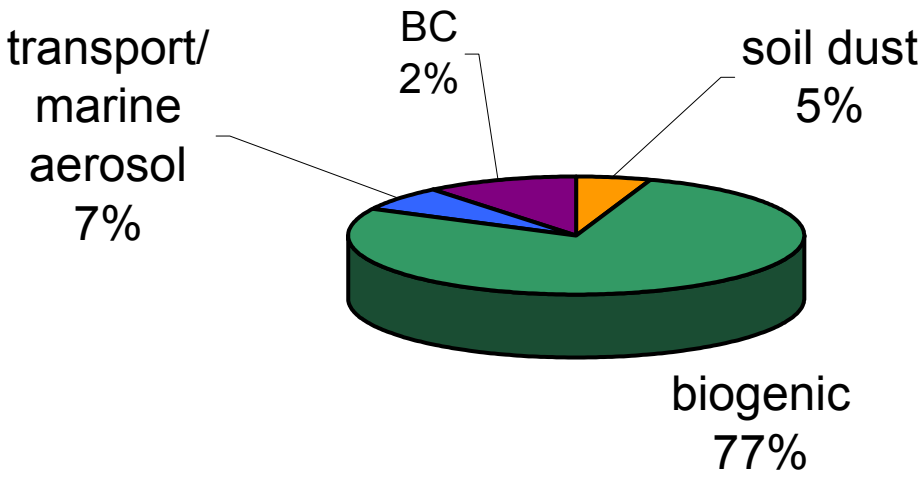
Factor Analysis – Balbina – Coarse fraction of aerosol

	Wet Season				Dry Season				
	Soil	Biogênic + soil	Transport	COM	Soil	Biogênic	Transport	BC	COM
Si	**0.95**	0.17	0.25	*0.99*	**0.90**	0.04	**0.39**	0.04	*0.97*
Al	**0.94**	0.21	0.23	*0.98*	**0.96**	0.08	0.25	0.04	*0.98*
Fe	**0.94**	0.22	0.23	*0.99*	**0.95**	0.04	0.18	0.16	*0.96*
Ti	-	-	-	-	**0.97**	0.06	0.10	0.05	*0.96*
Ca	**0.86**	0.18	0.39	*0.92*	**0.52**	0.08	**0.72**	0.24	*0.85*
P	-0.21	**0.94**	-0.08	*0.94*	-0.23	**0.95**	-0.10	-0.03	*0.96*
Zn	0.22	**0.86**	0.19	*0.79*	0.22	**0.78**	-0.02	0.22	*0.72*
K	0.43	**0.86**	0.18	*0.94*	-0.04	**0.93**	0.18	0.10	*0.92*
MPG	0.44	**0.81**	0.25	*0.92*	0.24	**0.89**	0.16	0.03	*0.89*
BC	0.37	**0.68**	**0.48**	*0.81*	0.11	0.15	0.17	**0.94**	*0.95*
S	0.47	**0.61**	**0.58**	*0.91*	0.28	**0.49**	**0.62**	0.41	*0.87*
Cl	0.54	0.13	**0.80**	*0.92*	0.25	0.00	**0.92**	0.04	*0.92*
Variance (%)	40	35	17		35	29	17	10	

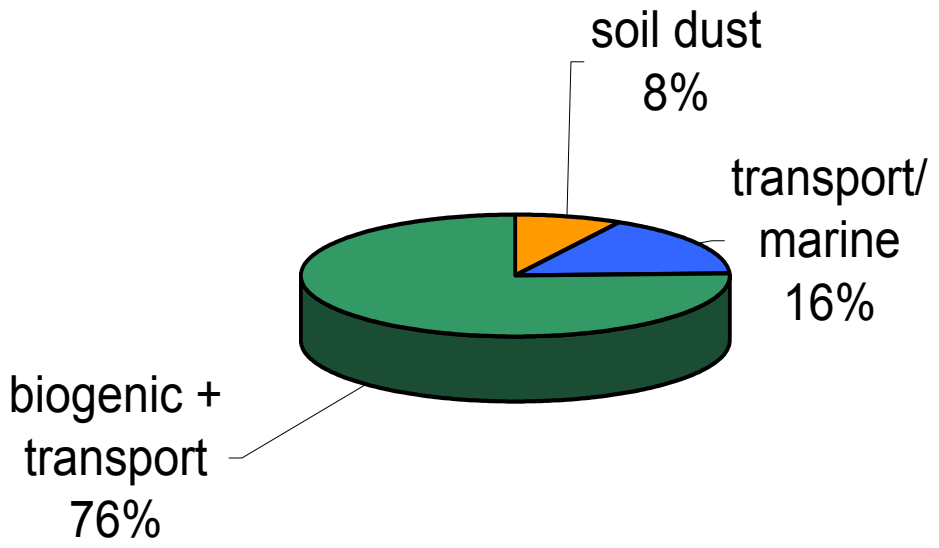
Balbina - Fine Fraction of aerosol



Balbina - Coarse Mode - Dry Season

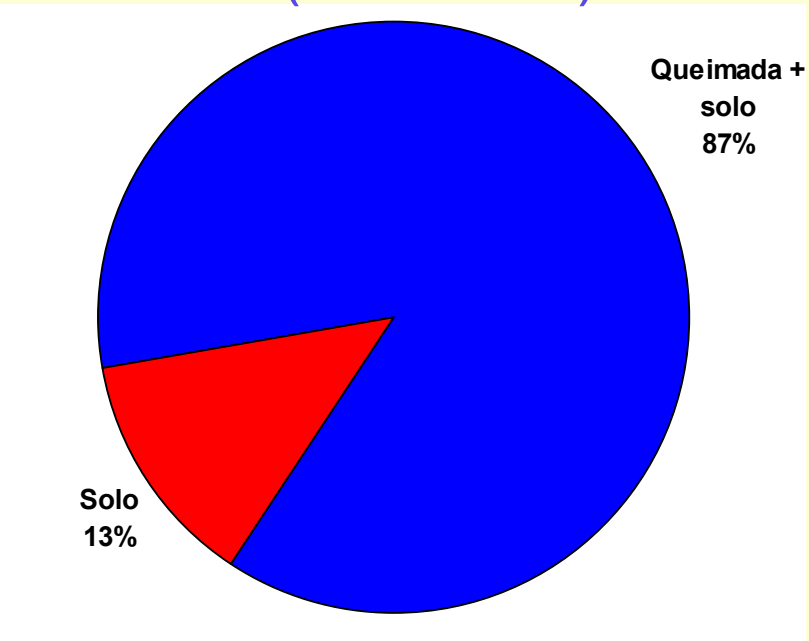


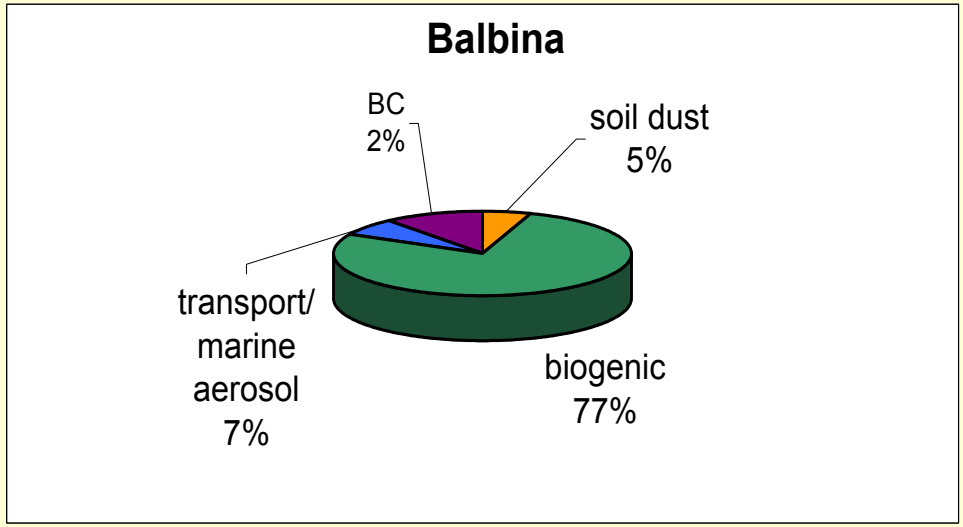
Balbina - Coarse Mode - Wet Season



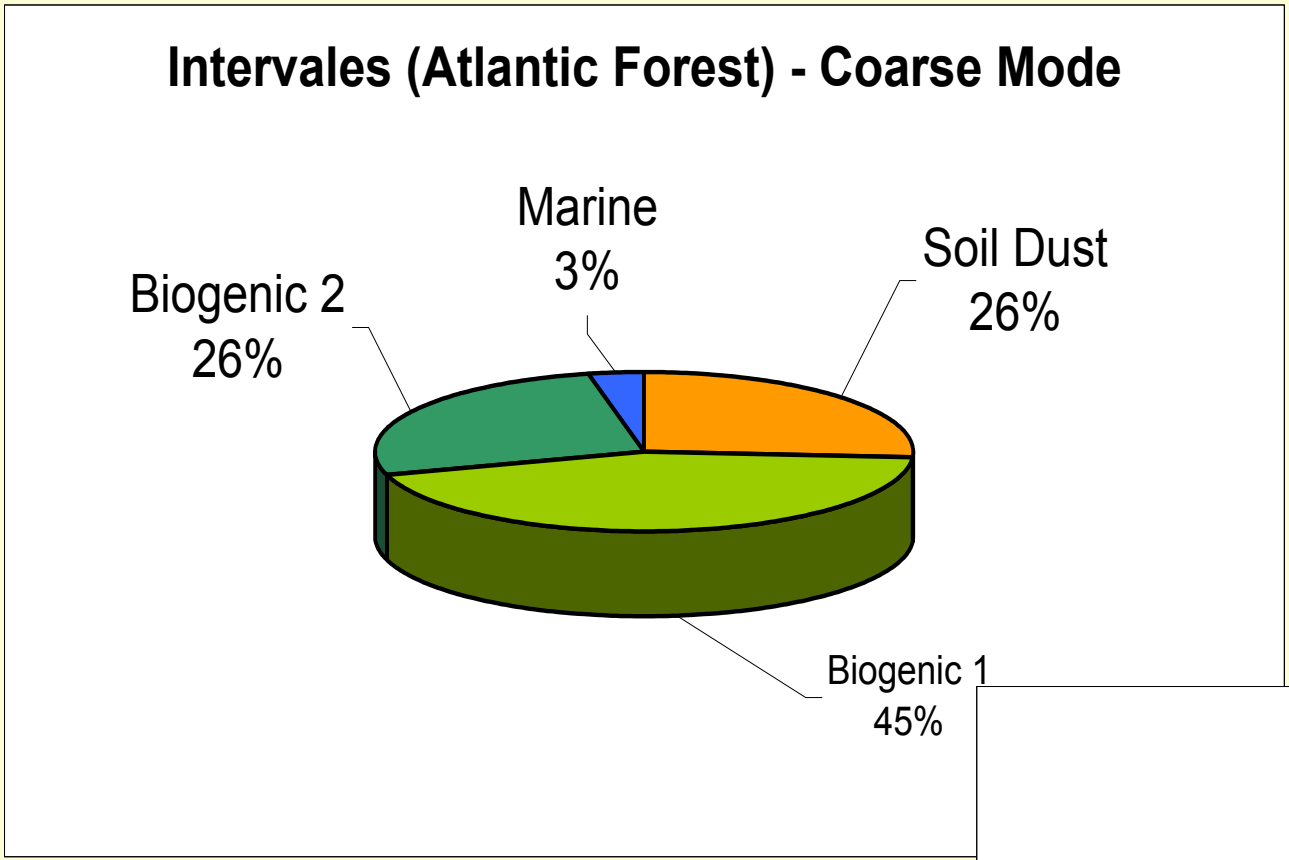
Comparing with Rondonia (No preserved area):

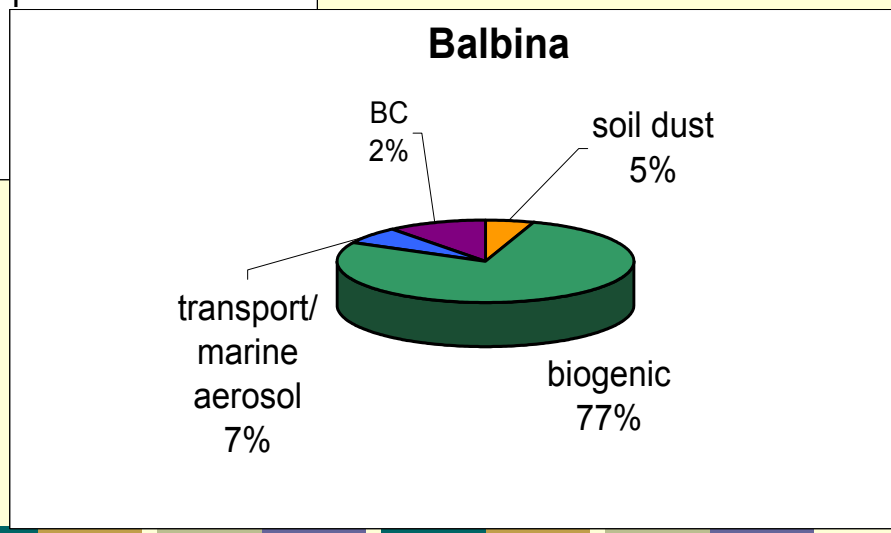
Coarse fraction of aerosol (Rondonia)





Comparing with another tropical forest – Atlantic Forest.





Precipitation Chemistry

	Wet Season				Dry Season			Mean
	1998	1999	2000	2001	1998	2000	2001	
pH	4.9	5.3	4.8	4.8	5.3	4.8	4.8	4.9
H^+	11.7	4.9	15	18	5.0	16	16	11.9
Na	3.4	3.7	1.7	5.7	6.9	5.0	4.5	3.8
NH_4^+			3.4	3.3		3.5	5.4	1.9
K^+	1.3	1.6	0.89	1.4	1.9	1.9	1.6	1.4
Mg^{2+}	1.5	1.7	1.7	2.4	2	2.4	2.6	1.9
Ca^{2+}	1.3	2.2	1.7	2.2	1.4	1.9	3.1	1.8
nss-Ca^{2+}	1.2	2	1.6	2.1	1.1	1.7	2.9	1.7
F^-			0.55	1.6			1.3	0.81
CH_3COO^-			5.2	3.3		5.2	6.3	5.1
$HCOO^-$			1.4	0.59		0.79	1.8	1.2
Cl^-	3.2	4.8	4.0	11	6.7	6.7	6.8	5.2
NO_2^-			0.043	0.039		0.045	0.14	0.052
Br^-			0.030	0.011		0.0089	0.027	0.021
NO_3^-	4.4	1.3	5.6	5.1	8.4	6.7	7.9	5.2
$C_4H_3O_4^-$			0.059			0.081	0.098	0.07
SO_4^{2-}	2.7	1.9	2.3	3.6	5.6	5.1	3.1	3.2
nss-SO_4^{2-}	2.3	1.5	1.9	3.2	4.7	4.7	2.4	3.0
$C_2O_4^{2-}$			0.21	0.20		0.27	0.35	0.24
PO_3^{4-}			0.0061	0.0082		0.0077	0.014	0.0075
$C_6H_5O_7^{3-}$			0.031	0.015		0.016	0.018	0.023
DIC			21	14		26	21	21.8

Precipitation samples - Factor Analysis

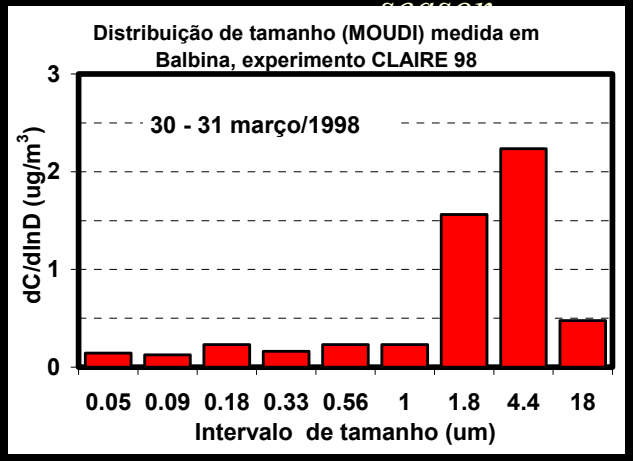
	Biogênic + marine	Organic acidity	BIO 1	BIO 2	BIO 3	COM
Na^+	**0.89**	0.29	0.15	0.24	0.10	*0.97*
Cl^-	**0.87**	0.35	0.14	0.14	0.06	*0.92*
$SO4^{2-}$	**0.85**	0.34	0.28	0.15	0.12	*0.95*
K^+	**0.83**	0.17	**0.38**	0.13	0.13	*0.90*
Mg^{2+}	**0.79**	0.48	0.20	0.25	0.18	*0.98*
Ca^{2+}	**0.76**	0.48	0.20	0.22	0.15	*0.92*
NO_3^-	**0.69**	**0.56**	0.26	0.15	0.24	*0.94*
CH_3COO^-	0.37	**0.84**	0.16	0.11	0.10	*0.89*
H^+	**0.57**	**0.76**	0.12	0.08	0.13	*0.94*
$C_2O_4^{2-}$	0.34	**0.52**	**0.52**	0.35	0.16	*0.80*
NH_4^+	0.30	0.15	**0.91**	0.07	0.04	*0.94*
PO_3^{4-}	0.26	0.13	0.10	**0.94**	0.06	*0.98*
$C_6H_5O_7^{3-}$	0.17	0.14	0.06	0.06	**0.97**	*1.00*
Variance (%)	41	21	12	10	9	

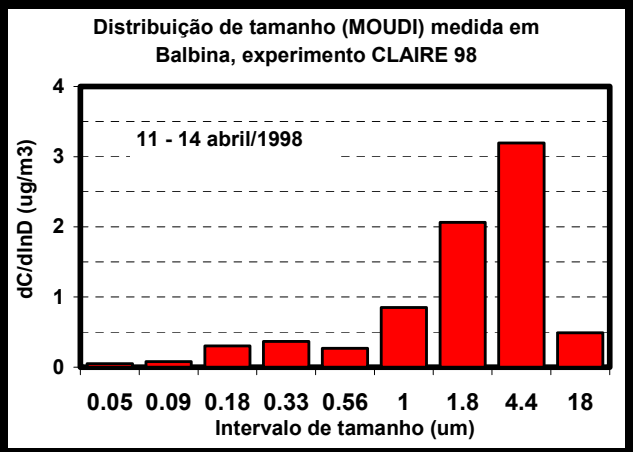
Disturbed area - Rondonia

	Marine + biogênic	organic acidity	Antropogenic emission	H_2SO_4	COM
Na^+	**0.88**	0.17	0.37	0.10	*0.94*
Ca^{++}	**0.87**	0.31	0.01	0.15	*0.88*
Cl^-	**0.70**	0.18	**0.55**	0.32	*0.92*
DOC	0.15	**0.94**	0.16	0.01	*0.92*
Mg^{++}	0.35	**0.84**	0.20	0.18	*0.89*
NO_3^-	0.17	0.21	**0.87**	0.13	*0.85*
K^+	**0.58**	0.14	**0.64**	0.23	*0.82*
H^+	0.18	**0.54**	**0.60**	**0.46**	*0.89*
SO_4^{--}	0.21	0.10	0.21	**0.93**	*0.97*
Variance (%)	29	23	23	15	

Size distribution – MOUDI

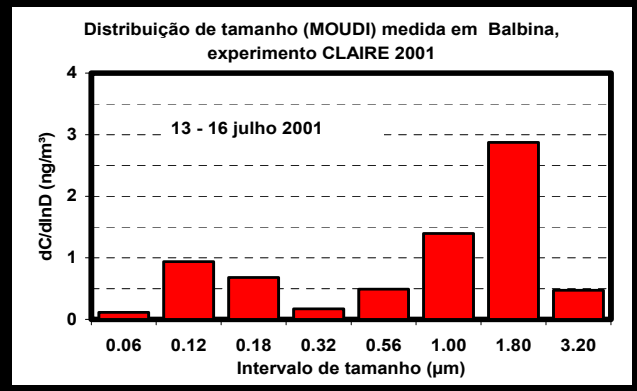
Wet season

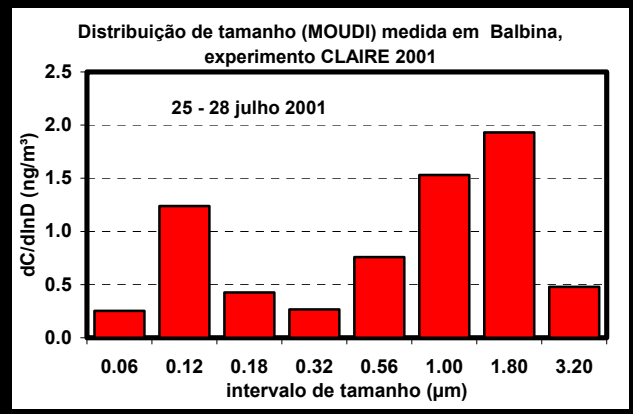




Fine fraction of aerosol

Dry season





Conclusions:

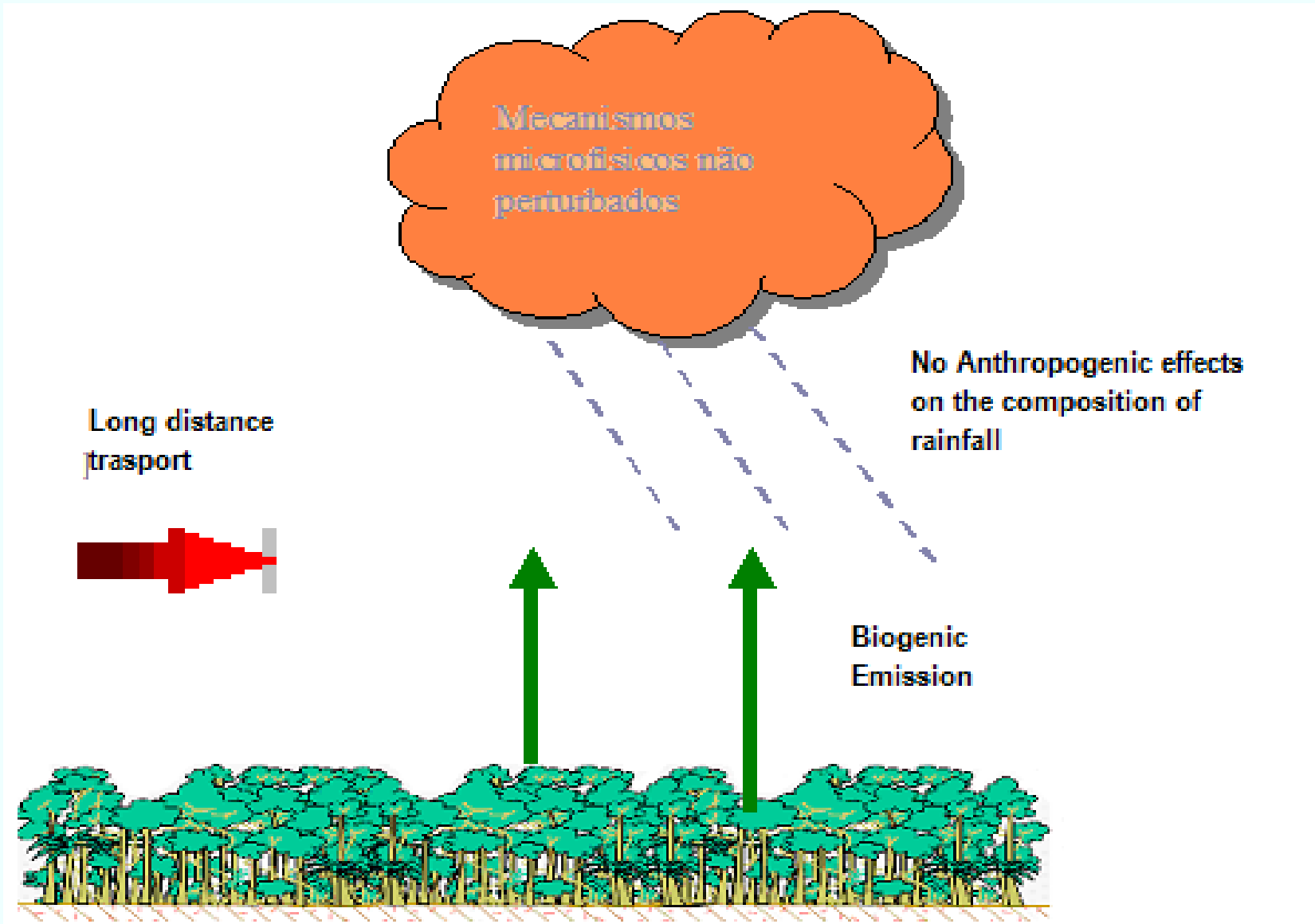
1) Biogenic Emissions dominated the particulate matter concentration.

2) Seasonality was observed in the fine fraction of aerosol due to large scale transport of biomass burning

3) Aerosols and precipitation resulted in similar extracted component (Biogenic and transport component).

4) Biomass burning was not observed in precipitation data analysis

Background condition, remote area




Thanks for your attention
We thank Alcides C. Ribeiro, Ana Lúcia Loureiro and Tarsis Germano for assistance in sample collection and analyses