BIOMASS BURNING AND THE CONCENTRATION ENHANCEMENT OF VARIOUS IONIC SPECIES

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Introduction

Biomass burning, in savanna areas, such as the Pantanal, is practiced to rejuvenate the pasture for the cattle stock of these regions, releasing in the atmosphere the so called "green house gases", as well as particulate matter. Worldwide studies have tentatively quantified the gases and particulate matter emitted by such savanna fires[1,2]. However, emission represent only a term in the atmospheric budget of green house species and, in the Pantanal for example, little is known about their local deposition rate. Consequently, the extent to which biomass burning can alter the local atmospheric composition remains to be quantified.

In this work, we present the results of an on going project which objective is to determine the impact of biomass burning on the chemical composition of rain and atmospheric total particulate matter (TPM). The intensity of the burning is obtained from satellite imagery and is corrolated to the variation of chemical composition in time.

Material and methods

Sampling activities were carried in Campo Grande, a locality close to the Pantanal. Particulate matter was collected weekly and rainwater on an event basis since August 1993 and were analysed for sodium, potassium, calcium, magnesium, chloride, sulfate, nitrate and ammonium. The sampling and analytical protocols, as well as the methodology adopted to calculate the deposition rates are described elsewhere[3,4]. Results are expressed in $\mu g/m^3$ for TPM, in mg/l for the rain and in $mg/m^2 \cdot day$ for the deposition rates. Finally, the fire counting in the vicinity of Campo Grande was extracted from the satellite imagery and, archived data ready to use, were kindly handed to us by A. Setzer (pers. comm.).

Results and Discussion

The mean seasonal concentrations of the various ions are presented in table 1. It is clear that during the dry season, which corresponds to the burning period, the concentrations are higher than during the wet season presumably because of the burning activity itself and lower rainfall. To verify this hypothesis, the complete time series of ionic concentrations in the TPM and rain were correlated to fire activity and rainfall.

As the absence of rain for a certain time generally implies a rise in the TPM concentrations, the inverse rainfall was selected as one independent variable for correlation purpose. The effect of burning intensity on the ionic concentrations was studied by setting 3 kinds of fire activity. These 3 independent variables are defined in fig. 1. The "local fire" and "proxy fire" variables represent the fire count in a 0.5° and 1.5° squares centered on Campo Grande respectively. The "distant fire" variable represents the fire count in a 2.5° square centered on Campo Grande excluding the "local fire". Results of the correlation study are displayed in fig. 2a and 2b.

The correlation coefficients for the ionic concentration in the TPM are shown in fig. 2a. The correlation coefficients are generally low (< 0.6), the chloride and sodium corrolations being the lowest, indicating that these ions may be controlled by long range transport from the ocean. The mean Cl^-/Na^+ ratio of 1.74 supports this (sea water = 1.78). All other ions show a fair correlation to the inverse rainfall which indicates that the rainfall cleansing power exert a good control over the concentration. The correlation of calcium and magnesium to the fire variables are very low indicating that burning may not be the sole source of these cations. The best correlation to fire is shown by potassium, sulfate, nitrate and ammonium. Interestingly, these correlation coefficients increase with distance. implying that fine aerosols, produced by distant fires, contribute significantly to the concentration of these ions.

The correlation between the ionic concentration in rain and the 4 independent variables is displayed in fig. 2b. In this case, the correlation coefficients are still low but somewhat more elevated than for the TPM case. As opposed to what was observed for the TPM, the "local fire" and "proxy fire" variables correlate better with the ionic concentration. The preferencial "washing" of large (and thus local) particulate matter by the rain is probably responsible for this.

The best overall correlation (> 0.8) for potassium, sulfate, nitrate and ammonium was obtained when all four independent variables, inverse rainfall (I), "local fire" (L), "proxy fire" (P) and "distant fire" (D), were used together. The concentration (C) of an ion (i), is then link to these variables by : $C_i = aI_i + bL_i + cP_i + dD_i + e$, where, a, b, c, d, are the regression coefficients and e is a constant. The concentration weight attributed to fire (W), both in the TPM and rain, was then estimated ($Wi = bL_i + CP_i + dD_i$). Using this result, the deposition rate attributed to fire activity was computed and is compared to the total deposition rate during the dry season. The non-fire or "natural" deposition is found by subtraction. It can be seen (fig. 3) that. during the dry season. the fire contributes to more than 50 % of the ammonium deposition. and almost 50 % of the potassium deposition.

Conclusion

The significant concentration increase of potassium. sulfate. nitrate and ammonium during the dry season. both in the TPM and rain. is linked to the fire activity within this period. Distant fires appears to contribute more to the TPM concentrations. while rain is more affected by local fire activity. As much as 25 to 50 % of the biogenic ions (K^+. SO_4^{--}, NO_3^-. NH_4^+) deposited locally. during the burning period. may origin from biomass burning.

References

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Table 1: Seasonal ionic concentrations in rain and TPM in Campo Grande

	TPM		Rain	
	Dry season	Wet season	Dry season	Wet season
Na^{+}	0.18	0.15	n.d.	n.d.
Ca^{++}	0.45	0.18	0.29	0.06
Mg^{++}	0.08	0.04	0.05	0.02
K^{+}	0.44	0.13	0.29	0.03
Cl^{-}	0.37	0.72	0.82	0.41
SO_4^{--}	1.70	0.75	0.76	0.26
NO_3^{-}	1.20	0.54	1.13	0.28
NH_4^{+}	0.67	0.12	0.77	0.19
TPM	86.50	34.34	n.a.	n.a.

n.d.: not disponible, n.a.: not applicable.

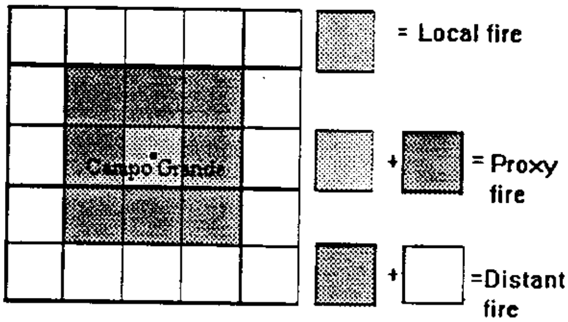

Fig. 1: Fire variables. Light gray squares represents the area where local fires are counted. Light + dark gray area is where the proxy fires are counted. White + dark gray area is where the distant fires are counted. Each square is 0.5° by 0.5°. Campo Grande is at the center of the figure.

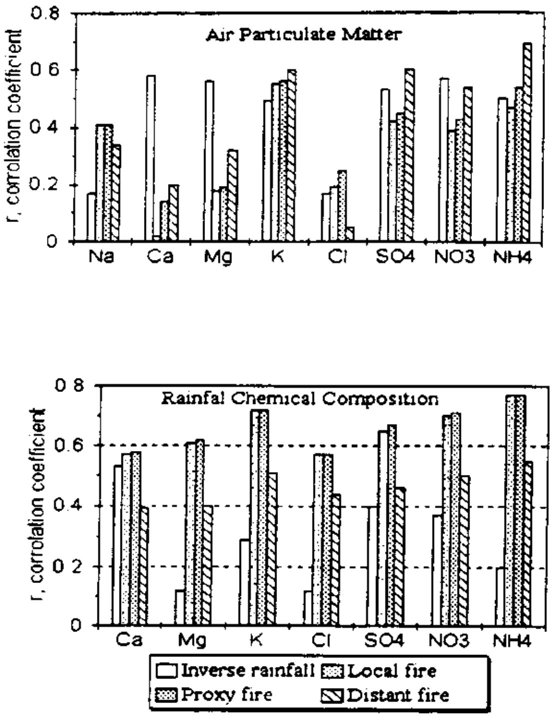

Fig. 2. Correlation between the dependent variable -ionic concentration series- and the independent variables -fire and inverse rainfall series (see text). a) TPM concentration series. b) rainfall concentrations series. Notice that K^{+}, SO_4^{--}, NO_3^{-} and NH_4^{+} series correlate well with fire series.

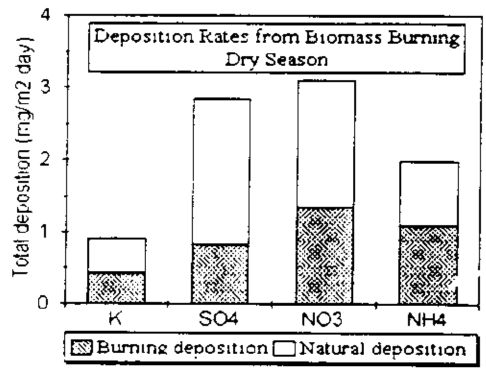

Fig. 3 : Deposition rates from biomass burning during the dry season. Total deposition (burning + natural deposition) is obtained from the original data set. Burning deposition rates, calculated from the model equations, account for about 50% of K^{+} and NH_4^{+} total deposition.