CHARACTERISTICS OF CLOUD-TO-GROUND LIGHTNING ACTIVITY OVER PORTUGAL IN RELATION TO AIR POLLUTANTS

Solange Leite[1], João A. Santos[1], Margarida Marques[2], Margarida Reis[1], João Sousa[3], Sandra Correia[4], Marcelo Fragoso[4]

[1]UTAD, CITAB, Physics Department, Vila Real, Portugal, solange@utad.pt
[2]UTAD, CITAB, Biological and Environmental Engineering Department, Vila Real, Portugal,
[3]Meteorological Institute, Lisbon, Portugal,
[4]Centre for Geographical Studies, Institute of Geography and Social Planning,
University of Lisbon, Portugal
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I. INTRODUCTION

Lightning plays a key role in determining the regional air chemistry. For instance, lightning directly releases NO_x throughout the entire troposphere. One main objective of this study is to assess how lightning, a natural source, influences lower tropospheric air pollution in Portugal. Air quality data is recorded on a daily basis by the Portuguese Environmental Agency at nine air quality stations. Cloud-to-ground (CG) lightning flash data, collected by the lightning detection network installed by Portuguese Meteorological Institute, is used to analyze the mutual effect on lightning activity and air pollutant concentrations over Portugal for the period of 2003-2009. Some results concerning the temporal scaling of the lightning activity for the same dataset were already presented in a previous study (Fragoso *et al*., 2010; Leite *et al*., 2011 and Santos *et al*., 2011).

CG lightning activity is considered in relation to hourly averages of ozone concentration (O_3), sulphur dioxide concentration (SO_2), nitrogen oxides (NO_x) and particulate matter (PM_{10}). Additional attention is also devoted to the extreme episodes, particularly to two long-lasting lightning episodes: from the 12th to the 18th of June 2006 and from the 9th to the 22nd of September 2007.

II. PRESENTATION OF RESEARCH

Figure 1 shows the location of the nine air quality stations. The four lightning detection sensors are also identified.

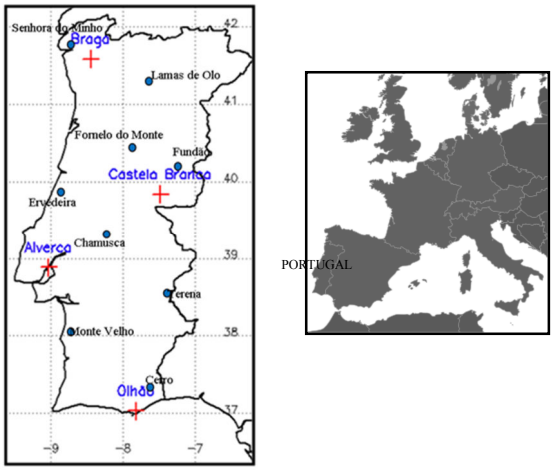

FIG. 1: Geography of lightning (+) and air quality (●) networks.

The geographical parameters are presented in Table 1. Although the lightning records start in 2003, our period of analysis is 2005-2009 because air quality data starts in 2005.

	Latitude	Longitude	Altitude (m)
Alverca	38,8	-9,1	1
Braga	41,6	-8,4	168
Castelo Branco	39,8	-7,4	384
Cerro	37,3	-7,7	300
Chamusca	39,4	-8,5	43
Ervedeira	39,9	-8,9	32
Fornelo do Monte	40,6	-8,1	741
Fundão	40,2	-7,3	473
Lamas de Olo	41,4	-7,8	1086
Monte-Velho	38,1	-8,8	53
Olhão	37,0	-7.8	8
Senhora do Minho	41,8	-8,7	777
Terena	38,6	-7,4	187

TABLE I: Geographical parameters of lightning and air quality stations.

We analyzed the efficiency of the air quality network concerning O_3, NO_x, SO_2 and PM_{10} records. The results are presented in Table II. As shown, only Ervedeira and Fundão are efficient air quality stations concerning all pollutants. In spite of being the official and national air quality network, data quality is not so good.

	O_3	NO_X	SO_2	PM_{10}
Cerro	48	40	38	23
Chamusca	98	29	33	97
Ervedeira	99	96	99	94
Fornelo do Monte	76	72	79	81
Fundão	99	97	99	96
Lamas de Olo	91	64	79	88
Monte Velho	74	95	99	93
Senhora do Minho	86	57	88	75
Terena	91	76	76	61

TABLE II: Efficiency of air quality network (in percentage). Values of efficiency higher than 90% are shadowed.

We pursued with the analysis of Ervedeira and Fundão records. We present in Figure 2 the O_3, NOx, SO_2 and PM_{10} daily records against the daily number of electrical discharges near the air quality station, for each year of the recording period. The dashed lines represent daily pollutant

concentrations and vertical bars represent the number of atmospheric electrical discharges (AED). The thin vertical lines identify the time discontinuities since only the days with electrical activity and the following week are shown.

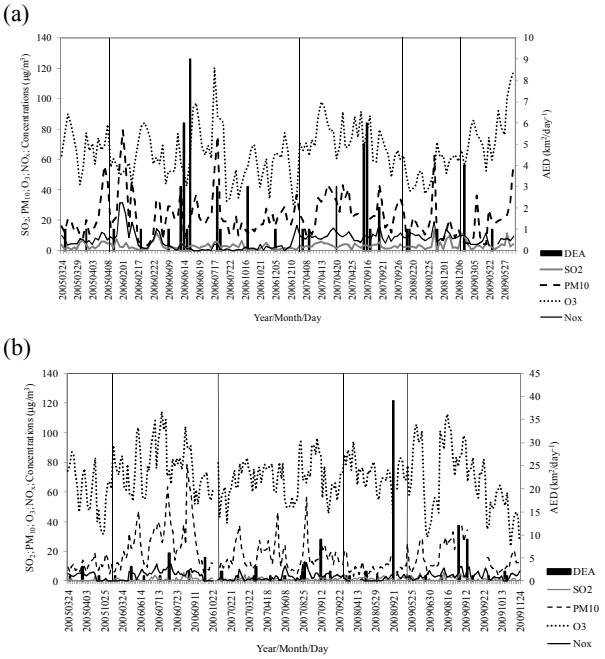

FIG. 2: Graphical representation of O_3, NOx, SO_2 and PM_{10} concentrations (dashed lines) and number of electrical discharges (vertical bars) in a daily base for: a) Ervedeira; b) Fundão. The vertical lines make remarkable the temporal discontinuities.

In Figure 3 we present the results of two long-lasting electrical activity episodes identified between 12th and 18th of June 2006 (a) and between 9th and 22nd of September 2007 (b), respectively. Only the efficient station/record pairs are presented, as shown in Table 2.

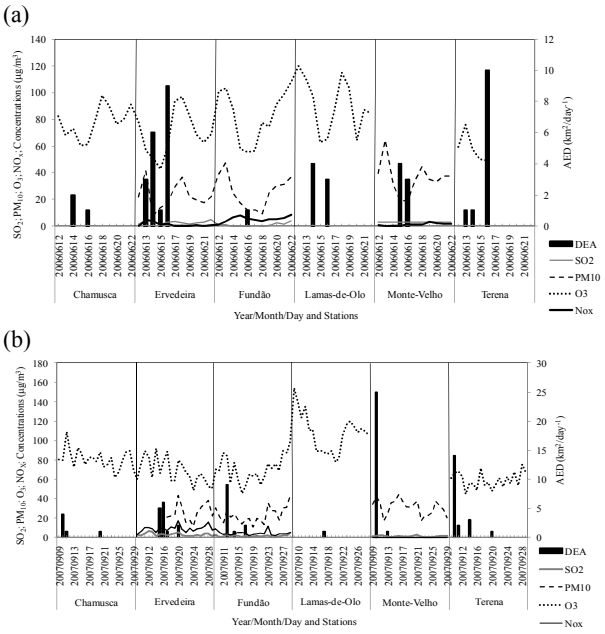

FIG.3: Graphical representation of O_3, NOx, SO_2 and PM_{10} concentrations (dashed lines) and number of electrical discharges (vertical bars) concerning both most active national lightning episodes: a) June, 12th-18th, 2006; b) September, 9th-22th, 2007. Only pollutant data with no missing values is shown.

III. RESULTS AND CONCLUSIONS

Generally speaking, the days with atmospheric electrical activity are followed by relative maxima of atmospheric O_3, NO_x, SO_2 and PM_{10} concentrations. Particular attention must be devoted to the two long-lasting episodes recorded in Ervedeira, the first between 13rd and 16th of June 2006 and the second between 15th and 20th of September 2007. Both of them are enclosed inside the two national episodes referred in section II. The upward trend in the concentration of the atmospheric pollutants, reaching a relative maximum, is clearly depicted. Off and on, we observe a downward trend which may be assigned to the effect of precipitation, now and then associated with atmospheric electrical activity. This effect is connected with the hydro solubility of O_3 and with the general precipitation washing effect of the atmosphere.

The occurrence of forest fires in the region of Ervedeira and Fundão, in the day or shortly before the occurrence of PM_{10} maxima, is also noteworthy. These forest fires may explain the PM_{10} peaks recorded at those air quality stations, which are clearly shown in Figure 2.

As previously stated, further attention is also devoted to the extreme episodes, particularly to two long-lasting lightning episodes. The number of discharges in the first episode, from the 12th to the 18th of June 2006, was 10592 while in the second episode, from the 9th to the 22nd of September 2007, it was 12053. Both episodes enclose the absolute maximum in 2006 (4317) and in 2007 (4952). Particularly for the first episode, the upward trend in O_3 and PM_{10} concentrations is apparent. The effect is also clear for the second episode in Ervedeira and Fundão, but for the other stations it is not so clear, mainly because of the lack of reliable air quality data.

IV. ACKNOWLEDGMENTS

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