An analysis of Potential Gradient, CO_2 and meteorological parameters relationships at a rural site

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Introduction

Electrical properties of the boundary layer can offer useful information about pollution acting as pollution index [1]. Moreover, their contribution in identifying or forecasting certain meteorological processes (i.e fog, convective clouds) has also been analyzed [2].

In the current work the local electrical climatology of a rural site in Northern Greece (Kimeria, Xanthi) is presented, by means of Potential Gradient (PG), as an attempt to define the typical electrical behavior of the site.

Relationships of standard meteorological parameters and CO_2 with Potential Gradient are also discussed. The sunrise / sunset effect is apparent on the PG data, while it is attempted to explore nighttime CO_2 levels as an indicator for convection and study the effects of convection on PG.

Experimental

A CS110 (Campbell Scientific) Electric Field Meter (EFM) has been installed and running since February 2011 at a rural site (Kimeria) 2 km from the town of Xanthi, NE Greece. Measurements of standard meteorological parameters (temperature, relative humidity, wind speed/direction, global radiation and pressure) and CO_2 are also being conducted using commercially available sensors. Data are sampled at the same frequency (1Hz) and recorded as 1-min means. In this work, 10-min and 1-hour means are presented. From the total experimental dataset the 12 successive months with the greatest data coverage for all parameters were selected (06/2011 – 05/2012) to construct the annual electrical climatology of the site.

Results and Discussion

The mean annual PG, calculated from hourly means, is 66.23 ±649.82 V/m (10). The standard deviation (STD) appears to be exceptionally high. This is due to frequent local thunderstorms at our site, especially during the afternoon (see Fig. 2). Fair Weather (FW) conditions were defined as conditions when PG was between 0 V/m and 350 V/m [3]. 73% of the total hourly PG values falls within this range, with 68.9% of it having STD <50V/m (Figure 1).

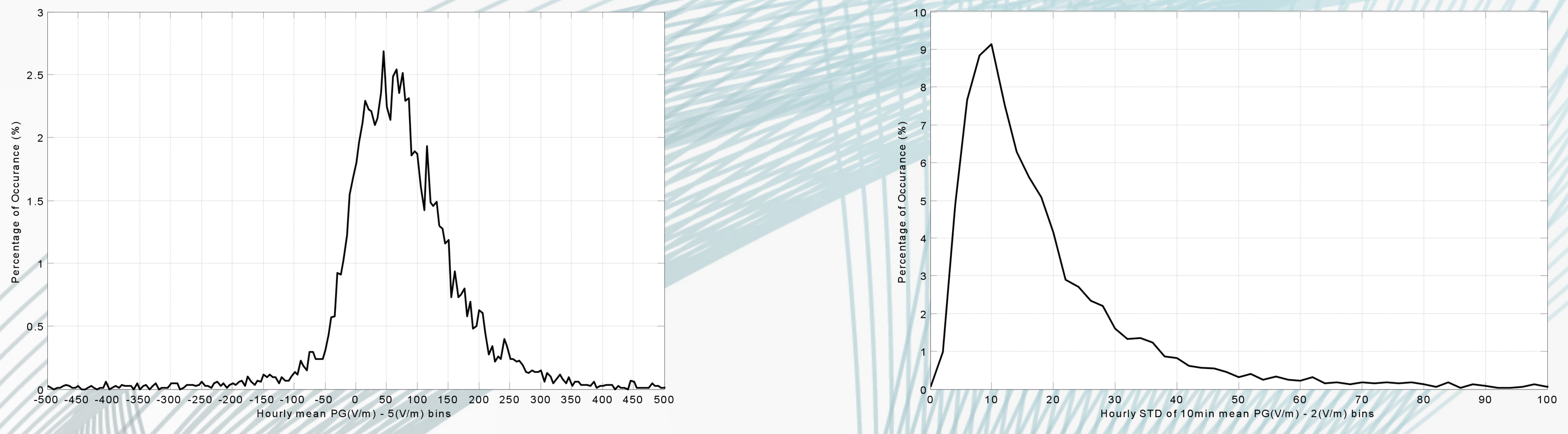

Figure 1. Histogram of hourly mean PG (V/m) in 5 V/m bins (left). Histogram of STD of 10-min values in each hour in 2 V/m bins (right).

In Figure 2, the mean diurnal variation (MDV) of PG for FW and all weather (AW) conditions is presented with the associated diurnal variation of mean hourly STDs. The FW–PG is always higher than the AW one [4], while they both exhibit their highest variability around 16:00 LT.

The MDV of FW–PG is more or less typical of a continental site, exhibiting double oscillation during some months (Fig. 3). However, the second maximum, when present, is not very pronounced, due to the influence of local factors.

The primary maximum appears at about 11:00 to 13:00 LT as a result of the morning convective conditions and human activity, the secondary one occurs at around 20:00 to 22:00 LT and is mainly the result of global thunderstorm activity. Two daily PG minima occur at approximately 5:00 and 19:00 LT. The seasonal variation in the timing of the diurnal extremes is attributed to seasonal effects and variations in local factors.

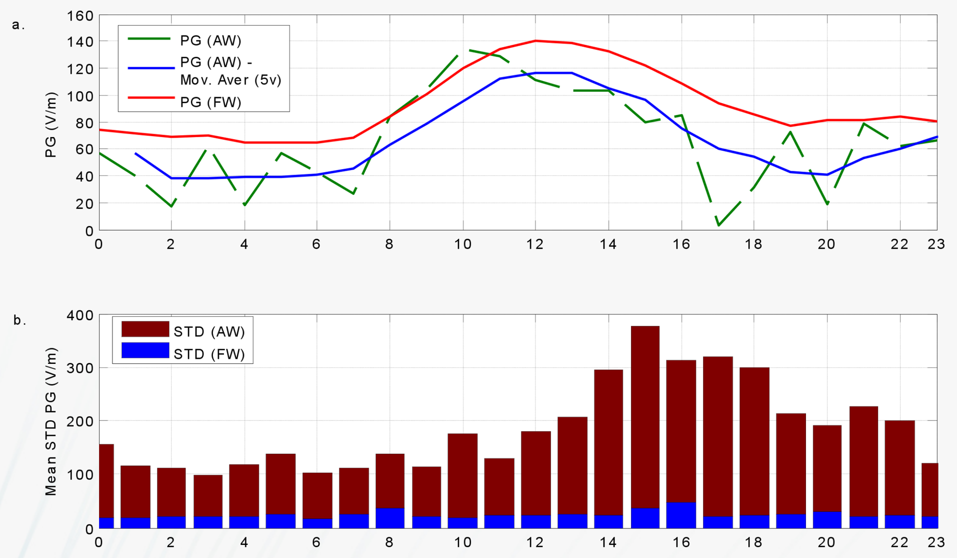

Figure 2. a. Mean diurnal variation of PG for AW and FW conditions. The moving average (5 values window) for AW conditions is also presented. b. Mean diurnal variation of mean hourly STDs for AW and FW conditions.

The annual variation of the mean monthly values is consistent with ones reported for other continental sites [4]. A winter maximum in PG is observed in February, while a summertime minimum is evident. High values of PG in June 2011 might be the result of biomass burning in the area.

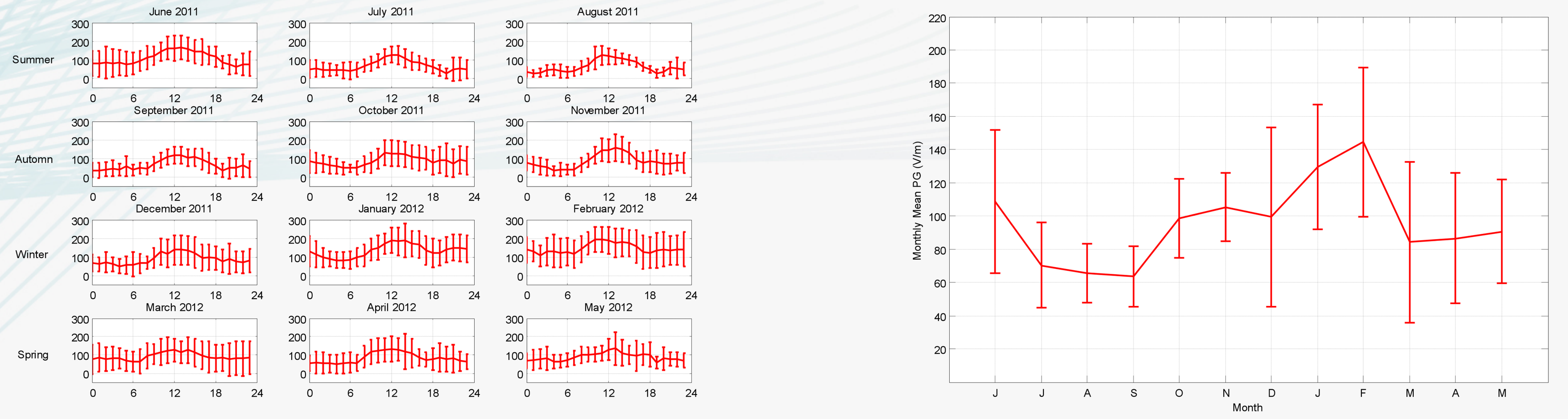

Figure 3. Mean diurnal variation of PG during FW conditions for every each month of the study period (left). Mean annual variation of FW PG daily means (right).

The sunrise / sunset effect on PG and CO_2 is evident, through the creation of updraft winds and the mixing of the boundary layer (Fig. 4).

The lower CO_2 values during the night of 13/12, as compared to previous nights, might imply, in the absence of horizontal wind, vertical air movement. We could hypothesize that ions created due to Rn emanation, are transported upwards, forming a respective convection current. PG, following these changes, exhibits a rather unstable behavior, being also negative most of the time.

Identification of convection periods using CO_2 values as indicator for the night of 12/12 and the first half of the 14/12 night may prove, through further analysis, useful for the justification of the respective PG response.

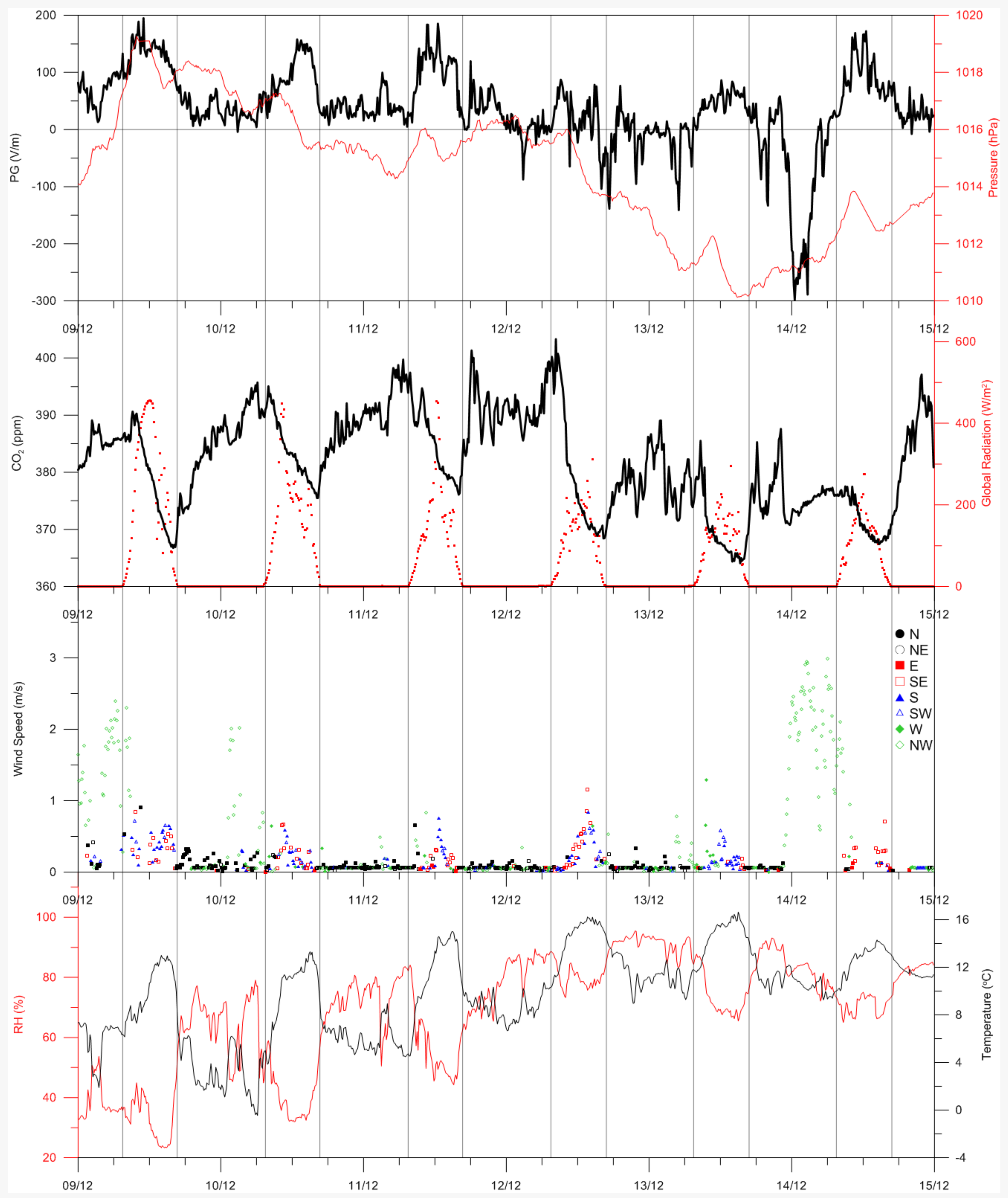

Figure 4. Comparison of PG (V/m), CO2 (ppm) and Global Radiation (W/m2), wind speed / direction (45- degrees sectors), temperature (oC) and RH (%). Vertical grid axes define sunrise and sunset. Days in horizontal axes indicate the start of the day.

References

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