A study of the effects of hyrdometeors (hail, snow, rain) and PM2.5 on Potential Gradient

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Abstract

We present here twelve (12) hail events, five (5) snow events and twenty (20) days with one or more rain events each in Xanthi, N. Greece, and their impact on Potential Gradient (PG). We also present some results on the impact of PM2.5 on PG.
All **hail** events except one occurred in the spring-summer season of the years 2011-2018. A decrease in PG has been observed which has been around 2000-3000 V/m during the five hail events which occurred concurrently with rain. In four events with no rain, the decrease has been varying between 0 and 2500 V/m. In the case of no drop, no concurrent drop in temperature has been observed, while for the other cases it appears that for each degree drop in temperature the drop in PG is 1000 V/m, hence we assume that the intensity of the hail event regulates the drop in PG.
Regarding **snow** events, the situation is more complicated, with PG fluctuating rapidly between high positive and high negative values.


Image: Nigh concert "Silver Tunes", maestro and choreographer Mr. Wind, dance group snowflakes, Lake Placid, NY, USA. Credit: Ekaterina Smirnova (distributed via imaggeo.egu.eu).

Methodology

We used hourly and mean daily PG and meteorological data from an electric field mill (CS110 Campbell Scientific) and a MET station from the Xanthi station for 2011-2019 (Kastelis et al., 2016; Nicoll et al., 2019). We also use five months of 2019 (11.7.-31.12.2019) in-situ data of PM2.5 collected during a PANACEA (PANhellenic infrastructure for Atmospheric Composition and climatE change) campaign.

PG and hail

We have 12 hail events 2011-2019 when PG measurements are available, in 10 of them meteorological data are also available (Table 1).

All **hail** events except one occurred in the spring-summer season of the years 2011-2018. A decrease in PG has been observed which has been around 2000-3000 V/m during the five hail events which occurred concurrently with rain. In four events with no rain, the decrease has been varying between 0 and 2500 V/m. In the case of no drop, no concurrent drop in temperature has been observed, while for the other cases it appears that for each degree drop in temperature the drop in PG is 1000 V/m, hence we assume that the intensity of the hail event regulates the drop in PG.

Table 1. Hail events in Xanthi, 2011-2019 and their impact on PG.

Date of event	**Hourly rain (mm)**	**Hourly ΔPG (V/m)@time of event***	**Hourly ΔPG (V/m)@1hr after event***	**Hourly ΔT***
22/5/12	15	-1000	-2300	-2
22/3/13	0.5	-2500	0	-2
11/4/14	2	-3000	0	-3
14/6/15	0	0	-80	0
28/6/16	0.1	-4000 (dropped to near 0 from +4000)	-4000	0
2/7/16	0	0	-6000	-3
14/6/18	0	-2500	-300	-2
3/8/19	20	-3000	0	-2
3/10/19	0	Difficult to say due to 20 mm rain 1 hr ago		+4

*ΔPG and ΔT relative to the hour before the event

PG and snow

Table 2. Snow events in Xanthi, 2011-2019 and their impact on PG.

Date of event (Temperature °C)	**Rain (mm)**	**ΔPG (V/m) @time of event***	**ΔPG (V/m) @1hr after the event***	**WV (m/s)**
22/12/2011 (+4)	Yes, at around 0.5-3 mm/hr for several hours before and after the snow event	+2000	+5000	5
02/02/2012 (-4)	No	-500	+500	3
26/01/2014 (+3)	Yes, at around 0.5 -4 mm/hr for several hours before and after the snow event	0	-1000	4
26/02/2018 (+1)	No	-2000	0	6
27/02/2018 (+2)	Yes, at 0.2 mm/hr	-4000	+1000	3

*ΔPG relative to the hour before the event

We notice that when there was no rain, PG mean hourly values dropped -500 to -2000 V/m. To our knowledge, the only study so far on the effects of snow on PG has been by Yair et al. (2019), which also observed polarity reversals with values of the order 20 kV/m for prolonged tens of minutes and suggested that the observed polarity reversals are caused by the gustiness of the local wind speed at the ground which affects the intensity of electrification.

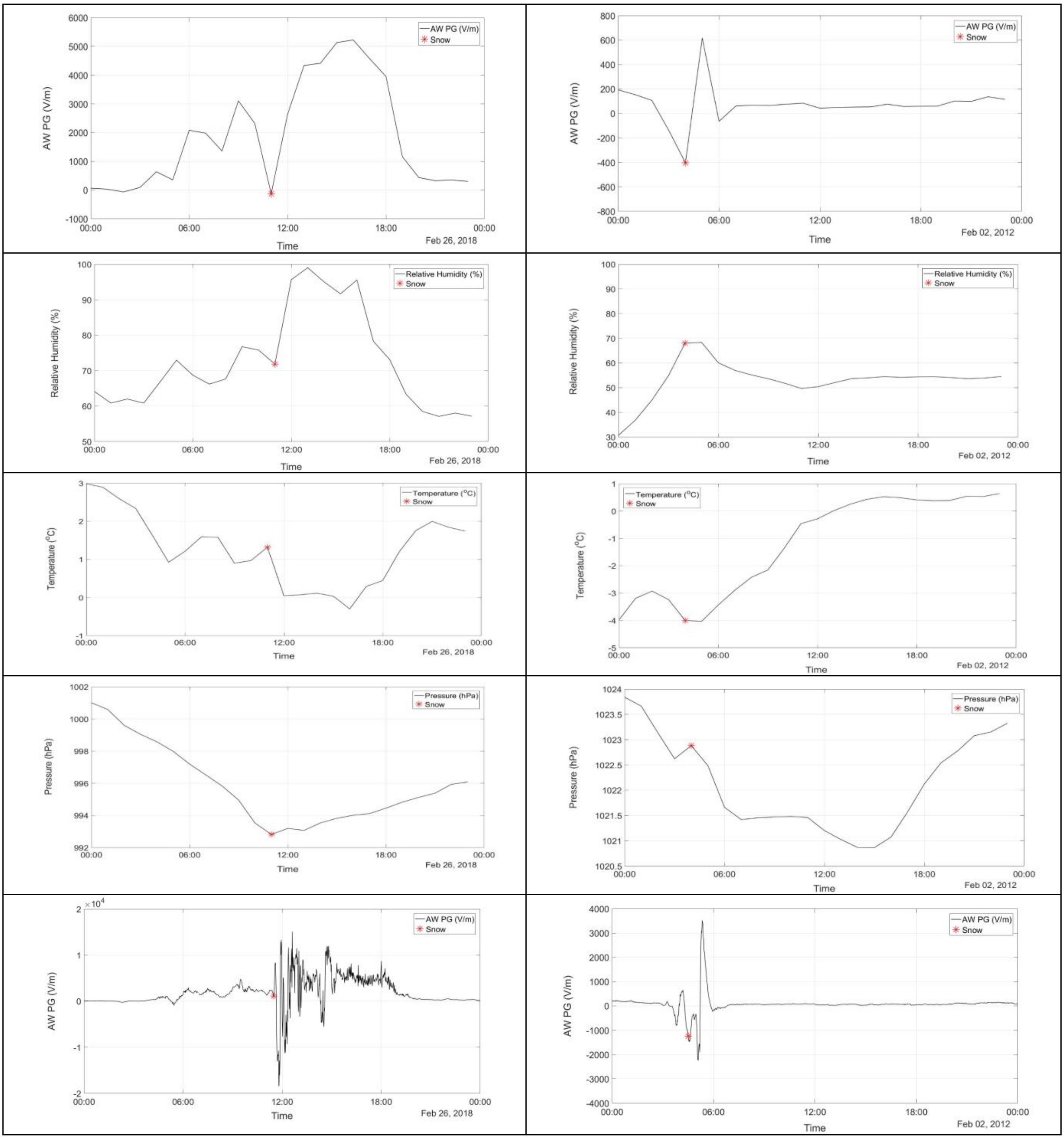

Fig. 1: Mean hourly values of PG, RH, T and P, and 1-min values of PG during the snow events of 26/02/2018 @11:30 GMT (left panels) and 02/02/2012 @04:30 GMT (right panels). The red asterisk marks the start of the snow event. Note that each PG panel has different axis scale.

PG and rain

Table 3. Studied rain events in Xanthi and their impact on PG. **Bold:** events where the time since the last rain was 9 to 15 days and there was a positive rebound of PG after the event has ended. *Italics:* events where the time from the last rain was 1 to 8 days and there was a positive rebound of PG after the event has ended. Blue: events during the warm part of the year.

Event No.	Date	Time from last rain	Hourly rain	Fall (-) or increase (+) of PG	PG positive rebound (difference above background)
1	21/09/2011	18 days	0.2 mm	0 V/m	-
2	21/09/2011	18 days	0.1 mm	- 600 V/m	-
3	21/09/2011	18 days	0.1 mm	+1000 V/m	-
4	21/01/2012	15 days	1.5 mm	- 450 V/m	-
5	21/01/2012	15 days	0.8 mm	- 300 V/m	-
6	21/01/2012	15 days	1.7 mm	**- 700 V/m**	**100 (50) V/m**
7	27/02/2012	14 days	1.4 mm	- 800 V/m	-
8	27/02/2012	14 days	1 mm	**- 950 V/m**	**200 (200) V/m**
9	09/03/2012	10 days	0.7 mm	- 300 V/m	-
10	09/03/2012	10 days	0.6 mm	- 480 V/m	-
11	09/03/2012	10 days	0.8 mm	**- 400 V/m**	**200 (100) V/m**
12	22/02/2013	2 days	2.5 mm	- 900 V/m	-
13	22/02/2013	2 days	0.9 mm	- 1100 V/m	-
14	*22/02/2013*	*2 days*	*2.2 mm*	*- 800 V/m*	*150 (120) V/m*
15	21/05/2013	2 days	1.4 mm	- 200 V/m	-
16	02/12/2013	1 day	0.9 mm	- 700 V/m	-
17	*02/12/2013*	*1 day*	*1.3 mm*	*- 600 V/m*	*180 (360) V/m*
18	23/02/2014	9 days	1.8 mm	- 420 V/m	-
19	23/02/2014	9 days	0.7 mm	**- 760 V/m**	**150 (170) V/m**
20	14/05/2014	4 days	1.5 mm	100 V/m	-
21	*03/11/2014*	*1 day*	*2.9 mm*	*+120 V/m*	*180 (80) V/m*
22	23/10/2015	1 day	1.1 mm	10 V/m	-
23	23/10/2015	1 day	1 mm	- 100 V/m	-
24	21/05/2016	4 days	4.8 mm	- 1000 V/m	-
25	14/06/2016	8 days	5.6 mm	- 200 V/m	-
26	14/06/2016	8 days	2.5 mm	500 V/m	-
27	*14/06/2016*	*8 days*	*0.4 mm*	*- 1200 V/m*	*200 (100) V/m*
28	11/10/2016	4 days	1.6 mm	+30 V/m	No data
29	*12/11/2016*	*2 days*	*5 mm*	*- 150 V/m*	*150 (30) V/m*
30	22/02/2018	1 day	2.3 mm	- 200 V/m	-
31	25/09/2018	19 days	0.7 mm	**- 290 V/m**	**120 (120) V/m**
32	*28/10/2018*	*8 days*	*3.9 mm*	*- 170 V/m*	*50 V/m*
33	28/10/2018	8 days	1 mm	- 100 V/m	-
34	27/03/2019	9 days	0.8 mm	+200 V/m	No data
35	13/11/2019	2 days	5 mm	- 150 V/m	-
36	*13/11/2019*	*2 days*	*2.2 mm*	*- 400 V/m*	*100 (0) V/m*
37	13/11/2019	2 days	0.8 mm	+10 V/m	-
38	03/12/2019	5 days	1.6 mm	- 600 V/m	-
39	03/12/2019	5 days	0.8 mm	- 700 V/m	-

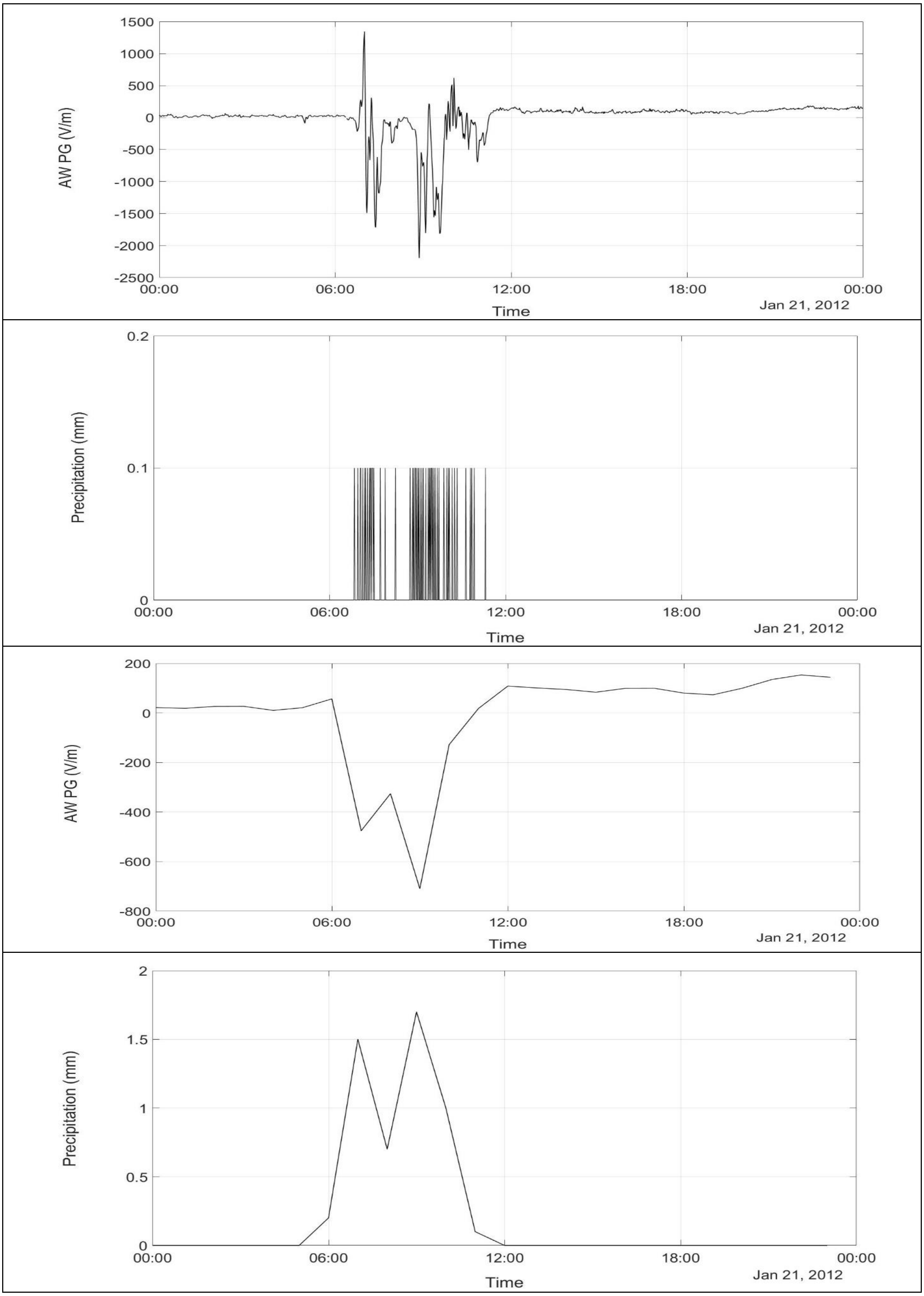

Fig. 2: Rain and PG during the 21/01/2012. 1-min values in the upper panels, hourly values on the two lower panels. There has been no rain for the last 15 days.

PG and PM2.5

Below some results on the response of Potential Gradient to concentrations of atmospheric particulates. We use in-situ measurements of PM2.5 collocated with PG measurements at a rural site in NE Greece (Xanthi). We use 6 months of measurements performed July-December 2019. It has been observed for some time, that pollution influences the electric field in the atmosphere (e.g. Jennings and Jones, 1976; Silva et al., 2014).

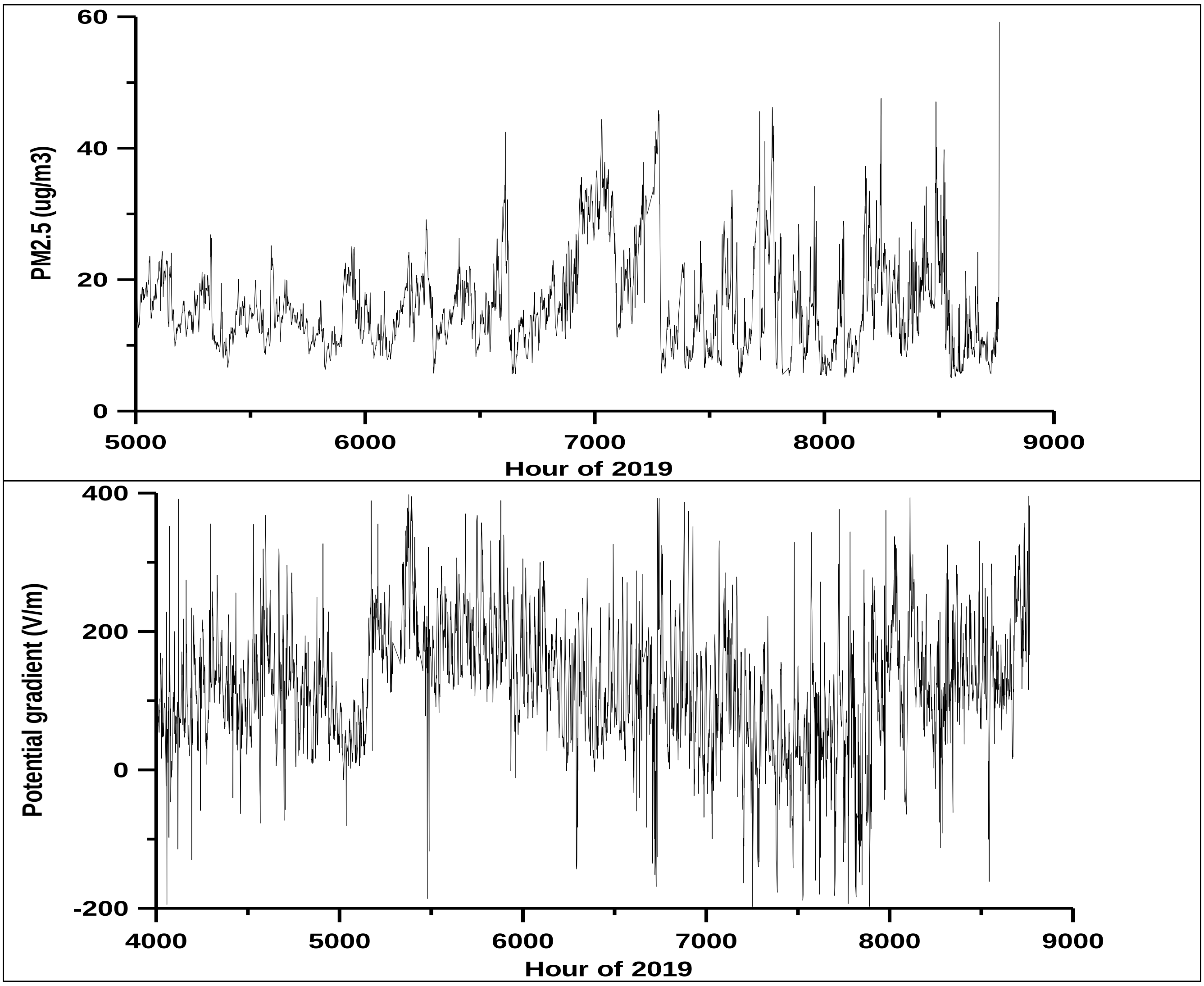

Fig. 3: Mean hourly values of PM2.5 (top) and mean hourly values of Potential Gradient (middle). As values of PG below -200 V/m or above 400 V/m are associated with very disturbed conditions (i.e. thunderstorms, nearby lightning or passage of electrified clouds), we show in the figure only the PG timeseries for PG values between -200 V/m and 400 V/m, although there were instances where PG went above 4000 V/m or below -8000 V/m.

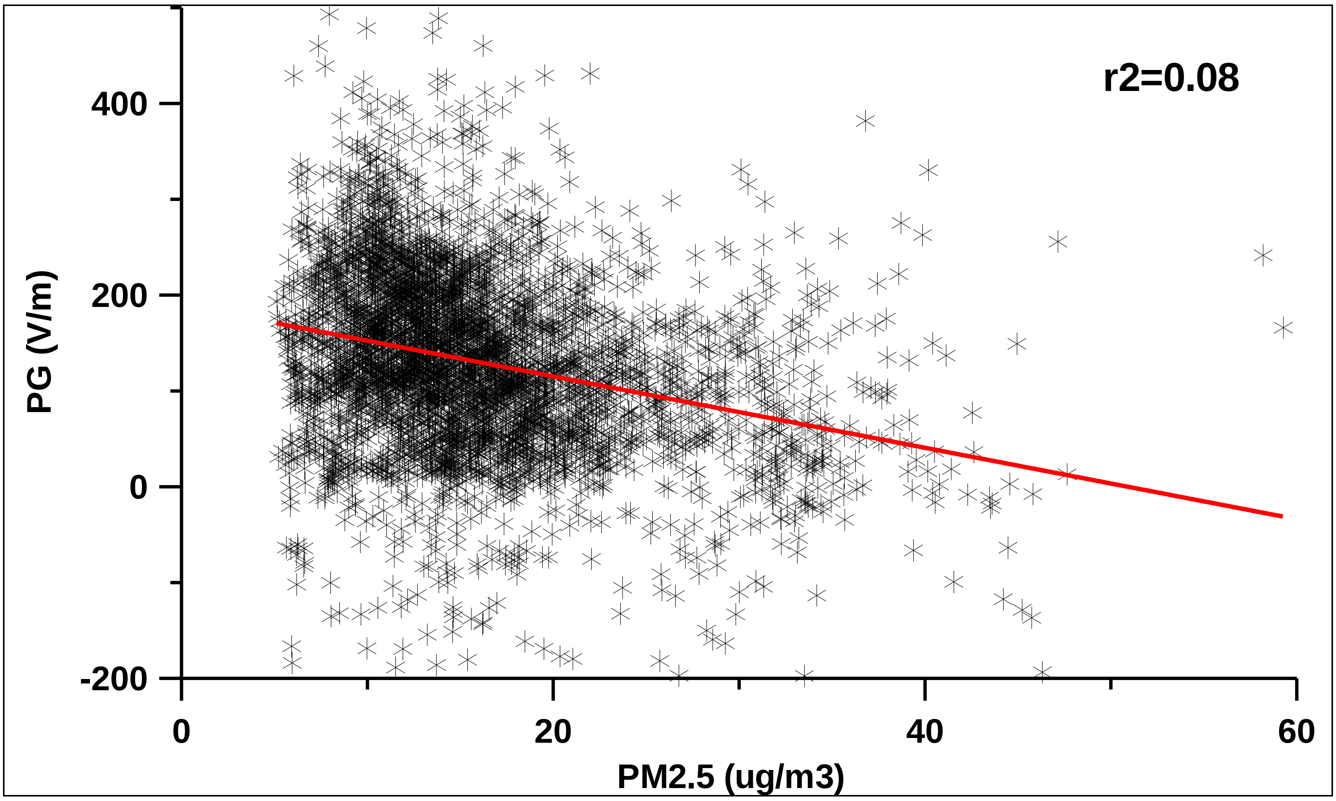

Fig. 4: Scatter plot of hourly values of PM2.5 versus PG (only for PG values between -200 and 400 V/m). R^2=0.08. There is some influence of the aerosol concentration, as determined by the in-situ measurements, on near-ground PG. An increase of PM2.5 by 10 μg/m3 decreases the field by around 37 V/m.

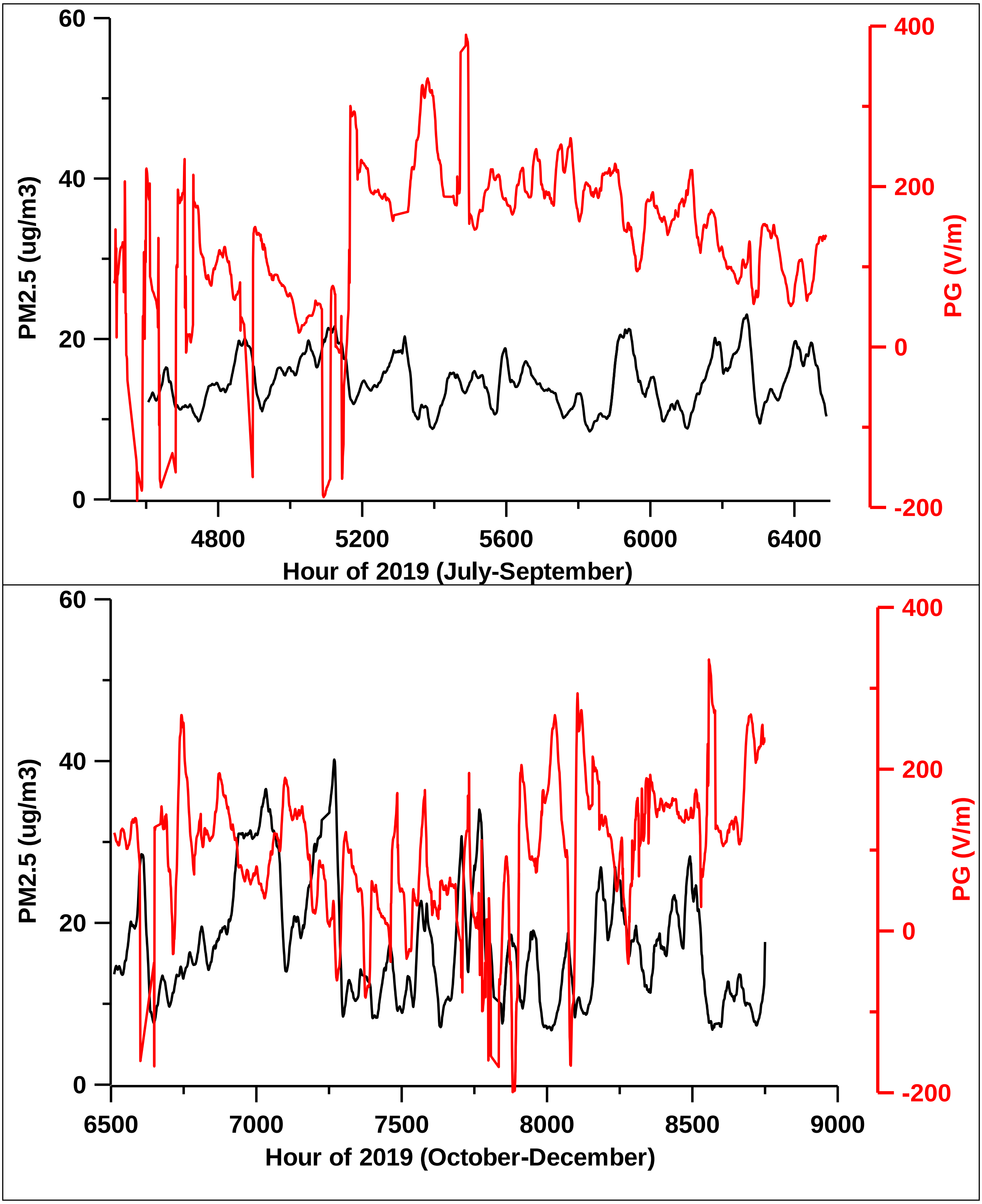

Fig. 5: Running average (window=23 hrs) of hourly PG and PM2.5 timeseries for summer and winter. Anticorrelation is evident, especially for summer (upper panel).

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