Atmospheric Research 215 (2019) 208–213

Contents lists available at ScienceDirect

Atmospheric Research

journal homepage: www.elsevier.com/locate/atmosres

Strong electric fields observed during snow storms on Mt. Hermon, Israel

Yoav Yair[a,*], Yuval Reuveni[a,b,c], Shai Katz[d], Colin Price[d], Roy Yaniv[b,c,d]

[a] School of Sustainability, Interdisciplinary Center (IDC) Herzliya, Israel
[b] Department of Physics, Ariel University, Israel
[c] Eastern R&D Center, Ariel, Israel
[d] Department of Earth Sciences, Tel-Aviv University, Israel

A B S T R A C T

We report observations of the behavior of the vertical component of the atmospheric electric field (Ez) during several snow storms, which occurred in December 2016 on top of Mount Hermon in northern Israel (33°18.3′N, 35°47.2′E, altitude 2020 m). The data was obtained at the Emilio Segre Cosmic ray Observatory (ESO) a site that continuously monitors atmospheric electrical parameters as well as gamma radiation from cosmic rays and ground level radon and radon progeny (Reuveni et al., 2017). The Ez observations were made with a CS-110 unit mounted on a 3 m pole sampled at 1 Hz, and the obtained Ez values were averaged and smoothed. Meteorological data, including ambient temperatures and hourly accumulated precipitation amounts (rain or snow) were obtained from the Israeli Hydrological Service station on the upper funicular station, at the same altitude of the ESO. During several snow episodes with snow rates > 1 mm hr^{-1}, there were very large fluctuations of the electric field with maximum values of ± 2.5·10^4 V m^{-1}, exhibiting polarity reversals on a time scale of several minutes. There is a complex relationship between the snowfall rate, the ambient temperature and the magnitude of the electric field fluctuations. The observed behavior of the electric field maps the wind speed, snowfall rate and the charge carried by the snow.

1. Introduction

The electrification of blowing snow has been known from the mid 1920s and attributed to mutual collisions between drifting snowflakes and due to splintering during impacts with the surface. Observations showed that the ambient potential gradient was intensified (more positive) indicating positive charge aloft, with “a compensating negative charge residing partly on the heavier snowflakes blown at a lower level and partly on the earth's surface” (Simpson, 1921). The intensity of the electric field was found to increase with the wind speed (Kikuchi, 1970), in an analogous manner to electrification of dust particles, suggesting a tribo-electric charging process within a saltation layer and a suspension layer above it (Gordon and Taylor, 2009). Snow electrification was also reproduced in laboratory and wind-tunnel experiments (Norinder and Siksna, 1953; Maeno et al., 1985; Schmidt et al., 1998; Omiya et al., 2011), motivated in part by the important effects that charging has on snow particle motion and saltation distances and hence on operational aspects like visibility, communication and public safety. Wind tunnel experiments by Maeno et al. (1985) showed that blowing snow particles were charged negatively. Electric charge-to-mass ratio increased with wind speed and with colder temperatures, reaching 0.85 μC kg^{-1} at −20 °C when the wind was 9 m s^{-1}, but were mostly found to be smaller by an order of magnitude around −5 °C when the wind was 5 m s^{-1}. Omiya et al. (2011) also conducted wind tunnel experiments and found negative values between −0.02 and − 3.58 μC kg^{-1}. Schmidt et al. (1999) conducted measurements of snow electrification with a miniature field mill at heights ranging from 5 to 37 cm above the surface. They reported *E*-field values in the range of 3.63 kV m^{-1} and 15.91 kV m^{-1}, when wind speeds were in the range of 11.7–14.96 m s^{-1}. A single measurement at 4 cm gave an exceptional value of 30 kV m^{-1}. When plotting the electric field strength against the height, they found a reasonable fit to a power law $E_z(z) = 3.85\, Z^{-0.34}$ where Z was the height of the field mill above the ground. When extrapolated to near surface height (within the saltation layer of snow particles) they predicted values ~90 kV m^{-1} (their Fig. 3). Measurements of the charge-to-mass ratios of drifting snow particles yielded values between −208 and +72 μC kg^{-1}. Gordon and Taylor (2009) measured snow electrification during 8 separate blowing snow events with a field mill at 0.5 m height above the snow. Their results show that above a wind speed threshold, electric field intensity shows a linear dependence $E_{max} = C_u(U_{max}-6)$ where C_u = 2.8 kV s m^{-2} and U is in m s^{-1}. Results show episodes with E_{max} = 30 kV m^{-1} when the ambient temperature was around −30 °C.

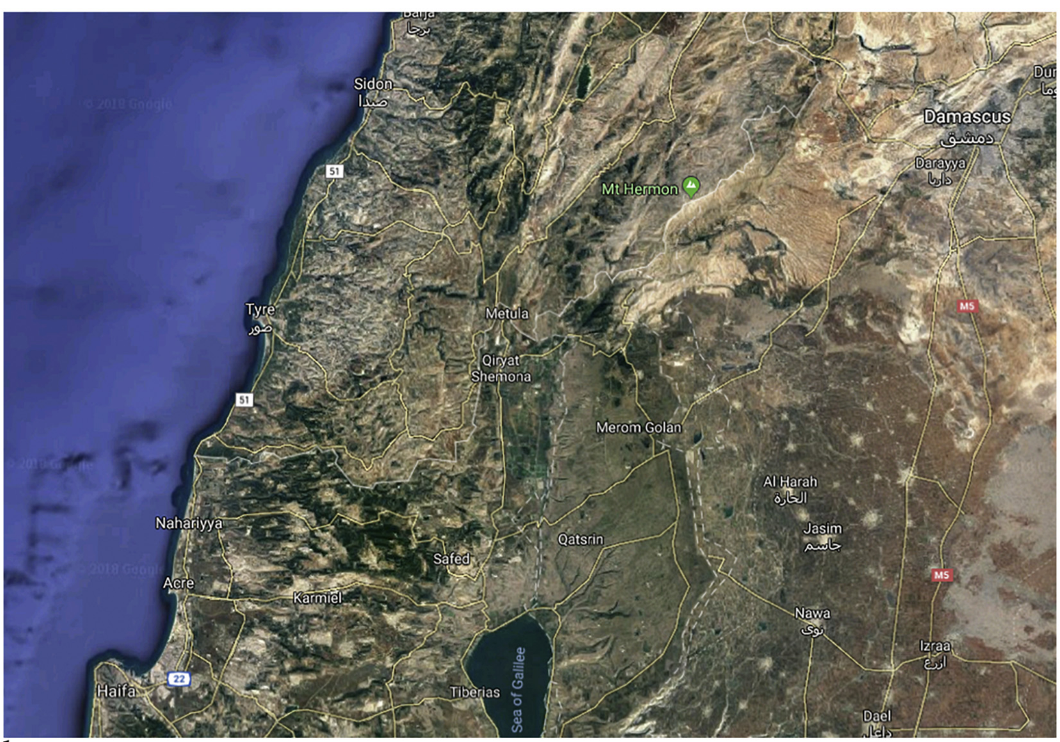
2. Site description

Our instruments are hosted by the Israel Cosmic Ray Observatory which is located on Mountain Hermon (30^{0}24′N, 35^{0}51′E) in northern

* Corresponding author at: Interdisciplinary Center (IDC) Herzliya, PO Box 167, Herzliya 4610101, Israel.
E-mail address: Yoav.yair@idc.ac.il (Y. Yair).

https://doi.org/10.1016/j.atmosres.2018.09.009
Received 29 April 2018; Received in revised form 7 August 2018; Accepted 11 September 2018
Available online 12 September 2018
0169-8095/

a



b

Fig. 1. (a) The CS110 electric field mill at the Mt. Hermon field station. The unit is located 3 m above the ground and is part of the Emilio Segre Observatory (in the background). Photo: R. Yaniv. (b) Google map showing the location of Mt. Hermon near the border between Israel and Syria.

Israel, at an altitude of 2055 m ASL), near the triple border between Israel, Lebanon and Syria. The mountain is the highest peak in Israel and its' only ski resort, and experiences frequent snow storms, almost exclusively during winter months (DJF). The CS-100 instrument measures the vertical component of the atmospheric DC electric field from a height of 3 m above the surface at a sampling frequency of 1 Hz (Fig. 1). The data is stored on a data-logger and is retrieved periodically (Yair et al., 2016). We also use the GDACCS instrument (Bennet and