Atmospheric Research 172–173 (2016) 119–125

Contents lists available at ScienceDirect

Atmospheric Research

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

Local and global impacts on the fair-weather electric field in Israel

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

[a] Department of Geosciences, Tel-Aviv University, Tel-Aviv, Israel
[b] School of Sustainability, Interdisciplinary Center (IDC) Herzliya, Israel
[c] Department of Life and Natural Sciences, The Open University, Ra'anana, Israel

ARTICLE INFO

Article history:
Received 29 September 2015
Received in revised form 23 December 2015
Accepted 31 December 2015
Available online 9 January 2016

Keywords:
Fair weather electricity
Global electric circuit
Carnegie curve

ABSTRACT

Ground-based measurements of the vertical electric field (Ez or potential gradient) during fair weather days in the Negev desert, southern Israel are presented for the period June 2013–July 2015. We show results of the diurnal variation of Ez on seasonal and annual time scales, and make comparisons with the well-known Carnegie curve. We show a positive correlation between the diurnal Ez values and the number of global thunderstorm clusters on the same days. However, the diurnal Ez curves observed in the Negev desert show a local morning peak (8–10 UT) that is missing from the Carnegie Curve, but observed in other land-based Ez data from around the world. The morning peak is assumed to be a local effect and shown to correlate with a peak in the local aerosol loading in the lower atmosphere due to the increase in turbulence and mixing caused by solar heating in the morning hours.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

The atmospheric electric field (Ez; sometimes referred to as the potential gradient, or PG) is one of several observable parameters that are used for studying the global electrical circuit (GEC), in addition to the atmospheric conductivity and the vertical conduction current. The Ez has been shown to be affected by natural and anthropogenic processes, with measurements going back more than a hundred years (Harrison, 2006; Aplin, 2012; Rycroft et al., 2012).

The Carnegie research vessel of the Carnegie Institution of Washington made hourly measurements of the atmospheric electric field in the Atlantic and Pacific Oceans between 1909 and 1929 (Torreson et al., 1946). From more than 200 days of observations, 82 days were selected and considered to represent undisturbed meteorological conditions (termed as fair weather days). The hourly values of Ez were averaged to obtain the diurnal variation and constitute the well-known "Carnegie curve". The Carnegie curve shows a robust diurnal variation with a maximum around 19 UT and a minimum around 3 UT. The fair weather electric field values that were measured by the Carnegie ranged from +100 to +300 V/m (pointing downward) with clear daily and seasonal variability (Torreson et al., 1946; Israël 1970; Rycroft et al., 2008; Harrison, 2013).

Whipple (1929) presented a correlation between the Carnegie curve and the diurnal variation of the global thunderstorm area. A strong positive correlation was found between the timing of the thunderstorm activity in the three "chimneys" (Williams and Sátori, 2004) – SE-Asia, Africa and the Americas – and peaks in the values of Ez at 7–9, 12–14 and 16–20 UT respectively. The minimum in the Carnegie curve correlated with the low lightning activity over the Pacific at 4 UT. Mach et al. (2011) showed a better fit to the Carnegie curve, when in addition to the thunderstorms over land, he included contributions from oceanic storms with and without lightning and shower clouds above land.

While the Carnegie curve was obtained from measurements over the oceans, land-based observations of Ez show that local meteorology and aerosol variations can lead to significant variability in the diurnal Ez behavior. Aerosols are known to decrease the conductivity and therefore, for maintaining a constant vertical current density in the global circuit (in accordance with Ohm's law), they cause an increase in Ez (Harrison, 2006; Aplin, 2012).

The land-based measurement of Ez from the past century showed two types of diurnal variation curves (Fig. 1). Some diurnal Ez land curves show a single peak (e.g. Potsdam, Germany [Kähler, 1925]) and some show a double peak (a morning and an evening peak at 8 and 20 local time) (e.g. Kew, UK [Scrase, 1934]). Both sites are also subject to seasonal changes. The diurnal Ez variations in Potsdam showed a single peak in the winter while during summer it showed a double peak around 8 and 20 local time, likely due to local meteorological effects (Fig. 2a) (Israël, 1970). Diurnal effects and especially a morning maximum were found next to areas with anthropogenic and natural pollution (Chalmers, 1965, Figs. 24–28 there). Fig. 2b shows the "summer time" PG effect of morning maximum found by Schonland (1953) representing a local effect during the morning hours. Anisimov et al. (2011, 2014) showed similar results of a morning peak from turbulent mixing and convective transfer of space charge at the Borok station, Russia. To address the difficulties in land observation due to Ez

* Corresponding author at: Sustainability Interdisciplinary Center (IDC) Herzliya P.O. Box 167, Herzliya 46150, Israel. Tel.: +972 9 9527952x3; fax: +972 9 9602401; mobile: +972 525415091.
E-mail addresses: yoavyair@gmail.com, yoav.yair@idc.ac.il (Y. Yair).

http://dx.doi.org/10.1016/j.atmosres.2015.12.025
0169-8095/© 2016 Elsevier B.V. All rights reserved.

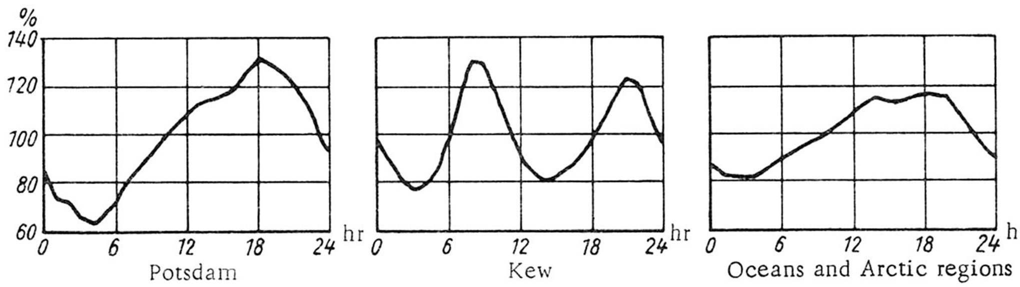

Fig. 1. Diurnal (percentage from the mean) Ez curves from land (Potsdam and Kew) and ocean (Israël, 1970).

variations, Burns et al. (2012) conducted measurements in a relatively unpolluted stable non-convective area (Vostok, Antarctica). The results showed a strong seasonal local impact due to very low temperatures (−70 °C) and high amounts of wind-blown snow (Burns et al., 2012; Williams and Mareev, 2014).

The annual cycle of the global lighting activity shows high flash rates during the northern-hemisphere summer months and low flash rates during the winter months (Cecil et al., 2014). Recently, Mezuman et al. (2014) used the World Wide Lightning Location Network (WWLLN) data and found that the diurnal variation of global thunderstorm cells represents 90% of the Carnegie curve variability. Hence, the second peak often seen in land measurements of Ez is likely to be caused by a local effect. In this paper we present new data from Israel with the goal of separating the local and global effects in measured Ez values.

2. Instrumentation and observation site

In the present study we used a CS110 electric field meter by Campbell Scientific Company (http://www.campbellsci.com/cs110-sensor).

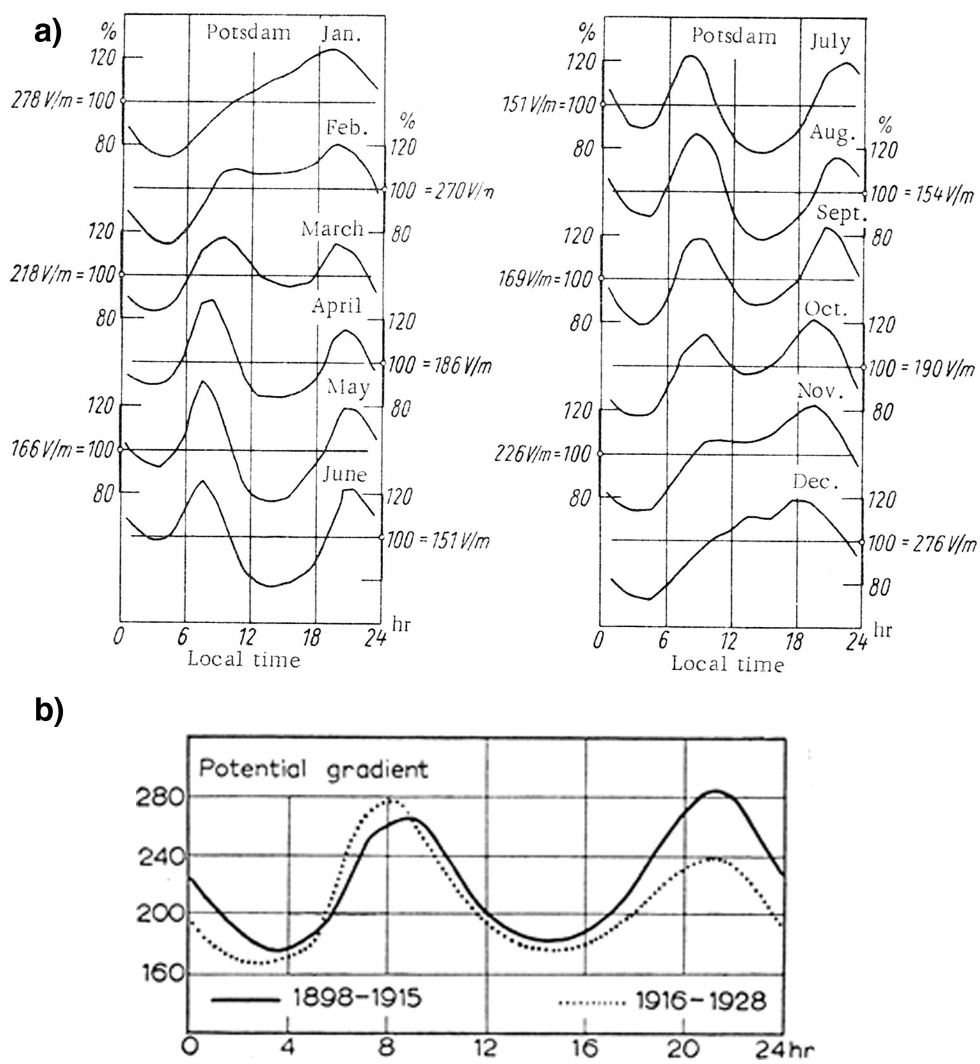

Fig. 2. a. Monthly Ez variations in Potsdam, Germany (Israël, 1970). b. Summer time PG effect on the morning maximum (Schonland, 1953).

Download English Version:

https://daneshyari.com/en/article/6343116

Download Persian Version:

https://daneshyari.com/article/6343116

Daneshyari.com