Atmospheric electricity measurements during the Carrington flare

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Introduction

The “Carrington flare” is one of the largest recorded space weather events, first observed by Richard Carrington on 1st September 1859. The “Carrington flare” was actually two substantial solar emissions on 28th August and 1st September, both of which caused spectacular aurorae, even in the tropics, and severe technological effects (such as permitting telegraph systems to run without batteries). As space weather events represent a hazard to modern society, it is important to evaluate the extent of previous extreme events in the historical record. Quantitative sources of information are particularly valuable, and here the hitherto unexplored resource in atmospheric electricity measurements is examined.

Flagstaff Observatory, Melbourne

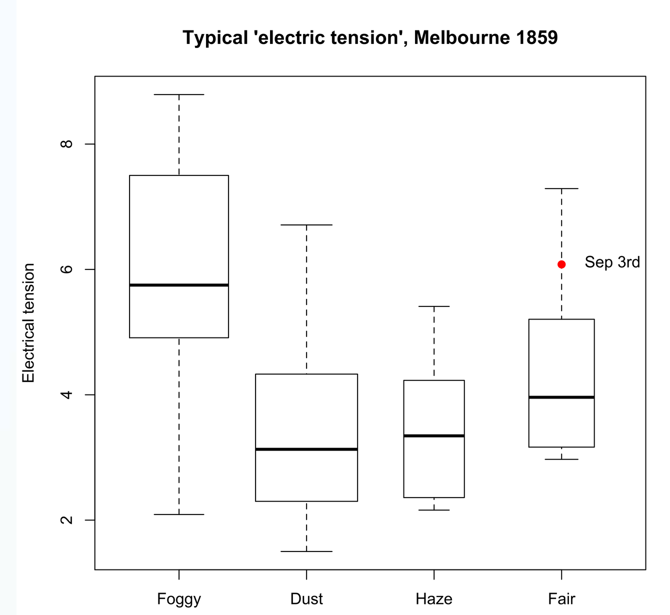
Flagstaff Observatory, Melbourne (centre picture), was established by Georg von Neumayer in 1858. Atmospheric electricity (known as “electric tension”) was measured with a flame probe from 15th April 1858 to 21st September 1862, when the observatory was moved. Careful meteorological and magnetic observations were also made at the same site, allowing detailed analysis of the effects of the Carrington flare.

Georg von Neumayer

There were substantial coincident magnetic disturbances, but at the time there were thought to be no atmospheric electrical effects, although extra electrometer observations were made specially (up to every 2 min instead of hourly – see below).

Modern analysis of the Melbourne data

Statistics calculated from the Melbourne data indicate that the increased electric tension on 3rd September was anomalous.



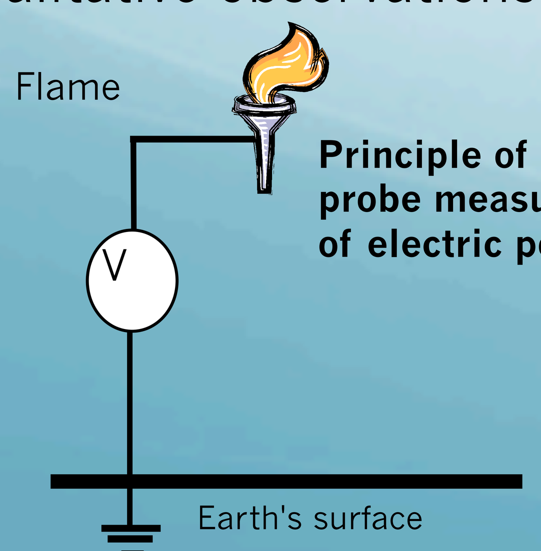
Typical “electric tension” in Melbourne under different weather conditions during spring 1859

Typical electric tension measurements from Melbourne are consistent with modern understanding of how the atmospheric electric field varies, giving confidence in the measurements. Despite good weather on 3rd September the electric tension was in the upper decile of all readings for the entire season, and cannot readily be explained by meteorological effects.

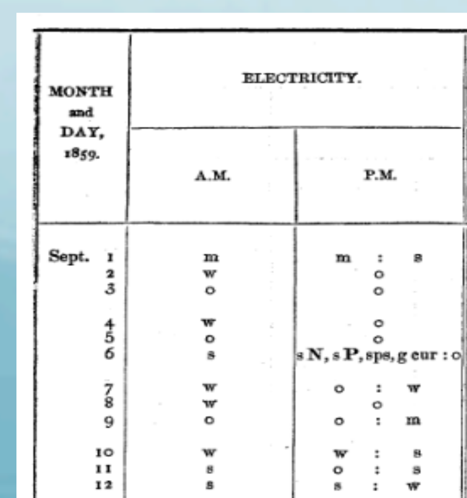
View of Melbourne from the Observatory by George Rowe. This painting is an accurate representation of the observatory (and some of its visitors). Though the atmospheric electricity instruments cannot be seen in the painting, it is most likely that they were on top of the white dome of the brick building used for magnetic observations.

Greenwich, London

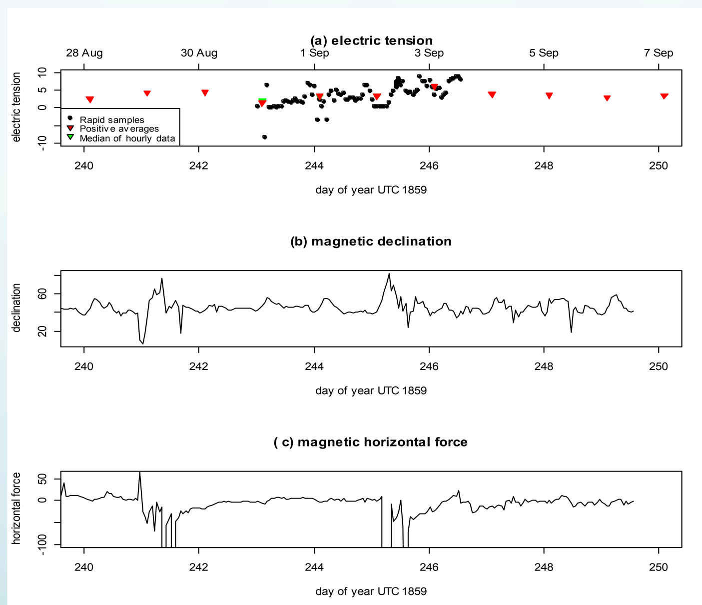
“Electricity” was measured at Greenwich Observatory during the Carrington event. The technique used a flame probe potential equaliser, known as the “electric light”, a standard method then used for measurement of atmospheric electric fields. Ionisation from the probe made the air conductive near the flame, allowing the probe to acquire the same potential as the local air. The atmospheric potential was measured with an electrometer. Only qualitative observations are available during the Carrington event.



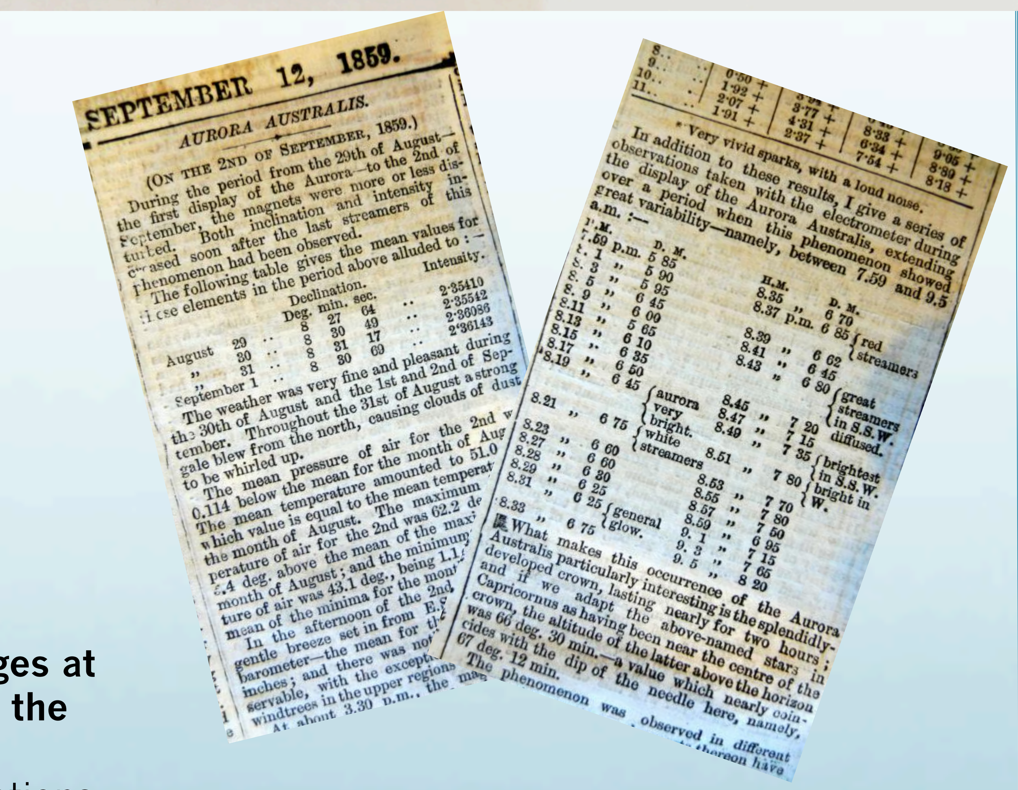
Principle of flame probe measurement of electric potential



Greenwich year book, showing qualitative electrical observations (e.g. “m”: medium, “s”: sparks, “o”: zero, etc



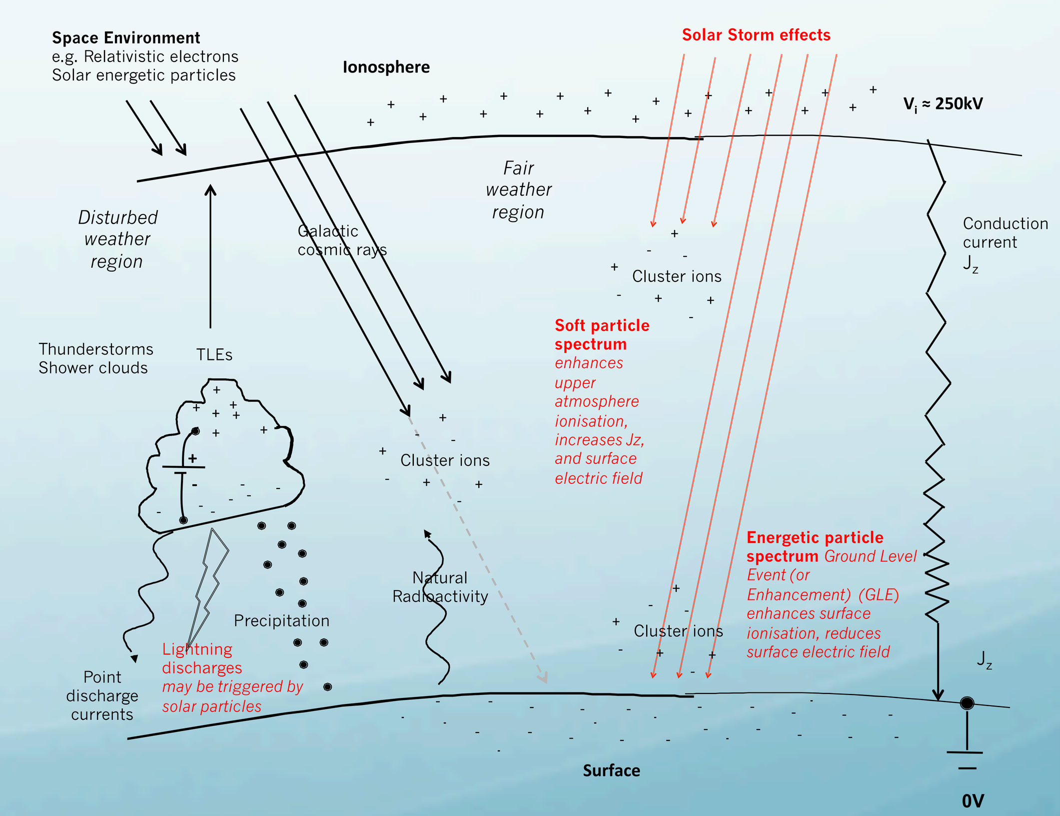
Atmospheric electrical and magnetic changes at Flagstaff Observatory, Melbourne, during the Carrington flare.
(a) shows the atmospheric electrical observations, with the daily average positive tension compared to both the rapidly sampled data and daily medians. (b) shows the magnetic declination and (c) the horizontal force (with over-range values), which allows the local time of the storm maximum to be confirmed.



Report in the ***Melbourne Argus*****, 12th September 1859**

“…the electric tension of the atmosphere appears not to have been greatly disturbed…”
G. B. von Neumayr, 1860

Interpretation



Possible solar storm effects on atmospheric electricity

Higher-energy particles reach the surface and increase the electric field, whereas lower-energy particles reduce the surface electric field. Lightning may also be triggered by solar energetic particles.

As the surface electric tension (field) was enhanced at Melbourne during the Carrington flare, it seems likely that the solar particles emitted were less energetic and did not reach the surface, to reduced the electric field.

Read more in Aplin and Harrison., Astron. Geophys. 55, 5.32-5.37

Thanks to staff at the State Library of Victoria