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Atmospheric Point Discharge Currents measured with a bi-polar logarithmic current amplifier

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Abstract

Point Discharge Currents (PDC) flow in conductors exposed to the atmosphere when strong ambient electric fields cause breakdown of air. This can occur because of field intensification around a sharp point. In some cases point discharge can even become visible, known as St Elmo's fire, one of the longest recognized phenomena in atmospheric electricity. Due to the wide range of magnitudes of currents of both polarities encountered in measuring PDCs, a bipolar logarithmic current amplifier is used here for atmospheric investigations. During an installation at the Reading Atmospheric observatory, it was able to detect PDC of magnitude 0.5μA during periods of strong electric fields, in disturbed weather. Two useful attributes for planetary applications have been suggested by these experiments. Firstly, it is sufficiently compact and light-weight that it seems appropriate for planetary exploration of the electrical properties of atmospheres. Secondly its wide bi polar logarithmic range (~ pA to uA) makes it robust enough to provide useful data despite the environment in which it is deployed being poorly quantified.

1. Introduction

When the atmospheric electric field (conventionally measured as the Potential Gradient (PG)) reaches a critical magnitude, air breaks down, allowing appreciable conduction. Electric fields are intensified around elevated points, causing a breakdown of the air allowing a Point Discharge Current to flow. This current is measured using the PDC Sensor.

2. Device description

The PDC sensor consisted of an upwards facing needle electrode, attached to a temperature compensated bi-polar logarithmic current amplifier. The current amplifier enables current measurements from 1pA to 10μA [1]. A plastic (PTFE) cap was placed around the needle to stop precipitation causing surface leakage currents The PDC instrument was installed on the Reading Atmospheric Observatory along side a electric field mill to measure the PG.

2.1 Calibration

To calibrate the wide range electrometer, input currents from ±10fA to ±3μA were generated using a Time Electronics 2003S DC voltage calibrator (accuracy 0.01%) and known value resistors connected to the input needle electrode, Fig 3. (The electrode was shielded during the calibration to minimise local laboratory space charge effects.) The resistor calibration was obtained from applying a known voltage across the resistor and measuring the current using a Keithley 6512 programmable electrometer. An excellent logarithmic response is seen over at least six decades.

3. Case study 11/9/2011

Between 0200 and 0400 on the 11/9/2011 two heavy showers occurred. The PG, as measured by the field mill, was strongly enhanced, with changing polarity. This resulted in large positive and negative PDC of ~0.5μA, lasting up to 2-3 minutes at a time (Fig 1). During a negative PG the PDC is negative and conversely during a positive PG the PDC is positive. The first shower induced a large negative PDC, which persisted for around 5 minutes. The PG exceeded the field mill scale, indicating a PG probably greater than the maximum value shown.

4. Conclusions

An upwards needle electrode connected to a temperature-compensated bipolar logarithmic current amplifier is effective for measuring atmospheric point discharge currents. Because of its low component cost (~£50) and wide dynamic range, it provides an alternative to field mill devices for observing the atmospheric electric field during disturbed weather. Future work will investigate new

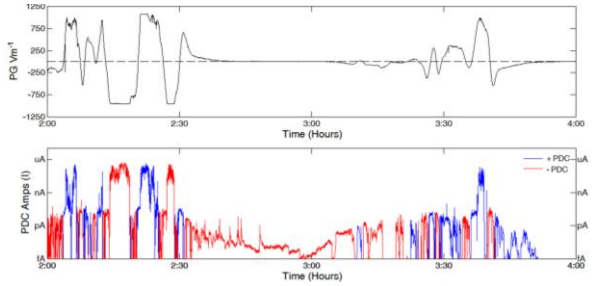

Figure 1 (Top) PG between 0200 Hours and 0400 hours on 11/09/2011. (Bottom) negative (red) and Positive (Blue) Point Discharge currents detected with the PDC Sensor between 0200 and 0400 hours on 11/09/2011

empirical relationships between PDC and PG. A simplified version of this sensor is being developed to fly on weather balloons to identify thunderclouds. Additionally, it is sufficiently compact and light-weight that it seems appropriate for planetary exploration of the electrical properties of atmospheres. It is further suited for planetary exploration as its wide bi polar logarithmic range allows it to provide useful data when deployed in environments which are poorly quantified.

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References

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