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Space weather balloon measurements in the upper troposphere lower stratosphere region

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Abstract

Measurements of ionisation at upper troposphere or lower stratosphere altitudes require an airborne platform which has conventionally required custom balloon flights. An underexploited measurement opportunity is presented by the conventional weather balloons (radiosondes), launched regularly globally by meteorological services, which could potentially provide a cost-effective alternative to custom balloon flights. The use of radiosondes to make measurements of particle fluxes at a wide range of altitude and latitudes is discussed, applicable to the above-thunderstorm region.

1. Introduction

Space weather is increasingly considered as a hazard to society's technological systems, including at aircraft flight altitudes. Effects of energetic particles themselves within the atmosphere, such as on thunderstorms and ultimately climate, also present an area in which new scientific knowledge needs to be developed.

The upper troposphere lower stratosphere (UTLS) atmospheric region, typically immediately above thunderstorms, shows considerable variations in ion production with space weather changes. This is apparent, for example, in long term routine measurements of energetic particle fluxes made above the surface by the Lebedev Institute in Moscow, since 1957. An alternative platform is, in principle, available from the conventional weather balloons (radiosondes) launched regularly globally by meteorological services. This could potentially provide a cost-effective alternative to custom balloon flights, which also includes meteorological information on the local atmospheric structure. Furthermore, since meteorological services' balloon flights form a global network, particle flux measurements opportunities become available at a wide range of geomagnetic latitudes. A fundamental requirement to exploit this is a small and low power ionisation sensor suitable for straightforward addition to meteorological balloons, with appropriate surface and laboratory characterisation.

2. Instrumentation

Atmospheric vertical profiles of the ionization from cosmic rays and radioactivity can be obtained using semiconductor or gas ionization sensors. Geiger tubes are still widely used as detectors, such as by the Lebedev Institute. At Reading, an interface and data system [1] has been developed to unlock the potential of routine meteorological radiosondes for science measurements beyond standard thermodynamic quantities. It is used here with Geiger tubes and semiconductor sensors to allow ionisation measurements in the upper troposphere and lower stratosphere.

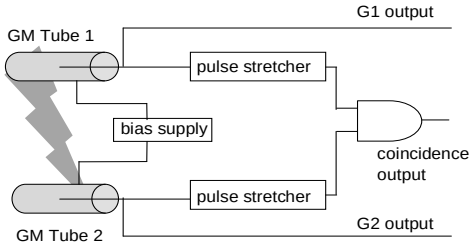

Figure 1. Principle of dual Geiger tube measurement system.

The Geiger tube balloon system consists of an efficient regulated high voltage bias supply and Geiger tube pulse stretchers, pulses from which are counted by a microcontroller together with the pulse

interval. The high voltage supply is based around an oscillator, driving a switched mode power supply combined with a Cockroft-Walton voltage multiplier chain, to generate the ~ 500V high tension bias supply sufficient for two miniature LND714 Geiger tubes. The total mass of the system is 39g. The ability to drive two tubes has the bonus that, recording the simultaneous triggering of the two tubes forms a coincidence counter (also known as a cosmic ray telescope), from which high energy cosmic ray events can be identified.

3. Results

The double Geiger tube system described was launched from Reading, and encountered winds which gave it a southerly trajectory. Figure 2 shows the trajectory and the retrieved variation of Geiger count rate with height for both tubes, obtained over the UHF radio link.

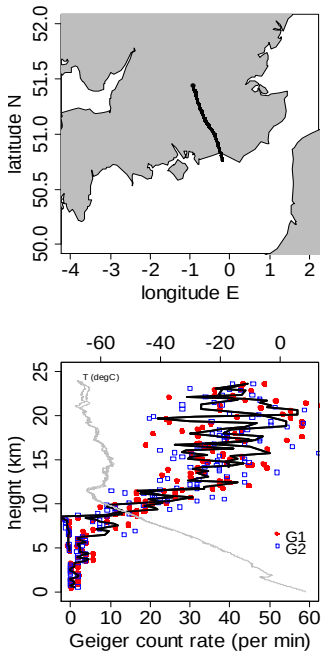

Figure 2. Trajectory and profiles (ascent and descent) showing uncorrected Geiger tube count rates (G1 and G2). The air temperature from the meteorological sensor is also given, with the mean of the two Geiger tubes' count rates is given.

4. Discussion

These measurements show that modern meteorological radiosondes have sufficient payload and battery power to allow compact ionisation sensors to be carried for space weather and radioactivity monitoring applications. The position and meteorological information, obtained as standard, provides additional useful data for corroboration and analysis. Furthermore, by using a microcontroller for the data acquisition, the low count rates generated small sensors can be circumvented by using event interval counting, with a microcontroller. Another important attribute of the radiosonde approach is that, subject to flight permissions, systems can be launched in immediate response to space weather events.

Acknowledgements

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References

[1] R.G. Harrison, K.A. Nicoll and A.G. Lomas, Programmable data acquisition system for research measurements from meteorological radiosondes *Rev Sci Instrum* **83**, 036106 (2012) doi: 10.1063/1.369771