Lerwick Compact Neutron Monitor: Instrumentation and First Results

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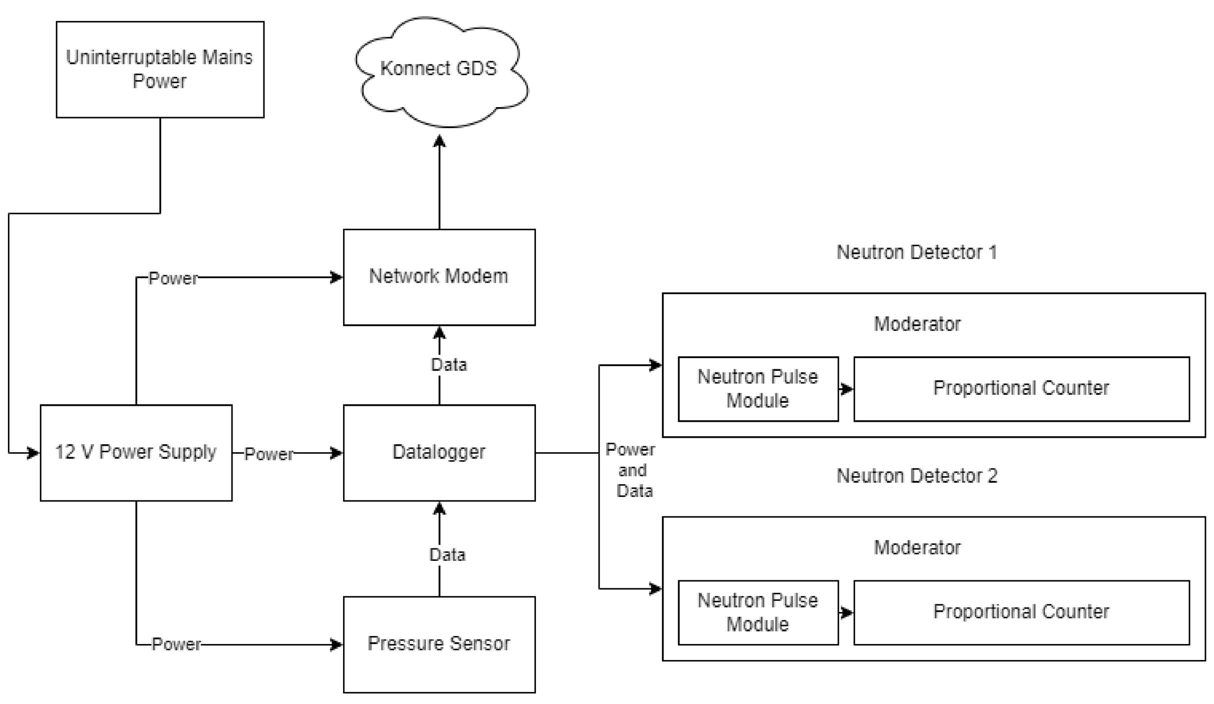
Introduction

Neutron Monitors (NMs) are vitally important tools for space weather operations. They measure atmospheric nucleons, which are created in cosmic ray air showers. High energy solar protons can traverse the geomagnetic field and trigger increases in atmospheric radiation, including nucleons, all the way to the ground. These events are known as Ground Level Enhancements (GLEs) and pose a hazard for aviation. The Compact NM (CNM) is a new kind of neutron monitor designed to observe hazardous GLEs. In April 2025, a CNM was installed at the Met Office observatory in Lerwick, in addition to an existing one at the SSC in Guildford.

Instrumentation

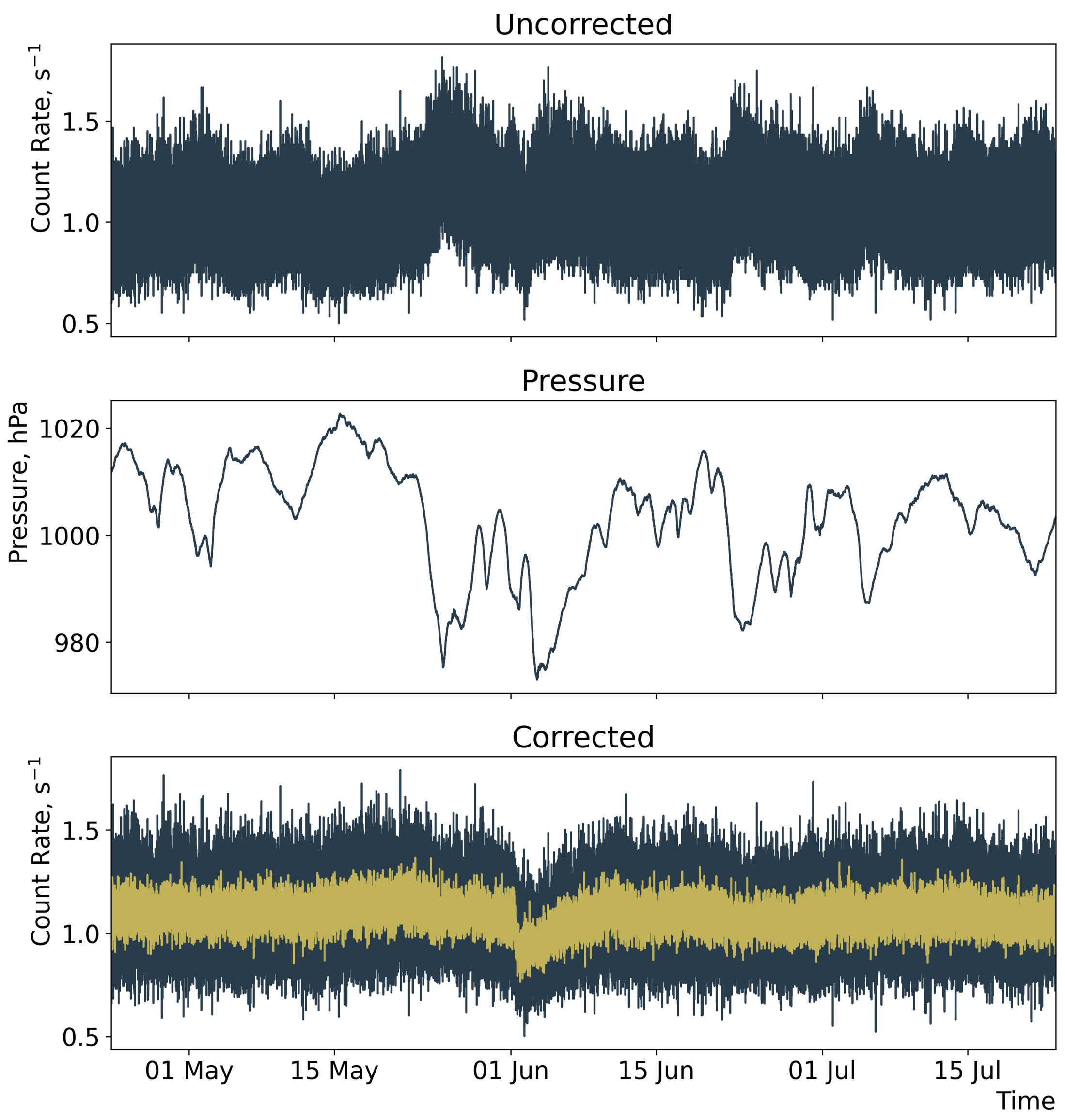


The installation consists of two moderated helium-3 neutron counters, with a pressure sensor for monitoring atmospheric pressure variations. The instrument is powered via a 12V power supply which is itself supplied by an uninterruptible power supply. Data is uploaded in real time to the cloud via a 4G mobile internet connection. The **left image** shows a block diagram of the instrument.

The **right image** shows the two moderated neutron detectors (black cylinders) installed inside the Dobson room at the Met Office's Lerwick observatory. The pressure sensor is the grey box on the door of the electrical box.

The northern latitude of the installation improves the signal from cosmic rays due to lower geomagnetic shielding; the cut-off rigidity is 1.1 GV.

Data Processing



The **top panel** displays the total count rate of the CNM at 1 minute resolution, and the **middle panel** shows the measured atmospheric pressure at Lerwick. The **bottom panel** shows the result of correcting the data for pressure at 1 minute and 5 minute resolution (blue and gold respectively).

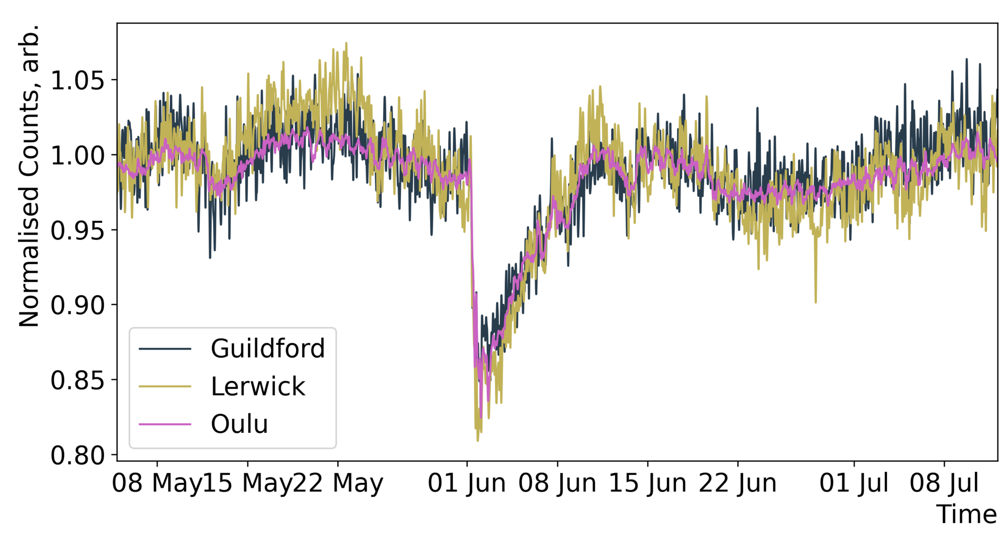
The raw count rate, R_r, is multiplied by a pressure correction factor to obtain the corrected counts:

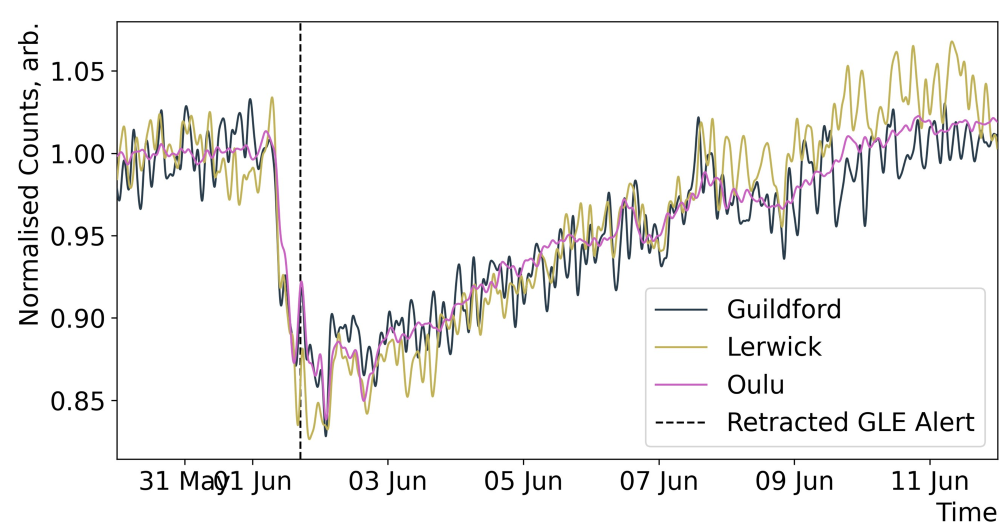
$$R_c = R_r \exp(B(p - p_r))$$

where:

- B = 0.0078 is the estimated barometric coefficient for the site
- p is the observed pressure
- p_r = 999.36 hPa is the long term average pressure at the Lerwick observatory

Forbush Decrease



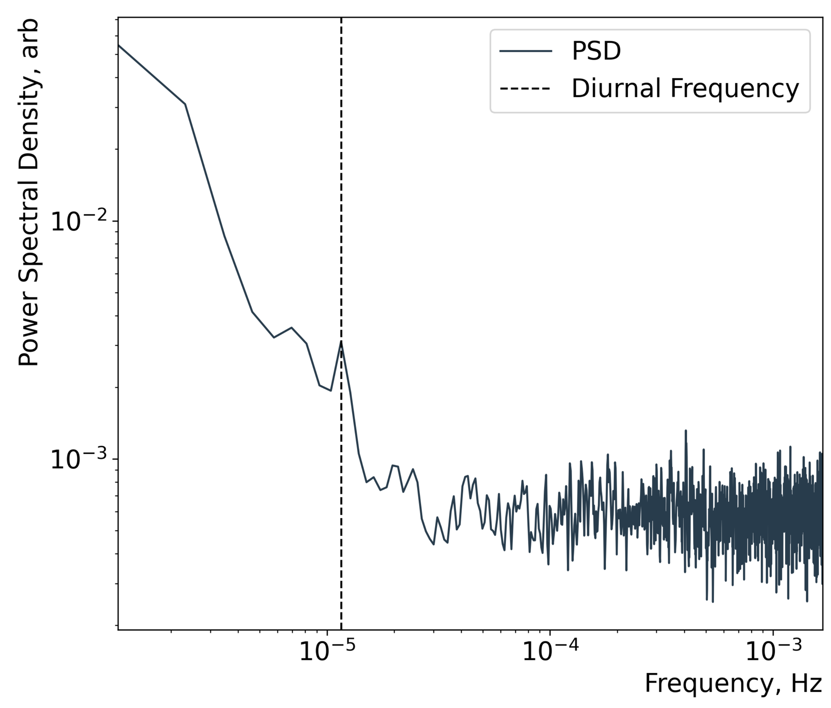


Forbush decreases are rapid decreases in the counting rate of cosmic ray detectors, typically followed by a gradual recovery. They are caused by magnetic structures, such as coronal mass ejections or stream interaction regions, arriving at Earth and modulating cosmic rays.

The **top panel** shows Fourier-filtered corrected data from the Lerwick CNM in gold, alongside the data from the Guildford CNM in blue and the Oulu NM64 in pink. A Forbush decrease is visible at the start of June.

The **bottom panel** shows the event in more detail. A notable structure in the data is a coincident spike in all three monitors, which also coincides with a GLE alert which was later retracted. The characteristics of the spike suggest it was a temporary reduction in modulation rather than an increase due to accelerated particles.

Diurnal Anisotropy



The **diurnal anisotropy** is known to be detectable in cosmic ray detectors such as neutron monitors. It is caused by the relative motion of the Earth and a bulk velocity in cosmic rays which is imparted by the interplanetary magnetic field corotating with the Sun.

The **left panel** shows the power spectral density of the Lerwick CNM, which highlights the frequency at which periodic variations occur in the data. There is spike at the frequency corresponding to 1 cycle per day, which can be attributed to the diurnal anisotropy.

Acknowledgements

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Further Reading

Please scan the QR code for references and recommended reading!