POSTER M20

The GOES-16 Energetic Heavy Ion Instrument Proton and Helium Fluxes for Space Weather Applications

C. Lopate and J. J. Connell, University of New Hampshire, Department of Physics and Space Science Center

ABSTRACT

The Energetic Heavy Ion Sensor (EHIS) was built by the University of New Hampshire, subcontracted to Assurance Technology Corporation, as part of the Space Environmental In-Situ Suite (SEISS) on the new GOES-16 satellite. The EHIS measures energetic ions in space over the range 10-200 MeV for protons, and energy ranges for heavy ions corresponding to the same stopping range. For the GOES Level 1-B and Level 2 data products, protons and helium are distinguished in the EHIS using discriminator trigger logic. Measurements are provided in five energy bands. The instrumental cadence of these rates is 3 seconds. However, the primary Level 1-B proton and helium data products are 1-minute and 5-minute averages. Protons and helium, comprising approximately ~99% of all energetic ions in space are of great importance for Space Weather predictions. We discuss the preliminary EHIS proton and helium data results and their application to Space Weather.

The EHIS instrument development project was funded by NASA under contract NNG06HX01C.

EHIS Theory of Operation for proton and helium measurements

The EHIS instrument has two modes for determining particle counts. For heavy ions, where the count rate is low and particle energy depositions are proportionally close, on-board calculations of the element charges are tabulated on 1-minute time scales through the use of some involved software calculations (see Poster M21).

For protons and helium, where the particle energy deposits are well separated, the counts are determined solely through a series of discriminator triggers, set to differentiate both particle species and energy range.

Absolute fluxes are calculated by dividing the counts by the geometrical factor (cm^2-ster), energy band width (MeV/nuc) and collection time (sec). Corrections for instrument dead time are applied to generate the final absolute fluxes.

EHIS in the Space Weather Suite on GOES-16

The Space Environmental In-Situ Suite (SEISS) on GOES-16 is a set of three instruments designed to monitor the electron, proton and heavy ion fluxes in geostationary orbit.

The Energetic Heavy Ion Sensor (EHIS) is an addition to previous GOES space weather suites. The new instrument EHIS has as its primary purpose to monitor the absolute flux of heavy ions, helium through nickel, in the near-Earth environment. EHIS has the additional capability to measure energetic protons.

In the energy range 10-200 MeV/nucleon for protons and helium, EHIS can be used to monitor and predict the mid-range energies for Solar particle events. These particles, comprising approximately 99% of all Solar energetic particles and have the same ranging capability. Protons and helium can penetrate farther into materials than any heavy ions, thus pose the greatest risk to the interior of space craft (e.g. rockets, satellites, the space station. Thus these particles need to be monitored for possible adverse afffects (e.g. SEUs, cell damage) to even the most protected systems in space.

Absolute Fluxes and Spectra

On 10 March 2017 the EHIS FM1 logic was reconfigured to cleanly separate protons, helium and electrons (which are note reported by EHIS, but constitute background in the instrument).

The EHIS 8-hour averaged absolute fluxes for protons (upper) and helium (middle) since 10 March 2017 are shown to the right. These fluxes are reported in 5 energy bands, with nominal energies listed.

Note that, in absence any of Solar energetic particles, the fluxes remain relatively constant, as expected from GCR on short time scales.

In the lower figure, the proton and helium spectra for a single 8-hour period are shown – both using the same scaling.

To the far lower-right, the helium spectra is compared with the required operating range for the EHIS instrument, as defined by the GOES-R PORD.

Note the scale change to accommodate the much higher flux requirements

As can be seen, since SEISS instrument turn-on, the fluxes of the charged particles are below the PORD minimum measurement levels.

EHIS still reports these low fluxes with reasonable precision when averaged over 8-hour intervals.

In the absence of any significant Solar activity, at energies >10 MeV/nuc, only Galactic Cosmic Ray and Anomalous Cosmic Ray fluxes are observed.

For the 8-hour period of the spectra shown (bottom) the data is fit for protons to a low-energy GCR shape, and for helium to a low-energy ACR+GCR shape.

The best-fit proton spectrum is a power-law:

$$J_p(E) = C\ E^{\gamma}$$

$$C = 1.9 \times 10^{-6} \pm 5.8 \times 10^{-7} \qquad \gamma = 1.56 \pm 0.38$$

The best-fit helium spectrum is Gaussian + power law:

$$J_\alpha(E) = A \exp(-(E-E_o/\sigma)^2) + C\ E^{\gamma}$$

$$A = 4.2 \times 10^{-5} \pm 4.5 \times 10^{-6} \quad E_o = 32.3 \pm 4.5 \quad \sigma = 9.8 \pm 2.2$$

$$C = 3.0 \times 10^{-7} \pm 1.3 \times 10^{-7} \qquad \gamma = 1.43 \pm 0.33$$

This gives a GCR H/He ratio of 6.3 ± 3.3

These results are fully consistent with expected Solar minimum condition fluxes: GCR protons and helium that consist of a combination of GCR and ACR particles.