GOES-17 SEISS EHIS Level 1b (L1b) Data Release
Storage Mode Data Quality
March 15, 2023
Read-Me for Data Users

A Peer Stakeholder - Product Validation Review (PS-PVR) for the GOES-17 Space Environment In-Situ Suite (SEISS) Energetic Heavy Ion Sensor (EHIS) L1b Full Maturity was not held while the satellite and sensor were activated. This is because GOES-17 SEISS EHIS did not get an opportunity to measure a large Solar Energetic Particle (SEP) event before GOES-17 entered storage mode on March 14, 2023. Therefore, Full Maturity for GOES-17 SEISS EHIS is deferred until the sensor measures the relevant event on-orbit. The data will remain at the Provisional Maturity level until that time.

The most recent large SEP event, which was used for the GOES-16 SEISS EHIS Provisional and Full Validation Reviews, occurred on September 10, 2017. The peak >10 MeV proton flux was 1490 protons/(cm^2 s sr) (pfu). An event approximately this large or larger is needed to validate GOES-17 SEISS EHIS heavy ions (depending on energy spectrum and relative heavy ion abundance). For reference, the number of such events in previous solar cycles was:

- Solar Cycle 24 (2008-2019): 4 (Largest: 6,530 pfu >10 MeV)
- Solar Cycle 23 (1996-2008): 15 (Largest: 31,700 pfu >10 MeV)

The L1b data product consists of 5-minute-cadence differential directional fluxes and associated systematic (instrumental) and statistical errors. Fluxes are produced for hydrogen (H) and helium (He); for the carbon-nitrogen-oxygen (CNO), neon-sulfur (Ne-S), and chlorine-nickel (Cl-Ni) mass groups; and for individual elements between beryllium and copper (Be-Cu) (but see below for a restriction on the beryllium and boron fluxes). EHIS has a single 60-degree (full cone angle) field-of-view directed radially outward from the Earth (toward zenith). The energy range is nominally 10-200 MeV/nucleon for hydrogen (protons) and helium (alpha particles), divided into five energy channels. The energy range increases with atomic number (Z) since the stopping power in silicon is the same for all species in each energy channel. Outside of solar energetic particle (SEP) events, EHIS observes backgrounds, some of which may be from galactic cosmic ray (GCR) fluxes.

The H and He fluxes are derived directly from coincidence rates (3-second cadence in the raw Level 0 data), as with SGPS, and can be averaged over longer periods to improve the counting statistics. However, the heavy ion fluxes are derived using a maximum likelihood (ML) fit to a histogram of Z values determined on-orbit (sum of five 1-minute cadence histograms) using the angle-detecting inclined sensor (ADIS) system incorporated into the EHIS telescope. While this ML fit is necessary for meeting requirements in the presence of very sparse heavy ion count rates, it limits the utility of the L1b data in post-processing. Moreover, when the lower one-sigma statistical error is equal to the mean value, only an upper limit exists (mean plus upper one-sigma statistical error). (In the L1b files, the mean fluxes are contained in the variable ‘BeCu5MinuteDifferentialFluxes', and the lower and upper statistical errors are contained in the variable ‘BeCu5MinuteDifferentialFluxStatErrorsBounds'.) Averaging ML fits will not improve the statistics and is invalid when the set of fits includes upper limits. As a result, derivation of heavy ion fluxes for periods longer than 5 minutes requires reprocessing from Level 0 raw data. This is a limitation that is independent of the maturity of the product.

Provisional validation means:

- Validation activities are ongoing and the general research community is now encouraged to participate.
- Severe algorithm anomalies are identified and under analysis. Solutions to anomalies are in development and testing.
- Incremental product improvements may still be occurring.
- Product performance has been demonstrated through analysis of a small number of independent measurements by another instrument on the same observatory, or by other observatories.
- Product analysis is sufficient to establish product performance relative to expectations (Performance Baseline).
- Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, and tested.
- Testing has been fully documented.
- Product is ready for operational use and for use in comprehensive calibration/validation activities and product optimization.

Users of the GOES-17 EHIS L1b data bear responsibility for inspecting the data and understanding the known caveats prior to use. Below is the list of caveats that have been identified and are under analysis. Solutions are in development and testing.

1. The primary caveat is that, as of the date GOES-17 entered storage mode, GOES-17 EHIS had not yet observed a large solar energetic particle (SEP) event. Current understanding of GOES-17 EHIS H and He performance is based on analysis of a weak SEP event that occurred on 27-30 August 2022, during which GOES-16, -17 and -18 EHIS data were compared. Significant heavy ion fluxes were not observed during this event, which precludes Full Validation.
2. Current understanding of GOES-17 EHIS heavy ion performance is based on analysis of histograms accumulated from raw data from 28 November 2018 through 11 April 2019. Good agreement with a GCR model was achieved by processing the non-prime counts from the pulse-height analysis (PHA) packets.
3. No EHIS L1b data processed prior to declaration of Provisional Maturity (May 21, 2019) should be used, owing to important updates to flight science tables and the ground LUT for Provisional Maturity.
4. Absolute calibrations are still being refined. For example, a temperature sensitivity that may impart a significant diurnal variation onto the observed proton (hydrogen) fluxes remains to be quantified.
5. EHIS solar energetic hydrogen and helium ion fluxes are low relative to SGPS. The root cause of this discrepancy has not been determined. In general, NOAA recommends that the SGPS proton (hydrogen) and alpha particle (helium) fluxes be used instead of the EHIS helium channels. SGPS produces hydrogen and helium fluxes over a wider energy range and in more energy channels than EHIS. However, since EHIS has an order-of-magnitude greater event-to-background ratio

than SGPS, studies of weak events should include EHIS data, keeping in mind the absolute calibration differences.

6. Lithium, beryllium, and boron ions of solar origin are never observed, being destroyed in the solar interior. The counts in those EHIS bins are from backgrounds. Therefore, L1b Be and B fluxes are replaced with fill values because they should never be used. (Lithium fluxes are not within the reported measurement range.)
7. Outside of SEP events, EHIS observes backgrounds, some of which may be from GCR fluxes. Under these conditions, the L1b fluxes are not accurate, since the processing uses geometrical factors and energy bandwidths derived for SEP spectra. Steep SEP spectra emphasize the lower-energy ends of the energy response functions while flatter GCR spectra more strongly emphasize the higher-energy tails of the response functions.
8. As described above, time-averaging L1b heavy ion fluxes, particularly those that are upper limits, does not result in improved counting statistics and therefore should not be performed.

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NCEI website for GOES-R Space Weather data (provides daily aggregations of EHIS L1b data):
https://www.ngdc.noaa.gov/stp/satellite/goes-r.html