GOES-18 SEISS EHIS Level 1b (L1b) Data Release
Full Data Quality
November 12, 2024
Read-Me for Data Users

The Peer Stakeholder - Product Validation Review (PS-PVR) for the GOES-18 Space Environment In-Situ Suite (SEISS) Energetic Heavy Ion Sensor (EHIS) L1b Full Validation Maturity was held on November 12, 2024. As a result of this review, the PS-PVR panel chair has declared that the GOES-18 EHIS L1b data are at Full Validation Maturity as of November 12, 2024.

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^{o} (full cone angle) field-of-view directed radially outward from the Earth (toward the zenith). The energy range is nominally 10-200 MeV/nucleon for hydrogen (protons) and helium (alpha particles), divided into five energy channels. (The actual GOES-18 energy ranges for hydrogen and helium SEPs are 11-237 and 11-166 MeV/n, respectively.) 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 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 the Solar and Galactic Proton Sensor (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 (see Literature). 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 higher-level processing. From the *Ground Processing Algorithm Document for the GOES-R Space Environment In-Situ Suite (SEISS), Rev. F* (p. 76): “EHIS data is accumulated over 3 second and 1 minute intervals. Data products for longer periods of time must be added together from the raw data and processed as shown below. Taking fluxes from five [or] 1-minute periods (particularly upper limits) and simply averaging them to obtain fluxes for a longer period, is not valid and EHIS reporting requirements will not be met.” Moreover, when, in the L1b data, 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‘.) As a result, derivation of heavy ion fluxes for periods longer than 5 minutes (e.g., SEP event fluences, GCR fluxes averaged over a solar rotation period of 27 days) requires reprocessing from Level 0 raw data. This is a limitation that is independent of the maturity of the product.

Full validation maturity, by definition, means:

- Validation, quality assurance, and anomaly resolution activities are ongoing;
- Incremental product improvements may still be occurring;
- Users are engaged and user feedback is assessed;
- Product performance for all products is defined and documented over a wide range of representative conditions via ongoing ground-truth and validation efforts;
- Products are operationally optimized, as necessary, considering mission parameters of cost, schedule, and technical competence as compared to user expectations;
- All known product anomalies are documented and shared with the user community;
- Product is operational.

Users of the GOES-18 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.

1. EHIS L1b data processed prior to declaration of Provisional Maturity (e.g., those available from CLASS) should not be used, owing to important updates to flight science tables and the ground look-up table (LUT) for Provisional Maturity. The first data processed with consistent Provisional-maturity flight science tables and LUTs were at 2104 UTC on November 16, 2022.
2. Current understanding of GOES-18 EHIS performance is based on a few small-to-moderate-sized SEP events between April and August 2022 and from July 2023, May 2024, and June 2024. In particular, understanding of heavy ion performance relies upon on the event whose onset was on 8 June 2024. This was an iron-rich event that enabled characterization of the iron flux measurements. However, during this event there were significant heavy ion fluxes only in the lowest energy channel. The other energy channels remain uncharacterized during SEP events.
3. Absolute and relative calibrations will be refined as new, moderate-to-large SEP events are observed.
4. EHIS hydrogen and helium 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 hydrogen and 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 in some channels than SGPS, studies of weak events may benefit from including EHIS data, keeping in mind the absolute calibration differences.
5. Since May 2023, the two lowest-energy EHIS helium channels in the L1b files are replaced with interpolated SGPS data. The decision to do this was based primarily on the fact that EHIS helium fluxes are low relative to SGPS, without considering the strengths of EHIS data, in particular its greater event-to-background ratio and its zenith look direction. This look direction is orthogonal to the eastward and westward look directions of the two SGPS units on each satellite and therefore provides additional scientific information on anisotropies in the solar particle fluxes. NOAA

recommends against use of the two lowest-energy EHIS helium channels from the L1b files - instead, use the SGPS data in the Level 2 five-minute-averages files, which have better energy resolution.

6. Lithium, beryllium (Be), and boron (B) ions of solar origin are never observed, being destroyed in the solar interior. 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.) It is believed that counts at these histogram locations are due to slow helium nuclei being counted as heavy ions.
7. Outside of SEP events, EHIS observes fluxes that are consistent with GCR flux levels. 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 ends of the energy response functions.
8. As described above, time-averaging L1b heavy ion fluxes, particularly those that are upper limits, does not result in improved accuracy 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