GOES-16 SEISS MPS-LO Level 1b (L1b) Data Release
Provisional Data Quality
March 27, 2019
Read-Me for Data Users

The GOES-R Peer Stakeholder - Product Validation Review (PS-PVR) for GOES-16 Space Environment In-Situ Suite (SEISS) Magnetospheric Particle Sensor – Low Energy (MPS-LO) L1b Provisional Maturity was held on March 27, 2019. As a result of this review NOAA has confirmed that the MPS-LO L1b data are at Provisional Validation Maturity as of March 27, 2019.

MPS-LO consists of two electrostatic analyzers (ESAs). The ESAs apply an electric field between two curved surfaces allowing charged particles in a narrow energy range to reach the detector. The electric field is stepped rapidly (15 energy steps plus a return step in 1 second) to fixed values to provide the energy coverage. MPS-LO measures electrons and ions in 15 energy channels between 0.03 and 30 keV in 14 angular zones, each approximately 15 degrees, spanning 180 degrees in the north-south plane. There are 2 pairs of overlapping zones centered at 7.5 and 22.5 degrees north and south of the zenith direction (spacecraft –Z direction), thus, there are 12 *unique* look directions. During each 1-second sweep, counts are accumulated at each energy for 0.0615 s, and the complete energy-angle distribution of counts is reported for both species every second. The outputs of all the zones are registered simultaneously on a set of microchannel plates (MCPs). The MCPs also include dark zones for measuring counts from penetrating radiation that are used by the ground processing algorithm to remove backgrounds from the illuminated zones. Since the background counts are measured independently, the background corrected (subtracted) count rates in the 1s L1b data may contain some negative values (non-physical), obeying the statistics of the difference between two Poisson distributed measurements. Longer time averages may also contain some negative values for reasons described below. The pitch angle (between particle velocity and local magnetic field direction) associated with each zone can be calculated using the magnetic field vector measured by the GOES-R magnetometer (MAG). Pitch angles are not reported in the L1b data.

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 SEP measurements;
- 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 cal/val activities and product optimization.

Users of the GOES-16 MPS-LO 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 to anomalies are in development and testing:

1. No MPS-LO L1b data processed prior to declaration of Provisional Maturity (e.g., those available from CLASS) should be used. NCEI will reprocess and release the early mission data using Provisional Maturity algorithms and look-up tables.
2. Anomalously high backgrounds have resulted in negative background corrected (subtracted) fluxes in much of the L1b data reported up to time of writing of this document. Implementation of empirically determined zone-energy dependent background removal coefficients has alleviated some of the trouble, but changing instrument characteristics since launch means that the background removal coefficients need periodic updating. There continues to be negative fluxes, on average, in some zone-energy channels.
3. Interzonal crosstalk at a level of 30% was observed in ground calibrations, and crosstalk is apparent in energy-sweep-voltage dependent count rates in the electron background zones in on-orbit data. Background subtraction performed in L1b processing provides a measure of correction for the crosstalk but results in reported fluxes that are too low (due to loss of signal). The full impact of the crosstalk on currently reported fluxes is unknown.
4. Post launch tests show evidence for significant error in absolute values of reported fluxes, e.g., significant differences between fluxes from overlapping zones, discrepancies with MPS-HI at highest MPS-LO energies, and in comparisons with other missions. It is likely that L1b processing geometric factors will be adjusted downward in general (raising reported fluxes) prior to full validation.
5. During arc jet firing there is a drop in flux in the lowest electron energy channels for electrons with small pitch angles (< approximately 20 deg.). There is no discernable effect on the ion fluxes during the same period. The typically high fluxes in the lowest MPS-LO electron energy channels (10s of eV) are due to photoelectric electrons emitted by the spacecraft surface when it is sunlit (i.e., the observed/measured flux is higher than the flux in the ambient plasma). These electrons are trapped in the vicinity of the spacecraft by a negative barrier potential surrounding the spacecraft [e.g., Whipple, 1976]. The barrier potential is neutralized by plasma from the spacecraft's arc jets, allowing the photoelectrons to escape.
6. High background counts typically dominate over in-band counts in the lower ion energy channels resulting in a very low signal to noise ratio in the background corrected ion fluxes. The problem is worse, affecting energy channels up to 1keV, when the source of backgrounds is high (e.g., when the radiation belts are elevated).
7. There are gaps in the L1b data.

Work on the items above is ongoing and will continue through Full Validation.

Literature

Pre-launch SEISS overview: Dichter, B. K., Galica, G. E., McGarity, J. O., Tsui, S., Golightly, M. J., Lopate, C., Connell, J. J. (2015), Specification, design and calibration of the space weather suite of instruments on the NOAA GOES-R program spacecraft. *IEEE Transactions on Nuclear Science, 62*(6), 2776–2783.

Whipple, E. C. (1976), Theory of the spherically symmetric photoelectron sheath: A thick sheath approximation and comparison with the ATS 6 observation of a potential barrier, *J. Geophys. Res., 81*(4), 601– 607, doi:10.1029/JA081i004p00601.

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