

SOLAR-1 MAG README, Provisional Maturity
April 13, 2026
Read-Me for Data Users

The SOLAR-1 Product Validation Review (PVR) for MAG Provisional maturity was held on March 31, 2026. The review panel concluded that the MAG data products had reached Provisional maturity as of this date. As a result, the data files may be shared, with the caveat “SWFO Preliminary, Non-Operational Data: These data are considered to be ready for operational use” until Initial Operational Capability is declared for the observatory.

The MAG data products consist of three-axis measurements of the interplanetary magnetic field by the inboard (IB) and outboard (OB) fluxgate magnetometers. Both magnetometers are mounted on a boom, the IB sensor at 3.9 m from the boom base and the OB sensor at 5.6 m from the base.

The MAG product levels include:

- Level 0a (generated by SWPC): raw binary CCSDS packets
- Level 0b (SWPC): raw data in counts, 64 samples per second (S/s)
- Level 1a (NCEI, SWPC): calibrated data in physical units (nT) in Magnetometer Orthogonal-aligned System (MOS) sensor reference frame, 64 S/s
- Level 1b (NCEI, SWPC): spacecraft vehicle system (SVS), spacecraft frame, 64 S/s
- Level 2 (NCEI, SWPC): Earth-Centered Inertial (ECI), Geocentric Solar Ecliptic (GSE) and Geocentric Solar Magnetospheric (GSM) frames, 64 S/s
- Level 3 (NCEI, SWPC): GSE and GSM frames, 1 second and 1 minute averaged. The 1-minute averages are used by the NOAA Space Weather Prediction Center (SWPC).

Note: Data taken during the Zone of Reduced Communications (ZORC) interval 10/24/2025-01/02/2026) were sampled at 8 S/s. In the Level 2 reprocessed data, they are provided on a 64 S/s grid with only every eighth sample being valid.

Note: The Level 3 time-averages are calculated using the robust iterative Huber M-estimator technique (Huber 1964). The Hodges-Lehmann estimator (Hodges and Lehmann 1963) is the backup method in case the Huber M-estimator does not converge. This method is insensitive to data anomalies such as spurious spikes in the high-rate data. A similar method has been used by SWPC to average DSCOVR magnetometer data.

The SOLAR-1 MAG Provisional-maturity data products are currently undergoing testing and calibration and validation. Following revisions to calibration parameters (including gains, offsets and rotation matrices), the products have been validated by comparisons with the magnetometer on NASA’s Interstellar Mapping and Acceleration Probe (IMAP). The two observatories were launched on the same rideshare rocket. They were, therefore, located within 5000 km of each other prior to January 1, 2026. NCEI continues to work with the NOAA SWPC forecast office and the instrument contractor to improve the MAG products. Changes in ground processing algorithms (GPAs) and calibration tables may still be expected.

Each day file contains an array (function of time) of 32-bit words called “flags”. Each bit of this variable represents a distinct data quality flag (DQF). The meanings of individual bits are described in the variable metadata. Examples include: one or more sensors in saturation; electronic board status; calibration mode; sensor or board yellow-limit temperature exceeded; spacecraft maneuver; missing attitude data; thruster firings.

Known issues include the following:

1. The field variation at the OB sensor due to the solar array has a maximum range of 0.12 nT, based on the range of charge control table (CCT) entries expected to be used on-orbit. This result is based on a test conducted prior to and following the boom deployment. This will be revisited if the CCT changes.
2. During thruster firings, the field strength is changed by a few tenths of a nanotesla in three axes. A new thruster_firing data quality flag was implemented, based on the thruster activity transmitted in the spacecraft telemetry, which can be used to mask these events. The flag is now included in all files for dates after 03/30/2026.
3. Narrow-band spectral enhancements with linearly time-varying peak frequencies are attributed to the four observatory reaction wheels, which each possess a permanent dipole moment. Their rotation produces ~ 0.01 nT delta-function spikes in the linear (aka “amplitude”) spectrum. The noise signal is only significant at wheel frequencies ≥ 1 Hz under typical solar wind conditions. The noise signal is too weak to be evident in 1-minute averages, and is easily distinguished in frequency-time spectrograms from natural signals. The nominal angular speeds of the reaction wheels, which are contained in the STIS instruments operational L0b files (variable ‘reaction_wheel_speed_rpm’), may be used to filter out the spectral peaks.
4. Rarely, spurious large spikes (which can exceed 100 nT magnitude) appear in the high-rate data (8 or 64 S/s) that seem to be related to ground transmission issues. Since total solar wind fields at 1 AU as large as 109 nT have been observed (Russell et al. 2013), NCEI is taking the cautious approach of masking and filling all field components greater than 150 nT until a more precise diagnosis of these spikes can be made. Data users are encouraged to report possibly spurious large spikes to NCEI for investigation and possible removal in future data versions.
5. Above ≥ 5 Hz, the power spectral density often begins to level off and diverge from the expected $f^{2.8}$ power law scaling of the solar wind dissipation range. This flattening (at power spectral densities 10^{-5} – 10^{-4} nT² Hz⁻¹) is attributed to the instrument’s intrinsic noise floor, which was measured in the laboratory and possesses the same spectral contour. Naturally, the flattening is less significant during intervals when the solar wind power is larger. NCEI will provide the instrumental noise floor spectrum to users by June 2026 at the latest.
6. On days before 02/21/2026, the sensor_temp_exceeded bit in the quality flag word was continuously on in the operational files. This was due to the unexpected low operating temperature of the outboard magnetometer observed after launch. The lower magnetometer sensor temperatures are now expected and the threshold was lowered

accordingly on 02/20/2026. For science-quality dayfiles prior to 02/21/2026, this flag has been automatically set to zero to avoid over-flagging the data; for dayfiles 02/21/2026 and after, no automatic zeroing of the sensor_temp_exceeded bit is applied. Note that the low operating temperature has a negligible effect on the accuracy of the measurements; it is more important that the temperatures, which help to determine the detector's zero-level offsets, are stable.

7. L0b, L1a, and L1b files may contain data gaps, missing times, or variable data rates (switching between 8 & 64 S/s). These gaps are filled with fill values in L2 files to a 64 S/s cadence. L3 files are averaged to 1 second and 1 minute cadences.

NCEI contacts for specific information on the SWFO-L1 MAG data:

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References:

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