GOES-** Magnetometer Level-2 README

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Description

The products contained here are full-resolution magnetometer (MAG) observations for the GOES-8 through GOES-17 series of 10 spacecraft, covering a time span of more than 27 years (from 1995 to present). Future spacecraft will be added as they are launched and become operational. The three-axis stabilized satellites were also known as GOES-I-M (G8-G12), GOES-NOP (G13-G15), GOES-R (G16) and GOES-S (G17) prior to their launch.

The GOES MAG subsystem consists of fluxgate magnetometer instruments monitoring three orthogonal components of the geomagnetic field at geosynchronous orbit (L = 6.6) with high resolution (sampling rate) (G8-15: 2 Hz and G16-17: 10 Hz). GOES MAG supports the following mission objectives:

- Measures the magnitude and direction of Earth's ambient magnetic field in the geosynchronous equatorial orbit.
- Determines the general level of geomagnetic activity.
- Detects disturbances such as: geostationary magnetopause crossings, storm sudden commencements, substorms and ultra-low-frequency (ULF) waves.
- Maps the space environment that controls charged particle dynamics in the outer region of the magnetosphere.

The GOES MAG measurements are provided as B field vectors in the ECI (Earth-centered inertial), EPN (earthward, poleward, normal/eastward), GSE (geocentric solar ecliptic), GSM (geocentric solar magnetospheric), VDH (dipole aligned), and body reference frame coordinate systems.

Data Variable Descriptions**

Total magnetic field, computed from EPN vector components [nT]
Magnetic field in EPN coordinates (x, y, z). E: earthward, P: perpendicular to the satellite orbital plane, N: ExP [nT] (eastward)
Magnetic field in Earth Centered Inertial coordinates (x, y, z) [nT]
Magnetic field in Geocentric Solar Ecliptic coordinates (x, y, z) [nT]
Magnetic field in Geocentric Solar Magnetospheric coordinates (x, y, z) [nT]
Magnetic field in VDH coordinates (x, y, z). V: anti-earthward, D: eastward, H: northward along dipole [nT]
Magnetic field in Body Reference Frame coordinates (spacecraft x=Roll, y=Pitch, z=Yaw). This is also the frame of the SEISS instrument [nT]
Data quality flag [0= good_quality]
G08-G15: [1= unspecified_degraded, 2= degraded_via_equitorial_approx, 65536=unspecified_bad, 2147483648= missing_data]
G16-G17: [1 = invalid_due_to_missing_L0_IB_and_OB_MAG_data_qf,
2 = degraded_due_to_IB_MAG_x-axis_potential_failure_or_off_state_or_IB_mag_potentially_in_maintenance_mode_qf,
4 = degraded_due_to_IB_MAG_y-axis_potential_failure_or_off_state_or_IB_mag_potentially_in_maintenance_mode_qf,

8 = degraded_due_to_IB_MAG_z-axis_potential_failure_or_off_state_or_IB_mag_potentially_in_maintenance_mode_qf,
16 = degraded_due_to_OB_MAG_x-axis_potential_failure_or_off_state_or_OB_mag_potentially_in_maintenance_mode_qf,
32 = degraded_due_to_OB_MAG_y-axis_potential_failure_or_off_state_or_OB_mag_potentially_in_maintenance_mode_qf,
64 = degraded_due_to_OB_MAG_z-axis_potential_failure_or_off_state_or_OB_mag_potentially_in_maintenance_mode_qf,
128 = degraded_due_to_IB_MAG_x-axis_magnetic_field_at_saturation_qf,
256 = degraded_due_to_IB_MAG_y-axis_magnetic_field_at_saturation_qf,
512 = degraded_due_to_IB_MAG_z-axis_magnetic_field_at_saturation_qf,
1024 = degraded_due_to_OB_MAG_x-axis_magnetic_field_at_saturation_qf,
2048 = degraded_due_to_OB_MAG_y-axis_magnetic_field_at_saturation_qf,
4096 = degraded_due_to_OB_MAG_z-axis_magnetic_field_at_saturation_qf,
8192 = degraded_due_to_MAG_calibration_maneuver_in_progress_qf,
16384 = degraded_due_to_potentially_stale_MAG_engineering_data_qf,
32768 = potentially_degraded_due_to_out_of_valid_range_IB_MAG_x-axis_thermistor_temperature_qf,
65536 = potentially_degraded_due_to_out_of_valid_range_IB_MAG_y-axis_thermistor_temperature_qf,
131072 = potentially_degraded_due_to_out_of_valid_range_IB_MAG_z-axis_thermistor_temperature_qf,
262144 = potentially_degraded_due_to_out_of_valid_range_OB_MAG_x-axis_thermistor_temperature_qf,
524288 = potentially_degraded_due_to_out_of_valid_range_OB_MAG_y-axis_thermistor_temperature_qf,
1048576 = potentially_degraded_due_to_out_of_valid_range_OB_MAG_z-axis_thermistor_temperature_qf,
2097152 = potentially_degraded_due_to_out_of_valid_range_IB_electronics_temperature_qf,
4194304 = potentially_degraded_due_to_out_of_valid_range_OB_electronics_temperature_qf,
8388608 = potentially_degraded_due_to_IB_MAG_in_shadow_qf,
16777216 = potentially_degraded_due_to_arcjet_firing_qf]

** Data Issues and other notes:

- The GOES satellites have two magnetometers (inboard and outboard sensors) and the magnetic field data available for plotting are usually the outboard sensor values. The source netcdf files (accessed via CDAWeb or NOAA-NCEI, see links below) contain variables not available for plotting at CDAWeb including both inboard and outboard sensor (*_ib_* and *_ob_* variables, respectively) data, the sensor data in additional coordinate frames, a flag indicating which sensor the estimated magnetic field data represents and additional quality flags. Please refer to the metadata description of each variable present in the netcdf files for more details.
- The time coverage listed does not imply continuity of the data during the entire interval.
- Due to data processing issues for the high resolution GOES mag data:
    - B_total can sometimes be NaN for G14. In this case, the user can calculate it using the EPN available vector components.
    - B_BRF is not always available for G08-G15 (showing fill values).
    - B_VDH occasionally shows unrealistic outliers due to spikes in the spacecraft attitude data used for the coordinate transformation.
- The satellite position extracted from the netcdf file variable “orbit_llr_geo” might contain some errors, especially for the longitude values. The GOES ephemeris data was reprocessed by NOAA-NCEI (only in 1-min resolution) and can be accessed in the links below:

G08-G15	https://satdat.ngdc.noaa.gov/sem/goes/data/sat_locations/
readme	https://satdat.ngdc.noaa.gov/sem/goes/data/sat_locations/GOES_8-15_Ephemeris_Data_Readme.pdf
G16	https://data.ngdc.noaa.gov/platforms/solar-space-observing-satellites/goes/goes16/l2/data/ephe-l2-orb1m/
G17	https://data.ngdc.noaa.gov/platforms/solar-space-observing-satellites/goes/goes17/l2/data/ephe-l2-orb1m/
readme	https://data.ngdc.noaa.gov/platforms/solar-space-observing-satellites/goes/goes16/l2/docs/GOES-R_Ephemeris_L2_Data_Readme.pdf

- Arcjet Contamination:
    - The GOES-R series satellites use hydrazine arcjet thrusters for periodic orbital maneuvers

for station keeping. When the arcjets are fired the magnetometer measurements (both inboard and outboard sensors are contaminated by up to ~20 nT. This is significant contamination relative to the typical 100 nT geomagnetic field magnitude at geostationary orbit. The arcjets fire once every 1 to 4 days and contamination can last ~90 minutes or less. When using the GOES-16 and GOES-17 magnetic field data, users are strongly encouraged to refer to the references below that describe and show examples of the arcjet signature in the magnetic field data.

Califf S., Loto'aniu T. M., Early D., and M. Grotenhuis (2020), Arcjet Thruster Influence on Local Magnetic Field Measurements from a Geostationary Satellite, Journal of Spacecraft and Rockets, 57:1, 177-186.

Califf, S., Early, D., Grotenhuis, M., Loto'aniu, T. M., and Kronenwetter, J. (2020). Correcting the arcjet thruster disturbance in GOES-16 magnetometer data. Space Weather, 18, e2019SW002347. https://doi.org/10.1029/2019SW002347.

Loto'aniu, T.M., Redmon, R.J., Califf, S. et al. (2019). The GOES-16 Spacecraft Science Magnetometer. Space Sci Rev 215, 32. https://doi.org/10.1007/s11214-019-0600-3.

- Arcjet flag: Arcjet firings can be identified in the "flag_meanings" attribute of the DQF variable defined as "potentially_degraded_due_to_arcjet_firing_qf".

- Older versions of GOES magnetometer data files available at CDAWeb are identified by names that begin with Gx where x is the satellite number. These are::
  a. GOES 6 and 7, 1-min data in EPN coordinates
  b. GOES 7 power spectral density plots for selected intervals
  c. GOES 8, 9, 10, 11, and 12 magnetometer data with 1-min resolution in various coordinate systems (duplicated with the newer processed files discussed above).
  d. Selected intervals of GOES-10, -11, and -12 magnetometer data at 0.512 sec resolution. (duplicated with the newer processed files discussed above).

For accessing the original high-resolution G08-G17 data product files at NOAA-NCEI, please visit the links listed below:

	Time res	Data coverage	Links:
G08	512 ms	95-01	https://satdat.ngdc.noaa.gov/sem/goes/data/science/mag/goes08/magn-l2-hires
G09	512 ms	95-01	https://satdat.ngdc.noaa.gov/sem/goes/data/science/mag/goes09/magn-l2-hires
G10	512 ms	97-05	https://satdat.ngdc.noaa.gov/sem/goes/data/science/mag/goes10/magn-l2-hires
G11	512 ms	00-10	https://satdat.ngdc.noaa.gov/sem/goes/data/science/mag/goes11/magn-l2-hires
G12	512 ms	01-09	https://satdat.ngdc.noaa.gov/sem/goes/data/science/mag/goes12/magn-l2-hires
G13	512 ms	10-17	https://satdat.ngdc.noaa.gov/sem/goes/data/science/mag/goes13/magn-l2-hires
G14	512 ms	12-17	https://satdat.ngdc.noaa.gov/sem/goes/data/science/mag/goes14/magn-l2-hires
G15	512 ms	11-17	https://satdat.ngdc.noaa.gov/sem/goes/data/science/mag/goes15/magn-l2-hires
G16	0.1 s	18-present	https://data.ngdc.noaa.gov/platforms/solar-space-observing-satellites/goes/goes16/l2/data/magn-l2-hires
G17	0.1 s	18-present	https://data.ngdc.noaa.gov/platforms/solar-space-observing-satellites/goes/goes17/l2/data/magn-l2-hires