

## **README: GOES-14 Storage-Mode Charged Particle Data Processed from NSOF Raw Counts**

Juan V. Rodriguez

juan.rodriguez@noaa.gov, ncei.info@noaa.gov

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The GOES-14 particle detector suite, named EPS/HEPAD, comprised the following instruments: EPEAD, HEPAD, MAGED and MAGPD. It was similar to that on GOES-13 and -15.

After November 20, 2009, GOES-14 was at 105 degrees west, the 'storage' longitude.

From November 2010 to November 2017, the GOES-14 space weather data were received and processed by SWPC only during select periods, to provide back-up to the other satellites in operations. Starting in December 2017, when GOES-13 was retired, SWPC processed the GOES-14 data continuously until early March 2020. GOES-14 particle data processed by SWPC in real time, or processed previously by NCEI from raw counts received by SWPC prior to the start of operational MAGED and MAGPD processing in December 2010, are available from NCEI for the following periods:

2009: MAGE/PD 1-minute averages only, July-November

2010: EPS (EPEAD, MAGED, MAGPD) time averages only, January 1 -November 4

2011: none

2012: August 15 - November 24

2013: none

2014: none

2015: May 20 - June 22

2016: April 7 - Nov 17

2017: August 8-23, December 1-31

2018-2020: January 1, 2018 - March 3, 2020

On November 4, 2010, the GOES-14 EPS/HEPAD suite was turned off. Following a GOES-13 satellite anomaly, EPS/HEPAD was turned on c. 0540 UT on May 23, 2013. NSOF recorded and archived the raw (compressed) EPS/HEPAD counts.

The purpose of this processing effort is to provide a continuous GOES-14 'storage mode' particle data set from May 23, 2013 to November 30, 2017, after which SWPC processed the GOES-14 data in real time continuously through the beginning of March 2020. This data set is not intended to duplicate the existing data from this period. It includes some science-quality features noted below. Some of the variables and files present in the real-time data sets are omitted, as described below.

The current release is version 2-0-0, for the full-time-resolution and the time averages, to distinguish it from prior science-quality (re)processing of the GOES 13-15 EPEAD electrons and processing of pre-2011 GOES 13-15 MAGED and MAGPD data from raw counts.

The filenames are similar in format to the file names of the data processed in real time by SWPC, with an extension '\_sci\_v2-0-0' to distinguish them from the real-time files.

### **Science-quality aspects of this data set:**

1. The motivation for the production and release of this data set is to enhance scientific inquiry. Longitudinal variations in magnetospheric particle fluxes (sometimes strong) make the GOES-East and -

West particle data not representative in general of the fluxes present at 105 W. With the release of these data, NCEI provides a nearly 7-year continuous record of particle fluxes at 105 W from May 23, 2013 to March 3, 2020.

2. Dead time corrections are applied to MAGED and MAGPD, as they were in the real time processing. Small differences with respect to the real-time-processed fluxes are observed owing to different methods of combining count rates observed at different cadences in the calculation of the correction.

3. The full-resolution time stamps have been corrected, as recommended by GOESN-ENG-048:

The accumulation periods are integral multiples of 2.048 s. The recorded times are 2.048 seconds after the end of the accumulation period. This offset is subtracted, and the time stamp is placed at the center of the accumulation period:

$$t' = t - (0.5 * \text{accumulation period} + 2.048 \text{ s})$$

Both the uncorrected and corrected full-resolution time stamps are provided.

4. The time averages are performed based on the corrected full-resolution time stamps. Full-resolution samples with corrected time stamps within the averaging period are included in the average. This should provide a more accurate representation of the fluxes during the averaging period than the real-time flux averages. The time stamps of the averages are at the start of the averaging period, as is the established practice with GOES particle data.

5. The MAGED and MAGPD full resolution fluxes have a saturation flag as follows:

-1: OK

0: zero counts, may be physically saturated (when in proximity to numerically saturated)

1: one quantization level below numerical saturation

2: greatest quantization level, numerically saturated

-99: fill

6. Turn-on transients on May 23, 2013 (observed prior to 0549 UTC) have been removed by hand.

### **Caveats:**

1. No contamination correction or background removal has been applied. Caution should be used, in particular in the interpretation of the EPEAD E2 and E3 electron channels, which are sensitive to solar energetic protons. More details are provided below.

2. Most in-flight calibrations (IFCs) have been removed automatically, based on a flag that is extended by 15 samples before and after the IFC flag (which had a 32.768-s cadence). IFCs took place on a weekly cadence. As a result, there are weekly data gaps lasting approx. 10 minutes.

3. Despite the automatic removal, some IFCs may have leaked through. A spike that precedes or follows a gap may be an IFC that was incompletely suppressed (despite the  $\pm 15$ -sample extension of the IFC flag). Other, unexplained spikes lasting only a few sample periods should probably be ignored. Please ask NCEI about any spikes that you are unsure of.

4. Three unusually long-duration IFCs, each lasting an hour or longer, have been removed by hand. These 'rogue' IFCs were not accompanied by IFC flags. It was particularly important to remove these since two

of them occurred during SEP events and could be confused with the response to a solar wind structure. The times of these 'rogue' IFCs are as follows:

2014-03-05, 1554-1724 UTC

2014-03-25, 1202-1334 UTC

2014-04-03, 1232-1338 UTC

### **Omitted Variables:**

Owing in part to resource limitations and in part to certain limitations of the data, not all of the data sets or variables created in the real-time processing have been provided in version 2-0-0.

1. No contamination-corrected or background-corrected fluxes are provided.

EPEAD E1: This omission has little impact on the E1 fluxes since the contamination and background corrections are almost always insignificant.

EPEAD E2: Contamination from protons can be large during solar proton events. (See, for example, the start of this data set during a SEP event, May 23-25, 2013.) Caution should be used in interpreting uncorrected data during solar proton events as the electron count rates may be much lower than the proton count rates. The SWPC correction performed well and was used in the scientific reprocessing of the real-time GOES 13-15 EPEAD electron fluxes by NCEI. Thus, it is a candidate for use in the next version of this data set.

EPEAD E3: Contamination from protons can be large during solar proton events. (See, for example, the start of this data set during a SEP event, May 23-25, 2013.) Caution should be used in interpreting uncorrected data during solar proton events as the electron counts may be much lower than the proton counts. The SWPC correction did not perform well, hence the corrected flux variables from the real time data should be avoided. NCEI is developing a correction that is a candidate for use in the next version of this data set.

EPEAD P1-P7: The contamination corrections and background removals have not been applied to the GOES-14 storage-mode P1-P7 fluxes.

MAGED: The correction provided by the vendor was applied in the real time data, but since the MAGPD fluxes have degraded, the accuracy of the correction during most of the mission is in question. Hence it has not been applied to the GOES-14 storage-mode MAGED data.

MAGPD: The correction provided by the vendor overcorrected in general since it relied on a power-law extrapolation from the MAGED energies (30-600 keV) to the MeV electron energies that cause the contamination. Therefore, corrected fluxes in the real time files should be avoided, and only uncorrected fluxes are provided in the GOES-14 storage-mode MAGPD files. A successful alternative correction method has not been developed.

2. Unlike the science-quality EPEAD fluxes produced daily during the mission, no dead-time-corrected EPEAD E1 and E2 fluxes are included in this release. Addition of these variables is a candidate for the next version of this data set.

3. No solar proton integral fluxes ('cpflux' files) are provided.

4. Certain time averages are not provided:

EPEAD alphas ('a16'), HEPAD protons and alphas ('ap'): In the light of the 32-s full-resolution cadence and low count rates in these data sets, 1-min averages are not provided. Only 5-min averages are provided. High-resolution studies of SEP events should rely on the 32-s full-resolution data.

EPEAD protons ('p17'): Since all channels but P1 have 32-s full resolution cadence, only 5-min averages are provided.

EPEAD electrons ('e13'): One-minute averages are provided, encouraged by the high SNR of the E1 channel and general interest in radiation belt phenomena at this time scale. At times, the E2 and E3 fluxes exhibit counting-statistical noise at this cadence. Five-minute averages are not provided.

MAGED and MAGPD: Five-minute averages are not provided since only contamination-corrected fluxes were provided in the real-time 5-min averages. One-minute averages are provided.

### **Acknowledgments**

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### **List of Abbreviations**

Acronym/Initialism	
EPEAD	Energetic Proton, Electron and Alpha Detector
EPS	Energetic Particle Sensor
GOES	Geostationary Operational Environmental Satellite
HEPAD	High Energy Proton and Alpha Detector
MAGED	Magnetospheric Electron Detector
MAGPD	Magnetospheric Proton Detector
NCEI	National Centers for Environmental Information
NSOF	NOAA Satellite Operations Facility
SWPC	Space Weather Prediction Center