GOES-16 through GOES-18 SUVI Level-2 (L2) Data Release
Full Maturity Data Quality
August 2026
Read-Me for Data Users

The GOES-R Peer Stakeholder - Product Validation Reviews (PS-PVR) for the Solar Ultraviolet Imagers (SUVI) Extreme Ultraviolet Imagery (EUV) L1b Full Validation Maturity were held on:

- November 5, 2020 for GOES-16
- September 17, 2021 for GOES-17
- November 30, 2023 for GOES-18

As a result of these reviews, NOAA has confirmed that the SUVI L1b data from these instruments are at Full Validation Maturity.

Full Validation Maturity means:

- Validation activities are ongoing and the general research community is now encouraged to participate.
- Incremental product improvements may still be occurring.
- Users are engaged and user feedback is assessed.
- Product performance has been demonstrated through analysis of a wide range of independent measurements obtained from other sun-observing EUV instruments.
- Products are operationally optimized, as necessary, considering mission parameters of cost and schedule, as compared to user expectations.
- All known product anomalies are documented, and shared with the user community.
- All product testing, analysis, and results have been fully documented.
- Products are considered operational.

SUVI data consist of solar images in six extreme-ultraviolet (EUV) passbands (or channels) — 94 Å, 131 Å, 171 Å, 195 Å, 284 Å, and 304 Å — with a variety of exposure times and filters in place to ensure each image set captures the full dynamic range of solar phenomena. SUVI images have a pixel resolution of 1280×1280 pixels, each with an angular resolution of 2.5 arcsec per pixel, for a total field of view of 53.3 arcmin square. Some corners of each passband are obscured by instrumental vignetting.

For more information about the GOES-R SUVI L1b files, please see the corresponding ReadMe file.

SUVI Level-2 data are produced by NOAA's National Centers for Environmental Information in Boulder, Colorado. They are derived from L1b data and consist of 3 different product categories:

- Composite Images
- Thematic Maps
- Report Products

The creation of these product categories is hierarchical. The Composite Images are created first, then the Thematic Maps using the Composites Images as input, and finally the Report Products are derived from the Thematic Maps. Each category is explained in more detail below.

Composite Images

The SUVI L2 Composite Images are high dynamic range (HDR) images produced in the form of a weighted average across co-aligned SUVI Level-1b image products retrieved from the GOES-R Ground Segment. The resulting HDR image encompasses a span of solar phenomena including faint structures such as coronal holes and extended corona dynamics, up to highly energetic X-class flares.

All SUVI Composite Images are monochannel, meaning that only one wavelength is used for a composite. This results in separate Composite Image data products for each wavelength channel (94 Å, 131 Å, 171 Å, 195 Å, 284 Å, and 304 Å).

The production of SUVI Composite Images uses the following recipe:

1. SUVI L1b products for a single SUVI channel within a 4 minute observation window are collected. The SUVI Level 1b data are in estimated radiometric units of radiance (W m-2 sr-1) and have had all appropriate calibration steps applied. SUVI's nominal observational sequence includes so-called long (1 s) and short flare (0.005 s) exposures to extend the instrumental dynamic range during flares. The short flare exposure uses an additional filter in the optical path to further diminish the signal during flares. Moreover, the 94 Å and 131 Å channels take an additional short exposure (also 0.005 s) without the extra filter to cover a wider range of signals. Because data are converted to radiometric units, all data are time-normalized.
2. The SUVI L1b images are co-aligned and averaged using a system of weights kept in lookup tables. The weights are tailored for each channel to favor the long exposure values in low-to-moderate signal regimes, and the short and/or short flare exposures for high-signal conditions (bright active regions and flares).
3. The Composite Image files contain metadata that captures the entire processing pipeline to provide sufficient context of the steps taken to produce the data to an end user. Much of the L1b metadata is also included, as well as metadata that establishes the provenance of the product.

The Composite Image files are provided in FITS format.

Thematic Maps

The SUVI Thematic Maps are produced using the Composite Images, and employ machine learning classification to generate a pixel-by-pixel map of notable solar features captured by all six spectral channels individually. The operational SUVI Thematic Maps are presently generated by a random forest classifier method (more information can be found in Hughes et al., 2019). The Thematic Maps are written to FITS files, and the pixel data stored in the main header data unit (HDU). A table mapping the features to the numeric value assigned to each theme is provided in the second HDU extension. The Thematic Maps capture 9 classified solar themes:

- flare
- coronal hole
- bright region
- filament
- prominence
- quiet sun
- limb
- outer space
- unlabeled

An example python script illustrating how to use and display thematic map files is available at https://cires-stp.github.io/goesr-spwx-examples/examples/suvi/thematic_map_example.html.

Model training is performed by providing sets of Composite Images and expert-created annotations for each theme to a machine learning algorithm that is used to generate the trained model utilized by the Thematic Map algorithm to classify these themes. The algorithm creates an ensemble of decision trees tuned specifically for Thematic Map creation based on the contents of SUVI Composite Images. The current version of the Thematic Map algorithm is location-aware in the sense that only specific categories are allowed depending on the location. For example, prominences are only allowed above the limb, filaments only on-disk. Note that coronal holes will only be classified on-disk.

The Thematic Map files are provided in FITS format.

Report products

Based on the corresponding categories in the Thematic Maps, the SUVI L2 algorithms will create three different report products:

- Bright Region Report
- Coronal Hole Boundaries
- Flare Location

All report products are provided in netCDF format.

Bright Region Report

A SUVI Bright Region is a region of the solar disk that demonstrates enhanced EUV brightness when compared to portions of the solar disk that are considered “quiet sun”. The enhanced brightness of the Bright Regions is responsible for increased EUV and X-ray flux, which affects upper atmospheric heating. Bright regions are not the same as, but are often associated with, solar active regions and NOAA reported sunspots.

Note on the boundary coordinates in the files: Legacy formatting requirements impose limits on the number of vertices, which are confined to between 6 and 16 points.

Note on the difference between center and peak locations: Peak location is simply the brightest pixel of the bright region for each wavelength. The center location is a weighted centroid of all pixels that were marked as “bright region” in the Thematic Map, also for each wavelength.

An example python script illustrating how to use and display information from these files is available at https://cires-stp.github.io/goesr-spwx-examples/examples/suvi/plot_suvi_l2_brght.html.

Coronal Hole Boundaries

A SUVI Coronal Hole Boundary describes a region on the solar disk that demonstrates diminished EUV brightness when compared to other regions on the solar disk. Coronal Holes are associated with regions of “open” magnetic field lines along which solar particles can flow freely into the Heliosphere.

Note on the boundary coordinates in the files: Legacy formatting requirements impose limits on the number of vertices, which are confined to between 6 and 16 points.

An example python script illustrating how to use and display information from these files is available at https://cires-stp.github.io/goesr-spwx-examples/examples/suvi/plot_suvi_l2_chbnd.html.

Flare Location

The SUVI Flare Location products are only generated if there is at least one pixel classified as the "flare" theme in the Thematic Map. The sensitivity depends on the Thematic Map training, but as a rule of thumb: flares above approximately C5 will generally be recognized by the Thematic Map algorithm.

Note on the difference between center and peak locations: Peak location is simply the brightest pixel of the bright region for each wavelength. The center location is a weighted centroid of all pixels that were marked as "bright region" in the Thematic Map, also for each wavelength.

An example python script illustrating how to use and display information from these files is available at https://cires-stp.github.io/goesr-spwx-examples/examples/suvi/plot_suvi_l2_flloc.html.

User feedback and known issues

Users of the GOES-R SUVI L2 data bear responsibility for inspecting the data and understanding the known caveats prior to use (see "Known Issues" below). Users are invited and encouraged to report anomalies or send other comments or questions about the files and data therein to the SUVI team via the email addresses below. The NCEI team will update these files to correct known errors and address user comments on a best-effort basis. User feedback will drive changes and optimization of files for realtime distribution.

Known issues

All GOES-16 L2 products:

1. Before 11 March 2024 at 19:00 UTC, the operational L1b files for GOES-16 were using a wrong template for cutting out the 1280x1280 pixel region of interest from the 1292x1330 raw image files. This means that before that time, the known bad pixels were not interpolated correctly. For the entire GOES-16 mission lifetime (i.e. before **and** after that date), the image registration for GOES-16 was working with wrong assumptions, so the accuracy of coordinates in operational GOES-16 L2 files should be assumed not to be better than ± 2 pixels, or ± 5 arcsec respectively. This will be mitigated in the science reprocessing of the GOES-16 L2 files.

Composite Images:

1. The SUVI instruments are susceptible to particle impacts that are most consistent with low-energy electrons. These impact the detector at an oblique angle resulting in elevated signals in adjacent pixels. Those "cosmic ray hits" are removed when creating the L2 Composite Images, but not always perfectly.
2. Occasionally there is only one SUVI L1b input file, particularly in the wavelength channels where only one set of images is taken in the 4 minute observation window (131 Å, 171 Å, and 284 Å). In

this case, no true high dynamic range image can be produced. Those Composite Images are marked as “degraded” in the metadata.

3. Starting around 17:00 UTC on 21 May 2025, the reported physical units in the L1b data are known to be wrong due to an erroneous change in the Ground Segment algorithm. This also impacts the Composite Images. The extent of the effect depends on the wavelength, but the most impacted is 94 Å being too bright by about a factor of 1.8. Until this is resolved, the compositing algorithm based on lookup tables will not operate correctly.
4. Fast moving structures can lead to image artifacts in the Composite Images, such as two CME fronts for the same CME.

Thematic Maps:

1. Occasionally not all required inputs are available with the latency and/or data quality required for real-time Thematic Map processing. In those cases, the quality of the map may be degraded. A FITS keyword (DEGRADED) indicates whether any quality issues were detected within the map inputs that could degrade product performance.
2. Real-time maps are generally produced at 4-minute cadence, but there are infrequent data gaps in the existing archive.
3. In general, the FITS metadata in the Thematic Map products identify the classifier method and classifier training set used in map generation (ALGORTHM and TRAINING keywords, respectively). However, some of the files in the initial release are missing these keywords. Contact the SUVI team for more information about the specific algorithm and training used to generate these files.
4. Improvements in data processing and products are ongoing. Users may encounter inconsistencies in file format, metadata, or data quality within the SUVI archive. Contact the SUVI team with questions regarding these ongoing improvements.
5. The issue with the incorrect physical units in the L1b files and subsequent Composite Images (see above) also impacts the Thematic Map performance.

Report products:

1. Before November 2022 (approximately), the “time” variable (in seconds since 2000-01-01 12:00 UTC) was rounded in such a way that the hours/minutes were excluded. Validation was done with files after this time only, due to the need to correlate data with a SunPy map made with data from a similar time.
2. There might be small variations in different coordinate systems due to differences in calculations done via textbook mathematical formulas vs. using SunPy/Astropy.
3. In older report products, some vertices in the Bright Region Reports and Coronal Hole Boundaries can be uncharacteristically small due to an error in the algorithm at the time, and do not properly surround the corresponding regions determined by the Thematic Map.
4. The issue with the incorrect physical units in the L1b files and subsequent Composite Images (see above) also impacts the Thematic Map performance, and hence also the Report Products being derived from those Thematic Maps.

Acknowledgement & data use policy

Do not redistribute these files. Refer all users to the NCEI file distribution site at: https://www.ncei.noaa.gov/products/goes-r-solar-ultraviolet-imager-suvi/

More SUVI information and visualizations are available at the Space Weather Portal (SPOT) here: https://ncei.noaa.gov/cloud-access/space-weather-portal/

The SUVI instrument paper is available here: http://doi.org/10.1029/2022SW003044

Where possible, users should acknowledge use of GOES data with the AAS Facilities keyword: http://journals.aas.org/authors/aastex/facility.html

Contact us

NCEI contacts for specific information on the SUVI L2 data:

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