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## L2 Daily Solar-Induced Fluorescence (SIF) from MetOp-A GOME-2, 2007-2018, V2

### Get Data

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Dataset Version: 2

### Summary

This dataset provides Level 2 (L2) Solar-Induced Fluorescence (SIF) of chlorophyll estimates derived from the Global Ozone Monitoring Experiment 2 (GOME-2) instrument on the European Meteorological Satellite (EUMETSAT) MetOp-A with ~0.5 nm spectral resolution and wavelengths between 734 and 758 nm. GOME-2 covers global land on an orbital basis at a resolution of approximately 40 km x 80 km (before 15 July 2013) or 40 km x 40 km (since 15 July 2013). Data are provided for the period from 2007-02-01 to 2018-02-01. Each file contains daily raw and bias-adjusted solar-induced fluorescence, quality control information, and ancillary data. SIF measurements can provide information on vegetation's functional status, including light-use efficiency and global primary productivity, which can be used for global carbon cycle modeling and agricultural applications. The GOME-2 SIF product is inherently noisy due to low signal levels and has undergone only a limited amount of validation. The data are provided in netCDF format.

There are 3868 data files in netCDF (\*.nc) format included in this dataset. Data variables are formatted as a CF Metadata Conventions-compliant trajectory.

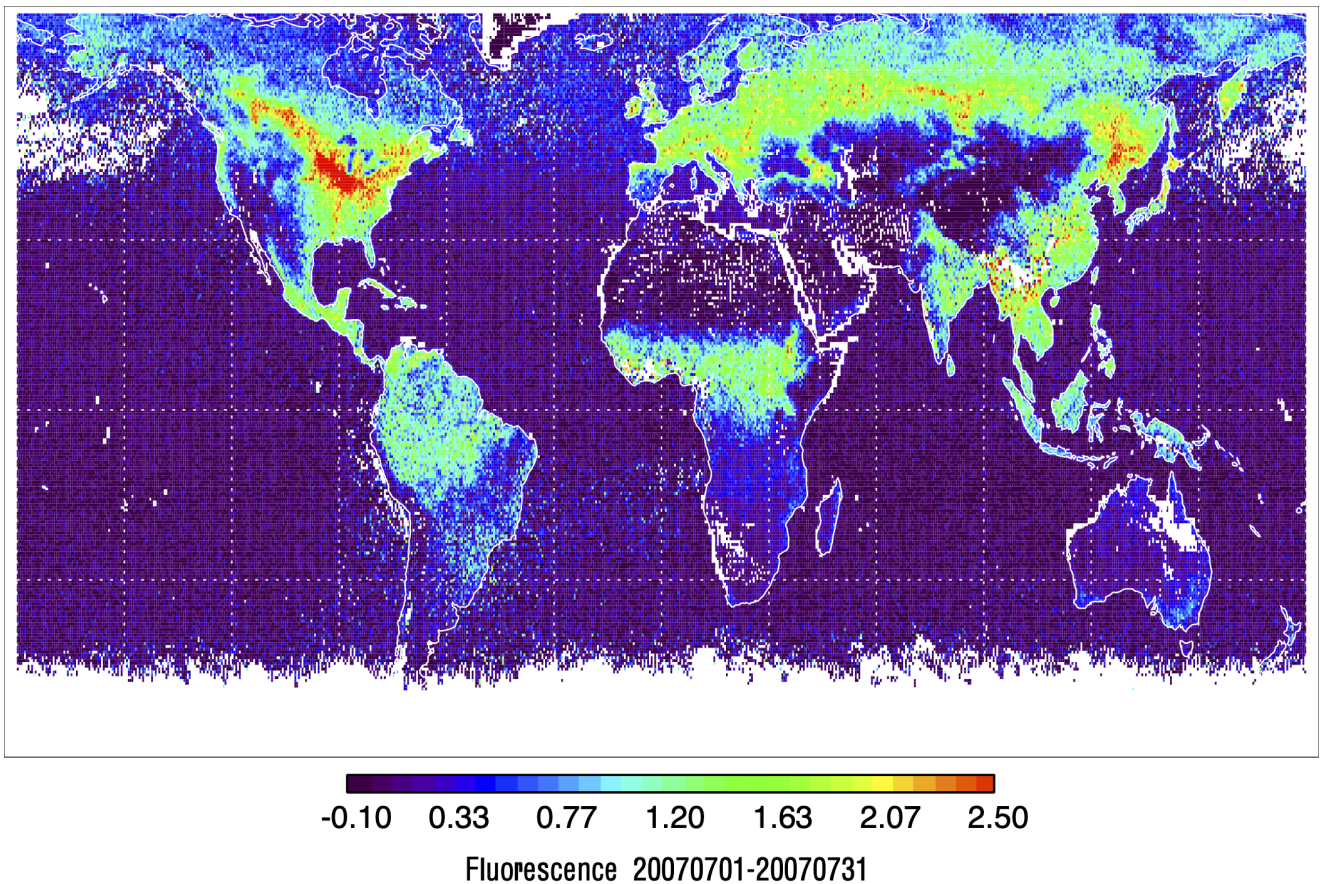


Figure 1. Monthly mean solar-induced fluorescence (SIF) values ( $\text{mW m}^{-2} \text{nm}^{-1} \text{sr}^{-1}$ ) at 740 nm and gridded at 0.5-degree spatial resolution, derived from this L2 dataset.

### Citation

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## 1. Dataset Overview

This dataset provides Level 2 (L2) Solar-Induced Fluorescence (SIF) of chlorophyll estimates derived from the Global Ozone Monitoring Experiment 2 (GOME-2) instrument on the European Meteorological Satellite (EUMETSAT) MetOp-A with ~0.5 nm spectral resolution and wavelengths between 734 and 758 nm. GOME-2 covers global land on an orbital basis at a resolution of approximately 40 km x 80 km (before 15 July 2013) or 40 km x 40 km (since 15 July 2013). Data are provided for the period from 2007-02-01 to 2018-02-01. Each file contains daily raw and bias-adjusted solar-induced fluorescence, quality control information, and ancillary data. SIF measurements can provide information on vegetation's functional status, including light-use efficiency and global primary productivity, which can be used for global carbon cycle modeling and agricultural applications. The GOME-2 SIF product is inherently noisy due to low signal levels and has undergone only a limited amount of validation.

**Project:** [Earth System Data Record - Solar-induced Fluorescence](#)

This project is developing a global, observation-based Earth System Data Record (ESDR) for quantifying global vegetation solar induced fluorescence (SIF) and photosynthesis gross primary productivity (GPP) from 1996-2020. It was funded under the 2017 Making Earth System Data Records for Use in Research Environments (MEaSUREs) call (17-MEASURES-0032).

### Related Publication

Joiner, J., L. Guanter, R. Lindstrot, M. Voigt, A.P. Vasilkov, E.M. Middleton, K.F. Huemmrich, Y. Yoshida, and C. Frankenberg. 2013. Global monitoring of terrestrial chlorophyll fluorescence from moderate-spectral-resolution near-infrared satellite measurements: methodology, simulations, and application to GOME-2. *Atmospheric Measurement Techniques* 6(10):2803–2823. <https://doi.org/10.5194/amt-6-2803-2013>

Joiner, J., Y. Yoshida, L. Guanter, and E.M. Middleton. 2016. New methods for the retrieval of chlorophyll red fluorescence from hyperspectral satellite instruments: simulations and application to GOME-2 and GOME-2. *Atmospheric Measurement Techniques* 9(8):3939–3967. <https://doi.org/10.5194/amt-9-3939-2016>

### Related Datasets

Additional SIF datasets are available on the ORNL DAAC [SIF-ESDR](#) project page.

### Acknowledgments

This work was supported by the NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) program (grants NNX15AH95G, 17-MEASURES-0032).

## 2. Data Characteristics

**Spatial Coverage:** global land surface

**Spatial Resolution:** 40 km x 80 km or 40 km x 40 km footprint at nadir

**Temporal Coverage:** 2007-02-01 to 2018-02-01

**Temporal Resolution:** Daily

**Study Area:** Latitude and longitude are given in decimal degrees.

Site	Northernmost Latitude	Southernmost Latitude	Easternmost Longitude	Westernmost Longitude
global land surface	89.59958	-89.78042	180	-180

### Data File Information

There are 3868 data files in netCDF (\*.nc) format included in this dataset. Data variables are formatted as a [CF Metadata Conventions](#)-compliant trajectory.

Files are named *NSIFv2.6.2.GOME-2A.YYYYMMDD\_all.nc* (e.g., NSIFv2.6.2.GOME-2A.20070201\_all.nc), where **YYYYMMDD** represents the observation date. The data version is indicated in the file name (i.e., v2.6.2).

Table 1. File names and descriptions.

File Names	Description
<i>NSIFv2.6.2.GOME-2A.YYYYMMDD_all.nc</i>	Daily raw and bias-adjusted SIF on an orbital basis for land pixels. Variables are structured as GeoTrajectory, where the observations for a flight segment are connected along a one-dimensional track in space and with time increasing monotonically along the track.

### Data File Details

Missing values are represented by -9999. The Coordinate Reference System is WGS84 (EPSG:4326).

Table 2. Variable names and descriptions.

Variable Name	Units	Description
Cloud_Fraction	1	Effective cloud fraction MLER (mixed Lambertian-equivalent reflectivity) model
Daily_Averaged_SIF	$\text{mW m}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$	SIF adjusted to daily average based on cosSZA
Delta_Time	seconds since 2007-01-01 00:00:00	Time (in UTC) of data collection
Earth_Radius	km	Earth radius
Iterations	N/A	Number of iterations in a retrieval
Latitude	degree north	Latitude at center of pixel
Latitude_Corners	degree north	Latitudes of pixel corners
Longitude	degree east	Longitude at center of pixel
Longitude_Corners	degree east	Longitudes of pixel corners
Quality_Flag	-	Pixel retrieval quality flags: 0 = bad 1 = good passed all QC checks (cloud fraction >30%) 2 = good and passed cloud check (cloud fraction <30%) For gridding data, use pixels with a quality flag value of 2.
Refl670	1	Reflectance 670 nm, not atmospherically corrected
Refl780	1	Reflectance 780 nm, not atmospherically corrected
Residual	percent	RMS over wavelengths of residual in percent of radiance
Satellite_Height	km	Height of satellite above Earth
Scan_Number	1	Granule scan position
SIF_740	$\text{mW m}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$	Solar-induced fluorescence at 740 nm
SIF_Unadjusted	$\text{mW m}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$	Raw SIF, no adjustment
SIF_Uncertainty	$\text{mW m}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$	SIF estimated uncertainty
Surface_Pressure	hPa	Surface Pressure from digital elevation map at STP
SAz	degree	Satellite azimuth angle
SZA	degree	Solar zenith angle
VAz	degree	Sensor azimuth angle
VZA	degree	Sensor zenith angle

### 3. Application and Derivation

Measurements of solar-induced fluorescence (SIF) of chlorophyll can provide information on the functional status of vegetation including light-use efficiency and global primary productivity that can be used for global carbon cycle modeling and agricultural applications.

### 4. Quality Assessment

Uncertainties were assessed using machine learning over the ocean where SIF is expected to be zero. This produced error estimates resulting from instrument noise as a function of sun-satellite geometry and latitude.

These dataset products are inherently noisy due to low signal levels. Users should expect to see negative values; users should retain negative values and treat them like they would any other noisy dataset. For example, if fluorescence is zero, there should be a distribution of measurements centered about zero including negative values. Any attempts to remove negative values or force them to zero for the purpose of averaging will bias results.

This dataset has undergone a limited amount of validation (e.g., the same algorithm applied to the ERS-2 GOME (Joiner et al., 2019) and SCIAMACHY (Joiner et al., 2021) data sets has been compared with ground-based data in Yang et al., 2015). The output of far-red retrievals from GOME-2 has been compared with the filling-in signal near 758 nm from the GOSAT TANSO-FTS instrument that is derived from a simpler algorithm (Joiner et al., 2013) and with OCO-2 (Sun et al., 2018; Parazoo et al., 2019; Bacour et al., 2019) as well as with the GOME-2 retrievals from Köhler et al. (2015). The retrieval performed well when compared with results using simulated data from thousands of realizations (Joiner et al., 2013).

### 5. Data Acquisition, Materials, and Methods

Level 2 (L2) SIF estimates were derived from reflectance measured by the GOME-2 instrument on the EUMETSAT MetOp-A satellite with ~0.5 nm spectral resolution and wavelengths between 734 and 758 nm. This dataset's products were written as L2 orbital files for the day specified in the filename similar to the related ERS-2 GOME and SCIAMACHY datasets (Joiner et al., 2019, 2021).

The retrievals use a principal component analysis technique to account for absorption and scattering in the atmosphere (Joiner et al., 2013, 2016). Similar approaches have been used with different details in the fitting window and number of principal components used (Köhler et al., 2015) as documented in Parazoo et al. (2019). Other retrievals might give different overall magnitudes but provide similar spatial and temporal variability. Envisat had an equator crossing time of 10:00 AM which is half an hour later than the EUMETSAT Met-Op satellites that host the GOME-2 instruments. Other changes have been

made to the algorithm since Joiner et al.(2013) (see Joiner et al., 2014, 2016).

### Known Algorithm and Instrument Features and Caveats

1. Month-to-month (temporal) variations may incorporate instrumental effects.
2. All relevant retrievals are retained in the L2 dataset and quality control is in the hands of the user (see below for further details).
3. The GOME-2 instrument has a relatively large footprint; the native resolution of approximately 40 km x 80 km at nadir in the nominal nadir mode and 40 km x 40 km in the smaller swath mode that is used after July 2013.
4. Due to the large pixels, clouds and aerosols are present in nearly every observation. Although the retrieval approach can tolerate cloud contamination, clouds will screen the surface signal from the satellite view. Therefore, temporal and spatial variations in the data may also be due to cloud contamination. A cloud filtering approach is described in Joiner et al. (2012). For a more complete description of the errors, please see Joiner et al. (2013). Users may wish to apply additional cloud screening using the effective cloud fraction data field depending upon their application. Cloud fractions are reported as computed. There are negative values reported along with values >1. For practical purposes, values >1 can be considered as 1, and negative values as zero.
5. Some issues with data at very high solar zenith angles (SZA), such as in winter at high latitudes, have been noted (fluorescence is slightly positive or negative when it is expected to be zero). Data with SZA >75° have been excluded.
6. There has been no attempt as of yet to reconcile the differences between the SIF from GOME-2 on MetOp-A and -B, ERS-2 GOME (Joiner et al., 2019), and SCIAMACHY (Joiner et al., 2021). There are calibration differences that produce SIF differences between the datasets. Users are advised to proceed with caution if data sets are used together. Analysis of all datasets is ongoing.
7. SIF values are sensitive to the absolute calibration of the solar irradiances. The GOME-2 instrument degraded during its lifetime. The datasets use the latest available version of GOME-2 Level 1B (L1B) data (radiance and irradiances). The data have not been analyzed for potential false trends caused by instrument degradation and, therefore, are NOT recommended for long-term trend analysis.
8. The data have been corrected for small zero-level offset problems (Köhler et al., 2015; Joiner et al., 2016) using a machine learning approach (Joiner et al., 2020). Both the corrected and uncorrected data are provided. Bias correction is imperfect, and small biases remain, particularly over high albedo (high radiance) and non-vegetated surfaces such as the Sahara desert. One change from Joiner et al. (2016) is that a machine learning approach (a neural network) is used to estimate the biases; this technique produces a smoother bias field as a function of latitude than the previous regression approach.
9. The quality control values are 2 = good retrievals with cloud fraction <30%, 1 = good retrievals with cloud fraction >30%, and 0 = retrievals not passing various quality control checks.
10. For gridding data, pixels with a quality control value of 2 are recommended.
11. Estimated daily-averaged SIF values based on a single observation are provided. The estimates use an approximate clear sky PAR proxy (cosine of the solar zenith angle) at the observation time and a similar clear-sky PAR weighting for all other hours. This is similar to what is provided in related datasets.

Several fields, such as sun-satellite geometry are provided directly as given in the L1B data, and others (Delta\_Time) are computed from the L1B data.

## 6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

### L2 Daily Solar-Induced Fluorescence (SIF) from MetOp-A GOME-2, 2007-2018, V2

Contact for Data Center Access Information:

- E-mail: [uso@daac.ornl.gov](mailto:uso@daac.ornl.gov)
- Telephone: +1 (865) 241-3952

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## 8. Dataset Revisions

Version	Release Date	Revision Notes
2.0	2024-01-25	Added 24 files that were unintentionally excluded from Version 1.1. All files were re-processed to account for an error in the time variable. The time error caused the day to be off by 1 day for times after 12Z.
1.1	2023-02-23	Added 71 files that were unintentionally excluded from Version 1.0. Processing was the same for the new files. There were no changes made to files in Version 1.0.
1.0	2022-08-29	Initial release.



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