GOME-F SOLAR-INDUCED FLOURESCENCE (SIF) README FILE

Overview

This document presents a brief description of the GOME_F solar-induced fluorescence (SIF) data products. These are produced by Joanna Joiner as part of a NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) program led by Nick Parazoo. GOME_F version 2.8.0 (V2.8.0) retrievals from the Global Ozone Monitoring Experiment (GOME) instrument on the European Space Agency's (ESA's) European Remote-Sensing 2 (ERS-2) satellite use channel 4 with ~0.5 nm spectral resolution and wavelengths between 734 and 758 nm (a smaller fitting window than that presented in Joiner et al., 2013). Note that ERS-2 had an equator crossing time of 10:30 AM which is one 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). Contact information is provided below for more details.

Data Quality Assessment

GOME_F products are inherently noisy due to low signal levels. Users should expect to see negative values in both level 2 and level 3 data sets. When using level 2 data sets, users should retain those negative values and treat them like they would for any other noisy data set. 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 then bias results. Level 3 data are monthly gridded averages, yet still there are some negative values owing to imperfect bias correction, noise, etc. Users may treat the negative monthly values as zero for certain applications. However, in other applications, such as averaging over a number of years, the negative values should be retained.

Users should be aware that the GOME data set provided here has undergone only a limited amount of validation (e.g., the algorithm applied to GOME-2 has been compared with ground-based data in Yang et al., 2015). 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).

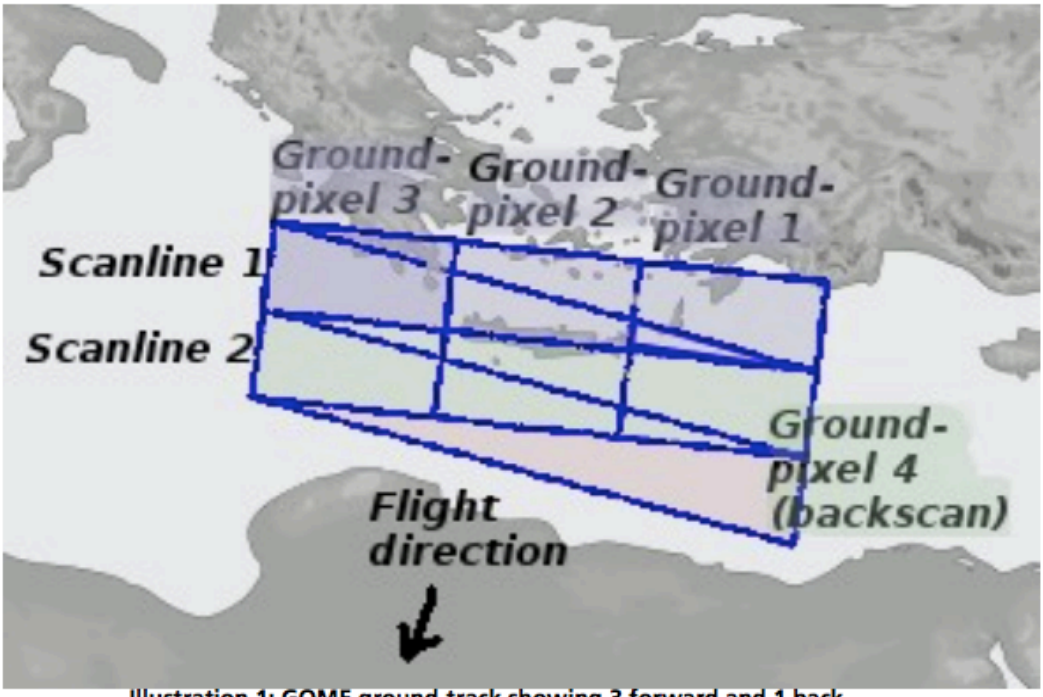

Illustration 1: GOME ground-track showing 3 forward and 1 back-scan ground_pixel per scanline

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Figure 1: From Aberle et al. (2018) shows the default NADIR and NADIR_BACKSCAN modes.

Known Algorithm and Instrumental Features:

1) Month to month (temporal) variations may incorporate instrumental and algorithmic effects.
2) All relevant retrievals are retained in level 2 data sets and quality control of level 2 is in the hands of the user (see below for further details). The GOME instrument has a relatively large footprint, approximately 40 km x 320 km at nadir in the nominal NADIR mode (see Figure 1). There are 3 pixels in the forward scan mode, giving a swath width of 960 km that provides global coverage in approximately three days. The pixel width in the nadir backscan mode is three times larger (40 km x 960 km) and has not be processed in the current data set. There is also a small swath mode on ~1-2 days per month with 40 km x 80 km pixels in forward scan mode and 40 x 240 km in the backscan mode. These data are provided in the level 2 files. The instrument mode is also provided in the level 2 files for all pixels.
3) Due to the large pixels, clouds and aerosol are present in nearly every observation. Although our retrieval approach can tolerate a small amount of cloud contamination, clouds will screen the surface signal from satellite view. Therefore, temporal and spatial variations in the data may also be due to cloud contamination. The 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 cloud fraction data field depending upon their application.

4) Some issues with data at very high solar zenith angles (in winter at high latitudes) have been noted (fluorescence is slightly positive or negative when it is expected to be zero). We have not included any data with SZA > 75°.
5) Level 3 data have had various filtering applied but include cloud-contaminated data (cloud fractions of up to 30% are included). Please check for updates as we expect to improve the gridding to account for known sources of error.
6) There has been no attempt as of yet to reconcile the differences between the ERS-GOME SIF and SIF from GOME-2 on MetOp-A and –B. There is a difference in calibration that causes differences between the data sets (GOME data have larger magnitudes than GOME-2). Users are advised to proceed with caution if both data sets are used together. Analysis of both data sets is ongoing; the data are provided on a best effort basis.
7) SIF values are sensitive to absolute calibration of the solar irradiances. The GOME instrument degraded during its lifetime. We are using the latest version of GOME level 1B data (radiances and irradiances) as is and as documented by Coldewey-Egbers et al. (2019). We have not analyzed the data for potential false trends caused by instrument degradation and therefore can NOT recommend use of these data for long-term trend analysis.
8) SIF values are provided over ocean for monitoring of biases. We have attempted to correct for small zero-level offset problem in previous versions (Joiner et al., 2016). We provide both the corrected and uncorrected SIF_740 data fields. As the bias correction is not perfect, small biases still remain, particularly over high albedo (high radiance), non-vegetated surfaces such as the Sahara desert.
9) The quality control values are 2 for good retrievals with cloud fraction < 30%, 1 for good retrievals with cloud fraction > 30%, and 0 for retrievals not passing various quality control checks.
10) For level 3 gridded data, we use an unweighted scheme with all pixels having a quality control value of 2.
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 other data sets.
12) The cross-track position (Scan_Number) is provided as a number 1-3. Numbers 1-3 are in the forward scan and 4 are for the back scans. The Scanline number (Line_Number) is also provided.
13) Several fields, such as glint possibility (Glint), Reference Time and Delta Time, sun-satellite geometry, etc. are provided directly as given in the L1B GOME data. Please refer to Aberle et al. (2018) for more information.

Product Description

The GOME_F level 2 product is written as a self-describing netCDF4 level 2 orbital file for the day and orbit specified in the filename similar to previously released GOME-2 data sets but netCDF4 instead of netCDF3 (classic). A few new fields are provided. A

simple IDL reader has been provided. The information provided on these files includes: Latitude, longitude, SIF (SIF_740) referenced to 740 nm, and reflectance near 670 and 780 nm. This is a preliminary release. It is expected that the file format will change slightly when the release is officially made as part of the MEaSUREs record.

The GOME_F level 3 product is written as a self-describing netCDF level 3 monthly gridded file for the month and year specified in the filename. A simple IDL reader has been provided. The information provided on these files includes: Latitude, longitude, counts, SIF (SIF_740) referenced to 740 nm (mean and standard deviation), and NDVI derived from 670 and 780 nm (mean and standard deviation). Note that the NDVI is cloud contaminated and no attempt has been made to apply atmospheric correction. This field is given for a rough reference and convenience only and it is not meant to be used for scientific investigations. The level 3 data sets contain only the corrected data.

Contact

All questions related to the GOME_F datasets should be directed to Joanna Joiner (Joanna.Joiner@nasa.gov). Dr. Joiner has detailed knowledge of data issues that may be important to the scientific use of these data. Regular updates to this README file will be posted based on user questions and feedback.

Acknowledgments

This work is funded by the NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) program. We gratefully acknowledge ESA and the German Aerospace Centre (DLR), particularly Diego Loyola, for providing the GOME data used here.

References

Aberle, B.: GOME ERS-2 Level 1 Product User Manual, Tech. rep., German Aerospace Centre (DLR), Oberpfaffenhofen, Germany, ER-PS-DLR-GO-0016, Issue 6/D, available at: https://earth.esa.int/documents/700255/3497594/GOME-DLR-L1-PUM_6D.pdf/f33fee60-20a8-4065-859f-e79a5b1b740b, last access: 26 July 2018.

Coldewey-Egbers, M., Slijkhuis, S., Aberle, B., Loyola, D., and Dehn, A.: The Global Ozone Monitoring Experiment: review of in-flight performance and new reprocessed 1995–2011 level 1 product, Atmos. Meas. Tech., 11, 5237-5259, https://doi.org/10.5194/amt-11-5237-2018, 2018.

Joiner, J., Yoshida, Y., Vasilkov, A. P., Middleton, E. M., Campbell, P. K. E., Yoshida, Y., Kuze, A., and Corp, L. A., 2012: Filling-in of near-infrared solar lines by terrestrial fluorescence and other geophysical effects: simulations and space-based observations from SCIAMACHY and GOSAT, Atmos. Meas. Tech., 5, 809-829, doi:10.5194/amt-5-809-2012.
Paper available online.

Joiner, J., Guanter, L., Lindstrot, R.,Voigt, M., Vasilkov, A. P.,Middleton, E. M., Huemmrich, K. F., Yoshida, Y., and Frankenberg, C., 2013: Global monitoring of terrestrial chlorophyll fluorescence from moderate spectral resolution near-infrared satellite measurements: methodology, simulations, and application to GOME-2, Atmos. Meas. Tech., 6, 2803-2823, doi:10.5194/amt-6-2803-2013.
Paper available online.

Joiner, J., Yoshida, Y., Vasilkov, A. P., Schaefer, K., Jung, M., Guanter, L., Zhang, Y., Garrity, S., Middleton, E. M., Huemmrich, K. F., Gu, L., Belelli Machesini, L., 2014: The seasonal cycle of satellite chlorophyll observations and its relationship to vegetation phenology and ecosystem-atmosphere carbon exchange, Remote Sens. Environ., doi:10.1016/j.rse.2014.06.022.

Joiner, J., Yoshida, Y., Guanter, L., and Middleton, E. M.: New methods for retrieval of chlorophyll red fluorescence from hyper-spectral satellite instruments: simulations and application to GOME-2 and SCIAMACHY, Atmos. Meas. Tech., 9, 3939-3967, doi:10.5194/amt-9-3939-2016.

Yang, X., Tang, J., Mustard, J. F. et al. 2015: Solar-induced chlorophyll fluorescence that correlates with canopy photosynthesis on diurnal and seasonal scales in a temperate deciduous forest, Geophys. Res. Lett., 42, 2977-2987 doi: 10.1002/2015gl063201.