As of 10 June 2016

This GOES-R Level 2+ space weather Algorithm Theoretical Basis Document (ATBD) is preliminary and subject to change as the GOES-R Program prepares for a launch in late 2016.

The NOAA National Centers for Environmental Information (NCEI) is currently developing a demonstration version of the Satellite Product Analysis and Distribution Enterprise System (SPADES) which will host the L2+ algorithms. The operational SPADES will be instantiated by the National Weather Service in FY2017 to serve the needs of the Space Weather Prediction Center (SWPC).

Updated versions of the L2+ ATBDs will periodically be made available and posted to the SPADES website.

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NCEI

http://www.ngdc.noaa.gov/stp/space-weather/online-publications/stp_sii/spades/

NOAA NESDIS CENTER for SATELLITE APPLICATIONS and RESEARCH

GOES-R EXIS EUVS.07 DAILY AVERAGE ALGORITHM THEORETICAL BASIS DOCUMENT
Version 1.2

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TITLE: EXIS EUVS DAILY AVERAGE ALGORITHM THEORETICAL BASIS DOCUMENT VERSION
1.2

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EXIS EUVS DAILY AVERAGE ALGORITHM THEORETICAL BASIS DOCUMENT VERSION HISTORY SUMMARY

Version	Description	Revised Sections	Date
1.0	Created by Don Woodraska, LASP, from template provided by Mary Shouldis CIRES/SWPC	New Document	Jan, 2010
1.1	Updated for CDR	Most changed due to a design change and inclusion of test results	July, 2010
1.2	Updated for algorithm walkthrough	Updated figures, separated ancillary data from metadata, updated exception handling and assumptions and limitations	Sept, 2010

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LIST OF ACRONYMS

ATBD	Algorithm Theoretical Basis Document
AWG	Algorithm Working Group
CIRES	Cooperative Institute for Research in Environmental Sciences
EXIS	EUV and X-ray Instrument Suite
EUVS	Extreme Ultraviolet Sensor
LASP	Laboratory for Atmospheric and Space Physics
NA	Not Applicable
SET	Space Environment Technologies
STAR	Center for Satellite Applications and Research
SWPC	Space Weather Prediction Center

ABSTRACT

This document provides a description of the EUVS.07 algorithm implemented to calculate daily averages for the EUV Sensor (EUVS) solar irradiance data. The EUVS data include specific spectral lines and bands of the solar EUV irradiance, as well as modeled solar EUV spectral irradiances and solar proxies such as the Mg II core-to-wing ratio. The EUVS.07 algorithm (procedure) is flexible enough that it can be applied for any EUVS data set. The logical flow of the algorithm, including exception handling, is outlined. Validation and examples of the algorithm using proxy data sets based on modeled solar EUV spectral irradiance are presented.

1.0 INTRODUCTION

1.1 Purpose of This Document

The purpose of this document is to describe the development and design of the EUVS.07 algorithm produced to calculate the daily average, including details needed for implementation of the algorithm and examples of use and validation. It provides the operational requirements for this product and defines how these requirements are met with this algorithm. The algorithm inputs, processing and outputs are described in enough detail to design, develop, test, and implement the necessary processing software and storage mechanisms.

1.2 Who Should Use This Document

This document provides product developers, reviewers, and users with a theoretical description (scientific and mathematical) of the GOES-R EUVS daily average algorithm.

The members of the Space Weather Forecast Office and the Research and Customer Requirements Section of the SWPC should use this ATBD to verify that the proposed algorithm meets the necessary operational requirements. They should also use it to understand the strengths and weaknesses of the algorithm as well as its accuracy and applicability. The STAR AIT group should use this document to integrate the algorithm into their collaborative framework environment. It should also be used by the ground segment contractor to design, develop, test, validate and implement the algorithm into the final operational processing system.

1.3 Inside Each Section

Section 2.0 OBSERVING SYSTEM OVERVIEW:
Describes the EXIS instrument suite and the measurements that serve as input to the algorithm.

Section 3.0 ALGORITHM DESCRIPTION:

Describes the development, theory and mathematics of the algorithm. Describes the logical flow of the algorithm, including input and output flow.

Section 4.0 TEST DATA SETS AND OUTPUTS:
Describes the test data sets used to characterize the performance of the algorithm and the data product quality. Describes the results from the algorithm processing on simulated input data.

Section 5.0 PRACTICAL CONSIDERATIONS:
Discusses issues involving numerical computation, programming and procedures, quality assessment and diagnostics and exception handling.

Section 6.0 ASSUMPTIONS AND LIMITATIONS:
Describes assumptions made in the implementation of the calculation of the EUVS daily averages and assumptions made in validation, testing, and error handling of the algorithm.

Section 7.0 REFERENCES:
Provides all references mentioned in the ATBD.

1.4 Related Documents

GOES-R EUVS.07 Daily Average Test Plan and Results, Version 1.0, 2010.

GOES-R Series Mission Requirements Document (MRD), P417-R-MRD-0070, Version 3.1, December 5, 2007.

GOES-R Series Performance and Operational Requirements Document, 417-R-EXISPORD-0116_V_2_2, Jan 15, 2008.

1.5 Revision History

Version 1.0 Jan 12, 2010, Donald Woodraska, Initial Version
Version 1.1 July 12, 2010, Donald Woodraska, Revised for CDR delivery
Version 1.2 Sept 24, 2010, Donald Woodraska, Revised for Algorithm Walkthrough

2.0 OBSERVING SYSTEM OVERVIEW

2.1 Product Generated

The EXIS EUVS.07 daily average algorithm is a new function and expands the capability of the SWPC. The function returns a daily average for each of the EXIS bands provided in an array. It is expected that this will be called from a cron (daemon) or similar routine daily cadence to operate on data that is already available. This algorithm is expected to be part of a larger routine that collects the necessary measurements and passes them to the daily average function. Similarly, the returned results are provided as arrays that would then need to be stored in a manner consistent with existing storage retention criteria for other data products. The details of the input and output data formats are beyond the scope of this document.

2.2 Instrument Characteristics

The EXIS instrument suite on GOES-R+ is comprised of several science instruments. These instruments are XRS, EUVS-A, EUVS-B, and EUVS–C. The XRS instrument consists of X-ray photometers for spectral bands named A (0.05-0.4 nm) and B (0.1-0.8 nm). The EUVS instruments are grating spectrographs that measure specific spectral ranges in the EUV and UV. The EUVS-A measures corona and transition region emission lines in the 17-34 nm range. The EUVS-B measures transition region and chromosphere emission lines in the 117-141 nm range. The EUVS-C measures the Mg II chromosphere emission lines and photospheric continuum near 280 nm, as used to generate the Mg II core-to-wing ratio.

The EUVS-C data cadence is normally 10-seconds, but is changeable from 0.25-64 seconds. The cadence is not fixed since daily calibration interrupts the routine cadence. After the daily calibration is completed, the 10-second offset may not be temporally aligned with the previous expected value.

The EUVS-A and EUVS-B channels will now operate at a cadence of 1-second, so they are always aligned to the same start time. However, internal instrument calibration allows for EUVS-A (or B) to remain in normal science operation while the EUVS-B (or A) begins an internal calibration. The channels are designed to directly measure selected fixed, wavelength bands. A proxy model uses these

bands as inputs to create a model spectrum over the full EUV range. The proxy model creates the spectrum at a 30-second cadence from the available measurements in that time interval.

The EXIS data is time averaged to 1-min averages before being used in this EUVS.07 algorithm. This algorithm is also compatible with level 1b 30-second output with one minor variable change (N_TIMES would change from 1440 to 2880).

The EUVS instrument package includes a door, filter mechanism, and flat-field stimulus lamps (LEDs). There are times when EUVS is not taking solar data, such as during spacecraft maneuvers or flat-field lamp measurements. The status flags for those non-solar data are indicated as invalid data so that they will not be included in the daily average.

3.0 ALGORITHM DESCRIPTION

3.1 Algorithm Overview

The EUVS daily average algorithm fulfills the needs for a large and growing user community that includes SET, SWPC, and the U.S. Air Force. Many models have been created that rely on solar proxies that are only available as daily averages. For example, the Air Force Space Battlelab uses daily averages to model the thermosphere as part of their space weather operations to forecast satellite drag (e.g. Bowman *et al.* 2008). Daily averaged solar proxies are also used to assist in satellite tracking and collision avoidance. Furthermore, the NOAA SWPC uses near realtime data and daily averages of the solar EUV irradiance to model / forecast Earth's ionosphere and thermosphere densities and temperatures to support various communications and navigation applications (e.g. GPS).

The algorithm described is straightforward, and is enhanced through appropriate filtering. The algorithm provides basic exception handling to properly account for missing values. Limits have been chosen that prevent the daily average from being calculated if insufficient data are available.

3.2 Processing Outline

The daily average algorithm is represented in Figure 1 and is summarized by the following steps.

1. Setup: Declare and initialize constants, declare internal arrays and return variables, initialize returned variables (Figure 2)
2. Data Ingest: Receive 1-minute averaged data, metadata, and ancillary data inputs (Figure 3)
3. Data Filter: Verify/check that input values are reasonable and copy input data and flags into internal data arrays. Perform data filtering on working arrays, remove invalid values, and set internal quality flags appropriately (Figure 4)
4. Process Data: Calculate the daily average, percent coverage, and quality flag for each band (Figure 5)
5. Return

In this discussion, using variables will keep the description concise. The variables used are described in Table 1.

Table 1. Variable Descriptions Used in this Document

Variable Name	Units	Description
dataIn	Arbitrary, W/m² or dimensionless	Input Data (Primary) for each band
qualityIn	NA	Input Quality flags for dataIn
limits	Same as dataIn	Low and high valid ranges for each band
dataToAvg	Same as dataIn	Local variable to hold a copy of the available data
dataWeight	NA	Local weighting factors for dataToAvg
dailyAverage	Same as dataIn	Daily Average for each band, returned
qFlagOut	NA	Quality flags for dailyAverage, returned
percentCoverage	Percent	Percentage complete for each band in dailyAverage, returned
numerator	Same as dataIn	The numerator of Equation 2
denominator	NA	The denominator of Equation 2
n_Times	NA	The total number of time intervals (minutes in one UT day, 1440)
n_Bands	NA	The total number of bands in dataIn to average
bandIndex	NA	Band designator (0 means 1 band)
timeIndex	NA	Time interval designator (minute of day number 0-1439)

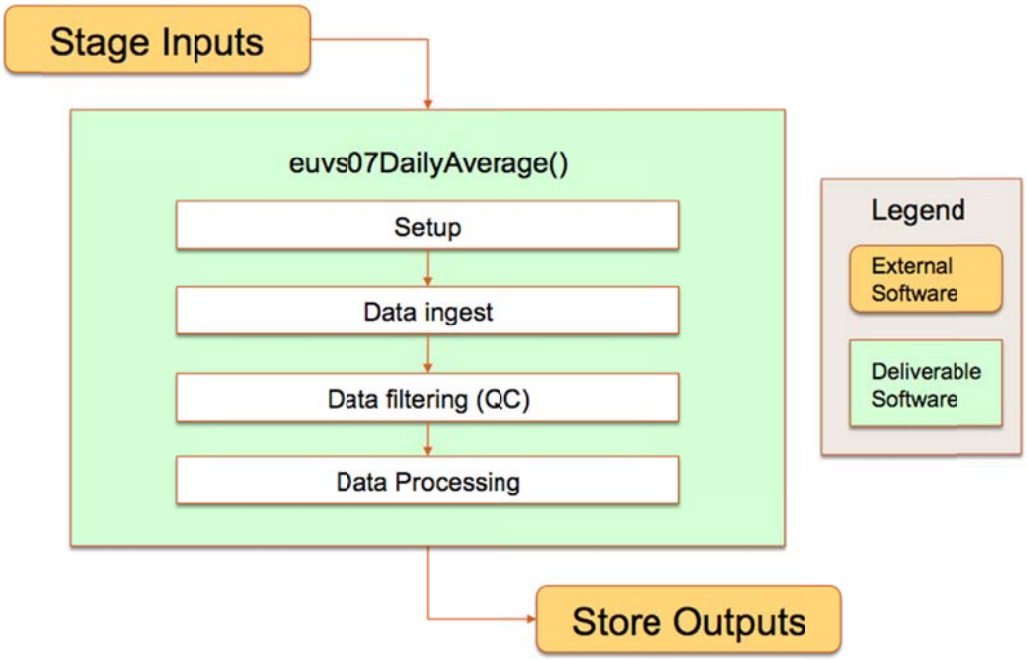


Figure 1. EUVS Daily Average Algorithm Overview Flowchart

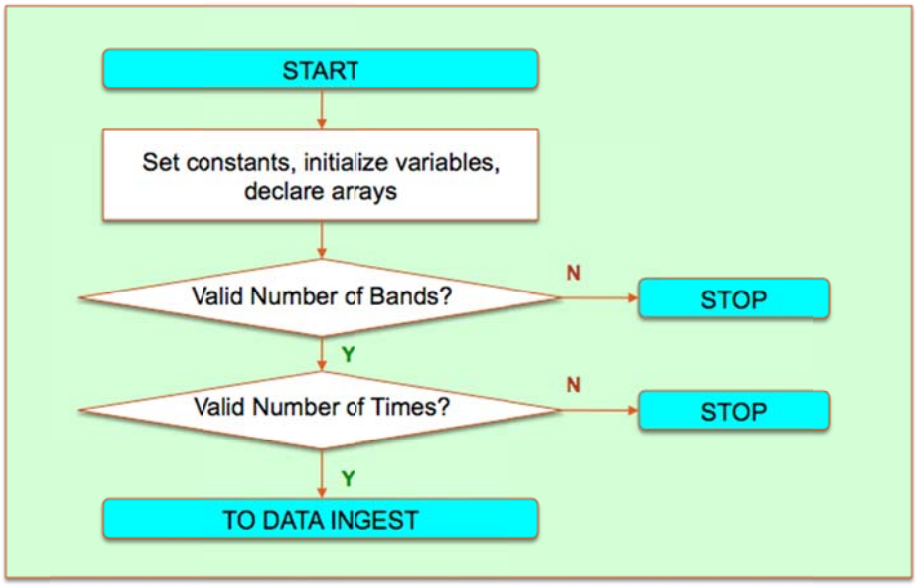


Figure 2. EUVS Daily Average - Setup

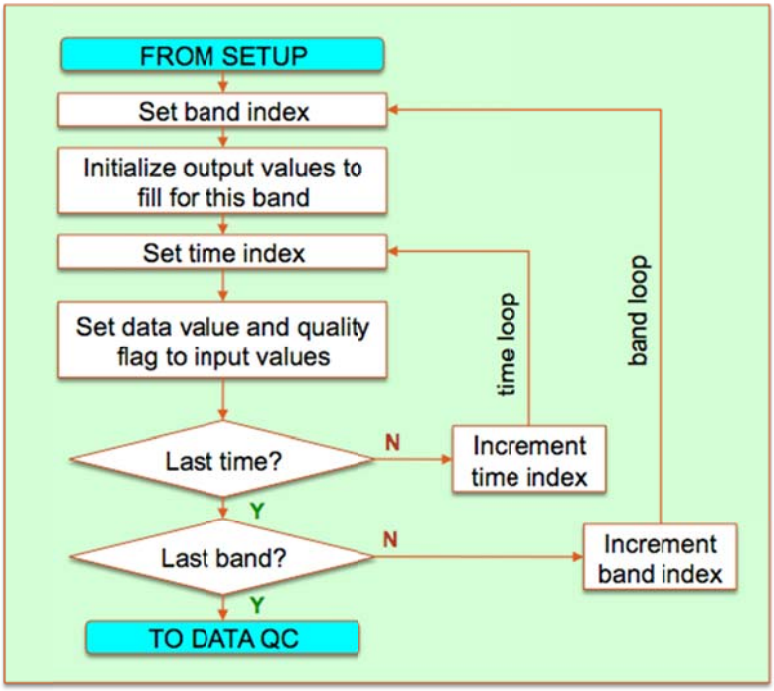


Figure 3. EUVS Daily Average - Data Ingest

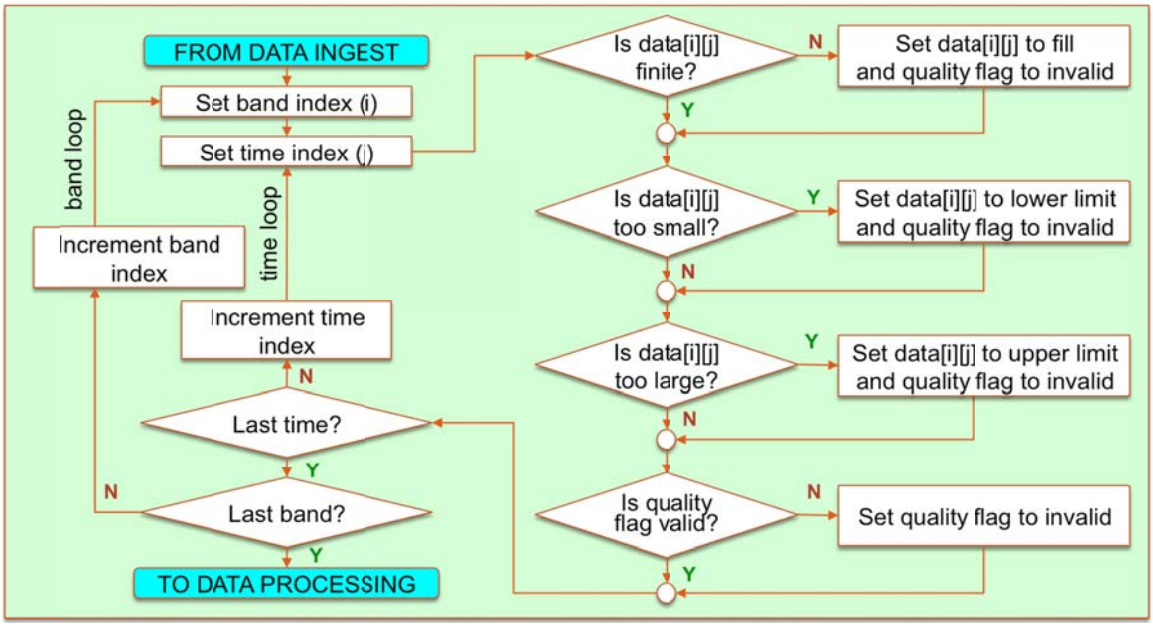


Figure 4. EUVS Daily Average - Data Filter, Quality Compare (QC)

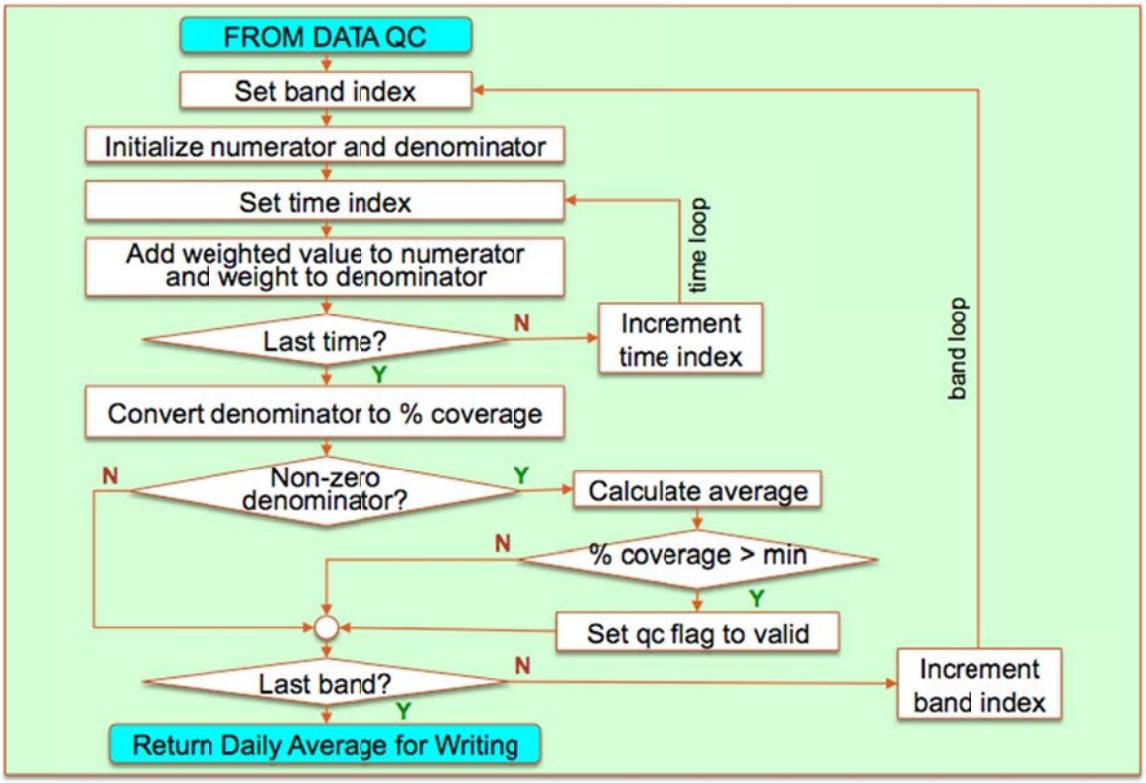


Figure 5. EUVS Daily Average - Data Processing for Averages

All necessary input data described in the section titled Algorithm Input shall be provided to the EUVS Daily Average software.

3.3 Algorithm Input

The inputs to the algorithm are expected to consist of 1-minute averages of EUVS data for each time interval and the associated quality (or validity) flags. The flag values are 0 (invalid) or 1 (valid) only.

Any number of bands could be allowed, but the expected minimum value is 24 (22 of the 5 nm spectrum bands, plus Lyman-alpha, plus Mg II). The 6 other directly measured lines from EUVS-A and EUVS-B could easily be appended as additional bands. Even more bands (for example, XRS long channel) could be added up to the limit of 100 by changing a variable (n_Bands). Expansion beyond this limit is also possible by increasing the variable maxNumBands in the function euvs07DailyAverage.

By changing a constant (N_TIMES), from 1440 to 2880, the algorithm could be made to work directly with level 1b 30-second spectrum.

3.3.1 Primary Sensor Data

The GOES-R EUVS level 1b product will contain 5 nm spectral data that spans 5-115 nm, plus Hydrogen Lyman-alpha, and the 7 primary measurements from the three EUVS channels.

The primary measurements available in level 1b include, Fe XV 28.4 nm, H I (Lyman-alpha) 121.6 nm, and the Mg II core to wing ratio.

The secondary measurements are He II 25.6 nm, He II 30.4 nm, C III 117.5 nm, C II 133.5 nm nm, and Si IV / O IV 140.5 nm.

The number of measurement bands (n_Bands) is a variable to allow the algorithm to be used with GOES-13 EUVS broad bands, or the GOES-R spectrum and bands. The number of times (N_TIMES) is expected to be 1440, corresponding to the number of minutes in one UT day, when using 1-minute average data. For 30-second spectrum data, the number of times used would need to be adjusted accordingly.

Explicitly, the input data are the primary measurement matrix (N_TIMES by n_Bands). These are summarized in Table 2.

Table 2. EUVS Daily Average Algorithm Input Data

Input Data	Dimension Sizes	Units	Purpose in EUVS daily average algorithm
dataIn, Primary satellite measurements (1-minute averaged)	N_TIMES by n_Bands	Arbitrary, results have the same units	The calibrated quantities to be averaged.

3.3.2 Metadata

Each 1-minute average will have a corresponding time stamp indicating the minute in the UT day for each measurement set.

It is convenient to provide a scalar that contains the number of bands under consideration, n_Bands.

Additionally, a quality (or validity) flag shall be provided that indicates the data is present and valid for each band, at each time. Zero and one are the only valid values for these flags. Valid is indicated by a value of one.

Explicitly, the input metadata are: the primary measurement quality flags (N_TIMES by n_Bands), the limits for each band (n_Bands by 2), and the number of bands to average. These are summarized in Table 3.

3.3.2 Ancillary Data

Another input variable is used to provide limit checking of the data. To protect the results from possible data corruption, data values that are outside these limits for a given band be replaced with the fill value and the associated quality flag will be set to the invalid value. This provides additional protection from random or unphysical inputs. The limits are currently read from a file, so these can be updated as needed without changing the code.

Each primary measurement band shall have an associated valid limit range comprising low and high values. The validity check uses a greater or equal comparison to the low limit value, and a less than or equal to comparison against the upper limit value. Explicitly, the only input ancillary data are the limits for each band (n_Bands by 2). This is shown in Table 4.

In principle, the limits may be different for different instruments. That is, each instrument has detectors and electronics that have subtle variations that may cause one to exhibit lower or higher noise allowing for small differences in the achievable full dynamic range. Some analysis is needed for very low and very high solar activity conditions to adjust these for each instrument. A default limits file is provided with the test datasets.

Table 3. EUVS Daily Average Algorithm Input Metadata

Input Metadata	Data Type	Dimension Sizes	Units	Purpose in EUVS daily average algorithm
n_Times	16-bit unsigned integer	Scalar	NA	Used to define array lengths for primary data
n_Bands	16-bit unsigned integer	Scalar	NA	Used to define array lengths for primary data
qualityIn, Primary quality flags	8-bit unsigned char array	N_TIMES by n_Bands	NA	Identify present but invalid measurements to exclude from the average

Table 4. EUVS Daily Average Algorithm Input Ancillary Data

Input Metadata	Data Type	Dimension Sizes	Units	Purpose in EUVS daily average algorithm
limits	double array	n_Bands by 2	same as dataIn	Used to identify and exclude data that is outside the valid range

3.4 Theoretical Description

3.4.1 Physics of the Problem

The daily average is a time average. For irradiance bands, this represents the total energy flux received at the Earth per day. For the Mg II core-to-wing ratio, the daily average represents a measure of time averaged, relative solar activity. The algorithm is generic enough that any quantity provided (as a band), would be time averaged over a day, so the physical interpretation depends upon the input band description.

3.4.2 Mathematical Description

If all measurements were available over the day, then the time average would reduce to the simple average (so-called boxcar average) in Equation 1. Here, E

indicates the average (dailyAverage), and E_i represents one measurement band (dataIn) at time interval j (timeIndex).

Equation 1. $$E = \frac{1}{N_{times}} \sum_{j=0}^{N_{times}-1} E_j$$

However, this is a special case. Under normal operational conditions, there will be data gaps (fill data and flagged data). For these instances it is preferred to instead calculate the weighted average over the available data, and report a metric indicating the completeness of the average. In Equation 2, i indicates the band under consideration (bandIndex), E indicates the measurement data (dataIn), and W represents the weights (qualityIn). In this convention, W=0 for missing or invalid data, and W=1 for valid data. W is derived from the quality flags. Mathematically, the weights are the reciprocal variances ($1/\sigma^2$, see Bevington and Robinson 1994).

Equation 2. $$E_{i,Daily} = \frac{\sum_{j=0}^{N_{times}-1} E_{i,j} \cdot W_{i,j}}{\sum_{j=0}^{N_{times}-1} W_{i,j}}$$

The completeness of the average is manifested in the denominator of Equation 2. However, we choose to provide a more human-friendly metric, the percentage complete. This is mathematically represented in Equation 3.

Equation 3. $$f_{i,percent} = \frac{100}{N_{times}} \sum_{j=0}^{N_{times}-1} W_{i,j}$$

The value of $f_{percent}$ (percentCoverage) determines the value of the output quality flag. For values of $f_{percent}$ that are less than 10%, the output quality flag is set to invalid. If the calculation of $f_{percent}$ would cause a divide by zero, the calculation is not performed. For that case, the previously initialized fill values are returned for the averages, and the output quality flags (qFlagOut) remain set to invalid.

3.4.3 Algorithm Output

The algorithm outputs are summarized in Table 5.

Table 5. EUVS Daily Average Algorithm Outputs

Result	Dimensions	Data Type	Description
percentCoverage	n_Bands	32-bit floating point array	Completeness as a percent (0-100)
dailyAverage	n_Bands	32-bit floating point array	An array of averages in each band
qFlagOut	n_Bands	8-bit unsigned char array	Valid (1) or invalid (0) for each band

4.0 TEST DATA SETS AND OUTPUTS

4.1 Simulated/Proxy Input Data Sets

Although there are no EUVS sensors on GOES spacecraft, the algorithms presented in this document can be tested using GOES-NOP EUVS sensor data. However, more realistic signals (and problems) may be found by using TIMED-SEE or SDO-EVE data when available. Certain models also exist (i.e. FISM) that can also provide high-time cadence, realistic, simulated data. For this study, we use FISM (1-minute and daily averages) and the NOAA Mg II daily average dataset (see references section for more details).

FISM has been selected because it provides high-time cadence (1-minute) data for the entire GOES-R EXIS wavelength range, with one exception. The Mg II core to wing ratio is not covered by FISM, however, this data set is available on a daily basis from NOAA. The physical properties of the solar plasma are used to identify the FISM 133.5 nm bin as a good candidate for emulating the Mg II behavior. The 133.51 nm C II emission dominates that 1 nm band and largely originates in the chromosphere, the same as the Mg II h and k emission lines in the core. We therefore expect the Mg II behavior to agree very well with the C II behavior. This is observed using a linear correlation of the FISM daily average and the NOAA Mg II daily average dataset. We find the correlation is approximately 98% during 2003, which is sufficient for our needs. The following figure shows the result of applying the daily correlation results to the 1-minute FISM 133.5 nm band. The FISM results are the black dots, and the NOAA daily values are the red diamonds.

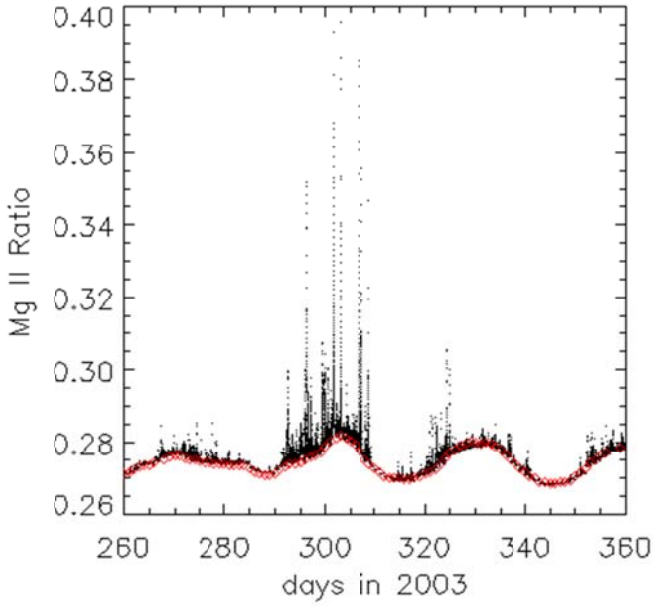
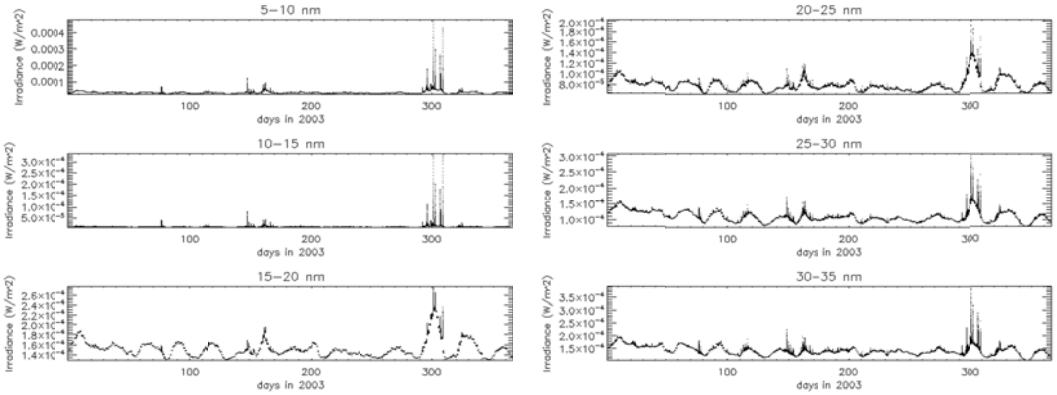


Figure 6. Mg II core to wing ratio derived from correlating NOAA Mg II and FISM 133.5 nm bin.

Note that the FISM model indicates a lot of solar activity around day 300. This time period represents and extremely active period in the declining phase of the solar cycle where very large flares occurred. For this reason, we choose this whole year of 2003 to produce test cases.

FISM provides long-term high time-cadence EUV data as shown in the following figures.



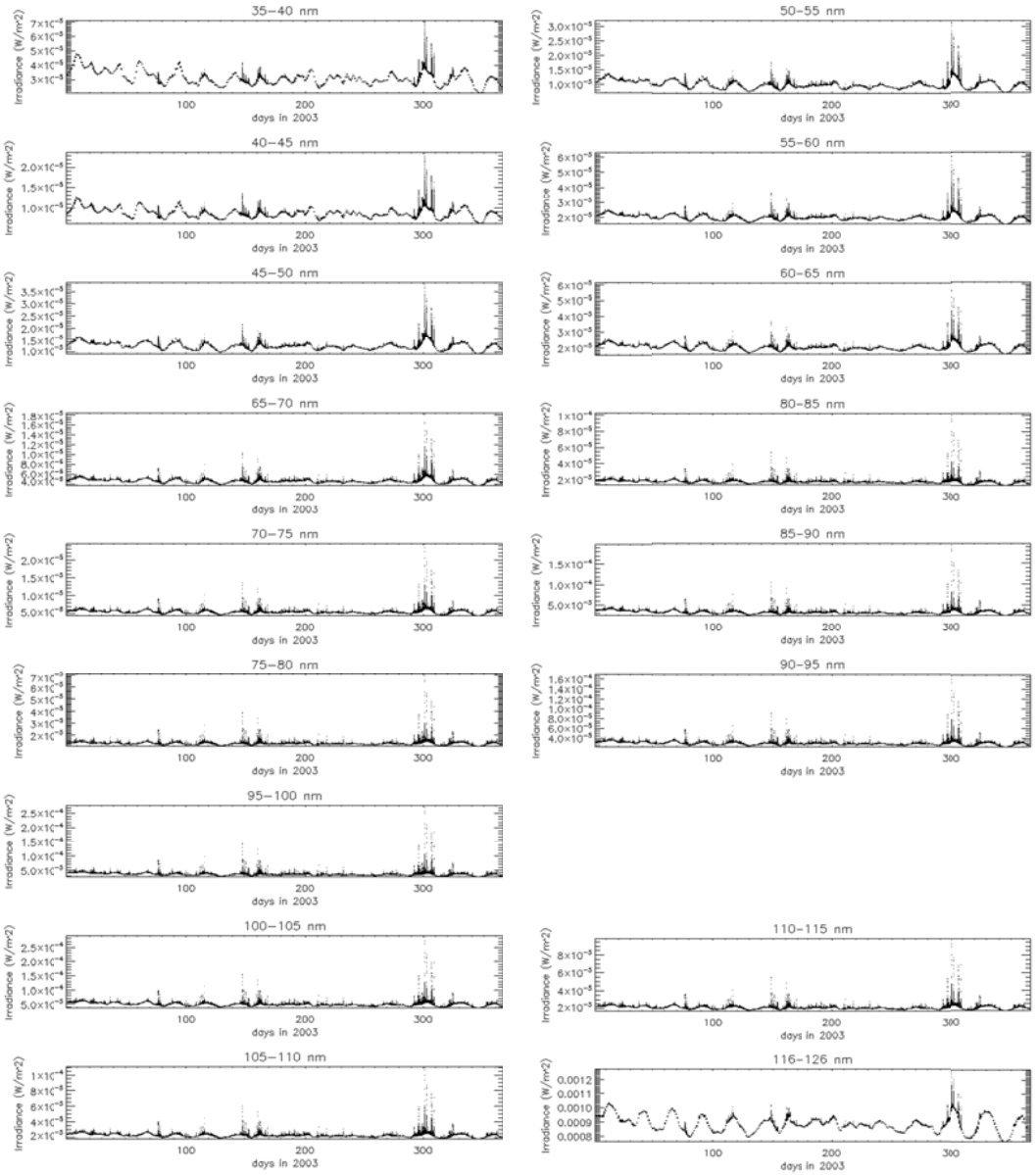


Figure 7. FISM-derived proxy data representative of GOES-R EXIS for 2003.

The data available in the FISM model is at 1 nm sampling, so wavelength averaging was implemented to match the GOES-R EXIS level 1b spectrum.

Although long time-series data are available, the following graph demonstrates the high time-cadence feature of FISM.

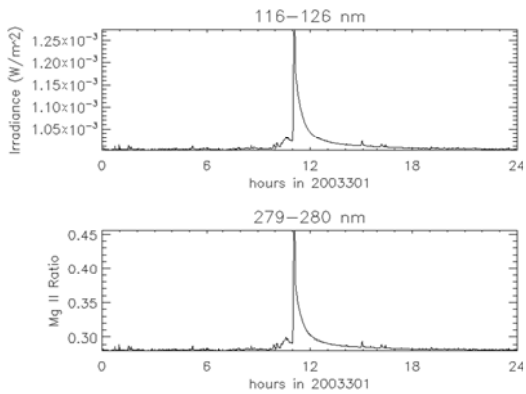


Figure 8. FISM 1-minute data for the Lyman-a band and the derived Mg II ratio.

An IDL procedure was created to generate ASCII text files from this data. For testing, a c-shell script was created to pass these files in to the wrapper function that calls the EUVS.07 daily average algorithm. Each test operates on only one 24 hour time period.

Additional special test data sets may be added later.

4.2 Output from Simulated/Proxy Inputs Data Sets

The results of testing the EUVS.07 Daily Average algorithm on each day are recorded in ASCII files. Another IDL procedure has been written to read all of the test results and merge the information together to provide a unified overview of the series of test results.

4.2.1 Precisions and Accuracy Estimates

The precision requirement is 2%, so single precision floating point arithmetic operations are sufficient to stay well below this threshold. If we assume that the daily average accuracy is represented by the standard deviation of the mean, and each input measurement has the same uncertainty, each sample is independent, and the inputs are sampling the same population distribution, then the accuracy can be expressed as approximately $s_{i,j}$ / 37.9 for one minute time sampling. Of course, all of these assumptions are violated under certain conditions. There is always some non-zero autocorrelation, since the last value is a fairly good predictor of the next value, but not the value 12 hours later.

4.2.2 Error Budget

The error budget is applicable to the instrument measurements. This algorithm is outside the scope of the error budget.

5.0 PRACTICAL CONSIDERATIONS

5.1 Numerical Computation Considerations

The algorithm is straightforward to implement in software. A large fraction of the software can be derived, with minor modifications, based on the data flow diagram shown in Figure 1. The algorithm described in this document allows for an arbitrary number of averages to be calculated, but real limits are based on hardware, specifically the physical limitations of memory needed to hold the data on the production system. Single precision floating operations are adequate to meet the accuracy requirements (20%).

5.2 Programming and Procedural Considerations

This algorithm has been implemented in C/C++. It is comprised of one source file. The source file contains a main function that is used to test the EUVS Daily Average algorithm. However, the averaging function is going to be directly called by another function. The algorithm is simple enough and small enough that modularity is not a concern. The header dependency diagram generated by the static analysis tool Klocwork is shown in Figure 9.

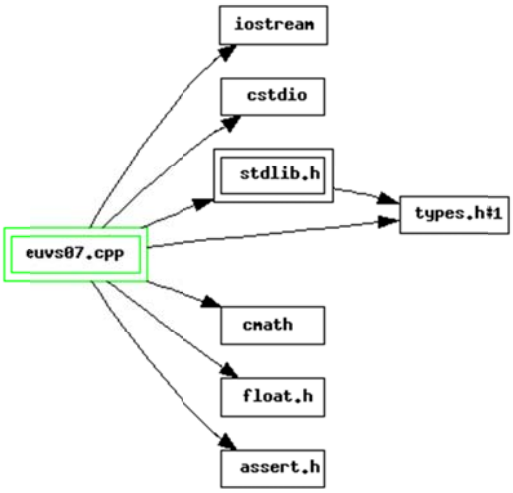


Figure 9. C/C++ standard library dependency diagram.

5.3 Quality Assessment and Diagnostics

Quality assessments of the operational results are based on the quality flag, qFlagOut, and the measure of the percentage complete, percentCoverage. For values of percentCoverage that are less than 10%, the quality flag is set to invalid.

5.4 Exception Handling

The primary exception that is possible with this algorithm involves division by zero for the case where all data are marked invalid. This exception is eliminated because the denominator of Equation 2 must be greater than zero to calculate the average. In that case, the fill value is returned.

There is an additional check performed for the metadata values for n_Bands and N_TIMES. If n_Bands is less than 1 or greater than a configurable constant (maxNumBands=100) than the input data does not make sense and cannot be trusted. This causes an abort condition with no result being returned, because there is no way to tell how many bands were supposed to be returned. If the constant N_TIMES is outside the valid range of 3 to (86401*4 + 1), then there is probably a typographical error in the definition of the constant. This is also an abort condition. Either of these could cause the program to read past the end of the declared arrays and would probably generate a runtime error. This type of exception handling needs to be handled consistently by the framework, which remains undefined.

5.5 Algorithm Validation

The algorithm can be validated against proxy or test data only. Since this is a new algorithm for GOES-R, there is no existing precedence to validate against. We choose to validate the algorithm by generating a test data set where all measurements are valid, and the average can be determined analytically. The algorithm can use this test data to reproduce the analytical results.

For example, the average of 2.0 is obtained by selecting an evenly divided distribution of input data with 50% of the values being 3.0, and the other half being 1.0. Of course, there are a very large number of distributions that can be

constructed to produce the same result. The same result should be obtained if matching symmetrical values are marked as invalid.

6.0 ASSUMPTIONS AND LIMITATIONS

It is assumed that this function runs periodically through the use of cron or a similar mechanism.

It is assumed that this algorithm is called from another function, and that the other function is responsible for obtaining and formatting the data into arrays that can be passed to the averaging algorithm.

It is assumed that daily averages are desired from datasets of different cadences. To accommodate this, the N_TIMES value should be adjusted to the number of measurements to provide accurate percent coverage values, and this function should be called separately for each of the different measurement cadences. This becomes troublesome when trying to use data directly from the instrument suites since the cadences are not constant. Each day the routine calibration has the opportunity to change the offset of the cadence. For example, if EUVS-A begins the day integrating at 0, 9, 18, … seconds, and a calibration is performed later, the times after the calibrations may not correspond to an integer multiple of 9 seconds. Spacecraft clock drift may also cause an off-by-one discrepancy when using the highest cadence data.

By allowing N_TIMES to vary, the algorithm could support arbitrary time averages. The author recommends at least 10 time samples should be included in the average due to the comparison using the percentage complete.

It is further assumed that the returned values are used by another function to store/record the results in a format and method that is consistent with NOAA standards for data retention and distribution.

It is assumed that the one-minute average data are calculated from only valid data and filled with the missing value. Furthermore, it is assumed that the level 1b flags are used.

This algorithm is compatible with the EUVS level 1b data product at a cadence of 30 seconds.

If quality flags are not available, a properly sized quality array filled with the VALID value (1) could be used. This makes the algorithm rely only on the limits specified in the input. Values outside the limits specified are treated as missing and count against the percent coverage.

6.1 Performance

The preliminary timing testing indicates the entire algorithm (including main with reads and writes) executes in 75 +/- 40 milliseconds.

6.2 Assumed Sensor Performance

The EXIS detectors are assumed to perform according to the instrument design specifications and the requirements in the Goddard Space Flight Center document 417-R-EXISPORD-0116_V_2_2.pdf.

6.3 Pre-Planned Product Improvements

There are no pre-planned product improvements.

7.0 REFERENCES

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