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**Joint Polar Satellite System (JPSS)
Operational Algorithm Description (OAD)
Document for VIIRS Vegetation Index (VI)
Environmental Data Records (EDR)
Software**

For Public Release

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**Joint Polar Satellite System (JPSS)
Operational Algorithm Description (OAD)
Document for VIIRS Vegetation Index (VI) Environmental
Data Records (EDR) Software**

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Preface

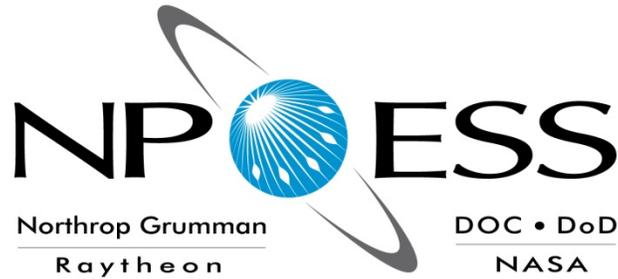
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NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION FOR VEGETATION INDEX (VI) EDR

**SDRL No. S141
SYSTEM SPECIFICATION SS22-0096**

**RAYTHEON COMPANY
INTELLIGENCE AND INFORMATION SYSTEMS (IIS)
NPOESS PROGRAM
OMAHA, NEBRASKA**

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Revision/Change Record

Document Number D36951

| Revision | Document Date | Revision/Change Description | Pages Affected |
|----------|----------------------|--|----------------|
| --- | 4-30-03 | Initial Release. | All |
| A1 | 12-4-03 | Updated to reflect Science To Operational Code Conversion. | All |
| A2 | 4-20-05 | Reflects NGST comment corrections plus inserted new logo and updated upper right header date, title/signature page dates, Revision/Change Record. | All |
| A3 | 6-15-05 | Reflects additional comments posted on 19Apr05 to the eRoom "Post-Sci2Ops OAD Review Comments" site. | All |
| A4 | 7-1-05 | Under Section 1.3.3, Source Code and Test Data References, inserted a more detailed table listing paths to find applicable source code within the ClearCase configuration management tool. | Pg 2 |
| A5 | 7-12-05 | Per Dan Antzoulatos' request, changed the wording of information added by the 01 Jul 2005 Revision/Change Record line. | Pg 2 |
| A6 | 6-15-07 | Logo, cleanup updates. Delivered to NGST. | All |
| A7 | 12-10-07 | ECR A-103, EDRPR 1.8 CP 3 updates -Format changes for CDFCB-X compliance- removed Table 5. Granule Level Quality Flag Structure. Output section tables have been updated. | All |
| A8 | 1-4-08 | Reformatted to new template. Updated in response to comments from NGST. Tech Memo NP-EMD-2006.510.0042 implemented. Prepared for delivery to NGST. | All |
| A9 | 1-8-08 | ECR A-103 Action Item updates to add Datatype field in Table 4. VVI Output Contents. | All |
| A10 | 6-12-08 | Updated data quality monitoring section. Implemented tech memo NP-EMD.2008.510.0006_NPP_Cirrus_flag_testing_update_for_Vegetation_Index. | 10 |
| A11 | 10-29-08 | Prepared for TIM/ACCB. | All |
| A | 12-17-08 | Addressed TIM/ACCB comments. ECR A-177 Rev. A. | All |
| B1 | 04-27-09 09-28-09 | Updated with IDPS PCR020193 Table 7. Updated with PCR21119 changes | 8 5 & 7 |
| B2 | 1-20-09 | Updated for TIM/ARB; updated SCN; updated Table1, added TM 2009.510.0069 (PCR22065) into Tables 1 & 2 (no actual OAD updates associated with this TM) | All |
| B | 3-17-10 | Incorporated TIM comments and prepared for ACCB | All |
| C1 | 3-31-10 | Incorporated TM 2010.510.0005 updates. | Tables 1 & 2 |
| C | 5-19-10 | Prepared for TIM/ARB/ACCB | All |
| D1 | 10-13-10 | Updated due to document convergence | All |
| D2 | 09-27-11 | Updated OAD for PCR026626. | ALL |

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1.0 INTRODUCTION

1.1 Objective

The purpose of the Operational Algorithm Description (OAD) document is to express, in computer-science terms, the remote sensing algorithms that produce the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) end-user data products. These products are individually known as Raw Data Records (RDRs), Temperature Data Records (TDRs), Sensor Data Records (SDRs) and Environmental Data Records (EDRs). In addition, any Intermediate Products (IPs) produced in the process are also described in the OAD.

The science basis of an algorithm is described in a corresponding Algorithm Theoretical Basis Document (ATBD). The OAD provides a software description of that science as implemented in the operational ground system -- the Data Processing Element (DPE).

The purpose of an OAD is two-fold:

1. Provide initial implementation design guidance to the operational software developer.
2. Capture the “as-built” operational implementation of the algorithm reflecting any changes needed to meet operational performance/design requirements.

An individual OAD document describes one or more algorithms used in the production of one or more data products. There is a general, but not strict, one-to-one correspondence between OAD and ATBD documents. This particular document describes operational software implementation for the Visible/infrared Imager/Radiometer Suite (VIIRS) Vegetation Index (VI) Environmental Data Record (EDR).

1.2 Scope

The scope of this document is limited to the description of the core operational algorithms required to create the VIIRS VI EDR. It provides a general overview and is intended to supplement in-line software documentation and interface control documentation for maintenance of the operational software. The theoretical basis for this algorithm is described in Section 3.3 of the VIIRS Vegetation Index (VVI) Algorithm Theoretical Basis Document ATBD, 474-00039.

1.3 References

1.3.1 Document References

The science and system engineering documents relevant to the algorithms described in this OAD are listed in Table 1.

Table 1. Reference Documents

| Document Title | Document Number/Revision | Revision Date |
|---|--------------------------|---------------|
| VIIRS Vegetation Index (VVI) Algorithm Theoretical Basis Document ATBD | 474-00039 | 22 Apr 2011 |
| VIIRS Vegetation Index Unit Level Detailed Design | Y2499 Ver. 5 Rev. 4 | May 2003 |
| VIIRS Radiometric Calibration Algorithm Theoretical Basis Document ATBD | 474-00027 | 22 Apr 2011 |
| VIIRS Radiometric Calibration Component Detailed | Y2490 Ver. 5 Rev. 4 | 30 Sep 2004 |

| Document Title | Document Number/Revision | Revision Date |
|---|--------------------------|---------------|
| Design Document | | |
| VIIRS Algorithm Verification Status Report | D36812 Rev. 2.04 | 2 Dec 2003 |
| NPOESS Calibration/Validation Plan | D34484 Draft Version 3.0 | 17 Dec 2002 |
| JPSS Environmental Data Record (EDR) Production Report for NPP | 474-00012 Rev. A | 09 Feb 2011 |
| JPSS Environmental Data Record (EDR) Interdependency Report (IR) for NPP | 474-0007 Rev. A | 09 Feb 2011 |
| NPP Mission Data Format Control Book and App A (MDFCB) | 472-REF-00057 | 06 Jan 2011 |
| JPSS Common Data Format Control Book - External - Volume I - Overview | 474-00001-01, Rev- | 10-Dec-10 |
| JPSS Common Data Format Control Book - External - Volume II - RDR Formats | 474-00001-02, Rev- | 10-Dec-10 |
| JPSS Common Data Format Control Book - External - Volume III - SDR/TDR Formats | 474-00001-03, Rev- | 16-Feb-11 |
| JPSS Common Data Format Control Book - External - Volume IV - Part I - IPs, ARPs, and Geolocation Data | 474-00001-04-01, Rev- | 10-Dec-10 |
| JPSS CDFCB - External - Volume IV - Part II - Imagery, Atmospheric, and Cloud EDRs | 474-00001-04-02, Rev- | 10-Dec-10 |
| JPSS Common Data Format Control Book - External - Volume IV - Part III - Land and Ocean/Water EDRs | 474-00001-04-03, Rev- | 10-Dec-10 |
| JPSS Common Data Format Control Book - External - Volume IV - Part IV - Earth Radiation Budget and Space EDRs | 474-00001-04-04, Rev- | 18-Feb-11 |
| JPSS Common Data Format Control Book - External - Volume V - Metadata | 474-00001-05, Rev- | 16-Feb-11 |
| JPSS CDFCB - External - Volume VI - Ancillary Data, Auxiliary Data, Messages, and Reports | 474-00001-06, Rev- | 10-Dec-10 |
| JPSS Common Data Format Control Book - External - Volume VII - Part I - JPSS Downlink Data Formats | 474-00001-07-01, Rev- | 16-Feb-11 |
| JPSS CDFCB - External - Volume VII - Part 2 - JPSS Downlink Data Formats - CrIS | 474-00001-07-02, Rev- | 16-Feb-11 |
| JPSS CDFCB - External - Volume VII - Part 3 - JPSS Downlink Data Formats - OMPS | 474-00001-07-03, Rev- | 16-Feb-11 |
| JPSS CDFCB - External - Volume VII - Part 4 - JPSS Downlink Data Formats - ATMS | 474-00001-07-04, Rev- | 16-Feb-11 |
| JPSS CDFCB - External - Volume VII - Part 5 - JPSS Downlink Data Formats - VIIRS | 474-00001-07-05, Rev- | 16-Feb-11 |
| JPSS Common Data Format Control Book - External - Volume VIII - Look Up Table Formats | 474-00001-08. Rev - | 10-Dec-10 |
| NPP Command and Telemetry (C&T) Handbook | D568423 Rev. C | 30 Sep 2008 |
| JPSS CGS Data Processor Inter-subsystem Interface Control Document (DPIS ICD) Vol I – IV | IC60917-IDP-002, Rev C | 29-Sep-11 |
| JPSS CGS Acronyms and Glossary | LI60917-GND-005, Rev - | 17-Oct-11 |
| NGST/SE technical memo – VegIndex_QF_Memo | NP-EMD-2005.510.0025 | 17 Jan 2005 |
| NGST/SE technical memo – NPP_VIIRS_VI_EVI_Range | NP-EMD-2006.510.0042 | 28 June 2006 |
| NGST/SE technical memo – _Cirrus_flag_testing_update_for_Vegetation_Index | NP-EMD.2008.510.0006 | 18 Jan 2008 |
| Operational Algorithm Description Document for VIIRS | D38697 Rev. B | 24 Feb 2010 |

| Document Title | Document Number/Revision | Revision Date |
|---|----------------------------|---------------|
| Surface Reflectance IP | | |
| NGAS/SE technical memo – Vegetation_Index_fill_Value_Processing_Update | NP-EMD.2009.510.0069 | 3 Dec 2009 |
| NGAS/SE technical memo – Granule-Level Summary Exclusion Flag Definition Rev. C | NP-EMD-2010.510.0005.Rev-C | 2 Mar 2010 |
| Joint Polar Satellite System (JPSS) Common Ground System (CGS) IDPS Pro Software User's Manual Part 2 | UG60917-IDP-026 Rev, A | 7 Jul 2011 |

1.3.2 Source Code References

The science and operational code and associated documentation relevant to the algorithms described in this OAD are listed in Table 2.

Table 2. Source Code References

| Reference Title | Reference Tag/Revision | Revision Date |
|---|--|----------------------------|
| VIIRS Vegetation Index (VVI) science-grade software | ISTN_VIIRS_NGST_2.2(OAD Rev ---) | 30 May 2003 |
| VIIRS Vegetation Index (VVI) operational software | B1.3 (OAD Rev A3) | 15 Jun 2005 |
| VIIRS Vegetation Index (VVI) science-grade software | ISTN_VIIRS_NGST_2.2.1 | 20 Aug 2007 |
| VIIRS Vegetation Index (VVI) operational software | B1.5 (OAD Rev A8) | 04 Jan 2008 |
| NGST/SE technical memo – Cirrus_flag_testing_update_for_Vegetation_Index | NP-EMD.2008.510.0006 | 18 Jan 2008 |
| VIIRS Vegetation Index (VVI) operational software | Build 1.5.x.1 (OAD Rev A10) | 12 Jun 2008 |
| ACCB (no code changes) | OAD Rev A | 17 Dec 2008 |
| VIIRS Vegetation Index (VVI) operational software PCRs20193 & 21119 | B1.5.post-x (OAD Rev B1) | 27 Apr 2009 28 Sep 2009 |
| NGAS/SE technical memo – Vegetation_Index_fill_Value_Processing_Update (PCR22065) | NP-EMD.2009.510.0069 (OAD Rev B2) | 3 Dec 2009 |
| ACCB (no code changes) | OAD Rev B | 17 Mar 2010 |
| PCR 02283 | Sensor Characterization Build SC-8 (OAD Rev C1) | 31 Mar 2010 |
| ACCB | OAD Rev C | 19 May 2010 |
| Convergence (No Code Updates) | (OAD Rev D1) | 13 Oct 2010 |
| PCR026626 (OAD changes for ADL) | (OAD Rev D2) | 27 Sep 2011 |

2.0 ALGORITHM OVERVIEW

The VIIRS Vegetation Index (VVI) consists of two vegetation indices--Normalized Difference Vegetation Index (NDVI) from top-of-atmosphere (TOA) reflectances and Enhanced Vegetation Index (EVI) from top of canopy (TOC) reflectances. These indices are produced at the VIIRS image channel resolution (i.e. nominally 375m at nadir).

The VIIRS Vegetation Index EDR is computed after the RDR, SDR, and intermediate products processing is complete. The processing relationship is illustrated in Figure 1 below.

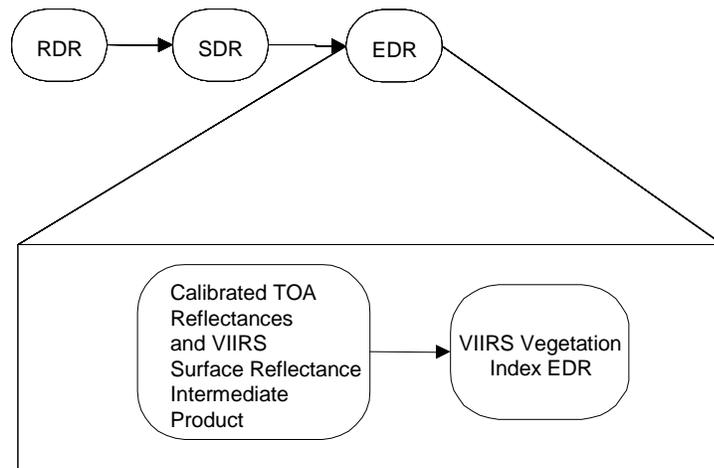


Figure 1. Processing Chain Associated with VIIRS Vegetation Index EDR

2.1 Algorithm: Vegetation Index Environmental Data Record Description

2.1.1 Interfaces

To begin processing the data, the Infrastructure (INF) Software Item (SI) initiates the VIIRS Vegetation Index algorithm. The INF SI provides tasking information to the algorithm indicating which granule is processed. The Data Management Subsystem (DMS) SI provides data storage and retrieval capability. A library of C++ classes is used to implement the SI interfaces. More information regarding these topics is found in document UG60917-IDP-026 with reference in particular to sections regarding PRO Common (CMN) processing and the IPO Model.

2.1.1.1 Inputs

The VIIRS Vegetation Index EDR requires: calibrated TOA reflectances (bands I1, I2), SDR auxiliary data (solar zenith angle), and Surface Reflectance (bands I1, I2, M3, Land Quality Flags).

VVI is calculated for all land retrievals with a solar zenith angle less than 85 degrees but is required to meet specification performance at angles less than 65 degrees. "Land" is allowed to

include inland water bodies and rivers. Pixels labeled as “probably clear” or “probably cloudy” by the Surface Reflectance Land Quality Flags are processed but flagged accordingly. This same quality flag also indicates whether sufficient aerosol is present to warrant flagging the pixel as obscured, i.e., AOT>1. Table 3 describes the VVI EDR Inputs. Refer to the CDFCB-X, D34862, for a detailed description of the inputs.

Table 3. VVI EDR Inputs

| Input | Type | Description | Units/Valid Range |
|------------------------------|-------------|---|--|
| Reflectance_Img | Float | Calibrated TOA Reflectances for band I1 | Please refer to VIIRS Radiometric Calibration Document, D43777 |
| Reflectance_Img | Float | Calibrated TOA Reflectances for band I2 | Please refer to VIIRS Radiometric Calibration Document, D43777 |
| SolZenAng_Img | Float | Solar zenith angle at each pixel from VIIRS SDR IMG geolocation structure | Radians / 0 – 2Pi |
| VIIRS Surface Reflectance IP | Float | Surface Reflectance (TOC) for band I1 | Please refer to D38697 |
| VIIRS Surface Reflectance IP | Float | Surface Reflectance (TOC) for band I2 | Please refer to D38697 |
| VIIRS Surface Reflectance IP | Float | Surface Reflectance (TOC) for band M3 | Please refer to D38697 |
| VIIRS Surface Reflectance IP | Bytes | Land Quality Flags in moderate resolution 48-bit unsigned integer array | Please refer to D38697 |
| VVI Retrieval Coefficients | Structure | Vegetation Index Coefficients for TOC EVI processing, I1, M3, and C | Please refer to CDFCB-X, D34862, Table 3.2.2.5.20-1, VIIRS Vegetation Index EDR Tunable Parameters |
| VI DQTT | Structure | Reports erroneous pixels through a DQN | Performs a bitmask tests on LQFs |

2.1.1.2 Outputs

2.1.1.2.1 Granule Level Summary Quality Flags

There are two granule level summary quality flags each for NDVI and EVI--the percent of retrievals with high quality and the percent of pixels with one or more exclusion condition. See the CDFCB-X, D34862, Vol. IV, Part 3, Table 5.4.7.4-1 for more details.

2.1.1.2.1.1 Summary NDVI Quality

For a NDVI retrieval to be classified as high quality, the following six conditions must be met (otherwise, the retrieval is classified as low quality): (1) VIIRS SDR Band I1 top of atmosphere reflectance is good; (2) VIIRS SDR Band I2 top of atmosphere reflectance is good; (3) Cloud confidence is confidently clear; (4) No thin cirrus; (5) Solar Zenith Angle is less than 65 degrees and (6) No Sun Glint. The percentage is the number of retrievals with high quality divided by the total number of retrievals (i.e. non fill pixels) multiplied by 100 percent.

2.1.1.2.1.2 Summary EVI Quality

For an EVI retrieval to be classified as high quality, the following eight conditions must be met (otherwise, the retrieval is classified as low quality): (1) VIIRS SR IP for Band I1 is good; (2) VIIRS SR IP for Band I2 is good; (3) VIIRS SR IP for Band M3 is good; (4) Cloud confidence is confidently clear; (5) No thin cirrus; (6) Solar Zenith Angle is less than 65 degrees; (7) No Sun Glint and (8) EVI is within range. The percentage is the number of retrievals with high quality divided by the total number of retrievals (i.e. non fill pixels) multiplied by 100 percent.

2.1.1.2.1.3 NDVI Exclusion Summary

For NDVI, a pixel is considered excluded if one or more of the following conditions are detected:

- (1) Cloud confidence isn't confidently clear;
- (2) Solar Zenith Angle is greater than 85 degrees or
- (3) Surface is classified as ocean or coastal.

The percentage is the number of pixels with one or more exclusion condition divided by the total number of pixels less trimmed pixels multiplied by 100 percent.

2.1.1.2.1.4 EVI Exclusion Summary

For EVI, a pixel is considered excluded if one or more of the following conditions are detected: (1) Cloud confidence isn't confidently clear; (2) Solar Zenith Angle is greater than 85 degrees; (3) Surface is classified as ocean or coastal or (4) Aerosol Optical Thickness is greater than one. The percentage is the number of pixels with one or more exclusion condition divided by the total number of pixels less trimmed pixels multiplied by 100 percent.

2.1.1.2.2 VVI Output Contents

The VVI EDR contains two fields that are written to the DMS in internal IDPS data format. Table 4 describes the VVI Output Contents. Refer to the CDFCB-X, D34862, for a detailed description of the outputs.

Table 4. VVI Output Contents

| Output | Type | Description | Units/Valid Range |
|------------------------------|------------------|--|-------------------|
| TOA_NDVI | Unsigned Integer | Top of Atmosphere (TOA) NDVI at imagery resolution | -1 to +1 |
| TOC_EVI | Unsigned Integer | Top of Canopy (TOC) EVI at imagery resolution | -1 to +4 |
| Byte 0 VVI EDR Quality Flags | Byte | Vegetation Index Quality Byte 0 Flags. See Table 5 for detailed description. | N/A |
| Byte 1 VVI EDR Quality Flags | Byte | Vegetation Index Quality Byte 1 Flags. See Table 6 for detailed description. | N/A |
| Byte 2 VVI EDR Quality Flags | Byte | Vegetation Index Quality Byte 2 Flags. See Table 7 for detailed description. | N/A |
| NDVI Scale | Float | NDVI scale factor | N/A |
| NDVI Offset | Float | NDVI offset | N/A |
| EVI Scale | Float | EVI scale factor | N/A |
| EVI Offset | Float | EVI offset | N/A |

| Output | Type | Description | Units/Valid Range |
|---------|-----------|--|-------------------|
| VVI DQN | Structure | This optional output item is only produced if an erroneous pixel is found during processing. | Internal format. |

Table 5. QF1 (Byte 0) Quality Flag Structure

| Byte | VIIRS VI Flag | Result | Bits |
|------|------------------------|---|------|
| 0 | Overall NDVI Quality | 1 = High 0 = Low NOTE: NDVI quality is set to high (1) if ALL of these conditions are met: 1) I1 TOA reflectance flag = avail 2) I2 TOA reflectance flag = avail 3) Cloud Confidence flag = confidently clear 4) Thin Cirrus flag = no thin cirrus 5) Solar Zenith Angle < 65 deg 6) Sun glint (Geometry based) = none | 1 |
| | Overall EVI Quality | 1 = High 0 = Low NOTE: EVI quality is set to high (1) if ALL of these conditions are met: 1) I1 Surface reflectance flag = avail 2) I2 Surface reflectance flag = avail 3) M3 Surface reflectance flag = avail 4) Cloud Confidence flag = confidently clear 5) Thin Cirrus flag = no thin cirrus 6) Solar Zenith Angle < 65 deg 7) Sun glint (Geometry based) = none 8) EVI range flag = in range | 1 |
| | I1 TOA Reflectance | 1 = Not Available 0 = Available | 1 |
| | I2 TOA Reflectance | 1 = Not Available 0 = Available | 1 |
| | I1 Surface Reflectance | 1 = Not Available 0 = Available | 1 |
| | I2 Surface Reflectance | 1 = Not Available 0 = Available | 1 |
| | M3 Surface Reflectance | 1 = Not Available 0 = Available | 1 |
| | EVI Range | 1 = Out of Range 0 = In Range | 1 |

Table 6. QF2 (Byte 1) Quality Flag Structure

| Byte | VIIRS VI Flag | Result | Bits |
|------|---------------------------|---|------|
| 1 | *Land/Water | 101 = Coastal 011 = Sea Water 010 = Inland Water 001 = Land / No Desert 000 = Land & Desert | 3 |
| | *Cloud Confidence | 11 = Confidently Cloudy 10 = Probably Cloudy 01 = Probably Clear 00 = Confidently Clear | 2 |
| | *Sun Glint | 11 = Geometry & Wind 10 = Wind Speed Based 01 = Geometry Based 00 = None | 2 |
| | *Thin Cirrus (reflective) | 1 = Cloud 0 = No Cloud | 1 |

* Copied from Surface Reflectance IP

Table 7. QF3 (Byte 2) Quality Flag Structure

| Byte | VIIRS VI Flag | Result | Bits |
|------|-------------------------------------|---|------|
| 2 | Stratification – Solar Zenith Angle | 1 = 65 Degrees <= SZA <= 85 Degrees 0 = SZA < 65 Degrees or SZA > 85 Degrees | 1 |
| | *Excl – AOT > 1.0 | 1 = AOT > 1.0 0 = AOT <= 1.0 | 1 |
| | Excl – Solar Zenith Angle > 85 Deg | 1 = SZA > 85 degrees 0 = SZA <= 85 degrees | 1 |
| | Spare Bits | Initialized to 0 | 5 |

* Copied from Surface Reflectance IP

2.1.2 Algorithm Processing

This section provides a summary of the as-built VVI operational code. Figure 2 shows the Vegetation Index Data Flow.

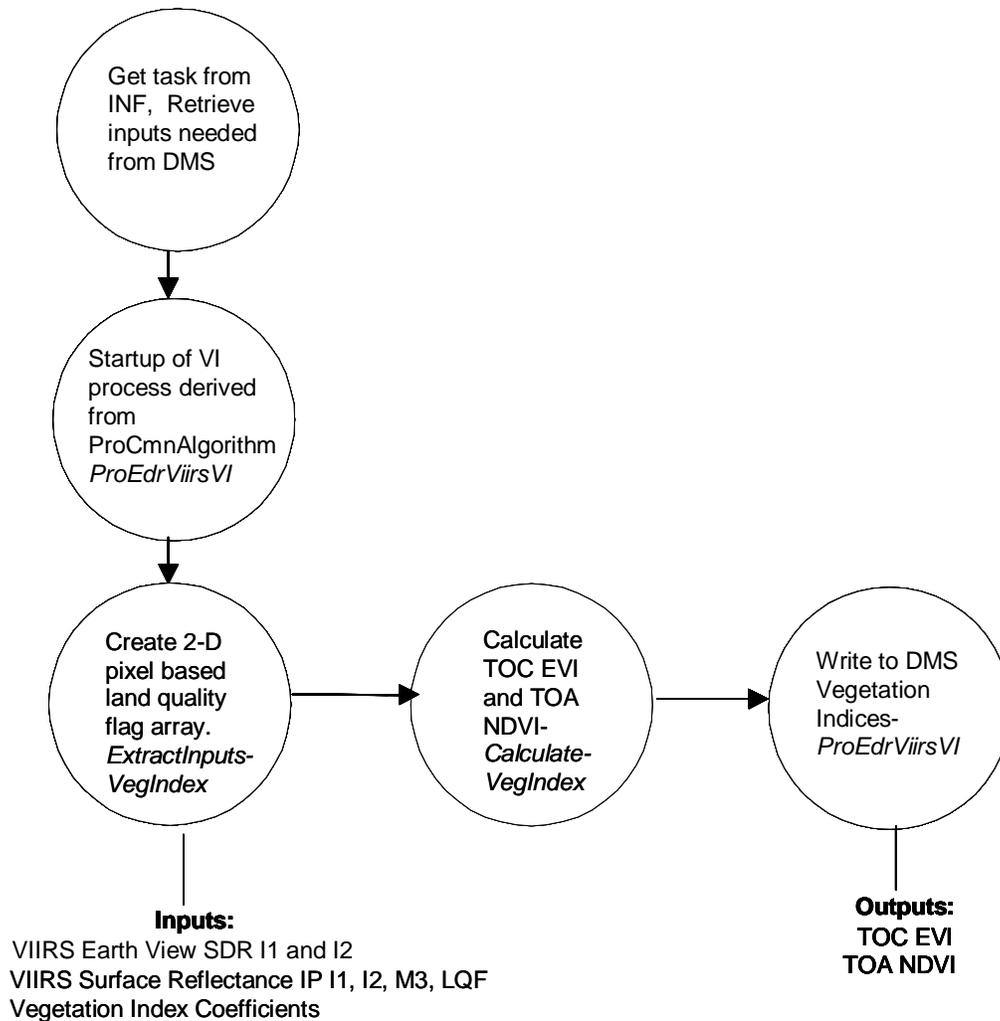


Figure 2. Data Flow Diagram of Overall VVI EDR Call Sequence from the Main Program

2.1.2.1 Main Module - ProEdrViirsVI.cpp

This is the Vegetation Index derived algorithm and is a subclass from the ProCmnAlgorithm of the common I/O design. ProEdrViirsVI creates a list of input data items that are read from DMS and passes all of the required data into the algorithm for processing. The input list includes a Vegetation Index Data Quality Threshold Table (DQTT) and the output includes a list of Data Quality Notifications if any were produced. When the algorithm has finished, the output data items are written to DMS. Refer to UG60917-IDP-026 for more information.

2.1.2.2 Calculate_VegIndex

This function calculates: (1) the top of canopy EVI from VIIRS bands M3, I1, and I2 and (2) the top of atmosphere NDVI from VIIRS bands I1 and I2.

2.1.2.2.1 EVI

The following algorithm is used to calculate the top of canopy EVI:

$$\text{TOC EVI} = (1 + \text{VegIndex_Coeffs.EVI}) * (\text{SurfReflect.I2} - \text{SurfReflect.I1}) / (\text{SurfReflect.I2} + \text{VegIndex_Coeffs.EVI.I1} * \text{SurfReflect.I1} - \text{VegIndex_Coeffs.EVI.M3} * \text{SurfReflect.M3} + \text{VegIndex_Coeffs.EVI})$$

Where VegIndex_Coeffs.EVI are unitless coefficients used to compute EVI. EVI ranges from -1 to 4; pixels with EVI values outside of this range are assigned a fill value of 65528.

Note that under thin cirrus conditions for a given pixel no Surface Reflectance IP value is produced and so accordingly no EVI may be computed.

2.1.2.2.2 NDVI

The following algorithm is used to calculate the top of atmosphere NDVI:

$$\text{TOA NDVI} = (\text{TOAReflect.I2} - \text{TOAReflect.I1}) / (\text{TOAReflect.I2} + \text{TOAReflect.I1})$$

NDVI ranges from -1 to 1; pixels with NDVI values outside of this range are assigned a fill value of 65528.

2.1.3 Graceful Degradation

2.1.3.1 Graceful Degradation Inputs

There is one case where input graceful degradation is indicated in the Vegetation Index EDR

1. An input retrieved for the algorithm has its N_Graceful_Degradation metadata field set to YES (propagation).

2.1.3.2 Graceful Degradation Processing

None.

2.1.3.3 Graceful Degradation Outputs

None.

2.1.4 Exception Handling

Software was added to check for divide by zero situations for TOA NDVI and TOC EVI.

Pixels trimmed Onboard and Onground are not processed.

NDVI is not calculated if Calibrated Reflectance I1 or I2 contain FILL value. NDVI is instead set to a FILL value.

EVI is not calculated if Surface Reflectance I1, I2, or M3 contain FILL value. EVI is instead set to a FILL value.

2.1.5 Data Quality Monitoring

Each algorithm uses specific criteria contained in a Data Quality Threshold Table (DQTT) to determine when a Data Quality Notification (DQN) is produced. The DQTT contains the

threshold used to trigger the DQN as well as the text contained in the DQN. If a threshold is met, the algorithm stores a DQN in DMS indicating the test(s) that failed and the value of the DQN attribute. For more algorithm specific detail refer to the CDFCB-X, D34862.

2.1.6 Computational Precision Requirements

The VVI algorithm requires input items to be a combination of 32-bit floating-point precision values and unsigned 8-bit integers. The 32-bit floating-point precision items are VIIRS Calibrated TOA Reflectances (bands I1, I2), VIIRS Surface Reflectance IP (bands I1, I2, M3), and the VVI coefficients. The unsigned 8-bit integer item is the Land Quality Flags from the moderate surface reflectance.

The output values of the algorithm are unsigned 16-bit integers with a measurement precision of 0.0002 NDVI units.

2.1.7 Algorithm Support Considerations

DMS should be up and running. All the data (primary or secondary) needed for the VVI calculations must be available in the DMS for the successful completion of the process.

INF must be running so the process can retrieve the tasks send messages to INF upon successful completion or failure to complete the process.

A C++ compiler is necessary to compile the VVI source code.

The PRO Common library is available.

The imake files can create the Makefile used to compile VVI.

2.1.8 Assumptions and Limitations

2.1.8.1 Assumptions

The baseline software assumes co-registration exists between the channels, and assumes nesting of the imagery pixels around the moderate pixels.

2.1.8.2 Limitations

Retrievals are not performed under nighttime conditions. This is defined as instances where the solar zenith angle exceeds 85 degrees.

Retrievals are not performed under confident cloudy conditions.

Retrievals are not performed over ocean surfaces.

Retrievals of EVI and other surface parameters are questionable under conditions of extreme aerosol loading, such as events associated with volcanic eruptions or biomass burning, and retrievals of EVI over snow are not guaranteed to meet the performance specification.

If for any reason the TOA or Surface Reflectance data is not available in DMS, the Vegetation Index algorithm is not performed.

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

The current glossary for the NPOESS program is D35836_H_NPOESS_Glossary. Table 8 contains those terms most applicable for this OAD.

Table 8. Glossary

| Term | Description |
|--|---|
| Algorithm | <p>A formula or set of steps for solving a particular problem. Algorithms can be expressed in any language, from natural languages like English to mathematical expressions to programming languages like FORTRAN. On NPOESS, an algorithm consists of:</p> <ol style="list-style-type: none"> 1. A theoretical description (i.e., science/mathematical basis) 2. A computer implementation description (i.e., method of solution) 3. A computer implementation (i.e., code) |
| Algorithm Configuration Control Board (ACCB) | <p>Interdisciplinary team of scientific and engineering personnel responsible for the approval and disposition of algorithm acceptance, verification, development and testing transitions. Chaired by the Algorithm Implementation Process Lead, members include representatives from IWPTB, Systems Engineering & Integration IPT, System Test IPT, and IDPS IPT.</p> |
| Algorithm Verification | <p>Science-grade software delivered by an algorithm provider is verified for compliance with data quality and timeliness requirements by Algorithm Team science personnel. This activity is nominally performed at the IWPTB facility. Delivered code is executed on compatible IWPTB computing platforms. Minor hosting modifications may be made to allow code execution. Optionally, verification may be performed at the Algorithm Provider's facility if warranted due to technical, schedule or cost considerations.</p> |
| EDR Algorithm | <p>Scientific description and corresponding software and test data necessary to produce one or more environmental data records. The scientific computational basis for the production of each data record is described in an ATBD. At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.</p> |
| Environmental Data Record (EDR) | <p><i>[IORD Definition]</i> Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geophysical parameters (including ancillary parameters, e.g., cloud clear radiation, etc.).</p> <p><i>[Supplementary Definition]</i> An Environmental Data Record (EDR) represents the state of the environment, and the related information needed to access and understand the record. Specifically, it is a set of related data items that describe one or more related estimated environmental parameters over a limited time-space range. The parameters are located by time and Earth coordinates. EDRs may have been resampled if they are created from multiple data sources with different sampling patterns. An EDR is created from one or more NPOESS SDRs or EDRs, plus ancillary environmental data provided by others. EDR metadata contains references to its processing history, spatial and temporal coverage, and quality.</p> |
| Model Validation | <p>The process of determining the degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management]</p> |
| Model Verification | <p>The process of determining that a model implementation accurately represents the developer's conceptual description and specifications. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management]</p> |
| Operational Code | <p>Verified science-grade software, delivered by an algorithm provider and verified by IWPTB, is developed into operational-grade code by the IDPS IPT.</p> |
| Operational-Grade Software | <p>Code that produces data records compliant with the System Specification requirements for data quality and IDPS timeliness and operational infrastructure. The software is modular relative to the IDPS infrastructure and compliant with IDPS application programming interfaces (APIs) as specified for TDR/SDR or EDR code.</p> |

| Term | Description |
|----------------------------|--|
| Raw Data Record (RDR) | <p><i>[IORD Definition]</i></p> <p>Full resolution digital sensor data, time referenced, with absolute radiometric and geometric calibration coefficients appended, but not applied, to the data. Aggregates (sums or weighted averages) of detector samples are considered to be full resolution data if the aggregation is normally performed to meet resolution and other requirements. Sensor data shall be unprocessed with the following exceptions: time delay and integration (TDI), detector array non-uniformity correction (i.e., offset and responsivity equalization), and data compression are allowed. Lossy data compression is allowed only if the total measurement error is dominated by error sources other than the data compression algorithm. All calibration data will be retained and communicated to the ground without lossy compression.</p> <p><i>[Supplementary Definition]</i></p> <p>A Raw Data Record (RDR) is a logical grouping of raw data output by a sensor, and related information needed to process the record into an SDR or TDR. Specifically, it is a set of unmodified raw data (mission and housekeeping) produced by a sensor suite, one sensor, or a reasonable subset of a sensor (e.g., channel or channel group), over a specified, limited time range. Along with the sensor data, the RDR includes auxiliary data from other portions of NPOESS (space or ground) needed to recreate the sensor measurement, to correct the measurement for known distortions, and to locate the measurement in time and space, through subsequent processing. Metadata is associated with the sensor and auxiliary data to permit its effective use.</p> |
| Retrieval Algorithm | <p>A science-based algorithm used to 'retrieve' a set of environmental/geophysical parameters (EDR) from calibrated and geolocated sensor data (SDR). Synonym for EDR processing.</p> |
| Science Algorithm | <p>The theoretical description and a corresponding software implementation needed to produce an NPP/NPOESS data product (TDR, SDR or EDR). The former is described in an ATBD. The latter is typically developed for a research setting and characterized as "science-grade".</p> |
| Science Algorithm Provider | <p>Organization responsible for development and/or delivery of TDR/SDR or EDR algorithms associated with a given sensor.</p> |
| Science-Grade Software | <p>Code that produces data records in accordance with the science algorithm data quality requirements. This code, typically, has no software requirements for implementation language, targeted operating system, modularity, input and output data format or any other design discipline or assumed infrastructure.</p> |
| SDR/TDR Algorithm | <p>Scientific description and corresponding software and test data necessary to produce a Temperature Data Record and/or Sensor Data Record given a sensor's Raw Data Record. The scientific computational basis for the production of each data record is described in an Algorithm Theoretical Basis Document (ATBD). At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.</p> |
| Sensor Data Record (SDR) | <p><i>[IORD Definition]</i></p> <p>Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to calibrated brightness temperatures with associated ephemeris data. Temperature Data Records (TDRs) are geolocated, antenna temperatures with all relevant calibration data counts and ephemeris data to revert from T-sub-a into counts. The existence of the SDRs provides reversible data tracking back from the EDRs to the Raw data.</p> <p><i>[Supplementary Definition]</i></p> <p>A Sensor Data Record (SDR) is the recreated input to a sensor, and the related information needed to access and understand the record. Specifically, it is a set of incident flux estimates made by a sensor, over a limited time interval, with annotations that permit its effective use. The environmental flux estimates at the sensor aperture are corrected for sensor effects. The estimates are reported in physically meaningful units, usually in terms of an angular or spatial and temporal distribution at the sensor location, as a function of spectrum, polarization, or delay, and always at full resolution. When meaningful, the flux is also associated with the point on the Earth geoid from which it apparently originated. Also, when meaningful, the sensor flux is converted to an equivalent top-of-atmosphere (TOA) brightness. The associated metadata includes a record of the processing and sources from which the SDR was created, and other information needed to understand the data.</p> |

| Term | Description |
|-------------------------------|--|
| Temperature Data Record (TDR) | <p><i>[IORD Definition]</i> Temperature Data Records (TDRs) are geolocated, antenna temperatures with all relevant calibration data counts and ephemeris data to revert from T-sub-a into counts.</p> <p><i>[Supplementary Definition]</i> A Temperature Data Record (TDR) is the brightness temperature value measured by a microwave sensor, and the related information needed to access and understand the record. Specifically, it is a set of the corrected radiometric measurements made by an imaging microwave sensor, over a limited time range, with annotation that permits its effective use. A TDR is a partially-processed variant of an SDR. Instead of reporting the estimated microwave flux from a specified direction, it reports the observed antenna brightness temperature in that direction.</p> |

3.2 Acronyms

The current acronym list for the NPOESS program, D35838_H_NPOESS_Acronyms, can be found on eRooms. Table 9 contains those terms most applicable for this OAD.

Table 9. Acronyms

| Term | Expansion |
|-------------|---|
| AM&S | Algorithms, Models & Simulations |
| AOT | Aerosol Optical Thickness |
| API | Application Programming Interfaces |
| ARP | Application Related Product |
| CDFCB-X | Common Data Format Control Book - External |
| DMS | Data Management Subsystem |
| DQTT | Data Quality Test Table |
| DPIS ICD | Data Processor Inter-subsystem Interface Control Document |
| EVI | Enhanced Vegetation Index |
| GMVI | Gridded Monthly Vegetation Index |
| GVI | Global Vegetation Index |
| GWVI | Gridded Weekly Vegetation Index |
| INF | Infrastructure |
| ING | Ingest |
| IP | Intermediate Product |
| LUT | Look-Up Table |
| MDFCB | Mission Data Format Control Book |
| MVI | MODIS Vegetation Index |
| NDVI | Normalized Difference Vegetation Index |
| QF | Quality Flag |
| SDR | Sensor Data Record |
| SI | International System of Units |
| TBD | To Be Determined |
| TBR | To Be Resolved |
| TOA | Top of the Atmosphere |
| VI | Vegetation Index |
| VVI | VIIRS Vegetation Index |

4.0 OPEN ISSUES

Table 10. TBXs

| TBX ID | Title/Description | Resolution Date |
|---------------|--------------------------|------------------------|
| None | | |