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Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Ice Surface Temperature (IST) Environmental Data Records (EDR) Software

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National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Joint Polar Satellite System (JPSS)
Operational Algorithm Description (OAD) Document for VIIRS Ice Surface Temperature (IST) Environmental Data Records (EDR) Software
JPSS Electronic Signature Page

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Preface

This document is under JPSS Ground Algorithm ERB configuration control. Once this document is approved, JPSS approved changes are handled in accordance with Class I and Class II change control requirements as described in the JPSS Configuration Management Procedures, and changes to this document shall be made by complete revision.

Any questions should be addressed to:

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Change History Log

Revision	Effective Date	Description of Changes (Reference the CCR & CCB/ERB Approve Date)
Original	06/03/2011	This version incorporates **474-CCR-11-0088** which converts D39141, Operational Algorithm Description (OAD) Document for VIIRS Ice Surface Temperature (IST) EDR, Rev B dated 05/18/2010 to a JPSS document, Rev -. This was approved by the JPSS Ground Algorithm ERB on June 3, 2011.
Revision A	01/18/2012	**474-CCR-11-0261:** This version baselines 474-00072, Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Ice Surface Temperature (IST) Environmental Data Records (EDR) Software, for the Mx 6 IDPS release. This CCR was approved by the JPSS Algorithm ERB on January 18, 2012.
Revision B	05/14/2013	**474-CCR-13-0948:** This version authorizes 474-00072, JPSS OAD Document for VIIRS IST EDR Software, for the Mx 7.0 IDPS release. Includes Raytheon PCR032720; 474-CCR-13-0916/ECR-ALG-0037: Update applicable OAD filenames/template/Rev/etc. for Mx7 Release.
Revision C	03/13/2017	**474-CCR-17-3243 (ECR-CGS-0734):** This version authorizes 474-00072, JPSS OAD Document for VIIRS IST EDR Software, for the Block 2.0 IDPS release. Includes Raytheon PCR045678**:** Block 2.0: PRO: OAD: CCR: 474-CCR-15-2444: General OAD Clean-up CCR/PCR, affects all 35/37 OADs. All sections and tables may be affected.

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS ICE SURFACE TEMPERATURE (IST) EDR

SDRL No. S141
SYSTEM SPECIFICATION SS22-0096

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

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TITLE: NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS ICE SURFACE TEMPERATURE (IST) EDR

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Engineering & Manufacturing Development (EMD) Phase
Acquisitions &Operations Contract

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Operational Algorithm Description
VIIRS Ice Surface Temperature (IST) EDR Software

Document Number: D39141

Document Date: Sep 21, 2011 **Revision: C5**

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This document has been identified per the NPOESS Common Data Format Control Book – External Volume 5 Metadata, D34862-05, Appendix B as a document to be provided to the NOAA Comprehensive Large Array-data Stewardship System (CLASS) via the delivery of NPOESS Document Release Packages to CLASS.

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Revision/Change Record

Document Number D39141

Revision	Document Date	Revision/Change Description	Pages Affected
---	7-30-04	Initial Release.	All
A1	11-30-04	Reflects Science To Operational Code Conversion.	All
A2	3-22-05	Inserted Unit Test Procedure/Results.	Pgs 17-31
A3	4-27-05	Reflects NGST comment corrections plus updated upper right header date, title/signature page dates, Revision/Change Record.	All
A4	7-01-05	Removed export markings per 26May05 official policy change and 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.	All
A5	7-11-05	Per a Justin Ip request, changed Table 2.2-6, Pg 9, Byte 2, Bit 5, to read “AOT condition (550 nm)” versus previous wording “AOT condition (M11)”.	Pg 9
A6	7-13-05	Per a Dan Antzoulatos 11Jul05 comment, reworded the table under Section 1.3.3 defining a path on ClearCase to find applicable source code.	Pg 2
A7	10-05-06	Updated OAD for EDRPR quality flag changes.	All
A8	1-29-07	New logo, cleanup grammar, etc.	All
A9	8-02-07	New Document number. TMs NP-EMD.2005.510.0005, NP-EMD.2006.510.0012 & NP-EMD-2006.510.0081 have been implemented in B1.5. Delivered to NGST.	All
A10	11-30-07	Updated OAD for EDRPR/CDFCB-X quality flag changes.	All
A11	9-12-08	Reformatted document to implement template D41851 format. Modified graceful degradation and DQN sections. New cover sheet, update references, acronym list, prepare for peer review. Delivered to NGST. Accept all changes after delivery.	All
A12	02-18-09	Updated per 080917 SDRL S141.	All
A	3-18-09	Incorporated TIM comments and prepared for final ARB/ACCB delivery.	All
B1	12-01-09	Updated Table 1 due to G.Mulvey RFA comment (No RFA number), and updated subcontract number.	Title pg & 1-2
B	5-19-10	Prepared for TIM/ARB/ACCB	All
C1	8-18-10	Updated Table 1 & 2 due to omission of TM 2010.510.0005.Rev-C	Table 1 & 2
C2	8-27-10	ECR1061/PCR024068 update output field range	Table 9

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Revision/Change Record

Document Number D39141

Revision	Document Date	Revision/Change Description	Pages Affected
C3	9-27-10	Updated OAD for IST retrieval quality flag code corrections corresponding to technical memos: NP-EMD.2010.510.0067 & NP-EMD.2010.0068	P1-3, P8 P10-15
C4	10-21-10	Updated due to document convergence	All
C5	09-21-11	Update for PCR026166	Tables 1 & 2

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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 Joint Polar Satellite System (JPSS) 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 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.

1.2 Scope

The scope of this document is limited to the description of the core operational algorithm(s) required to create the VIIRS Ice Surface Temperature EDR. The theoretical basis for this algorithm is described in Section 3.3 of VIIRS Ice Surface Temperature Algorithm Theoretical Basis Document ATBD, D0001-M01-S01-018.

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 Ice Surface Temperature Algorithm Theoretical Basis Document ATBD	D0001-M01-S01-018	Latest
VIIRS Radiometric Calibration Algorithm Theoretical Basis Document ATBD	D0001-M01-S01-003	Latest
Operational Algorithm Description Document for VIIRS Geolocation (GEO) Sensor Data Record (SDR) and Calibration (CAL) SDR	474-00090	Latest
Operational Algorithm Description Document for VIIRS Cloud Mask Environmental Data Record (VCM EDR)	474-00062	Latest

Document Title	Document Number/Revision	Revision Date
Operational Algorithm Description Document for VIIRS Sea Ice Concentration (SIC) Intermediate Product (IP)	474-00094	Latest
Operational Algorithm Description Document for VIIRS Aerosol Products (AOT, APSP & SM) Intermediate Product (IP)/Environmental Data Records (EDR)	474-00073	Latest
JPSS Program Lexicon	474-00175	Latest
NGST/SE technical memo – IST OAD Update	NP-EMD.2005.510.0005	11 Jan 2005
NGST/SE technical memo – NPP_VIIRS_IST_QFFillValues_SPCR_ALG972	NP-EMD.2006.510.0012	30 Jan 2006
NGST/SE technical memo – NPP_VIIRS_IST_LST_STIP_BugsFix	NP-EMD.2006.510.0081	31 Oct 2006
NGST/SE technical memo – NPP_IST_ThinCirrusFlag_Updates	NP-EMD.2007.510.0055	09 Sep 2007
NGST/SE technical memo – NPP_VIIRS_LST_IST_AOTExclusion_RevB	NP-EMD.2006.510.0097.Rev-B	07 Feb 2007
NGST/SE technical memo – Granule-Level Summary Exclusion Flag Definition Rev. C.doc	NP.EMD.2010.510.0005.Rev-C	02 Mar 2010
NGST/SE technical memo – NPP_IST_AOTFlagUpdate	NP-EMD.2009.510.0056	06 Nov 2009
NGST/SE technical memo – NPP_IST_Retrieval_Quality_Flag_Corrections	NP-EMD.2010.510.0067	13 Sep 2010
NGST/SE technical memo – NPP_IST_OAD_Updates_for_Retrieval_Quality_Flag_ Corrections	NP-EMD.2010.510.0068	27 Sep 2010
Joint Polar Satellite System (JPSS) Algorithm Specification	474-00448-02-01_JPSS-DD-Vol-II-Part-1 474-00448-02-06_JPSS-DD-Vol-II-Part-06 474-00448-02-11_JPSS-DD-Vol-II-Part-11 474-00448-02-12_JPSS-DD-Vol-II-Part-12 474-00448-02-17_JPSS-DD-Vol-II-Part-17	Latest

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/Version	Revision Date
VIIRS IST Science-grade Software	Rev. 2.6	30 Jul 2004
VIIRS IST Operational Software	B1.3 (OAD Rev A1)	30 Sep 2004
VIIRS IST Science-grade Software	Rev. 2.6.1	15 Jan 2005
VIIRS IST Operational Software	B1.5 (OAD Rev A9)	Jul 2007
VIIRS IST Science-grade Software	Rev. 4.11	03 Sep 2008
NGST/SE Technical Memo – NPP_VIIRS_IST_QFFillValues_SPCR_ALG972	NP-EMD.2006.510.0012	Jan 2006

NGST/SE Technical Memo – NPP_VIIRS_IST_LST_STIP_BugsFix	NP-EMD.2006.510.0081	Oct 2006
NGST/SE Technical Memo – NPP_IST_ThinCirrusFlag_Updates	NP-EMD.2007.510.0055	Sep 2007
PCR 019285	Build 1.5.x.1 (OAD Rev A12)	12 Jan 2009
ACCB (includes PCR019679)	OAD –Rev A	18 Mar 2009
RFA work (no code changes)	(OAD Rev B1)	01 Dec 2009
PCR 21689 (TM 2009.510.0056)	Build Sensor Characterization SC-06 (No OAD Reference)	18 Jan 2010
PCR 21489 [TM 2010.510.0005.Rev-C] (No OAD update required)	Build Sensor Characterization SC-09	13 Apr 2010
ACCB (no code changes)	OAD –Rev B	19 May 2010
ECR1061/PCR024068 update output field range	(OAD – Rev C2)	27 Aug 2010
VIIRS IST Science-grade Software Includes TMs 2010.510.0067 & 2010.510.0068	ISTN_VIIRS_NGST_4.11.1 (OAD updated by 2010.510.0068)	29 Sep 2010
VIIRS IST Operational Software implements TMs 2010.510.0067 & 2010.510.0068 (PCRs 24769 & 24779)	Build Mx.1.5.4.00 (OAD Rev C3 & C4)	21 Oct 2010
VIIRS IST Science-grade Software	ISTN_VIIRS_NGST_4.11.2	13 Jan 2011
VIIRS IST Operational Software (PCR025922)	Build Mx.1.5.6._F (OAD not updated)	11 Aug 2011
PCR026166 (OAD Update for 4.11.2)	(OAD Rev C5)	21 Sep 2011
OAD transitioned to JPSS Program – this table is no longer updated.		

2.0 ALGORITHM OVERVIEW

The purpose of the IST Module is to retrieve the IST for each cloud-free land pixel at VIIRS moderate-resolution. Brightness Temperature data from the VIIRS SDR, VIIRS Aerosol Optical Thickness (AOT) Intermediate Product (IP), VIIRS Cloud Mask (VCM) EDR, and Ice Concentration IP are used to decide whether the pixel is processed and whether a 2-band split window baseline algorithm or a single-band split window fallback algorithm is used. The IST is retrieved using a regression equation with separate coefficients for day and night retrievals. The calculated Ice Surface Temperature and Quality Flag bytes are written to the VIIRS IST EDR. The IST processing chain is shown in Figure 1.

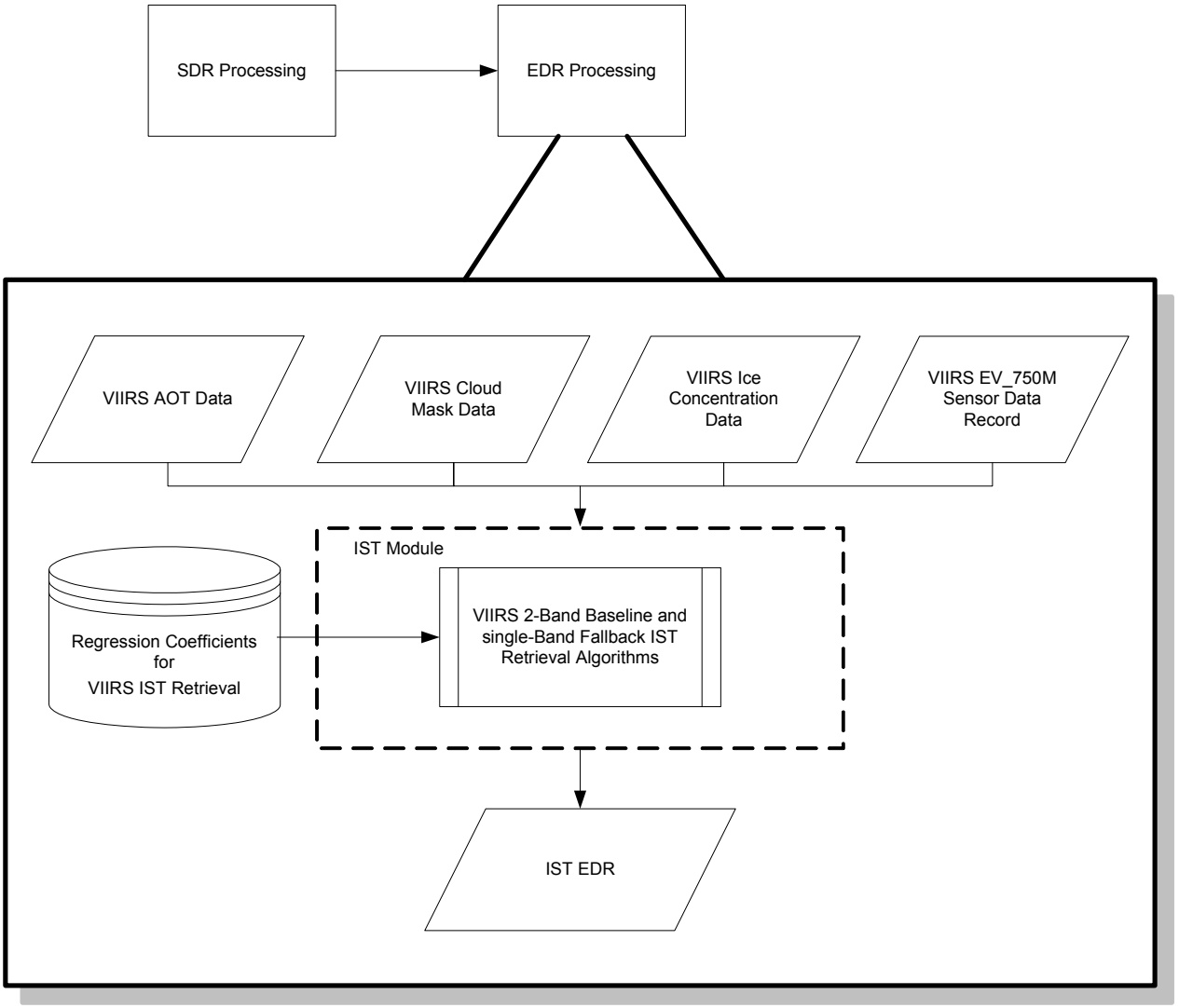


Figure 1: IST Processing Chain

2.1 Ice Surface Temperature EDR Description

The IST retrieval algorithm and its theoretical basis are described in detail within the VIIRS Ice Surface Temperature Algorithm Theoretical Basis Document ATBD, D0001-M01-S01-018.

2.1.1 Interfaces

The IST algorithm is initiated by the Infrastructure (INF) Software Item (SI) to begin processing the data. The INF SI provides tasking information to the algorithm indicating which granule is to be processed. The Data Management System (DMS) SI provides data storage and retrieval capability. The interface to these SIs is implemented by a library of C++ classes. The IPO Model interface to INF and DMS is shown in Figure 2.

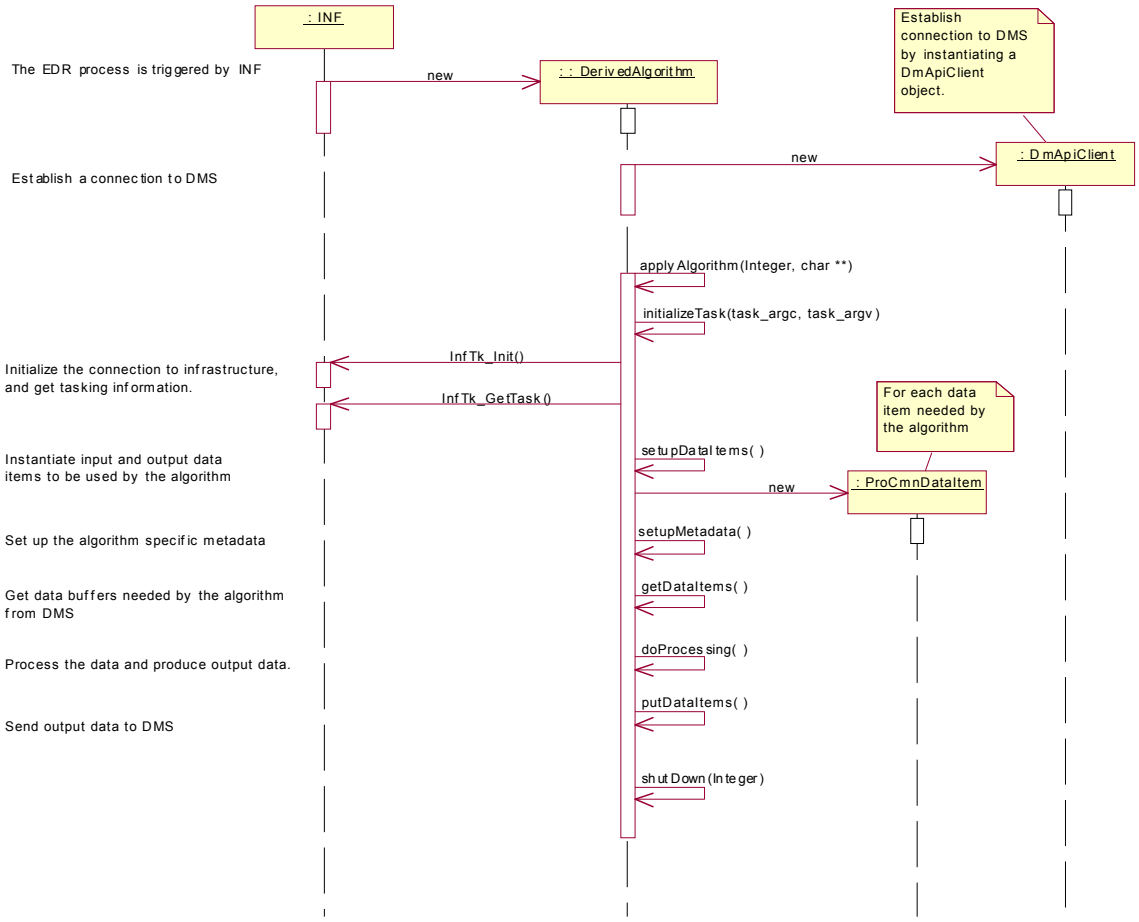


Figure 2: IPO Model Interface to INF and DMS

2.1.1.1 Inputs

Table 3 and Table 4 lists the VIIRS Ice Surface Temperature algorithm inputs.

Table 3: IST Inputs

Input	Description	Reference Document
VIIRS M15 and M16 Moderate Band SDRs	Band M15 - radiance & emittance at nominal center wavelength 10763 nm. Band M16 - radiance & emittance at nominal center wavelength 12013 nm.	474-00448-02-06_JPSS-DD-Vol-II-Part-06
VIIRS Mod Geo	VIIRS Moderate Band SDR Geolocation	474-00448-02-06_JPSS-DD-Vol-II-Part-06
VIIRS Cloud Mask EDR	The VIIRS Cloud Mask (VCM) technique incorporates a number of cloud detection tests that determine whether a cloud obstructs a cell. If a cloud is detected, the VCM indicates whether its phase is water, ice, or mixed. Additionally, the VCM specifies whether aerosols, fire, or shadows are detected within the cell field of view (FOV). A spatial uniformity test is also performed on the scene.	474-00448-02-11_JPSS-DD-Vol-II-Part-11
VIIRS AOT IP	The VIIRS Aerosol Optical Thickness RIP contains thickness values at assorted spectral bands over land and water as well as associated quality flags	474-00448-02-12_JPSS-DD-Vol-II-Part-12
VIIRS Ice Conc IP	The VIIRS Ice Concentration IP contains the ice fractions and summed concentration weights for each pixel.	474-00448-02-17_JPSS-DD-Vol-II-Part-17
VIIRS IST PC	The VIIRS Ice Surface Temperature EDR Ephemeral PC provides tunable processing coefficients for use by the algorithm during execution. The coefficients can be modified (tuned) through a configuration control process in response to algorithm, performance, inputs, sensitivity, etc. changes.	474-00448-02-17_JPSS-DD-Vol-II-Part-17
VIIRS IST DQTT	Data Quality Test Table	474-00448-02-17_JPSS-DD-Vol-II-Part-17

Table 4: IST LUT Data

Input	Type	Description/Source	Units/Valid Range
Ist Coeffs	Float*32 x [term][day/night][algorithm][regime]	IST Regression Coefficients LUT / IST LUT data	Unitless

2.1.1.2 Outputs

Table 5 lists the Ice Surface Temperature outputs.

Table 5: IST Outputs

Output	Description	Reference Document
VIIRS IST EDR	The Ice Surface Temperature EDR using VIIRS data. The overall scientific objective of the VIIRS IST retrievals is to provide improved measures of global and regional IST fields. The VIIRS IST EDR requires a 0.5 K measurement uncertainty. The requirements are met, provided accurate cloud/ice discrimination is available.	474-00448-02-17_JPSS-DD-Vol-II-Part-17
VIIRS IST EDR DQN	Data Quality Notification	474-00448-02-01_JPSS-DD-Vol-II-Part-1

2.1.2 Algorithm Processing

The IST EDR code is written in C but uses a C++ compiler to facilitate interfaces with the IDPS Infrastructure (INF) and Data Management Subsystem (DMS). The objective of the IST algorithm is to calculate IST at each pixel in a moderate resolution (750 m) granule with all the available input. Two similar regression algorithms are used to perform this retrieval:

1) a baseline 2-band split window algorithm which uses the brightness temperature from a pair of VIIRS wavebands in the Long-Wavelength Infrared (LWIR) atmospheric window (Bands M15 and M16), and
2) a fallback single-band algorithm where only the LWIR band M16 is used.

Quality assessment flags for each pixel are stored in the IST Flag output.

2.1.2.1 Main Module – ist.cpp

The ist.cpp routine is the main driver. It calls the following subroutines: ProCmnVcm_Extractor(), AggregateIce(), and RetrieveIst().

2.1.2.2 ProCmnVcmExtractor( )

This derived function extracts information from the VCM EDR to help define the processing path. In addition to cloud cover assessment, the VCM EDR provides information on land/water, snow/ice, day/night, shadow, thin cirrus, and active fires.

2.1.2.3 AggregateIce( )

This subroutine aggregates imagery resolution ice concentration data to determine if ice is present within the moderate resolution pixels. This function does not process any moderate

pixel that has an imagery pixel with zero weight and only aggregate pixels with all positive non-zero weights. Weight information comes from the ice weight input.

2.1.2.4 RetrieveIst( )

The logic flow of the IST retrieval algorithm is provided in Figure 3 The core logic occurs in two functions, setIstQualFlags()and calculateIst(). In the current implementation, IST QFs additionally serve as decision flags. Their values are used in the decision of whether IST can be retrieved and, if so, which algorithm to use.

Details of the IST retrieval conditions and exclusions are documented in 474-00448-04-17_JPSS-SRSPF-Vol-IV-Part-17_A_Cryosphere-EDR.

For processed pixels, IST is retrieved by either the baseline 2-band split window algorithm or the single-band fallback algorithm. In general, the 2-band split window algorithm is used under optimal conditions: ice covered pixel, and “in-range” brightness temperatures for both the M15 and M16 bands. Otherwise, the single-band fallback algorithm is used. The logic to determine which algorithm is used is provided in Table 7.

Equations for the 2-band split window and single-band algorithms are specified in Table 7 7. The implementation is presented in calculateIst(). Daytime and nighttime retrievals are identical except that a different set of regression coefficients is used in the look-up table (LUT).

The AOT values from the VIIRS AOT IP at 550 nm band (slant path) are used for AOT exclusion. The exclusion is based on the slant path 550 nm band AOT.

2.1.2.5 IST QF Logic

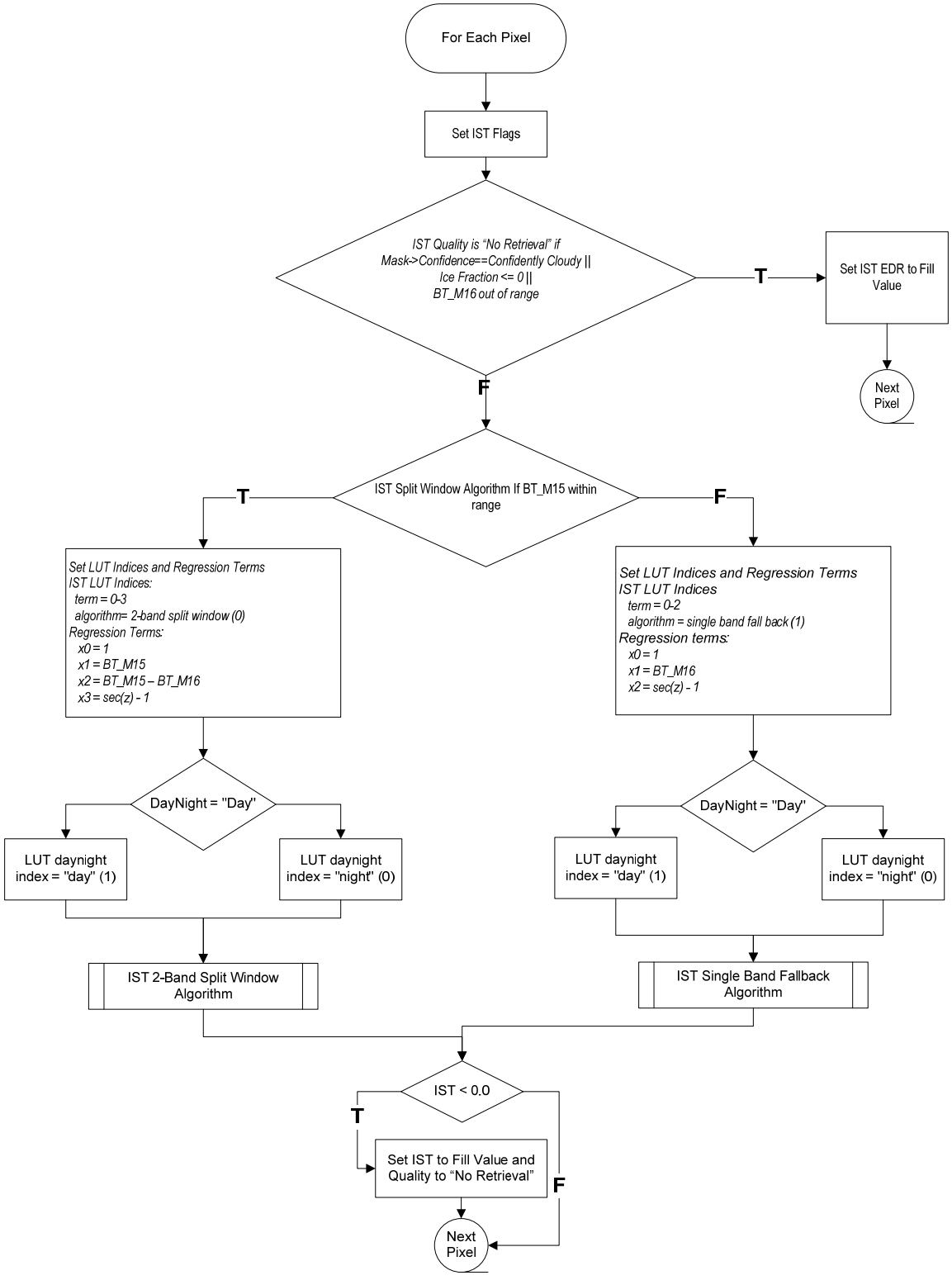
Details of the IST QF conditions and exclusions are documented in 474-00448-04-17_JPSS-SRSPF-Vol-IV-Part-17_A_Cryosphere-EDR.

2.1.2.6 IST LUT Coefficient Selection

A unique set of regression coefficients is derived offline for IST. Each IST equation found in Table 7 uses a different set of coefficients for a given day/night condition. Access to the coefficients is achieved by setting index values based on the given pixel viewing conditions and indicating which algorithm approach to use. Once indices are specified, coefficients are retrieved for the desired IST algorithm by indexing on the “term” index. Currently, the “regime” index should be set to “0” and has only one value. It is a placeholder for possible future improvement by further stratification of atmospheric conditions. For the 2-band split window algorithm, there are four coefficients. For the single-band fallback algorithm, there are three coefficients. For the latter, an additional zero-valued coefficient is present as “filler” in the LUT.

Example:

> LUTCoeffs[n][1][0][0], where n is indexed from 0 to 3, corresponds to the coefficients a_0 to a_3 of the 2-band split window algorithm under daytime viewing conditions.



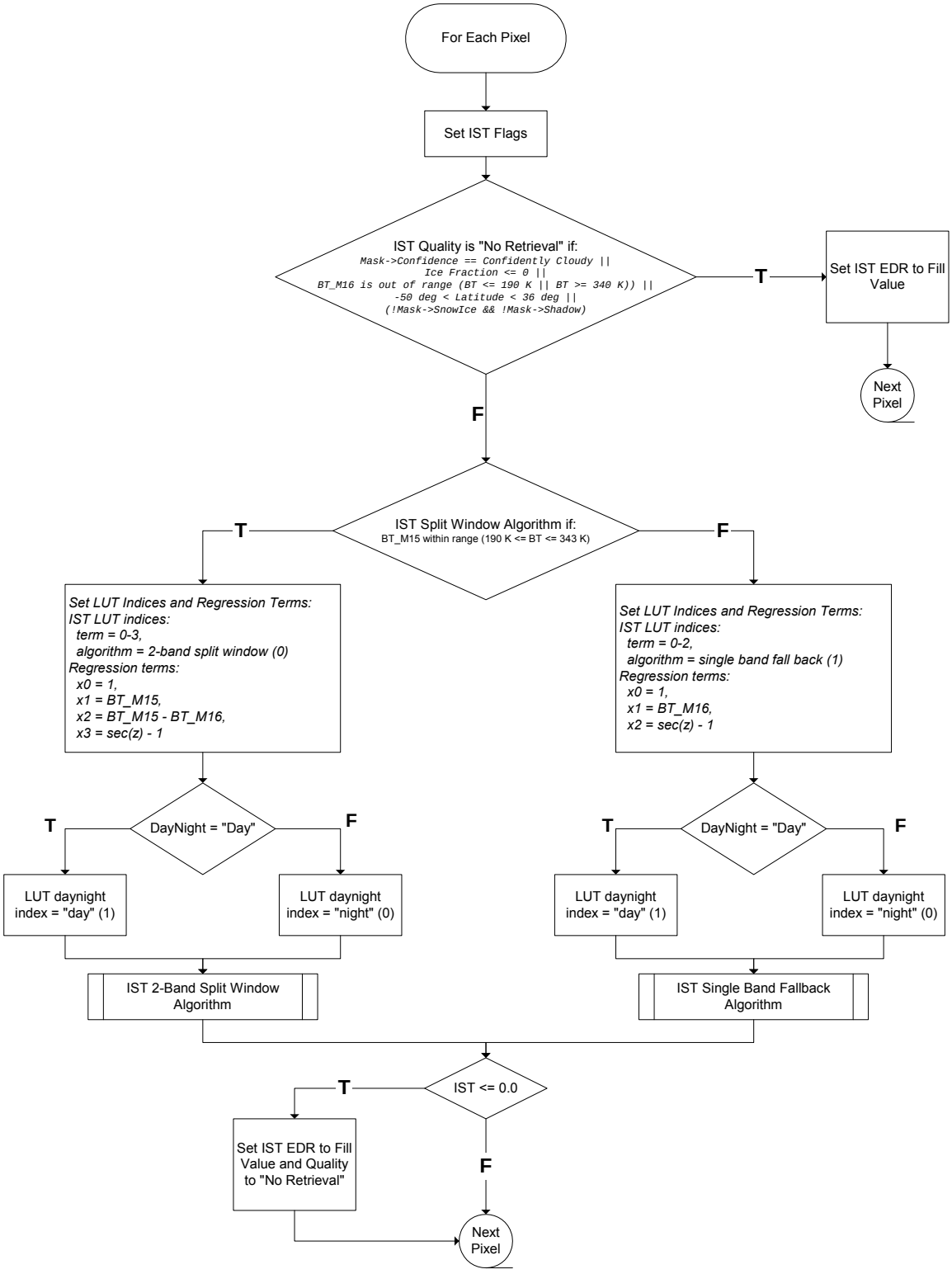


Figure 3: IST Retrieval Logic Flow

Table 6: IST QF Logic

IST Flag	Input Source	Flag Setting

Horizontal Ice Coverage zone	VIIRS Earth View 750-meter SDR	if (36º ≤ Latitude ≤ 90º or –90º ≤ Latitude ≤ -50º)
		set to “within ice coverage zone”
		otherwise
		set to “outside ice coverage zone”
		end if

Snow/Ice Surface	VCM EDR/Snow/Ice Flag	IST Snow/Ice Flag = VCM Snow/Ice Flag

Band M15 Brightness Temperature Quality	VIIRS Earth View 750-meter SDR	if (180 K < BT_{M15} < 350 K)
		set to “within range”
		otherwise
		set to “out of range”
		end if

Band M16 Brightness Temperature Quality	VIIRS Earth View 750-meter SDR	if (180 K < BT_{M16} < 350 K)
		set to “within range”
		otherwise
		set to “out of range”
		end if

AOT Exclusion (VIIRS 550 nm band, slant path)	VIIRS AOT IP	if (AOT ≤ 1.0)
		set to “within range”
		otherwise
		set to “out of range”
		end if

Day/Night	VIIRS Earth View 750-meter SDR	if (0º ≤ Solar Zenith Angle ≤ 85º)
		set to “Day”
		otherwise
		set to “Night”
		end if

Shadow Detected	VCM EDR/ Shadow Flag	IST Shadow Flag = VCM Shadow Flag
Thin Cirrus	VCM EDR/ Thin Cirrus Flag	IST Thin Cirrus Flag = VCM Thin Cirrus Flag
Fire	VCM EDR/ Fire Flag	IST Fire Flag = VCM Fire Flag
Cloud Confidence Indicator	VCM EDR/ Cloud Detection and Confidence Indicator	IST Cloud Confidence Indicator = VCM Cloud Confidence Indicator
Adjacent Pixel Cloud Confidence Indicator	VCM EDR/ Adjacent Pixel Cloud Confidence Indicator	IST Cloud Confidence Indicator = VCM Adjacent Pixel Cloud Confidence Indicator
Land/Water	VCM EDR/ LandWater Flag	IST LandWater = VCM LandWater flag

Ice Fraction	VIIRS Ice Concentration IP / Ice Fraction	if (Ice Fraction = 1.00)
		set to “Ice”
		else if (0.95 ≤ Ice Fraction < 1.00)
		set to “Primarily Ice”
		else if (0.00 < Ice Fraction < 0.95)
		set to “Ice-Water Mix”
		otherwise
		set to “Not Ice”
		end if

Algorithm	Logical combination of IST Flags	if (BT_{M15} is “within range”) and (BT_{M16} is “within range”)
		set to “2-Band”
		otherwise
		set to “1-Band”
		end if

Quality	Logical combination of IST Flags	See Section 2.1.2.5

IST Flag	Input Source	Flag Setting
Out of range	Computed in algorithm	Set to IST_OUTSIDE if IST values are greater than max allowable IST temp or less than min allowable IST temp
Exclusion Summary	Logical combination of IST and cloud mask computations and inputs.	Currently set to the value of the AOT exclusion flag

Table 7: IST Core Equations

VIIRS IST baseline split window algorithm
Daytime:
$IST = a_0 + a_1 T_{M15} + a_2 (T_{M15} - T_{M16}) + a_3 (\sec\theta - 1)$
Nighttime:
$IST = b_0 + b_1 T_{M15} + b_2 (T_{M15} - T_{M16}) + b_3 (\sec\theta - 1)$
VIIRS IST fallback single-band algorithm
Daytime:
$IST = a_0 + a_1 T_{M16} + a_2 (\sec\theta - 1)$
Nighttime:
$IST = b_0 + b_1 T_{M16} + b_2 (\sec\theta - 1)$
where • IST is the retrieved ice surface temperature, • a_n and b_n are coefficients in the IST LUT and are dependent on day/night conditions, • θ is the sensor zenith angle, • T_{M15} and T_{M16} are the brightness temperatures at VIIRS bands M15 and M16 respectively. The equations above correspond to the IST ATBD, D0001-M01-S01-018, Section 3.3.2.1, Equations (10) and (11) with minor modifications.

2.1.3 Graceful Degradation

2.1.3.1 Graceful Degradation Inputs

There are two cases where input graceful degradation is indicated in the Ice Surface Temperature EDR

1. The primary input denoted in the algorithm configuration guide cannot be successfully retrieved but an alternate input can be retrieved
2. Graceful degradation is indicated if an input retrieved for the algorithm has its N_Graceful_Degradation metadata field set to YES (propagation).

Table 8 details the instances of this case for IST. Note that the shaded cells indicate that the graceful degradation was done upstream at product production.

Table 8: IST Graceful Degradation

Input data description	Satellite	Baseline data source	Primary backup data source	Secondary backup data source	Tertiary backup data source	Graceful degradation done upstream
Aerosol Optical Thickness	NPP,PM1, TR1	VIIRS_GD_15.4.1 VIIRS AOT IP	VIIRS_GD_25.4.1 NAAPS	VIIRS_GD_15.4.1 Climatology	N/A	Yes, backup only.

2.1.3.2 Graceful Degradation Processing

None.

2.1.3.3 Graceful Degradation Outputs

None.

2.1.4 Exception Handling

When IST cannot be retrieved due to conditions such as invalid SDR data, cloudy pixel, non-Ice pixel, and BT_M16 out of range, IST pixel values are set to ERR_FLOAT32_FILL. The IST QFs are unaffected by this condition and should still be set as they provide information on why IST was not retrieved successfully.

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.

2.1.6 Computational Precision Requirements

The VIIRS IST EDR requires accuracy and precision on the order of tenths of degrees. Input data used meets this degree of precision requirement. Regression equations are executed using a combination of 32-bit floating-point precision values.

2.1.7 Algorithm Support Considerations

The list of configurable algorithm parameters can be found in 474-00448-02-17_JPSS-DD-Vol-II-Part-17, Table 7.2.2.1.2-1.

2.1.8 Assumptions and Limitations

2.1.8.1 Assumptions

The IST retrieval algorithm assumes VIIRS M15 SDR, VIIRS M16 SDR, VCM EDR, VIIRS Ice Concentration, and VIIRS AOT IP are available before processing.

2.1.8.2 Limitations

The IST EDR is retrieved under clear conditions with known ice type classification and valid brightness temperature from at least the VIIRS M16 band.

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

Table 9 contains terms most applicable for this OAD.

Table 9: Glossary

Term	Description
Algorithm	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 JPSS, an algorithm consists of: 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 Engineering Review Board (AERB)	Interdisciplinary board of scientific and engineering personnel responsible for the approval and disposition of algorithm acceptance, verification, development and testing transitions. Chaired by the Data Process Algorithm Lead, members include representatives from STAR, DPES, IDPS, and Raytheon..
Algorithm Verification	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.
Ancillary Data	Any data which is not produced by the JPSS System, but which is acquired from external providers and used by the JPSS system in the production of JPSS data products.
Auxiliary Data	Auxiliary Data is defined as data, other than data included in the sensor application packets, which is produced internally by the JPSS system, and used to produce the JPSS deliverable data products.
EDR Algorithm	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.
Environmental Data Record (EDR)	*[IORD Definition]* 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.). *[Supplementary Definition]* 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 JPSS SDRs or EDRs, plus ancillary environmental data provided by others. EDR metadata contains references to its processing history, spatial and temporal coverage, and quality.
Model Validation	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]
Model Verification	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]
Operational Code	Verified science-grade software, delivered by an algorithm provider and verified by IWPTB, is developed into operational-grade code by the IDPS IPT.

Term	Description
Operational-Grade Software	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.
Raw Data Record (RDR)	*[IORD Definition]* Full resolution digital sensor data, time referenced and earth located, 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. *[Supplementary Definition]* 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 JPSS (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.
Retrieval Algorithm	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.
Science Algorithm	The theoretical description and a corresponding software implementation needed to produce an NPP/JPSS 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".
Science Algorithm Provider	Organization responsible for development and/or delivery of TDR/SDR or EDR algorithms associated with a given sensor.
Science-Grade Software	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.
SDR/TDR Algorithm	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.
Sensor Data Record (SDR)	*[IORD Definition]* Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to calibrated brightness temperatures with associated ephemeris data. The existence of the SDRs provides reversible data tracking back from the EDRs to the Raw data. *[Supplementary Definition]* 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.

Term	Description
Temperature Data Record (TDR)	*[IORD Definition]* 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. *[Supplementary Definition]* 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.

3.2 Acronyms

Table 10 contains terms most applicable for this OAD.

Table 10: Acronyms

Acronym	Description
AM&S	Algorithms, Models & Simulations
API	Application Programming Interfaces
ARP	Application Related Product
CAL	Calibration
DMS	Data Management Subsystem
DQTT	Data Quality Test Table
INF	Infrastructure
ING	Ingest
IP	Intermediate Product
IST	Ice Surface Temperature
LUT	Look-Up Table
QF	Quality Flag
SDR	Sensor Data Record
SI	International System of Units
TBD	To Be Determined
TBR	To Be Resolved
VCM	VIIRS Cloud Mask

4.0 OPEN ISSUES

Table 11: Open TBXs

No.	DESCRIPTION	Resolution Date
None		