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Joint Polar Satellite System (JPSS) Ground Project
Code 474
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Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Sea Ice Age (SIA) Environmental Data Record (EDR) Software

For Public Release

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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 Sea Ice Age (SIA) Environmental Data Record (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:

JPSS Configuration Management Office
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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-11-0102** which converts D39593, Operational Algorithm Description Document for VIIRS Sea Ice Age Environmental Data Record (EDR), Rev B dated 06/09/2010 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-11-0268:** This version baselines, Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Sea Ice Age (SIA) Environmental Data Record (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 474-00087, JPSS OAD Document for VIIRS SIA 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.

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS SEA ICE AGE ENVIRONMENTAL DATA RECORD (EDR)

SDRL No. S141
SYSTEM SPECIFICATION SS22-0096

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

This data was developed pursuant to Contract Number F04701-02-C-0502 with the US Government under subcontract number 7600002744. The US Government's right in and to this copyrighted data are as specified in DFAR 252.227-7013, which was made part of the above contract.

IAW DFAR 252.227-7036, Raytheon hereby declares that, to the best of its knowledge and belief, the technical data delivered under Subcontract No. 7600002744 is complete, accurate, and complies with all requirements of the Subcontract.

TITLE: NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS SEA ICE AGE ENVIRONMENTAL DATA RECORD (EDR)

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

CAGE NO. 11982

Operational Algorithm Description
VIIRS Sea Ice Age EDR

Document Number: D39593
Document Date: Sep 19, 2011 **Revision: C5**

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Under
Contract No. F04701-02-C-0502
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 **D39593**

Revision	Document Date	Revision/Change Description	Pages Affected
---	5-6-05	Initial PCIM Release – Reference ECR A049.	All
A1	6-5-06	11Oct05 – Inserted the NP-EMD.2005.510.0115 Tech Memo changes plus reflects Raytheon-Omaha's edits for Science To Operational Code Conversion (i.e., added Raytheon coversheet, Raytheon title signature page, etc.) 03Apr06 – Removed Ice Quality and Ice Concentration information, updated coversheet copyright year, corrected info on TBD/TBR page, removed Figures 1, 2, 3, updated Table of Contents, updated List of Figures, updated List of Tables. 05Apr06 – Added information from 23Mar06 I-P-O CUTPR code comments into Section 2.3 (Detailed Algorithm Description) and corrected info on TBD/TBR page. 06Apr06 – Per precedence to separate out all three Ice Characterization executables into individual OADs, updated the document number (i.e., D39593-IDP-003) in upper right header. Ice Quality OAD (i.e., D39593-IDP-001) and Ice Concentration (i.e., D39593-IDP-002). Updated coversheet title to All Capital letters and spelled out "EDR" acronym. Updated TBD/TBR page numbers. Updated Table of Contents to capture insertion of new Sections 2.3.1 through 2.3.14. Made other minor spacing and format edits. 14Apr06 – Removed Table 2's reference to Previous Ice Age Region Mask which was removed from the NP-EMD.2005.510.0115 Tech Memo. Added wsubreg data to Table 3 because it was not added when the NP-EMD.2005.510.0115 Tech Memo was incorporated. 01Jun06 – Updated Table 2's Data Type/Size Column per the NP-EMD.2006.510.0028 Tech Memo. 05 Jun 06 – Final edits.	All
A2	5-16-07	Updated document for TM #: NP-EMD.2005.510.0038. Modified Section 2.2.2, changed HC_ROWS and HC_COLS. Modified Table 9, changed HC_ROWS and HC_COLS, Modified Section 2.2.3.1 added verbiage describing code changes for cross granule processing.	All
A3	6-15-07	Logo, cleanup updates. Delivered to NGST.	All
A4	9-6-07	Updated for the implementation of Tech Memo changes. TM #s: NP-EMD.2006.510.0062, NP-EMD.2006.510.0028, NP-EMD.2006.510.0063, NP-EMD.2006.510.0065, NP-EMD.2006.510.0066, NP-EMD.2006.510.0074, & NP-EMD.2006.510.0083.	All
A5	10-5-07	Updated with correction based on current algorithm processing. Updated with responses to comments from June delivery.	All
A6	10-17-07	Delivered to NGST.	All
A7	11-9-07	Added spacecraft position, velocity, and attitude to geolocation output.	All

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Document Number **D39593**

Revision	Document Date	Revision/Change Description	Pages Affected
A8	12-4-07	Updated for the implementation of TM #NP-EMD-2006.510.0095 and comments received from NGST.	All
A9	12-14-07	Delivered to NGST.	All
A10	12-14-07	ECR A-103, EDRPR 1.8 CP 3 updates -Format changes for CDFCB-X compliance- Sea Ice Age Granule-Level Quality Flags table.	All
A11	3-10-08	Implemented TM #NP-EMD-2007.510.0046.	All
A12	10-29-08	Updated Graceful Degradation. Implemented TM #NP-EMD-2008.510.0018. Prepared for TIM/ACCB. Updated for TIM comments.	All
A	12-10-08	Addressed TIM comments. ECR A-181.	All
B1	04-15-09	Incorporated document PCR 20212 changes and minor formatting.	5 & Table 9
B2	06-17-09	Added D48316_---_CmnAdjacency_OAD.doc to Reference Table	1 - 3
B3	11-4-09	Updated for SDRL (Removed Cmn Adj reference upon further investigation—not used)	All
B4	01-07-10	Updated based on SDRL review comments from A&DP; revised SCN and copyright year	Table 9
B5	2-24-10	Updated for TIM	All
B6	3-17-10	Incorporated TIM commented and prepared for ARB/ACCB	All
B7	5-10-10	Incorporated TM 2010.510.0034, which was the result of comments from the ARB held on 3-24-2010.	All
B	6-09-10	Returned to 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	10-21-10	Technical memo NP-EMD.2010.510.0078 corrections: Corrected tables 6, 7 and 8. Added clarifications about FORTRAN versus C++ array order differences. Added statements to section 2.1.2.5 regarding operational implementation differences of the energy balance computation from that of the ATBD. Changed table 5 title from “Ice Age LUT” to “VIIRS Sea Ice Ephemeral PC” for consistency with CDFCB-X Vol. VIII. Also changed entry “Ice Age LUT” in table 4 to “VIIRS Sea Ice Age Ephemeral PC”.	p.8;10-13 p.18 p.8;9
C3	10-21-10	Updated due to document convergence to include tech memos 2010.510.0078 & 2010.510.0011	All
C4	12-07-10	Updated table 10 due to PCR025300	Table 10
C5	09-19-11	Updated for PCR027383.	17

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Revision/Change Record

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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 for the Visible/Infrared Imager/Radiometer Suite (VIIRS) Sea Ice Age Environmental Data Record (EDR).

1.2 Scope

The scope of this document is limited to describing operational algorithm implementation required to create the VIIRS Sea Ice Age EDR software. The theoretical basis for this algorithm is described in Section 3.3 of the VIIRS Sea Ice Characterization Algorithm Theoretical Basis Document (ATBD), 474-00047.

1.3 References

The primary software detailed design documents listed here include science software documents, NPOESS program documents, plus source code and test data 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 Sea Ice Characterization Algorithm Theoretical Basis Document (ATBD)	474-00047	Latest
JPSS Environmental Data Record (EDR) Production Report for NPP	474-00012	Latest

Document Title	Document Number/Revision	Revision Date
JPSS Environmental Data Record (EDR) Interdependency Report (IR) for NPP	474-00007	Latest
NPP Mission Data Format Control Book and App A (MDFCB)	429-05-02-42_MDFCB	Latest
JPSS Common Data Format Control Book - External - – Block 1.2.2 (All Volumes)	474-00001-01-B0122 CDFCB-X Vol I 474-00001-02-B0122 CDFCB-X Vol II 474-00001-03-B0122 CDFCB-X Vol III 474-00001-04-01-B0122 CDFCB-X Vol IV Part 1 474-00001-04-02-B0122 CDFCB-X Vol IV Part 2 474-00001-04-03-B0122 CDFCB-X Vol IV Part 3 474-00001-04-04-B0122 CDFCB-X Vol IV Part 4 474-00001-05-B0122 CDFCB-X Vol V 474-00001-06-B0122 CDFCB-X Vol VI 474-00001-08-B0122 CDFCB-X Vol VIII	Latest
JPSS Common Data Format Control Book - External - Block 1.2.3 (All Volumes)	474-00001-01-B0123 CDFCB-X Vol I 474-00001-02-B0123 CDFCB-X Vol II 474-00001-03-B0123 CDFCB-X Vol III 474-00001-04-01-B0123 CDFCB-X Vol IV Part 1 474-00001-04-02-B0123 CDFCB-X Vol IV Part 2 474-00001-04-03-B0123 CDFCB-X Vol IV Part 3 474-00001-04-04-B0123 CDFCB-X Vol IV Part 4 474-00001-05-B0123 CDFCB-X Vol V 474-00001-06-B0123 CDFCB-X Vol VI 474-00001-08-B0123 CDFCB-X Vol VIII	Latest
JPSS Data Format Control Book - Internal Volume III – Retained Intermediate Product Formats (IDFCB) – Block 1.2.3	474-00020-03-B0123 IDFCB Vol III	Latest
NPP Command and Telemetry (C&T) Handbook	D568423 Rev. C	30 Sep 2008
VIIRS Sea Ice Age Unit Level Detailed Design Document	Y3231 Ver. 5 Rev. 5	21 Mar 2005
VIIRS Snow/Ice Module Interface Control Document	Y0011650 Ver. 5 Rev. 5	21 Mar 2005
VIIRS Snow/Ice Module Software Architecture Document	Y2477 Ver. 5 Rev. 6	21 Mar 2005
VIIRS Snow/Ice Module Data Dictionary	Y2482 Ver. 5 Rev. 5	21 Mar 2005
JPSS CGS Data Processor Inter-subsystem Interface Control Document (DPIS ICD) Vol I – IV	IC60917-IDP-002	Latest

Document Title	Document Number/Revision	Revision Date
JPSS Program Lexicon	474-00175	Latest
IDPS Processing SI Common IO Design Document	DD60822-IDP-011 Rev. A	21 Jun 2007
Operational Algorithm Description Document for VIIRS Sea Ice Quality (SIQ) Intermediate Product (IP) and Surface Temperature (ST) IP	474-00095	Latest
Operational Algorithm Description Document for VIIRS Sea Ice Concentration (SIC) Intermediate Product (IP)	474-00094	Latest
Operational Algorithm Description Document for the Granulate Ancillary Software	474-00089	Latest
VIIRS Ice Age LUT Generation document	DAL No. D277c, ITSS Document number ME60822-VIR-022 Rev. ---	02 Dec 2004
NGST/SE technical memo – Cross-granule Processing Memo	NP-EMD.2005.510.0038	07 Mar 2005
NGST/SE technical memo – MS_Engineering_Memo_IceAge_OAD_Update	NP-EMD.2005.510.0115	14 Nov 2005
NGST/SE technical memo – MS_Engineering_Memo_SeaIce_OAD_QualityFlag_Update	NP-EMD.2005.510.0137	14 Nov 2005
NGST/SE technical memo – NPP_VIIRS_IceAge_Ancillary Data EDRIR Compliance	NP-EMD.2006.510.0028 Rev. A	24 Oct 2007
NGST/SE technical memo – NPP_VIIRS_SeaIce_AOT_field_corrections	NP-EMD.2006.510.0047 Rev. A	24 Oct 2007
NGST/SE technical memo – Conversion of NCEP Ancillary Data Relative Humidity to Specific Humidity	NP-EMD.2007.510.0064	24 Oct 2007
NGST/SE technical memo – NPP_VIIRS_IceAge_AMI_IP_removal	NP-EMD.2006.510.0062	16 Aug 2006
NGST/SE technical memo – NPP_VIIRS_IceAge_terminator_continuity_fix_RevA	NP-EMD.2006.510.0063	07 Sep 2006
NGST/SE technical memo – NPP_VIIRS_IceAge_missing_openwater_fill_fix_0065	NP-EMD.2006.510.0065	13 Sep 2006
NGST/SE technical memo – NPP_VIIRS_IceAge_logical_expression_fixes_066	NP-EMD.2006.510.0066	14 Sep 2006
NGST/SE technical memo – NPP_VIIRS_IceAge_550nmAOT_OAD_update	NP-EMD.2006.510.0074	15 Oct 2006
NGST/SE technical memo – NPP_VIIRS_IceAge_VCM_ThinCirrus_Flag	NP-EMD.2006.510.0083	07 Nov 2006
NGST/SE technical memo – NPP_VIIRS_SeaIce_Night_granule_AOT_RevA	NP-EMD-2006.510.0095 Rev. A	26 Jan 2007
NGST/SE technical memo – NPP_VIIRS_3.4.4_delta_delivery_OAD_update	NP-EMD.2007.510.0046	08 Aug 2007
NGST/SE technical memo – NPP_VIIRS_SeaIce_v3.4.5_delta_delivery_OAD_updates	NP-EMD.2008.510.0018	15 Apr 2008
NGST/SE technical memo – Sea Ice Age Bug Fix to Remove nmy in subroutine IA_ice_age	NP-EMD.2008.510.0057	30 Oct 2008
NGST/SE technical memo – Sea Ice Age Algorithm Array Initialization Bug Fix in Energy Balance Subroutine	NP-EMD.2008.510.0071	15 Dec 2008
NGAS/A&DP technical memo – SeaIceAge_OAD_Update	NP-EMD.10.510.0034	03 May 2010
NGAS/A&DP technical memo – SeaIceAge_heavyAOT_QF_test_fix	NP-EMD.10.510.0036	29 Apr 2010

Document Title	Document Number/Revision	Revision Date
NGAS/A&DP technical memo – SeaIceAge_Input_Data_Quality_Flag_fix	NP-EMD.10.510.0037	03 May 2010
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 – SeaIceAge_OAD_Corrections	NP-EMD.2010.510.0078	18 Sep 2010
NGST/SE technical memos: LUT_OAD_Drop History_Corrections	NPOESS GJM-2010.510.0011	21 Sep 2010

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. Indented rows are included as a reference to other Sea Ice Characterization algorithms.

Table 2. Source Code References

Reference Title	Reference Tag/Revision	Revision Date
VIIRS SeaIceCharacterization science-grade software (original reference source) (ECR-A049)	ISTN_VIIRS_NGST_3.4 (ECR A049) (OAD Rev ---)	05 May 2005
VIIRS Sea Ice Age Operational Software	B1.3 (OAD Rev ---)	06 May 2005
VIIRS SeaIceCharacterization science-grade software (ECR-A066)(Sea Ice Age) Includes Tech Memo: NP-EMD.2005.510.0115	ISTN_VIIRS_NGST_3.4.1 (ECR A066)	29 Sep 2005
Implemented TM NP-EMD.2005.510.0115	B1.3 (OAD Rev A1)	10 Oct 2005
VIIRS Sea Ice Age Operational Software	B1.4 (OAD Rev A1)	05 Jun 2005
VIIRS SeaIceCharacterization science-grade software (ECR-A073)(Sea Ice Quality) Includes OAD update Tech Memo: NP-EMD.2005.510.0137 (SIQ)	ISTN_VIIRS_NGST_3.4.2 (ECR-A073)	14 Nov 2005
NGST/SE technical memo – MS_Engineering_Memo_SeaIce_OAD_QualityFlag_Update	NP-EMD.2005.510.0137	14 Nov 2005
VIIRS Sea Ice Age Operational Software	B1.4 (OAD Rev A2)	06 May 2006
VIIRS SeaIceCharacterization science-grade software (ECR-A073 & A108)(Sea Ice Age)	ISTN_VIIRS_NGST_3.4.3 (ECRs -A073 &-A108)	18 Dec 2006
Implemented TM 2005.510.0038	B1.4 (OAD Rev A2)	16 May 2007
VIIRS Sea Ice Age Operational Software includes implementation of TMs: NP-EMD.2006.510.0062, NP-EMD.2006.510.0028, NP-EMD.2006.510.0063, NP-EMD.2006.510.0065, NP-EMD.2006.510.0066, NP-EMD.2006.510.0074, & NP-EMD.2006.510.0083	B1.5 (OAD Rev A4)	06 Sep 2007
VIIRS SeaIceCharacterization science-grade software (ECR-A127A)(Sea Ice Age) Includes Tech Memo: NP-EMD.2007.510.0046	ISTN_VIIRS_NGST_3.4.4 (ECR-A127A)	29 Aug 2007 & 11 Sep 2007
VIIRS Sea Ice Age Operational Software includes TM 2007.510.0095.Rev-A	B1.5 (OAD Revs A5 - A9)	14 Dec 2007
Implemented TM 2007.510.0046 (PCR14258) (ECR A-127)	B1.5 (OAD Rev A11)	07 Mar 2008
VIIRS SeaIceCharacterization science-grade software (Sea	ISTN_VIIRS_NGST_3.4.5	14 May 2008

Reference Title	Reference Tag/Revision	Revision Date
Ice Characterization) Includes OAD update Tech Memo: NP-EMD.2008.510.0018	(ECR-A149)	
VIIRS Sea Ice Age Operational Software implemented TMs 2006.510.0095.Rev-A (PCR 14275) and 2008.510.0018	B1.5.x.1 (OAD Rev A12)	24 Oct 2008
Implemented TM 2008.510.0057 (PCR18951)	Build 1.5.x.1-I (No OAD Update)	10 Nov 2008
ACCB	OAD Rev A	10 Dec 2008
Implemented TM 2008.510.0071 (PCR19267)	Build 1.5.x.1-J (No OAD Update)	17 Dec 2008
PCR 20212 (OAD PCR-no code update)	(OAD Rev B1)	15 Apr 2009
Updated due to Common Adjacency OAD TIM-no code update	(OAD Rev B2)	17 Jun 2009
SDRL	(OAD Rev B3)	04 Nov 2009
VIIRS SeaIceCharacterization science-grade software (Sea Ice Characterization) Includes OAD update Tech Memos: NP-EMD.20098.510.0049 & NP-EMD.20098.510.0068 (PCR 21984) (no OAD changes, science code bug fix only)	ISTN_VIIRS_NGST_4.17 (ECRs –A263)	16 Dec 2009
ARB	(OAD Rev B6)	17 Mar 2010
PCR 21630 [TM 2010.510.0005.Rev-C] (No OAD update required)	Build Sensor Characterization SC-09	14 Apr 2010
VIIRS Sea Ice Age Operational Software includes tech memos Implemented: --NGAS/A&DP technical memo – SeaIceAge_OAD_Update NP-EMD.10.510.0034 --NGAS/A&DP technical memo – SeaIceAge_heavyAOT_QF_test_fix NP-EMD.10.510.0036 --NGAS/A&DP technical memo – SeaIceAge_Input_Data_Quality_Flag_fix NP-EMD.10.510.0037	Build Sensor Characterization SC-11 (OAD Rev B7)	25 May 2010
ACCB	OAD Rev B	09 Jun 2010
Convergence Updates (No code updates) includes TM 2010.510.0078 (PCR 24723)	(OAD Rev C2 & C3)	21 Oct 2010
Updated table 10 due to PCR025300	(OAD Rev C4)	07 Dec 2010
PCR027383	(OAD Rev C4)	19 Sep 2011
OAD transitioned to JPSS Program – this table is no longer updated.		

2.0 ALGORITHM OVERVIEW

The Sea Ice Age algorithm produces a Sea Ice Age EDR product. The Sea Ice Age EDR is used to report on "Ice free", "New/Young", and "All other ice" classifications at an aggregated cell size of 2x2 VIIRS imagery pixels. Due to the 2x2 imagery pixel aggregation, the Ice Age EDR product size is equal to moderate resolution product size, therefore, the algorithm produces no geolocation product. The Moderate Resolution VIIRS SDR GEO product should be used whenever geolocation data is required for Ice Age EDR data". The algorithm utilizes Intermediate Product (IP) files produced by other VIIRS algorithms, auxiliary files from the National Center for Environmental Prediction (NCEP) and Lookup Tables (LUT) to produce the output EDRs.

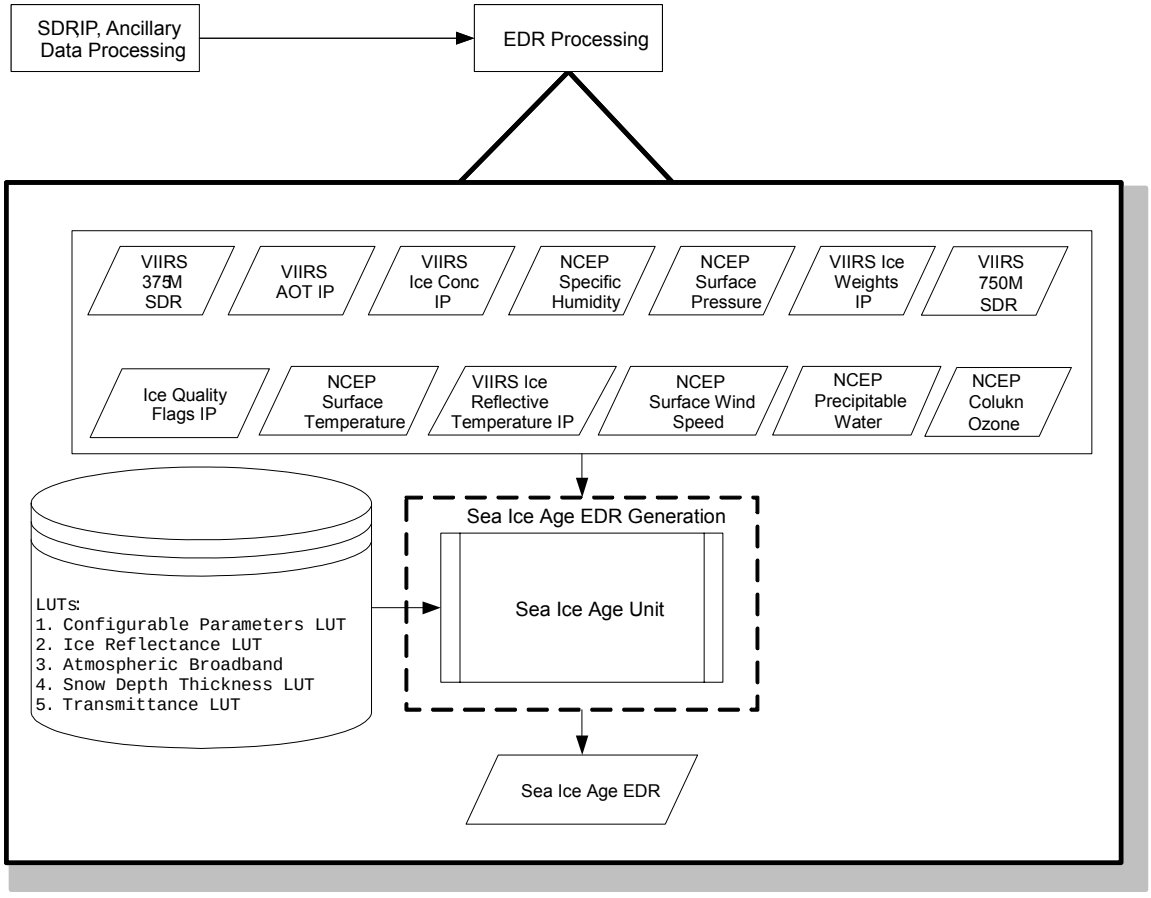


Figure 1. Sea Ice Age EDR Processing Chain

2.1 Sea Ice Characterization EDR Description

The Sea Ice Characterization EDR retrieval algorithm and the theoretical basis are described in detail in the VIIRS Sea Ice Characterization ATBD, 474-00047.

2.1.1 Interfaces

The Sea Ice Characterization algorithm, Ice Age, EDR output is not an input to other algorithms.

2.1.1.1 Inputs

Table 3 describes the Sea Ice Age global attributes. Table 4 describes the main inputs for Sea Ice Age.

Table 3. Global Attributes (Sea Ice Age)

Input	Type	Description/Source	Units/Valid Range
VIIRS_RDR_SCANS	Int32	Number of RDR scans	Unitless/ VIIRS_RDR_SCANS > 0 ***(Currently set to 48)***
M_DETECTORS	Int32	Number of Moderate detectors	Unitless/ M_DETECTORS > 0 ***(Currently set to 16)***
I_DETECTORS	Int32	Number of Image detectors	Unitless/ I_DETECTORS > 0 ***(Currently set to 32)***
M_VIIRS_SDR_ROWS	Int32	Number of moderate Viirs rows	Unitless/ VIIRS_RDR_SCANS * M_DETECTORS
M_VIIRS_SDR_COLS	Int32	Number of moderate Viirs columns	Unitless/ M_VIIRS_SDR_COLS > 0 ***(Currently set to 3200)***
I_VIIRS_SDR_ROWS	Int32	Number of image Viirs rows	Unitless/ VIIRS_RDR_SCANS * I_DETECTORS
I_VIIRS_SDR_COLS	Int32	Number of image Viirs columns	Unitless/ I_VIIRS_SDR_COLS > 0 ***(Currently set to 6400)***
IC_BANDS	Int32	Number of bands, extracted from the Ice Quality Flags IP, now represent band I1, I2, and surface temperature (not I5 brightness temperature values)	Unitless/ IC_BANDS > 0 ***(Currently set to 3 => I1,I2,STIP)***
VIIRS_MODERATE_PIXEL_COUNT	Int32	Number of moderate columns X rows	Unitless/ M_VIIRS_SDR_ROWS * M_VIIRS_SDR_COLS
sea_ice_out_of_range_granule	int*8	Flags whether the granule is entirely outside the sea ice range	Unitless/ 0 = No 1 = Yes
fw_ice_out_of_range_granule	int*8	Flags whether the granule is entirely outside the fresh water ice range	Unitless/ 0 = No 1 = Yes

Table 4. Main Inputs (Sea Ice Age)

Input	Data Type/Size	Description/Source	Units/Valid Range
scanStartTime	Int*64 x VIIRS_RDR_SCANS	Start Time of Scan in IET, from the IMG Geolocation SDR	Microseconds 0 to 1E+38
scanMidTime	Int*64 x VIIRS_RDR_SCANS	Mid Time of Scan in IET, from the IMG Geolocation SDR	Microseconds 0 to 1E+38
Latitude	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Latitude @ Imagery Resolution, from the IMG Geolocation SDR	-90 ≤ Latitude ≤ 90 *FILL_VALUE = -999.9*

Input	Data Type/Size	Description/Source	Units/Valid Range
Longitude	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Longitude @ Imagery Resolution, from the IMG Geolocation SDR	-180 ≤ Longitude ≤ 180 *FILL_VALUE = -999.9*
SolZenAng	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Solar Zenith Angle @ Imagery Resolution, from the IMG Geolocation SDR	-90 ≤ SolZenAng ≤ 90 *FILL_VALUE = 32767* (Integer Scaled)
SenZenAng	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Sensor Zenith Angle @ Imagery Resolution, from the IMG Geolocation SDR	-90 ≤ SenZenAng ≤ 90 *FILL_VALUE = 32767* (Integer Scaled)
SolAziAng	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Solar Azimuth Angle @ Imagery Resolution, from the IMG Geolocation SDR	-180 ≤ SolAziAng ≤ 180 *FILL_VALUE = 32767* (Integer Scaled)
SenAziAng	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Sensor Azimuth Angle @ Imagery Resolution, from the IMG Geolocation SDR	-180 ≤ SenAziAng ≤ 180 *FILL_VALUE = 32767* (Integer Scaled)
Height	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Terrain height of the VIIRS pixels @ Imagery Resolution, from the IMG Geolocation SDR	Meters -400 <= Height <= 10000
Range	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	The distance from the ground position represented by the pixel to the S/C @ Imagery Resolution, from the IMG Geolocation SDR	Meters 800000<=Range <=2000000
scPosition	float*32 x VIIRS_RDR_SCANS	Spacecraft position in orbit at mid-scan time	Meters -7.46E+06 <= Position <= 7.46E+06
scVelocity	float*32 x VIIRS_RDR_SCANS	Spacecraft velocity in orbit at mid-scan time	Meters/second -6600 <= Velocity <= 6600
scAttitude	float*32 x VIIRS_RDR_SCANS	Spacecraft attitude in orbit at mid-scan time	Arcseconds -648000 <= Attitude <= 648000
scanFlags	UInt8* x VIIRS_RDR_SCANS	Scan quality flags, from the IMG Geolocation SDR	Unitless/
PixelQuality	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Pixel quality flags from the IMG Geolocation SDR	Unitless/
Actual Scans	Int*32	Number of scans in the granule, from the IMG Geolocation SDR	Unitless/ Actual Scans > 0
Ice Quality Flags	int8* x IC_BANDS x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Ice Quality Flags from the Ice Quality IP	See Sea Ice Quality IP and STIP OAD (474-00095) IDFCB Volume III (474-00020-03)
Ice Weights	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Output Ice Weights for each Imagery Band (I1, I2, I5- corresponds to Surface Temperature) from the Ice Weights IP	Unitless 0.0 ≤ Ice Weights ≤ 1.0 See Sea Ice Concentration OAD (474-00094); IDFCB Volume III (474-00020-03)
IceTiePoints	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Ice Tie Points computed for the two reflectance bands and the STIP, from the Ice Reflectance and Ice Temperature IP	Unitless IceTiePoints ≥ 0.0 See Sea Ice Concentration OAD (474-00094); IDFCB Volume III (474-00020-03)
IceFraction	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Ice Fraction, from the Ice Concentration IP	Unitless 0.0 ≤ IceFraction ≤ 1.0 See Sea Ice Concentration OAD (474-00094); IDFCB Volume III (474-00020-03)
ConcWgt	float*32 x I_VIIRS_SDR_ROWS x I_VIIRS_SDR_COLS	Ice Concentration Weights, from the Ice Concentration IP	Unitless 0.0 ≤ ConcWgt ≤ 1.0 See Sea Ice Concentration OAD (474-00094); IDFCB Volume III (474-00020-03)

Input	Data Type/Size	Description/Source	Units/Valid Range
AOT	float*32 x M_VIIRS_SDR_ROWS x M_VIIRS_SDR_COLS	Aerosol Optical Thickness (550 nm) @ 750m, from the *AOT IP*	Unitless See IDFCB Volume III (474-00020-03)
O3	float*32 x M_VIIRS_SDR_ROWS x M_VIIRS_SDR_COLS	VIIRS granulated NCEP (or OMPS[1]) Total Column Ozone	Atm-cm See VIIRS Granulate Ancillary OAD (474-00089); DPIS ICD ; EDRIR
PW	float*32 x M_VIIRS_SDR_ROWS x M_VIIRS_SDR_COLS	VIIRS granulated NCEP Total Column Precipitable Water	cm See VIIRS Granulate Ancillary OAD (474-00089); DPIS ICD
Surf_Temp	float*32 x M_VIIRS_SDR_ROWS x M_VIIRS_SDR_COLS	VIIRS granulated NCEP Surface Air Temperature	Kelvin See VIIRS Granulate Ancillary OAD (474-00089); DPIS ICD
SWS	float*32 x M_VIIRS_SDR_ROWS x M_VIIRS_SDR_COLS	VIIRS granulated NCEP Surface Wind Speed	m/s See VIIRS Granulate Ancillary OAD (474-00089); DPIS ICD
Surf_Pres	float*32 x M_VIIRS_SDR_ROWS x M_VIIRS_SDR_COLS	VIIRS granulated NCEP Surface Pressure	hectoPascals (hPa) See VIIRS Granulate Ancillary OAD (474-00089); DPIS ICD
Specific_hum	float*32 x M_VIIRS_SDR_ROWS x M_VIIRS_SDR_COLS	VIIRS granulated NCEP Surface Air Specific Humidity	kg/kg See VIIRS Granulate Ancillary OAD (474-00089); DPIS ICD
Sea Ice Age Ephemeral PC	See Table 5	Algorithm tunable parameter coefficient and thresholds table. Formerly known as the Ice Age LUT. See Table 5	See Table 5
Ice Reflectance LUT	See Table 6	See Table 6	See Table 6
SnowDepth /Ice Thickness LUT	See Table 7	See Table 7	See Table 7
Broadband Transmittance LUT	See Table 8	See Table 8	See Table 8

The Sea Ice Age unit requires several input data files that are generated offline. LUTs are required for the modeled ice TOA reflectance, atmospheric transmittance, broad band spectral albedo, narrow band spectral albedo, and Climatology Snow Depth-Ice Thickness (data base). Contents of the modeled ice Top of Atmosphere (TOA) reflectance LUT are described in Table 6. The TOA reflectance LUT is required to be rerun only if errors are detected in the table values or to improve accuracy of the reflectances. The TOA reflectance LUT delivered has been generated using a LUT generation tool. Contents of the broadband albedo and spectral albedo LUTs are also defined in Table 6. Currently, the broadband albedo LUT is populated with values only for the VIIRS I1 band.

The atmospheric transmittance LUT and Climatology Snow Depth-Ice-Thickness LUTs have been generated by ITSS according to the description provided in the VIIRS Ice Age LUT Generation document, DAL No. D277c, ITSS Document number ME60822-VIR-022. Table 7 details the Snow Depth/Ice Thickness LUT information. It should be noted that multi-dimensional arrays defined in Tables 6, 7 and 8 have array indices that are in reverse order from that of the corresponding definitions in the Common Data Format Control Book (474-00001). This is due to the array storage order differences between the FORTRAN90 based Sea

Ice Age source code and the C++ based I/O modules that read LUTs into memory. The italicized text in the tables indicate the corresponding CDFCB-X parameter names. Array extent limits such as n_sza are implemented as program constants.

Table 5. VIIRS Sealce Age Ephemeral PC

Input	Data Type/Size	Description/Source	Units/Valid Range
h00	float*32	Young/First Year ice thickness threshold (cm)	cm >0.0 **(Currently set to 30.0)**
min_conc	float*32	Minimum ice concentration for ice age processing	Unitless 0.0 ≤ min_conc ≤ 1.0 ***(Currently set to 0.10)***
min_twgt	float*32	Minimum temperature weight for processing	Unitless 0.0 ≤ min_twgt ≤ 1.0 ***(Currently set to 0.05)***
max_thick_dev	float*32	Maximum allowed difference between I1 and I2 thickness	cm > 0.0 ***(Currently set to 5.0)***
q0	float*32	Solar irradiance (W/m^2)	W/m^2 >0.0 **(Currently set to 1368)**
atmo_const	float*32 x (2 constants)	Atmospheric constants (empirical) used to compute long wave heat flux as a function of humidity and temperature	Unitless >0.0 ***(Currently set to 0.65; 0.055)***
ct	float*32	Coefficient of turbulent heat exchange (sensible heat)	Unitless >0.0 **(Currently set to 0.0017)**
ce	float*32	Coefficient of turbulent heat exchange (latent heat)	Unitless >0.0 **(Currently set to 0.0017**
specific_heat	float*32	Specific heat (J/kg/K)	J/kg/K >0.0 **(Currently set to 1005)**
latent_heat	float*32	Latent heat of evaporation (J/kg)	J/kg/K >0.0 **(Currently set to 2.456E6)**
latent_heat_fus	float*32	Latent heat of fusion (J/kg)	J/kg >0.0 **(Currently set to 3.E5)**
sb_const	float*32	Stephan-Boltzmann constant (W/m^2/K^4)	W/m^2/K^4 5.6704E-8
emiss	float*32	Surface emissivity	Unitless 0 <= emiss <= 1.0 **(Currently set to 1.0)**
ice_conduct	float*32	Ice conductivity (W/m/K)	W/m/K >0.0 **(Currently set to 2.093)**
snow_conduct	float*32	Snow conductivity (W/m/K)	W/m/K >0.0 **(Currently set to 0.279)**
t_freeze	float*32	Freezing point of sea water (K)	deg. K 271.4
sza_thre_r	float*32	Red/Yellow SZA threshold for energy balance	degrees 0< sza_thre_r < 90 **(Currently set to 80.0)**
sza_thre_y	float*32	Yellow/Green SZA threshold (Degrees) for energy balance	degrees 0< sza_thre_r < 90 **(Currently set to 85.0)**
trans_thre_r	float*32	Red/Yellow SZA threshold (Degrees) for transmittance	degrees 0< sza_thre_r < 90 **(Currently set to 76.0)**

Input	Data Type/Size	Description/Source	Units/Valid Range
arctic_haze_aot _thresh	float*32	Arctic haze aerosol optical thickness threshold	Unitless (**Currently set to 0.1)**
iceAirDeltaT	float*32	Temperature difference threshold for Ice-Surface Air Temperature	Degrees C (**Currently set to -999.0**) Note: Setting the threshold to -999.0 effectively disables a branch to classify ice age First Year using a temperature difference threshold. This will allow the algorithm to fully utilize the energy balance equation.

Table 6. Sea Ice Reflectance LUT

Input	Data Type/Size	Description/Source	Units/Valid Range
thick *(iceThick)*	float*32	Ice Thickness Bin Values	cm thick = [5,10,20,30,40]
depth *(snowThick)*	float*32x n_depth	Snow Depth Bin Values	cm depth = [0.0, 0.25, 0.5, 1.0, 2.0, 3.0]
aot	float*32 x n_aot	AOT Bin Values	Unitless aot = [0.0, 0.2366, 0.5472,1.0]
snowGrainSize	float*32	Snow Grain Size	(not used by code)
snowDensity	float*32	Snow Density	(not used by code)
iceGrainSize	float*32	Ice Grain Size	(not used by code)
iceDensity	float*32	Ice Density	(not used by code)
normIceDensity	float*32	Normal Ice Density	(not used by code)
brineGrainSize	float*32	Brine Grain Size	(not used by code)
brineDensity	float*32	Brine Grain Density	(not used by code)
subRefl	float*32	Substrate Reflectance	(not used by code)
sza_bins *(sunZen)*	float*32x n_sza	Solar Zenith Angle Bin Values Values are cosines equally spaced in cos(sza) corresponding to 0:85 degrees. Size of dimensions n_sza =11	Unitless -1.0 <= sza_bins <= 1.0
vza_bins *(viewZen)*	float*32x n_vza	View Zenith Angle Bin Values Values are cosines equally spaced in cos(vza) corresponding to 0:70 degrees Size of dimensions n_vza =7	Unitless -1.0 <= vza_bins <= 1.0
relaz_bins *(relAzm)*	float*32x n_relaz	Relative Azimuth Angle Bin Values	Degrees 0 <= relaz_bins <= 180. relaz_bins = [0, 30, 60, 90,120,150,180]
snowType		Snow Type Code	(not used by code)
wvot	float*32x n_wvot	Precipitable Water Bin Values	gm/cm^2 wvot = [0.0, 0.4323, 2.0]
oot *(totClmnOzn)*	float*32x n_oot	Ozone Column Bin Values	cm-atm oot = [0.0, 0.1967, 0.5]
aeroModel	float*32x n_am	Aerosol model index n_am= 2	Unitless aeroModel values: 1 = continental, 2 = maritime
aot *(aotBin)*	float*32x n_aot	AOT Bin Values	Unitless aot = [0.0, 0.2366, 0.5472,1.0]

Input	Data Type/Size	Description/Source	Units/Valid Range
toa_reflectance *(iceRefl)*	float*32x n_am x n_bands x n_thick x n_depth x n_aot x n_wvot x n_oot x n_sza x n_vza x n_relaz	TOA Reflectances From 6s RTM	Unitless >0.0
ice_albedo *(sphrAlbedo)*	float*32x n_thick x n_depth	Broadband From 6s radiative transfer model (RTM)	Unitless 0.0 <= ice_albedo <= 1.0
albedo_spectral *(narrowSphrAlbedo)*	float*32x n_nthick x ndepth x n_bands	Spectral Albedo from 6s RTM	Unitless 0.0 <= spectral_albedo <= 1.0

Table 7. Snow Depth/Ice Thickness LUT

Input	Data Type/Size	Description/Source	Units/Valid Range
nlat_bins	float*32 x n_nlat	Northern Hemisphere latitudes at 2.5 deg increments. n_nlats = 23	Degrees -90 ≤ nlat_bins ≤ 90 nlat_bins = [35., 37.5, 40…85., 87.5, 90.]
slat_bins	float*32 x n_slat	Southern Hemisphere latitudes at 2.5 deg increments. n_slat = 17	Degrees -90 ≤ slat_bins ≤ 90 slat_bins = [-90., -87.5, -85…-55., -52.5, -50.]
lon_bins	float*32 x n_lon	Longitudes at 2.5 deg increments n_lon = 145	Degrees -180 ≤ lon_bins ≤ 180 lon_bins = [0, 2.5, 5.0…355, 357.5, 360.]
date_bins	float*32 x n_date	Day of year for the middle of each month. n_date = 13	Day number >0.0 date_bins = [15.5, 46., 76.5…320.5, 351., 381.5]
ice_bins	float*32 x n_ice	Ice thickness n_ice = 5	cm >0.0 ice_bins = [5.0,10.0,20.0,30.0,40.0]
sdc_n	float*32 x n_ice x n_nlat x n_lon x n_date	Snow depth from climatology model for Northern Hemisphere	cm >0.0
sdc_s	float*32 x n_ice x n_slat x n_lon x n_date	Snow depth from climatology model for Northern Hemisphere	cm > 0.0

Table 8. Atmospheric Broadband Transmittance LUT

Input	Data Type/Size	Description/Source	Units/Valid Range
nsza	int*8	Number of Solar Zenith Angle Bins	Unitless nsza > 0 ***(Currently set to 11)***
aotbin	float*32 x naot	AOT Boundary Values naot = 6	Unitless aotbin = [0.0,0.01,0.1,0.2,0.6,1.0]

Input	Data Type/Size	Description/Source	Units/Valid Range
szabin	float*32 x nsza	Solar Zenith Angle Boundary Values. nsza = 11	Degrees/ -90 ≤ szabin ≤ 90, szabin = [48.0,52.0,56.0,60.0,64.0, 68.0,72.0,76.0,80.0,84.0, 88.0]
bbtranslut	float*32 x naot x nsza	Atmospheric Broadband Transmittance values, extracted from 6s RTM. In the "Units/Range" column, each set of "naot" values are represented by each pair of lines of data (three numbers in each line). The 11 pairs of lines represent "nsza".	Unitless/ bbtranslut = [0.913416,0.913416,0.883998, 0.852080,0.734581,0.634458;**(1)** 0.906948,0.906948,0.874509, 0.839625,0.714074,0.610474;**(2)** 0.898996,0.898996,0.862829, 0.824371,0.689830,0.583017;**(3)** 0.889093,0.889093,0.848281, 0.805525,0.661177,0.551780;**(4)** 0.876536,0.876536,0.829884, 0.781987,0.627344,0.516514;**(5)** 0.860251,0.860251,0.806199, 0.752198,0.587501,0.477124;**(6)** 0.838493,0.838493,0.774994, 0.713922,0.540873,0.433793;**(7)** 0.808251,0.808251,0.732683, 0.663920,0.487026,0.387159;**(8)** 0.763895,0.763895,0.673236, 0.597567,0.426465,0.338517;**(9)** 0.705639,0.705639,0.596868, 0.514757,0.359083,0.287918;**(10)** 0.633377,0.633377,0.503474, 0.415542,0.284933,0.235338]**(11)**

The Sea Ice Age EDR input file specifications are shown in Table 9.

Table 9. Sea Ice Age EDR Input File Specifications

Input	Object/Format	Source
VIIRS Ice Quality Flags IP	Binary	VIIRS Ice Quality/STIP Module
VIIRS Image Resolution TC GEO	Binary	VIIRS SDR GEO Module
VIIRS Ice Reflectance and Temperature IPs	Binary	VIIRS Ice Concentration IP Module
VIIRS Ice Concentration IP	Binary	VIIRS Ice Concentration IP Module
VIIRS Ice Weights IP	Binary	VIIRS Ice Quality/STIP Module
VIIRS AOT IP (550 nm AOT)	Binary	VIIRS AOT IP Module
VIIRS granulated NCEP Ozone Total Column	Binary	Ancillary Data Processing
VIIRS granulated NCEP Precipitable Water	Binary	Ancillary Data Processing
VIIRS granulated NCEP Surface Specific Humidity	Binary	Ancillary Data Processing
VIIRS granulated NCEP Surface Air Temperature	Binary	Ancillary Data Processing
VIIRS granulated NCEP Surface Pressure	Binary	Ancillary Data Processing
VIIRS granulated NCEP Surface Wind Speed	Binary	Ancillary Data Processing
VIIRS Sea Ice Age Ephemeral PC	Binary	Lookup Table Generation

Input	Object/Format	Source
Sea Ice Reflectance LUT	Binary	Lookup Table Generation
Snow Depth/Ice Thickness LUT	Binary	Lookup Table Generation
Broadband Transmittance LUT	Binary	Lookup Table Generation

It should be noted in Table 5 (VIIRS Sea Ice Age Ephemeral PC) that the minimum temperature band weight tunable parameter “min_twgt” has been changed to 0.05, from that of 0.25 as originally defined in the detailed design document. During unit testing it was determined that the value of min_twgt must be less than that of the “band_wgts” of 0.1. If min_twgt is greater than band_wgts, all pixels based on temperature are filtered and thus all night pixel retrievals for ice age fail.

2.1.1.2 Outputs

The Sea Ice Age Unit outputs the Sea Ice Age Characterization EDR. Table 10 shows the Sea Ice Age EDR output with horizontal cell resolution. The EDR is reported at aggregated resolution based on the value of the constant “hcsize”.

The CELL_SIZE parameter is the aggregated pixel resolution. The aggregated cell size is defined as:

$$CELL\_SIZE = hcsize.$$

The setting for hcsize for 2x2 aggregation to be performed is hcsize=2.

Table 10. Sea Ice Age EDR Output Description

Output	Data Type/Size	Description	Units/Valid Range
IceAgeWeight	float*32 x HCROWS x HCCOLS	Ice Age Weighting Factors for I1, I2, STIP and weighted cell total	Unitless 0.0 ≤ IceAgeWeight ≤1.0
IceAgeQuality	uint*8 x 3 x HCROWS x HCCOLS	See Table 11, Sea Ice Age Pixel-Level Quality Flags	See Table 11, Sea Ice Age Pixel-Level Quality Flags
IceAge	int*8 x HCROWS x HCCOLS	Various classifications of ice for I1, I2, STIP, and weighted cell total	Unitless/ 0 = Unclassified Fill 1 = Ice Free 2 = New or Young Ice 3 = spare 4 = All other Ices 5-9 = spare 10 = Land Fill 11 = spare 12 = Cloud Fill

Table 11. Sea Ice Age Pixel-Level Quality Flags

BYTE	Bit	Flag Description Key	Result
0	0-1	Ice Age Overall Quality	00 = GREEN (good) 01 = YELLOW (degraded) 10 = RED (bad) 11 = No Retrieval (Fill)
	2	Input Data Quality	0 = Good 1 = Bad Flag set to bad indicates bad input SDR reflectance (I1, I2) or thermal (I5) band in the cell for day. For night, it is set to bad for bad thermal (I5) SDR detected in the cell.
	3-4	Cloud Confidence	00 = confidently clear 01 = probably clear 10 = probably cloudy 11 = confidently cloudy
	5	Thermal Contrast Degradation	0 = No, 1 = Yes (1.5K<Thermal Contrast<2.2K) Open Water Temp– Ice Temp
	6	Sea ice valid region	0 = Within latitude range (pixel within valid processing region) 1 = Out of latitude range (pixel is not within a valid processing region) Valid latitude ranges are lat > 36 deg N. or lat > 50 deg S.
	7	Aerosol Optical Thickness Exclusion	0 = No 1 = Yes (550nm AOT exclusion condition slant path aot > 1.0)
1	0	Thermal Contrast Exclusion	0 = No 1 = Yes (Thermal Contrast <1.5K)
	1	No Ice in Cell	0 = Ice in cell (ice present if conc > min_conc) 1 = No Ice in cell detected (exclusion set for no ice)
	2	Ocean/No ocean exclusion	0 = Ocean 1 = No Ocean
	3-4	Algorithm Branching	Unclassed 00 RT : Reflectance Threshold Method 01 THB : Thermal Heat Balance Method 10
	5	Heavy Aerosol	0 = No heavy aerosol 1 = Heavy aerosol
	6	Spare	Spare
	7	Thin Cirrus (based on VCM thin cirrus flag)	0 = No 1 = Yes (thin cirrus detected)
2	0	Shadow Detected	0 = No cloud shadow 1 = Cloud shadow detected
	1-2	Cloud Phase	clear; (00) water; (01) ice; (10) mixed (11)
	3	Fire Detected	0 =No 1 = Yes
	4	Sun Glint	0 =No 1 = Yes
	5	Coast Line	0 =No 1 = Yes (coast line within cell)
	6	Spare	Spare
	7	Spare	Spare

The Sea Ice Age EDR attributes are shown in Table 12.

Table 12. Sea Ice Age EDR Attributes/Metadata

Attribute	Data Type/Size	Description

Attribute	Data Type/Size	Description
sea_ice_out_of_range_granule	int*8	Flags whether the granule is entirely outside the sea ice range (1=YES, 0 = NO)

2.1.2 Algorithm Processing

2.1.2.1 Main Module – IA_main:

IA_main is the main driver for Sea Ice Age Unit. The processing approach developed for the Sea Ice Characterization algorithm, Ice Age, is based on per pixel processing of imagery resolution pixels in a granule. The output Sea Ice Age EDR is reported at an aggregated (2x2) horizontal cell resolution. This algorithm only processes if the granule is within the specified range of latitude.

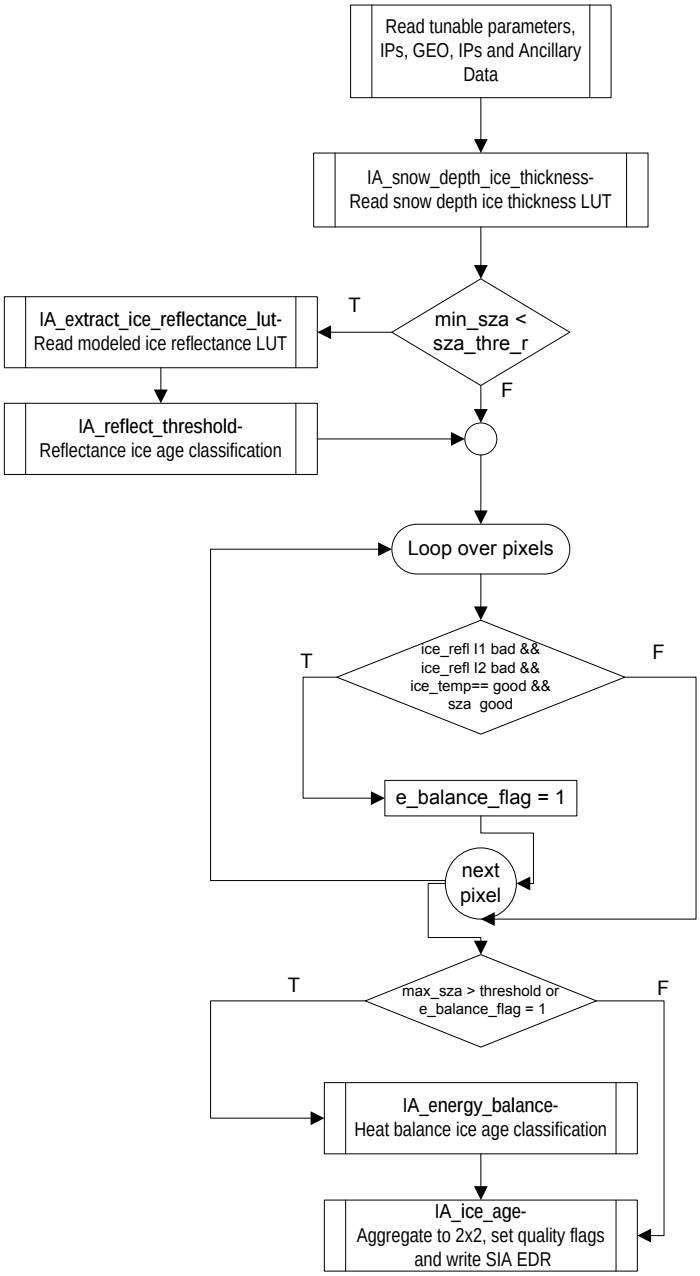


Figure 2. IA_main (main module) logic flow

2.1.2.2 IA_snow_depth_ice_thickness:

IA_snow_depth_ice_thickness extracts the snow-depth-to-ice-thickness ratios from Snow Depth / Ice Thickness LUT.

2.1.2.3 IA_extract_ice_reflectance_lut:

IA_extract_ice_reflectance_lut extracts and interpolates the ice reflectance LUT.

2.1.2.4 IA_reflect_threshold:

IA_reflect_threshold performs ice age classification at VIIRS imagery resolution based on the VIIRS imagery resolution ice reflectance data and the modeled sea ice reflectance LUT.

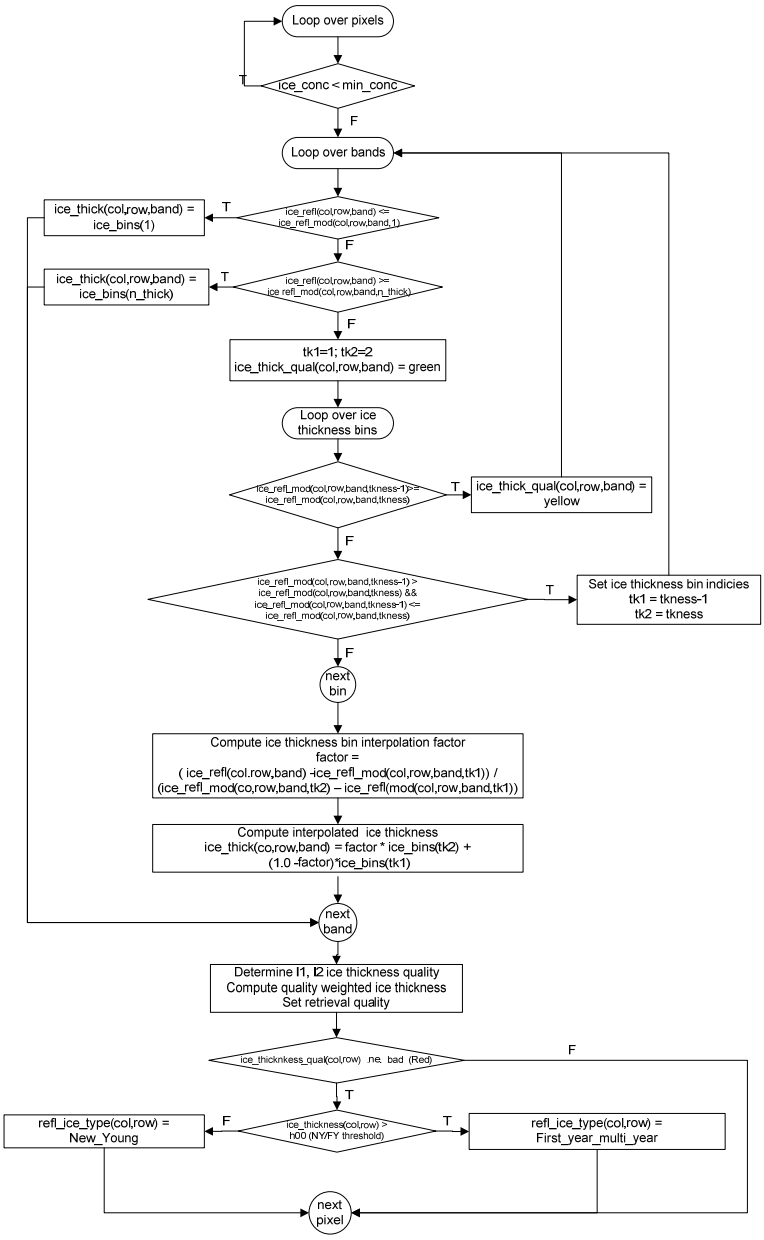


Figure 3. IA_reflect_threshold logic flow

2.1.2.5 IA_energy_balance:

IA_energy_balance performs ice age classification at VIIRS imagery resolution based on an energy balance model using ice temperature data. Note that the operational implementation of the energy balance is based on a surface air specific humidity input instead of surface air relative humidity as described in the VIIRS Sea Ice Characterization ATBD, 474-00047. Since the vapor pressure can be computed directly from the specific humidity, the relative humidity

based computations for vapor pressure and dew point temperature defined in the ATBD as equations 3.3.4.1.4 and 3.3.4.1.5 respectively have been replaced by following equivalent equation for computation of vapor pressure in the operational implementation:

```
vp = specific_hum(col_m,row_m)*surf_press(col_m,row_m)/( 0.62197 +
     0.37803*specific_hum(col_m,row_m)
```

Also, the computation of surface air specific humidity defined as equation 3.3.4.1.9 in the ATBD is no longer required since the operational implementation reads surface air specific humidity as input.

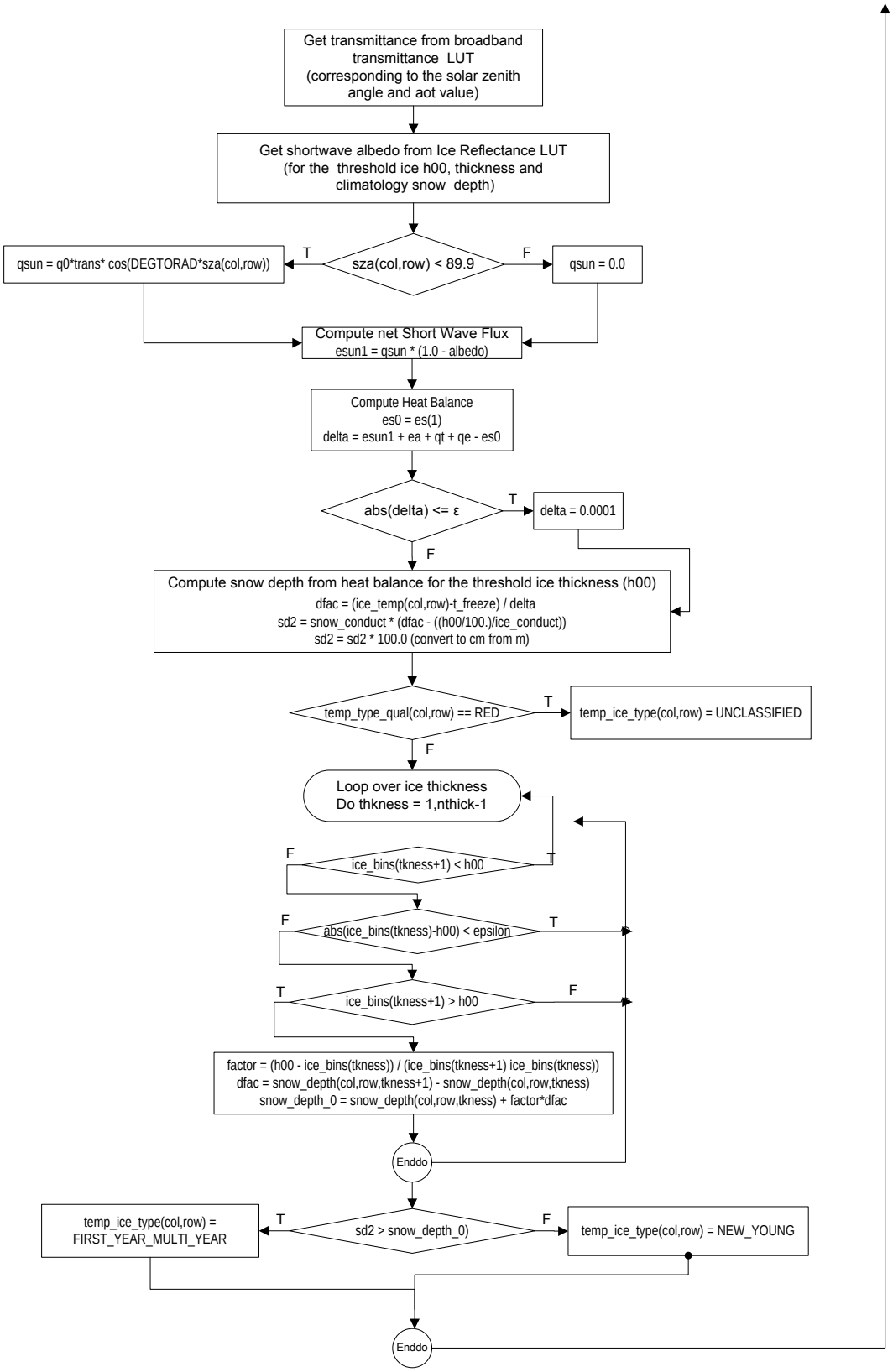
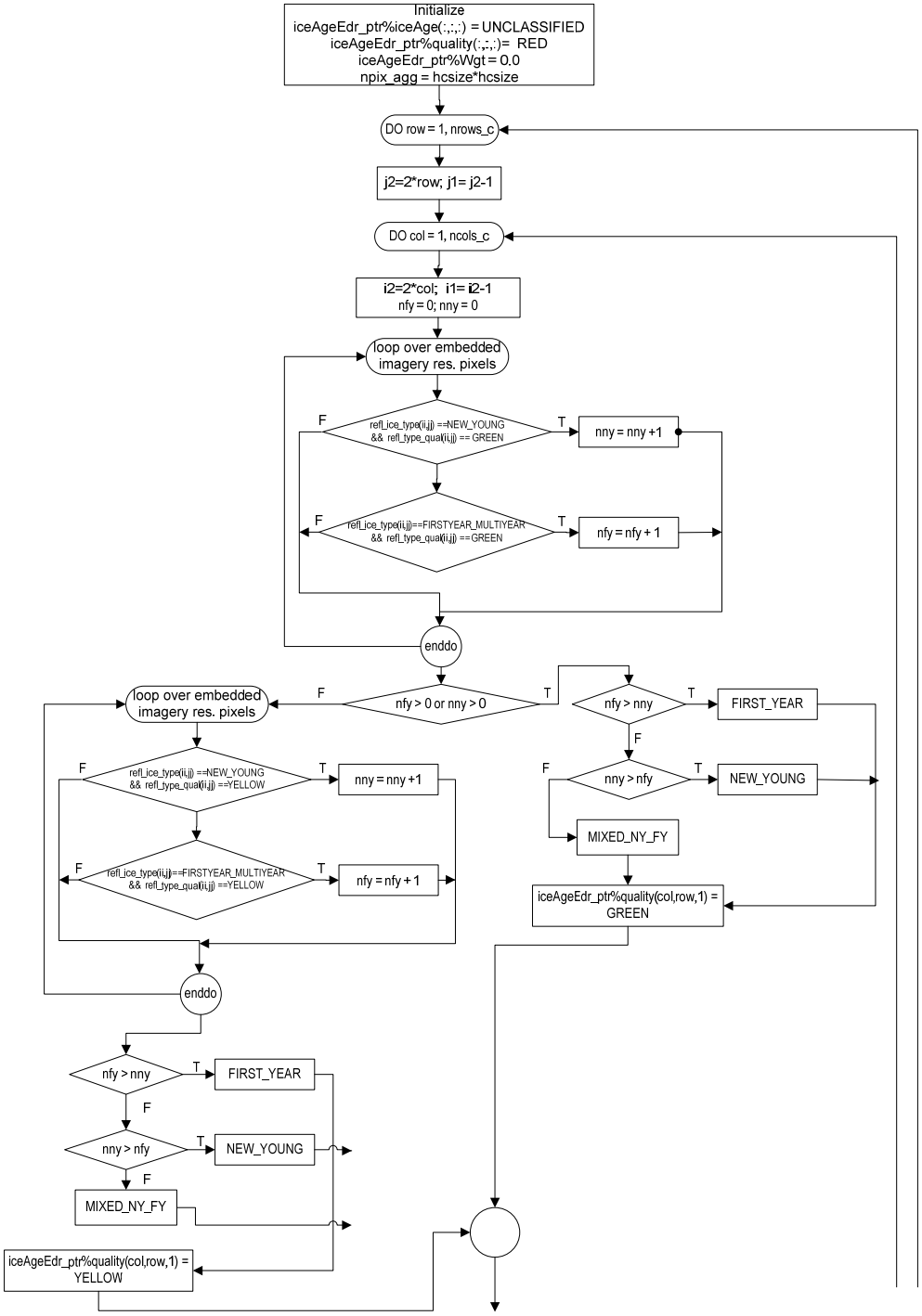
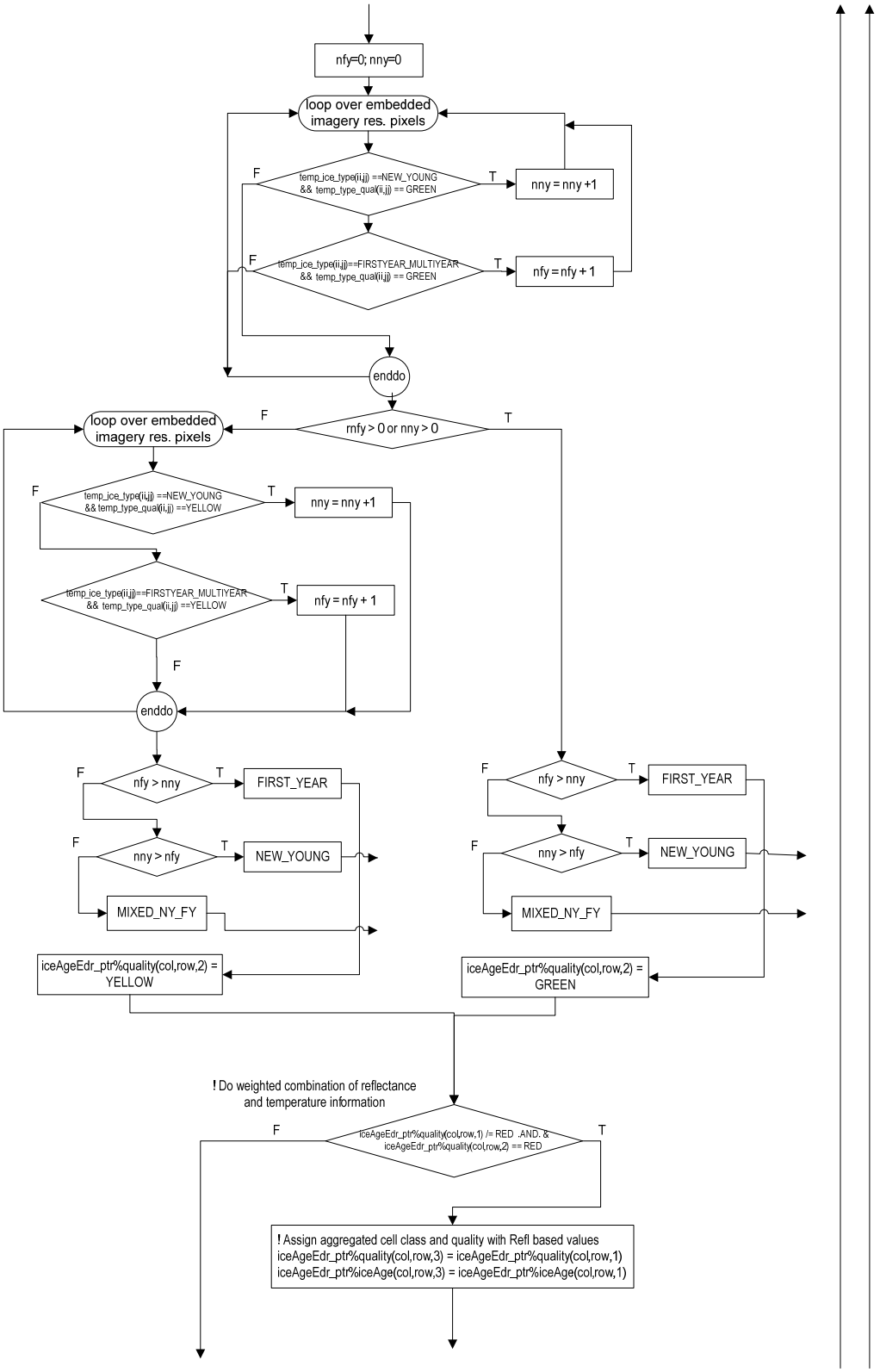


Figure 4. IA_energy_balance logic flow

2.1.2.6 IA_ice_age:

IA_ice_age determines ice age aggregated to VIIRS moderate resolution.




nfy=0; nny=0
loop over embedded imagery res. pixels
temp_ice_type(ii,jj) ==NEW_YOUNG && temp_type_qua(ii,jj) == GREEN
nny = nny +1
temp_ice_type(ii,jj)==FIRSTYEAR_MULTIYEAR && temp_type_qua(ii,jj) == GREEN
nfy = nfy + 1
enddo
rnfy > 0 or nny > 0
loop over embedded imagery res. pixels
temp_ice_type(ii,jj) ==NEW_YOUNG && temp_type_qua(ii,jj) ==YELLOW
nny = nny +1
temp_ice_type(ii,jj)==FIRSTYEAR_MULTIYEAR && temp_type_qua(ii,jj) ==YELLOW
nfy = nfy + 1
enddo
nfy > nny
FIRST_YEAR
nny > nfy
NEW_YOUNG
MIXED_NY_FY
iceAgeEdr_ptr%quality(col,row,2) = YELLOW
nfy > nny
FIRST_YEAR
nny > nfy
NEW_YOUNG
MIXED_NY_FY
iceAgeEdr_ptr%quality(col,row,2) = GREEN
! Do weighted combination of reflectance and temperature information
iceAgeEdr_ptr%quality(col,row,1) /= RED .AND. & iceAgeEdr_ptr%quality(col,row,2) == RED
! Assign aggregated cell class and quality with Refl based values
iceAgeEdr_ptr%quality(col,row,3) = iceAgeEdr_ptr%quality(col,row,1)
iceAgeEdr_ptr%iceAge(col,row,3) = iceAgeEdr_ptr%iceAge(col,row,1)
F
T

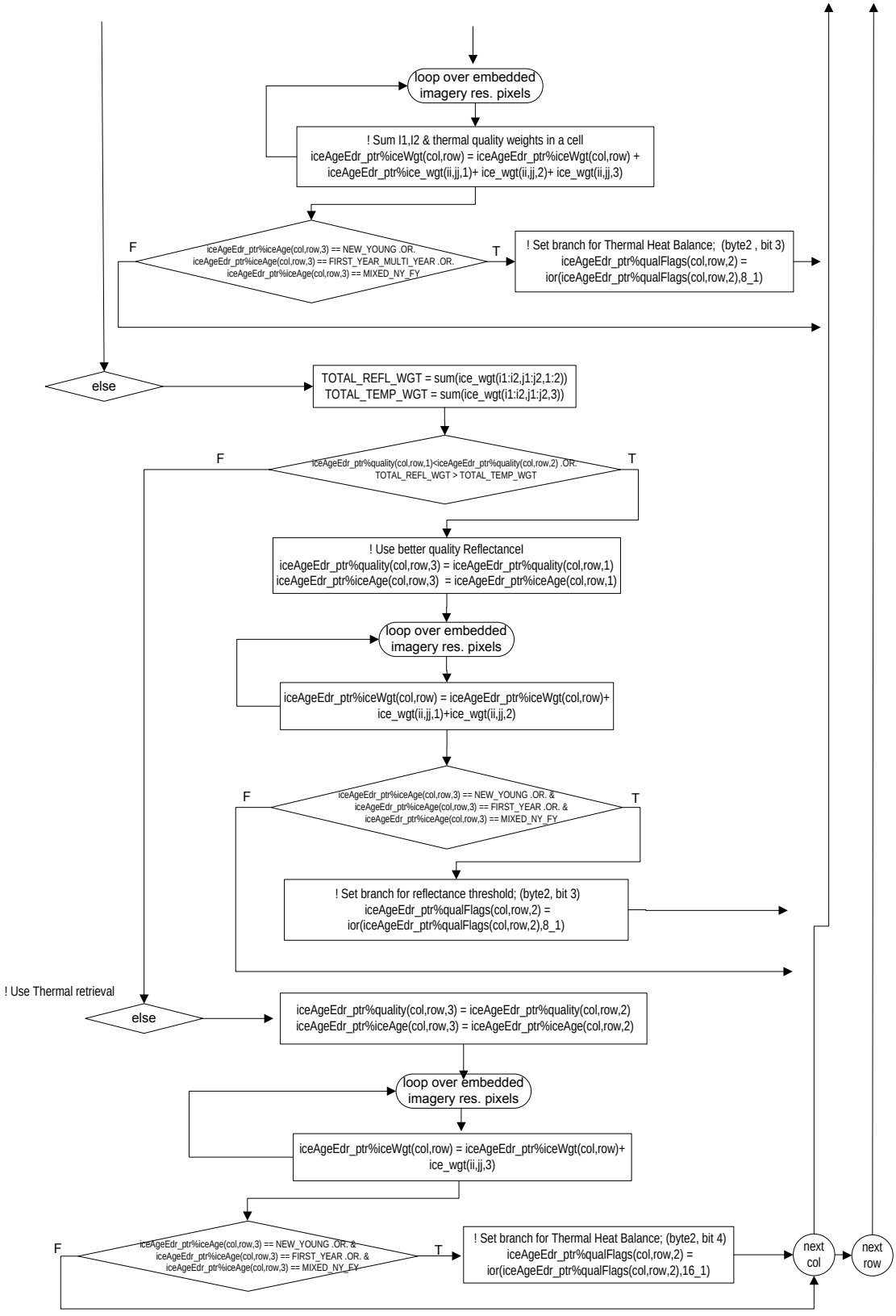
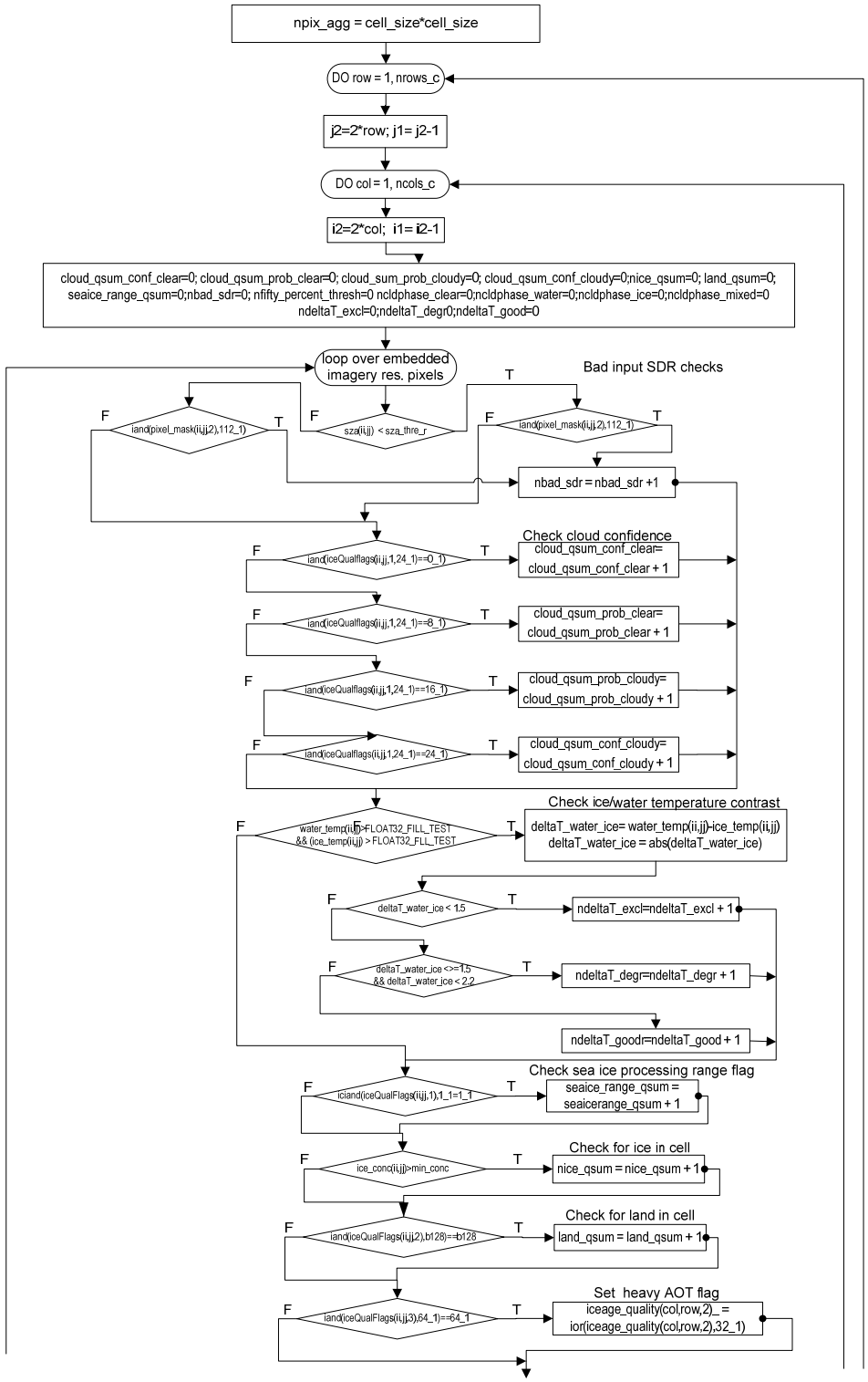
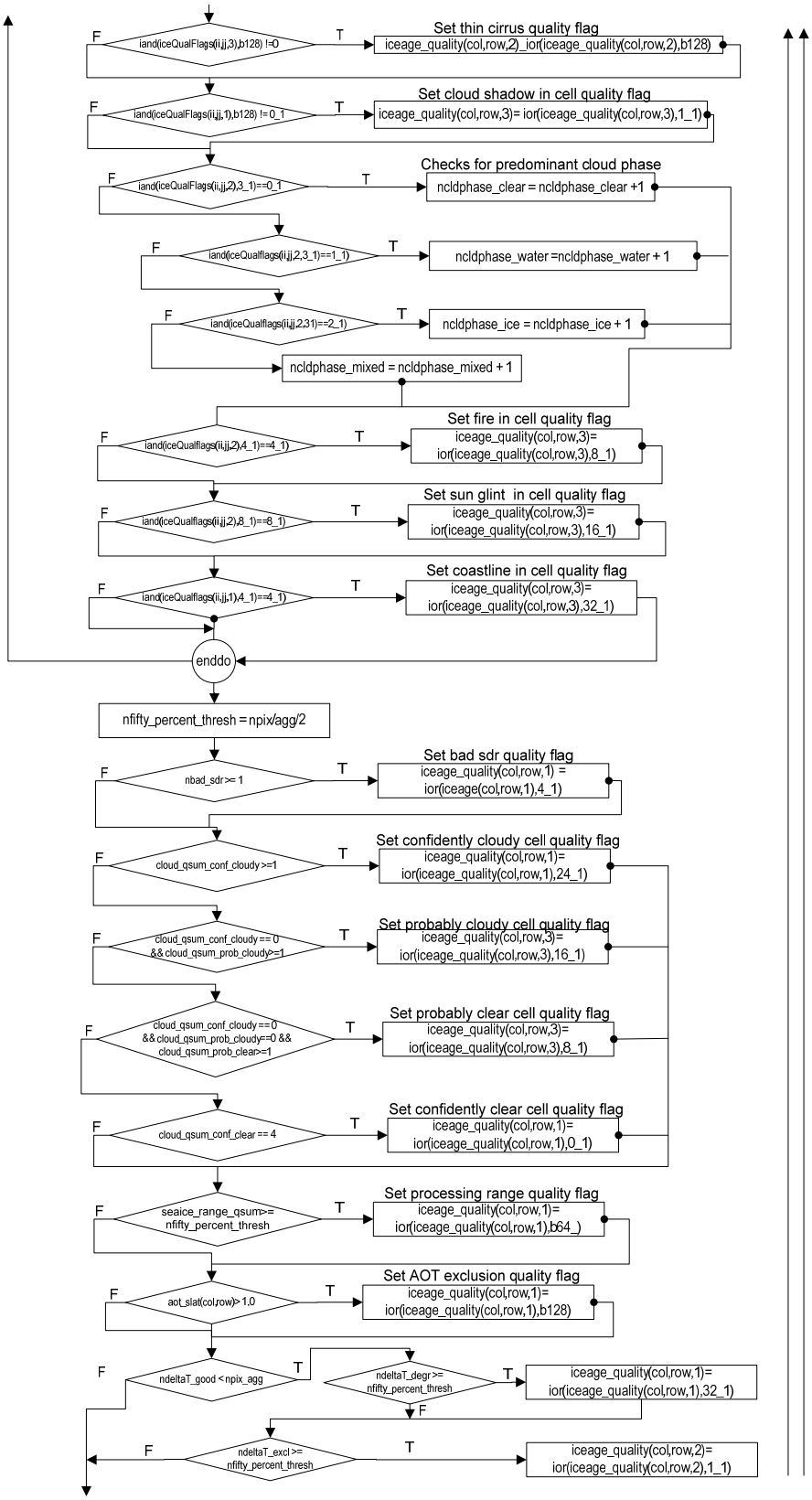


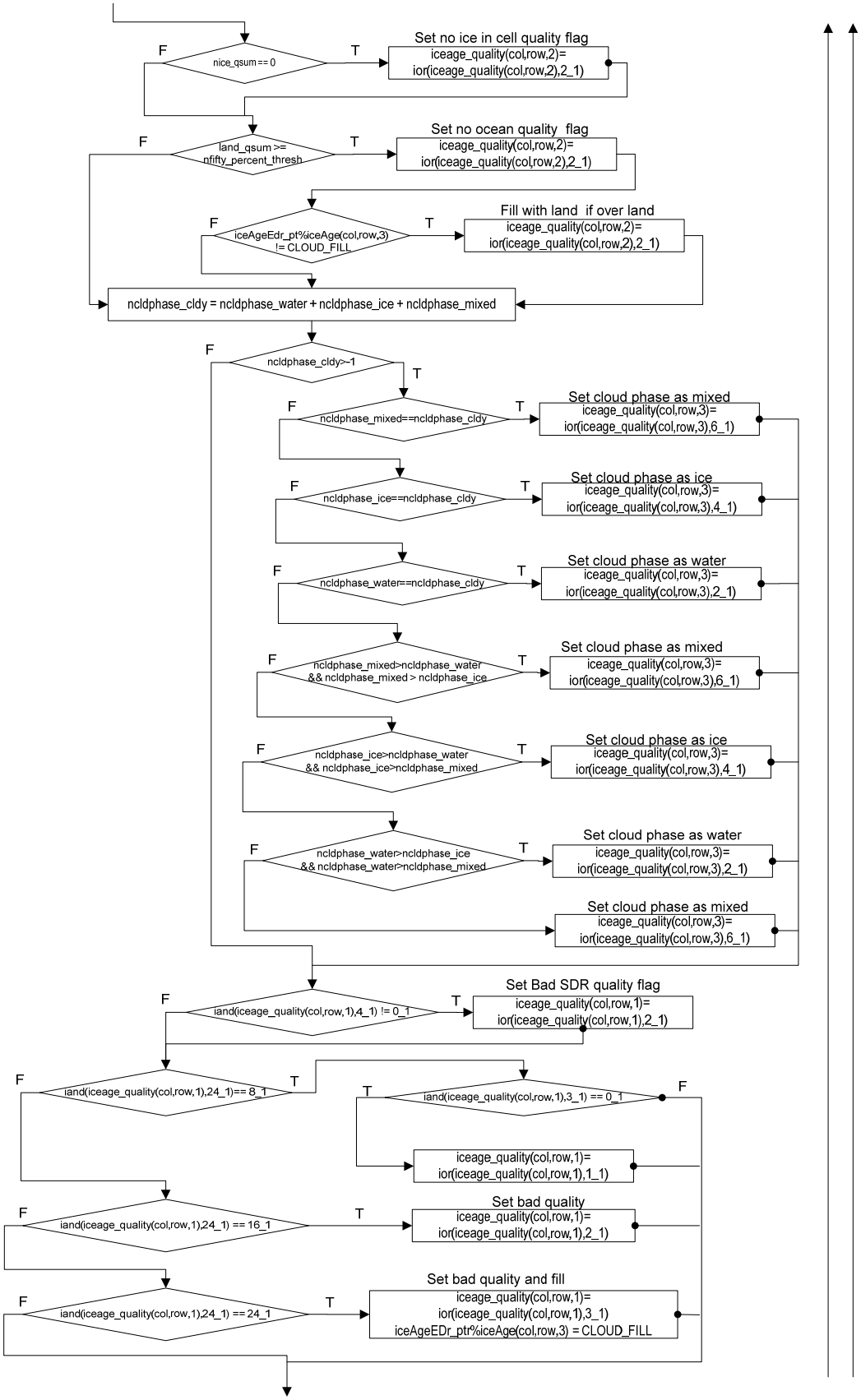
Figure 5. IA_ice_age logic flow

2.1.2.7 IA_set_qflags:

IA_set_qflags sets the pixel level quality flags.







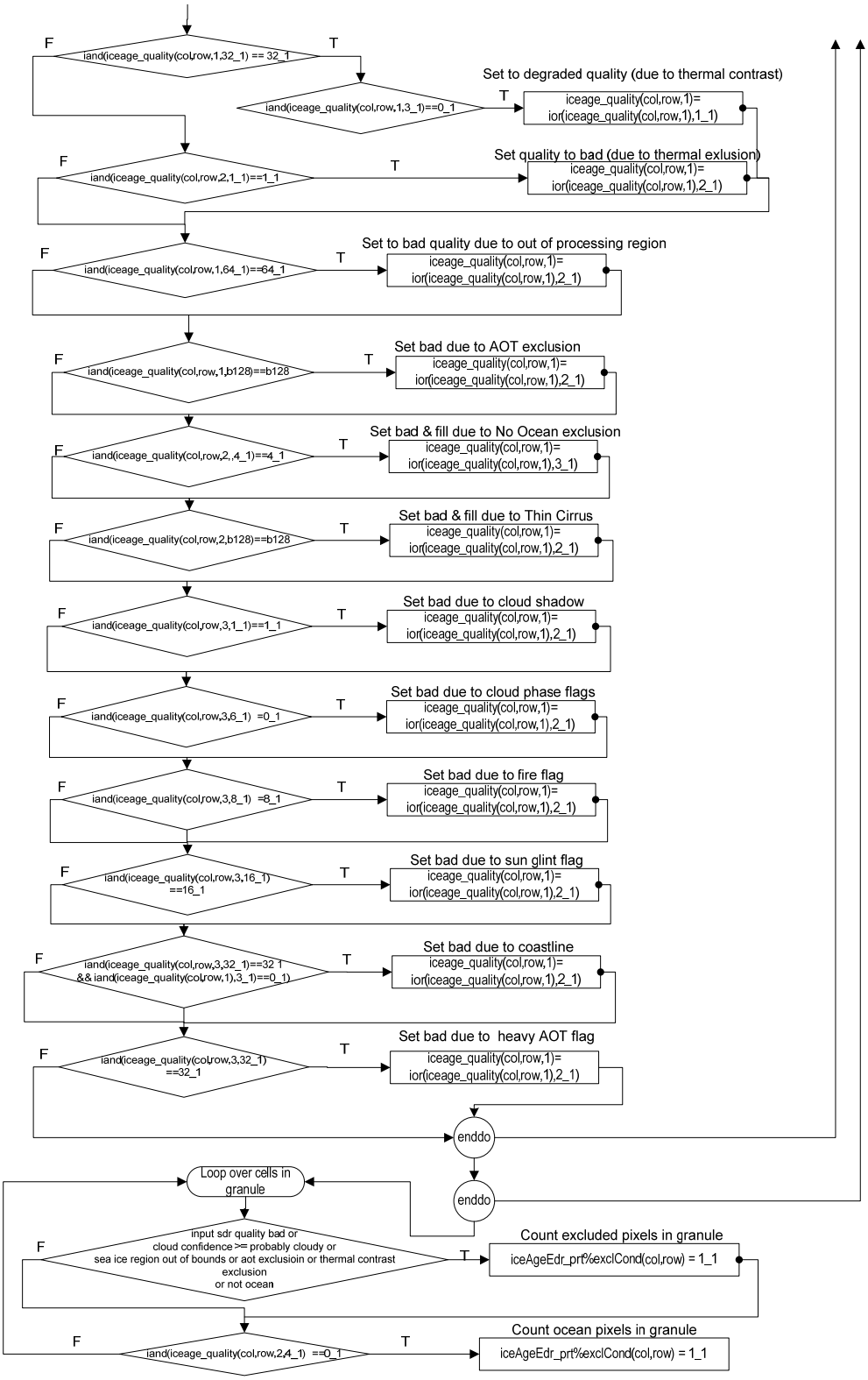


Figure 6. IA_set_qflags logic flow

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 Age:

1. A primary input denoted in the algorithm configuration guide cannot be successfully retrieved but an alternate input can be retrieved.
2. An input that is retrieved for an algorithm has the N_Graceful_Degradation metadata field set (propagation).

Table 13 details the instances of these cases. Note that the shaded cells indicate that the graceful degradation was done upstream at product production.

Table 13. Graceful Degradation

Input Data Description	Baseline Data Source	Primary Backup Data Source	Secondary Backup Data Source	Tertiary Backup Data Source	Graceful Degradation Done Upstream
Sea Surface Wind Speed and Direction	VIIRS_GD_09.4.2 NCEP	VIIRS_GD_09.4.2 NCEP (Extended Forecast)	N/A	N/A	Yes
Adjusted Surface Pressure	VIIRS_GD_28.4.1 NCEP	VIIRS_GD_28.4.1 NCEP (Extended Forecast)	N/A	N/A	Yes
Surface Air Temperature	VIIRS_GD_09.4.10 NCEP	VIIRS_GD_09.4.10 NCEP (Extended Forecast)	N/A	N/A	Yes
Specific Humidity at Surface	VIIRS_GD_09.4.12 NCEP	VIIRS_GD_09.4.12 NCEP (Extended Forecast)	N/A	N/A	Yes
Aerosol Optical Thickness	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
Total Column Precipitable Water	VIIRS_GD_09.4.11 NCEP	VIIRS_GD_09.4.11 NCEP (Extended Forecast)	N/A	N/A	Yes
Total Column Ozone	VIIRS_GD_09.4.1 NCEP	VIIRS_GD_09.4.1 NCEP (Extended Forecast)	N/A	N/A	Yes

2.1.3.2 Graceful Degradation Processing

None.

2.1.3.3 Graceful Degradation Outputs

None.

2.1.4 Exception Handling

The current implementation of the software does not allow the program to continue execution if an invalid value of surface pressure or other input IP value is encountered.

2.1.5 Data Quality Monitoring

It was determined that a Data Quality Notification (DQN) was needed for the Ice Age output latitude, longitude, weight, and age. The DQN test looks for any output pixel which is set to NA, MISS, or ERR. If the test is true, a product is populated into DMS that contains what check was done and how many pixels were within this range. For a detailed description of DQN, please refer to the Processing SI Common IO Design, DD60822-IDP-011, Section 6.3.

2.1.6 Computational Precision Requirements

Single precision 32-bit floating point computations are required.

2.1.7 Algorithm Support Considerations

Tunable parameters (in a LUT or processing coefficient file) are updated and provided to IDPS by DQM in an operational system. Table 14 contains tunable algorithm parameters. Note: The "hcsize" constant controls the aggregation cell size that is used for the Ice Age EDR. The setting of hcsize is hcsize =2 and results in 2x2 aggregation.

Table 14. List of Tunable Algorithm Parameters

Input	Data Type/Size	Description	Units/Valid Range
h00	float*32	Young/First Year ice thickness threshold (cm)	Cm > 0.0 (Currently set to 30.0)
min_conc	float*32	Minimum ice concentration for ice age processing	0.1
min_twgt	float*32	Minimum temperature weight for processing	Unitless 0.0 ≤ min_twgt ≤ 1.0 ***(Currently set to 0.05)***
max_thick_dev	float*32	Maximum allowed difference between I1 and I2 thickness	cm > 0.0 ***(Currently set to 5.0)***
q0	float*32	Solar irradiance (W/m^2)	W/m^2 >0.0 **(Currently set to 1368)**
atmo_const	float*32 x (2 constants)	Atmospheric constants	Unitless >0.0 ***(Currently set to 0.65; 0.055)***
ct	float*32	Coefficient of turbulent heat exchange (sensible heat)	Unitless >0.0 **(Currently set to 0.0017)**
ce	float*32	Coefficient of turbulent heat exchange (latent heat)	Unitless >0.0 **(Currently set to 0.0017**
specific_heat	float*32	Specific heat (J/kg/K)	J/kg/K >0.0 **(Currently set to 1005)**
latent_heat	float*32	Latent heat of evaporation (J/kg)	J/kg/K >0.0 **(Currently set to 2.456E6)**

Input	Data Type/Size	Description	Units/Valid Range
latent_heat_fus	float*32	Latent heat of fusion (J/kg)	J/kg >0.0 **(Currently set to 3.E5)**
sb_const	float*32	Stephan-Boltzmann constant (W/m^2/K^4)	W/m^2/K^4 5.6704E-8
emiss	float*32	Surface emissivity	Unitless 0 <= emiss <= 1.0 **(Currently set to 1.0)**
ice_conduct	float*32	Ice conductivity (W/m/K)	W/m/K >0.0 **(Currently set to 2.093)**
snow_conduct	float*32	Snow conductivity (W/m/K)	W/m/K >0.0 **(Currently set to 0.279)**
t_freeze	float*32	Freezing point of sea water (K)	deg. K 271.4
sza_thre_r	float*32	Red/Yellow SZA threshold for energy balance	degrees 0< sza_thre_r < 90 **(Currently set to 80.0)**
sza_thre_y	float*32	Yellow/Green SZA threshold (Degrees) for energy balance	degrees 0< sza_thre_r < 90 **(Currently set to 85.0)**
trans_thre_r	float*32	Red/Yellow SZA threshold (Degrees) for transmittance	degrees 0< sza_thre_r < 90 **(Currently set to 76.0)**
arctic_haze_aot_thresh	float*32	Arctic haze aerosol optical thickness threshold	Unitless (**Currently set to 0.1)**
IceAirDeltaT	float*32	Temperature difference threshold for Ice-Surface Air Temperature	Degrees C (**Currently set to -999.0**) Note: Setting the threshold to -999.0 effectively disables a branch to classify ice age First Year using a temperature difference threshold. This will allow the algorithm to fully utilize the energy balance equation.

2.1.8 Assumptions and Limitations

None.

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

Table 15 contains terms most applicable for this OAD.

Table 15. 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 NPOESS, 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 Configuration Control Board (ACCB)	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.
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 NPOESS System, but which is acquired from external providers and used by the NPOESS system in the production of NPOESS 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 NPOESS system, and used to produce the NPOESS 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 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.
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 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.
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/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".
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 16 contains terms most applicable for this OAD.

Table 16. Acronyms

ACRONYM	DESCRIPTION
AM&S	Algorithms, Models & Simulations
API	Application Programming Interfaces
ARP	Application Related Product
CDFCB-X	Common Data Format Control Book - External
COT	Cloud Optical Thickness
DMS	Data Management Subsystem
DPIS ICD	Data Processor Inter-subsystem Interface Control Document
IET	IDPS Epoch Time
IIS	Intelligence and Information Systems
INF	Infrastructure
ING	Ingest
IP	Intermediate Product
LUT	Look-Up Table
MDFCB	Mission Data Format Control Book
PRO	Processing
PW	Precipitable Water
QF	Quality Flag
RTM	Radiative Transfer Model
SDR	Sensor Data Records
SI	Software Item or International System of Units
SWS	Surface Wind Speed
TBD	To Be Determined
TBR	To Be Resolved
TOA	Top of the Atmosphere
VCM	VIIRS Cloud Mask

4.0 OPEN ISSUES

Table 17. TBXs

TBX ID	Title/Description	Resolution Date
None		