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**Joint Polar Satellite System (JPSS)  
Operational Algorithm Description  
(OAD)  
Document for VIIRS Sea Ice Quality  
(SIQ) Intermediate Product (IP) and  
Surface Temperature (ST) IP Software**

**For Public Release**

The information provided herein does not contain technical data as defined in the International Traffic in Arms Regulations (ITAR) 22 CFC 120.10. This document has been approved For Public Release to the NOAA Comprehensive Large Array-data Stewardship System (CLASS).



**Goddard Space Flight Center  
Greenbelt, Maryland**

**Joint Polar Satellite System (JPSS)  
Operational Algorithm Description (OAD) Document for  
VIIRS Sea Ice Quality (SIQ) Intermediate Product (IP) and  
Surface Temperature (ST) IP 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 <b>474-CCR-11-0110</b> which converts D42821, Operational Algorithm Description Document for VIIRS Sea Ice Quality (SIQ) Intermediate Product (IP) and Surface Temperature (ST) IP, Rev B dated 03/17/2010 to a JPSS document, Rev -. This was approved by the JPSS Ground Algorithm ERB on June 3, 2011.
Revision A	01/18/2012	<b>474-CCR-11-0281:</b> This version baselines 474-00095, Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Sea Ice Quality (SIQ) Intermediate Product (IP) and Surface Temperature (ST) IP 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	<b>474-CCR-13-0948:</b> This version authorizes 474-00095, JPSS OAD Document for VIIRS SIQ IP ST IP Software, for the Mx 7.0 IDPS release. Includes Raytheon PCR032720; <b>474-CCR-13-0916/ECR-ALG-0037:</b> Update applicable OAD filenames/template/Rev/etc. for Mx7 Release.
Revision C	03/13/2017	<b>474-CCR-17-3243 (ECR-CGS-0734):</b> This version authorizes 474-00095, JPSS OAD Document for VIIRS SIQ IP ST IP 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 SEA ICE QUALITY (SIQ) INTERMEDIATE PRODUCT (IP) AND SURFACE TEMPERATURE (ST) IP**

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

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

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

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 VIIRS Sea Ice Quality (SIQ) Intermediate Product IP and Surface  
 Temperature (ST) IP**

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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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A6	10-17-07	Delivered to NGST.	All
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A8	3-5-08	Changed SolZenAng values to sunzen to agree with true input values (SPCR # 17013).	All
A9	3-7-08	Implemented changes specified in TM #NP-EMD-2007.510.0046.	All
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B2	1-19-10	Updated based on TM NP-EMD-2009.510.0068	All
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B	3-17-10	Incorporated TIM comments and prepared for ARB/ACCB.	All

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C2	10-21-10	Corrections to Table 5 and Table 15 to remove entry for "fwRange" Added clarification statement about "fwRange" not implemented in the operational algorithm Corrections Table 7 ice quality flags entry (removed IQ_N_BANDS) for consistency with IDFCB Vol III definition. Corrected name of Table 5 to Sea Ice Quality PC LUT and references to Table 5 appearing throughout the document. Added clarification statement for quality weights for fire and sun glint. Added clarification statements for quality weights for low light condition Formatting error corrections	p. 8;9; 21 p. 9  p. 9  p. 16  p. 19  All
C3	10-21-10	Updated due to document convergence to include tech memos 2010.510.0077.Rev-A, 2010.510.0011, 2010.510.0012 & 2010.510.0014,	All
C4	06-29-11	Updated due to ISTN_VIIRS_NGST_4.17.2	All
C5	09-19-11	Updated for PCR027383.	11
C6	09-27-11	Updated OAD for PCR027831.	p. 4;11

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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 algorithms required to create the VIIRS Sea Ice Quality IP and VIIRS ST IP software. The theoretical basis for these algorithms is described in Section 3.3 of the VIIRS Sea Ice Characterization Algorithm Theoretical Basis Document (ATBD), D0001-M01-S01-016, and Section 3.3 of the 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. Document References**

Document Title	Document Number/Revision	Revision Date
VIIRS Sea Ice Characterization Algorithm Theoretical Basis Document	D0001-M01-S01-016	Latest
Operational Algorithm Description Document for VIIRS Ice Surface Temperature (IST) Environmental Data Records (EDR) Software	474-00072	Latest
Joint Polar Satellite System (JPSS) Algorithm Specification Part 17	474-00448-01-17_JPSS-SRS-Vol-I-Part-17 474-00448-02-17_JPSS-DD-Vol-II-Part-17	Latest

Document Title	Document Number/Revision	Revision Date
	474-00448-03-17_JPSS-OAD-Vol-III-Part-17 474-00448-04-17_JPSS-SRSPF-Vol-IV-Part-17	
Joint Polar Satellite System (JPSS) Algorithm Specification Part 06	474-00448-02-06_JPSS-DD-Vol-II-Part-06, Section 6.2/6.3	Latest
Joint Polar Satellite System (JPSS) Algorithm Specification Part 11	474-00448-02-11_JPSS-DD-Vol-II-Part-11, Section 5.1	Latest
Joint Polar Satellite System (JPSS) Algorithm Specification Part 12	474-00448-02-12_JPSS-DD-Vol-II-Part-12, Section 4.2	Latest
Joint Polar Satellite System (JPSS) Algorithm Specification Part 16	474-00448-02-16_JPSS-DD-Vol-II-Part-16, Section 5.1.4	Latest
VIIRS Ice Surface Temperature Algorithm Theoretical Basis Document (ATBD)	D0001-M01-S01-018	Latest
JPSS CGS Data Processor Inter-subsystem Interface Control Document (DPIS ICD) Vol I – IV	IC60917-IDP-1001	Latest
JPSS Program Lexicon	470-00041	Latest
NGST/SE technical memo – NPP_VIIRS_STIP_CodeQFUpdate_SPCR_ALG987	NP-EMD.2006.510.0059	27 Feb 2006
NGST/SE technical memo – MS_EngMemo_STIP_codefix_SPCR982_971	NP-EMD.2006.510.0004	03 Mar 2006
NGST/SE technical memo – NPP_VIIRS_STIP_QFUpdate_SPCR_ALG1010	NP-EMD.2006.510.0018	17 Mar 2006
NGST/SE technical memo – NPP_VIIRS_IceQual_VCM_ThinCirrus_Flag	NP-EMD.2006.510.0080	14 Nov 2006
NGST/SE technical memo – NPP_VIIRS_IST_LST_STIP_BugsFix_20061031	NP-EMD.2006.510.0081	01 Nov 2006
NGST/SE technical memo – NPP_VIIRS_Sealce_Night_granule_AOT_RevA	NP-EMD-2006.510.0095 Rev. A	26 Jan 2007
NGST/SE technical memo – NPP_VIIRS_Sealce_3.4.4_delta_delivery_OAD_updates	NP-EMD.2007.510.0046	08 Aug 2007
NGST/SE technical memo – NPP_VIIRS_Sealce_v3.4.5_delta_delivery_OAD_updates	NP-EMD.2008.510.0018	15 Apr 2008
NGAS/SE technical memo – NPP_VIIRS_SealceQualSTIP_v4.17_OAD_updates	NP-EMD.2009.510.0068	20 Nov 2009
NGST/SE technical memo – SealceQualStip_OAD_Corrections	NP-EMD.2010.510.0077.Rev-A	21 Sep 2010
NGST/SE technical memos: LUT_OAD_Drop_History_Corrections LUT_Format_Corrections PC_Format_Corrections	NPOESS GJM-2010.510.0011 NPOESS GJM-2010.510.0012 NPOESS GJM-2010.510.0014	21 Sep 2010 21 Sep 2010 22 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 SealceCharacterization science-grade software (original reference source) (ECR-A049)	ISTN_VIIRS_NGST_3.4 (OAD Rev. ---)	05 May 2005
VIIRS SealceCharacterization (SIQ-STIP) operational software	B1.4 (OAD Rev. A1)	07 Feb 2006
VIIRS SealceCharacterization science-grade software (ECR-A066)(Sea Ice Age) Includes Tech Memo: NP-EMD.2005.510.0115	ISTN_VIIRS_NGST_3.4.1	29 Sep 2005
VIIRS SealceCharacterization science-grade software (ECR-A073)(Sea Ice Quality) Includes OAD update Tech Memo: NP-EMD.2005.510.0137	ISTN_VIIRS_NGST_3.4.2	14 Nov 2005
VIIRS SealceCharacterization (SIQ-STIP) operational software	B1.5 (OAD Rev. A2)	18 Oct 2006
VIIRS SealceCharacterization science-grade software (ECR-A073 & A108)(Sea Ice Age)	ISTN_VIIRS_NGST_3.4.3 Data	18 Dec 2006
VIIRS SealceCharacterization science-grade software (ECR-A127A)(Sea Ice Age) Includes Tech Memo: NP-EMD.2007.510.0046	ISTN_VIIRS_NGST_3.4.4 Data	11 Sep 2007
Implemented TM 2006.510.0080 (ECR A-108) (PCR14258)	B1.5 (OAD Not referenced)	17 Sep 2007
Implemented TM 2007.510.0046 (PCR14258) (ECR A-127)	B1.5 (OAD Rev A9)	07 Mar 2008
VIIRS SealceCharacterization science-grade software (Sea Ice Characterization) Includes OAD update Tech Memo: NP-EMD.2008.510.0018	ISTN_VIIRS_NGST_3.4.5 (OAD updated by TM)	14 May 2008
VIIRS SealceCharacterization (SIQ-STIP) operational software implemented TMs 2006.510.0095.Rev-A (PCR 14275) and 2008.510.0018	B1.5x1 (OAD Rev. A11)	20 Oct 2008
ACCB (no code changes)	OAD Rev A	17 Dec 2008
VIIRS SealceCharacterization science-grade software (Sea Ice Characterization) Includes OAD update Tech Memos: NP-EMD.20098.510.0049 & NP-EMD.20098.510.0068 (PCR 21984)	ISTN_VIIRS_NGST_4.17 (OAD updated by TM)	16 Dec 2009
VIIRS SealceCharacterization (SIQ-STIP) operational software (PCRs 21984-SIQ & 21983-SIC)	Sensor Characterization (Build SC-6) (OAD Rev B2)	19 Jan 2010
ACCB	OAD Rev B	31 Mar 2010
PCR024712	Mx11.5.4 (OAD Rev C1)	30 Sep 2010
Convergence Updates (No code updates) includes Tm 2010.510.0077.Rev-A	(OAD Rev C2 & C3)	21 Oct 2010
VIIRS SealceCharacterization science-grade software	ISTN_VIIRS_NGST_4.17.2	25 Jan 2011
VIIRS SealceCharacterization (SIQ-STIP) operational software (PCRs025896 & 026162)	ECR-A0003 Maintenance Build 1.5.05.00.01 (OAD Rev. C4)	07 Mar 2011 & 29 Jun 2011 (OAD)
PCR027383	(OAD Rev C5)	19 Sep 2011
PCR027831 (OAD update for ADL)	(OAD Rev C6)	27 Sep 2011
OAD transitioned to JPSS Program – this table is no longer updated.		

## 2.0 ALGORITHM OVERVIEW

### 2.1 Sea Ice Characterization Description

The Sea Ice Characterization EDR retrieval algorithm and the theoretical basis are described in detail in the VIIRS Sea Ice Characterization ATBD (D0001-M01-S01-016). That document also gives the theoretical basis for the Ice Quality algorithm in Section 3.3.2.

The Sea Ice Characterization Ice Quality algorithm is the first executable in the Sea Ice Characterization chain. The Ice Quality algorithm produces the Ice Quality Flags IP and the Ice Weights IP. They utilize the VIIRS 375m Sensor Data Record (SDR), IP files from other VIIRS algorithms, and Look-Up-Tables (LUTs). Figure 1 shows the input and output data flow associated with the Ice Quality algorithm. The flowchart box for Ice Quality IP shown in orange is highlighted to indicate that the IP, formerly known as the Ice Mask IP, is now named the Ice Quality Flags IP. The flow chart box for Ice Location IP is shown in red to indicate that this IP is not produced by the operational code.

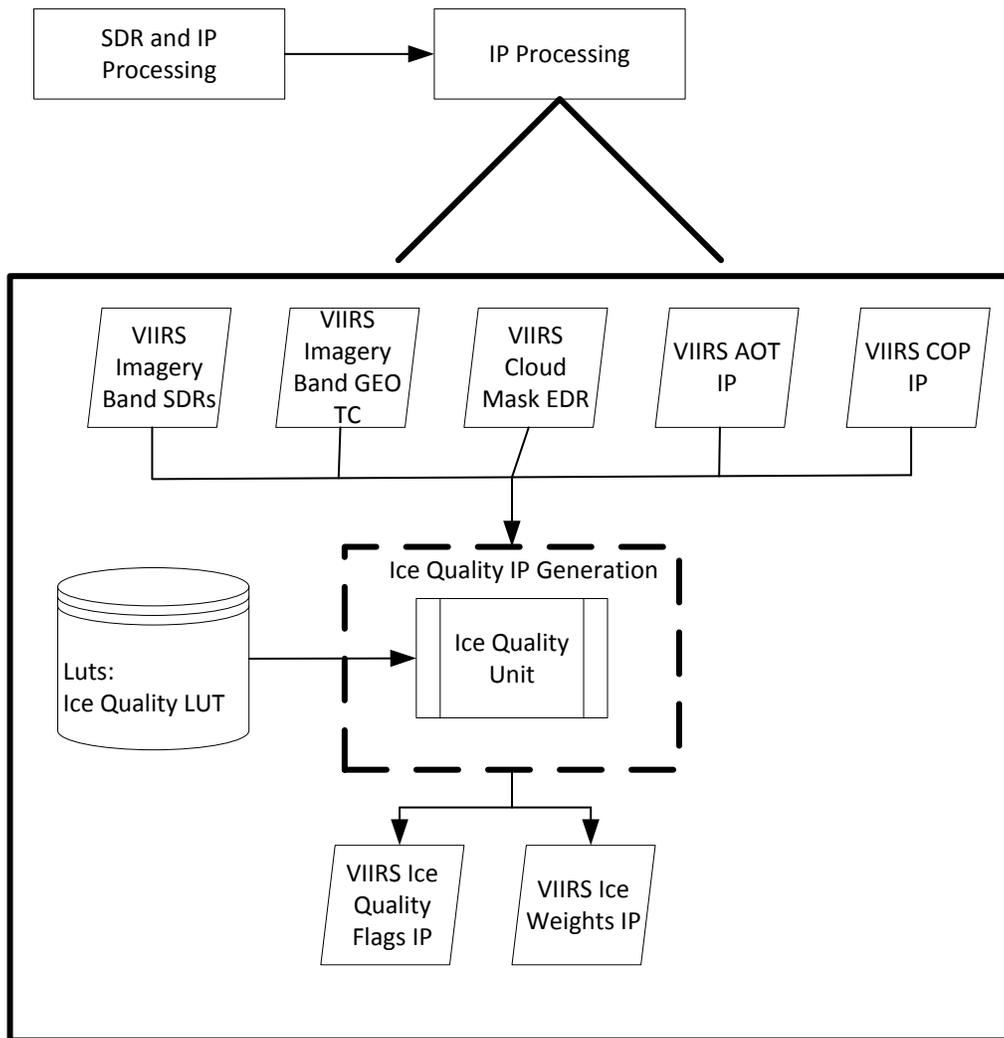


Figure 1. Ice Quality Unit IP Processing Chain

**2.1.1 Interfaces**

Inputs are listed in 474-00448-01-17\_JPSS-SRS-Vol-I-Part-17, Table 3-1 (rows 12-14). A detailed list of inputs is provided below, along with a reference to its supporting Data Dictionary.

**2.1.1.1 Inputs**

**Table 3. Sea Ice Quality Inputs**

Input	Description	Reference Document
VIIRS Img GEO	VIIRS Imagery Band Geolocation	474-00448-02-06_JPSS-DD-Vol-II-Part-06
VIIRS I1, I2 and I5 SDRs	Band I1 - radiance & reflectance at nominal center wavelength 640 nm. Band I2 - radiance & reflectance at nominal center wavelength 865 nm. Band I5 - radiance & reflectance at nominal center wavelength 11450 nm.	474-00448-02-06_JPSS-DD-Vol-II-Part-06
VIIRS COT EDR	Cloud optical thickness is defined as the extinction (scattering and absorption) vertical optical thickness of each distinguishable cloud layer in a vertical column of the atmosphere as well as the average optical thickness of all layers. This EDR will be produced from all nominal JPSS orbits, but the measurement accuracy for a terminator orbit will be degraded due to VIIRS calibration limitations for a terminator orbit. The Cloud Optical Thickness EDR is reported for up to four cloud layers (ordered from the Top of Atmosphere to Surface) and will include the averaged cloud optical thickness, integrated vertically per cell. This EDR is reported as the unitless quantity Tau.	474-00448-02-16_JPSS-DD-Vol-II-Part-16
VIIRS Aerosol Optical Thickness IP	The VIIRS Aerosol Optical Thickness RIP contains thickness values at assorted spectral bands over land and water as well as associated quality flags. (See Y2480 VIIRS Aerosol Particle Size Parameter Unit Level Detailed Design Document).	474-00448-02-12_JPSS-DD-Vol-II-Part-12

Input	Description	Reference Document
VIIRS Cloud Mask IP	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
Ice Quality LUT	The VIIRS Sea Ice Quality PCT file contains ice quality algorithm thresholds.	474-00448-02-17_JPSS-DD-Vol-II-Part-17

### 2.1.1.2 Outputs

**Table 4. Sea Ice Quality Outputs**

Input	Description	Reference Document
VIIRS Ice Quality Flags	The VIIRS Ice Quality Flags IP is output from the VIIRS Ice Quality unit. The Ice Quality Flags IP gives quality bit information at imagery resolution for each pixel and each band in the VIIRS granule.	474-00448-02-17_JPSS-DD-Vol-II-Part-17
VIIRS Ice Weights IP	The VIIRS Ice Weights IP contains the statistical weights for three Imagery Bands, indicating the reliability of each band for further processing.	474-00448-02-17_JPSS-DD-Vol-II-Part-17

### 2.1.2 Algorithm Processing

#### 2.1.2.1 Main Module - ProEdrViirsIceQual.cpp

The ProEdrViirsIceQual.cpp code produces outputs listed in 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 4.2. The output IPs are determined using a series of tests, which determine the quality of each pixel. Each pixel’s “quality” depends upon the quality of the VIIRS Cloud Mask (VCM), Cloud Optical Thickness (COT), and Aerosol Optical Thickness (AOT) IPs. Based on these inputs, weighting factors from the Sea Ice Quality PC are applied to each pixel. The use of these input parameters for testing pixel quality takes place in the following functions: calcIqStip() (Section 2.1.2.5), and calcBandWeights() (Section 2.1.2.6). The I1 and I2 Reflectance qualities and the I5 Brightness Temperature qualities are used in calcIqStip() to compute the quality of each band. This algorithm only processes if the granule is within the specified range of latitude.

#### 2.1.2.2 setupDataItems (ProEdrViirsIceQual.cpp)

The setupDataItems method works in conjunction with auto-generated source code class "AutoGeneratedProEdrViirsIceQual" to set-up the input & output data item class objects (DMS

data structures) that are required by the algorithm for processing, for both Ice Quality IP and Surface the Temperature IP (see Section 2.2).

### **2.1.2.3 doProcessing (ProEdrViirsIceQual.cpp)**

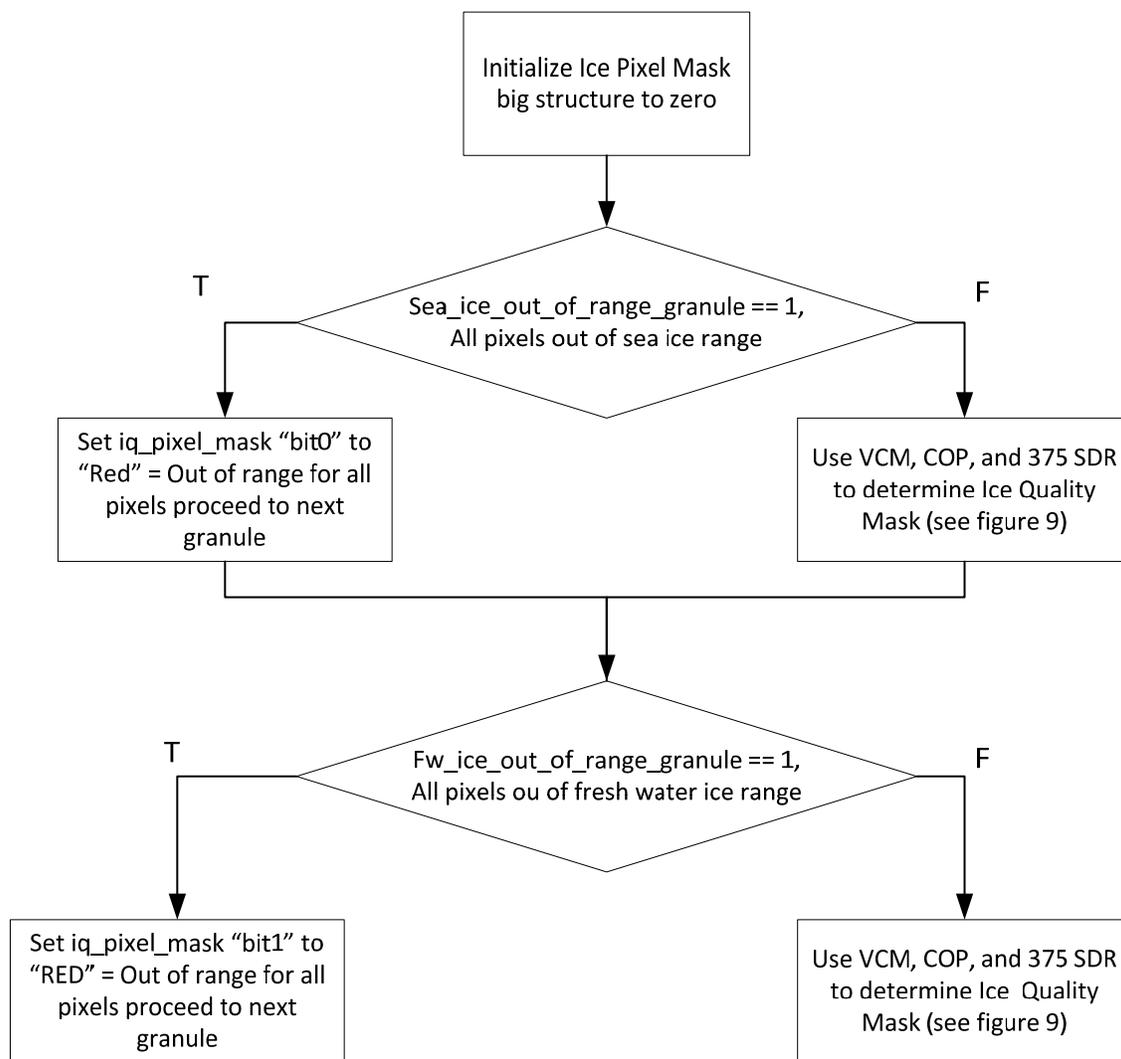
The doProcessing method performs further initialization of data assigns pointers, allocates temporary memory for and extracts VIIRS Cloud Mask data, and then calls functions “determinelceRange” and “calclqStip” to process the data buffers retrieved from DMS. These pointers are then used by the algorithm to read and update the DMS data buffers. After processing has completed, temporary memory is deleted.

### **2.1.2.4 determinelceRange (ProEdrViirsIceQual.cpp)**

The determinelceRange method is used to determine if the granule is “out of range” for sea ice or fresh water ice.

### **2.1.2.5 calclqStip (ProEdrViirsIceQual.cpp)**

The calclqStip method is the main method of ProEdrViirsIceQuality algorithm. This method calculates the ice quality flags, ice weights, and calls calcSurfTemp (see Section 2.2.2.1) for each pixel. It uses the VCM EDR to produce Ice Quality Flags, which contains the quality flags (bits) for each pixel. The Ice Quality Flags bit structure is detailed in 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 4.2. See Figure 2 for the logic flow in the creating of the Ice Quality Flags.



**Figure 2. Logic Flow to Create the Ice Quality Flags**

In Figure 2 all tests done using COP or the VCM are done at the moderate resolution pixel level. Table 6 details the results of these tests. A test with the LUT field “qualWgts” against the weighting factors computed in calcBandWeights() is performed in order to determine the overall qualities for bands I1, I2, and I5; these are described in 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 4.2.

The VCM has recently been updated to handle more cloud phases. However, because the number of phases has increased, the number of bits necessarily must increase. In order to minimize the number of changes to the VCM output bit structure, the cloud phase has moved from byte 4 (on a 0-5 scale) to byte 5. Table 5 details the mapping of the new VCM to the current cloud phases handled by the Sea Ice algorithm.

Note that the new VCM no longer produces a cloud phase for “PROBABLY CLEAR” pixels and instead uses a “PARTLY CLOUDY” label. Ice Quality Unit, using the new VCM, classifies formerly “PROBABLY CLEAR” pixels as “CONFIDENTLY CLEAR.”

**Table 5. Mapping of New VCM to Ice Quality Flags**

<b>VCM Cloud Phase</b>	<b>Mapped Cloud Phase in Ice Quality Flags</b>	<b>2-Bit Assignment</b>
Not Executed	Not Executed	00
Clear	Not Executed	00
Partly Cloudy	Not Executed	00
Water	Water	01
Mixed	Mixed	11
Opaque Ice	Ice	10
Cirrus	Ice	10
Overlap	Mixed	11

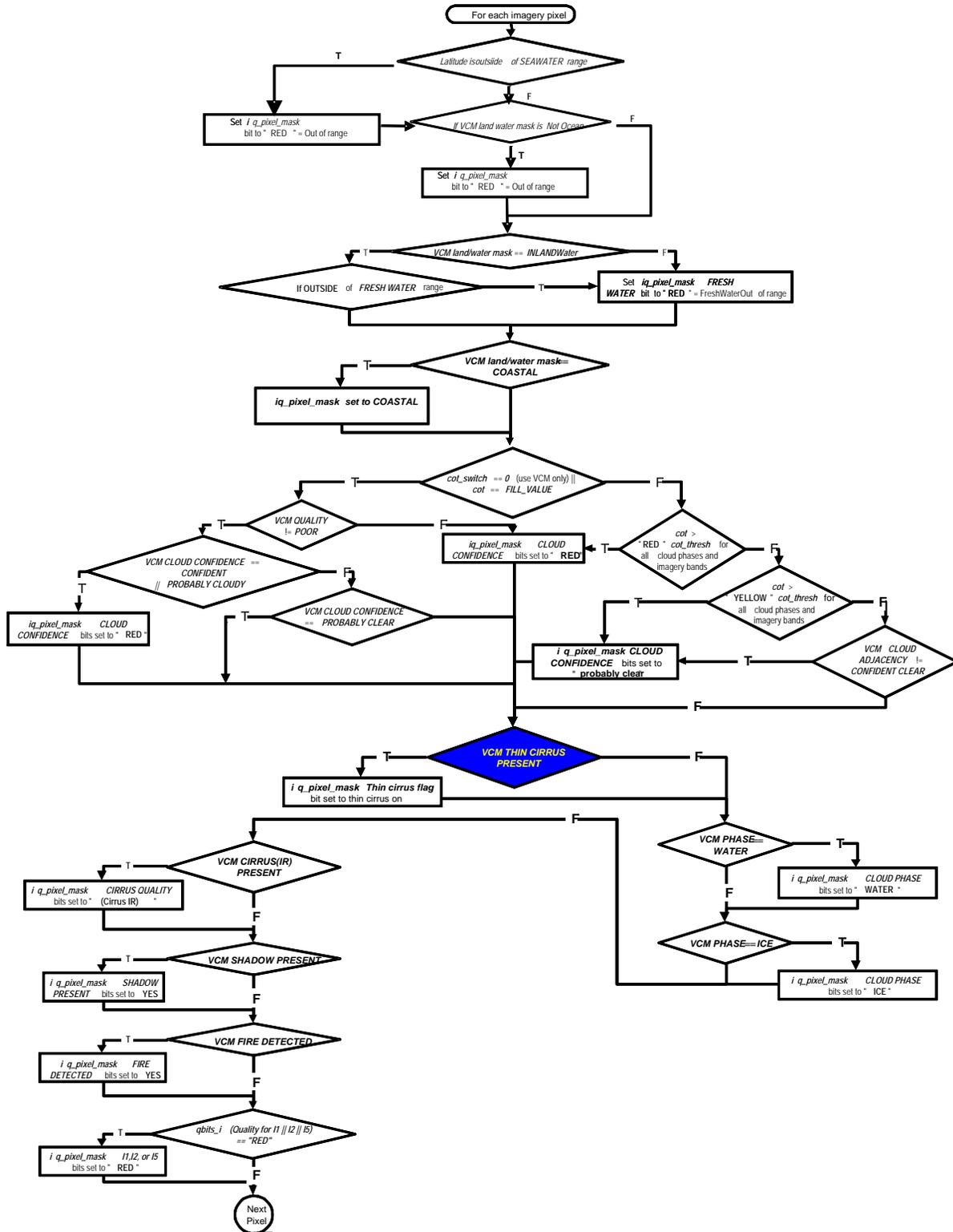
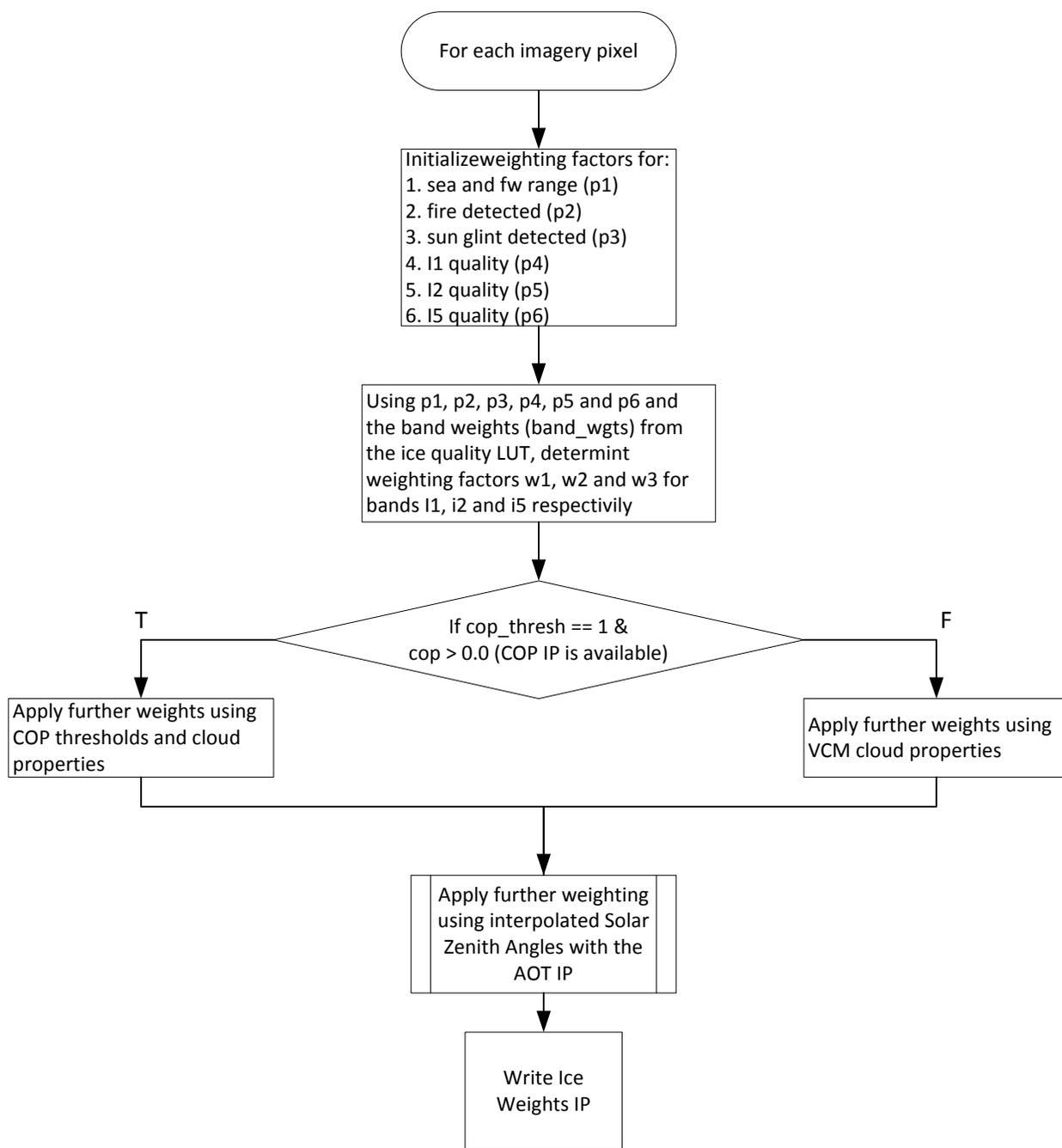


Figure 3. Detailed Logic Flow to Create the Ice Quality Flags

### 2.1.2.6 calcBandWeights (ProEdrViirsIceQual.cpp)

Band weighting factors, which are a function of the “quality” of the IPs, are determined using threshold and weight values in the Ice Quality LUT. The algorithm determines weights in applyToWeights() due to cloud effects or cloud optical thickness values if COT is available. If the COT IP is not available the algorithm uses the VCM cloud properties to define the weighting factors for each of the ice pixels.

This function does, however, perform an initial weighting on the reflectance and brightness temperature bands based on various VCM tests results determined earlier in the calcIqStip() function. Figure 4 details the logic flow of calcBandWeights().



**Figure 4. Logic Flow of calcBandWeights**

The computation of all weighting factors (due to clouds and AOT) are detailed in 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 4.4. These band weights include weights computed by calcBand\_weights(), applyToWeights(), and applyAotSunZen().

**Table 6. Factors Determining the Ice Weights IP**

Band Weight Parameters	Final Band Weight Computation
Parameters for I1 (s = along-scan, t = along-track): $p1(t,s)$ = sea or fresh water present (0 = No, 1 = yes) $p2(t,s)$ = fire detected (1 = Yes, 1 = No)	IF COP is not available IF Cloud Confidence == Probably Clear

Band Weight Parameters	Final Band Weight Computation
<p><b>p3(t,s)</b> = sun glint detected (1 = Yes, 1 = No)  <b>p4(t,s)</b> = I1 quality (0 = Poor, 1 = Good)  <b>w<sub>0</sub>(I1)</b> = I1 weighting factor from the Ice Quality PC = bandWgts(1) in Table 18                      Note: For other parameter definitions see Table 5, Table 6 and Table 7.</p>	<p><b>w(I1,t,s)</b> = <b>w<sub>0</sub>(I1)</b> × <b>p1</b> × <b>p2</b> × <b>p3</b> × <b>p4</b> × <b>cw1</b> × <b>cw3</b> × <b>a_sza</b> × <b>s0</b> (if shadow detected)                      ELSE IF Cloud Confidence == Probably Cloudy  <b>w(I1,t,s)</b> = <b>w<sub>0</sub>(I1)</b> × <b>p1</b> × <b>p2</b> × <b>p3</b> × <b>p4</b> × <b>cw2</b> × <b>cw3</b> × <b>a_sza</b> × <b>s0</b> (if shadow detected)                      END IF                      ELSE  <b>w(I1,t,s)</b> = <b>w<sub>0</sub>(I1)</b> × <b>p1</b> × <b>p2</b> × <b>p3</b> × <b>p4</b> × <b>w_x</b> × <b>a_sza</b> × <b>s0</b> (if shadow detected)                      END</p>
<p>Parameters for I2:  <b>p1(t,s)</b> = sea or fresh water present (0 = No, 1 = yes)  <b>p2(t,s)</b> = fire detected (1 = Yes, 1 = No)  <b>p3(t,s)</b> = sun glint detected (1 = Yes, 1 = No)  <b>p5(t,s)</b> = I2 quality (0 = Poor, 1 = Good)  <b>w<sub>0</sub>(I2)</b> = I2 weighting factor from the Ice Quality PC= bandWgts(2) in Table 18                      Note: For other parameter definitions see Table 5, Table 6 and Table 7.</p>	<p>IF COP is not available                      IF Cloud Confidence == Probably Clear  <b>w(I2,t,s)</b> = <b>w<sub>0</sub>(I2)</b> × <b>p1</b> × <b>p2</b> × <b>p3</b> × <b>p5</b> × <b>cw1</b> × <b>cw3</b> × <b>a_sza</b> × <b>s0</b> (if shadow detected)                      ELSE IF Cloud Confidence == Probably Cloudy  <b>w(I2,t,s)</b> = <b>w<sub>0</sub>(I2)</b> × <b>p1</b> × <b>p2</b> × <b>p3</b> × <b>p5</b> × <b>cw2</b> × <b>cw3</b> × <b>a_sza</b> × <b>s0</b> (if shadow detected)                      END IF                      ELSE  <b>w(I2,t,s)</b> = <b>w<sub>0</sub>(I2)</b> × <b>p1</b> × <b>p2</b> × <b>p3</b> × <b>p5</b> × <b>w_x</b> × <b>a_sza</b> × <b>s0</b> (if shadow detected)                      END</p>
<p>Parameters for I5:  <b>p1(t,s)</b> = sea or fresh water present (0 = No, 1 = yes)  <b>p2(t,s)</b> = fire detected (1 = Yes, 1 = No)  <b>p6(t,s)</b> = I5 quality (0 = Poor, 1 = Good)  <b>w<sub>0</sub>(I5)</b> = I5 weighting factor from the Ice Quality PC= bandWgts(3) in Table 18                      Note: For other parameter definitions see Table 5, Table 6 and Table 7.</p>	<p>IF COP is not available                      IF Cloud Confidence == Probably Clear  <b>w(I5,t,s)</b> = <b>w<sub>0</sub>(I5)</b> × <b>p1</b> × <b>p2</b> × <b>p6</b> × <b>cw1</b> × <b>cw3</b>                      ELSE IF Cloud Confidence == Probably Cloudy  <b>w(I5,t,s)</b> = <b>w<sub>0</sub>(I5)</b> × <b>p1</b> × <b>p2</b> × <b>p6</b> × <b>cw2</b> × <b>cw3</b>                      END IF                      ELSE  <b>w(I5,t,s)</b> = <b>w<sub>0</sub>(I5)</b> × <b>p1</b> × <b>p2</b> × <b>p6</b> × <b>w_x</b>                      END</p>

Note that weighting of band I5 does not depend on the presence of sun glint. This is because I5 is a LWIR band, which is not affected by sun glint. The weights for band I1 and I2 are not set to 0 for fire and sun glint to allow retrievals to be produced for these conditions. Quality flags are set for these conditions.

**2.1.2.7 applyToWeights (ProEdrViirsIceQual.cpp )**

This function uses either COT data or VCM cloud properties to do thresholding and weighting on each of the ice pixels. The logic for using VCM cloud properties is detailed in Figure 5. Cloud weight LUT values corresponding to shadows only affect bands I1 and I2. This again is due to I5’s bandwidth. All the other weight factors, calculated in this function, are computed for all three imagery bands. The cloud weighting parameters are listed in 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 4.4.

Figure 6 details the logic to compute additional weighting factors due to clouds. The weighting parameters are listed in Table 7. Since the COT IP is reported at 750-meters resolution and the Ice Quality is computed at the 375-meters, the COT values at each moderate resolution pixel must be replicated over the four imagery pixels.

**Table 7. Weighting Parameters Computed in applyToWeights for VCM Cloud Properties**

(See 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 7.2.2.1.3 for a description of “cloudWgts”.)

Band Weight Parameter	Definition/Computation
<b>cw1(c,b)</b> where <i>c(t,s) = 1-4 (cloud phase)</i> <i>b = band (I1, I2, I5)</i> <i>t = along-track,</i> <i>s = along-scan</i>	This is the cloud-weighting factor, from "cloud_wgts", which corresponds to a particular cloud phase and for each imagery band.
<b>cw2(c,b)</b> where <i>c(t,x) = 7 (cloud adjacency property)</i> <i>b = band (I1, I2, I5)</i> <i>t = along-track,</i> <i>s = along-scan</i>	This is the cloud-weighting factor, from "cloud_wgts", which corresponds to the cloud adjacency property and for each imagery band.
<b>cw3(c,b)</b> where <i>c(t,s) = 5 (cirrus cloud property)</i> <i>b = band (I1, I2, I5)</i> <i>t = along-track,</i> <i>s = along-scan</i>	This is the cloud-weighting factor, from "cloud_wgts", which corresponds to the cirrus cloud property and for each imagery band.
<b>s0(t,s,c,b)</b> where <i>t = along-track,</i> <i>s = along-scan</i> <i>c = 6 (shadow detected property)</i> <i>b = band (I1, I2)</i>	This is the cloud-weighting factor, from "cloud_wgts", which corresponds to the shadow detected property and for each imagery band.

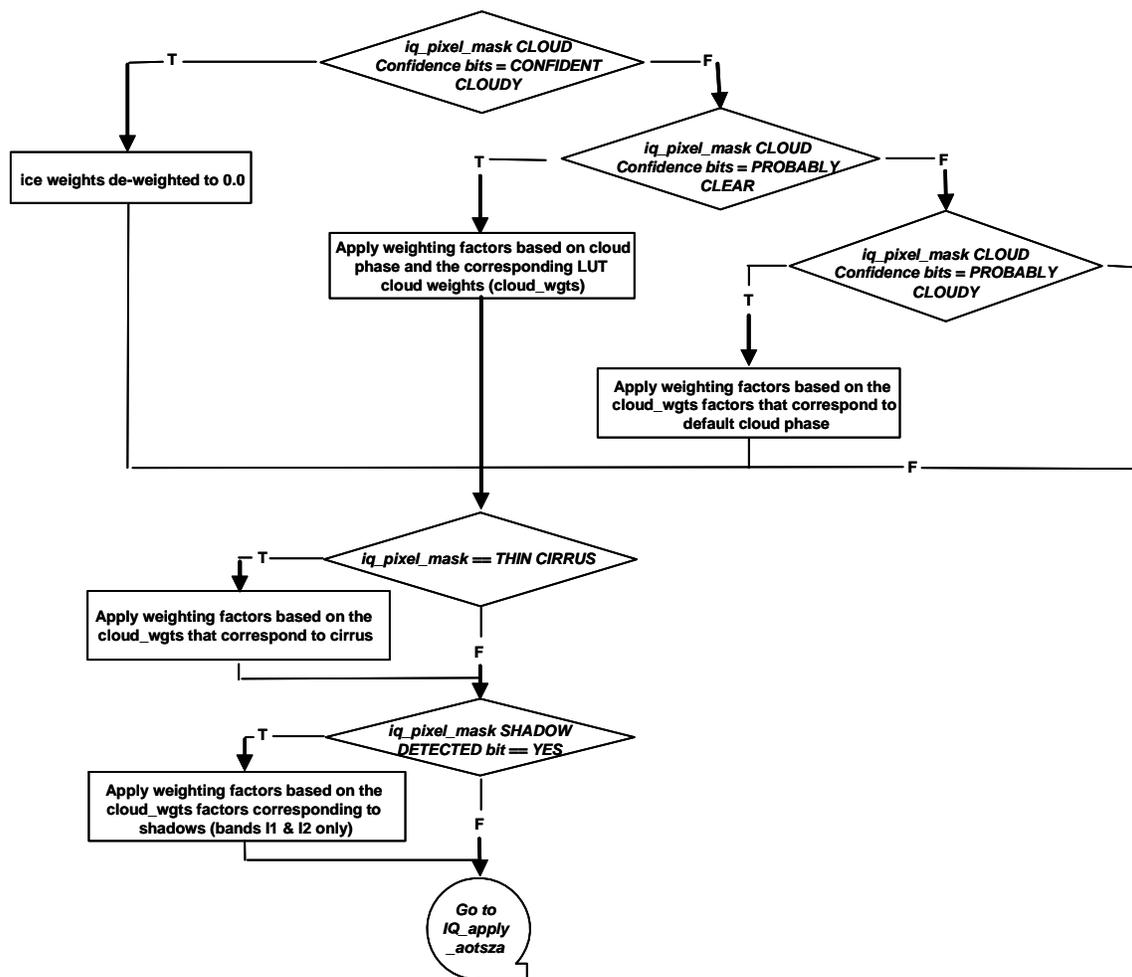
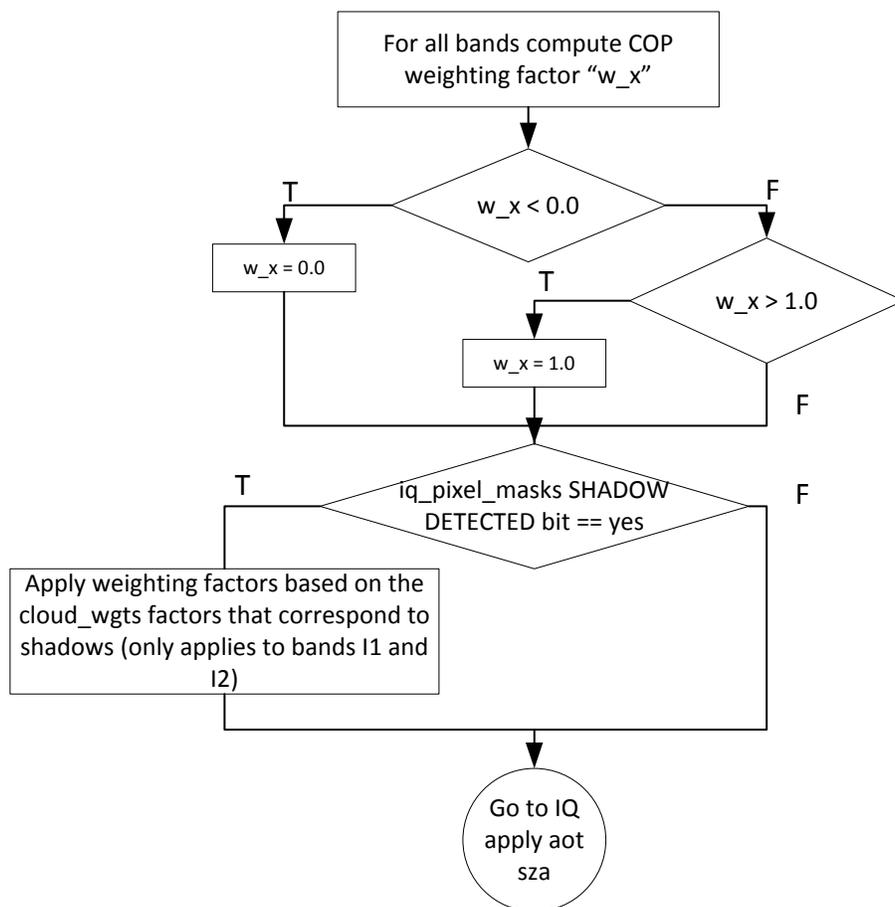


Figure 5. Logic Flow of Using VCM Cloud Properties in applyToWeights

**Table 8. Weighting Parameters Computed in applyToWeights for COP**

(See 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 7.2.2.1.3 for a description of “cloudWgts” and “copThresh”.)

Band Weight Parameter	Definition/Computation
$w_x(c, ct, b)$ where $c(t, s) = 1-4$ (cloud phase) $ct =$ cloud optical thickness $b =$ band (I1, I2, I5) $t =$ along-track, $s =$ along-scan	$w_x = [\text{cop\_thresh}(c, 1, b) - \text{cop}(t, s)] / [\text{cop\_thresh}(c, 1, b) - \text{cop\_thresh}(c, 2, b)]$ where “cop_thresh” are the cloud optical thickness weighting factors extracted from the Ice Quality LUT.
$s0(t, s, c, b)$ where $t =$ along-track, $s =$ along-scan $c = 6$ (shadow detected property) $b =$ band (I1, I2)	This is the cloud-weighting factor, from “cloud_wgts”, which corresponds to the shadow detected property and for each imagery band.



**Figure 6. Logic Flow of Using COP Data in applyToWeights**

**2.1.2.8 applyAotSunZen (ProEdrViirsIceQual.cpp )**

After applying weights due to cloud effects, this function computes weighting factors by interpolating solar zenith angle intersections for each reflectance band, given the AOT for a pixel. If any AOT (input from the AOT IP) is outside the boundaries of the AOT values defined in “aotBin”, the band weight is set to 0.0. This also occurs if the input LUT parameter of “aotBin”

is out of order. See 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 7.2.2.1.3 for Ice Quality LUT description. After determining that the current AOT value for the pixel falls within the boundaries of “aotBin”, the code must determine which intermediate values of “aotBin” the AOT falls between. The two “aotBin” values serve as interpolation points. The following equation interpolates the solar zenith angles for each band reflectance band, given the AOT for the current pixel:

$$\theta_k(t,s,b) = \theta'_{i,k}(b) \left( \frac{\tau'_{i+1} - \tau(t,s)}{\tau'_{i+1} - \tau'_i} \right) + \theta'_{i+1,k}(b) \left( \frac{\tau(t,s) - \tau'_i}{\tau'_{i+1} - \tau'_i} \right),$$

where the  $\theta'_{i,k}$ ,  $\tau$ , and  $\tau'_i$  represent the solar zenith angle values from the LUT parameter “qAotSunZen”, AOT of the pixel, and the AOT intermediate boundary values (aotBin) respectively. The index “i” represents the column index in “aotBin” and “row” index in “qAotSunZen” as described in Table 1;  $i = 1 \dots 4$ . The index “k” corresponds to the “quality” of the interpolation, which refers to the “column” index in “qAotSunZen”;  $k = 1$  (Green/Yellow quality) or 2 (Yellow/Red quality). The index “b” refers to the band bin index  $b=1$  (VIIRS I1 band) or 2 (VIIRS I2 band). The weighting factor depends on the difference between  $\theta_2$  and  $\theta_1$  (where the indices correspond to  $k$ ). Figure 7 gives the logic flow of this function; see Table 9 for weighting calculation. As with the COP IP, the AOT IP values at each moderate resolution pixel must be replicated over the four imagery pixels.

Thermal band quality weights are not modified by AOT or solar zenith angle. The band specific quality weights are used to determine the “relative” retrieval quality of retrievals for each band (used to determine whether a VIIRS I1 band based retrieval is of better quality than a VIIRS I2 or Thermal band based retrieval.) Low light associated degradation of retrieval quality for reflectance based retrievals is inherently captured by relative quality weights, the setting of the Ice Quality Flags IP “relative” overall quality flags for each band and the algorithm branch flags in the downstream Sea Ice Age algorithm. The relative quality however are cumulative flags in the sense that other conditions such as cloud shadows can also lower the quality of reflectance bands relative to the thermal band. The quality weights are passed to the Sea Ice Concentration and the Sea Ice Age algorithms and are used internally to determine whether the overall retrieval is based on a reflective or thermal band. No explicit quality flag is implemented to indicate low light condition.

**Table 9. Weighting Parameter Computation in applyAotSunZen**

Band Weight Parameter	Definition/Computation
<p><b>a_sza</b>(<math>\tau, \theta_{t,s}, b</math>) where  <math>\tau(t,s)</math> = Aerosol Optical Thickness  <math>b</math> = band (I1, I2), no I5 since only reflective bands are necessary  <math>\theta_{t,s}</math> = Solar Zenith Angle of the pixel  <math>t</math> = along-track,  <math>s</math> = along-scan</p>	<p>Weighting factor due to AOT where,  <math display="block">\mathbf{a\_sza} = \frac{\theta_2 - \theta_{t,s}}{\theta_2 - \theta_1},</math>  <math display="block">\mathbf{a\_sza} = 0, \text{ if } \theta_{t,s} \geq \theta_2</math></p>

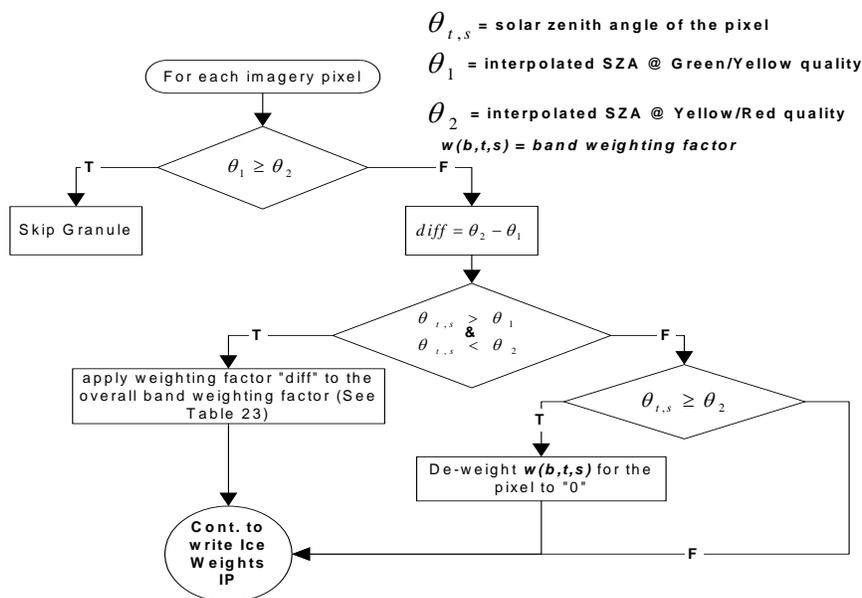


Figure 7. Logic Flow of applyAotSunZen

2.1.2.9 Current Issues

None.

2.1.3 Graceful Degradation

2.1.3.1 Graceful Degradation Inputs

There are two cases where input graceful degradation is indicated in the Sea Ice Quality EDR.

1. The primary input denoted in the algorithm configuration guide cannot be successfully retrieved but 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 10 details the instances of this case for SIQ. Note that the shaded cells indicate that the graceful degradation was done upstream at product production.

Table 10. SIQ 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 processing a Night scene, the AOT cannot be applied to the I1 and I2 weights. The Ice Weights for I1 and I2 are set to 0.0.

If an error occurs applying the AOT to the I1 and I2 weights, the Ice Weights for I1 and I2 are set to 0.0.

If the geolocation data is invalid, the Ice Quality Flags is set to RED for I1, I2, and I5. The Ice Weights are set to 0.0 for I1, I2, and I5.

### **2.1.5 Data Quality Monitoring**

The only data quality monitoring is by way of the Ice Quality IP quality flags listed in 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 4.2.

### **2.1.6 Computational Precision Requirements**

Single precision 32-bit floating point computations are required for the Ice Quality IP.

### **2.1.7 Algorithm Support Considerations**

See 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 7.2.2.1.3 contains the tunable algorithm parameters that may need adjustment throughout the JPSS program.

The tunable parameters described and defined in 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 7.2.2.1.3 consist of two categories: 1) relative empirical and 2) physical. Empirical parameters define the relative quality weights where 0 is bad quality and 1 represents good quality. The recommended values listed in table 16 are empirically based on testing with MODIS proxy scenes. Physical parameters are those such as angle and latitude, longitude thresholds and AOT quality weight bin values. These thresholds are determined based on inspection of the MODIS proxy scenes tested. Optimal values are to be determined during calibration/validation.

### **2.1.8 Assumptions and Limitations**

#### **2.1.8.1 Assumptions**

None identified.

#### **2.1.8.2 Limitations**

None identified.

## 2.2 Surface Temperature Description

The ST IP retrieval algorithm and its theoretical basis are described in detail within the VIIRS IST Algorithm Theoretical Basis Document, D0001-M01-S01-018. The operational implementation of the IST EDR algorithm is described in the Operational Algorithm Description Document for the VIIRS Ice Surface Temperature (IST) EDR, 474-00072.

The purpose of the ST IP module is to retrieve the Surface Temperature for each cloud-free ocean pixel at VIIRS imagery-resolution. Brightness Temperature data from the VIIRS SDR, VIIRS Aerosol Optical Thickness (AOT) IP, VIIRS Ice Quality Flags IP and Ice Weight IP are used to decide whether the pixel is processed and, whether to use a 2-band split window baseline algorithm or a single-band split window fallback algorithm. The ST IP is retrieved using a regression equation with separate coefficients for day and for night retrievals. ST and ST quality information are written to the VIIRS ST IP. Figure 8 below shows the ST IP Processing Chain.

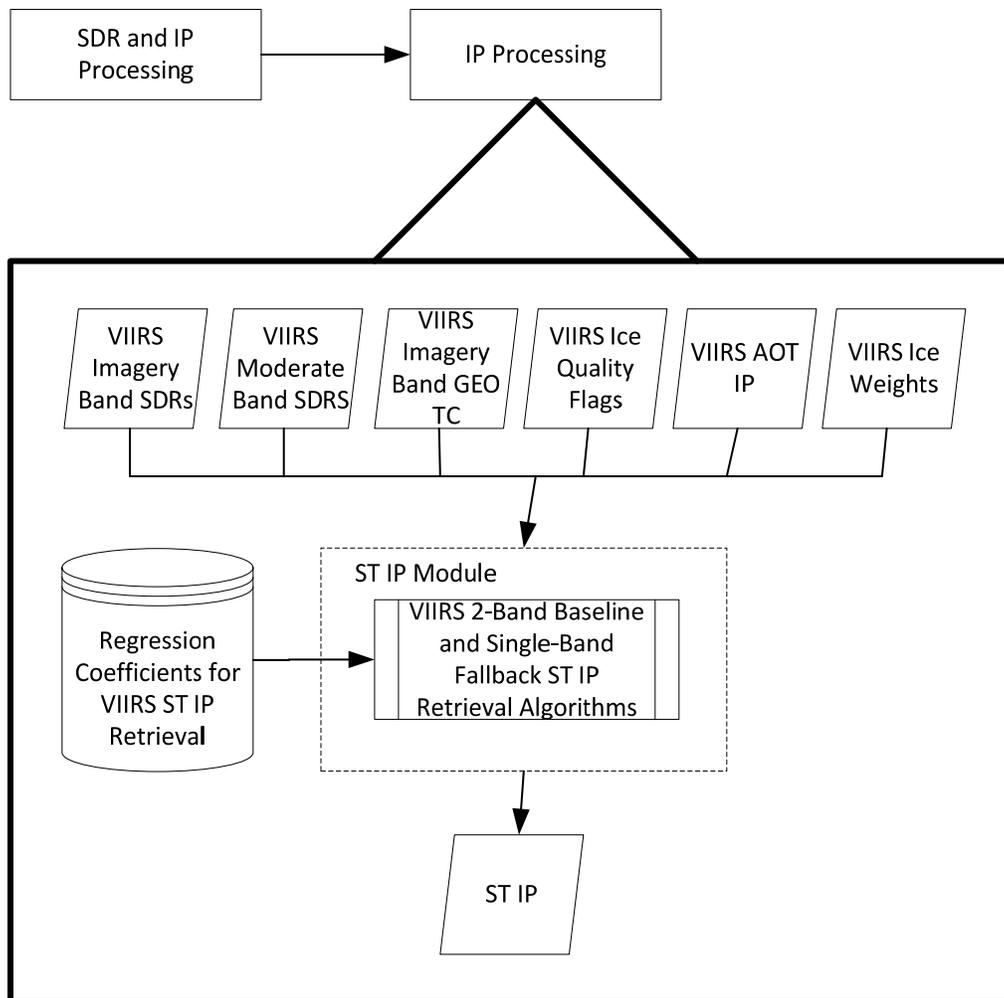


Figure 8. Surface Temperature IP Processing Chain

### 2.2.1 Interfaces

2.2.1.1 Inputs

Table 11. Surface Temperature IP Inputs

Input	Description	Reference Document
VIIRS Img GEO	VIIRS Imagery Band Geolocation	474-00448-02-06_JPSS-DD-Vol-II-Part-06
VIIRS Imagery I5 SDR	Band I5 - radiance & reflectance at nominal center wavelength 11450 nm.	474-00448-02-06_JPSS-DD-Vol-II-Part-06
VIIRS Moderate Band M15 and M16	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 Aerosol Optical Thickness IP	The VIIRS Aerosol Optical Thickness RIP contains thickness values at assorted spectral bands over land and water as well as associated quality flags. (See Y2480 VIIRS Aerosol Particle Size Parameter Unit Level Detailed Design Document).	474-00448-02-12_JPSS-DD-Vol-II-Part-12
VIIRS Cloud Mask IP	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 Surf Temp Coeff LUT	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

2.2.1.2 Output

Table 12. Surface Temperature IP Output

Input	Description	Reference Document
VIIRS Surface Temperature IP	Surface temperature (over ice and ocean) at imagery resolution, including Quality Flags (1byte)/pixel	474-00448-02-17_JPSS-DD-Vol-II-Part-17

## 2.2.2 Algorithm Processing

### 2.2.2.1 Main Module - calcSurfTemp() (ST IP)

The objective of the ST IP algorithm is to calculate the ocean and sea-ice surface temperature at each pixel indicated by the VIIRS Ice Quality Flags IP at VIIRS imagery resolution (375 m) when all the necessary inputs are available. 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) at moderate resolution and Band I5 at imagery resolution, and
- 2) A fallback single-band algorithm where only the LWIR band I5 at imagery resolution is used.

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

This module is called by calcIqStip (see Section 2.1.2.5). Sections 2.2.2.2 through 2.2.2.4 provide a detailed description of this module.

### 2.2.2.2 ST IP Logic

The ST IP's retrieval logic flow diagram is provided in Figure 9. The core logic occurs in two functions, setStipQualFlags() and calculateSt(). In the current implementation, ST IP QFs additionally serve as decision flags. Their values are used in the decision of whether ST IP can be retrieved and, if so, which algorithm to use.

ST IP is not retrieved if any of the following conditions occur:

- The pixel is confidently cloudy, or
- Band I5 Brightness Temperature is outside the SDR defined range, or
- The pixel is "Not to process".

These pixels are filled (-999.9) and marked with an ST IP quality flag of "No Retrieval".

For the pixels that are processed, ST IP 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: "to process" pixel indicated by the Sea Ice Range flag, no fire, and "in-range" brightness temperatures for the M15 and M16 and I5 bands. Otherwise, the single-band fallback algorithm is used. The logic to determine which algorithm is used is provided in the ST IP QF Logic table, Table 13.

The equations for the 2-band split-window and single-band algorithms are specified in Table 10. The implementation is presented in calculateSt(). Daytime and nighttime retrievals are identical except with different sets of regression coefficients in the LUT.

For an off-nominal condition where a negative ST IP is retrieved, the ST IP field is filled with -999.9 and the ST IP quality bit field is set to "No Retrieval".

The AOT values from the VIIRS band 550 nm are used. Final data type of AOT and its availability are subject to change and should be verified once becoming available.

### 2.2.2.3 ST IP QF Logic

ST IP Flags consist of one 8-bit word shown in 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 4.5. The logic to set these quality flags is performed in function `setStipQualFlags()` and provided in Table 13. The first byte of the ST IP quality flags is written as output for use by the Sea Ice Concentration algorithm.

Overall quality of the ST IP pixel is represented by the quality bit field

### 2.2.2.4 ST IP LUT Coefficient Selection

A unique set of regression coefficients is derived offline for ST IP. Each ST IP equation (Table 14) 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 these indices are specified, coefficients are retrieved for the desired ST IP algorithm by selecting a specific “term” index. For example, 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 fallback single-band algorithm, there are two coefficients. For the latter, an additional zero-valued coefficient is present as “filler” in the LUT file.

Example:

`LUTCoeffs[n][1][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.

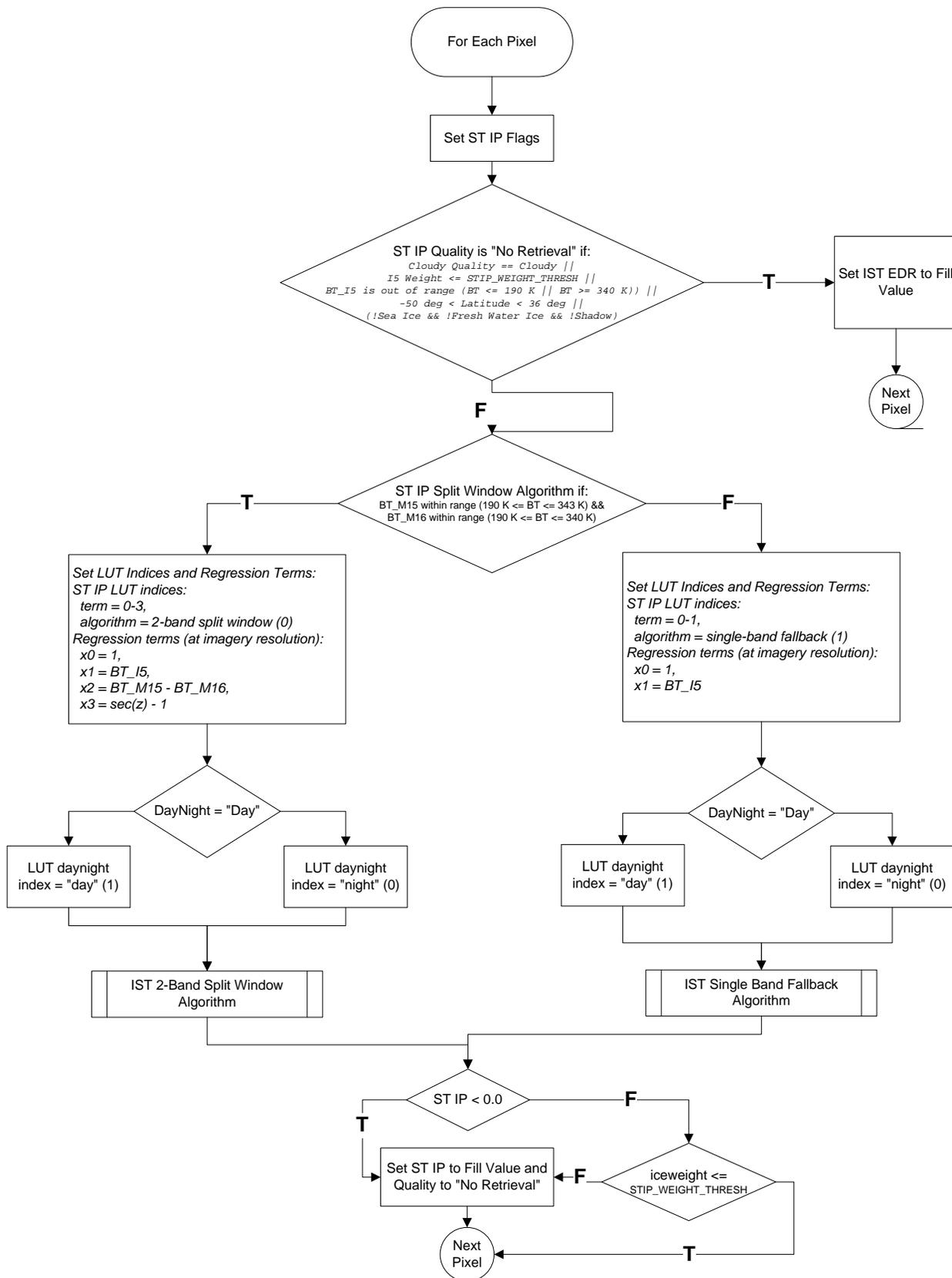


Figure 9. Surface Temperature IP Retrieval Logic Flow

**Table 13. Surface Temperature IP QF Logic**

ST IP Flag	Input Source	Flag Setting
Sea Ice Flag	VIIRS Ice Quality Flags IP/Sea Ice Range Flag	ST IP Sea Ice Flag = VIIRS Ice Quality Flags IP Sea Ice Range Flag
Fresh Water Ice Flag	VIIRS Ice Quality Flags IP/Fresh Water Ice Range Flag	ST IP Fresh Water Ice Flag = VIIRS Ice Quality Flags IP Fresh Water Ice Range Flag
Band M15 Brightness Temperature Range	VIIRS Earth View 750-meter SDR	if (190 K < $BT_{M15}$ < 343 K) set to "within range" otherwise set to "out of range" end if
Band M16 Brightness Temperature Range	VIIRS Earth View 750-meter SDR	if (190 K < $BT_{M16}$ < 340 K) set to "within range" otherwise set to "out of range" end if
Band I5 Brightness Temperature Range	VIIRS Earth View 375-meter SDR	if (190 K < $BT_{I5}$ < 340 K) set to "within range" otherwise set to "out of range" end if
Band I5 Quality	VIIRS Ice Quality Flags IP/I5 Quality Flag	I5 Quality Flag = VIIRS Ice Quality Flags IP I5 Quality
Band I5 Overall Quality	VIIRS Ice Quality Flags IP/I5 Overall QF	I5 Overall Quality Flag = VIIRS Ice Quality Flags IP I5 Overall Quality Flag
AOT Condition	VIIRS AOT IP	if (0 <= AOT <= 1.0) set to "within range" otherwise set to "out of range" end if
Day/Night	VIIRS Earth View 375-meter SDR	if (0° <= Solar Zenith Angle <= 85°) set to "Day" otherwise set to "Night" end if
Cloud Shadow	VIIRS Ice Quality Flags IP/Cloud Shadow Flag	ST IP Cloud Shadow Flag = VIIRS Ice Quality Flags IP Cloud Shadow Flag
Fire Detection	VIIRS Ice Quality Flags IP/Fire Detection Flag	ST IP Fire Flag = VIIRS Ice Quality Flags IP Fire Flag
Cloud Confidence Indicator	VIIRS Ice Quality Flags IP/Cloud Confidence Indicator	ST IP Cloud Confidence Flag = VIIRS Ice Quality Flags IP Cloud Confidence Flag
Cirrus Confidence Indicator	VIIRS Ice Quality Flags IP/Cirrus Confidence Indicator	ST IP Cirrus Quality Flag = VIIRS Ice Quality Flags IP Cirrus Confidence Flag
Algorithm	Logical combination of ST IP Flags	if ( $BT_{M15}$ is "within range") and ( $BT_{M16}$ is "within range") and ( $BT_{I5}$ is "within range") set to "2-Band" otherwise set to "1-Band" end if
ST IP Retrieval Quality	Logical combination of ST IP Flags	See Logic Table

**Table 14. Surface Temperature IP Core Equations**

VIIRS ST IP Baseline Split Window Algorithm
<p><b>Daytime:</b></p> $ST = a_0 + a_1 t_{I5} + a_2 (T_{M15} - T_{M16}) + a_3 (\sec \theta - 1)$ <p><b>Nighttime:</b></p> $ST = b_0 + b_1 t_{I5} + b_2 (T_{M15} - T_{M16}) + b_3 (\sec \theta - 1)$
VIIRS ST IP fallback single-band algorithm
<p><b>Daytime:</b></p> $ST = a_0 + a_1 t_{I5}$ <p><b>Nighttime:</b></p> $ST = b_0 + b_1 t_{I5}$
<p>where</p> <ul style="list-style-type: none"> <li>• <math>ST</math> is the retrieved ice surface temperature at imagery resolution,</li> <li>• <math>a_n</math> and <math>b_n</math> are coefficients in the ST IP LUT and are dependent on day/night conditions,</li> <li>• <math>\theta</math> is the sensor zenith angle,</li> <li>• <math>T_\lambda</math> is the brightness temperature at <math>\lambda =</math> VIIRS Bands M15, M16,</li> <li>• <math>t_{I5}</math> is the brightness temperature at <math>11.5 \mu\text{m} =</math> VIIRS Band I5.</li> </ul> <p>The equations above correspond to the IST ATBD (D0001-M01-S01-018) Appendix A, Section A.3.3.2 and A.3.3.3, Equations (A-13) and (A-14) with minor modifications.</p>

## 2.2.3 Graceful Degradation

### 2.2.3.1 Graceful Degradation Inputs

See Section 2.1.3.1.

### 2.2.3.2 Graceful Degradation Processing

None.

### 2.2.3.3 Graceful Degradation Outputs

None.

## 2.2.4 Exception Handling

When ST IP cannot be retrieved due to conditions such as invalid SDR data, cloudy pixel, non-processing pixel, ST IP pixel values are set to a FILL\_VALUE of -999.9. The ST IP QFs are unaffected by this condition and should still be set as they provide information on why the ST IP was not retrieved successfully.

## 2.2.5 Data Quality Monitoring

The only data quality monitoring is by way of the Surface Temperature IP quality flags listed in 474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 4.5.

## **2.2.6 Computational Precision Requirements**

Single precision 32-bit floating point computations are required for the Surface Temperature IP.

## **2.2.7 Algorithm Support Considerations**

474-00448-02-17\_JPSS-DD-Vol-II-Part-17, Section 7.2.2.3 contains the algorithm parameter coefficients and descriptions that may need updating throughout the JPSS program.

## **2.2.8 Assumptions and Limitations**

### **2.2.8.1 Assumptions**

The ST IP retrieval algorithm assumes VIIRS 375 M SDR, VIIRS 750 M SDR, VIIRS Ice Quality Flags IP, VIIRS Ice Weights IP, and VIIRS AOT IP are available before processing.

### **2.2.8.2 Limitations**

See 474-00448-04-17\_JPSS-SRSPF-Vol-IV-Part-17.

### 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 JPSS, an algorithm consists of: <ol style="list-style-type: none"> <li>1. A theoretical description (i.e., science/mathematical basis)</li> <li>2. A computer implementation description (i.e., method of solution)</li> <li>3. A computer implementation (i.e., code)</li> </ol>
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 GRAVITE facility. Delivered code is executed on compatible GRAVITE 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)	<p><i>[IORD Definition]</i>                      Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geophysical parameters (including ancillary parameters, e.g., cloud clear radiation, etc.).</p> <p><i>[Supplementary Definition]</i>                      An Environmental Data Record (EDR) represents the state of the environment, and the related information needed to access and understand the record. Specifically, it is a set of related data items that describe one or more related estimated environmental parameters over a limited time-space range. The parameters are located by time and Earth coordinates. EDRs may have been resampled if they are created from multiple data sources with different sampling patterns. An EDR is created from one or more 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.</p>
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.
Model Verification	The process of determining that a model implementation accurately represents the developer's conceptual description and specifications.
Operational Code	Verified science-grade software, delivered by an algorithm provider and verified by GRAVITE, is developed into operational-grade code by the IDPS IPT.
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.

Term	Description
Raw Data Record (RDR)	<p><i>[IORD Definition]</i></p> <p>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.</p> <p><i>[Supplementary Definition]</i></p> <p>A Raw Data Record (RDR) is a logical grouping of raw data output by a sensor, and related information needed to process the record into an SDR or TDR. Specifically, it is a set of unmodified raw data (mission and housekeeping) produced by a sensor suite, one sensor, or a reasonable subset of a sensor (e.g., channel or channel group), over a specified, limited time range. Along with the sensor data, the RDR includes auxiliary data from other portions of 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.</p>
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)	<p><i>[IORD Definition]</i></p> <p>Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to calibrated brightness temperatures with associated ephemeris data. The existence of the SDRs provides reversible data tracking back from the EDRs to the Raw data.</p> <p><i>[Supplementary Definition]</i></p> <p>A Sensor Data Record (SDR) is the recreated input to a sensor, and the related information needed to access and understand the record. Specifically, it is a set of incident flux estimates made by a sensor, over a limited time interval, with annotations that permit its effective use. The environmental flux estimates at the sensor aperture are corrected for sensor effects. The estimates are reported in physically meaningful units, usually in terms of an angular or spatial and temporal distribution at the sensor location, as a function of spectrum, polarization, or delay, and always at full resolution. When meaningful, the flux is also associated with the point on the Earth geoid from which it apparently originated. Also, when meaningful, the sensor flux is converted to an equivalent top-of-atmosphere (TOA) brightness. The associated metadata includes a record of the processing and sources from which the SDR was created, and other information needed to understand the data.</p>

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

### 3.2 Acronyms

Table 16 contains terms most applicable for this OAD.

**Table 16. Acronyms**

<b>Term</b>	<b>Expansion</b>
ACO	Atmospheric Correction over Ocean
AM&S	Algorithms, Models & Simulations
API	Application Programming Interfaces
ARP	Application Related Product
CDR	Climate Data Records
CI	Configured Item
COT	Cloud Optical Thickness
DMS	Data Management Subsystem
DQN	Data Quality Notification
IET	IDPS Epoch Time
IIS	Intelligence and Information Systems
INF	Infrastructure
ING	Ingest
IP	Intermediate Product
LUT	Look-Up Table
PRO	Processing
PW	Precipitable Water
QF	Quality Flag
RTM	Radiative Transfer Model
SDR	Sensor Data Records
SI	Software Item or International System of Units
SST	Sea Surface Temperature
ST	Surface Temperature
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		