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**Joint Polar Satellite System (JPSS)
Operational Algorithm Description (OAD)
Document for VIIRS Snow Cover
Environmental Data Record (EDR) Software**

For Public Release

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Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Snow Cover Environmental Data Record (EDR) Software

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Preface

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NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS SNOW COVER ENVIRONMENTAL DATA RECORD (EDR)

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

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

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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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Table of Contents

1.0	INTRODUCTION.....	1
1.1	Objective.....	1
1.2	Scope	1
1.3	References	1
1.3.1	Document References	1
1.3.2	Source Code References	3
2.0	ALGORITHM OVERVIEW	4
2.1	VIIRS Snow Cover EDR Description	4
2.1.1	Interfaces	4
2.1.1.1	Inputs	5
2.1.1.2	Outputs	11
2.1.2	Algorithm Processing.....	15
2.1.2.1	Main module – scd_main	15
2.1.2.2	SN_extract_data1	16
2.1.2.3	SN_make_pixel_masks	17
2.1.2.4	SN_binary_map	20
2.1.2.5	SN_write_edr	21
2.1.2.6	SN_bmap_qflags	25
2.1.2.7	SN_aggfrac_qflags	26
2.1.3	Graceful Degradation.....	26
2.1.3.1	Graceful Degradation Inputs	26
2.1.3.2	Graceful Degradation Processing	26
2.1.3.3	Graceful Degradation Outputs	26
2.1.4	Exception Handling	26
2.1.5	Data Quality Monitoring	27
2.1.12	Computational Precision Requirements	27
2.1.13	Algorithm Support Considerations	27
2.1.14	Assumptions and Limitations	27
3.0	GLOSSARY/ACRONYM LIST	29
3.1	Glossary	29
3.2	Acronyms.....	32
4.0	OPEN ISSUES	33

List of Figures

Figure 1. Snow Cover EDR Processing Overview..... 4
 Figure 2. Snow Cover Interfaces 5
 Figure 3. Snow Cover Algorithm Flow 16
 Figure 4. Logic flow for the Snow Cover Binary Map Algorithm..... 21
 Figure 5. Logic flow of SN_write_edr 22
 Figure 6. Logic Flow for the Snow Fraction Aggregation 23
 Figure 7. Logic Flow for SN_bmap_qflags to set Binary Map Quality Flags 24
 Figure 8. Logic Flow for Snow Fraction Quality Portion of SN_write_edr()..... 25

List of Tables

Table 1. Reference Documents 1
 Table 2. Source Code References..... 3
 Table 3. Snow Cover Global Attributes 6
 Table 4. Snow Cover Input: VIIRS SDR Moderate Resolution 6
 Table 5. Snow Cover Input: VIIRS SDR Imagery Resolution 7
 Table 6. Snow Cover Input: AOT IP..... 7
 Table 7. Snow Cover Input: Cloud Mask IP 7
 Table 8. Snow Cover Input: COP IP 8
 Table 9. Snow Cover Input: Snow Cover LUT 8
 Table 10. Snow Cover Input: Algorithm Processing Coefficients..... 9
 Table 11. Snow Cover Input: Snow Cover Quality LUT..... 9
 Table 12. Snow Cover Output: Snow Cover Binary Map EDR 12
 Table 13. Snow Cover Output: Aggregated Snow Fraction Binary Snow Map EDR 13
 Table 14. Description of VCM and Band Quality Bits (mask_i)..... 18
 Table 15. Description of VCM and Band Quality Bits (mask_m) 19
 Table 16. Relevant Parameters in SN_binary_map..... 20
 Table 17. Data Quality Threshold Table Tests 27
 Table 18. Glossary 29
 Table 19. Acronyms 32
 Table 20. TBXs 33

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.

1.2 Scope

The scope of this document is limited to the description of the core operational algorithm required to create the VIIRS Snow Cover EDR. The theoretical basis for this algorithm is described in Section 3.3 of the VIIRS Snow Cover Algorithm Theoretical Basis Document ATBD, 474-00038.

1.3 References

1.3.1 Document References

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

Table 1. Reference Documents

Document Title	Document Number/Revision	Revision Date
VIIRS Snow Cover Algorithm Theoretical Basis Document ATBD	474-00038	22 Apr 2011
Operational Algorithm Description Document for VIIRS Cloud Mask Intermediate Product (VCM IP)	474-00062, Rev A	27 Jan 2012
JPSS Environmental Data Record (EDR) Production Report for NPP	474-00012 Rev. A	09 Feb 2011
JPSS Environmental Data Record (EDR) Interdependency Report (IR) for NPP	474-0007 Rev. A	09 Feb 2011
NPP Mission Data Format Control Book and App A (MDFCB)	472-REF-00057, Rev B	06 Jan 2011
JPSS Common Data Format Control Book - External -	474-00001-01, Rev-	10-Dec-10

Document Title	Document Number/Revision	Revision Date
Volume I - Overview		
JPSS Common Data Format Control Book - External - Volume II - RDR Formats	474-00001-02, Rev-	10-Dec-10
JPSS Common Data Format Control Book - External - Volume III - SDR/TDR Formats	474-00001-03, Rev-	16-Feb-11
JPSS Common Data Format Control Book - External - Volume IV - Part I - IPs, ARPs, and Geolocation Data	474-00001-04-01, Rev-	10-Dec-10
JPSS CDFCB - External - Volume IV - Part II - Imagery, Atmospheric, and Cloud EDRs	474-00001-04-02, Rev-	10-Dec-10
JPSS Common Data Format Control Book - External - Volume IV - Part III - Land and Ocean/Water EDRs	474-00001-04-03, Rev-	10-Dec-10
JPSS Common Data Format Control Book - External - Volume IV - Part IV - Earth Radiation Budget and Space EDRs	474-00001-04-04, Rev-	18-Feb-11
JPSS Common Data Format Control Book - External - Volume V - Metadata	474-00001-05, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VI - Ancillary Data, Auxiliary Data, Messages, and Reports	474-00001-06, Rev-	10-Dec-10
JPSS Common Data Format Control Book - External - Volume VII - Part I - JPSS Downlink Data Formats	474-00001-07-01, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VII - Part 2 - JPSS Downlink Data Formats - CrIS	474-00001-07-02, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VII - Part 3 - JPSS Downlink Data Formats - OMPS	474-00001-07-03, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VII - Part 4 - JPSS Downlink Data Formats - ATMS	474-00001-07-04, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VII - Part 5 - JPSS Downlink Data Formats - VIIRS	474-00001-07-05, Rev-	16-Feb-11
JPSS Common Data Format Control Book - External - Volume VIII - Look Up Table Formats	474-00001-08, Rev-	10-Dec-10
NPP Command and Telemetry (C&T) Handbook	D568423 Rev. C	30 Sep 2008
JPSS CGS Data Processor Inter-subsystem Interface Control Document (DPIS ICD) Vol I – IV	IC60917-IDP-002, Rev C	29-Sep-11
VIIRS Snow Cover Unit Detailed Design Document	Y3234 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
NGST/SE technical memo – Snow Cover Algorithm Ocean Fill Value Fix	NP-EMD.2007.510.0028	19 Apr 2007
NGST/SE technical memo – Snow Cover Algorithm OAD Updates for Fresh Water Lake Processing Drop	NP-EMD.2007.510.0021	23 Feb 2007
NGST/SE technical memo – NPP_VIIRS_SnowCover_550nmAOT_OAD_update	NP-EMD.2006.510.0075	15 Oct 2006
NGST/SE technical memo – MS_Engineering_Memo_SnowCover_OAD_Update	NP-EMD.2005.510.0129	14 Nov 2005
IDPS Processing SI Common IO Design Document	DD60822-IDP-011 Rev. A	21 Jun 2007
JPSS CGS Acronyms and Glossary	LI60917-GND-005, Rev -	17-Oct-11
NGST/SE technical memo – Granule-Level Summary Exclusion Flag Definition Rev. C	NP-EMD.2010.510.0005.Rev-C	02 Mar 2010
NGST/SE technical memo – Snow Cover OAD Update for b _{max} thermal threshold	NP-EMD.2010.510.0097	22 Dec 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.

Table 2. Source Code References

Reference Title	Reference Tag/Revision	Revision Date
VIIRS Snow Cover -- science-grade software	ISTN_VIIRS_NGST_3.3 (ECR A-048 (OAD Rev ---))	29 Apr 2005
VIIRS Snow Cover -- operational software	Build 1.4 (OAD Rev A1)	04 May 2005
VIIRS Snow Cover -- science-grade software	ISTN_VIIRS_NGST_3.3.1 (ECR A-074) (OAD: see TM 2005.510.0129)	14 Nov 2005
VIIRS Snow Cover -- operational software	Build 1.4 Follow-on (OAD Rev A3)	16 Jan 2006
VIIRS Snow Cover -- science-grade software	ISTN_VIIRS_NGST_3.3.3 (ECR A-121A) (OAD: see TM 2007.510.0021)	04 Apr 2007
VIIRS Snow Cover -- operational software	Build 1.5 (OAD Rev A7)	May 2007
VIIRS Snow Cover -- science-grade software	ISTN_VIIRS_NGST_3.3.4 (No OAD dropped by NG)	26 Apr 2007
VIIRS Snow Cover -- operational software	Build 1.5 Follow-on (OAD Rev A9)	24 Oct 2007
ACCB (No code updates)	OAD Rev A	15 Jan 2009
RFA Update (No code updates)	(OAD Rev C1)	01 Dec 2009
Implement TIM comments	(OAD Rev C2)	25 May 2010
PCR20629 (TM 2010.510.00005.Rev-C)	Sensor Characterization Build SC-09 (No OAD Update)	22 Apr 2010
ACCB (no code update)	OAD Rev C	07 Jul 2010
VIIRS Snow Cover - Algorithm Development Library	Mx1.5.4.00 (OAD Rev D2)	29 Sep 2010
Convergence Update (No code updates)	Mx1.5.4.00 (OAD Rev D3)	13 Oct 2010
PCR023893	Mx1.5.5_A (OAD Rev D4)	28 Oct 2010
VIIRS Snow Cover -- science-grade software (includes TM 2010.510.0097)	ISTN_VIIRS_NGST_3.3.5	14 Jan 2011
VIIRS Snow Cover -- operational software (PCR025927)	Mx1.5.6_B (OAD not updated)	10 May 2011
PCR026168 (OAD Update for 3.3.5/TM 2010.510.0097)	(OAD Rev D5)	21 Sep 2011

2.0 ALGORITHM OVERVIEW

The purpose of the Snow Cover EDR algorithm is to produce the following products:

- Snow Cover Binary Map (@ 375M resolution)
- Snow Fraction (@ 750M resolution).

The Snow Cover algorithm requires SDR, IP, and LUT input to produce the EDR output. This algorithm is heavily reliant on lookup tables (LUTs) which are described in Section 2.1.1.1. The overall processing chain is shown in Figure 1.

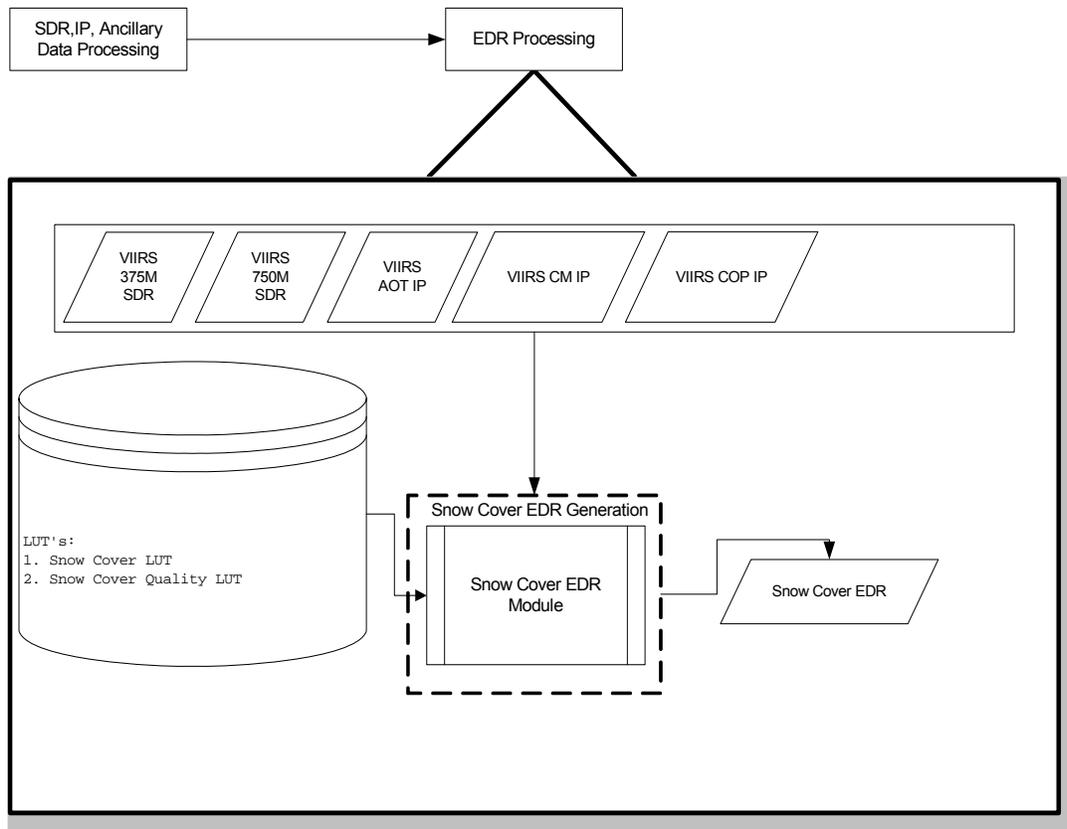


Figure 1. Snow Cover EDR Processing Overview

2.1 VIIRS Snow Cover EDR Description

The Snow Cover EDR retrieval algorithm and the theoretical basis are described in detail in the VIIRS Snow Cover Algorithm Theoretical Basis Document ATBD, 474-00038, Section 3.3.

2.1.1 Interfaces

The main interfaces to the operational Snow Cover EDR algorithm are shown in Figure 2 below. The Snow Cover EDR algorithm receives all the required input data from DMS. The derived algorithm (ProEdrViirsSnow) retrieves input and output data buffers from DMS and supplies them to the algorithm. When all the input data needed for processing is available, the main module (scd_main) is called to produce the Snow Binary Map EDR output data and the Snow Fraction EDR output data.

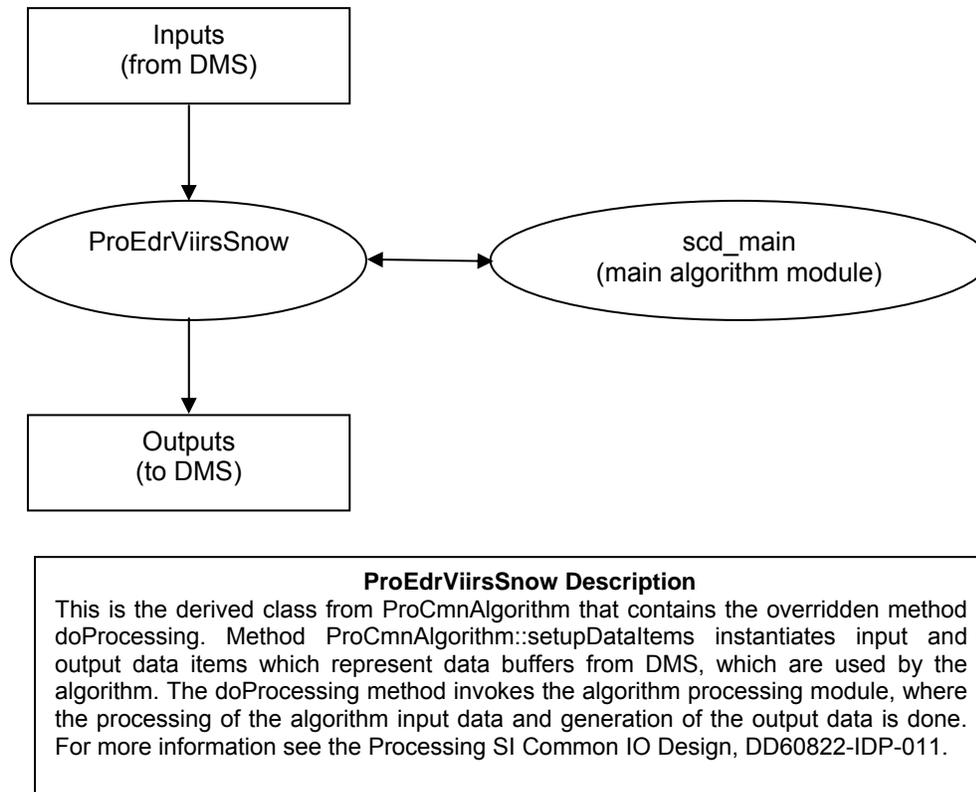


Figure 2. Snow Cover Interfaces

Note: For Sections 2.1.1.1 and 2.1.1.2 below, the following applies:

- Fill values corresponding to the individual pixels in each product that do not contain valid data are dictated by the datatype. The following fill values apply: NA_UINT8_FILL for UInt8 datatypes, -1 for Int8 datatypes, NA_FLOAT32_FILL for Float32 datatypes, 0 for quality flags.
- For detailed descriptions of the quality flags in Tables 6 through 8, refer to the applicable I-P-O algorithm OAD (AOT, CM, or COP).
- Table 3 shows global attributes used in the input/output descriptions.

2.1.1.1 Inputs

Tables 4 through 11 describe the inputs for the Snow Cover algorithm. Table 3 describes global attributes used in the array dimensions.

All fields italicized and flagged with an asterisk are related to the legacy Multiple End-member Spectral Mixture Analysis (MESMA) algorithm. It should be noted that NGST has commented out branches that allow invoking the MESMA method in the delivered science code so that it may be implemented at a later time if deemed necessary. Therefore, the spectral mixture method is not implemented operationally at the current time.

Table 3. Snow Cover Global Attributes

Input	Type	Description	Units/Valid Range
Global attributes for Data Items			
I_VIIRS_SDR_COLS	int*32	Number of imagery resolution pixels in scan direction (VIIRS scan dimension)	Unitless/ I_VIIRS_SDR_COLS > 0 (Currently set to 6400)
I_VIIRS_SDR_ROWS	int*32	Number of imagery resolution along-track lines in a VIIRS granule (VIIRS along-track dimension)	Unitless/ I_VIIRS_SDR_ROWS > 0 (Currently set to 1536)
M_VIIRS_SDR_COLS	int*32	Number of moderate resolution pixels in scan direction (VIIRS scan dimension)	Unitless/ M_VIIRS_SDR_COLS > 0 (Currently set to 3200)
M_VIIRS_SDR_ROWS	int*32	Number of moderate resolution along-track lines in a VIIRS granule (VIIRS along-track dimension)	Unitless/ M_VIIRS_SDR_ROWS > 0 (Currently set to 768)
nbands_m	int*32	Number of Moderate Resolution Bands	Unitless/ nbands_m > 0 (Currently set to 9)
nbands_i	int*32	Number of Imagery Resolution Bands	Unitless/ nbands_i > 0 (Currently set to 3)
<i>ntypes</i> *	int*32	Number of Snow Types 24 snow types = 6 grain sizes (50, 100, 250, 500, 750, 1000 micron radius) x 4 impurity levels (0, 1, 10, 100ppmw)	Unitless/ 1 ≤ ntypes ≤ 24 (Currently set to 24)
<i>n_ami</i> *	int*32	Number of Aerosol Models	Unitless/ 1 ≤ n_ami ≤ 9 (Currently using 2 models, "Continental" and "Marine")

* Fields that are related to the legacy MESMA algorithm.

Table 4. Snow Cover Input: VIIRS SDR Moderate Resolution

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
BrightTemp_M15 bt15_m	float*32 x M_VIIRS_SDR_COLS x M_VIIRS_SDR_ROWS	Band M15 Brightness Temperatures	Units: Kelvin Range: bt15_m ≥ 0.0
BrightTemp_M16 bt16_m	float*32 x M_VIIRS_SDR_COLS x M_VIIRS_SDR_ROWS	Band M16 Brightness Temperatures	Units: Kelvin Range: bt16_m ≥ 0.0
SolZenAng_Mod sza_m	float*32 x M_VIIRS_SDR_COLS x M_VIIRS_SDR_ROWS	Solar Zenith Angle @ Moderate Resolution (from Geolocation)	Units: Degrees Range: 0 ≤ sza_m ≤ 180

Table 5. Snow Cover Input: VIIRS SDR Imagery Resolution

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
Reflectance_I1 toa_refl_i(:,:1)	float*32 x I_VIIRS_SDR_CO LS x I_VIIRS_SDR_RO WS	TOA Reflectances for band I1	Units: Unitless Range: toa_refl_i ≥ 0.0
Reflectance_I2 toa_refl_i(:,:2)	float*32 x I_VIIRS_SDR_CO LS x I_VIIRS_SDR_RO WS	TOA Reflectances for band I2	Units: Unitless Range: toa_refl_i ≥ 0.0
Reflectance_I3 toa_refl_i(:,:3)	float*32 x I_VIIRS_SDR_CO LS x I_VIIRS_SDR_RO WS	TOA Reflectances for band I3	Units: Unitless Range: toa_refl_i ≥ 0.0
BrightTemp_I5 bt5_i	float*32 x I_VIIRS_SDR_CO LS x I_VIIRS_SDR_RO WS	Band I5 Brightness Temperatures	Units: Kelvin Range: bt5_i ≥ 0.0
SolZenAng_Img sza_i	float*32 x I_VIIRS_SDR_CO LS x I_VIIRS_SDR_RO WS	Solar Zenith Angle @ Imagery Resolution Resolution (from Geolocation)	Units: Degrees Range: 0 ≤ sza_i ≤ 180
SenZenAng_Img vza_i	float*32 x I_VIIRS_SDR_CO LS x I_VIIRS_SDR_RO WS	Sensor Zenith Angle @ Imagery Resolution Resolution (from Geolocation)	Units: Degrees Range: -90 ≤ vza_i ≤ 90

Table 6. Snow Cover Input: AOT IP

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
AOT aot_m	float*32 x M_VIIRS_SDR_COLS x M_VIIRS_SDR_ROWS	Aerosol Optical Thickness (550 nm) @ 750m	Units: Unitless aot_m ≥ 0.0

Table 7. Snow Cover Input: Cloud Mask IP

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
GranuleAllOcean	uint*8	Flag indicating the granule is all ocean	Bitwise flags
Pixel-Level Data Items			
Vcm0	uint*8 x M_VIIRS_SDR_C OLS x M_VIIRS_SDR_R OWS	VIIRS Cloud Mask IP byte 0	Bitwise flags
Vcm1	uint*8 x M_VIIRS_SDR_C OLS x M_VIIRS_SDR_R OWS	VIIRS Cloud Mask IP byte 1	Bitwise flags

Input	Type	Description	Units/Valid Range
Vcm2	uint*8 x M_VIIRS_SDR_C OLS x M_VIIRS_SDR_R OWS	VIIRS Cloud Mask IP byte 2	Bitwise flags
Vcm3	uint*8 x M_VIIRS_SDR_C OLS x M_VIIRS_SDR_R OWS	VIIRS Cloud Mask IP byte 3	Bitwise flags
Vcm4	uint*8 x M_VIIRS_SDR_C OLS x M_VIIRS_SDR_R OWS	VIIRS Cloud Mask IP byte 4	Bitwise flags
Vcm5	uint*8 x M_VIIRS_SDR_C OLS x M_VIIRS_SDR_R OWS	VIIRS Cloud Mask IP byte 5	Bitwise flags

Table 8. Snow Cover Input: COP IP

Input	Type	Description	Units/Valid Range
<i>Pixel-Level Data Items</i>			
COP IP cot_m	float*32 x M_VIIRS_SDR_R OW x M_VIIRS_SDR_C OLS	Cloud Optical Thickness @ 750m resolution	Units: Unitless Range: cot_m ≥ 0.0

Table 9. Snow Cover Input: Snow Cover LUT

Input	Type	Description	Units/Valid Range
<i>nbands_m</i> *	int*32	Number of moderate resolution bands	Unitless/ nbands > 0 (Currently set to 9)
<i>band_m</i> *	int*32 x nbands_m	Band Numbers (nbands_m in size)	Unitless/ [1,2,3,4,5,7,8,10,11]
num_r_water	int*32	Number of water reflectance thresholds (For I1 and I2)	Unitless/ num_r_water > 0 (Currently set to 2)
r_water	float*32 x num_r_water	Water Reflectance Thresholds (For I1 and I2)	Unitless/ 0.0 ≤ r_water ≤ 1.0 r_water = [0.11, 0.11]
ndsi_thre1	float*32	First NDSI Threshold	Unitless/ (Currently set to 0.4)
ndsi_thre2	float*32	Second NDSI Threshold	Unitless (Currently set to 0.1)
n_max_coeff	int*32	Number of NDVI Maximum Coefficients	Unitless n_max_coeff > 0 (Currently set to 4)

Input	Type	Description	Units/Valid Range
ndvi_max_coeff	float*32 x n_max_coeff	NDVI Maximum Coefficients	Unitless ndvi_max_coeff = [-0.28,6.4,- 12.0,10.0]
n_min_coeff	int*32	Number of NDVI Minimum Coefficients	Unitless n_min_coeff > 0 (Currently set to 2)
ndvi_min_coeff	float*32 x n_min_coeff	NDVI Minimum Coefficients	Unitless/ ndvi_min_coeff = [0.32,-0.70]
btmax	float*32	Brightness Temperature Threshold	Kelvin/ (Currently set to 281.0)
ntypes *	int*32	Number of Snow Types (6 grain size * 4 impurities = 24 types)	Unitless/ 1 ≤ ntypes ≤ 24 (Currently set to 24)
frac_option	int*32	Flag which determines which snow fraction algorithm to run	Unitless/ 0 = Spectral Mixing Algorithm 1 = Binary Snow Map Aggregation 2 = Both (Currently set to 1)

* Fields that are related to the legacy MESMA algorithm.

Table 10. Snow Cover Input: Algorithm Processing Coefficients

Input	Type	Description	Units/Valid Range
cot_switch	int*32	Switch to flag use of VIIRS Cloud Mask or Cloud Optical Thickness for determining cloud confidence	Unitless/ 0 = Use VCM 1 = Use COT (Currently set to 0)

Table 11. Snow Cover Input: Snow Cover Quality LUT

Input	Type	Description	Units/Valid Range
nbands_i	int*32	Number of Imagery Resolution Bands	Unitless/ nbands_i > 0 (Currently set to 3)
nbands_m *	int*32	Number of Moderate Resolution Bands	Unitless/ nbands_m > 0 (Currently set to 9)
band_wgt *	float*32 x nbands_m	Default Moderate Resolution Band Weights	Unitless/ 0.0 ≤ band_wgt ≤ 1.0 band_wgt = [1.0,1.0,1.0, 1.0,1.0,1.0, 1.0,1.0,1.0]
num_aot_bins	int*32	Number of AOT bins, corresponding to the number of AOT values used for thresholding (aot_bin, this table)	Unitless/ num_aot_bins > 0 (Currently set to 4)
aot_bins	float*32 x num_aot_bins	AOT Bin Boundary Values	Unitless/ 0.0 ≤ aot_bin ≤ 1.0 aot_bin = [0.0,0.15,0.5,1.0]

Input	Type	Description	Units/Valid Range
num_thresh	int*32	Number of Solar Zenith Angle Thresholds	Unitless num_thresh > 0 (Currently set to 2)
q_aot_sza**	float*32 x (nbands_i + nbands_m) x num_aot_bins x num_thresh	Solar Zenith Angle values that correspond to the Solar Zenith Angle quality regimes (G/Y = "Green/Yellow", Y/R = "Yellow/Red", this corresponds to the "2" in the "Data Types/Size" column) and to the "aot_bin" values ((1) -> 0.0, (2) -> 0.15, (3) -> 0.5, (4) -> 1.0). The order for each num_aot_bin x num_thresh matrix of angles is: I1, I2, I3, M1, M2, M3, M4, M5, M7, M8, M10, and M11	Radians/ -π/2 ≤ sza_bin ≤ π/2 (I1,I2,I3,M1,M2,M3, M4,M5,M7,M8,M10, M11) (G/Y) (Y/R) [75.0, 85.0;(1) 70.0, 85.0;(2) 65.0, 80.0;(3) 60.0, 75.0](4) (Order of bands follows the scheme showed above)
cot_switch	int*32	Switch to flag use of VIIRS Cloud Mask or Cloud Optical Thickness for determining cloud confidence	Unitless/ 0 = Use VCM 1 = Use COT (Currently set to 0)
num_cloud_types	int*32	Number of Cloud Types	Unitless/ num_cloud_types > 0 (Currently set to 7)
cloud_wgts**	float*32 x num_cloud_types x nbands	Cloud weights corresponding to the 3 imagery bands + 9 moderate bands and the 7 cloud properties – 4 phases = Default (1), Water (2), Ice (3), Mixed (4), and 3 types = cirrus (5), shadow (6), adjacency (7); the parenthetical values correspond to the rows of the matrix shown in the "Units/Range" cell, the column represent the bands I1, I2, I3, M1, M2, M3, M4, M5, M7, M8, M10, and M11 in this order.	Unitless/ 0.0 ≤ cloud_wgts ≤ 1.0 cloud_wgts = (I1,I2,I3,M1,M2,M3, M4,M5,M7,M8,M10, M11) [0.5;(1) 0.5;(2) 0.5;(3) 0.5;(4) 0.6;(5) 0.3;(6) 0.8](7)
cot_gy	float*32 x (nbands_i + nbands_m) x num_cloud_types	Cloud Optical Thickness "GREEN/YELLOW" quality threshold values	Unitless/ cot_gy = 0.2
cot_yr	float*32 x (nbands_i + nbands_m) x num_cloud_types	Cloud Optical Thickness "YELLOW/RED" quality threshold values	Unitless/ cot_yr = 0.5
qwgt_r	float*32 x (nbands_i + nbands_m)	Solar Zenith Angle boundaries "RED"	Unitless/ qwgt_r = 0.3
qwgt_y	float*32 x (nbands_i + nbands_m)	Solar Zenith Angle boundaries "YELLOW"	Unitless/ qwgt_y = 0.5
qwgt_g	float*32 x (nbands_i + nbands_m)	Solar Zenith Angle boundaries "GREEN"	Unitless/ qwgt_g = 0.7
frac_wgt_yr	float*32	Fractional Weight "YELLOW/RED" Threshold	Unitless/ (Currently frac_wgt_yr = 0.4)
fract_wgt_gy	float*32	Fractional Weight "GREEN/YELLOW" Threshold	Unitless/ (Currently frac_wgt_gy = 0.6)

Input	Type	Description	Units/Valid Range
sfrac_bmap_excl_t hresh1	float*32	Snow fraction threshold lower limit for binary map exclusion (0.2 < snow fraction < 0.7)	Unitless sfrac_bmap_excl_t hresh1 = 0.2
sfrac_bmap_excl_t hresh2	float*32	Snow fraction threshold upper limit for binary map exclusion (0.2 < snow fraction < 0.7)	Unitless sfrac_bmap_excl_t hresh2 = 0.7
sza_sfrac_degrad_t hresh1	float*32	Solar zenith angle threshold lower limit for degraded snow fraction condition (70 deg <=sza<=85 deg)	Radians sza_sfrac_degrad_t hresh1 = 70 * DEG2RAD
sza_sfrac_degrad_t hresh2	float*32	Solar zenith angle threshold upper limit for degraded snow fraction condition (70 deg <=sza<=85 deg)	Radians sza_sfrac_excl_thre sh2 = 85 * DEG2RAD
sza_bmap_excl_thr esh	float*32	Solar zenith angle threshold for binary map exclusion (sza > 60 deg)	Radians sza_bmap_excl_thr esh = 60 * DEG2RAD
sza_sfrac_excl_thre sh	float*32	Solar zenith angle threshold for snow fraction exclusion (sza > 85 deg)	Radians sza_sfrac_excl_thre sh = 85 * DEG2RAD
aot_excl_thresh	float*32	Aerosol optical thickness exclusion threshold (aot>1.0)	Unitless aot_excl_thresh = 1.0
sza_daynight_thres h	float*32	Solar zenith angle threshold for setting night fill values.	Radians sza_daynight_thres h = 85 * DEG2RAD

* Fields that are related to the legacy MESMA algorithm.

** q_aot_sza and cloud_wgts arrays contain imagery band weights and legacy MESMA algorithm weight values.

2.1.1.2 Outputs

Tables 12 and 13 describe the outputs of the Snow Cover algorithm.

The Snow Cover Algorithm produces a Snow Binary Map EDR output file and a Snow Fraction EDR output File. Setting frac_option to one or two produces a Snow Fraction EDR based on 2x2 aggregation of the binary snow cover map. In the science code, setting frac_option to zero produces a Snow Fraction EDR based on the spectral mixture method and setting frac_option to two produces both the Snow Binary Map EDR and the Snow Fraction EDR based on the spectral mixing method. NGST commented out branches that allow invoking the spectral mixture method in the delivered code so that the spectral mixture method may be implemented at a later time if deemed necessary. This code is not implemented operationally at this time.

The Snow Cover Binary Map EDR file is a binary format output file consisting of four imagery resolution layers. The contents of this file are shown in Table 12. The binary map quality (BinaryMapQual) is a data field consisting of three bytes of quality flags per pixel.

Table 12. Snow Cover Output: Snow Cover Binary Map EDR

Input	Type/Size	Description			Units/Valid Range
Granule-Level Data Items					
Binary Map Quality (Metadata)	int*8	Percent of pixels with high quality			Percent / 0-100
Exclusion Summary (Metadata)	int*8	Percent of pixels with excluded conditions			Percent / 0-100
Pixel-Level Data Items					
BinaryMap	int*8 x I_VIIRS_S DR_COLS x I_VIIRS_S DR_ROWS	Snow Binary Map			Unitless/ 0 = No Snow 1 = Snow <i>FILL_VALUE</i> = (See CDFCB-X Vol IV part 3 (D34862-04-03), Table 5.4.5.2.1.2-1 for fill values)
BinaryMapQual (quality bit flags)	int*8 x I_VIIRS_S DR_COLS x I_VIIRS_S DR_ROWS	0	0-1	Overall Pixel Quality	00 = GREEN (high) 01 = YELLOW (medium) 10 = RED (bad) 11 = FILL (no retrieval)
			2	Input SDR Quality (bands I1, I2, I3)	0 = Good 1 = Bad
			3-4	Cloud Confidence	00 = confidently clear 01 = probably clear 10 = probably cloudy 11 = confidently cloudy
			5	Solar Zenith Angle Exclusion	0 = No (no exclusion) 1 = Yes (exclusion condition: sza > 60 deg)
			6	Aerosol Optical Thickness Exclusion	0 = No (no exclusion) 1 = Yes (exclusion condition: aot > 1.0; based on slant path AOT)
			7	Snow Fraction Exclusion	0 = No (no exclusion) 1 = Yes (exclusion condition: snow fraction between 0.2 and 0.7)
		1	0	Thin Cirrus	0 = No 1 = Yes (thin cirrus detected; based on VCM thin cirrus quality flag)
			1	Cloud Shadow	0 = No 1 = Yes
			2-3	Cloud Phase	00 = Clear 01 = Water 10 = Ice 11 = Mixed
			4	Forest	0 = No 1 = Yes

Input	Type/Size	Description		Units/Valid Range	
			5-6	Land/Water	00 = Land 01 = Coastal 10 = Inland Water 11 = Ocean
			7	Sun Glint	0 = No 1 = Yes
		2	0	Thermal Threshold Exceeded	0 = No 1 = Yes
			1	NDSI Quality	0 = Good 1 = Bad
			2	NDVI Quality	0 = Good 1 = Bad
			3	Fire	0 = No 1 = Yes
			4-7	Spare	Spare

The Snow Fraction Binary Snow Map is a binary file consisting of five moderate resolution layers. The contents of this file are shown in Table 13. The snow fraction quality (FractionQual) is a data field consisting of three bytes of quality flags per pixel.

Table 13. Snow Cover Output: Aggregated Snow Fraction Binary Snow Map EDR

Input	Type/Size	Description		Units/Valid Range	
Granule-Level Data Items					
Snow Fraction Quality (Metadata)	int*8	Percent of pixels with high quality		Percent / 0-100	
Degradation Summary (Metadata)	int*8	Percent of pixels with degraded conditions		Percent / 0-100	
Exclusion Summary (Metadata)	int*8	Percent of pixels with excluded conditions		Percent / 0-100	
Pixel-Level Data Items					
FractionFromBinary Map	float*32 x M_VIIRS_S DR_COLS x M_VIIRS_S DR_COLS	Snow Fraction reported at Moderate Resolution		Unitless/ 0.0 ≤ FractionFromBinary Map ≤ 1.0 <i>FILL_VALUE</i> = (See CDFCB-X Vol IV part 3 (D34862-04-03), Table 5.4.5.2.2.2- 1for fill values)	
NumAggPix	int*8 x M_VIIRS_S DR_COLS x M_VIIRS_S DR_ROWS	Number of Imagery Pixels Aggregated		Unitless/ 0 ≤ NumAggPix ≤ 4 <i>FILL_VALUE</i> = (See CDFCB-X Vol IV part 3 (D34862-04-03), Table 5.4.5.2.2.2- 1for fill values)	
FractionQual	int*8 x M_VIIRS_S DR_COLS x M_VIIRS_S DR_ROWS	0	0-1	Overall Pixel Quality	00 = GREEN (high) 01 = YELLOW (medium) 10 = RED (bad) 11 = FILL (no retrieval)
			2	Input SDR quality (bands I1, I2, I3)	0 = Good 1 = Bad

Input	Type/Size	Description	Units/Valid Range
		3-4	Cloud Confidence 00 = confidently clear 01 = probably clear 10 = probably cloudy 11 = confidently cloudy
		5	Solar Zenith Angle Degradation 0 = No (no degradation) 1 = Yes (degradation condition: sza between 70 and 85 deg)
		6	Forest Exclusion 0 = No 1 = Yes
		7	Solar Zenith Angle Exclusion 0 = No (no exclusion) 1 = Yes (exclusion condition: sza > 85 deg)
1	0	Aerosol Optical Thickness Exclusion	0 = No (no exclusion) 1 = Yes (exclusion condition aot > 1.0; based on slant path AOT)
	1	Thin Cirrus	0 = No 1 = Yes (thin cirrus detected; based on VCM thin cirrus quality flag)
	2	Cloud Shadow	0 = No 1 = Yes
	3-4	Cloud Phase	00 = Clear 01 = Water 10 = Ice 11 = Mixed
	5-6	Land/Water	00 = Land 01 = Coastal 10 = Inland Water 11 = Ocean
	7	Sun Glint	0 = No 1 = Yes
2	0	Snow Reflectance (place holder)	0 = Good 1 = Bad
	1	Non-snow Reflectance (place holder)	0 = Good 1 = Bad
	2	Snow Fraction Out of Valid Range (place holder)	0 = No 1 = Yes
	3	Fire	0 = No 1 = Yes
	4-7	Spare	Spare

The aerosol optical thickness exclusion is based on a slant path AOT. A vertical column AOT is also utilized in the Snow Cover algorithm for all Lookup table applications such as the input interpolation coordinate for computing pixel quality weights (AOT/SZA quality LUT) and spectral mixture method computations (spectral mixture method not implemented operationally).

2.1.2 Algorithm Processing

The Snow Cover EDR algorithm calculates two datasets: a snow cover binary map (375M) and snow fraction (750M). The algorithms that produce the snow cover binary map and the snow fraction are encapsulated in one large Fortran 90 routine (scd_main). The binary map algorithm only requires a few LUT table parameters, various VCM bits, and the quality of the imagery reflectance bands I1, I2, and I3. The brightness temperature in the I5 band is also utilized for performing thermal threshold screening. The brightness temperatures in the M15 and M16 bands are utilized for the thermal threshold screening for graceful degradation in the event that the I5 band quality is bad. The binary map logic and computation are described in Section 2.1.2.4. The Snow Cover EDR algorithm subroutine calls are shown in Figure 3.

2.1.2.1 Main module – scd_main

The main module is a driver routine that calls four subroutines in order to produce the binary map and snow fraction. First, SN_extract_data1 is called to extract SDR, IP and LUT data to be used by the algorithm. Next, SN_make_pixel_masks is called to create the moderate and imagery resolution pixel masks for use in determining the binary snow map quality and snow fraction quality. SN_binary_map is then called to create the snow cover binary map. Lastly, the SN_write_edr subroutine is called. This routine generates the snow fraction values and writes the snow cover EDR data to output buffers. It calls routines to set the snow cover binary map quality flags and the snow fraction quality flags. The sequence of subroutine calls is shown in Figure 3.

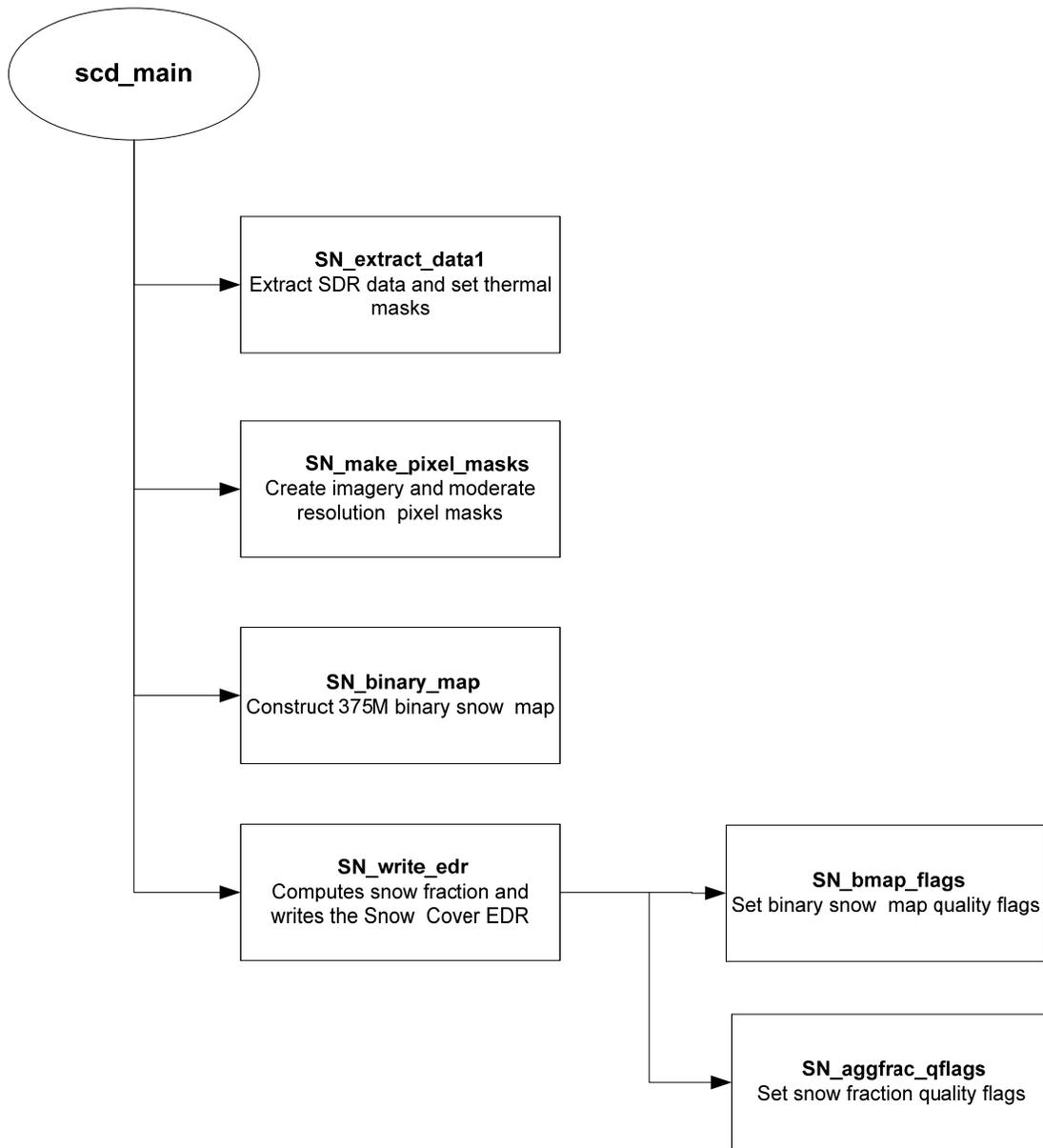


Figure 3. Snow Cover Algorithm Flow

2.1.2.2 SN_extract_data1

This routine extracts data from the moderate and imagery resolution SDR data for later use in creating the moderate and imagery resolution pixel masks. Imagery and Moderate resolution thermal masks are also created here from brightness temperatures for I5, M15, and M16. A brightness temperature threshold is read from the Snow Cover Quality LUT. The thermal mask is set for each pixel. If the threshold is exceeded for at least one band, then the mask value is set to zero. If all bands exceed the threshold, then the mask is set to -1. Otherwise the mask is set to one. The imagery resolution thermal mask is used in setting the thermal mask quality bit in SN_bmap_qflags. If the thermal mask value is set to one for a pixel, then the binary snow cover map will be set to zero (no snow) for that pixel in routine SN_binary_map.

2.1.2.3 SN_make_pixel_masks

This routine performs pixel masking and pixel weighting, using information in the VIIRS moderate and imagery resolution SDR, VIIRS Aerosol Optical Thickness IP, VIIRS Cloud Optical Thickness IP (if COT switch is set to use COT), VIIRS Cloud Mask IP, and the Snow Quality LUT.

Pixel weights are determined for each band and for both imagery resolution and moderate resolution. The weights are obtained by reducing an initialized band weight (w_0) by various weight reduction factors:

$$w(\text{band, pixel}) = w_0(\text{band}) * W_{\text{cloud}} * W_{\text{aerosol}}$$

where:

- w_0 is the initial default value for a band
- W_{cloud} is the weight reduction factor for cloud contamination
- W_{aerosol} is the weight reduction factor for aerosols

The moderate resolution weights are first initialized with default values from Snow Cover Quality LUT and the imagery resolution weights are initialized to 1.0.

Weight reduction factors for cloud contamination are obtained from the Snow Cover Quality LUT. The LUT includes factors for various cloud types (water, ice, and mixed), thin cirrus, cloud shadow, and cloud adjacency. The algorithm allows for the option of determining cloud weight reduction factors from cloud optical thickness (COT), obtained from the VIIRS Cloud Optical Properties IP. This option is controlled by the COT usage switch which is the only processing coefficient currently used by this algorithm. The COT-dependent weight reduction factor is determined from the COT thresholds obtained from the Snow Quality LUT. These include “Red/Yellow” and “Yellow/Green” thresholds. If the pixel COT is greater than the “Red/Yellow” threshold for a given band, the pixel/band weight is set to zero. If the pixel COT is less than the “Yellow/Green” threshold for a given band, the pixel/band weight is unaffected. For a pixel COT in the range between the two thresholds, the pixel/band weight is reduced by a factor computed by linear interpolation of COT between the two thresholds:

$$W_{\text{cloud}} = (\text{COT_YR}(\text{band}) - \text{COT}(\text{pixel})) / (\text{COY_YR}(\text{band}) - \text{COT_GY}(\text{band}))$$

Weight reduction factors for aerosols are determined in combination with the solar zenith angle (SZA), to allow for greater aerosol degradation at higher SZA. Band-dependent threshold values of SZA for a set of aerosol optical thickness (AOT) nodes are obtained from the Snow Quality LUT. These include “Red/Yellow” and “Yellow/Green” thresholds. If the pixel SZA is greater than the “Red/Yellow” threshold for a given band, the pixel/band weight is set to zero. If the pixel SZA is less than the “Yellow/Green” threshold for a given band, the pixel/band weight is unaffected. For a pixel SZA in the range between the two thresholds, the pixel/band weight is reduced by a factor computed by linear interpolation of SZA between the two thresholds:

$$W_{\text{aerosol}} = (\text{SZA_YR}(\text{band}) - \text{SZA}(\text{pixel})) / (\text{SZA_YR}(\text{band}) - \text{SZA_GY}(\text{band}))$$

Pixel quality masks are determined for both imagery resolution (Table 14) and moderate resolution (Table 15) pixels. This routine takes the VCM and constructs quality bits, stored in the variables “mask_i” and “mask_m”, for the purpose of determining the binary snow map quality and snow fraction quality respectively.

Table 14. Description of VCM and Band Quality Bits (mask_i)

BYTE	Bit	Flag Description Key	Result
0	0	Land/Ocean Background	0 = Land 1 = Ocean
	1	Forest	0 = No 1 = Yes
	2	Coastline	0 = No 1 = Yes
	3-4	Cloud Quality	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR) (Result of VCM cloud confidence and cloud quality, adjacency, thin cirrus or cot mode COT threshold tests)
	5	Thin Cirrus	0 = No 1 = Yes (from VCM Thin Cirrus Quality Flag)
	6	Cirrus (VCM Solar or IR Tests)	0 = No 1 = Yes (if either VCM solar or IR cirrus test quality flag is positive)
	7	Cloud Shadow	0 = No 1 = Yes
1	0-1	Cloud Phase	00 = Clear 01 = Water 10 = Ice 11 = Mixed
	2	Fire	0 = No 1 = Yes
	3	Sun Glint	0 = No 1 = Yes
	4	Imagery Band Quality (I1)	0 = GREEN (GOOD) 1 = RED (POOR)
	5	Imagery Band Quality (I2)	0 = GREEN (GOOD) 1 = RED (POOR)
	6	Imagery Band Quality (I3)	0 = GREEN (GOOD) 1 = RED (POOR)
	7	Spare	Spare
2	0-1	I1 Overall Quality	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	2-3	I2 Overall Quality	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	4-5	I3 Overall Quality	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	6	Solar Zenith Angle Exclusion	0 = No 1 = Yes
	7	Aerosol Optical Thickness Exclusion	0 = No 1 = Yes (based on slant path AOT)

Table 15. Description of VCM and Band Quality Bits (mask_m)

BYTE	Bit	Flag Description Key	Result
0	0	Land/Ocean Background	0 = Land 1 = Ocean
	1	Forest	0 = No 1 = Yes
	2	Coastline	0 = No 1 = Yes
	3-4	Cloud Quality	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR) (Result of VCM cloud confidence and cloud quality, adjacency, thin cirrus or cot mode COT threshold tests)
	5	Thin Cirrus (Solar)	0 = No 1 = Yes (from VCM Thin Cirrus Quality Flag)
	6	(VCM Solar or IR Tests)	0 = No 1 = Yes (if either VCM solar or IR cirrus test quality flag is positive)
	7	Cloud Shadow	0 = No 1 = Yes
1	0-1	Cloud Phase	00 = Clear 01 = Water 10 = Ice 11 = Mixed
	2	Fire	0 = No 1 = Yes
	3	Sun Glint	0 = No 1 = Yes
	4	Moderate Band Quality (M1) *	0 = GREEN (GOOD) 1 = RED (POOR)
	5	Moderate Band Quality (M2) *	0 = GREEN (GOOD) 1 = RED (POOR)
	6	Moderate Band Quality (M3) *	0 = GREEN (GOOD) 1 = RED (POOR)
	7	Moderate Band Quality (M4) *	0 = GREEN (GOOD) 1 = RED (POOR)
2	0	Moderate Band Quality (M5) *	0 = GREEN (GOOD) 1 = RED (POOR)
	1	Moderate Band Quality (M7) *	0 = GREEN (GOOD) 1 = RED (POOR)
	2	Moderate Band Quality (M8) *	0 = GREEN (GOOD) 1 = RED (POOR)
	3	Moderate Band Quality (M10) *	0 = GREEN (GOOD) 1 = RED (POOR)
	4	Moderate Band Quality (M11) *	0 = GREEN (GOOD) 1 = RED (POOR)
	5-6	Overall M1 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	7	Overall M2 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
3	0	Overall M2 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	1-2	Overall M3 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	3-4	Overall M4 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)

BYTE	Bit	Flag Description Key	Result
	5-6	Overall M5 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	7	Overall M7 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
4	0	Overall M7 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	1-2	Overall M8 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	3-4	Overall M10 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	5-6	Overall M11 Quality *	00 = GREEN (GOOD) 01 = GREEN/YELLOW 10 = YELLOW/RED 11 = RED (POOR)
	7	Overall Quality	0 = GREEN (GOOD) 1 = RED (POOR)

* Fields that are related to the legacy MESMA algorithm.

2.1.2.4 SN_binary_map

This routine generates the binary snow map. The binary map calculation requires inputs from the VCM bits (described in the Operational Algorithm Description Document for VIIRS Cloud Mask Intermediate Product (VCM IP), 474-00062,) and LUTs (described in Table 9, Table 10, and Table 11). Furthermore, the code requires the quality of each imagery reflectance band. The band quality and VCM bits are stored in a variable “mask_i” in a total of three bytes; Table 14 gives the bit description of “mask_i.”

Using the bit description and the LUT parameters, a snow binary map is constructed. Table 16 describes variables used in constructing the map.

Table 16. Relevant Parameters in SN_binary_map

Parameter	Description
toa_refl_i	TOA Reflectance for Imagery Bands I1, I2, and I3
P	Current Pixel
binary_map	Binary Snow Map
Ndvi	Normalized Difference Vegetation Index (NDVI)
Ndsi	Normalized Difference Snow Index (NDSI)
ndvi_quality	NDVI Quality (0 = GOOD/GREEN, 1 = POOR/RED)
ndsi_quality	NDSI Quality (0 = GOOD/GREEN, 1 = POOR/RED)

The quality of each binary map pixel is determined and written out in the SN_write_edr routine, detailed in Section 2.2.1.5. The binary map quality segment of SN_write_edr could be moved to the SN_binary_map routine without affecting the output contents.

The logic flow for the snow cover binary map algorithm is shown in Figure 4. Definitions of equations used in the algorithm can be found in the ATBD, 474-00038.

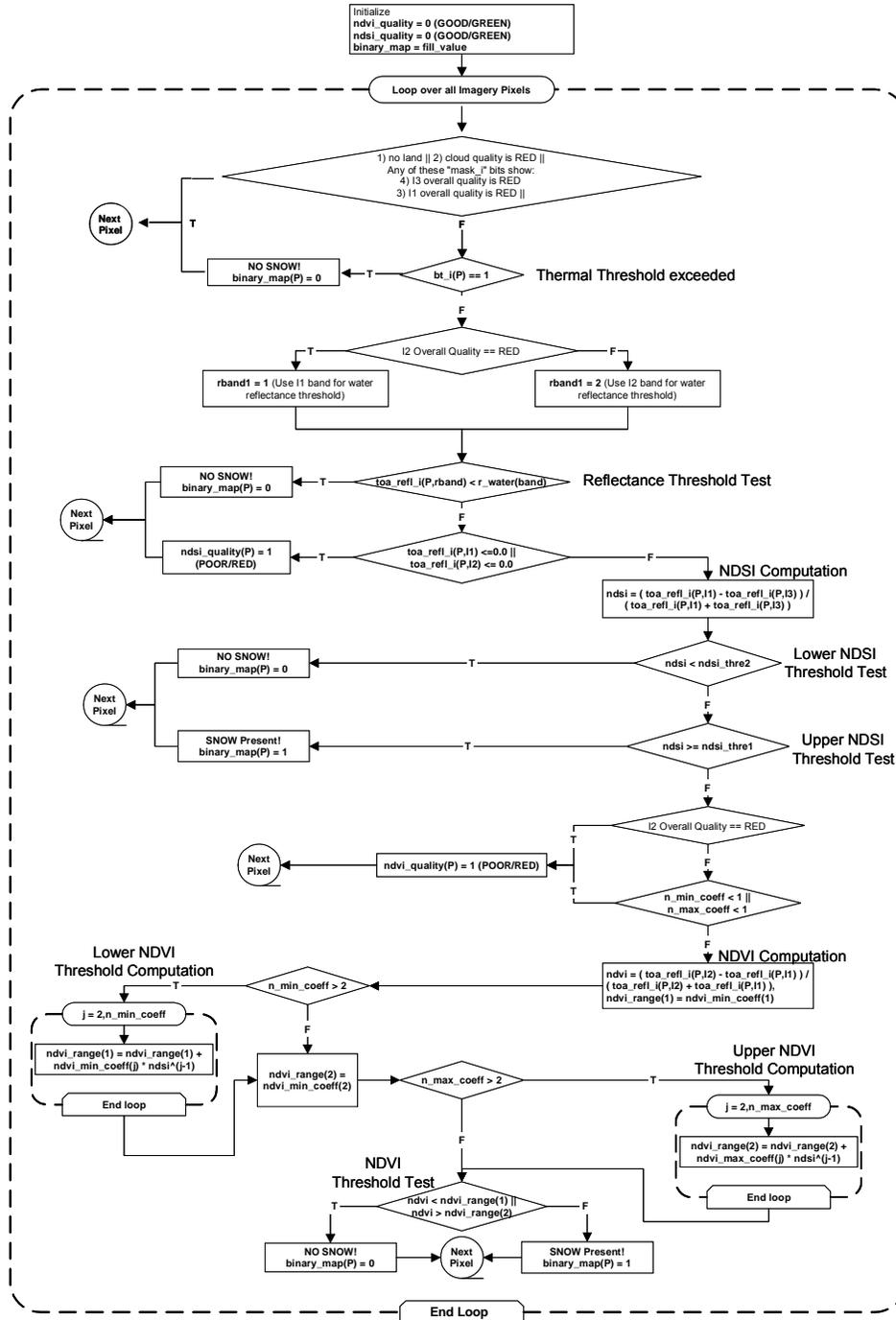


Figure 4. Logic flow for the Snow Cover Binary Map Algorithm

2.1.2.5 SN_write_edr

This routine computes a fractional snow cover and produces the quality flag parameters for both the snow binary map and snow fraction EDRs. The fractional snow cover is computed by performing a 2x2 aggregation of the imagery resolution snow binary map. The snow fraction measurement uncertainty using this technique will be 25%. Aggregation is performed by counting the number of snow filled pixels within each 2x2 pixel aggregation window of the imagery resolution snow map, and dividing by the total number of pixels. Snow fraction (at moderate resolution) is determined to 25% measurement uncertainty. The “frac_option” flag

(last entry of the snow_cover.lut configuration file), set to a value of one, selects this branch of the Snow Cover algorithm.

Subroutine SN_bmap_qflags is called to generate the snow binary map quality flags, but they are stored to the Snow Cover Binary Map EDR buffer in this routine. Also granule quality metadata, derived from the pixel level quality flags, is calculated and stored to the Snow Cover Binary Map EDR in this routine. The quality flags are documented in Table 12.

Subroutine SN_aggfrac_qflags is called to calculate the aggregated snow fraction quality flags, but they are stored to the Aggregated Snow Fraction Binary Snow Map EDR buffer in this routine. Also granule quality metadata, derived from the pixel level quality flags, is calculated and stored to the Aggregated Snow Fraction Binary Snow Map EDR buffer in this routine. The quality flags are documented in Table 13.

In the current operational algorithm, computation of the snow fraction using the spectral mixing algorithm is not implemented, so choosing frac_option = 0 will result in the Snow Fraction Binary Snow Map EDR data containing fill values. The logic flow in the SN_write_edr routine is shown in Figure 5. The logic flow for the snow fraction aggregation is shown in Figure 6. The logic flow for SN_bmap_qflags to set binary map quality flags is shown in Figure 7. The logic flow for the snow fraction quality portion of SN_write_edr() is shown in Figure 8.

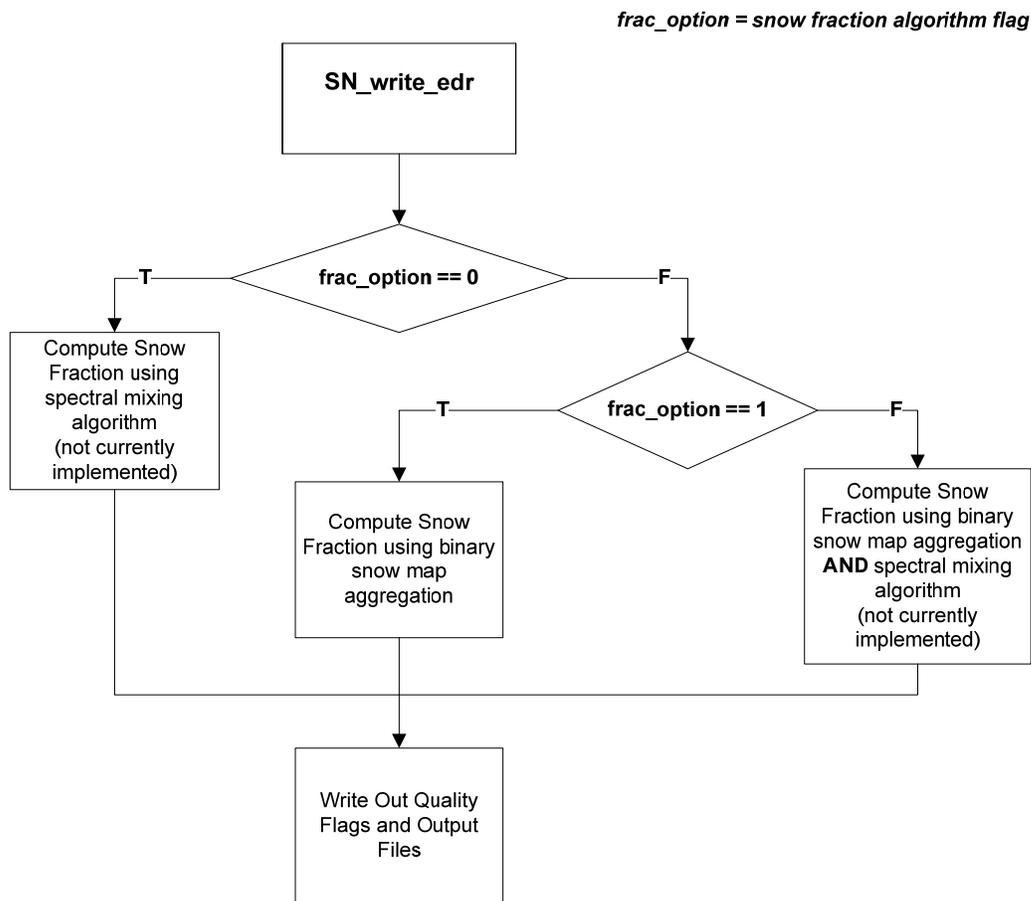


Figure 5. Logic flow of SN_write_edr

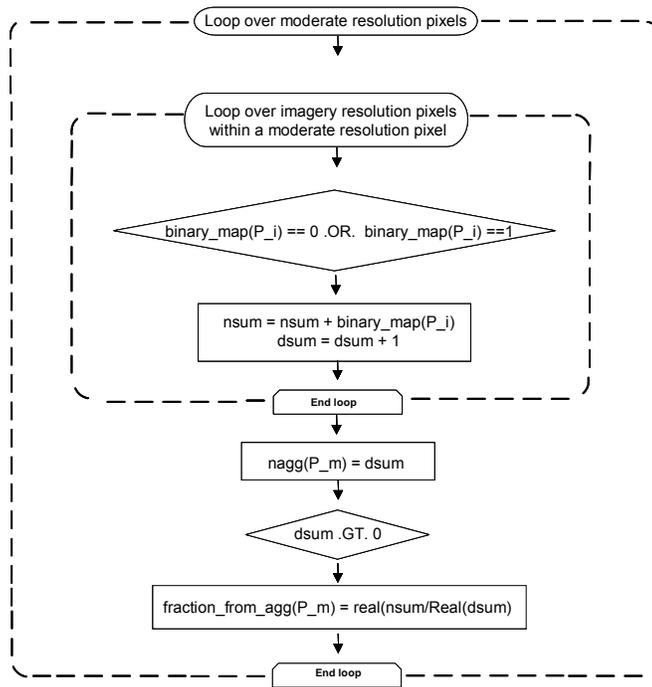


Figure 6. Logic Flow for the Snow Fraction Aggregation

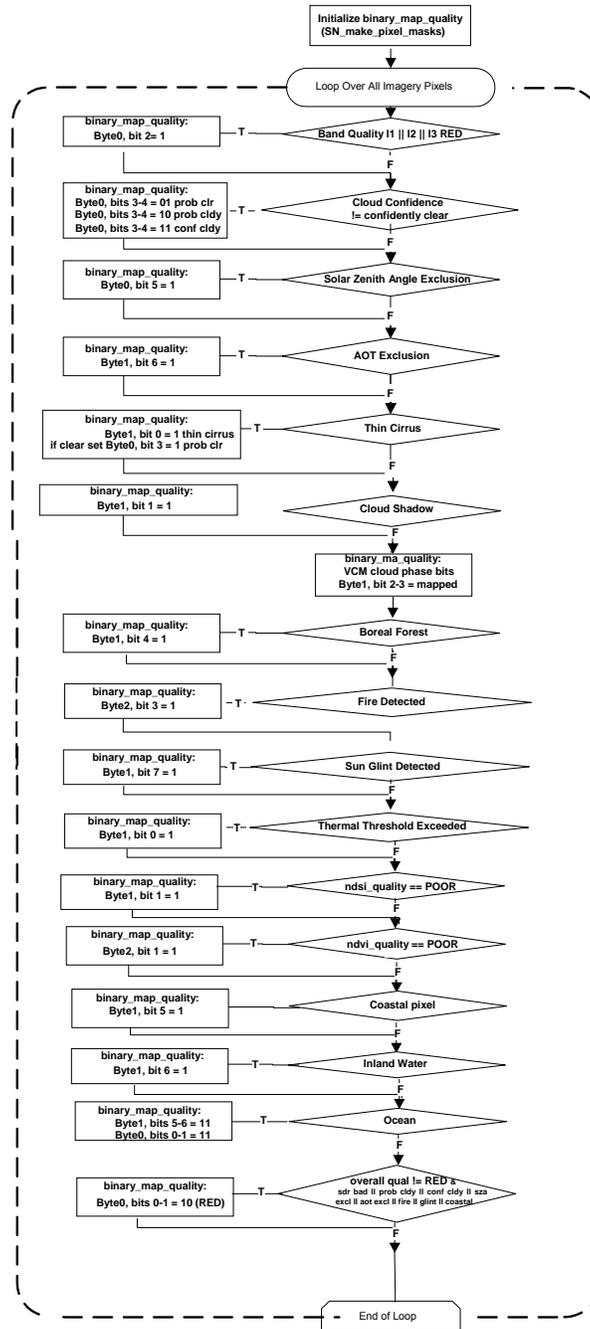


Figure 7. Logic Flow for SN_bmap_qflags to set Binary Map Quality Flags

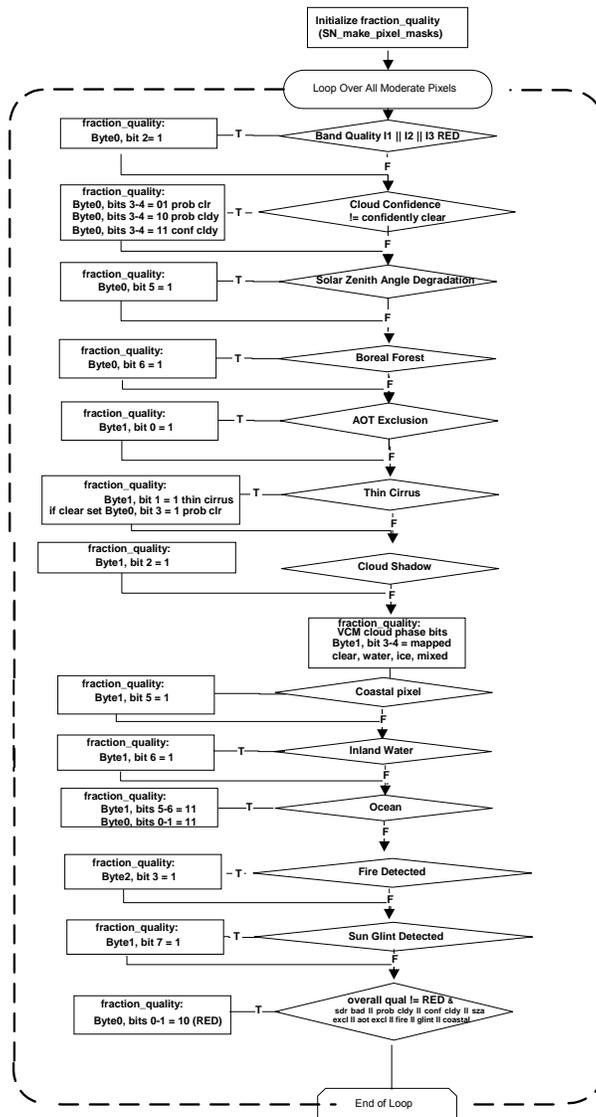


Figure 8. Logic Flow for Snow Fraction Quality Portion of SN_write_edr()

2.1.2.6 SN_bmap_qflags

This routine generates the Snow Cover Binary Map EDR quality flags. These quality flags are documented in Table 12. Almost all tests determining the binary map quality are set using the quality bits of “mask_i” (see Table 14). The exceptions are:

- the thermal mask is used to set the thermal mask quality flag
- the NDVI quality is used to set the NDVI quality flag (flag set if I2 quality is bad or no NDVI coefficients available)
- the NDSI quality is used to set the NDSI quality flag (flag is set if I1 or I3 reflectance is bad)
- the overall quality can be set to FILL if the binary snow map contains a fill value

The Snow Binary Map Quality flags are written to the Binary Snow Cover Map EDR buffer in SN_write_edr.

2.1.2.7 SN_aggfrac_qflags

This routine generates the Aggregated Snow Fraction Binary Snow Map EDR quality flags. These quality flags are documented in Table 13. Almost all tests determining the binary map quality are derived from the Snow Cover Binary Map EDR quality flags and the “mask_m” (documented in Table 15) quality bits. The exceptions are:

- the SZA degradation flag is set if any of the imagery resolution SZAs are within the degradation
- the SZA exclusion flag is set if any of the imagery resolution SZAs exceed the exclusion threshold
- the AOT exclusion flag is set if the AOT value exceeds the aot exclusion threshold
- the fraction quality is set to FILL if the snow fraction binary snow map value is fill

The exclusion and degradation thresholds are defined in the Snow Quality LUT table (Table 9).

2.1.3 Graceful Degradation

2.1.3.1 Graceful Degradation Inputs

There is one case where input graceful degradation is indicated in the Snow Cover EDR.

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

2.1.3.2 Graceful Degradation Processing

None.

2.1.3.3 Graceful Degradation Outputs

None.

2.1.4 Exception Handling

There are no optional inputs (with the exception of DQTT threshold tables). A failure to get input data from DMS or store output data to DMS during the Input/Output (I/O) stages of the algorithm are reported and result in process termination. No output products are produced.

Errors extracting VCM values result in an error message and process termination with no output products produced.

If AOT values are out of range or fill, the pixel weight is set to zero and a quality flag is set.

If solar zenith angles are out of range or fill, the pixel weight is set to zero and a quality flag is set.

There are currently no conditions which result in returning a PRO_FAIL status from the algorithm main module (scd_main).

2.1.5 Data Quality Monitoring

Table 17 lists the data quality monitoring tests which are defined in the Snow Binary Map and Snow Fraction EDR Data Quality Threshold Tables. If any of these tests fail, a Data Quality Notification will be sent to DQM.

Table 17. Data Quality Threshold Table Tests

2.1.6 Test Description	2.1.7 Test Type	2.1.8 Text	2.1.9 Value	2.1.10 Test Parameters	2.1.11 Action
Check for Binary Map Quality in Binary Map EDR	Threshold – less than	scdBinaryMapQuality is below 91 percent	Logical / Boolean	Min = 91%	Send DQN if flag is below threshold
Check for Exclusion Summary in Binary Map EDR	Threshold – greater than	scdExclusionSummary exceeds 89 percent	Logical / Boolean	Max = 89%	Send DQN if flag exceeds threshold
Check for Snow Fraction Quality in Aggregated Fraction EDR	Threshold – less than	scdSnowFractionQuality is below 91 percent	Logical / Boolean	Min = 91%	Send DQN if flag is below threshold
Check for Degradation Summary in Aggregated Fraction EDR	Threshold – greater than	scdDegradationSummary exceeds 89 percent	Logical / Boolean	Max = 89%	Send DQN if flag exceeds threshold
Check for Exclusion Summary in Aggregated Fraction EDR	Threshold – greater than	scdExclusionSummary exceeds 89 percent	Logical / Boolean	Max = 89%	Send DQN if flag exceeds threshold

2.1.12 Computational Precision Requirements

Single precision floating point computations are required by the Snow Cover algorithm.

2.1.13 Algorithm Support Considerations

The Snow Cover algorithm uses tunable parameters contained in the Snow Cover LUT (Table 9) and the Snow Cover Quality LUT (Table 11). These LUTs contain thresholds used by the algorithm. They are generated by offline processes and may be updated when needed, but do not require periodic updating.

2.1.14 Assumptions and Limitations

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

Retrievals are not performed under confidently cloudy conditions.

Retrievals are not performed over ocean.

Retrievals over inland water are performed but are not required to meet performance specification.

Retrievals of the binary snow map and snow fraction are questionable under conditions of extreme aerosol loading, such as events associated with volcanic eruptions or biomass-burning. The results are not guaranteed to meet the performance specification for these circumstances.

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

The current glossary for the NPOESS program, D35836_H_NPOESS_Glossary, can be found on eRooms. Table 18 contains those terms most applicable for this OAD.

Table 18. Glossary

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

Term	Description
Raw Data Record (RDR)	<p><i>[IORD Definition]</i></p> <p>Full resolution digital sensor data, time referenced 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 NPOESS (space or ground) needed to recreate the sensor measurement, to correct the measurement for known distortions, and to locate the measurement in time and space, through subsequent processing. Metadata is associated with the sensor and auxiliary data to permit its effective use.</p>
Retrieval Algorithm	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)	<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

The current acronym list for the NPOESS program, D35838_H_NPOESS_Acronyms, can be found on eRooms. Table 19 contains those terms most applicable for this OAD.

Table 19. Acronyms

Term	Expansion
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
DQTT	Data Quality Test Table
IIS	Intelligence and Information Systems
INF	Infrastructure
ING	Ingest
IP	Intermediate Product
LUT	Look-Up Table
MDFCB	Mission Data Format Control Book
NDSI	Normalized Difference Snow Index
PRO	Processing
QF	Quality Flag
SDR	Sensor Data Records
SI	Software Item or International System of Units
TBD	To Be Determined
TBR	To Be Resolved
TOA	Top of the Atmosphere
VCM	VIIRS Cloud Mask

4.0 OPEN ISSUES

Table 20. TBXs

TBX ID	Title/Description	Resolution Date
None		