Effective Date: June 3, 2011
Revision -

GSFC JPSS CMO
December 7, 2011
Released

Joint Polar Satellite System (JPSS) Ground Project
Code 474
474-00085

Joint Polar Satellite System (JPSS) Operational Algorithm Description Document for VIIRS Cloud Cover/Layers (CCL) and Generate Cloud EDR (GCE) 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.

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

Check the JPSS MIS Server at https://jpssmis.gsfc.nasa.gov/frontmenu_dsp.cfm to verify that this is the correct version prior to use.

This page intentionally left blank.

Joint Polar Satellite System (JPSS) Operational Algorithm Description Document for VIIRS Cloud Cover/Layers (CCL) and Generate Cloud EDR (GCE) Software

JPSS Electronic Signature Page

Prepared By:

Neal Baker
JPSS Data Products and Algorithms, Senior Engineering Advisor
(Electronic Approvals available online at (https://jpssmis.gsfc.nasa.gov/mainmenu_dsp.cfm)

Approved By:

Heather Kilcoyne
DPA Manager
(Electronic Approvals available online at (https://jpssmis.gsfc.nasa.gov/mainmenu_dsp.cfm)

Goddard Space Flight Center
Greenbelt, Maryland

This page intentionally left blank.

Preface

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

Any questions should be addressed to:

JPSS Ground Project Configuration Management Office
NASA/GSFC
Code 474
Greenbelt, MD 20771

This page intentionally left blank.

Change History Log

Revision	Effective Date	Description of Changes (Reference the CCR & CCB/ERB Approve Date)
Original	06/03/2011	**474-CCR-11-0100:** This version baselines D39590, Operational Algorithm Description Document for VIIRS Cloud Cover/Layers (CCL) and Generate Cloud EDR (GCE) Software, Rev B dated 03/17/2010 as a JPSS document, version Rev –. This is the version that was approved for NPP launch. Per NPOESS CDFCB - External, Volume V – Metadata, doc number D34862-05, this has been approved for Public Release into CLASS. This CCR was approved by the JPSS Algorithm ERB on June 3. 2011.

This page intentionally left blank.

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS CLOUD COVER/LAYERS (CCL) AND GENERATE CLOUD EDR (GCE) SOFTWARE (D39590 Rev B)

CDRL No. A032

Northrop Grumman Space & Mission Systems Corporation
One Space Park
Redondo Beach, California 90278

Copyright © 2004-2010
Northrop Grumman Corporation and Raytheon Company
Unpublished Work
ALL RIGHTS RESERVED

Portions of this work are the copyrighted work of Northrop Grumman and Raytheon. However, other entities may own copyrights in this work.

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

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.

The information provided herein does not contain technical data as defined in the International Traffic in Arms Regulations (ITAR) 22 CFR 120.10.

This document has been approved by the Unites States Government for public release in accordance with NOAA NPOESS Integrated Program Office.

Distribution: Statement A: Approved for public release; distribution is unlimited.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS CLOUD COVER/LAYERS (CCL) AND GENERATE CLOUD EDR (GCE) SOFTWARE (D39590 Rev B)

ELECTRONIC APPROVAL SIGNATURES:

_____

Roy Tsugawa Date
Algorithm & Data Processing IPT Lead &
Algorithm Change Control Board Chairperson

_____

Ben James Date
Operations & Support IPT Lead

The following individuals are recognized for their contributions to the current or previous versions of this document.

David Hogan
Eric Wong
Joy Marion

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Revision/Change Record

Document Number **D39590**

Revision	Document Date	Revision/Change Description	Pages Affected
--	**12-23-04**	**Initial Release to NGST for P1187-SW-I-017; TM # NP-EMD.2005.510.0077 already implemented.**	All
A1	1-21-05	<u>Initial PCIM Release. ECR A046</u> Release as Document D39590, SPCR 736 Correct various typos and formatting nits Update to referenced documents Update to CCL Processing chain diagram to use Corrected IPs Update CCL/GCE Input table to use Corrected Ips State in CCL Cloud Cover and CCL EDR output tables that Total Cloud Cover output is cloud fraction *summed* over all layers instead of *averaged* Add comment regarding future implementation of GCE quality flags, add TBD addressing this issue to TBD table Add content to Test Procedure and Results sections for CCL and GCE.	All various 1 3 5 9, 12 I, 19 24, 27
A2	6-12-05	Implementation of quality flags and function arguments per SPCR ALG 629.	All
A3	6-12-05	Implementation of CCL logic based on AER doc P1187-SW-I-017_CCL_and_GCE-OAD.doc SPCR ALG 843.	21
A4	3-22-06	Reflects Raytheon-Omaha's initial edits for Science To Operational (Sci2Ops) Code Conversion Process, adding Raytheon coversheet, title/signature page, etc. Updated coversheet copyright; replaced old Unit Test with the latest 16Feb06 version; did other edits per Omaha QA comments posted for I-P-O CUTPR and TM # NP-EMD.2006.510.0007. Removed Sections 2.3.6.15 through 2.3.6.20 per the PRO SW engineer working the GCE algorithm. Renamed Figures 1 and 2 to differentiate CCL versus GCE processing chain then updated List of Figures.	All
A5	12-6-06	Updated for error handling and data quality, combining 2 ccl outputs into 1, Figure 1, Tables 1 and 10, Sections 2.2, 2.3.4, and 4.4.	3,5,8,26,36
A6	1-6-07	Updated per EH DQ DDPR reviewer comments.	All
A7	1-19-07	Updated per Optimization DDPR review comments.	All
A8	2-15-07	Final update of CCL portion per new OAD template format.	All
A9	2-16-07	Delivered to NGST.	All

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Revision/Change Record

Document Number **D39590**

Revision	Document Date	Revision/Change Description	Pages Affected
A10	4-26-07	Updated for TM # NP-EMD.2005.510.0038. Updated Section 2.1.2 to include information regarding reading the last scan from the previous granule and the first scan of the next granule and supply this information to the algorithm for processing. Removed EdgeHandlingMode row from Table 11 since field was not used. Updated Table 12, added missing value.	All
A11	5-30-07	Updated per GCE sci2ops error handling and data quality. Removed granule flags from EDRs (they are now posted to metadata). Added summaries for GCE functions. Updated per code completion review comments.	All
A12	6-14-07	Updated GCE portion to new format: updated tables including listing quality flags at the bit-level; modified figures; updated function descriptions and removed input/output tables for functions; added tech memos to reference doc table. Updated CCL portion for output product names.	All
A13	6-15-07	Delivered to NGST.	All
A14	6-26-07	Update scale and offset to Float32.	27-32
A15	7-12-07	Added cell_copy_out() per fix in PCR013942.	18,20
A16	8-9-07	TM NP-EMD.2007.510.0034 is implemented in CCL in B1.5.	All
A17	8-20-07	Removed scaling coefficients from GCE Coefficients table (Table 17), scaling of products is now performed in common code (i.e. ProCmnProductDictionary) instead.	25
A18	10-24-07	Made corrections for flipped layer assignments. Delivered OAD to NGST.	All
A19	11-9-07	Added spacecraft position, velocity, and attitude to geolocation output. Responded to ECR A-122 PR comments.	14-15
A20	12-17-07	ECR A-103 Updates: added many new fields to the output geolocation structure and added a new method assignScanLevelGeolocationData().	All
A21	7-10-08	Accepted track changes. Rewrote DQN text.	All
A22	7-23-08	Prepared for delivery to ACCB. Updated Acronym list and references. Implemented new cover sheet from NGST.	All
A	9-2-08	ECR A-167. Incorporated interim changes and addressed TIM comments.	All
B1	10-20-08	Modify Cloud Cover Layers Algorithm (CCL) to read the new cloud mask bits and fix software bugs identified by IDPS(tech memo -NP-EMD-2008.510.0017). Also removed the flipped layer code from CCL. Test results were delivered to NGST (GR_SE_EMD_16294)	3 and 19
B2	11-09-08	Modified GCE algorithm to re-implement TM NP-EMD.2007.510.0034.	37

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Revision/Change Record

Document Number **D39590**

Revision	Document Date	Revision/Change Description	Pages Affected
B3	5-21-09	Tech Memo NP-EMD.2008.510.0069, Rev A. Update Generate cloud EDRs Code to be consistent with System Spec Rev N	1, 9, 10, 27
B4	8-13-09	Updated TBD01 (PCR019987)	Tables 19 & 32
B5	11-04-09	Updated for SDRL	All
B6	01-13-10	Implemented NP-EMD.2009.510.0048 Rev A VIIRS Geo Quality Flags Logic Updates	Table 14
B7	01-20-10	Implemented NP-EMD.2009.510.0072 Fix software bug in cloud layering in the Generate Cloud EDRs Algorithm, and prepared for TIM/ARB	2.2.2.14, 2.2.2.15
B	03-17-10	Incorporated comments from TIM and prepared for ACCB .Reference ECR A-268. Approved for Public Release per Contracts Letter 100610-02.	All

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table Of Contents

1.0 INTRODUCTION 1
1.1 Objective 1
1.2 Scope 1
1.3 References 2
1.3.1 Document References 2
1.3.2 Source Code References 3
2.0 ALGORITHM OVERVIEW 5
2.1 CCL Description 5
2.1.1 Interfaces 6
2.1.1.1 Inputs 7
2.1.1.2 Outputs 13
2.1.2 Algorithm Processing 16
2.1.2.1 Main Module - cclDriver() 20
2.1.2.2 setScan() 20
2.1.2.3 ccl_cluster() 20
2.1.2.4 ccl_product() 21
2.1.2.5 cell_copy_out() 22
2.1.2.6 recalcClusters() 22
2.1.2.7 cloudDist() 22
2.1.2.8 normDist () 22
2.1.2.9 mbkm_first_guess() 22
2.1.2.10 ekm_first_guess() 23
2.1.2.11 apply_kmeans() 23
2.1.2.12 assign_cloud_type () 23
2.1.2.13 produceQualityFlags () 23
2.1.2.14 fillOutputs() 23
2.1.2.15 loadAggTbl() 23
2.1.2.16 getAggCell() 24
2.1.2.17 assignScanLevelGeolocationData() 24
2.1.3 Graceful Degradation 24
2.1.4 Exception Handling 24
2.1.5 Data Quality Monitoring 24
2.1.6 Computational Precision Requirements 24
2.1.7 Algorithm Support Considerations 24
2.1.8 Assumptions and Limitations 25

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

2.2 GCE Description 26
2.2.1 Interfaces 26
2.2.1.1 Inputs 27
2.2.1.2 Outputs 28
2.2.2 Algorithm Processing 38
2.2.2.1 Main Module – GCE_main() 39
2.2.2.2 getScan() 39
2.2.2.3 average2d() 40
2.2.2.4 average3d() 40
2.2.2.5 Aggregate() 40
2.2.2.6 Height_Conversion() 40
2.2.2.7 posOutdata() 40
2.2.2.8 put_4_level() 40
2.2.2.9 put_dominant() 40
2.2.2.10 QF_Lyr_2d() 40
2.2.2.11 QF_Lyr_3d() 41
2.2.2.12 QF_2d() 41
2.2.2.13 ComputeGranuleQualityFlags() 41
2.2.2.14 sortLyrOrder() 41
2.2.2.15 sort_lyrs() 41
2.2.2.16 loadAggTbl() 41
2.2.2.17 getAggCell() 41
2.2.3 Graceful Degradation 41
2.2.4 Exception Handling 41
2.2.5 Data Quality Monitoring 42
2.2.5.1 Quality Flags 42
2.2.6 Computational Precision Requirements 42
2.2.7 Algorithm Support Considerations 42
2.2.8 Assumptions and Limitations 42
3.0 GLOSSARY/ACRONYM LIST 44
3.1 Glossary 44
3.2 Acronyms 47
4.0 OPEN ISSUES 49

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

List of Figures

Figure 1. CCL Algorithm Overview 6
Figure 2. Cloud Cover Layers Overall Flow Diagram 7
Figure 3. Conceptual Process for Cloud Cover Layers 17
Figure 4. GCE Algorithm Overview 26
Figure 5. Generate Cloud EDRs Overall Flow Diagram 27
Figure 6. Conceptual Process for Generate Cloud EDRs 39

List of Tables

Table 1. Reference Documents 2
Table 2. Source Code References 3
Table 3. Fill Values 8
Table 4. CCL/GCE Inputs Summary 8
Table 5. CCL/GCE: VIIRS SDR Moderate Resolution GEO Auxiliary Data Inputs 9
Table 6. CCL/GCE Input: VIIRS Parallax Corrected Cloud Mask IP 9
Table 7. CCL/GCE Input: VIIRS Parallax Corrected Cloud Optical Properties IP 10
Table 8. CCL/GCE Input: VIIRS Parallax Corrected Cloud Top Parameters IP 11
Table 9. CCL/GCE VIIRS Cloud Aggregation LUT Auxiliary Data Inputs 12
Table 10. CCL VIIRS Cloud Type LUT Auxiliary Data Inputs 12
Table 11. CCL Tunable Parameters and Processing Coefficients 12
Table 12. CCL Output: VIIRS Cloud Layer Type IP 14
Table 13. CCL Output: VIIRS Cloud Cover Type IP 14
Table 14. CCL Output: VIIRS Cloud Aggregate GEO 15
Table 15. CCL/GCE Aggregation Tables 20
Table 16. GCE Input: VIIRS Cloud Base Height IP 28
Table 17. GCE Tunable Parameters and Processing Coefficients 28
Table 18. Layered and Total Quality Flags (QF_LYR_CLOUD) for Horizontal Cell 29
Table 19. Non-cloud Related Quality Flags (QF_CLOUD) for a Horizontal Cell 29
Table 20. GCE Output: VIIRS CBH EDR 30
Table 21. GCE Output: VIIRS CCL EDR 31
Table 22. GCE Output: VIIRS CEPS EDR 32
Table 23. GCE Output: VIIRS COT EDR 33
Table 24. GCE Output: VIIRS CTH EDR 33
Table 25. GCE Output: VIIRS CTP (Pressure) EDR 35
Table 26. GCE Output: VIIRS CTT EDR 35

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 27. GCE (Optional) Output: VIIRS CCL FEDR (Full Resolution) 37
Table 28. GCE (Optional) Output: VIIRS CTH FEDR (Full Resolution) 37
Table 29. GCE (Optional) Output: VIIRS CTP (Pressure) FEDR (Full Resolution) 38
Table 30. Glossary 44
Table 31. Acronyms 47
Table 32. TBXs 49

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

1.0 INTRODUCTION

1.1 Objective

The purpose of an 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(s) required to create the CCL related outputs:

VIIRS Cloud Layer Type IP
VIIRS Cloud Cover Type IP
VIIRS Cloud Aggregate Geolocation (GEO)

and the GCE related outputs:

VIIRS Cloud Base Height (CBH) EDR
VIIRS Cloud Cover/Layers (CCL) EDR
VIIRS Cloud Effective Particle Size (CEPS) EDR
VIIRS Cloud Optical Thickness (COT) EDR
VIIRS Cloud Top Height (CTH) EDR
VIIRS Cloud Top Pressure (CTP) EDR
VIIRS Cloud Top Temperature (CTT) EDR).

Note: GCE is referred to as Grid Cloud EDRs in some supporting documentation. The theoretical basis for these algorithms is described in the Cloud Cover/Layers Visible/Infrared Imager/Radiometer Suite ATBD.

The theoretical basis for the CCL and GCE algorithms are described in Sections 4.2 and 4.3, respectively, of the Cloud Cover/Layers Algorithm Theoretical Basis Document (ATBD), D43317.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

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
Cloud Cover/Layers Algorithm Theoretical Basis Document (ATBD) (ref P1187-TR-I-006)	D43317 Rev. A	28 Nov 2007
NPP EDR Production Report	D37005 Rev. D	11 Feb 2009
EDR Interdependency Report	D36385 Rev. E	28 Jan 2009
NPP Mission Data Format Control Book (MDFCB)	D48190-01 Rev A	05 May 2009
CDFCB-X Volume I - Overview	D34862-01 Rev. E	20 May 2009
CDFCB-X Volume II – RDR Formats	D34862-02 Rev. D	03 Jun 2009
CDFCB-X Volume III – SDR/TDR Formats	D34862-03 Rev. D	27 May 2009
CDFCB-X Volume IV Part 1 – IP/ARP/GEO Formats	D34862-04-01 Rev. D	04 Jun 2009
CDFCB-X Volume IV Part 2 – Atmospheric, Clouds, and Imagery EDRs	D34862-04-02 Rev. D	04 Jun 2009
CDFCB-X Volume IV Part 3 – Land and Ocean/Water EDRs	D34862-04-03 Rev. D	04 Jun 2009
CDFCB-X Volume IV Part 4 – Earth Radiation Budget EDRs	D34862-04-04 Rev. D	04 Jun 2009
CDFCB-X Volume V - Metadata	D34862-05 Rev. E	14 May 2009
CDFCB-X Volume VI – Ancillary Data, Auxiliary Data, Reports, and Messages	D34862-06 Rev. G	21 May 2009
CDFCB-X Volume VII – NPOESS Downlink Formats	D34862-07-01 Rev. B	27 May 2009
CDFCB-X Volume VIII – Look Up Table Formats	D34862-08 Rev. B	05 Jun 2009
NPP Command and Telemetry (C&T) Handbook	D568423 Rev. C	30 Sep 2008
VIIRS Cloud Cover/Layers Unit Level Detailed Design	P1187-SW-I-015-CCL-DDD Ver. 6 Rev. 3	16 June 2005
VIIRS Cloud Module-Level Software Architecture	Y2472 Ver. 5 Rev. 12	Jan 2005
VIIRS Cloud Module Level Interface Control Document	Y3278 Ver. 5 Rev. 9	Oct 2004
VIIRS Cloud Module Data Dictionary	Y0010871 Ver. 5 Rev. 11	Jan 2005
Generate Cloud EDRs (GCE) Unit Level Detailed Design	P1187-SW-I-016-GCE-DDD Ver. 6 Rev. 1	Jan 2005
VIIRS Cloud Cover/Layers IP Science Grade Software Unit Test Document	NP-EMD.2005.510.0008 Rev. B	10 Apr 2008
VIIRS Generate Cloud EDRs (GCE) Science Grade Software Unit Test Document	NP-EMD.2005.510.0009 Rev. ---	21 Jan 2005
Operational Algorithm Description Document for the VIIRS Cloud Optical Properties (COP) Software	D39298 Rev. A5	19 June 2008
Operational Algorithm Description Document for the VIIRS Cloud Top Parameters (CTP) EDR Software	D39568 Rev. B6	19 June 2008
Operational Algorithm Description Document for the VIIRS Cloud Mask Intermediate Product (VCM IP) Software	D36816 Rev. A	12 Apr 2006
Operational Algorithm Description Document for VIIRS Geolocation (GEO) Sensor Data Record (SDR) and Calibration (Cal) SDR Software	D41868 Rev. A11	22 Feb 2008
NPOESS System Specification	SY15-0007 Ver. E	1 Aug 2002

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Document Title	Document Number/Revision	Revision Date
Data Processor Inter-subsystem Interface Control Document (DPIS ICD)	D35850 Rev. W.1	19 Aug 2009
Processing SI Common IO Design Document	DD60822-IDP-011 Rev. A	21 June 2007
D35836_G_NPOESS_Glossary	D35836_E Rev. G	10 Sep 2008
D35838_G_NPOESS_Acronyms	D35838_E Rev. G	10 Sep 2008
Operational Algorithm Description Document for the VIIRS Perform Parallax Correction (PPC) Software	D40382 Rev. A15	23 July 2008
IDPS Scaled Integers Proposed Solution	NP-IDPS-226	13 July 2005
NGST/SE technical memo – Cross-granule Processing Memo	NP-EMD.2005.510.0038	7 Mar 2005
NGST/SE technical memo – VIIRS Cloud Mask (VCM) OAD Update	NP-EMD.2004.510.0050	3 Dec 2004
NGST/SE technical memo – MS Engineering Memo_CCL_GCE OAD Update	NP-EMD.2005.510.0077	7 July 2005
NGST/SE technical memo – NPP_VIIRS_GCE _QF Defns SPCR ALG980	NP-EMD.2006.510.0007	31 Jan 2006
NGST/SE technical memo – NPP_VIIRS_CCL_ARRAYS_INITIALIZATION	NP-EMD.2006.510.0057	7 Aug 2006
NGST/SE technical memo – NPP_VIIRS_GCE_LAYER_ORDERING_RevA	NP-EMD.2007.510.0034 Rev. A	8 June 2007
NGST/SE technical memo – NP-EMD-2008.510.0017_NPP_VIIRS_CCL_bug_fixes_and_new_cloud_mask	NP-EMD-2008.510.0017	26 Mar 2008
NGAS/AM&S technical memo – Update Generate cloud EDRs to be consistent with System Spec Rev N	NP-EMD.2008.510.0069	4 Dec 2008
NGAS/SE technical memo – VIIRS Geo Quality Flags Logic Updates (PCR21471)	NP-EMD.2009.510.0048 Rev A	12 Oct 2009
NGAS/AM&S technical memo – VIIRS_NPP_GCE_bug_fix_in_layering (PCR22174)	NP-EMD.2009.510.0072	3 Dec 2009

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
$SPDSHOME/src/clouds/gce	NA	NA
$SPDSHOME/include	NA	NA
VIIRS Cloud Cover/Layers – science-grade software	20050812_ISTN_VIIRS_NGST_3.5 Ver. 6 Rev. 3	16 June 2005
VIIRS Cloud Cover/Layers – operational software	/PRO/EDR/VIIRS/clouds/ccl/ B1.5 Ver. D.1.1.6	01 Feb 2007
VIIRS Generate Cloud EDRs – science-grade software	20050812_ISTN_VIIRS_NGST_3.5 Ver. 6 Rev. 3	16 June 2005
VIIRS Generate Cloud EDRs – operational software	/PRO/EDR/VIIRS/clouds/gce/ B1.5	Oct 2007
NGST/SE technical memo – NP-EMD-2008.510.0017_NPP_VIIRS_CCL_bug_fixes_and_new_cloud_mask	B1.5x1 (OAD Rev B1)	26 Mar 2008

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Reference Title	Reference Tag/Revision	Revision Date
Modified GCE algorithm to re-implement TM NP-EMD.2007.510.0034.	(OAD Rev B2)	09 Nov 2008
NGAS/AM&S technical memo – Update Generate cloud EDRs to be consistent with System Spec Rev N	Build Post-X-I (OAD Rev B3)	26 May 2009
PCR019987	Sensor Characterization Build (SC-2)(OAD Rev B4)	13 Aug 2009
SDRL	OAD Rev B5	04 Nov 2009
Operational Software (Includes PCR21471)	Sensor Characterization (Build SC-6) (OAD Rev B6)	13 Jan 2010
Operational Software (Includes PCR22174)	Sensor Characterization (Build SC-6) (OAD Rev B7)	20 Jan 2010
ACCB (no code changes)	OAD Rev B	17 Mar 2010

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

2.0 ALGORITHM OVERVIEW

For this section, the definition of an algorithm is a logical grouping of operational algorithm modules for which there is a single Input-Processing-Output (I-P-O) architecture with a single defined set of external inputs and outputs (e.g., IPs or xDRs).

The retrieval of cloud cover and layers follows execution of the VIIRS CloudMask/Phase algorithm, COP algorithm, and CTP (Parameters) algorithm. These algorithms provide the necessary inputs describing the cloud mask, cloud phase, COP, and CTP (Parameters) for each pixel. The Perform Parallax Correction (PPC) module, which is also executed prior to the CCL, is assumed to produce parallax corrected IPs written in the identical format as the uncorrected IPs. CCL outputs are used as inputs to CBH and GCE modules.

The retrieval of generate cloud EDRs follows execution of the VIIRS CCL and CBH algorithms. The SDR MOD GEO, PPC IPs, CBH IPs, and CCL IPs and GEO are used as inputs to the GCE module. GCE produces EDRs which are end-products of the cloud processing chain and are not used by any other software units. GCE also produces Full resolution EDRs (FEDRs) which are expected to be used by other software units.

2.1 CCL Description

The CCL algorithm is implemented during IP/EDR processing and requires SDR, IP, and Look-Up Table (LUT) inputs to produce IP and GEO outputs. A top-level diagram for the CCL algorithm is shown in Figure 1.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

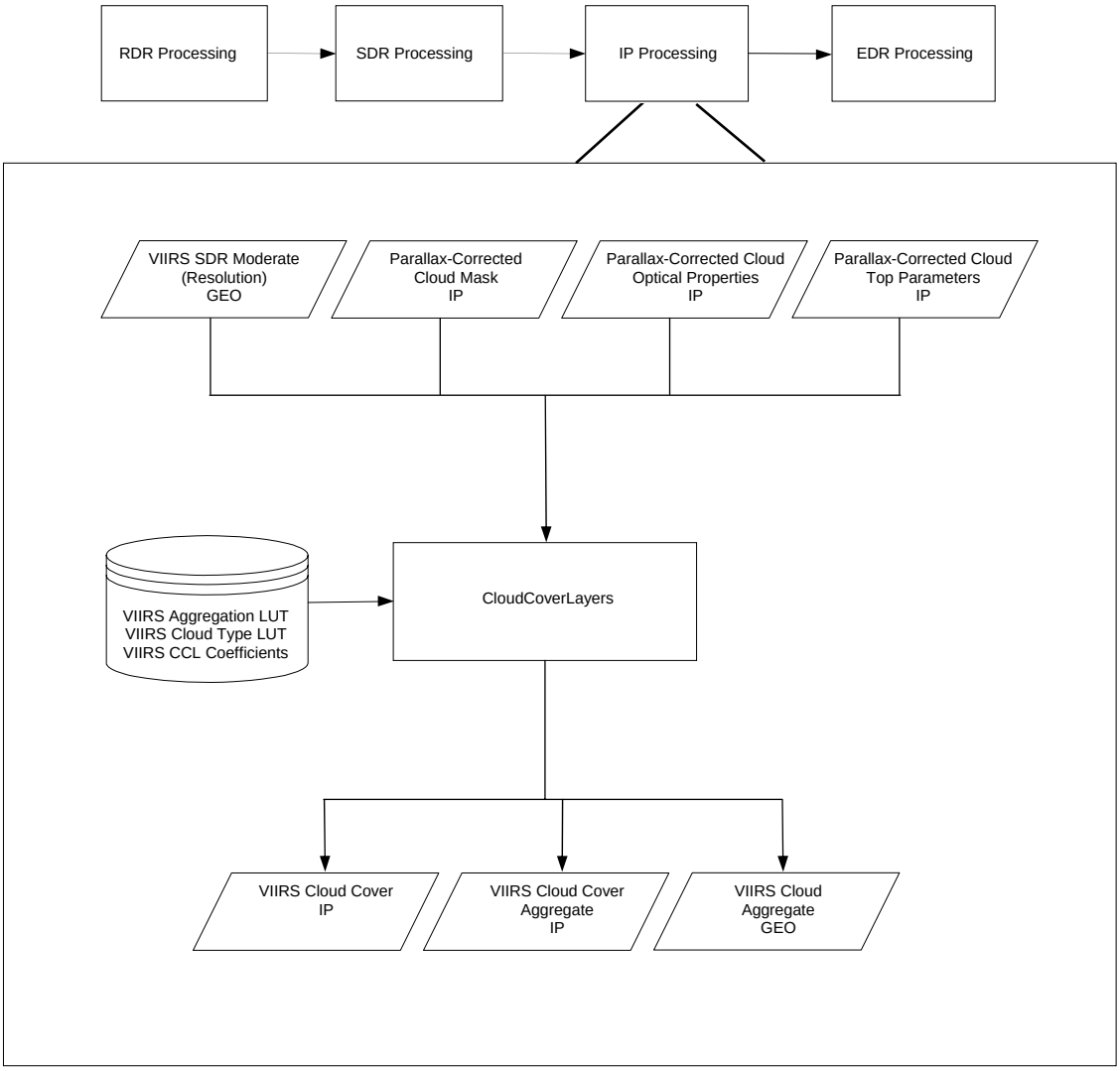


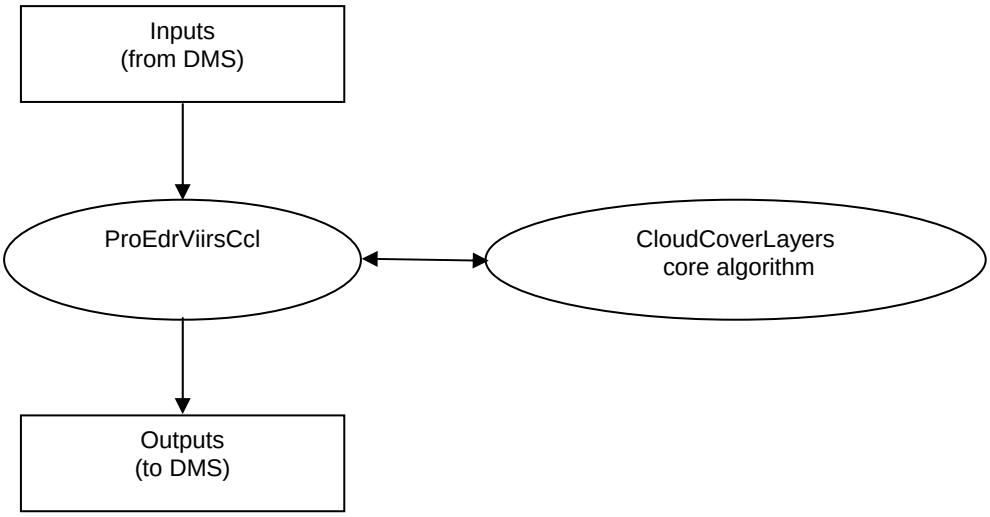
Figure 1. CCL Algorithm Overview

2.1.1 Interfaces

CCL consists of derived and core algorithm modules. The derived algorithm module ProEdrViirsCcl functions as a wrapper for the core algorithm module and handles the I-O stages in the I-P-O architecture. ProEdrViirsCcl initiates the core algorithm module Cloud Cover/Layers which makes up the P stage.

The main flow of the operational CCL algorithm is shown in Figure 2 below. The CCL algorithm gets all the required input data from DMS. When all the input data needed for processing is available, the core algorithm CloudCoverLayers is called to determine cloud cover layers. All inputs from and outputs to DMS are in binary format.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO



ProEdrViirsCcl Description

This is the derived class from ProCmnAlgorithm that contains overridden methods setupDataItems and doProcessing. Method setupDataItems instantiates input and output data items which represent data buffers to be used by the algorithm. doProcessing is the method where processing of the algorithm input data and generation of the output data by the algorithm is done. For more information see the Processing SI Common IO Design, DD60822-IDP-011.

Figure 2. Cloud Cover Layers Overall Flow Diagram

The CCL Module requires VIIRS Moderate Geolocation (GEO), VIIRS Parallax Corrected Cloud Mask (CM) IP, VIIRS Parallax Corrected Cloud Optical Properties (COP) IP, VIIRS Parallax Corrected Cloud Top Parameters (CTP) IP, VIIRS Cloud Aggregation (AGG) LUT, VIIRS Cloud Type LUT, and VIIRS CCL IP Algorithm Coefficients as inputs to produce the following outputs: VIIRS Cloud Layer Type IP, VIIRS Cloud Cover Type IP, VIIRS Cloud Aggregate GEO. A detailed itemization of the inputs and outputs for the CCL Module is provided in Sections 2.1.1.1 and 2.1.1.2. See Section 2.3 of the Cloud Cover/Layers ATBD, D43317, for more information.

2.1.1.1 Inputs

Note: For Sections 2.1.1.1, 2.1.1.2, 2.2.1.1, and 2.2.1.2 below, the following applies:

- Fill values corresponding to the individual pixels and horizontal cells in each product that do not contain valid data are dictated by the datatype (see Table 3). Exception: bitwise flags (i.e. cloud mask data, quality flags) are filled with zeros.
- Table Constants
  - M_VIIRS_SDR_ROWS = SCANS PER GRANULE X NUM_MOD_DETECTORS
  - M_VIIRS_SDR_COLS = 3200
  - VIIRS_CLD_HC_ROWS = SCANS PER GRANULE X 2
  - VIIRS_CLD_HC_COLS = 508
  - VIIRS_CLD_LYRS = 4

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 3. Fill Values

Input	Type	Description	Units/Valid Range
NA_FLOAT32_FILL	Float32	Float32 not applicable fill value	Unitless / -999.9
MISS_FLOAT32_FILL	Float32	Float32 missing fill value	Unitless / -999.8
ONBOARD_PT_FLOAT32_FILL	Float32	Float32 onboard pixel trim fill value	Unitless / -999.7
ONGROUND_PT_FLOAT32_FILL	Float32	Float32 on ground pixel trim fill value	Unitless / -999.6
ERR_FLOAT32_FILL	Float32	Float32 error fill value	Unitless / -999.5
NA_UINT16_FILL	Uint16	UInt16 not applicable fill value	Unitless / 65535
MISS_ UINT16_FILL	Uint16	UInt16 missing fill value	Unitless / 65534
ONBOARD_PT_ UINT16_FILL	Uint16	UInt16 onboard pixel trim fill value	Unitless / 65533
ONGROUND_PT_ UINT16_FILL	Uint16	UInt16 on ground pixel trim fill value	Unitless / 65532
ERR_ UINT16_FILL	Uint16	UInt16 error fill value	Unitless / 65531
NA_UINT8_FILL	UInt8	UInt8 not applicable fill value	Unitless / 255
MISS_ UINT8_FILL	UInt8	UInt8 missing fill value	Unitless / 254
ONBOARD_PT_ UINT8_FILL	UInt8	UInt8 onboard pixel trim fill value	Unitless / 253
ONGROUND_PT_ UINT8_FILL	UInt8	UInt8 on ground pixel trim fill value	Unitless / 252
ERR_ UINT8_FILL	UInt8	UInt8 error fill value	Unitless/ 251

Many of the inputs are common to both CCL and GCE modules. In addition, the CCL outputs are required as inputs in the GCE. This section describes the algorithm inputs and identifies those inputs required by the CCL and those common to CCL/GCE modules. Table 4 serves as an overview.

Table 4. CCL/GCE Inputs Summary

Source	Parameter	CCL	GCE
SDR Auxiliary	Latitude	Input	
	Longitude	Input	
	Sensor Zenith Angle	Input	
	Solar Zenith Angle		Input
	Actual Scans	Input	Input
Corr. Cloud Mask IP	Cloud Mask	Input	(Optional) Input
Corr. Cloud Optical Properties IP	Cloud Optical Thickness	Input	Input
	Effective Particle Size	Input	Input
	COP Quality		Input
Corr. Cloud Top Parameters IP	Cloud Top Height	Input	Input
	Cloud Top Temperature		Input
	Cloud Top Pressure		Input
	CTP (Parameters) Quality		Input
Cloud Base Height IP	Cloud Base Height		Input
	CBH Quality		Input
Cloud Layer Type IP (pixel level)	Cloud Layer	Output	Input
	Cloud Type	Output	
	CCL Quality	Output	
Cloud Cover Type IP (cell level)	Layer Cloud Cover	Output	Input
	Total Cloud Cover	Output	Input
	Cloud Type	Output	Input
Cloud Aggregate GEO (cell level)	lat	Output	Input
	lon	Output	
VIIRS Aggregation LUT	All	Input	Input
CCL Cloud Type LUT	All	Input	
CCL Coefficients	All	Input	
GCE Coefficients	All		Input

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Tables 5 through 11 describe the variables in each of the input files required by CCL (and, in some cases, GCE) modules. In each case, the variable type is identified, a short description is provided, and the units and range for the variable are identified. No range checking of these inputs is performed in the code. The expected valid range of inputs is provided for reference where known. The data is expected to be non-scaled. Any scaled data is to be un-scaled by the Processing Common Code prior to use in this algorithm.

Table 5. CCL/GCE: VIIRS SDR Moderate Resolution GEO Auxiliary Data Inputs

Input	Type	Description	Units/Valid Range
Latitude	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Latitude of the VIIRS pixels	Radians / -(PI / 2)(S) to (PI /2)(N)
Longitude	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Longitude of the VIIRS pixels	Radians / -PI(W) to PI(E)
Satellite Zenith	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Satellite Zenith of the VIIRS pixels	Radians / 0 to PI/2
Solar Zenith	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Solar Zenith of the VIIRS pixels	Radians / 0 to PI
Actual scans	Int32	Actual number of scans in a granule determined by the sdr (sdr may be less than full)	Unitless / 0 to VIIRS RDR Scans

Table 6. CCL/GCE Input: VIIRS Parallax Corrected Cloud Mask IP

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
Cloud confidence	2-bit unsigned field	Cloud Detection Result & Confidence Indicator	0 – Confidently clear 1 – Probably clear 2 – Probably cloudy 3 – Confidently cloudy
Sun glint	2-bit unsigned field	Sun glint	0 – No sun glint 1 – Geometry Based 2 – Wind Speed Based 3 – Geometry & Wind
Cloud phase	3-bit unsigned field	Cloud phase	0 - Not Executed 1 - Clear 2 - Partly Cloudy 3 - Water 4 - Mixed 5 - Opaque Ice 6 - Cirrus 7 - Overlap
Snow ice	1-bit unsigned field	Snow / Ice Surface	0 - Not 1 - Snow/Ice

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Input	Type	Description	Units/Valid Range
Land water	3-bit unsigned field	Land / Water Background	0 - Land & Desert 1 - Land no Desert 2 - Inland Water 3 - Sea Water 5 - Coastal

Table 7. CCL/GCE Input: VIIRS Parallax Corrected Cloud Optical Properties IP

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
Cot	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled cloud optical thickness	Unitless / 0.1 to 64.0
Eps	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled cloud effective particle size (radius)	microns / 0.0 to 120.0
Cloud phase	3-bit unsigned field	Cloud phase	0 - COP_PHASE_NOT_EXE 1 - COP_PHASE_CIRRUS 2 - COP_PHASE_OPQ_ICE 3 - COP_PHASE_WATER 4 - COP_PHASE_MIXED 5 - COP_PHASE_MUL_LYR
COP_QF_DAY_WATER_CONVERGENCE	1-bit unsigned field	Iteration convergence	0 – Not 1 - Convergent
COP_QF_DAY_ICE_CONVERGENECE	1-bit unsigned field	Iteration convergence	0 – Not 1 - Convergent
COP_QF_WATER_COT_LT1_DAY	1-bit unsigned field	Water cot < 1 at daytime	0 – Not 1 - True
COP_QF_ICE_COT_LT1_DAY	1-bit unsigned field	Ice cot < 1 at daytime	0 – Not 1 - True
COP_QF_WATER_COT_LT1_NIGHT	1-bit unsigned field	Water cot < 1 at nighttime	0 – Not 1 - True
COP_QF_ICE_COT_LT1_NIGHT	1-bit unsigned field	Ice cot < 1 at nighttime	0 – Not 1 - True
COP_QF_CLOUD_CONFIDENCE	1-bit unsigned field	Cloud confidence	0 – Not 1 – Probably/Confidently cloudy
COP_QF_EXCLUDE_SUN_GLINT	1-bit unsigned field	Sun glint	0 – Not 1 – Sun glint
COP_QF_COT_WATER_OUT_OF_BOUNDS	1-bit unsigned field	Water cot out of bound Day: (0.1-30) Night: (0.1-30)	0 – Not 1 – Out of bound
COP_QF_COT_ICE_OUT_OF_BOUNDS	1-bit unsigned field	Ice cot out of bound Day: (0.1-30) Night: (0.5-30)	0 – Not 1 – Out of bound
COP_QF_EPS_WATER_OUT_OF_BOUNDS	1-bit unsigned field	Ice eps out of bound (1-50 micrometers)	0 – Not 1 – Out of bound
COP_QF_EPS_ICE_OUT_OF_BOUNDS	1-bit unsigned field	Water eps out of bound (1-50 micrometers)	0 – Not 1 – Out of bound
COP_QF_DEGRADED_ICE_COT_GT_TEN	1-bit unsigned field	Degraded condition for ice cloud cot > 10	0 – Not 1 – Yes

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Input	Type	Description	Units/Valid Range
Bad SDR	2-bit unsigned field	Bad SDR flag data	0 – good 1 – bad 2 – no calibration

Table 8. CCL/GCE Input: VIIRS Parallax Corrected Cloud Top Parameters IP

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
Ctt	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled Cloud Top Temperature	K / 170 to 310
Cth	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled Cloud Top Height	km / 0 to 30
Ctp	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled Cloud Top Pressure	hPa / 50.0 to 1100.0
qf_cth_range	1-bit unsigned field	Cloud top height out of range (0-20 km)	0 - Not 1 - Out of range
qf_ctp_range	1-bit unsigned field	Cloud top pressure out of range (50-1050 mb)	0 - Not 1 - Out of range
qf_ctt_range	1-bit unsigned field	Cloud top temperature out of range (175-310 Kelvin)	0 - Not 1 - Out of range
qf_ctp_snowice	1-bit unsigned field	Snow / Ice Surface	0 - Not 1 - Snow/Ice
qf_ctp_surfType	3-bit unsigned field	Surface type	0 - Land desert; 1 - Land not desert; 2 - Inland water; 3 - Sea water; 5 - Coastal
qf_residual_night_water	1-bit unsigned field	IR ice ctt convergence	0 - Not 1 - Convergence
qf_residual_night_ice	1-bit unsigned field	IR ice ctt convergence	0 - Not 1 - Convergence
qf_residual_ir_day_ice	1-bit unsigned field	IR ice ctt convergence	0 - Not 1 - Convergence
qf_ctp_runbackup	3-bit unsigned field	Quality flags for using black cloud approach	0 - clear; 1 - non-day/water convergence 2 - day/water convergence 3 - black cloud 1 convergence 4 - black cloud 2 in bound 5 - black cloud 3 (not used) 7 - nonconvergence
qf_ctp_windowIR_converge	1-bit unsigned field	A quality flag to indicate if WindowIR for daywater clouds converges	0 – not converge 1 – converge

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 9. CCL/GCE VIIRS Cloud Aggregation LUT Auxiliary Data Inputs

Input	Type	Description	Units/Valid Range
At_agg_cell	Int32	Number of aggregation cells (output) in the along-track direction	Unitless / VIIRS_CLD_HC_ROWS
Xt_agg_cell	Int32	Number of aggregation cells in the cross-track direction	Unitless / VIIRS_CLD_HC_COLS
At_npix	Int32	Number of along track pixels in a swath	Unitless / NUM_MOD_DETECTORS
Xt_npix	Int32	Number of cross track (along scan) pixels in a swath	Unitless / M_VIIRS_SDR_COLS
i_agg_at	Int32[VIIRS_AGG TBL_ENTRIES]	Index of the aggregation (target) cell in the along-track direction (zero reference)	Unitless / 0 to (VIIRS_CLD_HC_ROWS – 1)
i_agg_xt	Int32[VIIRS_AGG TBL_ENTRIES]	Index of the target aggregation cell in the cross track direction	Unitless / 0 to (VIIRS_CLD_HC_COLS – 1)
scan	Int32[VIIRS_AGG TBL_ENTRIES]	Scan (previous scan, current scan, next scan)	Unitless / -1 to +1 -1 = previous 0 = current +1 = next
i_at	Int32[VIIRS_AGG TBL_ENTRIES]	Along track pixel number (0-base) in the referenced swath	Unitless / 0 to (NUM_MOD_DETECTORS – 1)
i_xt	Int32[VIIRS_AGG TBL_ENTRIES]	Cross track pixel number (0-base)	Unitless / 0 to (M_VIIRS_SDR_COLS – 1)
agg_type	Int32[VIIRS_AGG TBL_ENTRIES]	Pixel type: cluster cell only pixel; product cell only pixel; cluster and product cell pixel	Unitless / 0 to 3 1 = Cluster 2 = Product 3 = Product and Cluster

Table 10. CCL VIIRS Cloud Type LUT Auxiliary Data Inputs

Input	Type	Description	Units/Valid Range
height	Float32[CLOUD_ TYPE_LAYERS]	Mean cloud top height for stratus, altocumulus, cumulus, cirrus, cirrocumulus clouds	Kilometers / {1.3, 3.5, 3.3, 9.0, 10.5}
size	Float32[CLOUD_ TYPE_LAYERS]	Mean cloud effective particle size for stratus, altocumulus, cumulus, cirrus, cirrocumulus clouds	Micrometers / {13.5, 17, 27.5, 55, 75}
op_thick	Float32[CLOUD_ TYPE_LAYERS]	Mean cloud optical thickness for stratus, altocumulus, cumulus, cirrus, cirrocumulus clouds	Unitless / { 5.5, 17, 26.5, 2.5, 4.5 }

Table 11. CCL Tunable Parameters and Processing Coefficients

Input	Type	Description	Units/Valid Range
wgtCth	Float32	K-means algorithm cluster assignment weight for cloud top height (0.5 is the reciprocal of 2.0, optimization)	Kilometers / 0.5
wgtCot	Float32	K-means algorithm cluster assignment weight for cloud optical thickness	Unitless / 0.0

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Input	Type	Description	Units/Valid Range
wgtEps	Float32	K-means algorithm cluster assignment weight for cloud effective particle size (0.2 is the reciprocal of 5.0, optimization)	Microns / 0.2
wgtPhase	Float32	K-means algorithm cluster assignment weight for cloud phase (2.0 is the reciprocal of 0.5, optimization)	Unitless / 2.0
EkmCthThresh1	Float32	Ekm_first_guess() threshold on CTH for not splitting layers	0.75
EkmCthThresh2	Float32	Ekm_first_guess() threshold on CTH variance for splitting layers	1.6
EkmCthThresh3	Float32	Ekm_first_guess() threshold on CTH separation factor for splitting layers	1.6
Cluster_Flag_Threshold	Float32	Percentage of cloudy product pixels	0.75
CTH_LOW_THRESH	Float32	Mbkm_first_guess() lower CTH threshold	2.5
CTH_MID_THRESH	Float32	Mbkm_first_quess() middle CTH threshold	5.0
CTH_HIGH_THRESH	Float32	Mbkm_first_guess() high CTH threshold	7.5
PHASE_WATER	Float32	Water cloud	0.0
PHASE_MIXED	Float32	Water and ice cloud	0.5
PHASE_ICE	Float32	Ice cloud	1.0
gracefulDegradationMode	UInt8	Switch for handling missing pixel data 0 - use the pixel but omit missing variable from analysis for all pixels 1 - omit the pixeledge from the analysis (pixel is treated as non-cloudy)	Unitless / 0 to 1 0=ignore variable 1=ignore pixel Default = 0
kmeansAlgorithm	UInt8	Switch to select the first guess algorithm for layer analysis	Unitless / 0 to 1 0=MBKM 1=EKM
kmeansMaxIter	UInt8	Maximum number of iterations	3
clusterConvergCrit	UInt8	Convergence criteria = number of pixel reassignments	14

2.1.1.2 Outputs

For the outputs in this section, see Note 1 in Section 2.1.1.1.

The CCL module writes three output products in binary format: VIIRS Cloud Layer Type IP; VIIRS Cloud Cover Type IP; VIIRS Cloud Aggregate GEO. The VIIRS Cloud Layer Type IP (see Table 12) contains pixel level layer, type, and quality data. The VIIRS Cloud Cover Type IP (see Table 13) contains total cloud cover, layer cloud cover, and layer cloud type for HCs. The VIIRS Cloud Aggregate GEO (see Table 14) is produced separately from the IPs and is intended to be packaged with the output EDR products from GCE by Data Delivery.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 12. CCL Output: VIIRS Cloud Layer Type IP

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
Cloud_Layer	UInt8[M_VIIRS_SDR_ROWS][M_VIIRS_SDR_COLS]	Pixel-level cloud layer identification	Unitless / 0 to 3 3 <= cth low threshold 2 <= cth mid threshold 1 <= cth high threshold 0 > cth high threshold
Cloud_Type	UInt8[M_VIIRS_SDR_ROWS][M_VIIRS_SDR_COLS]	Pixel-level cloud type identification	Unitless / 1 to 5 1-Stratus 2-Alto Cumulus 3-Cumulus 4-Cirrus 5-CirrusCumulus
CCL_IP_Quality	UInt8[M_VIIRS_SDR_ROWS][M_VIIRS_SDR_COLS]	Pixel level CCL Quality Flags	Bitwise flags
		0-1 Cloud confidence	0-Confidently clear 1-Probably clear 2-Probably cloudy 3-Confidently cloudy
		2-4 Surface types	0-Land desert 1-Land not desert 2-Inland water 3-Sea water 5-Coastal
		5 Sun glint	0-No sun glint 1-Sun glint
		6 Snow/ice surface	0-No snow/ice 1-Snow/ice
		7 Spare	NA

Table 13. CCL Output: VIIRS Cloud Cover Type IP

Input	Type	Description	Units/Valid Range
Cell-Level Data Items			
Layer_Cloud_Cover	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud fraction for each layer	Unitless / 0 to 1
Total_Cloud_Cover	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cloud fraction summed over all layers	Unitless / 0 to 1
Cloud_Type	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud type for each layer	Unitless / 1 to 5 1-Stratus 2-Alto Cumulus 3-Cumulus 4-Cirrus 5-CirrusCumulus

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 14. CCL Output: VIIRS Cloud Aggregate GEO

Input	Type	Description	Units/Valid Range
Structure Data Items			
Scan Start Time	Int64[VIIRS_RDR_SCANS]	Starting Time of Scan in IET	Microseconds / 0.00 to 1.00E+38
Scan Mid Time	Int64[VIIRS_RDR_SCANS]	Mid Time of Scan in IET	Microseconds / 0.00 to 1.00E+38
Latitude	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Latitude at the center of each horizontal cell grid point	Degrees / -90(S) to +90(N)
Longitude	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Longitude at the center of each horizontal cell grid point	Degrees / -180(W) to +180(E)
Solar Zenith Angle	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Solar Zenith Angle	Degrees / 0 to 180
Solar Azimuth Angle	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Solar Azimuth Angle	Degrees / -180 to 180
Sensor Zenith Angle	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Sensor Zenith Angle	Degrees / 0 to 180
Sensor Azimuth Angle	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Sensor Azimuth Angle	Degrees / -180 to 180
S/C Position	Float32[VIIRS_RDR_SCANS][3]	Spacecraft position in orbit at mid-scan time	Meters / -7.46E+06 to 7.46E+06
S/C Velocity	Float32[VIIRS_RDR_SCANS][3]	Spacecraft velocity in orbit at mid-scan time	Meters per second / -6600 to 6600
S/C Attitude	Float32[VIIRS_RDR_SCANS][3]	Spacecraft attitude in orbit at mid-scan time	Arcseconds / -300 to 300
S/C Solar Zenith Angle	Float32[VIIRS_RDR_SCANS]	Solar zenith angle with respect to the solar diffuser reference frame z-axis, where the SD z-axis is normal to the SD surface.	Degrees / 0 to 180
S/C Solar Azimuth Angle	Float32[VIIRS_RDR_SCANS]	Solar azimuth angle measured counterclockwise about the solar diffuser reference frame z-axis with respect to the solar diffuser x-axis (with positive z-axis towards the observer)	Degrees / 0 to 360

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Input	Type	Description	Units/Valid Range		
scanQual	UInt8[VIIRS_RDR_SCANS]	Scan-level quality flags	0-1	Interpolation Stage	0-Nominal 1-Missing data <= small gap 2-Small gap < Missing data <= Granule boundary 3-Missing data > Granule boundary
			2-3	HAM Impulse Flag	0: Good data – all encoder data is valid 1: Bad data – either HAM encoders, RTA encoders or both corrupted for the entire scan 2: Degraded data – either HAM encoders, RTA encoders or both are corrupted within the scan. 3: Missing data – Missing encoder data for the scan (dropped engineering packets)
			4	Above South Atlantic Anomaly	0-False 1-True
			5	Solar Eclipse	0-False 1-True
			6-7	Spare	NA
cellQual	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cell-level quality flags	0	Invalid Input Data	0-Valid 1-Invalid
			1	Bad pointing	0-Good pointing 1-Bad pointing
			2	Bad Terrain	0-Good terrain 1-Bad terrain
			3	Invalid Solar Angles	0-Valid solar angles 1-Invalid solar angles
			4-7	Spare	NA

2.1.2 Algorithm Processing

The purpose of the CCL module is to classify cloudy pixels into as many as four cloud layers and to determine the cloud type for each layer. The module produces Intermediate Products (IPs) that describe the pixel-level assignment of the cloud layers and types plus cloud cover (CC) and cloud type (CT) products generated over horizontal cells (HC) and reported for each of the four layers plus averaged over all layers. See Section 2.5 of the Cloud Cover/Layers ATBD, D43317, for more information. The dataflow model for the CCL algorithm is illustrated in Figure 3.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

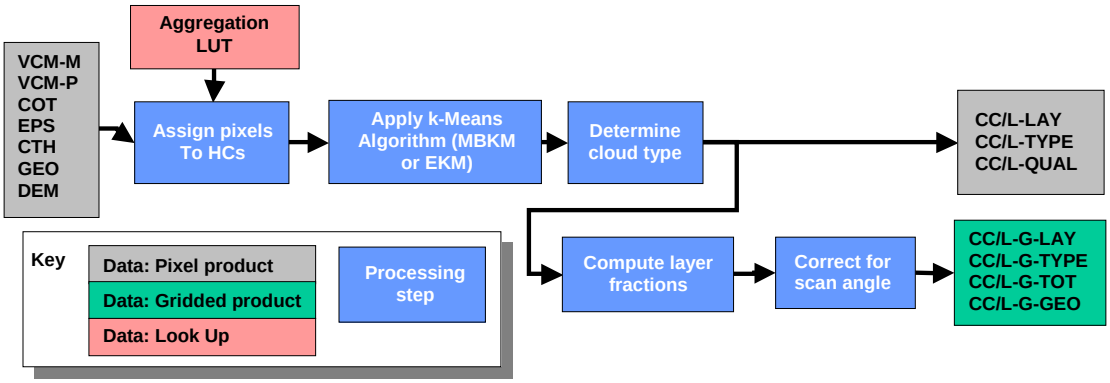


Figure 3. Conceptual Process for Cloud Cover Layers

The CCL reads and processes the data one scan at a time. Horizontal product cells are always comprised of pixels within a single scan. The assignment of pixels to product cells is accomplished using an aggregation table. For each scan line, CCL loops over all product cells and generates outputs based on the pixel-level cloud IPs identified with each cell. The aggregation approach developed for the CCL allows for a larger group of pixels surrounding each HC (or product cell) to better identify the layers via the k-means analysis. This extended region is referred to as the clustering cell. It includes pixels from the adjacent scans. The first and last scan lines in a granule require that the cluster cells contain pixel information from the previous/next scans of the preceding and succeeding granules. To accomplish this, the last scan of the previous granule and the first scan of the next granule is read and passed to the algorithm as the cluster cells when the product cell is the first or last scan. CCL uses a method called setScan() to read the previous, current and next scan input data. The aggregation table is read using loadAggTbl() and the pixels associated with each cell are identified with getAggCell(). The CCL routine keeps data from the previous, current, and next scans in memory as the information from all three scans may be required in the clustering analysis. See Section 2.4 of the Cloud Cover/Layers ATBD, D43317, for more information.

> Note: It should be noted that reading one scan before and one scan after the current granule differs somewhat from the science code that reads two scans from the previous granule and nothing from the next granule. Using the method defined in the science code would have shifted the output by one scan, therefore the one scan before and the one scan after method was used to avoid shifting the output.

Retrieval Logic

The CCL module uses a preprocessing routine called cell_copy_in() which copies the cloud IP data associated with each cell to temporary arrays. Each pixel in the cell is identified as either 1=product, 2=cluster, or 3=product and cluster pixels. In practice, all pixels in the product cell are also used in the clustering analysis so pixels are identified as 1 or 3 in normal operating modes. Pixels assigned to each cell may originate from the previous, current, or next scans; however product pixels are always associated with the current scan. The preprocessing routine also computes the mean latitude, longitude, and sensor zenith angle for the product cell. Logic is included in cell_copy_in() to handle missing data. Two options for dealing with missing data are available as configuration parameters. Option 1 sets the k-means cluster weights for COT and EPS to zero if values for these inputs are missing. If CTH is missing, then the pixel is not used in the clustering calculations. Option 2 eliminates any pixel that is missing CTH, COT, or EPS from the k-means clustering evaluation. The k-means weight defaults to the values

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

specified in the configuration file if the input CTH, COT, and EPS are available. Cloud phase is converted to a float with 0.0 indicating water, 0.5 indicating mixed phase, partly cloudy or overlapping cloud, and 1.0 indicating cirrus or opaque ice phase. Any pixels not identified as confident cloudy in the VIIRS cloud mask are treated as clear by the CCL algorithm.

Pixels identified with the overlapping cloud phase are a problem for the CCL routine as these pixels represent information from more than one layer. This problem is addressed by excluding the multi-layer pixels from the process of layer determination in one of two ways:

(1) Multi-layer pixels assigned as “cluster” cell only are omitted from the current “product” cell analysis.

(2) Multi-layer pixels assigned as “product-plus-cluster” cell are reassigned as “product” cell only for the current “product” cell analysis. Therefore, the pixels are included in the cloud fraction determination for the horizontal cell but omitted from the layer/type statistic analysis.

The CCL algorithm is divided into two parts. The first, ccl_cluster(), performs the analysis of cloud layer based on the selected inputs and produces pixel-level assignment of cloud layer and type for the cell. If no pixels in a given cell are cloudy then the ccl_cluster() function returns fill values for the cloud layer and type for the cell.

Ccl_cluster function determines a “pixel-level” cloud layer and cloud type. This is an IP output, not EDR. The cloud fraction is determined from the number of cloudy pixels in the HC and is independent of the cloud layer and type determined in the CCL_Cluster function. If there is no cloud in the product cell, i.e. the horizontal cell, the cloud fraction is zero, not FILL. The product quality is computed based on the parameters used in the k-mean analysis.

The first guess module makes the initial assignment of cloudy pixels into layers. Two algorithms are available. The function mbkm_first_guess() executes the modified baseline routine and assigns the initial cloud layers based on CTH thresholds (at 2.5, 5.0 and 7.5 km). The function ekm_first_guess() executes the extended algorithm and assigns initial cloud layers based on a statistical analysis of CTH. This routine begins with all cloudy pixels in one cluster. If the standard deviation of the cloud heights is greater than the specified threshold (0.75 km), then an attempt is made to split the clouds into two layers. This is accomplished via a k-means distance clustering using height as the only variable. The standard deviations of the resulting cluster are compared with the separation in mean height between the clusters. If this quantity exceeds a specified threshold (1.6 km) or the standard deviation of the original cluster exceeds a threshold (1.6 km), then the cloudy pixels are split into the two layers. The process repeats for the layer with the largest standard deviation in CTH until a maximum of four layers is defined.

Once the initial layer assignments are complete, the apply_kmeans() routine is used to refine the layer assignments based on the variables (i.e., CTH, COT, EPS, and phase) specified in the configuration file. The k-means algorithm compares normalized distance relative to the mean for each layer based on all selected input variables. Cloudy pixels are re-assigned to layers based on the minimum distance. The algorithm iterates a number of times, KMEANS_MAXITER, and updates the layer means with each iteration. If the number of pixel reassignments is less than a critical value, CLUSTER_CONVERG_CRIT, then the process is terminated.

Finally the CTs are assigned for each pixel in the function assign_cloud_type(). For each pixel, the cloud phase determines the possible CTs. The CTH, COT, and EPS of the pixel are

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

compared with the mean values for each CT and the minimum distance is used as the criteria for assigning the type.

The second component of the CCL algorithm, ccl_product(), processes the pixels in the product cell to derive the CC fraction and CT for each cloud layer. This component includes the oblique angle correction to the CC fraction estimates. In a given layer, it is possible for cloudy pixels within an HC to be classified as different types (e.g., if the phase is different). If this situation should arise, the code assigns the prevalent CT to the HC. The ccl_product() code also includes a preprocessing step used to re-number the cloud layers assigned by the EKM algorithm if the product cell contains fewer layers than the cluster cell. At the end of ccl_product(), the aggregation table data is used to assign pixel-level values from each cell to the appropriate scan locations.

Configurable Parameters

Configurable inputs to the CCL algorithm are specified in a single configuration file. The configurable parameters are summarized in Table 11. The table identifies the mean values of CTH, COT, and EPS for each of five cloud types. A set of normalization factors (or weights) are used to specify the relative importance of CTH, COT, EPS, and cloud phase in the k-means clustering analysis. Use of these parameters can be turned off by setting the values to zero. Non-zero factors represent the range of variability of each parameter. Careful selection of these parameters provides the desired balance between the variables in the k-means algorithm.

Two options for dealing with missing data are available in the code and can be selected with the GRACEFUL_DEGRADATION configuration parameter. If COT and/or EPS are selected as k-means parameters (i.e., non-zero normalization) and are not present for a given pixel, then either the pixel is omitted from the analysis (IGNORE_PIXEL) or the missing variable is omitted from the analysis (IGNORE_VARIABLE). If CTH is missing, then the pixel is omitted from the analysis because CTH is required by the first guess algorithm. Cloud phase is always required for the cloud layer analysis.

The modified baseline k-means (MBKM) algorithm is based on an initial guess that groups cloudy pixels into layers based on fixed height thresholds (at 2.5, 5.0, and 7.5 km). The extended k-means (EKM) algorithm determines the initial estimate of the cloud layers based on a statistical analysis of the cloud height distributions. These options can be selected with the KMEANS_ALGORITHM configuration parameter.

For each cloud type the mean values of CTH, EPS, and COT are provided. The types appropriate for each cloud phase (i.e., water, ice and mixed) are determined by limits set in the assign_cloud_type() function (e.g., water = type 0 to 2, ice = type 1 to 4, mixed = type 1 to 2).

Aggregation Tables

The product cell size for the VIIRS Cloud aggregated output is approximately 6 km from nadir to end-of-scan (EOS). The product cells are constructed from pixels in one half of the 16 pixel scan. At nadir, the product cell size is 8 by 8 pixels. At EOS, the product cell is 4 by 4 pixels. In total there are 2 x 508 product cells per scan. The cluster cell size defines the region surrounding the product cell that is used to identify and classify the cloud layers. Three cluster cell sizes are considered: 6 km, 12 km, and 18 km (currently, only the aggregation table with the 12 km cluster cell size is being used). Aggregation tables are used to identify the pixels belonging to each product/cluster cell. Table 15 summarizes aggregation tables that have been generated for VIIRS data.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 15. CCL/GCE Aggregation Tables

Name	Lines per Scan	SPA	Product Cell Size	# of Cells	Nadir Pixels	EOS Pixels	Cluster Cell Size		
viirs06	16	Yes	6 km	508x2	8x8	4x4	6 km	12 km	18 km

2.1.2.1 Main Module - cclDriver()

This function is the main driver for the core CCL algorithm. Called by ProEdrViirsCcl(), cclDriver() sets the scan pointers, loads the aggregation table data, prefills output data buffers, sets (produces) output quality flags, determines the total number of cells per scan, and processes valid scans in the granule. For each cell in a scan, cell_copy_in() copies cell data into temporary variables for calculations, ccl_cluster() calculates pixel-level cloud layers and types, ccl_product() calculates aggregate-level cloud layers and types, and cell_copy_out() writes pixel-level cloud layer and type to the output.

2.1.2.2 setScan()

cclDriver() calls setScan() to set the scan pointers (previous, current, next) used in processing to the appropriate locations in the IP data.

cell_copy_in() copies in the pixel-values for all input variables as identified by the aggregation table for a given cell.

- getAggCell() is called to retrieve data from the aggregation table for the current cell.
- Sensor zenith angles, latitudes and longitudes are computed for the product cell (for previous, current, and next scans). Latitudes and longitudes are computed as follows:

  x = sin(Lat) * cos(Lon)
  y = sin(Lat) * sin(Lon)
  z = cos(Lat)

- COT, EPS, CTH, Phase, and Cloud Confidence data is obtained for cluster defined pixels in a cell for previous, current, and next scans.
- For confidently cloudy pixels with valid cloud phase, if the pixels are missing COT, or EPS, the pixels are ignored (if mode set to IGNORE_PIXEL) or the corresponding pixel COT and EPS weights are set to zero (if mode set to IGNORE_VARIABLE).
- For confidently cloudy pixels with valid data, the phase is assigned according to cloud mask.
- The clustering flag is set based on percentage of cloudy product pixels in the cell.
- Aggregate solar zenith, solar azimuth, sensor zenith, sensore azimuth angles and latitude and longitude are calculated for the cell.
  The solar and sensor angles are averaged, while latitudes and longitudes are computed as follows:

  Calculate average for each value: x, y, z
  sqrt_result = sqrt($x_{avg}^2+y_{avg}^2+z_{avg}^2$)
  cell latitude = acos(z_{avg} / sqrt_result)
  cell longitude = atan2(y_{avg}, x_{avg})

2.1.2.3 ccl_cluster()

The purpose of ccl_cluster() is to apply the k-means algorithm to all pixels in the cluster cell and to set the pixel-level layer and type values. A first guess at layer (also referred to as cluster)

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

assignments for pixels is used to initialize the k-means cluster analysis. The configurable parameter kmeansAlgorithm selects which of the two available first guess algorithms to use (mbkm_first_guess() or ekm_first_guess()). The default is mbkm_first_guess(). At this point, assignments of layers to pixels were based on CTH thresholds (if mbkm algorithm was used) or CTH statistical analysis (if ekm algorithm was used).

Cluster results from the first guess algorithm are used by apply_kmeans() to further refine the layer assignments by reassigning pixels to layers using CTH, COT, EPS, and PHASE (involves k-means calculations).

The output IP pixel layer values are set using cluster results from apply_kmeans().

Assign_cloud_type() processes cluster means and cluster count results from apply_kmeans() to set the output IP pixel type values.

2.1.2.4 ccl_product()

ccl_product() determines aggregate layer type and cloud cover layer (fraction) based on product cell pixel-level layer and type assignments.

If the EKM algorithm was used, layer adjustments are computed for layers that do not contain any product pixels. Beginning with the lowest layer that does not contain product pixels, all product pixels assigned to layers higher than the empty layer are shifted down one layer.

For all product pixels in a cell that contain valid layer and type data, cloud and cluster counters are incremented and the CTHs for each layer are accumulated in cluster_cth_means. Next, the cloud type with the highest occurrence in a layer is assigned as the cloud type for that layer in the cell.

Cloud fraction for the cell is then calculated as follows:

1. Determine apparent fractional coverage.
   Appar_frac = cloud count / product pixels

2. Use the apparent fractional coverage to determine cloud fraction from the cloud fraction look-up table.

3. Determine horizontal cloud top height (i.e. cloud top height for the cell).
   Hcth = cluster count * cluster means

4. Use the horizontal cloud top height to determine cloud altitude from the cloud altitude look-up table.

5. Determine cloud fraction view angle correction parameters.
   Use the cloud fraction and cloud altitude as indexes into the gamma look-up table to obtain the correct cloud masking exponent (gamma).

   theta = sensor zenith angle for the cell
   x_value = 1.0 + theta * tan(theta) + (1./cos(theta))
   x_value = 2.0 / x_value
   f_value = pow(x_value, gamma)

6. Compute cloud fraction.
   Cloud frac = f _value* cluster count / product pixels

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Refer to Cloud Cover/Layers ATBD in the Scan Angle Effect and Correction for Cloud Fraction section.

2.1.2.5 cell_copy_out()

cell_copy_out() is called by cclDriver() to write pixel cloud layer and type for only current scan product pixels to the output IP.

2.1.2.6 recalcClusters()

recalcClusters() is called by apply_kmeans() to calculate cluster counts, cluster means and phase counts for cloud layers. This function only processes pixels defined as cluster pixels. The frequency of each cloud phase (water, ice, mixed) for cluster pixels in a cell is determined for later use by assign_cloudType(). Also, the CTH, COT, EPS and Phase values are summed up for applicable layers. Counters and checksums are used to ensure that the correct number of pixels was processed for the cell. CTH, COT, EPS and Phase means are calculated.

2.1.2.7 cloudDist()

Called by assign_cloudType(), this function measures the normalized “distance” between cluster means (if valid) and Cloud Type Table values (COT, CTH, EPS) for the cloud type indicated. The following formula is used:

$$
\begin{aligned}
&(\text{COT cluster means} / \text{cloud type table COT})^2 \\
&+ (\text{CTH cluster means} / \text{cloud type table CTH})^2 \\
&+ (\text{EPS cluster means} / \text{cloud type table EPS})^2 \\
&= \text{normalized distance}
\end{aligned}
$$

2.1.2.8 normDist ()

This function normalizes the “distance” between pixel values and cluster means for CTH, COT, EPS, and Phase (where valid) for different cloud phases using weighted coefficients. Note: if the graceful degradation mode is set to IGNORE_VARIABLE, the weights for COT and EPS are zero. The following formula is used:

$$
\begin{aligned}
&((\text{COT} - \text{COT cluster means}) / \text{COT weight})^2 \\
&+ ((\text{CTH} - \text{CTH cluster means}) / \text{CTH weight})^2 \\
&+ ((\text{EPS} - \text{EPS cluster means}) / \text{EPS weight})^2 \\
&+ ((\text{Phase} - \text{Phase cluster means}) / \text{Phase weight})^2 \\
&= \text{normalized distance}
\end{aligned}
$$

2.1.2.9 mbkm_first_guess()

The purpose of mbkm_first_guess() is to provide the first guess at layer identification based on fixed cloud top height ranges. For each product or product-and-cluster pixel in a cell that contains valid phase data, the CTH is compared to the cloud top height thresholds (low, mid, high) starting with low. CTH thresholds correspond to cloud layers as follows:

Layer 0: CTH <= CTH_LOW_THRESH
Layer 1: CTH <= CTH_MID_THRESH
Layer 2: CTH <= CTH_HIGH_THRESH
Layer 3: CTH > CTH_HIGH_THRESH

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Cluster counters keep track of the number of pixels assigned to each layer, including the NULLAYER used to capture pixels that are PRODUCT only. Cluster counts for each layer are used as checksums to verify all pixels in the cell were processed.

2.1.2.10 ekm_first_guess()

The EKM algorithm begins with all cloudy pixels assigned to a single layer. If the standard deviation of CTH is greater than some threshold (e.g., 0.75 km) then an attempt is made to assign the cloudy pixels into two layers. This is accomplished via a Euclidean distance metric with CTH as the only variable. Once the clusters are established, the standard deviation of CTH for each distribution is computed, as is the separation between the mean values of CTH. The clusters are accepted as distinct if the separation divided by the sum of the two standard deviations is greater than a prescribed threshold value (e.g., 1.5). Alternatively, if this is not the case but the standard deviation of the initial combined group is greater than yet another critical value (e.g., 1.6 km), then the two clusters are also retained. This process is repeated for the cluster with the largest standard deviation in CTH until a maximum of four cloud layers is established. The three thresholds (EkmCthThresh1, EkmCthThresh2, EkmCthThresh3) used by this algorithm are tunable parameters.

2.1.2.11 apply_kmeans()

The apply_kmeans() algorithm calls recalcClusters() to initially calculate the cluster means. Next, this function loops through the following steps (get normalized distance (call normDist()), set cluster pixel to minimum distance, calculate cluster means (call recalcClusters()), test for convergence) to iteratively reassign pixels to layers until cluster convergence criteria is met or the maximum number of iterations is reached.

2.1.2.12 assign_cloud_type ()

In ccl_cluster(), assign_cloud_type() is called to determine the frequency of each cloud phase (water, ice, mixed) for the pixels in a cell and to assign the phase with the highest frequency to the cell. The cell phase is then compared to phase constants to obtain the max/min indexes for the range of cloud types associated with that phase in the cloud type table. Cluster means of CTH, COT, and EPS for the cell are compared to cloud types within range in the cloud type table using cloudDist(). The result with the minimum distance is assigned as the cloud type.

2.1.2.13 produceQualityFlags ()

In cclDriver() initialization, produceQualityFlags() is called to set the output quality flags for every pixel in the granule according to cloud mask flags for cloud confidence, surface type, sun glint, and snow/ice. This function requires pixel locations, cloud mask data, and location of quality flags to be filled.

2.1.2.14 fillOutputs()

During CCL cell-level processing, if a cell-level function fails, then fillOutputs() is called to fill the CCL outputs with error fill values and the quality flags with zero for the indicated cell and all pixels associated with that cell. This function requires pixel and cell locations to be filled.

2.1.2.15 loadAggTbl()

Used by CCL and GCE algorithms, the loadAggTbl() function takes each entry in the aggregation table (an entry contains pixel row/col, scan, cell row/col, product) and populates a temporary aggregation structure containing an array of cells with corresponding data for those cells. As the cells are populated with data, a counter logs and stores the number of pixels that were mapped to a cell.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

2.1.2.16 getAggCell()

Used by CCL and GCE algorithms, the getAggCell() function accesses the temporary aggregation structure to get data for the indicated cell. Cell data includes: pixel indexes; pixel scan values (previous, current, next); pixel product masks (product, cluster, product and cluster); total number of pixels mapped to the cell.

2.1.2.17 assignScanLevelGeolocationData()

After looping through the scans in cclDriver(), this function is called with the current cross-granule data and the geolocation output pointers as its parameters. Its basic function is simply to copy scan-level fields from the VIIRS-MOD-GEO input over to the VIIRS-CLD-AGG-GEO output.

2.1.3 Graceful Degradation

The CCL module does not implement graceful degradation. CCL retrievals rely entirely on the availability of data from the VIIRS cloud IPs. No logic is included to replace missing data with secondary sources.

2.1.4 Exception Handling

Error-handling in the Input (I) and Output (O) stages of the I-P-O algorithm addresses errors associated with reading/writing of databases. If an error occurs, the error is reported, the process is terminated and no outputs are produced.

Error-handling in the Processing (P) stage involves granule level, cell level, and pixel level errors. All outputs are initialized with Not Applicable (NA) FILL (except quality flags which are initialized to zero) so all unprocessed cell level or pixel level data contains FILL values.

For granule level errors, i.e. errors resulting from loading the aggregation table or an invalid number of scans, the error is reported, the process is terminated and no outputs are produced.

For pixel level errors, the errors are reported and the pixel level function fails back to the cell level function call.

For cell level errors, the errors are reported, cell level outputs and pixel level outputs associated with the cell being processed are filled with Error (ERR) FILL (quality flags are set to zero) and processing continues with the next cell.

2.1.5 Data Quality Monitoring

The CCL algorithm produces IP and GEO outputs, therefore quality assessment and diagnostics are not done in this algorithm. Any Data Quality Notification (DQN) produced for the Cloud algorithms are handled by the Generate Clouds EDR (GCE) process.

2.1.6 Computational Precision Requirements

The CCL module employs single precision throughout.

2.1.7 Algorithm Support Considerations

Aggregation tables used by the CCL and GCE modules are based on the current VIIRS sensor design. Changes to the design (e.g., sub-pixel aggregation boundaries, number of pixels per line) may require an off-line recalculation of the aggregation tables.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

2.1.8 Assumptions and Limitations

The CCL algorithm assumes that the VIIRS 750m SDR auxiliary data, the VCM IP including Cloud Phase, the COP IP, and CTP (Parameters) IP are all available for processing. All inputs are expected in binary format at M-band pixel resolution.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

2.2 GCE Description

The GCE algorithm is implemented during EDR processing and requires GEO, IP, and Look-Up Table (LUT) inputs to produce the cloud EDR outputs averaged over HCs and report the sum over all layers for each cloud layer. A top-level diagram for the GCE algorithm is shown in Figure 4. See Section 3.2 of the Cloud Cover/Layers ATBD, D43317, for more information.

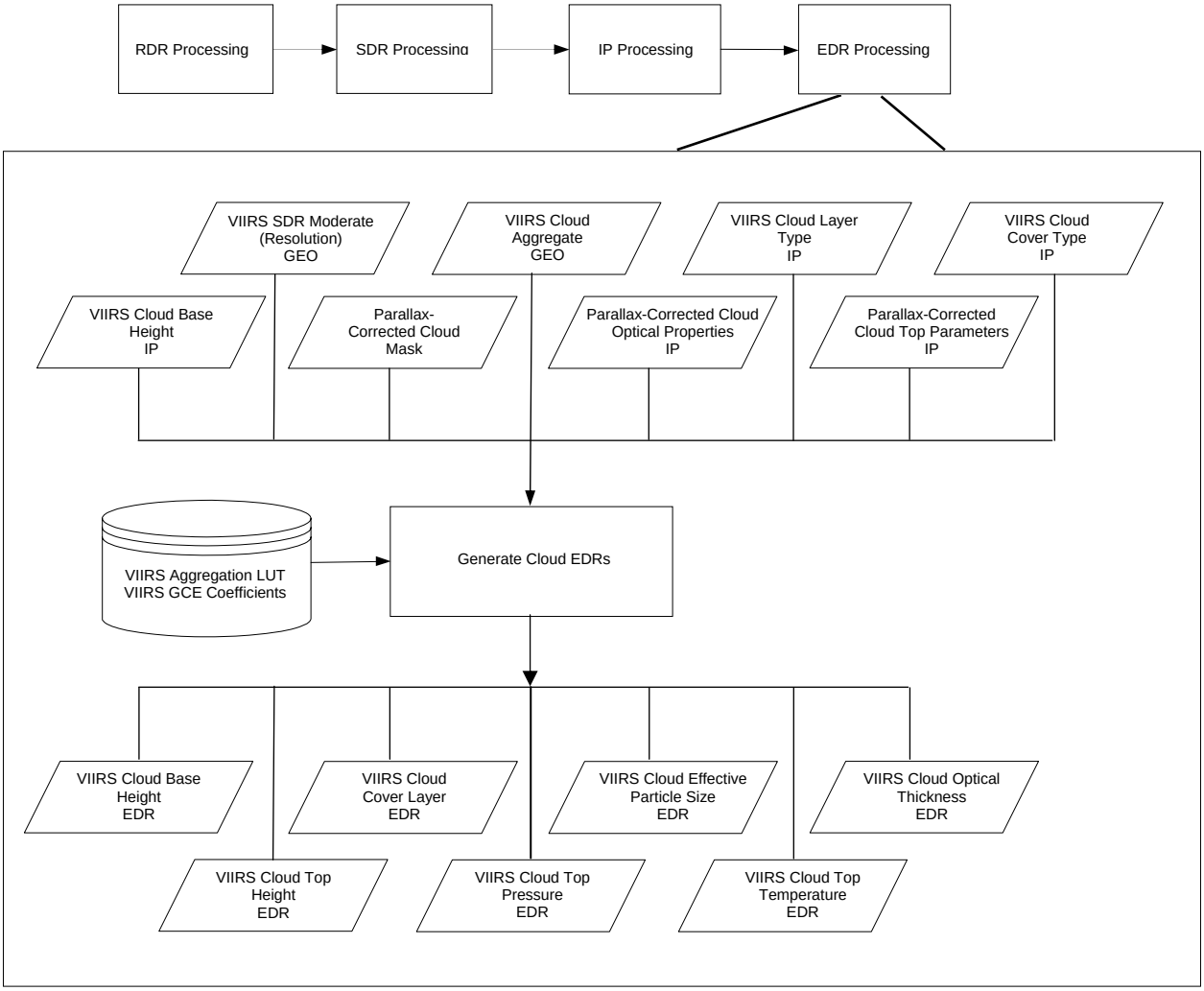


Figure 4. GCE Algorithm Overview

2.2.1 Interfaces

GCE consists of derived and core algorithm modules. The derived algorithm module ProEdrViirsGce functions as a wrapper for the core algorithm module and handles the I-O stages in the I-P-O architecture. ProEdrViirsGce initiates the core algorithm module GenerateCloudEDRs which makes up the P stage.

The main flow of the operational GCE algorithm is shown in Figure 5 below. The GCE algorithm gets all the required input data from DMS. When all the input data needed for processing is available, the core algorithm GenerateCloudEDRs is called to produce cloud EDRs. All inputs from and outputs to DMS are in binary format.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

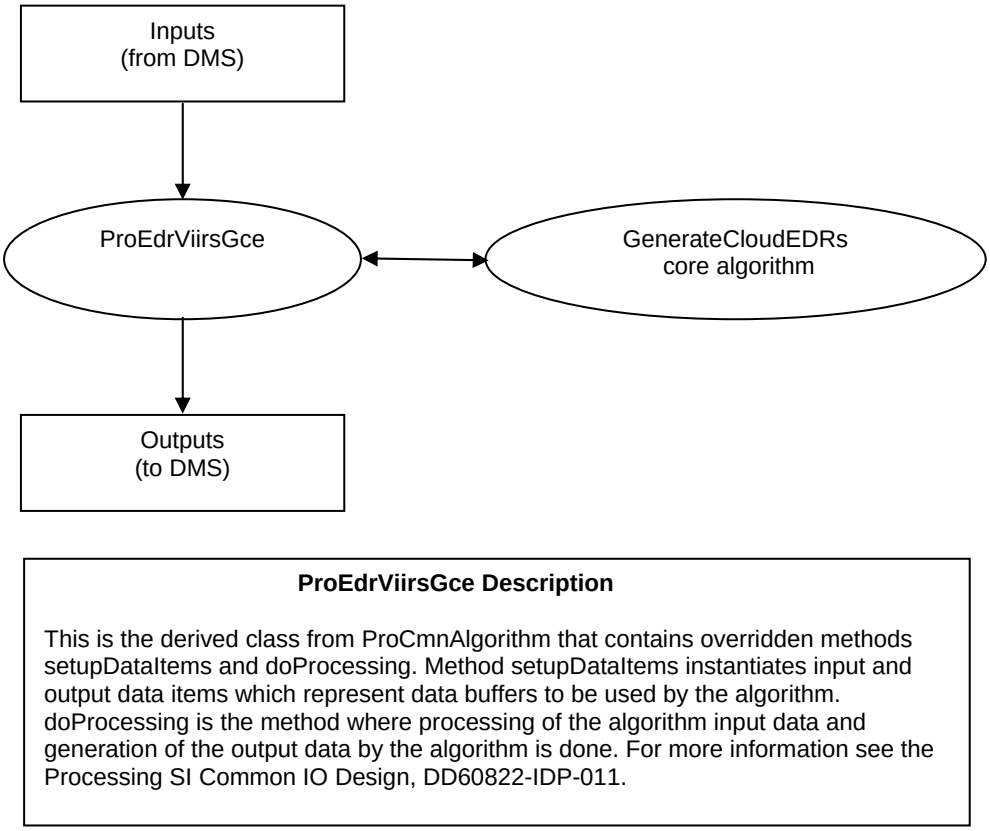


Figure 5. Generate Cloud EDRs Overall Flow Diagram

The GCE Module requires VIIRS Moderate Geolocation (GEO), VIIRS Cloud Aggregate GEO, VIIRS Cloud Base Height (CBH) IP, VIIRS Cloud Cover Type IP, VIIRS Cloud Layer Type IP, VIIRS Parallax Corrected Cloud Optical Properties (COP) IP, VIIRS Parallax Corrected Cloud Top Parameters (CTP) IP, VIIRS Cloud Aggregation (AGG) LUT, and VIIRS GCE IP Algorithm Coefficients as inputs to produce the following outputs: VIIRS Cloud Base Height EDR, VIIRS Cloud Cover Layer EDR, VIIRS Cloud Effective Particle Size EDR, VIIRS Cloud Optical Properties EDR, VIIRS Cloud Top Height EDR, VIIRS Cloud Top Pressure EDR, and VIIRS Cloud Top Temperature EDR. See Section 2.3 of the Cloud Cover/Layers ATBD, D43317, for more information.

VIIRS Parallax Corrected Cloud Mask (CM) IP is an optional input used only for metadata purposes. A detailed itemization of the inputs and outputs for the GCE Module is provided in Sections 2.2.1.1 and 2.2.1.2.

2.2.1.1 Inputs

See Section 2.1.1.1 for inputs common to both GCE and CCL and for applicable fill values.

Tables 16 and 17 describe the variables in each of the input files (not already listed in Section 2.1.1.1) required by the GCE module. In each case, the variable type is identified, a short description is provided, and the units and range for the variable are identified. No range checking of these inputs is performed in the code. The expected valid range of inputs is provided for reference where known. The data is expected to be non-scaled. Any scaled data is un-scaled by the Processing Common Code prior to using it in this algorithm.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 16. GCE Input: VIIRS Cloud Base Height IP

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
Cbh	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Cloud Base Height	km / -1 to 30
Out of Range	1-bit unsigned field	Out of Range flag (0-20)	0 - Not 1 - Out of Range

Table 17. GCE Tunable Parameters and Processing Coefficients

Input	Type	Description	Units/Valid Range
QF COT Solar Zenith Angle Threshold	Float32	Threshold (in radians) used to set Day/Night/Transition quality flags	Radians / (75*pi)/180
c1	Float32	Coefficient in geopoential to geomentric height correction in height_conversion()	Unitless / 0.002644
c2	Float32	Coefficient in geopoential to geomentric height correction in height_conversion()	Unitless / 0.0089
c3	Float32	Coefficient in geopoential to geomentric height correction in height_conversion()	Unitless / 6245.

2.2.1.2 Outputs

For the outputs in this section, see Note 1 in Section 2.1.1.1 for applicable fill values.

The GCE module generates cloud EDRs reported over HCs. A common HC size is used for all cloud EDRs (i.e., approximately 6 km). These products are in binary format. Along with the EDR output, QF values are also reported over the HC. Both scaled (integerized) and full resolution (nonscaled) EDRs are produced (refer to IDPS Scaled Integers Proposed Solution). Scaled EDRs include CBH, CCL, CEPS, COT, CTH, CTP (Pressure), and CTT. Full resolution EDRs (FEDRs) include CCL, CTH, and CTP (Pressure).

Each EDR contains two types of data (layered and total) and three types of quality flags (layered, total, and non-cloud related). CCL EDR also contains type data. Layered data contains the retrieved values of, for example, COT on a layer-by-layer basis, and total contains the average over the HC (except for cloud cover, which represents the total fraction over the HC). Additionally, scaled EDRs contain scale and offset values whereas full EDRs do not. Furthermore, layered data are arranged according to the layered CTH, where the 1st layer has the highest cloud height, and the 2nd layer has the next lower cloud height, etc. As such, no cloud will ever appear in layer 2 or 3 when the 1st layer is FILL.

In the “layered” and “total” COT, EPS, CTH, CTT, CTP and CBH the data field will be ‘FILL’ if there is no cloud in the designated layer or HC. For layered and “total” cloud cover, however, the data field is set to “0” if there is no cloud in the designated layer or HC. For cloud type, the type will be “FILL” if there is no cloud in the designated layer.

Tables 18 and 19 describe in detail each of the QFs implemented in all the cloud EDRs. These quality flags have essentially the same meaning in each EDR except for those QFs where specific thresholds are used (for example, COT and EPS have different out-of-bound threshold values).

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Notice that both Layer and Total quality flags use identical quality flag bytes. For example, in the COT EDR output file, there is “Layer COT EDR Quality” and “Total COT EDR Quality”; both are interpreted as in Table 18. For the non-cloud related QFs, their values are reported in “COT EDR Quality” as described by Table 19. All Cloud EDR QF bitmasks are defined in ProEdrViirsGceGbl.h.

Table 18. Layered and Total Quality Flags (QF_LYR_CLOUD) for Horizontal Cell

Name – Byte 0	Bitfield	Description/Source	Value
qf_cld_confidence	0-1	Cloud confidence	Cloudiness classified in 4 levels *
qf_phs	2-7	Cloud phase	Bits 2-3: water cloud in classified 4 levels* Bits 4-5: multi-layer cloud classified in 4 levels * Bits 6-7: mixed cloud classified in 4 levels *
Name – Byte 1	**Bitfield**	**Description/Source**	**Value**
qf_overall_set	0-1	Overall pixel level quality flag	Good Quality** classified in 4 levels
qf_out_bound	2	Check if out of bound	If pixels that are out of bound in a Horizontal Cell exceed 50%, set to 1; otherwise set to 0
qf_residual	3	Check convergence	If pixels that are convergent in a Horizontal Cell exceed 50%, set to 1; otherwise set to 0
qf_tau	4	Check if cot < 1.0	If pixels whose cot < 1.0 in a Horizontal Cell exceed 50%, set to 1; otherwise set to 0
qf_alg_branch***	5-6	Indicate degree of opaque cloud algorithm used	Algorithm branching classified in 4 levels (only used by Cloud Top Parameter EDRs)
qf_ice_tau10	7	Check degraded condition for ice cloud, cot > 10	If ice cloud pixels whose cot > 10.0 in a Horizontal Cell exceed 50%, set to 1; otherwise set to 0

* The 4 level classifications represent 0: 0 to <25%; 1: 25 to <50%; 2: 50 to- <75%; 3: 75 to 100%.
** The value of the overall quality is defined as the ratio of valid retrievals excluding non-convergent, sun glint and bad SDR pixels and the total number of cloudy pixels.
*** The value of algorithm branching is defined as the ratio of the number of pixel retrievals that use the “opaque cloud” algorithm, and the total number of valid retrievals. This QF is applicable only to CTP (Pressure), CTH and CTT.

Table 19. Non-cloud Related Quality Flags (QF_CLOUD) for a Horizontal Cell

Name – Byte 0	Bitfield	Description/Source	Value
qf_snowice	0-1	Snow/ice surface	Snow/ice surface in 4-level percent
qf_excl_sunglint	2-3	Sun glint region	Sun glint region in 4-level percent
qf_day_night	4-5	Day/night/transition	1: Day; 2: Night; 3: Transition
qf_bad_sdr_data	6-7	Bad SDR data flag	Bad sdr data 0=good, 1=bad, 2=no calibration
Name – Byte 1	**Bitfield**	**Description/Source**	**Value**
qf_surfType	0-3	Surface type	Bits 0-1: water in 4-level percent Bits 2-3: coastal in 4-level percent

EDR data output for each Cloud EDR is discussed below (Tables 20 – 26 for EDRs, Tables 27 – 29 for FEDRs). Please refer to the CDFCB-X, D34862, Vol. IV, Part 2 for additional quality flag information. Note: Non-layered means that all layers are “summed up” into a single layer in the following tables.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 20. GCE Output: VIIRS CBH EDR

Output	Type	Description	Units/Valid Range
Granule-Level Data Items			
scale	Float32	Scale value for the CBH Layer and Total fields	None
offset	Float32	Offset value for the CBH Layer and Total fields to be used in unscaling	None
Cell-Level Data Items			
Layer_CBH	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Base Height for each cloud layer	kilometers / -1 to 30
Total_CBH	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Base Height averaged over layers	kilometers / -1 to 30
Layer CBH Quality0 (QF1)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer CBH Quality1 (QF2)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cbh_out_range: (0-20 km)
Total CBH Quality0 (QF3)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure
Total CBH Quality1 (QF4)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte1 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cbh_out_range: (0-20 km)
CBH Quality0 (QF5)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 0	QF_CLOUD structure
CBH Quality1 (QF6)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Flags of QF_CLOUD byte 1	QF_CLOUD structure

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 21. GCE Output: VIIRS CCL EDR

Output	Type	Description	Units/Valid Range
Granule-Level Data Items			
scale	Float32	Scale value for the CCL Layer and Total fields	None
offset	Float32	Offset value for the CCL Layer and Total fields to be used in unscaling	None
Cell-Level Data Items			
Layer_Cloud_Cover	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud fraction for each cloud layer	None / 0 to 1 Note: the range listed is prior to scaling data from Float32 to UInt16
Total_Cloud_Cover	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud fraction summed over layers	None / 0 to 1 Note: the range listed is prior to scaling data from Float32 to UInt16
Cloud Type	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud type for each cloud layer	Unitless / 1 to 5 1-Stratus 2-Alto Cumulus 3-Cumulus 4-Cirrus 5-CirrusCumulus
Layer CCL Quality0 (QF1)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer CCL Quality1 (QF2)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cot_out_range
Total CCL Quality0 (QF3)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure
Total CCL Quality1 (QF4)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 1 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cot_out_range
CCL Quality0 (QF5)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 0	QF_CLOUD structure
CCL Quality1 (QF6)	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Flags of QF_CLOUD byte 1	QF_CLOUD structure

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 22. GCE Output: VIIRS CEPS EDR

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
scale	Float32	Scale value for the CEPS Layer and Total fields	Unitless / none
offset	Float32	Offset value for the CEPS Layer and Total fields to be used in unscaling	Unitless / none
Cell-Level Data Items			
Layer_CEPS	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Effective Particle Size for each layer	microns / 0 to 120
Total_CEPS	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Effective Particle Size averaged over layers	microns / 0 to 120
Layer CEPS Quality0 (QF1)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer CEPS Quality1 (QF2)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as eps_out_range: (1-50 micron) for ice; and (1-50 micron) for water
Total CEPS Quality0 (QF3)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure
Total CEPS Quality1 (QF4)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 1 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as eps_out_range: (1-50 micron) for ice; and (1-50 micron) for water
CEPS Quality0 (QF5)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 0	QF_CLOUD structure
CEPS Quality1 (QF6)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 1	QF_CLOUD structure

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 23. GCE Output: VIIRS COT EDR

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
scale	Float32	Scale value for the COT Layer and Total fields	Unitless / none
offset	Float32	Offset value for the COT Layer and Total fields to be used in unscaling	Unitless / none
Cell-Level Data Items			
Layer_COT	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Optical Thickness for each layer	Unitless / 0 to 200
Total_COT	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Optical Thickness averaged over layers	Unitless / 0 to 200
Layer COT Quality0 (QF1)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer COT Quality1 (QF2)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cot_out_range Day: (0.1-10) Night: (0.5-10)
Total COT Quality0 (QF3)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Non-layered* QF_LYR_CLOUD structure
Total COT Quality1 (QF4)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 1 over a non-layered horizontal cell	Non-layered* QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cot_out_range Day: (0.1-10) Night: (0.5-10)
COT Quality0 (QF5)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 0	QF_CLOUD structure
COT Quality1 (QF6)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 1	QF_CLOUD structure

Table 24. GCE Output: VIIRS CTH EDR

Output	Type	Description	Units/Range
Granule-Level Data Items			
scale	Float32	Scale value for the CTP (Pressure) Layer and Total fields	Unitless / None
offset	Float32	Offset value for the CTP (Pressure) Layer and Total fields to be used in unscaling	Unitless / None
Cell-Level Data Items			
Layer_CTH	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Height for each layer	km / 0 to 30

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Output	Type	Description	Units/Range
Total_CTH	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Height averaged over layers	km / 0 to 30
Layer CTH Quality0 (QF1)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer CTH Quality1 (QF2)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cth_out_range: (0-20 km)
Total CTH Quality0 (QF3)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Nonlayered QF_LYR_CLOUD structure
Total CTH Quality1 (QF4)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 1 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cth_out_range: (0-20 km)
CTH Quality0 (QF5)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 0	QF_CLOUD structure
CTH Quality1 (QF6)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 1	QF_CLOUD structure

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 25. GCE Output: VIIRS CTP (Pressure) EDR

Output	Type	Description	Units/Range
Granule-Level Data Items			
scale	Float32	Scale value for the CTP (Pressure) Layer and Total fields	None
offset	Float32	Offset value for the CTP (Pressure) Layer and Total fields to be used in unscaling	None
Cell-Level Data Items			
Layer_CTP	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Pressure for each cloud layer	mbar / 50 to 1100
Total_CTP	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Pressure averaged over layers	mbar / 50 to 1100
Layer CTP Quality0 (QF1)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Pressure layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer CTP Quality1 (QF2)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Pressure layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as ctp_out_range: (50-1050 mb)
Total CTP Quality0 (QF3)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cloud Top Pressure flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Nonlayered QF_LYR_CLOUD structure
Total CTP Quality1 (QF4)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cloud Top Pressure flags of QF_LYR_CLOUD byte 1 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as ctp_out_range: (50-1050 mb)
CTP Quality0 (QF5)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cloud Top Pressure flags of QF_CLOUD byte 0	QF_CLOUD structure
CTP Quality1 (QF6)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cloud Top Pressure flags of QF_CLOUD byte 1	QF_CLOUD structure

Table 26. GCE Output: VIIRS CTT EDR

Output	Data Type/size	Description	Units/Range
Granule-Level Data Items			
scale	Float32	Scale value for the CTT Layer and Total fields	Unitless / None
offset	Float32	Offset value for the CTT Layer and Total fields to be used in unscaling	Unitless / None
Cell-Level Data Items			
Layer_CTT	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Temperature for each layer	K / 170 to 310
Total_CTT	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Temperature averaged over layers	K / 170 to 310

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Output	Data Type/size	Description	Units/Range
Layer CTT Quality0 (QF1)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer CTT Quality1 (QF2)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as ctt_out_range: (175-310 Kelvin)
Total CTT Quality0 (QF3)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Nonlayered QF_LYR_CLOUD structure
Total CTT Quality1 (QF4)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 1 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as ctt_out_range
CTT Quality0 (QF5)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 0	QF_CLOUD structure
CTT Quality1 (QF6)	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 1	QF_CLOUD structure

Tables 27 – 29 list the optional output full resolution EDRs (FEDRs) for CCL, CTH, and CTP.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Table 27. GCE (Optional) Output: VIIRS CCL FEDR (Full Resolution)

Output	Type	Description	Units/Range
Cell-Level Data Items			
Layer_Cloud_Cover	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud fraction for each cloud layer	None / 0 to1
Total_Cloud_Cover	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud fraction summed over layers	None / 0 to1
Cloud Type	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud type for each cloud layer	Unitless / 1 to 5 1-Stratus 2-Alto Cumulus 3-Cumulus 4-Cirrus 5-CirrusCumulus
Layer CCL Quality0	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer CCL Quality1	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cot_out_range
Total CCL Quality0	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure
Total CCL Quality1	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 1 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cot_out_range
CCL Quality0	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 0	QF_CLOUD structure
CCL Quality1	UInt16[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Flags of QF_CLOUD byte 1	QF_CLOUD structure

Table 28. GCE (Optional) Output: VIIRS CTH FEDR (Full Resolution)

Output	Type	Description	Units/Range
Cell-Level Data Items			
Layer_CTH	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Height for each layer	km / 0 to 30
Total_CTH	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Height averaged over layers	km / 0 to 30
Layer CTH Quality0	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer CTH Quality1	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cth_out_range: (0-20 km)

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Output	Type	Description	Units/Range
Total CTH Quality0	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure
Total CTH Quality1	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_LYR_CLOUD byte 1 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as cth_out_range: (0-20 km)
CTH Quality0	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 0	QF_CLOUD structure
CTH Quality1	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Flags of QF_CLOUD byte 1	QF_CLOUD structure

Table 29. GCE (Optional) Output: VIIRS CTP (Pressure) FEDR (Full Resolution)

Output	Type	Description	Units/Range
Cell-Level Data Items			
Layer_CTP	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Pressure for each cloud layer	mbar / 50 to 1100
Total_CTP	Float32[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Pressure averaged over layers	mbar / 50 to 1100
Layer CTP Quality0	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Pressure layered flag of QF_LYR_CLOUD byte 0	Layered QF_LYR_CLOUD structure
Layer CTP Quality1	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS][VIIRS_CLD_LYRS]	Cloud Top Pressure layered flag of QF_LYR_CLOUD byte 1	Layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as ctp_out_range: (50-1050 mb)
Total CTP Quality0	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cloud Top Pressure flags of QF_LYR_CLOUD byte 0 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure
Total CTP Quality1	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cloud Top Pressure flags of QF_LYR_CLOUD byte 1 over a non-layered horizontal cell	Non-layered QF_LYR_CLOUD structure, the flag qf_out_bound is defined as ctp_out_range: (50-1050 mb)
CTP Quality0	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cloud Top Pressure flags of QF_CLOUD byte 0	QF_CLOUD structure
CTP Quality1	UInt8[VIIRS_CLD_HC_ROWS][VIIRS_CLD_HC_COLS]	Cloud Top Pressure flags of QF_CLOUD byte 1	QF_CLOUD structure

2.2.2 Algorithm Processing

The objective of the GCE module is to classify cloud pixels into layers and to generate cloud products (i.e., COT, EPS, CTT, CTH, CTP (Pressure), CBH, CC fraction, and CT) for these layers averaged over horizontal cells. The module uses, as input, the pixel-level identification of cloud layer produced by the CCL module and the CCL aggregation table to create the products. See Section 2.5 of the Cloud Cover/Layers ATBD, D43317, for more information. The dataflow model for the GCE algorithm is illustrated in Figure 6.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

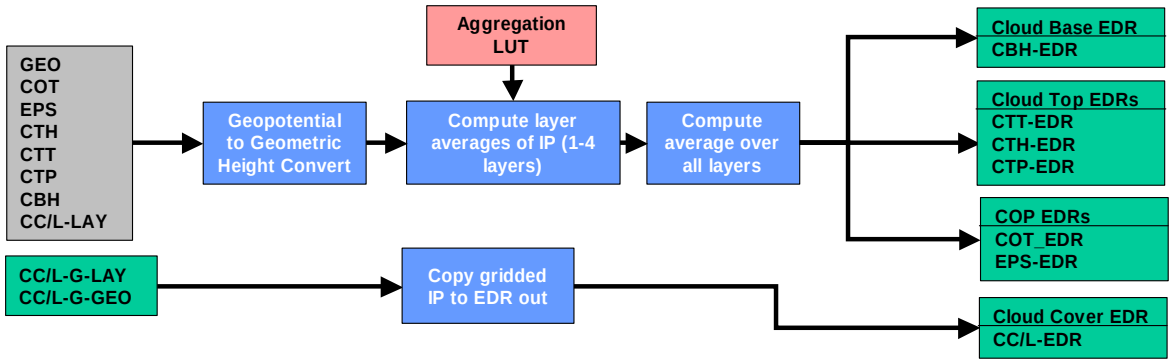


Figure 6. Conceptual Process for Generate Cloud EDRs

GCE reads and processes data one scan at a time. Horizontal product cells are always comprised of pixels within a single scan. The assignment of pixels to product cells is accomplished using an aggregation table. For each scan line, GCE loops over all product cells and generates outputs based on the pixel-level cloud IPs identified with each cell. GCE uses a routine called getScan() to read the input data. The aggregation table is read using loadAggTbl() and the pixels associated with each cell are identified with getAggCell(). The GCE routine requires only the current scan.

Retrieval Logic

The main processing of the GCE module is carried out in the aggregate() routine. This routine takes pixel-level inputs for each product cell as identified by the aggregation table and computes average values for each cell and for each cloud layer identified in the cell. The routines, average2d() and average3d(), process each of the cloud products (COT, EPS, CTT, CTH, CTP (Pressure), and CBH) to produce the result for each cell and for each layer in each cell. These routines include logic to handle missing data. The averaging routines also ensure that only pixels belonging to the product cell, and identified with the current scan, are included. Separate routines, QF_Lyr_2d(), QF_Lyr_3d(), QF_Lyr(), are used to process IP quality data. At this point a correction from geopotential to geometric height is also applied to the CBH and CTH products. The CC and CT products are copied directly from the cell-averaged products supplied by the CCL algorithm.

2.2.2.1 Main Module – GCE_main()

GCE_main() is the main driver for the core GCE algorithm. Called by ProEdrViirsGce(), GCE_main() loads the aggregation table via loagAggTbl(), assigns scan pointers and processes granule data one scan at a time. For each cell in a scan, getAggCell() gets cell information from the aggregation table and Aggregate() aggregates pixel data into cells. After all scans have been processed, CCL IP Layer and Total fields are copied directly to the output EDRs, layered fields are flipped to obtain top-to-bottom stacking of clouds, and ComputeGranuleQualityFlags() is called to process granule quality flag data.

2.2.2.2 getScan()

getScan() assigns scan data pointers to the appropriate locations in the IP data using offsets calculated with pixel and cell position configuration information.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

2.2.2.3 average2d()

average2d() is the averaging function for 2-dimensional data. It calculates the pixel average for the current cell and returns the result. Only valid pixels (i.e. assigned a cloud layer by CCL, determined to be product and current scan pixel according to the aggregation table, does not contain fill data) are used in calculations. If no valid pixels were processed, then a fill value is returned.

2.2.2.4 average3d()

average3d() is the averaging function for 3-dimensional (layered) data. It calculates the pixel averages for the current cell layers and returns the results. Only valid pixels (i.e. assigned a cloud layer by CCL, determined to be product and current scan pixel according to the aggregation table, does not contain fill data) are used in calculations. If no valid pixels were processed for a layer, then a fill value is returned for that layer.

2.2.2.5 Aggregate()

Aggregate() calls the averaging functions for data (average2d(), average3d()) and quality flags (QF_Lyr_3d(), QF_Lyr_2d(), QF_2d()) to process pixel data into cells and saves the outputs to the output structures. CBH and CTH data is converted to geometric height (Height_Conversion()) prior to being stored in output structures.

2.2.2.6 Height_Conversion()

Height_Conversion() converts geopotential to geometric height. This function requires latitude (in radians) and formula constants (c1, c2, c3) for processing.

2.2.2.7 posOutdata()

posOutdata () assigns scan data pointers to the appropriate locations in the output EDRs using offsets calculated with pixel and cell position configuration information.

2.2.2.8 put_4_level()

put_4_level(), called during quality flag processing, calculates the ratio data/count to determine which of the four categories the ratio falls within (0: 0 to <25%, 1: 25 to <50%, 2: 50 to <75%, 3: 75 to 100%) and sets the appropriate bit positions in the output flag using the offset supplied.

2.2.2.9 put_dominant()

put_dominant(), called during quality flag processing, calculates the ratio data/count to determine which of the two categories the ratio falls within (0: 0 - 50%, 1: 50 - 100%) and sets the appropriate bit positions in the output flag using the offset supplied.

2.2.2.10 QF_Lyr_2d()

QF_Lyr_2d() is the averaging function for 2-dimensional quality flag data and it gathers granule level quality data. After accumulating quality flag data for the current cell, put_4_level() and put_dominant() are called to average the data. The results are then copied to all the EDRs. For out-of-bound and algorithm-branching quality flags that are EDR specific, the previously stored flags are overwritten.

Only valid pixels (i.e. assigned a cloud layer by CCL, determined to be product and current scan pixel according to the aggregation table, does not contain fill data) are used in calculations. If no valid pixels were processed, no quality flags are set for the current cell.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

2.2.2.11 QF_Lyr_3d()

QF_Lyr_3d() is the averaging function for 3-dimensional (layered) quality flag. After accumulating quality flag data for the current cell, put_4_level() and put_dominant() are called to average the data per cell layer. The results are then copied to all the EDRs. For out-of-bound and algorithm-branching quality flags that are EDR specific, the previously stored flags are overwritten.

Only valid pixels (i.e. assigned a cloud layer by CCL, determined to be product and current scan pixel according to the aggregation table, does not contain fill data) are used in calculations. If no valid pixels were processed, no quality flags are set for the current cell layers.

2.2.2.12 QF_2d()

QF_2d() is the averaging function for 2-dimensional non-cloud-related quality flags. After accumulating quality flag data for the current cell, put_4_level() is called to average the data. The results are then copied to all the EDRs.

Only valid pixels (i.e. assigned a cloud layer by CCL, determined to be product and current scan pixel according to the aggregation table, does not contain fill data) are used in calculations. If no valid pixels were processed, no quality flags are set for the current cell.

2.2.2.13 ComputeGranuleQualityFlags()

ComputeGranuleQualityFlags() captures the number of retrieved, converged, and exclusion/degraded pixels for the granule and stores them in a form that common code data quality threshold testing can process.

2.2.2.14 sortLyrOrder()

sortLyrOrder() flips the layer order from bottom up to top down. Then, based on the CBH EDR product, it copies the rest of the EDR products in the similar sort.

2.2.2.15 sort_lyrs()

sort_lyrs() sorts an array with NLAYERS elements in descending order and indexes them. This routine is called within sortLyrOrder() routine.

2.2.2.16 loadAggTbl()

See Section 2.1.2.15.

2.2.2.17 getAggCell()

See Section 2.1.2.16.

2.2.3 Graceful Degradation

The GCE module does not implement graceful degradation. GCE retrievals rely entirely on the availability of data from the VIIRS cloud IPs. No logic is included to replace missing data with secondary sources.

2.2.4 Exception Handling

A mechanism for external termination of the algorithm has been implemented, called a stop callback. If a stop callback is issued, processing is terminated and no outputs are produced.

Error-handling in the Input (I) and Output (O) stages of the I-P-O algorithm addresses errors associated with reading/ writing of databases. If an error occurs with required inputs, the error

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

is reported, the process is terminated and no outputs are produced. For optional inputs, a failure to get VIIRS Cloud Mask results in no cloud cover metadata being reported, and a failure to get a Data Quality Threshold Table results in that particular set of Data Quality Threshold Tests not being executed and no Data Quality Notification output for that set of tests is produced.

Error-handling in the Processing (P) stage involves granule level and cell level errors. All outputs are initialized with Not Applicable (NA) FILL (except quality flags which are initialized to zero) so all unprocessed cell level data contain FILL values.

For granule level errors, i.e. errors resulting from loading the aggregation table or an invalid number of scans, the error is reported, the process is terminated, and no outputs are produced.

For cell level errors, i.e. errors resulting from loading aggregation table cell data, the errors are reported and processing continues with the next cell.

2.2.5 Data Quality Monitoring

Each algorithm uses specific criteria contained in a Data Quality Threshold Table (DQTT) to determine when a Data Quality Notification (DQN) is produced. The DQTT contains the threshold used to trigger the DQN as well as the text contained in the DQN. If a threshold is met, the algorithm stores a DQN in DMS indicating the test(s) that failed and the value of the DQN attribute. For more algorithm specific detail refer to the CDFCB-X.

2.2.5.1 Quality Flags

The cloud processing chain has defined many QFs. The QFs of CCL at IP level are essentially the same as those defined in COP IP product. The GCE module computes the QFs of the EDR products based on the QFs of the IPs for the pixels making up each cell. The values of the QF may be represented either by a four-level classification, or a one-level indicated by either zero or one. In a four-level QF, the value of the QF is set to 0-3, corresponding to 0 to <25%, 25 to <50%, 50 to <75% and 75 to <100%. The one-level QF can have values either zero or one, with zero being less than 50% quality. The four-level flag is calculated by the function put_4_level() and the one-level flag is calculated by the function put_dominant().

Since each cloud EDR output, e.g., COT, is reported both in layered values and values averaged over the entire HC, three types of EDR QFs are stored in all cloud EDR outputs. They are 3-D “layer” flags, 2D “total” flags (by combining all layers), and non-layered “EDR” QFs for the HC, generated by functions QF_Lyr_3d(), QF_Lyr_2d(), and QF_2d(), respectively.

2.2.6 Computational Precision Requirements

The GCE module employs single precision throughout, with one exception. Scale information is stored as single precision in the binary files and must be read as such in the code.

2.2.7 Algorithm Support Considerations

See Section 2.1.7.

2.2.8 Assumptions and Limitations

The GCE retrieval algorithms assume that the VIIRS 750m SDR auxiliary data, the VCM IP including Cloud Phase, the COP IP, CTP (Parameters) IP, and CBH IP are all available for processing. All inputs are expected in binary format at M-band pixel resolution.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

The GCE QC flags (confidence flags) are derived from the values present in the QC for the individual cloud IPs.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

The current glossary for the NPOESS program, D35836_G_NPOESS_Glossary, can be found on eRooms. Table 30 contains those terms most applicable for this OAD.

Table 300. Glossary

Term	Description
Algorithm	A formula or set of steps for solving a particular problem. Algorithms can be expressed in any language, from natural languages like English to mathematical expressions to programming languages like FORTRAN. On NPOESS, an algorithm consists of: 1. A theoretical description (i.e., science/mathematical basis) 2. A computer implementation description (i.e., method of solution) 3. A computer implementation (i.e., code).
Algorithm Configuration Control Board (ACCB)	Interdisciplinary team of scientific and engineering personnel responsible for the approval and disposition of algorithm acceptance, verification, development and testing transitions. Chaired by the Algorithm Implementation Process Lead, members include representatives from IWPTB, Systems Engineering & Integration IPT, System Test IPT, and IDPS IPT.
Algorithm Verification	Science-grade software delivered by an algorithm provider is verified for compliance with data quality and timeliness requirements by Algorithm Team science personnel. This activity is nominally performed at the IWPTB facility. Delivered code is executed on compatible IWPTB computing platforms. Minor hosting modifications may be made to allow code execution. Optionally, verification may be performed at the Algorithm Provider's facility if warranted due to technical, schedule or cost considerations.
Ancillary Data	Any data which is not produced by the NPOESS System, but which is acquired from external providers and used by the NPOESS system in the production of NPOESS data products.
Auxiliary Data	Auxiliary Data is defined as data, other than data included in the sensor application packets, which is produced internally by the NPOESS system, and used to produce the NPOESS deliverable data products.
EDR Algorithm	Scientific description and corresponding software and test data necessary to produce one or more environmental data records. The scientific computational basis for the production of each data record is described in an ATBD. At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.
Environmental Data Record (EDR)	*[IORD Definition]* Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geophysical parameters (including ancillary parameters, e.g., cloud clear radiation, etc.). *[Supplementary Definition]* An Environmental Data Record (EDR) represents the state of the environment, and the related information needed to access and understand the record. Specifically, it is a set of related data items that describe one or more related estimated environmental parameters over a limited time-space range. The parameters are located by time and Earth coordinates. EDRs may have been resampled if they are created from multiple data sources with different sampling patterns. An EDR is created from one or more NPOESS SDRs or EDRs, plus ancillary environmental data provided by others. EDR metadata contains references to its processing history, spatial and temporal coverage, and quality.
Operational Code	Verified science-grade software, delivered by an algorithm provider and verified by IWPTB, is developed into operational-grade code by the IDPS IPT.
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.

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

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

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Term	Description
Temperature Data Record (TDR)	*[IORD Definition]* Temperature Data Records (TDRs) are geolocated, antenna temperatures with all relevant calibration data counts and ephemeris data to revert from T-sub-a into counts. *[Supplementary Definition]* A Temperature Data Record (TDR) is the brightness temperature value measured by a microwave sensor, and the related information needed to access and understand the record. Specifically, it is a set of the corrected radiometric measurements made by an imaging microwave sensor, over a limited time range, with annotation that permits its effective use. A TDR is a partially-processed variant of an SDR. Instead of reporting the estimated microwave flux from a specified direction, it reports the observed antenna brightness temperature in that direction.
Model Validation	The process of determining the degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management]
Model Verification	The process of determining that a model implementation accurately represents the developer's conceptual description and specifications. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management]

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

3.2 Acronyms

The current acronym list for the NPOESS program, D35838_G_NPOESS_Acronyms, can be found on eRooms. Table 31 contains those terms most applicable for this OAD.

Table 31. Acronyms

Acronym	Description
ACO	Atmospheric Correction over Ocean
ADCS	Advanced Data Collection System
AFM	Airborne Fluxes and Meteorology Group
AOS	Acquisition of Signal
CBH	Cloud Base Height
CC	Cloud Cover
CCL	Cloud Cover/Layers
CDA	Command and Data Acquisition
CDR	Climate Data Records
CEPS	Cloud EPS
CI	Configured Item
COMSAT	Communications Satellite
COP	Cloud Optical Properties
COT	Cloud Optical Thickness
CT	Cloud Type
CTH	Cloud Top Height
CTP	Cloud Top Parameters
CTP	Cloud Top Pressure
CTT	Cloud Top Temperature
DES	Digital Encryption System
DHN	Data Handling Node
DQTT	Data Quality Test Table
EOS	End Of Scan
EPS	Effective Particle Size
ERBS	Earth Radiation Budget Suite
ESD	Electrostatic Discharge
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FEDR	Full resolution Environmental Data Records
FMH	Federal Meteorological Handbook
GCE	Generate Cloud EDR (or Grid Cloud EDR)
GPS	Global Positioning System
GSE	Ground Support Equipment
HC	Horizontal Cells
HRD	High Rate Data
IGS	International GPS Service
IJPS	Initial Joint Polar System
IOC	Initial Operational Capability
IP	Intermediate Product
LEO&A	Launch, Early Orbit, & Anomaly Resolution
LOS	Loss of Signal
LRD	Low Rate Data
LST	Local Solar Time
LUT	Look-Up Table or Local User Terminal
Metop	Meteorological Operational Program

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

Acronym	Description
MSS	Mission System Simulator
NA	Non-Applicable
NCA	National Command Authority
NDT	Nitrate-Depletion Temperature
OAD	Operational Algorithm Description Document
OC/C	Ocean Color/Chlorophyll
PIP	Program Implementation Plan
PMT	Portable Mission Terminal
POD	Precise Orbit Determination
PPC	Perform Parallax Correction
RSR	Remote Sensing Reflectance
S&R	Search and Rescue
SCA	Satellite Control Authority
SDE	Selective Data Encryption
SDP	Software Development Plan
SDR	Sensor Data Records
SDS	Science Data Segment
SGI®	Silicon Graphics, Inc.
SI	International System of Units
SN	NASA Space Network
SOC	Satellite Operations Center
SPA	Sub-Pixel Aggregation
SRD	Sensor Requirements Documents
SS	Space Segment
SST	Sea Surface Temperature
TBD	To Be Determined
TBR	To Be Resolved
TBS	To Be Supplied
TEMPEST	Telecommunications Electronics Material Protected from Emanating Spurious Transmissions
TOA	Top of the Atmosphere
USB	Unified S-band
UTC	Universal Time Coordinated
VCM	VIIRS Cloud Mask

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO

4.0 OPEN ISSUES

Table 32. TBXs

TBX ID	Title/Description	Resolution Date
None		

D39590, B. PDMO Released: 2010-06-22 (VERIFY REVISION STATUS)
PDMO