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**Joint Polar Satellite System (JPSS)
Operational Algorithm Description (OAD)
Document for VIIRS Perform Parallax
Correction (PPC) Intermediate Product (IP)
Software**

For Public Release

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Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for VIIRS Perform Parallax Correction (PPC) Intermediate Product (IP) Software

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Preface

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

Any questions should be addressed to:

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NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS CLOUD PERFORM PARALLAX CORRECTION (PPC)

**SDRL No. 141
SYSTEM SPECIFICATION SS22-0096**

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

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VIIRS Perform Parallax Correction (PPC) Software**

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

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1.0 INTRODUCTION

1.1 Objective

The purpose of the Operational Algorithm Description (OAD) document is to express, in computer-science terms, the remote sensing algorithms that produce the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) end-user data products. These products are individually known as Raw Data Records (RDRs), Temperature Data Records (TDRs), Sensor Data Records (SDRs) and Environmental Data Records (EDRs). In addition, any Intermediate Products (IPs) produced in the process are also described in the OAD.

The science basis of an algorithm is described in a corresponding Algorithm Theoretical Basis Document (ATBD). The OAD provides a software description of that science as implemented in the operational ground system -- the Data Processing Element (DPE).

The purpose of an OAD is two-fold:

1. Provide initial implementation design guidance to the operational software developer.
2. Capture the "as-built" operational implementation of the algorithm reflecting any changes needed to meet operational performance/design requirements.

An individual OAD document describes one or more algorithms used in the production of one or more data products. There is a general, but not strict, one-to-one correspondence between OAD and ATBD documents.

1.2 Scope

The scope of this document is limited to the description of the core operational algorithm(s) required to create the VIIRS Parallax Corrected Cloud Mask (CM) IP, VIIRS Parallax Corrected Cloud Optical Properties (COP) IP, and VIIRS Parallax Corrected Cloud Top Parameters (CTP) IP. The theoretical basis for this algorithm is described in Section 4.1 of VIIRS Cloud Cover/Layers Algorithm Theoretical Basis Document (ATBD), 474-00044.

1.3 References

1.3.1 Document References

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

Table 1. Reference Documents

Document Title	Document Number/Revision	Revision Date
VIIRS Cloud Cover/Layers Algorithm Theoretical Basis Document (ATBD)	474-00044	22 Apr 2011
Department of Defense World Geodetic System 1984 – Its Definition and Relationship with Local Geodetic Systems	N/A	(NIMA 1997)
JPSS Environmental Data Record (EDR) Production Report for NPP	474-00012 Rev. A	09 Feb 2011
JPSS Environmental Data Record (EDR) Interdependency Report (IR) for NPP	474-0007 Rev. A	09 Feb 2011
NPP Mission Data Format Control Book and App A (MDFCB)	472-REF-00057, Rev B	06 Jan 2011
JPSS Common Data Format Control Book - External - Volume I - Overview	474-00001-01, Rev-	10-Dec-10
JPSS Common Data Format Control Book - External - Volume II - RDR Formats	474-00001-02, Rev-	10-Dec-10
JPSS Common Data Format Control Book - External - Volume III - SDR/TDR Formats	474-00001-03, Rev-	16-Feb-11
JPSS Common Data Format Control Book - External - Volume IV - Part I - IPs, ARPs, and Geolocation Data	474-00001-04-01, Rev-	10-Dec-10
JPSS CDFCB - External - Volume IV - Part II - Imagery, Atmospheric, and Cloud EDRs	474-00001-04-02, Rev-	10-Dec-10
JPSS Common Data Format Control Book - External - Volume IV - Part III - Land and Ocean/Water EDRs	474-00001-04-03, Rev-	10-Dec-10
JPSS Common Data Format Control Book - External - Volume IV - Part IV - Earth Radiation Budget and Space EDRs	474-00001-04-04, Rev-	18-Feb-11
JPSS Common Data Format Control Book - External - Volume V - Metadata	474-00001-05, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VI - Ancillary Data, Auxiliary Data, Messages, and Reports	474-00001-06, Rev-	10-Dec-10
JPSS Common Data Format Control Book - External - Volume VII - Part I - JPSS Downlink Data Formats	474-00001-07-01, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VII - Part 2 - JPSS Downlink Data Formats - CrIS	474-00001-07-02, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VII - Part 3 - JPSS Downlink Data Formats - OMPS	474-00001-07-03, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VII - Part 4 - JPSS Downlink Data Formats - ATMS	474-00001-07-04, Rev-	16-Feb-11
JPSS CDFCB - External - Volume VII - Part 5 - JPSS Downlink Data Formats - VIIRS	474-00001-07-05, Rev-	16-Feb-11
JPSS Common Data Format Control Book - External - Volume VIII - Look Up Table Formats	474-00001-08, Rev-	10-Dec-10
NPP Command and Telemetry (C&T) Handbook	D568423 Rev. C	30 Sep 2008
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

Document Title	Document Number/Revision	Revision Date
VIIRS Cloud Module Data Dictionary	Y0010871 Ver. 5 Rev. 11	Jan 2005
Operational Algorithm Description Document for VIIRS Cloud Optical Properties (COP) Software	474-00074, Rev A	27 Jan 2012
Operational Algorithm Description Document for VIIRS Cloud Mask Intermediate Product (VCM IP)	474-00062, Rev A	27 Jan 2012
Operational Algorithm Description Document for VIIRS Geolocation (GEO) Sensor Data Record (SDR) and Calibration (CAL) SDR	474-00090, Rev A	27 Jan 2012
Operational Algorithm Description Document for Common Geolocation	474-00091, Rev A	27 Jan 2012
Operational Algorithm Description Document for VIIRS Cloud Cover/Layers (CCL) and Generate Cloud EDR (GCE) Software	474-00085, Rev A	27 Jan 2012
NPOESS System Specification	SY15-0007 Ver. E	1 Aug 2002
JPSS CGS Data Processor Inter-subsystem Interface Control Document (DPIS ICD) Vol I – IV	IC60917-IDP-002, Rev C	29-Sep-11
VIIRS Geolocation Algorithm Theoretical Basis Document (ATBD)	474-00053	22 Apr 2011
IDPS Processing SI Common IO Design Document	DD60822-IDP-011 Rev. A	21 June 2007
JPSS CGS Acronyms and Glossary	LI60917-GND-005, Rev -	17-Oct-11
Detailed Description of the VIIRS Science RDR to Verified RDR Conversion Whitepaper	N/A	6 Dec 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_PPC OAD Update	NP-EMD.2005.510.0076	7 July 2005
NGST/SE technical memo – NPP_VIIRS_PPC_FIX_BACKFILL_DETR_XTRAS CAN	NP-EMD.2006.510.0092	5 Dec 2006
NGST/SE technical memo – VIIRS GEO EVtimesUPdates	NP-EMD.2008.510.0050	29 Oct 2008
NGST/SE technical memo – NPP_VIIRS_PPC_bug_fix_backfil	NP-EMD.2008.510.0022	11 Apr 2008
NGAS/SE technical memo – VIIRS Geo Quality Flags Logic Updates	NP-EMD.2009.510.0048 Rev A	12 Oct 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
VIIRS Perform Parallax Correction --- science-grade software	20050812_ISTN_VIIRS_NG ST_3.5	12 Aug 2005
VIIRS Perform Parallax Correction --- operational software	/PRO/EDR/VIIRS/clouds/pp c/ B1.5, Vers. D.1.1.6 (OAD Rev A10)	28 Nov 2006
NGST/SE technical memo – VIIRS GEO EVtimesUPdates	NP-EMD.2008.510.0050 (OAD Rev B2)	29 Oct 2008

Reference Title	Reference Tag/Revision	Revision Date
SDRL	(OAD Rev B4)	04 Nov 2009
OAD update only—no code changes	(OAD Rev B5)	13 Jan 2010
ACCB (no code changes)	OAD Rev B	17 Mar 2010
Convergence Update (No code changes)	(OAD Rev C1)	12 Oct 2010

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 Perform Parallax Correction (PPC) algorithm is implemented during IP/EDR processing and requires RDR, SDR, IP and LUT inputs to produce IP outputs. A top-level diagram for the PPC algorithm is shown in Figure 1.

PPC consists of derived and core algorithm modules. The derived algorithm module ProEdrViirsPpc (represented by the shaded portion in Figure 1) functions as a wrapper for the core algorithm module and handles the I-O stages in the I-P-O architecture. ProEdrViirsPpc initiates the core algorithm module PerformParallaxCorrection which makes up the P stage.

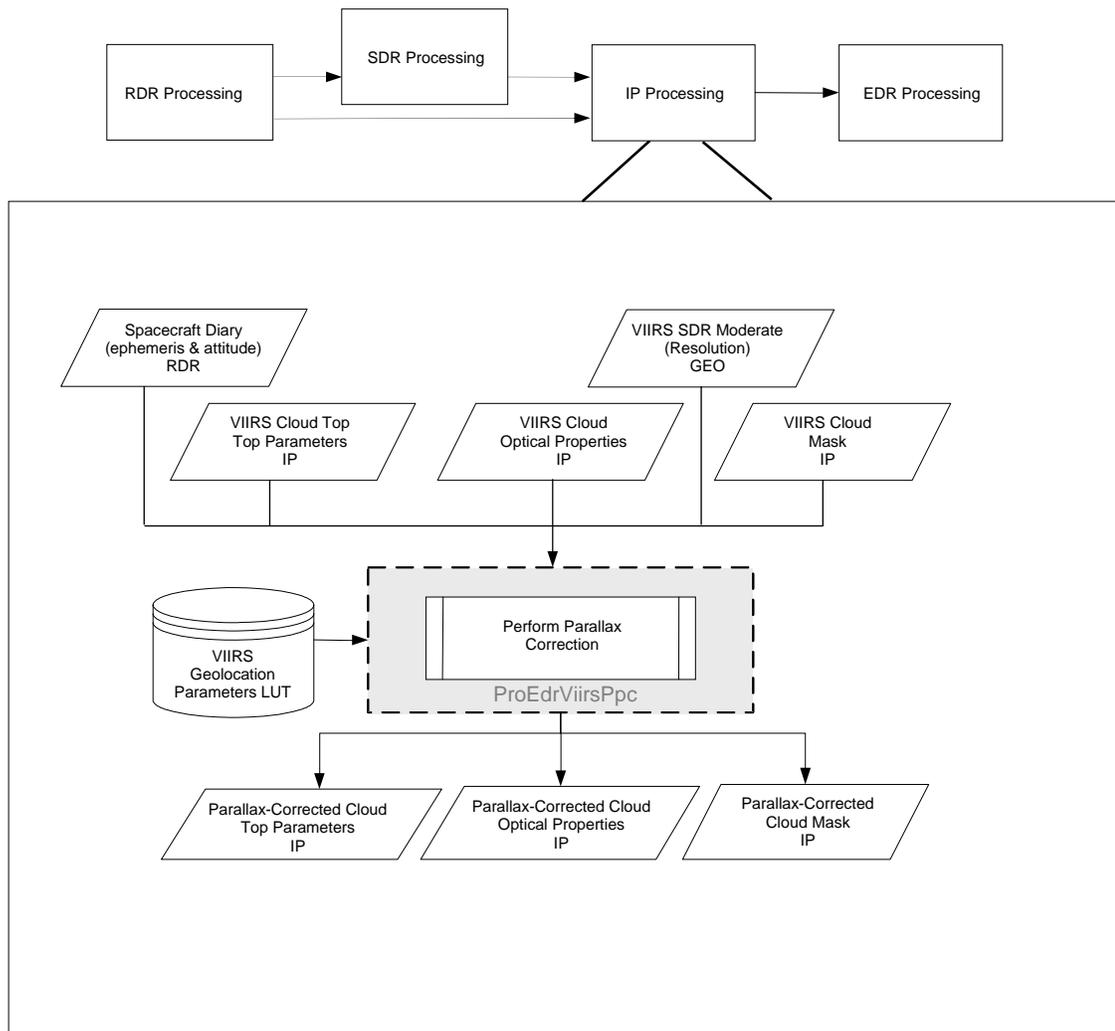


Figure 1. Algorithm Overview

2.1 VIIRS Cloud Perform Parallax Correction Description

The PPC Module is part of the Cloud IP processing chain. Its purpose is to determine the geolocation on the surface of the Earth where a locally vertical line intercepts the cloud. Since the cloud is viewed from a slant path, the “parallax corrected” geolocation depends on the cloud top height and the viewing scan angle. The PPC Module therefore determines the “corrected” geolocation due to slant path effects so that geolocation for the cloud Environmental Data Records (EDRs) is reported at the local vertical.

A dataflow diagram for the VIIRS Cloud Module, of which the VIIRS Cloud PPC Module is a member, is shown in Figure 2. Each circle represents a stand-alone unit of the VIIRS Cloud Module. Processing order is indicated by the number in each circle. The VIIRS Cloud PPC Module is “shadowed” in the diagram.

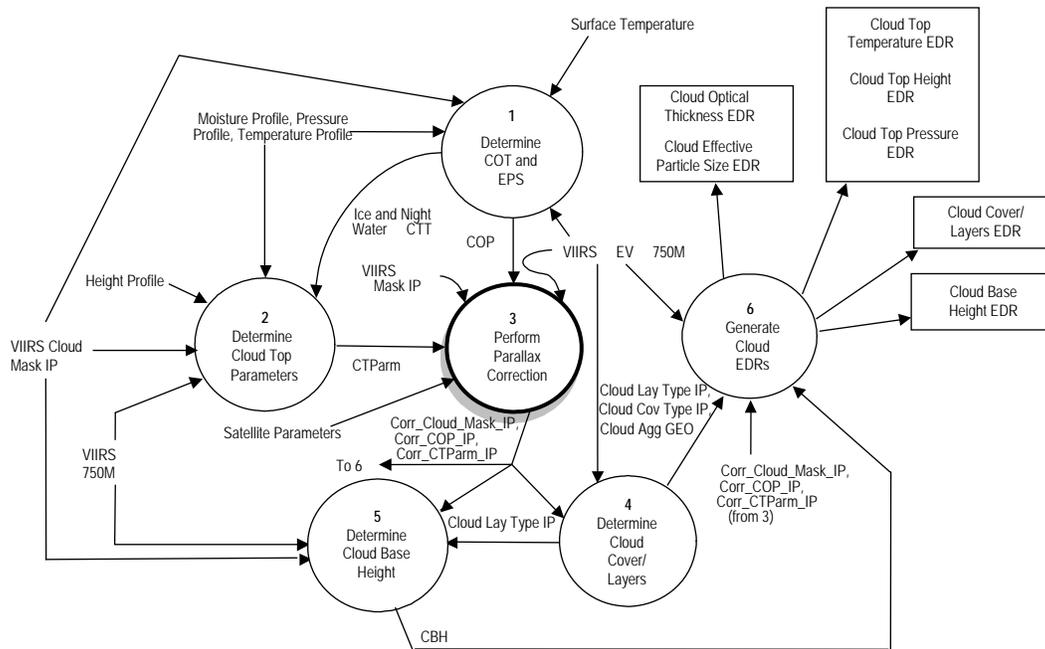


Figure 2. Cloud Module Data Flow

2.1.1 Interfaces

The main flow of the operational PPC algorithm is shown in Figure 3 below. The PPC algorithm receives all the required input data from DMS. The first step is to use the verified RDR routine to unpack and byte-align the Space Craft Diary RDR. Then the algorithm uses a Common Geolocation (CMN GEO) library of functions to set up the ephemeris and attitude data. When all the input data needed for processing is available, the main module (PerformParallaxCorrection) is called to produce Corrected Cloud Mask, Corrected COP and Corrected CTP.

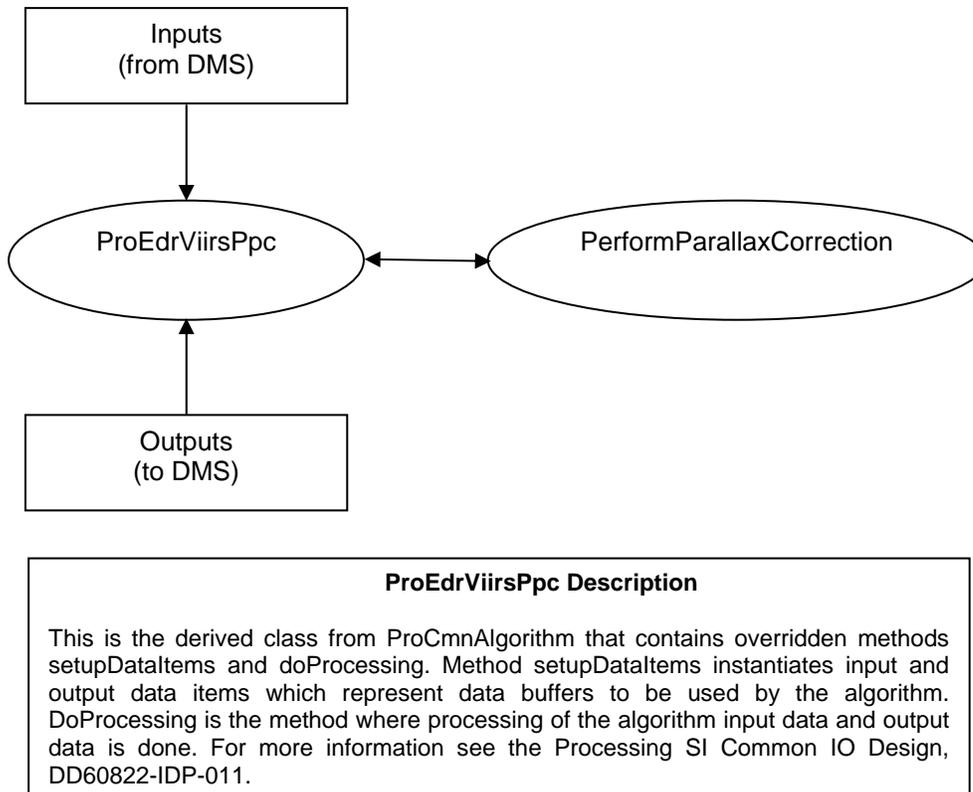


Figure 3. Perform Parallax Correction Overall Flow Diagram

The PPC Module requires Spacecraft Diary RDR, VIIRS Moderate Geolocation (GEO), VIIRS CM IP, VIIRS COP IP, VIIRS CTP IP, and VIIRS SDR Moderate Geolocation Parameters Look-Up Table (LUT) as inputs to produce the following outputs: VIIRS Parallax Corrected CM IP; VIIRS Parallax Corrected COP IP; VIIRS Parallax Corrected CTP IP. A detailed itemization of the inputs and outputs for the PPC Module is provided below.

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

- Fill values corresponding to the individual pixels in each product that do not contain valid data are dictated by the datatype. The following fill values apply: NA_UINT8_FILL for UInt8 datatypes, NA_FLOAT32_FILL for Float32 datatypes, zero for quality flags.
- For detailed descriptions of the quality flags in the tables below, refer to the applicable I-P-O algorithm OAD (CM, COP, or CTP).
- M_VIIRS_SDR_ROWS = NUMBER of SCANS PER GRANULE X NUMBER of MODERATE DETECTORS
- M_VIIRS_SDR_COLS = 3200

2.1.1.1 Inputs

Tables 3-8 describe the inputs for the PPC algorithm.

Table 3. PPC Input: Spacecraft Diary RDR

Input	Type	Description	Units/Valid Range
RDR-Level Data Items			
sc_pos	Float64[3]	S/C position vector	Meters / 0 to 7,300,000

Table 4. PPC Input: VIIRS Cloud Mask IP

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
GranuleAllOcean	UInt8	Flag indicating the granule is all ocean	Unitless
GranuleNoOcean	UInt8	Flag indicating the granule does not contain any ocean	Unitless
Row-Level Data Items			
ScanNoOcean	UInt8[M_VIIRS_SDR_ROWS]	Flag indicating the scan does not contain any ocean	Unitless
ScanAllOcean	UInt8[M_VIIRS_SDR_ROWS]	Flag indicating the scan is all ocean	Unitless
Pixel-Level Data Items			
Vcm0	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP quality flags: quality, cloud confidence, day/night, snow/ice, sun glint	See Table 9
Vcm1	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP quality flags: Land/water, shadow detected, non cloud obstruction, fire detected, cirrus solar, cirrus IR	See Table 9
Vcm2	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP quality flags: IR Threshold Cloud Test (BTM15), High Cloud (BTM12-BTM16) Test, IR Temperature Difference Test (BTM14 – BTM15 & BTM15 – BTM16), Temperature Difference Test (BTM15 – BTM12), Temperature Difference Test (BTM12 – BTM13), Visible Reflectance Test (RM5). Visible Reflectance Test (RM7), also Visible Reflectance Test (RM1), Visible Ratio Test (RM7 / RM5)	See Table 9
Vcm3	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP quality flags: Adjacent Pixel Cloud Confident Value, Conifer Boreal Forest, Spatial Uniformity, Dust candidate, Smoke candidate, Dust / Volcanic Ash	See Table 9
Vcm4	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP quality flags: Spare	See Table 9
Vcm5	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP quality flags: Cloud Phase, Thin Cirrus Flag, Ephemeral Water Flag, Degraded TOC NDVI Flag, Degraded Sun Glint Flag, Degraded Polar Night Flag	See Table 9

Table 5. PPC Input: VIIRS Cloud Optical Properties IP

Input	Type	Description	Units/Valid Range
<i>Pixel-Level Data Items</i>			
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 radius	microns / 1.0 to 50.0
copQf0	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	COP IP quality flags: quality, ice cot out of bound, water cot out of bound, ice eps out of bound, water eps out of bound, cloud phase	See Table 10
copQf1	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	COP IP quality flags: day water convergence, day ice convergence, day water cot < 1, day ice < 1, night water cot < 1, night ice cot < 1, sun glint, probably/confidently cloudy	See Table 10
copQf2	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	COP IP quality flags: ice cloud cot > 10, Bad SDR Flag	See Table 10

Table 6. PPC Input: VIIRS Cloud Top Parameters IP

Input	Type	Description	Units/Valid Range
<i>Pixel-Level Data Items</i>			
Ctt	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled Cloud Top Temperature	K / 180 to 310
Cth	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled Cloud Top Height	km / 0 to 20
Ctp	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled Cloud Top Pressure	hPa / 50.0 to 1050.0
ctParmQf0	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Cloud Top Parameters IP quality flags: altitude range check, surface type, sun glint, out of range, snow/ice	See Table 11
ctParmQf1	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Cloud Top Parameters IP quality flags: cloud phase, cth out of range, ctt out of range, residual night water, residual night ice, residual day ice	See Table 11
ctParmQf2	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Cloud Top Parameters IP quality flags: runbackup (black cloud), ctp windowIR converge	See Table 11

Table 7. VIIRS SDR Moderate Resolution GEO Data

Input	Type	Description	Units/Valid Range
Scan Start Time	Int64[VIIRS_RDR_SCANS]	Scan start time, defined at the leading edge of the first Earth View frame in IET	Microseconds / 0 <= scanStartTime <= 1.00E+38
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)

Input	Type	Description	Units/Valid Range
Satellite Azimuth	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Satellite Azimuth 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 Azimuth	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Solar Azimuth of the VIIRS pixels	Radians / -PI(W) to PI(E)
Solar Zenith	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Solar Zenith of the VIIRS pixels	Radians / 0 to PI
Satellite Height	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Satellite Height of the VIIRS pixels	Meters
Satellite Range	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Satellite Range of the VIIRS pixels	Meters
Quality Flag	char[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Bitwise Quality flags of the VIIRS pixels 0 Invalid Input Data 1 Bad Pointing 2 Bad Terrain 3 Invalid Solar Angles 4-7 SPARE	0=INPUT VALID 1=FALSE 0=GOOD POINTING 1 = BAD POINTING 0=GOOD TERRAIN 1=BAD TERRAIN 0=VALID SOLAR ANGLES 1= INVALID SOLAR ANGLES
Actual scans	Int32	Actual number of scans in a granule	Unitless

Table 8. VIIRS SDR GEO MOD PARAM LUT Operating Parameters

Input	Type	Description	Units/Valid Range
detector_sampling_rate	Float64	The rate at which the detectors are sampled	Microseconds / sensor dependent
latch_to_center	Float64	Offset for center time of pixel	Unitless / 0.5
t_reset	Float64	Time to reset sample at beginning of frame	Unitless / 0
agg_zone_bounds	Int32[5]	Aggregation zone boundaries	Unitless / 0 to 3200

2.1.1.2 Outputs

Tables 9-11 describe the outputs for the PPC algorithm.

Table 9. PPC Output: VIIRS Parallax Corrected Cloud Mask IP

Input	Type	Description	Units/Valid Range																		
Granule-Level Data Items																					
GranuleAllOcean	UInt8	Flag indicating the granule is all ocean	Unitless																		
GranuleNoOcean	UInt8	Flag indicating the granule does not contain any ocean	Unitless																		
Row-Level Data Items																					
ScanNoOcean	UInt8[M_VIIRS_SDR_ROWS]	Flag indicating the scan does not contain any ocean	Unitless																		
ScanAllOcean	UInt8[M_VIIRS_SDR_ROWS]	Flag indicating the scan is all ocean	Unitless																		
Pixel-Level Data Items																					
Vcm0	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	<p>VIIRS Cloud Mask IP Quality (parallax corrected) Bitwise flags Exception: Day/Night, Snow/Ice, Sun glint flags are not parallax corrected.</p> <table border="0"> <tr> <td>0-1</td> <td>CLOUD MASK QUALITY</td> <td>0-POOR 1-LOW 2-MEDIUM 3-HIGH</td> </tr> <tr> <td>2-3</td> <td>CLOUD CONFIDENCE</td> <td>0-CONFIDENTLY CLEAR 1-PROBABLY CLEAR 2-PROBABLY CLOUDY 3-CONFIDENTLY CLOUDY</td> </tr> <tr> <td>4</td> <td>DAY / NIGHT</td> <td>0-NIGHT 1-DAY</td> </tr> <tr> <td>5</td> <td>SNOW/ICE SURFACE</td> <td>0-NO SNOW/ICE 1-SNOW/ICE</td> </tr> <tr> <td>6-7</td> <td>SUN GLINT</td> <td>0-NO SUN GLINT 1-GEOMETRY BASED 2-WIND SPEED BASED 3-GEOMETRY & WIND</td> </tr> </table>	0-1	CLOUD MASK QUALITY	0-POOR 1-LOW 2-MEDIUM 3-HIGH	2-3	CLOUD CONFIDENCE	0-CONFIDENTLY CLEAR 1-PROBABLY CLEAR 2-PROBABLY CLOUDY 3-CONFIDENTLY CLOUDY	4	DAY / NIGHT	0-NIGHT 1-DAY	5	SNOW/ICE SURFACE	0-NO SNOW/ICE 1-SNOW/ICE	6-7	SUN GLINT	0-NO SUN GLINT 1-GEOMETRY BASED 2-WIND SPEED BASED 3-GEOMETRY & WIND				
0-1	CLOUD MASK QUALITY	0-POOR 1-LOW 2-MEDIUM 3-HIGH																			
2-3	CLOUD CONFIDENCE	0-CONFIDENTLY CLEAR 1-PROBABLY CLEAR 2-PROBABLY CLOUDY 3-CONFIDENTLY CLOUDY																			
4	DAY / NIGHT	0-NIGHT 1-DAY																			
5	SNOW/ICE SURFACE	0-NO SNOW/ICE 1-SNOW/ICE																			
6-7	SUN GLINT	0-NO SUN GLINT 1-GEOMETRY BASED 2-WIND SPEED BASED 3-GEOMETRY & WIND																			
Vcm1	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	<p>VIIRS Cloud Mask IP Quality (parallax corrected) Bitwise flags Exception: Land/Water background, Shadow detected, Non cloud Obstruction, Fire Detected flags are not parallax corrected.</p> <table border="0"> <tr> <td>0-2</td> <td>LAND / WATER BACKGROUND</td> <td>0-LAND & DESERT 1-LAND NO DESERT 2-INLAND WATER 3-SEA WATER 5-COASTAL</td> </tr> <tr> <td>3</td> <td>SHADOW DETECTED</td> <td>0-NO SHADOW 1-SHADOW</td> </tr> <tr> <td>4</td> <td>NON CLOUD OBSTRUCTION (HEAVY AEROSOL)</td> <td>0-NO AEROSOL 1-AEROSOL</td> </tr> <tr> <td>5</td> <td>FIRE DETECTED</td> <td>0-NO FIRE 1-FIRE</td> </tr> <tr> <td>6</td> <td>CIRRUS DETECTION (SOLAR) (RM9)</td> <td>0-NO CLOUD 1-CLOUD</td> </tr> <tr> <td>7</td> <td>CIRRUS DETECTION (IR) (BTM15-BTM16)</td> <td>0-NO CLOUD 1-CLOUD</td> </tr> </table>	0-2	LAND / WATER BACKGROUND	0-LAND & DESERT 1-LAND NO DESERT 2-INLAND WATER 3-SEA WATER 5-COASTAL	3	SHADOW DETECTED	0-NO SHADOW 1-SHADOW	4	NON CLOUD OBSTRUCTION (HEAVY AEROSOL)	0-NO AEROSOL 1-AEROSOL	5	FIRE DETECTED	0-NO FIRE 1-FIRE	6	CIRRUS DETECTION (SOLAR) (RM9)	0-NO CLOUD 1-CLOUD	7	CIRRUS DETECTION (IR) (BTM15-BTM16)	0-NO CLOUD 1-CLOUD	
0-2	LAND / WATER BACKGROUND	0-LAND & DESERT 1-LAND NO DESERT 2-INLAND WATER 3-SEA WATER 5-COASTAL																			
3	SHADOW DETECTED	0-NO SHADOW 1-SHADOW																			
4	NON CLOUD OBSTRUCTION (HEAVY AEROSOL)	0-NO AEROSOL 1-AEROSOL																			
5	FIRE DETECTED	0-NO FIRE 1-FIRE																			
6	CIRRUS DETECTION (SOLAR) (RM9)	0-NO CLOUD 1-CLOUD																			
7	CIRRUS DETECTION (IR) (BTM15-BTM16)	0-NO CLOUD 1-CLOUD																			

Input	Type	Description	Units/Valid Range
Vcm2	Uint8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP Quality (parallax corrected) Bitwise flags 0 IR THRESHOLD CLOUD TEST (BTM15) 1 HIGH CLOUD (BTM12–BTM16) TEST 2 IR TEMPERATURE DIFFERENCE TEST (BTM14-BTM15 & BTM15-BTM16) 3 TEMPERATURE DIFFERENCE TEST (BTM15-BTM12) 4 TEMPERATURE DIFFERENCE TEST (BTM12-BTM13) 5 VISIBLE REFLECTANCE TEST (RM5) 6 VISIBLE REFLECTANCE TEST (RM7), ALSO VISIBLE REFLECTANCE TEST (RM1) 7 VISIBLE RATIO TEST (RM7/RM5)	0-No CLOUD 1-CLOUD 0-No CLOUD 1-CLOUD 0-No CLOUD 1-CLOUD 0-No CLOUD 1-CLOUD 0-No CLOUD 1-CLOUD 0-No CLOUD 1-CLOUD 0-No CLOUD 1-CLOUD
Vcm3	Uint8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP Quality (parallax corrected) Bitwise flags Exception: Conifer Boreal Forest, Spatial Uniformity flags are not parallax corrected 0-1 Adjacent Pixel Cloud Confident Value 2 Conifer Boreal Forest 3 Spatial Uniformity Dust candidate 5 Smoke candidate 6 Dust / Volcanic Ash 7 Spare	11=Confident Cloudy 10=Probably Cloudy 00=Confident Clear 01=Probably Clear 1=Yes 0=No 1=Yes 0=No 1=Yes 0=No 1=Yes 0=No 1=Yes 0=No
Vcm4	Uint8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP Quality (parallax corrected) Bitwise flags 0-7 SPARE	

Input	Type	Description	Units/Valid Range
Vcm5	Uint8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	VIIRS Cloud Mask IP Quality (parallax corrected) Bitwise flags	
		0-2 CLOUD PHASE	0-NOT EXECUTED 1-CLEAR 2-PARTLY CLOUDY 3-WATER CLOUD 4-SUPERCOOLED WATER/MIXED 5-OPAQUE ICE CLOUD 6-CIRRUS CLOUD 7-CLOUD OVERLAP
		3 THIN CIRRUS	0-No 1-YES
		4 EPHEMERAL WATER	0-No 1-YES
		5 Degraded TOC NDVI Flag	1=YES 0=No
		6 Degraded Sun Glint Flag	1=YES 0=No
		7 Degraded Polar Night Flag	1=YES 0=No

Table 10. PPC Output: VIIRS Parallax Corrected Cloud Optical Properties IP

Input	Type	Description	Units/Valid Range
<i>Pixel-Level Data Items</i>			
Cot	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled cloud optical thickness (parallax corrected)	Unitless / 0.1 to 64.0
Eps	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled cloud effective particle radius (parallax corrected)	microns / 1.0 to 50.0

Input	Type	Description	Units/Valid Range
copQf0	Uin8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS	COP IP Quality (parallax corrected) bitwise flags 0 OVERALL PIXEL LEVEL FLAG 1 ICE COT OUT OF BOUND Day: (0.1-30) Night: (0.1-30) 2 WATER COT OUT OF BOUND Day: (0.1-30) Night: (0.1-30) 3 ICE EPS OUT OF BOUND (1-50 MICROMETERS) 4 WATER EPS OUT OF BOUND (1-50 MICROMETERS) 5-7 CLOUD PHASE	0-NOT 1-COP QUALITY FLAG IS SET 0-NOT 1-OUT OF BOUND 0-NOT 1- OUT OF BOUND 0-NOT 1- OUT OF BOUND 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
copQf1	Uin8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS	COP IP Quality (parallax corrected) bitwise flags Exception: Sun glint flag is not parallax corrected 0 DAY WATER ITERATION CONVERGENCE 1 DAY ICE ITERATION CONVERGENCE 2 WATER COT < 1 AT DAYTIME 3 ICE COT < 1 AT DAYTIME 4 WATER COT < 1 AT NIGHTTIME 5 ICE COT < 1 AT NIGHTTIME 6 SUN GLINT REGION 7 PROBABLY/CONFIDENTLY CLOUDY	0-NOT 1-CONVERGENT 0-NOT 1-CONVERGENT 0-NOT 1-TRUE 0-NOT 1-TRUE 0-NOT 1-TRUE 0-NOT 1-SUN GLINT 0-NOT 1-TRUE
copQf2	Uin8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS	COP IP Quality (parallax corrected) bitwise flags 0 DEGRADED CONDITIONS FOR ICE CLOUD COT > 10 1-2 BAD SDR FLAG DATA 3-7 SPARE	0-NOT 1-DEGRADED 0-GOOD 1-BAD 2-NO CALIBRATION

Table 11. PPC Output: VIIRS Parallax Corrected Cloud Top Parameters IP

Input	Type	Description	Units/Valid Range																																										
<i>Pixel-Level Data Items</i>																																													
Ctt	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled Cloud Top Temperature (parallax corrected)	K / 180 to 310																																										
Cth	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled Cloud Top Height (parallax corrected)	km / 0 to 20																																										
Ctp	Float32[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	Unscaled Cloud Top Pressure (parallax corrected)	hPa / 50.0 to 1050.0																																										
ctParmQf0	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	<p>CTP IP Quality (parallax corrected) bitwise flags Exception: surface type, sun glint, snow/ice flags are not parallax corrected</p> <table border="0"> <tr> <td>0-1</td> <td></td> <td>1 - < 3</td> </tr> <tr> <td></td> <td>ALTITUDE RANGE CHECK</td> <td>2 - >3 && < 7</td> </tr> <tr> <td></td> <td></td> <td>3 - > 7 (KM)</td> </tr> <tr> <td>2-4</td> <td></td> <td>0 - LAND DESERT</td> </tr> <tr> <td></td> <td>SURFACE TYPE</td> <td>1 - LAND NOT DESERT</td> </tr> <tr> <td></td> <td></td> <td>2 - INLAND WATER;</td> </tr> <tr> <td></td> <td></td> <td>3 - SEA WATER</td> </tr> <tr> <td></td> <td></td> <td>5 - COASTAL</td> </tr> <tr> <td>5</td> <td>SUN GLINT</td> <td>0 - NOT</td> </tr> <tr> <td></td> <td></td> <td>1 - SUN GLINT</td> </tr> <tr> <td>6</td> <td>CTP OUT OF RANGE (50-1050 MB)</td> <td>0-NOT</td> </tr> <tr> <td></td> <td></td> <td>1- OUT OF RANGE</td> </tr> <tr> <td>7</td> <td>SNOW/ICE SURFACE</td> <td>0-NOT</td> </tr> <tr> <td></td> <td></td> <td>1- SNOW/ICE</td> </tr> </table>	0-1		1 - < 3		ALTITUDE RANGE CHECK	2 - >3 && < 7			3 - > 7 (KM)	2-4		0 - LAND DESERT		SURFACE TYPE	1 - LAND NOT DESERT			2 - INLAND WATER;			3 - SEA WATER			5 - COASTAL	5	SUN GLINT	0 - NOT			1 - SUN GLINT	6	CTP OUT OF RANGE (50-1050 MB)	0-NOT			1- OUT OF RANGE	7	SNOW/ICE SURFACE	0-NOT			1- SNOW/ICE	
0-1		1 - < 3																																											
	ALTITUDE RANGE CHECK	2 - >3 && < 7																																											
		3 - > 7 (KM)																																											
2-4		0 - LAND DESERT																																											
	SURFACE TYPE	1 - LAND NOT DESERT																																											
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7	SNOW/ICE SURFACE	0-NOT																																											
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ctParmQf1	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	<p>CTP IP Quality (parallax corrected) bitwise flags</p> <table border="0"> <tr> <td>0-2</td> <td></td> <td>0 - BAD DATA</td> </tr> <tr> <td></td> <td>CLOUD PHASE</td> <td>1 - WATER</td> </tr> <tr> <td></td> <td></td> <td>2 - ICE</td> </tr> <tr> <td></td> <td></td> <td>3 - MIXED</td> </tr> <tr> <td>3</td> <td>CTH OUT OF RANGE (0-20 KM)</td> <td>0 - NOT</td> </tr> <tr> <td></td> <td></td> <td>1 - OUT OF RANGE</td> </tr> <tr> <td>4</td> <td>CTT OUT OF RANGE (180-310 KELVIN)</td> <td>0 - NOT</td> </tr> <tr> <td></td> <td></td> <td>1 - OUT OF RANGE</td> </tr> <tr> <td>5</td> <td>RESIDUAL NIGHT WATER IR ICE CTT CONVERGENCE</td> <td>0-NOT</td> </tr> <tr> <td></td> <td></td> <td>1- CONVERGENCE</td> </tr> <tr> <td>6</td> <td>RESIDUAL NIGHT ICE IR ICE CTT CONVERGENCE</td> <td>0-NOT</td> </tr> <tr> <td></td> <td></td> <td>1- CONVERGENCE</td> </tr> <tr> <td>7</td> <td>RESIDUAL DAY ICE IR ICE CTT CONVERGENCE</td> <td>0-NOT</td> </tr> <tr> <td></td> <td></td> <td>1- CONVERGENCE</td> </tr> </table>	0-2		0 - BAD DATA		CLOUD PHASE	1 - WATER			2 - ICE			3 - MIXED	3	CTH OUT OF RANGE (0-20 KM)	0 - NOT			1 - OUT OF RANGE	4	CTT OUT OF RANGE (180-310 KELVIN)	0 - NOT			1 - OUT OF RANGE	5	RESIDUAL NIGHT WATER IR ICE CTT CONVERGENCE	0-NOT			1- CONVERGENCE	6	RESIDUAL NIGHT ICE IR ICE CTT CONVERGENCE	0-NOT			1- CONVERGENCE	7	RESIDUAL DAY ICE IR ICE CTT CONVERGENCE	0-NOT			1- CONVERGENCE	
0-2		0 - BAD DATA																																											
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6	RESIDUAL NIGHT ICE IR ICE CTT CONVERGENCE	0-NOT																																											
		1- CONVERGENCE																																											
7	RESIDUAL DAY ICE IR ICE CTT CONVERGENCE	0-NOT																																											
		1- CONVERGENCE																																											

Input	Type	Description	Units/Valid Range	
ctParmQf2	UInt8[M_VIIRS_SDR_ROW][M_VIIRS_SDR_COLS]	CTP IP Quality (parallax corrected) bitwise flags		
		0-2	RUNBACKUP (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
		3	WINDOWIR FOR DAYWATER CLOUDS CONVERGENCE	0-NOT 1- CONVERGENCE
		4-7	SPARE	

2.1.2 Algorithm Processing

The approach for parallax correction is to find the vector that intersects the sensor line-of-sight (LOS) at the altitude of the cloud top height (CTH). The sensor LOS is determined from the pixel position vector and the satellite position vector at the given pixel time. The vector intersecting the sensor LOS at the CTH is the position vector of the cloud. After transforming the cloud position vector into geodetic coordinates, the cloud latitude/longitude is compared with that of pixels along the sensor scan line. The pixel latitude/longitude closest to the cloud latitude/longitude is taken as the cloud's new pixel location.

Parallax correction is not performed for pixels that have filled CTH values.

For operational software, the parallax correction module uses non terrain-corrected geolocation data.

2.1.2.1 Main Module - PerformParallaxCorr()

The logic flow of the PPC Module retrieval algorithm is shown in Figure 4.

PerformParallaxCorr copies original IP data (inputs) to corrected IP data (outputs) thereby maintaining original IP data for pixels that are not relocated (parallax corrected).

CMN GEO method GEO_determine_sample_time_offsets() is called to determine the scan sample time offsets (discussed in VIIRS Geolocation (GEO) SDR OAD, 474-00091) and scan start times are retrieved from the VIIRS SDR MOD GEO. Scan start times and sample time offsets are used in ComputeParallaxCorrection() to calculate pixel time.

For each pixel with cloud data present, the cloud top height is converted from geopotential to geometric height by Height_Conversion(). ComputeParallaxCorrection() determines the cloud parallax corrected latitude and longitude, then FindNewPixel() determines the pixel that corresponds to the cloud parallax corrected latitude and longitude. Original cloud IP data at the original pixel is then copied to corrected cloud IP data at the new pixel. Note: For quality flags,

only cloud related quality flags are copied to the new pixel, all non-cloud related quality flags (for example: sun glint, day/night) are not copied (refer to CM, COP, and CTP OADs for quality flag information). The original pixel is then backfilled to clear the data.

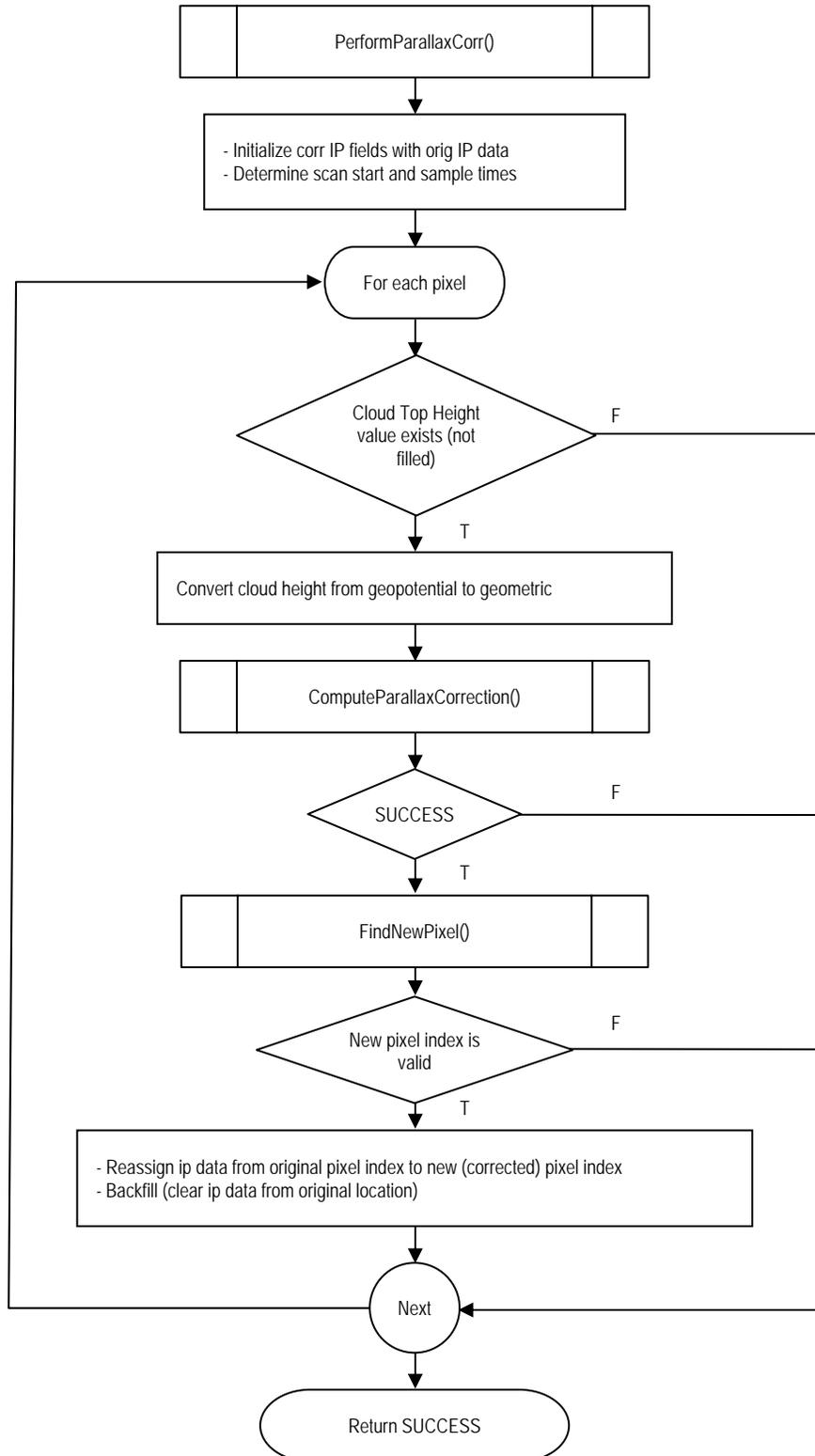


Figure 4. PerformParallaxCorrection() Logic Flow

2.1.2.2 ComputeParallaxCorrection()

This function computes the true geodetic coordinates of the observed cloud. To compute the parallax correction, the following steps are required:

1. Transform the pixel position vector from geodetic to Earth Centered Earth Fixed (ECEF) coordinates.
2. Retrieve the satellite position vector for the time of the pixel and perform vector subtraction to obtain the sensor LOS vector.
3. Solve for the intersection of the sensor LOS vector and the reference ellipsoid plus the cloud top height. This is the cloud position vector in ECEF coordinates (see PPC_ellipIntersect())
4. Transform the cloud position vector from ECEF to geodetic coordinates (see PPC_ellipIntersect()).

The following mathematical description of the steps listed above has been derived from the equations in the VIIRS Geolocation ATBD, 474-00053, Section 3.3.1.3, ECEF to Geodetic, and Section 3.3.2.2, Basic Earth Ellipsoid Intersection Algorithm. Steps 3 and 4 are performed in the operational algorithm by PPC_ellipIntersect(). To complete the correction, a new pixel index must be determined by the FindNewPixel() function, as discussed below.

Step 1: Transform the pixel position vector from geodetic to ECEF coordinates.

The relationship between ECEF and geodetic coordinates can be expressed simply in its direct form as discussed in Department of Defense World Geodetic System 1984 – Its Definition and Relationship with Local Geodetic Systems, (NIMA 1997):

$$\begin{aligned}
 x &= (N + h_{terrain}) \cos(lat) \cos(lon) \\
 y &= (N + h_{terrain}) \cos(lat) \sin(lon) \\
 z &= (N(1 - e^2) + h_{terrain}) \sin(lat) \\
 N &= a / (1 - e^2 \sin^2(lat))^{\frac{1}{2}} \\
 e^2 &= 1 - \frac{b^2}{a^2}
 \end{aligned}$$

where:

(x, y, z)	-	ECEF coordinates
$(lat, lon, h_{terrain})$	-	Geodetic coordinates
N	-	Ellipsoid radius of curvature in the prime vertical
e	-	Ellipsoid eccentricity
a	-	Earth equatorial radius (ellipsoid semi-major axis)
b	-	Earth polar radius (ellipsoid semi-minor axis)

The geodetic coordinates, lat and lon , are inputs from the GEO data. Geolocation data used by the cloud module is non terrain-corrected, therefore $h_{terrain} = 0$. Parameters e , a and b are well known physical constants. Note that constants e and N are calculated from a and b .

Step 2: In the operational code, pixel time is calculated by adding scan start time and sample time offset. Pixel time is used by CMN GEO method satPosAtt() to interpolate the satellite position for the exact time of interest (pixel time). A description of satPosAtt() can be found in the VIIRS Common Geolocation OAD, 474-00091. Vector subtraction is then performed to obtain the sensor LOS.

$$\vec{u}_{ecef} = \vec{g}_{ecef} - \vec{p}_{ecef}$$

where:

- \vec{u}_{ecef} - LOS unit vector in ECEF
- \vec{g}_{ecef} - pixel position vector in ECEF
- \vec{p}_{ecef} - spacecraft position vector in ECEF

2.1.2.3 PPC_ellipIntersect()

Function PPC_ellipIntersect(), (a modification of CMN GEO ellipIntersect()) to include cloud height in calculations), solves for the intersection of the sensor LOS vector and the reference ellipsoid plus the cloud top height. This is the cloud position vector in ECEF coordinates. It then transforms the cloud position vector from ECEF to geodetic coordinates and returns the parallax corrected latitude and longitude.

Step 3: (continued from above) Solve for the intersection of the sensor LOS vector and the reference ellipsoid plus the cloud top height (as depicted in Figure 5).

Re-scale the viewing vector and satellite vector using the ellipsoid of interest semi-major a' and semi-minor b' axis dimensions (a', a', b'):

$$\mathbf{u}' = \begin{bmatrix} u_1 / a' \\ u_2 / a' \\ u_3 / b' \end{bmatrix} \qquad \mathbf{p}' = \begin{bmatrix} p_1 / a' \\ p_2 / a' \\ p_3 / b' \end{bmatrix}$$

where:

$$a' = a + h_{cloud} \quad \text{and} \quad b' = b + h_{cloud}$$

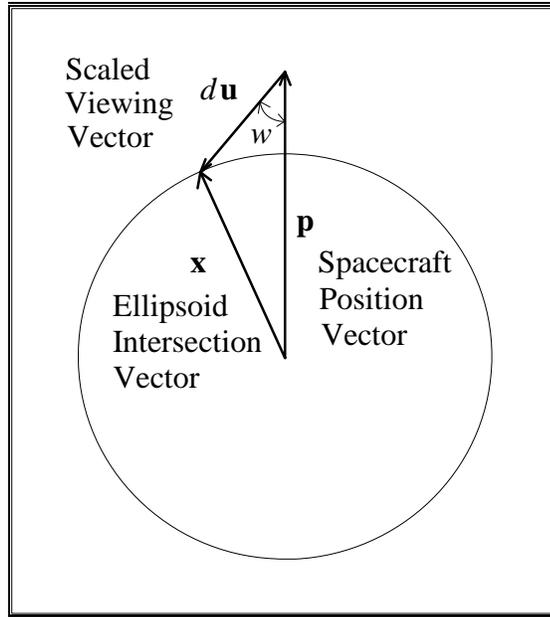


Figure 5. Ellipsoidal Viewing Vector Intersection

Note:

$$\mathbf{x}' = \begin{bmatrix} x_1 / a' \\ x_2 / a' \\ x_3 / b' \end{bmatrix} \quad \text{- the unknown cloud position vector (re-scaled)}$$

Solve for the scaling d of \mathbf{u}' which intersects the unit sphere:

From the law of cosines:

$$|\mathbf{x}'|^2 = |d\mathbf{u}'|^2 + |\mathbf{p}'|^2 - 2|d\mathbf{u}'||\mathbf{p}'|\cos(w)$$

Using the dot-product, the cosine of the acute angle w between \mathbf{u}' and $-\mathbf{p}'$ is:

$$\cos(w) = -(\mathbf{u}' \cdot \mathbf{p}') / (|\mathbf{u}'||\mathbf{p}'|)$$

By definition $|\mathbf{x}'| = 1$ so:

$$1 = d^2|\mathbf{u}'|^2 + |\mathbf{p}'|^2 + 2d|\mathbf{u}'||\mathbf{p}'|(\mathbf{u}' \cdot \mathbf{p}') / (|\mathbf{u}'||\mathbf{p}'|)$$

Simplifying and rearranging:

$$d^2|\mathbf{u}'|^2 + 2d(\mathbf{u}' \cdot \mathbf{p}') + |\mathbf{p}'|^2 - 1 = 0$$

This can be solved for d using the quadratic formula:

$$d = \frac{-(\mathbf{u}' \cdot \mathbf{p}') - \sqrt{(\mathbf{u}' \cdot \mathbf{p}')^2 - |\mathbf{u}'|^2(|\mathbf{p}'|^2 - 1)}}{|\mathbf{u}'|^2}$$

This is the smaller of the two solutions for d , the intersection closest to the satellite. If the solution is not real, then there is no intersection.

Use d to compute \mathbf{x}' and \mathbf{x} :

$$\mathbf{x}' = \mathbf{p}' + d\mathbf{u}'$$

$$\mathbf{x} = \begin{bmatrix} x'_1 a' \\ x'_2 a' \\ x'_3 b' \end{bmatrix} = \begin{bmatrix} (p'_1 + du'_1) a' \\ (p'_2 + du'_2) a' \\ (p'_3 + du'_3) b' \end{bmatrix} = \begin{bmatrix} p'_1 a' + du'_1 a' \\ p'_2 a' + du'_2 a' \\ p'_3 b' + du'_3 b' \end{bmatrix}$$

$$\mathbf{x} = \mathbf{p} + d\mathbf{u}$$

Step 4: Transform the cloud position vector from ECEF to geodetic coordinates. Convert the ECR ellipsoid pierce point to geodetic coordinates (special case direct solution).

$$lon = \tan^{-1} \left(\frac{x_2}{x_1} \right)$$

$$lat = \tan^{-1} \left(\frac{x_3 / (1 - e^2)}{\sqrt{x_1^2 + x_2^2}} \right)$$

$$h_{terrain} = 0$$

2.1.2.4 FindNewPixel()

Function FindNewPixel() compares the parallax corrected (cloud) latitude and cloud longitude to the nearest pixels along the same scan line. The pixel whose latitude and longitude is closest to the cloud latitude and longitude is taken as the cloudy pixel's new location. The linear position of that pixel is stored in *newPixIndex*.

The algorithm to find the pixel in the current scanline with the closest geolocation to the cloud is as follows:

1. Initialize minimum distance, *range*, to a large value.
2. Initialize *newPixIndex* to original pixel index.
3. Calculate scan pixel number.
 $pixel_number = original_pixel_index \% n_pixels$
4. Compute arc length on ellipsoid from current pixel lat/lon to cloud lat/lon using spherical ellipsoid approximation.
 $new_range =$
$$\arccos(\sin(lat_{pixel}) \sin(lat_{cloud}) + \cos(lat_{pixel}) \cos(lat_{cloud}) \cos(lon_{cloud} - lon_{pixel}))$$
5. Compare arc length to minimum distance.
If $new_range < range$; set $range = new_range$; otherwise go to step 8.
6. Determine direction toward scan nadir.
If $pixel_number \leq n_pixels/2$, increase *newPixIndex*
If $pixel_number > n_pixels/2$, decrease *newPixIndex*
7. Repeat steps 4 through 6 until minimum distance is found.

8. Move one pixel towards nadir.

If pixel_number > n_pixels/2, increase newPixIndex

If pixel_number <= n_pixels/2, decrease newPixIndex

Note that this algorithm is based on the assumption that the pixel nearest the sub-cloud location is on the same scan line as the pixel where the cloud was observed.

2.1.2.5 Height_conversion()

Function height_conversion() converts geopotential height to geometric height above the ellipsoid (refer to Section 4.3.1 of the Cloud Cover/Layers ATBD, 474-00044).

2.1.2.6 Backfill()

Function backfill() fills the corrected IP outputs (COP, CTP) with FILL values for the pixel location given and sets the quality flags and corrected IP output CM to zero.

2.1.3 Graceful Degradation

None.

2.1.4 Exception Handling

Errors that occur during the Input/Output (I/O) stages of the algorithm are reported and result in process termination. No outputs are produced.

In the processing stage of the algorithm, the PPC Module checks for a valid number of scans before any pixels are processed.

- If the number of scans is invalid, the error is reported, processing terminates and no outputs are produced.
- If the number of scans is valid but less than the expected number of scans, the pixels for the valid scans are processed, the missing scans are backfilled with FILL values, and outputs are produced.
- If the number of scans is valid, the pixels are processed. If an error occurs during pixel level processing, the error is reported, the pixel data remains at its original index, and processing continues with the next pixel. The following pixel level errors are handled: divide by zero; invalid satellite position; no ellipsoid intersection; invalid pixel index. Pixel level errors do not prevent PPC from producing outputs.

2.1.5 Data Quality Monitoring

None. (There are no Data Quality Threshold Tables (DQTTs) or Data Quality Notifications (DQNs) defined for PPC.)

2.1.6 Computational Precision Requirements

Floating-point calculations are carried out in single-precision arithmetic.

2.1.7 Algorithm Support Considerations

None.

2.1.8 Assumptions and Limitations

To determine the parallax-corrected pixel, the assumption is made that the pixel nearest the sub-cloud location is on the same scan line as the pixel where the cloud was observed.

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

The current glossary for the NPOESS program, D35836_H_NPOESS_Glossary, can be found on eRooms. Table 12 contains those terms most applicable for this OAD.

Table 12. Glossary

Term	Description
Algorithm	<p>A formula or set of steps for solving a particular problem. Algorithms can be expressed in any language, from natural languages like English to mathematical expressions to programming languages like FORTRAN. On NPOESS, an algorithm consists of:</p> <ol style="list-style-type: none"> 1. A theoretical description (i.e., science/mathematical basis) 2. A computer implementation description (i.e., method of solution) 3. A computer implementation (i.e., code)
Algorithm Configuration Control Board (ACCB)	<p>Interdisciplinary team of scientific and engineering personnel responsible for the approval and disposition of algorithm acceptance, verification, development and testing transitions. Chaired by the Algorithm Implementation Process Lead, members include representatives from IWPTB, Systems Engineering & Integration IPT, System Test IPT, and IDPS IPT.</p>
Algorithm Verification	<p>Science-grade software delivered by an algorithm provider is verified for compliance with data quality and timeliness requirements by Algorithm Team science personnel. This activity is nominally performed at the IWPTB facility. Delivered code is executed on compatible IWPTB computing platforms. Minor hosting modifications may be made to allow code execution. Optionally, verification may be performed at the Algorithm Provider's facility if warranted due to technical, schedule or cost considerations.</p>
Ancillary Data	<p>Any data which is not produced by the NPOESS System, but which is acquired from external providers and used by the NPOESS system in the production of NPOESS data products.</p>
Auxiliary Data	<p>Auxiliary Data is defined as data, other than data included in the sensor application packets, which is produced internally by the NPOESS system, and used to produce the NPOESS deliverable data products.</p>
EDR Algorithm	<p>Scientific description and corresponding software and test data necessary to produce one or more environmental data records. The scientific computational basis for the production of each data record is described in an ATBD. At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.</p>
Environmental Data Record (EDR)	<p><i>[IORD Definition]</i> Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geophysical parameters (including ancillary parameters, e.g., cloud clear radiation, etc.).</p> <p><i>[Supplementary Definition]</i> An Environmental Data Record (EDR) represents the state of the environment, and the related information needed to access and understand the record. Specifically, it is a set of related data items that describe one or more related estimated environmental parameters over a limited time-space range. The parameters are located by time and Earth coordinates. EDRs may have been resampled if they are created from multiple data sources with different sampling patterns. An EDR is created from one or more NPOESS SDRs or EDRs, plus ancillary environmental data provided by others. EDR metadata contains references to its processing history, spatial and temporal coverage, and quality.</p>
Operational Code	<p>Verified science-grade software, delivered by an algorithm provider and verified by IWPTB, is developed into operational-grade code by the IDPS IPT.</p>
Operational-Grade Software	<p>Code that produces data records compliant with the System Specification requirements for data quality and IDPS timeliness and operational infrastructure. The software is modular relative to the IDPS infrastructure and compliant with IDPS application programming interfaces (APIs) as specified for TDR/SDR or EDR code.</p>

Term	Description
Raw Data Record (RDR)	<p><i>[IORD Definition]</i></p> <p>Full resolution digital sensor data, time referenced and earth located, with absolute radiometric and geometric calibration coefficients appended, but not applied, to the data. Aggregates (sums or weighted averages) of detector samples are considered to be full resolution data if the aggregation is normally performed to meet resolution and other requirements. Sensor data shall be unprocessed with the following exceptions: time delay and integration (TDI), detector array non-uniformity correction (i.e., offset and responsivity equalization), and data compression are allowed. Lossy data compression is allowed only if the total measurement error is dominated by error sources other than the data compression algorithm. All calibration data will be retained and communicated to the ground without lossy compression.</p> <p><i>[Supplementary Definition]</i></p> <p>A Raw Data Record (RDR) is a logical grouping of raw data output by a sensor, and related information needed to process the record into an SDR or TDR. Specifically, it is a set of unmodified raw data (mission and housekeeping) produced by a sensor suite, one sensor, or a reasonable subset of a sensor (e.g., channel or channel group), over a specified, limited time range. Along with the sensor data, the RDR includes auxiliary data from other portions of NPOESS (space or ground) needed to recreate the sensor measurement, to correct the measurement for known distortions, and to locate the measurement in time and space, through subsequent processing. Metadata is associated with the sensor and auxiliary data to permit its effective use.</p>
Retrieval Algorithm	<p>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.</p>
Science Algorithm	<p>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".</p>
Science Algorithm Provider	<p>Organization responsible for development and/or delivery of TDR/SDR or EDR algorithms associated with a given sensor.</p>
Science-Grade Software	<p>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.</p>
SDR/TDR Algorithm	<p>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.</p>
Sensor Data Record (SDR)	<p><i>[IORD Definition]</i></p> <p>Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to calibrated brightness temperatures with associated ephemeris data. The existence of the SDRs provides reversible data tracking back from the EDRs to the Raw data.</p> <p><i>[Supplementary Definition]</i></p> <p>A Sensor Data Record (SDR) is the recreated input to a sensor, and the related information needed to access and understand the record. Specifically, it is a set of incident flux estimates made by a sensor, over a limited time interval, with annotations that permit its effective use. The environmental flux estimates at the sensor aperture are corrected for sensor effects. The estimates are reported in physically meaningful units, usually in terms of an angular or spatial and temporal distribution at the sensor location, as a function of spectrum, polarization, or delay, and always at full resolution. When meaningful, the flux is also associated with the point on the Earth geoid from which it apparently originated. Also, when meaningful, the sensor flux is converted to an equivalent top-of-atmosphere (TOA) brightness. The associated metadata includes a record of the processing and sources from which the SDR was created, and other information needed to understand the data.</p>

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

3.2 Acronyms

The current acronym list for the NPOESS program, D35838_H_NPOESS_Acronyms, can be found on eRooms. Table 13 contains those terms most applicable for this OAD.

Table 13. Acronyms

Acronym	Description
ACO	Atmospheric Correction over Ocean
ADCS	Advanced Data Collection System
AFM	Airborne Fluxes and Meteorology Group
AOS	Acquisition of Signal
CDA	Command and Data Acquisition
CDR	Climate Data Records
CI	Configured Item
CM	Cloud Mask
COMSAT	Communications Satellite
COP	Cloud Optical Properties
CTH	Cloud Top Height
CTP	Cloud Top Parameters
DES	Digital Encryption System
DHN	Data Handling Node
ECEF	Earth Centered Earth Fixed
ECR	Earth Centered Rotating
EOS	Earth Observing System
ERBS	Earth Radiation Budget Suite
ESD	Electrostatic Discharge
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FMH	Federal Meteorological Handbook
GEO	Geolocation
GPS	Global Positioning System
GSE	Ground Support Equipment
HRD	High Rate Data
IGS	International GPS Service
IJPS	Initial Joint Polar System

Acronym	Description
IOC	Initial Operational Capability
IP	Intermediate Product
LEO&A	Launch, Early Orbit, & Anomaly Resolution
LOS	Line Of Sight
LRD	Low Rate Data
LST	Local Solar Time
LUT	Look-Up Table or Local User Terminal
Metop	Meteorological Operational Program
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
QF	Quality Flag
RSR	Remote Sensing Reflectance
S&R	Search and Rescue
SCA	Satellite Control Authority
SDE	Selective Data Encryption
SDP	Science Data Production
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
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

4.0 OPEN ISSUES

Table 14. TBXs

TBX ID	Title/Description	Resolution Date
None		