Effective Date: September 10, 2014
Revision D

GSFC JPSS CMO
September 22, 2014
Released

Joint Polar Satellite System (JPSS) Ground Project
Code 474
474-00081

Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for Ozone Mapping and Profiler Suite (OMPS) Nadir Profile (NP) Sensor Data Record (SDR) Software

For Public Release

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

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and
Space Administration

Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for Ozone Mapping and Profiler Suite (OMPS) Nadir Profile (NP) Sensor Data Record (SDR) Software
JPSS Electronic Signature Page

Prepared By:

Bruce Guenther
JPSS Data Products and Algorithms SDR Lead
(Electronic Approvals available online at (https://jpssmis.gsfc.nasa.gov/mainmenu_dsp.cfm)

Approved By:

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

Goddard Space Flight Center
Greenbelt, Maryland

Preface

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

Any questions should be addressed to:

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

Change History Log

Revision	Effective Date	Description of Changes (Reference the CCR & CCB/ERB Approve Date)
Original	06/03/2011	This version incorporates **474-CCR-11-0096** which converts D39546, Operational Algorithm Description (OAD) Document for OMPS Nadir Profile (NP) SDR, Rev B, dated 05/13/2009 to a JPSS document, Rev -. This was approved by the JPSS Ground Algorithm ERB on June 3, 2011.
Revision A	01/18/2012	**474-CCR-11-0249:** This version baselines 474-00081, Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for Ozone Mapping and Profiler Suite (OMPS) Nadir Profile (NP) Sensor Data Record (SDR) Software, for the Mx 6 IDPS release. This CCR was approved by the JPSS Algorithm ERB on January 18, 2012.
Revision B	05/14/2013	**474-CCR-13-0948:** This version authorizes 474-00081, JPSS OAD Document for OMPS NP SDR Software, for the Mx 7.0 IDPS release. Includes Raytheon PCR032720; 474-CCR-13-0916/ECR-ALG-0037: Update applicable OAD filenames/template/Rev/etc. for Mx7 Release.
Revision C	03/05/2014	**474-CCR-14-1590:** This version authorizes 474-00081, JPSS OAD Document for OMPS NP SDR Software, for the Mx 8.3 IDPS release. Includes Raytheon PCR036548; CHILD: PRO: OAD: 474-CCR-13-1249: Stray Light Correction for the OMPS Nadir Profiler - DR 4823, in Table 29 [new] and section 2.1.2.2.3.
Revision D	09/10/2014	**474-CCR-14-1976:** This version authorizes 474-00081, JPSS OAD Document for OMPS NP SDR Software, for the Mx 8.6 IDPS release. Includes Raytheon PCR039566; Child: PRO: OAD: CCR-14-1767: OMPS NP Documentation Update for Obsolete Waveflag and Radflag - DR 7614, in Table 40.

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR OMPS NADIR PROFILE (NP) SDR

SDRL 141
SYSTEM SPECIFICATION SS22-0096

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

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

TITLE: NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) OPERATIONAL ALGORITHM DOCUMENT FOR OMPS NADIR PROFILE (NP) SDR

APPROVAL SIGNATURES:

____

Stephen E. Ellefson Date
ING/PRO Lead

____

Gabriela A. Ostler Date
Mission Assurance and Enterprise Effectiveness (MAEE)

Northrop Grumman Space & Mission Systems
Space Technology
One Space Park
Redondo Beach, CA 90278

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

CAGE NO. 11982

Operational Algorithm Description
OMPS Nadir Profile SDR

Document Number: D39546
Document Date: Nov 06, 2011 **Revision: D5**

PREPARED BY:

Scott Farrow *Date* *A&DP, OMPS Algorithm Lead*	Paul D. Siebels *Date* *IDPS PRO SW Manager*

ELECTRONIC APPROVAL SIGNATURES:

Roy Tsugawa *Date* *A&DP Lead & ACCB Chair*	Stephen E. Ellefson *Date* *IDPS Processing SI Lead*
Bob Hughes *Date* *A&DP Deputy & ARB Chair*	

Prepared by
Northrop Grumman Space Technology
One Space Park
Redondo Beach, CA 90278

Prepared for
Department of the Air Force
NPOESS Integrated Program Office
C/O SMC/CIK
2420 Vela Way, Suite 1467-A8
Los Angeles AFB, CA 90245-4659

Under
Contract No. F04701-02-C-0502

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

Northrop Grumman Space & Mission Systems Corp. **Space Technology** One Space Park Redondo Beach, CA 90278	NORTHROP GRUMMAN Raytheon

Revision/Change Record	**Document Number** **D39546**

Revision	Document Date	Revision/Change Description	Pages Affected
---	09-09-04	Initial Release	ALL
A	01-21-05	Revision mandated by SPCR ALG00000597 in preparation of formal release (TIM/ARB/ACCB reviews) to IDPS	ALL
A	01-21-05	Reflects Science To Operational Code Conversion	ALL
A	01-21-05	Added discussion for SCD to SDPTLK data conversion	45-86
B1	01-21-09	Implemented TM NP-EMD.2008.510.0043-Rev-A, then reformatted document to conform to template D41851 and updated for code completion review.	ALL
B2	02-26-09	Updated with CCPR comments and prepared for SDRL delivery	ALL
B	05-13-09	Prepared for TIM/ARB/ACCB.	ALL
C1	07-09-09	Updates based on Technical Memorandum NP-EMD_2009_510_0001_OMPS_NP_SDR_OAD_RevB and sensor characterization 4.3.1. SDRL delivery	ALL
C2	8-19-09	Updates from SDRL comments.	6, 13, 34
C3	9-2-09	Updated based on software changes made in PCR020445 and PCR020831	14, 15, 16
C4	12-18-09	Updated due to NP-EMD.2009.510.0053_NPP_OMPS_NP_SDR_errorterms.	All
C5	5-24-10	Updated due to ECR-1053A and ECR-1054B, includes PCR023161 and PCR023367.	All
C	7-7-10	Updated for TIM/ARB/ACCB	All
D1	7-16-10	Updated Table 2 for implementation of ECR-A306	Table 2
D2	10-20-10	Updated due to document convergence to include tech memos 2010.510.0013 and 2101.510.0014	All
D3	10-2-10	Updated due to ECR-A317B and tech memo 2010.510.0041.	All
D4	06-29-11	Updated for ECR A-0016 and TM 2011.510.0007	All
D5	11-06-11	Updated for PCRs PCR026493, PCR026710, PCR026938, PCR027342 & PCR027485	All

Table of Contents

1.0 INTRODUCTION 1
1.1 Objective 1
1.2 Scope 1
1.3 References 1
1.3.1 DOCUMENT REFERENCES 1
1.3.2 SOURCE CODE REFERENCES 3
2.0 ALGORITHM OVERVIEW 5
2.1 OMPS Nadir Profiler SDR Description 5
2.1.1 INTERFACES 5
2.1.1.1 INPUTS 7
2.1.1.1.1 CALIBRATION INPUTS 7
2.1.1.1.2 EARTH VIEW INPUTS 17
2.1.1.1.3 RDR INPUT 18
2.1.1.1.4 CONTROL/INITIALIZATION INPUTS 19
2.1.1.1.4.1 Control Parameters 19
2.1.1.1.4.2 Sensor Parameters 21
2.1.1.1.4.3 Initialization Parameters 22
2.1.1.1.5 SENSOR CHARACTERIZATION DATABASES 22
2.1.1.2 OUTPUTS 23
2.1.1.2.1 CALIBRATION SDR OUTPUTS 23
2.1.1.2.2 PROPOSED UPLOAD TABLES 28
2.1.1.2.3 EARTH VIEW SDR OUTPUTS 29
2.1.2 ALGORITHM PROCESSING 31
2.1.2.1 CALIBRATION MAIN SCIENCE MODULE - NP_PIPELINE_CAL.F 31
2.1.2.1.1 SUBROUTINE NP_PROCESS_PIPE_CAL.F 31
2.1.2.1.2 SUBROUTINE RDF_INPUT_CAL.F 32
2.1.2.1.3 SUBROUTINE READ_SPEC_CAL.F 32
2.1.2.1.4 SUBROUTINE NP_CALIB.F 32
2.1.2.2 EARTH VIEW MAIN SCIENCE MODULE - NP_PIPELINE.F 32
2.1.2.2.1 SUBROUTINE RDF_INPUT_EARTH.F 33
2.1.2.2.2 SUBROUTINE READ_SPEC_EARTH.F 33
2.1.2.2.3 SUBROUTINE NP_EARTH_VIEW.F 33
2.1.2.3 SHARED MODULES 33
2.1.2.3.1 SUBROUTINE GET_EVTABLE.F 33

2.1.2.3.2 SUBROUTINE GET_MACROTABLE.F 34
2.1.2.3.3 SUBROUTINE GET_SCTABLE.F 34
2.1.2.3.4 SUBROUTINE GET_LEDTABLE.F 34
2.1.2.3.5 SUBROUTINE GET_TIMETABLE.F 34
2.1.2.3.6 SUBROUTINE GET_INSTRUM_PARAMS_NP.F 34
2.1.2.3.7 SUBROUTINE READ_RESP.F 34
2.1.2.3.8 SUBROUTINE READ_WAVE_REF.F 34
2.1.2.3.9 SUBROUTINE READ_RDR_HDR.F 34
2.1.2.3.10 SUBROUTINE RDR_LIMITS.F 35
2.1.2.3.11 SUBROUTINE SAVE_RDR_HDRS.F 35
2.1.2.3.12 SUBROUTINE FILL_LIMIT_FLAGS.F 35
2.1.2.3.13 FUNCTION GET_INSTRUM_PARAMS_NP.F 35
2.1.2.3.14 SUBROUTINE BAND_CENTER_READ.F 35
2.1.2.3.15 SUBROUTINE FLAG_WAVES.F 35
2.1.2.3.16 SUBROUTINES STATS.F AND STATS4.F 35
2.1.2.3.17 SUBROUTINE GET_BIAS.F 35
2.1.2.3.18 SUBROUTINE LINEARIZE_DARK.F 35
2.1.2.3.19 SUBROUTINE SUM_DARKS.F 36
2.1.2.3.20 SUBROUTINE DO_STATS.F 36
2.1.2.3.21 SUBROUTINE SDR_WRITE_SAA_DARK.F 36
2.1.2.3.22 SUBROUTINE GET_BAD_PIXELS.F 36
2.1.2.3.23 SUBROUTINE READ_DARK.F 36
2.1.2.3.24 SUBROUTINE LINEARITY_NP.F 36
2.1.2.3.25 SUBROUTINE SDR_WRITE_DARK.F 36
2.1.2.3.26 SUBROUTINE SDR_WRITE_LAMP.F 36
2.1.2.3.27 SUBROUTINE LINEARIZE_SOLAR.F 37
2.1.2.3.28 SUBROUTINE SAVE_BIAS.F 37
2.1.2.3.29 SUBROUTINE SUB_DARK_SOLAR.F 37
2.1.2.3.30 SUBROUTINE SUBTRACT_SMEAR_SOLAR.F 37
2.1.2.3.31 SUBROUTINE GONIOMETRY.F 37
2.1.2.3.32 SUBROUTINE READ_SOLAR_REF.F 37
2.1.2.3.33 SUBROUTINE GET_HITS_SOLAR.F 37
2.1.2.3.34 SUBROUTINE COMBINE_SOLAR.F 38
2.1.2.3.35 SUBROUTINE READ_RAWFLUX_NP.F 38
2.1.2.3.36 SUBROUTINE RAWFLUX_WRITE_NP.F 38

2.1.2.3.37 SUBROUTINE WAVE_MONITOR_NP.F 38
2.1.2.3.38 SUBROUTINE READ_TABLE_REF_SHIFTS.F 39
2.1.2.3.39 SUBROUTINE INTERPOLATE.F 40
2.1.2.3.40 SUBROUTINE READ_WSHIFTS.F 40
2.1.2.3.41 SUBROUTINE INIT_WSHIFTS.F 40
2.1.2.3.42 SUBROUTINE CALC_CONT_SHIFTS.F 40
2.1.2.3.43 SUBROUTINE CALC_LINE_SHIFTS.F 40
2.1.2.3.44 SUBROUTINE WRITE_WSHIFTS.F 40
2.1.2.3.45 SUBROUTINE WAVE_TREND_NP.F 40
2.1.2.3.46 SUBROUTINE READ_WSHIFTS.F 41
2.1.2.3.47 SUBROUTINE FIT_LINE_SHIFTS.F 41
2.1.2.3.48 SUBROUTINE SHIFT_CORRECT.F 41
2.1.2.3.49 SUBROUTINE FLUX_WRITE_NP.F 41
2.1.2.3.50 SUBROUTINE TREND_ALBEDO.F 41
2.1.2.3.51 SUBROUTINE LINFIT.F 42
2.1.2.3.52 SUBROUTINE SDR_WRITE_SOLAR.F..42
2.1.2.3.53 SUBROUTINE SUB_BIAS_EARTH.F 42
2.1.2.3.54 SUBROUTINE SUB_DARK_EARTH.F 42
2.1.2.3.55 SUBROUTINE READ_SAA_DARK.F 42
2.1.2.3.56 SUBROUTINE SUBTRACT_SMEAR_EARTH.F 42
2.1.2.3.57 SUBROUTINE CALC_SMEAR_EARTH.F 42
2.1.2.3.58 SUBROUTINE READ_CAL_FACTORS_NP.F 42
2.1.2.3.59 SUBROUTINE SDR_WRITE_EARTH_NP.F...42
2.1.3 GRACEFUL DEGRADATION 43
2.1.3.1 GRACEFUL DEGRADATION INPUTS 43
2.1.3.2 GRACEFUL DEGRADATION PROCESSING 43
2.1.3.3 GRACEFUL DEGRADATION OUTPUTS 43
2.1.4 EXCEPTION HANDLING...43
2.1.5 DATA QUALITY MONITORING 43
2.1.6 COMPUTATIONAL PRECISION REQUIREMENTS 43
2.1.7 ALGORITHM SUPPORT CONSIDERATIONS 43
2.1.8 ASSUMPTIONS AND LIMITATIONS 43
2.1.8.1 ASSUMPTIONS...43
2.1.8.2 LIMITATIONS...44
3.0 GLOSSARY/ACRONYM LIST 45

3.1 Glossary 45
3.2 Acronyms..47
4.0 OPEN ISSUES 48
5.0 APPENDIX A...49

List of Figures

Figure 1: Processing Chain Associated with the OMPS NP Ozone. 5
Figure 2: Calibration SDR Processing Schematic 6
Figure 3: Earth View SDR Processing Schematic 7
Figure 4: CCD Radiance Storage 19
Figure 5: Layout of Nadir Profile CCD 50
Figure 6: Clipped layout of NP CCD 51

List of Tables

Table 1: Reference Documents 1
Table 2: Source Code References 3
Table 3: OMPS Nadir Profile SDR Input: Biases 7
Table 4: OMPS Nadir Profile SDR Input: BRDF Grids 7
Table 5: OMPS Nadir Profile SDR Input: Calibration Constants 8
Table 6: OMPS Nadir Profile SDR Input: Calibration Factors - Solar 8
Table 7: OMPS Nadir Profile SDR Input: Darks 8
Table 8: OMPS Nadir Profile SDR Input: SAA Darks 9
Table 9: OMPS Nadir Profile SDR Input: Field Angles Map 9
Table 10: OMPS Nadir Profile SDR Input: Flux 9
Table 11: OMPS Nadir Profile SDR Input: Line Shifts 10
Table 12: OMPS Nadir Profile SDR Input: Observed Solar 10
Table 13: OMPS Nadir Profile SDR Input: Predicted Solar 10
Table 14: OMPS Nadir Profile SDR Input: Raw Flux 10
Table 15: OMPS Nadir Profile SDR Input: Solar Irradiance Calibration Constants 11
Table 16: OMPS Nadir Profile SDR Input: Solar Irradiance 11
Table 17: OMPS Nadir Profile SDR Input: Spectral Response Function 11
Table 18: OMPS Nadir Profile SDR Input: Spectral Registration Pixel Map 11
Table 19: OMPS Nadir Profile SDR Input: Wave Monitor 12
Table 20: OMPS Nadir Profile SDR Input: Wave Fitting Parameters 12
Table 21: OMPS Nadir Profile SDR Input: Ground ISF Approved Earth View Sample Table 13
Table 22: OMPS Nadir Profile SDR Input: Ground ISF Approved LED Sample Table 13
Table 23: OMPS Nadir Profile SDR Input: Ground ISF Approved Linearity Table 14
Table 24: OMPS Nadir Profile SDR Input: Ground ISF Approved Macropixel Table 14
Table 25: OMPS Nadir Profile SDR Input: Ground ISF Approved Solar Calibration Sample Table 14
Table 26: OMPS Nadir Profile SDR Input: Ground ISF Approved Timing Pattern Table 14

Table 27: OMPS Nadir Profile SDR Input: Ground ISF Approved Wavelengths Table 15
Table 28: OMPS Nadir Profile SDR Input: Calibration Coefficients...16
Table 29: OMPS Nadir Profiler SDR Input: Stray Light Correction LUT 16
Table 30: OMPS Table Version Lookup Table 17
Table 31: OMPS Nadir Profile SDR Input: Ground ISF Approved Calibration Factors - Earth ...18
Table 32: OMPS Nadir Profile SDR Output: Bad Pixels 23
Table 33: OMPS Nadir Profile SDR Output: Calibration Geolocation 23
Table 34: OMPS Nadir Profile SDR Output: Calibration SDR..25
Table 35: OMPS Nadir Profile SDR Output: Flat Field History...27
Table 36: OMPS Nadir Profile SDR Output: Flat Fields Proposed Upload.................................27
Table 37: OMPS Nadir Profile SDR Output: Lamp 27
Table 38: OMPS Nadir Profile SDR Output: Linearity...28
Table 39: OMPS Nadir Profile SDR Output: Earth View Geolocation 29
Table 40: OMPS Nadir Profile SDR Output: Earth View SDR..30
Table 41: Glossary...45
Table 42: Acronyms 47
Table 43: List of OAD TBD/TBR...48
Table 44: Parameter Definitions 49

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 OMPS Nadir Profile (NP) SDR. The theoretical basis for this algorithm is described in OMPS Nadir Profile Ozone Algorithm Theoretical basis Document (ATBD), 474-00026.

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	Publication Date
OMPS NADIR Total Column Ozone Algorithm Theoretical Basis Document ATBD	474-00029	Latest
OMPS Nadir Profile Ozone Algorithm Theoretical basis Document (ATBD)	474-00026	Latest
OMPS Command and Telemetry Handbook	D568423 Rev. C	30 Sep 2008
NPP Mission Data Format Control Book and App A (MDFCB)	429-05-02-42_MDFCB	Latest
Operational Algorithm Description Document for Ozone Mapping and Profiler Suite (OMPS) Total Column (TC) Sensor Data Records (SDR)	474-00077	Latest
OMPS Nadir Profile SDR Delivery 4.3: updates required for previous OADs	NP-EMD.2008.510.0043	16 Jul 2008

Document Title	Document Number/Revision	Publication Date
OMPS Algorithm Verification Status Report	D36812 Version 1.0	31 Mar 2003
JPSS CGS Data Processor Inter-subsystem Interface Control Document (DPIS ICD) Vol I – IV	IC60917-IDP-002	Latest
JPSS Environmental Data Record (EDR) Production Report for NPP	474-00012	Latest
JPSS Environmental Data Record (EDR) Interdependency Report (IR) for NPP	474-00007	Latest
JPSS Common Data Format Control Book - External - –Block 1.2.2 (All Volumes)	474-00001-01-B0122 CDFCB-X Vol I 474-00001-02-B0122 CDFCB-X Vol II 474-00001-03-B0122 CDFCB-X Vol III 474-00001-04-01-B0122 CDFCB-X Vol IV Part 1 474-00001-04-02-B0122 CDFCB-X Vol IV Part 2 474-00001-04-03-B0122 CDFCB-X Vol IV Part 3 474-00001-04-04-B0122 CDFCB-X Vol IV Part 4 474-00001-05-B0122 CDFCB-X Vol V 474-00001-06-B0122 CDFCB-X Vol VI 474-00001-08-B0122 CDFCB-X Vol VIII	Latest
JPSS Common Data Format Control Book - External - Block 1.2.3 (All Volumes)	474-00001-01-B0123 CDFCB-X Vol I 474-00001-02-B0123 CDFCB-X Vol II 474-00001-03-B0123 CDFCB-X Vol III 474-00001-04-01-B0123 CDFCB-X Vol IV Part 1 474-00001-04-02-B0123 CDFCB-X Vol IV Part 2 474-00001-04-03-B0123 CDFCB-X Vol IV Part 3 474-00001-04-04-B0123 CDFCB-X Vol IV Part 4 474-00001-05-B0123 CDFCB-X Vol V 474-00001-06-B0123 CDFCB-X Vol VI 474-00001-08-B0123 CDFCB-X Vol VIII	Latest
NPP Command and Telemetry (C&T) Handbook	D568423 Rev. C	30 Sep 2008
IDPS Processing SI Common IO Design Document	DD60822-IDP-011 Rev. A	21 Jun 2007
Joint Polar Satellite System (JPSS) Program Lexicon	470-00041	Latest
NGST/DPSE Tech Memo OMPS Nadir Profile SDR Delivery 4.3: updates required for previous OADs	NP-EMD.2008.510.0043-Rev-A	05 Aug 2008
JPSS Data Format Control Book – Internal Volume III – Retained Intermediate Product Formats (IDFCB) – Block 1.2.3	474-00020-03-B0123 IDFCB Vol III	Latest
NGAS/A&DP Tech Memo OMPS Nadir Profile SDR Delivery 4.3.1:	NP-EMD.2009.510.0001	04 Feb 2009

Document Title	Document Number/Revision	Publication Date
OAD updates		
Sensor Characterization Database Interface Control Document (SCD ICD)	2255337 Rev C	23 Mar 2007
NGAS/A&DP Tech Memo NPP_OMPS_NP_SDR_errorterms	NP-EMD.2009.510.0053	09 Oct 2009
NGST/SE technical memos: PC_OAD_Last_Drop_Corrections PC_Format_Corrections	NPOESS GJM-2010.510.0013 NPOESS GJM-2010.510.0014	22 Sep 2010 22 Sep 2010
NGAS/A&DP Tech Memos NPP OMPS Nadir Table ID and Version Table_Version_LUT	NP-EMD.2010.510.0041.Rev-D NP-EMD.2010.510.0041	16 Aug 2010 16 Aug 2010
NGST/A&DP Tech Memo OMPS_inst2sc	NP-EMD.2011.510.0007_	21 Feb 2011

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

Document Title	Document Number/ Version	Publication Date
OMPS Unit Test Data D39312	RevD	04 Jul 2009
ClearCase Configuration Controlled Source Code	V 5.1	31 Mar 2003
ClearCase Configuration Controlled Source Code	ISTN_OMPS_NP_NGST_2.4	10 Sep 2004
ClearCase Configuration Controlled Source Code	ISTN_OMPS_NP_NGST_3.2	21 Jan 2005
ClearCase Configuration Controlled Source Code	ISTN_OMPS_NP_NGST_3.2.1	30 Aug 2005
ClearCase Configuration Controlled Source Code	ISTN_OMPS_NP_NGST_4.3	09 Sep 2008
NGST/DPSE Tech Memo OMPS Nadir Profile SDR Delivery 4.3: updates required for previous OADs	NP-EMD.2008.510.0043-Rev-A_ (OAD Rev B1)	5 Aug 2008
ClearCase Configuration Controlled Source Code	ISTN_OMPS_NP_NGST_4.3 Rev A	11 Dec 2008
OMPS NP SDR Operational software	I1.5.00.37 (OAD Rev B2)	01 Jan 2009
ClearCase Configuration Controlled Source Code	ISTN_OMPS_NP_NGST_4.3.1	04 Feb 2009
NGAS/A&DP Tech Memo OMPS Nadir Profile SDR Delivery 4.3.1: OAD updates	NP-EMD.2009.510.0001 (OAD Rev C1)	04 Feb 2009
ClearCase Configuration Controlled Source Code	ISTN_OMPS_NP_NGST_4.3.2	10 Jun 2009
OMPS NP SDR Operational software	Sensor Char build SC-4 (OAD Rev C3)	10 Oct 2009
OMPS NP SDR Operational software NP-EMD.2009.510.0053	Sensor Char build SC-5 (OAD Rev C4)	18 Dec 2009
ECR-1053A and ECR-1054B, includes PCR023161 and PCR023367	Sensor Char build SC-10 (OAD Rev C5)	24 May 2010
ClearCase Configuration Controlled Source Code	ISTN_OMPS_NP_NGST_4.3.4	26 May 2010
ACCB	OAD Rev C	07 Jul 2010
PCR023947 (ECR-A306)	Sensor Char build SC-12 (OAD Rev D1)	16 Jul 2010

Document Title	Document Number/ Version	Publication Date
ClearCase Configuration Controlled Source Code	ISTN_OMPS_NP_NGST_4.3.5_Data (ECR 317)	20 Sep 2010
Convergence Updates (No code updates)	(OAD Rev D2)	20 Oct 2010
OMPS NP SDR Operational software Implemented ECR 317 and tech memo 2010.510.0041D	Build MX.1.5.4.00 (OAD Rev-D3)	02 Nov 2010
OMPS TC SDR Operational software (ECR-A0016) NP-EMD.2011.510.0007 (PCRs 026132 & 026133)	Build MX.1.5.5.00 (OAD Rev-D4)	10 Mar 2011 & 29 Jun 2011 (OAD)
ClearCase Configuration Controlled Source Code (ECR-ALG-0021)	ISTN_OMPS_NP_NGST_4.4	28 Feb 2011
OMPS NP SDR Operational software Implemented (ECR-ALG-0021) (PCR026937)	Build MX.1.5.6.D	14 Jul 2011
ClearCase Configuration Controlled Source Code (ECR-ALG-0023)	ISTN_OMPS_NP_NGST_4.4.1	08 Mar 2011
PCR027341/474-CCR-11-0132	Build MX.1.5.6.F	09 Aug 2011
OMPS NP SDR Operational software Implemented (ECR-ALG-0023) (PCR026492)	Build MX.1.5.6.H	01 Sep 2011
PCR027463	Build MX.1.5.6.J	17 Oct 2011
Updated for PCRs PCR026493, PCR026710, PCR26938, PCR027342 & PCR027485 (OAD update only)	Build MX.1.5.6.00 (OAD Rev-D5)	06 Nov 2011
OAD transitioned to JPSS Program – this table is no longer updated.		

2.0 ALGORITHM OVERVIEW

This document is the operational algorithm description for the NP SDR algorithms. The processing relationship between RDRs, SDRs and the NP IP is illustrated in Figure 1 below.

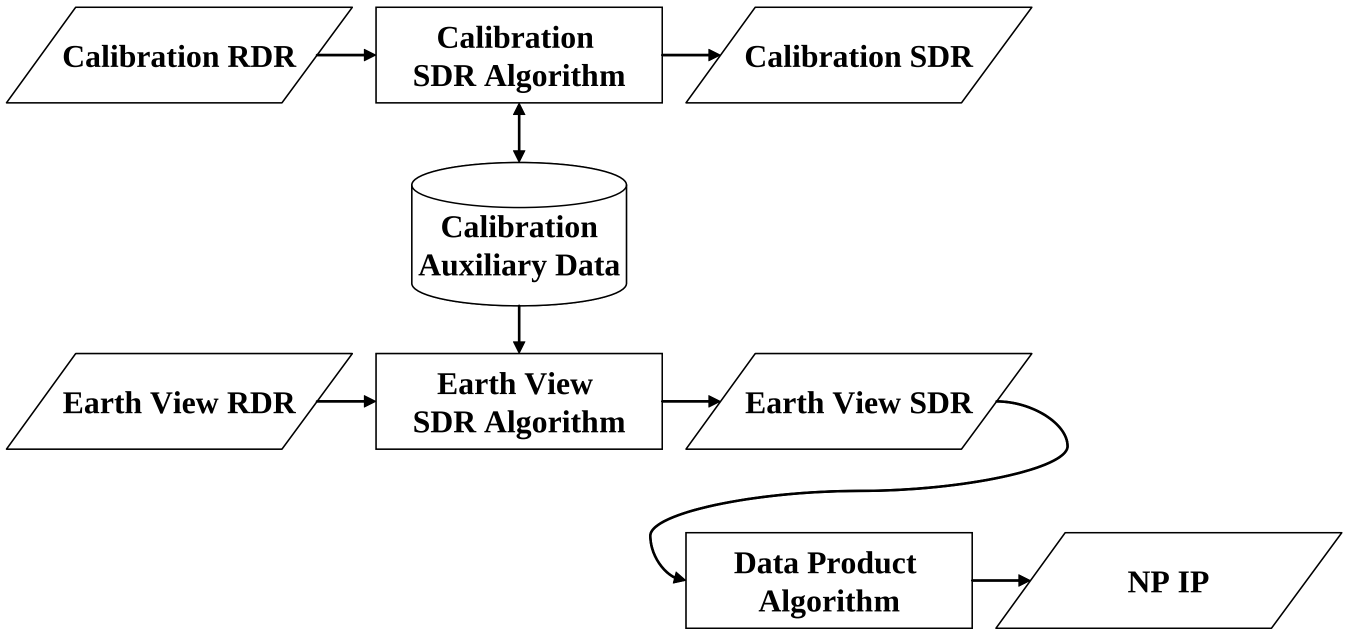

Figure 1: Processing Chain Associated with the OMPS NP Ozone.

2.1 OMPS Nadir Profiler SDR Description

The OMPS Nadir Profiler SDR algorithm processes input from Raw Data Records (RDRs) into Sensor Data Records (SDRs). Two basic RDR types, Earth view and calibration, are processed by separate SDR Algorithm processes. The primary products of calibration processing are auxiliary data that store the results of calibration analyses. These auxiliaries are subsequently used during Earth data processing to adjust the spectral and radiometric calibrations of those data. The basic components of SDR data processing: signal correction, calibration analysis, and calibration application, are all automated. Intervention is required only for approving upload tables and the synchronized configuration tables used in the ground system.

In addition to the two types of output SDRs, the SDR Algorithm stores cumulative histories of the calibration observations in a separate set of auxiliary products, some of which are used in subsequent SDR processing for trending and signal processing corrections.

2.1.1 Interfaces

The NP SDR algorithm is initiated by the Infrastructure (INF) Software Item (SI) to begin processing the data. The INF SI provides tasking information to the algorithm indicating which granule is processed. The Data Management (DMS) SI provides data storage and retrieval capability. The interface to these SIs is implemented by a library of C++ classes.

A simplified form of the Calibration SDR algorithm is shown in Figure 2**.** The driver instantiates an algorithm wrapper that facilitates a systematic approach to several key activities performed by all IDPS algorithms: process initialization, acceptance of tasking information from INF, retrieval of inputs via DMS, initialization of outputs, metadata handling, and storage of outputs via DMS.

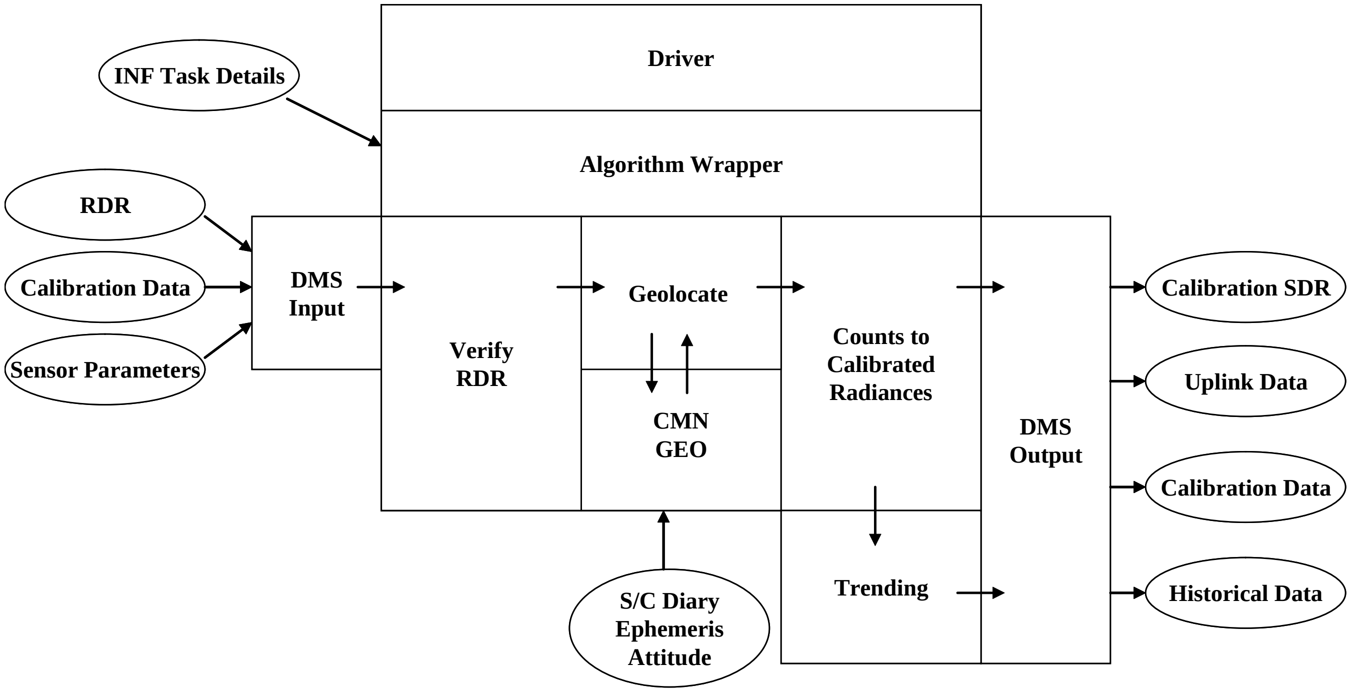

Figure 2: Calibration SDR Processing Schematic

The INF Time API is used for observation time conversion. The CMN GEO, OMPS Utility, and quaternian libraries are used for geolocation, calculation of observing angles, and goniometric corrections. These libraries are compiled separately from the NP SDR algorithms and are linked to the NP SDR algorithms as a library.

A simplified form of the Earth View SDR algorithm is shown in Figure 3. It gains similar benefits from the algorithm wrapper as does the Calibration algorithm, although it is tailored to the specific input and output needs of Earth View SDR processing. After inputs are retrieved, RDRs are verified and granule data is geolocated with the aid of the CMN GEO library. The algorithm executes the Earth View signal correction code to yield calibrated radiances and stores SDRs via DMS.

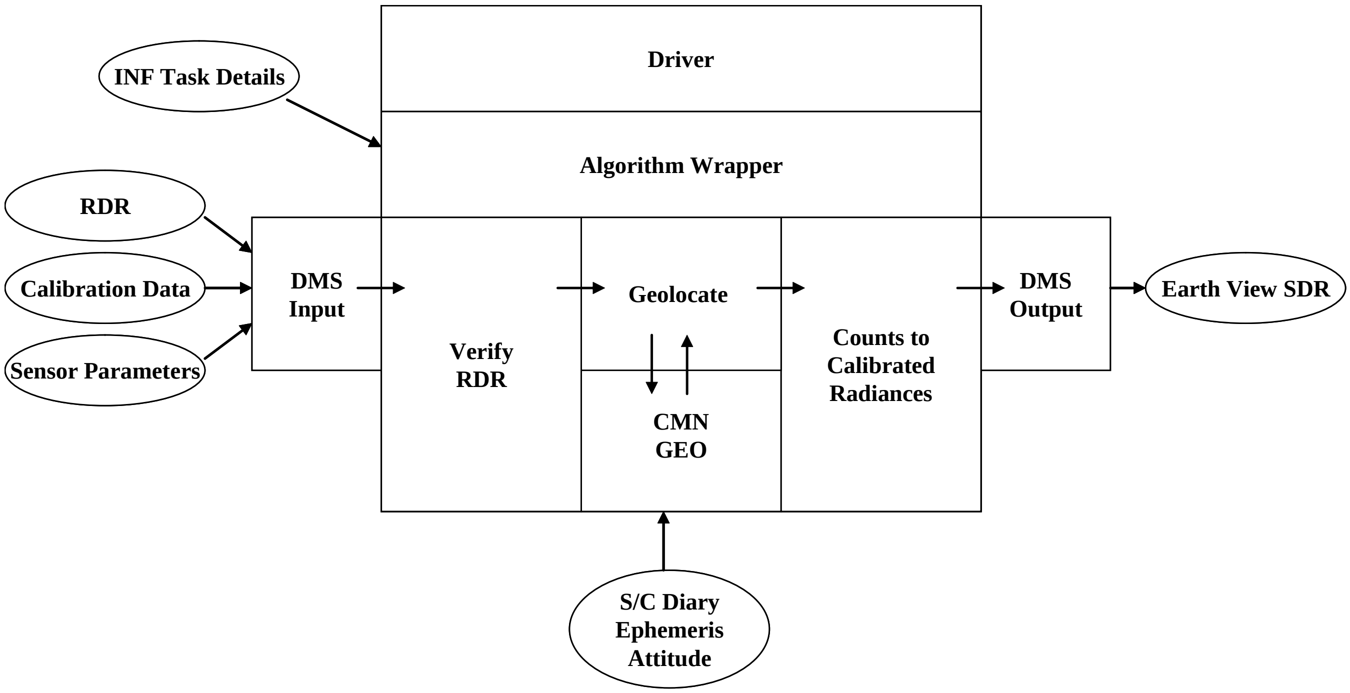

Figure 3: Earth View SDR Processing Schematic

2.1.1.1 Inputs

Separate sections for Calibration and Earth View inputs have been provided. In each case, an individual table represents a single input. Each row of a table represents a specific field in the respective input.

2.1.1.1.1 Calibration Inputs

The Calibration algorithm uses a number of inputs. Each input is listed as a separate table in this section in Table 3 through Table 30.

Table 3: OMPS Nadir Profile SDR Input: Biases

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
bias1	Float32	Electronics bias value for 1st CCD image half, derived from dark data	counts / 0 - 1.00E+05

Table 4: OMPS Nadir Profile SDR Input: BRDF Grids

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
minAzim	Float32 * 2	Minimum solar azimuth	Degrees / None - None
maxAzim	Float32 * 2	Maximum solar azimuth	Degrees / None - None
minElev	Float32 * 2	Minimum solar elevation	Degrees / None - None
maxElev	Float32 * 2	Maximum solar elevation	Degrees / None - None
gspat_offset	Int32 * 2	starting spatial index for non-fill calibrated data in full CCD coordinates	Unitless / None - None

Input	Type	Description	Units/Valid Range
gspec_offset	Int32 * 2	starting spectral index for non-fill calibrated data in full CCD coordinates	Unitless / None - None
gspat_size	Int32 * 2	extent of spatial indices for calibrated data	Unitless / None - None
gspec_size	Int32 * 2	extent of spectral indices for calibrated data	Unitless / None - None
gazim_size	Int32 * 2	number of azimuth angles	Unitless / None - None
gelev_size	Int32 * 2	number of elevation angles	Unitless / None - None
Pixel-Level Data Items			
BRDF_grid	Float32 * 2 * 150 * 155 * 40 * 40	Bi-directional Reflectance Directional Function (for working and reference diffuser)	Unitless / None - None

Table 5: OMPS Nadir Profile SDR Input: Calibration Constants

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
radevresp	Float32 * 2 * 364 * 390	Radiometric sensitivities for the full CCD; one set each for primary and redundant electronics.	counts/W/cm^3/sterad / 2.89661 - 3299.13

Table 6: OMPS Nadir Profile SDR Input: Calibration Factors - Solar

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
obs_year	Int32 * 29	Year of calibration record	years / 2000 - 2050
obs_day	Int32 * 29	Day of calibration record	days / 1 - 366
old_nmonitor	Int32 * 29	Number of observations used in trending	unitless / 1 - 20
monitor_year	Int32 * 29	Last year of data used for flat field trending	years / 2000 - 2050
monitor_day	Int32 * 29	Last day of data used for flat field trending	days / 1 - 366
Pixel-Level Data Items			
extrap_cfsolar	Float32 * 29 * 364 * 350	Radiometric calibration factors	unitless / 0 - None

Table 7: OMPS Nadir Profile SDR Input: Darks

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
good_darks	Int32	Number of good dark frames that made up the average dark data	Unitless / 0 - None
Scan-Level Data Items			
recid_dark	Int32 * 5	Record identification number	unitless / 0 - None
lseq_dark	Int32 * 5	Logical sequence number	unitless / 0 - None
iyear_dark	Int32 * 5	Year of observation	years / 2000 - 2050
iday_dark	Int32 * 5	Day of observation	days / 1 - 366
time_start_dark	Float64 * 5	Time start of observation	seconds / 0 - None
time_end_dark	Float64 * 5	Time end of observation exposure time	seconds / 0 - None
expose_dark	Float64	Exposure time	seconds / 0 - None
qual_dark	Int16 * 5	Quality of processing	unitless / -13 - None
istat_dark	Int16 * 5	Instrument status	Unitless / Minimum - Maximum
analog_dark	Float32 * 5	Instrument/data record status	Unitless / Minimum - Maximum

Input	Type	Description	Units/Valid Range
saa_dark	Float32 * 5	Average of SAA severity at begin and end of observations	percent / 0 - 100
Pixel-Level Data Items			
dark_data	Float32 * 364 * 390	Corrected dark current counts	counts / None - None

Table 8: OMPS Nadir Profile SDR Input: SAA Darks

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
recid_darksaa	Int32 * 5	Record identification number	Unitless / 0 - None
lseq_darksaa	Int32 * 5	Logical sequence number	Unitless / 0 - None
iyear_darksaa	Int32 * 5	Year of observation	years / 2000 - 2050
iday_darksaa	Int32 * 5	Day of observation	days / 1 - 366
time_start_darksaa	Float64 * 5	Time start of observation	seconds / 0 - None
time_end_darksaa	Float64 * 5	Time end of observation	seconds / 0 - None
delta_time_darksaa	Float64 * 5	Integration time during observation	seconds / 0 - None
SAA_darksaa	Float32 * 5	South Atlantic Anomaly severity flag	percent / 0 - 100
istat_darksaa	Int16 * 5	Instrument status	Unitless / Minimum - Maximum
analog_darksaa	Float32 * 5	Instrument/data record status	Unitless / Minimum - Maximum
Pixel-Level Data Items			
darksaa_array	Float32 * 364 * 390	corrected dark current counts	counts / 0 - None

Table 9: OMPS Nadir Profile SDR Input: Field Angles Map

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
angles	Float64 * 390 * 2	Pre-launch angles map 1. cross-track view angles 2. along-track view angles	nanometer / -1 - 8.6044729E-02

Table 10: OMPS Nadir Profile SDR Input: Flux

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
rsf_iyear	Int32	Reference solar flux observation year	years / 2000 - 2050
rsf_iday	Int32	Reference solar flux observation day	days / 1 - 366
rsf_solar_beta	Float32	Reference solar flux observation	degrees / -180 - 180
rsf_diffuser_surface	Int16	Diffuser surface number	Unitless / 1 - 2
rsf_number_coadds	Int32	Number of solar observations constituting reference flux	unitless / 1 - 28
rsf_avg_scan_time	Float64	Average exposure time of reference solar flux observations	seconds / 0 - None
rsf_expose	Float64	Total exposure time of reference solar	seconds / 0 - None
no_observations	Int32	Number of observations	unitless / 1 - None
Scan-Level Data Items			
iyear_solar	Int32 * 10	Year of current solar data	years / 2000 - 2050
iday_solar	Int32 * 10	Day of current solar data	days / 1 - 366
avg_solar_beta	Float32 * 10	Angle between current orbital plane and sun vector	degrees / -180 - 180
diffuser_surface_num	Int32 * 10	Working diffuser surface number	unitless / 1 - 1
no_work_frames	Int32 * 10	Number of solar data observations	unitless / 0 - None
avg_sol_scan_time	Float64 * 10	Average exposure time of raw flux solar data	seconds / 0 - None

Input	Type	Description	Units/Valid Range
total_sol_expose	Float64 * 10	Total exposure time of raw flux solar data	seconds / 0 - None
Pixel-Level Data Items			
rsf_data	Float32 * 364 * 390	The baseline reference solar flux	W/cm/sterad / None - None
rsf_counts	Float32 * 364 * 390	The baseline reference solar counts	counts / None - None
shift_flux	Float32 * 10 * 364 * 390	The current solar flux, ratioed	Unitless / None - None

Table 11: OMPS Nadir Profile SDR Input: Line Shifts

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
nlines	Int16	Number of lines	unitless / 10 - 10
offset	Int16	Pixel offset	pixels / 1 - 1
nshift	Int16	Number of shifts	unitless / 169 - 169
Scan-Level Data Items			
indexes	Int16 * 10	Line pixel number	pixels / 37 - 136
wlines	Float64 * 10	Selected wavelength lines for monitoring	nanometers / 265.0 - 306.2
refshifts	Float64 * 10 * 169	Selected wavelength shifts for monitoring	nanometers / None - None
irraddiff	Float64 * 10 * 169	Selected irradiance shifts for monitoring	unitless / None - None
wref_l	Float64 * 364	Reference wavelengths	nanometers / 250 - 310

Table 12: OMPS Nadir Profile SDR Input: Observed Solar

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
osol_data	Float32 * 364 * 390	Baseline OMPS observed reference solar irradiances	W/cm^3/sterad / 0 - ~656
osol_count	Float32 * 364 * 390	Baseline OMPS observed reference solar counts	counts / 9520.00 - 485757.0

Table 13: OMPS Nadir Profile SDR Input: Predicted Solar

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
womps	Float64 * 4000	OMPS solar wavelengths predicted from spectral functions.	nanometers / ~249 - ~315
fomps	Float64 * 4000	OMPS solar irradiances predicted from spectral functions.	W/cm^3/sterad / 0 - ~800

Table 14: OMPS Nadir Profile SDR Input: Raw Flux

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
rsf_iyear	Int32	Reference solar flux observation year	years / 2000 - 2050
rsf_iday	Int32	Reference solar flux observation day	days / 1 - 366
rsf_solar_beta	Float32	Angle between orbital plane and sun vector	degrees / -180 - 180
rsf_diffuser_surface	Int16	Diffuser surface number	unitless / 1 - 2
rsf_number_coadds	Int32	Number of solar observations constituting reference flux	unitless / 1 - 28

Input	Type	Description	Units/Valid Range
spat_dim	Int32	Number of spatial pixels in the data	pixels / 0 - None
spec_dim	Int32	Number of spectral pixels in the data	pixels / 0 - None
rsf_avg_scan_time	Float64	Average exposure time of reference solar flux observations	seconds / 0 - None
rsf_expose	Float64	Total exposure time of reference solar flux	seconds / 0 - None
avg_solar_beta	Float32	Angle between current orbital plane and sun vector	degrees / -180 - 180
diffuser_surface_num	Int32	Working diffuser surface number	unitless / 1 - 1
no_work_frames	Int32	Number of solar data observations constituting raw flux	unitless / 0 - None
avg_sol_scan_time	Float64	Average exposure time of raw flux solar data	seconds / 0 - None
total_sol_expose	Float64	Total exposure time of raw flux solar data	seconds / 0 - None
Scan-Level Data Items			
iyear_solar	Int32 * 10	Year of current solar data	years / 2000 - 2050
iday_solar	Int32 * 10	Day of current solar data	days / 1 - 366
Pixel-Level Data Items			
rsf_data	Float32 * 364 * 390	Reference solar flux	W/cm^3 / 0 - 1800
rsf_counts	Float32 * 364 * 390	Reference solar counts	counts / None - None
rawflx_data	Float32 * 364 * 390	Ratio of current observed solar counts to reference solar counts	unitless / None - None

Table 15: OMPS Nadir Profile SDR Input: Solar Irradiance Calibration Constants

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
iradsolresp	Float32 * 2 * 364 * 390	Radiometric sensitivities	counts/(W/cm^3/sterad) / ~2 - ~1110

Table 16: OMPS Nadir Profile SDR Input: Solar Irradiance

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
wsun	Float64 * 4000	Solar wavelengths of calibration standard.	nanometers / ~250 - ~314
fsun	Float64 * 4000	Solar irradiances of calibration standard.	W/cm^3/sterad / 0 - ~750

Table 17: OMPS Nadir Profile SDR Input: Spectral Response Function

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
offsetw	Float64 * 251	Offset wavelengths	nanometers / -1.5 - 1.5
wavefunc	Float64 * 251	Wavelengths	Unitless / 0 - 1

Table 18: OMPS Nadir Profile SDR Input: Spectral Registration Pixel Map

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
wmap	Float64 * 364 * 390	Pre-launch wavelengths map	nanometers / 240 - 320

Table 19: OMPS Nadir Profile SDR Input: Wave Monitor

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
wmin	Float32	Wavelength minimum	nanometers / 240 - 320
wmax	Float32	Wavelength maximum	nanometers / 240 - 320
nlines	Int16	Number of monitor lines	unitless / 1 - 10
offset	Int16	Offset pixel monitored	pixels / 1 - 3
no_observations	Int32	Num of observations for trending	unitless / 1 - None
Scan-Level Data Items			
line_locates	Int16 * 10	Line pixel numbers	unitless / 1 - 145
wlines	Float32 * 10	Line monitor wavelengths	nanometers / 240 - 320
iyear_solar	Int32 * 10	Year of observation	years / 2000 - 2050
iday_solar	Int32 * 10	Day of observation	days / 1 - 366
avg_solar_beta	Float32 * 10	Solar mean beta-angle	degrees / -180 - 180
diffuser_surface_ solar	Int16 * 10	Diffuser surface	unitless / 1 - 2
no_solar_frames	Int32 * 10	Number of solar observations used	unitless / 1 - 28
resolution	Float32 * 10	FWHM wavelength resolution	nanometers / 0 - None
c_shifts	Float64 * 10 * 5	Waveshift	nanometers / None - None
c_scales	Float64 * 10 * 5	Wavestretch	unitless / None - None
fitness	Float64 * 10 * 5	Reduced Chi^2	unitless / 0 - None
l_shift	Float64 * 10 * 5	Group lineshift	nanometers / None - None
l_shift_err	Float64 * 10 * 5	Precision of group lineshift	nanometers / 0 - None
l_add	Float64 * 10 * 5	Fit lineshift	nanometers / None - None
l_stretches	Float64 * 10 * 5	Fit slope	unitless / None - None
linear	Float64 * 10 * 5	Correlation	unitless / -1 - 1
shift	Float32 * 10 * 10 * 5	Individual lineshifts	nanometers / None - None

Table 20: OMPS Nadir Profile SDR Input: Wave Fitting Parameters

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
iterate	Int32	Processing switches	unitless / 0 - none
write_fit	Int32	Processing switches	unitless / 0 - none
weight	Int32	Processing switches	unitless / 0 - none
mirror	Int32	Processing switches	unitless / 0 - none
autodiff	Int32	Processing switches	unitless / 0 - none
wavlo	Float64	Wavelength limits for fitting	nanometers / 255.83 - 308.58
wavhi	Float64	Wavelength limits for fitting	nanometers / 255.83 - 308.58
delchi	Float64	Convergence criteria	unitless / 1.00E-12 - 1.00E-12
provar	Float64	Convergence criteria	unitless / 1.00E-12 - 1.00E-12

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
var	Float64 * 64	Polynomial parameters	unitless / 1.00E-12 - 1.00E-12
if_varied	Int32 * 64	vary parameter	unitless / 0 - none
diff	Float64 * 64	Increment parameter	unitless / 0 - None
lock	Int32 * 64	Unused lock	unitless / 0 - 0
block	Float64 * 64	Unused lock	unitless / 0 - 0
alock	Float64 * 64	Unused lock	unitless / 0 - 0

Earth view sample table

The array in this input contains a map of the full CCD. It is in the flight-like sample table convention. The values indicate which pixels on the CCD are used (or not used) and which are bad. The data is derived from BATC's STB database (sample table and bad pixel). See Table 21.

Table 21: OMPS Nadir Profile SDR Input: Ground ISF Approved Earth View Sample Table

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
badpixBATC	Int32 * 364 * 390	Flight-like earth view sample table of pixels	none / 0 – 3: 0=unused pixel 1 = macropixel A 2= macropixel B 3= bad pixel

LED Sample Table

The array in this input contains a map of the full CCD for each of the primary and redundant electronics. It indicates which pixels are downloaded for the linearity calibration. The data is derived from BATC's STB database (sample table and bad pixel). See Table 22.

Table 22: OMPS Nadir Profile SDR Input: Ground ISF Approved LED Sample Table

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
lampsample	Int32 * 364 * 390	Linearity LED sample table array	unitless / 0 - 2

Linearity Table

Linearity table is a linearity lookup table. The linearity look up table is used to convert the measured counts to linearized counts. It compensates for the non-linearity of the amplifiers in the electronics chain. There is a set for each of the primary and redundant electronics. The data is derived from BATC's LED database (Linearity and LED signal). See Table 23.

Table 23: OMPS Nadir Profile SDR Input: Ground ISF Approved Linearity Table

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
linearity_table	Float32 * 2 * 16384	linearity conversion LUT primary CCD1 redundant CCD1	counts / 1 - 16384

Macropixel sample table

The array in this input contains a map of the full CCD. All pixels corresponding to an Earth view Macropixel contain a value from 1-N where N is the total number of macropixels. A value of zero indicates that the pixel is not part of a macropixel. A negative value indicates that the pixels is part of a macropixel that is all bad. The data is derived from BATC's STB database (sample table and bad pixel). See Table 24.

Table 24: OMPS Nadir Profile SDR Input: Ground ISF Approved Macropixel Table

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
macrot	Int32 * 364 * 390	Macropixel table array Negative number indicates all bad macropixel	none / -N - N

Solar Calibration Sample Table

The array in this input contains a map of the full CCD for the solar diffuser. It indicates which pixels are illuminated by the solar diffuser. The data is derived from BATC's STB database (sample table and bad pixel). See Table 25.

Table 25: OMPS Nadir Profile SDR Input: Ground ISF Approved Solar Calibration Sample Table

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
macrot	Int32 * 364 * 390	Sample table array for solar diffuser position 4	unitless / 0 - 2

Timing Pattern Table

The timing pattern table gives the number of frames, coadds and integration times for each of the different types of datatypes: Earth, Dark, Solar and Lamp. The lamp integration times come from BATC's LED database (Linearity and LED Signal). See Table 26.

Table 26: OMPS Nadir Profile SDR Input: Ground ISF Approved Timing Pattern Table

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
TPev_num	Int32	Number of Earth View frames	Unitless / 1 - np::NO_SCANS_PER_GRANULE
TPsol_num	Int32	Number of Solar frames	Unitless / 1 - np::NO_SOLAR_IMAGES

Input	Type	Description	Units/Valid Range
TPdark_num	Int32	Number of Dark frames	Unitless / 1 - np::NO_DARK_IMAGES
TPled_num	Int32	Number of Lamp frames	Unitless / 1 - np::NO_LAMP_IMAGES
TPev_conum	Int32	Number of Earth View coadds	Unitless / 1 - np::NO_COADDS_E
TPsol_conum	Int32	Number of Solar coadds	Unitless / 1 - np::NO_COADDS_S
TPdark_conum	Int32	Number of Dark coadds	Unitless / 1 - np::NO_COADDS_D
TPled_conum	Int32	Number of Lamp coadds	Unitless / 1 - np::NO_COADDS_L
ev_time_offset	Int64	Delta time for Earth View time correction	microseconds / 0 - Maximum
sol_time_offset	Int64	Delta time for Solar time correction	microseconds / 0 - Maximum
dark_time_offset	Int64	Delta time for Dark correction	microseconds / 0 - Maximum
led_time_offset	Int64 * 150	Delta times for Lamp correction	microseconds / 0 - Maximum
Scan-Level Data Items			
TPev_time	Float64 * 5	Total integration time for each frame	seconds / 1 - None
TPsol_time	Float64 * 27	Total integration time for each frame	seconds / None - None
TPdark_time	Float64 * 5	Total integration time for each frame	seconds / 1 - None
TPled_time	Float64 * 150	Total integration time for each frame	seconds / 0.1 - None

Table 27: OMPS Nadir Profile SDR Input: Ground ISF Approved Wavelengths Table

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
obs_year	Int16 * 29 * 5	Year	years / 2000 - 2050
obs_day	Int16 * 29 * 5	Day	days / 1 - 366
resolution	Float32 * 29 * 5	FWHM wavelength resolution	nanometers / 0 - None
spatial	Int16 * 29 * 5	Spatial cell number	unitless / 1 - None
intercept	Float64 * 29 * 5	Intercept line	nanometers / None - None
slope	Float64 * 29 * 5	Slope line	unitless / None - None
straight	Float64 * 29 * 5	Correction	unitless / 0 - None
nmonitor	Int32 * 29 * 5	Number of calibrations used for trend	unitless / 3 - None
year	Int16 * 29 * 5	Year of newest calibration trended	years / 2000 - 2050
day	Int16 * 29 * 5	Day of newest calibration trended	days / 1 - 366
wbands	Float64 * 29 * 364 * 5	Wavelengths	nanometers / 240 - 320

Table 28: OMPS Nadir Profile SDR Input: Calibration Coefficients

Input	Type	Description
deviate	Float64	Correlation threshold for identifying deviations
deviateWidth	Float64	Width of correlation threshold for identifying deviations
qUpPrimaryElec	Float64	Upper tie point for primary electronics (for Linearity use)
qUpRedundantElec	Float64	Upper tie point for redundant electronics (for Linearity use)
mountMatrix	Float64 * 3 * 3	Matrix of mounting errors describing the rotation from sensor frame to spacecraft frame
flopdownAngle	Float64	Flopdown angle used in goniometric corrections. Y rotation in addition to orbital motion in degrees
xAngle	Float64	X rotation takes into account diffuser rotation in the rotor plane. Its sign corresponds to counterclockwise direction if viewed from the motor side of assembly.
chiTol	Float32	Threshold reduced Chi-square for line wavelength use
fullWidth	Float32	Expected nominal spectral FWHM (full width at half maximum)
edge	Float32	Extra bandpass in nm around wave min and max
motorRate	Float32	Motor rate coefficient
diffusersOffset	Float32	Angle between reference diffuser stowed position and mid position (degrees).
diffuserSep	Float32	Separation angle between nominal diffuser positions (degrees).
radHigh	Float32	Maximum expected radiance.
badSaa	Float32	Threshold SAA value for bad flag.
waveStdTol	Float32	Threshold wavelength precision to adjust calibration fluxes.
biasDefault	Float32	Default electronics bias value in counts.
solarSize	Float32	Sun disk diameter
diffEdgeAngle	Float32	Tolerance angle from diffuser edge in degrees.
wmonInterval	Int32	Number of solar calibrations to trend wavelengths
cfInterval	Int32	Number of days.
badPixLowerThreshold	Int32	The lower threshold for bad pixels. Values below this number are considered bad.
badPixUpperThreshold	Int32	The upper threshold for bad pixels. Values above this number are considered bad.
biasIndex	Int32 * 4	The lower and upper bounds of the serial overclock pixels to be used in the bias estimate.
smearSpatCcdIndex	Int32 * 2	Beginning and Ending spatial pixel index in the Smear Region of the CCD
viewSpatCcdIndex	Int32 * 2	Beginning and Ending spatial pixel index in the View Region of the CCD
specCcdIndex	Int32 * 2	Beginning and Ending spectral pixel index of the CCD. To account for the spectral bias region, the no_bias_pix value needs to be added and subtracted from these indices (defined in np_global.f).
offset	Int16	The number of pixels on both sides of a line to monitor
trendGapMax	Int16	How many days are tolerated between cal events before you cannot do trending.
goniometryOn	bool	Switch for processing goniometry during execution.
cfSolarCorrect	Bool	Switch for using extrapolated solar calibration factors
Padbytes	Int16	Pad bytes added by the compiler to memory align the structure

Table 29: OMPS Nadir Profiler SDR Input: Stray Light Correction LUT

Input	Type	Description	Units/Valid Range
nblock	Int32	Number of regions	Unitless / 1 - None
nfov	Int32	Number of spatial macropixels	Unitless / 1 – None
nchan	Int32	Number of spectral channels	Unitless / 1 - None
indx_blck	Int32 * 2 * 14	Index of block boundaries-inclusive	Unitless / 1 - nchan
indx_oor	Int32 * 4	Index super channels	Unitless / 1 - nchan
C300	Float32	Predictor	Unitless / 1 – nchan
C290	Float32	Predictor	Unitless / 1 – nchan
c_power	Float32	Predictor	Unitless / 1 – nchan
sl_cor_oor	Float32 * 200 * 5	OOR stray light coefficients	Unitless / reals
sl_cor_coef	Float32 * 14 * 5 * 200*5	Stray light correction coefficients	Unitless / reals

Table 30: OMPS Table Version Lookup Table

Input	Type	Description	Units/Valid Range
numEntriesUsed	Int32	Number of Ground Software version entries in the table.	none / 1 - 30
flightTableIds	UInt16 * 22	Table IDs specified in the Flight Software.	none / 0 - Maximum
flightTableVersions	UInt16 * 30 * 22	Table Version numbers specified in the Flight Software for each Ground Software version.	none / 0 - Maximum
tcSolSampVer	UInt16 * 30	Ground Software version numbers for the OMPS TC Solar Calibration Sample Tables.	none / 0 - Maximum
tcTimPatVer	UInt16 * 30	Ground Software version numbers for the OMPS TC Timing Pattern Tables.	none / 0 - Maximum
tcLinearityVer	UInt16 * 30	Ground Software version numbers for the OMPS TC Linearity Tables.	none / 0 - Maximum
tcLampSampVer	UInt16 * 30	Ground Software version numbers for the OMPS TC Lamp Calibration Sample Tables.	none / 0 - Maximum
tcEvSampVer	UInt16 * 30	Ground Software version numbers for the OMPS TC Earth View Sample Tables.	none / 0 - Maximum
npSolSampVer	UInt16 * 30	Ground Software version numbers for the OMPS NP Solar Calibration Sample Tables.	none / 0 - Maximum
npTimPatVer	UInt16 * 30	Ground Software version numbers for the OMPS NP Timing Pattern Tables.	none / 0 - Maximum
npLinearityVer	UInt16 * 30	Ground Software version numbers for the OMPS NP Linearity Tables.	none / 0 - Maximum
npLampSampVer	UInt16 * 30	Ground Software version numbers for the OMPS NP Lamp Calibration Sample Tables.	none / 0 - Maximum
npEvSampVer	UInt16 * 30	Ground Software version numbers for the OMPS NP Earth View Sample Tables.	none / 0 - Maximum

2.1.1.1.2 Earth View Inputs

Each Earth View input is listed as a separate table in this section. Most Earth View inputs are also Calibration inputs. In the case that an Earth View input has already been described in an earlier section of this document, a reference is made back to the table in which the input was first described. A Calibration input that is not referenced in this section indicates an input that is used solely by Calibration.

See Table 30: OMPS Table Version Lookup Table. This input is in the same format as the Calibration Table Version Lookup Table.

See Table 3: OMPS Nadir Profile SDR Input: Biases. This input is in the same format as the Biases input.

See Table 5: OMPS Nadir Profile SDR Input: Calibration Constants. This input is in the same format as the Calibration Constants input.

See Table 7: OMPS Nadir Profile SDR Input: Darks. This input is in the same format as the Darks input.

See Table 8: OMPS Nadir Profile SDR Input: SAA Darks. This input is in the same format as the SAA Darks input

See Table 9: OMPS Nadir Profile SDR Input: Field Angles Map. This input is in the same format as the Field Angles Map input.

See Table 12: OMPS Nadir Profile SDR Input: Observed Solar. This input is in the same format as the Observed Solar input.

See Table 13: OMPS Nadir Profile SDR Input: Predicted Solar. This input is in the same format as the Predicted Solar input.

See Table 15: OMPS Nadir Profile SDR Input: Solar Irradiance Calibration Constants. This input is in the same format as the Calibration Constants input.

See Table 17: OMPS Nadir Profile SDR Input: Spectral Response Function. This input is in the same format as the Spectral Response Function input.

See Table 18: OMPS Nadir Profile SDR Input: Spectral Registration Pixel Map. This input is in the same format as the Spectral Registration Pixel Map input.

See Table 21: OMPS Nadir Profile SDR Input: Ground ISF Approved Earth View Sample Table. This input is in the same format as the Ground ISF Approved Earth View Sample Table.

See Table 23: OMPS Nadir Profile SDR Input: Ground ISF Approved Linearity Table. This input is in the same format as the Ground ISF Approved Linearity Table input.

See Table 24: OMPS Nadir Profile SDR Input: Ground ISF Approved Macropixel Table. This input is in the same format as the Ground ISF Approved Macropixel Table input.

See Table 26: OMPS Nadir Profile SDR Input: Ground ISF Approved Timing Pattern Table. This input is in the same format as the Ground ISF Approved Timing Pattern Table input.

See Table 27: OMPS Nadir Profile SDR Input: Ground ISF Approved Wavelengths Table. This input is in the same format as the Ground ISF Approved Wavelengths Table Input.

See Table 28: OMPS Nadir Profile SDR Input: Calibration Coefficients. This input is in the same format as the Ground ISF Approved Calibration Coefficients input.

Table 31: OMPS Nadir Profile SDR Input: Ground ISF Approved Calibration Factors - Earth

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
obs_year	Int32 * 29	Year of calibration record	years / 2000 - 2050
obs_day	Int32 * 29	Day of calibration record	days / 1 - 366
old_nmonitor	Int32 * 29	Number of observations used in trending	Unitless / 0 - None
monitor_year	Int32 * 29	Last year of data used for flat field trending	years / 2000 - 2050
monitor_day	Int32 * 29	Last day of data used for flat field trending	days / 1 - 366
cfearth	Float32 * 29 * 364 * 5	Radio-metric calibration factors	Unitless / 0 - None

2.1.1.1.3 RDR Input

The MDFCB contains the RDR input parameters assumed by the SDR algorithm for the Nadir Profiler Earth View RDR (APID 561) and calibration RDR (APID 565). The size of the radiance data block stored in each RDR depends on whether the RDR is an Earth view or calibration RDR and which type of calibration RDR it is: lamp, dark, or solar. For images that are less than full frame, the quantity of radiance data can be determined by consulting the appropriate sample table for that image type. Appendix A contains additional details of coordinate systems used by the sample tables.

Figure 4 illustrates the radiance data storage locations expected by the SDR algorithm. The information from the sample tables will supply the specific pixel locations of the radiance data, overclock pixels and smear pixels on the full array (390x364).

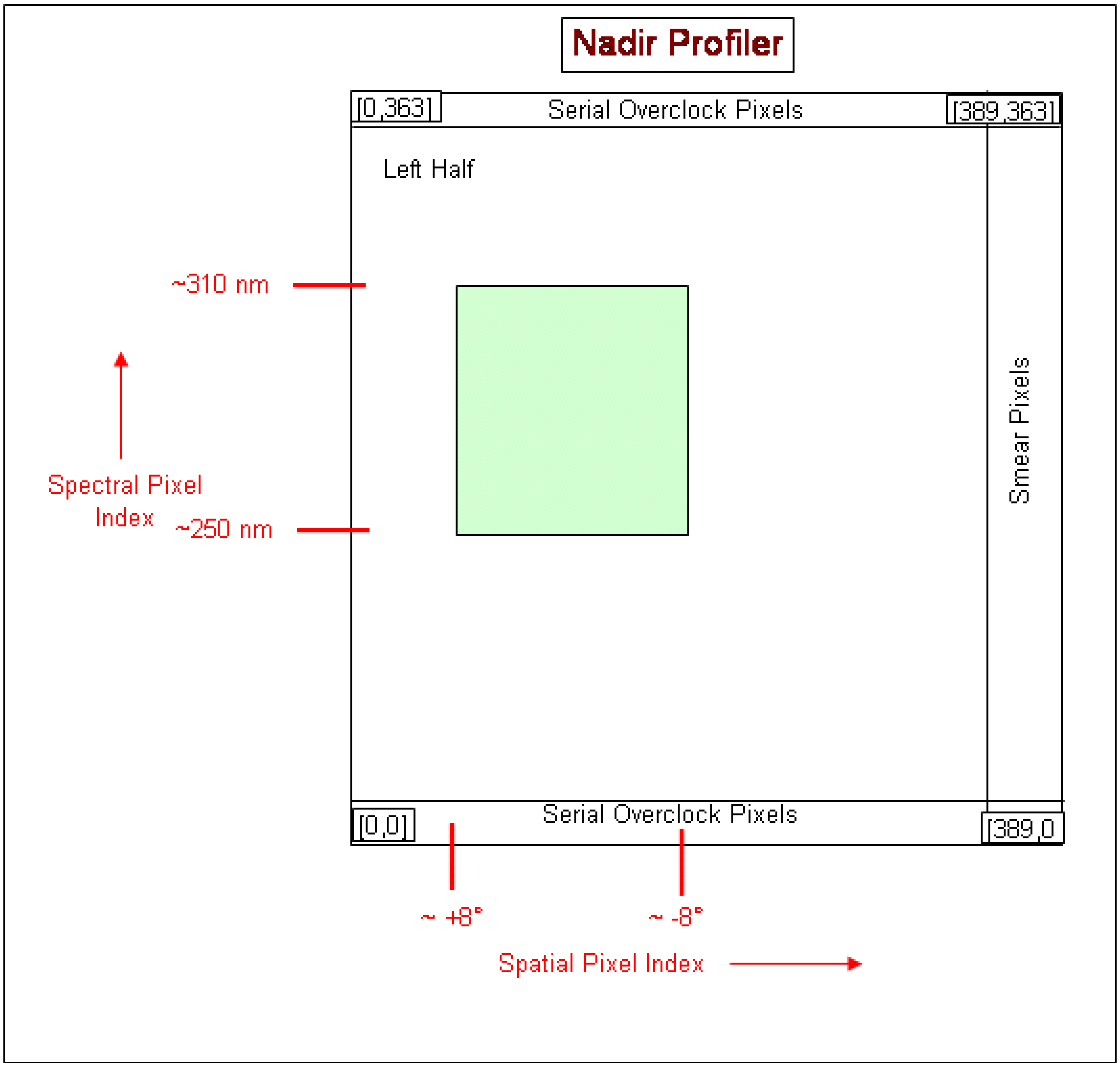

Figure 4: CCD Radiance Storage

2.1.1.1.4 Control/Initialization Inputs

2.1.1.1.4.1 Control Parameters

Wavelength Fitting Parameters (e.g. cont_par_np)

These fitting parameters are input from DMS into the SDR Algorithm and rarely need to be changed. The parameters define the wavelength range over which the algorithm monitors wavelengths, the convergence criteria of the fitting, the starting parameter values, and the increments of the wavelength fitting parameters. Spectral response width, radiometric scaling, and wavelength shifts are some of the parameters supplied to the algorithm. Parameters selected from a list of 12:

(a) #1-4 a cubic polynomial in baseline radiometric correction (the first 4 parameters)
(b) #5-8 a cubic polynomial in overall radiometric scaling (the second group of 4 parameters)
(c) #9 solar intensity
#10 slit width (Gaussian half-width at 1/e intensity)
#11 -shift (the additive wavelength shift needed to register the solar reference onto the measurement; the calibration is thus the negative of this parameter)

#12 wavelength multiplicative scaling factor.

Parameter #5 is normally fixed at 1.0, since it has almost exactly the same effect as #9.

The wavelength fitting procedure is further described in the NP ATBD, 474-00026, (Sections 3.1.3.3, 3.1.3.5.5, 3.1.3.5.6 and,3.1.3.5.7).

There are a few fossils remaining in the program. Most notably, it retains the possibility to lock parameters together with a linear offset.

```
omps solar wavelength calibration
#logical parameters iterate, write_fit, weight, mirror, autodiff

# if (iterate) then iterate to a solution, otherwise calculate a
# spectrum with the starting parameters

# if (write_fit) calculate the spectrum output - if you are fitting
# individually, you usually would.  If you are fitting 1000 spectra,
# you probably wouldn't.

# if (weight) read in a third column of uncertainties sig (i), and
# weight the fit by 1/sig(i)**2.  For this application, the fitting
# region is selected explicitly, so the would normally be
# false.  Sometimes I select out of a wider spectrum and weight
# accordingly.

# if (mirror) recreate the input file at the end of the output file,
# with updated parameters.  I have found this invaluable for studies
# where I want the change things one at a time and gauge the
# results.  You can easily grep from the comment line to the end to
# create an updated input file.

# if (autodiff), use 0.001 times the input parameters as the increment
# for finite-differencing in calculating the partial derivatives
# needed for least-squares fitting.  This ignores the values in the
# third column for each individual parameter.  I normally use autodiff
# feature except for very fine work involve spectral frequencies.

  T  T  F  T  T

# wavelength limits for fitting, and convergence criteria.  This files
fits 345-350 nm, for example.  345.00000  350.00000  1.0000E-12  1.0000E-12
# finally, the fitting parameters: each line contains a
# parameter.  whether it is fixed or varied in the fitting, the
# increment for finite-differencing if (.not. autodiff), and three
# locking parameters which are not being used at present:

  1.3266737E+12   T   1.42710E+09    0   0.00000E+00   0.00000E+00 baseline offset
```

See Table 20 for the format of this data.

2.1.1.1.4.2 Sensor Parameters

Field Angles Map

The nominal NP nadir view along the ground track consists of a set of angles relative to the nadir. To geolocate the NP data, the algorithm uses a map of these field angles derived from pre-launch view characterizations. To fully geolocate the NP data, the algorithm combines the view angles with the cross track angle separations from nadir and the spacecraft attitude and ephemeris. Therefore one must supply the algorithm with all the field angles, both along track and cross track, for it to have a map of the view angles for every illuminated pixel in the input RDR data. These look angles are derived from the SRG (spatial registration) database from BATC.

Goniometry Parameters

The instrument sensitivity to solar irradiance varies with illumination angle. This arises primarily because of the cosine effect and the non-Lambertian diffuser response. The angular dependence of the irradiance response is characterized during pre-launch calibrations (BRDF and angle table are derived from the GON database). These observations are considered in a Flattery analysis and are used to create grids with regular intervals. Each grid contains the angle information, BRDF information, and indices which describe where on the CCD there are characterized data. For diffuser position 4, the dimensions are larger as this diffuser position overlaps both detectors. See Table 4 for BRDF Grid format.

Calibration Constants

The algorithm uses radiometric calibration constants to convert detected counts into irradiances or radiances. A single constant relates the digital number to radiometric units for each pixel. The radiometric response varies with wavelength and spatial position, and is measured by the calibration team before launch for input to the algorithm.

The radiometric calibration constants are used in the np_earth_view subroutine to calculate earth radiances. This data is derived from BATC's RAD database. It contains the irradiance calibration coefficients and is used in the combine_solar.f subroutine to calculate the solar flux. This data is derived from BATC's IRD database. The data is organized into groups: one for primary electronics, the other for secondary electronics. See Table 5 and Table 15 for format details

Spectral Registration Pixel Map

The algorithm uses a spectral registration pixel map as a starting point for calibrating the current detected wavelengths of the NP sensor. This map describes the pre-launch wavelength band centers for all illuminated pixels on the CCDs. These band centers correspond to the centroids of the spectral response functions discussed above. Whether calibrated on the ground or derived from baseline solar measurements, the band centers and response functions together define the baseline sensor spectral registration. The map is filled with zeros where no characterization data are available. This data is derived from BATC's CBC database (channel bandcenters). See Table 17 for format details.

Spectral Response Functions

The algorithm uses a set of spectral response functions to determine the current wavelengths detected by the NP sensor. The sensor spectral response at each wavelength is the combined sensitivity of the optics and a CCD detector to an incident light spectrum. This relative sensitivity distribution is normalized to unity and is a peaked quasi-Gaussian response function whose strength varies with separation from a central wavelength. For different central wavelengths, the width and shape of the spectral response function can vary.

The sensor spectral response is characterized during pre-launch calibrations and functions are provided for each wavelength band. A full set of response functions at every nominal wavelength must be input into the SDR Algorithm. If the functions are measured at fewer wavelength centers than the entire OMPS spectrum, the calibration team must interpolate the measured spectral responses to other central wavelengths and store the functions in a LUT for input to the SDR Algorithm. Note that in general the spectral responses will vary with slit and gain across the NP sensor. The algorithm assumes that the shape but not width of the spectral responses remains homologous during the OMPS mission. This data is derived from BATC's BPS database (bandpass). See Table 18 for format details.

Line Shift Table

As a check on the derived wavelength scale, the Algorithm compares a table of standard shifts at selected absorption lines with the actual shifts derived from irradiance changes. The Algorithm needs the line shift table to do the analysis and record the results in the wavelength monitoring output. See Table 11 for format details.

2.1.1.1.4.3 Initialization Parameters

Standard High-Resolution Solar Irradiance LUT and its low resolution analogs Observed Solar and Predicted Solar LUTs

The wavelength and radiance monitoring in the SDR Algorithm depends on having a standard solar irradiance spectrum, highly calibrated in both wavelength and irradiance. Because the wavelength monitoring convolves the spectral functions with the standard irradiance in order to model an observed OMPS solar spectrum, the standard spectrum must be more highly sampled and at a higher resolution than the OMPS spectrum. The algorithm also uses for wavelength monitoring and for solar irradiance calculations lower resolution, lower sampled solar spectrum as well as a lower resolution, highly sampled spectrum.

The content of the solar flux data set is as follows:

SOLSTICE V9:	249.05 - 418.93 nm	0.05 nm step (similar resolution)
SOLSPEC:	419.0 - 820.5 nm	~1 nm step (similar resolution)
NOAO FTS:	820.5 - 1052 nm	~0.5 nm step (much better resolution)

Data are given at their native resolution - no smoothing. There is no overlap between the three inputs, just an abrupt transition from one to the next. SOLSTICE data were taken from UARS day 1209, which is at solar minimum.

2.1.1.1.5 Sensor Characterization Databases

The sensor characterization databases (SCDBs) contain the information needed to geolocate and calibration the measured radiances. Their use and format are described in detail in the SCDB ICD (Document #2255337, Rev C). The values in the databases are taken from the hdf5 format delivered by BATC to DPSE and converted directly into text format. IDPS has converted this text format to these formats now used in the operational algorithm:

1. Table 21: OMPS Nadir Profile SDR Input: Ground ISF Approved Earth View Sample Table
2. Table 24: OMPS Nadir Profile SDR Input: Ground ISF Approved Macropixel Table

3. Table 25: OMPS Nadir Profile SDR Input: Ground ISF Approved Solar Calibration Sample Table
4. Table 22: OMPS Nadir Profile SDR Input: Ground ISF Approved LED Sample Table
5. Table 26: OMPS Nadir Profile SDR Input: Ground ISF Approved Timing Pattern Table
6. Table 23: OMPS Nadir Profile SDR Input: Ground ISF Approved Linearity Table

The input of these tables is controlled by the Table Versions Lookup Table which contains the configuration combinations used in the flight software and maps that configuration to the ground versions used by O&S. See Table 30 for the format of the Table Versions Lookup Table.

2.1.1.2 Outputs

A description of the SDR outputs begins in Section 3.1.1.2 of the NP ATBD, 474-00026. Earth view SDRs are discussed in Section 3.1.1.2.1, Calibration SDRs are explained in Section 3.1.1.2.2, calibration databases are detailed in Section 3.1.1.2.3 and uplink files are described in Section 3.1.1.2.4.

2.1.1.2.1 Calibration SDR Outputs

Each Calibration output is listed in a table in this section in Table 32 though Table 40 as well as references to other tables. Many Calibration outputs are also Calibration inputs and have already been described in this document. In the case that a Calibration output has already been described in an earlier section of this document, a reference is made back to the table in which the output was first described.

Table 32: OMPS Nadir Profile SDR Output: Bad Pixels

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
bad_pixels	Int32 * 364 * 390	Pixels flagged bad if dark data for that pixel exceeds thresholds. 0 = bad 1 = good	pixels / Minimum - Maximum
dark_data	Float32 * 364 * 390	Corrected dark current counts	counts / None - None

See Table 3: OMPS Nadir Profile SDR Input: Biases. The output is in the same format as the Biases input.

See Table 31: OMPS Nadir Profile SDR Input: Ground ISF Approved Calibration Factors - Earth. Calibration produces an Earth Calibration Factors auxiliary product that is in the same format as the Ground ISF Approved Calibration Factors – Earth.

See Table 6: OMPS Nadir Profile SDR Input: Calibration Factors - Solar. The output is in the same format as the Calibration Factors – Solar input.

Table 33: OMPS Nadir Profile SDR Output: Calibration Geolocation

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
numSolar	Int16	Actual number of solar frames (images)	unitless / 0 - None
numDark	Int16	Actual number of dark frames (images)	unitless / 0 - None
numLamp	Int16	Actual number of lamp frames (images)	unitless / 0 - None
Scan-Level Data Items			
startTimeSolar	Int64 * 27	Start time of solar frame in IET (1/1/1958)	microseconds / 0 - None

Input	Type	Description	Units/Valid Range	
midTimeSolar	Int64 * 27	Mid-Time of solar frame in IET (1/1/1958)	microseconds / 0 - None	
endTimeSolar	Int64 * 27	End time of solar frame in IET (1/1/1958)	microseconds / 0 - None	
latitudeSolar	Float32 * 27 * 1	Sub-Satellite Latitude (positive North) at midTime_Solar	degrees / -90 - 90	
longitudeSolar	Float32 * 27 * 1	Sub-Satellite Longitude (positive East) at MidTime_Solar	degrees / -180 - 180	
moonVectorSolar	Float32 * 27 * 3	Lunar Position in Spacecraft Coordinates at MidTime_Solar	meters / 0 - None	
sunVectorSolar	Float32 * 27 * 3	Solar position in Spacecraft Coordinate System at MidTime_Solar	meters / 0 - None	
spaceCraftPosition Solar	Float32 * 27 * 3	Spacecraft position in ECR Coordinates (X, Y, Z) at MidTime_Solar	meters / 0 - None	
spaceCraftVelocity Solar	Float32 * 27 * 3	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at MidTime_Solar	meters/seconds / 0 - None	
spaceCraftAttitudeS olar	Float32 * 27 * 3	Spacecraft attitude with respect to Geodetic Reference Frame Coordinates (roll, pitch, yaw) at MidTime_Solar	radians / -pi - pi	
startTimeDark	Int64 * 5	Start time of dark frame in IET (1/1/1958)	microseconds / 0 - None	
midTimeDark	Int64 * 5	Mid-Time of dark frame in IET (1/1/1958)	microseconds / 0 - None	
endTimeDark	Int64 * 5	End time of dark frame in IET (1/1/1958)	microsecons / 0 - None	
latitudeDark	Float32 * 5 * 1	Sub-Satellite Latitude (positive North) at MidTime_Dark	degrees / -90 - 90	
longitudeDark	Float32 * 5 * 1	Sub-Satellite Longitude (positive East) at MidTime_Dark	degrees / -180 - 180	
spaceCraftPosition Dark	Float32 * 5 * 3	Spacecraft position in ECR Coordinates (X, Y, Z) at MidTime_Dark	meters / 0 - None	
spaceCraftVelocity Dark	Float32 * 5 * 3	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at MidTime_Dark	meters/second / 0 - None	
spaceCraftAttitude Dark	Float32 * 5 * 3	Spacecraft attitude with respect to Geodetic Reference Frame Coordinates (roll, pitch, yaw) at MidTime_Dark	radians / -pi - pi	
startTimeLamp	Int64 * 150	Start time of lamp frame in IET (1/1/1958)	microseconds / 0 - None	
midTimeLamp	Int64 * 150	Mid-Time of lamp frame in IET (1/1/1958)	microseconds / 0 - None	
endTimeLamp	Int64 * 150	End time of lamp frame in IET (1/1/1958)	microseconds / 0 - None	
latitudeLamp	Float32 * 150 * 1	Sub-Satellite Latitude (positive North) at MidTime_Lamp	degrees / -90 - 90	
longitudeLamp	Float32 * 150 * 1	Sub-Satellite Longitude (positive East) at MidTime_Lamp	degrees / -180 - 180	
spaceCraftPosition Lamp	Float32 * 150 * 3	Spacecraft position in ECR Coordinates (X, Y, Z) at MidTime_Lamp	meters / 0 - None	
spaceCraftVelocityL amp	Float32 * 150 * 3	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at MidTime_Lamp	meters/second / 0 - None	
spaceCraftAttitudeL amp	Float32 * 150 * 3	Spacecraft attitude with respect to Geodetic Reference Frame Coordinates (roll, pitch, yaw) at MidTime_Lamp	radians / -pi - pi	
QF1_GEOSOLAR	UInt8 * 27	Attitude/Ephemeris availability status during Solar Calibration	Nominal - E&A data available 0	0
			Missing Data <= Small Gap 1 Small Gap <	1
			Missing Data < Granule Boundary 2	2
			Missing Data >= Granule Boundary	3

Input	Type	Description	Units/Valid Range	
QF2_GEODARK	UInt8 * 5	Attitude/Ephemeris availability status during Dark Calibration	Nominal - E&A data available 0 Missing Data <= Small Gap 1 Small Gap < Missing Data < Granule Boundary 2 Missing Data >= Granule Boundary	0 1 2 3
QF3_GEOLAMP	UInt8 * 150	Attitude/Ephemeris availability status during Lamp Calibration	Nominal - E&A data available 0 Missing Data <= Small Gap 1 Small Gap < Missing Data < Granule Boundary 2 Missing Data >= Granule Boundary	0 1 2 3

Table 34: OMPS Nadir Profile SDR Output: Calibration SDR

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
bias1	Float32	Average electronics bias CCD side 1	counts / None - None
expose_dark	Float64	Exposure time of dark current (expose_dark)	seconds / 0 - None
expose_lamp	Float64	Exposure time of lamp counts (expose_lamp)	seconds / 0 - None
no_work_frames	Int16	Number of solar frames from working diffuser	unitless / 1 - 28
no_ref_frames	Int16	Number of solar frames from reference diffuser	unitless / 1 - 28
no_dark_frames	Int16	Number of dark frames (images)	unitless / 1 - 28
no_lamp_frames	Int16	Number of lamp frames (images)	unitless / 1 - 101
no_coadds_solar	Int16	Number of Co-adds during solar calibration	unitless / 1 - 1000
no_coadds_dark	Int16	Number of coadds during Dark calibration	unitless / 1 - 1000
no_coadds_lamp	Int16	Number of coadds during Lamp calibration.	unitless / 1 - 1000
total_sol_expose	Float64	Total Solar Exposure time (total_sol_expose)	seconds / 0 - None
rsf_expose	Float32	Reference solar exposure time (rsf_expose)	seconds / 0 - None
median_dark	Float32	Median dark current	counts / 0 - 2.00E+05
completeFlag	Int16	Completeness of solar calibration data	unitless / 0 - 7
Scan-Level Data Items			
badpix	Float32 * 200 * 370	Map of pixels used for solar data (badpix)	unitless / 0 - 1
wmap	Float64 * 200 * 370	Wavelenth map (wmap)	unitless / 240 - 320
flat	Float32 * 200 * 370	Local relative normalized radiometric sensitivities	unitless / None - None
ccd	Float64 * 200 * 370	Count rate of sun (ccd)	counts/second / None - None
rsf_data	Float32 * 200 * 370	Reference solar counts (rsf_data)	counts / 0 - None

Input	Type	Description	Units/Valid Range
raw_solar	Float32 * 27 * 364 * 390	Raw Solar Radiances	counts / None - None
smear_data_solar	Float32 * 27 * 200	Smear Data Solar Radiances	counts / None - None
solar_beta1	Float32 * 27	Angle between orbital plane and sun at start of solar observation	degrees / -180 - 180
solar_beta2	Float32 * 27	Angle between orbital plane and sun at end of solar observation	degrees / -180 - 180
diff_incid_angle	Float32 * 27	Angle from normal of incident solar flux	degrees / 0 - 90
diffuser_position_solar	Int16 * 27 * 2	Starting and ending pixel column for each solar measurement	unitless / 1 - 7
iyear_solar	Int32 * 27	Year of Solar Observation	years / 2000 - 2050
iday_solar	Int32 * 27	Day of Year for Solar Observation	days / 1 - 366
diffuser_surface_solar	Int32 * 27	Diffuser Surface used for Solar Calibration	unitless / 0 - 2
tccdnp_solar	Int16 * 27	CCD Temperature	counts / 0 - None
tmotnad_solar	Int16 * 27	Motor Temperature at Nadir	counts / 0 - None
tlmpnad_solar	Int16 * 27	Lamp Temperature at Nadir	counts / 0 - None
tradnad_solar	Int16 * 27	Radiator Temperature at Nadir	counts / 0 - None
tel1nad_solar	Int16 * 27	Electronics 1 Temperature at Nadir	counts / 0 - None
tel2nad_solar	Int16 * 27	Electronics 2 Temperature at Nadir	counts / 0 - None
pccdnp_solar	Int16 * 27	Profile of CCD	counts / 0 - None
vtecnp_solar	Int16 * 27	Voltage of Electronics	counts / 0 - None
ctecnp_solar	Int16 * 27	Electronics current	counts / 0 - None
gon_par	Float32 * 27 * 200 * 200	Goniometric correction to solar counts	unitless / None - None
flux_data	Float32 * 27 * 364 * 200	Final corrected solar counts of individual solar observation	W/cm3 / None - None
tccdnp_dark	Int16 * 5	CCD Temperature	counts / 0 - None
tmotnad_dark	Int16 * 5	Motor Temperature at Nadir	counts / 0 - None
tlmpnad_dark	Int16 * 5	Lamp Temperature at Nadir	counts / 0 - None
tradnad_dark	Int16 * 5	Radiator Temperature at Nadir	counts / 0 - None
tel1nad_dark	Int16 * 5	Electronics 1 Temperature at Nadir	counts / 0 - None
tel2nad_dark	Int16 * 5	Electronics 2 Temperature at Nadir	counts / 0 - None
pccdnp_dark	Int16 * 5	Profile of CCD	counts / 0 - None
vtecnp_dark	Int16 * 5	Voltage of Electronics	counts / 0 - None
ctecnp_dark	Int16 * 5	Current of Electronics	counts / 0 - None
tccdnp_lamp	Int16 * 150	CCD Temperature	counts / 0 - None
tmotnad_lamp	Int16 * 150	Motor Temperature at Nadir	counts / 0 - None
tlmpnad_lamp	Int16 * 150	Lamp Temperature at Nadir	counts / 0 - None
tradnad_lamp	Int16 * 150	Radiator Temperature at Nadir	counts / 0 - None
tel1nad_lamp	Int16 * 150	Electronics 1 Temperature at Nadir	counts / 0 - None
tel2nad_lamp	Int16 * 150	Electronics 2 Temperature at Nadir	counts / 0 - None
pccdnp_lamp	Int16 * 150	Profile of CCD	counts / 0 - None
vtecnp_lamp	Int16 * 150	Voltage of Electronics	counts / 0 - None
ctecnp_lamp	Int16 * 150	Current of Electronics	counts / 0 - None
qual_lamp	Int16 * 150	Reliability of lamp processing	unitless / -12 - 2
qual_solar	Int16 * 27	Reliability of solar processing	unitless / -4 - 5
qual_dark	Int16 * 5	Reliability of dark processing	unitless / -13 - None
fitness	Float64 * 5	Chi-squared goodness of fit for wavelengths	unitless / 0.5 - 5000
saa_lamp	UInt8 * 150	Spacecraft within South Atlantic Anomaly during lamp calibration (extent in percent based on Climatological data)	unitless / 0 - 100
saa_solar	UInt8 * 27	Spacecraft within South Atlantic Anomaly during solar calibration (extent in percent based on Climatological data)	unitless / 0 - 100

Input	Type	Description	Units/Valid Range
saa_dark	UInt8 * 5	Spacecraft within South Atlantic Anomaly during dark calibration (extent in percent based on Climatological data)	unitless / 0 - 100
eclipse	UInt8 * 27	Eclipse - All or part of the S/C is affected by a solar eclipse, umbra or penumbra viewing.	unitless / 0 - 1
occult_flag	UInt8 * 27	Occultation of the diffuser during solar observation	unitless / 0 - 3
Pixel-Level Data Items			
dark_data	Float32 * 364 * 390	Dark current corrected coadded counts	counts / None - None
dark_array	Float32 * 5 * 364 * 390	Correct counts of an individual dark current image.	counts / None - None
lamp_data	Float32 * 150 * 364 * 390	Correct counts of an individual lamp image	counts / None - None

See Table 7: OMPS Nadir Profile SDR Input: Darks. The output is in the same format as the Darks input.

See Table 8: OMPS Nadir Profile SDR Input: SAA Darks. The output is in the same format as the SAA Darks input.

Table 35: OMPS Nadir Profile SDR Output: Flat Field History

Input	Type	Description	Units/Valid Range
Scan-Level Data Items			
present_year	Int32 * 29	Year of flat field record	years / 2000 - 2050
present_day	Int32 * 29	Day of flat field record	days / 1 - 366
nmonitor	Int32 * 29	Number of calibration times used for trending flat field	unitless / 1 - 20
history_year	Int32 * 29	Last year of data used for flat field trending	years / 2000 - 2050
history_day	Int32 * 29	Last day of data used for flat field trending	days / 1 - 366
Pixel-Level Data Items			
flat	Float32 * 29 * 364 * 390	Flat field: Local relative normalized radiometric sensitivities	unitless / none - none

Table 36: OMPS Nadir Profile SDR Output: Flat Fields Proposed Upload

Input	Type	Description	Units/Valid Range
Pixel-Level Data Items			
flat	Float32 * 364 * 390	Local relative normalized pixel radiometric sensitivities	unitless / 0.5 – 1.5

See Table 10: OMPS Nadir Profile SDR Input: Flux. The output is in the same format as the Flux input.

Table 37: OMPS Nadir Profile SDR Output: Lamp

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
no_lamp_frames	Int32	Number of lamp frames	unitless / 3 - 101
Scan-Level Data Items			
recid_lamp	Int32 * 88	Record identification number	Unitless / 0 - None
lseq_lamp	Int32 * 88	Logical sequence number	Unitless / 0 - None
iyear_lamp	Int32 * 88	Year of observation	years / 2000 - 2050
iday_lamp	Int32 * 88	Day of observation	days / 1 - 366
time_start_lamp	Float64 * 88	Time start of observation	seconds / 0 - None

Input	Type	Description	Units/Valid Range
time_end_lamp	Float64 * 88	Time end of observation	seconds / 0 - None
delta_time_lamp	Float64 * 88	Exposure time	seconds / 0 - None
qual_lamp	Int16 * 88	Quality of processing	Unitless / -12 - 2
istat_lamp	Int16 * 88	Instrument status	Unitless / Minimum - Maximum
analog_lamp	Float32 * 88	Instrument/data record status	Unitless / Minimum - Maximum
saa_lamp	Float32 * 88	South atlantic anomaly severity flag	percent / 0 - 100
Pixel-Level Data Items			
lamp_data	Float32 * 88 * 364 * 390	Raw lamp counts for each exposure	counts / None - None

See Table 23: OMPS Nadir Profile SDR Input: Ground ISF Approved Linearity Table. The proposed output is in the same format as the Linearity input.

Table 38: OMPS Nadir Profile SDR Output: Linearity

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
no_lamp_frames	Int32	Number of lamp observations	unitless / 2 - 150
tref	Float32	Reference lamp integration time	seconds / 0 - None
qup	Float64 * 2	upper tie points (primary and redundant electronics)	unitless / >0
nramp	Int32	number of ramp lamp frames	unitless / 2 – 88
nref	Int32	Number of reference lamp frames	unitless / 2 – 88
slope	Float64	slope between tie points	unitless / 0 - None
Scan-Level Data Items			
iyear_lamp	Int32 * 88	Lamp observation time	years / 2000 - 2050
iday_lamp	Int32 * 88	Lamp observation time	days / 1 - 366
lamp_integration	Float32 * 88	Individual exposure time of lamp	seconds / 0 - None
lamp_uc_ramp	Float32 * 88	Weighted integration times	unitless / None - None
qideal	Float64 * 88	Ramp tie points	unitless / 0 - None

See Table 14: OMPS Nadir Profile SDR Input: Raw Flux. The output is in the same format as the Raw Flux input.

See Table 27: OMPS Nadir Profile SDR Input: Ground ISF Approved Wavelengths Table. Calibration produces a Wavelengths auxiliary that is in the same format as the Ground ISF Approved Wavelengths.

See Table 19: OMPS Nadir Profile SDR Input: Wave Monitor. The output is in the same format as the Wave Monitor input.

2.1.1.2.2 Proposed Upload Tables

The calibration algorithm creates three tables that are specifically intended to be taken into consideration by the Ground ISF when creating official tables for upload to the sensor.

Badpixels

The Badpixels product indicates whether the Calibration algorithm has detected extreme dark counts. Dark data is checked against a range of thresholds before flagging a pixel to be proposed as being bad. The Ground ISF can then use this information to alter various sample tables that are uploaded to the sensor. For example, a bad pixel would be excluded from spatial binning by the flight software if configured in the uploaded Earth View Sample Table. See Table 32 for the detailed format of the Badpixels Auxiliary product and the IDFCB vol III for completeness.

Linear Proposed Upload

The Linearity proposed upload (see Table 38 for format and the IDFCB vol III for completeness) is used by the Ground ISF for generating linear upload correction table for the sensor and also for generating the Linearity table used as an input to the SDR algorithms. This table nominally contains 2^{14} entries whose value at a position give the correction for the pixel count value that has the same number as the position number in the table. In other words, the table index position is the input count that it to be correct; the output count is adjusted by the table entry value, 1.0 for true linearity.

Flat Fields Proposed Upload

The Flat Fields proposed upload (see

Table 36 for format and the IDFCB vol III for completeness) is used by the Ground ISF for generating the gain correction table to be uploaded to the sensor for use by the flight software.

2.1.1.2.3 Earth View SDR Outputs

Each Earth View output is listed as a separate table in this section.

Table 39: OMPS Nadir Profile SDR Output: Earth View Geolocation

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
numberOfSwaths	Int16	Number of actual swaths in granule	unitless / 0 - None
numberOfIFOVs	Int16	Number of actual IFOVs	unitless / 0 - None
QF1_OMPSNPGEO	UInt8 * 5	Attitude/Ephemeris availability status	NA / 00 - 3
Scan-Level Data Items			
startTime	Int64 * 5	Starting Time of Swath in IET (1/1/1958)	microseconds / 0 - None
midTime	Int64 * 5	Mid Time of Swath in IET (1/1/1958)	microseconds / 0 - None
moonVector	Float32 * 5 * 3	Lunar position in Spacecraft Coordinates at MidTime	meters / 0 - None
sunVector	Float32 * 5 * 3	Solar position in Spacecraft Coordinates at MidTime	meters / 0 - None
scPosition	Float32 * 5 * 3	Spacecraft position in ECR Coordinates (X, Y, Z) at MidTime	meters / 0 - None
scVelocity	Float32 * 5 * 3	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at MidTime	meters/second / 0 - None
scAttitude	Float32 * 5 * 3	Spacecraft attitude with respect to the Geodetic Reference Frame (roll, pitch, yaw) at MidTime	radians / -pi - pi
Pixel-Level Data Items			
latitude	Float32 * 5 * 5	Latitude of each IFOV (positive North)	degrees / -90 - 90
longitude	Float32 * 5 * 5	Longitude of each IFOV (positive East)	degrees / -180 - 180
latitudeCorner	Float32 * 5 * 5 * 4	Latitude of each IFOV Corner – Array starts at upper right and proceeds clockwise	degrees / -90 - 90
longitudeCorner	Float32 * 5 * 5 * 4	Longitude of each IFOV Corner - Array starts at upper right and proceeds clockwise	degrees / -180 - 180

Input	Type	Description	Units/Valid Range
solarZenithAngle	Float32 * 5 * 5	Zenith angle of sun at each IFOV position	degrees / 0 - 180
solarAzimuthAngle	Float32 * 5 * 5	Azimuth angle of sun (measured clockwise positive from North) at each IFOV position	degrees / -180 - 180
satelliteZenithAngle	Float32 * 5 * 5	Zenith angle to satellite at each IFOV position	degrees / 0 - 180
satelliteAzimuthAngle	Float32 * 5 * 5	Azimuth angle (measured clockwise positive from North) to Satellite at each IFOV position	degrees / -180 - 180
relativeAzimuthAngle	Float32 * 5 * 5	Difference between solar and satellite azimuth angles at each IFOV position (solar – satellite)	degrees / -180 - 180
height	Float32 * 5 * 5	Ellipsoid-Geoid separation	meters / 0 - None
satelliteRange	Float32 * 5 * 5	Line of sight distance from the ellipsoid intersection to the satellite	meters / 0 - None

Table 40: OMPS Nadir Profile SDR Output: Earth View SDR

Input	Type	Description	Units/Valid Range
Granule-Level Data Items			
darkExposeEarth	Float64	Integration time for dark data (expose_dark)	seconds / 0 - None
numberOfSwaths	Int16	Number of actual swaths in granule	unitless / 0 - None
numberOfIFOVs	Int16	Number of actual IFOVs	Unitless / -32768 – 32767
numberOfSpecPix	Int16	Number of actual spectral pixels	Unitless / 32768 – 32767
outDatedCal	UInt8	Cal factor is out of date (greater than 28 days old)	unitless / 0 - 3
Scan-Level Data Items			
smearDataEarth	Float32 * 5 * 1 * 200	Raw smear counts of Earth image	counts / 1.4E-45 - 3.4028235E38
wavelengths	Float64 * 5 * 200	Wavelengths used in SDR processing (wref)	nanometers / 240 - 320
solarFlux	Float32 * 5 * 200	Reference solar flux from calibration database (rsf_piece)	W/cm^3 / 0 - 1500
bias1	Float32 * 1	Average electronics bias CCD Side 1	counts / 1.4E-45 - 3.4028235E3
darkCurrentEarth	Float32 * 6 * 200	Dark current in earth data (dark_piece)	counts / 1.4E-45 - 3.4028235E38
cal	Float32 * 5 * 200	Radiometric calibration	W/cm^3/sterad / 0 - None
linTblVersion	UInt16 * 2	Version and Profile ID of on-board Linearity Table from RDR	Unitless / 0 – 65535
gainTblVersion	UInt16 * 2	Version and Profile ID of on-board Gain Table from RDR	Unitless / 0 – 65535
npLinearCor	UInt8 * 5	Indicates Linearity Correction performed inflight	unitless / 0 - 1
SAA	UInt8 * 5	Spacecraft within South Atlantic Anomaly (extent in percent based on Climatological data)	percent / 0 - 100
qualEarth	Int16 * 5	Earth processing reliability (cumulative relative quality indicator count)	unitless / -16 - 8
Pixel-Level Data Items			
radiancesEarth	Float32 * 5 * 5 * 200	Calibrated Earth View Radiances	W/(cm^3*sr) / 1.4E-45 - 3.4028235E38
sunGlint	UInt8 * 5 * 5	Sun glint indication (scattering angle and surface type thresholds)	unitless / None - None
solarEclipse	UInt8 * 5 * 5	All or part of the IFOV is affected by a solar eclipse, umbra or penumbra viewing.	unitless / 0 - 1
waveFlag	UInt8 * 5 * 5	This data field is obsolete	unitless / 0 - 1
radFlag	Float32 * 5 * 5	This data field is obsolete	unitless / 0 - 1

2.1.2 Algorithm Processing

The Calibration SDR algorithm processes an individual granule at a time. After verifying the RDR, the number of images is verified to prevent rapid degradation in automatic processing coefficients in the operational environment. The number of solar, stepped lamp, and coadded full-frame dark images are totaled and individually compared to the prescribed configuration in the Timing Pattern Table. If the quantities match, processing continues. If the quantities do not match, the task is rejected and an SDR_NOACTION message is sent to INF to prevent retasking for this granule until a time at which more complete data has been received by IDPS.

The Calibration SDR algorithm safely assumes that it only needs to process raw calibration data since the ING SI has conveniently only allowed data received under calibration APID 565 to be stored as OMPS NP Calibration RDRs. Similarly, only raw Earth View data received under APID 561 is stored as OMPS NP Science RDRs.

When processing a granule of OMPS data, whether it is calibration or earth view, the resultant SDR contains scene-specific data only for scenes observed during that granule.

Due to the specialization of processing between calibration and earth view and the assumptions made in the organization of raw data, the science algorithm has been developed into two separate executables. One exclusively processes Earth View RDRs; the other exclusively processes Calibration RDRs. High level modules have been specialized for each of these executables; however, many modules are still usable by both executables. Section 2.1.2.1 and its subsections describe processing details exclusive to calibration processing. Similarly, section 2.1.2.2 and its subsections detail the specialized Earth View processing. Finally, section 2.1.2.3 and its subsections discuss modules that may be called from within either executable. These sections include low level assumptions, data checks, and assessments that are performed in the algorithm.

Earth view processing is presented in Section 3.1.2 of the NP ATBD, 474-00026, and calibration processing is discussed in ATBD, 474-00026, Section 3.1.3.

2.1.2.1 Calibration Main Science Module - np_pipeline_cal.f

The **np_pipeline_cal.f** function represents the interface between the algorithm wrapper and the science processing. This function calls a series of subroutines (**Get_evtable.f, Get_macrotable.f, Get_sctable.f, Get_ledtable.f,** and **Get_timetable.f**) to read in the SCDBs to establish the working array sizes, find the bad pixels in the data, and get additional information required for calibration. This function calls **Get_instrum_params_np.f** to define the OMPS NP sensor parameters (CCD reference angles, CCD spatial map, CCD spectral map, and channel spectral functions). It also calls **RDF_input_cal.f** to gather both engineering and raw CCD data from the verified RDR. Finally, this function calls **np_process_pipe_cal.f** to perform the science processing for a Calibration RDR.

2.1.2.1.1 Subroutine np_process_pipe_cal.f

Subroutine **np_process_pipe_cal.f** continues the setup and initialization process before calling **np_calib.f**. The solar reference spectrum is input by **Read_spec_cal.f**. Then, **np_calib.f** is called. The band center wavelengths are checked with **Flag_waves.f**. The **np_calib.f** is a major processing module that is described in its own section below. **np_process_pipe_cal.f** calls **Band_center_read**, **Read_spec_cal** and **np_calib** and is called by **np_pipeline_cal**.

2.1.2.1.2 Subroutine RDF_input_cal.f

RDF_input_cal.f is called once per tasking, accepting a verified RDR as its input. It then extracts RDR Command & Telemetry header data and raw calibration CCD data. This subroutine also checks limits on all the RDR data.

read_RDR_hdr_cal.f is called to extract header information from the verified RDR. Next, depending on the calibration image type, one of three strategies for interpreting the raw CCD data is used. For coadded dark images, the full-frame image is accepted as-is. For solar calibration, the SC sample table is used. Finally, for lamp calibration, the led sample table is consulted to position the stream of samples into full CCD coordinates.

Header information is stored with **save_rdr_hdrs.f** and radiances stored in array *raw_data* are transferred to solar, lamp, dark, bias storage arrays. The **fill_limits_flags.f** subroutine stores limits flags set in **rdr_limits.f** for each data type. For the dark, lamp, and solar data, the arrays are converted from the Full Array into CWS coordinates using **FullCCD2clipwsmear.f** and **IntFullCCD2clipwsmear.f**.

2.1.2.1.3 Subroutine Read_spec_cal.f

This subroutine inputs low resolution solar reference spectrum. It is called by **np_process_pipe_cal** and **Wave_monitor_np**.

2.1.2.1.4 Subroutine np_calib.f

The calibration subroutine performs numerous steps in processing the calibration images. It follows the steps found in NP ATBD, 474-00026, Figures 3.1-15 and 3.1-16.

After each type of data has been calibrated (i.e. debiased, dark-subtracted, etc.), it is coadded and stored in the calibration SDR and also in individual auxiliaries for lamp and dark image types.

2.1.2.2 Earth View Main Science Module - np_pipeline.f

The **np_pipeline.f** function represents the interface between the algorithm wrapper and the science processing. This function calls **Get_instrum_params_np.f** to define the OMPS NP sensor parameters (CCD spatial map, CCD spectral map, and channel spectral functions). It also calls **RDF_input_earth.f** to input each one of the NP verified RDRs in the current granule. Finally the function calls **np_process_pipe.f** to perform the science processing for an Earth View RDR by calling **np_earth_view.f**.

Subroutine np_process_pipe_earth.f

Subroutine **np_process_pipe_earth.f** continues the setup and initialization process before calling **np_earth_view.f**. The solar reference spectrum is gathered by **Read_spec.f**. Then wavelengths are gathered in **Band_center_read.f**. The **np_earth_view.f** subroutine is a major module that is described in its own sections below. **np_process_pipe_earth.f** calls **Get_instrum_params_np**, **Read_spec_earth**, **Band_center_read**, **Flag_waves**, **np_earth_view** and is called by **np_pipeline_earth**.

2.1.2.2.1 Subroutine RDF_input_earth.f

RDF_input.f is called once per tasking, accepting a verified RDR as its input. It then extracts RDR Command & Telemetry header data and raw Earth View CCD data. This subroutine also checks limits on all the RDR data.

read_RDR_hdr_earth.f is called to extract header information from the verified RDR. Next, the EV sample table is consulted to position the stream of samples into CCD coordinates.

Header information is stored with **save_rdr_hdrs.f** and radiances stored in array *raw_data* are transferred to Earth storage arrays. The **fill_limits_flags.f** subroutine stores limits flags set in **rdr_limits.f** for the Earth data type

This subroutine calls **read_RDR_hdr_earth**, **rdr_limits**, **save_rdr_hdrs**, and **fill_limit_flags**. It is called by **np_pipeline_earth**.

2.1.2.2.2 Subroutine Read_spec_earth.f

This subroutine inputs low resolution solar reference spectrum. It is called by **np_process_pipe_earth**.

2.1.2.2.3 Subroutine np_earth_view.f

A major branch of the SDR Algorithm is the processing of Earth view data, Implementation steps correspond to the lower portion of Figure 3.1-2 in Section 3.1.2 of the NP ATBD, 474-00026. The routine np_earth_view.f starts with some initialization for stray light. The routine **np_earth_view.f** starts by acquiring bias data by using **Get_bias.f**. The bias is subtracted from all Earth view data by **sub_bias_earth.f**. Next, the dark data is read and subtracted from the Earth view data by **sub_dark_earth.f,** and the smear data is calculated and removed by **subtract_smear_earth.f**. If the stray light correction flag is turned on, stray light correction is performed. Calibration factors applicable for the day of the observations are selected by **Read_cal_factors_np.f**. The reference solar spectrum is input by **Read_solar_ref.f**, omitting irradiances on bad pixels**,** and transformed to the current wavelength scale by using irradiance shift factors from the Wavelengths auxiliary input. The sensor response calibration factors are also re-binned to Earth view macro-pixel resolution, while dropping bad pixels. The overall calibration is computed and applied to the earth counts to yield calibrated radiances, which are stored in the array *earth*. The calibrated radiances for the macropixels are then checked and flagged for unusually high radiances. Finally, earth radiances are stored in the Earth View SDR in shared memory.

The bias, dark, smear and stray light corrections are discussed in NP ATBD, 474-00026, Section 3.1.2.6. The radiometric correction is presented in NP ATBD, 474-00026, Section 3.1.2.7. Mapping of the signal and radiometric corrections to the following subroutines is straightforward.

2.1.2.3 Shared Modules

Several routines are generic enough to be callable from either the calibration or EV executable.

2.1.2.3.1 Subroutine Get_evtable.f

This subroutine interprets the earth-view sample table which dictates which pixels are used for data processing. The variable, badpixBATC, contains 0 for bad or unused pixels and 1 for good pixels.

2.1.2.3.2 Subroutine Get_macrotable.f

This subroutine interprets the macrotable which indicates which pixels belong to which macropixel. This subroutine along with Get_sctable and Get_ledtable specify the mapping information need to process the RDR. See Appendix A for the variables associated with mapping.

2.1.2.3.3 Subroutine Get_sctable.f

This subroutine interprets the solar calibration sample table which indicates which pixels were used in the solar calibration frames.

2.1.2.3.4 Subroutine Get_ledtable.f

This subroutine interprets the LED sample table which indicates which pixels were used in the lamp observations.

2.1.2.3.5 Subroutine Get_timetable.f

This subroutine gathers info from the timing pattern table which contains the exposure times for the various observations (lamp, solar cal, dark, etc.).

2.1.2.3.6 Subroutine Get_instrum_params_np.f

Get_instrum_params.f inputs a series of sensor parameters. The satellite zenith angles in the cross-track spatial direction are input by subroutine **Get_optical_angles.f** from Field Angles Map LUT. Next, **d**ata in the radiance calibration constants and irradiance calibration constants inputs are ingested into the processing environment by the subroutine **Read_resp.f**, and stored in arrays *radevresp* (used with **resp_piece.f** to calculate the cal variable in **np_earth_view.f** subroutine) and *iradsolresp* (used in the **Combine_solar.f** subroutine) respectively. Earth scene reference wavelengths are calculated from the *wmap* values along with min and max wavelengths. Finally, the data in the spectral response function input is used to update the *wave_pro*f, *offsetw*, and *wavefunc* arrays. It is called by **np_pipeline_cal** and **np_pipeline_earth.**

2.1.2.3.7 Subroutine Read_resp.f

This subroutine reads in the radiance calibration constants and irradiance calibration constants , converts the data from Full Array coordinates to CVO coordinates (using **FullCCD2viewonly.f**), and removes any bad pixels. It calls **FullCCD2viewonly.f** and is called by **Get_instrum_params_np.f**.

2.1.2.3.8 Subroutine Read_wave_ref.f

This subroutine transfers values from the Spectral Registration Pixel Map LUT to the *wmap* array. It is called by **Get_instrum_params_np.f**.

2.1.2.3.9 Subroutine read_RDR_hdr.f

This subroutine reads the header parameters listed in Table 6 and uses the header parameters to initialize program variables. Observation times are converted from CCSDS segmented time code (CDS), 1958 Epoch time, to International Atomic Time (TAI) and IDPS Epoch Time (IET) and are used by the SDR algorithm. The CCSDS time is encoded in three contiguous fields of 64 bits (total) for NPP/NPOESS. The Command and Telemetry Handbook also defines three fields that are treated as decimal expressions of these three fields. When the Command and Telemetry handbook is brought into compliance with the CCSDS format, the time conversion portion of this subroutine will have to be modified. Start times of each observation are calculated from the ending observation times and observation integration period defined in the Timing Pattern Table.

CCSDS_APID is used to specify the datatype (561=EARTH, 565=CALIB). For CALIB data N_PROFILE_ID specifies the dataform (LAMP=17, DARK=10, SOLAR=20). Full frame data is ignored (LEDff=15 and DRKff=1). Note that TC_ROWS and TC_COLS are not used.

2.1.2.3.10 Subroutine rdr_limits.f

RDR values are screened by this subroutine. Currently the minimum and maximum values used in the screening process are simply based on the planned storage size of the variable. These must be updated with more physically realistic values to be effective for operations. It is called by **RDF_input_cal** and **RDF_input_earth**.

2.1.2.3.11 Subroutine save_rdr_hdrs.f

Transfer header variables into storage arrays by data type.

2.1.2.3.12 Subroutine fill_limit_flags.f

Transfer limits flags into storage arrays by data type.

2.1.2.3.13 Function Get_instrum_params_np.f

Get_instrum_params_np.f inputs a series of sensor parameters. Please see description above.

2.1.2.3.14 Subroutine Band_center_read.f

If the Wavelengths auxiliary input does not exist, set band center wavelengths to original values. If input exists, select wavelengths and supporting data entries for the same day as the current Earth view data.

2.1.2.3.15 Subroutine Flag_waves.f

Performs statistical analysis of wavelengths assigned to each Earth view RDRs, wavelength flag is set if wavelengths fall outside pre-determined min/max range.

2.1.2.3.16 Subroutines Stats.f and Stats4.f

Subroutine **Stats** computes median, mean, standard deviation, min and max values of real*8 array x of n elements. **Stats4** computes the same products for array x of type real*4.

2.1.2.3.17 Subroutine Get_bias.f

The subroutine **Get_bias** collects the most recent bias value from the Biases auxiliary input.

2.1.2.3.18 Subroutine Linearize_dark.f

Subroutine **Linearize_dark** applies to the dark data a linearity correction using the Linearity LUT. It corrects for the CCD amplifier non-linearities. The correction is based on the raw count levels of the data itself. All dark images are corrected. NP ATBD, 474-00026, Section 3.1.3.4.3 also discusses this process.

2.1.2.3.19 Subroutine sum_darks.f

Dark data from all dark images in the granule are summed and then averaged on a per pixel basis. Subroutine contains some code to discriminate between SAA and non-SAA data. The equation describing this process is found in NP ATBD, 474-00026, Section 3.1.3.4.7.

2.1.2.3.20 Subroutine do_stats.f

Subroutine **do_stats** calculates the statistics for the dark data array (minimum, maximum, median, mean, and stand deviation).

2.1.2.3.21 Subroutine sdr_write_SAA_dark.f

This subroutine stores dark data obtained from within the SAA to the SAA Darks auxiliary output.

2.1.2.3.22 Subroutine get_bad_pixels.f

This subroutine finds potentially bad pixels based on threshold values from BATC. Dark data is used. This information is not used during processing but is sent for HITL review. During processing, data derived from the EV sample table is used to remove pixels from processing.

Bad pixels are stored in the Badpixels auxiliary output. The tunable parameters are BadPixThreshold1, BadPixThreshold2= lower and upper bounds.

2.1.2.3.23 Subroutine read_dark.f

Subroutine **read_dark** obtains, from the Darks auxiliary input, the most recent dark current image and store it in memory for further use during data processing

2.1.2.3.24 Subroutine Linearity_np.f

Calculates the linearity from the raw lamp data. Methodology is same as used by BATC to generate the LinearityTable LUT. Refer to OMPS DADD- Nadir Total Column Linearity and LED Signal (IN0092SDB-015). The coefficients calculated by this subroutine are not immediately used in processing. Instead, the Linearity LUT, which is based on human-reviewed coefficients is used for processing.

Linearity LUT is used in processing; it must match the linearity table used onboard.

2.1.2.3.25 Subroutine sdr_write_dark.f

Subroutine stores data to the Darks auxiliary output. Only dark images not affected by SAA written out here.

2.1.2.3.26 Subroutine sdr_write_lamp.f

Subroutine stores the raw individual lamp frames that went into the linearity correction.

2.1.2.3.27 Subroutine Linearize_solar.f

Subroutine **Linearize_solar** applies to the solar data a previously calculated polynomial correction for CCD amplifier non-linearities. The correction is based on the raw count levels of the data itself. All solar frames are corrected. NP ATBD, 474-00026, Section 3.1.3.4.3 also discusses this process.

2.1.2.3.28 Subroutine Save_bias.f

This subroutine stores the bias value to the Biases auxiliary output.

2.1.2.3.29 Subroutine sub_dark_solar.f

Subroutine **sub_dark_solar** subtracts the dark, pixel by pixel, from the solar data. NP ATBD, 474-00026, Section 3.1.3.4.3 also discusses this process.

2.1.2.3.30 Subroutine subtract_smear_solar.f

Subroutine **subtract_smear_solar** subtracts the average smear data from the solar data. The solar frames have already been linearized using previous linearity measurements. NP ATBD, 474-00026, Section 3.1.3.4.3 also discusses this process.

2.1.2.3.31 Subroutine goniometry.f

The goniometry subroutine calculates the solar angles on the diffuser, given the location of the spacecraft for a specific time. BRDF values for efficiency of reflectance are calculated for the solar viewing geometry and applied to the radiance data. The calculation loops over the working and reference diffusers. The BRDF grid and their associated angular grid are input in one LUT. Stored solar frames are checked against the current combination of diffuser and diffuser position. If a match is made, a series of calls to the quaternion and CMN GEO libraries are made to calculate the sun vector. The diffuser is checked to make sure it is not occulted by the satellite, subroutine **bilinear_interpolation** is called to perform the BRDF interpolation on a regularly spaced angular grid, and the resulting BRDF is applied to the solar data to obtain the correct solar counts that would be due to irradiances striking normally on the sensor. There is an earth-sun distance correction applied based on the day of the year.

NP ATBD, 474-00026, Section 3.1.3.4.6 expands on this discussion.

2.1.2.3.32 Subroutine Read_solar_ref.f

Subroutine **Read_solar_ref** gets the Day 1 Reference Solar Flux (RSF) from the Observed Solar LUT.

2.1.2.3.33 Subroutine get_hits_solar.f

This subroutine finds a range of deviant pixels from a bias and dark subtracted solar CCD frame, using standard deviation cuts at seven times sigma both above and below the count medians. The flag table is the same as given above for identifying bad pixels from the dark data, though the flagged pixels from the solar data are additional pixels that have become bad or are transiently hit since the dark data were acquired. These transient pixels are not output to the BADPIXELS_NP database but are merely applied within the algorithm for processing only the current set of solar data.

2.1.2.3.34 Subroutine Combine_solar.f

Subroutine **Combine_solar** combines the solar CCD data frames into a complete solar image. For the NP RDRs, only the central diffuser position (four) is expected to be downloaded from the spacecraft. Subroutine goniometry.f only recognizes diffuser position four. If other positions are absent, as is nominal, the array elements will be zero at those positions, and by separating the smear columns from the array, the resulting solar data array has dimensions of 350 x 145 pixels.

The subroutine obtains these results:

counts_ccd is the total counts as would be measured in one solar exposure,
ccd is the count rate (per sec),
rawflx_data is a normalized count rate (per sec), relative to a reference solar flux

Previously identified anomalous (hit) pixels are excluded from the coadded data if good data from other frames exists at those pixels. The resulting data quality for the pixels is recorded in a badpixel array.

Solar data from the working diffuser are handled separately from the reference diffuser solar data. However, if the reference solar flux is lacking as an input, this subroutine uses the current solar data to calculate a reference solar flux, resulting in:

rsf_counts is the reference solar flux in counts, and rsf_data is the irradiance in physical units.

In any case, whether the reference solar flux is input or is an output of this subroutine, the exposure times of the current solar flux and the reference solar flux are used to normalize the counts before dividing one flux by the other flux, so that a proper ratio can be calculated.

We also extract the useable coadded data and store it into a single (350 x 145) data array by removing the smear columns from the array.

Outputs: counts_ccd, rawflx_data, and CCD.

The equation describing this process is found in NP ATBD, 474-00026, Section 3.1.3.4.7.

2.1.2.3.35 Subroutine Read_rawflux_np.f

Subroutine **Read_rawflux_np** acquires data from the Rawflux auxiliary input. Variables in COMMON with the main Nadir Profiler pipeline software are passed through F90 modules.

2.1.2.3.36 Subroutine Rawflux_write_np.f

Subroutine **Rawflux_write_np** creates a new Rawflux auxiliary output. It will initialize if a Rawflux auxiliary input was not available. If the input was available, pertinent data is propagated to the new Rawflux auxiliary output. Variables in COMMON with the main Nadir Profiler pipeline software are passed through F90 modules. If a reference solar flux has not successfully been input to the Algorithm, but the Rawflux auxiliary input exists, this subroutine reads and uses the reference solar flux contained in the Rawflux auxiliary input.

2.1.2.3.37 Subroutine Wave_monitor_np.f

This subroutine, **Wave_monitor_np**, analyzes a spectral/spatial CCD image by comparing the observed solar spectrum with the standard spectrum from solar_ref. The derived wavelength shifts along a spatial row are binned spatially before being stored to the Wave Monitor auxiliary output. Shifts are determined both from a continuum method that uses a Nonlinear Least Squares algorithm, based on an implementation by Bevington (1969) of the Levenberg-Marquardt approach, which includes linearization of the chi squared (fitting) function and a gradient search. The method also forms a set of pre-determined absorption lines whose radiances are used as a shift grid to find a wavelength shift by linearly interpolating to the measured irradiance differences. Wavelength shifts, uncertainties, and related statistical measures are accumulated for each binned spatial cell up to a maximum number of trending days. A general product header stores wavelength parameters that were used in the analyses.

The inputs are all parameters in the SUBROUTINE definition. An input reference spectrum LUT is necessary. Also, an input Line Shifts LUT that was created pre-launch by an IDL program, WAVETABLE.PRO, is important for the algorithm to record non-uniform shifts throughout a spectrum at a fixed spatial row. Resolution history, as line FWHM in the variable "resolution", is stored in the Wave Monitor auxiliary output and should be used to monitor instrument wavelength performance.

The spectral image data are passed as "ccd", and the all important standard comparison wavelength scale is "wmap". Critical instrument parameters are set previously by the subroutine Get_instrum_params_np in the parent calling routine and are passed by F90 modules. The initial pre-launch sensor response, previously input from Calibration Constants LUT, is used by **Wave_monitor.f** to rectify the observed solar spectrum. Subsequently, after a sufficient number of wavelength monitorings (nwave_trends), the observed solar spectrum is rectified in **Wave_monitor.f** by the solar calibration factors (CF_SOLAR)

The Wave Fitting Parameters LUT contains critical spectral fitting parameters and is used by the subroutine **Calc_cont_shifts**.

The outputs are stored in the Wave Monitor auxiliary output. This auxiliary product contains line and continuum wavelength parameters in a header, as well as date in records, and finally shifts, uncertainties, reduced chi-squared, and linear correlation statistics.

Subroutines called are **Read_spec**, **sdr_head_write**, **Calc_cont_shifts** (contains many subroutines), **Calc_line_shifts**, **Read_table_ref_shifts**, **Fit_line_shifts**, **Init_wshifts**, **Write_wshifts**, **Read_wshifts**, **Stats**, **dp_sort**, and **interpolate**.

The module **Fit_line_shifts** was patterned after Data Reduction for Physical Sciences (Bevington). The **Calc_line_shifts** and dependent subroutines for chi-squared fitting were adapted from GOME satellite software generously donated by Kelly Chance at Harvard University. The marquardt subroutine was developed by Mark Kowitt at Raytheon ITSS and the Gauss-Jordan component was developed by Cori Carter and Mark Kowitt.

NP ATBD, 474-00026, Section 3.1.3.5.5 develops the continuum fitting approach to wavelength monitoring while Section 3.1.3.5.6 develops the discrete line approach.

2.1.2.3.38 Subroutine Read_table_ref_shifts.f

Subroutine **Read_table_ref_shifts** loads data from the Line Shifts LUT for the wavelength monitoring subroutine to compare with the observed solar image.

Resolution history, as line FWHM in the variable "resolution", is stored in the Wave Monitor auxiliary output and should be used to monitor instrument wavelength performance and possibly update the input table_line_shifts.f, which has values for a FWHM of about 0.83 nm.

2.1.2.3.39 Subroutine Interpolate.f

This subroutine finds a value by linear interpolation of array x, y for point u.

2.1.2.3.40 Subroutine Read_wshifts.f

Subroutine **Read_wshifts** finds the newest wave_trend number of records in the Wave Monitor Auxiliary product and returns the wavelength shift information for all those records, so that the trending subroutine can use the shifts.

2.1.2.3.41 Subroutine Init_wshifts.f

Subroutine **Init_wshifts** initializes a Wave Monitor auxiliary product by inserting header information containing:

- wmin, wmax: the wavelength extrema
- nlines: the number of discrete spectral lines monitored
- line_locates
- offset
- w
- good: condition flag for program execution.

It is initialized only if the Wave Monitor auxiliary input was not retrieved.

2.1.2.3.42 Subroutine Calc_cont_shifts.f

This subroutine finds a wavelength shift between observed and reference spectra by using a min chi-squared routine (marquardt). This subroutine calls **specfit.f,** the driver for the min chi-squared routine, **marquardt.f**. It also calls **spectrum.f** which computes the spectrum corresponding to a given set of fitting parameters. **Quick_convolve.f** is used to convolve a high resolution spectrum with a sensor spectral function. A series of other subroutines are also called as part of the wavelength continuum fitting.

2.1.2.3.43 Subroutine Calc_line_shifts.f

This subroutine calculates wavelength shifts using a reference shift table of the solar spectrum line shifts. It assumes that the reference spectrum and shifted spectrum have same wavelength resolution and scale as the reference table.

2.1.2.3.44 Subroutine Write_wshifts.f

Subroutine **Write_wshifts** adds the wavelength shift information for the current orbit into the specified Wave Monitor auxiliary product.

2.1.2.3.45 Subroutine Wave_trend_np.f

Using previously measured wavelength shifts of a two-dimensional spectral-spatial detector, the subroutine **Wave_trend_np**, predicts the central wavelengths of all pixels in a spectrum for each recorded spatial channel, for each extrapolated day, and inserts the expected wavelengths into the Wavelengths auxiliary output. The most recent wavelength shift values are first read from a Wave Monitor auxiliary input, and then the wavelength extrapolations are calculated from a linear fit in time to the recent wavelength shift measurements. Both a measured constant shift and a measured wavelength linear varying shift are used to predict future wavelengths.

This trend of the wavelength shifts is determined separately for each CCD spatial channel, and a wavelength scale is calculated and written into a wavelength database for every day for each detector spatial channel. If wavelengths are missing, the program projects forward from the current date, the nominal number of days past the next wavelength monitoring. If the next wavelength monitoring occurs before the last day for which wavelengths have been previously predicted, the new values will always supersede older, extrapolated values.

Wavelength trending over time is discussed in NP ATBD, 474-00026, Section 3.1.3.5.7.

2.1.2.3.46 Subroutine Read_wshifts.f

Subroutine **Read_wshifts** finds the newest wave_trend number of records in the Wave Monitor auxiliary product and returns the wavelength shift information for all those records, so that the trending subroutine can use the shifts.

2.1.2.3.47 Subroutine Fit_line_shifts.f

Subroutine **Fit_line_shifts** calculates a linear fit to measured line shifts and returns the slope, intercept, and chi-squared statistic.

2.1.2.3.48 Subroutine Shift_correct.f

This subroutine takes newly measured wavelengths and shifts the observed normalized solar raw flux back to the wavelength scale of the reference solar flux. The corrected flux ratio then contains irradiance variations but not variations due to wavelength shifts. Thus, the resultant ratio can be used to calculate radiance calibration factors to apply to the Earth data after a calibration trend is derived. Note that resolution changes between the reference solar flux and the current instrument resolution can cause errors in this correction. However, for 5% resolution changes, the rough error in the correction is about 2e-4, or 0.02% in the irradiances. Resolution history, as line FWHM in the variable "resolution", is stored in the Wave Monitor auxiliary output. It may be used to monitor instrument performance and possibly update the Predicted Solar LUT for a different resolution other than the nominal 1.0 nanometer FWM with which it was created by convolving the inputs Spectral Response Function LUT and Solar Irradiance LUT. The correction is only valid if the reference solar flux has the wavelengths defined by wmap, which was used to derive the shifts

This correction is discussed in NP ATBD, 474-00026, Sections 3.1.3.4.8 and 3.1.3.5.8.

2.1.2.3.49 Subroutine Flux_write_np.f

This subroutine supplies data for the Flux auxiliary product. The reference solar flux and counts arrays are stored. This subroutine will store the corresponding measured CCD counts. Variables in COMMON with the main Nadir Profiler pipeline software are passed through F90 modules.

2.1.2.3.50 Subroutine trend_albedo.f

Subroutine **trend_albedo** gathers the solar irradiance data needed to do the trend for the next few weeks from the Flux auxiliary and stores the latest estimates for the albedo correction into the Calibration Factors (CF) products. In particular, the Earth CFs are derived by binning the solar CFs, excluding the bad pixels. Also, the subroutine uses the solar CFs to store the CCD flat field sensitivities to the Flat Fields auxiliary product.

This processing is described in NP ATBD, 474-00026, Sections 3.1.3.5.3 and 3.1.3.5.4.

2.1.2.3.51 Subroutine linfit.f

Performs a least squares fit of a line to per pixel historical data using last nmonitor values. Slope and intercept are used to extrapolate.

2.1.2.3.52 Subroutine sdr_write_solar.f

This subroutine stores a calibration SDR containing solar, lamp, dark, bias, and smear information that was used to determine the sensor wavelength and irradiance calibrations. Coadded data are stored in the calibration SDR. The individual SDRs constituting the coadded data are also stored.

2.1.2.3.53 Subroutine sub_bias_earth.f

Subroutine **sub_bias_earth** subtracts sensor electronics bias from all Earth view frames, using the bias value from the newest dark data.

2.1.2.3.54 Subroutine sub_dark_earth.f

Using the most appropriate recent available dark data, this subroutine subtracts dark counts from the earth view data. The process is carried out in three steps: 1) defining the dark data to use, 2) binning dark data at calibration resolution to Earth view macro-pixel resolution, 3) subtracting dark counts from Earth view counts. The subroutine obtains the appropriate dark from either the Darks or SAA Darks auxiliary inputs. Next, the average dark counts are calculated at Earth view macro-pixel resolution for three CCD regions: beginning smear, middle data, and ending smear columns. Finally, the locally spatially averaged macro-pixel dark signal is subtracted from the Earth view counts for each separate spatial Earth data cell.

2.1.2.3.55 Subroutine Read_SAA_dark.f

Subroutine **read_dark** passes SAA dark data from the SAA Darks auxiliary input into memory for use in subtracting SAA darks data from SAA Earth data.

2.1.2.3.56 Subroutine subtract_smear_earth.f

This subroutine calculates, with **calc_smear_earth.f,** the smear and then subtracts the smear from the earth data.

2.1.2.3.57 Subroutine calc_smear_earth.f

This subroutine calculates the amount of smear in the dataset. It assumes that the smear is found in the center of the nosmear rows of the data array. These data are averaged over each column and that value is subtracted from "real" earth data in that column to estimate the excess light hitting the CCD while it is being read-out.

2.1.2.3.58 Subroutine Read_cal_factors_np.f

This subroutine retrieves appropriate calibration factors from the Cal Factors – Earth auxiliary input based on day and year.

2.1.2.3.59 Subroutine sdr_write_earth_np.f

Write an Earth view SDR.

2.1.3 Graceful Degradation

None.

2.1.3.1 Graceful Degradation Inputs

None.

2.1.3.2 Graceful Degradation Processing

None.

2.1.3.3 Graceful Degradation Outputs

None.

2.1.4 Exception Handling

The SDR algorithm has been designed to complete execution under a wide variety of non-optimum situations. For example, missing input data are created from best available data when possible (and reasonable) and the code includes workarounds for many situations where the quality of the CCD data is low.

Any exceptions or errors are reported to IDPS using the appropriate INF API. All input is assumed to be available until the graceful degradation plan has been implemented.

Long-term bad pixels are identified in **get_bad_pixels.f** and are excluded from calculations only after being approved by the Ground ISF. The identification of long term bad pixels currently relies only on snapshots of the dark current. A fit in time to the dark current images, as well as comparison to solar image flagged pixels would improve the accuracy of long term bad pixel identification.

2.1.5 Data Quality Monitoring

None.

2.1.6 Computational Precision Requirements

The OMPS NP SDR algorithm is coded to use ‘real’ and ‘integer’ declared variables for the most part. Double precision real variables are used for computational accuracy in the **goniometry.f** subroutine. In general, wavelength computations (*_wshifts.f, Wave_monitor.f, Wave_trend.f, etc.) were implemented with double precision and (ir)radiance calculations performed in single precision real*4.

2.1.7 Algorithm Support Considerations

None.

2.1.8 ASSUMPTIONS AND LIMITATIONS

2.1.8.1 Assumptions

All necessary data will be available and provided within the necessary time constraints.

When tasked with a calibration granule that lacks necessary images, the calibration executable will reject the task and send an SDR_NOACTION message to INF. Similarly, if reference solar data is detected, a descriptive message will be sent to the IDP operator.

2.1.8.2 Limitations

None have been identified at this time.

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

Table 41: 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
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

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.
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.: DoD 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.: DoD 5000.59-DoD Modeling and Simulation Management]

3.2 Acronyms

Table 42: Acronyms

Acronym	Description
ADCS	Advanced Data Collection System
ARF	Anisotropic Reflectance Factor
GVVSLE	Gain Value Versus Scene Lunar Elevation
GVVSSE	Gain Value Versus Scene Solar Elevation

4.0 OPEN ISSUES

A list of TBDs and TBRs can be found in Table 43.

Table 43: List of OAD TBD/TBR

No.	DESCRIPTION	PAGES AFFECTED
None		

5.0 APPENDIX A

This appendix provides a detailed description of the coordinate systems and variables used to describe them throughout the SDR Algorithm. BATC has generated a series of SCDBs characterizing the Nadir Profile sensor. The original assumption of a uniform data structure (all used data contained on the same 390x145 pixels on the CCD) is no longer valid, so a more flexible array sizing scheme was required.

The BATC databases give detailed information on macropixel sampling, bad pixels, solar diffuser sampling and lamp sampling. The array variations occur in both the spatial and spectral directions. In the spectral dimension, spectral smile causes the spectral size to be non-uniform. In the spatial dimension, OMPS DADD-Nadir Profile Sample Table and Bad Pixel Database (IN0092SDB-011) outlines how the macropixel sizing can vary depending on the SPATIALFLAG setting. Table 44 shows the parameters defined from the sample table. The information is discussed in more detail in the rest of the appendix. Most of the arrays used throughout the Algorithm are initialized to the maximum possible size, and then only the "working" part of the array is used once the dimensions have been determined from the sample tables.

For ease of coding, the smear pixels and non-smear pixels were treated in separate arrays. All of the arrays are described using a series of vectors throughout the code. In all the most recent versions of the DADDs, only one macropixel is expected for NP, but the flexibility to allow for additional macropixels has been built into the code.

Figure 5 and Figure 6 visually show some of the dimensions described in the table. Whenever the array refers to a pixel size it is relative to the frame of reference shown in Figure 5. Figure 6 shows the maximum sizes of the smear and view regions, but the typical used region is much smaller, as indicated in Figure 5.

Table 44: Parameter Definitions

Parameter	Definition and Notes
nmacro	**Total number of macropixels (smear and view) (nominally 284)**
noctpx	**Number of view macropixels (nominally 1)**
nosmear	**Number of smear macropixels (nominally 1)**
no_spat_ccd	**total number of spatial pixels on the CCD (fixed 390)**
no_spec_ccd	**total number of spectral pixels on the CCD (fixed 364)**
nospace	**total number of spatial pixels on the CCD without smear (tunable 350)**
macrospat(nmacro, 4)	**(nmacro,1) : start spatial pixel of this macropixel** **(nmacro,2) : end spatial pixel of this macropixel** **(nmacro,3) : size** **(nmacro,4) : macro pixel number in this row (1 to noctpx for view, 1 to nosmear for smear)**
macrotype(nmacro)	**Type of macropixel for each macropixel: 1 = view macropixel, 2 = smear macropixel**
macromin(3)	**macromin(1) : minimum location in CCD coordinates of view pixels in the spatial dimension** **macromin(2) : minimum location in CCD coordinates of smear pixels in the spatial dimension** **macromin(3) : minimum number of pixels in spectral dimension**
macromax(3)	**macromax(1) : maximum location in CCD coordinates of view pixels in the spatial dimension** **macromax(2) : maximum location in CCD coordinates of smear pixels in the spatial dimension** **macromax(3) : maximum number of pixels in spectral dimension**
macrosize(3)	**macrosize(1) : size of view macropixel in pixels** **macrosize(2) : size of smear macropixel in pixels** **macrosize(3) : spectral dimension in pixels**
macrospec(nmacro)	**spectral location of each of the macropixels**

badpixBATC	**Dimensions: (2,no_spat_ccd, no_spec_ccd)** **1st dimension = array electronics (primary or redundant)** **Values:** **< 1 = unused pixel** **1 = good pixel**
solarmaskBATC	**(no_spat_ccd,no_spec_ccd)** **Values:** **0 = not used** **1 = used**

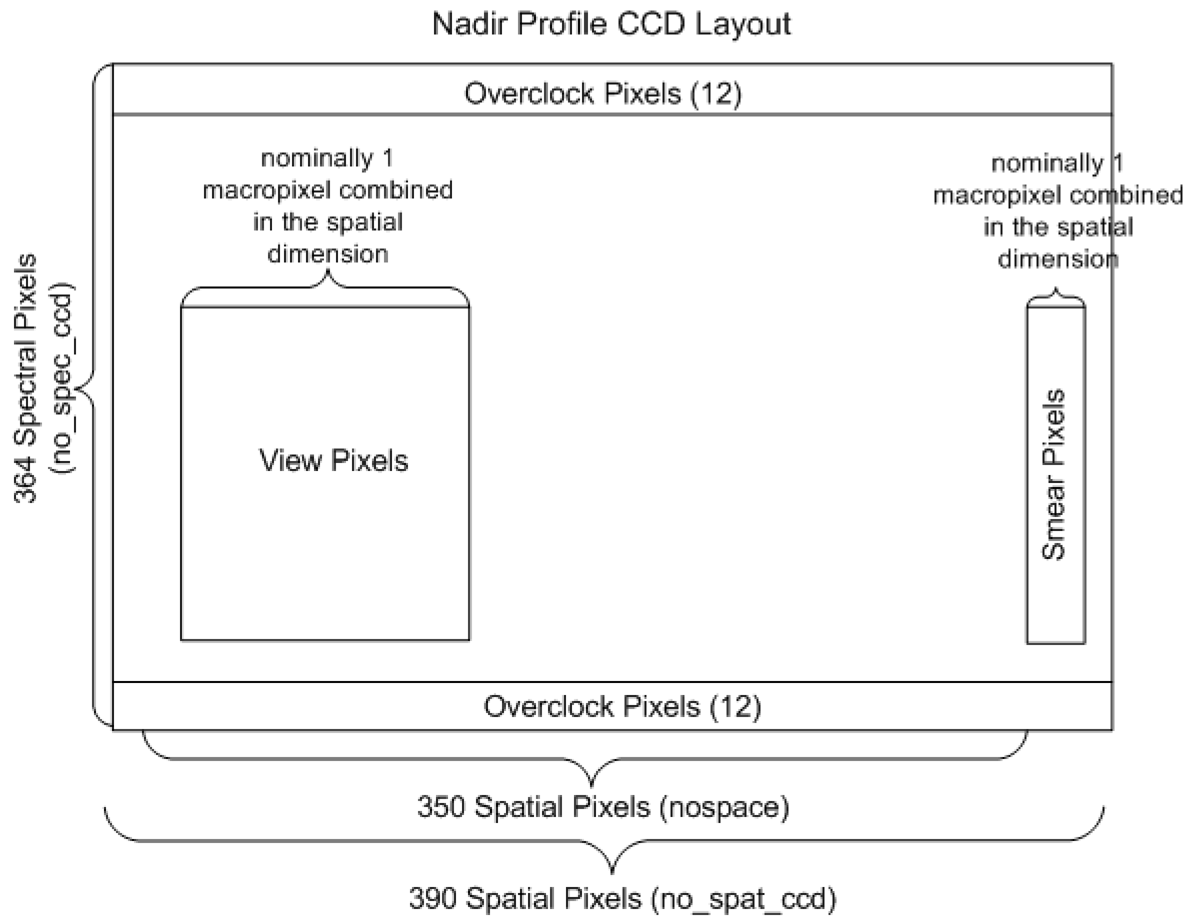

Figure 5: Layout of Nadir Profile CCD

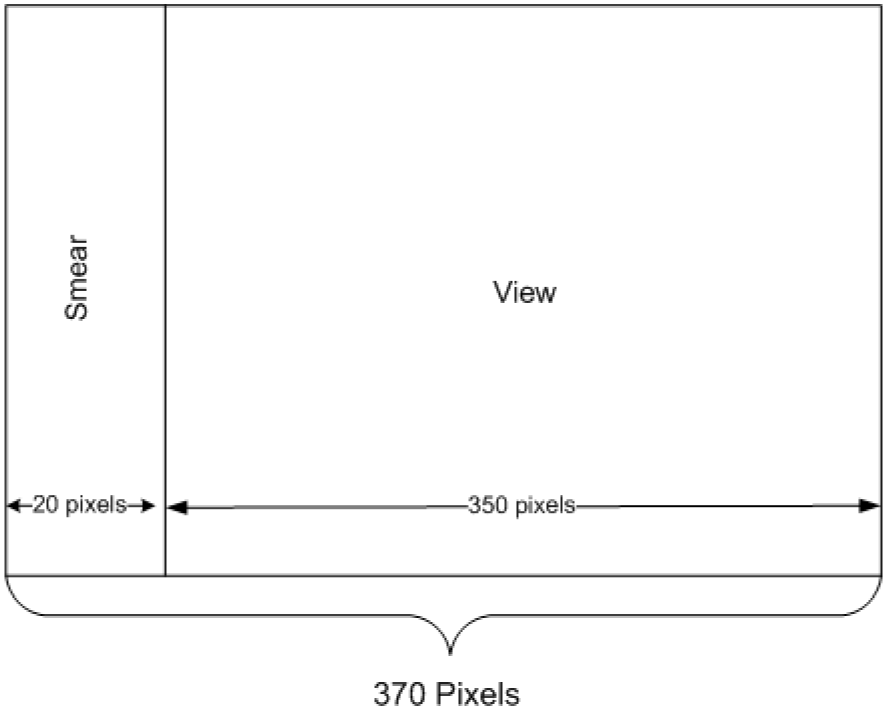

Figure 6: Clipped layout of NP CCD